Water Treatment Plant

Service Delivery - Energy Audit – Final Report
Project Location: Township of Chapleau
Wood Project Number: BE20102014

Prepared for:

Township of Chapleau
20 Pine Street W. P.O. Box 129

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Prepared by:

Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited
900 Maple Grove Rd, Unit 10, Cambridge ON, N3H 4R7

7 October 2020

Executive Summary

Water Treatment Plant Audit

Wood PLC (Wood) was retained by the Township of Chapleau to conduct an energy audit on the Water Treatment Plant located at 1 Water Plant Rd, Chapleau Ontario.

An energy assesment consistent with ASHRAE Level 2 guidelines was conducted for the Facility. The site visit associated with this project was conducted on July 29th, 2020 by Nathan Sokolowski.

The aim of this study was to analyze the current energy performance of the Facility, conduct an onsite energy assessment, and produce a list of Energy Conservation Measures (ECMs) complete with relevant Opinion of Probable Costs.

The summary table below presents a list of opportunties during the energy assessment of the site Facility along with estimated costs, savings, and simple payback.

It is recommended that the Township of Chapleau carefully review the potential to implement these measures.

Table E-1 Summary of ECMs

ECMs	Measure	Opinion of Probable Cost	Estimated Savings				Estimated Total Savings	Simple Payback
			Propane	Electricity	Demand	Maintenance		
		($)	(L)	(kWh)	(kW)	($)	($)	(Years)
ECM-1	Infiltration Reduction	8,700	-	22,309 3.2%	15 8.7%	-	2,976	2.9
ECM-2	Wall Upgrades	27,000	-	27,080 3.9%	15 9.0%	-	3,612	7.5
ECM-3	Roof Upgrade	23,000	-	22,371 3.3%	11 6.6%	-	2,984	7.7
ECM-4	Thermostat Night-time Setback	5,100	-	13,237 1.9%	25 14.7%	-	1,766	2.9
ECM-5	Propane Source MUA	57,000	(6,671)	137,799 20.1%	118 69.3%	-	14,409	4.0
ECM-6	Low Lift VFD Retrofit	39,000	-	38,460 5.6%	4 2.4%	-	5,130	7.6
ECM-7	Interior Lighting Retrofit	19,000	-	30,528 4.4%	8 4.8%	260	4,332	4.4
ECM-8	Exterior Lighting Retrofit	1,600	-	5,652 0.8%	1 0.7%	40	794	2.0
Scenario 1		110,000	(5,847)	175,993 25.6%	121 71.5%	300	20,294	5.4
Scenario 2		125,000	-	121,143 17.6%	44 26.0%	300	16,459	7.6

Notes:

(1) It should be noted that the estimated savings associated with each scenario may not match the aggregated sum of the included measures evaluated separately. This is due to interactive effects between measures.

Wood recommends that the Township proceeds with the implementation Scenario 2.

Scenario 2, which contains:

- ECM-1: Infiltration Reduction;
- ECM-2: Wall Insulation (R-20) Retrofit;
- ECM-3: Roof Insulation (R-30) Retrofit;
- ECM-4: Temperature Control Set Points;
- ECM-6: Low lift pump VFD;
- ECM-7: Interior LED Retrofit & Controls; and
- ECM-8: Exterior LED Retrofit.

By implementing the recommended measures listed above, the following potential savings may be anticipated relative to the simulated baseline year:

- 121,143 kWh (17.6%) of electrcity savings

Wood recommends that the Township proceeds with the following building management and behavioral opportunities:

- Recommissioning;
- Unit heater maintenance;
- Staff Training and Occupant Awareness; and
- Procurement Policy.

Wood recommends that the Township investigate further possibility of implementing the following opportunity/opportunities:

- Solar Photovoltaic Panels.

Further analysis is required to determine the potential savings and costs of these measures more accurately. It is recommended that the Township move forward to review the potential to incorporate these measures into the existing site energy and environmental management strategy.

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Acronyms and Abbreviations

ACH	Air changes per hour
BTU	British Thermal Unit
C	Celsius
ccASHP	Cold Climate Air Source Heat Pump
CDD	Cooling Degree Day
CFL	Compact Fluorescent
CO_2e	Carbon Dioxide Equivalent
ECM	Energy Conservation Measure
EUI	Energy Utilization Index
ft	Feet
ft^2	Square feet
g	Gram
GSHP	Geothermal Source Heat Pump
GJ	Gigajoule
HDD	Heating Degree Day
HP	Horse Power
HPS	High Pressure Sodium
HST	Harmonized sales tax
IRR	Internal Rate of Return
kW	Kilowatt
kWh	Kilowatt hour
L	Litre
LED	Light emitting diode
m	Meter
m^2	Square meter
m^3	Cubic meter
NPV	Net Present Value
SCADA	Supervisory Control and Data Acquisition
UH	Unit Heater
VFD	Variable Frequency Drive
VUH	Vertical Unit Heater

W	Watt
Wood	Wood Environment & Infrastructure Solutions, Inc
U-Value	Thermal transmittance measured in BTU/(hr·ft^2·°F)

1.0 Introduction

Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited (Wood) was retained by the Township of Chapleau (client) to conduct energy audits for six (6) township buildings. This report is specific for the Water Treatment Plant (WTP) located at 1 Water Plant Rd, Chapleau Ontario.

The assessment involved a review of approximately 696 m^2 (7,495 ft^2) of floor space, the majority of which is dedicated to water treatment process structures such as clarifiers, settling tanks, sludge hoppers, filters and various pumping equipment. This revealed the potential for the implementation of energy management measures which may improve the overall efficiency of the facility.

Our assessment methodology can be found in **Appendix A.**

1.1 PURPOSE

The Purpose of this project is to conduct an energy assessment on the Town's owned facilities to assess and determine energy usage for equipment/facility consumption and operational performance. The goal of the energy assessment is to provide recommendations based on behavioral, operational, facility, and equipment performance and how the facilities can be improved to reduce energy consumption and overall operating costs. The assessment will identify both operating and capital improvements and provide a detailed analysis on simple payback and energy consumption reductions.

The overall goal of the assessment is to enable the Township to implement efficient upgrades and operations processes at the Facility thereby reducing energy and increasing the efficiency of the infrastructure and operational performance.

1.2 SCOPE OF ASSESSMENT

The detailed energy assessment consists of an on-site facility assessment, a utility analysis, and a detailed review and analysis of Energy Conservation Measures (ECMs). The energy assessment report is organized as follows:

- Facility Description;
- Utility Analysis and Benchmarking;
- ECMs; and
- Conclusions and Recommendations.

The Township of Chapleau provided the following documents to Wood for review:

- Utility records; and
- Facility drawings (floor plans).

The following appendices referenced below provide further background that form part of this report:

- Appendix A Assessment Methodology;
- Appendix B Assest Details;
- Appendix C Lighting Inventory;
- Appendix D Modeling Methodology; and
- Appendix E Utility Data Summary.

1.3 BACKGROUND

1.3.1 Client Information

The following table summarizes key client information related to this assignment.

Table 1-1 Key Client Information Summary

Customer Name	Township of Chapleau
Site Address	1 Water Plant Rd, Chapleau Ontario
Contact Person	Ms. Charley Goheen
Contact information	cgoheen@chapleau.ca
Utility Provider	Chapleau Hydro
Account No.	055028011

1.3.2 Acknowledgements

Wood would like to acknowledge the contribution of the Township of Chapleau and Facility staff whose help was invaluable in completing this assignment.

2.0 FACILITY DESCRIPTION AND CONDITION

The following sections summarize the observations made during the site investigation.

2.1 OVERVIEW

The WTP was constructed between 1974 and 1975. The main floor which has 7.6 m (25 ft) high ceilings is built over a series of wells and houses the clarifiers, settling tanks, sludge hoppers and filters. A second partial floor approximately 137m^2 (1475 ft^2) with 2.6 m (8.5 ft) high ceilings contains an office, laboratory, lunchroom, laundry, dry chemical storage and a polymer mixing area. The building is controlled with a SCADA system and the WTP operates 7 days a week by 2-3 staff members from the hours of 7:30 AM to 4:00 PM.

Table 2-1 General Building Information

Building Type	**Water Treatment Facility**
General Occupants	2-3
Gross Total Floor Area	696.31 m^2
Floors	2
Year Built	1974-1975
Occupancy schedule	7:30 AM to 4:00 PM

2.2 UPGRADES/CHANGES

The facility went through a renovation in 2013 which included a retrofit of lighting fixtures to fluorescent T8 and T5 fixtures, replacement of windows and installation of plant room ceiling fans. Process equipment was upgraded circa 2015 including new motors and VFDs for two (2) 20 HP high lift pumps and two (2) 60 HP high lift pumps. In 2019 the motor starters in the main electric panels were replaced.

2.3 BUILDING ENVELOPE

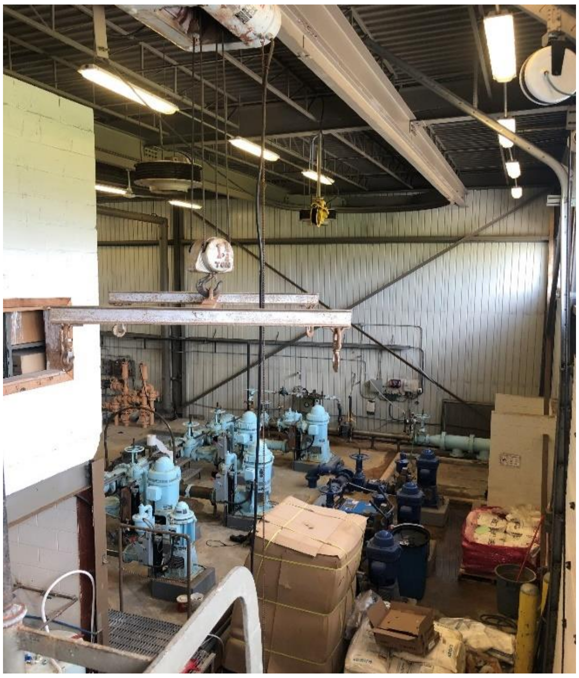
The exterior walls of the WTP are sheet steel wall assemblies with an estimated 5 ½" of batt insulation. The roof is a built-up roof assembly sitting on 2" of board insulation and a steel deck. The windows were replaced in 2013 with thermally broken aluminum windows that have low-e double glazing. The majority of windows are fixed and insulated glass with the exception of a handful in the office area which are vertical sliders. Interior rooms are divided with painted concrete blocks. Select photos representative of the general building envelope construction and interior are presented below and captured under Figure 2-1 in the table of contents.

Figure 2-1 Water Treatment Plant Site Photos

WTP - North East façade

Plant Room – Pre Contact Tank and Clarifiers

Main floor - chemical feed room



Plant Room – High and Low Lift Pumps

Second Floor - Laboratory

2.4 MECHANICAL SYSTEMS

The following mechanical systems and components were identified during the walk-through assessment.

2.4.1 Process Equipment

Raw water is gravity fed from the Kebsquasheshing River into a wet well where it is pumped via low lift pumps to a main level pre-contact tank and onward to clarifier basins. Water then proceeds through a cycle of filters towards a sequence of underground holding reservoirs. After the reservoirs, water reaches the clear well and it is distributed to the township via high lift pumps. In total there are three (3) 15 HP low lift pumps, two (2) 20 HP high lift pumps with VFD and four (4) 60 HP high lift pumps, two (2) of which equipped with VFD.

2.4.2 Heating, Ventilating and Air Conditioning

The building is 100% electric heat served by ceiling mounted verticals unit heaters (VUHs), wall mounted unit heaters (UHs) and electric baseboard heaters. Perimeter rooms on the lower level contain horizontal UHs between 3 kW and 7.5 kW on analogue thermostats and second floor rooms such as the office, laboratory and bathroom contain 2 kW baseboard heaters with built-in thermostats. The plant room is heated by five (5) Chromalox VUHs with an electrical input of 25 kW each. These heaters are individually controlled with manual thermostats and are tied with dedicated ceiling fans mounted nearby the VUHs to help destratify the warm air at ceiling level.

The plant room contains two (2), ½ HP Exhaust Fans (EF) rated at 3,900 CFM which operate when chlorine vapours intensify. There are multiple EFs estimated to be ¼ HP situated in chemical rooms, bathroom, laboratory, lunchroom, and office spaces.

2.4.3 Building Controls

The Facility process equipment are linked to a SCADA system. The Facility is not equipped with a Building Automation System (BAS), the UHs are controlled by local manual thermostats and switches.

2.4.4 Domestic Hot Water

Domestic Hot Water (DHW) is manufactured by RHEEM and is rated at 2.9 kW (9.9 MBH) with a storage capacity of 285 L (75 USG). There is a second tank to double the hot water storage capacity. The use of the main hot water is to warm soda ash prior to mixing with raw water.

2.5 ELECTRICAL SYSTEMS

The following electrical systems and components were identified during the site walk-through assessment.

2.5.1 Lighting Systems

The interior lighting systems were upgraded in 2013 to fluorescent fixtures and electronic ballasts equipped with a minimium of 9 kWs of T8 and T5 lamps. The plant room ceiling is equipped with high output T5 fixtures and the vast majority of remaining interior lighting systems are T8. There is a small amount of incandescent or compact fluorescent (CFL) lamps remaining in closet, storage, and washroom areas. All interior lighting is operated with manual on/off switches. Exterior lighting consists of a combination of halogen incandescent, high pressure sodium (HPS) and mercury vapour on integrated photocell control.

A lighting Inventory can be found in **Appendix C.**

2.5.2 Plug Loads

Plug loads include desktops, laptops, printers and common office equipment. It also includes equipment in designated lunchrooms such as refrigerators, microwaves, stoves and coffee makers.

2.6 ANCILLARY SYSTEMS AND LOADS

The following sections detail the presence of additional building features which may contribute to the overall building energy consumption.

2.6.1 Miscellaneous Loads

The Facility houses multiple pieces of electrical equipment required for water treatment processes. These include a 3 HP settling tank pump, two (2) 2.2 HP waste pit pumps and a 1.5 HP chlorine booster pump. There are multiple motors under 1 HP that are used to mix polymers and chemicals like aluminum sulphate and sodium hydroxide.

3.0 UTILITY ANALYSIS AND BENCHMARKING

The following sections detail the energy analysis that was performed for the Facility, and includes a utility analysis, a comparison to a benchmark, and a breakdown of energy consumed by fuel type and major end-use.

The utility electricity consumption data is summarized for the years 2018 to 2019 in Table 3-1 below.

Table 3-1 Summary of Utility Data for January 2018 to December 2019

Year	Electricity	
	Consumption (kWh)	Cost ($)
Jan-2018 to Dec-2018	702,000	93,637
Jan-2019 to Dec-2019	694,800	92,677

3.1 ELECTRICITY

There is one (1) electricity meter on site which measures the purchased energy for the building, as well as the exterior lighting. Collected utility data can be found in **Appendix E.**

Utility data was provided for a period of two (2) years from January 2018 to December 2019. A review of electricity costs from 2019 Chapleau Hydro invoices yielded a blended rate of $0.18/kWh which accounts for transmission, use, regulatory fees, global adjustment and HST.

The figure below illustrates the electrical consumption for the facility.

Figure 3-1 Monthly Electricity Consumption

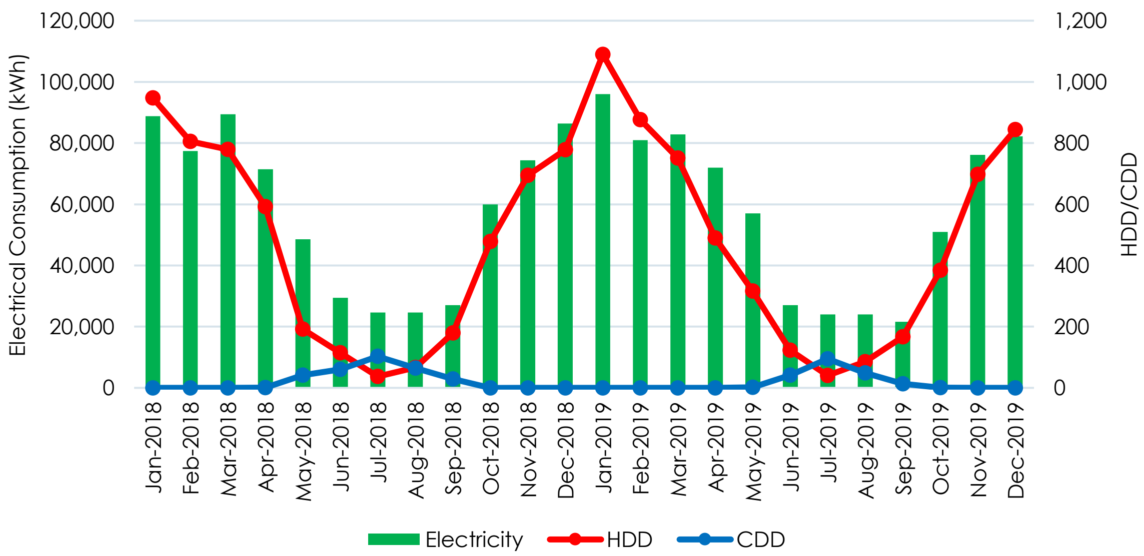


Figure 3-1 shows that electricity consumption peaks in the heating season (winter months); this is to be expected for a building in a heating dominated climate with electricity being the only energy source present. There is approximately 20,000 kWh of a baseload consisting of process pumping, DHW heating, lighting, plug loads, and exhaust fans.

To establish a baseline year, a linear regression analysis (R-squared analysis) was completed on the electricity data The R^2 value is a measure of the degree of correlated agreement between the electricity consumed and the dependent variable chosen, in this case CDD and HDD. An R^2 value of 1 represents a perfect correlation, while a lower value indicates a lesser degree of influence between the variables. In general, an R^2 value indicates a strong correlation between 0.8 and 1; a moderate correlation between 0.7 and 0.8; and a weak correlation below 0.7. By using an R^2 analysis to correlate energy usage to outdoor temperature, it may be possible to normalize data to a typical year, thereby removing the effects of temporary peaks or lulls due to varying weather patterns and determine how closely energy consumption is related to the weather.

The calculated R^2 value of **0.93** for HDD and **0.61** for CDD shows the facilities electricity consumption is heavily influenced by a dropping outdoor air temperature. The correlation between CDD is weak as there are no sources of air conditioning throughout the building.

3.2 SIMULATED BASELINE YEAR

Using a combination of Carrier's Hourly Analysis Program (HAP 5.11) software and Microsoft Excel based calculations, a baseline energy simulation was created and calibrated against the modeled energy consumption described previously to within the target of 20% of the annual consumption value. The accuracy of the calibration changes between utility record datasets due to the variability of weather; the modeled consumption has been normalized against weather, removing peaks and lulls due to varying weather patterns and allowing for a more accurate calibration. This model has been used as the basis for the end-use breakdowns in the subsequent sections. The modeling methodology can be found in **Appendix D.** Table 3-2 summarizes the simulated baseline year for the facility.

Table 3-2 Summary of Simulated Baseline Year Energy Consumption

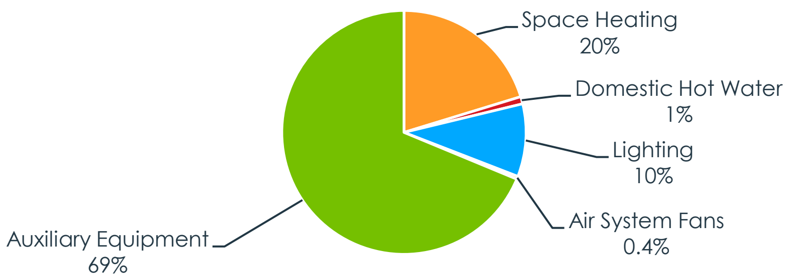
Year	Electricity	
	Consumption (kWh)	Cost ($)
Baseline	687,047	91,643

3.3 ANNUAL ENERGY CONSUMPTION BREAKDOWN BY MAJOR END-USE

The total annual energy consumption of the Facility was analyzed and broken down into major end-use categories. These categories included in this analysis consist of:

- **Space Heating** – This includes all electric space heating provided by ceiling mounted unit heaters and perimeter heat;
- **Domestic Hot Water** – All domestic hot water used in building;
- **Lighting** – All interior and exterior lighting;
- **Air System Fans** – All exhaust fans serving the facility; and
- **Auxiliary Equipment** – This includes all energy consumed by all plugged in equipment such as computers and telephones, kitchen appliances, and process water equipment mentioned earlier.

Figure 3-2 Annual Energy Consumption Breakdown by Major End-Use



From the figure above, auxiliary equipment is the end use that consumes the most energy at the facility at 69%. This is to be expected as the high and low lift pumps are required to operate year round at different output profiles to manage the water supplied to the Township's distribution system. Space heating is the next largest end user at 20%. Lighting systems make up 10% of energy use and domestic hot water represents 1%. The facility does not contain air systems other than simple low horsepower exhaust fans which provide little air movement placing all the heating load on ceiling mounted heaters and perimeter base boards.

3.4 BUILDING ENERGY PERFORMANCE BENCHMARKING

The facility Energy Utilization Index (EUI) was calculated by dividing the total annual energy used by the average daily amount water takings from the Kebsquasheshing River[1]. The table below compares the EUI at the Facility to the Energy Star Portfolio Manager benchmarks for **Drinking Water Treatment & Distribution** to assess the Facility's energy performance against similar buildings.

Table 3-3 EUI Benchmarking

Calculated in Utility Analysis	Energy Star Portfolio Manager Benchmark
GJ/m3/day	GJ/m3/day
1.60	1.18

Based on the analysis, the EUI for the estimated baseline year for the facility is approximately 36% greater than the Energy Star Benchmark.

4.0 ASSESSMENT FINDINGS

This section provides an overview of the ECMs analyzed in this report. For each measure, estimates of the annual savings in each of the following were determined:

- Electricity demand and consumption;
- Fuel switch consumption;
- Total energy cost;
- Maintenance cost; and,
- GHG emissions.

[1] Data from the 2019 Annual Compliance and Summary Report for the Chapleau Drinking Water System

The first two (2) items were determined using the simulated baseline model wherever possible. For some measures, hand calculations were used when the model was not able to simulate the measure. The maintenance cost premiums were estimated using commercial cost estimating software or based on Wood's experience with similar projects.

GHG emission reductions were calculated based on the results from the detailed analysis. The following table lists the GHG emission factors used.

Table 4-1 Energy Source Emission Factors

Energy Source	Emission Factor
Electricity	0.0000393 tonnes/kWh
Propane	1.55 tonnes/m^3

The following ECMs were reviewed:

- ECM-1: Infiltration Reduction;
- ECM-2: Wall Insulation (R-20) Retrofit;
- ECM-3: Roof Insulation (R-30) Retrofit;
- ECM-4: Temperature Control Set Points;
- ECM-5.1: Heating System Upgrade Option 1 – Heat Pumps;
- ECM-5.2: Heating System Upgrade Option 2 – Ground Water Source Heat Pumps;
- ECM-5.3: Heating System Upgrade Option 3 – Propane RTUs;
- ECM-6: Low lift pump VFD;
- ECM-7: Interior LED Retrofit & Controls; and
- ECM-8: Exterior LED Retrofit

4.1 BUILDING ENVELOPE

4.1.1 ECM-1: INFILTRATION REDUCTION

Existing Condition

All structural components within the building envelope are bound to experience varying levels of air or heat exchange at transection. Infiltration into the building can also create a significant heating load source in the buildings. Due to the age, construction and usage, the Facility may experience large heating loads due to air leakage and excessive infiltration through door openings, window openings, cracks, and exhaust/plumbing penetrations which can increase heating energy. Infiltration will occur during all hours of the day due to the absence of a ventilation system to provide positive pressurization to the building,

Because of the constant variation in wind speed and pressure, along with actual air infiltration greatly varying throughout the year, the average infiltration rate for the Facility was assumed to be 2.25 air changes per hour (ACH).

Proposed Condition

The installation or replacement of worn or broken weather stripping, window caulking, and foam sealants can contribute towards reducing air infiltration around doors, windows, piping, cracks, and exhaust/plumbing penetrations.

Analysis

This measure was analyzed using the end-use model generated from Carrier's HAP software as a basis. The infiltration ACH for spaces with doors, walls and windows were reduced on average by 12% because of weather-stripping and caulking.

A detailed building envelope or thermography testing could be conducted to identify anomalies related to thermal bridges, air infiltration/exfiltration, and heat transfer due to design or construction of the building.

The following assumptions were made during the analysis of this measure:

- For calculation purposes, weather-stripping and caulking of walls, windows and doors can reduce infiltration by a minimum of 12%; and
- Replacing worn and/or broken weather-stripping and caulking would not require additional modifications to the buildings structure.

The following table summarizes the estimated energy savings associated with this measure.

Table 4-2 ECM-1: Infiltration Reduction Annual Energy Savings

Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
22,309	3.2	14.8	8.7	-	2,976	2.2

The following table summarizes the financial analysis associated with this measure.

Table 4-3 ECM-1: Infiltration Reduction Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
8,700	2,976	2.9	10,588	25.7	3.0

This measure offers attractive financials and provides a simple payback of under three (3) years.

The following table summarizes the costs associated with this measure.

Table 4-4 ECM-1: Infiltration Reduction Opinion of Probable Cost Breakdown

Item	Cost ($)
Door Seal (x5)	285
Loading Dock (x1)	1,630
Window Caulking	3,240
Installation	1,800
Engineering (11%)	570

Item	Cost ($)
Commissioning and Training (7%)	360
Contingency (10%)	790
TOTAL (to nearest hundredth)	**8,700**

4.1.2 ECM-2: WALL INSULATION (R-20) RETROFIT

Existing Condition

It was assumed that the existing wall insulation at the Facility is under-insulated and uses an assumed thermal batt insulation of R-10 due to the buildings originally constructed in the 1970s.

Proposed Condition

An exterior energy retrofit can be considered which consists of adding new batt insulation to the exterior existing wall structure, upgrading the framing and sheathing systems and additional wall cladding allowing to create a tighter and a more insulated building envelope. Due to unavailable space and clearance for process equipment within the interiors of the building, the exterior energy retrofit can be more effective and easier to install.

In terms of implementation, it has been assumed that sufficient space will be required to attach exterior building insulation and wall cladding. There are no additional space requirements in interior spaces, as they should able to directly replace or attach to the exterior side of the walls. As there is little difference in the operation and maintenance of the new building envelope, no training will be required.

Analysis

This measure was analyzed using the end-use model generated from Carrier's HAP software as a basis. The wall insulation thickness was increased by 3" resulting in an effective thermal resistance of R-20, which is the minimum required for Ontario Building Code (OBC).

The following assumptions were made during the analysis of this measure:

- Existing finishing materials can either be easily removed or additional batt insulation can be easily installed on the exterior;
- Framing and additional exterior cladding costs are not included in the analysis due to many different types available;
- Process equipment and operation will not be majorly impacted during the retrofit process;
- Existing doors and windows can still be utilized;
- There is adequate space available for exterior building envelope retrofit;
- The exterior building envelope retrofit will not cause any structure implications;
- The existing humidity levels within the building will not be affected and any additional mechanical ventilation will not be required; and,
- Any existing issues and damages to the building envelope will be repaired during the retrofit process.

The following table summarizes the estimated energy savings associated with this measure.

Table 4-5 ECM-2: Wall Insulation (R-20) Retrofit Annual Energy Savings

Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
27,080	3.9	15.3	9.0	-	3,612	2.7

The following table summarizes the financial analysis associated with this measure.

Table 4-6 ECM-2: Wall Insulation (R-20) Retrofit Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
27,000	3,612	7.5	32,287	9.8	8.2

This measure offers savings with a moderate payback of 7.5 years. A positive NPV and IRR suggest that the Township can further look at investigating the opportunity to upgrade the building's envelope in the near future.

The following table summarizes the costs associated with this measure.

Table 4-7 ECM-2: Wall Insulation (R-20) Opinion of Probable Cost Breakdown

Item	Cost ($)
Project Cost	13,400
Installation (70%)	9,250
Engineering (11%)	1,500
Contingency (10%)	2,400
TOTAL (to nearest thousand)	**27,000**

4.1.3 ECM-3: ROOF INSULATION (R-30) RETROFIT

Existing Condition

It was assumed that the existing roof insulation at the Facility is under-insulated and uses an assumed rigid board insulation of R-15 that is original to the building's construction in 1970s.

Proposed Condition

An interior retrofit can be considered which consists of adding closed cell type spray foam to the interior roof structure allowing to create an air tight and moisture resistant building envelope.

In terms of implementation, it is assumed that electrical conduits for lighting, ceiling unit heaters and ceiling fans will need to be relocated to allow for the spray insulation to cover the inner roof surface.

Analysis

This measure was analyzed using the end-use model generated from Carrier's HAP software as a basis. The roof insulation thickness was increased by 3" resulting in an effective thermal resistance of R-30, which is the minimum required from Ontario Building Code for flat roofs.

The following assumptions were made during the analysis of this measure:

- Process equipment and operation will not be majorly impacted during the retrofit process;
- The existing humidity levels within the building will not be affected and any additional mechanical ventilation will not be required;
- Any existing issues and damages to the building roof will be repaired during the retrofit process; and
- Lifting and hoisting equipment rental is required.

The following table summarizes the estimated energy savings associated with this measure.

Table 4-8 ECM-3: Roof Insulation (R-30) Retrofit Annual Energy Savings

Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
22,371	3.3	11.2	6.6	-	2,984	2.2

The following table summarizes the financial analysis associated with this measure.

Table 4-9 ECM-3: Roof Insulation (R-30) Retrofit Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
23,000	2,984	7.7	3,859	3.0	8.4

This measure offers savings with a moderate payback of 7.7 years. A positive NPV and IRR suggest the township can look further at investigating the opportunity to upgrade the building envelop in the near future.

The following table summarizes the costs associated with this measure.

Table 4-10 ECM-3: Roof Insulation (R-30) Opinion of Probable Cost Breakdown

Item	Cost ($)
Project Cost	11,400
Installation (70%)	7,950
Engineering (11%)	1,250
Contingency (10%)	2,050
TOTAL (to nearest thousand)	**23,000**

4.2 HVAC

4.2.1 ECM-4: TEMPERATURE CONTROL SET POINTS

Existing Condition

The existing ceiling and wall mounted UHs which serve the process areas and rooms on the lower level including the former generator room and the chemical feed room, are programmed to operate based on the space temperature and set point of the spaces are controlled by local thermostats. These spaces are typically occupied less than 10% of the time and are not visited frequently. This can contribute towards wasting energy by conditioning to higher heating set points during unrequired times. It should be noted that the thermostats are not locked-out and anyone in the building can adjust the temperature set point to whatever they see fit.

Proposed Condition

The existing manual thermostats can be upgraded to programmable thermostats to allow adjusting of temperature that best suit the space and its scheduling needs, as well as maintain a constant temperature in the given space.

The temperature setting for process-driven areas, mechanical and electrical rooms can have an approximate minimum heating temperature set points between 12-15 °C (54-59 °F). This control strategy will save energy by reducing the amount of heating required within the spaces.

In terms of implementation, there are no additional space requirements for the programmable thermostats, as they should be able to directly replace the existing manual thermostats in the same space. The programmable thermostats are typically reliable with proper maintenance, and there are several vendors that carry them as part of their product line.

Analysis

This measure was analyzed using the end-use model generated from Carrier's HAP software as a basis. The heating set points were reduced from an average of 15 °C (59 °F) to an average of 12 °C (53.6 °F) in spaces where the measure is to be incorporated.

The following assumptions were made during the analysis of this measure:

- The thermostats' set points are maintained at the suggested temperatures throughout the year with no variance; and
- The existing UHs can support programmable thermostats and will operate accordingly.

The following table summarizes the estimated energy savings associated with this measure.

Table 4-11 ECM-4: Temperature Control Set Points Retrofit Annual Energy Savings

Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
13,237	1.9	25	14.7	-	1,766	1.3

The following table summarizes the financial analysis associated with this measure.

Table 4-9 ECM-4: Temperature Control Set Points Retrofit Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
5,100	1,766	2.9	10,793	30.0	3.0

This measure has a simple payback of under three (3) years and will result in reduced run times of the ceiling and wall mounted UHs. The following table summarizes the costs associated with this measure.

Table 4-10 ECM-4: Temperature Control Set Points Opinion of Probable Cost Breakdown

Item	Cost ($)
Project Cost	3,950
Engineering (11%)	450
Commissioning and Training (7%)	250
Contingency (10%)	465
TOTAL (to nearest hundredth)	**5,100**

4.2.2 ECM-5: HEATING SYSTEM UPGRADE

Existing

The existing Facility is currently served by electric resistance heating in the form of ceiling/wall mounted unit heaters and perimeter baseboard heaters.

Proposed Option 1: Air to Air Source Heat Pumps

Multizone cold climate air to air source heat pumps (ccASHP) can be used to provide heating. One outdoor condenser unit can be combined with upwards of 8 indoor evaporator fan coils to provide zoned climate control with individual thermostats. The electric heat may be retained in case there is a need for backup heat source and can be used if supplemental heating is required on very cold days.

In terms of implementation, heat pumps should always be installed by licensed, trained professionals. Upgrades to the building envelope to improve insulation and air tightness should be addressed before installing new equipment to ensure the right size of equipment is installed for the building heating load. Outdoor units can be ground mounted or roof mounted and in either scenario there is adequate space at the facility to do so. A small space needs to be allocated to the indoor coil, but it is versatile as it can be mounted either on the floor, wall or ceiling. The sensors would be tied into programmable thermostats to control each zone individually. Consideration will need to be given to the details of wiring the sensor to the controller. Several vendors carry ccASHP in their product line and they require periodic maintenance to maintain proper operation such as keeping the outdoor unit free from snow, ice and debris. As the system will be largely automated little training will be required.

Analysis

This heating system option was analyzed using the end-use model generated from Carrier's HAP software as a basis. The electric fan coils and UHs throughout the Facility were replaced with split DX fan coils that have an average coefficient of performance (COP) rating of 3.2 and a backup electric auxiliary heating that initiates at 4.4°C (40°F).

Proposed Option 2: Geothermal Heat Pump

Geothermal heat pumps operate on the same principals of an ccASHP with the benefit of higher COP especially during extreme cold weather. The Kebsquasheshing River adjacent to the building can be used as a renewable energy source and supply heat to the Facility. A heat pump can concentrate heat by compressing refrigerant and then transferring this heat into spaces via indoor coils or heat exchangers. The refrigerant gas becomes cold when the pressure is release and this coldness can be exchanged with warmer water from the river. The river has a more consistent temperature profile throughout the year than the outdoor air meaning the need for an auxiliary heating source (in the case of ASHP) is eliminated.

In terms of implementation, these types of systems typically use a series of pumps and closed loops of piping that are submerged and anchored so they float a couple feet above the bottom of river bed. Some trenching will be required for the supply and return legs of the geothermal loop. An experience geo-exchange designer along with environmental permits and legal approvals are challenges to implementation.

Analysis

This heating system option was analyzed using the end-use model generated from Carrier's HAP software as a basis. The electric fan coils and unit heaters throughout the Facility were replaced with a ground water source heat pump that uses surface water instead of a cooling tower and has an average COP rating of 3.6.

Proposed Option 3: Propane MUA unit

A make up air unit, capable of bringing in outdoor air, could provide tempered air into the zones of the Facility using propane as the fuel source. This would require the installation of a 1,500 L fuel storage tank outside the facility, connection gas piping and some duct work as propane is currently not available on site.

Analysis

This measure was analyzed using the end-use model generated from Carrier's HAP software as a basis. The electric fan coils and unit heaters throughout the Facility were replaced with a constant air volume make up air unit to provide 15°C (60°F) tempered air to the zones throughout the Facility. The unit was sized based on the ASHRAE 90.1 2013 ventilation standard using an average efficiency of 80%. A rate of $0.5954/L is used for propane including purchase cost and GHG carbon tax.

The following table summarizes the estimated energy savings associated with this measure.

Table 4-11 ECM-5: Heating System Upgrade Annual Energy Savings

Option	Estimated Propane Use		Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
	(L)	(%)	(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
1	-	-	75,221	10.9	42.8	25.2	-	10,033	7.5
2	-	-	89,051	13.0	89.1	52.5	-	11,878	8.9
3	6,671	-	137,799	20.1	118	69.3	-	14,409	3.5

The following table summarizes the financial analysis associated with this measure.

Table 4-12 ECM-5: Heating System Upgrade Financial Savings

Option	Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
	($)	($)	(years)	($)	(%)	(years)
1	255,000	10,033	N/A	(125,699)	-7.8	N/A
2	289,000	11,878	24.3	(94,038)	-3.7	N/A
3	57,000	14,409	4.0	128,684	21.9	4.2

Option 1 and 2 do not justify implementation on energy savings alone. These options generally require additional study to refine the project merit. These options are presented as an HVAC technology benchmark showing the energy savings potential based on an increase in the COP. This provides the township of Chapleau with a comparison if the WTP were to continue using electric sourced heating when the existing equipment reaches its end of life. Option 3 offers attractive financials and provides a simple payback of four (4) years. The following table summarizes the costs associated with this measure.

Table 4-13 ECM-5: Heating System Upgrade Opinion of Probable Cost Breakdown

Item	Option 1 Cost ($)	Option 2 Cost ($)	Option 3 Cost ($)
Project Cost	196,800	222,800	43,600
Engineering (11%)	21,700	24,500	8,800
Commissioning and Training (7%)	13,800	15,600	3,000
Contingency (10%)	23,200	26,300	5,100
TOTAL (to nearest hundredth)	**255,000**	**289,000**	**57,000**

4.3 PROCESS EQUIPMENT UPGRADES

4.3.1 ECM-6: LOW LIFT PUMP VARIABLE FREQUENCY DRIVE RETROFIT

Existing Condition

The three (3) low lift pumps are constant speed and operate on a duty standby cycle with one running at any given time. The low lift pump runs wide open pushing against a throttled (partially closed) globe valve to stretch and elongate the treatment process which is done to maintain water treatment quality.

Proposed Condition

It would be beneficial to upgrade the three (3) low lift pumps to VFD and adding a fluctuating valve on the raw well header to reduce pump consumption while providing the exact quantity of water required for the desired plant throughput.

Analysis

This measure was analyzed using an online VFD calculator. The following assumptions were made during the analysis of this measure

- The low lift pumps could operate between 60% and 80% instead of continuously at 100%;
- The existing motors are capable of VFD implementation;
- Three variable frequency drives are required, one for each motor; and,

- Costing includes one (1) fluctuation valve on the main header with linkage to SCADA.

The following table summarizes the estimated energy savings associated with this measure.

Table 4-14 ECM-6: Low Lift Pump VFD Retrofit Annual Energy Savings

Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
38,460	5.6	4.	2.4	0	5,130	3.8

The following table summarizes the financial analysis associated with this measure.

Table 4-15 ECM-6: Low Lift Pump VFD Retrofit Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
39,000	5,130	7.6	45,203	9.6	8.3

The measure offers savings with a moderate payback of 7.6 years. A positive NPV and IRR suggest that the township can further look at investigating in the opportunity to provide additional process flow flexibility.

The following table summarizes the costs associated with this measure.

Table 4-16 ECM-6: Low Lift Pump VFD Retrofit Opinion of Probable Cost Breakdown

Item	Cost ($)
Project Cost	30,000
Engineering (11%)	3,300
Commissioning and Training (7%)	2,100
Contingency (10%)	3,600
TOTAL (to nearest hundredth)	**39,000**

4.4 LIGHTING

4.4.1 ECM-7: INTERIOR RETROFIT & CONTROLS

Existing Condition

The current lighting system is manually operated with the majority of the spaces throughout the Facility currently using T8 fixtures with lamps rated at 32 W each and T5 fixtures with lamps rated at 54 W each.

Proposed Condition

The T8 lamps could be replaced with 16 W LED lamps and T5 lamps could be replaced with 15 W LED lamps. Note that since LED lamps have a longer service life than fluorescent lamps, maintenance savings will be achieved through fewer lamp replacements.

There are no additional space requirements for the new lamps, as they should be able to directly replace the existing lamps in the same space as the current fixtures. Depending on the style of the fixture, the entire fixture may need to be replaced rather than the lamp only; it is also possible that Town staff may wish to replace the fixture for cosmetic reasons.

LED lamps and fixtures are widely available from several vendors. Energy Star or Design Lighting Consortium (DLC) lamps and fixtures should be selected to ensure compliance with incentive programs. As there is little difference in the operation and maintenance of the new LED lamps no training will be required.

The Facility can utilize occupancy sensors with override capability to enable lighting setbacks in these areas when they are not being used, or when Facility personnel inadvertently keeps the lights on. This configuration would reduce energy consumption by only having the lights on when the space is occupied. However, it is important that manual switches be readily accessible in case of emergency situations to control the lighting in the space or due to failure of the occupancy sensors.

The following list of spaces could be equipped with occupancy sensors:

- Plant area;
- Mechanical rooms;
- Electrical panel area;
- Chemical storage; and
- Second floor offices and rooms including the designated lunch area and laboratory

In terms of implementation, a relatively small space needs to be allocated to the occupancy sensor, as it needs to be mounted either on the wall or ceiling. The sensors would be tied into the controller to control each zone individually. Consideration will need to be given to the details of wiring the sensor to the controller. Several vendors carry occupancy sensors in their product line and they require little maintenance to maintain proper operation. As the system will be largely automated little training will be required.

Analysis

This measure was analyzed using the end-use model generated from the HAP software as a basis. The lighting wattages of the specified areas, after implementing interior lighting LED retrofit, were reduced by 10% based on the ASHRAE 90.1-2013 requirements for power adjustment percentages for automatic lighting controls. This was modified in the HAP software model to reduce the occupied time of each space, which simulated the effect of utilizing occupancy sensors to turn off lighting in these areas when unoccupied.

The following assumptions were made during the analysis of this measure:

- Existing lamp lifetime is 5 years and are replaced at the rate of 20% per year;
- Proposed LED lamp lifetime is 10 years;
- Proposed LED lamps replacing T8 and T5 lamps will utilize 16 W and 15 W LED lamps;
- Minimum effort required to upgrade fixture with low ceiling heights;
- Lifting and hoisting equipment rental is required for high ceiling hung T5 lamp replacement;
- Occupancy sensors will reduce the lighting operating hours by approximately 50%; and,
- 20 sensors would be required for proper coverage within the spaces listed.

The following table summarizes the estimated energy savings associated with this measure.

Table 4-17 ECM-7: Interior Lighting Retrofit Annual Energy Savings

Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
30,528	4.4	8.2	4.8	260	4,072	3.1

The following table summarizes the financial analysis associated with this measure.

Table 4-18 ECM-7: Interior Lighting Retrofit Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
19,000	4,332	4.4	19,993	16.4	4.6

The measure offers a payback under 5 years and has a positive NPV and IRR. LED lamps can be acquired in bulk for potential savings in terms of cost/lamp or the LED lamps can replace the existing lamps on an as fail basis.

The following table summarizes the costs associated with this measure.

Table 4-19 ECM-7: Interior Lighting Retrofit & Controls Opinion of Probable Cost Breakdown

Item	Cost ($)
Project Cost	14,900
Engineering (11%)	1,600
Commissioning and Training (7%)	1,000
Contingency (10%)	1,800
TOTAL (to nearest hundredth)	**19,000**

4.4.2 ECM-8: EXTERIOR LIGHTING RETROFIT

Existing Condition

The exterior lamps at the Facility currently use HID fixtures with lamps rated at 70 W and 75 W along some Mercury Vapor fixtures with lamps rated at 175 W each. The exterior lamps are on photocell control.

Proposed Condition

The HID lamps could be retrofitted with 22 W LED lamps and the mercury vapor lamps could be replaced with 50 W LED lamps.

Analysis

This measure was analyzed using the end-use model generated from Carrier's HAP software as a basis. The lighting wattages of the exterior building were reduced to simulate the effect of the lower wattage LED lamps.

The following assumptions were made during the analysis of this measure:

- Existing lamp lifetime is 5 years and are replaced at the rate of 20% per year;
- Proposed LED lamp lifetime is 10 years;
- Proposed LED lamps replacing HID and Mercury Vapour lamps will utilize 22 W and 50 W LED lamps; and,
- Minimum effort required to upgrade fixtures around building exterior and along driveway entrance.

The following table summarizes the estimated energy savings associated with this measure.

Table 4-20 ECM-8: Exterior Lighting Retrofit Annual Energy Savings

Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
5,652	0.8	1.2	0.7	40	754	0.6

The following table summarizes the financial analysis associated with this measure.

Table 4-21 ECM-8: Exterior Lighting Retrofit Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
1,600	794	2.0	5,546	45.8	2.1

This measure offers attractive financials and a payback of two (2) years due to the efficiency gain using LED technology over conventional light sources such as HPS and incandescent lamps.

The following table summarizes the costs associated with this measure.

Table 4-22 ECM-8: Exterior Lighting Retrofit Opinion of Probable Cost Breakdown

Item	Cost ($)
Project Cost	1,240
Engineering (11%)	140
Commissioning and Training (7%)	90
Contingency (10%)	150
TOTAL (to nearest hundredth)	**1,600**

5.0 IMPLEMENTATION GUIDELINES

It is recommended that the measures that are the simplest and have the least interruption to the occupants be implemented first. It is important to consider phasing as a means of implementation in order avoid occupant disruption, levels of expenditure, and time to implement. The following table summarizes the implementation guidelines for each measure, which are high level timeline estimates and can vary considerably.

Table 5-1 ECM Implementation Plan Outline by Measure

ECM/Scenario	Design Period	Construction Period	Seasonal Requirements	Occupant Disruption
Infiltration Reduction	1-2 Weeks	1-2 Weeks	None	None
Wall Insulation (R-20) Retrofit	3-4 Months	4-6 Months	None	High
Roof Insulation (R-30) Retrofit	1-2 Months	2-3 Months	Ideally summer	Moderate
Temperature Control Set Points	1-2 Weeks	None	None	None
Heating System Upgrade	2-4 Weeks	3-4 Weeks	Ideally summer	High
Low Lift Pump VFD Retrofit	2-4 Weeks	3-4 Weeks	None	High
Interior LED Retrofit	4-8 weeks	1-2 Months	None	Moderate
Exterior LED Retrofit	1-2 Weeks	1-2 Weeks	None	Moderate
Scenario 1	3-4 Months	4-6 Months	Ideally summer	High
Scenario 2	5-6 Months	6-8 Months	Ideally summer	High

6.0 BUILDING MANAGEMENT AND BEHAVIOURAL OPPORTUNITIES

6.1 Re-commissioning

Re-commissioning is the process of returning the building systems to their design specifications after the Facility has been in operation for a period of time, typically about five years, as well as updating operations to match the current needs of the Facility.

It is recommended the building undergo re-commissioning again in the near future.

6.2 Unit Heater Maintenance

Electric heaters should be cleaned once a year to keep them working safely and efficiently. Debris such as dirt, dust, garbage and hair can accumulate on the fins. The heater cover should be removed and any visible debris inside the unit should be cleaned using a vacuum, soft brush or even a steam pressure cleaner. If any of the fins are bent or damaged they should be straighten using a pair of needle-nose pliers, metal scrapper or putty knife. The motor shaft should turn freely with bearing lubricated to ensure adequate operation and motors using belt drives should have the belt tension checked. Electrical connections should be tightened to ensure they are secure and have not vibrated loose from operation during the heating season.

6.3 Staff Training and Occupant Awareness

Equipment operation practices and policies can also have a significant impact upon energy consumption. There is generally ample opportunity for energy savings from general equipment left on when not in use. An energy efficiency awareness program should be put in place to encourage staff to frequently check temperature set points if heating is not required, similarly if lights are manually left on when not in use at the end of the day, and for the weekends.

6.4 Procurement Policy

Purchasing efficient products reduces energy costs without compromising quality. It is strongly recommended that a procurement policy be implemented as a key element for the overall energy management strategy at the Township. An effective policy would direct procurement decisions to select EnergyStar® qualified equipment in contracts or purchase orders. For products not covered under EnergyStar®, the EnerGuide labeling should be reviewed to select products with upper level performance in their category. Improved energy performance will involve the investment in energy efficient equipment coupled with a user education and awareness program.

7.0 OTHER OPPORTUNITIES CONSIDERED

7.1 Ceiling Fan Upgrades

Ceiling fans assist with air destratification by reducing the stack, or chimney effect of heat loss and also serve to distribute heated air more evenly throughout a space. It is recommended the Township of Chapleau replace existing ceiling fans on an as fail basis with high volume low speed (HVLS) destratification fans.

7.2 Solar Photovoltaic Panels

There exists strong potential to install solar photovoltaic (PV) panels on the available roof and surrounding ground area. A high level study was conducted using the National Renewable Energy Laboratory's (NREL) PVWatts® software tool to establish a preliminary estimate of the electricity production potential of a roof mounted solar PV system. The roof footprint was assessed, and a roof mount installation was proposed on the flat roof with no modifications to the exhaust and makeup air systems. The assumption was made that 75% of the proposed roof space could be utilized and was unobstructed (clear of vents and protrusions).

The following table summarizes the estimated energy savings associated with this measure.

Table 7-1 Estimated solar PV generation potential

System Type	Available Panel Space (m^2)	Estimated System Size (kW)	Array Azimuth (deg)	Array Tilt (deg)	Array Output (kWh/yr)
Roof mount	380	57	200	40	71,500

Based on results from the PVWatts simulations, it is estimated, based on PV system physical and design characteristics summarized above, that 71,500 kWh could potentially be generated at the WTP. This would offset 10.4% of the existing site wide electricity load. Hardware (solar panels, inverters, racking systems, balance of system) costs and soft costs (installation labour, deposit upgrade etc.) make up the installation cost of a PV system. To inform capital cost estimates and expected ongoing operation and maintenance costs, wood applied an installed cost per watt of $2.59/W, based on market guidance and past engineering experience, along with 11% engineering fee, 7% commissioning and training and 10% contingency.

The following table summarizes the financial analysis associated with this measure.

Table 7-2 Solar PV System Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
191,000	9,140	20.9	14,811	0.5	27.2

8.0 IMPLEMENTATION SCENARIO

Wood has identified strategic implementation scenarios for the measures recommended in this assessment report.

It should be noted that the estimated savings associated with each scenario may not match the aggregated sum of the included measures evaluated separately. This is due to interactive effects between measures.

- Scenario-1, which contains:
  - ECM-1: Infiltration Reduction;
  - ECM-3: Roof Insulation (R-30) Retrofit;
  - ECM-5: Heating System Upgrade;
  - ECM-7: Interior Retrofit & Controls; and
  - ECM-8: Exterior LED Retrofit.

The following table summarizes the estimated energy savings associated with this scenario.

Table 8-1 ECM-Scenario 1: Annual Energy Savings

Estimated Propane Use		Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
(L)	(%)	(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
5,847	-	175,993	25.6	121	71.5	300	19,994	8.5

The following table summarizes the financial analysis associated with this implementation scenario.

Table 8-2 ECM-Scenario 1: Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
110,000	20,294	5.4	72,665	10.9	5.8

The scenario upgrades components and systems in major Facility end users including the building envelope, heating system and lighting system and offers a payback under six (6) years with a positive NPV and IRR.

The following table summarizes the costs associated with this implementation scenario.

Table 8-3 ECM-Scenario 1: Opinion of Probable Cost Breakdown

Item	Cost ($)
Project Cost	76,200
Installation	9,800
Engineering (11%)	8,400
Commissioning and Training (7%)	5,300
Contingency (10%)	10,000
TOTAL (to nearest hundredth)	**110,000**

- Scenario-2, which contains:
  - ECM-1: Infiltration Reduction;
  - ECM-2: Wall Insulation (R-20) Retrofit;
  - ECM-3: Roof Insulation (R-30) Retrofit;
  - ECM-4: Temperature Control Set Points;
  - ECM-6: Low lift pump VFD;
  - ECM-7: Interior LED Retrofit & Controls; and
  - ECM-8: Exterior LED Retrofit.

The following table summarizes the estimated energy savings associated with this scenario.

Table 8-4 ECM-Scenario 2: Annual Energy Savings

Estimated Electricity Savings		Estimated Demand Savings		Estimated Maintenance Savings	Estimated Total Cost Savings	Estimated GHG Reduction
(kWh)	(%)	(kW)	(%)	($)	($)	(t CO_2e)
121,143	17.6	44.2	26.0	300	16,159	12.1

The following table summarizes the financial analysis associated with this implementation scenario.

Table 8-5 ECM-Scenario 2: Financial Analysis

Opinion of Probable Cost	Net Cost Savings	Simple payback	Net Present Value	IRR	Discounted payback
($)	($)	(years)	($)	(%)	(years)
125,000	16,459	7.6	23,147	3.3	8.3

The scenario retains the existing electric heating systems incorporating temperature set backs at night while providing upgrades to the building envelope, process equipment and lighting systems. This scenario offers a simple payback of 7.6 years with a positive NPV and IRR.

The following table summarizes the costs associated with this implementation scenario.

Table 8-6 ECM-Scenario 2: Opinion of Probable Cost Breakdown

Item	Cost ($)
Project Cost	80,200
Installation	19,000
Engineering (11%)	8,800
Commissioning and Training (7%)	5,600
Contingency (10%)	11,400
TOTAL (to nearest hundredth)	**115,000**

9.0 CONCLUSIONS AND RECOMMENDATIONS

Several ECMs were identified during the detailed energy assessment**.** The following table summarizes all the ECMs that were reviewed along with estimated costs, savings, and simple payback.

Table E-1 Summary of ECMs

ECM	Measure	Opinion of Probable Cost	Estimated Savings				Estimated Total Savings	Simple Payback
			Propane	Electricity	Demand	Maintenance		
		($)	(L)	(kWh)	(kW)	($)	($)	(Years)
ECM-1	Infiltration Reduction	8,700	-	22,309 3.2%	15 8.7%	-	2,976	2.9
ECM-2	Wall Upgrades	27,000	-	27,080 3.9%	15 9.0%	-	3,612	7.5
ECM-3	Roof Upgrade	23,000	-	22,371 3.3%	11 6.6%	-	2,984	7.7
ECM-4	Thermostat Night-time Setback	5,100	-	13,237 1.9%	25 14.7%	-	1,766	2.9
ECM-5	Propane Source MUA	57,000	(6,671)	137,799 20.1%	118 69.3%	-	14,409	4.0
ECM-6	Low Lift VFD Retrofit	39,000	-	38,460 5.6%	4 2.4%	-	5,130	7.6
ECM-7	Interior Lighting Retrofit	19,000	-	30,528 4.4%	8 4.8%	260	4,332	4.4
ECM-8	Exterior Lighting Retrofit	1,600	-	5,652 0.8%	1 0.7%	40	794	2.0
Scenario 1		110,000	(5,847)	175,993 25.6%	121 71.5%	300	20,294	5.4
Scenario 2		125,000	-	121,143 17.6%	44 26.0%	300	16,459	7.6

Notes:
It should be noted that the estimated savings associated with each scenario may not match the aggregated sum of the included measures evaluated separately. This is due to interactive effects between measures.

Wood recommends that the Township proceeds with the suggested ECMs stated in implementation scenario 2. Upgrades to the building envelope to improve insulation and air tightness should be addressed before installing new HVAC equipment to ensure the right size of equipment is installed for the building heating load. This includes the following ECMs:

- Scenario-2, which contains:
    - ECM-1: Infiltration Reduction;
    - ECM-2: Wall Insulation (R-20) Retrofit;
    - ECM-3: Roof Insulation (R-30) Retrofit;
    - ECM-4: Temperature Control Set Points;
    - ECM-6: Low lift pump VFD;
    - ECM-7: Interior LED Retrofit & Controls; and
    - ECM-8: Exterior LED Retrofit.

By implementing the recommended measures listed above, the Facility has a potential savings of 121,143 kWh, equivalent to a 17.6% reduction that may be anticipated relative to the simulated baseline year.

10.0 STUDY LIMITATIONS

It must be noted that an energy audits prime goal is to identify the energy savings opportunities that likely meet the Township of Chapleau's minimum payback criteria. Energy savings and installation costs are estimates only. Detailed designs are always recommended before proceeding, along with final complete payback analysis.

This report documents work that was performed using methods and procedures that are generally consistent with the ASHRAE level 2 guidelines, subject to the level of investigative effort outlined in this report and generally accepted and prevailing industry standards at the time and location in which the services were provided. No other representations, warranties, or guarantees are made, including no assurance that this work has uncovered all potential issues associated with the identified property that may impact energy consumption or implementation of proposed measures.

This report provides an evaluation of potential for energy conservation opportunities at the WTP located at 1 Water Plant Rd in Chapleau, Ontario, that was assessed at the time the work was conducted and is based on information obtained by and/or provided to Wood at that time. There are no assurances regarding the accuracy and completeness of this information. All information received from the client or third parties in the preparation of this report has been assumed by Wood to be correct. Wood assumes no responsibility for any deficiency or inaccuracy in information received from others.

Activities at the property or additional information subsequent to Wood's assessment may have significantly altered the potential and feasibility of the opportunities or conclusions identified within the report.

Conclusions made within this report consist of Wood's professional opinion as of the time of the writing of this report and are based solely on the scope of work described in the report, the limited data available, and the results of the work. The savings calculations are our estimate of saving potentials and are not a guarantee. The impact of building changes in space functionality, operations, usage, equipment retrofit, and weather need to be considered when evaluating the savings.

This report has been prepared for the exclusive use of the client identified herein and any use by any third party is prohibited. Wood assumes no responsibility for losses, damages, liabilities or claims, howsoever arising, from third party use of this report.

This report is limited by the following:

- Our interpretation of the objective and scope of works during the study period;
- The information provided by the Municipality; and,
- Measures identified in this report are subject to the professional engineering design process before being implemented.

The recommendations and our opinion of probable costs associated with these recommendations, as presented in this report, are based on walk-through non-invasive observations of the parts of the building which were readily accessible during our visual review. Conditions may exist that are not as per the general condition of the system being observed and reported in this report. Opinions of probable costs presented in this report are also based on information received during interviews with operations and maintenance staff.

The opinions of probable costs are intended for global budgeting purposes only. The scope of work and the actual costs of the work recommended can only be determined after a detailed examination of the site element in question, understanding of the site restrictions, understanding of the effects on the ongoing operations of the site/building, definition of the construction schedule, and preparation of tender documents. We expressly waive any responsibilities for the effects of any action taken as a result of these endeavors unless we are specifically advised of prior to, and participate in the action, at which time, our responsibility will be negotiated.

11.0 CLOSURE

Wood conducted an Energy Audit at the Water Treatment Plant located at 1 Water Plant Rd in Chapleau Ontario. Electricity conservation and efficiency measures were investigated, provided, and assessed in terms of energy savings, fuel switch opportunities and utility cost savings along with capital project costs and financial analysis. Through our analysis we have identified eight (8) ECMS including one (1) fuel switch opportunity.

Wood has presented two (2) strategic implementation scenarios for the measures recommended in this assessment report. Scenario 1 is estimated to reduce site electricity by 25.6% which is widely due to swapping the electric heating systems in favour of a propane base make up air unit, capable of brining in outdoor air and tempering it to programmed temperature control set points defined for each zone in the facility. The overall annual cost savings for scenario 1 relative to the baseline year is $20,294. Scenario 2 is estimated to reduce site electricity by 17.6% which is widely due to upgrades to the building envelope and reducing the amount of infiltration and heat gain which is currently occurring. The overall annual cost savings for scenario 2 relative to the baseline year is $16,459.

Wood recommends proceeding with scenario 2 and maintaining the existing perimeter heating system while it still has useful life. Additional recommendations include the following building management and behavioral opportunities:

- Recommissioning;
- Unit heater maintenance;
- Staff Training and Occupant Awareness; and
- Procurement Policy.

Wood Environment & Infrastructure Solutions

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Prepared by:	Reviewed by:
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Signature: Nathan Sokolowski	**Signature:** Ayman Nicola

Appendix A

Appendix A Assessment Methodology

Site Visits

The visit included a detailed interview with technical staff regarding the buildings' function as well as discussing any issues that were persistent and opportunities for operational optimization. A comprehensive tour of the site was also conducted to evaluate the HVAC, lighting, and controls systems.

Utility Analysis

An analysis of the Water Treatment Plants consumption provides a good starting point from which to:

- Identify potential energy conservation measures (ECMs); and,
- Develop a baseline against which ECM performance can be quantified.

The consumption (and demand) registered on historical data for the utility meter can also be examined to identify issues that are affecting the energy performance of the site.

Utility data for electricity was provided by the Township of Chapleau dating back to 2018 for the Chapleau Hydro utility meter.

Utility Rates

In terms of savings related to the identified measures, a blended rate is used which effectively assumes that reduction in consumption will only reduce the cost by the rate that applies to the last unit of energy used. The blended rates naturally include all fees, taxes, and bulk charges which may be included in each utility provider's billings. These rates are listed the table below.

Table A-1 Utility Rates (January 2018 – December 2019)

Item	Value	Units
Electricity Rate	0.18	$/kWh

Envelope System Assessment

The envelope and architectural assessment involves a non-intrusive visual inspection of the facility and a review of any available drawings to determine the condition and type of construction. Special attention will be paid to doors and windows during this review.

Mechanical System Assessment

The mechanical portion of the assessment involves taking a comprehensive inventory of mechanical components and an accurate appraisal of operational times and efficiencies for each mechanism. This is inclusive of all HVAC, Domestic Hot Water, and process related equipment. The Building Automation System (BAS) and/or manual equipment controls will be inventoried and assessed for integration. Sequence of operations will be examined for improvement opportunities.

Electrical System Assessment

A comprehensive assessment of the site's lighting includes a detailed review the existing fixtures and controls throughout the site. Consideration is also given to operational hours and the diligence of occupants at switching OFF manually operated lighting. A comprehensive assessment of the site's other electrical equipment including motors, transformers and process equipment.

Energy Conservation Measure Identification and Analysis

Each measure proposed for implementation on this project has been selected based on its viability, as measured against the following criteria:

- costs and savings within overall criteria for evaluation guidelines;
- appropriateness for tasks performed in the space;
- condition of existing systems;
- consistency of application (all areas of similar function are consistent);
- equipment approval by facilities personnel; and,
- impact on occupant behaviour and general acceptance of changes.\

The energy savings calculations are based on a best estimate of the anticipated reductions taking into consideration direct savings from electrical consumption and electrical demand where appropriate. Savings associated with heating and cooling measures are calculated relating to heating and cooling degree-days for the site which are taken from the most appropriate local weather data source, which assumes an average balance point[2] temperature of 18°C (64.4 °F).

Costs associated with implementing the respective measures are estimated based on the approximate 'capital cost' for the materials and labor (including demolition and installation). Costs are determined from previous project experience and/or through published cost estimate data (RS Means…). All costs represent Wood's opinion on probable cost and are provided as approximate estimates to give economies of scale. Further investigation and detailed costing should be carried out prior to implementation.

For any systems or equipment that are on site and not functioning (not consuming energy) no energy conservation measures have been considered. The scope of this exercise is to find opportunities to reduce energy consumption and where there is no possibility to do so, no measures have been discussed in the report.

Recommendations

From the options considered, recommendations are put forward based on financial and practical feasibility using indicators such as simple payback, capital cost and net present value (NPV).

[2] The balance point temperature is the external temperature at which the building's heating equipment is initiated.

Appendix B

Appendix B Asset Details

This table below presents the equipment inventory for the Facility at the time of the site visit.

Description	Floor	Location	Room	Manufacturer	Model	Quantity	Phase	Voltage	Amps	HP	Demand (kW)
Base Board Heater	Upper	Bathroom	203	N/A	N/A	1	1	120	4.6	0.74	0.6
Base Board Heater	Upper	Bathroom Kick Space	203	N/A	N/A	1	1	120	14.4	2.3	1.7
Unit Heater	Upper	Super Office	204	N/A	N/A	1	3	600	2.5	3.5	2.6
Unit Heater	Lower	Generator Room	106	Stel Pro	SHU0763CT	1	3	600	7.3	10.2	7.6
Unit Heater	Lower	Hall	103	Stel Pro		1	3	600	7.3	10.2	7.6
Unit Heater	Lower	Chlorine Room	107	Oulette Canada	OAS 03939	1	3	600	2.89	4.0	3.0
Ceiling Heaters		WTP		Chromalux	W77	5	3	208	69.47	33.6	25.0
Ceiling Fans		Plant Room Ceiling	110	Banvil	185C-MR	4	1	115		0.13	0.10
EF-1 Exhaust		Plant Room Ceiling	110	N/A	N/A	1	1	115		0.50	0.4
EF-2 Exhaust		Plant Room Ceiling	110	N/A	N/A	1	1	115		0.50	0.4
EF-3 Exhaust	Upper	Office & Lunch Room	206 / 207	N/A	N/A	1	1	115		0.25	0.2
EF-4 Exhaust	Upper	Lab & Washroom	203 / 205	N/A	N/A	1	1	115		0.25	0.2
EF-5 Exhaust	Upper	Dry Chemical Storage	210	N/A	N/A	1	1	115		0.25	0.2
Exhaust	Lower	Chlorine Room	107	General Electric	4J36DGA5	1	1	115	6	0.25	0.2
Hot Water Heater	Lower	Storage	111	Rheem	XE60T61ST38C0	1	1	208			2.9
Pump #1 Low Lift	Lower	Plant Room	110	US Electrical Motors	9600674-D-776 ER10466	1	3	575	15.8	15	11.2
Pump #2 Low Lift	Lower	Plant Room	110	US Electrical Motors	9600674-D-776 ER10466	1	3	575	15.8	15	11.2

Description	Floor	Location	Room	Manufacturer	Model	Quantity	Phase	Voltage	Amps	HP	Demand (kW)
Pump #3 Low Lift	Lower	Plant Room	110	US Electrical Motors	9600674-D-776 ER10466	1	3	575	15.8	15	11.2
Pump # 1 High Lift w VFD	Lower	Plant Room	110	NIDEC Motor Corp	13705096-100	1	3	575	20.5	20	14.9
Pump # 2 High Lift w VFD	Lower	Plant Room	110	NIDEC Motor Corp	13705096-100	1	3	575	20.5	20	14.9
Pump # 3 High Lift	Lower	Plant Room	110	US Electrical Motors	9503617-D-576 BR90462	1	3	575	58	60	44.7
Pump #4 High Lift w VFD	Lower	Plant Room	110	NIDEC Motor Corp	13704841-100	1	3	575	54	60	44.7
Pump #5 High Lift w VFD	Lower	Plant Room	110	NIDEC Motor Corp	13704841-100	1	3	575	54	60	44.7
Pump # 6 High Lift	Lower	Plant Room	110	US Electrical Motors	9505353-D-621 BR90511	1	3	575	58	60	44.7
[redacted]											
Booster Pump	Lower	Chlorine Room	107	WEG	B5HC	1	3	575	1.5	1.5	1.1
Settling Tank Pump	Lower	Plant Room	110	Brook Crompton	2315208-90	1	3	575	3.5	3	2.2
Waste Pit Pump 1	Lower	Plant Room	110	Flygt	3085.181-6002	1	3	600	2.6	2.2	1.6
Waste Pit Pump 2	Lower	Plant Room	110	Flygt	3085.181-6002	1	3	600	2.6	2.2	1.6
Poly System-Mixer	Lower	Hall	103	Not Available	9K346	1	1	115	4.9	0.1667	0.1
Poly System- Sludge Pump	Lower	Hall	103	General Electric	5KC47UG694X	1	1	115	13.2	1	0.7
Poly System- Injector Pump	Lower	Hall	103	Flojet	2130-571-115	1	1	115	1.2		0.1
Portable Chem Mixer	Upper	Loading & Storage	208	SPX Flow Lightnin	EV5P25	2				0.25	0.2
[redacted]											
Hoist		Plant Room	110	Meteor	5815	1					
Hoist Motor 1		Plant Room	110	Chisolm Moore	P14736	1		575	0.34	0.5	0.4

Description	Floor	Location	Room	Manufacturer	Model	Quantity	Phase	Voltage	Amps	HP	Demand (kW)
Hoist Motor 2		Plant Room	110	Columbus McKinnon	Not Available	1		575	2.8	2	1.5
Welder		Plant Room	110	Miller	BlueStar 185	1			60-195		
[redacted]											
Washing Machine	Upper	Laundry	209	Kenmore	110.2601201	1	1	120	6		0.7
Dryer	Upper	Laundry	209	GE	GTD40EBMK0WW	1	1	120	22		5.6

Appendix C

Appendix C **Lighting Inventory**

The table below presents the existing fluorescent lighting at the facility at the time of the site visit.

Space	Fixture #	Fixture Housing	Fluorescent Lamp Type	Lamps	Lamp Length (ft)	Lamp Watts	Ballast	Fixture Watts	Total Watts
Entry	11	Surf, linear	T8, Instant start	1	3	25	Electronic	26	286
Hall, Chem Feed Rm, Control Panel, Storage, Alum Tank	12	Surf, 1x4	T8, Instant start	2	4	32	Electronic	65	780
Chlorine Room	2	Surf, 1x4	T8, Instant start	2	4	32	Electronic	65	130
Shop	2	Surf, linear	T8, Instant start	4	4	32	Electronic	118	236
Plant Room	6	Surf, 1x4	T8, Instant start	2	4	32	Electronic	65	390
Sludge Bagging Room	9	Surf, 1x4	T8, Instant start	2	4	32	Magnetic	65	585
Corridor	3	Surf, 1x4	T8, Instant start	2	4	32	Electronic	65	195
Washroom, Hallway	6	Surf, 1x4	T8, Instant start	1	4	32	Electronic	31	186
Office, Laboratory	6	Rec, 2x4 trofer	T8, Instant start	2	4	32	Electronic	59	354
Laundry	2	Rec, 1x4 troffer	T8, Instant start	2	4	32	Electronic	59	118
Loading & Storage	5	Surf, 1x4	T8, Instant start	2	4	32	Electronic	65	325
Office, Lunch	6	Rec, 1x4 troffer	T8, Instant start	2	4	32	Electronic	59	354
Dry Chem Storage	3	Rec, 1x4 troffer	T8, Instant start	2	4	32	Electronic	59	177
Plant Room	45	Susp, linear	T5, Standard, High output lamp	2	4	54	Electronic	117	5265

The table below presents the existing non-fluorescent lighting at the facility at the time of the site visit.

Space	Fixture #	Fixture Housing	Lens Cover	Fixture Type	Lamps #	Lamp Watts	Fixture Watts	Total Watts
Janitors Closet	1	Susp, circular	None	Incandescent	1	100	100	100
Shower	2	Susp, circular	Frosted	Compact Fluorescent	2	11	26	52
Exterior Entrance	2	Rec, down	Frosted	Halogen Incandescent	1	75	75	150
Exterior Building	8	Surf, sconce	Clear	High Pressure Sodium	1	70	95	760
Exterior Building	3	Grnd-Mnt, Pole	Frosted	Mercury Vapor	1	175	205	615

Appendix D

Appendix D Modelling Methodology

The building simulation program Carrier HAP version 5.11 was used to simulate how each recommendation would perform under the existing buildings characteristics. The program uses typical weather data along with input from the user of the building's HVAC equipment, building occupancy schedule, envelope materials, plug loads, and process loads to simulate design alternatives.

The Facility's internal gains were entered in the baseline model using occupancy counts and estimating electrical appliances such as computers, copiers, and printers amongst others; the ASHRAE Fundamentals 2013 Handbook was used as a guide for estimating the loads from this equipment.

To determine the Facility's lighting load consumption, lighting counts were taken on site and verified against the electrical reflected ceiling drawings, the lighting inventory was then used to determine the interior, exterior, and perimeter lighting loads. Where lighting information could not be obtained ASHRAE Fundamentals 2013 Handbook was used as a guide.

The Facility's HVAC components were generated in the model using a combination of manufacturer specifications, mechanical drawings, schedules, and equipment asset details for the HVAC systems. A combination of manufacturer specifications and nameplates were used for units within the Facility. In addition, the building operator's description of the Facility's HVAC sequences of operations and BAS information and setpoints were also accounted for in the model.

To ensure that the baseline model was operating similarly to the existing building, the Facility's baseline consumption based on the utility billing data was compared to the building simulation's energy consumption outputs. This comparison was done both analytically by comparison to total consumption and visually by comparing monthly trends to expected consumption.

Appendix E

Appendix E Utility Data Summary

The table below presents the collected utility data for the site.

Month-Year	Days in Billing Period	Electricity Consumption (kWh)	Electricity Cost ($)
Jan-2018	31	88,800	-
Feb-2018	28	77,400	-
Mar-2018	31	89,400	-
Apr-2018	30	71,400	-
May-2018	31	48,600	-
Jun-2018	30	29,400	-
Jul-2018	31	24,600	-
Aug-2018	31	24,600	-
Sep-2018	30	27,000	-
Oct-2018	31	60,000	-
Nov-2018	30	74,400	-
Dec-2018	31	86,400	-
Jan-2019	31	96,000	$10,994.41
Feb-2019	28	81,000	$9,508.90
Mar-2019	31	82,800	$8,002.43
Apr-2019	30	72,000	$6,090.73
May-2019	31	57,000	$7,733.77
Jun-2019	30	27,000	$3,709.88
Jul-2019	31	24,000	$4,205.41
Aug-2019	31	24,000	$2,115.98
Sep-2019	30	21,600	$3,469.65
Oct-2019	31	51,000	$10,492.73
Nov-2019	30	76,200	$13,605.74
Dec-2019	31	82,200	$12,747.15

Month-Year	Days in Billing Period	Electricity Demand (kW)
Jan-2019	31	160.8
Feb-2019	28	157.8
Mar-2019	31	137.4
Apr-2019	30	137.4
May-2019	31	127.8
Jun-2019	30	56.4
Jul-2019	31	55.8
Aug-2019	31	46.8
Sep-2019	30	52.8
Oct-2019	31	122.4
Nov-2019	30	135
Dec-2019	31	154.8