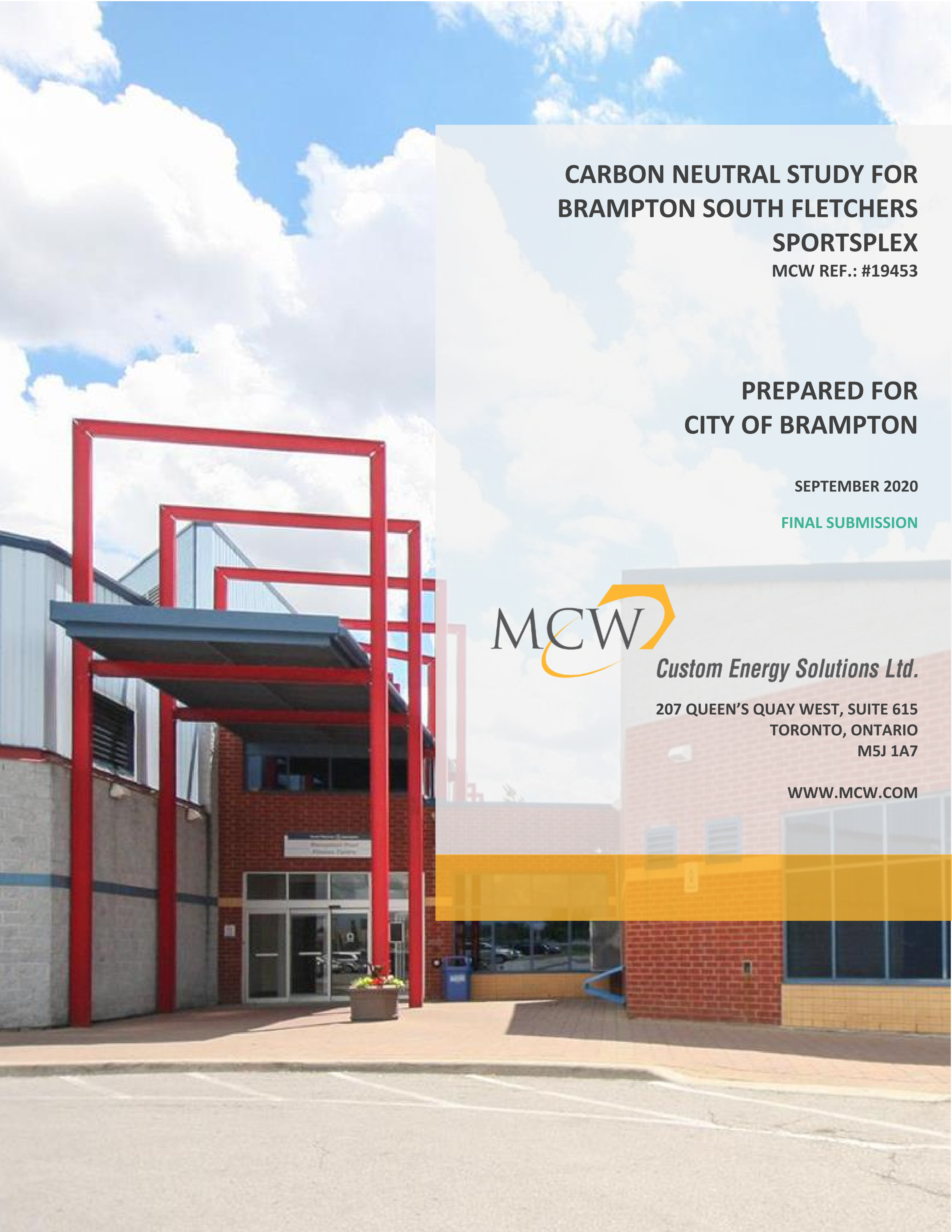

CARBON NEUTRAL STUDY FOR BRAMPTON SOUTH FLETCHERS SPORTSPLEX

MCW REF.: #19453

PREPARED FOR CITY OF BRAMPTON

SEPTEMBER 2020

FINAL SUBMISSION

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BRAMPTON SOUTH FLETCHERS SPORTSPLEX
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SECTION 1

EXECUTIVE SUMMARY

1 EXECUTIVE SUMMARY

1.1 OVERVIEW & TERMS OF REFERENCE

MCW Custom Energy Solutions Ltd. has been commissioned to provide a Carbon Study at the South Fletchers Sportsplex Building located at 500 Ray Lawson Blvd, Brampton, ON. The objective of this study is to complete a comprehensive technical and financial analysis of options and determine the best approach to reduce the building's carbon footprint. The Carbon Neutral Study is to identify opportunities to significantly reduce the building's energy consumption and resulting greenhouse gas (GHG) emissions. The proposed changes should also significantly reduce the energy costs for the building.

The South Fletchers Sportsplex is a (172,827 ft^2) community centre located in Brampton, ON. The two-storey facility was constructed in 1996. This report provides a comprehensive analysis of the facilities energy consumption, carbon footprint, existing asset service life and corresponding expenditure, and ties each component together through a Life Cycle Cost Analysis (LCCA) to determine which solution has the best Net Present Value (NPV) for the facility.

The preparation of this feasibility study was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities (FCM). Notwithstanding this support, the views expressed are the personal views of the authors, and the FCM and the Government of Canada accept no responsibility for them.

1.1.1 CARBON SAVINGS TARGETS

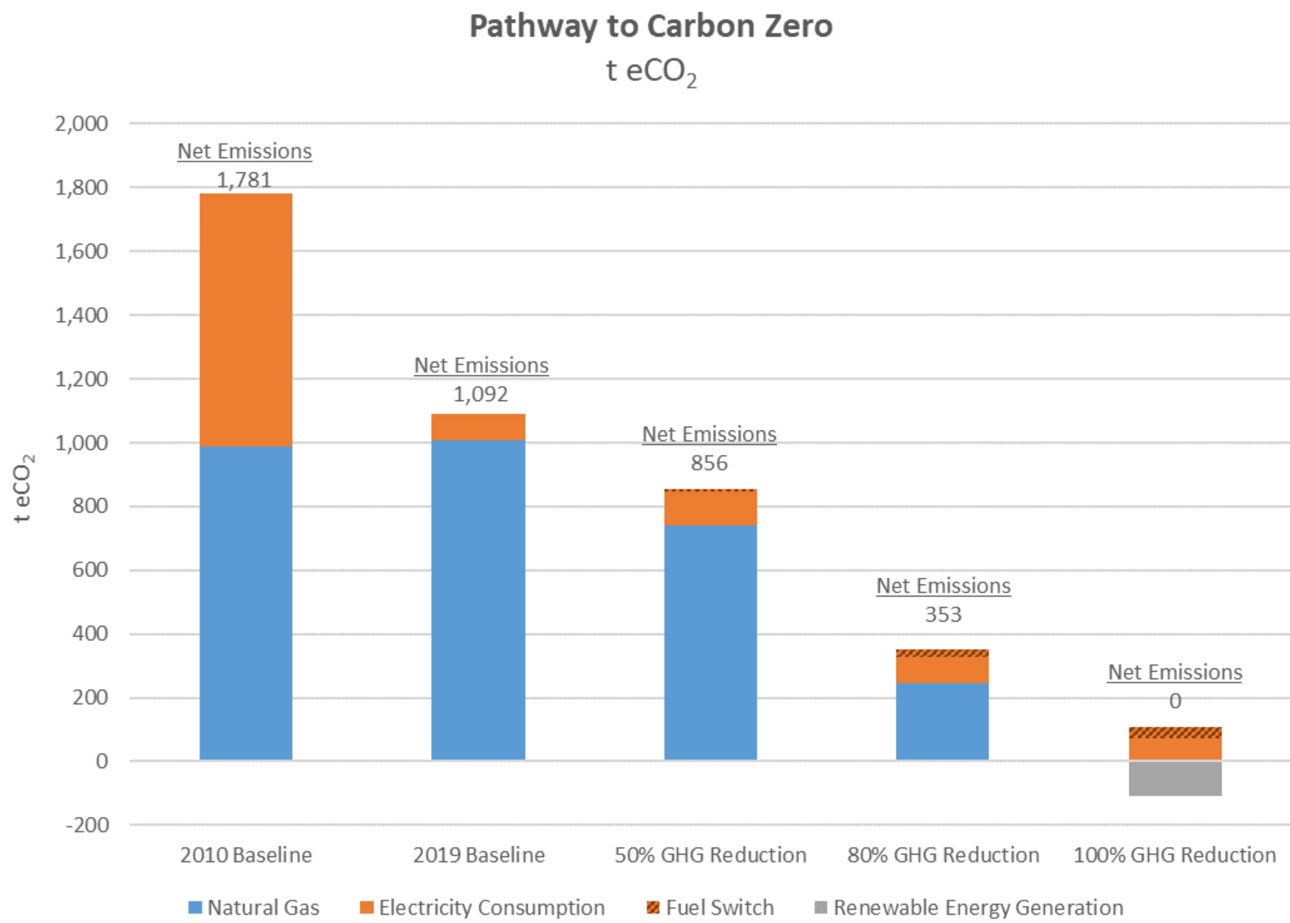
As part of this iterative design process the City has requested ten Energy Retrofit Program options for comparison. The stated requirements of the options are:

- Option 0: Existing Building Operation
- Option 1-3: 50% Carbon reduction from status quo
- Option 4-6: 80% Carbon reduction from status quo
- Option 7-9: 100% Carbon reduction from status quo

Carbon reductions can be achieved through various means. Available strategies include energy conservation measures, fuel switching, renewable energy generation, and renewable energy credits/carbon offsets. All of these strategies have been considered as part of this report and more are included as the carbon reduction target increases. To what extent each strategy is used is a function of the carbon target (i.e. 100% targets require that a full fuel switch from on site natural gas use to electric be completed) and feasibility.

Before the energy audit of the building was completed, a benchmarking exercise was completed in order to determine the extent to which each of these strategies would need to be entertained to achieve each reduction target. How the benchmarks were arrived at is presented in *Section 3 – Utility Analysis*, but the results of this benchmarking exercise are presented here, so as to inform the reader of how the targets stack up against the existing conditions. This "Roadmap to Carbon Zero" served as the bases for the energy audit and ECM generation that is presented in this report.

1 EXECUTIVE SUMMARY



1 EXECUTIVE SUMMARY

1.2 ENERGY RETROFIT PROGRAMS

Energy Retrofit Programs have been assembled to meet the targets as follows. All programs include those ECMs determined to be low payback which present a viable business case (A01 - LED lighting retrofits, A04 – Arena lighting controls, B01 – Battery Energy Storage System, and H01 – Domestic Water Retrofits). Additional ECMs:

- Option 1, 50% Target: This option includes a retrofit of the ice plants with new C02 chillers with a higher heat recovery capacity
- Option 2, 50% Target: This option includes a retrofit of the ice plants, but with ammonia chillers instead of C02. As a result, integration onto a district energy heating system is required to hit the reduction target.
- Option 3, 50% Target: This option considers implementing all those measures with capital projects under consideration (ice plant replacement, BAS upgrades, and replacements of the boilers, air handlers, and heat pumps).

Energy Retrofit Programs with 80% targets and above require a significant electrification of the building's heating system. This is accomplished through the installation of a ground source heat loop that displaces the requirement for the boilers to serve building's low temperature heating loop.

- Option 4, 80% Target: This option includes a retrofit of the boilers, ice plants, and air handlers, and BAS.
- Option 5, 80% Target: This option includes a retrofit of the boilers, ice plants, and air handlers, and BAS. Additional lighting retrofits add to the carbon savings.
- Option 6, 80% Target: This option is similar to option 4, but forgoes retrofits of the air handlers and substitutes a partial recladding of the building envelope.

Energy Retrofit Programs with 100% targets, carbon neutral operation, require a full electrification of building heating. Additional retrofits reduce the carbon footprint of the electrical consumption.

- Option 7, 100% Target: This option includes the installation of a ground source heating loop to serve the entirety of the buildings heating needs. Retrofits of the air handlers, BAS, and ice plants are also included. All heating sources including in stand heating and dehumidifiers are decarbonized, as are the arena's ice resurfacers. A significant recladding of the building is also included.
- Option 8, 100% Target: This option is similar to option 7, but building heat is generated from a waste water source heat pump tied into a region of Peel sewer trunk north west of the building, in lieu of the ground source system envisioned in option 7.
- Option 9, 100% Target: This option is similar to option 7, but forgoes recladding the building envelope.

Options 7 – 9 do not meet the 100% carbon reduction targets using traditional EMCs, but the use of Renewable Energy Credits and/or Carbon Offsets allow for carbon neutral operation of the building.

1 EXECUTIVE SUMMARY

1.2.1 SCENARIO MEASURE SCOPE MATRIX

Each of the energy retrofit programs requires a different selection of ECMs. These scenarios are summarized in the following Measure Scope Matrix:

Measure Scope Matrix											
Measures			50% Annual GHG Emissions Reduction			80% Annual GHG Emissions Reduction			Carbon-Neutral Operations		
Group	Tag	Name	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
	A	Lighting Retrofits & Redesigns									
	A01	LED Retrofits & New Fixtures (Interior)	IN	IN	IN	IN	IN	IN	IN	IN	IN
	A02	LED New Fixtures (Exterior)					IN		IN	IN	IN
	A03	Lighting Controls (Basic)					IN		IN	IN	IN
	A04	Lighting Controls (Arena)	IN	IN	IN	IN	IN	IN	IN	IN	IN
	B	Electrical Modifications									
	B01	Battery Energy Storage System (City Owned)	IN	IN	IN	IN	IN	IN	IN	IN	IN
	B02	Battery Energy Storage as a Service									
	C	Building Automation System									
	C01	Demand Control Ventilation			IN	IN	IN		IN	IN	IN
	C02	Analytic Control Tuning							IN	IN	IN
	D	HVAC									
	D01	Heating Boilers - Condensing			IN						
	D02	Heating Boilers - Condensing Lower Water Temperature				IN	IN	IN			
	D03	DHW Boiler - Condensing			IN	IN	IN	IN			
	D04	Pool Boiler - Condensing			IN	IN	IN	IN			
	D05	Ground Source Heat Loop - Low Temp Loop				IN	IN	IN			
	D06	Ground Source Heat Loop - High Temp Loop							IN		IN
	D07	AHU Replacement			IN	IN	IN	IN	IN	IN	IN
	D08	AHU VAV Conversion				IN	IN		IN	IN	IN
	D09	Heat Pump Replacement			IN				IN	IN	IN
	D10	Low Temp Loop Variable Speed Pumping							IN	IN	IN
	D11	Waste Water HR - High Temp Loop								IN	
	D12	District Energy Integration		IN							

Measure Scope Matrix

Measures			50% Annual GHG Emissions Reduction			80% Annual GHG Emissions Reduction			Carbon-Neutral Operations		
Group	Tag	Name	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
	E	Refrigeration									
	E01	Chiller Replacement w HR - Ammonia Plate and Frame		IN							
	E02 A	Chiller Replacement w HR - C02 - Indirect Slab Cooling	IN		IN	IN	IN	IN	IN	IN	IN
	E02 B	Chiller Replacement w HR - C02 - Direct Slab Cooling									
	E03	Cold Water Flooding					IN		IN	IN	IN
	E04	Ice Resurfacer Replacement							IN	IN	IN
	E05	Radiant Heating Conversion				IN	IN	IN	IN	IN	IN
	E06	Dehumidifier Conversion				IN	IN	IN	IN	IN	IN
	F	Pool Systems									
	F01	Pool and Whirlpool VFD									
	F02	Pool Temperature Setback	IN	IN	IN	IN	IN	IN	IN	IN	IN
	G	Building Envelope									
	G01	High Performance Glazing							IN	IN	
	G02	Roof Insulation - Phase I							IN	IN	
	G03	Roof Insulation - Phase II							IN	IN	
	G04	Exterior Wall Insulation - Phase I							IN	IN	
	G05	Exterior Wall Insulation - Phase II						IN	IN	IN	
	G06	Interior Window Replacement									
	H	Domestic Water Conservation									
	H01	Domestic Water Retrofits	IN	IN	IN	IN	IN	IN	IN	IN	IN
	I	Renewable Energy Generation									
	I01A	Solar PV - Roof - 1.18 MW array									
	I01B	Solar PV - Roof - 0.60 MW array							IN	IN	IN
	I02	Solar PV - Parking Lot - 1.03 MW array									
	I03	Solar Thermal - Pool Heating									
	J01	Remove In Stand Heating									

1.2.2 SCENARIO FINANCIAL PERFORMANCE SUMMARY

The following Financial Performance Summary table presents the financial results and GHG emissions reductions associated with each Option.

Design Option	Implementation Cost	Annual Energy Cost	Life Cycle Cost	Annual GHG Emissions	Annual GHG Reduction		Cost/GHG Reduction
					[Tonnes eCO2]	[%]	
Option 0	-	$846,500	$22,380,000	1781	-		-
Option 1 50% A	$4,414,000	$445,200	$14,630,000	716	1,065	60%	$4,143
Option 2 50% B	$4,496,000	$422,200	$14,340,000	895	886	50%	$5,601
Option 3 50% C	$8,830,000	$409,900	$17,900,000	635	1,146	64%	$7,705
Option 4 80% A	$12,710,000	$345,500	$19,400,000	373	1,408	79%	$9,028
Option 5 80% B	$12,870,000	$339,800	$19,300,000	375	1,406	79%	$9,153
Option 6 80% C	$13,250,000	$354,200	$19,260,000	361	1,420	80%	$9,331
Option 7 100% A	$29,230,000	$275,400	$31,430,000	53	1,728	97%	$16,991
Option 8 100% B	$28,930,000	$274,400	$31,190,000	52	1,729	97%	$16,737
Option 9 100% C	$20,840,000	$301,200	$25,870,000	57	1,724	97%	$12,091

NOTES:

1. Annual greenhouse gas (GHG) emissions reduction is compared to Option 0 using a GHG baseline of 2010.

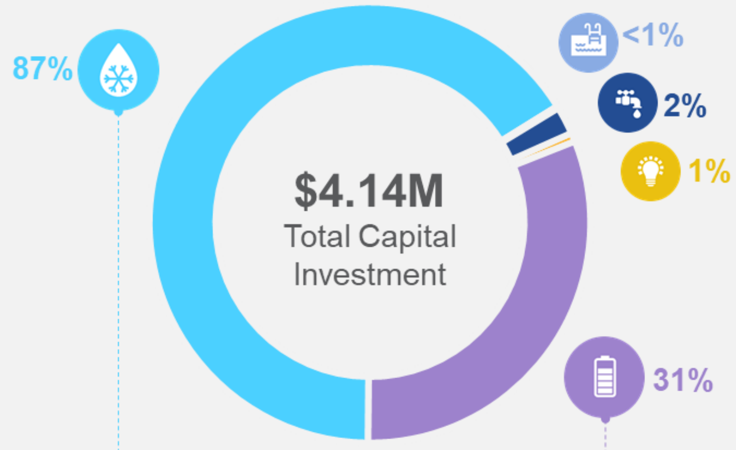
1.2.3 SCENARIO SUMMARY INFOGRAPHIC

The following pages include infographics that provide a high-level overview of each Scenario's program scope in terms of measure group % of total project cost alongside key financial and energy performance indicators.

Scenario Analysis: Pathway to Carbon-Neutrality
50% Reduction in Annual GHG Emissions

Scope of Work

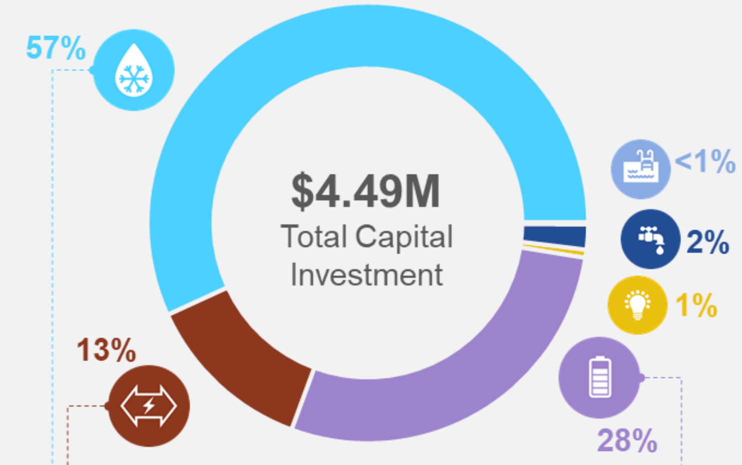
Option 1



Key Scope Items

- Heat Recovery Chiller – CO2
- City-owned Battery Storage

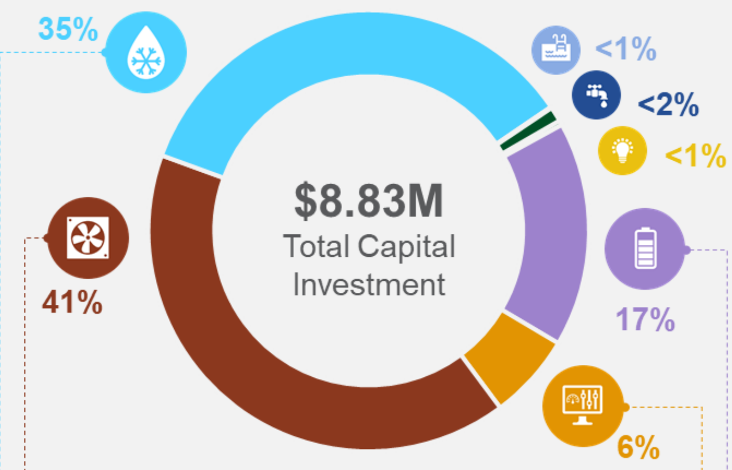
Option 2



Key Scope Items

- HR Chiller – Ammonia Plate & Frame
- City-owned Battery Storage
- Sheridan College DES Tie-in

Option 3



Key Scope Items

- Heat Recovery Chiller – CO2
- City-owned Battery Storage
- Heating Plant & HVAC Renewal
- Demand Control Ventilation

KPIs

Option 1

60% Reduction in Annual GHG Emissions
[1,065 Tonnes eCO_2]

*Annual GHG emissions reductions in this scenario equal **123 cars taken off the road***

$401,300
Annual utility costs savings from this Scenario

$7.75M
Project lifecycle cost savings from this Scenario

Option 2

50% Reduction in Annual GHG Emissions
[886 Tonnes eCO_2]

*Annual GHG emissions reductions in this scenario equal **14,650 trees planted***

$424,300
Annual utility costs savings from this Scenario

$8.04M
Project lifecycle cost savings from this Scenario

Option 3

64% Reduction in Annual GHG Emissions
[1,146 Tonnes eCO_2]

*Annual GHG emissions reductions in this scenario equal **132 homes' energy use***

$436,600
Annual utility costs savings from this Scenario

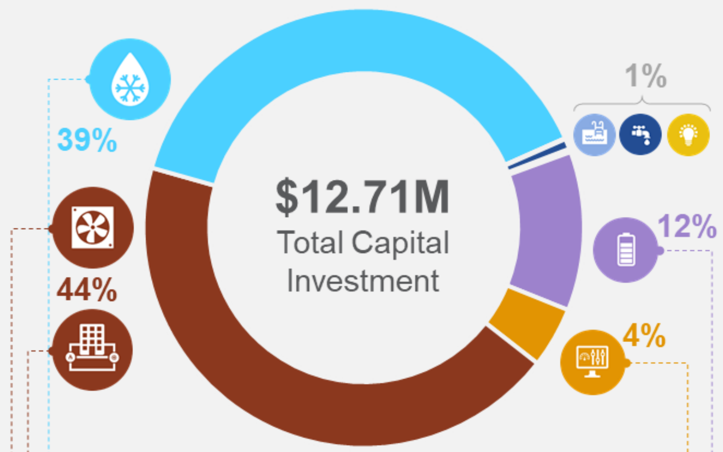
$4.48M
Project lifecycle cost savings from this Scenario

Scenario Analysis: Pathway to Carbon-Neutrality

80% Reduction in Annual GHG Emissions

Scope of Work

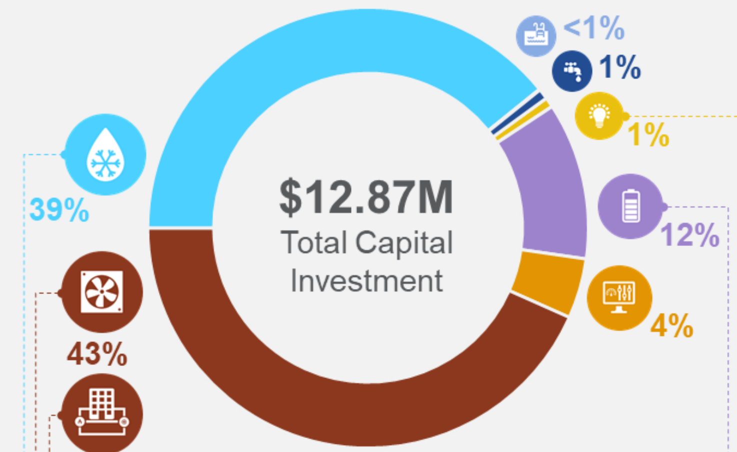
Option 4



Key Scope Items

- CO_2 HR Chiller & Rink Systems
- City-owned Battery Storage
- Heating Plant & HVAC Renewal
- New Low-temp Geo-Exchange Loop
- Demand Control Ventilation

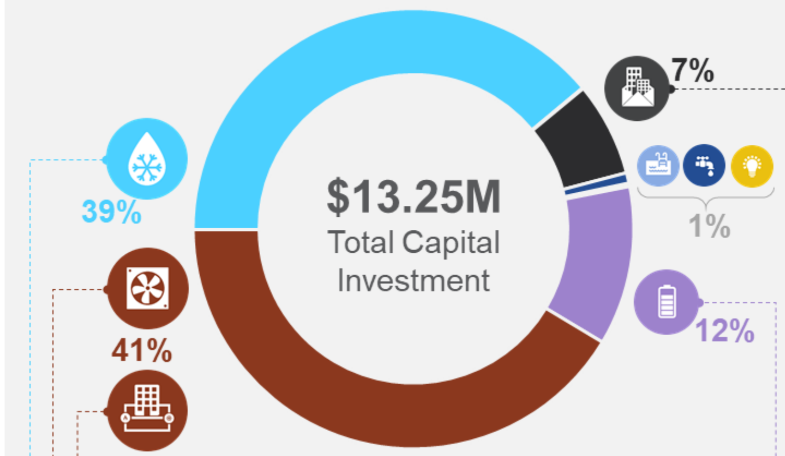
Option 5



Key Scope Items

- CO_2 HR Chiller & Rink Systems
- City-owned Battery Storage
- Heating Plant & HVAC Renewal
- New Low-temp Geo-Exchange Loop
- Expanded Lighting Program

Option 6



Key Scope Items

- CO_2 HR Chiller & Select Rink Systems
- City-owned Battery Storage
- Heating Plant & HVAC Renewal
- New Low-temp Geo-Exchange Loop
- Exterior Wall Insulation (Phase 2)

KPIs

Option 4

79% Reduction in Annual GHG Emissions
[1,408 Tonnes eCO_2]

Annual GHG emissions reductions in this scenario equal ***304 cars taken off the road***

$501,000
Annual utility costs savings from this Scenario

$2.98M
Project lifecycle cost savings from this Scenario

Option 5

79% Reduction in Annual GHG Emissions
[1,406 Tonnes eCO_2]

Annual GHG emissions reductions in this scenario equal ***23,249 trees planted***

$506,700
Annual utility costs savings from this Scenario

$3.08M
Project lifecycle cost savings from this Scenario

Option 6

80% Reduction in Annual GHG Emissions
[1,420 Tonnes eCO_2]

Annual GHG emissions reductions in this scenario equal ***164 homes' energy use***

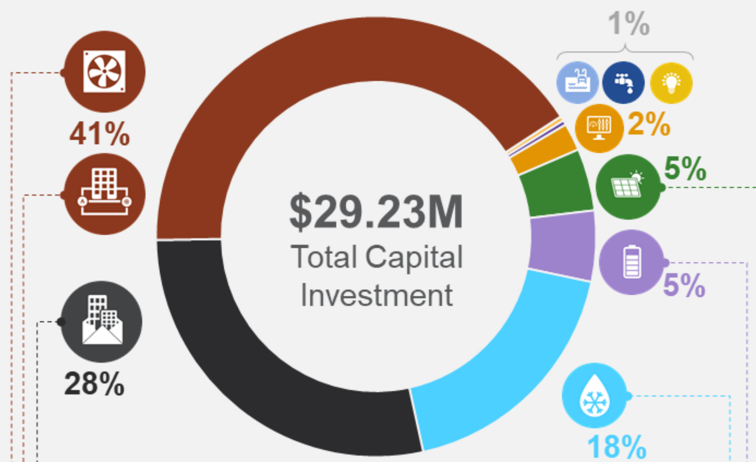
$492,300
Annual utility costs savings from this Scenario

$3.12M
Project lifecycle cost savings from this Scenario

Scenario Analysis: Pathway to Carbon-Neutrality
Carbon-Neutral (Net Zero) Operations

Scope of Work

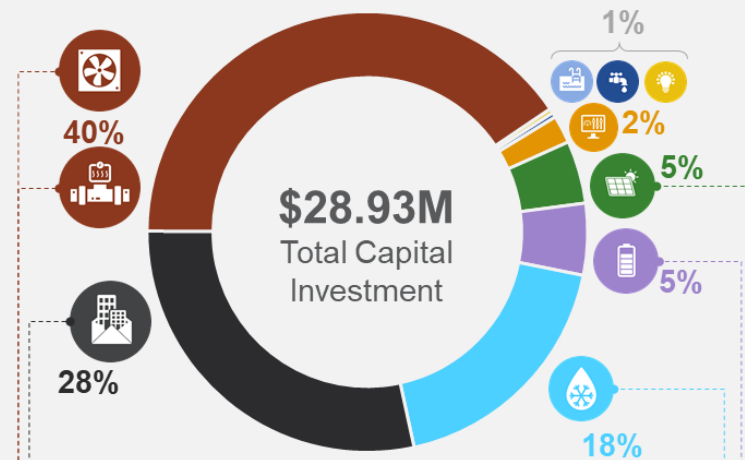
Option 7



Key Scope Items

- Glazing, Roof (Ph. 1 & 2), Ext. Wall (Ph. 1 & 2)
- CO2 HR Chiller & Rink Systems
- City-owned Battery Storage
- HVAC Renewal
- New Hi-temp Geo-Exchange Loop & Low-temp VSP
- 0.6MW Rooftop Solar PV

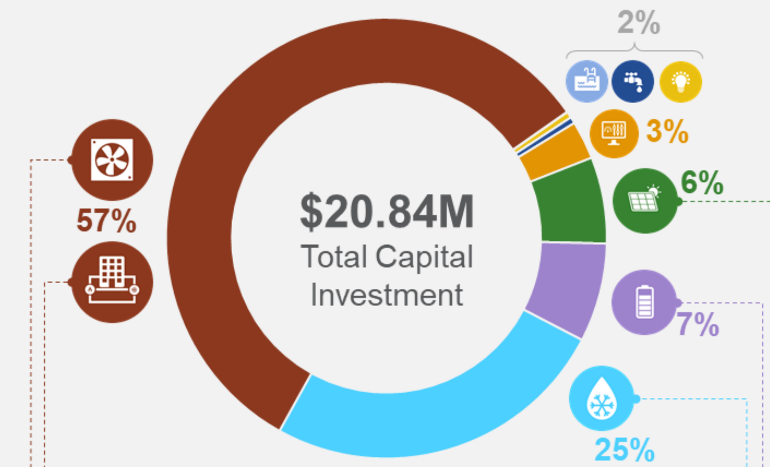
Option 8



Key Scope Items

- Glazing, Roof (Ph. 1 & 2), Ext. Wall (Ph. 1 & 2)
- CO2 HR Chiller & Rink Systems
- City-owned Battery Storage
- HVAC Renewal & Low-temp Loop VSP
- New Hi-temp Wastewater Heat Exchanger
- 0.6MW Rooftop Solar PV

Option 9



Key Scope Items

- HVAC Renewal
- New Hi-temp Geo-Exchange Loop & Low-temp VSP
- CO2 HR Chiller & Rink Systems
- City-owned Battery Storage
- 0.6MW Rooftop Solar PV

KPIs

Option 7

97% Reduction in Annual GHG Emissions
[1,728 Tonnes eCO_2]

Annual GHG emissions reductions in this scenario equal ***373 cars taken off the road***

$571,100
Annual utility costs savings from this Scenario

$(9.05M)
Project lifecycle cost savings from this Scenario

Option 8

97% Reduction in Annual GHG Emissions
[1,729 Tonnes eCO_2]

Annual GHG emissions reductions in this scenario equal ***28,589 trees planted***

$572,100
Annual utility costs savings from this Scenario

$(8.81M)
Project lifecycle cost

Option 9

97% Reduction in Annual GHG Emissions
[1,724 Tonnes eCO_2]

Annual GHG emissions reductions in this scenario equal ***199 homes' energy use***

$545,300
Annual utility costs savings from this Scenario

$(3.49M)
Project lifecycle cost

1 EXECUTIVE SUMMARY

1.3 COST AND SAVINGS METHODOLOGY

1.3.1 PROJECT COST

Net costs for each measure have been estimated through a combination of contractor pricing and direct MCW project experience with measures used in similar applications. The Total Costs includes all of the costs to deliver a turn-keyed project including, engineering, project management, construction management, and administration. For more information on how ECMs were costed, the reader is advised to consult *Appendix B – Cost Consultant Report*. Project cost are presented without HST.

1.3.2 SAVINGS

Savings are generated through the use of Integrated Environmental Solutions Virtual Environment (IES-VE-VE) modeling software. The Energy modeling provides a thorough review and evaluation of the energy use profiles of the facility. This analysis establishes a baseline of energy consumption that is reconciled with the actual metered consumption. The savings are then measured from the baseline energy model and serves as a guide to investigate certain building systems and operations exhibiting energy saving potential.

The energy analysis was carried out based on the gathering of building equipment data and information on the hours of operation for all building equipment through system schedules, discussion with building operators, control system analysis and site observations. IES-VE-VE permits the complex system integrations to interact with various control strategies and capture the building properties such as the thermal mass and stratification effects from the existing systems at the South Fletchers Sportsplex Building.

Savings rates, and carbon emission factors used in reporting savings are discussed in Section 03 – Utility Analysis.

1.4 PROGRAM FINANCIAL SUMMARY

The Program Financial Summary on the following page provides an overview of the financial results associated with the ECMs which have been identified and evaluated as part of this report. Of note this represents the impact of each ECM if it was to be implemented without any interactive effects of other ECMs being taken into consideration.

Program Financial Summary: South Fletcher's Sportsplex

BUILDING / MEASURE		SAVINGS								COSTS				TOTALS	
BLDG # MSR TAG	BUILDING MEASURE	TOTAL SAVINGS [$]	ELECTRICITY CONSUMPTION [kWh]	ELECTRICITY DEMAND PEAK/MONTH [kW]	GLOBAL ADJUSTMENT KW [kW]	NATURAL GAS [m³]	WATER [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL ECM COST [$]	$/TONNE eCO2 [$]	CAPITAL CONTRIBUTIONS [$]	INCENTIVES [$]	TOTAL MEASURE COST w/INCENTIVES & CC [$]	SIMPLE PAYBACK w/INCENTIVES & CC [Years]
A - LIGHTING RETROFITS & REDESIGN		**$ 5,890**	**170,955**	**3.2**	**3**	**-**	**-**	**-**	**26**	**$ 107,362**	**$ 4,187**	**-**	**$ 8,548**	**$ 98,814**	**16.8**
A01	LED Retrofits & New Fixtures (Interior)	$ 2,739	25,574	3.2	3	-	-	-	4	$ 24,401	$ 6,361	-	$ 1,279	$ 23,122	8.4
A02	LED New Fixtures (Exterior)	$ 541	24,943	-	-	-	-	-	4	$ 50,042	$ 13,375	-	$ 1,247	$ 48,795	>50
A03	Lighting Controls (Basic)	$ 399	18,420	-	-	-	-	-	3	$ 21,555	$ 7,801	-	$ 921	$ 20,634	>50
A04	Lighting Controls (Arena)	$ 2,211	102,018	-	-	-	-	-	15	$ 11,364	$ 743	-	$ 5,101	$ 6,263	2.8
B - ELECTRICAL MODIFICATIONS		**$ 414,698**	**-219,000**	**-**	**475**	**-**	**-**	**109,550**	**-33**	**$ 1,090,101**	**NA**	**-**	**-**	**$ 1,090,101**	**2.6**
B01	Battery Energy Storage System (City Owned)	$ 326,296	-109,500	-	475	-	-	50,775	-16	$ 1,090,100	NA	-	-	$ 1,090,100	3.3
B02	Battery Energy Storage as a Service	$ 88,402	-109,500	-	-	-	-	58,775	-16	$ 1	NA	-	-	$ 1	0
C - BUILDING AUTOMATION SYSTEMS		**$ 10,408**	**192,676**	**-**	**-**	**21,917**	**-**	**-**	**71**	**$ 660,550**	**$ 9,358**	**-**	**$ 26,939**	**$ 633,611**	**>50**
C01	Demand Control Ventilation	$ 6,478	113,446	-	-	14,132	-	-	44	$ 651,200	$ 14,835	-	$ 22,689	$ 628,511	>50
C02	Analytic Control Tuning	$ 3,931	79,230	-	-	7,785	-	-	27	$ 9,350	$ 350	-	$ 4,250	$ 5,100	1.3
D - HVAC		**$ 217,284**	**-2,492,230**	**-**	**-**	**1,103,770**	**-**	**-42,622**	**1,488**	**$ 27,496,700**	**$ 18,478**	**$ 4,384,600**	**$ 66,218**	**$ 23,045,882**	**>50**
D01	Heating Boilers - Condensing	$ 11,848	-	-	-	41,660	-	-	79	$ 508,200	$ 6,414	$ 380,600	$ 8,332	$ 119,268	10.1
D02	Heating Boilers - Condensing Lower Water Temperature	$ 18,010	-9,420	-	-	64,043	-	-	120	$ 508,200	$ 4,221	$ 380,600	$ 12,809	$ 114,791	6.4
D03	DHW Boiler - Condensing	$ 1,596	-	-	-	5,613	-	-	11	$ 161,700	$ 15,146	$ 111,100	-	$ 50,600	31.7
D04	Pool Boiler - Condensing	$ 5,082	846	-	-	17,806	-	-	34	$ 206,800	$ 6,083	$ 114,400	$ 3,561	$ 88,839	17.5
D05	Ground Source Heat Loop - Low Temp Loop	$ 19,598	-47,713	-	-	72,546	-	-	131	$ 2,652,100	$ 20,272	$ 380,600	-	$ 2,271,500	>50
D06	Ground Source Heat Loop - High Temp Loop	$ 63,276	-1,452,095	-	-	333,134	-	-	416	$ 9,574,400	$ 23,026	$ 380,600	-	$ 9,193,800	>50
D07	AHU Replacement	$ 10,535	21,233	-	-	35,424	-	-	71	$ 2,494,800	$ 35,356	$ 1,124,200	-	$ 1,370,600	>50
D08	AHU VAV Conversion	$ 18,577	309,937	-	-	41,705	-	-	126	$ 375,100	$ 2,981	-	$ 39,335	$ 335,765	18.1
D09	Heat Pump Replacement	$ -169	68,126	-	-	-5,786	-	-	-1	$ 837,100	$ -1,064,915	$ 751,300	-	$ 85,800	NA
D10	Low Temp Loop Variable Speed Pumping	$ -103	21,819	-	-	-2,026	-	-	-1	$ 174,900	$ -301,239	-	$ 2,182	$ 172,718	NA
D11	Waste Water HR - High Temp Loop	$ 64,298	-1,404,963	-	-	333,134	-	-	423	$ 9,243,300	$ 21,858	$ 380,600	-	$ 8,862,700	>50
D12	District Energy Integration	$ 4,736	-	-	-	166,517	-	-42,622	79	$ 760,100	$ 9,593	$ 380,600	-	$ 379,500	>50
E - REFRIGERATION		**$ 159,767**	**674,279**	**-**	**-**	**507,850**	**277**	**-**	**1,067**	**$ 17,410,100**	**$ 16,316**	**$ 10,342,200**	**$ 117,606**	**$ 6,950,294**	**43.5**
E01	Chiller Replacement w HR - Ammonia Plate and Frame	$ 27,494	321,532	-	-	72,173	-	-	186	$ 3,447,400	$ 18,584	$ 3,447,400	$ 46,588	$ -46,588	0
E02A	Chiller Replacement w HR - C02 - Indirect Slab Cooling	$ 51,859	268,379	-	-	161,895	-	-	348	$ 3,610,200	$ 10,369	$ 3,447,400	$ 59,217	$ 103,583	2.0
E02B	Chiller Replacement w HR - C02 - Direct Slab Cooling	$ 54,809	482,863	-	-	155,927	-	-	369	$ 7,984,900	$ 21,639	$ 3,447,400	-	$ 4,537,500	>50
E03	Cold Water Flooding	$ 4,730	106,361	-	-	8,528	-	-	32	$ 108,900	$ 3,385	-	$ 10,636	$ 98,264	20.8
E04	Ice Resurfacer Replacement	$ 1,009	11,654	-	-	118	277	-	2	$ 183,000	$ 92,774	-	$ 1,165	$ 181,835	>50
E05	Radiant Heating Conversion	$ 3,731	-297,793	-	-	35,810	-	-	23	$ 172,700	$ 7,367	-	-	$ 172,700	46.3
E06	Dehumidifier Conversion	$ 16,135	-218,717	-	-	73,399	-	-	107	$ 1,903,000	$ 17,819	-	-	$ 1,903,000	>50
F - POOL		**$ 2,004**	**40,000**	**-**	**-**	**4,000**	**-**	**-**	**14**	**$ 50,600**	**$ 3,718**	**-**	**$ 4,800**	**$ 45,800**	**22.8**
F01	Pool and Whirlpool VFD	$ 867	40,000	-	-	-	-	-	6	$ 41,800	$ 6,967	-	$ 4,000	$ 37,800	43.6
F02	Pool Temperature Setback	$ 1,138	-	-	-	4,000	-	-	8	$ 8,800	$ 1,157	-	$ 800	$ 8,000	7.0
G - BUILDING ENVELOPE UPGRADES		**$ 25,971**	**104,606**	**-**	**-**	**83,348**	**-**	**-**	**174**	**$ 9,577,700**	**$ 54,975**	**-**	**$ 26,999**	**$ 9,550,701**	**>50**
G01	High Performance Glazing	$ 1,021	4,583	-	-	3,241	-	-	7	$ 464,200	$ 67,748	-	$ 1,107	$ 463,094	>50
G02	Roof Insulation - Phase I	$ 543	-1,608	-	-	2,032	-	-	4	$ 2,911,700	$ 803,524	-	$ 406	$ 2,911,294	>50
G03	Roof Insulation - Phase II	$ 1,843	10,861	-	-	5,651	-	-	12	$ 3,041,500	$ 245,731	-	$ 2,216	$ 3,039,284	>50
G04	Exterior Wall Insulation - Phase I	$ 6,071	11,722	-	-	20,453	-	-	41	$ 1,809,500	$ 44,503	-	$ 5,263	$ 1,804,237	>50
G05	Exterior Wall Insulation - Phase II	$ 16,357	76,736	-	-	51,667	-	-	110	$ 1,006,500	$ 9,168	-	$ 18,007	$ 988,493	>50
G06	Interior Window Replacement	$ 137	2,312	-	-	304	-	-	1	$ 344,300	$ 372,213	-	-	$ 344,300	>50
H - DOMESTIC WATER CONSERVATION		**$ 17,034**	**-**	**-**	**-**	**12,866**	**5,126**	**-**	**24**	**$ 111,100**	**$ 4,540**	**$ 111,100**	**-**	**-**	**0**
H01	Domestic Water Retrofits	$ 17,034	-	-	-	12,866	5,126	-	24	$ 111,100	$ 4,540	$ 111,100	-	-	0
I - RENEWABLE ENERGY		**$ 73,622**	**3,249,218**	**-**	**-**	**11,293**	**-**	**-**	**509**	**$ 16,748,768**	**$ 32,914**	**-**	**$ 2,259**	**$ 16,746,510**	**>50**
I01A	Solar PV - Roof - 1.18 MW array	$ 29,385	1,356,000	-	-	-	-	-	203	$ 4,552,900	$ 22,384	-	-	$ 4,552,900	>50
I01B	Solar PV - Roof - 0.60 MW array	$ 14,941	689,491	-	-	-	-	-	103	$ 1,491,768	$ 14,424	-	-	$ 1,491,768	>50
I02	Solar PV - Parking Lot - 1.03 MW array	$ 26,091	1,204,000	-	-	-	-	-	181	$ 10,626,000	$ 58,837	-	-	$ 10,626,000	>50
I03	Solar Thermal - Pool Heating	$ 3,206	-273	-	-	11,293	-	-	21	$ 78,100	$ 3,643	-	$ 2,259	$ 75,841	23.7
J - OPERATIONAL CHANGES		**$ 8,834**	**9,201**	**-**	**-**	**30,360**	**-**	**-**	**59**	**$ 1**	**$ 0**	**-**	**-**	**$ 1**	**0**
J01	Remove In Stand Heating	$ 8,834	9,201	-	-	30,360	-	-	59	$ 1	$ 0	-	-	$ 1	0

SECTION 1

EXECUTIVE SUMMARY

SECTION 2

BUILDING PROFILE

2 BUILDING PROFILE

2.1 OVERVIEW

2.1.1 BRAMPTON SOUTH FLETCHERS SPORTSPLEX

BUILDING NAME:	Brampton South Fletchers Sportsplex
BUILDING ADDRESS:	500 Ray Lawson Blvd.
CATEGORY:	Recreation Centre
TOTAL FLOOR AREA (FT^2):	172,827
STOREYS ABOVE GRADE:	2
STOREYS BELOW GRADE:	-
YEAR OPENED:	1996

2.1.2 BUILDING DESCRIPTION

The South Fletchers Sports plex is a Community Centre located at 500 Raw Lawson Bldg, Brampton, ON. The building consists of two (2) storeys above grade. The centre provides services for the community by hosting a four pad arena, pool, gymnasium, workout space, childcare centre, and a library. There are also meeting spaces for community centre activities.

The building is owned and operated by the City of Brampton. The building is serviced with electricity, natural gas and city water services. The facility was constructed in two phases. The arena, referred to as Phase I, was completed in 1995. The Community Centre, Phase II, followed in 1996.

2 BUILDING PROFILE

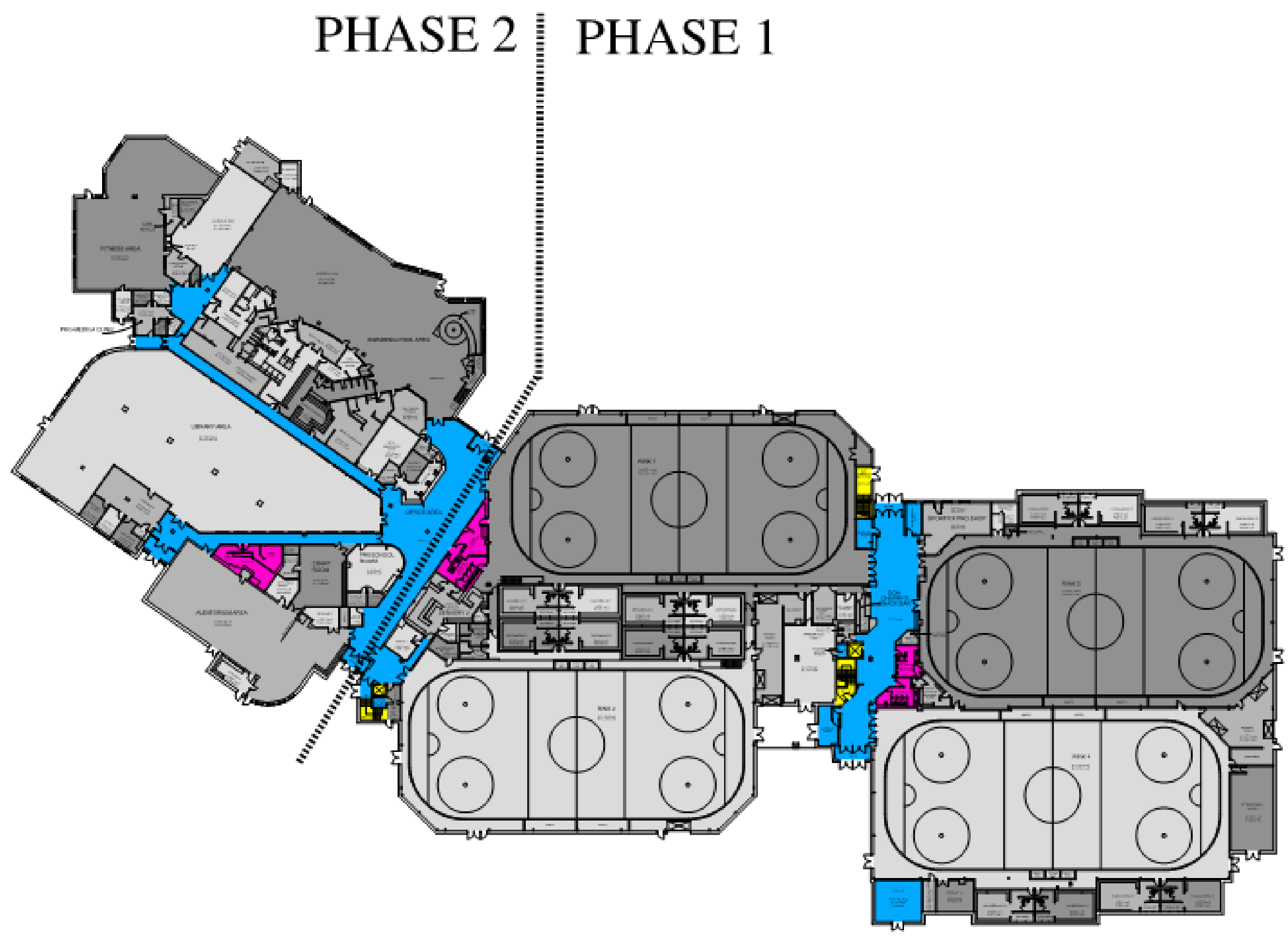


Figure 2.1.1: South Fletcher's Sportsplex Floor Plan

2.1.3 BUILDING ENVELOPE SYSTEMS

The phase I walls have two primary constructions. The upper portions are insulated metal panel on 75 mm of insulation on masonry block. The lower portions are brick on 75 mm insulation on masonry block.

The phase I roof consists of a pitched standing seam metal roof on 75 mm fibreglass insulation on vinyl sheet air/vapour barrier on 250 mm steel purlins on a steel frame.

The phase II roof consists of rounded Gravel Ballast on four ply built up roofing on 13 mm fibreboard on 75mm rigid insulation on air/vapour barrier on 38 metal deckwalls.

2.1.4 LIGHTING SYSTEMS

Almost all lighting in the building has recently been upgraded to LED. The majority of the general spaces are illuminated by a combination of 1’x4’, 2’x4’ and 2’x2’ recessed troffer fixtures and downlights, whereas change rooms have suspended integrated strip fixtures. The arenas, pool, and gymnasium have LED high bay luminaries. One area of note is the main lobby with its still existing metal halide decorative fixtures.

Most lighting is controlled by line voltage toggle switches with no occupancy sensors in the building. The four arenas are controlled by an *nLight Wired* system allowing for dimming and scene control.

The exterior wall packs are mix LED and metal halide wall packs, whereas the pole lighting remains metal halide. It was not determined how the exterior lighting is controlled.

2.1.5 ELECTRICAL SYSTEMS

Electricity is purchased from Alectra Utilities and supplied to the facility by a Y-Y connection transformer of 500 kVA capacity, located inside of a transformer vault. The main service has a 347/600 volt, 3 phase, 4 wire system, set at 2000 amp. The building operates on 347/600 volt and 120/208 volt systems. The system is comprised of approximately 28 panels boards located in centrally distributed sub-electrical rooms. The main distribution switchboard is equipped with digital check meters.

2.1.6 HVAC SYSTEM

Building heating is provided by three (3) x 1825 MBH atmospheric natural gas boilers. Domestic water is provided by a 1467 MBH atmospheric natural gas boiler.

Terminal heating is provided by thirteen (13) horizontal discharge unit heaters serving mechanical rooms, seven (7) cabinet unit heaters serving vestibules and stairwells, fifteen (15) cabinet convectors serving interior spaces, and sixteen (16) finned tube radiators serving the arena change rooms.

The building is served by two primary loops, a high temperature loop that serves air handlers, and terminal units, and a low temperature loop that serves the heat pumps. The low temperature loop is provided with a fluid cooler for heat rejections when operating in cooling mode.

The building is served by six (6) main air handling units that provide conditioned fresh air to the space.

Equipment Tag	Make	Air Flow	HTG	CLG	Function
AIR HANDLING UNITS					
AHU-1 ERV	AAON, Inc.	3,600 CFM	195 MBH	11 Ton	AHU providing ventilation air to change rooms along perimeter wall of Rink 3
AHU-2 ERV	AAON, Inc.	3,600 CFM	195 MBH	11 Ton	AHU providing ventilation air to change rooms along perimeter wall of Rink 4
HRU-1	Main Air	18,000 CFM	1000 MBH	50 Ton	AHU providing ventilation air to change rooms inbetweem Rinks 1&2
HRU-2	Engineered Air	18,000 CFM	1000 MBH	50 Ton	Outdoor packaged AHU unit providing ventilation air to all of Phase 2 office, washrooms, and library spaces.
MUA-1	Lennox		126 MBH	3 Ton	MUA providing ventilation make up air to fitness zone of the facility
Dry-O-Thon	Dectron	18000 CFM	525 MBH	30 Tons (Nominal)	Pool dehumidifier using high temp loop for heating and low temp loop for reheat

Air handlers HRU1, and the Dectron are served by the hot water loop, while the rest have direct natural gas connections. The air handlers are all provided with air cooled DX condensers for cooling. All of the air handlers are equipped with air side heat recovery systems, either enthalpy wheels, or in the case of HRU1 a heat pipe.

Space heating and cooling is augmented by forty three (43) water source heat pumps. The heat pumps mix outdoor air and recirculated space air and further condition air to be supplied to the spaces by either heating or cooling it.

The arena is served by two ice plants each serving two pads. Each ice plant includes two 90 ton built up ammonia chillers, one plant is served by five (5) reciprocating compressors, the other is served by six (6). Each ice plant is equipped with a dedicated cooling tower. Under-pad heating and snow melting is accomplished from heat recovery off the chiller plants, however not enough heat is recovered to accomplish all the required snow melting.

The arenas are served by desiccant dehumidifiers. One dehumidifier serves rinks 1 & 2 regenerated electrically and one serves each of rinks 3 & 4 regenerated by natural gas.

The arena is also served by twenty (20) in stand natural gas radiant heaters in rinks 1 & 2.

The pool is served by an 825 MBH atmospheric natural gas boiler. The whirlpool is served by a 150 MBH atmospheric natural gas boiler.

The reader is encouraged to consult ***Appendix C – Mechanical Energy Flow Diagram*** for a schematic outlining the existing HVAC system.

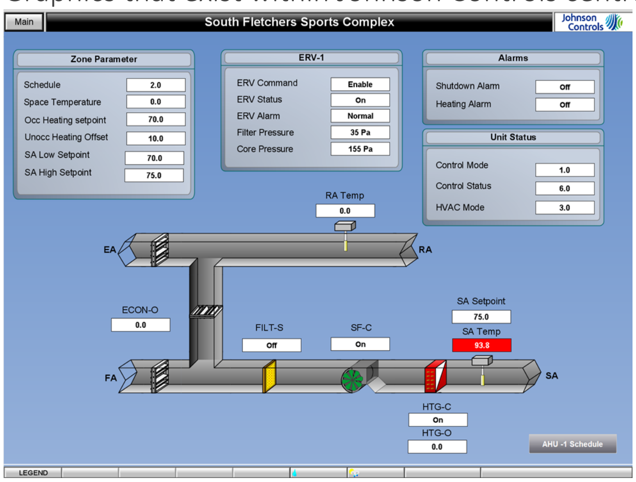
2.1.7 CONTROLS

The existing controls system in the facility is a Johnson Controls Metasys system comprised of two general vintages: 1990s vintage legacy N2 protocol communicating DX9100 and Unitary controllers, as well as newer BACnet protocol based FEC controllers.

These two vintages of controls are connected to a Johnson Controls NAE55. The NAE55 reads and maps both the proprietary N2 objects and non-proprietary BACnet MS/TP objects as a collection of 2599 (at time of audit) objects that are visualized as BACnet objects accessible via BACnet/IP integral to the NAE55 (specifically: Object 512 at 192.168.11.37:47808).

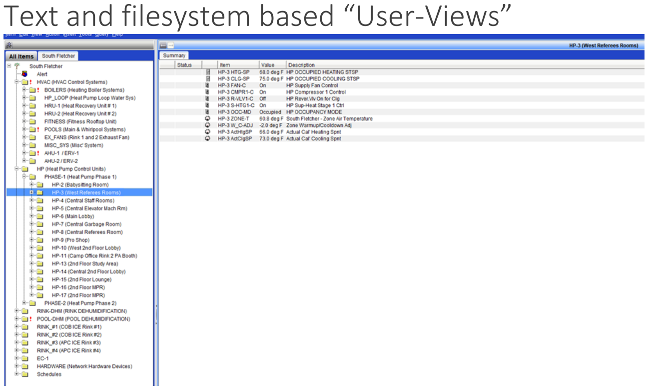
The graphical interface has two components:

1) Graphics that exist within Johnson Controls central ADX server (residing in BASJCVM)



This interface is limited and appears to be incomplete. There is limited information available in terms of sequences of operation, location of equipment, and service thereof.

2) Text and filesystem based "User-Views"



The user views have a comprehensive and structured view of the equipment within the facility, however the learning curve for this style of interface is much steeper than a simple schematic depiction of a system allowing an operator situational awareness in the event a system is not controlling appropriately.

From an operational perspective, there were no apparent issues with existing methods of control.

SECTION 3

UTILITY ANALYSIS

3 UTILITY ANALYSIS

3.1 UTILITIES OVERVIEW

Utility Services & Accounts

Table 3.1.1 summarizes the main utility services at South Fletcher's Sportsplex.

Table 3.1.1: Summary of Main Utility Providers & Accounts

Utility	Utility Provider	Account #	Meter #
Electricity	Alectra Utilities	1165485074	B139780
Natural Gas	Enbridge	82 18 26 67999 1	1003697
Water	Region of Peel	5897110000	SFW01

3.2 ANALYSIS OF UTILITIES

3.2.1 BASLINE SELECTION

A 2010 baseline was selected in order to align this report with the City of Brampton's *Energy and Emissions Management Plan 2019-2024: A Zero Carbon Transition*. As the building's energy consumption and the carbon intensity of Ontario's electrical grid have materially changed during the period 2010 – 2020 this presents the following implications for savings reported in this document:

Where Energy Retrofit Programs are presented, their carbon reduction savings are presented against 2010 carbon consumption, but their utility cost reduction is presented against current operation.

Where Energy Conservation Measures are presented, their carbon reduction savings are presented against current operation, as are reported utility cost reductions.

3.2.2 ELECTRICITY ANALYSIS

Electricity Consumption

Figure 3.2.1 below shows the historical electricity use at South Fletcher's Sportsplex building over the past three years, as well as the consumption during the 2010 GHG baseline period. The recent data was obtained from the Region of Peel and represents adjusted usage billed to South Fletcher's. While electricity consumption was higher in 2010, consumption in more recent years has been lower and relatively constant, with reduced usage in the summer.

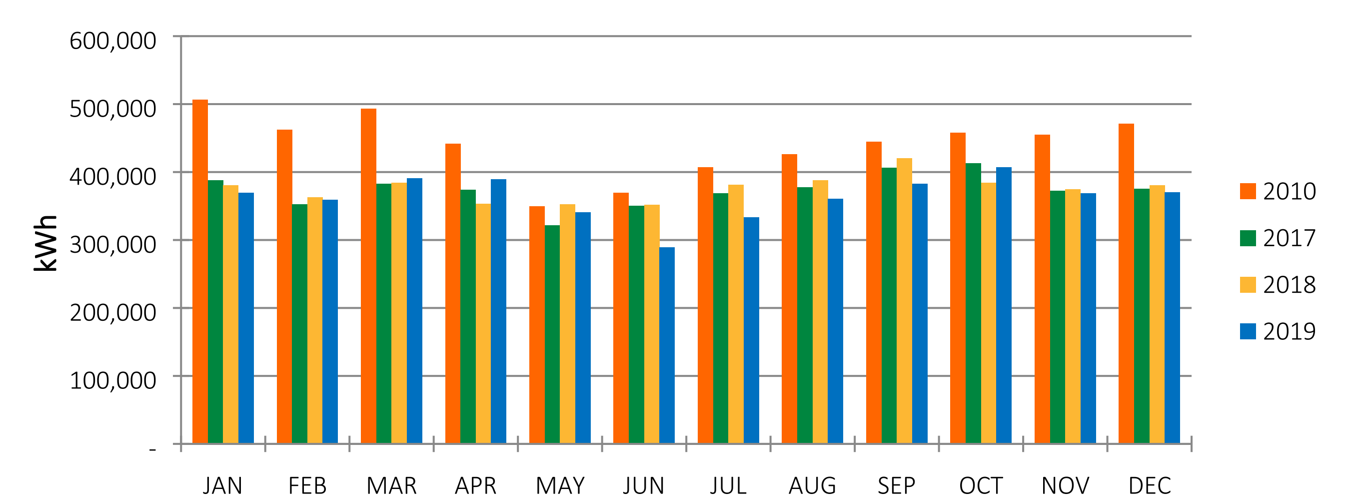


Figure 3.2.1: South Fletcher's Sportsplex Electricity Consumption Profile

Electricity Demand

Figure 3.2.2 below shows the historical electricity demand at South Fletcher's Sportsplex since 2016, as well as the 2010 baseline period. Similar to electricity consumption, demand is reduced in the summer months.

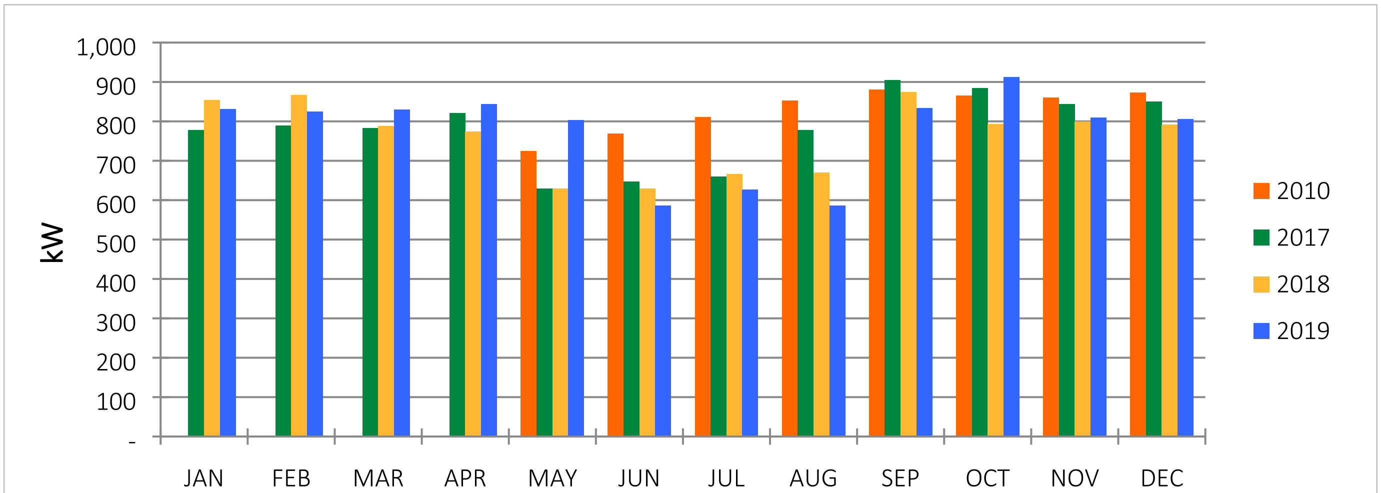


Figure 3.2.2: South Fletcher's Sportsplex Electricity Demand Profile

3.2.2.1 ELECTRICITY RATE STRUCTURE

In Ontario there are 3 main components that determine the cost of electricity for non-residential accounts:

1. A commodity charge levied on each kWh consumed at the Hourly Cost of Electricity (HOEP rate)
2. A demand charge levied on each kW occurring on the facility's peak hour
3. A Global Adjustment charge

Background on Global Adjustment

The Global Adjustment (GA) charge is the Province's catch-all cost to offset all the costs associated with running the electrical grid, including costs associated with ensuring that enough electricity supply will be available over the long term. Without the GA charge the grid operator (the IESO) would consistently run a deficit. A more detailed outline what the global adjustment funds and how it reacts to the spot market price (HOEP) can be found at the IESO's website http://www.ieso.ca/power-data/price-overview/global-adjustment

The GA is applied to each electrical account in one of two ways; Class A or Class B. Class A participation is reserved for those accounts with an average peak demand in excess of 1,000 kW which precludes most facilities from participation. Under class A the GA charge is applied as a function of peak demand, whereas under class B the charge applied as a function of energy consumption. By default all accounts are Class B unless they have opted into Class A.

Electricity charges for South Fletcher's Sportsplex is currently under a Class B rate structure. MCW has investigated the feasibility and financial return of a move to Class A and it is our opinion the Facility would benefit financially if it were to be included in a Class A rate structure. The ECMs outlined in this study, specifically ECMs B01 and B02 relating to battery energy storage allow for the building to opt into the Class A rate structure.

This in turn paves the way for ECMs that involve the electrification of mechanical equipment, and increase electrical consumption by making their implementation less financially onerous. By way of comparison ECM E05 converts the radiant arena stand heaters from gas operation to electric, a requirement to reach carbon neutral operation. Under a class A rate structure this results in a utility savings of $3,731 annually. Under a class B rate structure the same ECM would result in a net cost of $28,894 annually.

Class A customers are those who have a monthly demand peak greater than 1,000 kW. Falling into this category, South Fletcher's Sportsplex will be eligible to participate in the Industrial Conservation Initiative (ICI), and have the ability to manipulate the portion of the provincial GA at which it pays.

Class A Global Adjustment

The GA charge for Class A customers is determined using two (2) variables:

1. The Peak Demand Factor (PDF) (calculated yearly)
2. The System-wide GA Rate (calculated monthly, published by the IESO).

Peak Demand Factor (PDF): The PDF represents the customer's electrical demand compared to the total provincial electrical demand. It is calculated by taking the sum of the facility's coincident demand during the top 5 Ontario demand peaks, and dividing this value by the sum of the Top 5 system-wide peaks. The PDF is expressed as a percentage, and can be considered as the fractional use of the grid during peak events.

There is a lag between when the PDF is calculated and when it is applied for billing purposes, as each cycle of the ICI starts with a base period. At the end of the base period, noted below in ***Figure 3.2.1.1***, customers are assessed for eligibility. Customers who qualify as a Class A will be notified of their PDF. The PDF is then used to calculate costs during an Adjustment Period. Performance in year X is therefore applied to year X+1.

Base Period (Peak-setting period) = May 1, (Year X) to April 30, (Year X+1)

Adjustment Period (Billing period) = July 1, (Year X+1) to June 30, (Year X+2)

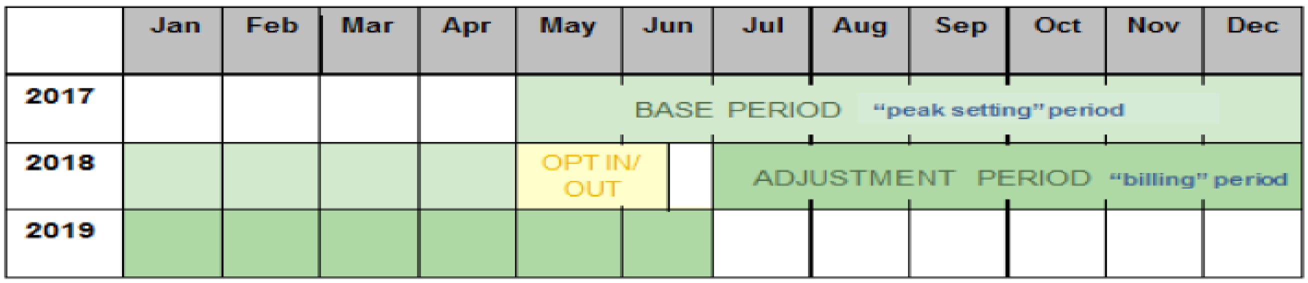


Figure 3.2.1.1: GA Base and Adjustment Periods

System-wide GA Rate: As the GA charge accounts for differences between the wholesale market price for electricity and regulated rates applicable for Ontario Power Generation's nuclear and hydroelectric generating stations, the global adjustment varies from month to month. When the HOEP is lower, the global adjustment is generally higher in order to cover the costs of regulated and contracted generation.

GA Charge: The resultant Class A customer GA charge is calculated monthly based on these two factors:

GA Charge (calculated monthly) = PDF x System-wide monthly Global Adjustment Rate

In addition to the GA Charge, Class A customers pay a portion of the province-wide total Capacity Based Recovery (CBR) amount, also calculated using their site PDF. This is done by multiplying the monthly Ontario-wide total CBR Amount costs by the PDF.

CBR Cost (calculated monthly) = PDF x System-wide monthly CBR Amount

Class A Rate Structure Benefits

The Class A Global Adjustment charges can have significant cost benefits over the Class B Global Adjustment charges if the customer can effectively manage their electrical demand, shifting usage to lower demand periods, thereby reducing their PDF. The lower the demand during the top 5 Ontario peaks, the lower the PDF, and therefore lower monthly GA Charges. Class B customers do not have this same opportunity, as they pay towards the system-wide total on an electricity consumed basis, regardless of how much (or little) electricity they consume during provincial peak hours.

The Peak Provincial hours typically occur late in the day during the summer months, coinciding with high residential air conditioning use. This can prove advantageous for South Fletcher's as electrical demand is reduced in the summer when the rink capacity is reduced.

An analysis of the relative cost of Class A vs Class B participation has been undertaken for South Fletcher's Sportsplex, seen in Figure 3.2.2 and detailed further in ***Appendix A***:

- For the Base Period of May 2018 – April 2019, savings would have totalled $53,121 operating under Class A. This represents a cost savings of 8.4% of the calendar 2019 electricity spend.

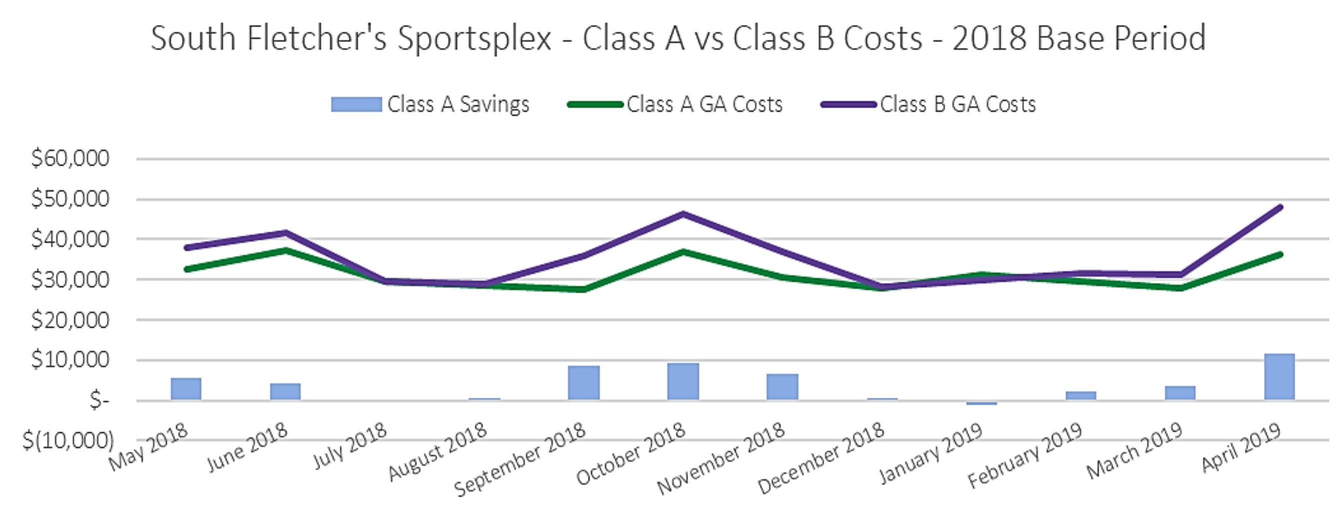


Figure 3.2.1.2: Class A vs. Class B GA Costs and Savings

As electricity usage increases at South Fletcher's Sportsplex, the savings potential from operating as a Class A customer will also increase, due to the large difference in electrical savings rates between Class A and Class B. These are detailed below in **Table 3.2.1** and further explained in ***Appendix A: Extended Utility Analysis***.

Table 3.2.1: Class A vs. Class B Electrical Savings Rates (Tax Excluded)

Utility	Class B Rates	Class A Rates
Electricity Consumption	$ 0.1309 per kWh	$ 0.0217 per kWh
Electricity Demand	$ 8.8691 per kW	$ 8.8691 per kW
GA and CBR Rate[1]	-	$ 585.0392 per kW

Notes:

1. *Global adjustment savings are annual savings for kW reductions that occur in all 5 GA hours.*

Class A Rate Structure Risks

As outlined above the Class A rate structure provides an avenue for considerable cost savings, and allows for a more financially viable pathway to low carbon operation for the facility, but there are risks associated with Class A rate class participation.

Firstly the facility must take care to manage its peak in response to provincial peaks. Under a Class A rate structure an errant peak can be quite costly for the facility negating any potential savings. This risk can be managed through by ensuring facility staff are aware of potential peak events. It is for this reason that enrollment in a peak advisory service is included in measure B01 – Battery Energy Storage System.

Secondly, there is a risk that the IESO could change the way the Global Adjustment is levied. In a worst case scenario the province could move to an entirely consumption based rate class system. This would potentially negate the savings outlined above available under a rate class switch. That said, any adjustment made to how the Global Adjustment is levied would not be without considerable consequence to the Ontario electricity market, and it is expected that such a change would not be made without the provision of a considerable amount of forward guidance from the IESO (as was the case when the ICI was enacted). This risk is of particular import to measure B01 – Battery Energy Storage System, but it is expected that if this ECM was implemented that it would reach financial payback within a potential forward guidance period, and in all likelihood the ECM would retain some value in a new rate structure that retained some component of demand and/or time of us pricing.

At the time of writing the ICI program has been put on hiatus due to the ongoing Covid-19 pandemic. The Government's stated objective in enacting this hiatus is: "to allow industrial and commercial businesses to focus on recovering from the impacts of COVID-19", see Ontario news release: Ontario Provides Stable Electricity Pricing for Industrial and Commercial Companies issued June 26, 2020 3:30 P.M.

Every indication from the Ontario Government is that this indeed a hiatus and not a shift towards a different rate regime. The highest coincident peak of 2020 without the ICI program in effect was 24,446 MW, considerably higher than the highest 2019 peak, 21,275 MW. This disparity indicates how effective the ICI program is at reducing peak demand and how if the ICI program was to be modified, that peak demand would remain a strong focus.

3.2.3 NATURAL GAS ANALYSIS

Figure 3.2.3 shows the historical natural gas consumption at South Fletcher's Sportsplex since 2016, as well as the 2010 baseline period. This data was obtained from Enbridge historical gas bills for the site and represents actual usage. As South Fletcher's Sportsplex is billed mid-month, the monthly profile seen in *Figure 3.2.3* is based upon the bill end date. Natural gas consumption is higher in the winter months, indicating a heating component to usage. Correlation to weather detailed in **Appendix A** is based on calendar days.

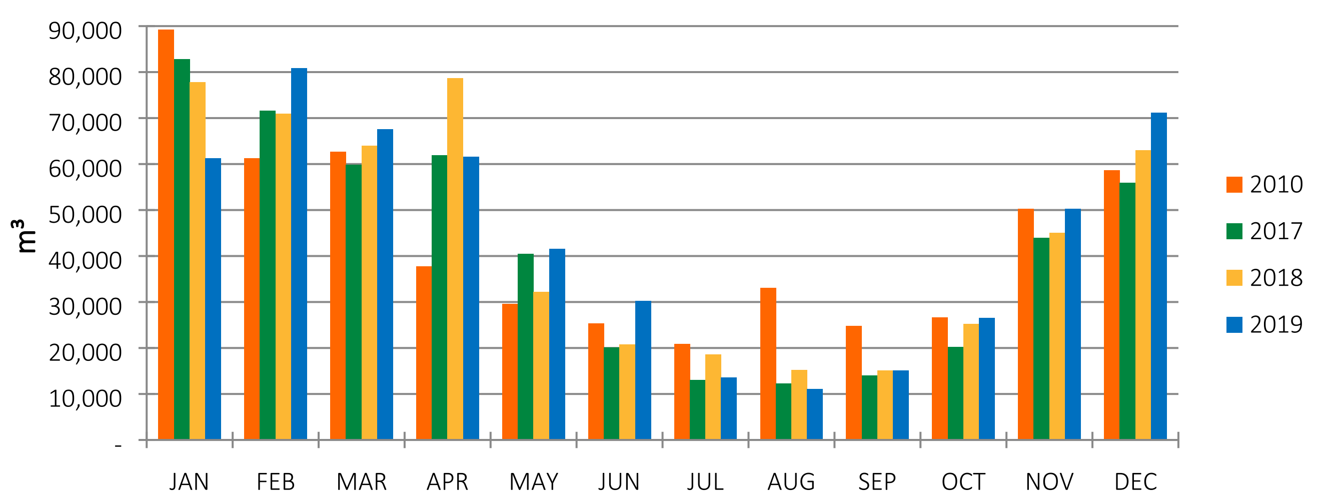


Figure 3.2.3: South Fletcher's Sportsplex Natural Gas Consumption Profile

3.2.4 WATER ANALYSIS

Water Consumption

Figure 3.2.4 below shows the historical water use at the South Fletcher's Sportsplex over the past 3 years, as well as the 2010 baseline period. This data was obtained from the Region of Peel and represents actual usage. Water consumption is variable and does not have any clear correlation to weather in recent years or during the baseline period.

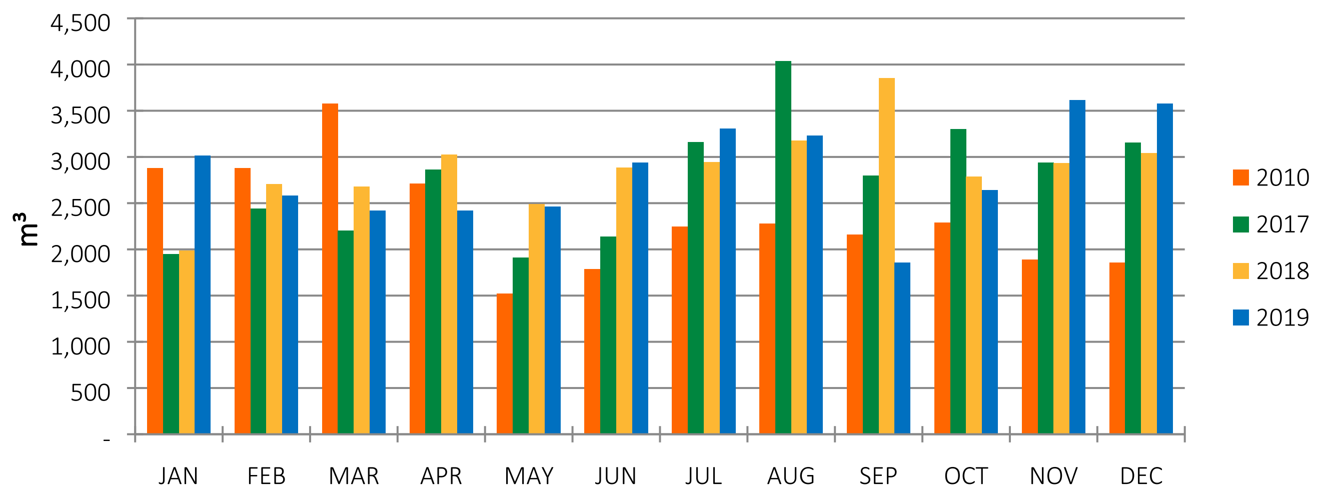


Figure 3.2.4: South Fletcher's Sportsplex Water Consumption Profile

3.2.5 UTILITY USAGE SUMMARY

The following summary of utility consumption in **Table 3.2.2** is based on Calendar Year (CY) 2010 for all utilities, while costs shown are retrieved from utility bills provided for CY2019. This reflects the baseline utility data against which Energy Retrofit Programs are measured.

As electricity demand data was not available for the 2010 baseline period under investigation, both demand data and costs shown are reflective of CY2019.

The 2010 baseline was selected in order to align this report with the City of Brampton's *Energy and Emissions Management Plan*.

Table 3.2.2: South Fletcher's Sportsplex Summary of Annual Utilities (Tax Excluded)

Utility	Costs ($)	Annual Usage	Annual Energy Usage (ekWh)	Energy Use Intensity (ekWh/ft^2)	GHG Emissions (Tonnes eC0_2)
Electricity Consumption	$ 561,477	5,282,745 kWh	5,282,745	30.6	792 (Scope 2)
Electricity Demand	$ 73,425	9,290 kW	-	-	-

Table 3.2.2: South Fletcher's Sportsplex Summary of Annual Utilities (Tax Excluded)					
Utility	Costs ($)	Annual Usage	Annual Energy Usage (ekWh)	Energy Use Intensity ($ekWh/ft^2$)	GHG Emissions (Tonnes eCO_2)
Natural Gas	$ 123,971	519,606 m^3	5,367,530	31.1	988 (Scope 1)
Water	$ 87,627	28,090 m^3	-	-	-
Total	**$ 846,500**		**10,650,275**	**61.6**	**1,781**

Notes:

- *a. Annual usage data is based on CY2010 utility data provided by City of Brampton.*
- *b. Annual costs reported are based on CY2019 utility invoices provided by the utility providers.*
- *c. Electricity Demand data is based on CY2019.*
- *d. Energy Use Intensity is based on an overall floor area of 172,827 ft^2.*
- *e. GHG Emissions are based on CY2010 emission factors, outlined in Table 3.1.2.*

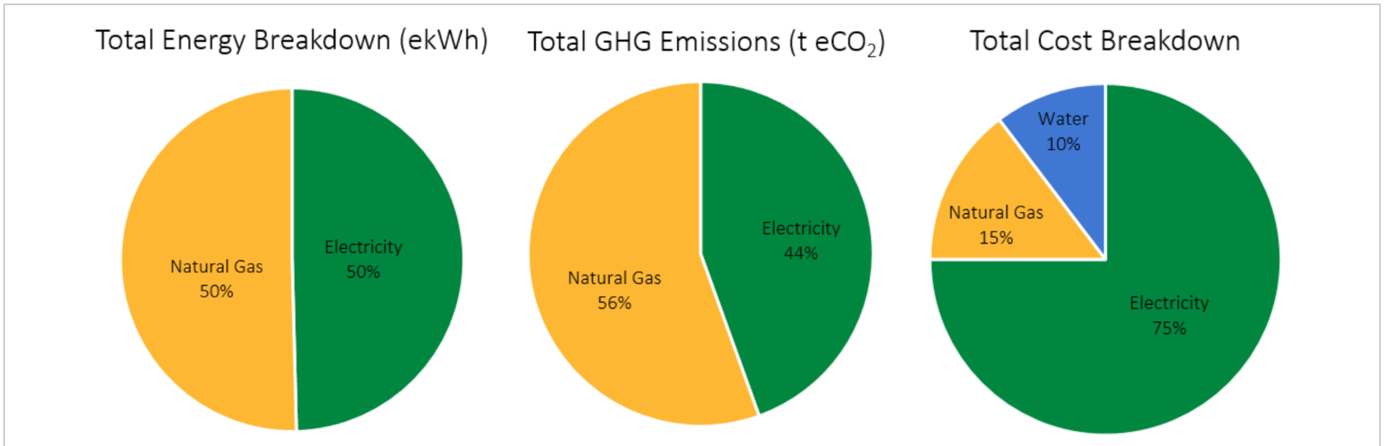


Figure 3.2.5: South Fletchers Sportsplex 2010 Utility Usage Breakdown

3.2.6 SAVINGS RATES SUMMARY

Table 3.2.3 summarizes the utility rates used. These savings rates refer to those rates used for the purpose of calculating energy and water savings to determine Program Financials, based on the most recent rates available from the respective utility providers. Determination of these rates are detailed further in ***Appendix A: Extended Utility Analysis***.

Table 3.2.3: Savings Rates (Tax Excluded)		
Utility	Savings Rate	
Electricity Consumption	$	0.02167 per kWh
Electricity Demand	$	8.8691 per kW

Table 3.2.3: Savings Rates (Tax Excluded)		
Utility	Savings Rate	
Global Adjustment Demand	$	585.04 per GA kW
Natural Gas	$	0.2844 per m^3
Water	$	2.6092 per m^3

3.2.7 SUMMARY OF GHG EMISSION FACTORS

The GHG emissions factors used to calculate the GHG emissions and GHG savings resulting from the project are shown in **Table 3.1.4,** and are 2010 emission factors for Ontario from the Federal National Inventory Report of GHG Sources and Sinks.

Table 3.2.4: GHG Emission Factors by Utility		
Utility	Emissions Factors (eCO_2 Metric Tonnes)	
Electricity	0.000150	per kWh
Natural Gas	0.001902	per m^3

SECTION 4

ENERGY MODEL

4 ENERGY MODEL

4.1 BASELINE MODEL INPUT SUMMARY

The baseline energy model for the South Fletcher's Sportsplex was created by using the available design information provided by the City of Brampton. This information was supplemented by the results of both the ASHRAE Level 2 Audit completed in 2018, and the audit completed as a part of this study. For parameters such as envelope thermal performance and infiltration, reasonable first estimates were made given what is known about the constructions and vintage of the building. These parameters were then varied as a part of the calibration exercise. Information such as the thermographic scans of the building helped validate the inputs.

4.1.1 WEATHER AND CALENDAR

The baseline model was simulated using weather for the 365 days starting December 17, 2018. This aligned with the range of the most up-to-date utility bills. The billing cycle for electricity aligns with the calendar month while the natural gas cycle is mid-month. The weather was aligned with the natural gas billing cycle because natural gas consumption is much more weather dependent than the electricity consumption as shown in the Utility Analysis section of this report. The weather file was created by taking the CWEC weather file for Toronto Pearson Airport (WMO: 71624) and updating it with the dry-bulb and wet-bulb temperatures from Environment Canada for the same location.

4.1.2 MODEL GEOMETRY

The model geometry was based on the original architectural design documents from 1996 with updates as appropriate for the interior design updates from 2010. The overall model floor area is 16,211 m^2, and well within the 5% range of the actual floor area that is commonly deemed acceptable in energy modelling

The model geometry is shown as a ground floor plan with zones coloured in Figure 4.1.1 and a 3-D version of the model shown in Figure 4.1.2

4 ENERGY MODEL

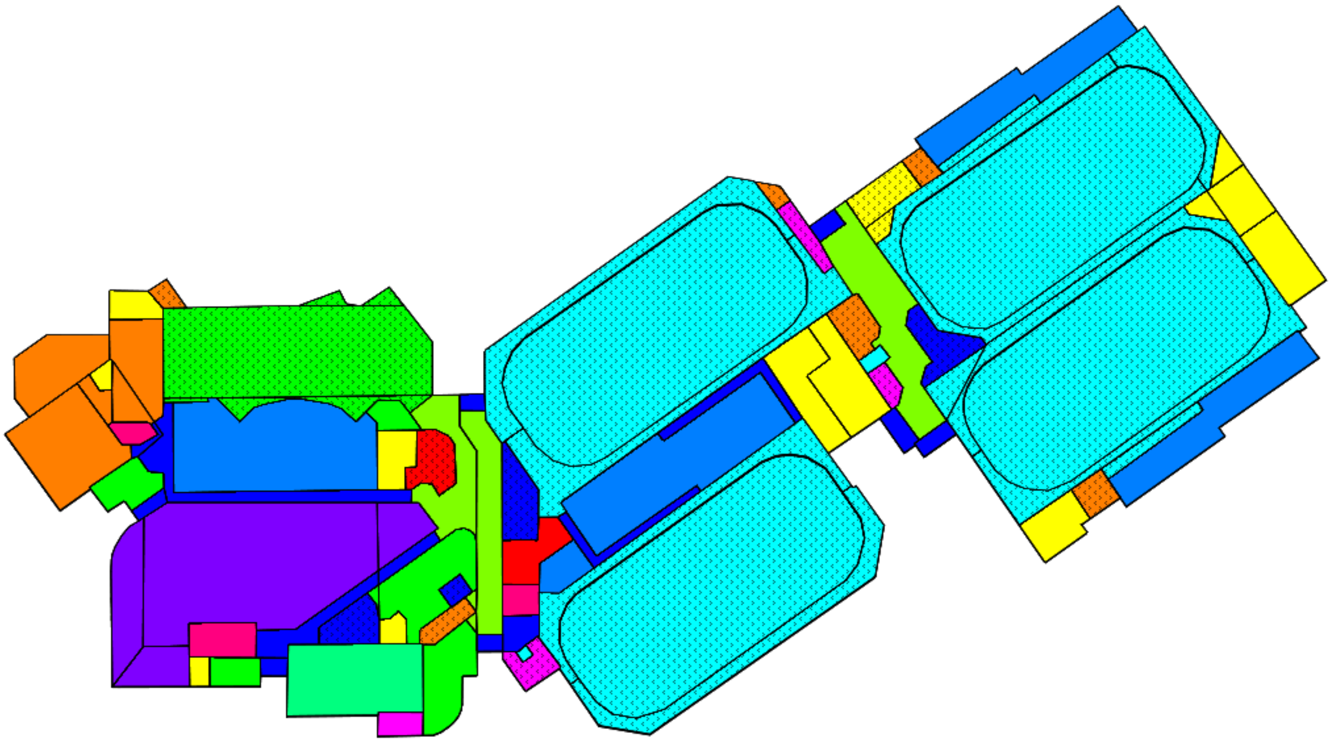


Figure 4.1.1: South Fletchers Sportsplex ground floor plan

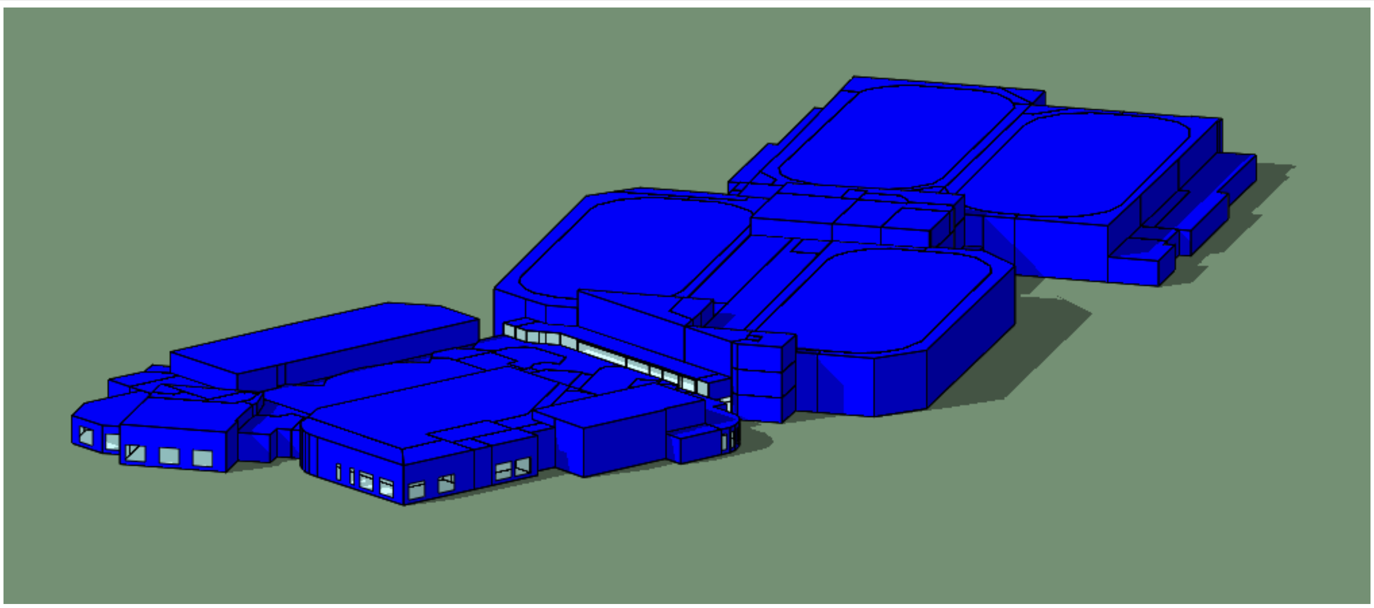


Figure 4.1.2: South Fletchers Sportsplex 3D model view

4.1.3 INTERNAL GAINS

The schedules used for internal gains were based on the operating hours of the library, community centre, and rinks.

Lighting

The lighting was originally based on the lighting power densities from ASHRAE90.1-2016 based on space type with updates according to the audit completed as a part of this study. The ASHRAE90.1-2016 lighting power represents a very good starting point for the building as the LED retrofit occurred in 2016. The ASHRAE90.1-2016 LPDs used as a base are shown in **Table 4.1.3**.

Table 4.1.3: Summary of ASHRAE90.1-2016 Lighting Power Density used in Model

Space Type	Lighting Power (W/m2)
Daycare	13.347
Conference/ Meeting/ Multipurpose	13.24
Corridor	7.104
Restaurant – Dining Area	9.58
Electrical/ Mechanical	4.521
Food preparation	13.024
Fitness center - Exercise area	7.75
Gymnasium - Playing area	12.9
Library	11.41
Lobby	9.688
Locker Room	8.073
Office - Enclosed	11.948
Office - Open plan	10.549
Restrooms	10.549
Retail	15.5
Sports Arena - Audience Seating	4.628
Sports arena - Playing area 4	12.917
Stairs	7.427
Storage	6.781

Receptacle Loads

Receptacle loads are difficult to know *a priori* in a calibrated energy model and therefore the defaults in IES<VE> were used with some changes made during the calibration process in order to better reflect the building operation.

Table 4.1.4: Summary of ASHRAE90.1-2016 Receptacle Loads used in Model

Space Type	Receptacle Loads (W/m2)
Daycare	1.0
Conference/ Meeting/ Multipurpose	1.0
Corridor	0.0
Restaurant – Dining Area	5.382
Electrical/ Mechanical	0.0
Food preparation	16.146
Fitness center - Exercise area	1.0
Gymnasium - Playing area	1.0
Library	7.5
Lobby	5.382
Locker Room	5.382
Office - Enclosed	7.5
Office - Open plan	7.5
Restrooms	0.0
Retail	5.382
Sports Arena - Audience Seating	7.5
Sports arena - Playing area	1.0
Stairs	0.0
Storage	2.153

Occupants

The occupant numbers were based on default IES<VE> numbers per space type with modifications made to better reflect the actual operation of the facility.

4.1.4 BUILDING ENVELOPE PERFORMANCE

The building envelope performance was originally based on the design drawings for the envelope assemblies taking into account thermal bridging for the clear field performance. Further degradation was added to account for other thermal bridges such has wall-to-parapet lengths, window-to-wall transition lengths, and wall-to-wall transitions lengths. The degradation of envelope thermal performance due to thermal bridges (both clear field and at interfaces) can be quite large compared to installed insulation performance. The BC Hydro Thermal Envelope Bridging Guide provided methods and guidance for evaluating envelope performance for the building. Additionally, the thermographic scans showed that in some areas wall performance was quite bad and not greatly different from window performance. Finally, the infiltration in the model was originally assumed to be 0.25 $l/s/m^2$ of façade (as per NECB modelling rules) but as a result of calibration this was increased to 1.2 $l/s/m^2$ of façade area. This corresponds to a whole building infiltration rate of 10.2 $l/s/m^2$ façade at 75 Pa.

The overall modelled envelope performance and details in the calibrated model are shown in **Table 4.1.5**.

Table 4.1.5: Summary of Envelope Constructions

Type	Details	Performance U (W/m2K)
Wall	Insulated metal panel on steel with 75 mm insulation – Upper Rink Walls	1.18
	Brick on 75mm insulation on LWB – Lower Rink Walls	1.27
	Brick on 50 mm insulation on LWB – Community Centre	1.59
	Metal Panel on 50 mm insulation on LWB – Community Centre	2.06
Roof	Rounded gravel ballast on four ply built up roofing on 13 mm fibreboard on 75 mm rigid insulation on metal deck – Community Centre Roof	0.311
	Standing seam roof with insulation – Rink Roof	0.261
Glazing	Double glazed with aluminum frames	3.18

4.1.5 RINK OPERATIONS

The operation of the rinks and how these details are modelled in IES<VE> are essential to creating a well calibrated energy model. The rink operations include rink occupancy and flooding schedules, flood temperatures and volumes. **Table 4.1.6** summarizes the inputs to the calibrated energy model for rink operation. The calibration procedure hinted at certain operational details such as March Break and summer rink usage confirmed by the facility booking schedule for 2019 provided by the City of Brampton.

Table 4.1.6: Summary of Rink Operations in Model

Input	Details	Notes
Usage Schedule	5am - 9am and 6 pm –midnight Monday to Friday 5 am to midnight Saturday and Sunday	Increased usage during March Break
Flooding Load – Rinks 1 & 2	46 kWh heating and 130 kWh cooling per flood	Heating is sensible heating only, cooling includes latent to freeze water
Flooding Load – Rinks 3 & 4	9.2 kWh heating and 90 kWh cooling per flood	Heating is sensible heating only, cooling includes latent to freeze water
Summer operation	May 1 – August 31	Rinks 1 and 2 no ice, Rink 4 used with ice present on Rink 3

4.1.6 POOL OPERATIONS AND MODELLING DETAILS

There is no specific module for modelling natatoriums in IES<VE> however the evaporation of pool water, humidity control, and pool water make-up volumes can all easily be simulated directly in the software. The pool water zone was simulated as a zone with the volume and thermal mass matching the pool water. This zone had sensible gain from occupants in the pool and a sensible loss from the evaporation of water from the pool surface. The evaporation adds latent gain to the zone above the pool water zone. The pool evaporation rate was estimated using the methods laid out in *2003 ASHRAE Applications Handbook*.

4 ENERGY MODEL

4.1.7 HVAC SYSTEMS

Air-side HVAC

There are 3 major air-side system types in the South Fletcher's Sportsplex, which are:

1. Dedicated outdoor air systems with water-loop heat pumps serving zones (HRU-1, HRU-2, RTU-1)
2. Pool dehumidification system
3. Rink Dehumidification systems

The modelling of each of these systems is summarized in Table 4.1.7.

Table 4.1.7: Summary of Air-side HVAC systems

System	Description	Details
HRU-1	DOAS with water-loop heat pumps serving zones	HRU-1 Supply fan: 15.7 kW Return fan: 6.8 kW Sensible energy recovery effectiveness: 50% Hot water heating coil in HRU-1 with DX cooling coil WLHPs in zone Heating COP 3.8, cooling COP 3.5.
HRU-2	DOAS with water-loop heat pumps serving zones	HRU-2 Supply fan: 14.3 kW Return fan: 5.8 kW Sensible energy recovery effectiveness: 65% Latent energy recovery effectiveness: 60% Furnace for heating with DX cooling coil WLHPs in zone Heating COP 3.8, cooling COP 3.5.
RTU-1	RTU serving fitness area	Supply fan: 1 kW Return fan: 0.5 kW Furnace for heating with DX cooling coil
Pool System	Dectron system for pool dehumidification	Exhaust heat recovery, hot water heating coil, DX cooling coil with hot gas reheat and heat recovery for pool water heating, economizer operation. DX coil modelled as part-load chiller with heat recovery providing heat to hot-gas reheat coil and pool water heating system. Supply fan: 12 kW Return fan: 8 kW

Table 4.1.7: Summary of Air-side HVAC systems		
System	Description	Details
Rink Dehumidification	Three active desiccant wheel dehumidification systems (Rink 1/2, Rink 3, and Rink 4)	Desiccant wheel modelled with negative latent recovery efficiency with extra dehumidification efficiency due to regen simulated with “dummy” cooling coil consuming no energy. Regen modelled to supply 113°C air via direct-fired natural gas furnace. Runs to supply ventilation when CO2 limit is reached or when dew-point exceeds 3°C Rink 1/2 Regen fan: 1 kW, Rink 1/2 Supply fan: 5 kW Rink 3 Regen fan: 0.5 kW, Rink 3 Supply fan: 2.6 kW Rink 4 Regen fan: 0.5 kW, Rink 3 Supply fan: 2.6 kW

Water-side HVAC

There are three major water-side HVAC systems, the hot water system, the water-loop heat pump system and the rink refrigeration system. The hot water system supplies heat to hot water coils in air handling units as well as a variety of perimeter radiation and unit heaters throughout the facility. The boilers have been modelled as 80% efficient non-condensing boilers (1835 MBH each) using the default performance curves in IES<VE>. The pumping is primary only with constant speed operation with the pump riding the pump curve.

The water-loop heat pump system receives heat from the hot water loop. However, IES<VE> is not capable of having a hot water-loop directly supply heat to the water-loop heat pump loop and therefore one of the three installed boilers is used in the water-loop heat pump system (with the other two serving the hot water loop directly).

Rink Systems

The refrigeration plants are each modelled as two chillers with a cooling tower. The compressors have not been modelled separately but combined into each chiller with an overall COP set for the chiller of. The chillers each have a capacity of 90 tons while the cooling towers have a capacity of 300 tons each. The ice-slabs are modelled by in-floor radiant slabs in IE<VE>. The extra cooling load due to flooding is applied directly to the chilled water loop rather than to the ice slab zones. This approach allowed for better control of ice temperature compared to applying the load directly to the ice slab zones despite being a slight approximation of the actual operation.

4.2 BASELINE MODEL CALIBRATION REPORT

The calibration of the model was done in accordance with ASHRAE Guideline 14-2014. The specific requirements for a calibrated model are that the Normalized Mean Bias Error (NMBE) is 5% maximum and Co-efficient of variation of root-mean-square error (CV(RSME)) is limited to 15% for monthly utility data. As noted in ASHRAE-211 the goal of calibrating the model is not "to find a unique and best calibrated solution" but instead to have a plausible and realistic model of the building. The vast number of independent variables in an energy model allows for the ability to easily "over-calibrate" the model. The NMBE and CV(RSME) are defined as shown below:.

$$\text{NMBE} = \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)}{(n-p)\times \bar{y}} \qquad \text{CV(RMSE)} = \frac{\sqrt{\frac{\sum (y_i - \hat{y}_i)^2}{(n-p)}}}{\bar{y}}$$

Where y_i is the utility data, $\hat{y}_i$ is the modelled data, $n = 12$ is the number of months and $p = 1$.

The results of the calibration with Electricity and Natural Gas Utility bills are shown in **Figure 4.2.1** and **Figure 4.2.2** respectively. For electricity the NMBE is 4.8% and CV(RSME) is 7%, and natural gas the NMBE is 4.1% and CV(RMSE) is 15.0%. All measures are below the ASHRAE Guideline 14 recommendations for a calibrated energy model. As per the weather and calendar section, the calibration is for the 365 days starting December 17, 2018. For natural gas calibration shown in **Figure 4.2.2** the month represents the billing period ending on or around the 15th of that month.

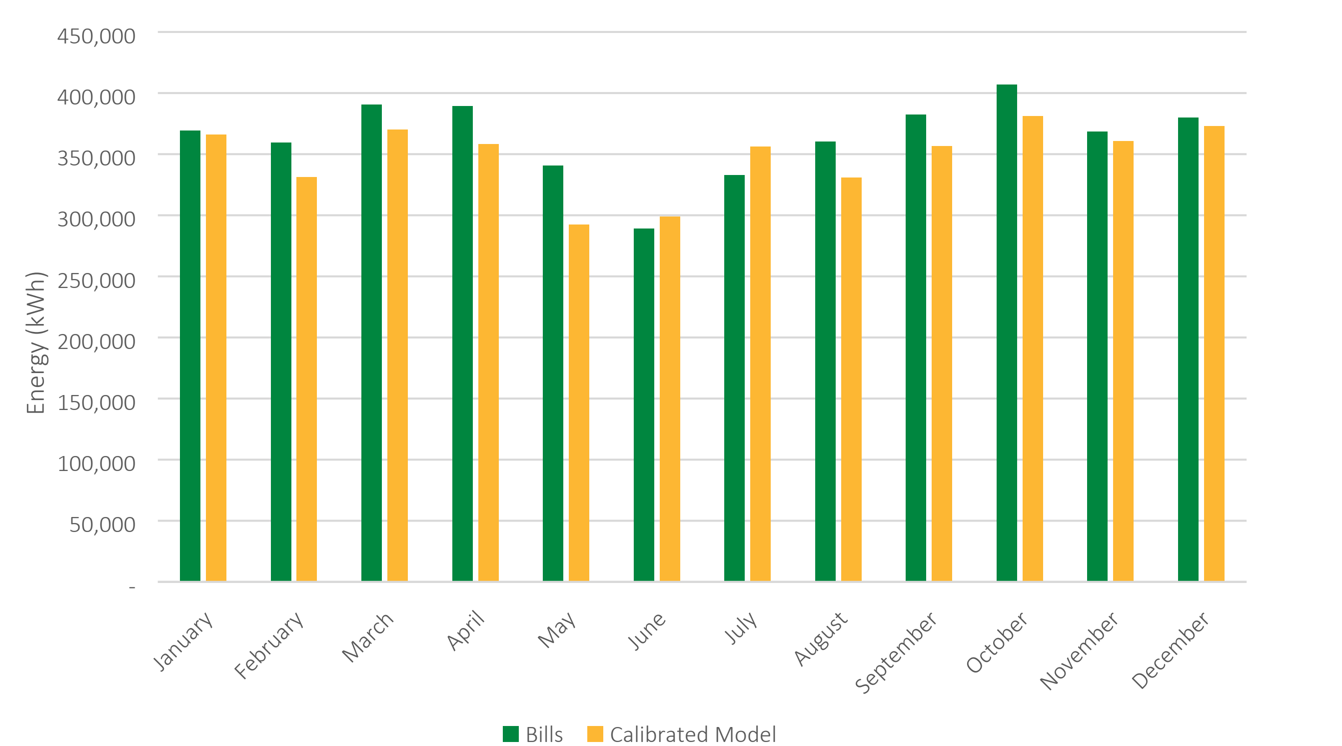


Figure 4.2.1: Electricity Calibration results for South Fletcher's Sportsplex

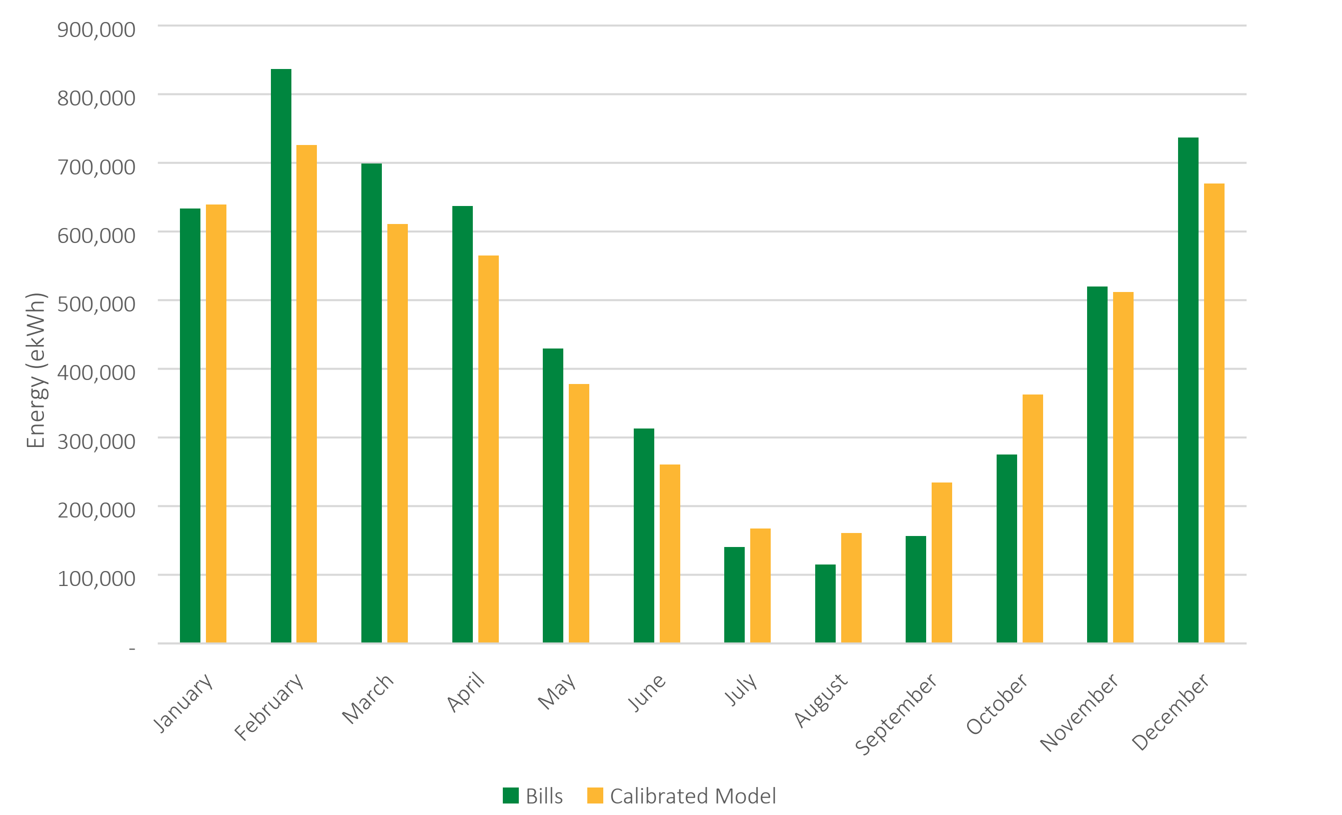


Figure 4.2.2: Natural Gas Calibration results for South Fletcher's Sportsplex

4 ENERGY MODEL

4.2.1 BASELINE END-USE SUMMARY

The end-uses for the baseline model are shown in Figure 4.2.3 for both energy and GHG emissions (using 2010 emissions factors). From the data the major energy end-use and GHG contributor is due to heating. In fact almost 60% of GHG emissions are from space heating. This shows the importance of reducing space heating in terms of magnitude and emission factor (by fuel switching) as a part of the drive to reduce total GHG emissions. The refrigeration plant also is a major contributor to energy consumption. The magnitude of this consumption highlights the potential for heat recovery from the refrigeration plant and how this may offset some of the heating requirements of the facility.

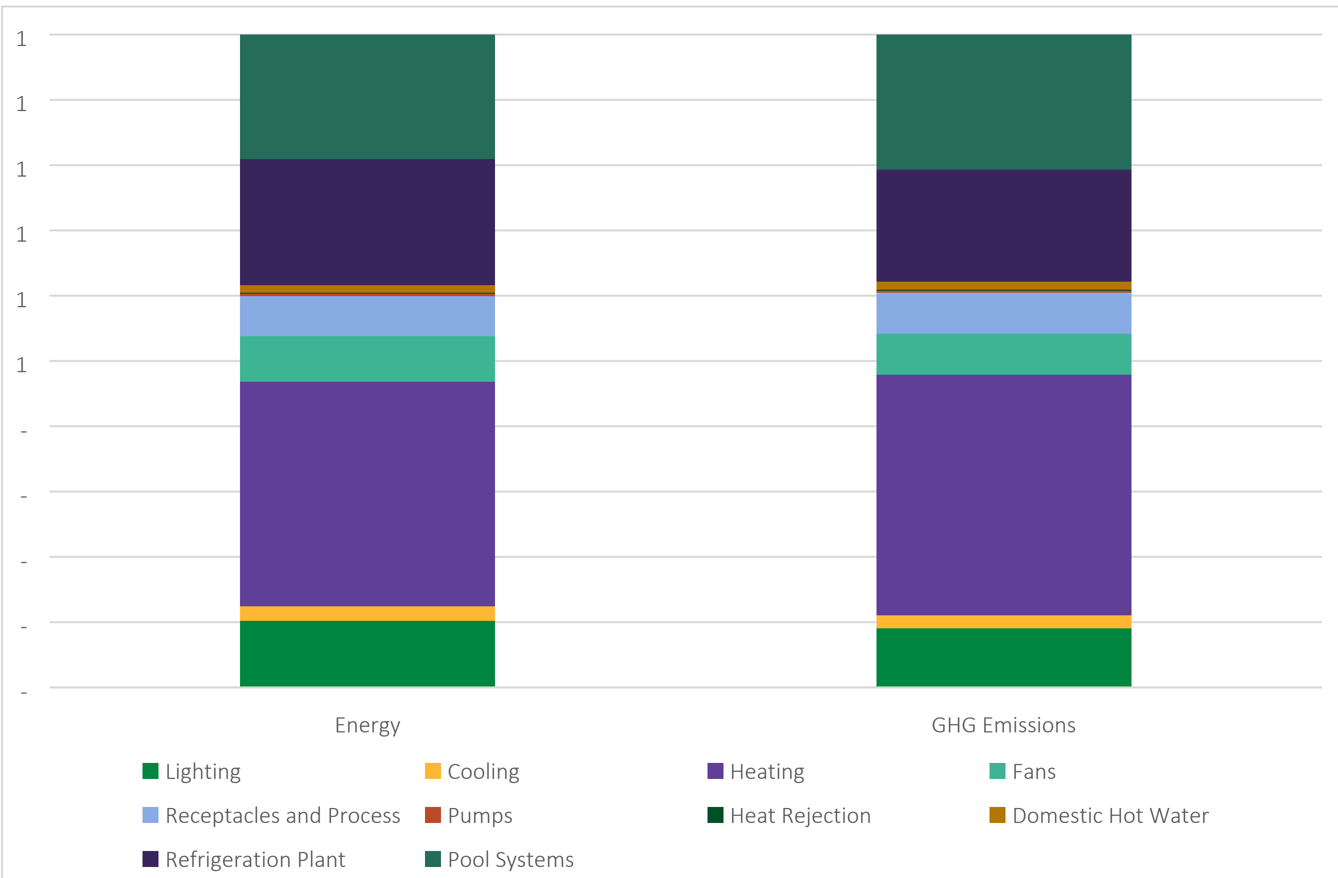


Figure 4.2.3: Energy and GHG baseline Use Summary

4.3 PARAMETRIC MODELLING

Parametric modelling was included as a part of the study to investigate the impact of varying numerous design parameters on energy performance. The specific parameters under investigation here were:

1. Infiltration
2. Solar Heat Gain Coefficient of windows,
3. Window U-value,
4. Phase 1 Wall U-value,

5. Phase 1 Roof U-value,
6. Phase 2 Wall U-value,
7. Phase 2 Roof U-value, and
8. ERV effectiveness of HRU-1 and HRU-2

The calibrated business as usual model was used as the basis for the analysis with the 2018-2019 weather data used for calibration. By varying the parameters above and running a number of simulations, a "metamodel" of the energy model response to varying these parameters was created[i]. From this metamodel a parallel co-ordinates plot was created. Parallel co-ordinates plots are interactive tools and therefore the plot has not been included here directly, but instead can be found at:

https://tedi-calc.mcw-labs.net/project/19453/parallel_coords

The units for the Greenhouse Gas Intensity (GHGI) are $kgCO2e/m^2$ and Energy Use Intensity (EUI) are kWh/m^2.

It is possible to take the derivative of the metamodel parameters with respect to GHGI to reveal which parameters are most important to greenhouse gas emissions. The most important parameters of those under investigation is ERV effectiveness followed by infiltration. Conversely the least important parameters are window solar heat gain coefficient and U-value. These results make intuitive sense because both infiltration and ERV effectiveness represent the conditioning of outdoor air using carbon intensive natural gas while the window-to-wall ratio of the building is very low such that window parameters are not important. Finally, the sign of the derivative is important and reveals that increasing infiltration or any envelope U-value parameter increases GHGI, while increasing SHGC or ERV effectiveness decreases GHGI.

4.4 CLIMATE ADAPTATION MODELLING

As a part of the study climate adaptation modelling has been included by using expected future weather data. The hourly future weather data used is a result of the Sustainable Buildings Canada white paper "Modelling Weather Futures" which represents expected typical weather in the 2040's. This future weather data was created using a Weather Research and Forecasting Model for the years 2040-2049 for Toronto Pearson Airport ("Toronto's Future Weather and Climate Driver Study" by SENES Consultants Ltd). Using the TMY2 methodology this future decade's worth of weather data was converted into a single typical year weather.

As expected this future weather data is warmer than current typical weather resulting is substantially lower heating degree days, and higher cooling degree days. The result of which was a 23% decrease in natural gas consumption and 16% increase in electrical consumption for a typical MURB ("Modelling Weather Futures" from Sustainable Buildings Canada).

Table 4.4.1 compares the natural gas and electricity consumption changes as a result of going from 2018-2019 weather to typical year 2040's future weather data as produced by the Sustainable Building Canada white paper. Similar to the MURB results in the Sustainable Buildings Canada white paper, natural gas usage decreases using future weather while cooling increases. The impact is slightly smaller compared to the MURB case due to the relative importance of end-uses which have lower weather dependence, such as pool heating and rink refrigeration.

Table 4.4.1: Energy Differences for Each Package Due to Future Weather

Package	Natural Gas (ekWh)	Electricity (kWh)
50A	-455,801	219,056
50B	-440,597	215,835
50C	-371,045	219,985
80A	-257,742	99,220
80B	-276,315	100,812
80C	-215,238	120,746
100A	0	143,357
100B	0	145,899
100C	0	60,651

[i] see "Review of metamodeling techniques in support of engineering design optimization" G.G. Wang and S. Shan in *Journal of Mechanical Design* vol. 129, no.4 pp. 370-380

SECTION 5

ENERGY CONSERVATION MEASURES

5 ENERGY CONSERVATION MEASURES

5.1 OVERVIEW

The following Measure Profile Summary table contains a brief overview of the identified Energy Conservation Measures ("**ECM**"), which is the subject of this Carbon Neutral Study.

Table 5.1: Energy Conservation Measures List

ECM Tag	Measure Name	Description
A LIGHTING RETROFIT & REDESIGN		
A01	LED Retrofits & New Fixtures (Interior)	Replace lobby fixtures with new fixtures and retrofit T8 fluorescent fixtures with T8 LED lamps.
A02	LED New Fixtures (Exterior)	Replace all metal halide wall packs & pole lighting with LED luminaires.
A03	Lighting Controls (Basic)	Ceiling mounted occupancy sensors will be installed in all change rooms, washrooms and corridors. Wall switch timers will be installed in all mechanical spaces.
A04	Lighting Controls (Arena)	nLight enable occupancy sensors will be installed in the arenas, enabling the arena lighting to automatically dim when space is vacant.
B ELECTRICAL MODIFICATION		
B01	Battery Energy Storage System (City Owned)	Installation of a Battery Energy Storage System (BESS) to allow for the building to enrol in the ICI program.
B02	Battery Energy Storage as a Service	Installation of a Battery Energy Storage System (BESS) by a third party to allow for the building to enrol in the ICI program.
C BUILDING AUTOMATION SYSTEMS		
C01	Analytic Control Tuning	Install data acquisition devices to trend and analyse HVAC operations.
C02	Demand Control Ventilation	Augment the existing space temperature sensors with combination C02/occupancy sensors, set back the outdoor air and temperature setpoint to unoccupied areas.
D HVAC MODIFICATIONS		
D01	Heating Boilers - Condensing	Replace the existing atmospheric heating boilers with condensing boilers
D02	Heating Boilers – Condensing Lower Water Temperature	Replace the existing atmospheric heating boilers with condensing boilers, convert the high temperature loop to a lower water temperature
D03	DHW Boiler - Condensing	Replace the existing atmospheric DHW boiler with a condensing boiler
D04	Pool Boilers - Condensing	Replace the existing atmospheric pool and whirlpool boilers with condensing boilers
D05	Ground Source Heat Loop – Low Temperature Loop	Install a ground source heat loop to serve the low temperature heating loop.

5 ENERGY CONSERVATION MEASURES

Table 5.1: Energy Conservation Measures List

ECM Tag	Measure Name	Description
D06	Ground Source Heat Loop – High Temperature Loop	Install a ground source heat loop to replace the main heating boilers and electrify the building heating source
D07	AHU Replacement	Replace the existing air handlers and add them to the low temperature loop
D08	AHU VAV Conversion	Install Variable Speed Drives and VAV boxes to reduce the amount of fresh air that must be conditioned by the air handlers
D09	Heat Pump Replacement	Replace the water to air heat pumps on the low temperature loop with newer more efficient ones.
D10	Low Temp Loop Variable Speed Pumping	Install variable speed drives on the low temperature loop pumps, provide control valves at each heat pump.
D11	Waste Water Heat Recovery – High Temp Loop	Install a waste water source heat loop to replace the main heating boilers and electrify the building heating source
D12	District Energy Integration	Integrate the building's heating system with a new district energy system served by the Sheridan College central plant.
E REFRIGERATION		
E01	Chiller Replacement w HR - Ammonia Shell and Tube	Replace the existing built up ice plants with new packaged Ammonia Plate and Frame equivalent
E02A	Chiller Replacement w HR - C02 Plate and Frame – Indirect Slab Cooling	Replace the existing built up ice plants with new packaged C02 Plate and Frame equivalent
E02B	Chiller Replacement w HR - C02 Plate and Frame – Direct Slab Cooling	Replace the existing built up ice plants with new packaged C02 Plate and Frame equivalent, replace in slab piping.
E03	Cold Water Flooding	Install an air separating system to allow for ice resurfacing to be completed with cold water.
E04	Ice Resurfacer Replacement	Replacement of fossil fuel powered ice resurfacers with electric models equipped with Laser Ice Levelling Systems
E05	Radiant Heating Conversion	Replace the radiant stand heaters with electric equivalents
F POOL		
F01	Pool and Whirlpool VFD	Install variable speed drives on the main pool and whirlpool circulating pumps.
F02	Pool Temperature Setback	Reduce Pool Temperature Setpoint During Unoccupied Hours
G BUILDING ENVELOPE UPGRADES		
G01	High Performance Glazing	Replace existing windows with new high performance glazing.
G02	Roof Insulation – Phase I	Install additional insulation on the roof of the arena section of the building
G03	Roof Insulation-Phase II	Install additional insulation on the roof of the community centre section of the building
G04	Exterior Wall Insulation – Phase I	Provide a recladding of the exterior walls of the arena
G05	Exterior Wall Insulation – Phase II	Provide a recladding of the exterior walls of the community centre
G06	Interior Window Replacement	Replace single pane windows partitioning the arena from the rest of the building

Table 5.1: Energy Conservation Measures List

ECM Tag	Measure Name	Description
H DOMESTIC WATER CONSERVATION		
H01	Domestic Water Retrofits	Install low flow domestic water fixtures to replace high flow fixtures
I RENEWABLE ENERGY		
I01A	Solar PV – Roof – 1.18MW array	Installation of a 1.18 MW roof mounted Photo Voltaic (PV) Solar Array to generate renewable electricity.
I01B	Solar PV – Roof – 0.60 MW array	Installation of a 0.60 MW roof mounted Photo Voltaic (PV) Solar Array to generate renewable electricity.
I02	Solar PV - Parking Lot – 1.03 MW array	Installation of a 1.03 MW parking lot stand mounted Photo Voltaic (PV) Solar Array to generate renewable electricity.
I03	Solar Thermal - Pool Heating	Installation of Solar Thermal panel array tied directly into the pool heating system.
J OPERATIONAL CHANGES		
J01	Remove In Stand Heating	Remove the radiant in stand heating from the arena
K GREEN POWER & CARBON OFFSETS		
K01	Renewable Energy Credits	Purchase Renewable Energy Credits as required to achieve carbon neutral operation
K02	Carbon Offsets	Purchase Carbon Offsets as required to achieve carbon neutral operation

5.2 ENERGY CONSERVATION MEASURES

5.2 MEASURE DESCRIPTION GROUP A – LIGHTING RETROFIT & REDESIGN

5.2.1 A01 – LED RETROFITS & NEW FIXTURES (INTERIOR)

MEASURE ID:	A01
MEASURE NAME:	LED Retrofits & New Fixtures (Interior)
MEASURE SUMMARY:	Replace lobby fixtures with new fixtures and retrofit T8 fluorescent fixtures with T8 LED lamps.

Scope of Work

The primary lighting in the lobby currently consists of 35 metal halide decorative fixtures that operate 24/7. These fixtures draw 96W each. Each fixture will be replaced on a 1-for-1 basis with a new LED luminaire with similar aesthetics and better light distribution.

All change room showers each currently have a vapour proof fixture containing a pair of T8 fluorescent lamps powered by an electronic ballast (29 fixtures total). These fixtures draw 59W each. All lamps will be replaced with 10W T8 LED plastic lamps, and all ballasts will be replaced with a high efficiency instant start low ballast factor ballast.

Impact on Operations and Maintenance

The quality of light in the lobby will be greatly improved. LED lighting is known to have much higher CRI (colour rendering index) than metal halide. Also unlike with metal halide lamps, LED fixtures can have their colour temperature (CCT) pre-selected based on the space requirements. A photometric analysis will be done to ensure that the space will be uniformly illuminated, and if possible reduce the number of fixtures. The lights will now be able to be turned on/off instantly, and dimmed (dimming will require additional controls). This opens the possibility (not discussed in this study) for the fixtures to be dimmed at night, and/or controlled by occupancy sensors, for additional savings.

Given the high failure rate of both metal halide lamps and ballast, a significant amount of maintenance time will be saved.

Visually, the lighting produced from the vapour proof fixtures will remain the same. The lamps will however last significantly longer.

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
BAU Annual Operation and Maintenance Cost (Retain existing light fixtures)	$5,800
ECM Annual Operation and Maintenance Cost	$1,800
Annual O&M Cost Beyond Business as Usual Case	($4,000)
Equipment Expected Useful Life	13 years

IES Model Input Variables

Savings for this ECM were manually calculated. See Appendix F for a summary of these calculations.

General Assumptions:

- Calculations were calculated using a custom in-house Lighting Database
- Existing and proposed lamp & luminaire wattages were procured from manufacturer technical information sheets
- Building and room occupancy hours were estimated based on talks with staff present, building operators, and general observations during audit
- Refer to **Appendix F: Lighting Line-By-Line** for room-by-room breakdown of all lighting associated with project
- Existing wiring is code compliant.
- Existing electrical grounding systems are code compliant and do not need to be modified.
- No seismic updates are required as a result of lighting changes.

Sample Calculations:

$$kWh = [Load(W) \cdot FixtureQuantity \cdot Hours]\frac{1}{1000}$$

$$kW = [Load(W) \cdot FixtureQuantity \cdot Diversity\ Factor^{*}]\frac{1}{1000}$$

*Where Diversity factor represents the probability the luminaires will be on during peak demand, estimated to be in late afternoon

5.2 ENERGY CONSERVATION MEASURES

Figures

Figure A01.1 – Main lobby lighting.

Figure A01.2 – Proposed lobby fixtures, by Lithonia.

Cost & Savings Summary

A summary for this improvement is outlined below.

A01 LED RETROFITS & NEW FIXTURES (INTERIOR)								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	ELECTRICITY DEMAND PEAK/MONTHLY [kW]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
25,574	3	-	4	$2,739	$24,401	$1,279	8.4	$ 10,620

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.2 ENERGY CONSERVATION MEASURES

5.2.2 A02 – LED NEW FIXTURES (EXTERIOR)

MEASURE ID:	A02
MEASURE NAME:	LED New Fixtures (Exterior)
MEASURE SUMMARY:	Replace all metal halide wall packs & pole lighting with LED luminaires.

Scope of Work

The building's exterior lighting is currently a mix of LED and metal halide fixtures. It is likely that as the metal halide fixtures fail, they are replaced with LED equivalents. This will be fast-tracked and all metal halide fixtures will be replaced with LED fixtures. There currently remains 25 metal halide wall packs. Each of these draw 96 W.

The parking lots are currently illuminated by pole mounted metal halide fixtures. They too will be replaced with LED fixtures. A photometric analysis will be done to ensure minimum light levels are met throughout the entire parking area. There currently exists 7 pole fixtures mounted at 15' drawing 185W each, and 24 pole fixtures mounted at 25' drawing 292W each.

Impact on Operations and Maintenance

By replacing all metal halide fixtures at the same time, going forward a group fixture replacement can be done for the LED fixtures when approaching their end of rated life (24 years). This length of time has is based on the rated life of typical exterior LED products (>100,000 hours) and the assumption that exterior lighting is "on" for a daily average of 12 hours per day.

The quality of light coming from the new fixtures will also be greatly improved with a uniform distribution around the space it's illuminating. Light quality will also be improved, and lumen depreciation will be negligible in the cold weather.

Maintenance of the fixtures will be significantly reduced given that they will not need to be replaced for many years.

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
BAU Annual Operation and Maintenance Cost (Retain existing light fixtures)	$5,700
ECM Annual Operation and Maintenance Cost	$1,600
Annual O&M Cost Beyond Business as Usual Case	($4,100)
Equipment Expected Useful Life	24 years

IES Model Input Variables

Savings for this ECM were manually calculated. See Appendix F for a summary of these calculations.

General Assumptions:

- Calculations were calculated using a custom in-house Lighting Database
- Existing and proposed lamp & luminaire wattages were procured from manufacturer technical information sheets
- Building and room occupancy hours were estimated based on talks with staff present, building operators, and general observations during audit
- Refer to **Appendix F: Lighting Line-By-Line** for room-by-room breakdown of all lighting associated with project
- Existing wiring is code compliant.
- Existing electrical grounding systems are code compliant and do not need to be modified.
- No seismic updates are required as a result of lighting changes.

Sample Calculations:

$$kWh = [Load(W) \cdot FixtureQuantity \cdot Hours]\frac{1}{1000}$$

$$kW = [Load(W) \cdot FixtureQuantity \cdot Diversity\ Factor^{*}]\frac{1}{1000}$$

*Where Diversity factor represents the probability the luminaires will be on during peak demand, estimated to be in late afternoon

5.2 ENERGY CONSERVATION MEASURES

Figures

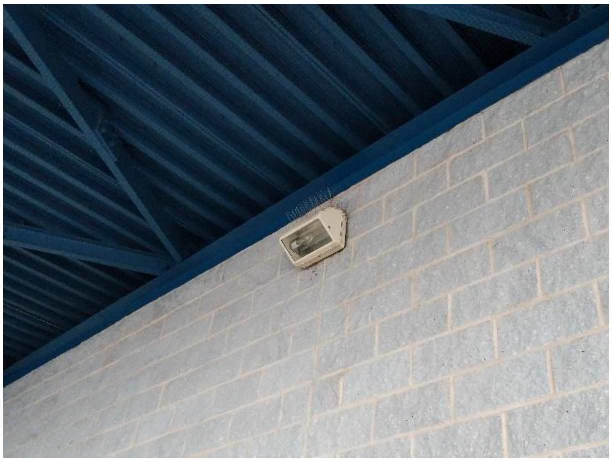


Figure A02.1 – Existing metal halide wall packs

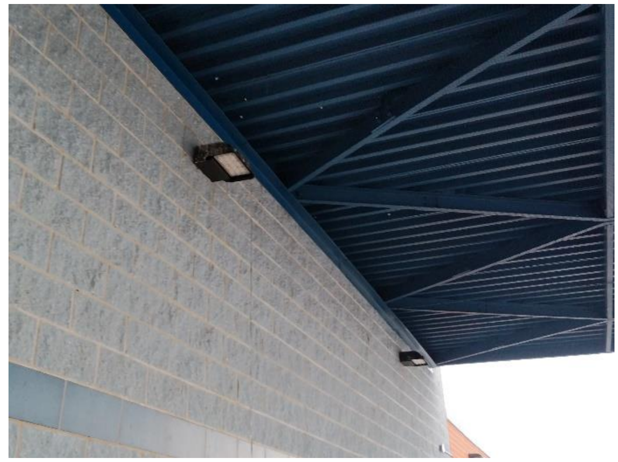


Figure A02.2 – LED wall pack replacements

Figure A02.3 – Typical metal halide pole lighting illuminating the parking area

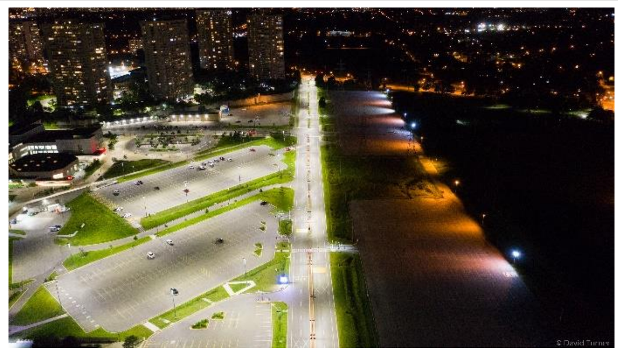


Figure A02.4 – A side by side comparison of LED (left) and metal halide/high pressure sodium (right, out of scope). This lighting retrofit was completed by MCW in 2019.

Cost & Savings Summary

A summary for this improvement is outlined below.

A02 LED NEW FIXTURES (EXTERIOR)								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	ELECTRICITY DEMAND PEAK/MONTHLY [kW]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
24,943	-	-	4	$541	$50,042	$1,247	>50	-$ 36,355

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.2 ENERGY CONSERVATION MEASURES

5.2.3 A03 – LIGHTING CONTROLS (BASIC)

MEASURE ID:	A03
MEASURE NAME:	Lighting Controls (Basic)
MEASURE SUMMARY:	Ceiling mounted occupancy sensors will be installed in all change rooms, washrooms and corridors. Wall switch timers will be installed in all mechanical spaces.

Scope of Work

All change rooms and corridors are currently controlled by a line voltage toggle switch within each room. Some washrooms also have switches, while others are on a remote timer set to operate 24/7. All change rooms and washrooms will have ceiling mounted occupancy sensors installed in the space. The low voltage sensor will be connected to a powerpack, which will control the lights in the space. All sensors will have ultrasonic (sounds) and infrared (movement) technologies, ensuring occupants are always detected even when in washroom stalls or around a corner. Occupancy sensors in hockey change rooms will come with a protective cage to ensure they are not damaged.

Mechanical rooms are also currently controlled by a line voltage toggle switch within each room, however it was observed that some rooms have been inadvertently left on 24/7. All wall switches will be replaced with switches with timers, such that after a pre-determined number of hours the lights will turn off automatically. The switch timers will feature a warning system, such that 15 minutes prior to light shutoff, the lights will begin to flash, notifying the occupant. That in addition to ample emergency lighting will ensure safety is not compromised in the spaces.

All control devices proposed in this measure are considered “stand alone” devices, such that they would not be integrated into the building’s BAS, nor would they have that capability for future consideration.

Impact on Operations and Maintenance

Occupancy sensors and switch timers are both quite reliable and do not require maintenance.

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
BAU Annual Operation and Maintenance Cost (Do not install occupancy sensors)	$0
ECM Annual Operation and Maintenance Cost	$0
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	20 years

IES Model Input Variables

Savings for this ECM were manually calculated. See Appendix F for a summary of these calculations.

General Assumptions:

- Calculations were calculated using a custom in-house Lighting Database
- Existing and proposed lamp & luminaire wattages were procured from manufacturer technical information sheets
- Building and room occupancy hours were estimated based on talks with staff present, building operators, and general observations during audit
- Refer to **Appendix F: Lighting Line-By-Line** for room-by-room breakdown of all lighting associated with project
- Existing wiring is code compliant.
- Existing electrical grounding systems are code compliant and do not need to be modified.
- No seismic updates are required as a result of lighting changes.

Sample Calculations:

$$kWh = [Load(W) \cdot FixtureQuantity \cdot Hours]\frac{1}{1000}$$

$$kW = [Load(W) \cdot FixtureQuantity \cdot Diversity\ Factor^{*}]\frac{1}{1000}$$

*Where Diversity factor represents the probability the luminaires will be on during peak demand, estimated to be in late afternoon

5.2 ENERGY CONSERVATION MEASURES

Figures

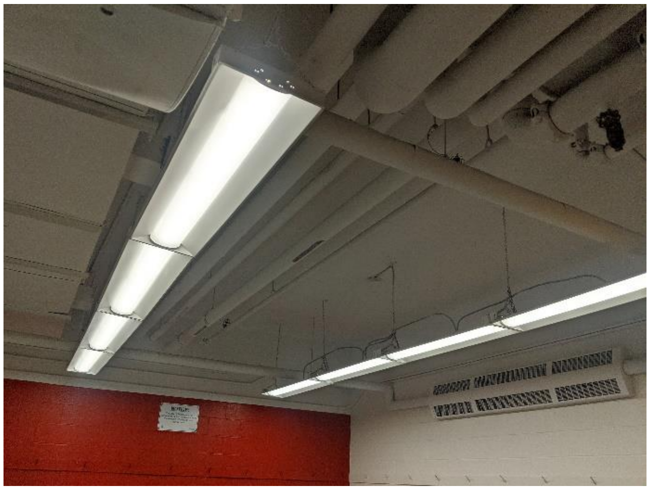


Figure A03.1 – Typical lighting layout in a change room. Occupancy sensor to be place in center of room.

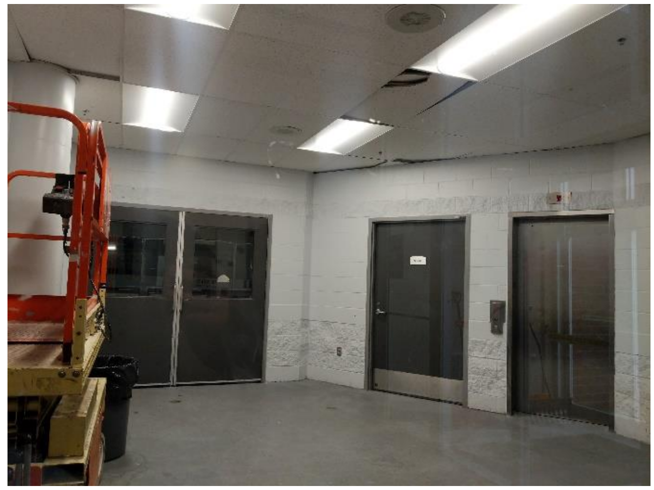


Figure A03.2 – Vestibule between main lobby and arena. Space is not used but lights remain on; good opportunity for an occupancy sensor.

Figure A03.3 – Timerclock used to control some washroom lighting, set to operated 24/7.

5.2 ENERGY CONSERVATION MEASURES

Cost & Savings Summary

A summary for this improvement is outlined below.

A03 LIGHTING CONTROLS (BASIC)								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	ELECTRICITY DEMAND PEAK/MONTHLY [kW]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
18,420	-	-	3	$399	$21,555	$921	>50	-$ 13,551

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.2.4 A04 – LIGHTING CONTROLS (ARENA)

MEASURE ID:	A04
MEASURE NAME:	Lighting Controls (Arena)
MEASURE SUMMARY:	*nLight* enable occupancy sensors will be installed in the arenas, enabling the arena lighting to automatically dim when space is vacant.

Scope of Work

The arena lighting is currently controlled by an *nLight Wired* lighting controller. All fixtures are daisy chained via Cat5e cable to the controller and switches, located in the Zamboni room. Though fixtures can be dimmed and scenes have been programmed, it appears the fixtures are rarely dimmed/turned off when spaces are vacant. *nLight* enabled occupancy sensors will be installed over and around each rink, and connected back to the system. When vacancy is detected for 15 minutes by all sensors in the space, the lights will be commanded to dim to 20% output, allowing for significant savings while still ensuring the space is bright enough to easily navigate.

Impact on Operations and Maintenance

Occupancy sensors are quite reliable and do not require maintenance.

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
BAU Annual Operation and Maintenance Cost (Do not install occupancy sensors)	$0
ECM Annual Operation and Maintenance Cost	$0
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	20 years

IES Model Input Variables

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered IES Model Input Variables

Savings for this ECM were manually calculated. See Appendix F for a summary of these calculations.

General Assumptions:

- Calculations were calculated using a custom in-house Lighting Database
- Existing and proposed lamp & luminaire wattages were procured from manufacturer technical information sheets
- Building and room occupancy hours were estimated based on talks with staff present, building operators, and general observations during audit
- Refer to **Appendix F: Lighting Line-By-Line** for room-by-room breakdown of all lighting associated with project
- Existing wiring is code compliant.
- Existing electrical grounding systems are code compliant and do not need to be modified.
- No seismic updates are required as a result of lighting changes.

Sample Calculations:

$$kWh = [Load(W) \cdot FixtureQuantity \cdot Hours]\frac{1}{1000}$$

$$kW = [Load(W) \cdot FixtureQuantity \cdot Diversity\ Factor^{*}]\frac{1}{1000}$$

*Where Diversity factor represents the probability the luminaires will be on during peak demand, estimated to be in late afternoon

Figures

Figure A04.1 – The current nLight control system. No changes will be made to the front end of the system.

Figure A04.2 – Typical rink. Each rink will have eight fixtures installed.

Cost & Savings Summary

A summary for this improvement is outlined below.

A04 LIGHTING CONTROLS (ARENA)								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	ELECTRICITY DEMAND PEAK/MONTHLY [kW]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
102,018	-	-	15	$2,211	$11,364	$5,101	2.8	$ 32,966

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.3 MEASURE DESCRIPTION GROUP B – ELECTRICAL MODIFICATIONS

5.3.1 MEASURE B01: BATTERY ENERGY STORAGE SYSTEM (CITY OWNED)

MEASURE ID:	B01
MEASURE NAME:	Battery Energy Storage System (City Owned)
MEASURE SUMMARY:	Installation of a Battery Energy Storage System (BESS) to allow for the building to enrol in the ICI program.

Scope of Work

As the building currently operates as a class B electrical consumer, electricity is billed largely as a function of consumption. By installing a Battery Energy Storage System, the building can be artificially brought into the class A rate whereby its electricity costs would become a function of peak demand. Please see Section 3 of this report for a discussion of the two rate classes.

The building currently experiences monthly peak demand events that are close to, but not above the 1.0 MW threshold to participate in the class A rate. A BESS would be discharged monthly during off peak hours to ensure the monthly peak demand of the building was in excess of 1.0 MW. The BESS would also be used in conjunction with a Global Adjustment prediction service to lower the building's demand during global adjustment events.

In order to electrify the building's heat source, which is required in order to achieve carbon neutral operation, a shift to a demand based rate structure is preferable. It will require a significant increase in electrical consumption without a similarly significant increase to the building's electrical demand.

This measure installs a new 500kW x 2 hr battery array adjacent to the building exterior. The installation includes:

- NMC Lithium ion battery packs, sized such that the array could discharge 1,000 kWh over a two hour window
- Concrete equipment pad, including security fencing located adjacent to the building. The pad orientation is customizable but requires approximately 1,000 sqft for an array of this size.
- Inverters, transformer (480V to 600V) and associated switchgear
- Electrical installation to tie the array into the electrical distribution system. The assumed point of connection is distribution panel DP1 which has the capacity to accommodate such an array
- Battery control system that automatically charges and discharges the array based on market conditions.

On days where no peak event is expected the array can be used to take advantage of fluctuations in the hourly cost of electricity or the carbon intensity of the grid. Under a class A rate structure the building is still charged the Hourly Ontario Energy Price (HOEP) on each kWh consumed. The HOEP varies hourly but it does so in patterns that are, for the most part, predictable. Energy prices are typically $0.018/kWh higher during the daytime as compared to the evening. By charging the array when the HOEP is low and discharging when the HOEP is high additional cost savings can be achieved. Similarly an analysis of IESO data for the 2016 year indicates the Ontario grid uses 54.4 g C02/kWh during peak hours and only 28.62 g C02/kWh during off peak hours.

Running the array daily yields an additional $6,300 in time of use savings and 9 tonnes of C02 annually. When assessed against the cost of operating and maintaining the BESS given the additional use it is preferable to keep the BESS idle and only operate it in order to reduce global adjustment peaks.

The proposed BESS would be specified such that it is to be compliant with the following safety standards:

- Battery cells to UL 1642 - Lithium Batteries
- System to UL 1642 - Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications
- System to UL 9450 - Standard for Energy Storage Systems and Equipment
- System to UL 9450A - Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
- System to UL 1741 - Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

Impact on Operations and Maintenance

Lithium Ion NMC battery cells experience wear however when used correctly (not left in extremely high or low charge states for extended periods) industry standard is 3000 cycles while retaining 70% charge rating. If the BESS is used only for peak shaving and boosting the building to class A, it is expected that its useful life would exceed 50 years. If it is used more frequently this would decrease, but even at daily use it would still be expected to provide a 20 year service life.

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$10,000
BAU Annual Operation and Maintenance Cost (Do not install a BESS)	$0

Annual O&M Cost Beyond Business as Usual Case	$10,000
Equipment Expected Useful Life	30 years

IES Model Input Variables

Savings for this measure were calculated manually, outside of IES-VE.

Figures

Figure B01.1 – Extended battery installation representative of installation for proposed measure

Cost & Savings Summary

A summary for this improvement is outlined below.

B01 BATTERY ENERGY STORAGE SYSTEM (CITY OWNED)							
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]
ELECTRICITY CONSUMPTION [kWh]	GLOBAL ADJUSTMENT KW [kW]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]			
-109,500	475	50,775	-16	$326,296	$1,090,100	3.3	$6,419,438

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.3.2 MEASURE B02: BATTERY ENERGY STORAGE SYSTEM (ESAS)

MEASURE ID:	B02
MEASURE NAME:	Battery Energy Storage as a Service
MEASURE SUMMARY:	Installation of a Battery Energy Storage System (BESS) by a third party to allow for the building to enrol in the ICI program.

Scope of Work

This ECM is effectively identical to measure B01, however in this case the BESS is installed and operated by a third party under an Energy Storage as a Service (ESAS) contract at no initial cost to the City.

Under an ESAS contract the building could still be moved to the ICI program (class A), but the savings stream is diminished to allow for the ESAS provider to recoup the cost of installing and operating the BESS.

ESAS contracts are typically enrolled in with a 10 year term. Termination fees do apply if the City elects to terminate the ESAS contract early.

ESAS projects are typically larger than the 500kW array proposed for measure B01. An array of this size would garner an annual payout to the city in the $8,000 range. This figure grows quick as the array size does. A 1MW array can provide an annual payout in the $175,000 range, however the facility does not have a large enough electrical demand load to support such an array.

Impact on Operations and Maintenance

As the BESS would be owned and operated by a third party, this ECM would have no impact to operations and maintenance.

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$0
BAU Annual Operation and Maintenance Cost (Do not install a BESS)	$0
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	NA

IES Model Input Variables

Savings for this measure were provided in consultation with third party ESAS providers.

Figures

N/A.

Expected Service Life of Measure

The ESAS contract can be tailored to have differing terms, this is at the option of the City.

Cost & Savings Summary

A summary for this improvement is outlined below.

B02 BATTERY ENERGY STORAGE AS A SERVICE								
ANNUAL SAVINGS						TOTAL MEASURE COST [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	ELECTRICITY DEMAND PEAK/MONTHLY [kW]	GLOBAL ADJUSTMENT KW [kW]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]			
-109,500	-	-	58,885	-16	$88,402	$1	0.0	$ 1,318,186

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.4 MEASURE DESCRIPTION GROUP C – BUILDING AUTOMATION SYSTEMS

5.4.1 MEASURE C01: DEMAND CONTROL VENTILATION

MEASURE ID:	C01
MEASURE NAME:	Demand Control Ventilation
MEASURE SUMMARY:	Augment the existing space temperature sensors with combination C02/occupancy sensors, set back outdoor air and temperature setpoint to unoccupied areas.

Scope of Work

The concept of this measure is to ensure that new variable air primary (i.e. outdoor air) boxes are controlled to satisfy dilution of CO2 in occupied spaces, and that unoccupied spaces have their space temperature setpoints offset from normal occupied temperature.

This measures proposes to provide this by installing new network connected, display-less, combination temperature, humidity, CO2, and occupancy sensor by Johnson Controls: NSB8MTC042-0. These would be installed on a per-zone basis, and the setpoints associated with the operation of variable air volume ventilation and heat pump conditioning would be coordinated for different conditions: when there is no scheduled occupancy of the facility (i.e. a deep setback of 14 deg C heating/28 deg C cooling), when there is scheduled occupancy of facility but no detected occupancy (i.e. a light setback of 18 deg C heating/24 deg C cooling), and when there is schedule occupancy and detected occupancy (normal occupied temperature setpoint).

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$15,000
BAU Annual Operation and Maintenance Cost (Retain Existing BAS)	$12,000
Annual O&M Cost Beyond Business as Usual Case	$3,000
Equipment Expected Useful Life	10 years

IES Model Input Variables

Demand control ventilation was implemented in the appropriate spaces directly in IES by using CO2 sensors. However, without full VAV conversion the minimum flow was set to a value of 70%.

Parameter	Calibrated Model	ECM Implementation
Minimum flow ratio to zones	1.0	0.7

Figures

Figure C02.1 Depiction of the various networkable sensors (Johnson Controls power + BACnet MS/TP communications' SA-bus) available for connection to their VMA controllers.

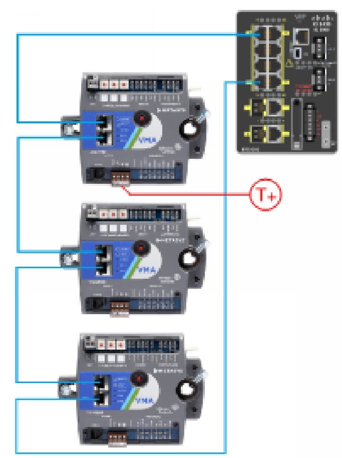


Figure C02.2 Depiction of the daisy-chained Ethernet ring topology for fast communication of the information being retrieved from network combination sensors (shown as T+).

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

C01 DEMAND CONTROL VENTILATION								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
113,446	14,132	-	44	$6,478	$651,200	$22,689	>50	-$ 556,863

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.4.2 MEASURE C02: ANALYTIC CONTROL TUNING

MEASURE ID:	C02
MEASURE NAME:	Analytic Control Tuning
MEASURE SUMMARY:	Install data acquisition devices to trend and analyse HVAC operations.

Scope of Work

Proper identification and correction of excursions in the operation of a building's energy system can lead to substantial savings. This measure proposes the installation of a data aggregator and analytics software package. This system will aggregate BACnet trend logs into a single database, which is then mirrored into a cloud based software platform. The intent of the software platform is to be able to apply logical rules to the information that is captured from site so that fault finding algorithms can capture instances of equipment behaving erroneously.

Predicted faults include:

- Systems that are commanded to be disabled, but are showing status due to starters being in hand control.
- Ongoing drift associated with the operation of a motor, whether it's current is deviating from normal levels.
- Whether speed is changing as a function of expected load (potentially indicative of poor set point or sensor placement).
- System input values that have not changed over hours, based on COV reporting (indicative of faulty sensors).
- Execution of calibration routines to assess whether the mixed air dampers are holding shut through temperature monitoring during full recirculation morning warmup.
- Assessment of leaking valves through the application of differential temperature measurement while valves are closed.

The cost of implementation associated with this measure is based on a one time cost of installation in addition to a subscription fee for the first year of the service. The first year after implementation will serve as a demonstration of the capabilities of the technology and the savings that can be realized through the use of a Data Capture and Analytics system. Subscription to the service in subsequent years will be determined at a future date. Historically this service has shown to bring continued value through its ability to flag faults and excursions affecting system performance, thereby increasing likelihood of savings performance.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

There is little to no expected maintenance costs associated with this ECM, however an ongoing service subscription is required.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$8,500
BAU Annual Operation and Maintenance Cost (Do not implement building analytics)	$0
Annual O&M Cost Beyond Business as Usual Case	$8,500
Equipment Expected Useful Life	25 years

IES Model Input Variables

The savings for this measure were estimated based on a review of the BAS performance. This estimate was revised downward to reflect the close involvement the City's energy group has in reviewing the ongoing operation of the BAS.

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

C02 ANALYTIC CONTROL TUNING								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
79,230	7,785	-	27	$3,931	$9,350	$4,250	1.3	$113,670

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.5 MEASURE DESCRIPTION GROUP D – HVAC MODIFICATIONS

5.5.1 MEASURE D01: HEATING BOILERS - CONDENSING

MEASURE ID:	D01
MEASURE NAME:	Heating Boilers - Condensing
MEASURE SUMMARY:	Replace the existing atmospheric heating boilers with condensing boilers

Scope of Work

The perimeter heating, HRU 1, HRU 2, and the Deck-Tron are served by a hydronic system consisting of three Raytherm 1825 MBH atmospheric boilers. These boiler are at the end of their useful life.

This measure proposes to replace these boilers with boilers with new, higher efficiency condensing boilers to be used to supply the hydronic heating system load. The new boilers would also include a more intelligent controls interface that would allow them to communicate with a separate outdoor air reset package. The new replacement boilers would have a rated efficiency of up to 97%, and thus be able to fulfill the heating needs of the building with less natural gas consumption.

The high rated efficiency of a condensing boiler is only reached when the boiler is operating at a condensing temperature. Without modifying the existing hot water loop to work with a lower supply temperature, the new boilers will experience some loss of efficiency in the coldest months of the winter when they would not condense. During the shoulder season the condensing boiler would be able to operate at full rated efficiency for much of the time. Please see ECM D02 for a further discussion of this.

The replacement of the boilers would also require replacement of the existing boiler stacks to allow for condensing operation as the condensed flue gas would corrode the existing stacks.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$7,500
BAU Annual Operation and Maintenance Cost (Install standard mid efficiency boilers)	$7,500
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

5 ENERGY CONSERVATION MEASURES

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Rated Boiler Efficiency	80%	93%
Boiler Performance Curve	Default Non-condensing boiler	Default Condensing boiler
Minimum Supply Water Reset Temperature	None	130°F

Figures

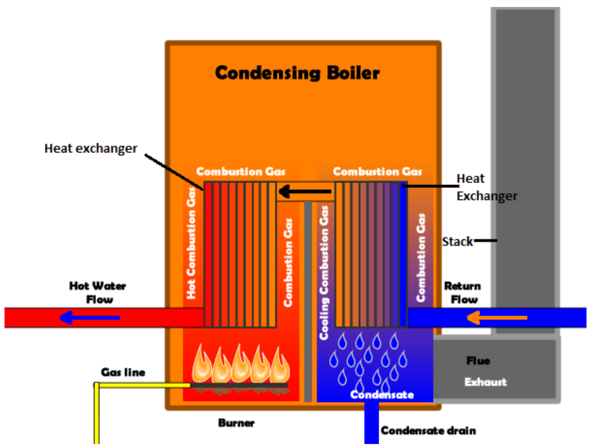


Figure D01.1- Principle of operation for a condensing boiler

Figure D01.2 – Existing Atmospheric Boiler

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D01 HEATING BOILERS - CONDENSING								
ANNUAL SAVINGS				TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]					
41,660	-	79	$11,848	$508,200	$380,600	$8,332	10.1	$ 304,858

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.5.2 MEASURE D02: CONDENSING BOILERS – LOWER WATER TEMPERATURE

MEASURE ID:	D02
MEASURE NAME:	Heating Boilers – Condensing Lower Water Temperature
MEASURE SUMMARY:	Replace the existing atmospheric heating boilers with condensing boilers, convert the high temperature loop to a lower water temperature

Scope of Work

This ECM is effectively equivalent to measure D01, however the savings presented represent the effect of lowering the heating water temperature of the high temperature heating loop from 155 deg F to 130 deg F. This would allow the new boilers to run in condensing mode for nearly the entirety of the heating season.

To accomplish this all terminal equipment (unit heaters, perimeter rads, and cabinet heaters) would need to be replaced to accommodate the lower temperature water. Similarly air handlers served by the high temperature loop (HRU1, and the Deck Tron) would need to be retrofitted with new heating coils.

The costs associated with these conversions is carried in other measures presented in this report (measure D07 for air handlers and measures E01/02 for terminal equipment). This ECM is presented not as a stand-alone project, but rather to reinforce to the reader the degree of interdependence between each of the individual mechanical measures.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$7,500
BAU Annual Operation and Maintenance Cost (Install standard mid efficiency boilers)	$7,500
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Rated Boiler Efficiency	80%	93%
Boiler Performance Curve	Default Non-condensing boiler	Default Condensing boiler
Supply Water Temperature	180°F	130°F

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D02 HEATING BOILERS - CONDENSING LOWER WATER TEMPERATURE									
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]					
-9,420	64,043	-	120	$18,010	$508,200	$380,600	$12,809	6.4	$ 532,510

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.5.3 MEASURE D03: DHW BOILER - CONDENSING

MEASURE ID:	D03
MEASURE NAME:	DHW Boiler - Condensing
MEASURE SUMMARY:	Replace the existing atmospheric DHW boiler with a condensing boiler

Scope of Work

Domestic hot water is provided by a single Raytherm 1,467 MBH atmospheric boiler. This boiler serves all domestic water loads in the buildings, but does not serve the ice rink flooding. The existing domestic water boiler is of a similar make, vintage, and performance as the main water heating boilers.

This ECM replaces this boiler with a high efficiency condensing boiler designed to provide domestic hot water at 140 deg F. Domestic hot water represents an ideal application for condensing boilers as the lower water temperature allow for condensing operation at all times.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$1,500
BAU Annual Operation and Maintenance Cost (Install standard mid efficiency DHW boiler)	$1,500
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Rated Boiler Efficiency	85%	95%
Boiler Performance Curve	Default Non-condensing boiler	Default Condensing boiler

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D03 DHW BOILER - CONDENSING							
ANNUAL SAVINGS				TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
5,613	-	11	$1,596	$161,700	$111,100	31.7	$ 6,544

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.5.4 MEASURE D04: POOL BOILERS - CONDENSING

MEASURE ID:	D04
MEASURE NAME:	Pool Boilers - Condensing
MEASURE SUMMARY:	Replace the existing atmospheric pool and whirlpool boilers with condensing boilers

Scope of Work

The existing pool and whirlpool boiler is of a similar make, vintage, and performance as the main water heating boilers. Each is served by a single atmospheric boiler rated at 825MBH and 150MBH respectively. Pool heating and whirlpool heating represent ideal candidates for condensing boiler retrofits as they are low temperature applications that do not require lowering the supply temperature in order to achieve the high performance available through condensing operation.

This ECM replaces these boilers with high efficiency condensing boilers and to replace the existing boiler stacks to accommodate condensing operation.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$1,500
BAU Annual Operation and Maintenance Cost (Install standard mid efficiency pool boilers)	$1,500
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Rated Boiler Efficiency	85%	95%
Boiler Performance Curve	Default Non-condensing boiler	Default Condensing boiler

Figures

Figure D03.1 – Existing Atmospheric Pool Boiler

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D04 POOL BOILER - CONDENSING									
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]					
846	17,806	-	34	$5,082	$206,800	$114,400	$3,561	17.5	$ 92,860

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.5.5 MEASURE D05: GROUND SOURCE HEAT LOOP – LOW TEMPERATURE LOOP

MEASURE ID:	D05
MEASURE NAME:	Ground Source Heat Loop – Low Temperature Loop
MEASURE SUMMARY:	Install a ground source heat loop to serve the low temperature heating loop.

Scope of Work

The building is served by two hydronic loops. A high temperature loop and a low temperature loop. The low temperature loop serves the water to air heat pumps that provide much of the heating and cooling for the air supplied to the spaces. These heat pumps, and by extension the low temperature loop, are served by the high temperature where heat is injected indirectly from the building's heating boilers.

In essence the existence of the low temperature loop presents an opportunity to electrify a significant portion of the building's HVAC system without resorting to invasive changes to air handlers, terminal devices or piping that will be required as part of a full electrification of the building's heating system that will be required as part of carbon neutral operation.

This measure proposes to install a ground source heating loop sized to carry the operation of the low temperature loop (200 tons). A conservative estimate of the required borehole field yields a field consisting of 50 holes to a depth of 600 feet. This field fits well within the greenspace area north of the building. This estimate would need to be verified by conducting a test drill before proceeding to detailed design.

High lift heat pump technology has recently improved such that this application can be served by heat pumps equipped with centrifugal compressors in lieu of positive displacement compressors. This allows for the heat pump to be added to the facility without negatively impacting its TSSA rating.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$4,500
BAU Annual Operation and Maintenance Cost (Low temp loop supplied by mid efficiency boilers)	$1,500
Annual O&M Cost Beyond Business as Usual Case	$3,000
Equipment Expected Useful Life	25 years

IES Model Input Variables

A ground-source heat exchanger was added to the water-loop heat pump loop to add heat during the winter and act as a sink in summer. The ground water temperature was estimated by on a month-by-month basis using the software program Ground Loop Design and the simulated loads on the ground loop.

Figures

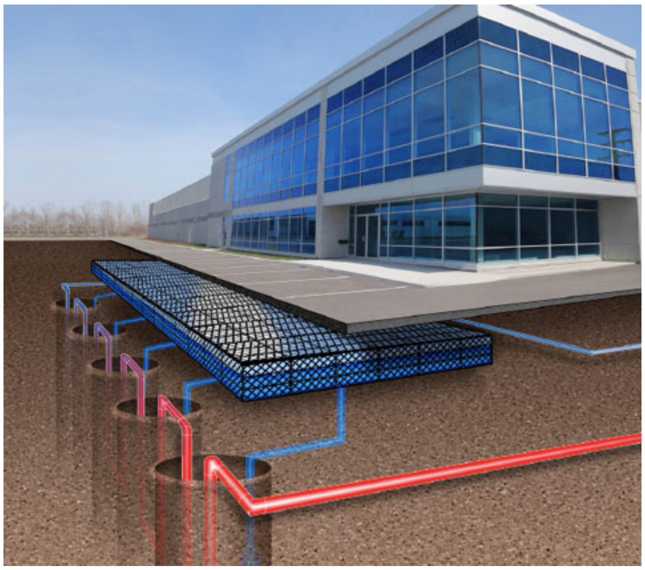


Figure D05.1- Ground Source Heat Loop

Figure D05.2- Ground Source Heat Pump

Figure D05.3- Low Temp Loop Required Bore Hole Area

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D05 GROUND SOURCE HEAT LOOP - LOW TEMP LOOP								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
-47,713	72,546	-	131	$19,598	$2,652,100	$380,600	>50	-$ 1,556,730

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.5.6 MEASURE D06: GROUND SOURCE HEAT LOOP – HIGH TEMPERATURE LOOP

MEASURE ID:	D06
MEASURE NAME:	Ground Source Heat Loop – High Temperature Loop
MEASURE SUMMARY:	Install a ground source heat loop to replace the main heating boilers and electrify the building heating source

Scope of Work

In order to achieve carbon neutral operation, the main heating boilers, pool boilers, and domestic hot water boilers must be electrified.

This measure proposes to install a ground source heating loop sized to carry the operation of the entire building. A conservative estimate of the required borehole field yields a field consisting of 200 holes to a depth of 600 feet. This field fits within the greenspace area north of the building without having to disrupt the parking lot. This estimate would need to be verified by conducting a test drill before proceeding to detailed design.

As part of the electrification process the high temperature water loop would have its temperature reduced from 155 deg F to 130 deg F. This lower heating water temperature 130 def F represents something of a "magic number" for the building for three reasons:

- 130 deg F is the maximum temperature of heat recovery water that can be recovered as superheat from the arena ice plants
- 130 deg F is the minimum temperature that can be used to regenerate the arena's desiccant dehumidifiers
- 130 deg F is the maximum temperature that a heat pump can reasonably lift to from ground water temperature before a sharp drop off in its COP is encountered

This measure includes the resizing of all terminal heating equipment (rads, unit heaters, and cabinet heaters) to ensure they are able to operate at the new heating water temperature, and tying the heat rejection from the arena desuperheaters onto the high temperature loop.

This measure also includes tying the domestic hot water, pool, and whirlpool heating loads onto the low temperature loop with dedicated heat pumps, new low temperature loop distribution piping, and upsizing the pumps on the low temperature loop. The reader is directed to Appendix C – Mechanical Energy Flow Diagram

High lift heat pump technology has recently improved such that this application can be served by heat pumps equipped with centrifugal compressors in lieu of positive displacement compressors. This allows for the heat pump to be added to the facility without negatively impacting its TSSA rating.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$11,000
BAU Annual Operation and Maintenance Cost (Install standard mid efficiency boilers)	$7,500
Annual O&M Cost Beyond Business as Usual Case	$3,500
Equipment Expected Useful Life	25 years

IES Model Input Variables

A water-to-water heat pump was modelled in IES. The heat pump had a constant seasonal COP of 3.0 as linking a water-to-water heat pump to a variable temperature source is not possible.

Figures

Figure D06.1- High Temp Loop Required Bore Hole Area

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D06 GROUND SOURCE HEAT LOOP - HIGH TEMP LOOP								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
-1,452,095	333,134	-	416	$63,276	$9,574,400	$380,600	>50	-$ 6,526,472

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.5.7 MEASURE D07: AHU REPLACEMENT

MEASURE ID:	D07
MEASURE NAME:	AHU Replacement
MEASURE SUMMARY:	Replace the existing air handlers and add them to the low temperature loop

Scope of Work

The facility is served by six main air handlers that provide preheating and cooling of the outdoor air before it is passed onto the ventilation system where the air is further conditioned by the space heat pumps.

Air Handler	Serves	End of Life	Heating Source	Flow (Cfm)	Heating (MBH)	Cooling (Ton)
HRU 1	Arena	Yes	High Temp Loop	18,000	1,000	50
HRU 2	Community Centre	Yes	Natural Gas	18,000	1,000	50
Dectron	Pool	No	High Temp Loop	18,000	525	30
MUA 1	Workout Space	Yes	Natural Gas	1,000*	126	3
ERV 1	Arena change area	No	Natural Gas	3,600	195	11
ERV 2	Arena change area	No	Natural Gas	3,600	195	11

*Estimated

All of these air handlers are equipped with air side heat recovery.

This measure proposes to replace the air handlers in order to electrify the building's heating system and achieve carbon neutral operation. All of the units will be moved from the high temp loop or natural gas heating onto the low temperature loop and will be equipped with self contained heat pumps in order to provide sufficient and cooling heating to the ventilation system.

Moving the units from direct expansion air cooled condensers to heat pumps allows for variable speed operation at a lower speed. The proposed units are able to turn down cooling operation to as little as 10% of full rating, as such this measure and measure D08 AHU VAV Conversion are strongly interdependent.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$12,000
BAU Annual Operation and Maintenance Cost (Install new standard efficiency air handles for HRU1, HRU2, MUA1, retain other air handlers)	$10,500
Annual O&M Cost Beyond Business as Usual Case	$1,500
Equipment Expected Useful Life	25 years

IES Model Input Variables

The heat recovery effectiveness of the AHUs was increased to 85% sensible, and 80% latent effectiveness to model a heat wheel. The AHU heating coils were all set to water-loop heat pumps and coupled to the water-loop heat pump loop.

Parameter	Calibrated Model	ECM Implementation
HRU-1 Sensible Recovery Effectiveness	50%	85%
HRU-1 Latent Recovery Effectiveness	0%	80%
HRU-2 Sensible Recovery Effectiveness	65%	85%
HRU-2 Latent Recovery Effectiveness	60%	80%
HRU-1 Heating Coil	Hot water	Water-loop heat pump
HRU-2 Heating Coil	Natural gas furnace	Water-loop heat pump

Figures

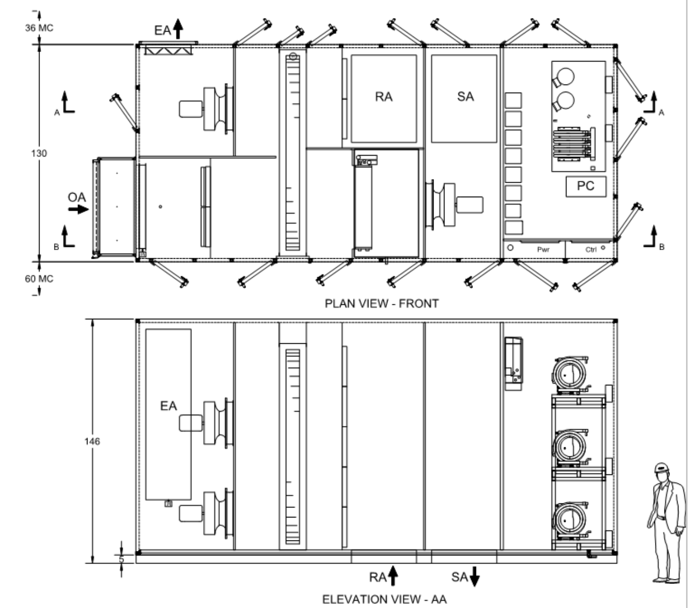


Figure D07.1- HRU-1 Proposed Retrofit Air Handler


Figure D07.2- Existing Air Handler MUA-1

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D07 AHU REPLACEMENT								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
21,233	35,424	-	71	$10,535	$2,494,800	$1,124,200	>50	-$ 999,371

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.5.8 MEASURE D08: AHU VAV CONVERSION

MEASURE ID:	D08
MEASURE NAME:	AHU VAV Conversion
MEASURE SUMMARY:	Install Variable Speed Drives and VAV boxes to reduce the amount of fresh air that must be conditioned by the air handlers

Scope of Work

The existing air handlers, while largely efficient in their operation, are all constant volume units. Their fans run at a constant volume regardless of the air volume required.

This measure proposes to add variable speed drives to all air handlers (save for the Dectron) and reduce air flow based on minimum OA requirements. VAV boxes would also be provided for each space heat pump, with new VAV controllers tied to the C02 sensors described in measure C02 – Demand Control Ventilation.

This measure also has a large interdependency with measure D07 air handler replacement as the existing air handlers are equipped with air cooled condensers and care must be taken to ensure air flow isn't reduced to the point that the coils are at risk of freezing.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$2,500
BAU Annual Operation and Maintenance Cost (Retain existing constant volume operation)	$0
Annual O&M Cost Beyond Business as Usual Case	$2,500
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Minimum flow ratio to zones	1.0	Meet ASHRAE62.1 minimum
Demand control ventilation	None	CO2 sensors

Figures

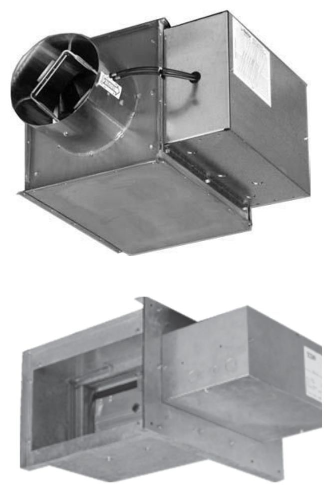


Figure D08.1- VAV Box retrofit Kits

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D08 AHU VAV CONVERSION								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
309,937	41,705	-	126	$18,577	$375,100	$39,335	18.1	$ 243,392

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.5.9 MEASURE D09: HEAT PUMP REPLACEMENT

MEASURE ID:	D09
MEASURE NAME:	Heat Pump Replacement
MEASURE SUMMARY:	Replace the water to air heat pumps on the low temperature loop with newer more efficient ones.

Scope of Work

The building is served by forty one (41) water to air heat pumps on the low temperature loop. These heat pumps provide conditioning to building spaces in either heating or cooling mode.

Heat Pump Quantity	Size (MCA)	Cooling Capacity (kW)	Heating Capacity (kW)
1	0.5	2.6	3.2
1	3.8	2.0	2.4
3	6.6	3.4	4.3
4	7.8	4.0	5.2
2	8.7	11.0	13.1
2	9.5	4.0	5.2
3	10.0	7.9	9.8
2	11.6	17.4	21.6
2	12.0	NA (Snowmelt)	25.0
1	12.5	6.6	7.7
2	12.6	7.7	8.7
2	13.1	4.9	6.6
2	13.6	6.5	7.8
2	13.7	30.8	36.4
1	15.2	9.1	11.0
5	16.5	10.2	11.0
1	19.9	34.4	44.8
1	22.4	43.7	41.1
2	22.9	60.7	72.3
1	25.3	42.0	49.2
1	81.0	80.3	79.3

Many of these heat pumps are nearing the end of their useful life and will need to be replaced soon. At the time of construction the heat pumps were charged with Refrigerant R-22 (Chlorodifluoromethane). R-22 was phased out and as of January 1 2020 is no longer manufactured (though it can be reclaimed and reused) in keeping with the Montreal protocol.

Newer heat pumps use Refrigerant R-413A, an HFC with less ozone depletion potential, but advances in heat pump design since the building was constructed allow for comparable performance to the existing R-22 units for heat pumps of the same size.

This measure proposes that the heat pumps be replaced with new high efficiency heat pumps with larger coils than a normal like for like replacement would entertain.

This measure does not provide an optimal payback given the class A rate structure adopted for the purpose of this study, but it's implementation should be considered in energy retrofit programs where carbon neutral operation is targeted.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$8,000
BAU Annual Operation and Maintenance Cost (Install mid efficient heat pumps)	$8,000
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

The heat pump performance was modified to represent current state-of-the-art by using the performance prescribed in the latest version of ASHRAE90.1 and adding ECM motors to reduce fan power.

Parameter	Calibrated Model	ECM Implementation
Heating COP	3.8	4.5
Cooling COP	3.5	3.8
Fan Power	0.3 W/CFM	0.25 W/CFM
Fan speed control	2-speed	3-speed

Figures

Figure D09.1- High efficiency water source heat pumps in vertical and horizontal configurations

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D09 HEAT PUMP REPLACEMENT								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
68,126	-5,786	-	-1	-$169	$837,100	$751,300	>50	-$ 110,729

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.5.10 MEASURE D10: LOW TEMP LOOP VARIABLE SPEED PUMPING

MEASURE ID:	D10
MEASURE NAME:	Low Temp Loop Variable Speed Pumping
MEASURE SUMMARY:	Install variable speed drives on the low temperature loop pumps, provide control valves at each heat pump.

Scope of Work

This low temperature loop is served by constant speed pumps which operates at full speed 100% of the time. Balancing valves are shown on mechanical drawings so its likely flow to the heat pumps has been balanced.

If a variable speed drive is used with a centrifugal pump, the energy consumed is directly proportional to the cube of pump speed, the pump head is directly proportional to the square of the pump speed and the flow is directly proportional with the pump speed. Therefore, a small reduction in the flow or head obtained by a small reduction in the pump speed results in a much larger reduction of the energy used by the pump. By reducing the pumped flow or head to match the distribution system requirements, significant energy savings can be achieved. Pump speed will vary through a pressure control device so that the water distribution system requirements are always satisfied with the least amount of pumping power

This measure proposes to install variable speed drives on the low temperature loop pumps (pumps 3 & 4, both are 20Hp) so that they can run at a lower speed. The implementation of this measure will also require new pressure independent control valves (PICVs) at each of the heat pumps. Valves and VFDs would be added to the BAS.

This measure does not provide an optimal payback given the class A rate structure adopted for the purpose of this study, but it's implementation should be considered in energy retrofit programs where carbon neutral operation is targeted. This measure should also be considered for implementation if either measure D09 Heat Pump replacement or C02 demand control ventilation are selected for implementation given the proximity of the work in those ECMs to what is proposed in D10.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$2,000
BAU Annual Operation and Maintenance Cost (Retain existing constant flow operation)	$0
Annual O&M Cost Beyond Business as Usual Case	$2,000
Equipment Expected Useful Life	25 years

IES Model Input Variables

The pumps serving the low temperature loop were changed to be variable speed using the default VFD pump curves.

Parameter	Calibrated Model	ECM Implementation
Pump speed control	Constant speed	Variable speed
Pump performance curve	Default pump riding the curve	Default VFD pump curve

Figures

Figure D10.1- PICV with actuator

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D10 LOW TEMP LOOP VARIABLE SPEED PUMPING								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
21,819	-2,026	-	-1	-$103	$174,900	$2,182	0	-$ 182,462

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.5.11 MEASURE D11: WASTE WATER HEAT RECOVERY – HIGH TEMP LOOP

MEASURE ID:	D11
MEASURE NAME:	Waste Water Heat Recovery – High Temp Loop
MEASURE SUMMARY:	Install a waste water source heat loop to replace the main heating boilers and electrify the building heating source

Scope of Work

This measure is similar to measure D06 in that it proposes to electrify the buildings heating system, however instead of a ground source geothermal heat pump the heat source would be a waste water sewer trunk. A Region of Peel sewer trunk large enough to serve as a heat source/sink exists ~350m North West of the building. Discussions with the Region of Peel indicate that the flow in this trunk is adequate to act as an adequate heat source/sink.

The system has four main components:

1. Sewer: system is independent of sewer shape and size. Even small flow rates are handled without problems due to the gravity system and intake near the sewer bottom.
2. Wet Well – Shaft with Screen: The shaft is located directly at the sewer and has two functions. It serves as a sump for the pump feeding the heat exchanger and houses the pumping station screen. This type of screen has been specially developed for this application and is well-proven to ensure pre-screening of the wastewater to protect the heat exchanger against coarse material. A vertical screw conveyor with brushes transports the separated solids upwards and at its top discharges them to the sewer.
3. Heat Exchanger: The Heat Exchanger is selected especially for wastewater applications. The tank is completely made of stainless steel and is odour-tight, and therefore can be installed even in residential areas. A self-cleaning mechanism and sediments removal screw inside ensure continuous system operation with low maintenance requirements.
4. Heat Pump: Similar in capacity to measure D06, but as waste water is at a constant temperature, and higher than ground water the heat pump in this system can operate at a higher COP.

This measure also includes the requisite actions to lower the building heating loop to 130F, and electrify the heating system.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$14,000
BAU Annual Operation and Maintenance Cost (Install standard mid efficiency boilers)	$7,500
Annual O&M Cost Beyond Business as Usual Case	$6,500
Equipment Expected Useful Life	25 years

IES Model Input Variables

A water-to-water heat pump was modelled in IES. The heat pump had a constant seasonal COP of 3.5 as linking a water-to-water heat pump to a variable temperature source is not possible. The low temperature was loop was modelled as having a constant source temperature of 20°C to simulate the relatively constant temperatures attainable from this system.

Parameter	Calibrated Model	ECM Implementation
Heating COP	None	3.5
Water-source temperature	None	20°C

Figures

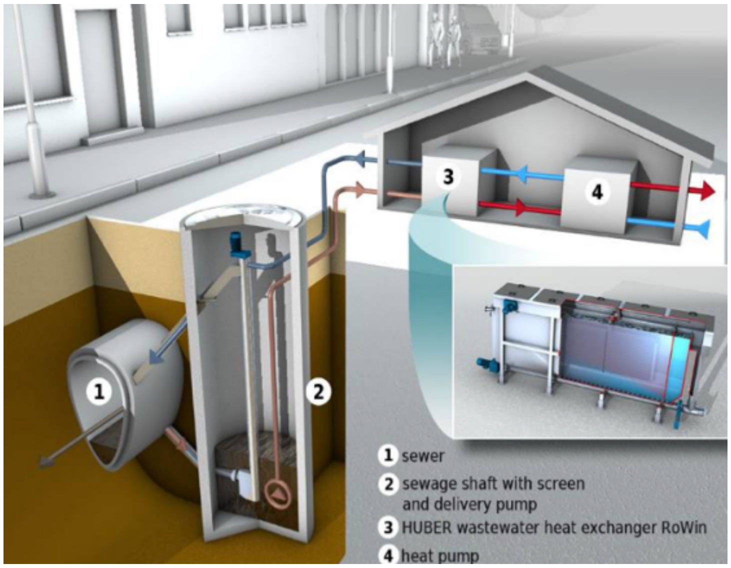


Figure D11.1- Principle of operation for a waste water source heat pump


Figure D11.2- Waste Water Source Heat Pump

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D11 WASTE WATER HR - HIGH TEMP LOOP								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
-1,404,963	333,134	-	423	$64,298	$9,243,300	$380,600	>50	-$6,171,866

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.5.12 MEASURE D12: DISTRICT ENERGY INTEGRATION

MEASURE ID:	D12
MEASURE NAME:	District Energy Integration
MEASURE SUMMARY:	Integrate the building's heating system with a new district energy system served by the Sheridan College central plant.

Scope of Work

Sheridan College Davis Campus occupies the adjacent plot north of the facility. The College is equipped with a central plant system that provides heat (and other utilities) to the various buildings/wings of the College.

The College is amenable to expanding the distribution system of the central plan to serve the Sportsplex as a client facility. This would provide the Sportsplex the opportunity to benefit from the economics of scale associated with running a larger heating plant that are not necessarily feasible at a smaller, stand-alone facility. The College's central plant utilizes natural gas fired combined heat and power (CHP) units that operate at a considerably higher efficiency relative the existing boilers at the Sportsplex.

In order to integrate with the Sheridan distribution system piping would need to be run between the College and the Sportsplex and a heat transfer station installed within the Sportsplex. For the purposes of this report it is assumed that the City would be required to assume the cost of construction for the heat transfer station, and piping to the property line between the College and the Sportsplex. It is also assumed that the cost of energy from the system would be set to reflect 90% of the current heating cost to operate the heating boilers and DHW boiler.

Two of the existing three heating boilers would be demolished to provide room for the heat transfer station, one boiler would be retained for redundancy in the event the district energy system was not available. The DHW boiler would also remain but as a redundant asset.

This ECM is applicable to Energy Retrofit Programs targeting 50% carbon reduction, but is not suitable for more ambitious carbon reduction goals as the primary heat source for the building remains carbon intensive natural gas, even if used more efficiently.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$1,000
BAU Annual Operation and Maintenance Cost (Install standard mid efficiency boilers)	$7,500
Annual O&M Cost Beyond Business as Usual Case	($6,500)
Equipment Expected Useful Life	25 years

IES Model Input Variables

This ECM was not modelled in IES as it does not represent a change in building operation. IES was used to quantify the amount of energy used in the heating and DHW boilers to determine the cost savings available from switching to district energy.

Figures

Figure D12.1- Example of District Heating Substation

Figure D12.2- Extent of new buried district energy piping

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

D12 DISTRICT ENERGY INTEGRATION							
ANNUAL SAVINGS				TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
166,517	-	317	$47,357	$760,100	$380,600	8.0	$ 1,315,752

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.6 MEASURE DESCRIPTION GROUP E – REFRIGERATION

5.6.1 MEASURE E01: CHILLER REPLACEMENT W HR - AMMONIA PLATE AND FRAME

MEASURE ID:	E01
MEASURE NAME:	Chiller Replacement w HR - Ammonia Plate and Frame
MEASURE SUMMARY:	Replace the existing built up ice plants with new packaged Ammonia Plate and Frame equivalent

Scope of Work

This measure proposes to replace the existing built up ammonia plants (2 x 150 ton) with new packaged ammonia plate and frame chillers. The new chiller plants represent a significant increase in energy consumption performance (COP of 2.82 as compared to the existing plant which has an estimated COP of 2.00)

The availability of heat recovery from the new packaged plant is comparable to what is available now.

A general scope of work for this ECM would be as follows:

- Pump out all Ammonia for disposal
- Pump out all cold floor and warm floor glycol and stored for reuse.
- Removal and demolition of two Ammonia refrigeration rooms
- Supply & install 2 x 150 ton Refrigeration Package. Each package to contain;
  - 2 x Screw Compressors
  - 1 x Plate & Frame Chiller c/w Surge Drum
  - 1 x Plate & Frame Condenser
  - 1 x Plate & Frame Glycol to Water Heat Exchanger
  - 1 x Shell & Tube Underfloor Heat Exchanger
  - 2 x Cold Floor Glycol Pump
  - 1 x Warm Floor Glycol Pump
  - 1 x Condenser Glycol Pump
  - 1 x Shell & Tube Oil Cooler
  - 1 x Oil Separator
  - 1 x Starter Panel

- Supply & install 2 x Cooling Towers
- Supply & install 2 x Cooling Tower Water Pumps
- Supply & install 2 x Cooling Tower Tanks
- Supply & install 2 x SMART Hub DDC Controller
- Supply & install 2 x Cold Glycol Expansion Tank
- Supply & install 2 x Warm Glycol Expansion Tank
- Supply & install 2 x Water Treatment System
- All necessary power & control wiring between starter panel to refrigeration equipment
- All necessary insulation for refrigeration related piping within the refrigeration room
- Supply and charge new system with Ammonia

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$75,000
BAU Annual Operation and Maintenance Cost (This ECM represents BAU case)	$75,000
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Chiller plant COP	2.4	3.07
Maximum heat recovery available	None	90%
Heat recovery recipient	None	High temperature loop

Figures

Figure E01.1 – Packaged Ammonia ice plant

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

E01 CHILLER REPLACEMENT W HR - AMMONIA PLATE AND FRAME									
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]					
321,532	72,173	-	186	$27,494	$3,447,400	$3,447,400	$46,588	0	$ 941,712

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.6.2 MEASURE E02A: CHILLER REPLACEMENT W HR - C02 PLATE AND FRAME – INDIRECT SLAD COOLING

MEASURE ID:	E02A
MEASURE NAME:	Chiller Replacement w HR - C02 Plate and Frame – Indirect Slab Cooling
MEASURE SUMMARY:	Replace the existing built up ice plants with new packaged C02 Plate and Frame equivalent

Scope of Work

This measure proposes to replace the existing built up ammonia plants (2 x 150 ton) with new packaged carbon dioxide plate and frame chillers.

Carbon dioxide poses a similar threat compared to ammonia refrigerant in the event of a leak. It is odourless which can make leaks more difficult to detect, but a properly functioning monitoring system manages this risk. Carbon dioxide is also non-flammable while ammonia is slightly flammable.

ASHRAE categorizes Ammonia as a class B2L safety group refrigerant (lower flammability, higher toxicity) whereas Carbon Dioxide is categorized a class A1 safety group refrigerant (No flame propagation, lower toxicity). The A1 designation is the lowest risk designation assigned to refrigerants by ASHRAE.

A conversion to carbon dioxide plants would not meaningfully alter the TSSA registration of the plants. Attending operator requirements would be unchanged with a class B operator required 8hrs/day of operation.

This ECM retains the existing brine headers below the arena slabs. A more pronounced increase in efficiency is attained when the carbon dioxide refrigerant is piped directly beneath the arena slabs, but this requires new piping and a requisite replacement of the slabs. This is considered in ECM E02B.

The new chiller plants represent a significant increase in energy consumption performance (COP of 2.67 as compared to the existing plant which has an estimated COP of 2.00)

The availability of heat recovery from the new packaged plant is significantly augmented. A considerably amount of heat is available at a higher grade that can be used for building heating applications.

A general scope of work for this ECM would be as follows

- Pump out all Ammonia for disposal
- Pump out all cold floor and warm floor glycol and stored for reuse.
- Removal and demolition of two Ammonia refrigeration rooms
- Supply & install 2 x 150 ton Refrigeration Package. Each package to contain;
    - 10 x Semi-Hermetic Compressors

- 1 x Plate & Frame Chiller c/w Surge Drum
- 1 x Plate & Frame Condenser
- 1 x Plate & Frame Glycol to Water Heat Exchanger
- 1 x Shell & Tube Underfloor Heat Exchanger
- 2 x Cold Floor Glycol Pump
- 1 x Warm Floor Glycol Pump
- 1 x Condenser Glycol Pump
- 1 x Shell & Tube Oil Cooler
- 1 x Oil Separator
- 1 x Starter Panel

- Supply & install 2 x Cooling Towers
- Supply & install 2 x Cooling Tower Water Pumps
- Supply & install 2 x Cooling Tower Tanks
- Supply & install 2 x SMART Hub DDC Controller
- Supply & install 2 x Cold Glycol Expansion Tank
- Supply & install 2 x Warm Glycol Expansion Tank
- Supply & install 2 x Water Treatment System
- All necessary power & control wiring between starter panel to refrigeration equipment
- All necessary insulation for refrigeration related piping within the refrigeration room
- Supply and charge new system with CO2

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$75,000
BAU Annual Operation and Maintenance Cost (Implement ECM E01)	$75,000
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Chiller plant COP	2.4	2.92
Maximum heat recovery available	None	80%
Heat recovery recipient	None	High and low temperature loops

Figures

Figure E01.1 – Packaged Carbon Dioxide ice plant

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

E02A CHILLER REPLACEMENT W HR - C02 - INDIRECT SLAB COOLING									
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]					
268,379	161,895	-	348	$51,859	$3,610,200	$3,447,400	$59,217	2.0	$ 1,678,462

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.6.3 MEASURE E02B: CHILLER REPLACEMENT W HR - C02 PLATE AND FRAME – DIRECT SLAB COOLING

MEASURE ID:	E02B
MEASURE NAME:	Chiller Replacement w HR - C02 Plate and Frame – Direct Slab Cooling
MEASURE SUMMARY:	Replace the existing built up ice plants with new packaged C02 Plate and Frame equivalent, replace in-slab piping.

Scope of Work

This measure is essentially the same as measure E02B, however the scope of work is expanded to include the replacement of the brine headers under the arena slabs with direct refrigerant piping. This allows for an increase in the energy efficiency of the chillers, but requires a full replacement of the arena slabs as well.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$75,000
BAU Annual Operation and Maintenance Cost (Implement ECM E01)	$75,000
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Chiller plant COP	2.4	3.56
Maximum heat recovery available	None	80%
Heat recovery recipient	None	High and low temperature loops

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

E02B CHILLER REPLACEMENT W HR - C02 - DIRECT SLAB COOLING								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
482,863	155,927	-	369	$54,809	$7,984,900	$3,447,400	>50	-$ 2,709,245

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.6.4 MEASURE E03: COLD WATER FLOODING

MEASURE ID:	E03
MEASURE NAME:	Cold Water Flooding
MEASURE SUMMARY:	Install an air separating system to allow for ice resurfacing to be completed with cold water.

Scope of Work

Ice resurfacing, also referred to as flooding, is a very energy intensive process. Resurfacing the ice consists of pouring a thin film of water over the entire surface of the rink. The most common method of doing this is using hot water (between 130-140F) to ensure proper bonding exists within the ice, which mitigates cracking. Hot water is produced through the by gas tank heaters in the Zamboni room where the machines are filled. Once the water has been added to the ice pad it represents a significant load for the chiller plant to freeze it.

This Measure recommends the addition of a de-aerator cold-water treatment device for the Ice Resurfacing refill water. The device is typically wall mounted and located in the Zamboni room, or adjacent space. With the use of cold-water flooding not only will there be a major decrease in heating load coming from domestic hot water production, but there will also be a reduction seen on the cooling load from the ice plant.

The use of untreated cold water resurfacing can cause major issues such as brittle or soft ice susceptible to cracking. This technology is able to treat cold water by removing micro-air bubbles inherent in the liquid, resulting in a purer form with enhanced bonding properties that can properly and safely be used by staff to resurface the sheets of ice.

This ECM has already been partially implemented and has been piloted on two of the four ice pads with no reported issues.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$0
BAU Annual Operation and Maintenance Cost (Do not install air separator)	$0
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

The energy to warm water to flooding temperature was reduced in the model for each flood as well as the energy added by the flood water to the ice sheet at each flood.

Parameter	Calibrated Model	ECM Implementation
Flooding Heating Load – Rinks 1 & 2	46 kWh/flood	9.2 kWh/flood
Flooding Cooling Load – Rinks 1 & 2	130 kWh/flood	90 kWh/flood

Figures

Figure E03.1 – Detailed View of Air Separation Device

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

E03 COLD WATER FLOODING								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
106,361	8,528	-	32	$4,730	$108,900	$10,636	20.8	$ 41,602

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.6.5 MEASURE E04: ICE RESURFACER REPLACEMENT

MEASURE ID:	E04
MEASURE NAME:	Ice Resurfacer Replacement
MEASURE SUMMARY:	Replacement of fossil fuel powered ice resurfacers with electric models equipped with Laser Ice Levelling Systems

Scope of Work

The four (4) rinks in South Fletcher's Sportsplex are currently served by two (2) Olympia Millennium H model fossil fuel powered Ice Resurfacers. This Measure recommends the replacement of these with two new Olympia Millennium E electric models equipped with a Laser Ice Levelling System in order to achieve carbon neutral operation.

Laser Ice Levelling technology uses a laser to detect ice to a point within 0.5 mm and automatically control the cutting of the blade to cut ice with precision. Ice can therefore be maintained at a reduced, and consistent ice thickness.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Laser Ice Leveling reduces the wear and tear of the Ice Resurfacer machine and extends the blade life. The reduced ice thickness reduces the amount of flood water used, reduced runtime on the compressor plant, and reduced overall maintenance time.

While initial operator training is required, operator error is reduced and ice resurfacing time reduced by 5%. Edging can be reduced to twice a week.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$1,200
BAU Annual Operation and Maintenance Cost (Retain Existing Resurfacers)	$1,500
Annual O&M Cost Beyond Business as Usual Case	($300)
Equipment Expected Useful Life	15 years

IES Model Input Variables

Savings for this ECM were not calculated using IES-VE, a manual calculation method was used.

$$\textbf{\textit{Energy Savings}} = (\text{Energy Consumed by Fossil Fuel Ice Resurfacer}) - (\text{Energy Consumed by Electric Ice Resurfacer}) - (\text{Reduced Operation from Laser Level Ice System})$$

$$= \left(\left(15.5\ {}^{lb\ Natural\ Gas}/_{hr} \cdot\ 0.6542\ \text{m}^{m^3}/_{lb\ Natural\ Gas} \cdot 3102.5\ {}^{hr}/_{yr} \cdot 10.33\ {}^{kWh}/_{m^3}\right) - \left(\ 16\ \text{kW Operating Pow}\right.\right.$$

$$= 278{,}000\ ekWh/yr$$

Assumptions

1. Runtime hours: 3102.5 hr/yr
2. 5% Reduction in operating time

Figures

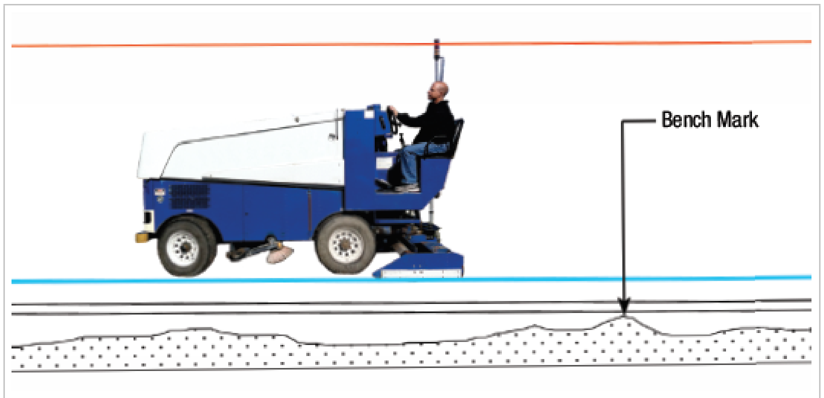


Figure E04.1 – Laser Level Ice Technology

Figure E04.2 – Example of Laser Mount

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

E04 ICE RESURFACER REPLACEMENT								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	WATER [m³]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
11,654	118	277	2	$1,009	$183,000	$1,165	>50	-$ 158,187

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.6.6 MEASURE E05: RADIANT HEATING CONVERSION

MEASURE ID:	E05
MEASURE NAME:	Radiant Heating Conversion
MEASURE SUMMARY:	Replace the radiant stand heaters with electric equivalents

Scope of Work

There are twenty (20) heaters serving the rinks to provide in stand heating. The heaters are radiant type, they heat the objects directly as opposed to the air, and run at a high temperature that precludes them from being fed by even the 155 deg F high temperature loop.

In order to decarbonize these heaters this measure proposes to replace them with electric equivalents. It should be noted that while these heaters are used sparingly, they are extremely energy intensive, and their conversion require a considerable amount of electric distribution equipment. The new heaters would use consume some 200kW, or approximately ~25% of the power that the entire building does currently. The existing distribution system can handle this additional load, but it cannot accommodate this ECM and other electrically intensive one with additional electrical work.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$500
BAU Annual Operation and Maintenance Cost (Retain Existing Gas Fired Stand Heaters)	$500
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Radiant heater fuel type	Natural gas	Electricity
Radiant heating efficiency	80%	100%

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

E05 RADIANT HEATING CONVERSION							
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]			
-297,793	35,810	-	23	$3,731	$172,700	46.3	$ 43,353

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.7 MEASURE DESCRIPTION GROUP F – POOL

5.7.1 MEASURE F01: POOL AND WHIRLPOOL VFD

MEASURE ID:	F01
MEASURE NAME:	Pool and Whirlpool VFD
MEASURE SUMMARY:	Install variable speed drives on the main pool and whirlpool circulating pumps.

Scope of Work

The pool and whirlpool circulation pumps, 10Hp and 7.5Hp respectively, are currently left to run at a full capacity at all times and flow is controlled by manually adjusted throttling valves.

The installation of variable speed drives on these pumps will allow for energy cost savings in lieu of wasteful throttling and provides the opportunity for them to set back to a reduced flow rate during unoccupied hours while still maintaining the requirements of the chemical treatment system.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$0
BAU Annual Operation and Maintenance Cost (Do not install VFDs)	$0
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Pump Throttling	30%	None, VFD control

Figures

Figure F01.1 – Pool Pump

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

F01 POOL AND WHIRLPOOL VFD							
ANNUAL SAVINGS				TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
40,000	-	6	$867	$41,800	$4,000	43.6	-$ 17,851

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.7.2 MEASURE F02: POOL TEMPERATURE SETBACK

MEASURE ID:	F02
MEASURE NAME:	Pool Temperature Setback
MEASURE SUMMARY:	Reduce Pool Temperature Setpoint During Unoccupied Hours

Scope of Work

The pool is currently maintained at a constant temperature of 86 deg F. During unoccupied periods this setpoint can be reduced to lower the requirement of the pool heating plant. It is proposed to reduce the setpoint as low as 75 deg F, though the thermal mass of the water will likely preclude it from ever cooling to this temperature. To ensure that the pool is brought back up to setpoint by the time it reopens the BAS will be programmed with an optimum start/stop algorithm. In addition to pool temperature the air temperature in the pool area will be reset to match the pool setback.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$0
BAU Annual Operation and Maintenance Cost (Do not modify existing sequence)	$0
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

The pool setback was included in the energy model by changing the set-point of the controller that controls pool temperature and including a setback. A setback of the air temperature in the pool area was included as well to match both the timing and setback of the water temperature.

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

F02 POOL TEMPERATURE SETBACK							
ANNUAL SAVINGS				TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
NATURAL GAS [m^3]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
4,000	-	8	$1,138	$8,800	$800	7.0	$ 32,723

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.8 MEASURE DESCRIPTION GROUP G – BUILDING ENVELOPE UPGRADES

5.8.1 MEASURE G01: HIGH PERFORMANCE GLAZING

MEASURE ID:	G01
MEASURE NAME:	High Performance Glazing
MEASURE SUMMARY:	Replace existing windows with new high performance glazing.

Scope of Work

The existing facility windows are aluminum double framed glazing with a low E coating. This measure proposes to replace them with triple glazed, low e coating argon filled windows supplied with thermally broken frames and warm edge spacers to minimize energy loses through the glazing.

Room	Rough Opening Area (m2)	Location	Note
L1 - Library - p	7.20	North West	
L1 - Library - p	7.20	North West	
L1 - Vestibule	4.37	West	Glass Doors
L1 - Vestibule	6.19	West	
L1 - Vestibule	1.31	West	
L1 - Vestibule	6.88	West	
L1 - Community Room	2.16	West	
L1 - Community Room	2.16	West	
L1 - Community Room	2.16	West	
L1 - Community Room	2.16	West	
L1 - Community Room	2.16	West	
L1 - Vestibule	4.37	West	Glass Door
L1 - Vestibule	2.81	West	
L1 - Vestibule	3.60	West	
L1 - Vestibule	3.09	West	
L1 - Vestibule	6.12	West	
L1 - Vestibule	3.75	East	Glass Door
L1 - Vestibule	3.51	East	
L1 - Vestibule	0.75	East	
L1 - Vestibule	4.76	East	
L1 - Vestibule	4.90	East	

Room	Rough Opening Area (m2)	Location	Note
L1 - Library - p	7.20	West	
L1 - Library - p	7.20	West	
L1 - Library - p	2.16	West	
L1 - Library - p	2.16	West	
L1 - Pool and Deck	7.20	East	
L1 - Pool and Deck	7.20	East	
L1 - Pool and Deck	7.20	East	
L1 - Pool and Deck	6.02	East	
L1 - Pool and Deck	7.20	East	
L1 - Pool and Deck	7.20	East	
L1 - Pool and Deck	7.20	East	
L1 - Lunch Room	7.20	West	
L1 - Lunch Room	7.20	West	
L1 - Lobby	14.65	Clerestory	All one big opening
L1 - Lobby	0.57	Clerestory	
L1 - Lobby	8.11	Clerestory	
L1 - Lobby	7.03	Clerestory	
L1 - Lobby	4.64	Clerestory	
L1 - Lobby	9.20	Clerestory	
L1 - Lobby	27.47	Clerestory	
L1 - Fitness	7.20	North	
L1 - Fitness	7.20	North	
L1 - Fitness	7.20	North	
L1 - Fitness	7.20	North	
L1 - Fitness	7.20	North	

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$9,500
BAU Annual Operation and Maintenance Cost (Retain existing windows)	$9,500
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	35 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
External glazing U-value	3.18 W/m²K	1.7 W/m²K

Figures

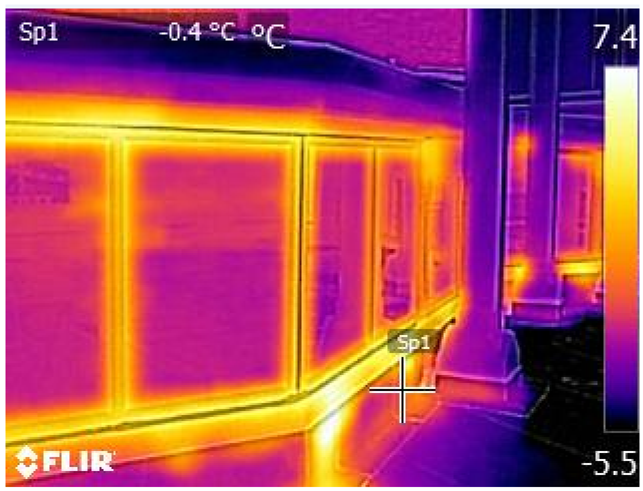


Figure G01.1– Thermal Imagine of existing windows indicating thermal bridging

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

G01 HIGH PERFORMANCE GLAZING								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
4,583	3,241	-	7	$1,021	$464,200	$1,107	453.5	-$ 427,812

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.8.2 MEASURE G02: ROOF INSULATION – PHASE I

MEASURE ID:	G02
MEASURE NAME:	Roof Insulation – Phase I
MEASURE SUMMARY:	Install additional insulation on the roof of the arena section of the building

Scope of Work

The sloped arena roof consist of standing seam metal roof on 75mm of fibreglass insulation on vinyl sheeting air/vapour barrier above a metal deck supported by steel purlins.

This measure proposes to install and additional 75mm of fibreglass insulation.

Counterintuitively this results in the building consuming additional electricity, though it does save natural gas. This is due to the heat being trapped in the arenas which must be removed by the chiller plants.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$1,000
BAU Annual Operation and Maintenance Cost (Retain existing roof)	$1,000
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Phase 1 Roof U-value	0.261W/m^{2}K	0.19 W/m^{2}K

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below. The increase in electricity consumption is due to increased refrigeration energy required in the winter. The better insulation traps more heat in the arena which must be cooled via the refrigeration plant.

G02 ROOF INSULATION - PHASE I								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
-1,608	2,032	-	4	$543	$2,911,700	$406	>50	-$ 2,891,408

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.8.3 MEASURE G03: ROOF INSULATION – PHASE II

MEASURE ID:	G03
MEASURE NAME:	Roof Insulation – Phase II
MEASURE SUMMARY:	Install additional insulation on the roof of the community centre section of the building

Scope of Work

The flat roof area consists of rounded gravel ballast on four ply built up roofing on a 13mm fibreboard on 75mm rigid insulation supported by a metal deck.

This measure proposes to install and additional 75mm of fibreglass insulation.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$1,000
BAU Annual Operation and Maintenance Cost (Retain existing roof)	$1,000
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	25 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Phase 2 Roof U-value	0.311W/m^{2}K	0.19 W/m^{2}K

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

G03 ROOF INSULATION - PHASE II								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
10,861	5,651	-	12	$1,843	$3,041,500	$2,216	>50	-$ 2,976,336

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.8.4 MEASURE G04: EXTERIOR WALL INSULATION – PHASE I

MEASURE ID:	G04
MEASURE NAME:	Exterior Wall Insulation – Phase I
MEASURE SUMMARY:	Provide a recladding of the exterior walls of the arena

Scope of Work

The upper portion of the area wall is constructed of insulated metal panels on steel with 75mm of insulation. The lower portion of the wall is constructed of brick on 75mm of insulation on light weight masonry block. This is the case for all four arenas.

This measure proposes to re-clad these constructions including a layer of R-35 mineral wool.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$0
BAU Annual Operation and Maintenance Cost (Retain existing cladding)	$0
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	50 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Phase 1 Wall – Brick	1.59 W/m²K	0.25 W/m²K
Phase 1 Wall – Metal Panel	2.06 W/m²K	0.25 W/m²K

Figures

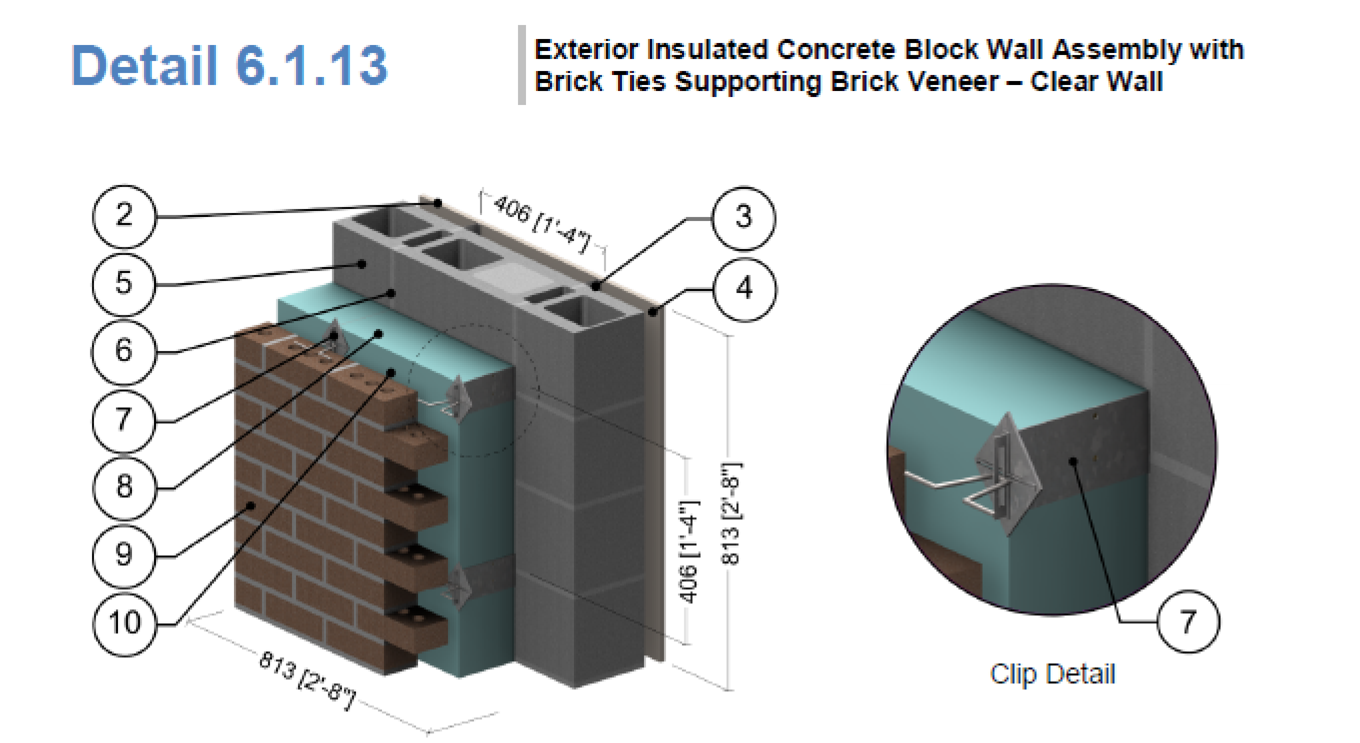


Figure G03.1: Proposed Construction Lower Arena Wall

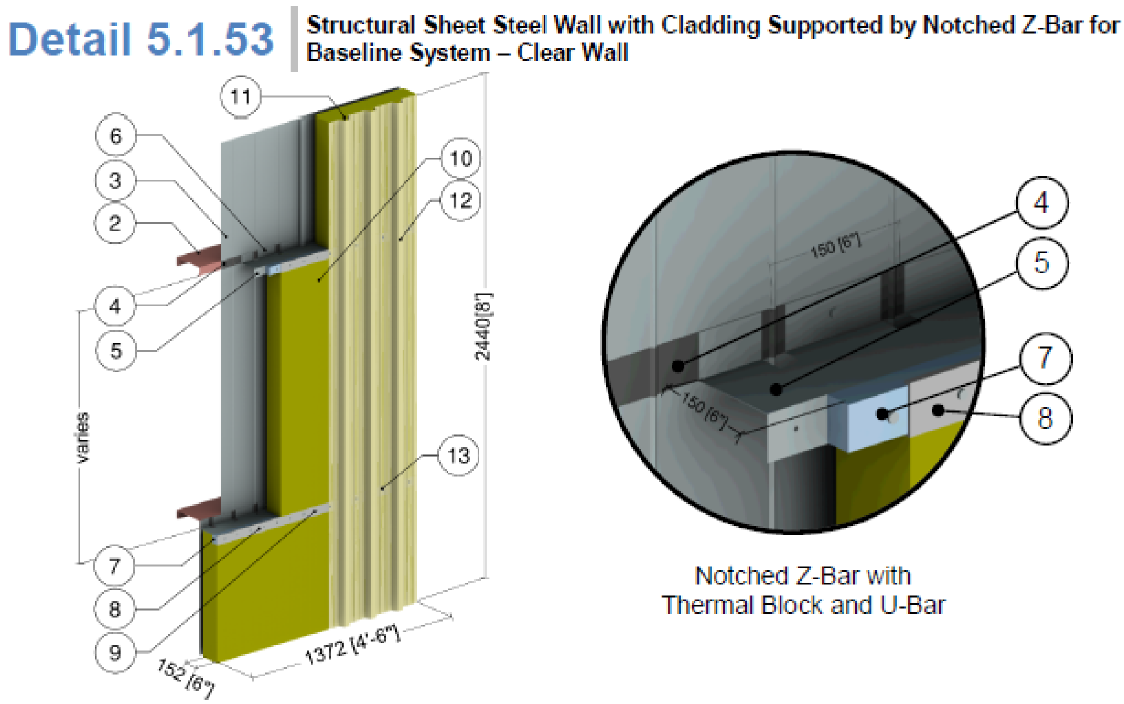


Figure G03.2: Proposed Construction Upper Arena Wall

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

G04 EXTERIOR WALL INSULATION - PHASE I								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
11,722	20,453	-	41	$6,071	$1,809,500	$5,263	>50	-$ 1,590,166

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.8.5 MEASURE G05: EXTERIOR WALL INSULATION – PHASE II

MEASURE ID:	G05
MEASURE NAME:	Exterior Wall Insulation – Phase II
MEASURE SUMMARY:	Provide a recladding of the exterior walls of the community centre

Scope of Work

The exposed portion of the community centre wall (portions of wall viewable from the ground) is constructed brick on 50 mm of insulation on light weight masonry block. The concealed portions of the wall is constructed of metal panels on 50mm of insulation on light weight masonry block.

This measure proposes to re-clad these constructions including a layer of R-30 mineral wool.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$0
BAU Annual Operation and Maintenance Cost (Retain existing cladding)	$0
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	50 years

5 ENERGY CONSERVATION MEASURES

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Phase 2 Wall – Brick	1.27 W/m²K	0.25 W/m²K
Phase 1 Wall – Metal Panel	1.18 W/m²K	0.25 W/m²K

Figures

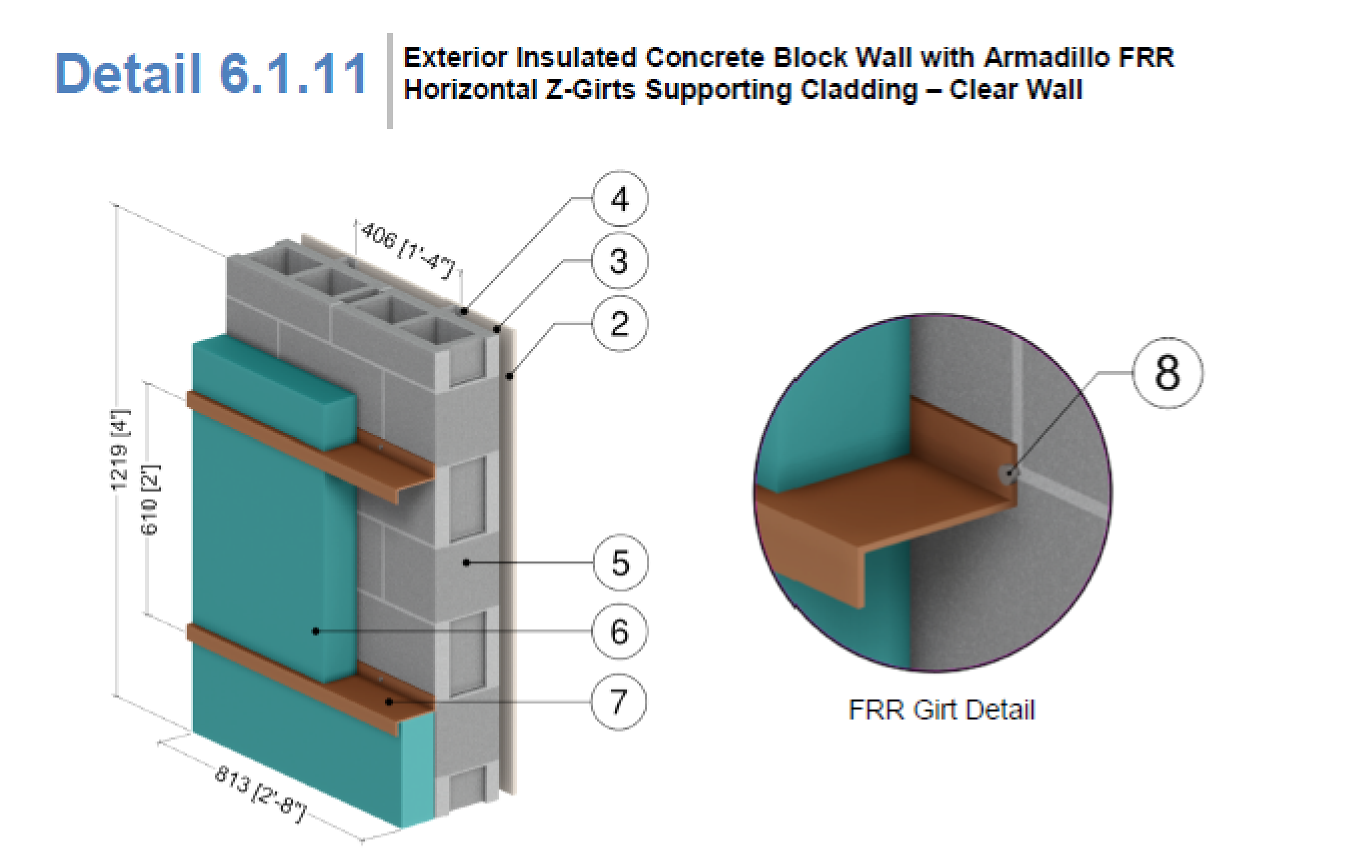


Figure G04.1: Proposed Construction – Concealed Wall Section

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

G05 EXTERIOR WALL INSULATION - PHASE II								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
76,736	51,667	-	110	$16,357	$1,006,500	$18,007	>50	-$ 424,219

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.8.6 MEASURE G06: INTERIOR WINDOW REPLACEMENT

MEASURE ID:	G06
MEASURE NAME:	Interior Window Replacement
MEASURE SUMMARY:	Replace single pane windows partitioning the arena from the rest of the building

Scope of Work

There are several areas on the second floor of the facility that allow occupants to view rinks 1 & 2 from conditioned spaces. These two areas are partitioned by single pane windows that allow migration of heat between the two spaces.

This measure proposes to replace these windows with new double pane windows.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$1,000
BAU Annual Operation and Maintenance Cost (Retain existing windows)	$0
Annual O&M Cost Beyond Business as Usual Case	$1,000
Equipment Expected Useful Life	35 years

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Interior Arena Window U-value	5.8 W/m²K	2.56 W/m²K

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

G06 INTERIOR WINDOW REPLACEMENT								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
2,312	304	-	1	$137	$344,300	-	>50	-$ 340,052

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.9 MEASURE DESCRIPTION GROUP H – DOMESTIC WATER CONSERVATION

5.9.1 MEASURE H01: DOMESTIC WATER RETROFITS

MEASURE ID:	H01
MEASURE NAME:	Domestic Water Retrofits
MEASURE SUMMARY:	Install low flow domestic water fixtures to replace high flow fixtures

Scope of Work

It is proposed to replace all mid flow domestic water fixtures with new, low flow counterparts.

Existing **tank type** and **flush valve toilets** with flow rates of 6 LpF or higher in woman's and gender neutral washrooms will be retrofitted with dual flush models with an effective flow rate of 4.8 LpF.

Flush valve urinals with flow rates of 3.8 LpF will be retrofitted with new 1.9 LpF flush valves.

All mid flow washroom **faucet aerators** will be retrofitted with 1.9 LpM aerators, and 8.3 LpM aerators will remain in areas where receptacle filling occurs frequently. Any kitchen or general areas with missing aerators will have an 8.3 LpM aerators installed.

Mid flow **showerheads** will be retrofitted with 5.7 LpM shower heads equipped with pressure resetting flow adjustment. Occupants may adjust the flow higher once the shower has been activated, but it will reset itself to 5.7 LpM flow once the shower is deactivated. This ensures that water conservation is balanced against occupant comfort.

Summaries of the existing fixtures and the proposed retrofits are as follows:

Existing Fixtures	Count
Faucet Aerator - 1.9 Lpm	31
Faucet Aerator- 5.7 Lpm	4
Faucet Aerator- 8.3 Lpm	14
Flush Valve Toilets Wall - 6Lpf	18
Flush Valve Toilets Floor - 6Lpf	27
Flush Valve Toilets Floor - 13Lpf	11
Flush Valve Urinal Wall - 3.8 Lpf	14
Shower - 7.6 Lpm	18
Shower - 9.5 Lpm	54

Retrofit Fixtures	Count
Faucet Aerator - 1.9 Lpm	10
Flush Valve Toilets Wall (Dual) (3.5,6 lpf)	18
Flush Valve Toilets Floor (Dual) (3.5,6 lpf)	38
Flush Valve Urinal - 1.9Lpf	14
Showerhead 5.7 Lpm	72

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$2,000
BAU Annual Operation and Maintenance Cost (This ECM represents the BAU Case)	$2,000
Annual O&M Cost Beyond Business as Usual Case	$0
Equipment Expected Useful Life	10 years

IES Model Input Variables

Domestic Water savings not modelled in IES-VE. A domestic water model spreadsheet was used to determine savings for this ECM. Water savings are based on the difference between the average flow rate of a building's existing fixtures and the average flow rate for the building's fixtures post retrofit.

Assumptions:

- Domestic hot water usage is roughly equal to 1/3 total domestic water use
- Female visitors use the washroom once every 3 hours
- Male visitors use the washroom once every 4 hours
- Bathroom sink use fraction 0.75

Calculations:

$$Savings = \frac{Occ \times Hrs \times Use \times FF \times (FLOW_{PRE} - FLOW_{POST}) \times Time \times 365\frac{days}{year}}{1000\ L/m^3}$$

Where:
FlowPRE = Average Pre-Retrofit flow rate in L/use
FlowPOST = Average Post-Retrofit flow rate in L/use
Occ = Average number of daily building occupants
Hrs = Average time each occupant spends in the building
Use = Average number of uses per hour
FF = Fixture Fraction (% of fixture type in given Zone)
Time = Amount of time fixture is used for (T=1 for toilets & urinals)

For faucets and showers, additional heating savings will result from the reduction of hot water use.

$$Savings = \frac{Water\ Savings \times HW_{\%} \times \rho \times C_p \times (T_2 - T_1)}{AFUE}$$

Where:
Water Savings = Volume of DW saved
HW% = % of water that is warmed
ρ = Water density (kg/m^3)
Cp = Specific heat capacity of water (kJ/(kg K))
T2 = Domestic Mixed Water Temp (K)
T1 = Domestic Cold Water Temp (K)

Refer to **Appendix H: Domestic Water Models**

Figures

Figure H01.1 – Example of Tamper Proof Low Flow Aerator

Figure H01.2 – Example of 6 Lpf manual flush valve.

Cost & Savings Summary

A summary for this improvement is outlined below.

H01 DOMESTIC WATER RETROFITS							
ANNUAL SAVINGS				TOTAL MEASURE COST [$]	CAPITAL CONTRIBUTIONS [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]
NATURAL GAS [m³]	WATER [m³]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
12,866	5,126	24	$17,034	$111,100	$111,100	0	$197,216

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.10 MEASURE DESCRIPTION GROUP I – RENEWABLE ENERGY

5.10.1 MEASURE I01A: SOLAR PV – ROOF – 1.18 MW ARRAY

MEASURE ID:	I01A
MEASURE NAME:	Solar PV – Roof – 1.18MW array
MEASURE SUMMARY:	Installation of a 1.18 MW roof mounted Photo Voltaic (PV) Solar Array to generate renewable electricity.

Scope of Work

Installation of a total of a 1.18 MW PV panel array. This array has been sized to maximize the amount of energy that can be generated from the existing roof structure taking into account all existing rooftop equipment and obstruction. The proposed system would consist of:

1. 3,017 x 390W PV panels (1.0 m x 2.0 m monocrystalline).
2. All panels will be ballast mounted so as to allow for roof repair and roof replacement in the future.
3. Solar panels will be fixed tilt at an optimal angle of 10deg, and will be flush mounted with the rack.
4. Installation will use a total of 40 x 25kW invertors

This ECM, along with ECM I02 are included to illustrate to the reader the magnitude of effort required to attain 100% carbon neutral operation of the facility using on site assets only.

An Energy Retrofit Program including these two ECMs, as well as the measures outlined in any of ECM Programs 100%A, 100%B, or 100%C would still require a net consumption of electricity from the grid. That is to say the solar array would not generate enough kWh over the course of the year to match the building's total kWh consumption.

At times the array would produce more power than the building could consume, which would be exported to the grid. Under current market conditions the city would not be compensated for this export, though for the purposes of determining the carbon savings of this ECM exported kWh carried at full value. Under current operation it is estimated that as much as 49% of the energy generated by the array would be exported, though this figure would drop if ECMs relating to electrification of carbon based energy consumption (D05, D06, D07, E05, and E06) were implemented in tandem. The battery energy storage system discussed (ECM B01) could also be used to offset this export.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$18,500
BAU Annual Operation and Maintenance Cost (Do not install PV array)	$0
Annual O&M Cost Beyond Business as Usual Case	$18,500
Equipment Expected Useful Life	25 years

IES Model Input Variables

This ECM was not included in the IES-VE Energy Model

Savings for this measure were calculated using a separate solar modeling software, Helioscope. The production model uses a variety of variables including building azimuth, module tilt, shading analysis, AC/DC ratio, and panel efficiency in order to provide an accurate generation estimate for the system.

Model Parameters:

- PV Module Characteristics: AE390M6-72 (AE Solar)
- Inverter Characteristics: Sunny Tripower 24000TL-US (SMA)
- Weather Dataset: TMY 10km Grid, meteonorm
- Solar Angle Location: Meteo Lag/LNG
- Transposition Model: Perez Model
- Temperature Model: Sandia Model
- Temperature Model Parameters:
    - Fixed Tilt a: -3.56, b: -0.075 Temperature Delta 3degC
    - Flush Mount a: -2.81 b: -0.046 Temperature Delta 0decC
- Soiling: 2%
- Irradiation Variance: 5%
- Cell Temperature Spread: 4 degC
- Module Binning Range: -2.5% to 2.5%
- AC System Derate: 0.50%

Figures

Figure I01A. 1: Helioscope rendering of proposed array

Cost & Savings Summary

The cost and savings for each improvement were extracted from the Helioscope modeling software and compiled in a database. A summary for this improvement is outlined below.

I01A SOLAR PV - ROOF - 1.18 MW ARRAY							
ANNUAL SAVINGS				TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
1,356,000	-	203	$29,385	$4,552,900	-	>50	-$ 3,876,630

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.10.2 MEASURE I01B: SOLAR PV - ROOF

MEASURE ID:	I01B
MEASURE NAME:	Solar PV – Roof – 0.60 MW array
MEASURE SUMMARY:	Installation of a roof mounted Photo Voltaic (PV) Solar Array to generate renewable electricity.

Scope of Work

This ECM considers the installation of a total of a 0.60 MW PV panel array. The City has indicated it is proceeding with a capital project including an array of this size, but no additional indication regarding roof location or other design parameters has been shared.

For the purposes of this report this ECM assumes that the PV array would be of a similar design of those proposed in ECM I01A and I02:

1. 1,538 x 390W PV panels (1.0 m x 2.0 m monocrystalline).
2. All panels will be ballast mounted so as to allow for roof repair and roof replacement in the future, the roof will need to be evaluated to assess what if any structural modifications would need to be made, but for the purposes of this report it is assumed none are required.
3. Solar panels will be fixed tilt at an optimal angle of 10deg, and will be flush mounted with the rack.
4. Installation will use a total of 24 x 25kW invertors

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$9,400
BAU Annual Operation and Maintenance Cost (Do not install PV array)	$0
Annual O&M Cost Beyond Business as Usual Case	$9,400
Equipment Expected Useful Life	25 years

IES Model Input Variables

This ECM was not included in the IES-VE Energy Model

Savings for this measure were calculated using a separate solar modeling software, Helioscope. The production model uses a variety of variables including building azimuth, module tilt, shading analysis, AC/DC ratio, and panel efficiency in order to provide an accurate generation estimate for the system.

Model Parameters:

- PV Module Characteristics: AE390M6-72 (AE Solar)
- Inverter Characteristics: Sunny Tripower 24000TL-US (SMA)
- Weather Dataset: TMY 10km Grid, meteonorm
- Solar Angle Location: Meteo Lag/LNG
- Transposition Model: Perez Model
- Temperature Model: Sandia Model
- Temperature Model Parameters:
  - Fixed Tilt a: -3.56, b: -0.075 Temperature Delta 3degC
  - Flush Mount a: -2.81 b: -0.046 Temperature Delta 0decC
- Soiling: 2%
- Irradiation Variance: 5%
- Cell Temperature Spread: 4 degC
- Module Binning Range: -2.5% to 2.5%
- AC System Derate: 0.50%

Figures

Figure I01B. 1: Proposed PV Panel, AE Solar 72 Cell Monocrystalline

Cost & Savings Summary

The cost and savings for each improvement were extracted from the Helioscope modeling software and compiled in a database. A summary for this improvement is outlined below.

I01B SOLAR PV - ROOF - 0.60 MW ARRAY						
ANNUAL SAVINGS				TOTAL MEASURE COST [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]			
689,491	-	103	$14,941	$1,491,768	>50	-$ 1,147,902

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.10.3 MEASURE I02: SOLAR PV - PARKING LOT

MEASURE ID:	I02
MEASURE NAME:	Solar PV - Parking Lot – 1.03 MW array
MEASURE SUMMARY:	Installation of 1.03 MW parking lot stand mounted Photo Voltaic (PV) Solar Array to generate renewable electricity.

Scope of Work

Installation of a total of a 1.03 MW PV panel array. This array has been sized to maximize the amount of energy that can be generated from the existing parking lot space. The proposed system would consist of:

1. 2,630 x 390W PV panels (1.0 m x 2.0 m monocrystalline).
2. All panels will be mounted directly to 285 carport support structures, each on a caisson foundation.
3. Solar panels will be fixed tilt at an optimal angle of 10deg, and will be flush mounted with the rack.
4. Installation will use a total of 35 x 25kW invertors.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$16,000
BAU Annual Operation and Maintenance Cost (Do not install PV array)	$0
Annual O&M Cost Beyond Business as Usual Case	$16,000
Equipment Expected Useful Life	25 years

IES Model Input Variables

This ECM was not included in the IESC VE Energy Model

Savings for this measure were calculated using a separate solar modeling software, Helioscope. The production model uses a variety of variables including building azimuth, module tilt, shading analysis, AC/DC ratio, and panel efficiency in order to provide an accurate generation estimate for the system.

Model Parameters:

- PV Module Characteristics: AE390M6-72 (AE Solar)
- Inverter Characteristics: Sunny Tripower 24000TL-US (SMA)
- Weather Dataset: TMY 10km Grid, meteonorm
- Solar Angle Location: Meteo Lag/LNG
- Transposition Model: Perez Model
- Temperature Model: Sandia Model
- Temperature Model Parameters:
  - Fixed Tilt a: -3.56, b: -0.075 Temperature Delta 3degC
  - Flush Mount a: -2.81 b: -0.046 Temperature Delta 0decC
- Soiling: 2%
- Irradiation Variance: 5%
- Cell Temperature Spread: 4 degC
- Module Binning Range: -2.5% to 2.5%
- AC System Derate: 0.50%

Figures

Figure I02.1: : Helioscope rendering of proposed array

Figure I02.2: : Proposed solar carport support structure, similar array installed at Mohawk College, Hamilton

Cost & Savings Summary

The cost and savings for each improvement were extracted from the Helioscope modeling software and compiled in a database. A summary for this improvement is outlined below.

I02 SOLAR PV - PARKING LOT - 1.03 MW ARRAY							
ANNUAL SAVINGS				TOTAL MEASURE COST [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]			
1,204,000	-	181	$26,091	$10,626,000	>50	-$ 10,025,536

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5.10.4 MEASURE I03: SOLAR THERMAL - POOL HEATING

MEASURE ID:	I03
MEASURE NAME:	Solar Thermal - Pool Heating
MEASURE SUMMARY:	Installation of Solar Thermal panel array tied directly into the pool heating system.

Scope of Work

Installation of a total of a 2,304sqft panel array tied directly into the existing pool supply heating line. This array has been sized based on the pool temperature and surface area. The proposed system would consist of:

1. 68 x 13 kWh/day solar thermal panels.
2. All panels will be mounted directly to the area roof with 4 deg spacers to ensure they are flat facing.
3. Installation includes dedicated system controller

As the system in installed directly into the existing pool heating system a storage tank is not required as is normally the case for solar thermal systems providing domestic water heating.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$3,500
BAU Annual Operation and Maintenance Cost (Do not install solar thermal array)	$0
Annual O&M Cost Beyond Business as Usual Case	$3,500
Equipment Expected Useful Life	20 years

5 ENERGY CONSERVATION MEASURES

IES Model Input Variables

Parameter	Calibrated Model	ECM Implementation
Solar thermal collector area	None	2304 sqft
Solar thermal model parameters	None	IES defaults

Figures

Figure I03.1: : Similar array installed at Tansley Woods community centre, Burlington

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

I03 SOLAR THERMAL - POOL HEATING								
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	TOTAL INCENTIVES [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]				
-273	11,293	-	21	$3,206	$78,100	$2,259	23.7	$ 38,993

Notes:
1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.11 MEASURE DESCRIPTION GROUP J – OPERATIONAL CHANGES

5.11.1 MEASURE J01: SCHEDULING RATIONALIZATION

MEASURE ID:	J01
MEASURE NAME:	Remove In Stand Heating
MEASURE SUMMARY:	Remove the radiant in stand heating from the arena

Scope of Work

The arena is served by twenty (20) in radiant heaters that serve the stands in arenas 1 & 2. Use of these heaters is rationed by the building operators as their use is very energy intensive and can negatively impact the operation of the ice plant. As these heaters are served by natural gas a conversion to electric heaters was contemplated in measure E05.

Another consideration could be to remove the heaters altogether. While this represents a reduction in service provided, that service must be weighed against the energy intensity of the heaters.

Impact on Operations and Maintenance

In the analyses of each potential ECM, the annual operations and maintenance costs (O&M), expected useful life (EUL) and major mid-life repair costs were included to provide a life cycle cost of the ECM being analyzed in addition to the energy impact of the measures. If a value is not populated, it is considered negligible. A summary of each is listed below for this improvement.

Item	Associated Costs
ECM Annual Operation and Maintenance Cost	$0
BAU Annual Operation and Maintenance Cost (Retain in stand heating)	$500
Annual O&M Cost Beyond Business as Usual Case	($500)
Equipment Expected Useful Life	NA

IES Model Input Variables

The radiators were removed from the model.

Cost & Savings Summary

The cost and savings for each improvement were extracted from the IES-VE modeling software and compiled in a database. A summary for this improvement is outlined below.

J01 REMOVE IN STAND HEATING							
ANNUAL SAVINGS					TOTAL MEASURE COST [$]	SIMPLE PAYBACK w/ INCENTIVES [YEARS]	NPV
ELECTRICITY CONSUMPTION [kWh]	NATURAL GAS [m³]	OPERATIONAL COSTS AND SAVINGS [$]	GHG EMISSIONS REDUCTIONS [Tonnes eCO2]	TOTAL [$]			
9,201	30,360	-	59	$8,834	$1	0.0	$ 113,670

Notes:

1. Annual Savings [$] based on Savings Rates as per Section 03 Utility Analysis
2. Consult Appendix B for detailed costing breakouts. A 10% cost for engineering design has been carried in the cost estimate presented here.

5 ENERGY CONSERVATION MEASURES

5.12 MEASURE DESCRIPTION GROUP K – GREEN POWER & CARBON OFFSETS

5.12.1 MEASURE K01: RENEWABLE ENERGY CREDITS

MEASURE ID:	K01
MEASURE NAME:	Renewable Energy Credits (RECs)
MEASURE SUMMARY:	Purchase Renewable Energy Credits as required to achieve carbon neutral operation

Scope of Work

RECs are certificates which can be purchased to offset scope 2 emissions. Scope 2 emissions are greenhouse gas emissions associated with the purchase of electricity. Scope 2 emissions will be related to how clean an electricity grid is in any given location. RECs are produced from renewable energy sources such as wind or solar. It is recommended RECs with recognized certifications be purchased to ensure reliable offsetting of scope 2 emissions.

Renewable energy generation facilities may be credited with one REC for every 1 mWh of renewable energy created and provided to a grid. Certified RECs are provided with a unique identifying number given to ensure savings are only accounted for once.

The amount of electricity to be offset must first be determined by the project team. Once determined, an environmental broker may facilitate a REC purchase agreement for a set number of years. Purchased RECs may only offset scope 2 emissions, which refers to emissions that result from generation of electricity, heat or steam purchased from a utility provider.

The certificates purchased can vary in production location and energy source, such as wind or solar. The source or location of the REC will impact cost. Purchasing RECs with a recognized certification helps to ensure legitimate offsetting of scope 2 emissions.

Regulating bodies that certify RECs include the ECOLOGO® Certification and Green-e Climate Standard programs. The ECOLOGO® Certification Program uses the standard *UL 2854 Renewable Low-Impact Electricity Products*. This standard covers both *Bundled Renewable Low-Impact Electricity* and *Renewable Energy Certificates* and allows for the commodification of renewable energy generation. The impacts of the products covered by this standard have low net GHG emissions, limit the depletion of non-renewable resources and have reduced impact on natural environments. The requirement of the Green-e Climate Standard include, a Green-e Climate Annual Verification Audit, and review by the Program Administrator of product disclosures and marketing materials to ensure transparency.

These voluntary, third party verified programs include rigorous requirements. Both the ECOLOGO® Certification Program and Green-e Energy program are recognized in third party building certifications such as the CaGBC Zero Carbon Building Standard and LEED®.

Cost Savings and Summary

Green power is a one time purchase that requires no physical impact to the project, there is no associated payback and the quantity of GHG emissions reduced is set by the purchaser. Indicative estimate for the cost of RECs is $0.025/kWh and this rate has been applied where they are carried in the energy retrofit program.

The cost per tonne of eCO2 depends on the type of electricity being offset, based on the emissions factor applied to this project (0.000150 Tonne eCO2/kWh) for electricity, the cost to offset one tonne of carbon with a REC is $166.7/tonne eCO2.

Typical purchase terms for RECs range from 2-5 years.

5.12.2 MEASURE K02: CARBON OFFSETS

MEASURE ID:	K02
MEASURE NAME:	Carbon Offsets
MEASURE SUMMARY:	Purchase Carbon Offsets as required to achieve carbon neutral operation

Scope of Work

Carbon offsets are certificates that can be purchased to offset scope 1 emissions. Scope 1 emissions are emitted directly from the burning of fossil fuels through energy consumption on site. Carbon offsets can be produced from a wide range of activities such as modifying agriculture practices, fuel switching, reducing methane emissions in waste and tree planting. These activities reduce, sequester or avoid emissions of GHGs and therefore are credited with a carbon offset. It is recommended carbon offsets with recognized certifications be purchased to ensure reliable offsetting of scope 1 emissions.

Carbon offsets are created through activities that reduce, sequester or avoid emissions of GHGs therefore warranting an offset. These activities are subject to standards which regulate project design, monitoring and reporting criteria to ensure consistency and accuracy of carbon offsets. Standard approaches allow for the quantification of GHGs avoided from project activities. This results in carbon offsets which are sold as equivalent tonnes of carbon (tCO_2e).

When purchasing a carbon offset, buyers can request the specific location, activity or vintage of the offset. The vintage refers to the year in which the offset is produced, location is the location of the offsetting activity. These are all contributing factors to the overall price of a carbon offset. More recent vintages, produced in more favourable locations and via more socially preferred activities, such as tree planting, will typically be on the higher end of the price spectrum.

The amount of carbon to be offset is must first be determined by the project team, through modelling or utility data review. Once determined, an environmental broker may facilitate a carbon offset purchase agreement for a set number of years.

Purchasing carbon offsets with a recognized certification helps to ensure legitimate offsetting of scope 1 emissions. Regulating bodies that certify carbon include the ECOLOGO® Certification and Green-e Climate programs. These voluntary, third party verified programs include rigorous requirements. Purchasing carbon offsets with a recognized certification helps to ensure legitimate offsetting of scope 2 emissions. Both the ECOLOGO® Certification Program and Green-e Energy program are recognized in third party building certifications such as the CaGBC Zero Carbon Building Standard and LEED®.

Cost Savings and Summary

Carbon offsets are a one time purchase that requires no physical impact to the project, they have no payback and the quantity of GHG emissions reduced is set by the purchaser. The average cost per for carbon offsets is in the range of \$5-\$20/tCO_2e, a rate of \$12 has been applied where they are carried in the energy retrofit program.

SECTION 6

INCENTIVE SUMMARY

6 INCENTIVE SUMMARY

6.1 OVERVIEW

Incentives and rebates are available from both Local Distribution Companies ("LDC") and Government Agencies and can be used to reduce the payback period associated with implementation of the measures related in the Energy Conservation Measures Program. Below **Table 5.1: Incentive Summary** provides a summary of the incentives which may be available should all measures be implemented.

Table 6.1: Incentive Summary

DESCRIPTION	AMOUNT ($)	DETAILS
IMPLEMENTATION FUNDING – TOTAL: $253,369		
IESO SAVEONENERGY RETROFIT PROGRAM	$153,845	**Lighting**: $400/kW of demand savings, or $0.05/kWh of first year electricity savings. **Non-Lighting:** $800/kW of demand savings, or $0.10/kWh of first year electricity savings (whichever is greater) A max. of 50% of the project cost. Electricity Consumption savings is base on the first year savings only. Prescriptive (per fixture rebates) are available for non-lighting measures as well. This incentive cap is for custom incentives (based on both material and labour costs) – for prescriptive the incentive cap is 100% of material costs
ENBRIDGE GAS COMMERCIAL RETROFIT INCENTIVE PROGRAM	$99,524	$0.10/m³ to $0.20/ m³ up to 50% of your project cost. (not to exceed $100,000)
AUDIT FUNDING – TOTAL: $4.000		
ENBRIDGE GAS ENGINEERING FEASIBILITY STUDY	$5,000	50% up to $4,000 (multi-site customer incentive cap $10,000 per customer)

NOTES:

1. IESO – Independent Electricity System Operator
2. Enbridge Gas Engineering Feasibility Study – Pre-approval Received
3. Implementation Funding Amount estimated, re-evaluation will be required during design phase.

6 INCENTIVE SUMMARY

6.2 IMPLEMENTATION FUNDING - INCENTIVES

IESO – SAVEONENERGY – RETROFIT PROGRAM

The **Retrofit Program** assists building owners and tenants to install and benefit from newer, more energy efficient measures to improve the overall efficiency of your building.

To participate, the project must receive pre-approval. The program includes two options to apply: PRESCRIPTIVE Track & CUSTOM Track

PRESCRIPTIVE TRACK "Quick System Upgrade"

- List of set measures which correspond with a predefined incentive amount.
- Worksheets include: HVAC Plug Loads, Refrigeration, VSD Compressed Air, Lighting, Exterior Lighting, Agribusiness, Unitary AC, Motors, Multi Res In Suite, Synchronous Belt, Variable Frequency Drive, AEM Service Hot Water
- Project must be worth a *minimum of $100* of incentives.

CUSTOM TRACK "Comprehensive Projects"

- Flexibility for more comprehensive projects with opportunities for increased energy savings
- Complex or innovated solutions not covered by Prescriptive Track
- Information provided on the worksheet: description of facility baseline electricity use, equipment being replaced, new equipment, disposal cost of old equipment, operating schedule, cost of new equipment.
- Worksheets include: Compressed Air, Combined Lighting, Lighting Controls, VSD Compressed Air, VSD Pump, VSD Fan, and Unitary AC.

Available Incentives

	Lighting	Non-Lighting* incl. Lighting Controls
PRESCRIPTIVE TRACK funded up to a maximum of 100% of material costs	Per Unit	Per Unit
CUSTOM TRACK	Greater of either; $400/kW of demand savings, or $0.05/kWh of first year electricity savings (to a max. of 50% of the project cost)	Greater of either; $800/kW of demand savings, or $0.10/kWh of first year electricity savings (to a max. of 50% of the project cost)

**Non-Lighting refers to mechanical, building controls, and lighting controls measures*
**The incentives can also be based on demand reduction ($400/kW for lighting, $800/kW for non-lighting).*
**Non-Lighting refers to mechanical and controls measures*

6 INCENTIVE SUMMARY

Eligibility

- Applicants must be owners or tenants of business premises served by the LDC.
- **Custom Track**, Project must be worth a minimum incentive of **$1500**
- All projects must be pre-approved and minimum estimated demand reduction of 1 kW or annual energy electricity of **2,000 kWh** of savings.
- The program eligibility period is until **December 31, 2020.**

Mandatory Program Requirements

- Register online and provide your business details.
- All applications must be completed on the saveonenergy.ca website.
- Participant will implement the projects as described in the project schedule provided in the application and in no event after December 31, 2020.
- Upon completion of the project, must provide contractor invoices, and any other evidence required upon completion of implementation no later than 90 days following completion date.
- Project must deliver energy savings for at least 48 months, starting first day of the month in which the LDC pays the Participant Incentive
- Projects that include Custom Measures to which incentives between $10,000 and $40,000 and greater, a Monitoring & Verification plan is required (see below for more details)
- All Environmental Attributes are to be transferred and assigned to the LDC, and the LDC will transfer the Environmental Attributes to IESO.

Monitoring & Verification Procedures

- **Basic M&V** – Custom Projects including Measures to which incentives are greater than $10,000 and equal to or lesser than $40,000 require a Basic M&V Plan. Which includes;
  - Project General Information
  - Energy Conservation Measures
  - (ECM) intent
  - Baseline: Period, Energy & Conditions
  - Basis for Adjustment
  - Analysis Procedure
  - Report Format
- **Enhanced M&V** - Large Custom Projects including Measures to which incentives greater than $40,000 require an Enhanced M&V Plan. Which includes;
  - Project General Information
  - Energy Conservation Measures (ECM) Intent
  - Selected IPMVP Option and Measurement Boundary
  - Baseline: Period, Energy & Conditions
  - Reporting Period
  - Basis for Adjustment
  - Quality Assurance
  - Analysis Procedure
  - Energy Prices
  - Meter Specification
  - Monitoring Responsibilities
  - Expected Accuracy
  - Budget
  - Report Format

6 INCENTIVE SUMMARY

- The following measures will be discounted by **25%** if supporting baseline data is provided to the LDC and **50%** if supporting baseline data is not provided to the LDC.
  - Building Automation Controls – Basic and Enhanced M&V
  - Lighting Controls – Basic and Enhanced M&V

Web Link	*https://saveonenergy.ca/Business/Program-Overviews/Retrofit-for-Commercial.aspx*

ENBRIDGE – CUSTOM ENGINEERING INCENTIVES

Enbridge provides financial incentives for the installation of specific types of energy efficient equipment as part of this program. This program will fund energy efficiency projects that reduce natural gas consumption for new and retrofitted applications. Pre-approval is required.

Typical Projects:

- Boilers
- High Efficiency Process Equipment
- Steam Systems Equipment
- Combined Heat & Power
- Building and Process Controls
- Building Envelope Technologies

The retrofit incentives for commercial customers are calculated on natural gas savings using the following rates:

Commercial Customers	
General Services (Rates M1, M2, R1, R10) $0.20/m³ to a max. $100,000	Total incentives cannot exceed 50% of the project cost
Contract Services (Rates M4, M5A, M7, T1, R20) $0.10/ m³ to a max. $100,000	

General Services Customers – Submit your project by June 30, 2020 and received $0.40/m3 for upgrading heating & hot water systems with high efficiency and condensing boilers.

Web Link	*https://www.uniongas.com/business/save-money-and-energy/engineering-projects*

6 INCENTIVE SUMMARY

UNION GAS – EQUIPMENT INCENTIVES (PRESCRIPTIVE)

Incentives are available under Prescriptive Track in which do not apply to current ECM proposed in this study.

Web Link	*https://www.uniongas.com/business/save-money-and-energy/equipment-incentive-program/space-heating-programs*

6.3 IMPLEMENTATION FUNDING – GRANTS

FCM – CAPTIAL PROJECT SIGNATURE INITIATIVE

The **Captial Project Signature Initiative** helps Canadian cities and communities of all sizes implement bold environmental projects that reduce GHG emissions and protect the air, water or land. This funding is designed to accommodate transformative, best-in-class municipal projects, meaning they're highly innovative and impactful.

Available Funding

Regular Loans and Grants
Low interest loan of up to $5 million, covering up to 80% of project costs. Grant of up to 15% of the loan
High Ranking Loans and Grants
Low interest loan of up to $10 million, covering up to 80% of project costs. Grant of up to 15% of the loan

6.4 AUDIT FUNDING

ENBRIDGE – ENGINEERING FEASIBILITY STUDY INCENTIVES

Enbridge provides study incentives to support energy efficiency measures on natural gas consumption equipment; gas related heating systems or facilities of commercial buildings.

Available Incentives

Commercial Customers

6 INCENTIVE SUMMARY

50% of the study cost, to a max. $4,000 (multi-site customer incentive cap $10,000 per customer)

Applications are submitted once the Final Energy Feasibility Study is complete.

Application Requirements:

- Baseline types and costs of all energy use per process/pieces of equipment
- Analysis of use, waste and potential impact on production
- In depth description of improvements to current operational procedures, process, and technology and installation of new equipment
- Projected/predicted future performance for all energy use for improvements
- Final analysis of opportunities sufficient to support customer management review and projected approval

Web Link	*https://www.uniongas.com/business/save-money-and-energy/engineering-projects*

Pre-approval	*Received by Enbridge Gas Distribution in the amount of $5,000*

APPENDICES

APPENDIX A

EXTENDED UTILITY ANALYSIS

A EXTENDED UTILITY ANALYSIS

A.1 SAVING RATES

Electricity Rate Structure Background

Electricity for South Fletcher's Sportsplex is serviced by Alectra Utilities, and is currently under a Class B rate structure. Electricity consumption supply rates outlined in **Table A.1** are based on the average CY2019 Class B rates published by the IESO. The Alectra Utilities delivery rates outlined in **Table A.2** are the most recent rates published for a business rate class for monthly demand of 700 to 4999 kW in Brampton. Fixed customer charges are not included as they do not apply to monthly usage.

Table A.1: Alectra Utilities Supply Rates (Tax Excluded)		
IESO Electricity Rates		
Hourly Ontario Energy Price (HOEP)[1]	per kWh	$0.0178
Global Adjustment – Class B[1]	per kWh	$0.1092
Regulatory Charges		
Wholesale Market Service Charge	per kWh	$0.0035
Capacity Based Recovery	per kWh	$0.0004
Total Rate	**per kWh**	**$0.1309**

Notes:
1) CY2019 Average.

Table A.2: Alectra Utilities Delivery Rates (Tax Excluded)		Monthly Demand of 700 to 4999 kW
Distribution Charge	per kW[1]	$3.4221
Transmission Network Charge	per kW[2]	$3.0385
Transmission Connection Charge	per kW[3]	$2.3309
Rate Rider for Recovery of Incremental Capital (2018)	per kW	$0.0317
Rate Rider for Disposition of Lost Revenue Adjustment Mechanism Variance Accounts (2020)	per kW	$0.0459
Total Rate	**per kW**	**$8.8691**

Notes:
1) Based on the greater of kW demand or 90% kVA incurred in a 15 minute rolling window for the month.
2) Based on the Peak Demand (actual kW demand or 90% kVA) incurred in a 60 minute rolling window between 7:00 AM and 7:00 PM, excluding weekends and statutory holidays.
3) Based on the Peak Demand (actual kW demand or 90% kVA) incurred in a 60 minute rolling window for the month.

As measures of this EPC increase electrical demand and will move South Fletcher's Sportsplex into a Class A rate structure, **Table A.3** outlines the electricity rates that will be applicable with this change. A description of these charges are also detailed below.

Table A.3: Class A Electricity Rates (Tax Excluded)	
Utility	**Savings Rate**
Electricity Consumption	$ 0.0217 per kWh
Electricity Demand	$ 8.8691 per kW
GA and CBR Charge[1]	$ 585.0392 per kW

Notes:
1) Global adjustment savings are annual savings for kW reductions that occur in all 5 GA hours

While the Alectra delivery fees do not change or impact the monthly demand charge, electricity consumption charges do not include the Global Adjustment rates, as shown below in **Table A.4**.

Table A.4: Class A Customer Consumption Rates (Tax Excluded)		
IESO Electricity Rates		
Hourly Ontario Energy Price (HOEP)[1]	per kWh	$0.0178
Regulatory Charges		
Wholesale Market Service Charge	per kWh	$0.0035
Capacity Based Recovery	per kWh	$0.0004
Total Rate	**per kWh**	**$0.1309**

Notes:
1) CY2019 Average.

Global Adjustment (GA) & Capacity Based Recovery (CBR) Charge

While Class A customers do not pay a GA Charge against consumption, they instead pay a monthly GA and CBR Charge based on the site peak demand factor (PDF) and System-wide GA monthly rate (published by the IESO), as discussed in ***Section 3.2.1.1***, and calculated as:

South Fletcher's Sportsplex GA Charge *(to be calculated monthly) = PDF * System-Wide monthly GA Rate*

To calculate the GA Charge savings rate, the annual System-wide GA rate and CBR amount during the baseline period is analyzed. The total GA charge is expressed as a $/kW for kWs occurring in all 5 peak hours, and can be calculated as:

$$\boldsymbol{Total\ GA\ Charge}\ \left(\$/_{kW}\right) = \frac{(\boldsymbol{System - wide\ GA\ Cost}\ (\$) + \boldsymbol{Total\ CBR}(\$))}{\boldsymbol{System - wide\ Consumption}\ (\boldsymbol{kW})} \cdot \mathbf{12} \cdot \mathbf{5}$$

For CY2019, the average GA & CBR charge was **$585.0392/kW**.

Table A.5: Class A GA & CBR Costs				
Month	System-Wide GA Cost (M$)	Total CBR Amount (M$)	System-Wide Consumption (MW)	Total GA Charge ($/kW)
January-2019	$956.20	$3.50	107,344.76	$536.42
February-2019	$908.10	$2.60	107,344.76	$509.03
March-2019	$857.60	$3.50	107,344.76	$481.31
April-2019	$1,118.70	$3.90	107,344.76	$627.47
May-2019	$1,133.30	$3.80	107,344.76	$635.58
June-2019	$1,261.30	$3.40	107,344.76	$706.90
July-2019	$1,149.60	$3.00	115,213.43	$600.24
August-2019	$1,327.70	$2.40	115,213.43	$692.68
September-2019	$1,082.90	$2.80	115,213.43	$565.40
October-2019	$1,209.60	$2.70	115,213.43	$631.33
November-2019	$979.00	$3.30	115,213.43	$511.55
December-2019	$1,000.20	$3.20	115,213.43	$522.54
CY2019 Average GA Cost & CBR Rate ($/kW)				$ 585.0392

While interval data was not available to calculate South Fletcher's PDF, it can be estimated using the monthly peaks corresponding to the top 5 Ontario peaks as follows:

Table A.6: South Fletcher's Sportsplex Estimated				
Top Five AQEW Peaks from May 1, 2018 to April 30, 2019				South Fletcher's Sportsplex
Rank	Date	Hour Ending	Total (MW)	Monthly Peak (kW)
1	September 5, 2018	17	23,627	873.41
2	July 5, 2018	15	23,834	666.36
3	July 4, 2018	18	22,857	666.36
4	August 28, 2018	17	22,713	669.60
5	September 4, 2018	17	22,182	873.41
	Total		115,213	3,749.14

$$\textit{South Fletcher's Sportsplex PDF} = \frac{3{,}749\ kW}{115{,}213\ MW \cdot 1000 kw/MW} = 0.0032541$$

This PDF can be used to estimate the applicable electricity savings for South Fletcher's Sportsplex from moving from a Class B to a Class A customer, as seen in **Table A.7**

Table A.7: Estimated Savings from Class A Rate Change

Measured Values			Class A			Class B		Difference (Class B vs. A)
Month	Demand	Consumption	System-Wide GA Cost	PDF	Class A Costs	GA Actual Rate	Class B Costs	
	kW	kWh	$mill		$	$/kWh	$	
May 2018	629	352,277	$1,001.10	0.000032541	$32,577	$0.1079	$38,021	$5,445
June 2018	630	351,634	$1,151.00	0.000032541	$37,454	$0.1190	$41,830	$4,376
July 2018	666	380,799	$911.80	0.000032541	$29,671	$0.0774	$29,462	-$208
August 2018	670	387,879	$876.40	0.000032541	$28,519	$0.0749	$29,052	$533
September 2018	873	419,922	$847.30	0.000032541	$27,572	$0.0858	$36,046	$8,474
October 2018	793	383,992	$1,135.30	0.000032541	$36,944	$0.1206	$46,306	$9,362
November 2018	799	374,198	$936.40	0.000032541	$30,471	$0.0986	$36,877	$6,406
December 2018	792	380,050	$853.20	0.000032541	$27,764	$0.0740	$28,139	$375
January 2019	831	369,456	$956.20	0.000032541	$31,116	$0.0809	$29,896	-$1,219
February 2019	824	359,358	$908.10	0.000032541	$29,550	$0.0881	$31,667	$2,116
March 2019	829	390,639	$857.60	0.000032541	$27,907	$0.0804	$31,411	$3,504
April 2019	843	389,311	$1,118.70	0.000032541	$36,403	$0.1233	$48,014	$11,610
FY 2018/2019	9,179	4,539,515			$375,947		$426,722	$50,775

Natural Gas Rate Structure Background

Natural gas pricing for South Fletcher's Sportsplex consists of distribution charges by Enbridge and commodity charges under a separate contract with Perimeter Energy Inc. Natural gas is distributed to the South Fletcher's Sportsplex by Enbridge as a Rate Class 6 customer. The savings rate has associated customer, delivery, and transportation to Enbridge charges, as detailed in **Table A.8** below. Enbridge rates are based on the most recent data available for Rate class 6, updated on January 1st, 2020. As usage for the building over the baseline period is over 28,300 m^3 on average, the marginal delivery charge of $.0.05116/m^3 is carried into the natural gas savings rate.

The applicable commodity charges from Perimeter Energy Inc. are based on the 2019 rate charged to South Fletcher's Sportsplex as indicated on the utility bills provided.

Table A.8 Natural Gas Savings Rates (Tax Excluded)							
Enbridge Charges (Rate 6)							
Transportation Charge	per m^3	$0.04336					
Delivery Charge	per m^3	First 500	Next 1050	Next 4500	Next 7000	Next 15250	Over 28300
		$0.10207	$ 0.08086	$ 0.06601	$ 0.05646	$ 0.05222	**$ 0.05116**
Cost Adjustment[1]	per m^3	-$0.00221					
Carbon Charge	per m^3	$0.03910					
Perimeter Energy Inc.							
Transportation Charge	per m^3	$0.05900					
Gas Supply Charge	per m^3	$0.09400					
Total Natural Gas Rate	**per m^3**	**$0.28441**					

Notes:
1) South Fletcher's Sportsplex is charged the Rate 6 Delivery Cost Adjustment from Enbridge

Water Rate Structure Background

Water for South Fletcher's Sportsplex is supplied by the Region of Peel. The water consumption savings rate outlined in **Table A.9** are taken from the most recent Region of Peel water rates published.

Table A.9: City of Hamilton Water Rates (Tax Excluded)		0 to 5000 m^3
Consumption Charges		
Water Charge	per m^3	$1.4725
Sewer Charge	per m^3	$1.1367
Total Rate	**per m^3**	**$2.6092**

A EXTENDED UTILITY ANALYSIS

A.2 UTILITY REGRESSION

A.2.1 ELECTRICITY

To understand the influence of weather on the building's electricity use, the most recent year of electricity consumption data was plotted against outside air temperature. Most recent data was used to be reflective of current usage patterns. As seen in ***Figure A.1***, usage does not show any clear weather dependency.

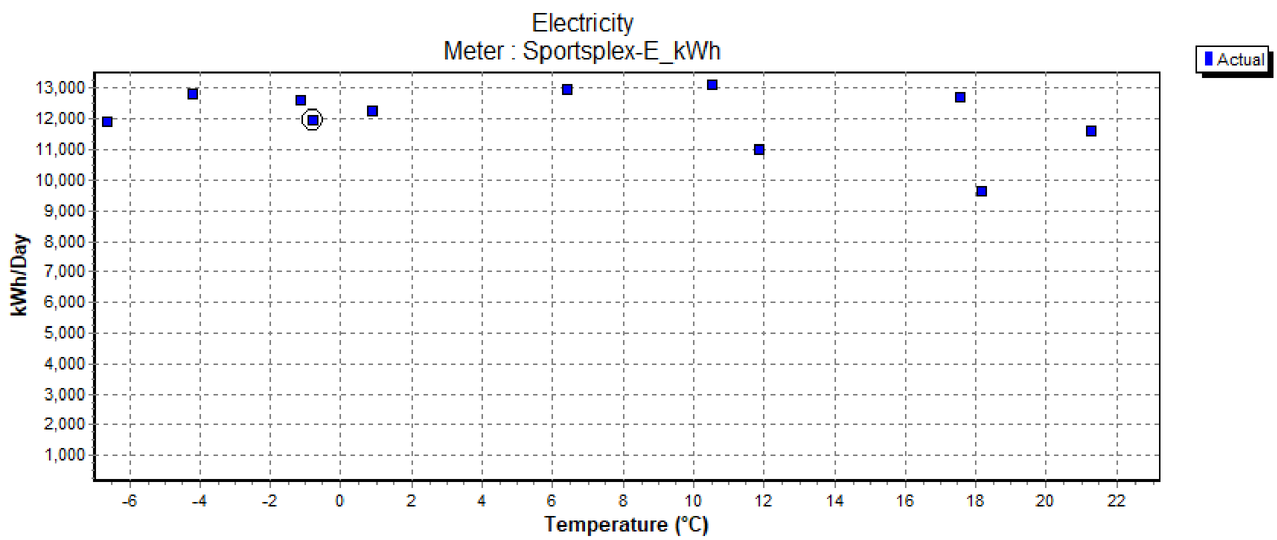


Figure A.1: South Fletcher's Sportsplex Electricity Consumption vs. Outdoor Air Temperature

Electricity Demand

When electricity demand is plotted against outside air temperature, demand is constant around 800 kW above 18C, above which demand is reduced, as seen in ***Figure A.2***. However, there was no apparent relationship to weather. This pattern could instead be due to the reduced load in the summer when two rinks are not operational.

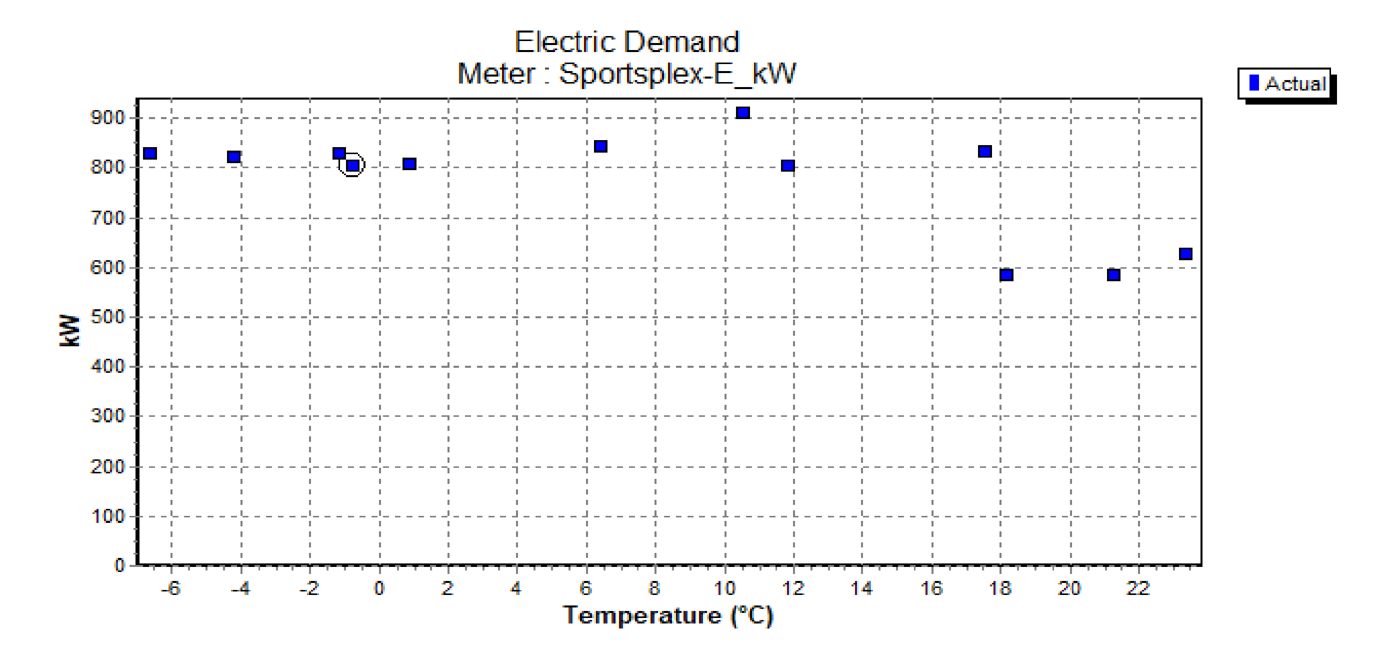


Figure A.2: South Fletcher's Sportsplex Electricity Demand vs. Outdoor Air Temperature

A.2.2 NATURAL GAS

When the most recent year of data is plotted against outdoor air temperature, natural gas usage decreases as temperature increases until 20°C, as seen in ***Figure** A.3*. This is indicative of natural gas used for heating spaces, as would be expected from the mechanical audits.

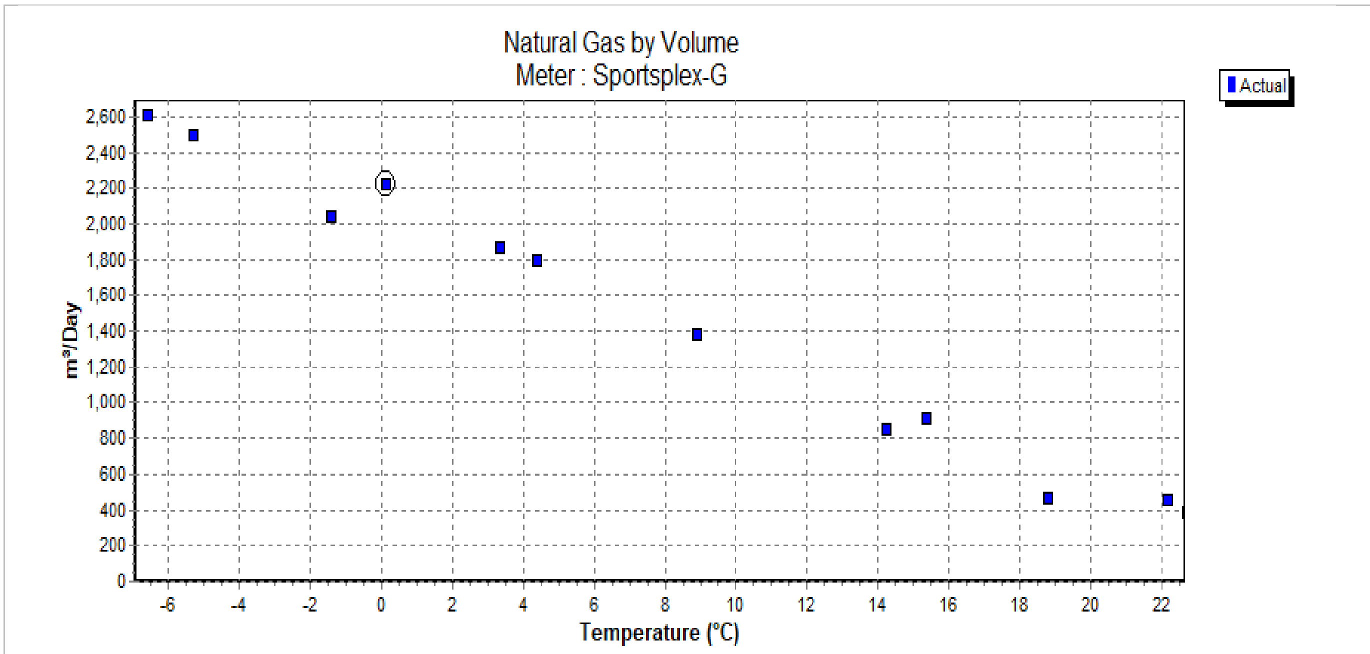
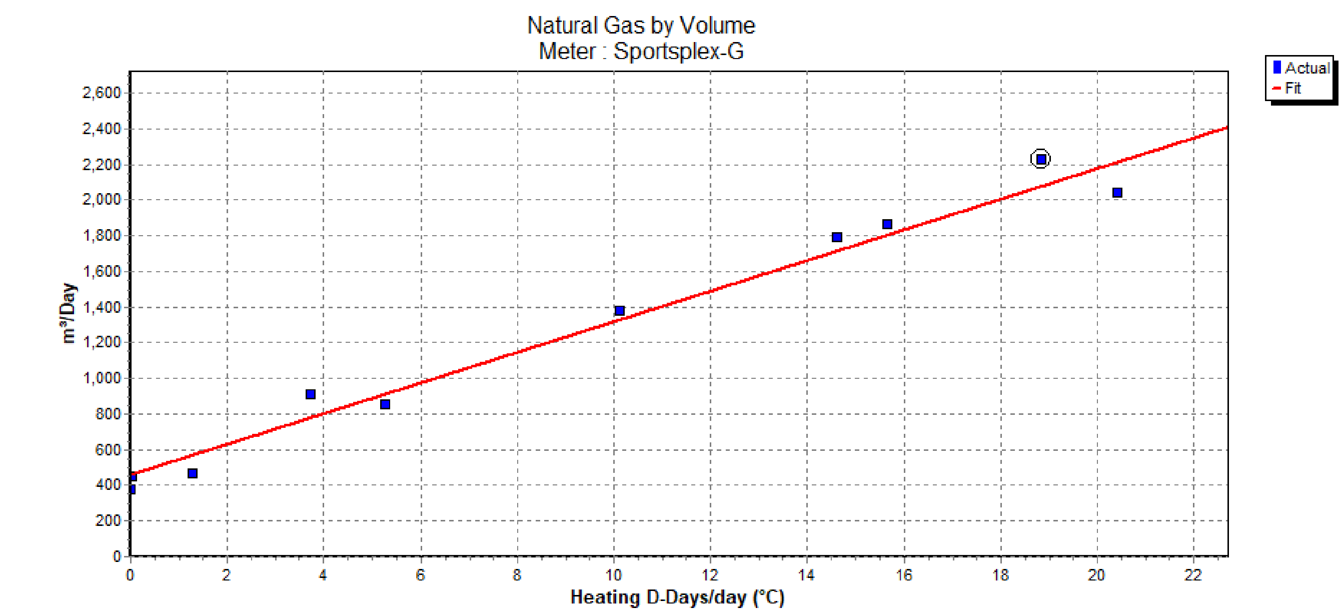


Figure A.3: South Fletcher's Sportsplex Natural Gas Consumption vs. Outdoor Air Temperature

When usage is plotted against heating degree days (HDDs), the resulting regression can be seen in ***Figure A.4***. The regression is considered acceptable if the R^2 value is at least 0.75, and if the CVRSME is no higher than 25. Setting the balance point temperature to 19°C for heating results the following regression equation with an R^2 value of 0.986, indicating an excellent correlation with weather;

*Regression Equation: m³= (458.9 * #Days) + (85.88 * HDD)*



m³= (458.9 * #Days) + (85.88 * HDD)
R2 = 0.986 ♦ CVRMSE = 6.94

Figure A.4: South Fletcher's Sportsplex Natural Gas Consumption vs. HDDs

A.2.3 WATER

When water consumption is plotted against outside air temperature, there is no clear relationship to weather during the baseline period.

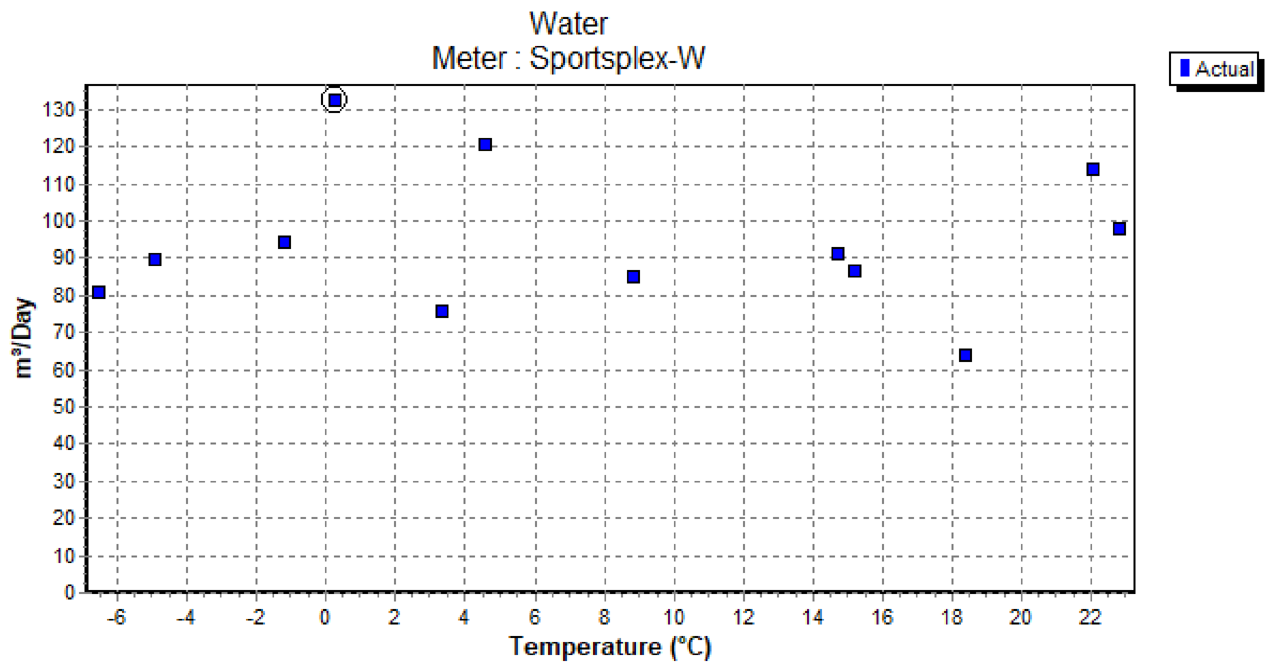


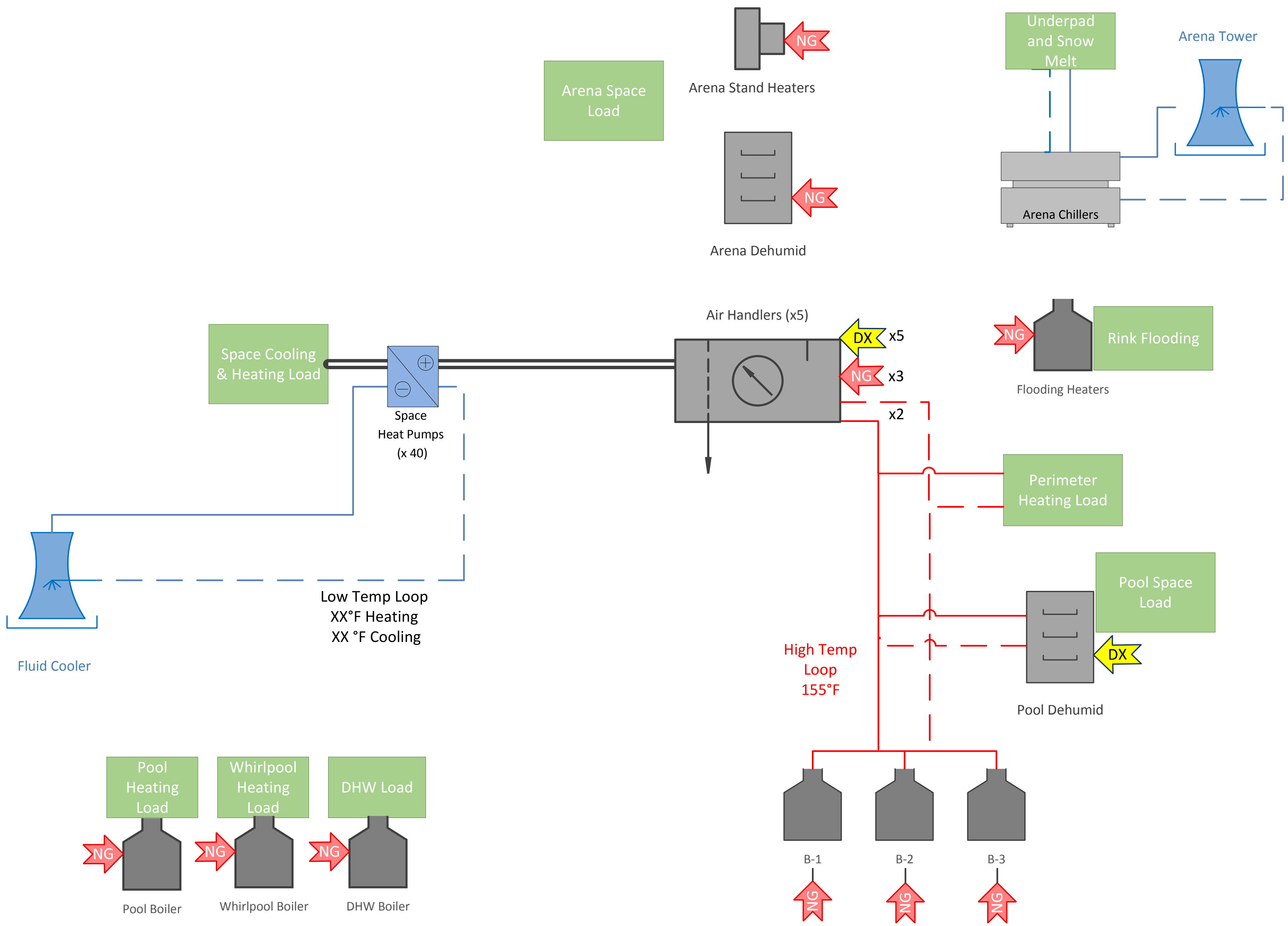
Figure A.7: South Fletcher's Sportsplex Water Consumption vs. Outdoor Air Temperature

APPENDIX B

COST CONSULTANT REPORT

APPENDIX C

MECHANICAL ENERGY FLOW DIAGRAM



South Fletcher's Sportsplex
Current Design

NOTES

MCW Custom Energy Solutions Ltd.

PROJECT

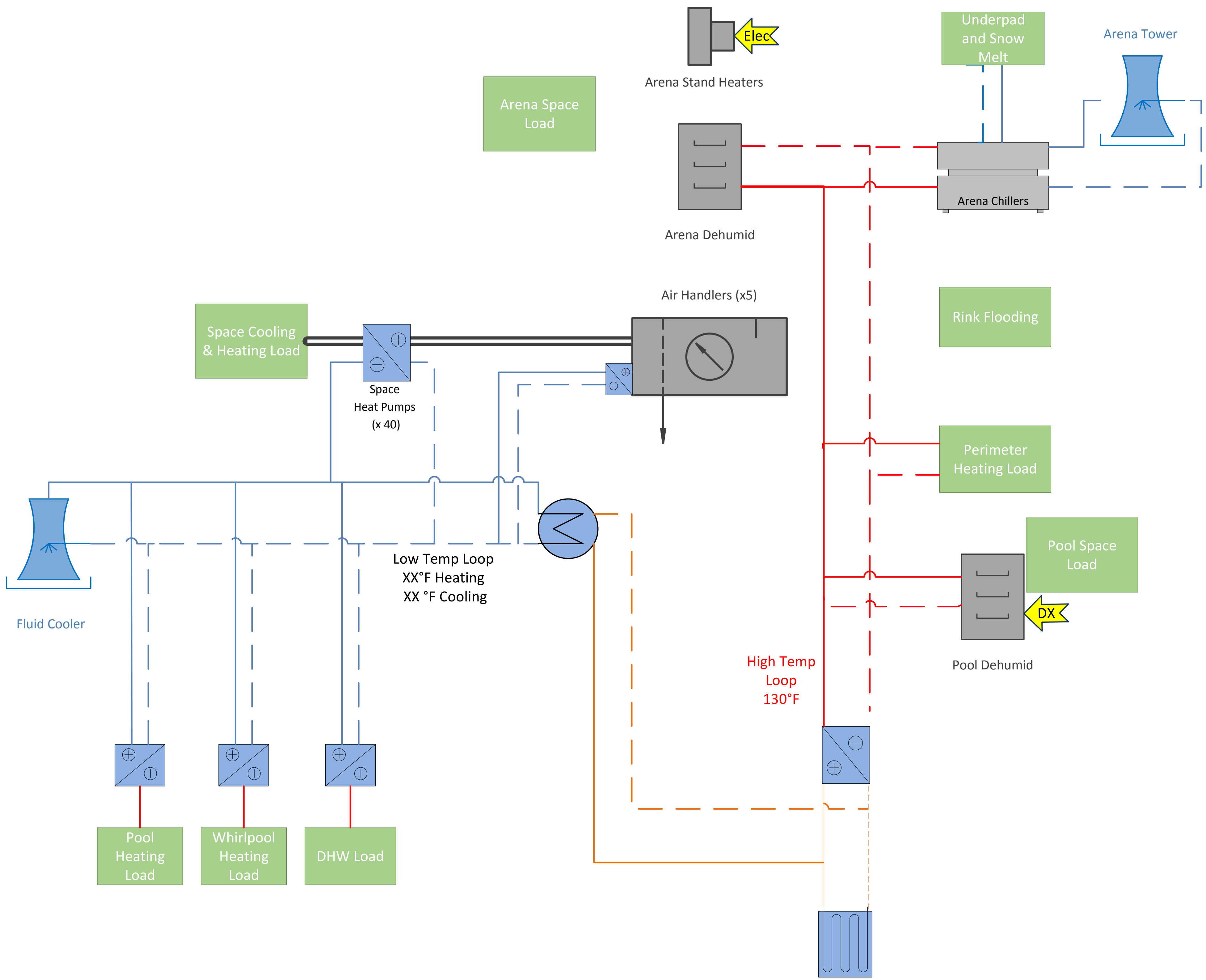
City of Brampton
South Fletcher's Sportsplex

DRAWING

PROJECT NO.

1958

DRAWN BY : SD	DATE: 2020-03-09
CHECKED BY: SB	DATE: 2020-03-09
SCALE: NTS	
FILE: SFS Energy Flow Schematic V2.vsdx	
SHEET	Current



South Fletcher's Sportsplex

Carbon Neutral Design

NOTES

MCW Custom Energy Solutions Ltd.

PROJECT

City of Brampton
South Fletcher's Sportsplex

DRAWING

PROJECT NO.

1958

DRAWN BY : SD	DATE: 2020-03-09
CHECKED BY: SB	DATE: 2020-03-09
SCALE: NTS	
FILE: SFS Energy Flow Schematic V2.vsdx	
SHEET	Carbon Neutral

APPENDIX D

THERMAL IMAGING REPORT

Custom Energy Solutions Ltd.

Thermography Report: Brampton South Fletcher's Sportsplex

City of Brampton, ON

March 12, 2020

Table of Contents

Introduction

The goal of this report is to provide insight into potential energy savings at the South Fletcher Sportsplex located in Brampton Ontario. The approach taken will be to analyse infrared imagery of the Sportsplex and determine locations of the building that are subject to thermal bridging and air leakage.

Thermal bridging is defined as movement of heat across an object that is more conductive than surrounding materials. This creates a thermal bridge between the indoor air and the outdoor air, and causes an increased heat transfer rate.

Locating and insulating thermal bridges is an effective way to reduce cooling and heating loads within South Fletcher Sportsplex. Reducing air leakage between window sills and doorways is another effective way to increase energy savings. Caulking window sills and ensuring gaps between doors remain as small as possible will help South Fletcher Sportsplex achieve its energy efficiency goals.

The following section will use thermal imagery to discuss areas of the Sportsplex that contain abnormally high rates of heat transfer, as well as the reason for these abnormalities.

MCW Custom Energy Solutions Ltd.

Results and Discussion

Figure 1: Outdoor Wall and the Ground

Thermal bridging can be noted at the intersection of the outdoor wall and the ground. This is caused by the use of a different material with a higher thermal conductivity at the bottom of the wall.

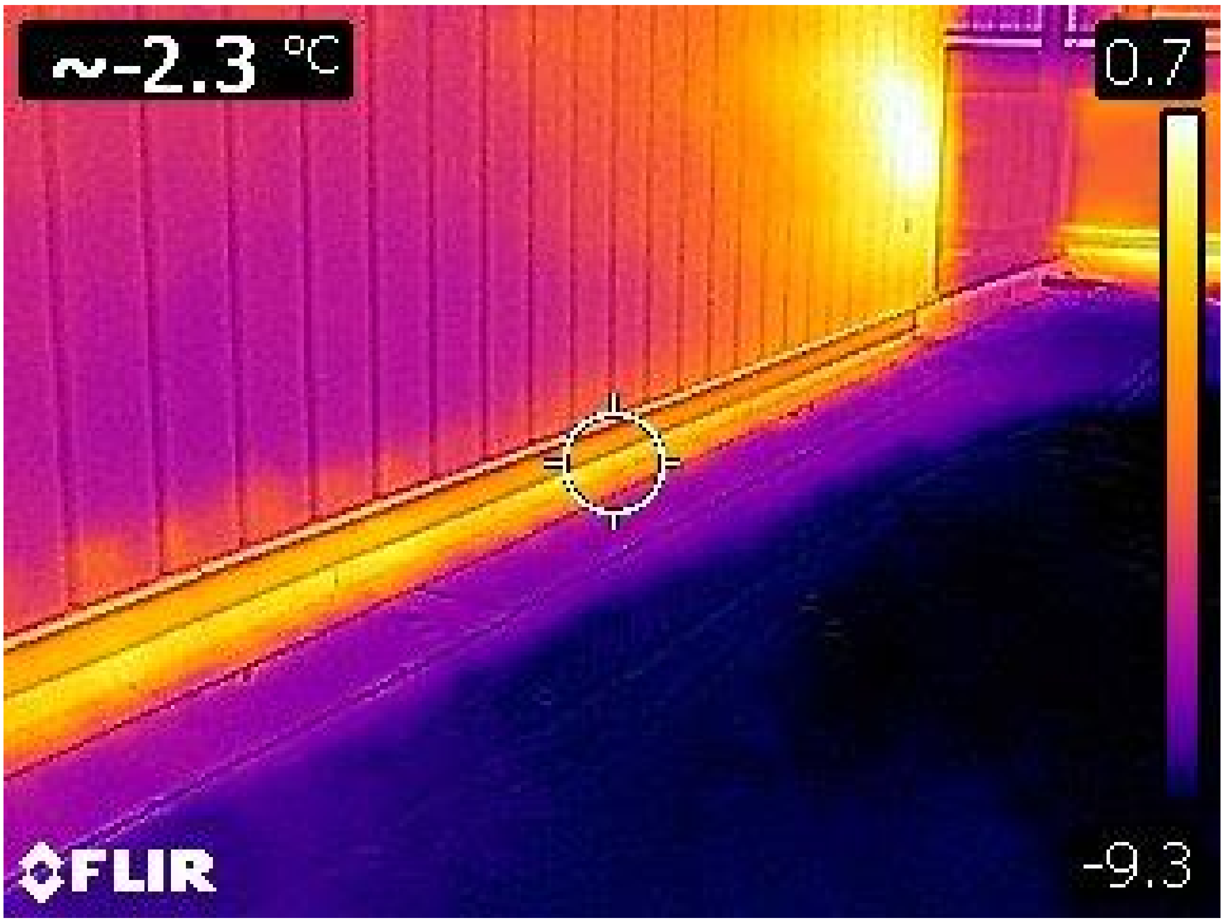


Figure 1

Figure 2: Window Borders & Lower Walls

Thermal bridging can be identified on the border of the windows as well as various sections of the wall below the windows. On top of this, a small amount of air leakage can be seen coming from the window seals.

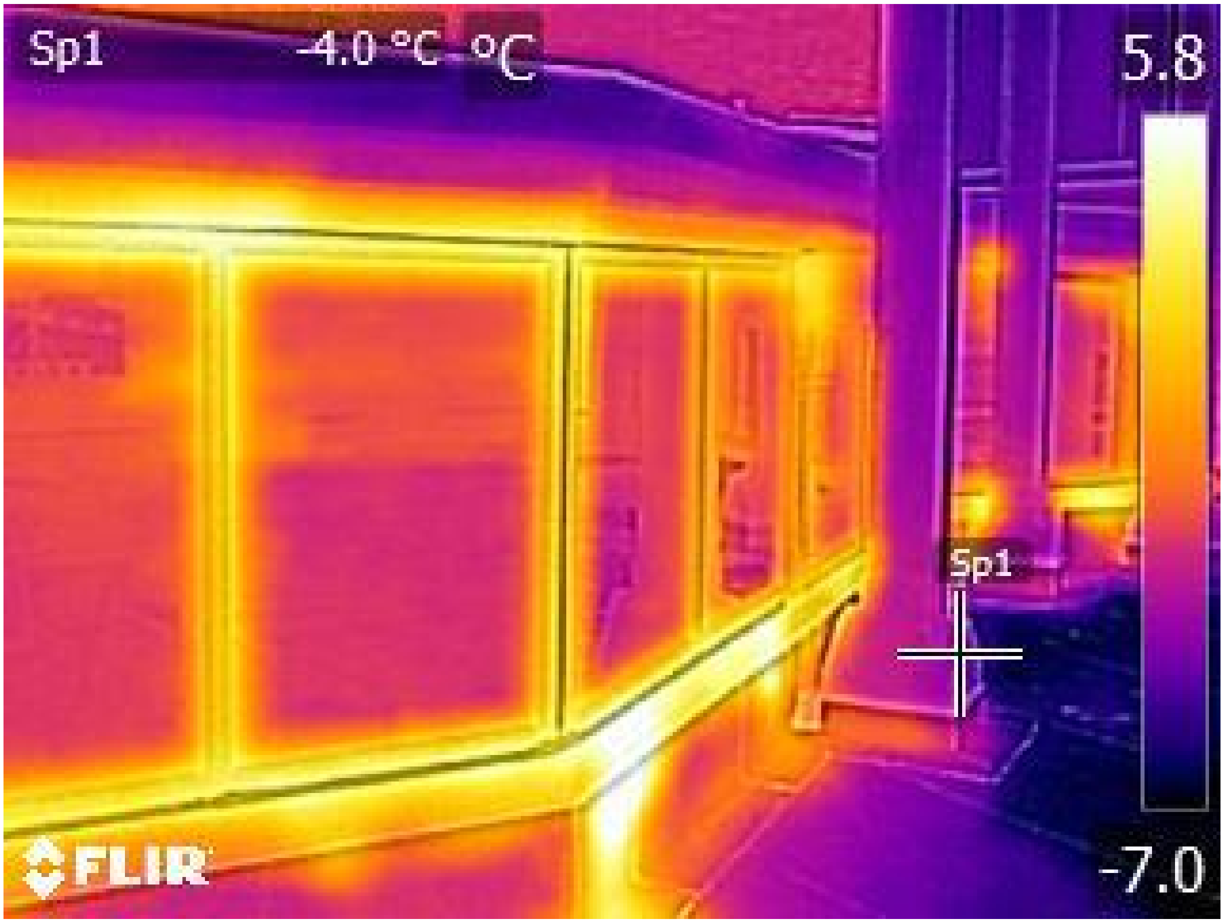


Figure 2

Figure 3: Window Siding

Thermal bridging can be seen on the siding of the windows, although no air leakage is present.

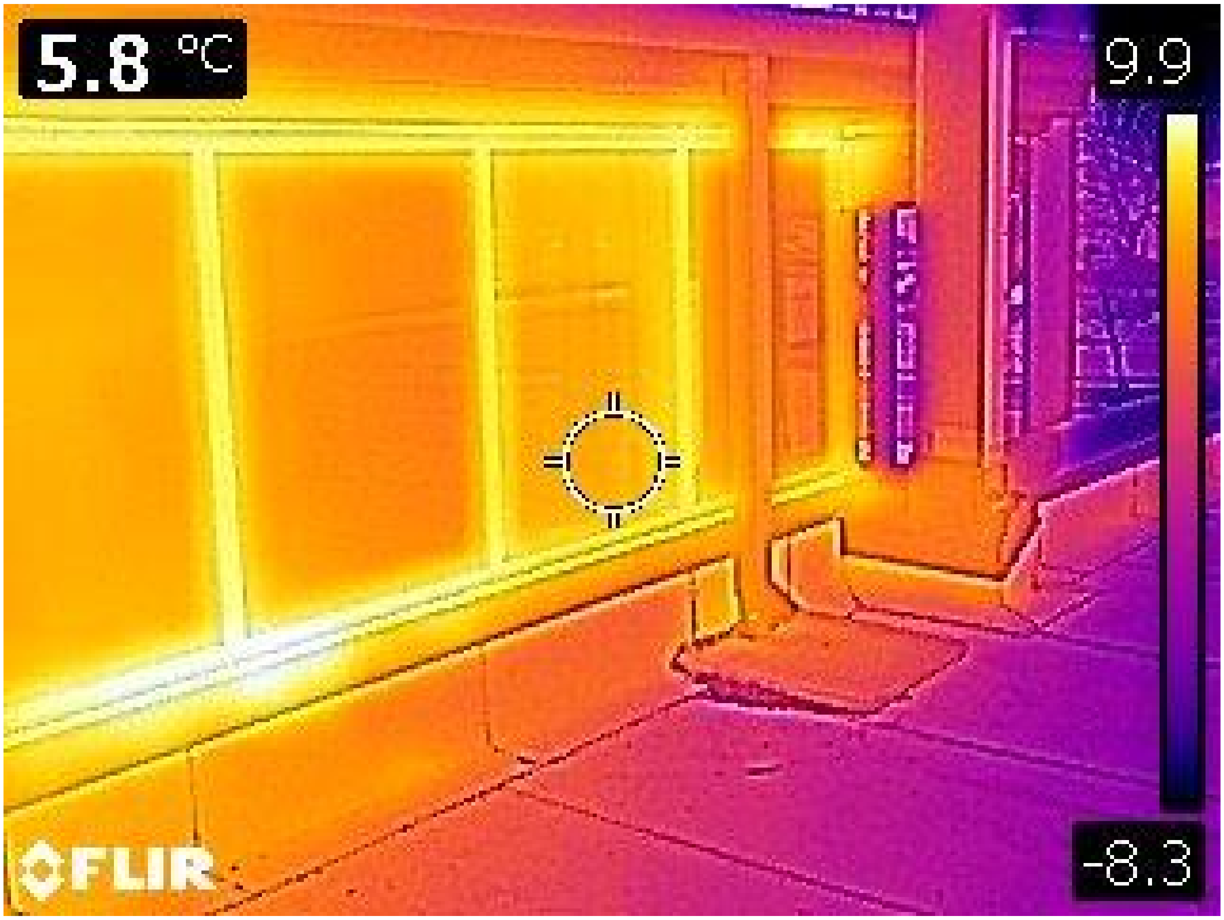


Figure 3

Figures 4-to-6: Doorways

Figure 4: Single Door Seal - Outdoor

Air leakage present around the perimeter of the doors. Although the door has a high thermal resistance, heat is allowed to escape through the cracks between the door and the wall.

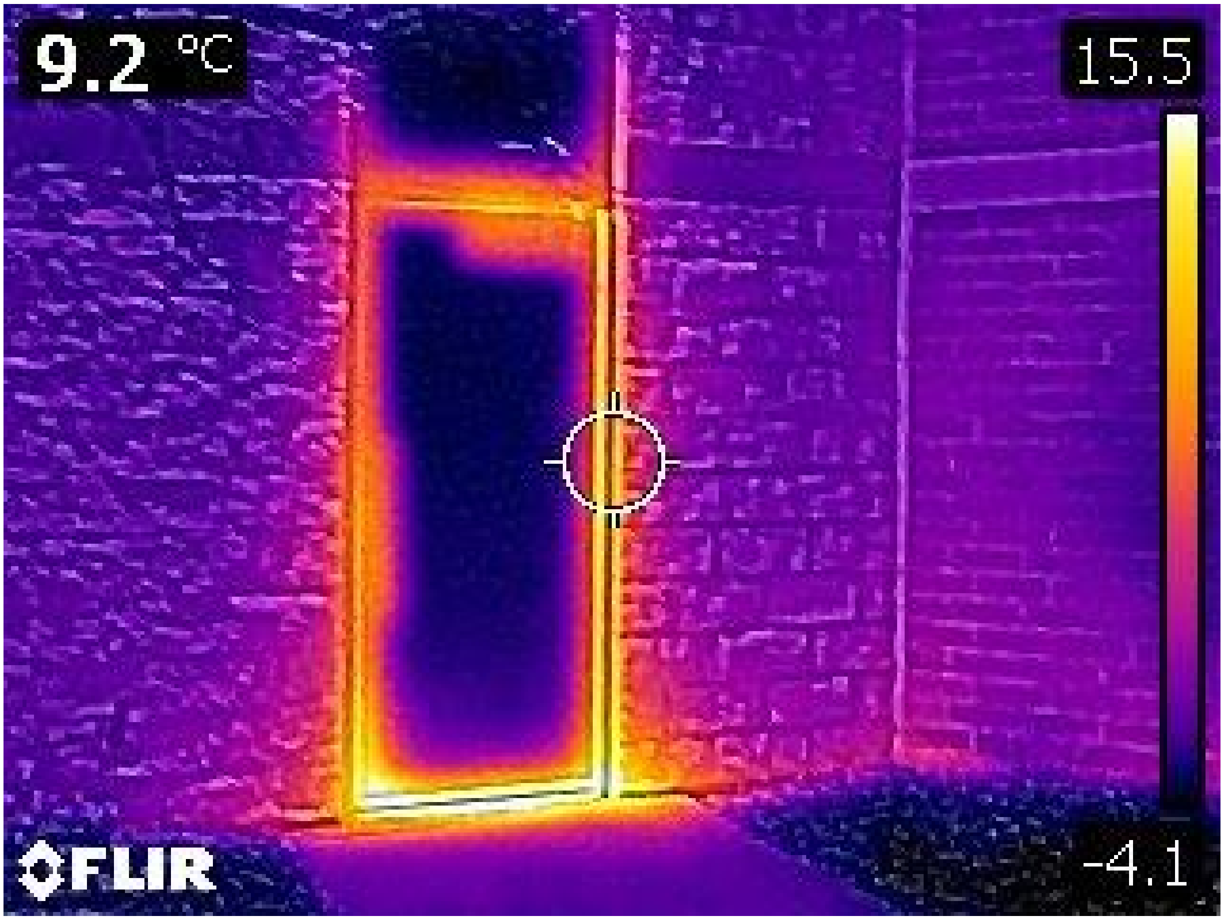


Figure 4

Figure 5: Double Doorway Seal - Outdoor

Thermal bridging and air leakage can be seen around the entire perimeter of the door. Air leakage is primarily present in the bottom right section of the door frame.

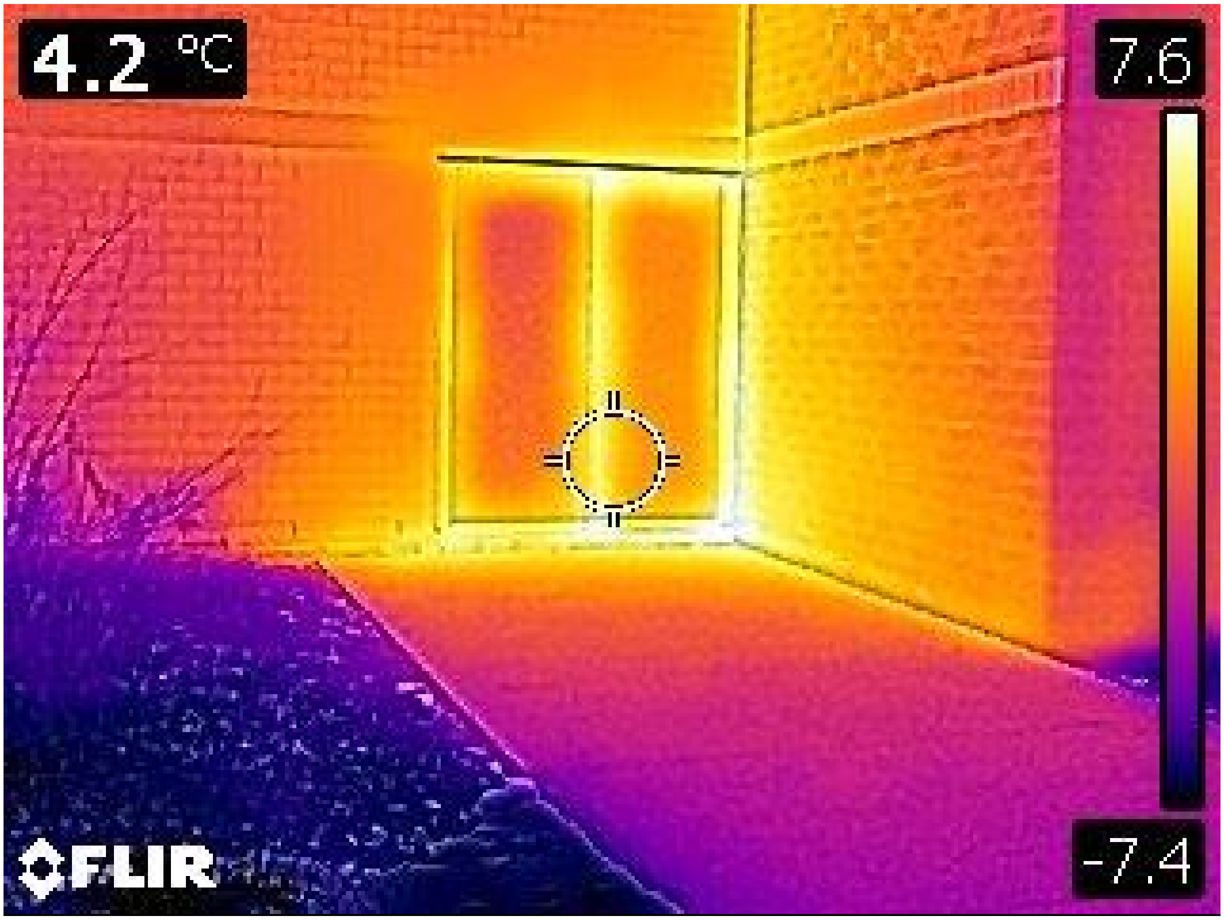


Figure 5

Figure 6: Double Doorway Seal – Indoor

Air leakage identified around the border of the door. The bottom of the door frame contains a higher degree of air leakage.

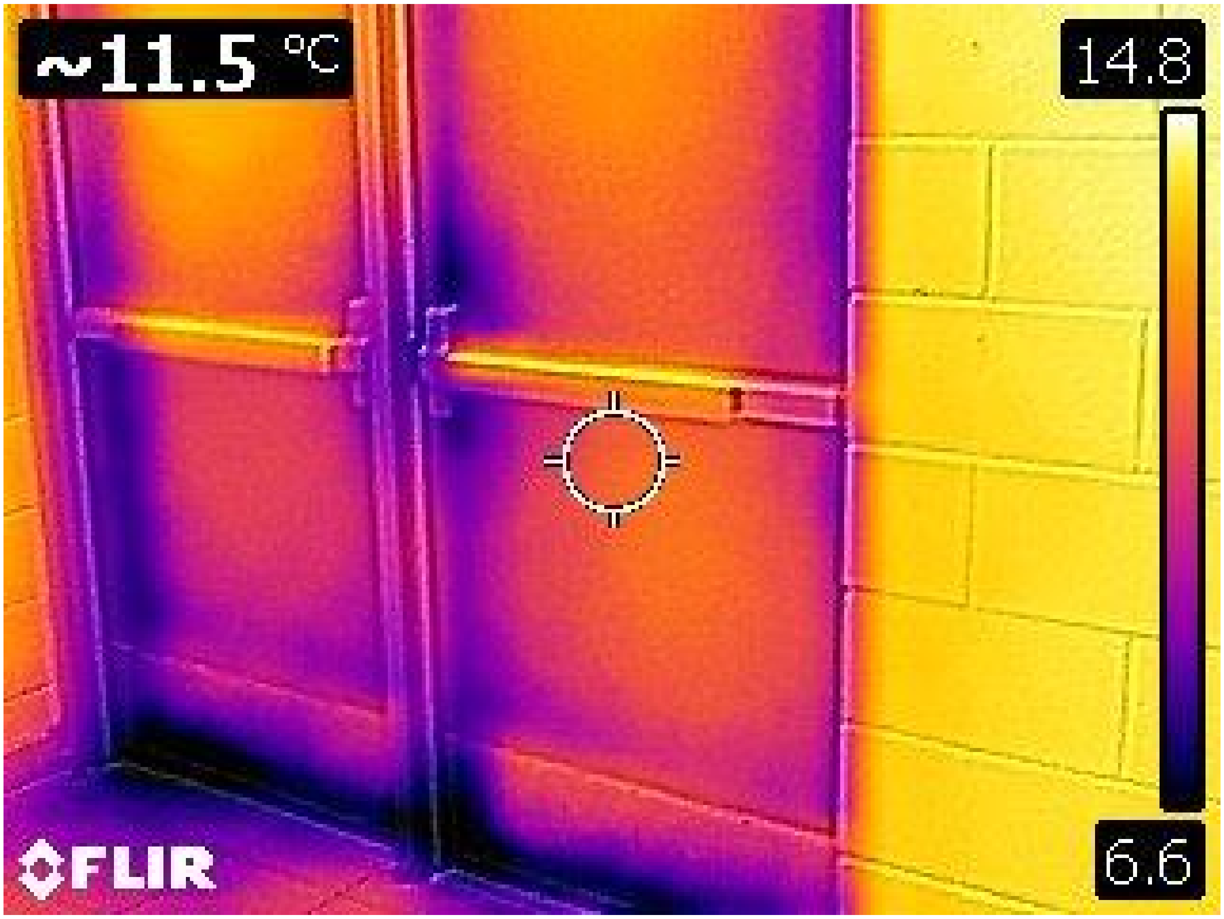


Figure 6

Conclusions

Thermal imaging was able to unveil various locations of the Brampton South Fletcher Sportsplex that are subject to air leakage and thermal bridging. It will be important to address these defects.in order to lower cooling and heating loads as much as possible, which will in turn increase energy efficiency.

This report includes thermal images that were taken on March 4th, 2020. While this is a suitable time for thermal imaging, MCW CES recommends conducting additional thermal imaging during the summer months. Summertime thermal imaging will enable greater visibility in to the impact of warm outdoor penetration on the cool, temperature-controlled indoor arena areas. This will be particularly important given the high costs for summertime cooling in the facility.

Appendix A:
Additional Thermal Imaging Samples

Figure A-1

Thermal bridging at the bottom of the wall.

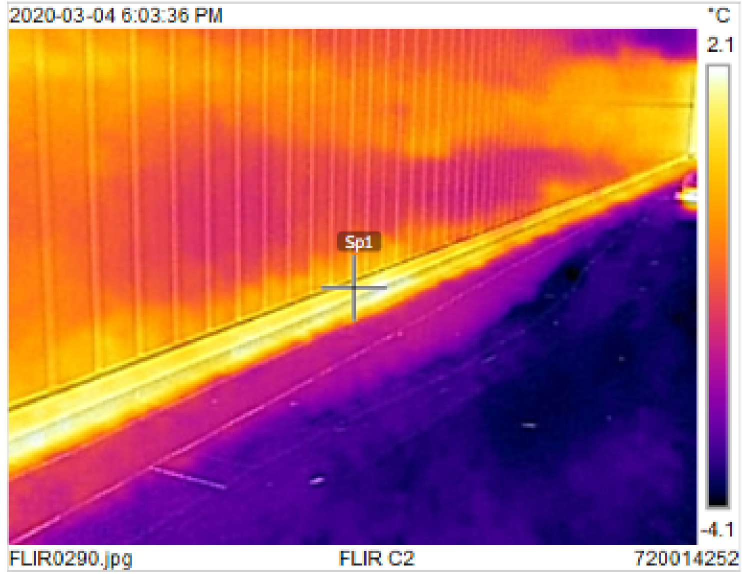


Figure A-2

Very slight thermal bridging at the lower portion of the wall.

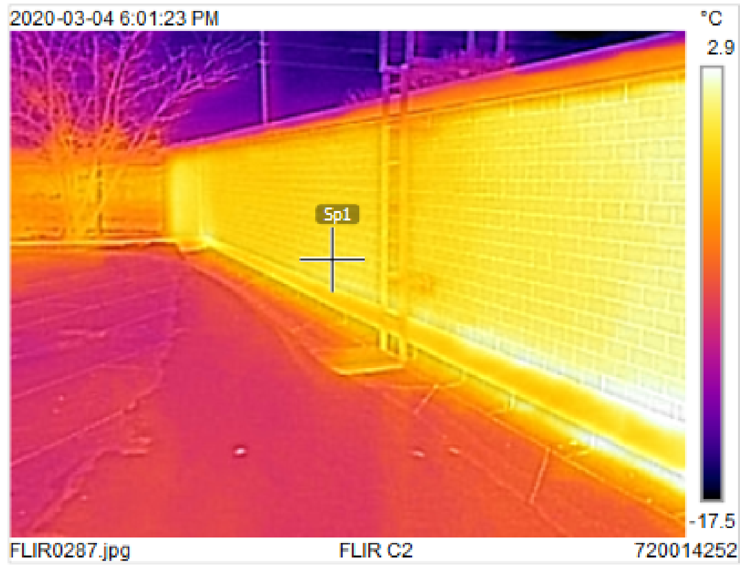


Figure A-3

Thermal bridging present around the window border.

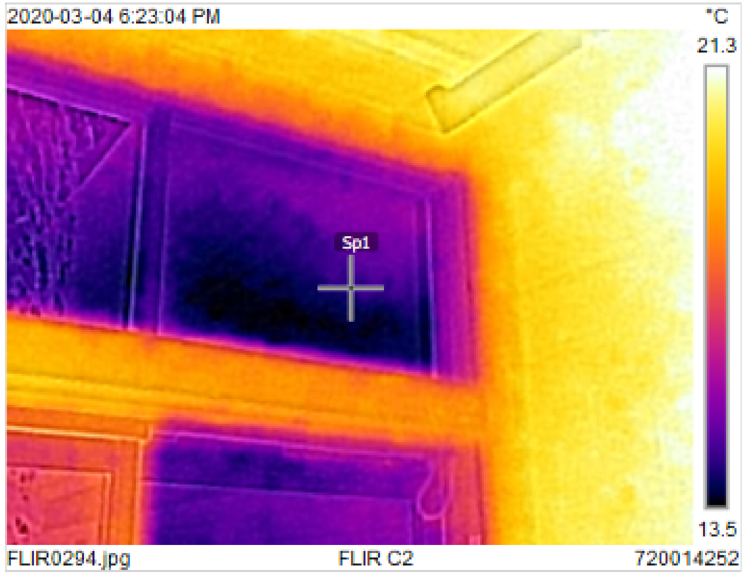


Figure A-4

Thermal bridging present around several window borders.

Figure A-5

Thermal bridging present around the border of the windows, as well as the supporting column.

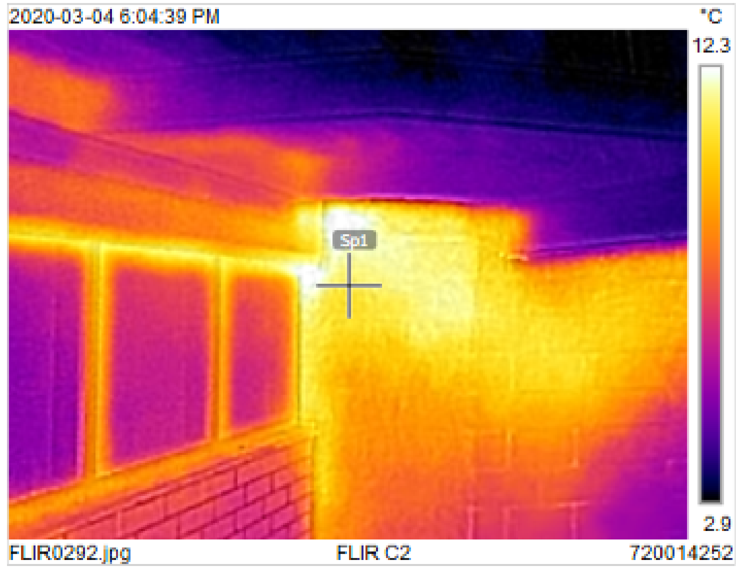
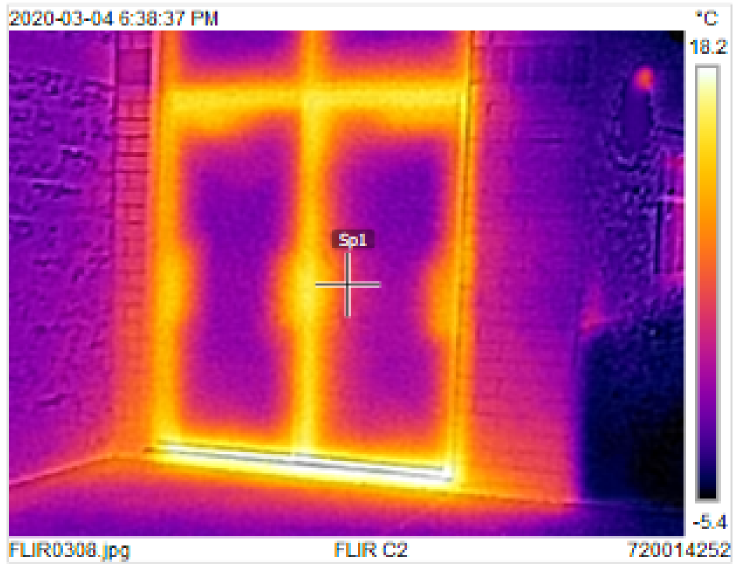


Figure A-6

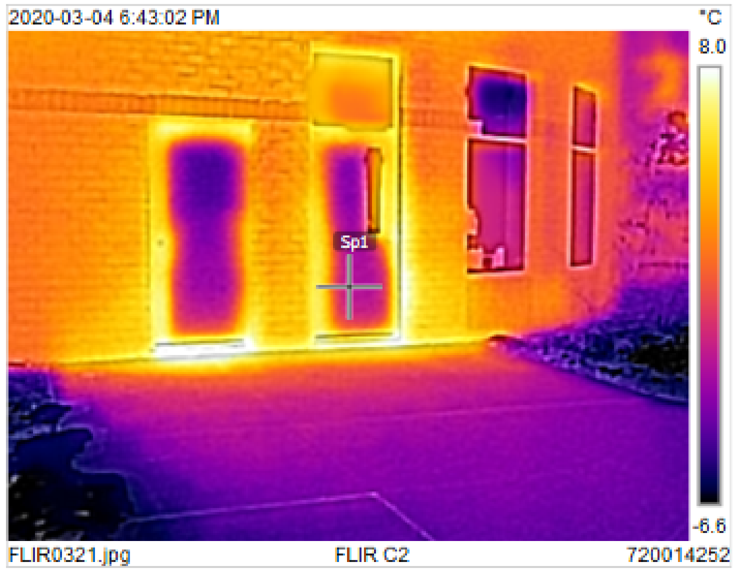
Serious air leakage around the entire border of the door, as well as thermal bridging on the lower portion of the door frame.



Custom Energy Solutions Ltd.

Figure A-7

Air leakage around the entire perimeter of the door, as well as thermal bridging on the lower section of both door frames.



APPENDIX E

LIGHTING LINE BY LINE AUDIT

APPENDIX F

BATTERY ENERGY STORAGE SYSTEM SINGLE LINE

APPENDIX G

DOMESTIC WATER MODEL

APPENDIX H

LIFE CYCLE COSTING ANALYSIS

OPTION 0 - BUSINESS AS USUAL CASE

BUILDING ASSETS

UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	$ 12,000	$ 1,200	$ 13,200
2	TEST	Exterior Lights	A02	IN	1996	30	24	2026	-	$ 30,000	$ 3,000	$ 33,000
3	TEST	BAS	C01	IN	1996	25	24	2021	$ 5,000	$ 400,000	$ 40,000	$ 440,000
4	TEST	Heating Boilers (Tagged to D01)	D01	IN	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
5	TEST	Heating Boilers (Tagged to D02)	D02	IN	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
6	TEST	DHW Boiler	D03	IN	1996	25	24	2021	$ 1,500	$ 110,100	$ 11,010	$ 121,110
7	TEST	Pool Boiler	D04	IN	1996	25	24	2021	$ 750	$ 65,000	$ 6,500	$ 71,500
8	TEST	Whilrpool Boiler	D05	IN	2010	25	10	2035	$ 750	$ 49,400	$ 4,940	$ 54,340
9	TEST	Heating Boilers (Tagged to D06)	D06	IN	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	IN	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	IN	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000
12	TEST	HRU 1	D07	IN	1996	30	24	2026	$ 3,000	$ 350,000	$ 35,000	$ 385,000
13	TEST	HRU 2	D07	IN	1996	30	24	2026	$ 3,000	$ 250,000	$ 25,000	$ 275,000
14	TEST	MUA 1	D07	IN	1996	30	24	2026	$ 1,000	$ 83,000	$ 8,300	$ 91,300
15	TEST	ERV 1&2	D07	IN	2018	30	2	2048	$ 2,000	$ 150,000	$ 15,000	$ 165,000
16	TEST	Dec-Tron	D07	IN	2018	30	2	2048	$ 3,000	$ 250,000	$ 25,000	$ 275,000
17	TEST	Terminal Heat Pumps	D09	IN	1996	30	24	2026	$ 2,500	$ 683,000	$ 68,300	$ 751,300
18	TEST	Heating Boilers (Tagged to D11)	D11	IN	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	IN	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	IN	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000
32	TEST	Heating Boilers (Tagged to D12)	D12	IN	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
21	TEST	Ice Plant (Tagged to E01)	E01	IN	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
22	TEST	Ice Plant (Tagged to E02A)	E02A	IN	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
33	TEST	Ice Plant (Tagged to E02B)	E02B	IN	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
23	TEST	Ice Resurfacers	E04	IN	2010	25	10	2035	$ 1,500	$ 183,000	-	$ 183,000
24	TEST	Arena Stand Heaters	E05	IN	1996	25	24	2021	$ 500	$ 62,000	$ 6,200	$ 68,200
25	TEST	Munters Arena Dehumidifier	E06	IN	2010	25	10	2035	$ 2,000	$ 200,000	$ 20,000	$ 220,000
26	TEST	Arid Ice Dehumidifiers	E06	IN	2018	25	2	2043	$ 2,000	$ 200,000	$ 20,000	$ 220,000
27	TEST	Windows	G01	IN	1996	50	24	2046	$ 9,500	$ 422,000	$ 42,200	$ 464,200
28	TEST	Phase I Roof	G02	IN	2018	25	2	2043	$ 1,000	$ 2,647,000	$ 264,700	$ 2,911,700
29	TEST	Phase II Roof	G03	IN	2018	25	2	2043	$ 1,000	$ 2,765,000	$ 276,500	$ 3,041,500
30	TEST	Phase I Exterior Walls	G04	IN	1996	50	24	2046	-	$ 1,645,000	$ 164,500	$ 1,809,500
31	TEST	Phase II Exterior Walls	G05	IN	1996	50	24	2046	-	$ 915,000	$ 91,500	$ 1,006,500
33	TEST	Interior Windows	G06	IN	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300
TOTAL						1,090	664		$ 227,500	$ 24,129,500	$ 2,394,650	$ 26,524,150

TERM YEARS / **TOTALS**

UNIFORMAT CODE	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
1	-	-	-	-	-	-	$ 13,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,280
2	-	-	-	-	-	-	$ 33,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -13,200
3	-	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -35,200
4	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
5	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
6	-	$ 121,110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -9,689
7	-	$ 71,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,720
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 54,340	-	-	-	-	-	-	-	-	-	$ -34,778
9	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
12	-	-	-	-	-	-	$ 385,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -154,000
13	-	-	-	-	-	-	$ 275,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -110,000
14	-	-	-	-	-	-	$ 91,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -36,520
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,000
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -55,000
17	-	-	-	-	-	-	$ 751,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -300,520
18	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
32	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
21	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
22	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
33	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	-	-	-	-	-	$ -117,120
24	-	$ 68,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,456
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 220,000	-	-	-	-	-	-	-	-	-	$ -140,800
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 220,000	-	$ -211,200
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 2,911,700	-	$ -2,795,232
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 3,041,500	-	$ -2,919,840
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
TOTAL	-	$ 13,136,312	-	-	-	-	$ 1,548,801	-	-	-	-	-	-	-	-	$ 457,341	-	-	-	-	-	-	-	$ 6,173,201	-	$ -10,457,014

PROGRAM 50% A

BUILDING ASSETS													TERM YEARS																									TOTALS
UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	TEST	Exterior Lights	A02	OUT	1996	30	24	2026	-	$ 30,000	$ 3,000	$ 33,000	-	-	-	-	-	-	$ 33,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -13,200
3	TEST	BAS	C01	OUT	1996	25	24	2021	$ 5,000	$ 400,000	$ 40,000	$ 440,000	-	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -35,200
4	TEST	Heating Boilers (Tagged to D01)	D01	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
5	TEST	Heating Boilers (Tagged to D02)	D02	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
6	TEST	DHW Boiler	D03	OUT	1996	25	24	2021	$ 1,500	$ 110,100	$ 11,010	$ 121,110	-	$ 121,110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -9,689
7	TEST	Pool Boiler	D04	OUT	1996	25	24	2021	$ 750	$ 65,000	$ 6,500	$ 71,500	-	$ 71,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,720
8	TEST	Whirlpool Boiler	D05	OUT	2010	25	10	2035	$ 750	$ 49,400	$ 4,940	$ 54,340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 54,340	-	-	-	-	-	-	-	-	-	$ -34,778
9	TEST	Heating Boilers (Tagged to D06)	D06	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
12	TEST	HRU 1	D07	OUT	1996	30	24	2026	$ 3,000	$ 350,000	$ 35,000	$ 385,000	-	-	-	-	-	-	$ 385,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -154,000
13	TEST	HRU 2	D07	OUT	1996	30	24	2026	$ 3,000	$ 250,000	$ 25,000	$ 275,000	-	-	-	-	-	-	$ 275,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -110,000
14	TEST	MUA 1	D07	OUT	1996	30	24	2026	$ 1,000	$ 83,000	$ 8,300	$ 91,300	-	-	-	-	-	-	$ 91,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -36,520
15	TEST	ERV 1&2	D07	OUT	2018	30	2	2048	$ 2,000	$ 150,000	$ 15,000	$ 165,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,000
16	TEST	Dec-Tron	D07	OUT	2018	30	2	2048	$ 3,000	$ 250,000	$ 25,000	$ 275,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -55,000
17	TEST	Terminal Heat Pumps	D09	OUT	1996	30	24	2026	$ 2,500	$ 683,000	$ 68,300	$ 751,300	-	-	-	-	-	-	$ 751,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -300,520
18	TEST	Heating Boilers (Tagged to D11)	D11	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
32	TEST	Heating Boilers (Tagged to D12)	D12	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
21	TEST	Ice Plant (Tagged to E01)	E01	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
22	TEST	Ice Plant (Tagged to E02A)	E02A	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	TEST	Ice Plant (Tagged to E02B)	E02B	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
23	TEST	Ice Resurfacers	E04	OUT	2010	25	10	2035	$ 1,500	$ 183,000	-	$ 183,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	-	-	-	-	-	$ -117,120
24	TEST	Arena Stand Heaters	E05	OUT	1996	25	24	2021	$ 500	$ 62,000	$ 6,200	$ 68,200	-	$ 68,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,456
25	TEST	Munters Arena Dehumidifier	E06	OUT	2010	25	10	2035	$ 2,000	$ 200,000	$ 20,000	$ 220,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 220,000	-	-	-	-	-	-	-	-	-	$ -140,800
26	TEST	Arid Ice Dehumidifiers	E06	OUT	2018	25	2	2043	$ 2,000	$ 200,000	$ 20,000	$ 220,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 220,000	-	$ -211,200
27	TEST	Windows	G01	OUT	1996	50	24	2046	$ 9,500	$ 422,000	$ 42,200	$ 464,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
28	TEST	Phase I Roof	G02	OUT	2018	25	2	2043	$ 1,000	$ 2,647,000	$ 264,700	$ 2,911,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 2,911,700	-	$ -2,795,232
29	TEST	Phase II Roof	G03	OUT	2018	25	2	2043	$ 1,000	$ 2,765,000	$ 276,500	$ 3,041,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 3,041,500	-	$ -2,919,840
30	TEST	Phase I Exterior Walls	G04	OUT	1996	50	24	2046	-	$ 1,645,000	$ 164,500	$ 1,809,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
31	TEST	Phase II Exterior Walls	G05	OUT	1996	50	24	2046	-	$ 915,000	$ 91,500	$ 1,006,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
33	TEST	Interior Windows	G06	OUT	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
	Energy Conservation M	LED Retrofits & New Fixtures (Interior)	A01	IN	2020	13	-	2033	$ -4,000	$ 22,183	$ 2,218	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	$ -3,754
	Energy Conservation M	LED New Fixtures (Exterior)	A02	OUT	2020	24	-	2044	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-
	Energy Conservation M	Lighting Controls (Basic)	A03	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Lighting Controls (Arena)	A04	IN	2020	20	-	2040	-	$ 10,331	$ 1,033	$ 11,364	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 11,365	-	-	-	-	$ -9,091
	Energy Conservation M	Battery Energy Storage System (City Owned)	B01	IN	2020	30	-	2050	$ 10,000	$ 991,000	$ 99,100	$ 1,090,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -218,020
	Energy Conservation M	Battery Energy Storage as a Service	B02	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Demand Control Ventilation	C01	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Analytic Control Tuning	C02	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing	D01	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing Lower Water Temperat	D02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	DHW Boiler - Condensing	D03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Pool Boiler - Condensing	D04	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - Low Temp Loop	D05	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - High Temp Loop	D06	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	AHU Replacement	D07	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	AHU VAV Conversion	D08	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Heat Pump Replacement	D09	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Low Temp Loop Variable Speed Pumping	D10	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Waste Water HR - High Temp Loop	D11	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	District Energy Integration	D12	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - Ammonia Plate and Fram	E01	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - C02 - Indirect Slab Coolin	E02A	IN	2020	25	-	2045	-	$ 3,282,000	$ 328,200	$ 3,610,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -144,408
	Energy Conservation M	Chiller Replacement w HR - C02 - Direct Slab Cooling	E02B	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Cold Water Flooding	E03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ice Resurfacer Replacement	E04	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Radiant Heating Conversion	E05	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Dehumidifier Conversion	E06	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Pool and Whirlpool VFD	F01	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Pool Temperature Setback	F02	IN	2020	50	-	2070	-	$ 8,000	$ 800	$ 8,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,576
	Energy Conservation M	High Performance Glazing	G01	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase I	G02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase II	G03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase I	G04	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase II	G05	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Interior Window Replacement	G06	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Domestic Water Retrofits	H01	IN	2020	10	-	2030	-	$ 101,000	$ 10,100	$ 111,100	-	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	$ -66,660
	Energy Conservation M	Solar PV - Roof - 1.18 MW array	I01A	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar PV - Roof - 0.60 MW array	I01B	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar PV - Parking Lot - 1.03 MW array	I02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar Thermal - Pool Heating	I03	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Remove In Stand Heating	J01	OUT	2020	-	-	2020	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL						203	48		$ 6,000	$ 4,414,514	$ 441,451	$ 4,855,965	-	$ 0	-	-	-	-	$ 0	-	-	-	$ 111,100	-	-	$ 24,401	-	-	-	-	-	-	$ 122,465	-	-	-	-	$ -446,509

PROGRAM 50% B

BUILDING ASSETS													TERM YEARS																									TOTALS
UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	TEST	Exterior Lights	A02	OUT	1996	30	24	2026	-	$ 30,000	$ 3,000	$ 33,000	-	-	-	-	-	-	$ 33,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -13,200
3	TEST	BAS	C01	OUT	1996	25	24	2021	$ 5,000	$ 400,000	$ 40,000	$ 440,000	-	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -35,200
4	TEST	Heating Boilers (Tagged to D01)	D01	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
5	TEST	Heating Boilers (Tagged to D02)	D02	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
6	TEST	DHW Boiler	D03	OUT	1996	25	24	2021	$ 1,500	$ 110,100	$ 11,010	$ 121,110	-	$ 121,110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -9,689
7	TEST	Pool Boiler	D04	OUT	1996	25	24	2021	$ 750	$ 65,000	$ 6,500	$ 71,500	-	$ 71,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,720
8	TEST	Whirlpool Boiler	D05	OUT	2010	25	10	2035	$ 750	$ 49,400	$ 4,940	$ 54,340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 54,340	-	-	-	-	-	-	-	-	-	$ -34,778
9	TEST	Heating Boilers (Tagged to D06)	D06	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
12	TEST	HRU 1	D07	OUT	1996	30	24	2026	$ 3,000	$ 350,000	$ 35,000	$ 385,000	-	-	-	-	-	-	$ 385,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -154,000
13	TEST	HRU 2	D07	OUT	1996	30	24	2026	$ 3,000	$ 250,000	$ 25,000	$ 275,000	-	-	-	-	-	-	$ 275,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -110,000
14	TEST	MUA 1	D07	OUT	1996	30	24	2026	$ 1,000	$ 83,000	$ 8,300	$ 91,300	-	-	-	-	-	-	$ 91,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -36,520
15	TEST	ERV 1&2	D07	OUT	2018	30	2	2048	$ 2,000	$ 150,000	$ 15,000	$ 165,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,000
16	TEST	Dec-Tron	D07	OUT	2018	30	2	2048	$ 3,000	$ 250,000	$ 25,000	$ 275,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -55,000
17	TEST	Terminal Heat Pumps	D09	OUT	1996	30	24	2026	$ 2,500	$ 683,000	$ 68,300	$ 751,300	-	-	-	-	-	-	$ 751,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -300,520
18	TEST	Heating Boilers (Tagged to D11)	D11	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
32	TEST	Heating Boilers (Tagged to D12)	D12	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	TEST	Ice Plant (Tagged to E01)	E01	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	TEST	Ice Plant (Tagged to E02A)	E02A	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
33	TEST	Ice Plant (Tagged to E02B)	E02B	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
23	TEST	Ice Resurfacers	E04	OUT	2010	25	10	2035	$ 1,500	$ 183,000	-	$ 183,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	-	-	-	-	-	$ -117,120
24	TEST	Arena Stand Heaters	E05	OUT	1996	25	24	2021	$ 500	$ 62,000	$ 6,200	$ 68,200	-	$ 68,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,456
25	TEST	Munters Arena Dehumidifier	E06	OUT	2010	25	10	2035	$ 2,000	$ 200,000	$ 20,000	$ 220,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 220,000	-	-	-	-	-	-	-	-	-	$ -140,800
26	TEST	Arid Ice Dehumidifiers	E06	OUT	2018	25	2	2043	$ 2,000	$ 200,000	$ 20,000	$ 220,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 220,000	-	$ -211,200
27	TEST	Windows	G01	OUT	1996	50	24	2046	$ 9,500	$ 422,000	$ 42,200	$ 464,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
28	TEST	Phase I Roof	G02	OUT	2018	25	2	2043	$ 1,000	$ 2,647,000	$ 264,700	$ 2,911,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 2,911,700	-	$ -2,795,232
29	TEST	Phase II Roof	G03	OUT	2018	25	2	2043	$ 1,000	$ 2,765,000	$ 276,500	$ 3,041,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 3,041,500	-	$ -2,919,840
30	TEST	Phase I Exterior Walls	G04	OUT	1996	50	24	2046	-	$ 1,645,000	$ 164,500	$ 1,809,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
31	TEST	Phase II Exterior Walls	G05	OUT	1996	50	24	2046	-	$ 915,000	$ 91,500	$ 1,006,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
33	TEST	Interior Windows	G06	OUT	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
	Energy Conservation M	LED Retrofits & New Fixtures (Interior)	A01	IN	2020	13	-	2033	$ -4,000	$ 22,183	$ 2,218	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	$ -3,754
	Energy Conservation M	LED New Fixtures (Exterior)	A02	OUT	2020	24	-	2044	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-
	Energy Conservation M	Lighting Controls (Basic)	A03	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Lighting Controls (Arena)	A04	IN	2020	20	-	2040	-	$ 10,331	$ 1,033	$ 11,364	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 11,365	-	-	-	-	$ -9,091
	Energy Conservation M	Battery Energy Storage System (City Owned)	B01	IN	2020	30	-	2050	$ 10,000	$ 991,000	$ 99,100	$ 1,090,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -218,020
	Energy Conservation M	Battery Energy Storage as a Service	B02	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Demand Control Ventilation	C01	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Analytic Control Tuning	C02	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing	D01	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing Lower Water Temperatu	D02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	DHW Boiler - Condensing	D03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Pool Boiler - Condensing	D04	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - Low Temp Loop	D05	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - High Temp Loop	D06	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	AHU Replacement	D07	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	AHU VAV Conversion	D08	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Heat Pump Replacement	D09	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Low Temp Loop Variable Speed Pumping	D10	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Waste Water HR - High Temp Loop	D11	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	District Energy Integration	D12	IN	2020	25	-	2045	-	$ 691,000	$ 69,100	$ 760,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -30,404
	Energy Conservation M	Chiller Replacement w HR - Ammonia Plate and Frame	E01	IN	2020	25	-	2045	-	$ 3,134,000	$ 313,400	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -137,896
	Energy Conservation M	Chiller Replacement w HR - C02 - Indirect Slab Cooling	E02A	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - C02 - Direct Slab Cooling	E02B	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Cold Water Flooding	E03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ice Resurfacer Replacement	E04	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Radiant Heating Conversion	E05	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Dehumidifier Conversion	E06	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Pool and Whirlpool VFD	F01	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Pool Temperature Setback	F02	IN	2020	50	-	2070	-	$ 8,000	$ 800	$ 8,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,576
	Energy Conservation M	High Performance Glazing	G01	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase I	G02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase II	G03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase I	G04	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase II	G05	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Interior Window Replacement	G06	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Domestic Water Retrofits	H01	IN	2020	10	-	2030	-	$ 101,000	$ 10,100	$ 111,100	-	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	$ -66,660
	Energy Conservation M	Solar PV - Roof - 1.18 MW array	I01A	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar PV - Roof - 0.60 MW array	I01B	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar PV - Parking Lot - 1.03 MW array	I02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar Thermal - Pool Heating	I03	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Remove In Stand Heating	J01	OUT	2020	-	-	2020	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL						253	72		$ 6,000	$ 4,957,514	$ 495,751	$ 5,453,265	-	$ 0	-	-	-	-	$ 0	-	-	-	$ 111,100	-	-	$ 24,401	-	-	-	-	-	-	$ 122,465	-	-	-	-	$ -470,401

PROGRAM 50% C

BUILDING ASSETS												
UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	-	-	-
2	TEST	Exterior Lights	A02	OUT	1996	30	24	2026	-	$ 30,000	$ 3,000	$ 33,000
3	TEST	BAS	C01	IN	1996	25	24	2021	-	-	-	-
4	TEST	Heating Boilers (Tagged to D01)	D01	IN	1996	25	24	2021	-	-	-	-
5	TEST	Heating Boilers (Tagged to D02)	D02	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
6	TEST	DHW Boiler	D03	IN	1996	25	24	2021	-	-	-	-
7	TEST	Pool Boiler	D04	IN	1996	25	24	2021	-	-	-	-
8	TEST	Whilrpool Boiler	D05	OUT	2010	25	10	2035	$ 750	$ 49,400	$ 4,940	$ 54,340
9	TEST	Heating Boilers (Tagged to D06)	D06	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000
12	TEST	HRU 1	D07	IN	1996	30	24	2026	-	-	-	-
13	TEST	HRU 2	D07	IN	1996	30	24	2026	-	-	-	-
14	TEST	MUA 1	D07	IN	1996	30	24	2026	-	-	-	-
15	TEST	ERV 1&2	D07	IN	2018	30	2	2048	-	-	-	-
16	TEST	Dec-Tron	D07	IN	2018	30	2	2048	-	-	-	-
17	TEST	Terminal Heat Pumps	D09	IN	1996	30	24	2026	-	-	-	-
18	TEST	Heating Boilers (Tagged to D11)	D11	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000
32	TEST	Heating Boilers (Tagged to D12)	D12	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
21	TEST	Ice Plant (Tagged to E01)	E01	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
22	TEST	Ice Plant (Tagged to E02A)	E02A	IN	1996	25	24	2021	-	-	-	-
33	TEST	Ice Plant (Tagged to E02B)	E02B	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
23	TEST	Ice Resurfacers	E04	OUT	2010	25	10	2035	$ 1,500	$ 183,000	-	$ 183,000
24	TEST	Arena Stand Heaters	E05	OUT	1996	25	24	2021	$ 500	$ 62,000	$ 6,200	$ 68,200
25	TEST	Munters Arena Dehumidifier	E06	OUT	2010	25	10	2035	$ 2,000	$ 200,000	$ 20,000	$ 220,000
26	TEST	Arid Ice Dehumidifiers	E06	OUT	2018	25	2	2043	$ 2,000	$ 200,000	$ 20,000	$ 220,000
27	TEST	Windows	G01	OUT	1996	50	24	2046	$ 9,500	$ 422,000	$ 42,200	$ 464,200
28	TEST	Phase I Roof	G02	OUT	2018	25	2	2043	$ 1,000	$ 2,647,000	$ 264,700	$ 2,911,700
29	TEST	Phase II Roof	G03	OUT	2018	25	2	2043	$ 1,000	$ 2,765,000	$ 276,500	$ 3,041,500
30	TEST	Phase I Exterior Walls	G04	OUT	1996	50	24	2046	-	$ 1,645,000	$ 164,500	$ 1,809,500
31	TEST	Phase II Exterior Walls	G05	OUT	1996	50	24	2046	-	$ 915,000	$ 91,500	$ 1,006,500
33	TEST	Interior Windows	G06	OUT	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300
	Energy Conservation M	LED Retrofits & New Fixtures (Interior)	A01	IN	2020	13	-	2033	$ -4,000	$ 22,183	$ 2,218	$ 24,401
	Energy Conservation M	LED New Fixtures (Exterior)	A02	OUT	2020	24	-	2044	-	-	-	-
	Energy Conservation M	Lighting Controls (Basic)	A03	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Lighting Controls (Arena)	A04	IN	2020	20	-	2040	-	$ 10,331	$ 1,033	$ 11,364
	Energy Conservation M	Battery Energy Storage System (City Owned)	B01	IN	2020	30	-	2050	$ 10,000	$ 991,000	$ 99,100	$ 1,090,100
	Energy Conservation M	Battery Energy Storage as a Service	B02	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Demand Control Ventilation	C01	IN	2020	20	-	2040	$ 3,000	$ 592,000	$ 59,200	$ 651,200
	Energy Conservation M	Analytic Control Tuning	C02	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing	D01	IN	2020	25	-	2045	-	$ 462,000	$ 46,200	$ 508,200
	Energy Conservation M	Heating Boilers - Condensing Lower Water Temperatu	D02	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	DHW Boiler - Condensing	D03	IN	2020	25	-	2045	-	$ 147,000	$ 14,700	$ 161,700
	Energy Conservation M	Pool Boiler - Condensing	D04	IN	2020	25	-	2045	-	$ 188,000	$ 18,800	$ 206,800
	Energy Conservation M	Ground Source Heat Loop - Low Temp Loop	D05	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - High Temp Loop	D06	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	AHU Replacement	D07	IN	2020	25	-	2045	$ 1,500	$ 2,268,000	$ 226,800	$ 2,494,800
	Energy Conservation M	AHU VAV Conversion	D08	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Heat Pump Replacement	D09	IN	2020	25	-	2045	-	$ 761,000	$ 76,100	$ 837,100
	Energy Conservation M	Low Temp Loop Variable Speed Pumping	D10	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Waste Water HR - High Temp Loop	D11	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	District Energy Integration	D12	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - Ammonia Plate and Frame	E01	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - C02 - Indirect Slab Cooling	E02A	IN	2020	25	-	2045	-	$ 3,282,000	$ 328,200	$ 3,610,200
	Energy Conservation M	Chiller Replacement w HR - C02 - Direct Slab Cooling	E02B	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Cold Water Flooding	E03	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Ice Resurfacer Replacement	E04	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Radiant Heating Conversion	E05	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Dehumidifier Conversion	E06	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Pool and Whirlpool VFD	F01	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Pool Temperature Setback	F02	IN	2020	50	-	2070	-	$ 8,000	$ 800	$ 8,800
	Energy Conservation M	High Performance Glazing	G01	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase I	G02	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase II	G03	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase I	G04	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase II	G05	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Interior Window Replacement	G06	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Domestic Water Retrofits	H01	IN	2020	10	-	2030	-	$ 101,000	$ 10,100	$ 111,100
	Energy Conservation M	Solar PV - Roof - 1.18 MW array	I01A	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Solar PV - Roof - 0.60 MW array	I01B	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Solar PV - Parking Lot - 1.03 MW array	I02	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Solar Thermal - Pool Heating	I03	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Remove In Stand Heating	J01	OUT	2020	-	-	2020	-	-	-	-
TOTAL						628	244		$ 10,500	$ 8,832,514	$ 883,251	$ 9,715,765

	TERM YEARS																									TOTALS
COMPONENT	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
Lobby Lights	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Lights	-	-	-	-	-	-	$ 33,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -13,200
BAS	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D01)	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D02)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
DHW Boiler	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pool Boiler	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whilrpool Boiler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 54,340	-	-	-	-	-	-	-	-	-	$ -34,778
Heating Boilers (Tagged to D06)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Hot Water Loop Piping (Tagged to D06)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
Hot Water Terminal Units (tagged to D06)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
HRU 1	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HRU 2	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MUA 1	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ERV 1&2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec-Tron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Terminal Heat Pumps	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D11)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Hot Water Loop Piping (Tagged to D11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
Hot Water Terminal Units (tagged to D11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
Heating Boilers (Tagged to D12)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Ice Plant (Tagged to E01)	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
Ice Plant (Tagged to E02A)	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ice Plant (Tagged to E02B)	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
Ice Resurfacers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	-	-	-	-	-	$ -117,120
Arena Stand Heaters	-	$ 68,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,456
Munters Arena Dehumidifier	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 220,000	-	-	-	-	-	-	-	-	-	$ -140,800
Arid Ice Dehumidifiers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 220,000	-	$ -211,200
Windows	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
Phase I Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 2,911,700	-	$ -2,795,232
Phase II Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 3,041,500	-	$ -2,919,840
Phase I Exterior Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
Phase II Exterior Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
Interior Windows	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
LED Retrofits & New Fixtures (Interior)	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	$ -3,754
LED New Fixtures (Exterior)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-
Lighting Controls (Basic)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Lighting Controls (Arena)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 11,365	-	-	-	-	$ -9,091
Battery Energy Storage System (City Owned)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -218,020
Battery Energy Storage as a Service	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demand Control Ventilation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 651,200	-	-	-	-	$ -520,960
Analytic Control Tuning	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Heating Boilers - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -20,328
Heating Boilers - Condensing Lower Water Temperatu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DHW Boiler - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,468
Pool Boiler - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -8,272
Ground Source Heat Loop - Low Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ground Source Heat Loop - High Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AHU Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -99,792
AHU VAV Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Pump Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,484
Low Temp Loop Variable Speed Pumping	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste Water HR - High Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District Energy Integration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chiller Replacement w HR - Ammonia Plate and Frame	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chiller Replacement w HR - C02 - Indirect Slab Cooling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -144,408
Chiller Replacement w HR - C02 - Direct Slab Cooling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cold Water Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ice Resurfacer Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Radiant Heating Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dehumidifier Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pool and Whirlpool VFD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Pool Temperature Setback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,576
High Performance Glazing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof Insulation - Phase I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof Insulation - Phase II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Wall Insulation - Phase I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Wall Insulation - Phase II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interior Window Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Domestic Water Retrofits	-	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	$ -66,660
Solar PV - Roof - 1.18 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar PV - Roof - 0.60 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar PV - Parking Lot - 1.03 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar Thermal - Pool Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Remove In Stand Heating	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	$ 1	-	-	-	-	$ 1	-	-	-	$ 111,100	-	-	$ 24,401	-	-	-	-	-	-	$ 773,665	-	-	-	-	$ -1,135,813

PROGRAM 80% A

BUILDING ASSETS

UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	-	-	-
2	TEST	Exterior Lights	A02	OUT	1996	30	24	2026	-	$ 30,000	$ 3,000	$ 33,000
3	TEST	BAS	C01	IN	1996	25	24	2021	-	-	-	-
4	TEST	Heating Boilers (Tagged to D01)	D01	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
5	TEST	Heating Boilers (Tagged to D02)	D02	IN	1996	25	24	2021	-	-	-	-
6	TEST	DHW Boiler	D03	IN	1996	25	24	2021	-	-	-	-
7	TEST	Pool Boiler	D04	IN	1996	25	24	2021	-	-	-	-
8	TEST	Whilrpool Boiler	D05	IN	2010	25	10	2035	-	-	-	-
9	TEST	Heating Boilers (Tagged to D06)	D06	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000
12	TEST	HRU 1	D07	IN	1996	30	24	2026	-	-	-	-
13	TEST	HRU 2	D07	IN	1996	30	24	2026	-	-	-	-
14	TEST	MUA 1	D07	IN	1996	30	24	2026	-	-	-	-
15	TEST	ERV 1&2	D07	IN	2018	30	2	2048	-	-	-	-
16	TEST	Dec-Tron	D07	IN	2018	30	2	2048	-	-	-	-
17	TEST	Terminal Heat Pumps	D09	OUT	1996	30	24	2026	$ 2,500	$ 683,000	$ 68,300	$ 751,300
18	TEST	Heating Boilers (Tagged to D11)	D11	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000
32	TEST	Heating Boilers (Tagged to D12)	D12	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
21	TEST	Ice Plant (Tagged to E01)	E01	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
22	TEST	Ice Plant (Tagged to E02A)	E02A	IN	1996	25	24	2021	-	-	-	-
33	TEST	Ice Plant (Tagged to E02B)	E02B	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
23	TEST	Ice Resurfacers	E04	OUT	2010	25	10	2035	$ 1,500	$ 183,000	-	$ 183,000
24	TEST	Arena Stand Heaters	E05	IN	1996	25	24	2021	-	-	-	-
25	TEST	Munters Arena Dehumidifier	E06	IN	2010	25	10	2035	-	-	-	-
26	TEST	Arid Ice Dehumidifiers	E06	IN	2018	25	2	2043	-	-	-	-
27	TEST	Windows	G01	OUT	1996	50	24	2046	$ 9,500	$ 422,000	$ 42,200	$ 464,200
28	TEST	Phase I Roof	G02	OUT	2018	25	2	2043	$ 1,000	$ 2,647,000	$ 264,700	$ 2,911,700
29	TEST	Phase II Roof	G03	OUT	2018	25	2	2043	$ 1,000	$ 2,765,000	$ 276,500	$ 3,041,500
30	TEST	Phase I Exterior Walls	G04	OUT	1996	50	24	2046	-	$ 1,645,000	$ 164,500	$ 1,809,500
31	TEST	Phase II Exterior Walls	G05	OUT	1996	50	24	2046	-	$ 915,000	$ 91,500	$ 1,006,500
33	TEST	Interior Windows	G06	OUT	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300
	Energy Conservation N	LED Retrofits & New Fixtures (Interior)	A01	IN	2020	13	-	2033	$ -4,000	$ 22,183	$ 2,218	$ 24,401
	Energy Conservation N	LED New Fixtures (Exterior)	A02	OUT	2020	24	-	2044	-	-	-	-
	Energy Conservation N	Lighting Controls (Basic)	A03	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation N	Lighting Controls (Arena)	A04	IN	2020	20	-	2040	-	$ 10,331	$ 1,033	$ 11,364
	Energy Conservation N	Battery Energy Storage System (City Owned)	B01	IN	2020	30	-	2050	$ 10,000	$ 991,000	$ 99,100	$ 1,090,100
	Energy Conservation N	Battery Energy Storage as a Service	B02	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation N	Demand Control Ventilation	C01	IN	2020	20	-	2040	$ 3,000	$ 592,000	$ 59,200	$ 651,200
	Energy Conservation N	Analytic Control Tuning	C02	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation N	Heating Boilers - Condensing	D01	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Heating Boilers - Condensing Lower Water Temperat	D02	IN	2020	25	-	2045	-	$ 462,000	$ 46,200	$ 508,200
	Energy Conservation N	DHW Boiler - Condensing	D03	IN	2020	25	-	2045	-	$ 147,000	$ 14,700	$ 161,700
	Energy Conservation N	Pool Boiler - Condensing	D04	IN	2020	25	-	2045	-	$ 188,000	$ 18,800	$ 206,800
	Energy Conservation N	Ground Source Heat Loop - Low Temp Loop	D05	IN	2020	25	-	2045	$ 4,500	$ 2,411,000	$ 241,100	$ 2,652,100
	Energy Conservation N	Ground Source Heat Loop - High Temp Loop	D06	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	AHU Replacement	D07	IN	2020	25	-	2045	$ 1,500	$ 2,268,000	$ 226,800	$ 2,494,800
	Energy Conservation N	AHU VAV Conversion	D08	IN	2020	25	-	2045	$ 2,500	$ 341,000	$ 34,100	$ 375,100
	Energy Conservation N	Heat Pump Replacement	D09	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Low Temp Loop Variable Speed Pumping	D10	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Waste Water HR - High Temp Loop	D11	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	District Energy Integration	D12	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Chiller Replacement w HR - Ammonia Plate and Fram	E01	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Chiller Replacement w HR - C02 - Indirect Slab Coolin	E02A	IN	2020	25	-	2045	-	$ 3,282,000	$ 328,200	$ 3,610,200
	Energy Conservation N	Chiller Replacement w HR - C02 - Direct Slab Cooling	E02B	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Cold Water Flooding	E03	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Ice Resurfacer Replacement	E04	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation N	Radiant Heating Conversion	E05	IN	2020	25	-	2045	-	$ 157,000	$ 15,700	$ 172,700
	Energy Conservation N	Dehumidifier Conversion	E06	IN	2020	25	-	2045	$ 1,000	$ 1,730,000	$ 173,000	$ 1,903,000
	Energy Conservation N	Pool and Whirlpool VFD	F01	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation N	Pool Temperature Setback	F02	IN	2020	50	-	2070	-	$ 8,000	$ 800	$ 8,800
	Energy Conservation N	High Performance Glazing	G01	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation N	Roof Insulation - Phase I	G02	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Roof Insulation - Phase II	G03	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Exterior Wall Insulation - Phase I	G04	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation N	Exterior Wall Insulation - Phase II	G05	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation N	Interior Window Replacement	G06	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation N	Domestic Water Retrofits	H01	IN	2020	10	-	2030	-	$ 101,000	$ 10,100	$ 111,100
	Energy Conservation N	Solar PV - Roof - 1.18 MW array	I01A	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Solar PV - Roof - 0.60 MW array	I01B	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Solar PV - Parking Lot - 1.03 MW array	I02	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation N	Solar Thermal - Pool Heating	I03	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation N	Remove In Stand Heating	J01	OUT	2020	-	-	2020	-	-	-	-
TOTAL						773	266		$ 18,500	$ 12,710,514	$ 1,271,051	$ 13,981,565

TERM YEARS / TOTALS

COMPONENT	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
Lobby Lights	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Lights	-	-	-	-	-	-	$ 33,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -13,200
BAS	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D01)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Heating Boilers (Tagged to D02)	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DHW Boiler	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pool Boiler	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whilrpool Boiler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D06)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Hot Water Loop Piping (Tagged to D06)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
Hot Water Terminal Units (tagged to D06)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
HRU 1	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HRU 2	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MUA 1	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ERV 1&2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec-Tron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Terminal Heat Pumps	-	-	-	-	-	-	$ 751,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -300,520
Heating Boilers (Tagged to D11)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Hot Water Loop Piping (Tagged to D11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
Hot Water Terminal Units (tagged to D11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
Heating Boilers (Tagged to D12)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Ice Plant (Tagged to E01)	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
Ice Plant (Tagged to E02A)	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ice Plant (Tagged to E02B)	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
Ice Resurfacers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	-	-	-	-	-	$ -117,120
Arena Stand Heaters	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Munters Arena Dehumidifier	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
Arid Ice Dehumidifiers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
Windows	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
Phase I Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 2,911,700	-	$ -2,795,232
Phase II Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 3,041,500	-	$ -2,919,840
Phase I Exterior Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
Phase II Exterior Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
Interior Windows	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
LED Retrofits & New Fixtures (Interior)	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	$ -3,754
LED New Fixtures (Exterior)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-
Lighting Controls (Basic)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Lighting Controls (Arena)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 11,365	-	-	-	-	$ -9,091
Battery Energy Storage System (City Owned)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -218,020
Battery Energy Storage as a Service	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demand Control Ventilation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 651,200	-	-	-	-	$ -520,960
Analytic Control Tuning	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Heating Boilers - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers - Condensing Lower Water Temperat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -20,328
DHW Boiler - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,468
Pool Boiler - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -8,272
Ground Source Heat Loop - Low Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -106,084
Ground Source Heat Loop - High Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AHU Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -99,792
AHU VAV Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -15,004
Heat Pump Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Low Temp Loop Variable Speed Pumping	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste Water HR - High Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District Energy Integration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chiller Replacement w HR - Ammonia Plate and Fram	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chiller Replacement w HR - C02 - Indirect Slab Coolin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -144,408
Chiller Replacement w HR - C02 - Direct Slab Cooling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cold Water Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ice Resurfacer Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Radiant Heating Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,908
Dehumidifier Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -76,120
Pool and Whirlpool VFD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Pool Temperature Setback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,576
High Performance Glazing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof Insulation - Phase I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof Insulation - Phase II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Wall Insulation - Phase I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Wall Insulation - Phase II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interior Window Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Domestic Water Retrofits	-	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	$ -66,660
Solar PV - Roof - 1.18 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar PV - Roof - 0.60 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar PV - Parking Lot - 1.03 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar Thermal - Pool Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Remove In Stand Heating	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	$ 1	-	-	-	-	$ 1	-	-	-	$ 111,100	-	-	$ 24,401	-	$ 0	-	-	-	-	$ 773,665	-	-	$ 0	-	$ -1,306,445

PROGRAM 80% B

BUILDING ASSETS

UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	-	-	-
2	TEST	Exterior Lights	A02	IN	1996	30	24	2026	-	-	-	-
3	TEST	BAS	C01	IN	1996	25	24	2021	-	-	-	-
4	TEST	Heating Boilers (Tagged to D01)	D01	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
5	TEST	Heating Boilers (Tagged to D02)	D02	IN	1996	25	24	2021	-	-	-	-
6	TEST	DHW Boiler	D03	IN	1996	25	24	2021	-	-	-	-
7	TEST	Pool Boiler	D04	IN	1996	25	24	2021	-	-	-	-
8	TEST	Whilrpool Boiler	D05	IN	2010	25	10	2035	-	-	-	-
9	TEST	Heating Boilers (Tagged to D06)	D06	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000
12	TEST	HRU 1	D07	IN	1996	30	24	2026	-	-	-	-
13	TEST	HRU 2	D07	IN	1996	30	24	2026	-	-	-	-
14	TEST	MUA 1	D07	IN	1996	30	24	2026	-	-	-	-
15	TEST	ERV 1&2	D07	IN	2018	30	2	2048	-	-	-	-
16	TEST	Dec-Tron	D07	IN	2018	30	2	2048	-	-	-	-
17	TEST	Terminal Heat Pumps	D09	OUT	1996	30	24	2026	$ 2,500	$ 683,000	$ 68,300	$ 751,300
18	TEST	Heating Boilers (Tagged to D11)	D11	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000
32	TEST	Heating Boilers (Tagged to D12)	D12	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
21	TEST	Ice Plant (Tagged to E01)	E01	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
22	TEST	Ice Plant (Tagged to E02A)	E02A	IN	1996	25	24	2021	-	-	-	-
33	TEST	Ice Plant (Tagged to E02B)	E02B	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
23	TEST	Ice Resurfacers	E04	OUT	2010	25	10	2035	$ 1,500	$ 183,000	-	$ 183,000
24	TEST	Arena Stand Heaters	E05	IN	1996	25	24	2021	-	-	-	-
25	TEST	Munters Arena Dehumidifier	E06	IN	2010	25	10	2035	-	-	-	-
26	TEST	Arid Ice Dehumidifiers	E06	IN	2018	25	2	2043	-	-	-	-
27	TEST	Windows	G01	OUT	1996	50	24	2046	$ 9,500	$ 422,000	$ 42,200	$ 464,200
28	TEST	Phase I Roof	G02	OUT	2018	25	2	2043	$ 1,000	$ 2,647,000	$ 264,700	$ 2,911,700
29	TEST	Phase II Roof	G03	OUT	2018	25	2	2043	$ 1,000	$ 2,765,000	$ 276,500	$ 3,041,500
30	TEST	Phase I Exterior Walls	G04	OUT	1996	50	24	2046	-	$ 1,645,000	$ 164,500	$ 1,809,500
31	TEST	Phase II Exterior Walls	G05	OUT	1996	50	24	2046	-	$ 915,000	$ 91,500	$ 1,006,500
33	TEST	Interior Windows	G06	OUT	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300
	Energy Conservation M	LED Retrofits & New Fixtures (Interior)	A01	IN	2020	13	-	2033	$ -4,000	$ 22,183	$ 2,218	$ 24,401
	Energy Conservation M	LED New Fixtures (Exterior)	A02	IN	2020	24	-	2044	$ -4,100	$ 45,493	$ 4,549	$ 50,042
	Energy Conservation M	Lighting Controls (Basic)	A03	IN	2020	20	-	2040	-	$ 19,595	$ 1,960	$ 21,555
	Energy Conservation M	Lighting Controls (Arena)	A04	IN	2020	20	-	2040	-	$ 10,331	$ 1,033	$ 11,364
	Energy Conservation M	Battery Energy Storage System (City Owned)	B01	IN	2020	30	-	2050	$ 10,000	$ 991,000	$ 99,100	$ 1,090,100
	Energy Conservation M	Battery Energy Storage as a Service	B02	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Demand Control Ventilation	C01	IN	2020	20	-	2040	$ 3,000	$ 592,000	$ 59,200	$ 651,200
	Energy Conservation M	Analytic Control Tuning	C02	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing	D01	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing Lower Water Temperat	D02	IN	2020	25	-	2045	-	$ 462,000	$ 46,200	$ 508,200
	Energy Conservation M	DHW Boiler - Condensing	D03	IN	2020	25	-	2045	-	$ 147,000	$ 14,700	$ 161,700
	Energy Conservation M	Pool Boiler - Condensing	D04	IN	2020	25	-	2045	-	$ 188,000	$ 18,800	$ 206,800
	Energy Conservation M	Ground Source Heat Loop - Low Temp Loop	D05	IN	2020	25	-	2045	$ 4,500	$ 2,411,000	$ 241,100	$ 2,652,100
	Energy Conservation M	Ground Source Heat Loop - High Temp Loop	D06	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	AHU Replacement	D07	IN	2020	25	-	2045	$ 1,500	$ 2,268,000	$ 226,800	$ 2,494,800
	Energy Conservation M	AHU VAV Conversion	D08	IN	2020	25	-	2045	$ 2,500	$ 341,000	$ 34,100	$ 375,100
	Energy Conservation M	Heat Pump Replacement	D09	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Low Temp Loop Variable Speed Pumping	D10	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Waste Water HR - High Temp Loop	D11	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	District Energy Integration	D12	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - Ammonia Plate and Fram	E01	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - C02 - Indirect Slab Coolin	E02A	IN	2020	25	-	2045	-	$ 3,282,000	$ 328,200	$ 3,610,200
	Energy Conservation M	Chiller Replacement w HR - C02 - Direct Slab Cooling	E02B	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Cold Water Flooding	E03	IN	2020	25	-	2045	-	$ 99,000	$ 9,900	$ 108,900
	Energy Conservation M	Ice Resurfacer Replacement	E04	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Radiant Heating Conversion	E05	IN	2020	25	-	2045	-	$ 157,000	$ 15,700	$ 172,700
	Energy Conservation M	Dehumidifier Conversion	E06	IN	2020	25	-	2045	$ 1,000	$ 1,730,000	$ 173,000	$ 1,903,000
	Energy Conservation M	Pool and Whirlpool VFD	F01	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Pool Temperature Setback	F02	IN	2020	50	-	2070	-	$ 8,000	$ 800	$ 8,800
	Energy Conservation M	High Performance Glazing	G01	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase I	G02	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase II	G03	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase I	G04	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase II	G05	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Interior Window Replacement	G06	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Domestic Water Retrofits	H01	IN	2020	10	-	2030	-	$ 101,000	$ 10,100	$ 111,100
	Energy Conservation M	Solar PV - Roof - 1.18 MW array	I01A	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Solar PV - Roof - 0.60 MW array	I01B	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Solar PV - Parking Lot - 1.03 MW array	I02	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Solar Thermal - Pool Heating	I03	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Remove In Stand Heating	J01	OUT	2020	-	-	2020	-	-	-	-
TOTAL						872	290		$ 14,400	$ 12,874,602	$ 1,287,460	$ 14,162,062

TERM YEARS / TOTALS

COMPONENT	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
Lobby Lights	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Lights	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAS	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D01)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Heating Boilers (Tagged to D02)	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DHW Boiler	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pool Boiler	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whilrpool Boiler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D06)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Hot Water Loop Piping (Tagged to D06)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
Hot Water Terminal Units (tagged to D06)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
HRU 1	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HRU 2	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MUA 1	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ERV 1&2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec-Tron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Terminal Heat Pumps	-	-	-	-	-	-	$ 751,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -300,520
Heating Boilers (Tagged to D11)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Hot Water Loop Piping (Tagged to D11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
Hot Water Terminal Units (tagged to D11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
Heating Boilers (Tagged to D12)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Ice Plant (Tagged to E01)	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
Ice Plant (Tagged to E02A)	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ice Plant (Tagged to E02B)	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
Ice Resurfacers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	-	-	-	-	-	$ -117,120
Arena Stand Heaters	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Munters Arena Dehumidifier	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
Arid Ice Dehumidifiers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
Windows	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
Phase I Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 2,911,700	-	$ -2,795,232
Phase II Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 3,041,500	-	$ -2,919,840
Phase I Exterior Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
Phase II Exterior Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
Interior Windows	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
LED Retrofits & New Fixtures (Interior)	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	$ -3,754
LED New Fixtures (Exterior)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 50,042	$ -50,042
Lighting Controls (Basic)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 21,555	-	-	-	-	$ -17,244
Lighting Controls (Arena)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 11,365	-	-	-	-	$ -9,091
Battery Energy Storage System (City Owned)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -218,020
Battery Energy Storage as a Service	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demand Control Ventilation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 651,200	-	-	-	-	$ -520,960
Analytic Control Tuning	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Heating Boilers - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers - Condensing Lower Water Temperat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -20,328
DHW Boiler - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,468
Pool Boiler - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -8,272
Ground Source Heat Loop - Low Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -106,084
Ground Source Heat Loop - High Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AHU Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -99,792
AHU VAV Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -15,004
Heat Pump Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Low Temp Loop Variable Speed Pumping	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste Water HR - High Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District Energy Integration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chiller Replacement w HR - Ammonia Plate and Fram	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chiller Replacement w HR - C02 - Indirect Slab Coolin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -144,408
Chiller Replacement w HR - C02 - Direct Slab Cooling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cold Water Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,356
Ice Resurfacer Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Radiant Heating Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,908
Dehumidifier Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -76,120
Pool and Whirlpool VFD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Pool Temperature Setback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,576
High Performance Glazing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof Insulation - Phase I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof Insulation - Phase II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Wall Insulation - Phase I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Wall Insulation - Phase II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interior Window Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Domestic Water Retrofits	-	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	$ -66,660
Solar PV - Roof - 1.18 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar PV - Roof - 0.60 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar PV - Parking Lot - 1.03 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar Thermal - Pool Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Remove In Stand Heating	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	$ 1	-	-	-	-	$ 1	-	-	-	$ 111,100	-	-	$ 24,401	-	$ 0	-	-	-	-	$ 795,220	-	-	$ 0	$ 50,042	$ -1,378,087

PROGRAM 80% C

BUILDING ASSETS													TERM YEARS																									TOTALS
UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	TEST	Exterior Lights	A02	OUT	1996	30	24	2026	-	$ 30,000	$ 3,000	$ 33,000	-	-	-	-	-	-	$ 33,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -13,200
3	TEST	BAS	C01	OUT	1996	25	24	2021	$ 5,000	$ 400,000	$ 40,000	$ 440,000	-	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -35,200
4	TEST	Heating Boilers (Tagged to D01)	D01	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
5	TEST	Heating Boilers (Tagged to D02)	D02	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	TEST	DHW Boiler	D03	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	TEST	Pool Boiler	D04	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	TEST	Whilrpool Boiler	D05	IN	2010	25	10	2035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-
9	TEST	Heating Boilers (Tagged to D06)	D06	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
12	TEST	HRU 1	D07	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	TEST	HRU 2	D07	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	TEST	MUA 1	D07	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	TEST	ERV 1&2	D07	IN	2018	30	2	2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	TEST	Dec-Tron	D07	IN	2018	30	2	2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	TEST	Terminal Heat Pumps	D09	OUT	1996	30	24	2026	$ 2,500	$ 683,000	$ 68,300	$ 751,300	-	-	-	-	-	-	$ 751,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -300,520
18	TEST	Heating Boilers (Tagged to D11)	D11	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
32	TEST	Heating Boilers (Tagged to D12)	D12	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
21	TEST	Ice Plant (Tagged to E01)	E01	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
22	TEST	Ice Plant (Tagged to E02A)	E02A	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	TEST	Ice Plant (Tagged to E02B)	E02B	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
23	TEST	Ice Resurfacers	E04	OUT	2010	25	10	2035	$ 1,500	$ 183,000	-	$ 183,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	-	-	-	-	-	$ -117,120
24	TEST	Arena Stand Heaters	E05	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	TEST	Munters Arena Dehumidifier	E06	IN	2010	25	10	2035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-
26	TEST	Arid Ice Dehumidifiers	E06	IN	2018	25	2	2043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
27	TEST	Windows	G01	OUT	1996	50	24	2046	$ 9,500	$ 422,000	$ 42,200	$ 464,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
28	TEST	Phase I Roof	G02	OUT	2018	25	2	2043	$ 1,000	$ 2,647,000	$ 264,700	$ 2,911,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 2,911,700	-	$ -2,795,232
29	TEST	Phase II Roof	G03	OUT	2018	25	2	2043	$ 1,000	$ 2,765,000	$ 276,500	$ 3,041,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 3,041,500	-	$ -2,919,840
30	TEST	Phase I Exterior Walls	G04	OUT	1996	50	24	2046	-	$ 1,645,000	$ 164,500	$ 1,809,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
31	TEST	Phase II Exterior Walls	G05	IN	1996	50	24	2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	TEST	Interior Windows	G06	OUT	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
	Energy Conservation M	LED Retrofits & New Fixtures (Interior)	A01	IN	2020	13	-	2033	$ -4,000	$ 22,183	$ 2,218	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	$ -3,754
	Energy Conservation M	LED New Fixtures (Exterior)	A02	OUT	2020	24	-	2044	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-
	Energy Conservation M	Lighting Controls (Basic)	A03	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Lighting Controls (Arena)	A04	IN	2020	20	-	2040	-	$ 10,331	$ 1,033	$ 11,364	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 11,365	-	-	-	-	$ -9,091
	Energy Conservation M	Battery Energy Storage System (City Owned)	B01	IN	2020	30	-	2050	$ 10,000	$ 1,550,000	$ 155,000	$ 1,705,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -341,000
	Energy Conservation M	Battery Energy Storage as a Service	B02	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Demand Control Ventilation	C01	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Analytic Control Tuning	C02	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing	D01	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing Lower Water Temperat	D02	IN	2020	25	-	2045	-	$ 462,000	$ 46,200	$ 508,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -20,328
	Energy Conservation M	DHW Boiler - Condensing	D03	IN	2020	25	-	2045	-	$ 147,000	$ 14,700	$ 161,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,468
	Energy Conservation M	Pool Boiler - Condensing	D04	IN	2020	25	-	2045	-	$ 188,000	$ 18,800	$ 206,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -8,272
	Energy Conservation M	Ground Source Heat Loop - Low Temp Loop	D05	IN	2020	25	-	2045	$ 4,500	$ 2,411,000	$ 241,100	$ 2,652,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -106,084
	Energy Conservation M	Ground Source Heat Loop - High Temp Loop	D06	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	AHU Replacement	D07	IN	2020	25	-	2045	$ 1,500	$ 2,268,000	$ 226,800	$ 2,494,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -99,792
	Energy Conservation M	AHU VAV Conversion	D08	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Heat Pump Replacement	D09	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Low Temp Loop Variable Speed Pumping	D10	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Waste Water HR - High Temp Loop	D11	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	District Energy Integration	D12	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - Ammonia Plate and Fram	E01	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - C02 - Indirect Slab Coolin	E02A	IN	2020	25	-	2045	-	$ 3,282,000	$ 328,200	$ 3,610,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -144,408
	Energy Conservation M	Chiller Replacement w HR - C02 - Direct Slab Cooling	E02B	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Cold Water Flooding	E03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ice Resurfacer Replacement	E04	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Radiant Heating Conversion	E05	IN	2020	25	-	2045	-	$ 157,000	$ 15,700	$ 172,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,908
	Energy Conservation M	Dehumidifier Conversion	E06	IN	2020	25	-	2045	$ 1,000	$ 1,730,000	$ 173,000	$ 1,903,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -76,120
	Energy Conservation M	Pool and Whirlpool VFD	F01	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Pool Temperature Setback	F02	IN	2020	50	-	2070	-	$ 8,000	$ 800	$ 8,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,576
	Energy Conservation M	High Performance Glazing	G01	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase I	G02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase II	G03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase I	G04	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase II	G05	IN	2020	50	-	2070	-	$ 915,000	$ 91,500	$ 1,006,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
	Energy Conservation M	Interior Window Replacement	G06	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Domestic Water Retrofits	H01	IN	2020	10	-	2030	-	$ 101,000	$ 10,100	$ 111,100	-	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	$ -66,660
	Energy Conservation M	Solar PV - Roof - 1.18 MW array	I01A	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar PV - Roof - 0.60 MW array	I01B	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar PV - Parking Lot - 1.03 MW array	I02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar Thermal - Pool Heating	I03	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Remove In Stand Heating	J01	OUT	2020	-	-	2020	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL						803	266		$ 13,000	$ 13,251,514	$ 1,325,151	$ 14,576,665	-	$ 1	-	-	-	-	$ 1	-	-	-	$ 111,100	-	-	$ 24,401	-	$ 0	-	-	-	-	$ 122,465	-	-	$ 0	-	$ -1,416,841

PROGRAM 100% A

BUILDING ASSETS													TERM YEARS																									TOTALS
UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	TEST	Exterior Lights	A02	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	TEST	BAS	C01	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	TEST	Heating Boilers (Tagged to D01)	D01	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
5	TEST	Heating Boilers (Tagged to D02)	D02	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
6	TEST	DHW Boiler	D03	OUT	1996	25	24	2021	$ 1,500	$ 110,100	$ 11,010	$ 121,110	-	$ 121,110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -9,689
7	TEST	Pool Boiler	D04	OUT	1996	25	24	2021	$ 750	$ 65,000	$ 6,500	$ 71,500	-	$ 71,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,720
8	TEST	Whirlpool Boiler	D05	OUT	2010	25	10	2035	$ 750	$ 49,400	$ 4,940	$ 54,340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 54,340	-	-	-	-	-	-	-	-	-	$ -34,778
9	TEST	Heating Boilers (Tagged to D06)	D06	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	IN	1996	50	24	2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	IN	1996	50	24	2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	TEST	HRU 1	D07	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	TEST	HRU 2	D07	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	TEST	MUA 1	D07	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	TEST	ERV 1&2	D07	IN	2018	30	2	2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	TEST	Dec-Tron	D07	IN	2018	30	2	2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	TEST	Terminal Heat Pumps	D09	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	TEST	Heating Boilers (Tagged to D11)	D11	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
32	TEST	Heating Boilers (Tagged to D12)	D12	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
21	TEST	Ice Plant (Tagged to E01)	E01	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
22	TEST	Ice Plant (Tagged to E02A)	E02A	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	TEST	Ice Plant (Tagged to E02B)	E02B	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
23	TEST	Ice Resurfacers	E04	IN	2010	25	10	2035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
24	TEST	Arena Stand Heaters	E05	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	TEST	Munters Arena Dehumidifier	E06	IN	2010	25	10	2035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
26	TEST	Arid Ice Dehumidifiers	E06	IN	2018	25	2	2043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
27	TEST	Windows	G01	IN	1996	50	24	2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	TEST	Phase I Roof	G02	IN	2018	25	2	2043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
29	TEST	Phase II Roof	G03	IN	2018	25	2	2043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
30	TEST	Phase I Exterior Walls	G04	IN	1996	50	24	2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	TEST	Phase II Exterior Walls	G05	IN	1996	50	24	2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	TEST	Interior Windows	G06	OUT	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
	Energy Conservation M	LED Retrofits & New Fixtures (Interior)	A01	IN	2020	13	-	2033	$ -4,000	$ 22,183	$ 2,218	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	$ -3,754
	Energy Conservation M	LED New Fixtures (Exterior)	A02	IN	2020	24	-	2044	$ -4,100	$ 45,493	$ 4,549	$ 50,042	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 50,042	$ -50,042
	Energy Conservation M	Lighting Controls (Basic)	A03	IN	2020	20	-	2040	-	$ 19,595	$ 1,960	$ 21,555	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 21,555	-	-	-	-	$ -17,244
	Energy Conservation M	Lighting Controls (Arena)	A04	IN	2020	20	-	2040	-	$ 10,331	$ 1,033	$ 11,364	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 11,365	-	-	-	-	$ -9,091
	Energy Conservation M	Battery Energy Storage System (City Owned)	B01	IN	2020	30	-	2050	$ 10,000	$ 991,000	$ 99,100	$ 1,090,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -218,020
	Energy Conservation M	Battery Energy Storage as a Service	B02	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Demand Control Ventilation	C01	IN	2020	20	-	2040	$ 3,000	$ 592,000	$ 59,200	$ 651,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 651,200	-	-	-	-	$ -520,960
	Energy Conservation M	Analytic Control Tuning	C02	IN	2020	20	-	2040	$ 8,500	$ 8,500	$ 850	$ 9,350	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 9,350	-	-	-	-	$ -7,480
	Energy Conservation M	Heating Boilers - Condensing	D01	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing Lower Water Temperat	D02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	DHW Boiler - Condensing	D03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Pool Boiler - Condensing	D04	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - Low Temp Loop	D05	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - High Temp Loop	D06	IN	2020	25	-	2045	$ 3,500	$ 8,704,000	$ 870,400	$ 9,574,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -382,976
	Energy Conservation M	AHU Replacement	D07	IN	2020	25	-	2045	$ 1,500	$ 2,268,000	$ 226,800	$ 2,494,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -99,792
	Energy Conservation M	AHU VAV Conversion	D08	IN	2020	25	-	2045	$ 2,500	$ 341,000	$ 34,100	$ 375,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -15,004
	Energy Conservation M	Heat Pump Replacement	D09	IN	2020	25	-	2045	-	$ 761,000	$ 76,100	$ 837,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,484
	Energy Conservation M	Low Temp Loop Variable Speed Pumping	D10	IN	2020	25	-	2045	$ 2,000	$ 159,000	$ 15,900	$ 174,900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,996
	Energy Conservation M	Waste Water HR - High Temp Loop	D11	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	District Energy Integration	D12	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - Ammonia Plate and Fram	E01	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - C02 - Indirect Slab Coolin	E02A	IN	2020	25	-	2045	-	$ 3,282,000	$ 328,200	$ 3,610,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -144,408
	Energy Conservation M	Chiller Replacement w HR - C02 - Direct Slab Cooling	E02B	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Cold Water Flooding	E03	IN	2020	25	-	2045	-	$ 99,000	$ 9,900	$ 108,900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,356
	Energy Conservation M	Ice Resurfacer Replacement	E04	IN	2020	20	-	2040	$ -300	$ 183,000	-	$ 183,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	$ -146,400
	Energy Conservation M	Radiant Heating Conversion	E05	IN	2020	25	-	2045	-	$ 157,000	$ 15,700	$ 172,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,908
	Energy Conservation M	Dehumidifier Conversion	E06	IN	2020	25	-	2045	$ 1,000	$ 1,730,000	$ 173,000	$ 1,903,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -76,120
	Energy Conservation M	Pool and Whirlpool VFD	F01	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Pool Temperature Setback	F02	IN	2020	50	-	2070	-	$ 8,000	$ 800	$ 8,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,576
	Energy Conservation M	High Performance Glazing	G01	IN	2020	50	-	2070	-	$ 422,000	$ 42,200	$ 464,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
	Energy Conservation M	Roof Insulation - Phase I	G02	IN	2020	25	-	2045	-	$ 2,647,000	$ 264,700	$ 2,911,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -116,468
	Energy Conservation M	Roof Insulation - Phase II	G03	IN	2020	25	-	2045	-	$ 2,765,000	$ 276,500	$ 3,041,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -121,660
	Energy Conservation M	Exterior Wall Insulation - Phase I	G04	IN	2020	50	-	2070	-	$ 1,645,000	$ 164,500	$ 1,809,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
	Energy Conservation M	Exterior Wall Insulation - Phase II	G05	IN	2020	50	-	2070	-	$ 915,000	$ 91,500	$ 1,006,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
	Energy Conservation M	Interior Window Replacement	G06	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Domestic Water Retrofits	H01	IN	2020	10	-	2030	-	$ 101,000	$ 10,100	$ 111,100	-	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	$ -66,660
	Energy Conservation M	Solar PV - Roof - 1.18 MW array	I01A	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar PV - Roof - 0.60 MW array	I01B	IN	2020	25	-	2045	$ 9,400	$ 1,356,153	$ 135,615	$ 1,491,768	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -59,671
	Energy Conservation M	Solar PV - Parking Lot - 1.03 MW array	I02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar Thermal - Pool Heating	I03	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Remove In Stand Heating	J01	OUT	2020	-	-	2020	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL						1,392	390		$ 33,000	$ 29,232,255	$ 2,904,925	$ 32,137,180	-	$ 1	-	-	-	-	$ 1	-	-	-	$ 111,100	-	-	$ 24,401	-	$ 0	-	-	-	-	$ 987,570	-	-	$ 1	$ 50,042	$ -3,817,774

PROGRAM 100% B

BUILDING ASSETS												
UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	-	-	-
2	TEST	Exterior Lights	A02	IN	1996	30	24	2026	-	-	-	-
3	TEST	BAS	C01	IN	1996	25	24	2021	-	-	-	-
4	TEST	Heating Boilers (Tagged to D01)	D01	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
5	TEST	Heating Boilers (Tagged to D02)	D02	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
6	TEST	DHW Boiler	D03	OUT	1996	25	24	2021	$ 1,500	$ 110,100	$ 11,010	$ 121,110
7	TEST	Pool Boiler	D04	OUT	1996	25	24	2021	$ 750	$ 65,000	$ 6,500	$ 71,500
8	TEST	Whirlpool Boiler	D05	OUT	2010	25	10	2035	$ 750	$ 49,400	$ 4,940	$ 54,340
9	TEST	Heating Boilers (Tagged to D06)	D06	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000
12	TEST	HRU 1	D07	IN	1996	30	24	2026	-	-	-	-
13	TEST	HRU 2	D07	IN	1996	30	24	2026	-	-	-	-
14	TEST	MUA 1	D07	IN	1996	30	24	2026	-	-	-	-
15	TEST	ERV 1&2	D07	IN	2018	30	2	2048	-	-	-	-
16	TEST	Dec-Tron	D07	IN	2018	30	2	2048	-	-	-	-
17	TEST	Terminal Heat Pumps	D09	IN	1996	30	24	2026	-	-	-	-
18	TEST	Heating Boilers (Tagged to D11)	D11	IN	1996	25	24	2021	-	-	-	-
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	IN	1996	50	24	2046	-	-	-	-
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	IN	1996	50	24	2046	-	-	-	-
32	TEST	Heating Boilers (Tagged to D12)	D12	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660
21	TEST	Ice Plant (Tagged to E01)	E01	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
22	TEST	Ice Plant (Tagged to E02A)	E02A	IN	1996	25	24	2021	-	-	-	-
33	TEST	Ice Plant (Tagged to E02B)	E02B	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400
23	TEST	Ice Resurfacers	E04	IN	2010	25	10	2035	-	-	-	-
24	TEST	Arena Stand Heaters	E05	IN	1996	25	24	2021	-	-	-	-
25	TEST	Munters Arena Dehumidifier	E06	IN	2010	25	10	2035	-	-	-	-
26	TEST	Arid Ice Dehumidifiers	E06	IN	2018	25	2	2043	-	-	-	-
27	TEST	Windows	G01	IN	1996	50	24	2046	-	-	-	-
28	TEST	Phase I Roof	G02	IN	2018	25	2	2043	-	-	-	-
29	TEST	Phase II Roof	G03	IN	2018	25	2	2043	-	-	-	-
30	TEST	Phase I Exterior Walls	G04	IN	1996	50	24	2046	-	-	-	-
31	TEST	Phase II Exterior Walls	G05	IN	1996	50	24	2046	-	-	-	-
33	TEST	Interior Windows	G06	OUT	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300
	Energy Conservation M	LED Retrofits & New Fixtures (Interior)	A01	IN	2020	13	-	2033	$ -4,000	$ 22,183	$ 2,218	$ 24,401
	Energy Conservation M	LED New Fixtures (Exterior)	A02	IN	2020	24	-	2044	$ -4,100	$ 45,493	$ 4,549	$ 50,042
	Energy Conservation M	Lighting Controls (Basic)	A03	IN	2020	20	-	2040	-	$ 19,595	$ 1,960	$ 21,555
	Energy Conservation M	Lighting Controls (Arena)	A04	IN	2020	20	-	2040	-	$ 10,331	$ 1,033	$ 11,364
	Energy Conservation M	Battery Energy Storage System (City Owned)	B01	IN	2020	30	-	2050	$ 10,000	$ 991,000	$ 99,100	$ 1,090,100
	Energy Conservation M	Battery Energy Storage as a Service	B02	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Demand Control Ventilation	C01	IN	2020	20	-	2040	$ 3,000	$ 592,000	$ 59,200	$ 651,200
	Energy Conservation M	Analytic Control Tuning	C02	IN	2020	20	-	2040	$ 8,500	$ 8,500	$ 850	$ 9,350
	Energy Conservation M	Heating Boilers - Condensing	D01	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing Lower Water Temperat	D02	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	DHW Boiler - Condensing	D03	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Pool Boiler - Condensing	D04	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - Low Temp Loop	D05	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - High Temp Loop	D06	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	AHU Replacement	D07	IN	2020	25	-	2045	$ 1,500	$ 2,268,000	$ 226,800	$ 2,494,800
	Energy Conservation M	AHU VAV Conversion	D08	IN	2020	25	-	2045	$ 2,500	$ 341,000	$ 34,100	$ 375,100
	Energy Conservation M	Heat Pump Replacement	D09	IN	2020	25	-	2045	-	$ 761,000	$ 76,100	$ 837,100
	Energy Conservation M	Low Temp Loop Variable Speed Pumping	D10	IN	2020	25	-	2045	$ 2,000	$ 159,000	$ 15,900	$ 174,900
	Energy Conservation M	Waste Water HR - High Temp Loop	D11	IN	2020	25	-	2045	$ 6,500	$ 8,403,000	$ 840,300	$ 9,243,300
	Energy Conservation M	District Energy Integration	D12	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - Ammonia Plate and Fram	E01	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - C02 - Indirect Slab Coolin	E02A	IN	2020	25	-	2045	-	$ 3,282,000	$ 328,200	$ 3,610,200
	Energy Conservation M	Chiller Replacement w HR - C02 - Direct Slab Cooling	E02B	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Cold Water Flooding	E03	IN	2020	25	-	2045	-	$ 99,000	$ 9,900	$ 108,900
	Energy Conservation M	Ice Resurfacer Replacement	E04	IN	2020	20	-	2040	$ -300	$ 183,000	-	$ 183,000
	Energy Conservation M	Radiant Heating Conversion	E05	IN	2020	25	-	2045	-	$ 157,000	$ 15,700	$ 172,700
	Energy Conservation M	Dehumidifier Conversion	E06	IN	2020	25	-	2045	$ 1,000	$ 1,730,000	$ 173,000	$ 1,903,000
	Energy Conservation M	Pool and Whirlpool VFD	F01	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Pool Temperature Setback	F02	IN	2020	50	-	2070	-	$ 8,000	$ 800	$ 8,800
	Energy Conservation M	High Performance Glazing	G01	IN	2020	50	-	2070	-	$ 422,000	$ 42,200	$ 464,200
	Energy Conservation M	Roof Insulation - Phase I	G02	IN	2020	25	-	2045	-	$ 2,647,000	$ 264,700	$ 2,911,700
	Energy Conservation M	Roof Insulation - Phase II	G03	IN	2020	25	-	2045	-	$ 2,765,000	$ 276,500	$ 3,041,500
	Energy Conservation M	Exterior Wall Insulation - Phase I	G04	IN	2020	50	-	2070	-	$ 1,645,000	$ 164,500	$ 1,809,500
	Energy Conservation M	Exterior Wall Insulation - Phase II	G05	IN	2020	50	-	2070	-	$ 915,000	$ 91,500	$ 1,006,500
	Energy Conservation M	Interior Window Replacement	G06	OUT	2020	50	-	2070	-	-	-	-
	Energy Conservation M	Domestic Water Retrofits	H01	IN	2020	10	-	2030	-	$ 101,000	$ 10,100	$ 111,100
	Energy Conservation M	Solar PV - Roof - 1.18 MW array	I01A	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Solar PV - Roof - 0.60 MW array	I01B	IN	2020	25	-	2045	$ 9,400	$ 1,356,153	$ 135,615	$ 1,491,768
	Energy Conservation M	Solar PV - Parking Lot - 1.03 MW array	I02	OUT	2020	25	-	2045	-	-	-	-
	Energy Conservation M	Solar Thermal - Pool Heating	I03	OUT	2020	20	-	2040	-	-	-	-
	Energy Conservation M	Remove In Stand Heating	J01	OUT	2020	-	-	2020	-	-	-	-
TOTAL						1,392	390		$ 36,000	$ 28,931,255	$ 2,874,825	$ 31,806,080

COMPONENT	TERM YEARS																								TOTALS
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
Lobby Lights	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exterior Lights	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAS	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D01)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Heating Boilers (Tagged to D02)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
DHW Boiler	-	$ 121,110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -9,689
Pool Boiler	-	$ 71,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,720
Whirlpool Boiler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 54,340	-	-	-	-	-	-	-	-	-	$ -34,778
Heating Boilers (Tagged to D06)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Hot Water Loop Piping (Tagged to D06)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
Hot Water Terminal Units (tagged to D06)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
HRU 1	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HRU 2	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MUA 1	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ERV 1&2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec-Tron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Terminal Heat Pumps	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D11)	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water Loop Piping (Tagged to D11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water Terminal Units (tagged to D11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers (Tagged to D12)	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
Ice Plant (Tagged to E01)	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
Ice Plant (Tagged to E02A)	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ice Plant (Tagged to E02B)	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
Ice Resurfacers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
Arena Stand Heaters	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Munters Arena Dehumidifier	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
Arid Ice Dehumidifiers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
Windows	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phase I Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
Phase II Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
Phase I Exterior Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phase II Exterior Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interior Windows	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
LED Retrofits & New Fixtures (Interior)	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	$ -3,754
LED New Fixtures (Exterior)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 50,042	$ -50,042
Lighting Controls (Basic)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 21,555	-	-	-	-	$ -17,244
Lighting Controls (Arena)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 11,365	-	-	-	-	$ -9,091
Battery Energy Storage System (City Owned)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -218,020
Battery Energy Storage as a Service	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demand Control Ventilation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 651,200	-	-	-	-	$ -520,960
Analytic Control Tuning	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 9,350	-	-	-	-	$ -7,480
Heating Boilers - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heating Boilers - Condensing Lower Water Temperat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DHW Boiler - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pool Boiler - Condensing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ground Source Heat Loop - Low Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ground Source Heat Loop - High Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AHU Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -99,792
AHU VAV Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -15,004
Heat Pump Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,484
Low Temp Loop Variable Speed Pumping	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,996
Waste Water HR - High Temp Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -369,732
District Energy Integration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chiller Replacement w HR - Ammonia Plate and Fram	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chiller Replacement w HR - C02 - Indirect Slab Coolin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -144,408
Chiller Replacement w HR - C02 - Direct Slab Cooling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cold Water Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,356
Ice Resurfacer Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	$ -146,400
Radiant Heating Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,908
Dehumidifier Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -76,120
Pool and Whirlpool VFD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Pool Temperature Setback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,576
High Performance Glazing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
Roof Insulation - Phase I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -116,468
Roof Insulation - Phase II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -121,660
Exterior Wall Insulation - Phase I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
Exterior Wall Insulation - Phase II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
Interior Window Replacement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Domestic Water Retrofits	-	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	$ -66,660
Solar PV - Roof - 1.18 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar PV - Roof - 0.60 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -59,671
Solar PV - Parking Lot - 1.03 MW array	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar Thermal - Pool Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
Remove In Stand Heating	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	$ 1	-	-	-	-	$ 1	-	-	-	$ 111,100	-	-	$ 24,401	-	$ 0	-	-	-	-	$ 987,570	-	-	$ 1	$ 50,042	$ -3,804,530

PROGRAM 100% C

BUILDING ASSETS													TERM YEARS																									TOTALS
UNIFORMAT CODE	GROUP	COMPONENT	ECM AFFECTING COMPONENT	IN/OUT	YEAR OF INSTALLATION OR REPAIR	EXPECTED USEFUL LIFE (EUL)	CURRENT AGE	YEAR OF REPLACEMENT (LIFE CYCLE)	ANNUAL MAINTENANCE COST	REPLACEMENT COST	SOFT COST	TOTAL COST	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	RECAP VALUE
1	TEST	Lobby Lights	A01	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	TEST	Exterior Lights	A02	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	TEST	BAS	C01	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	TEST	Heating Boilers (Tagged to D01)	D01	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
5	TEST	Heating Boilers (Tagged to D02)	D02	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
6	TEST	DHW Boiler	D03	OUT	1996	25	24	2021	$ 1,500	$ 110,100	$ 11,010	$ 121,110	-	$ 121,110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -9,689
7	TEST	Pool Boiler	D04	OUT	1996	25	24	2021	$ 750	$ 65,000	$ 6,500	$ 71,500	-	$ 71,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -5,720
8	TEST	Whilrpool Boiler	D05	OUT	2010	25	10	2035	$ 750	$ 49,400	$ 4,940	$ 54,340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 54,340	-	-	-	-	-	-	-	-	-	$ -34,778
9	TEST	Heating Boilers (Tagged to D06)	D06	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	TEST	Hot Water Loop Piping (Tagged to D06)	D06	IN	1996	50	24	2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	TEST	Hot Water Terminal Units (tagged to D06)	D06	IN	1996	50	24	2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	TEST	HRU 1	D07	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	TEST	HRU 2	D07	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	TEST	MUA 1	D07	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	TEST	ERV 1&2	D07	IN	2018	30	2	2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	TEST	Dec-Tron	D07	IN	2018	30	2	2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	TEST	Terminal Heat Pumps	D09	IN	1996	30	24	2026	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	TEST	Heating Boilers (Tagged to D11)	D11	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
19	TEST	Hot Water Loop Piping (Tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 400,000	$ 40,000	$ 440,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -228,800
20	TEST	Hot Water Terminal Units (tagged to D11)	D11	OUT	1996	50	24	2046	-	$ 120,000	$ 12,000	$ 132,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -68,640
32	TEST	Heating Boilers (Tagged to D12)	D12	OUT	1996	25	24	2021	$ 7,500	$ 380,600	$ 38,060	$ 418,660	-	$ 418,660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,493
21	TEST	Ice Plant (Tagged to E01)	E01	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
22	TEST	Ice Plant (Tagged to E02A)	E02A	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	TEST	Ice Plant (Tagged to E02B)	E02B	OUT	1996	25	24	2021	$ 50,000	$ 3,134,000	$ 313,400	$ 3,447,400	-	$ 3,447,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -275,792
23	TEST	Ice Resurfacers	E04	IN	2010	25	10	2035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
24	TEST	Arena Stand Heaters	E05	IN	1996	25	24	2021	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	TEST	Munters Arena Dehumidifier	E06	IN	2010	25	10	2035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-
26	TEST	Arid Ice Dehumidifiers	E06	IN	2018	25	2	2043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-
27	TEST	Windows	G01	OUT	1996	50	24	2046	$ 9,500	$ 422,000	$ 42,200	$ 464,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -241,384
28	TEST	Phase I Roof	G02	OUT	2018	25	2	2043	$ 1,000	$ 2,647,000	$ 264,700	$ 2,911,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 2,911,700	-	$ -2,795,232
29	TEST	Phase II Roof	G03	OUT	2018	25	2	2043	$ 1,000	$ 2,765,000	$ 276,500	$ 3,041,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 3,041,500	-	$ -2,919,840
30	TEST	Phase I Exterior Walls	G04	OUT	1996	50	24	2046	-	$ 1,645,000	$ 164,500	$ 1,809,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -940,940
31	TEST	Phase II Exterior Walls	G05	OUT	1996	50	24	2046	-	$ 915,000	$ 91,500	$ 1,006,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -523,380
33	TEST	Interior Windows	G06	OUT	1996	50	24	2046	-	$ 313,000	$ 31,300	$ 344,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -179,036
	Energy Conservation M	LED Retrofits & New Fixtures (Interior)	A01	IN	2020	13	-	2033	$ -4,000	$ 22,183	$ 2,218	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 24,401	-	-	-	-	-	-	-	-	-	-	-	$ -3,754
	Energy Conservation M	LED New Fixtures (Exterior)	A02	IN	2020	24	-	2044	$ -4,100	$ 45,493	$ 4,549	$ 50,042	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 50,042	$ -50,042
	Energy Conservation M	Lighting Controls (Basic)	A03	IN	2020	20	-	2040	-	$ 19,595	$ 1,960	$ 21,555	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 21,555	-	-	-	-	$ -17,244
	Energy Conservation M	Lighting Controls (Arena)	A04	IN	2020	20	-	2040	-	$ 10,331	$ 1,033	$ 11,364	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 11,365	-	-	-	-	$ -9,091
	Energy Conservation M	Battery Energy Storage System (City Owned)	B01	IN	2020	30	-	2050	$ 10,000	$ 991,000	$ 99,100	$ 1,090,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -218,020
	Energy Conservation M	Battery Energy Storage as a Service	B02	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Demand Control Ventilation	C01	IN	2020	20	-	2040	$ 3,000	$ 592,000	$ 59,200	$ 651,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 651,200	-	-	-	-	$ -520,960
	Energy Conservation M	Analytic Control Tuning	C02	IN	2020	20	-	2040	$ 8,500	$ 8,500	$ 850	$ 9,350	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 9,350	-	-	-	-	$ -7,480
	Energy Conservation M	Heating Boilers - Condensing	D01	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Heating Boilers - Condensing Lower Water Temperat	D02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	DHW Boiler - Condensing	D03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Pool Boiler - Condensing	D04	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - Low Temp Loop	D05	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Ground Source Heat Loop - High Temp Loop	D06	IN	2020	25	-	2045	$ 3,500	$ 8,704,000	$ 870,400	$ 9,574,400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -382,976
	Energy Conservation M	AHU Replacement	D07	IN	2020	25	-	2045	$ 1,500	$ 2,268,000	$ 226,800	$ 2,494,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -99,792
	Energy Conservation M	AHU VAV Conversion	D08	IN	2020	25	-	2045	$ 2,500	$ 341,000	$ 34,100	$ 375,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -15,004
	Energy Conservation M	Heat Pump Replacement	D09	IN	2020	25	-	2045	-	$ 761,000	$ 76,100	$ 837,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -33,484
	Energy Conservation M	Low Temp Loop Variable Speed Pumping	D10	IN	2020	25	-	2045	$ 2,000	$ 159,000	$ 15,900	$ 174,900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,996
	Energy Conservation M	Waste Water HR - High Temp Loop	D11	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	District Energy Integration	D12	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - Ammonia Plate and Fram	E01	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Chiller Replacement w HR - C02 - Indirect Slab Coolin	E02A	IN	2020	25	-	2045	-	$ 3,282,000	$ 328,200	$ 3,610,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -144,408
	Energy Conservation M	Chiller Replacement w HR - C02 - Direct Slab Cooling	E02B	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Cold Water Flooding	E03	IN	2020	25	-	2045	-	$ 99,000	$ 9,900	$ 108,900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,356
	Energy Conservation M	Ice Resurfacer Replacement	E04	IN	2020	20	-	2040	$ -300	$ 183,000	-	$ 183,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 183,000	-	-	-	-	$ -146,400
	Energy Conservation M	Radiant Heating Conversion	E05	IN	2020	25	-	2045	-	$ 157,000	$ 15,700	$ 172,700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -6,908
	Energy Conservation M	Dehumidifier Conversion	E06	IN	2020	25	-	2045	$ 1,000	$ 1,730,000	$ 173,000	$ 1,903,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -76,120
	Energy Conservation M	Pool and Whirlpool VFD	F01	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Pool Temperature Setback	F02	IN	2020	50	-	2070	-	$ 8,000	$ 800	$ 8,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -4,576
	Energy Conservation M	High Performance Glazing	G01	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase I	G02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Roof Insulation - Phase II	G03	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase I	G04	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Exterior Wall Insulation - Phase II	G05	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Interior Window Replacement	G06	OUT	2020	50	-	2070	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Domestic Water Retrofits	H01	IN	2020	10	-	2030	-	$ 101,000	$ 10,100	$ 111,100	-	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	-	-	-	-	-	$ 111,100	-	-	-	-	$ -66,660
	Energy Conservation M	Solar PV - Roof - 1.18 MW array	I01A	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar PV - Roof - 0.60 MW array	I01B	IN	2020	25	-	2045	$ 9,400	$ 1,356,153	$ 135,615	$ 1,491,768	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ -59,671
	Energy Conservation M	Solar PV - Parking Lot - 1.03 MW array	I02	OUT	2020	25	-	2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Energy Conservation M	Solar Thermal - Pool Heating	I03	OUT	2020	20	-	2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	$ 0	-	-	-	-	-
	Energy Conservation M	Remove In Stand Heating	J01	OUT	2020	-	-	2020	-	-	-	-	$ 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL						992	314		$ 33,000	$ 20,838,255	$ 2,065,525	$ 22,903,780	-	$ 1	-	-	-	-	$ 1	-	-	-	$ 111,100	-	-	$ 24,401	-	$ 0	-	-	-	-	$ 987,570	-	-	$ 0	$ 50,042	$ -1,873,942

APPENDIX I

WORKSHOP MATERIALS

Energy Management Group – Individual ECM Ranking Interpretation

	O+M	Occupant Impact	Impact to Site	Overall Rating	Simple Payback	Cost Ranking	Average
50% A CO2 Chiller	7.0	5.3	5.0	8.3	7.5	6.5	**6.6**
50% B Ammonia Chiller	7.1	5.2	5.1	8.0	6.1	6.4	**6.3**
50% C HVAC & BAS Heavy, DCV, VAV	6.9	5.3	5.1	8.0	5.9	6.6	**6.3**
80% A Solar Thermal, DCV, VAV	6.6	5.2	5.0	7.7	4.9	5.9	**6.0**
80% B Cold Water Flooding, Lighting+, DCV, VAV	6.8	5.3	5.1	7.8	3.8	6.6	**5.9**
80% C Solar Thermal, Envelope	6.6	5.2	5.0	7.6	4.9	6.1	**5.9**

Energy Management Group – Individual ECM Ranking Interpretation

	O+M	Occupant Impact	Impact to Site	Overall Rating	Simple Payback	Cost Ranking	Average
100% A High-Temp Ground Source, Envelope+	6.6	5.6	5.0	7.1	2.9	5.5	**5.5**
100% B Waste Water Heat Recovery, Envelope+	6.6	5.6	5.0	6.9	2.9	5.5	**5.4**
100% C High-Temp Ground Source, Renewable Energy Credits	6.7	5.3	5.1	7.6	3.6	6.2	**5.8**

Operations & Maintenance

	O+M	Occupant Impact	Impact to Site	Overall Rating	Cost to Implement	Average
50% A CO2 Chiller	5	5	8	5	8	**6.2**
50% B Ammonia Chiller	8	5	8	5	7	**6.6**
50% C HVAC & BAS Heavy, DCV, VAV	5	8	8	3	9	**6.6**
80% A Solar Thermal, DCV, VAV	5	5	5	5	6	**5.2**
80% B Cold Water Flooding, Lighting+, DCV, VAV	7	5	8	8	5	**6.6**
80% C Solar Thermal, Envelope	7	3	3	5	4	**4.4**

MCW

Operations & Maintenance

	O+M	Occupant Impact	Impact to Site	Overall Rating	Cost to Implement	Average
100% A High-Temp Ground Source, Envelope+	5	3	3	3	2	**3.2**
100% B Waste Water Heat Recovery, Envelope+	5	3	3	3	1	**3.0**
100% C High-Temp Ground Source, Renewable Energy Credits	5	5	5	5	3	**4.6**

MCW BD+C

	O+M	Occupant Impact	Impact to Site	Overall Rating	Cost to Implement	Average
50% A CO2 Chiller	5	7	3	3	8	**5.2**
50% B Ammonia Chiller	9	7	8	9	7	**8**
50% C HVAC & BAS Heavy, DCV, VAV	9	9	6	9	9	**8.4**
80% A Solar Thermal, DCV, VAV	4	7	3	3	6	**4.6**
80% B Cold Water Flooding, Lighting+, DCV, VAV	4	7	3	3	5	**4.4**
80% C Solar Thermal, Envelope	4	7	3	3	4	**4.2**

BD+C

	O+M	Occupant Impact	Impact to Site	Overall Rating	Cost to Implement	Average
100% A High-Temp Ground Source, Envelope+	4	7	2	2	2	**3.4**
100% B Waste Water Heat Recovery, Envelope+	2	7	1	2	1	**2.6**
100% C High-Temp Ground Source, Renewable Energy Credits	4	7	2	3	3	**3.8**

Asset Management

	O+M	Occupant Impact	Impact to Site	Overall Rating	Cost to Implement	Average
50% A CO2 Chiller	5	5	5	5	8	**5.6**
50% B Ammonia Chiller	5	5	5	5	7	**5.4**
50% C HVAC & BAS Heavy, DCV, VAV	10	10	5	10	9	**8.8**
80% A Solar Thermal, DCV, VAV	10	10	5	10	6	**8.2**
80% B Cold Water Flooding, Lighting+, DCV, VAV	5	5	5	5	5	**5**
80% C Solar Thermal, Envelope	10	10	5	10	4	**7.8**

SWOT

	Strength	Weakness
Internal Factors	Describe what this Program achieves - how does it improve the space? Is it better than other programs or the status quo?	Barriers to optimal function or implementation within the City of Brampton.
	Opportunity	**Threat**
External Factors	Favorable external factors that could have a beneficial impact on the Program or the City of Brampton.	Potentially harmful external factors that could be outside of the City's control.

SWOT – Programs 50%

Option 1, 50% Target: This option includes a retrofit of the ice plants with new C02 chillers with a higher heat recovery capacity. *CO2 Chiller*

	Strength	Weakness
Internal Factors	All ECMs are either low payback or supported by requirement for capital contribution Lowest implementation cost Showcase ECM	C02 Chiller - new technology Could be perceived as "business as usual"
	Opportunity	**Threat**
External Factors	ICI Rate Class Participation	Global Adjustment Rate Class Risk Future Legislation

SWOT – Programs 50%

Option 2, 50% Target: This option includes a retrofit of the ice plants, but with ammonia chillers instead of C02. As a result, integration onto a district energy heating system is required to hit the reduction target. *Chiller + District Energy*

	Strength	Weakness
Internal Factors	Overall low implementation cost Low maintenance costs	Lowest carbon impact
	Opportunity	**Threat**
External Factors	ICI Rate Class Participation Load conglomeration/economy of scale	Global Adjustment Rate Class Risk Locked into carbon intensive heating Locked into long term contract Future legislation

SWOT – Programs 50%

Option 3, 50% Target: This option considers implementing all those measures with capital projects under consideration (ice plant replacement, BAS upgrades, and replacements of the boilers, air handlers, and heat pumps). *Capital Projects*

	Strength	Weakness
Internal Factors	Significant Renewal of building assets Significant carbon impact beyond target	Could be perceived as business as usual
	Opportunity	**Threat**
External Factors	ICI Rate Class Participation	Global Adjustment Rate Class Risk Future Legislation

SWOT – Programs 80%

Option 4, 80% Target: This option includes a retrofit of the boilers, ice plants, and air handlers, and BAS. *Solar Thermal, DCV, VAV*

	Strength	Weakness
Internal Factors	Significant Renewal of building assets Showcase ECM	Considerable incremental investment beyond 50% targets for modest carbon savings
	Opportunity	**Threat**
External Factors	ICI Rate Class Participation Future Legislation	Global Adjustment Rate Class Risk

SWOT – Programs 80%

Option 5, 80% Target: This option includes a retrofit of the boilers, ice plants, and air handlers, and BAS. Additional lighting retrofits add to the carbon savings.
Cold Water Flooding, Lighting+, DCV, VAV

	Strength	Weakness
Internal Factors	More diverse ECM program Significant Renewal of buliding assets Showcase ECM	Considerable incremental investment beyond 50% targets for modest carbon savings
	Opportunity	**Threat**
External Factors	ICI Rate Class Participation Future Legislation	Global Adjustment Rate Class Risk

SWOT – Programs 80%

Option 6, 80% Target: This option is similar to option 4, but forgoes retrofits of the air handlers and substitutes a partial recladding of the building envelope.

Solar Thermal, Envelope

	Strength	Weakness
Internal Factors	Significant Renewal of building assets Showcase ECM Most visible, and most carbon savings of 80% target programs	Considerable incremental investment beyond 50% targets for modest carbon savings Least energy savings of 80% target programs
	Opportunity	**Threat**
External Factors	ICI Rate Class Participation Future Legislation	Global Adjustment Rate Class Risk

Option 7, 100% Target: This option includes the installation of a ground source heating loop to serve the entirety of the buildings heating needs. Retrofits of the air handlers, BAS, and ice plants are also included. All heating sources including in stand heating and dehumidifiers are decarbonized, as are the arena's ice resurfacers. A significant recladding of the building is also included.
High-Temp Ground Source, Envelope+

	Strength	Weakness
Internal Factors	Most Renewal of buliding assets Showcase ECMs, Renewable Generation Carbon Neutral	Considerable incremental investment beyond 80% targets for modest carbon savings Higher lifecycle costing than 50% or 80% targets
	Opportunity	**Threat**
External Factors	ICI Rate Class Participation Future Legislation	Global Adjustment Rate Class Risk

Option 8, 100% Target: This option is similar to option 7, but building heat is generated from a waste water source heat pump tied into a region of Peel sewer trunk north west of the building, in lieu of the ground source system envisioned in option 7. *Waste Water Heat Recovery, Envelope+*

	Strength	Weakness
Internal Factors	Most Renewal of building assets Showcase ECMs +, Renewable Generation Carbon Neutral Potential to act as a district energy host	Considerable incremental investment beyond 80% targets for modest carbon savings Higher lifecycle costing than 50% or 80% targets
	Opportunity	**Threat**
External Factors	ICI Rate Class Participation Future Legislation	Global Adjustment Rate Class Risk

Option 9, 100% Target: This option is similar to option 7, but forgoes recladding the building envelope. ***High-Temp Ground Source, Renewable Energy Credits***

	Strength	Weakness
Internal Factors	Significant Renewal of building assets Showcase ECMs, Renewable Generation Carbon Neutral, Lowest life cycle cost of carbon neutral options	Considerable incremental investment beyond 80% targets for modest carbon savings Recladding may still be required
	Opportunity	**Threat**
External Factors	ICI Rate Class Participation Future Legislation	Global Adjustment Rate Class Risk

Workshop II - Group I Discussion Notes

Program	Strength	Weakness
General		
1 (CO2 Chiller)		• Fear of new technology (EM) • Unknown risks (BDC) • Lifecycle of piping impacted by the CO2 (BDC) • How to do repairs if leaks (BDC)
2 (District Energy)		• Feasibility study by university is in "pre" stage (BDC)
3 (Capital Projects)	• Cost effective	• Did we do enough?
4 (Low Temp Loop + VAV)	• Flexibility of the boilers (EM)	• Footprint and piping requirements (BDC) • True heat transfer capacity required before implementation
5 (Option 4 + ECMs)	• Flexibility of the boilers (EM)	• Footprint and piping requirements (BDC) • True heat transfer capacity required before implementation
6 (Low Temp Loop + Recladding)	• Flexibility of the boilers (EM)	• Footprint and piping requirements (BDC) • True heat transfer capacity required before implementation
7 (Fully Electrify Ground + Reclad)		• Recladding roof interacting effects with solar panels?
8 (Fully Electrify Waste Water + Reclad)		
9 (Fully Electrify Ground)		
Programs	**Opportunity**	**Threat**
General		
1 (CO2 Chiller)		
2 (District Energy)		• Unknown pricing of district energy (EM) • At mercy of the university (EM) • Not currently in operation – would be new client (EM)
3 (Capital Projects)		

4 (Low Temp Loop + VAV)		
5 (Option 4 + ECMs)		
6 (Low Temp Loop + Recladding)		
7 (Fully Electrify Ground + Reclad)		
8 (Fully Electrify Waste Water + Reclad)		
9 (Fully Electrify Ground)		
General		
• Getting to carbon zero with carbon credits is cheaper but does not set a good example of technology options to reach targets and goals		

Workshop II - Group II Discussion Notes

Program	Strength	Weakness
General	• Adaptability of updates	• The report does not outline which ECMs do not work well together. •
1		• 50% Targets are not future ready.
2		• 50% Targets are not future ready. • Most other programs are scalable, this one is limiting because it is more difficult to reduce emissions from a DES.
3		• 50% Targets are not future ready.
4	• 80% low temp loop is a great opportunity to electrify • Future ready now (80&100) • Can provide increased training and skills for operations team.	• A concern over this program is that it may be harder to operate or add more steps to daily routines
5	• 80% low temp loop is a great opportunity to electrify • Future ready now (80&100)	
6	• 80% low temp loop is a great opportunity to electrify • Future ready now (80&100)	
7		• Diminishing returns on carbon reduction (100%)
8		•
9		• If recladding is not pursued then there are concerns that this program will not reach its required targets. There could be a larger makeup required with RECs.

Programs	Opportunity	Threat
General	• Incentive grants for higher tiers • The community accepts the climate emergency declaration. • Planning ahead for legislation rather than playing catch-up with some of the more ambitious retrofit goals. • Advanced planning to know what costs are and getting to market faster with plans. Limited players available to do deep energy retrofit. Being there quickly can allow for cost containment. • Councillors are supportive of sustainable targets at this time. • Savings from electricity based on future weather scenarios.	• Reliance on incentive funding (80&100) • Green funding incentives tend to be "Shovel Ready" so advanced planning is required.
1		
2		• Future legislation could negatively impact the DES incorporation. • The cost ratio of $/CO2 reduction for upper tier programs is high. • Technology could significantly improve over time, which is a risk to early adopters stuck with less efficient systems.
3		
4	• Ground loops can provide training to operators	
5		
6		
7		
8		
9		

General

- Having a better understanding about the budget available for retrofits would allow participants to make a better judgement call on the acceptance of costs. Environmental Planning and EMG provided informational background on capital developments funding and some availability of funds – 25% of all budget surplus is entered into energy retrofit funds (as informed by Environmental Planning)
- Zero-Over-Time (ZOT) approach would be an ideal component of this report to show how the City of Brampton could scale the ECMs
- 50% targets are not ambitious enough.