Appendix E

WASTEWATER TREATMENT PLANT

PRIMARY TREATMENT BUILDING

1135 CHEAKAMUS LAKE ROAD,
WHISTLER, BC V0N 1B1

ENERGY STUDY REPORT

MARCH 16TH, 2022

BUILDING ENERGY SOLUTIONS LTD.

T|778.371.3459

bes-canada.com

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1 ACKNOWLEDGEMENTS

The BES Ltd. team would like to acknowledge the help, time and resources offered by many employees of Resort Municipality of Whistler. The maintenance and operating staff provided invaluable information relative to their specific area of expertise and physical work areas that was essential in building an accurate energy model for this study.

The true commitment to sustainability and energy efficiency by all staff was evident throughout this process.

Specifically, BES Ltd. would like to acknowledge the help of the following staff members that were professionally involved throughout the completion of this project:

- Michelle Blattner (RMOW)
- Jeff Kawaguch (Custom Air)
- Chelsey Roberts (RMOW)

2 KEY CONTACTS INFORMATION

Facility Name:	Wastewater Treatment Plant
Facility Address:	1135 Cheakamus Lake Road, Whistler, BC V0N 1B1
Client Name:	Resort Municipality of Whistler
Client Contact:	Chelsey Roberts
Client Address:	1135 Cheakamus Lake Road, Whistler, BC V0N 1B1
Client Email:	croberts@whistler.ca
Client Tel#:	1.604.932.5535

Consultant Site Team:	Sean Mac Aodh, Dan Coffey
Consultant Team:	Sean Mac Aodh, Dan Coffey, Steven Arnold, Shayesteh Shahshahani
Consultant Contact:	Suite #722 – 550 West Broadway, Vancouver, BC, V5Z 0A9
Consultant Email:	smacaodh@bes-canada.com, dcoffey@bes-canada.com
Consultant Tel#:	1.778.371.3459

3 EXECUTIVE SUMMARY

3.1 Overview

BES Ltd. was commissioned by Resort Municipality of Whistler (RMOW) to complete an ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) Level 2 Energy Study at the Wastewater Treatment Plant located at 1135 Cheakamus Lake Road, Whistler. There is one (1) FortisBC gas meter and one (1) BC Hydro electricity meter serving this facility (12 buildings). There is no sub-metering data available for the audited building. For the purposes of this study, an estimated electrical and natural consumption was determined and confirmed by RMOW.

The site audit was completed in November 2021 and the subsequent analysis of energy efficiency upgrades and energy conservation opportunities are provided in the following report.

From the 12-month period comprised between January 2020 and December 2020, the Wastewater Treatment Plant Primary Treatment Building consumed an estimated **1,237 GJ** of natural gas which cost approximately **$11,310** (ex. taxes) at the current rate ($9.146/GJ). For the same 12-month period, the facility consumed an estimated **531,000 kWh** of electricity which cost approximately **$31,966** (ex. taxes) at the current rate ($0.064/kWh).

The main drivers of natural gas and electricity in this facility are attributed to the following:

Natural Gas	Electricity
Space Heating (79.4%) Domestic Hot Water Heater (10.5%) Miscellaneous (10.1%)	Space Cooling (11.8%) Lighting (14.1%) Fans & Pumps (71.3%) Miscellaneous – Plug Loads (14.6%)

In general, the status of energy efficiency initiatives at Wastewater Treatment Plant is average. The site audit revealed several deficiencies in either equipment or facility O&M as well as the implementation of some industry best practices for energy efficiency.

The building had an overall Energy Use Intensity (EUI) of 1,107 e-kWh/m^2/yr[1] in 2020. As this figure is for one building on a larger site, it is difficult to compare it to EUI of other WWTPs. The site as a whole has an EUI of 1841 e-kWh/m^2/yr, which is similar to other WWTP in the BES database.

The engineering analysis completed indicates that there are several opportunities to improve the efficiency of the building. If all the energy conservation measures selected in the recommended bundle are implemented, the Primary Treatment building will have a revised energy intensity of 668.9 e-kWh/m^2/yr.

[1] The total energy intensity includes all fuels and electricity consumed by the building.

3.2 Methodology

The Energy Study report is based on the historical energy consumption, existing mechanical and electrical systems, existing drawings, maintenance personnel discussions, and site visits conducted by BES Ltd. The energy end-use analysis was performed using standard engineering calculations based on occupancy, equipment operating conditions, historical energy consumption and weather data for the location.

The energy conservation measures are evaluated for electrical consumption savings (kWh), natural gas savings (GJ) and GhG Emission Savings (Tonnes e-CO2/yr). The capital costs estimates are based on Class C Construction Costs Estimates (+/-20%). Costing includes equipment cost, labour, equipment removal, design, construction, commissioning, overhead and contingency.

3.3 Consultant's Bundle of Recommended Conservation Measures in Order of Priority Ranking

Based upon BES Ltd. professional opinion and knowledge of the building, a broader set of criteria has been used to select a bundle of recommended Energy Efficiency and Energy Conservation Measures. These include:

- Ease of implementation (minimal resources required).
- Reduction of greenhouse gas emissions.
- Simple Payback.
- Measures that should be implemented to improve operation.
- Measures that should be implemented to facilitate the implementation of other measures.
- Importance in enhancing or maintaining good indoor environment for occupants with due consideration to the following: provision of acceptable ventilation and space temperatures for the majority of occupants in the majority of spaces.
- Improved ability to monitor and manage energy in the building.
- Expected remaining useful life of equipment.

The following table provides BES's recommended measures in order of priority:

Table 1: Top Recommended Measures in Order of Priority

Ranking #	ECM#	Recommended Energy Conservation Measure (ECM) or Capital Upgrade Project[2]	Type of Project[3]	Cost Benefit Analysis Based on Incremental Costs			Estimated Total Project Capital, Design & Install Cost ($)[4]	GhG Emission Savings (Tonnes eCO2/yr)
				Total Estimated Incremental Capital Cost Including Incentives[5] ($)	Estimated Total Annual Savings (Utility, Carbon, O&M) ($)	Simple Payback (yrs)		
1	ECM#M1	Install Aerators on Existing Plumbing Fixtures	**ECM**: Domestic Hot Water System	$40	$30	1.5	$40	0.11
2	ECM#M2	Install Thermal Insulation to Exposed Hot Water Pipework	**ECM**: Heating System	$380	$160	2.4	$380	0.69
3	ECM#M3	All Buildings: Repair/Replace Door Seals	**ECM**: Envelope	$800	$380	2.1	$800	1.68
4	ECM#M4	Retro-commissioning & Perform Boiler Control Optimization	**ECM**: Controls	$17,000	$1,820	9.3	$17,000	17.29
5	ECM#M11	Outdoor Air Temperature Reset	**Capital Project Upgrade**: Controls	$4,200	$1,00	4.2	$4,200	0.09
6	ECM#M12	Optimal Start Stop	**ECM**: Controls	$4,200	$650	6.5	$4,200	0.03
7	ECM#M13	Install roller door interlocks with HVAC equipment on lower floor	**ECM**: Controls	$5,200	$360	14.5	$5,200	0.03
8	ECM#M24	Improved Data Logging of Energy End-Uses	**Capital Project Upgrade:** Controls	N/A	N/A	N/A	N/A	N/A

[2] Note that the provided costs, savings, and associated paybacks are estimates, and should be investigated in further detail before proceeding with these measures. Readers are encouraged to read the report in its entirety for more detailed information.

[3] Capital project upgrade indicates installation of new equipment in place of existing if any and ECM indicates changes to existing system.

[4] Project Capital Cost is the total estimated capital cost including design & install which the client will incur for implementation of the measure.

[5] Incremental costs are shown (cost difference between a standard efficiency equipment and high efficiency equipment).

Ranking #	ECM#	Recommended Energy Conservation Measure (ECM) or Capital Upgrade Project[2]	Type of Project[3]	Cost Benefit Analysis Based on Incremental Costs			Estimated Total Project Capital, Design & Install Cost ($)[4]	GhG Emission Savings (Tonnes eCO2/yr)
				Total Estimated Incremental Capital Cost Including Incentives[5] ($)	Estimated Total Annual Savings (Utility, Carbon, O&M) ($)	Simple Payback (yrs)		
9	ECM#M16	Install Thermostatic Control Valves to Hydronic Baseboard Heaters in Common Areas & Suites	**ECM**: Domestic Hot Water System	$1,000	$320	3.2	$1,000	0.51
10	ECM#M17	Installation of Energy Saving Additive into Boiler Loop to Improve Heat Transfer and Efficiency of HVAC (Gas) System	**ECM**: Hot Water System	$4,020	$2,020	2.0	$4,020	9.06
11	ECM#M18	Kitchen and Office: Install Programmable Thermostats to Control Heating and Implement Unoccupied Temperature Set Back	**Capital Project Upgrade:** Controls	$600	$70	8.2	$600	0.01
12	ECM#M21	High Efficiency Motor Upgrade	**Capital Project Upgrade**: Motors	$33,100	$3,490	9.5	$4,000	1.79
13	ECM#M5	AHU-1, AHU-2 & AHU-3 – Install new Cold Climate Heat Pumps to supply new Hydronic Coil in each unit.	**Capital Project Upgrade**: HVAC	$37,000	$2,180	17	$167,000	34.13
15	ECM#L0	Lighting Upgrades	**Capital Project Upgrade**: Lighting	$17,807	$5,080	3.5	$14,490	0.72
TOTAL SUM OF BUNDLED MEASURES				**$125,340**	**$16,890**	**7.4**	**$255,340**	**50.38**

All costs are estimates of probable cost and should be used for budgetary purposes only and assume that they will be undertaken ‘in-house’ at one time. There are also some measures included in the body text which cannot be quantified and as such are not included in the summary table.

3.4 O&M Action Items (High Importance)

- The thermostat controlling the exhaust fan in the roof top compressor is being impacted by the heat produced by the compressors. It is recommended to relocate the thermostat to mitigate this issue.

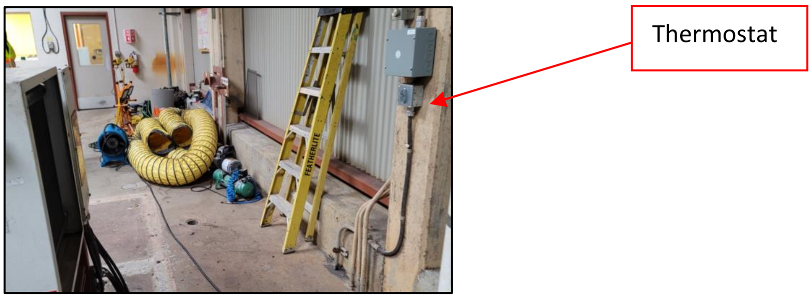

Figure 43: Compressor and Thermostat

- **Thermostat temperature set points were high** (greater than 20°C) in multiple rooms. The majority of these rooms are unoccupied and only host machinery. The temperature in these rooms should be reduced and kept at 14°C.

Figure 44: High Setpoint Thermostat

- It was noted that the **lighting levels in the facility were inconsistent**. It is proposed to redesign the lighting in this facility to ensure light levels meet recommended IESNA guidelines.
- **Equipment is unnecessarily operating out-of-hours**. It was apparent that timeclocks / controls were not installed to control the HVAC equipment.
- During the site audit and inspection of the **Water Entry Room there was a large penetration** in the wall observed that is covered with wood. This opening should be sealed with appropriate construction material in order to **prevent pipe freezing in sub zero temperatures**.
- **Louvre were installed on the external doors** to provide ventilation and free cooling to the space. Excessive heat may lead to a leakage in the integrated circuits of microprocessors and components which have **capacitors are at a greater risk of shortened lifespans** due to the **high sustained heat**.

Figure 22: MCC Panels & Door Grilles (close proximity)

It is recommended to **install a correctly sized dedicated HVAC system in this room**. A dedicated HVAC system and accurate thermal comfort control will mitigate failure and prolong the life of the electrical equipment.

- **Influent Pumping Room (AHU-1): Return air damper was manually closed** on this unit. As a result, 100% heated outdoor air was being unnecessarily introduced to the space. Recommended to install demand control ventilation system to reduce the quantity of tempered outdoor air required in the space.
- **Door and window seals** in the facility were **in poor/damaged condition**. These should be repaired and reinstalled in order to minimise heat loss/heat gain and excess HVAC system energy usage.
- **Tunnels** – **Distribution ductwork not installed to the end of the tunnel**. The duct should be extended the full length of the tunnel in order to achieve balanced air flow.

Figure 47: Tunnel Ductwork

- **Unit Heaters and HVAC - Units reaching end of life.** Recommended to replace with high efficiency alternative.

3.5 Summary of Savings from Recommended Bundle

The energy conservation measures (ECMs), and capital upgrade projects recommended have potential to deliver the savings in the following table.

Table 2: Potential Saving from Implementing Recommended ECMs and Capital Upgrade Projects

Recommended Energy Conservation Measure in order of priority		Total Sum of Bundled Measures
Cost Benefit Analysis Based on Incremental Costs	Total Energy (Natural Gas and Electricity) Savings (e-kWh)	346,359
	Estimated Total Annual Savings (Energy, Utility, Carbon, O&M) ($)	$16,890
	Pre-incentive Estimated Incremental Capital, Design & Install Cost ($)	$127,300
	Applicable Incentives ($)	$1,960
	Total Estimated Incremental Capital, Design & Install Cost ($)	$125,340
	Simple Payback (yrs)	**7.4**
	Energy Use Intensity Reduction (e-kWh/m^2/yr)	**438.6**
Estimated Total Project Capital, Design & Install Cost ($)		**$255,340**
GhG Emission Savings (Tonnes e-CO_2/yr)		**50.4**

The following Figure shows the annual greenhouse gas emissions reduction equivalent should all proposed measures be implemented.

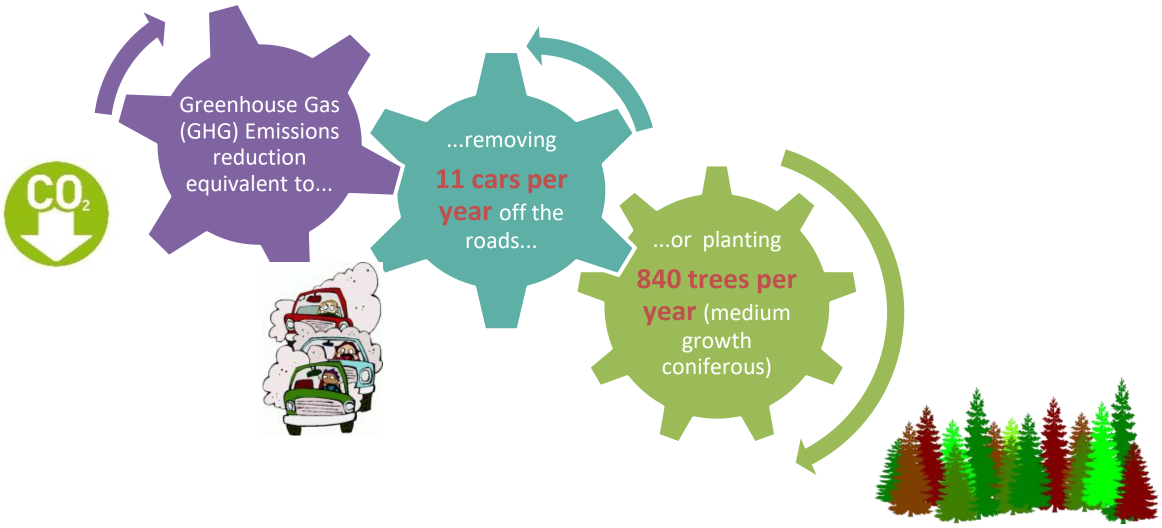

Figure 1: Annual Greenhouse Gas Emissions Reduction by Implementing the Recommended Measures[6]

[6] United States Environmental Protection Agency (EPA), *Greenhouse Gases Equivalencies Calculator*, www.epa.gov/energy/greenhouse-gases-equivalencies

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4 EXISTING FACILITY AND BUILDING DESCRIPTION

4.1 Overview

Facility Description: The facility is a wastewater treatment plant located at 1135 Cheakamus Lake Road, Whistler, BC. The Wastewater Treatment Plant uses a tertiary treatment system, with three levels of treatment for the wastewater, and a sophisticated odour-control system.

Facility Age: The facility was originally constructed in 1986 with an expansion in 1996.

Facility Size: 8,500 ft² (790m²).

Type of Use: Wastewater Treatment Plant.

Structure: The superstructure consists of a solid masonry structure.

Envelope: The envelope appears to be in average condition. Envelope weaknesses include high infiltration in entrance and exits. Envelope upgrades could improve the buildings overall R-Value, but this may not prove to be cost effective.

Occupancy: The projected occupancy of the facility is the same as the present occupancy as there is no planned change to the current occupants or activities.

Table 3: Occupancy Schedule

Area	Occupancy	
Wastewater Treatment Plant	7:00am – 4:30pm	7 days a week

4.2 Facility Utility Accounts and Rates

The 2021 utility rates were used to calculate energy savings throughout this report were obtained from BC Hydro and Fortis BC and are as follows:

4.2.1.1 Electricity (BC Hydro)

Consumption charge: $0.0602/kWh

Demand Charge: $12.26/kW

4.2.1.2 Natural Gas (Fortis BC – Rate 3)

Consumption charge*: $9.15/GJ

*including delivery, storage, and cost of gas

4.2.1.3 GhG Emissions Factor[7]

Natural gas GHG emissions intensity:	49.87 kg CO2e/GJ
Electricity GHG emissions intensity:	0.002587 kg CO2e/kWh

4.2.1.4 Carbon Tax[8]

Carbon Tax: \$40/e-tCO_2 of lifetime GhG savings.

Tax Rate based on \$40/ e-tCO_2: \$7.60 /m^3. [9]

4.3 Financial Analysis – Escalation Rates[10]

The following escalation rates are used in the financial analysis calculations within this report:

Electricity Escalation 2022 onwards:	3.0%
Natural Gas Escalation 2022 onwards:	3.0%
O&M Cost Escalation:	2.0%
Discount rate (including general inflation):	3.5%

[7] 2018 B.C. Methodological Guidance for Quantifying Greenhouse Gas Emissions, https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2018-pso-methodology.pdf, page 17.

[8] Carbon taxes paid by the District are currently eligible for rebate through the Province's Climate Action Revenue Incentive Program.

[9] British Columbia Carbon Tax, https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/carbon-tax

[10] BES's Business Case Standard Economic Assumptions Unit Conversions and Energy Prices.

4.4 Municipal Funding Programs & Incentives

The following provides funding and capital incentives programs to encourage energy efficient design, construction, and renovation in municipal buildings:

4.4.1.1 FortisBC Custom & Rebate Programs

Offers rebates on high-efficiency appliances, equipment, and lighting.

https://www.fortisbc.com/rebates-and-energy-savings/rebates-and-offers/rebates-business

4.4.1.2 Green Municipal Fund – "Capital project: Signature initiative"

Assists Municipalities implement high efficiency energy conservation projects that reduce GHG emissions. This funding is designed to accommodate transformative, innovative, best-in-class municipal projects. The Resort Municipality of Whistler may receive a low-interest loan of up to $5 million and a grant worth up to 15% of the loan; cover up to 80% of your eligible costs.

https://fcm.ca/en/funding/gmf/capital-project-signature-initiative

4.5 Site Layout Plan

The following site layout identifies the buildings studied as per the scope of the Energy Study:

Primary treatment building

Figure 2: Site Layout

4.6 Mechanical Systems

4.6.1 Heating System

Primary heating to the primary treatment building is provided by a single high efficiency VIESSMAN (model: VITOCROSSAL 200) natural gas fired condensing boiler. The boiler has an input rating of 873,000 BTU/hr with a predicated plant seasonal efficiency of approximately 92%.

VIESSMAN VITOCROSSAL 200 Boiler

Figure 3: Boilers serving Heating and Service Water

The VIESSMAN boiler was installed in 2020 and has approximately 23 years of useful life remaining, as per ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) life expectancy guidelines. ASHRAE life expectancy for a boiler is 25 years.

VIESSMAN VITOCROSSAL 200 Boiler

Figure 4: Boilers serving Heating and Service Water

Supplementary heating to the building is provided by an older FULTON (model: PHW-750) atmospheric natural gas fired boiler. It is understood that this boiler operates rarely throughout the year. The boiler has an input rating of 750,000 BTU/hr with an estimated efficiency of 85%. The Fulton boiler was installed in 2003 and has approximately 6 years of useful life remaining.

Three (3) constant speed hot water service (HWS) pumps (PR240, PR241, PR533) and one (1) variable speed (PR242) pump hot water to the unit heaters, hydronic coils in air handling units and hydronic baseboard heaters. The pumps appear to be in average condition. The pump PR 240 was installed in 2003, pumps PR241 and PR533 were installed in 2013. The ASHRAE life expectancy of a pipe mounted pump is 10 years, so pump PR240 is past its life expectancy. Pumps PR241 and PR533 have approximately 1 year of useful life remaining. The variable speed pump was installed in 2020 and appears to be in good working condition.

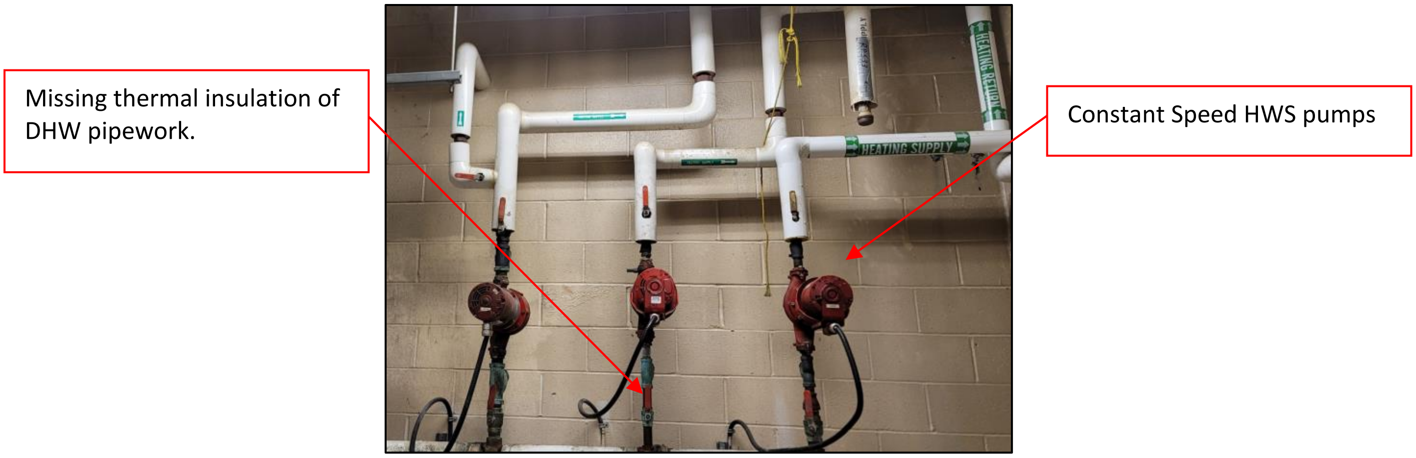


Figure 5: Constant Speed Heating Pumps (PR240, PR241, PR533)

Figure 6: Variable Speed Heating Pumps (PR242)

4.6.2 Domestic Hot Water

Domestic hot water is provided by two (2) instantaneous water heaters. These NAVIEN NP-240A water heaters have an input rating of 199,000 BTU/hr with a predicted plant seasonal efficiency of approximately 90%.

Figure 7: Boilers serving Heating and Service Water

: Instantaneous Domestic Hot Water Heaters

The NAVIEN water heaters were installed in 2011 and are reaching the end of their economic life expectancy (1-year useful life remaining) as per ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) life expectancy guidelines. ASHRAE life expectancy for a boiler is 12 years.

4.6.3 Thickener Room

The thickener room is heated by two (2) hydronic unit heaters (UH-6 & UH-7). These unit heaters provide heating to the thickener room of the Primary treatment building. The two units are 20MBH each and appear to be in poor condition. The units were installed in 1980 and are past the end of their economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for a hydronic unit heater is 20 years. The units are controlled manually by thermostats.

Figure 8: Hydronic Unit Heaters

Three (3) foul air exhausts ducts are routed through this thickener room to terminate through the external wall to the atmosphere. One of the exhausts ducts is no longer in use, if there is no planned use for this duct then it should be removed, and the wall sealed. One of the exhaust ducts extracts foul air from the grit channels. There is one exhaust fan installed on the odor testing port duct, which is a 1000 CFM unit. This fan appears to be in good working condition. It was installed in 2015, and according to ASHRAE the life expectancy is 20 years, therefore there is approximately 14 years of effective operation remaining.

Figure 9: Supply and exhaust air

Figure 10: Exhaust Fan

Two (2) odour tower liquid recycle water pumps are also located in this room. The pumps had no name plate data and appeared to be in average working condition. The two units are 15HP and 460V.

Figure 11: Liquid recycle pumps

4.6.4 Electrical Room

Ventilation to this room is provide by an exhaust fan controlled by a reverse acting thermostat. There is also a hydronic baseboard in this room that is used to provide heating when required. Controls is via a manual thermostat. The unit appears to be in average condition and was installed circa 1990.

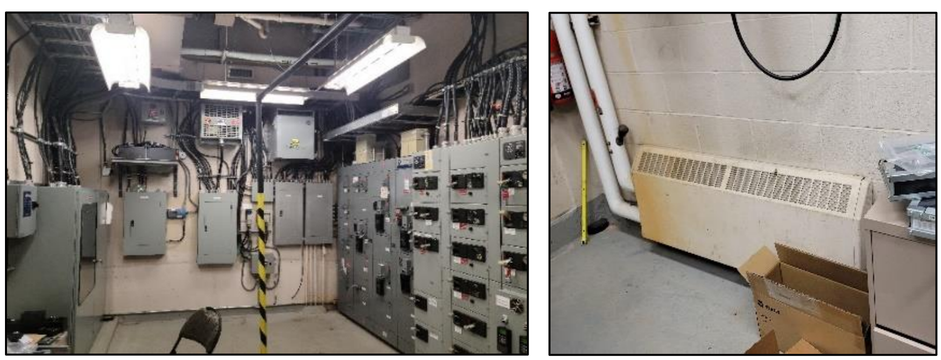


Figure 12: Electrical Room

4.6.5 Utility Corridor

The utility corridor is heated by one hydronic unit heater (UH-5). The unit is 20MBH and appears to be in average working condition. The unit was installed in 1997 and is past the end of its economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for a hydronic unit heater is 20 years.

Figure 13: Lower Floor Entrance Unit Heater

4.6.6 Water Entry Room

The water entry room is heated by two (2) hydronic unit heaters. The units are 20MBH and appears to be in average condition. The units were installed in 1980 and are past the end of their economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for a hydronic unit heater is 20 years.

Figure 14: Water Entry Room Unit Heater

There are two (2) 5HP sludge pumps (SP-250 and SP-252) in the water entry room, both which appear to be in good working condition. The units were installed in 2008 and the ASHRAE life expectancy for base mounted pumps is 20 years, therefore there is 7 years of effective operation left.

Figure 15: Water Entry Room Sludge Pumps

Figure 16: Sludge Pump Motor

There is also one (1) 3HP NORD gearing motor in the water Entry Room, which appeared to be in average working condition. This unit was installed in 2008 and according to ASHRAE there are 5 years of effective operation left per ASHRAE life expectancy guidelines. ASHRAE life expectancy for an electric motor is 18 years.

Figure 17: G-251 Gearing Motor

There is one (1) 3HP BALDOR gearing motor (G-253) in the water Entry Room, which appeared to be in good working order. This unit was installed in 2008 and according to ASHRAE years of effective operation left. is approaching the end of its economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for an electric motor is 18 years.

Figure 18: G-253 Gearing Motor

4.6.7 Maintenance Workshop

The maintenance workshop is heated by one hydronic unit heater. The unit has a heating capacity of 20MBH and appears to be in average condition. The unit was installed in 1980 and is past the end of its economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for a hydronic unit heater is 20 years

Figure 19: Maintenance workshop unit heater

There was one (1) 0.5HP OE Motors and Industrial Systems exhaust fan (EF535) in the maintenance workshop, which appeared to be in a poor condition. This unit should be replaced as soon as convenient as it is rusted and appears to be poor working order. This unit exhausts the foul air from the maintenance workshop.

Figure 20: Maintenance workshop exhaust fan

4.6.8 Electrical Workshop

The electrical workshop is heated by two electric unit heater. Both of the units are 2.5kW and appears to be in average condition. The units were installed in 1990 and are past the end of their economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for an electric unit heater is 13 years.

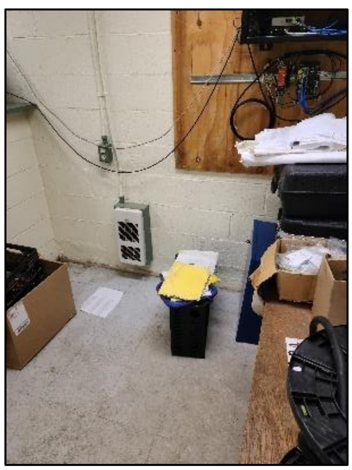


Figure 21: Electrical workshop unit heater

4.6.9 Storage/Safety Room

The storage/safety room is heated by one hydronic unit heater (UH-50). The unit has a heating capacity of 20MBH and appears to be in average condition. The unit was installed in 1980 and is past the end of its economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for a hydronic unit heater is 20 years.

Figure 22: Storage/Safety room unit heater

4.6.10 Electrical Room – Old Compressor Room (Changed Use)

Heating to this room is provided by ducted conditioned air from adjacent room. The AHU (AH-4172) has been decommissioned due to change of use in the room from Compressor Room to Electrical Room. Heating to this unit was provided by hydronic heating coil with cooling via a raw-water cooling coil and associated pump.

Figure 23: AHU – 4172 & Raw Water-Cooling Loop (Decommissioned)

As this AHU was decommissioned, there is currently no means of mechanical cooling in the room which houses MCC panels. Large grilles were installed on the external doors to provide ventilation and free cooling to the space. Whistler experiences sub zero temperatures in the winter and in excess of 35 °C in the summer. Excessive heat may lead to a leakage in the integrated circuits of microprocessors and components which have capacitors are at a greater risk of shortened lifespans due to the high sustained heat.

Figure 24: MCC Panels & Door Grilles (close proximity)

It is recommended to install a correctly sized dedicated HVAC system in this room. A dedicated HVAC system and accurate thermal comfort control will mitigate failure and prolong the life of the electrical equipment.

4.6.11 Influent Pumping Room

AHU-1 provides continuous ventilation and heating to the influent pumping room. The HAAKON AIRPACK Unit was installed in 1992

It was noted during the site visit that the return air damper was manually closed on this unit. As a result, 100% heated outdoor air was being unnecessarily introduced to the space. Supply air temperature to the space was measured at 23°C with outdoor air temperature at 6°C. As this space is intermittently used, it is recommended to redesign this system complete with upgraded controls to maximize energy efficiency. This unit has exceeded its useful life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for an air handling unit is 15 years.

Figure 25: AHU-1 – HAAKON (100% Outdoor Air)

The conditioned air is supplied to the influent pumping room by a network of distribution ductwork which terminates at high level in the space.

Figure 26: Distribution Ductwork

4.6.12 Headworks Area

Heating and ventilation to the headworks area is provided by two (2) HAAKON AIRPAK units. Each AHU (AHU-2 & AHU-3) is suspended at high level in the rooms and appear to be well maintained. AHU 1 & 2 were installed in 1996 and have been operational since. AHU-3 was replaced in 2017. AHU 1 & 2 have exceeded their useful life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for an air handling unit is 15 years.

Figure 27: AHU-2 – HAAKON (100% Outdoor Air)

Figure 28: AHU-3 – HAAKON (100% Outdoor Air)

The conditioned air is supplied to the headworks area by a network of distribution ductwork which terminates at high level in the space.

Figure 29: Distribution Ductwork

There are four (4) motors in the headworks area that serve the tunnels. The units appeared to be in average working condition. These units appear to be reaching the end of their economic life expectancy.

Figure 30: Headworks' area motors.

Supplementary heating to the headworks area is provided by two (2) hydronic unit heaters (UH-50 & UH-51). The units have a heating capacity of 20MBH. The units were installed in 1997 and are past the end of their economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for a hydronic unit heater is 20 years

Figure 31: Headworks Area unit heater

It was noted that there was a decommissioned heat exchanged located under the headworks area.

Figure 32: Sealed Pipework Penetrations from Decommissioned Heat Exchanger

Process Roof: General exhaust fan (EF-4222) is located on the roof and appears to be recently restored. The unit appears to be in good working condition.

Figure 33: EF-4222.

Compressor Room: There is two (2) PURESTREAM air dryers in the compressor room. These units are controlled via duty/standby operating philosophy. These units were installed in 2014 and appear to be in good condition.

Figure 34: Air dryers

There are two (2) compressors in (ME4140 and ME4141) provided compressed air to the facility. These units are each powered by a 3 phase 30HP motor. The units were installed in 2008 and according to ASHRAE there are 5 years of effective operation remaining. ASHRAE life expectancy for an electric motor is 18 years

Figure 35: Compressor and motor

The compressor room is heated by two (2) hydronic unit heaters (EH254 and EH255). Each unit heater has a heating capacity of 20MBH. The units were installed in 1980 and are past the end of their economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for a hydronic unit heater is 20 years.

Figure 36: Compressor Room - Unit Heaters (EH254 and EH255)

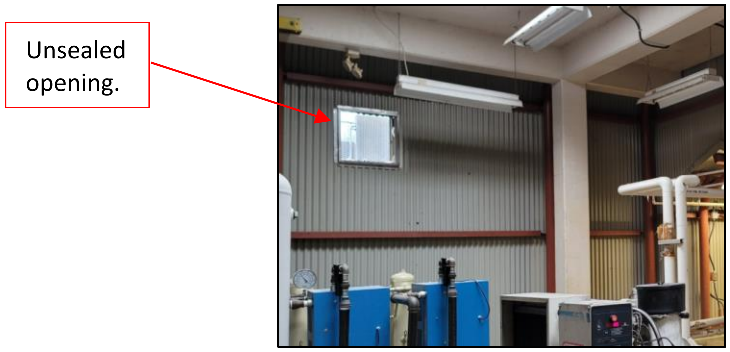


Figure 37: External Wall Opening

The compressor room has one (1) make up air unit (SF245). This unit supplies 3,500 CFM complete with supply fan, hydronic coil, and filter section. The unit appears to be in average condition. The unit was installed in 1990 and are past the end of their economic rated life, as per ASHRAE life expectancy guidelines. ASHRAE life expectancy for a MAU is 15 years.

There was an opening observed at the side of the room that was covered with mesh. It would be advisable to cover this opening during colder months when the room requires heating. During the site audit the room was being heated, but this opening causes unnecessary heat loss.

Figure 38: Compressor Room MAU.

Exhaust to this room provided a 1HP PENNBARRY fan. This appears to be in good working condition. This fan is controlled via a reverse acting thermostat. The fan was installed in 2015 and has 9 years left in its economic rated life, as per ASHRAE's guidelines.

Figure 39: Compressor Room Exhaust Fan.

It was also noted that the compressors are rejecting heat directly on the thermostat resulting in the exhaust fan unnecessarily operating continuously throughout the year. It is recommended to relocate this thermostat to eliminate this issue.

Heat rejection from compressor

Thermostat control for exhaust fan

Figure 40: Compressor and Thermostat

Primary Lab:

There are two (2) hydronic baseboards that are used for heating in the primary lab. It was noted that there was limited thermal insulation on the heating pipework. They appear to be in average working condition. These heat emitters are original to the building.

Figure 41: Baseboards

Washroom:

There is one (1) hydronic baseboard that is used for heating in the washroom. It was noted that there was limited thermal insulation on the heating pipework. They appear to be in average working condition. These heat emitters are original to the building.

Figure 42: Baseboard

Acetic Acid Storage:

There is one (1) electric unit heater that provides heating to the Acetic Acid storage location. The unit appears to be in good working condition. The unit was installed in 2020 and has 12 years of useful economic life remaining, as per ASHRAE guidelines. ASHRAE life expectancy for an electric unit heater is 13 years.

Figure 43: Unit Heater

There is a single 1HP GREENHECK supply fan providing ventilation to the acetic acid storage location. This unit has been installed on the floor of the corridor above the acetic acid storage location. This unit is running continuously through out the year. This fan appears to have surpassed its useful economic life, as per ASHRAE guidelines. ASHRAE life expectancy for a prop fan is 15 years. The unit is does not appear to be installed on a permanent mount.

Figure 44: Acetic Acid Storage Fan

Walkway: There is a single 1HP GREENHECK wall mounted fan installed in the walkway. This unit appears to be in poor working condition. The unit appears to be original to the building and is past its useful economic life, as per ASHRAE guidelines. ASHRAE life expectancy for a prop fan is 15years. The unit was not in operation during the time of the site visit.

Figure 45: Walkway fan

4.6.13 HVAC Equipment Tables

A complete inventory of HVAC equipment is provided in Appendix A.

4.6.14 HVAC Control System and Strategy

4.6.14.1 Description Control System

The Wastewater Treatment Plant has an automated control system for the wastewater treatment process equipment. Lighting, HVAC and DHW equipment are controlled via manual switches, stand-alone thermostats, or integral thermostats.

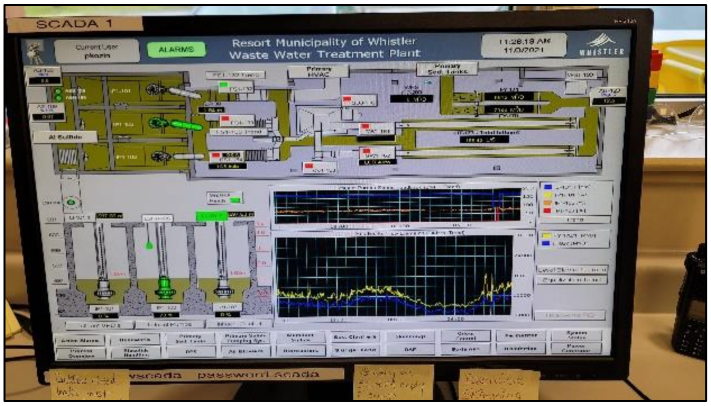


Figure 46: Existing Process Control System

4.6.14.2 Overall Controls Methodology

The following table is a summary of the Heating controls systems in the facility:

Table 4: HVAC and DHW System Setpoints

Description	Control Type
RTU & AHU	Programable & Manual Controlled Thermostats
Ductless Split System	Programmable Thermostats
Domestic Hot Water	Thermostat

4.6.15 Asset Management

During the site survey, there was limited O&M documentation available on the facility. It is typical with existing building that retrofits, and upgrades take place throughout its lifespan and as such the record documentation should be updated to ensure that efficient operation and maintenance can occur. It has been well documented and proven on numerous facilities throughout Canada and North America that substantial energy and maintenance savings occur on facilities that actively participate in an ongoing active asset management plan with paybacks ranging from 2-6 years.

In view of the several discrepancies found at the facility, it is highly recommended that a new active asset management strategy is implemented in conjunction with the existing facilities team. A budget cost for an active asset management strategy, including equipment asset renumbering/verification and new all-inclusive operation and maintenance manuals is approximately $5,500.

4.7 Electrical & Lighting Systems

4.7.1 Description of Electrical Systems

Power to the facility is distributed at 120/208V, 3PH / 60 Hz and is used for the facilities internal lighting, plug loads and the majority of mechanical equipment. Power (480V, 3PH, 60Hz) is also provide to a specified mechanical pumps and fans.

4.7.2 Lighting Description

The energy efficiency status of the lighting systems in the facility are generally below average due to the number of lighting retrofits over the past years.

The facility's lighting primarily consists of T8 linear fluorescent luminaries complete with electronic ballast (surface mounted, suspended, and recessed troffers) and 26W CFL pot lights, TLED lamps and 30W LED luminaires. All luminaires in the building are controlled manually by on/off switches. There is an opportunity to save energy and improve light levels by replacing inefficient linear fluorescent luminaries and CFLs with efficient LED luminaires.

Exterior lighting consists of inefficient 175W and 400W high pressure sodium (HPS) wall packs, 400W and 750W Metal Halide (MH) pole lights and an efficient 300W LED pole light. These external lights are controlled manually by photocell. There is an opportunity to save energy and maintenance costs by replacing these inefficient HPS wall packs and MH pole lights with efficient LED luminaires.

For a detailed inventory of luminaires in the facility, refer to Appendix A.

The following are typical luminaires observed onsite:

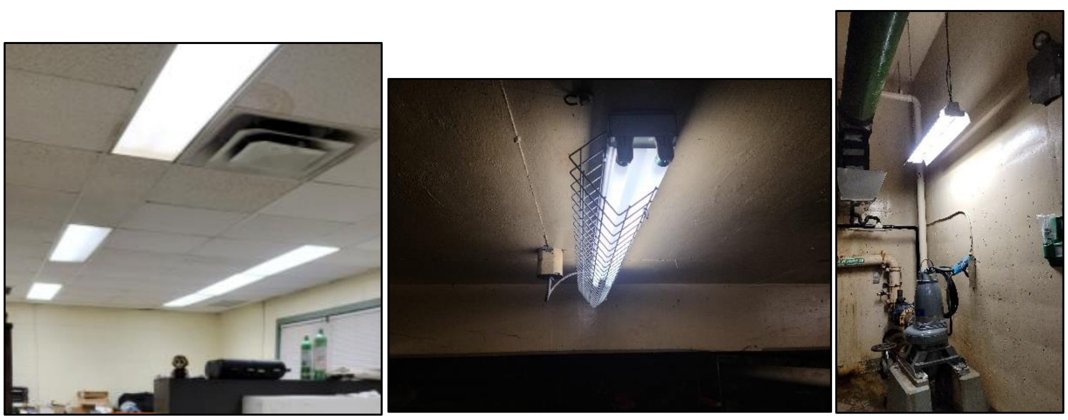


Figure 47: Typical T8-32W-2Lamp-4ft Recessed, Surface Mounted and Suspended Linear Fluorescent Luminaires

Figure 48: Typical Storage Lighting.

Figure 49: Typical Exterior Lightings.

Figure 50: LED Emergency Exit Sign

4.7.3 Non-mechanical Loads

The primary non-mechanical loads are related to the lighting, communication equipment and plug loads.

- Total Installed Lighting Power Capacity: 8.7 kW
- Estimated Annual Lighting Electricity Consumption: 75,097 kWh
- Estimated Annual Plug Load Electricity Consumption: 15,000 kWh

4.7.4 Lighting Levels

It was noted that the lighting levels in the facility were inconsistent. It is proposed to complete a lighting redesign in the facility to ensure light levels meet recommended IESNA LUX levels.

Figure 51: Inconsistent Lighting

The luminaires in the facility were observed to be controlled manually via on/off light switches. External lighting is controlled via photocell.

4.7.5 Plug Loads and Auxiliary Equipment

Plug loads include computers, copiers, scanners, kitchen equipment, sample testers.

4.7.6 Maintenance and Operating Issues

Inconsistent light levels were observed onsite. A complete lighting redesign is recommended to ensure light levels meet recommended IESNA guidelines.

The LED exit sign in the storage room and main entrance was broken. This should be replaced as soon as possible.

Figure 52: Broken LED Exit sign.

4.8 Wastewater Treatment Process

The Wastewater Treatment Plant uses a biological nutrient removal process to treat the wastewater so that it can be disposed of into Cheakamus River. The Whistler WWTP uses a dissolved air flotation system, an anerobic fermenter and two centrifuges to separate the solids from the water, breakdown and dewater the solids. The following is a simplified outline of the treatment process[11]:

1. The wastewater enters the plant and the influent pump station, where it is pumped to the headworks. Two mechanical fine screens and a bar-screen remove debris, and two grit conveyers remove any settled grit.
2. Water then flows into the primary clarifiers, where the water slows down, and the heavy organic materials settle out and are removed. The primary effluent then flows into the bioreactors.
3. The bioreactors allow microorganisms to use the nutrients and carbon to grow and multiply, creating a dense biomass.
4. After passing through the bioreactors, a fraction of the wastewater and biomass (Waste activated sludge) is wasted to the dissolved air floatation system to separate the solids while the rest of the water flows to the secondary clarifiers.
5. In the secondary clarifiers the process flow is slowed down to allow the biomass to settle out and be pumped back to the bioreactor as return activated sludge. The clear supernatant then flows over the weirs and to the UV disinfection stage.
6. The UV system which consists of two banks of 18 ultraviolet light blubs each are submersed in the wastewater channel. The UV lights then sterilizes any bacteria remaining in the wastewater and the water is then discharged into the Cheakamus River.
7. A percentage of the WWTP treated effluent is pumper over to the District Energy System (DES) Loop, where is crosses two heat exchangers to allow for the transfer of latent heat to the water flowing in the closed DES Loop.

[11] Information obtained from Plant-Profile-Whistler-WWTP.pdf (eocp.ca)

5 ENERGY ACCOUNTING SYSTEM

5.1.1 Description of Energy Accounting Methodology

Assessing energy use and evaluating efficiency is undertaken by benchmarking the facility's annual energy intensity (equivalent kWh/m^2/yr). This measure of building energy use must then be referenced against buildings of similar vintage, climatic region, use, and type. For the purposes of this project, Statistics Canada[12] and Energy Star Portfolio Manager[13] are used as references. This reference sources provides a comprehensive description and breakdown of energy by end-use for a wide range of building types throughout British Columbia and Canada.

In order to best prioritize and discuss energy conservation opportunities at the facility, an estimated end-use breakdown has been developed. This breakdown represents the probable energy consumption by end-use based upon historical annual utility records, detailed data on equipment and systems installed, and an understanding of facility operation strategies.

5.1.2 Historic Utility Records and Energy Intensity

The 2018, 2019 and 2020 utility records[14] and annual consumption profile are summarized in the following table and charts. As can be seen in the table below, the energy consumption remains fairly consistent over the reported period. As there is no submetering on site the energy usage of the building was based on observed equipment and estimated run hours.

Table 5: Summary of Historic Utility Records and Energy Intensity

Year	Electricity				Gas (Natural Gas)			**Total Energy Intensity**
	Peak Month Demand	Consumption		Annual Utility Cost	Consumption		Annual Utility Cost	
	[kW]	[kWh]	[kWh/m^2/yr]		[GJ]	[e-kWh/m^2/yr]		[e-kWh/m^2/yr]
2018	N/A	542,880	687.5	$32,681	1,264	444.6	$11,559	**1,132.0**
2019	N/A	549,480	695.8	$33,079	1,032	363.0	$9,438	**1,058.8**
2020	N/A	531,000	672.4	$31,966	1,237	435.1	$11,312	**1,107.5**

[12] Statistic Canada, *Survey of Commercial and Institutional Energy Use*, September 2016.

[13] Energy Star, *Portfolio Manager Technical Reference: Canadian National Energy Use Intensity,* March 2019.

[14] Utility Data provided by RMOW and deemed to be accurate.

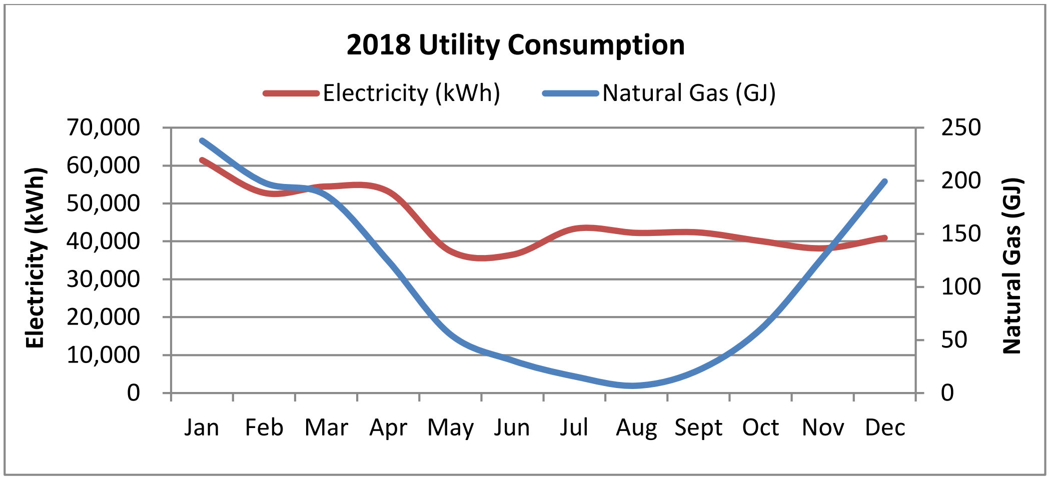


Figure 53: 2018 Annual Utility (Electrical and Gas Consumption) Profile

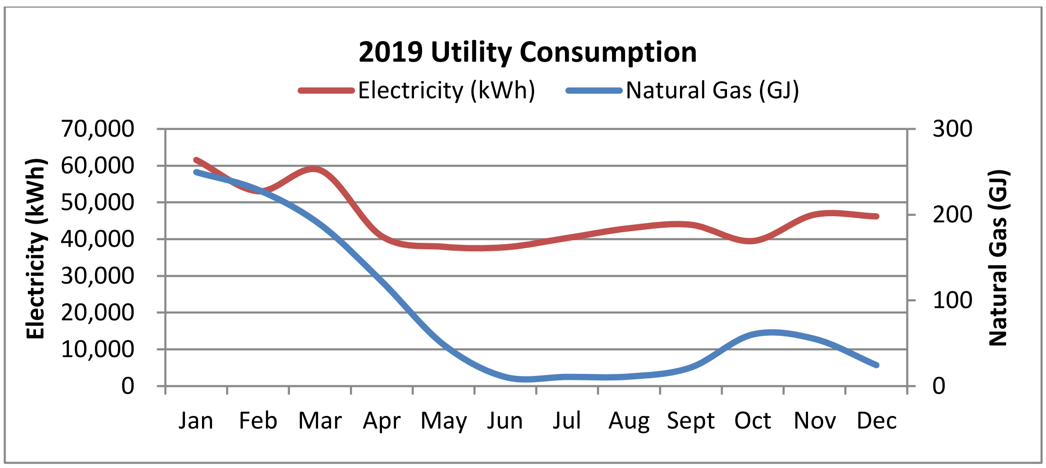


Figure 54: 2019 Annual Utility (Electrical and Gas Consumption) Profile

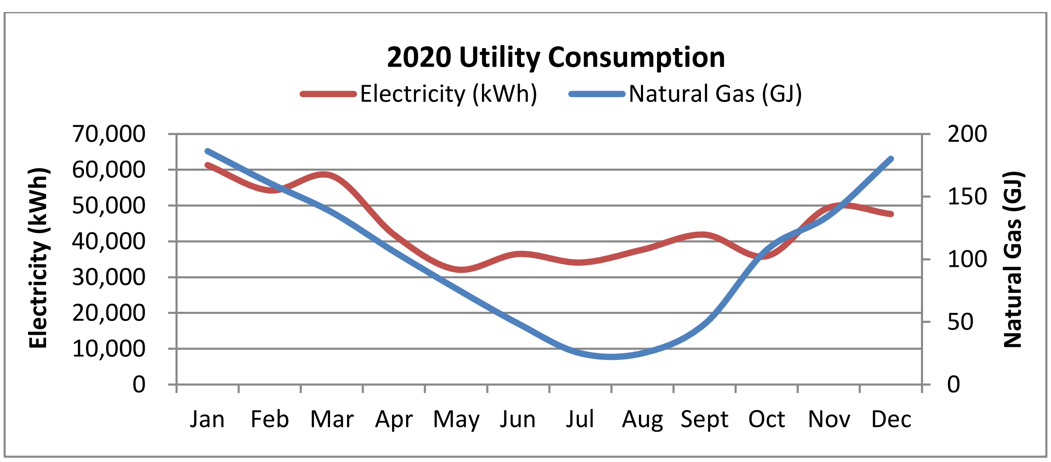


Figure 55: 2020 Annual Utility (Electrical and Gas Consumption) Profile

Electricity consumption remains fairly consistent over the reported period.

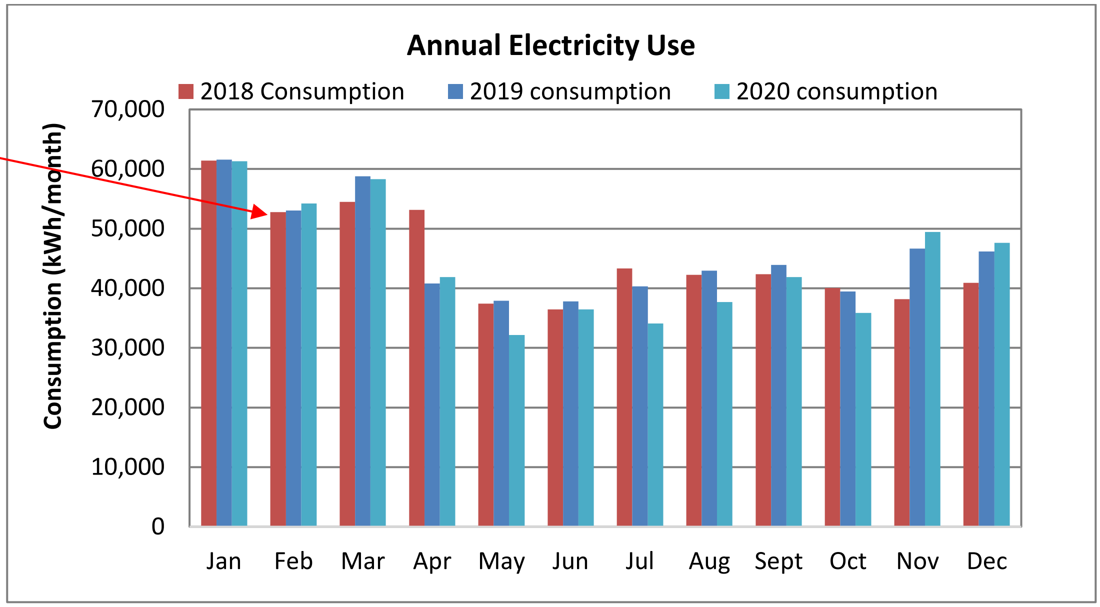
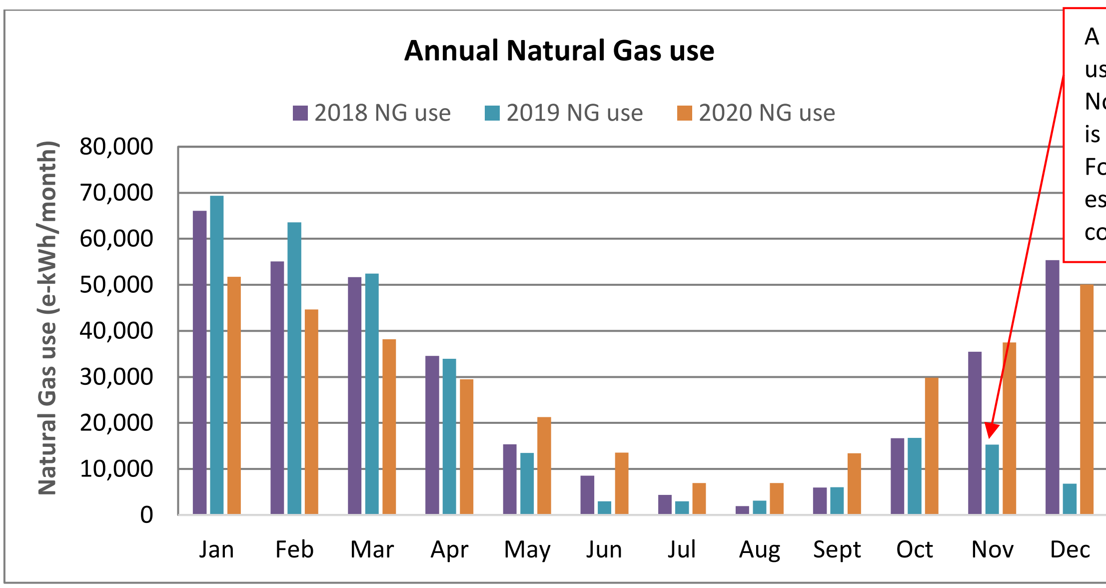


Figure 56: 2018 to 2020 Annual Utility (Electrical Consumption) Profile

The Annual Utility Profiles shows that natural gas usage is seasonal tied directly to the heating requirements of the building. The base natural gas load in the summer reflects domestic hot water use.



A reduction in usage in Nov/Dec 2019 is due to Fortis estimates of consumption.

Figure 57: 2018 to 2020 Annual Utility (Natural Gas Consumption) Profile

5.1.3 Heating Degree Day (HDD) Comparison

Heating Degree Day (HDD) is the number of degrees that a daily average temperature is below 18°C which is the base set point temperature. It is the measure of how cold it is, and it quantifies the demand for energy needed to heat a building. The Annual Natural Gas Consumption has been compared to heating degree days and these profiles below shows that usage relates well to heating degree days (HDD).

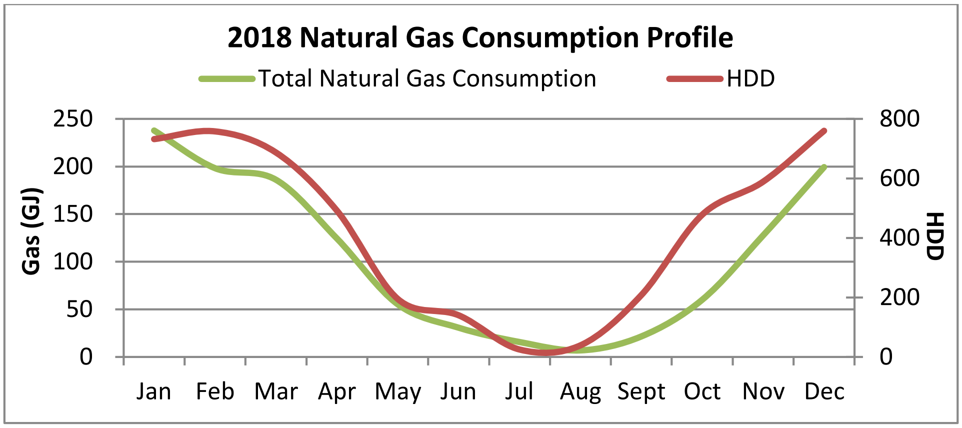


Figure 58: 2018 Annual Natural Gas Consumption Profile Compared to Heating Degree Days

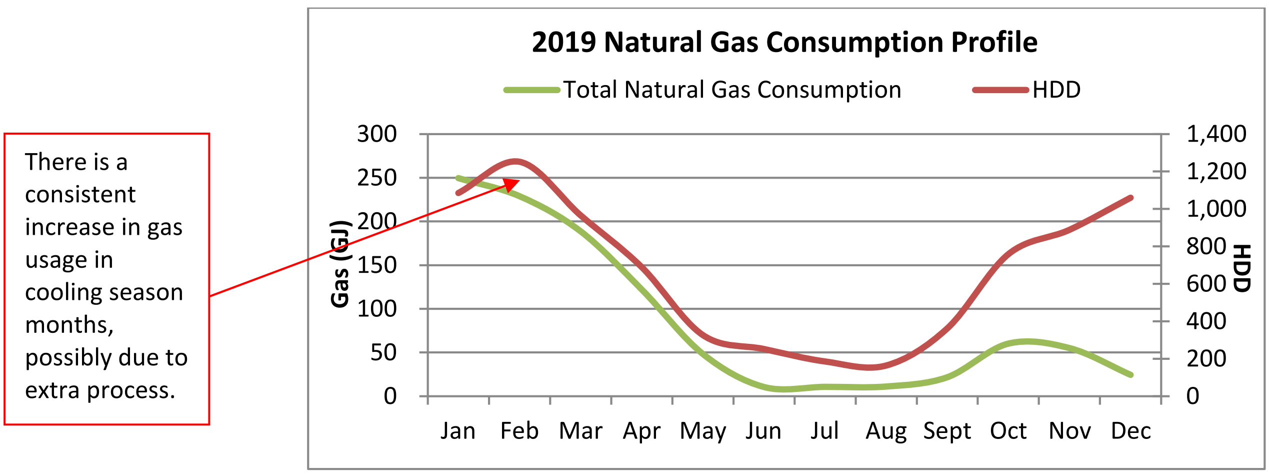


Figure 59: 2019 Annual Natural Gas Consumption Profile Compared to Heating Degree Days

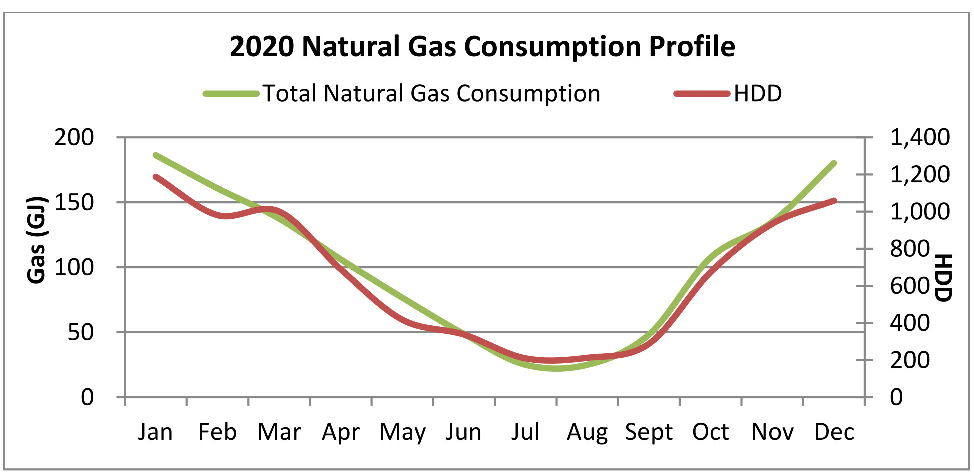


Figure 60: 2020 Annual Natural Gas Consumption Profile Compared to Heating Degree Days

5.1.4 Historic Greenhouse Gas (GhG) Emissions

Climate change is currently one of the most important global issues and a major concern for the Resort Municipality of Whistler. Climate change is caused by the increase in concentrations of greenhouse gases (GHGs) in the atmosphere. The 2018, 2019 and 2020 greenhouse gas emissions profile for the Wastewater Treatment Plant are summarized in the following table and charts.

Table 6: Summary of Historic GHG Emissions

Year	Annual GhG Emissions
2018	44.2 Tonnes e-CO2/yr
2019	42.5 Tonnes e-CO2/yr
2020	43.3 Tonnes e-CO2/yr

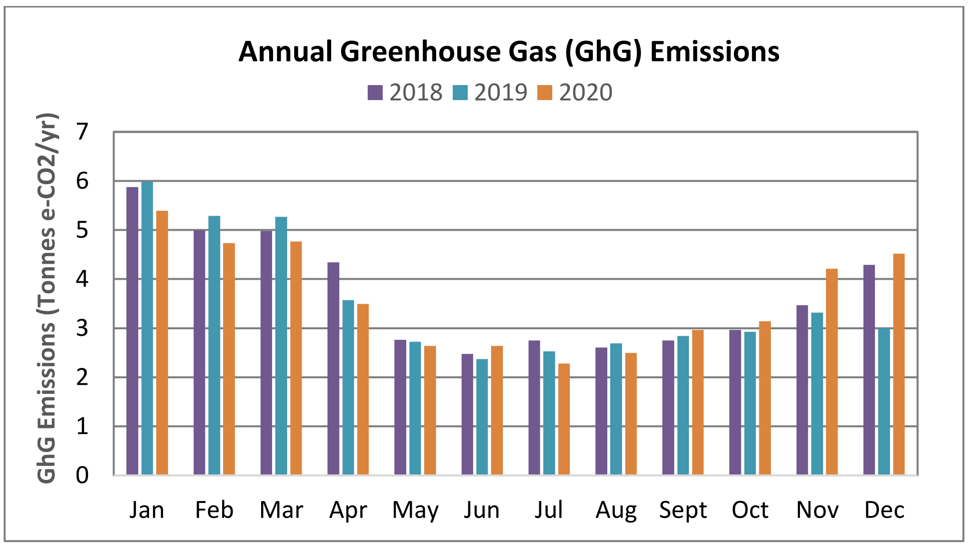


Figure 61: Annual Greenhouse Gas Emission Comparison

The Annual Utility Profiles shows that GhG emissions for the building is seasonally tied. The lighting, electrical and cooling systems in the facility have a minimal impact on the building with regards to GhG emissions.

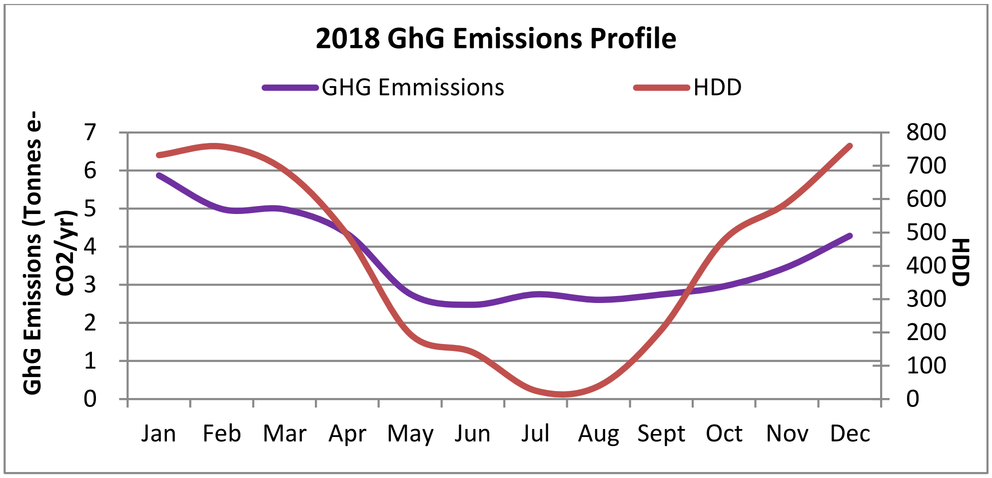


Figure 62: 2018 Annual GhG Emissions Profile Compared to Heating Degree Days

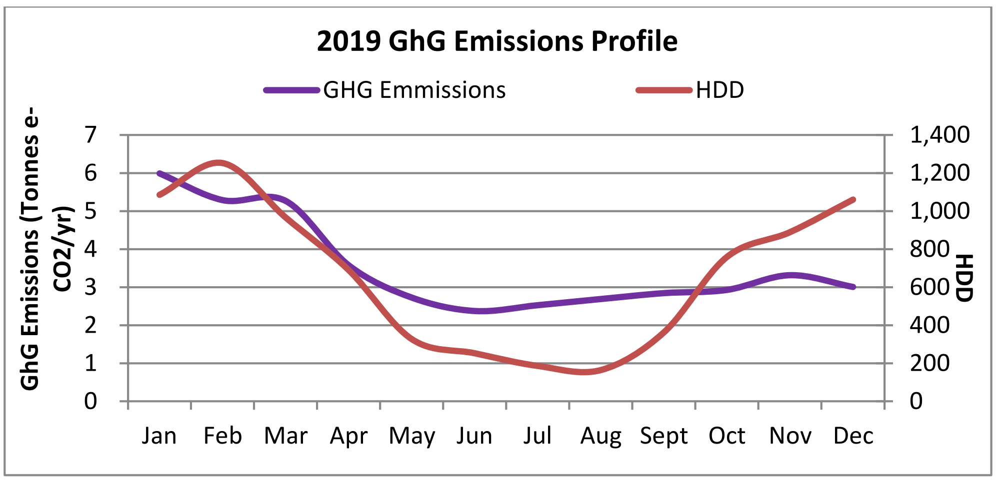


Figure 63: 2019 Annual GhG Emissions Profile Compared to Heating Degree Days

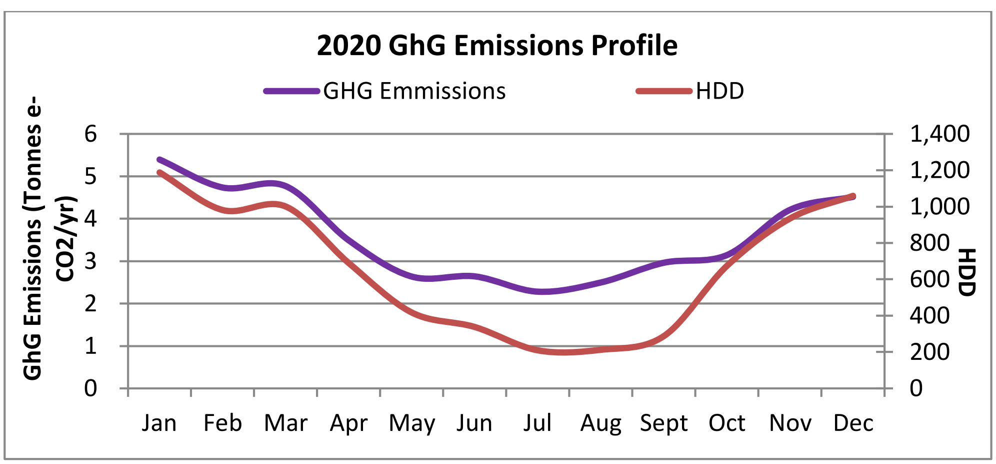


Figure 64: 2020 Annual GhG Emissions Profile Compared to Heating Degree Days

5.1.5 Energy End-use Breakdown

The following end-use breakdown is an order of magnitude estimate, based on the consulting team's understanding of the building systems, operation schedules, and existing utility records. Actual testing, measurement, and verification, which would prove both difficult and costly, would need to be undertaken to provide a more accurate breakdown.

Table 7: Actual End-Use Breakdown Estimate (2020)

	Total Natural Gas Consumption		Total Electricity Consumption		Overall Energy Consumption		Overall Facility Energy Intensity	
	[GJ]	%	[kWh]	%	[e-GJ]	[e-kWh]	[e-kWh/m^2/yr]	%
Domestic Hot Water	83	6.7%	0	0.0%	83	22,987	29.1	2.6%
Space Heating	982	79.4%	0	0.0%	982	272,826	345.5	31.2%
Space Cooling	0	0.0%	62,550	11.8%	225	62,550	79.2	7.2%
Lighting	0	0.0%	75,097	14.1%	270	75,097	95.1	8.6%
Total Fans/Pumps	0	0.0%	378,378	71.3%	1,362	378,378	479.2	43.3%
Miscellaneous (Computers, Kitchen Equipment, Block Heater, and Plug Loads)	172	13.9%	14,975	2.8%	226	62,734	79.4	7.2%
Total	**1,237**	100%	**531,000**	100%	**3,148**	**874,571**	**1,107.5**	100%

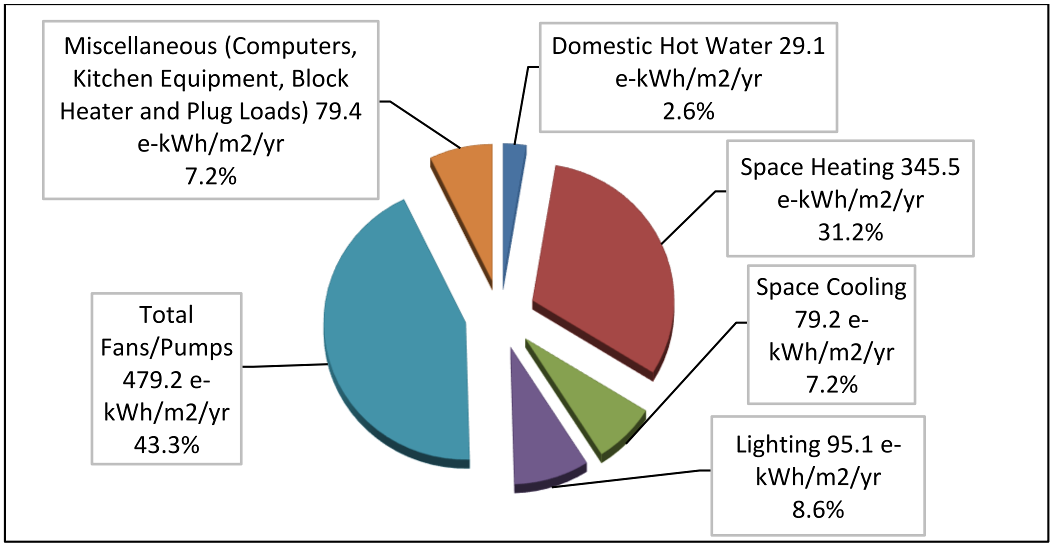


Figure 65: Energy Use Intensity (2020)

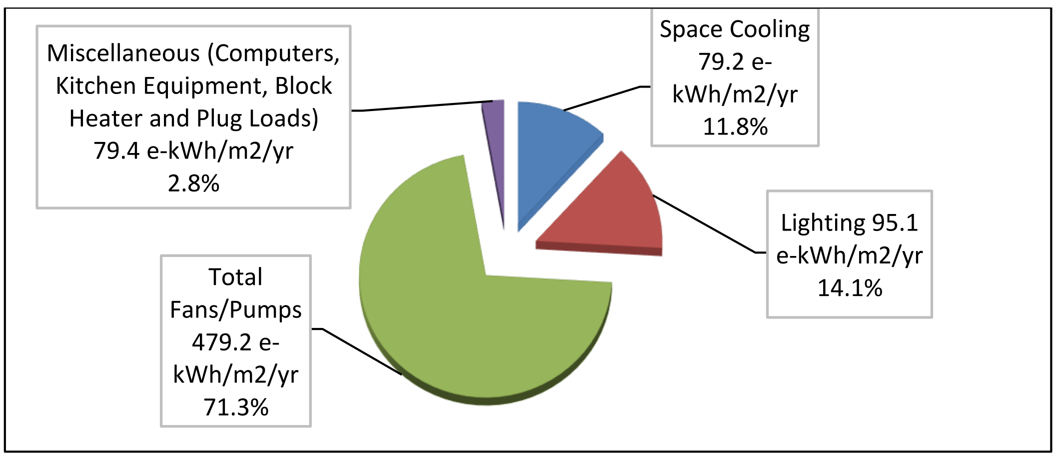


Figure 66: Electrical End-Use Breakdown (2020)

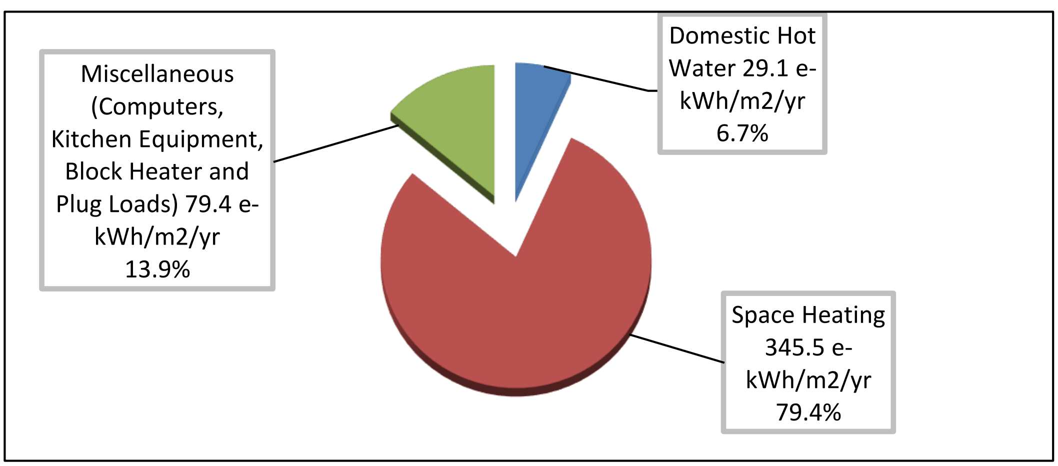


Figure 67: Natural Gas End-Use Breakdown (2020)

6 MECHANICAL & ELECTRICAL ENERGY CONSERVATION OPPORTUNITIES

6.1 Methodology

In order to comply with the technical requirements of energy retrofit funding programs, calculations have been completed to assess the potential energy savings associated with each energy conservation measure. Although, calculations are not able to take into account the dynamic effects and synergies of all building systems operating together, the calculations in the following sections are described in sufficient detail to understand their limitations. All costs are estimates of probable cost (+/- 20%) and should be used for budgetary purposes only. There are also some measures included in the body text which cannot be quantified and as such are not included in the summary table. In the event that energy conservation measures overlap and affect the same piece of equipment, these are identified as numbered options. In these cases, the Client will need to select the retrofit measure that best meets their financial and performance criteria.

It must also be noted that the technical descriptions of each energy conservation measure must not be used basis for design or tender. BES recommends the procurement of a registered Professional Engineer (EGBC) to carry out a full in-depth design in accordance with code of all energy conservation measures described within this report.

The following section provides a discussion of HVAC energy conservation measures.

6.2 Recommended Energy Conservation Measures for Implementation

6.2.1 Mechanical and Control Systems

The following section provides a discussion of potential energy conservation measures (ECMs) that apply to the facility's mechanical and control systems which have been selected for implementation.

6.2.1.1 ECM #M1: Install Aerators on Existing Plumbing Fixtures

Description:

It would be beneficial to address water conservation measures at this facility, as high-water usage is associated with high domestic, and service hot water loads and subsequent high electricity & natural gas usage. Further attention to water management through equipment upgrades, adjustment of controls and operational set points, and the development of operational practices that enhances water conservation while conforming to all health and safety requirements should be a priority. Properly calibrated controls can offer significant water and energy while enhancing cleanliness and saving time.

Water used by faucets in kitchens/washrooms within the facility have an impact on energy used for domestic hot water heating and total water consumption. As such, high performance and low-flow fixtures/aerators are required to best conserve energy. The following flow rates are proposed for consideration by the facility:

- 0.5 GPM (1.9 LPM) low laminar flow aerators in lavatory
- 1.5 GPM (5.7 LPM) low laminar flow aerators in kitchen sink

Currently in the facility, the faucets are generally installed with either 2.0 or 2.2 GPM flow aerators.

Figure 68: Stream Flow Faucet Aerator (0.5 GPM) (courtesy of Utility Savers® - Save Water Us)

Affected Area: All plumbing fixtures (1 lavatories and 2 sinks).

Implementation: It is proposed to trial a small percentage (5-10%) of the proposed new laminar flow aerators (0.5 GPM) to ensure they meet the expectations of the building occupants and management. Upon positive feedback and/or no complaints from the residents, the new low flow aerators will remain in place and the remaining aerators will be installed. In the event that they experience negative feedback, it is proposed to replace them with slightly higher flow aerators with a different flow pattern, until a satisfactory compromise is found.

Service Life: 10 Years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 8: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Install Aerators on Existing Plumbing Fixtures	0	0.0	83	0	0.0	2	$20	$40	1.86

Type of Energy Analysis Completed:

Energy savings calculated from this measure are based upon the reduction in water use and domestic hot water heating energy. The following tables show the existing fixtures and proposed fixtures.

Table 9: Existing Fixture Specifications

Fixture	Flow	Duration (LEED Baseline)
Lavatory	1.0 GPM	1 min
Sink	2.2 GPM	1 min

Table 10: Proposed Fixture Specifications

Fixture	Flow	Duration (LEED Baseline)
Lavatory	0.5 GPM	1 min
Sink	1.5GPM	1 min

Domestic Hot Water Heating Energy (kW) = GPH x 8.34lbs./Gal x ΔT x 1

Risk Assessment: It is proposed to trial a small percentage of the proposed new laminar flow aerators to ensure they meet the expectations of the building occupants and management.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced water consumption.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

Synergies: This measure will run in conjunction with ECM #M2: Install Thermal Insulation to Exposed Domestic and Service Hot Water Pipework.

6.2.1.2 ECM #M2: Install Thermal Insulation to Exposed Domestic and Service Hot Water Pipework

Description: During the site audit it was noted that the thermal insulation on certain sections of the Domestic and Service hot water pipework was missing. It is recommended that the pipework be insulated with suitable pipe insulation to prevent unnecessary heat loss, which will result in annual natural gas savings.

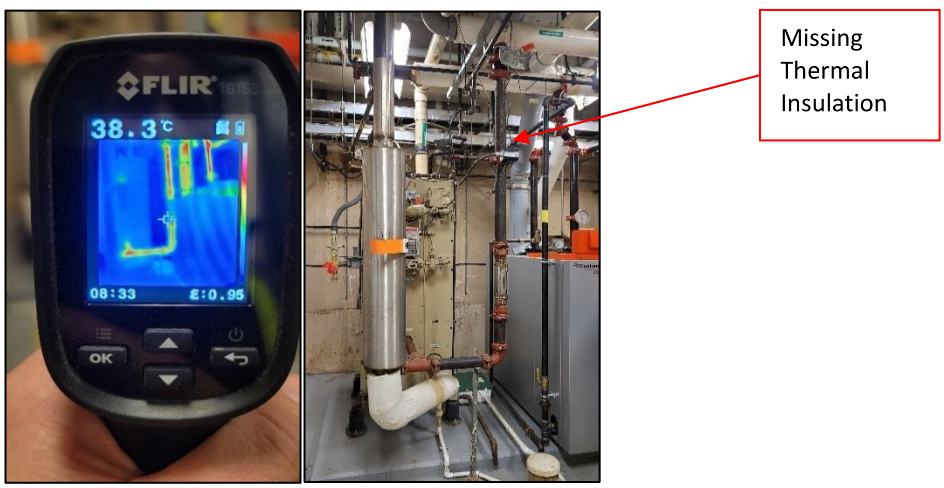


Figure 69: Missing Thermal Insulation – Primary treatment building

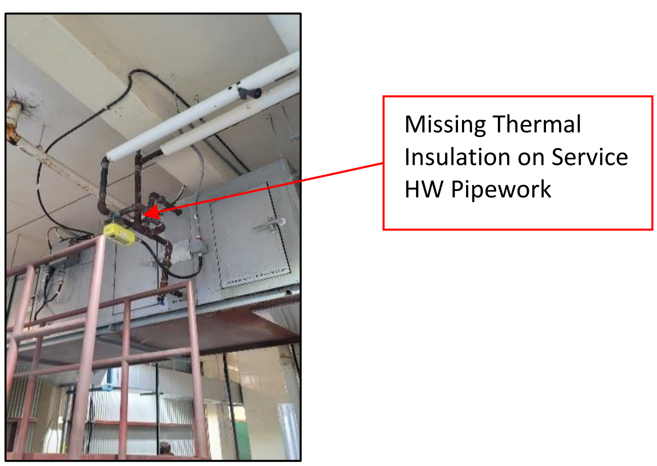


Figure 70: Missing Thermal Insulation – Primary treatment building

Figure 71: Examples of Thermal Insulation

Affected Area: DHW and Heating pipework in Primary treatment building.

Implementation: This measure would be implemented by installing thermal insulation on DHW pipework.

Service Life: 10 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 11: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Primary treatment building: Install Thermal Insulation to Exposed Hot Water Pipework	0	0.0	83	0	0.0	14	$160	$380	2.4

Type of Energy Analysis Completed

CIBSE Guide C 3.1 has been used to assess potential energy savings from the installation of insulation to the bare pipework.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced greenhouse gas emissions.
- Reduced space temperature in the mechanical room.
- Protection of pipes.
- Safety – if a pipe is carrying extreme temperatures and bursts the insulation will stop any spray.
- Noise reduction.
- Ensure the needed temperature of the liquid.
- Optimal functioning of ventilation.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.2.1.3 ECM #M3: Repair/Replace Door Seals

Description: During the site audit, it was noted that the seals on the exit doors throughout the building were in very poor condition. These poor seals allow for heat loss and air infiltrations to the facility. It is recommended to repair or replace the door seals as soon as possible to prevent unnecessary heat loss and air infiltration.

Figure 72: Existing Poor External Door Seals

A large opening in the wall of the Water Entry Room was observed. The opening is exposed to the outside. It is proposed to thermally insulate and seal this opening to prevent domestic cold-water pipework freezing in sub zero temperatures. Energy savings will also be observed from reduced heating in the space.

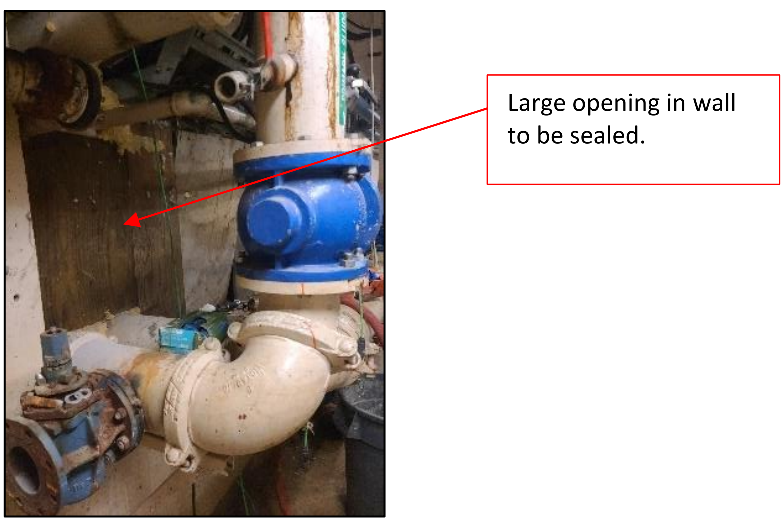


Figure 73: Water Entry Room - Wall Penetration

Area Affected: External doors and Water Entry Room Wall Opening

Implementation: Implementation of this measure would involve repairing/replacing the door seals to all the external doors of the building.

Service Life: 10 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 12: Summary of Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
All Buildings: Repair/Replace Door Seals	0	0.0	982	0	0.0	34	$380	$800	2.1

Type of Energy Analysis Completed: Energy conservation calculations are based upon the saving of energy that is otherwise lost through poor seals.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced greenhouse gas emissions.
- Reduced draughts.
- Improved occupant thermal comfort.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.2.1.4 ECM #M4: Retro-commissioning & Perform Boiler Control Optimisation

Description: Retro-commissioning is a systematic, documented process that identifies low-cost operational and maintenance improvements in existing buildings and brings the buildings up to the design intentions of its current use. It typically focuses on energy-using equipment such as mechanical equipment and related controls and usually optimizes existing system performance, rather than relying on major equipment replacement, typically resulting in improved indoor air quality, comfort, controls, energy, and resource efficiency. It is a process to improve the efficiency of an existing building's equipment and systems. It can often resolve problems that occurred during design or construction, or address problems that have developed throughout the building's life as equipment has aged, or as building usage has changed. Retro-commissioning involves a systemic evaluation of opportunities to improve energy-using systems

During a retro-commissioning exercise diagnostic monitoring and functional tests of building systems are executed and analyzed. All major plant and systems are reviewed and set points and schedules are retested and monitored to fine-tune the systems to ensure optimal performance. This process helps find and repair operational problems and reassess the systems operational strategies and involves a systematic review of control points and operational parameters in an effort to identify areas of waste within the system (i.e., valves passing, re-calibration/replacement of sensors, re-balancing, constriction, control feedback issues etc.).

Affected Area: Boilers in Boiler Room.

Implementation: This measure would be implemented by consulting a professional engineering firm to complete a detailed retro-commission study of the boilers.

Service Life: 2 years with ongoing recalibration.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 13: Summary of Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Retro-commissioning & Perform Boiler Control Optimization	6,296	0.6	982	776	0.0	60	$1,220	$17,000	14.0

Type of Energy Analysis Completed: Energy savings from this measure are based upon a computer simulation and the reduction of energy required to heat and the space.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced greenhouse gas emissions.
- Improved controllability.
- Reduced equipment breakdowns.
- Adjust out of calibration equipment.
- Identify systems that simultaneously heat and cool.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.2.1.5 ECM #M5: AHU-1, AHU-2 & AHU-3 – Install new Cold Climate Heat Pumps to supply new Hydronic Coil in each unit.

Description: AHU-1 provides continuous ventilation and heating to the influent pumping room. Heating and ventilation to the headworks area is provided by two (2) HAAKON AIRPAK units (AHU-2 & AHU-3). Each unit is complete with supply fan (2,200 CFM), hydronic heating coil (fed from existing boiler), dampers, filter section. The units have exceeded their useful life, as per ASHRAE life expectancy guidelines and are in need of replacement.

It is proposed to install new hydronic coils in each AHU. The new coils shall be fed by a new high efficiency cold-climate heat pump, which will be mounted on the roof of the facility. The benefits of the proposed system include:

- Saving energy: extracting more energy from the air (as heat) than it consumes (as electricity) and can offer space heating and cooling.
- Greenhouse gas emissions reduction.
- Resize the existing boiler serving the AHUs.
- Reducing costs: Using heat pump technology to create up to 10 kilowatts of heat energy for each kilowatt it consumes.
- Potentially adding cooling capacity, the space.

Area Affected: AHU-1, AHU-2 & AHU-3

Implementation: Remove the existing hydronic coil in each AHU and install a new hydronic coil fed from a new cold-climate air source heat pump to suit. The new heat pump shall be installed outdoors and will be complete with aluminum heat exchanger, variable speed motor and filter section. A new hydronic

It is anticipated that first stage heating will be provided by the heat pump coil with second stage heating provided by a hot water heating coil fed the existing hot water heating system.

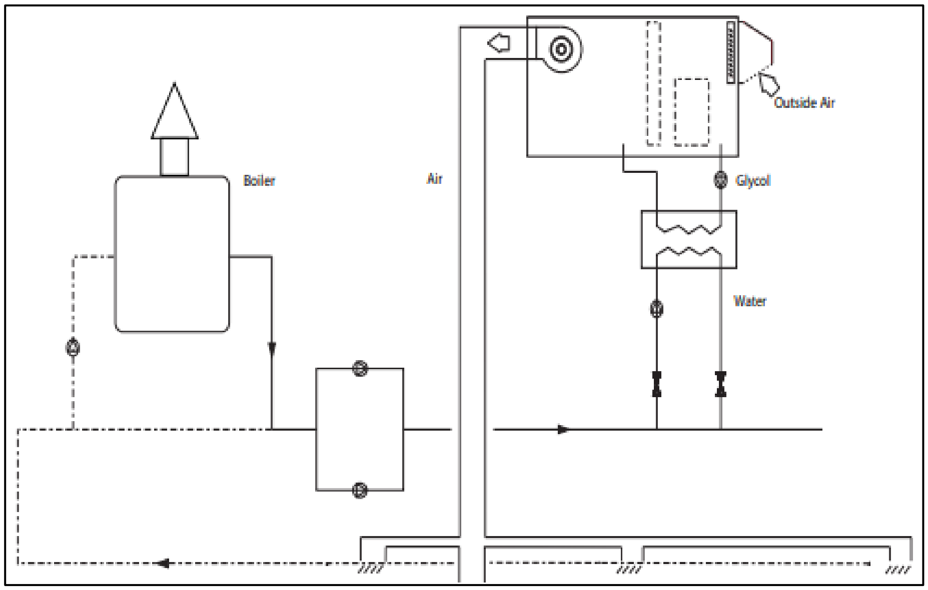


Figure 74: Proposed Air Handling Unit Schematic

BES recommends the procurement of a registered Professional Engineer (EGBC) to carry out a full in-depth design in accordance with code of this measure.

Figure 75: Proposed Heat Pump Unit

Service Life: 15 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period. The budget estimate for this measure will be approximately $180,600.

Table 14: Summary of ECM #M4 Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M ($/yr)	Total Estimated Incremental Cost (capital, install, design, incentive) *	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Replace Existing AHU Hydronic Coil with new Hydronic Coil and Matched Cold Climate Heat Pump.	47,667	3.6	755	-41,343	-28.8	693	$2,180	$37,000	17.0

Type of Energy Analysis Completed:

Energy and GHG savings from this measure are based on the reduction in gas usage with an air source heat pump system. The calculation accounts for the fact the coefficient of performance (COP) of the heat pump system changes based on outdoor air temperature. For example, the lower the outdoor air temperature the lower the COP.

Risk Assessment: This project would involve close project management control; whereby phased shutdowns would be required to ensure that the 'system' remains 'live' at all times. I.e., due to the nature of the facility, a full shutdown of the ventilation system may not be allowed. Existing electrical load will need to be confirmed prior to implementation to ensure sufficient capacity remaining for heat pump upgrade.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Longer lifetime and reduced operating cost.
- Reduced greenhouse gas emissions.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

Synergies: This measure will impact ECM#M1 - *Replace the Existing Standard Efficiency Boilers and DHW Storage Tanks with New High Efficiency Condensing DHW Water Heaters and Tanks*

Type of Energy Analysis Completed: Energy savings from this measure are based on the reduction in natural gas usage from replacing the existing AHU with the heat pump air handling unit. The calculation takes account of the coefficient of performance (COP) of the heat pump system based on outdoor air temperature. For example, the lower the outdoor air temperature the lower the COP.

Risk Assessment: This project would also involve close project management control, whereby phased shutdowns would be required to ensure that the 'system' remains 'live' at all times, i.e., due to the nature of the facility, a full shutdown of the heating and ventilation system may not be allowed. In accordance with the CSA requirements, close dust control measures must also be followed before any works are commenced.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced greenhouse gas emissions.
- Reduced equipment breakdowns.
- Improved controllability.

- Reduction in boiler size and corresponding maintenance savings
- Reduction in potential future carbon tax.
- Greater ambient air control.

In-House Resources: No extra In-house effort is required to operate or maintain measure.

6.2.1.6 ECM #M11: Heating System - Outdoor Air Temperature (OAT) Reset

Description: There is opportunity for energy savings by utilizing an outdoor air temperature reset to control the heating system. The outdoor reset controls the boiler to module heating demand based on the actual, real-time outdoor temperature. This allows the boiler to respond to the outdoor temperature by raising or lowering the boiler's supply water temperature being delivered to the heating system.

Affected Area: Heating System

Implementation: This measure would be implemented by installing outdoor air reset controls and commissioning the heating system.

Service Life: 10 years with ongoing monitoring

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 15: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Heating System - Outdoor Air Temperature (OAT) Reset	82,161	3.6	0	8,216	0.0	0	$1000	$4,200	4.2

Type of Energy Analysis Completed: Energy savings from this measure are based upon the reduction of heating energy required due to outdoor air temperature reset controls. All energy savings are calculated based upon the internal temperature setpoints and hourly historical climate normal for Whistler, BC.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Improved controllability.
- Reduced equipment breakdowns.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.2.1.7 ECM #M12: Optimal Start/Stop to HVAC Equipment

Description: It is proposed to implement optimal start stop to all HVAC equipment in the building. Optimal Start/Stop is used to anticipate the heating or cooling needs of a space by starting equipment early enough to reach setpoint just at the beginning of scheduled occupancy. The Optimal Start/Stop function in a buildings control software does this by calculating the difference between the actual temperature and the occupied temperature setpoint. Based on a heating or cooling slope, the unit is started early enough to bring the space temperature to the desired level.

Affected Area: Temperature Controllers building wide

Implementation: All EMS systems have an HVAC start/stop function; however, not all of them may be optimized for the specifics of your building. To optimize the HVAC start/stop function, some key data points are required, including the inside/outside air temperature, time of day, and the time necessary to bring the various building zones to desired setpoints.

Service Life: 2 Years with ongoing calibration.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 16: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Optimal Start/Stop	82,161	3.6	0	2,465	0.0	0	$650	$4,200	6.5

Type of Energy Analysis Completed:

Energy savings calculated from this measure are based upon the reduction in electrical and gas use due to reduction in operating hours.

Risk Assessment: It is proposed to trial the system and making ongoing changes based on feedback.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced GHG emissions.

In-House Resources: Ongoing calibration is required if building occupancy times change.

Synergies: This measure will not adversely impact any other ECM.

6.2.1.8 ECM #M13: Interlocking Roller Shutter Doors and Hydronic Unit Heaters.

Description: The hydronic unit heaters operate regardless of whether the external roller shutter doors are open or not. There is potential to save a significant amount of energy by installing an interlock between each of the hydronic unit heaters and the roller shutter doors. At present when the door is open to outside, the hydronic unit heater wastes energy. By installing a door interlock complete with alarm, this will ensure that the equipment does not operate when the door is open, and therefore wasted energy will be mitigated.

Figure 76: Shutter Doors

Affected Area: Primary treatment building HVAC Units and Shutter Doors

Implementation: This measure would be implemented by installing door switches on the roller shutter doors. These door switches would sense the position of the door, either open or closed. The sensor would be interlocked with respective hydronic unit heater in the space so that when the door was open the circuit would be 'broken' and the heater would not operate. When the door is closed, the circuit would be 'complete', and the heater(s) would operate as normal.

Service Life: 10 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 17: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Install roller door interlocks with HVAC equipment on lower floor	10,022	0.0	0	2,004	0.0	0	$320	$5,200	16.2

Type of Energy Analysis Completed: Energy savings from this measure are based upon the reduction of run hours of the heaters when the roller shutter doors are open.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced GHG emissions by less energy usage.
- Reduced equipment breakdowns due to less run time.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.2.1.9 ECM #M16: Upgrade Thermostatic Control Valves To All Hydronic Baseboards.

Description: Overtime, radiator control valves can become ‘out of calibration’ due to general wear and tear and the build-up of dust and grime on the actuator. It is therefore possible to achieve significant savings by replacing/repairing the radiator valves so that they control correctly. A correctly controlling radiator valve will ensure heating is supplied to the radiator only when required. For example, an ‘out of calibration’ radiator valve that does not ‘seat’ correctly could let by hot water constantly even when not required. This would result in increased boiler and pumping energy. It is also advantageous to check each of the existing radiator valves to ensure that they have not been tampered with by the tenants, which could also have a detrimental effect to their efficient operation.

Figure 77: Baseboards

Affected Area: Baseboard heaters

Implementation: This measure would be implemented by replacing the existing hydronic radiator valves with new Thermostatic Control Valves.

Service Life: N/A

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 18: Summary of Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, CO_2 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Upgrade thermostatic control valves to all hydronic baseboards.	0	0.0	11	0	0.0	10	$320	$1,000	3.2

Type of Energy Analysis Completed: Typically, aging valves allow hot water to pass through them so by servicing them and optimisation of valves this can yield an additional 9-15% in utility savings. A conservative estimate of 5% has been used in the calculation

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

Synergies: This measure will not adversely impact any other system or ECM

6.2.1.10 ECM #M17: Installation of Energy Saving Additive into Boiler Loop to Improve Heat Transfer and Efficiency of HVAC (Gas) System.

Description: BES recommends the addition of an additive to the heating system to improve heat transfer of the water in the system. Endotherm is 100% organic, biodegradable and is compatible with the corrosion inhibitors for your heating system. Endotherm has proven to reduce the surface tension of the boiler water by 60-70%, which increases the effective surface area reached by the circulating water which increases the rate of heat transfer.

FortisBC provide incentives for the use of endotherm in heating systems.

Affected Area: Heating Boilers.

Implementation: This measure would be implemented by adding Endotherm to the heating system water.

Service Life: 5 Years

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period. The budget estimate for this measure will be approximately $4,020.

Table 19: Summary of Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, CO_2 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Installation of Energy Saving Additive into Boiler Loop to Improve Heat Transfer and Efficiency of HVAC (Gas) System	0	0.0	2,270	0	0.0	182	$2,020	$4,020	2.0

Type of Energy Analysis Completed: Energy savings from this measure are based upon the increased thermal conductivity of the space heating hydronic system.

Risk Assessment: This measure has no risks associated with it.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced greenhouse gas emissions.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

Synergies: This measure will not adversely impact any other system.

6.2.1.11 ECM #M18: Kitchen and Office: Install Programmable Thermostats to Control Heating and Implement Unoccupied Temperature Set Back.

Description: During the site audit, it was noted that the baseboard heating in the Workshops and Lab is manually controlled. Manual control of the electric baseboard heating often leads to excessive usage. Energy savings could be realized if smart self-learning thermostats (NEST or similar) were retrofitted in place of these existing manual thermostats. The new smart thermostats can be installed to avoid simultaneous heating and cooling in the space and to avoid unnecessary operation of the heating/cooling system when the space is unoccupied.

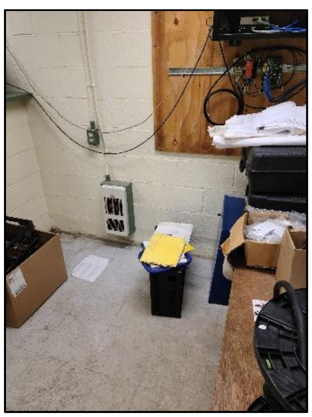


Figure 78: Existing Electric Baseboard

Affected Area: Temperature Controllers in the Workshop and

Lab.

Implementation: This measure would be implemented by replacing the existing thermostats with new programmable thermostats.

Figure 79: Typical Programmable Thermostat

Service Life: 10 Years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 20: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Kitchen and Office: Install Programmable Thermostats to Control Heating and Implement Unoccupied Temperature Set Back	10,080	2.5	0	1,210	0.0	0	$70	$600	8.2

Type of Energy Analysis Completed:

Energy savings from this measure are based upon the reduction of operation hours of the baseboard heaters.

Risk Assessment: It is proposed to trial this technology to ensure they meet the expectations of the building occupants and management.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Improved occupant thermal comfort.
- Improved controllability.
- Reduced equipment breakdowns.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.2.1.12 ECM #M21: High Efficiency Motor upgrade.

Description:

There is an opportunity for energy savings by upgrading motors in the facility to new premium efficiency motors. Energy-efficient motors only provide savings when they're running, and the more the motors run, the more energy and money they save. Second, maximum savings - and the fastest returns on investment - are attained in regions of the country where utility rates are highest. Even so, energy-efficient motors are highly recommended even in low energy-cost areas because they eventually provide savings that more than adequately justify their cost. Another thing to note is that utility costs are rising, so a more efficient motor will reduce this impact.

A further point to consider is that premium efficiency motors are generally made to higher manufacturing standards and tighter quality controls than the old standard-efficiency motors they are meant to replace. The new motors run cooler because they generate less I 2R heat, producing less stress on windings. This is generally taken to be an indication that the motors will last longer, and it can translate in reduced downtime and lower repair costs over the life of the motor.

A complete inventory of all motors is provided in Appendices.

The following table provides a summary of typical motor efficiency gains.

Table 21: Summary of Motor Retrofit Efficiency Gains

Motor Efficiency Schedules				
HP	Existing (%)*	New (%)**	Premium Efficiency (%)***	Capital Cost
0.05	35%	55%	55%	$270
0.1	35%	55%	55%	$270
0.125	35%	55%	55%	$270
0.17	35%	55%	55%	$300
0.25	54%	60%	60%	$300
0.33	56%	60%	60%	$300
0.5	60%	70%	70%	$330
0.75	72%	84%	84%	$330
1	75%	82.5%	86.5%	$350
1.5	77%	84.0%	86.5%	$360
2	79%	84.0%	86.5%	$390
3	81%	87.5%	89.5%	$270
5	82%	87.5%	90.2%	$310
7.5	84%	89.5%	91.7%	$410
10	85%	89.5%	91.7%	$490
15	86%	91.0%	92.4%	$690
20	87%	91.0%	93.0%	$820
25	88%	92.4%	93.6%	$1,040
30	89%	92.4%	94.1%	$1,190
40	89%	93.0%	94.5%	$1,660
50	89%	93.0%	94.5%	$1,970
60	89%	93.6%	95.0%	$2,970
75	90%	94.1%	95.4%	$3,420
100	90%	94.5%	95.4%	$4,480
125	90%	94.5%	95.4%	$6,050
150	91%	95.0%	95.8%	$7,560

Note:
* Based on data from ASHRAE 90.1 -1989 (EPA ACT 1992) for 1750 RPM
** Based on data from ASHRAE 90.1 -2004 (EPA ACT 1992) for 1750 RPM p6
*** Based on data from Baldor Premium Efficiency 2008

It is recommended that a motor retrofit program be implemented to replace motors outlined in the table below, with high efficiency or super high efficiency models as part of a rolling retrofit program as existing units fail.

Affected Area: Primary treatment building.

Implementation: This measure would be implemented by replacing standard efficiency motors with premium efficiency motors

Service Life: 15 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 22: Summary of ECM Costs and Savings

Description	Existing Energy Use (for equipment included in measures only)			Annual Energy Savings			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Install Premium Efficiency Fan Motors	142,563	13.6	0	5254.42	1.07	0	$970	$5,900	6.06
Install Premium Efficiency Pump Motors	235,814	72.7	0	24,275	4.7	0	$2,650	$22,200	8.37

Type of Energy Analysis Completed: Energy savings from this measure are based upon the reduction of energy resulting from the reduced power consumption of the pumps operating at lower rotational speeds.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced GHG emissions.
- Reduced equipment breakdowns.
- Easier Servicing.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

Synergies: This measure will not adversely impact any other system or ECM.

6.2.1.13 ECM #M22: Old Control: Replace Existing Hydronic Air Handling Unit with High Efficiency Air Handling Unit Complete With Economizer and Hydronic Heating Coil

Description: Ventilation and pressurization to the Primary Treatment Building is provided by three (3) hydronic Air Handling Units (AHU), two of which are past their economic useful life as per ASHRAE. These AHUs provide 100% tempered outdoor air to the building. The conditioned air is supplied to the building through discharge grilles located at high level. Each unit has an airflow capacity of 4,700 CFM.

It was noted that the AHU unit is at the end of its rated economical life as determined by ASHRAE.

Figure 80: Existing Air Handling Unit

Affected Area: Air Handling Units 1 & 2.

Implementation: Implementation of this measure involves the removal of the existing end of life hydronic AHUs and installing a new high efficiency air handling units complete with economizers and hydronic heating coils. The proposed systems shall comply with ASHRAE 62.1 guidelines for “Acceptable Indoor Air Quality” and building code requirements. It is recommended to obtain the services of a registered EGBC engineering firm to complete a detailed mechanical design of the proposed measure.

Service Life: The estimated service life of an AHU is approximately 15 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period. It should be noted that these costs show incremental cost of the project. Operation & Maintenance savings have also been considered as it is envisaged that there will be less annual maintenance service site visits.

Table 23: Summary of ECM Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Incremental Cost (capital, install, design, incentives) *	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Replace Existing Hydronic Air Handling Units (AHU-1 &2) with one High Efficiency Air Handling Units Complete with Economizers and Hydronic Heating Coils	31,778	7.3	503	2,889	0.7	61	$1,950	$30,000	15.4

*Incremental costs are shown (cost difference between a standard efficiency equipment and high efficiency equipment)

Type of Energy Analysis Completed: Energy savings from this measure are based upon the increase in efficiency from 80% for the existing AHU unit to the higher 91% efficient AHU unit. This measure will lead to a reduction in natural gas use by the high efficiency AHU unit.

Risk Assessment: N/A

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced greenhouse gas emissions.
- Reduced equipment breakdowns.
- Improved controllability.

In-House Resources: In-house effort is required to operate or maintain measure.

Synergies: This measure will not adversely affect any other ECM.

6.2.1.14 ECM #M23: Combined Heat and Power Unit (CHP)

Description: There is an opportunity for energy savings by utilising a CHP unit. This unit can utilise the emissions from the Wastewater Treatment and used it to produce heat and power to the WWTP.

CHP is a reliable, cost-effective option for WWTFs that have, or are planning to install, anaerobic digesters. The biogas flow from the digester can be used as fuel to generate electricity and heat in a CHP system using a variety of prime movers, such as reciprocating engines, microturbines, or fuel cells. The thermal energy produced by the CHP system is then typically used to meet digester heat loads and for space heating. A well-designed CHP system using biogas offers many benefits for WWTFs[15] because it:

- Produces power at a cost below retail electricity.

[15] US EPA '*Opportunities for Combined Heat and Power at Wastewater Treatment Facilities*' October 2011

- Displaces purchased fuels for thermal needs.
- May qualify as a renewable fuel source under state renewable portfolio standards and utility green power programs.
- Enhances power reliability for the plant.
- Produces more useful energy than if the WWTF were to use biogas solely to meet digester heat loads.
- Reduces emissions of greenhouse gases and other air pollutants, primarily by displacing utility grid power.

CHP plants are in place at 104 WWTP in the US as of 2011, and studies have shown that a CHP is technically feasible at 1,351 additional sites and economically attractive (i.e., payback of 7 years or less) at 662 of those sites.

A CHP unit would be a very beneficial addition to the Whistler Wastewater Treatment due to the very large electrical and heat requirement. With the current costs of electricity and gas expected to rise by approximately 3% year on year there is a big opportunity for savings by producing electrical and heat energy on site.

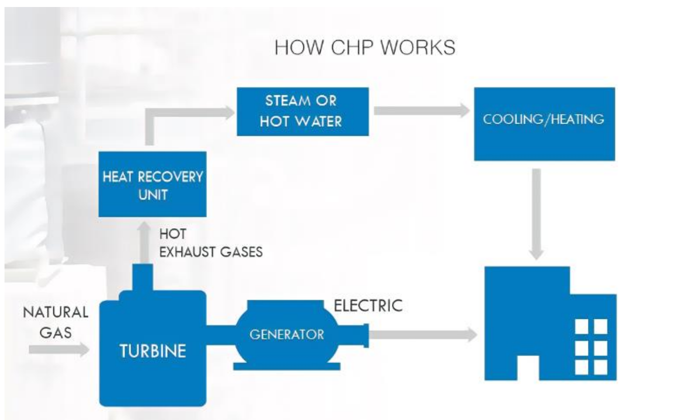


Figure 81: CHP Operation

Affected Area: Entire Site.

Implementation: This measure would be implemented by installing a CHP plant near the Process Plant

Service Life: 20 years.

Economic Analysis: A more detailed study would have to be undertaken of the gas emitted from the digestion process to understand the CHP potential at this site. From the study by the US EPA, it has been found that a CHP plant has a pay back of 7 years. The cost of a CHP plant is approximately $5,000/kw[16].

Type of Energy Analysis Completed: Energy savings from this measure are based upon the reduction of Utility Energy by the CHP plant providing all the power to the WWTP with a gas back up system.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

[16] US Dept. of Energy '*Combined Heat and Power Technology Fact Sheets*' July 2016

- Reduced GHG emissions.
- Power reliability in the event of a city utility blackout.
- Enhanced Public Perception.

In-House Resources: Further in-house effort is required to maintain measure once implemented.

Synergies: This measure will not run-in conjunction with other measures.

6.2.1.15 ECM #M24: Improved Data Logging of Energy End-Uses

Description At present there is no means to sub-meter and log energy consumption of the various systems in the different building.

Table 24: Whistler WWTP - Buildings

Whistler WWTP Campus	Area (sf)
Administration	4,700
Sludge Storage	3,200
Sludge Handling	3,200
Alum	1,300
UV (Disinfection Building)	700
Old Control	4,000
Clarifier	1,000
District Energy System (DES)	1,400
Blower Building	1,400
Generator Building	1,500
Maintenance Building	3,600
Fermenter	1,800

Without detailed monitoring capabilities in a facility with over, measurement and verification of energy conservation measures is a challenge, as is the ability of operators to identify more complicated energy conservation measures.

It is proposed that the facility operators systematically upgrade facility with the addition of sub-meters and equipment energy use logging capabilities which can easily be extracted for subsequent analysis. Some of the top benefits of this are:

- the ability to verify savings from energy efficiency measures,
- the ability to understand loads (i.e., cooling) and appropriately size new equipment to optimize operating efficiencies,
- the ability to assess savings from efficiency measures,
- the ability to verify performance of new renovations and additions.
- The ability to identify consumption anomalies as part of ongoing commissioning processes.

	This measure is recommended for implementation, although it is suggested that both energy managers and facility operators be involved in the selection of a logging system and graphical dashboard system that is user-friendly, flexible, and suited to the organizational requirements of the operations team at the facility.
Affected Area	Entire facility, with specific focus on point sources (i.e., mechanical equipment and electrical equipment)
Implementation	This measure should be implemented as part of an energy management strategy.
Service Life	1 Year with ongoing recalibration
Economic Analysis	No Economic analysis can be provided for this measure as implementation costs vary greatly. When paired with diligent monitoring and investigation of findings, end-use data logging efforts can often yield a 2-5% reduction in utilities, simply by identifying ongoing commissioning or control set point enhancements.
In-House Resources	Significant in-house effort is required to monitor and analyze energy data in order to see merits, in the form of energy savings, from this measure once implemented.
Synergies	This measure will not adversely impact any other system or ECM.

6.2.2 Electrical and Lighting Systems

The following section provides a discussion of potential energy conservation measures (ECMs) that apply to the facility's electrical and lighting systems. Where lighting ECMs have been specified, it is first recommended to carry out a mock-up of the proposed measure to ensure satisfactory lighting levels and performance. The new proposed LED lighting upgrades outlined below will provide improved lighting quality to building occupants, reduce energy consumption, and decrease building maintenance over the long term. In addition to calculated energy savings, operation & maintenance savings have also been included within cost benefit analysis for each ECM.

It must also be noted that the technical descriptions of each energy conservation measure must not be used as a basis for design or tender. BES recommends the procurement of a registered Professional Engineer (EGBC) to carry out a full in-depth lighting design in accordance with the code and IESNA Guidelines for all energy conservation measures described below.

Note: Electric demand charge is zero for all ECMs.

6.2.2.1 ECM #L1: Option A - Entire Facility: Replace Existing 32W-T8-2L-4ft Linear Fluorescent Lamps with Energy Efficient Energy Efficient 4' LED Tube-2L-70K-3500K Lamps

Description: At present, there are twenty-seven (27) T8-32W-2Lamp-4ft linear fluorescent luminaires with electronic ballasts in the facility. It is proposed to replace this existing inefficient T8-32W-4ft fluorescent lamps (total 27 lamps) with energy efficient Energy Efficient 4' LED Tube-2L-70K-3500K lamps. This measure can save significant electrical energy and maintenance costs.

It is recommended to carry out a mock-up of the proposed measure as actual light Levels may vary due to building features.

Affected Area: Mechanical Room, Storage, MCC 2 Elec Room, MCC Entrance, Basement Water Entry, Safety Room, MCC 2, Stairs, & Compressor Room.

Implementation: This measure would be implemented by replacing existing inefficient T8-32W-4ft linear fluorescent lamps with energy efficient 4' LED Tube-2L-70K-3500K+120V 2 Lamp Compatible Ballast.

Table 25: Proposed 4ft Luminaire – Performance Lumen Output

Performance	Light Output	Luminaire Efficacy	CCT	CRI
Philips 14T8/PRO/48-40/IF21/G 10/1 FB	2,100 lm	150	4,000K	80

Product Specifications: https://www.assets.lighting.philips.com/is/content/PhilipsLighting/fp929001343204-pss-global

Performance Criteria: The following table provides the recommended "Performance Criteria" of the luminaire suggested for implementation.

Table 26: Performance Criteria

Application	Minimum Light Output	Minimum Luminaire Efficacy	Allowable CCTs (ANSI C78.377-2008)	Minimum CRI	L70 Lumen Maintenance	Minimum Luminaire Warranty	Zonal Lumen Density
Four-Foot Linear Replacement Bare Lamp	1600 lm	100 lm/W	≤5,700 K	80	50,000	5 years	90-270°: 1.0-2.0 ≥75%: 0-60°

Service Life: The proposed LED lamp has life expectancy of at least 50,000 hrs (at 70% light output).

Type of Energy Analysis Completed: Calculations completed include an extensive spreadsheet of existing and proposed lighting. Existing fixture wattages are based upon information collected onsite or reference values, where existing ballast model numbers were not available.

Resources Required: No significant in-house effort is required to operate or maintain this measure.

Synergies: This measure will not adversely impact any other system or ECM.

Economic Analysis**:** The following table provides a summary of all estimated savings, costs, and simple payback period for each fixture type.

Table 27: Summary of ECM Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)		**Annual Energy Savings**		Total Savings - Energy, O&M, C02 ($/yr)	Tot. Cost (capital, install, design, incentive)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Electricity (kWh)	Electrical Demand (kW)			
Option A - Entire Facility: Replace Existing 32W-T8-2L-4ft Linear Fluorescent Lamps with Energy Efficient 4' LED Tube-2L-70K-3500K+120V 2 Lamp Compatible Ballast	16,151	4	9,581	2.3	$1,770	$4,230	1.2

6.2.2.2 ECM #L2: Option Storage Rooms, Stairs #2: Replace T8-32W-2L-4' & T12-32W-2L-4' Magnetic with Energy Efficient 4' LED Strip-24W-4000K Surface Mounted

Description: There are fifteen (15) T8-32W-2L-4' & T12-32W-2L-4' fluorescent luminaires with electronic ballast in the facility. With the new Energy Efficient 4' LED Strip-24W-4000K Surface Mounted luminaires, there is an opportunity to reduce energy consumption and maintenance costs.

Affected Area: Storage Room and Stairs #2.

Implementation: This measure would be implemented by replacing existing T8-32W-2L-4' & T12-32W-2L-4' fluorescent luminaires and electronic ballast with energy efficient 4' LED Strip-24W-4000K Surface Mounted luminaires (ASD LED Strip light Fixture 4 Feet 24W 4000K 3200lm 130lm/w DIM or similar).

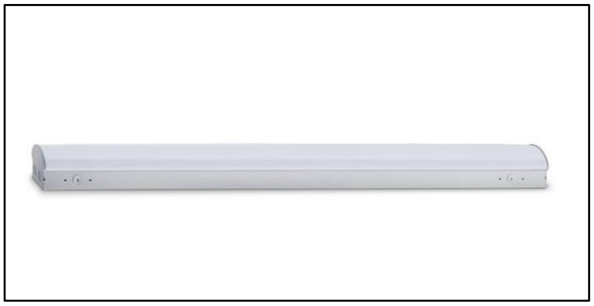


Figure 86: Proposed Energy Efficient 4' LED Strip-24W-4000K

Table 28: Proposed Luminaire – Performance Lumen Output

Performance	Light Output	Luminaire Efficacy	CCT	CRI
ASD LED Strip light Fixture 4 Feet 24W 4000K 3200lm 130lm/w DIM	3850 lm	131	4,000K	80

Product Specifications: https://ledsupplyco.com/asd-led-striplight-fixture-4-feet-24w-4000k-3200lm-130lm-w-dim.html

Performance Criteria: The following table provides the recommended “Performance Criteria” of the luminaire suggested for implementation.

Table 29: Performance Criteria

Application	Minimum Light Output	Minimum Luminaire Efficacy	Allowable CCTs (ANSI C78.377-2008)	Minimum CRI	L70 Lumen Maintenance	Minimum Luminaire Warranty	Zonal Lumen Density
Retrofit Kits for 4' LED Strip-24W-4000K Surface Mounted luminaires for Ambient Lighting of Interior Commercial Spaces	4000 lm	130 lm/W	≤4,000 K	80	50,000	5 years	0-180°: 1.0-2.0 90-270°: 1.0-2.0 ≥75%: 0-60°

Service Life: The ASD LED Strip light recessed troffers have a life expectancy of at least 54,000 hours.

Type of Energy Analysis Completed: Calculations completed include an extensive spreadsheet of existing and proposed lighting. Existing fixture wattages are based upon information collected onsite or reference values, where existing ballast model numbers were not available.

Resources Required: No significant in-house effort is required to operate or maintain this measure.

Synergies: This measure will not adversely impact any other system or ECM.

Economic Analysis: The following table provides a summary of all estimated savings, costs, and simple payback period for each fixture type.

Table 30: Summary of ECM Costs and Savings

Description	Existing Energy Use (for equipment included in measures only)		Annual Energy Savings		Total Savings - Energy, O&M, C02 ($/yr)	Tot. Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Electricity (kWh)	Electrical Demand (kW)			
Option A- Storage Rooms, Stairs #2: Replace T8-32W-2L-4' & T12-32W-2L-4' Magnetic with Energy Efficient 4' LED Strip-24W-4000K Surface Mounted	4,096	0.92	2,642	0.56	$620	$1,030	1.7

6.2.2.3 ECM #L3: Office areas, Kitchen, Washroom: Replace T8-32W-2L-4' with Energy Efficient 1FTx4FT Flat 100-347VAC Dimmable LED Panel Light Surface Mount Kit

Description: At present, there are eighteen (18) T8-32W-2L-4' Luminaires with electronic ballasts in the facility. It is proposed to replace these existing luminaires with energy efficient 1FTx4FT Flat 100-347VAC Dimmable LED Panel Light Surface Mount Kit Luminaires. This measure can save significant electrical energy and maintenance costs.

It is recommended to carry out a mock-up of the proposed measure as actual light Levels may vary due to building features.

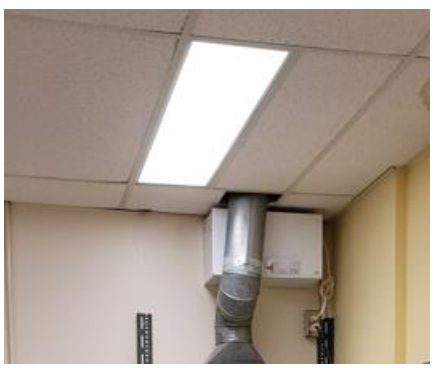


Figure 82: Existing T8-32W-2L-4' Luminaires

Affected Area: Kitchen and Washroom.

Implementation: This measure would be implemented by replacing existing inefficient T8 luminaires and electronic ballast with energy efficient 1FTx4FT Flat 100-347VAC Dimmable LED Panel Light Surface Mount Kit Luminaires.

Table 31: Proposed LED Luminaire – Performance Lumen Output

Performance	Light Output	Luminaire Efficacy	CCT	CRI
1FTx4FT Flat 100-347VAC	2900 lm	80	3,000K	82

Product Specifications: https://www.shopperplus.ca/p-370266-ro-14panel-347v-all-1ft-x-4ft-120-347vac-dimmable-led-panel-light-40w-cul-dlc-listed

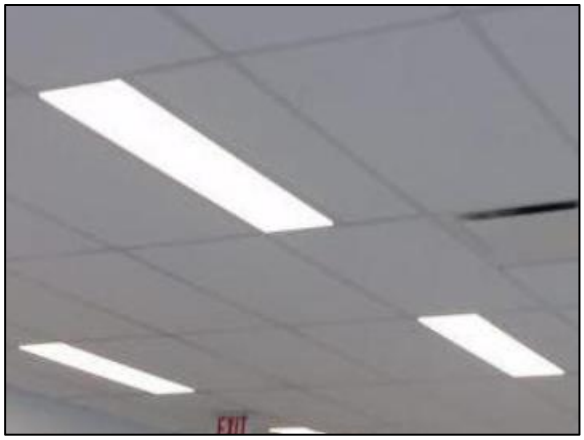


Figure 83: Proposed LED Flat Panels

Performance Criteria: The following table provides the recommended "Performance Criteria" of the luminaire suggested for implementation.

Table 32: Performance Criteria

Application	Minimum Light Output	Minimum Luminaire Efficacy	Allowable CCTs (ANSI C78.377-2008)	Minimum CRI	L70 Lumen Maintenance	Minimum Luminaire Warranty	Zonal Lumen Density
LED Flat Panel	2500 lm	45 lm/W	≤5,000 K	80	25,000	5 years	≥85%: 0–90°

Service Life: The proposed LED lights have life expectancy of 25,000 hrs.

Type of Energy Analysis Completed: Calculations completed include an extensive spreadsheet of existing and proposed lighting. Existing fixture wattages are based upon information collected onsite or reference values, where existing ballast model numbers were not available.

Resources Required: No significant in-house effort is required to operate or maintain this measure.

Synergies: This measure will not adversely impact any other system or ECM.

Economic Analysis**:** The following table provides a summary of all estimated savings, costs, and simple payback period for each fixture type.

Table 33: Summary of ECM Costs and Savings

Description	Existing Energy Use (for equipment included in measures only)		Annual Energy Savings		Total Savings - Energy, O&M, C02 ($/yr)	Tot. Cost (capital, install, design, incentive)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Electricity (kWh)	Electrical Demand (kW)			
Kitchen and Washroom: Replace T8-32W-2L-4' with Energy Efficient 1FTx4FT Flat 100-347VAC Dimmable LED Panel Light Surface Mount Kit	3,446	1	1,110	0.34	$390	$2,910	2.6

6.2.2.4 ECM #L4: Centrifuge Room, Stairs: Replace LED-40W-Flood Light with Energy Efficient LED-15W-Flood Light Fixtures

Description: At present, there are five (5) LED-40W-Flood Lights in the facility. With the new LED fixture, there is an opportunity to replace existing light fixtures with high efficiency LED fixtures that reduce energy consumption and maintenance costs.

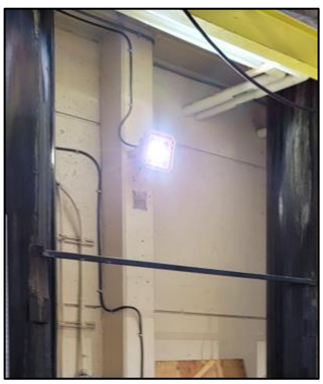


Figure 84: Existing LED-40W-Flood Light

Affected Area: Centrifuge Room and Stairs

Implementation: This measure would be implemented by replacing existing luminaires with energy efficient 15W LED flood light fixture.

Figure 85: 15W LED Flood Light

Product Specifications: https://www.lepro.ca/15w-outdoor-led-flood-light-with-motion-sensor-1500lm-5000k-white-security-light.html

Type of Energy Analysis Completed: Calculations completed include an extensive spreadsheet of existing and proposed lighting. Existing fixture wattages are based upon information collected onsite or reference values, where existing ballast model numbers were not available.

Resources Required: No significant in-house effort is required to operate or maintain this measure.

Synergies: This measure will not adversely impact any other system or ECM.

Economic Analysis: The following table provides a summary of all estimated savings, costs, and simple payback period for each fixture type.

Table 34: Summary of ECM Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)		**Annual Energy Savings**		Total Savings - Energy, O&M, C02 ($/yr)	Tot. Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Electricity (kWh)	Electrical Demand (kW)			
Replace LED-40W-Flood Light with Energy Efficient LED-15W-Flood Light Fixtures	1,051	0.2	690	0.13	$120	$900	3.3

6.2.2.5 ECM #L5: Exterior: Replace Hal-PAR38 -75W-2L with Energy Efficient LED PAR38-17W-2L

Description: At present, there is one (1) Hal-PAR38 -75W-2L external wall pack luminaires in the facility. It is proposed to replace these existing wall packs with energy efficient LED PAR38-17W-2L wall pack fixtures with integrated photocell sensors which can save electrical energy and maintenance costs.

It is recommended to carry out a mock-up of the proposed measure as actual light Levels may vary due to building features.

BES recommends the procurement of a registered Professional Engineer (EGBC) to carry out a full in-depth design in accordance with required light levels.

Affected Area: External.

Implementation: This measure would be implemented by replacing existing wall packs with energy efficient 17W LED wall packs

Table 35: Proposed Luminaire – Performance Lumen Output

Performance	Light Output	Luminaire Efficacy	CCT	CRI
TCP PAR38-17W-2L	1800 lm	105	5,000K	80

Product Specifications: https://www.tcpi.com/wp-content/uploads/2017/04/17W-Hight-Output-PAR38.pdf

Figure 86: Proposed TCP Energy Efficient LED PAR38-17W-2L

Performance Criteria: The following table provides the recommended "Performance Criteria" of the luminaire suggested for implementation.

Table 36: Performance Criteria

Application	Minimum Light Output	Minimum Luminaire Efficacy	Allowable CCTs (ANSI C78.377-2008)	Minimum CRI	L70 Lumen Maintenance	Minimum Luminaire Warranty	Zonal Lumen Density
Outdoor Wall-Mounted Luminaires	1800 lm	105 lm/W	≤5,700 K	80	25,000	5 years	=100%: 0-90° ≤10%:80-90°

Service Life: The proposed LED wall pack has a life expectancy of at least 25,000 hrs.

Type of Energy Analysis Completed: Calculations completed include an extensive spreadsheet of existing and proposed lighting. Existing fixture wattages are based upon information collected onsite or reference values, where existing ballast model numbers were not available.

Resources Required: No significant in-house effort is required to operate or maintain this measure.

Synergies: This measure will not adversely impact any other system or ECM.

Economic Analysis: The following table provides a summary of all estimated savings, costs, and simple payback period for each fixture type.

Table 37: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)		**Annual Energy Savings**		Total Savings - Energy, O&M, C02 ($/yr)	Tot. Cost (capital, install, design, incentive)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Electricity (kWh)	Electrical Demand (kW)			
Exterior: Replace Hal-PAR38 -75W-2L with Energy Efficient LED PAR38-17W-2L	657	0.15	508	0.12	$140	$200	1.4

6.2.2.6 ECM #L6: Tunnel, Mud Screen Unit: Replace LED MH-70W-Wall Pack with Energy Efficient LED-8W-Wall Pack.

Description: At present, there are seven (7) LED MH-70W-Wall Pack external wall packs in the facility. It is proposed to replace these existing wall packs with energy efficient LED-8W-Wall Pack fixtures which can save electrical energy and maintenance costs.

It is recommended to carry out a mock-up of the proposed measure as actual light Levels may vary due to building features.

BES recommends the procurement of a registered Professional Engineer (EGBC) to carry out a full in-depth design in accordance with required light levels.

Figure 87: Existing Tunnel lighting

Affected Area: Tunnels and Mudroom

Implementation: This measure would be implemented by replacing existing MH-70W-Wall Pack with Energy Efficient LED-8W wall packs.

Table 38: Proposed Luminaire – Performance Lumen Output

Performance	Light Output	Luminaire Efficacy	CCT	CRI
LIL LED 40K MVOLT PE DDBTXD	800 lm	100	4,000K	80

Product Specifications: LED Wall Pack with Photocell - 8W - 800 Lumens - Lithonia LIL LED 40K MVOLT PE DDBTXD | 1000Bulbs.com

Figure 88: Proposed LED Wall Pack

Performance Criteria: The following table provides the recommended "Performance Criteria" of the luminaire suggested for implementation.

Table 39: Performance Criteria

Application	Minimum Light Output	Minimum Luminaire Efficacy	Allowable CCTs (ANSI C78.377-2008)	Minimum CRI	L70 Lumen Maintenance	Minimum Luminaire Warranty	Zonal Lumen Density
Tunnel and Mud screen	800 lm	100 lm/W	≤4,700 K	65	50,000	5 years	=100%: 0-90°
							≤10%:80-90°

Service Life: The proposed LED wall pack has a life expectancy of at least 50,000 hrs (90% light output).

Type of Energy Analysis Completed: Calculations completed include an extensive spreadsheet of existing and proposed lighting. Existing fixture wattages are based upon information collected onsite or reference values, where existing ballast model numbers were not available.

Resources Required: No significant in-house effort is required to operate or maintain this measure.

Synergies: This measure will not adversely impact any other system or ECM.

Economic Analysis**:** The following table provides a summary of all estimated savings, costs, and simple payback period for each fixture type.

Table 40: Summary of ECM Costs and Savings

Description	Existing Energy Use (for equipment included in measures only)		Annual Energy Savings		Total Savings - Energy, O&M, C02 ($/yr)	Tot. Cost (capital, install, design, incentive)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Electricity (kWh)	Electrical Demand (kW)			
Tunnel, Mud Screen Unit: Replace LED MH-70W-Wall Pack with Energy Efficient LED-8W-Wall Pack	4,673	0.68	2,996	0.3	$470	$730	1.5

6.2.2.7 ECM #L7: Occupancy Sensors on Stairs/Hallways

Description: It is proposed to install occupancy sensors on lighting in the stairs/hallways which can save electrical energy and maintenance costs.

It is recommended to carry out a mock-up of the proposed measure as actual light Levels may vary due to building features.

BES recommends the procurement of a registered Professional Engineer (EGBC) to carry out a full in-depth design in accordance with required light levels.

Affected Area: Primary treatment building.

Implementation: This measure would be implemented by installing occupancy sensors in the stairs and hallways.

Figure 89: Occupancy Sensor

Type of Energy Analysis Completed: Calculations completed include an extensive spreadsheet of existing and proposed lighting. Existing fixture wattages are based upon information collected onsite or reference values, where existing ballast model numbers were not available.

Resources Required: No significant in-house effort is required to operate or maintain this measure.

Synergies: This measure will not adversely impact any other system or ECM.

Economic Analysis: The following table provides a summary of all estimated savings, costs, and simple payback period for each fixture type.

Table 41: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)		**Annual Energy Savings**		Total Savings - Energy, O&M, C02 ($/yr)	Tot. Cost (capital, install, design, incentive)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Electricity (kWh)	Electrical Demand (kW)			
Install occupancy sensors in the hallway/stairs	4,231	0.48	2,996	0.3	$470	$1390	1.5

6.3 Other Energy Conservation Measures Considered

6.3.1 Mechanical, Controls and Electrical Systems

The following section provides a discussion of potential energy conservation measures (ECMs) that apply to the facility's mechanical, control and lighting systems, which were considered, but have not been selected for immediate implementation due to high payback and/or high project implementation cost. Although these measures were not considered for immediate implementation, they should be included as part of the facility's long-term asset management plan.

6.3.1.1 ECM #M6*:* Replace Existing End-of-Life Hydronic Unit Heaters with High Efficiency Hydronic Unit Heaters and upgrade controls

Description: The existing hydronic unit heaters installed in the primary treatment building are at the end of their rated economical life as determined by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). There is an opportunity to realize gas energy savings by installing high efficiency models and upgrading the controls throughout the building.

A new high efficiency unit heater will provide a greater level of comfort with less energy usage. New high efficiency hydronic unit heaters have been shown to reduce consumption by 25-30%[17]. A suitable unit to replace the existing TRANE units would be the newer model TRANE "Expanse" unit heaters or similar. These units Options that address safety and durability provide even greater flexibility when configuring units for the unique operating conditions in your facility, including humid, corrosive, and flammable environments. There is also a vertical mount available should this option wish to be considered.

Additionally, to this measure, it would be very beneficial to install Smart Learning Thermostats to control the unit heaters and implement new a new heating schedule to reflect actual occupancy. It was observed numerous times in the audit that vacant rooms had very high thermostat set points.

Figure 90: Existing Unit Heater

[17] https://www.trane.com/content/dam/Trane/Commercial/global/products-systems/equipment/terminal-devices/unit-heaters/s-p-unit-heaters/UH-SLB004-EN_06172020.pdf

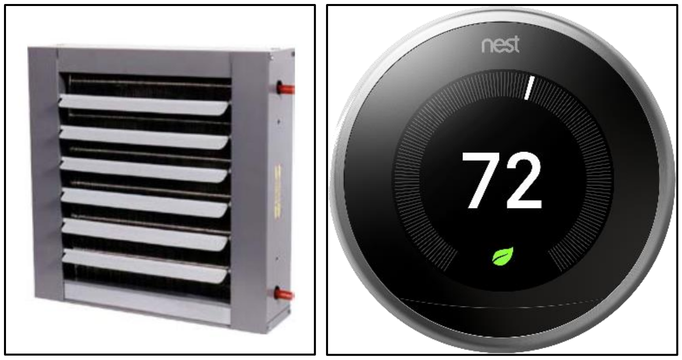


Figure 91: Proposed Unit Heater and Smart Thermostat

Affected Area: Primary treatment building.

Implementation: This measure would be implemented by replacing the existing hydronic unit heaters with new TRANE "Expanse" unit heaters or similar. This will save energy by having a more efficient unit heater and the smart thermostats will reduce consumption by adjusting temperature based on occupancy.

Service Life: 15 - 20 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 42: Summary of ECM Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Replace Existing End-of-Life Hydronic Unit Heaters with new High Efficiency Unit Heaters and upgrade controls	32,897	0.8	49	9,738	0.0	9	$690	$28,280	41.2

Type of Energy Analysis Completed: Energy savings from this measure are based upon the reduction of energy resulting from the reduced power consumption of the unit heaters and the improved operating schedule of the thermostats.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Improved controllability.
- Reduced equipment breakdowns.
- Improved thermal comfort

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.3.1.2 ECM #M7: Install Solar Panels to Preheat DHW.

Description: The installation of solar thermal panels to the DHW system will reduce the load of the DHW boilers. Currently the facilities Domestic Hot Water is provided by the two (2) Navien NP-240A domestic hot water heaters located in the boiler room. The solar panels may preheat the DHW before feeding the water heaters. Currently there is no storage tank for the DHW as it is an instantaneous boiler, a storage tank will need to be installed for the additional capacity of the solar panels.

Figure 92: Solar Panel and Storage Tank

Affected Area: Boiler Room and Facility Roof

Implementation: This measure would be implemented by installing a solar panel array onto the roof of the facility. This array will be connected to the DHW system. It is recommended to employ the services of a professional Engineering company to ensure the piping layout associated with the new equipment is correctly designed.

Service Life: The estimated service life of a solar system is approximately 15 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period. Operation & Maintenance savings have also been considered as it is envisaged that there will be less annual maintenance service site visits.

Table 43: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Incremental Cost (capital, install, design, incentives) *	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Install Solar Panels to Preheat DHW.	0	0.0	83	0	0.0	99	$1,110	$12,460	11.2

Type of Energy Analysis Completed:	The energy savings calculated from this measure are based upon the reduction of gas required to bring DHW temperature up to setpoint.

Risk Assessment:	This project would also involve the hiring of a structural engineer to make sure the mounting system is sufficient to secure the panels.
Non-Energy Benefits:	In addition to the savings shown in the table above, the following non-energy benefits shall also be observed: • Reduced greenhouse gas emissions. • Enhanced public perception
In-House Resources:	In-house effort required to operate or maintain measure is the same.

6.3.1.3 ECM #M8: Install Variable Frequency Drives (VFD) Heating Pumps.

Description:

The majority of existing hot water pumps in the facility operate at constant speed when enabled. There is an opportunity to realize electrical energy savings by installing a 'demand control' system with the utilization of a variable speed drive (VSD), whereby the VSD will control the flowrate of the liquid movement.

The use of a properly commissioned and optimized VSDs will vary the speed of the pumps (motor) so that they only deliver the required flow. The physical properties of a pump are referred to as the Affinity Laws and this allows the equipment to meet partial load requirement and save energy. The table below shows the relationship of speed, flow, and power.

It would be recommended to install the Grundfos Magna3 series VFD pump which is already installed on the fourth supply line. The MAGNA3 D circulator pump means double the performance and reduced downtime due to the three multi-pump modes: Alternating, backup, and cascade operation. With an Energy Efficiency Index (EEI) well below the EuP benchmark level you can achieve energy savings of up to 75% compared to a typical installed circulator and thereby a remarkably fast return on investment.

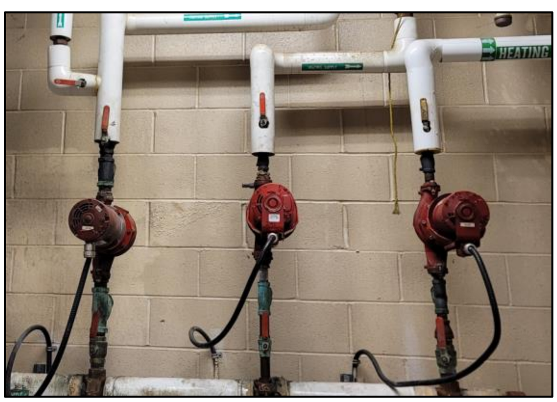


Figure 93: Existing Pumps (PR240, PR241, PR533)

Figure 94: Existing MAGNA3 Pump

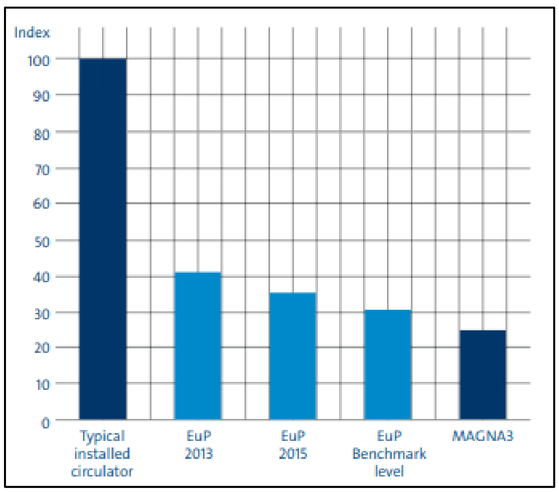


Figure 95: MAGNA3 performance

Table 44: Affinity Laws (Relationship of Speed, Flow and Power)

Speed	Volume or Flow	Power (HP)
100%	100%	100%
90%	90%	73%
80%	80%	51%
70%	70%	34%
60%	60%	22%
50%	50%	12.5%
40%	40%	6%
30%	30%	3%

Affected Area: Heating Pumps

Implementation: This measure would be implemented by replacing the existing constant speed pumps with variable speed pumps. This will save energy by adjusting the speed of the fan motors to meet the demand.

Service Life: 15 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 45: Summary of ECM Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Install Variable Frequency Drives (VFD) Heating Pumps	6,296	0.6	0	1,111	0.0	0	$1,070	$15,150	14.2

Type of Energy Analysis Completed: Energy savings from this measure are based upon the reduction of energy resulting from the reduced power consumption of the pumps operating at lower rotational speeds.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Improved controllability.
- Reduced equipment breakdowns.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.3.1.4 ECM #M9: DDC System Upgrade

Description: In general, the existing control system uses obsolete technology with limited remote monitoring. Pneumatic control systems use air pressure and actuators to control motors, dampers, and valves based on the input provided by thermostats and other sensors. DDC systems can replace some or all pneumatic controls with simple, reliable digital actuators, sensors, and controls that offer more precise control of HVAC equipment, valuable feedback, and greater convenience. Electromechanical devices can replace pneumatic actuators, or the system can be converted to all-digital systems for even better performance. DDC systems offer great features that enhance the use and control of your HVAC equipment, including:

- Reliable electronic sensors
- Individual control over specific zones
- Coordination between multiple systems
- Set points based on schedules and occupancy
- Computer-based data monitoring
- Trend and history monitoring
- Remote adjustments and control
- Economizer control for greater efficiency
- Airflow and pressure monitoring & Load shedding

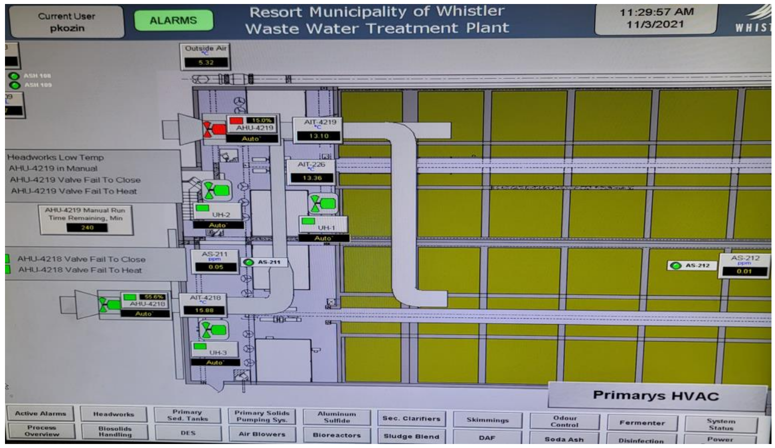


Figure 96: Existing Controls System

Affected Area: DDC System.

Implementation: This measure would be implemented by consulting a professional engineering firm

Service Life: 20 years with ongoing recalibration.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 46: Summary of Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
DDC System Upgrade	453,475	0.0	0	13,604	0.0	0	$1,830	$60,500	33.2

Type of Energy Analysis Completed: Energy savings from this measure are based upon a computer simulation and the reduction of energy required to heat and the space.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- More precise control over temperature, humidity, and air pressure
- Lower heating and cooling costs
- Improved comfort and greater productivity
- Advanced HVAC status monitoring and reporting
- Simple data collection for analysis of long-term HVAC performance
- Early warning in the event of HVAC problems or failures

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.3.1.5 ECM #M10: Entire Facility: Installation of Solar Photovoltaic system

Description: As part of a total system efficiency upgrade, the installation of a solar photovoltaic (PV) system on the roof and/or south facing areas. This will require a solar PV specific feasibility study which will investigate the potential energy savings and GHG reduction and include such matters as the solar shading effects of panels, life cycle cost analysis etc.

Due to anticipated available area, solar irradiance, and electrical demand of the facility, it is not envisaged that the entire demand can be met via solar PV panels. However, energy would be saved by reducing the load coming from the grid.

Affected Area: Facility rooftop.

Proposed Location of PV Panel

Figure 97: Aerial View of WWTP Rooftop, proposed location for PV installation

Implementation: This measure would be implemented by installing 25 x solar PV panels at suitable locations on the roof along with an inverter, a combiner box, a suitable mounting system for panels and other electrical equipment. In addition, it is proposed to install Solar Edge monitoring software. The monitoring software provides enhanced PV performance monitoring and yield assurance through immediate fault detection and alerts at the module level, string level and system level.

This software enables the Whistler WWTP maintenance staff to improve the site performance, assure the yield of the system, maximize solar power harvesting, and reduce maintenance costs by increasing system up-time and resolving faults more effectively.

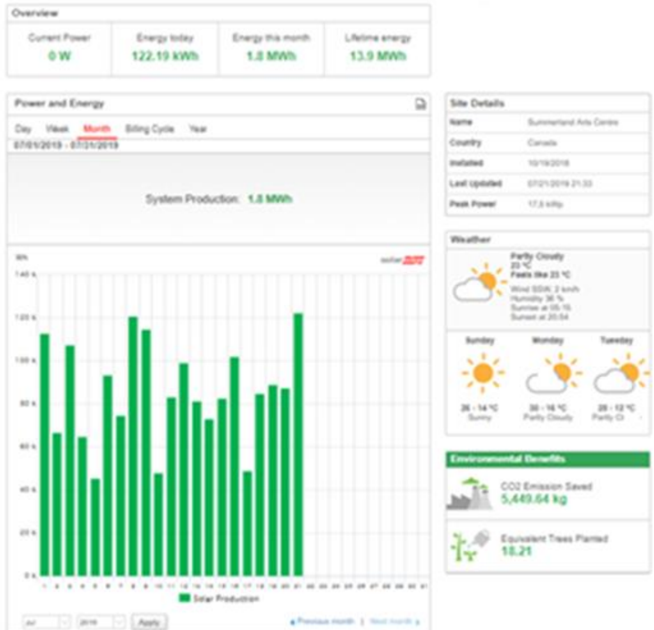


Figure 98: Solar Monitoring & Fault Detection

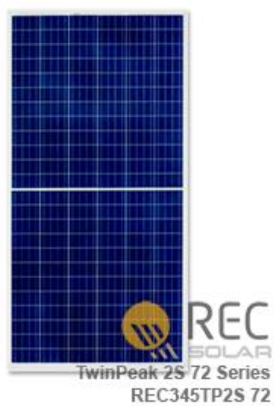


Figure 99: REC TwinPeak REC345TP2S 72 Solar Panel

Figure 100: Solar Edge SE14 4KUS-NNF (208V) Inverter

Product Specifications: The following tables provide additional information on the selected equipment.

Table 47: Panel specifications

Manufacturer	REC Solar
Model	REC345TP2S 72
Max power (W)	345
Voc (V)	46.5
Vpm (V)	38.7
Isc (A)	9.64
Ipm (A)	8.92
Efficiency	17.2%
NOCT (°C)	44.6
Temperature coefficient γ for Pmax (%/°C)	-0.36

Temperature coefficient β°c for Voc (%/°C)	-0.30
Temperature coefficient αsc for Isc (%/°C)	0.066
Length [in]	78.9
Width [in]	39.4

Table 48: Inverter specifications

Manufacturer		Solaredge
Model		SE14.4KUS
DC input	Max input voltage [V]	600
	MPPT input minimum voltage [V]	400
	MPPT input maximum voltage [V]	600
	Max input current [A]	38
AC output	Nominal output voltage [V]	208
	Phase	3
	Frequency [Hz]	60
	Output power [kW]	14.4
	Output current [A]	40
Peak efficiency [%]		97%

Estimated Service Life: New solar PV panels have a life expectancy of more than 25 years.

Economic Analysis: The following tables provide a summary of all costs, savings, and simple payback period.

Table 49: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Entire Facility: Installation of Solar Photovoltaic system	0	0.0	0	13,762	0.0	0	$1,830	$26,390	14.4

Type of Energy Analysis Completed:

Energy savings from this measure are based upon the solar irradiance onsite and the electricity production from the installation (includes losses and degradation of equipment).

Risk Assessment: This project would also involve the hiring of a structural engineer to make sure the mounting system is sufficient to secure the panels.

This project would also involve close project management control, whereby phased shutdowns of the affected equipment would be required to ensure minimal disruption to the occupants.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Sustainable strategy.
- Good public perception.

In-House Resources: Yearly maintenance is required for the inspection and cleaning of the equipment. Poor maintenance results in a drop in the energy production.

Synergies: This measure will not adversely impact any other system or ECM.

6.3.1.6 ECM #M14: Influent Pumping Room: AHU-1 – Install Demand Control Ventilation

Description: During the site visit, it was noted AHU-1, serving the that influent pumping room, was operating continuously to maintain a space temperature setpoint of 20°C throughout the day even when the room is unoccupied.

It is therefore proposed to install a variable speed drive (VSD) to AHU-1 complete with demand control ventilation in the space to improve the efficiency of the fans by matching the speed to maintain both space temperature setpoints and acceptable CO_2 levels for effective ventilation. The position of the existing outdoor air, exhaust air and mixed air dampers would also be determined by the measured level of CO_2 in both of the exhaust return ducts and return air duct. I.e., at times of low CO_2, the outdoor air damper would be closed to its lowest setting (as required by code) and the bypass mixed air would be open. And vice versa, when CO_2 is high (>800 ppm) the outdoor air damper would be fully open, and the mixed air would be closed. This will save energy by reducing the load on the hot water heating coil. During unoccupied times the motorized damper would close which would allow the supply fan to reduce its capacity.

Figure 101: AHU-1

Affected Area: AHU 1

Implementation: This measure would be implemented by installing CO_2 sensors in the space serving AHU-1. The CO_2 sensor shall be interlocked to the new variable speed drive controls on AHU-1, and the existing outdoor air and return air dampers. New motorized dampers would also be installed.

Service Life: The new CO_2 sensors associated with this measure do not have an expected service life, however; it is recommended that CO_2 sensors be recalibrated annually.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 50: Summary of ECM Costs and Savings

Description	Existing Energy Use (for equipment included in measures only)			Annual Energy Savings			Total Savings - Energy, CO_2 ($/yr)	Total Estimated Incremental Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Centrifugal Roof: Install Demand Control Ventilation	15,889	3.6	419	5,408	0.0	101	$1,450	$32,000	22.1

Type of Energy Analysis Completed:

Energy savings from this measure are based upon the reduction of fan run hours a day with the use of CO2 sensors and motorized dampers to control the AHU.

Heating energy savings are also calculated based upon the reduced volume of outdoor air that needs to be tempered. All energy savings are calculated based upon the internal temperature setpoints, the call for ventilation air, and hourly historical climate normal for Whistler, BC.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced greenhouse gas emissions
- Ease of service
- Greater thermal comfort
- Greater control

Risk Assessment: This project would also involve close project management control; whereby phased shutdowns would be required to provide sufficient ventilation to the respective spaces as required by code.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

Synergies: This measure will not adversely impact any other system or ECM.

6.3.1.7 ECM #M15: Install Passive Infra-Red (PIR) Sensors to Control the Washroom Exhaust Fans

Description: During the site audit, it was noted that the exhaust fan serving the washrooms operated continuously, even though the area was unoccupied. The exhaust fans are currently controlled via on/off switches located next to the light switch. It is therefore proposed to install occupancy sensors (PIR Sensors) which will turn the fans on only when each area is occupied. It is also proposed to incorporate a run-on timer (15 minutes) to ensure residual smells and humidity is removed from each area. The reduction in equipment operating hours as a result of this retrofit will achieve electrical energy savings

Affected Area: All Washroom exhaust fans

Implementation: This measure would be implemented by installing a PIR sensor to the Exhaust fans.

Service Life: 7 Years

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 51: Summary of Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, CO_2 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Install Passive Infra-Red (PIR) Sensors to Control the Washroom Exhaust Fans	587	1.1	0	293	0.0	0	$20	$300	16.9

Type of Energy Analysis Completed:

Energy savings are calculated based on the reduction of operating hours of the equipment.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced greenhouse gas emissions.
- Improved controllability
- Improved equipment life

Risk Assessment: This project will involve the installation of several electrical components, which will require the use of qualified electricians.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

Synergies: This measure will not adversely impact any other system or ECM

6.3.1.8 ECM #M19: Compressor Room: Install Interlock with Exhaust Fan and AHU/Install Heat Recovery from Compressors to preheat AHU.

Description: During the site audit, it was noted that the exhaust fan was operating continuously and there was significant heat output from the compressors operating. This heat is dumped from the room via the exhaust fan. It is proposed that a heat recovery coil is installed in the exhaust fan and that heat is used to pre heat the air to the AHU (SF245). This should result in savings as there will be less gas used in order to get the supply air up to the required temperature.

In view of this it is proposed to investigate the ability to reclaim the waste heat from local exhaust system EF-1 which is located approximately 10ft away from the compressors and use it to preheat incoming fresh air to the SF245.

It is therefore proposed to install a heat recovery system, using a glycol loop heat exchanger, to recover heat and transfer recovered energy back into the supply air path through a new pre-heat coil located in the incoming outdoor air ductwork plenum supplying the air-handling unit. A glycol heat recovery system has been chosen to ensure that there is no cross contamination of air streams between the supply and exhaust and to minimize chance of freezing.

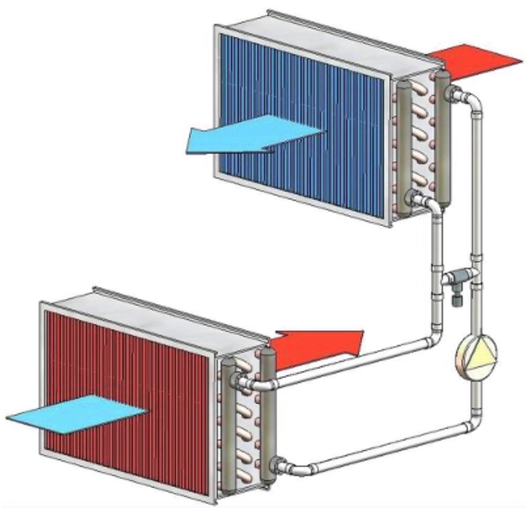


Figure 102: Heat Recovery Coil Schematic

Affected Area: Compressor Room – EF-1 and SF245.

Implementation: This measure would be implemented by installing a heat recovery coil to the exhaust fan of the compressor room and tie it in to the AHU (SF245). The exhaust fan would then be interlocked with the AHU, so they operate effectively.

Figure 103: Compressor Room Exhaust Fan and SF245

Service Life: 15 Years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 52: Summary of ECM Costs and Savings

	Existing Energy Use (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
Description	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Compressor Room: Install Interlock with Exhaust Fan and AHU/Install Heat Recovery from Compressors to preheat AHU.	19,302	2.2	75	-6,756	0.0	19	$200	$6,000	30.1

Type of Energy Analysis Completed:

Energy savings from this measure are based upon the reduction of gas used in the hydronic system

Risk Assessment: N/A

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Improved occupant thermal comfort.
- Improved controllability.
- Reduced GHG emissions.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.3.1.9 ECM #M20: Install Variable Frequency Drives (VFD) to Air Compressors (ME4140 & ME4141).

Description: The motors serving the Air Compressor's (ME4140 & ME4141) operate at constant speed when enabled. There is an opportunity to realize electrical energy savings by installing a 'demand control' system with the utilization of a variable frequency drive (VFD), whereby the VFD will control the flowrate of the compressed air.

The use of a properly commissioned and optimized VFDs will vary the speed of the pumps (motor) so that they only deliver the required flow. The physical properties of a motor are referred to as the Affinity Laws and this allows the equipment to meet partial load requirement and save energy. The table below shows the relationship of speed, flow, and power.

Figure 104: Typical Programmable Thermostat

Table 53: Affinity Laws (Relationship of Speed, Flow and Power)

Speed	Volume or Flow	Power (HP)
100%	100%	100%
90%	90%	73%
80%	80%	51%
70%	70%	34%
60%	60%	22%
50%	50%	12.5%
40%	40%	6%
30%	30%	3%

Affected Area: Primary treatment building Compressors.

Implementation: This measure would be implemented by installing a VFD on the existing compressors. This will save energy by adjusting the speed of the pump motors to meet the demand.

Service Life: 15 years.

Economic Analysis: The following table provides a summary of all savings, costs, and simple payback period.

Table 54: Summary of ECM Costs and Savings

Description	**Existing Energy Use** (for equipment included in measures only)			**Annual Energy Savings**			Total Savings - Energy, O&M, C02 ($/yr)	Total Estimated Cost (capital, install, design)	Simple Payback (yrs)
	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)			
Install Variable Frequency Drives (VFD) to Compressor's (ME4140 & ME4141)	135,131	20.1	0	55,747	0.0	0	$3,380	$22,600	6.7

Type of Energy Analysis Completed: Energy savings from this measure are based upon the reduction of energy resulting from the reduced power consumption of the pumps operating at lower rotational speeds.

Risk Assessment: N/A.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Improved controllability.
- Reduced equipment breakdowns.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

6.3.2 ECM #M26: Replace the Gas fired boilers with Air to Water Heat Pump with Gas Backup.

Description: For this measure it was considered replacing the gas fired boilers with Air to Water heat pumps with gas backup.

An air to water heat pumps system consists of four major elements that allow the refrigerant to pass from the liquid state to the gas: a compressor, a condenser, an expansion valve, and an evaporator.

1. A fan passes air over the evaporator, the refrigerant absorbs heat from the outside air. The refrigerant boils and evaporates at a low temperature giving us vapor.
2. The vapor passes into the compressor and compression increases the temperature.
3. The warm vapor is condensed is the heat exchanger and the rejected heat is passed onto the heating and hot water system
4. The condensed vapor returns to liquid, passes back through expansion valve, reducing pressure and temperature, ready to start cycle again

The air to water heat pumps recover 50 percent of energy conservation. It runs on electricity, but it does not consume high voltage power for heat transfer. It gets the heat from agency of air and supply it to the water system for the collection of the sufficient renewable energy for domestic usage.

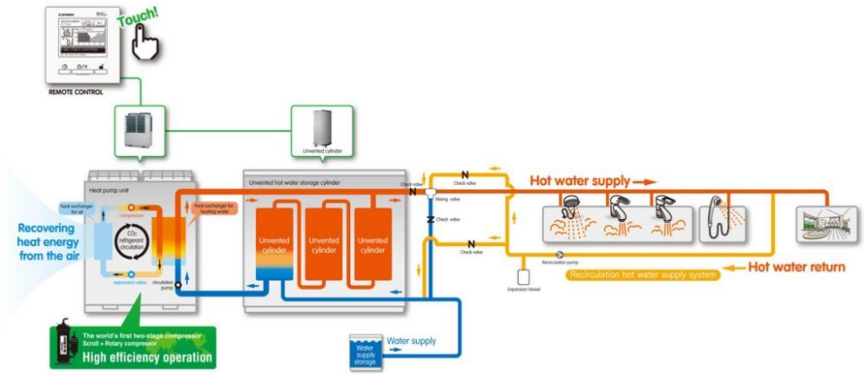


Figure 105: Air to Water Heat Pump Operation

Affected Area: Boiler Room

Implementation: This measure would be implemented by replacing the gas boilers and installing an air to water heat pump. The unit identified as the replacement for the two boilers in this case is the TRANE Ascend Air-Cooled Chiller Model ACS 230 Tons. This model has to capacity to replace both of the existing boilers, but one of them can be left to provide gas back up in case of extreme temperatures. The budget price for this unit before install is $450,000.

Figure 106: Proposed Air to Water System

Service Life: 15 Years

Economic Analysis: In-depth analysis of this system was not conducted due to very long payback terms of this unit.

Non-Energy Benefits: In addition to the savings shown in the table above, the following non-energy benefits shall also be observed:

- Reduced greenhouse gas emissions.
- Improved controllability

Risk Assessment: This project will involve the installation of several electrical components, which will require the use of qualified electricians.

In-House Resources: No significant in-house effort is required to maintain measure once implemented.

Synergies: This measure will not adversely impact any other system or ECM.

7 BUNDLED PROJECT DEFINITION

Based upon BES Ltd. professional opinion and knowledge of the building, a broader set of criteria has been used to select a bundle of recommended Energy Efficiency and Energy Conservation Measures. These include:

- Ease of implementation (minimal resources required).
- Reduction of greenhouse gas emissions by the process of electrification.
- Simple Payback.
- Measures that should be implemented to improve operation.
- Measures that should be implemented to facilitate the implementation of other measures.
- Importance in enhancing or maintaining good indoor environment for occupants with due consideration to the following: provision of acceptable ventilation and space temperatures for the majority of occupants in the majority of spaces.
- Improved ability to monitor and manage energy in the building.
- Importance as part of essential building system upgrades to replace aging equipment.

7.1 Energy Study Savings from Existing Systems

The following table provides a summary of potential savings from mechanical, electrical and control systems as per the scope of the Energy Study.

Note: The recommended bundle of measures is highlighted in Grey Cells.

Table 55: Summary Table of ECMs & Capital Upgrade Projects

ECM #	Description	Annual Energy Savings					Total Utility Cost Savings ($/yr)	Total Carbon Offset Savings ($/yr @ $40/Ton)	Total O&M Savings ($/yr)	Total Savings - Energy, O&M, C02, Utility ($/yr)	Estimated Incremental Capital Cost (capital & installation costs)	Estimated Design Cost ($)	Estimated Potential Incentive or Grant Monies (subject to change)	Based on Incremental Estimated Cost		Based on Actual Estimated Cost		GhG Emission Savings (Tonnes e-CO2/yr)	Energy Intensity Reduction (e-kWh/m2/yr)
		Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Total Utility Savings (e-kWh)	Total Utility Savings (e-GJ)								Total Incremental Estimated Cost (capital, install, design) ($)	Simple Payback (yrs)	Total Estimated Actual Cost (capital, install, design) ($)	Simple Payback (yrs)		
ECM#M1	Install Aerators on Existing Plumbing Fixtures	0	0.0	2	612	2.2	$20	$5	$0	$30	$40	$0	$0	$40	1.5	$40	1.5	0.1	0.8
ECM#M2	Install Thermal Insulation to Exposed Hot Water Pipework	0	0.0	14	3,863	13.9	$130	$30	$0	$160	$380	$0	$0	$380	2.4	$380	2.4	0.7	4.9
ECM#M3	All Buildings: Repair/Replace Door Seals	0	0.0	34	9,372	33.7	$310	$70	$0	$380	$800	$0	$0	$800	2.1	$800	2.1	1.7	11.9
ECM#M4	Retro-commissioning & Perform Boiler Control Optimization	776	0.0	60	17,446	62.8	$600	$120	$500	$1,220	$17,000	$0	$0	$17,000	14.0	$17,000	14.0	3.0	22.1
ECM#M5	AHU-1, AHU-2 & AHU-3 – Install new Cold Climate Heat Pumps to supply new Hydronic Coil in each unit.	-41,343	-28.8	693	151,267	544.6	-$390	$1,370	$1,200	$2,180	$35,000	$2,000	$0	$37,000	17.0	$167,000	76.7	34.1	191.6
ECM#M6	Replace Existing End-of-Life Hydronic Unit Heaters with High Efficiency Unit Heaters and upgrade controls	9,738	0.0	9	12,136	43.7	$670	$21	$0	$690	$28,500	$0	$225	$28,280	41.2	$28,280	41.2	0.5	15.4
ECM#M7	Installation of Solar Panels to the DHW system	0	0.0	99	27,615	99.4	$910	$200	$0	$1,110	$9,960	$2,500	$0	$12,460	11.2	$9,960	9.0	5.0	35.0
ECM#M8	Install Variable Frequency Drives (VFD) to HW Pumps (PR240, PR241, PR533) serving Service HW	1,111	0.0	0	1,111	4.0	$70	$0	$1,000	$1,070	$13,250	$1,900	$0	$15,150	14.2	$13,250	12.4	0.0	1.4
ECM#M9	Upgrade the DDC System	13,604	0.0	0	13,604	49.0	$820	$6	$1,000	$1,830	$55,000	$5,500	$0	$60,500	33.2	$55,000	30.1	0.1	17.2
ECM#M10	Entire Facility: Installation of Solar Photovoltaic system	13,762	0.0	0	13,762	49.5	$830	$6	$1,000	$1,830	$23,890	$2,500	$0	$26,390	14.4	$26,390	14.4	0.1	17.4
ECM#M11	Outdoor Air Temperature Reset	8,216	0.0	0	8,216	29.6	$495	$4	$500	$998	$4,200	$0	$0	$4,200	4.2	$4,200	4.2	0.1	10.4
ECM#M12	Optimal Start Stop	2,465	0.0	0	2,465	8.9	$148	$1	$500	$649	$4,200	$0	$0	$4,200	6.5	$4,200	6.5	0.0	3.1
ECM#M13	Install roller door interlocks with HVAC equipment on lower floor	2,004	0.0	0	2,004	7.2	$121	$1	$200	$322	$5,200	$0	$0	$5,200	16.2	$5,200	16.2	0.0	2.5
ECM#M14	AHU-1 – Install Demand Control Ventilation	5,408	0.0	101	33,375	120.1	$1,250	$200	$0	$1,450	$32,000	$0	$0	$32,000	22.1	$150,000	103.5	5.1	42.3

ECM #	Description	Annual Energy Savings					Total Utility Cost Savings ($/yr)	Total Carbon Offset Savings ($/yr @ $40/Ton)	Total O&M Savings ($/yr)	Total Savings - Energy, O&M, C02, Utility ($/yr)	Estimated Incremental Capital Cost (capital & installation costs)	Estimated Design Cost ($)	Estimated Potential Incentive or Grant Monies (subject to change)	Based on Incremental Estimated Cost		Based on Actual Estimated Cost		GhG Emission Savings (Tonnes e-CO2/yr)	Energy Intensity Reduction (e-kWh/ m2/yr)
		Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Total Utility Savings (e-kWh)	Total Utility Savings (e-GJ)								Total Incremental Estimated Cost (capital, install, design) ($)	Simple Payback (yrs)	Total Estimated Actual Cost (capital, install, design) ($)	Simple Payback (yrs)		
ECM#M15	Install Passive Infra-Red (PIR) Sensors to Control the Washroom Exhaust Fans	293	0.0	0	293	1.1	$20	$0	$0	$20	$300	$0	$0	$300	16.9	$300	16.9	0.0	0.4
ECM#M16	Install Thermostatic Control Valves to Hydronic Baseboard Heaters in Common Areas & Suites	0	0.0	10	2,862	10.3	$90	$21	$200	$320	$1,000	$0	$0	$1,000	3.2	$1,000	3.2	0.5	3.6
ECM#M17	Installation of Energy Saving Additive into Boiler Loop to Improve Heat Transfer and Efficiency of HVAC (Gas) System	0	0.0	182	50,444	181.6	$1,660	$360	$0	$2,020	$4,020	$0	$0	$4,020	2.0	$4,020	2.0	9.1	63.9
ECM#M18	Kitchen and Office: Install Programmable Thermostats to Control Heating and Implement Unoccupied Temperature Set Back	1,210	0.0	0	1,210	4.4	$70	$1	$0	$70	$600	$0	$0	$600	8.2	$600	8.2	0.0	1.5
ECM#M19	Install Interlock with Exhaust Fan and AHU/Install Heat Recovery from Compressors to preheat AHU.	-6,756	0.0	19	-1,547	-5.6	-$240	$30	$400	$200	$5,500	$500	$0	$6,000	30.1	$6,000	30.1	0.9	(2.0)
ECM#M20	Air Compressors VFD	55,747	0.0	0	55,747	200.7	$3,360	$20	$0	$3,380	$20,600	$2,000	$0	$22,600	6.7	$22,600	6.7	0.6	70.6
ECM#M21	High Efficiency Motor Upgrade	29,529	4.7	0	29,529	106.3	$2,470	$10	$1,000	$3,480	$28,100	$5,000	$0	$33,100	9.5	$33,100	9.5	0.3	37.4
ECM#M22	Replace Existing Hydronic Air Handling Units (AHU-1 &2) with one High Efficiency Air Handling Units Complete with Economizers and Hydronic Heating Coils	2,889	0.7	61	19,779	71.2	$830	$120	$1,000	$1,950	$30,000	$0	$0	$30,000	15.4	$110,000	56.4	3.1	25.0
ECM#L1	Mechanical Room, Storage, MCC 2 Elec Room, MCC Entrance, Basement Water Entry, Safety Room, MCC 2, Stairs, & Compressor Room: Replace T8-32W-2L-4' Hanging with Energy Efficient 4' LED Tube-2L-70K-3500K+120V 2 Lamp Compatible Ballast	9,581	2.3	0	9,581	34.5	$920	$5	$1,200	$2,120	$3,870	$0	$270	$3,600	1.7	$3,600	1.7	0.1	12.1
ECM#L2	Mechanical Room, Storage, MCC 2 Elec Room, MCC Entrance, Basement Water Entry, Safety Room, MCC 2, Stairs, & Compressor Room: Replace T8-32W-2L-4'	9,581	2.3	0	9,581	34.5	$240	$5	$600	$850	$4,700	$0	$600	$4,100	4.8	$4,100	4.8	0.1	12.1

ECM #	Description	Annual Energy Savings					Total Utility Cost Savings ($/yr)	Total Carbon Offset Savings ($/yr @ $40/Ton)	Total O&M Savings ($/yr)	Total Savings - Energy, O&M, C02, Utility ($/yr)	Estimated Incremental Capital Cost (capital & installation costs)	Estimated Design Cost ($)	Estimated Potential Incentive or Grant Monies (subject to change)	Based on Incremental Estimated Cost		Based on Actual Estimated Cost		GhG Emission Savings (Tonnes e-CO2/yr)	Energy Intensity Reduction (e-kWh/ m2/yr)
		Electricity (kWh)	Electrical Demand (kW)	Natural Gas (GJ)	Total Utility Savings (e-kWh)	Total Utility Savings (e-GJ)								Total Incremental Estimated Cost (capital, install, design) ($)	Simple Payback (yrs)	Total Estimated Actual Cost (capital, install, design) ($)	Simple Payback (yrs)		
	Hanging with Energy Efficient 4' LED Tube-2L-70K-3500K+120V 2 Lamp Compatible Ballast																		
ECM#L3	Mechanical Room, Storage, MCC 2 Elec Room, MCC Entrance, Basement Water Entry, Safety Room, MCC 2, Stairs, & Compressor Room: Replace T8-32W-2L-4' Hanging with Energy Efficient 4' LED Tube-2L-70K-3500K+120V 2 Lamp Compatible Ballast	9,581	2.3	0	9,581	34.5	$120	$5	$430	$550	$5,920	$0	$630	$5,290	9.6	$5,290	9.6	0.1	12.1
ECM#L4	Mechanical Room, Storage, MCC 2 Elec Room, MCC Entrance, Basement Water Entry, Safety Room, MCC 2, Stairs, & Compressor Room: Replace T8-32W-2L-4' Hanging with Energy Efficient 4' LED Tube-2L-70K-3500K+120V 2 Lamp Compatible Ballast	9,581	2.3	0	9,581	34.5	$60	$5	$60	$123	$1,000	$0	$150	$850	6.9	$850	6.9	0.1	12.1
ECM#L5	Mechanical Room, Storage, MCC 2 Elec Room, MCC Entrance, Basement Water Entry, Safety Room, MCC 2, Stairs, & Compressor Room: Replace T8-32W-2L-4' Hanging with Energy Efficient 4' LED Tube-2L-70K-3500K+120V 2 Lamp Compatible Ballast	9,581	2.3	0	9,581	34.5	$50	$5	$150	$200	$150	$0	$0	$150	0.8	$150	0.8	0.1	12.1
ECM#L6	Mechanical Room, Storage, MCC 2 Elec Room, MCC Entrance, Basement Water Entry, Safety Room, MCC 2, Stairs, & Compressor Room: Replace T8-32W-2L-4' Hanging with Energy Efficient 4' LED Tube-2L-70K-3500K+120V 2 Lamp Compatible Ballast	9,581	2.3	0	9,581	34.5	$350	$5	$260	$610	$1,910	$0	$210	$1,700	2.8	$1,700	2.8	0.1	12.1
ECM#L7	Mechanical Room, Storage, MCC 2 Elec Room, MCC Entrance, Basement Water Entry, Safety Room, MCC 2, Stairs, & Compressor	9,581	2.3	0	9,581	34.5	$220	$5	$390	$620	$2,210	$0	$100	$2,110	3.4	$2,110	3.4	0.1	12.1

ECM #	Description	Annual Energy Savings: Electricity (kWh)	Annual Energy Savings: Electrical Demand (kW)	Annual Energy Savings: Natural Gas (GJ)	Annual Energy Savings: Total Utility Savings (e-kWh)	Annual Energy Savings: Total Utility Savings (e-GJ)	Total Utility Cost Savings ($/yr)	Total Carbon Offset Savings ($/yr @ $40/Ton)	Total O&M Savings ($/yr)	Total Savings - Energy, O&M, C02, Utility ($/yr)	Estimated Incremental Capital Cost (capital & installation costs)	Estimated Design Cost ($)	Estimated Potential Incentive or Grant Monies (subject to change)	Based on Incremental Estimated Cost: Total Incremental Estimated Cost (capital, install, design) ($)	Based on Incremental Estimated Cost: Simple Payback (yrs)	Based on Actual Estimated Cost: Total Estimated Actual Cost (capital, install, design) ($)	Based on Actual Estimated Cost: Simple Payback (yrs)	GhG Emission Savings (Tonnes e-CO2/yr)	Energy Intensity Reduction (e-kWh/ m2/yr)
	Room: Replace T8-32W-2L-4' Hanging with Energy Efficient 4' LED Tube-2L-70K-3500K+120V 2 Lamp Compatible Ballast																		
MECHANICAL & OTHER: Total Projected Savings		2,858	-24	995	279,290	1,005.4	$5,730	$1,990	$4,100	$11,810	$100,530	$7,000	$0	$107,530	9.1	$237,530	20.1	49.7	353.7
LIGHTING & CONTROLS: Total Projected Savings		67,069	16	0	67,069	241.4	$1,960	$30	$3,090	$5,080	$19,770	$0	$1,960	$17,810	3.5	$17,810	3.5	0.7	84.9
TOTAL SUM OF BUNDLED MEASURES - Lighting & Mechanical		69,927	-7.9	995	346,359	1,246.9	$7,680	$2,020	$7,190	$16,890	$120,300	$7,000	$1,960	$125,340	7.4	$255,340	15.1	50.4	438.6

8 CONCLUSION

From the 12-month period ending in December 2020, the facility audited had a total annual utility cost of **$43,278** for natural gas and electricity. In general, the status of energy efficiency initiatives at the Wastewater Treatment Plant is average.

The energy engineering audits have identified many opportunities for action which align with the Municipality's conservation priorities and targets. Some of these measures may overlap with existing capital budgets for anticipated replacement or major repairs of system and may reduce the 'Capital Costs' provided.

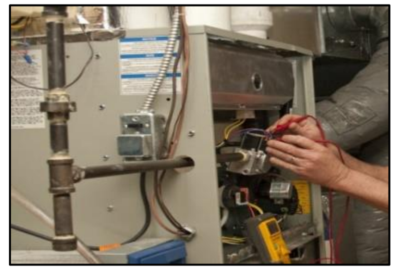
BES recommends a comprehensive bundle of energy measures be implemented, providing an overall simple payback of **7.4 years** at an estimated incremental capital cost of **$125,340** The Municipality should exercise caution if proceeding with only energy conservation measures for implementation and not capital upgrade projects as this will adversely affect the overall business case of the remaining bundle measures. These measures include 'low-hanging fruit' that help offset higher cost measures studied.

The energy conservation measures (ECMs), and capital upgrade projects recommended have potential to deliver the savings in the following table.

Table 56: Potential Saving from Implementing ECMs and Capital Upgrade Projects

Recommended Energy Conservation Measure in order of priority		Total Sum of Bundled Measures
Cost Benefit Analysis Based on Incremental Costs	Total Energy (Natural Gas and Electricity) Savings (e-kWh)	346,359
	Estimated Total Annual Savings (Energy, Utility, Carbon, O&M) ($)	$16,890
	Pre-incentive Estimated Incremental Capital, Design & Install Cost ($)	$127,300
	Applicable Incentives ($)	$1,960
	Total Estimated Incremental Capital, Design & Install Cost ($)	$125,340
	Simple Payback (yrs)	7.4
	Energy Use Intensity Reduction (e-kWh/m^2/yr)	438.6
Estimated Total Project Capital, Design & Install Cost ($)		$255,340
GhG Emission Savings (Tonnes e-CO_2/yr)		50.4

9 IMPLEMENTATION PLAN



The purpose of the implementation plan is to identify activities associated with the energy efficiency upgrade to ensure adequate preparation has taken place and adequate contingencies are in place. Implementation of ECMs developed and approved in this report requires personnel, engineering, and financial resources. The success of projects will hinge not only upon initial resources dedicated to projects, but to ongoing resources allocated to monitor and ensure performance is realized and sustained.

This study has been completed as part of the phased approach. As shown in the diagram below, there are 5 key phases in this project.

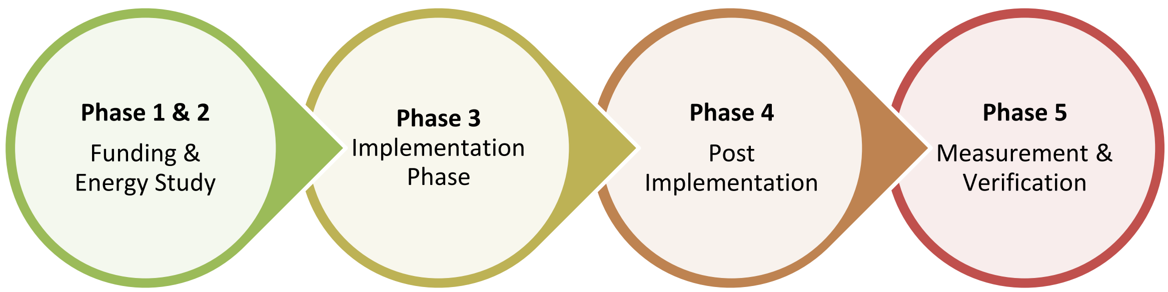


Figure 107: Project Phases 1 to 5

9.1 Phase 1 & 2: Funding and Energy Study

Phase 1 and Phase 2 illustrated above is now complete. Upon receipt of the Energy Study approval, the funding authority (Green Municipal Fund and FortisBC) will issue a funding approval letter along with an implementation guide to illustrate the next steps and outline the Capital Incentive Funding terms and conditions. The Capital Incentive Approval letter will also provide the level of financial involvement that will be made for the implementation of the recommended energy conservation measures.

9.2 Phase 3: Project Implementation

This phase consists of the implementation of the approved recommended bundle of measures as per Table 55. BES shall provide their professional services to the Resort Municipality of Whistler for an additional fee. It is our intention to streamline the implementation process as much as possible by ensuring the project is engineered and implemented to reflect the original design intent outlined in this report.
Our team will be able to call on our diverse experience and areas of specialization to generate the most effective and efficient management plane to complete the project goals on time and within budget.

Should BES be engaged for the implementation phase, for seamless integration, BES proposes the following 4 stage methodology:

i. Engineering Designs and Specifications

BES will continue from the conceptual design for each ECM as outlined in this study and progress this to the detailed engineering design. Regular meetings with the Resort Municipality of Whistler will ensure the design intent, cost and scheduling requirements are on track and meeting the project budget.

BES will provide design M&E engineering drawings and specifications for the tender and installation of equipment for each ECM. For applicable ECM's, BES will provide a tender package that will include engineering design drawings, specifications, and installation standards. Our team will meet with the Resort Municipality of Whistler's assigned representative to review the designs and specification and to address any concerns. BES's familiarity with the building and recommended measures will ensure that all measures are implemented according to the original intent of the study.

ii. Tender and Contract Preparation

Potential proponents will be selected based on their previous experience and availability to complete the work to the municipality's schedule. Typically, the tender will include a mandatory site visit to review onsite conditions and to answer any technical questions raised by the contactors.

iii. Tender Review and Recommendation

BES and the Resort Municipality of Whistler will review the contractor's proposals and evaluate it based on a point scoring matrix. This would include at a minimum compliance with specification, project cost, schedule of works and project experience. As BES are not affiliated with any products, suppliers, or contractors, our evaluation and recommendation will be based on the merits of the contractors and their proposals.

iv. Installation Overview

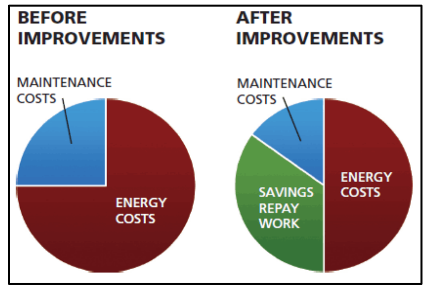
BES will review shop drawings submitted by contractors and will conduct field reviews during the construction phase to ensure the installation complies with the specifications. BES will resolve any potential issues that arise onsite. Emphasis will be placed on maintaining a clean site and not interfering with occupants' use of the building during the project.
Throughout the project, BES will act as a resource for the Resort Municipality of Whistler to review the contractor progress draws (partial invoices) and answer any technical questions relating to the design and its integration into the existing building.
BES will attend site throughout the duration of the project to ensure satisfactory workmanship and adherence to the mechanical & electrical engineering design. Field review reports will be conducted during the construction phase to ensure the installation complies with the drawings and specifications.
At project completion, our team will inspect the installation and review the commissioning procedures to ensure the project goals and basis of design are met.
The following are the tasks in which BES shall perform as part of Construction Administration for this project:

- Review shop drawings during construction phase.
- Working drawings and specifications.
- Field questions from bidding mechanical and electrical contractors and issue addenda as required during tender period.
- Field Reviews.
- Letters of Assurance and Compliance as required.

9.3 Phase 4 – Post Implementation

Following the Implementation Phase, BES will conduct an on-site inspection to ensure that all approved ECMs have been successfully implemented. At this point BES will contact the funding authority to advance all funding, including Capital Incentive Funding for any implemented approved energy conservation measures.

9.4 Phase 5 – Measurement & Verification



This phase consists of quantifying savings delivered from the implementation of the ECMs through the Measurement & Verification (M&V) process. M&V is the process of planning, measuring, collecting, and analyzing data for the purpose of verifying and reporting energy savings resulting from the implementation of ECMs. A key part of the M&V process is the development of an M&V Plan, which defines how the savings analysis will be conducted before the ECM is implemented. This provides a degree of objectivity that is absent if the savings are simply evaluated after implementation. The M&V plan defines how savings will be calculated and specifies any ongoing activities that will occur after equipment installation. The project-specific M&V plan includes project-wide items as well as details for each ECM.

The International Performance Measurement and Verification Protocol (IPMVP) defines key steps in implementing a robust M&V process. As certified M&V professional, BES can assist in this process if required.

The Table below presents an overview of the M&V options.

Table 57: Overview of M&V Options (IPMVP)

M&V Option (IPMVP)	How Savings Are Calculated
A. Partially Measured Retrofit Isolation	Engineering calculations using short term or continuous post-retrofit measurements and stipulations.
B. Retrofit Isolation	Engineering calculations using short term or continuous measurements
C. Whole Facility	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.
D. Calibrated Simulation	Energy use simulation, calibrated with hourly or monthly utility billing data and/or metering.

10 APPENDIX A: INVENTORY OF EQUIPMENT

Table 58: Inventory of Domestic Hot Water Heater Equipment

# Designation	NAV-01	NAV-02
Location	Boiler Room	Boiler Room
Area of Service	DHW	DHW
Manufacturer	Navian	Navian
Type	Gas Water Heater	Gas Water Heater
Model #	NP-240A	NP-240A
Serial #	-	-
Max Rated Input (Btu/hr)	199,000	199,000

Table 59: Inventory of Boilers

# Designation	Boiler 1	Boiler 2
Location	Boiler Room	Boiler Room
Area of Service	Process Building	Process Building
Manufacturer	Viessman	Fulton
Type	Vitocrossal 200	
Model #	CM2-246	PHW-750
Serial #	7201754800410	94762
Max Rated Input (Btu/hr)	873,000	750,000
Rated Output (Btu/hr)	851,000	675,000
Boiler Nameplate Efficiency	97%	90%
Seasonal Efficiency (SEER)	-	-
Estimated Service Life Remaining	23	6
ASHRAE Life Expectancy	25	25
Installation date	2020	2003

Table 60: Inventory of Air handling Units

# Designation	AH-4172	AHU 1	SF245	AHU 2	AHU 3
Location	Compressor Room - MCC	Centrifugal Room	Air Compressor Room	Upstairs process	Upstairs process
Area of Service	Not in Service	Process Building	Process Building	Process Building	Process Building
Manufacturer	TRANE	HAAKON	TRANE	HAAKON	HAAKON
Type	Hydronic	Hydronic	Hydronic	Hydronic	Hydronic
Model #	MCCA006NAGOSBCB01	Airpak	T3 LP HF TH	Airpak	Airpak
Serial #	K96K86303	606002-02	742763	606002-02	606002-02
Compressor LRA	-	-	-	-	-
Refrigerant	-	-	-	-	-
Voltage/Phase	575/3	460/3	460/3	460/3	460/3
Estimated Service Life Remaining	-11	-8	-14	-8	-8
ASHRAE Life Expectancy	15	15	15	15	15
Installation date	1996	1996	1990	1996	2010

Table 61: Inventory of Pumps

# Designation	Location	Service	Manufacturer	Model #	Serial #	HP
PR 240	Boiler Room	North Zones	Armstrong	117139-061	-	0.75
PR 241	Boiler Room	South Zones	Armstrong	117139-061	-	0.33
PR 533	Boiler Room	Basement/Water Entry	Armstrong	117139-061	--	0.25
PR242	Boiler Room	2 Floor	Grundfos	Magna3 65-150 F 340	10005226	2.0
-	-	-	-	-	-	
Odour tower liquid recycle Pump 1	North Storage Room	Odour tower liquid recycle	FLYGT	3153.185-184016	-	15.0
Odour tower liquid recycle Pump 2	North Storage Room	Odour tower liquid recycle	FLYGT	3153.185-184016	-	15.0
Sludge Pump SP3-250	Water Entry	Water Entry	Vogelsang	VX136-70	BJA3118.2171	5.0
Sludge Pump SP3-252	Water Entry	Water Entry	Vogelsang	VX136-70	BJA3118.2171	5.0
G-251	Water Entry	Water Entry	Nord	100LH/4 CUS	35712692	3.0
G-253	Water Entry	Water Entry	Baldor	100LH/4 CUS	35712692	3.0

# Designation	Location	Service	Manufacturer	Model #	Serial #	HP
Compressor Room	Compressor Room	Cooling line	Baldor	VM3554	35A13W206	1.5
Upstairs Process 1	Upstairs Process	Tunnels	U.S. Electrical Motors	610335 J96B	-	0.5
Upstairs Process 2	Upstairs Process	Tunnels	U.S. Electrical Motors	610335 J96B	-	0.5
Upstairs Process 3	Upstairs Process	Tunnels	U.S. Electrical Motors	610335 J96B	-	0.5
Upstairs Process 4	Upstairs Process	Tunnels	U.S. Electrical Motors	610335 J96B	-	0.5
ME4140	Penthouse Air Compressor Room	Air Floatation	Ingersoll-Rand	Intellisys	-	30
ME4141	Penthouse Air Compressor Room	Air Floatation	Ingersoll-Rand	Intellisys	-	30

Table 62: Inventory of Ventilation Systems

Designation	Location	Service	Manufacturer	Model #	Serial #	HP
UH6	Storage Room - North	Storage Room	TRANE	UHSA060S2DAAG	-	0.50
UH7	Storage Room - North	Storage Room	TRANE	UHSA060S2DAAG	-	0.50
EF1	Storage Room - North	Storage Room	Twin City Fan and Blower Co	-	-	2.00
EF2	Storage Room - North	Storage Room	Greenheck	-	-	1.00
UH5	Entry Corridor	Entry Corridor	TRANE	UHSA060S2DAAG	-	0.50
Water Entry UH 1	Water Entry Room	Water Entry Room	TRANE	UHSA060S2DAAG	-	0.50
Water Entry UH 2	Water Entry Room	Water Entry Room	TRANE	UHSA060S2DAAG	-	0.50
EF 535	South Storage Room	Exhaust Fan	OE Motors	5KH48UN6074	-	0.50
S. Office Unit Heater 1	South Storage Room Office	Unit Heater - Electric	-	-	-	0.50
S. Office Unit Heater 2	South Storage Room Office	Unit Heater - Electric	-	-	-	0.50

Designation	Location	Service	Manufacturer	Model #	Serial #	HP
UH 50	Safety Room	Safety Room	TRANE	UHSA060S2DAAG	-	1.00
AHU 4172	MCC	MCC	TRANE	MCCA006NAGOSBCB01	K96K86303	5.00
AHU 1	Centrifugal Room	Centrifugal Room	HAAKON	AirPak	-	5.00
AHU 2	Upstairs Process	Upstairs Process	HAAKON	AirPak	606002-02	5.00
AHU 3	Upstairs Process	Upstairs Process	HAAKON	AirPak	606002-02	5.00
Upstairs Process Unit Heater 1	Upstairs Process	Upstairs Process	TRANE	UHSA060S2DAAG	-	1.00
Upstairs Process Unit Heater 1	Upstairs Process	Upstairs Process	TRANE	UHSA060S2DAAG	-	1.00
Purestream Air dryer 1	Compressor Room	Air Dryer	Purestream	ACT350	-	1.50
Purestream Air dryer 2	Compressor Room	Air Dryer	Purestream	ACT350	-	1.50
SF245	Compressor Room	Process	TRANE	T3 LP HF TH	-	3.00
EF Compressor Room	Compressor Room	Exhaust Fan	Pennbarry	BHM24B	E20MZ83667	1.00
EH254	Compressor Room	Compressor Room	TRANE	UHSA060S2DAAG	-	1.00
EH255	Compressor Room	Compressor Room	TRANE	UHSA060S2DAAG	-	1.00
Unit Heater Storage	Chemical Storage	Unit Heater - Electric	-	-	-	0.50
EF 534	Chemical Storage	Exhaust Fan	OE Motors	5KH48UN6074	-	0.50
EF2	Storage Room - North	Storage Room	Greenheck	-	-	1.00
EF-4222	Process - Roof	Exhaust Fan	Twin City Fan and Blower Co	TCVA 21B7	18597851-3-1	15.00

11 APPENDIX B: GLOSSARY OF TERMS AND DEFINITIONS

A

AC (Alternating Current*): A type of current where the polarity is perpetually reversing, causing the directional flow in a circuit to reverse at regular intervals.*
ACCA: *Air Conditioning Contractors of America*
Acoustical: *Relating to sound, the science of sound, or a sense of hearing.*
Aerator: *A screen for water flow restriction. These devices are used to add oxygen to the water*
AFUE (Annual Fuel Utilization Efficiency): *A measurement used to rate furnace efficiencies by dividing the ratio of heat output by heat input.*
AGA: *American Gas Association, Inc.*
Air Conditioner: *A device that changes humidity levels, temperature or quality of air.*
Airflow Volume: *Measured in cubic feet per minute (cfm), this is the amount of air circulated in a space.*
AHU (Air Handling Unit): *Parts of a system including the fan-blower, filter and housing.*
AHRI: *Air Conditioning, Heating and Refrigeration Institute*
Ambient Temperature: *The temperature of the surrounding environment of an object (usually air)*
ASHRAE: *American Society of Heating, Refrigeration and Air Conditioning Engineers*

B

Baseline: *Utility consumption in a base year before a retrofit occurs*
EUI: *Energy Use Intensity. A measure of the building's energy use on a per unit floor area basis.*
BHP: *The net power required to operate a pump or a fan after the drive and motor efficiencies are considered*
Boiler: *A closed vessel in which water or other fluid is heated. (The fluid does not necessarily boil)*
BTU: *British thermal unit Measures the amount of heat required to raise or lower the temperature of one pound of water one degree Fahrenheit.*
BTU/h: *British Thermal Units per hour*
Burner: *The device that facilitates the combustion of air and gas.*
Burner Orifice: *The opening in the burner through which the gas or fuel passes prior to combustion.*

C

Capacity: *HVAC capacity is the output produced by the heating or cooling unit and is measured in BTUs per hour.*
CAV: *Constant Air Volume. A type of HVAC system that supplies constant airflow at variable temperature*
Celsius: *A temperature scale that registers the freezing point of water as 0° and the boiling point as 100° under normal atmospheric pressure.*
CFM (Cubic Feet per Minute): *A measurement of airflow volume.*
Charging a System: *Adding coolant, or refrigerant, to an HVAC system.*
Compressor: *A pump that increases the pressure of gas.*
Condensate: *Vapor that is turned into a liquid as its temperature is lowered.*
Condenser Coil: *Also an outdoors coil. A device that removes heat from the refrigerant, allowing the refrigerant to be converted from vapor to liquid.*
Condenser Fan: *A fan that passes air over the condenser coil to facilitate the removal of heat from the refrigerant.*

D

DC (Direct Current): *A type of electrical current that only flows in one direction.*
DDC (Direct Digital Control): *System used to automate functions in a building, including HVAC systems and Lighting systems etc.*
Damper: *Found at the exit point of ductwork, this plate usually contains grates that can be opened or closed to control the flow of air into a zone.*
DCW: *Domestic Cold Water*
Degree-Day: *Calculated by subtracting the average outdoor temperature for an area from 65º Fahrenheit. This measurement is used to estimate the amount of heating or cooling a home or building will need.*
Dehumidifier: *A device that removes humidity, or moisture, from the air.*
DHW: *Domestic Hot Water*
Diffuser: *A grille over an air supply duct with vanes that distribute the discharging air in a specific pattern or direction.*
DOE: *Department of Energy*
Down flow Furnace: *A furnace with an intake on the top and an air discharge at the bottom.*
Drain Pan: *Also, a condensate pan. As the refrigerant vapor is liquefied, the drain pan collects the condensate and funnels it to the drain line.*

Dry Bulb Temperature: *The temperature as measured without the consideration of humidity.*
Ductwork: *A network of metal, fiberboard or flexible material flowing throughout a space which delivers air from an HVAC unit to the respective zones of a home or office.*

E

EER: *Energy Efficiency Ratio*
EPA: *Environmental Protection Agency*
Expansion Valve: *A valve that meters the levels of refrigerant through a temperature or pressure control.*
Evaporator Coil: *Also, an indoor coil. A device that is designed to absorb heat in the air in order to change the liquid refrigerant that flows through it into a vapor.*

F

Fahrenheit: *A temperature scale in which water freezes at 32 degrees and boils at 212 degrees at normal atmospheric pressure.*
Fan: *A device that creates airflow.*
FC (Footcandle): *A unit of lighting illuminance.*
Filter: *A device that acts like a strainer to remove dirt or undesired particles.*
Flue: *A vent that removes the by-products of combustion from a furnace.*
Fluorescent: *A low pressure mercury-vapor gas-discharge lamp that uses fluorescence to produce visible light (i.e., T8, T12, CFl)*
Furnace: *The major component in heating a home. A device that facilitates the combustion of fuel and air to create heat.*
Fuse: *A delicate metal strip connecting two parts of an electrical circuit. This strip breaks, or melts, in the event of excess electrical charge, breaking the electrical circuit.*

G

GAMA: *Gas Appliance Manufacturers Association*
GJ (Gigajoule): *Standard unit of measurement for energy produced by gas energy*
GHG: *Greenhouse gas. I.e., Gases that are harmful to the environment and are responsible for Global Warming and the Greenhouse Effect*
GPM (Gallons per Minute): *Imperial measurement of water volume*

H

Heat Exchanger: *A device through which heat is transferred to a cold area or surface.*
Heat Gain: *The amount of heat added or created in a designated area.*
Heating Coil: *A coil that acts as a heat source for a heating system.*
Heat Loss: *The amount of heat subtracted from a designated area.*
Heat Pump: *A device used for either the heating or cooling of a space by transferring heat between two reservoirs.*
Heat Transfer: *Moving heat from one location to another.*
HID (High Intensity Discharge): *A type of electrical gas-discharge lamp which produces light by means of an electric arc between tungsten electrodes which is often used for outside lighting and large open areas such as gymnasiums (i.e. Metal Halide, Mercury Vapour, High Pressure Sodium)*
HP (Horsepower): *A unit of measurement of power*
HSPF (Heating Seasonal Performance Factor): *This factor rates the efficiency of the heating portion of the heat pump.*
Humidifier: *A device that adds humidity, or moisture, to the air.*
Humidistat: *The device that measures humidity and turns the humidifier on and off.*
Humidity: *Dampness in the air caused by water vapor.*
HVAC: *Heating, Ventilation and Air Conditioning*
HWR: *Hot Water Return*
HWS: *Hot Water Supply*

I

Ignition: *Elevating the temperature of a substance to the point of causing a combustion reaction.*
Incandescent: *A high demand electric light with a wire filament heated to a high temperature, by passing an electric current through it, until it glows with visible light*

K

kWh (Kilowatt Hours): *Standard unit for power consumption, equivalent to 1,000-watt hours*

L

Latent Heat: *A type of heat that when added to an area produces an effect other than an increase in temperature.*
L/S (litres per second): *A metric measurement of flow*
Lux: *A unit of lighting illuminance*

M

MBH: *1,000 BTU*
Media: *The fine material of a filter that traps dirt, dust, mildew, or bacteria.*

N

NATE: *North American Technician Excellence*
NEC: *National Energy Council / National Electric Code*
NEMA: *National Electrical Manufacturing Association*

O

Orifice: *An opening or hole.*

P

Package Unit: *A heating and cooling system contained in one outdoor unit.*
PAR: *Parabolic Aluminized Reflector (PAR) is a lamp type of halogen incandescent flood lamp*
Photocell: *Lighting Control based on the amount of ambient light*
Plug load: *Loads that are plugged into 120v AC i.e., computers, monitors, appliances, etc.)*
PRV: *Pressure Reducing Valve*
PSI: *Pounds per square inch*
PSIA: *Pounds per square inch, absolute*
PSIG: *Pounds per square inch gauge*
PVC: *Polyvinyl chloride; a type of plastic.*

R

Reciprocating Compressor: *A type of compressor used in cooling systems to compress refrigerant by using a piston action.*
Refrigerant: *A chemical that condenses from a vapor to liquid and, in the process, decreases in temperature.*
Refrigerant Charge: *The amount of refrigerant in a system.*
Retrofit: *Upgrade of an existing system with new components instead of replacing the entire system*
RTU: *Roof Top Unit*

S

SEER (Seasonal Energy Efficiency Ratio): *A rating system developed by the U.S. Government to indicate the efficiency level of cooling equipment.*
Self-contained System: *A package unit.*
Sensible Heat: *Heat added or subtracted that causes a change in temperature.*
Sensor: *A device that reacts to a change in conditions.*
Split System: *An outdoor unit combined with an indoor unit.*

T

Thermostat: *Sensors that monitor and control the output of an HVAC system.*
Thermostatic Expansion Valve: *A device that creates a constant evaporator temperature.*
Ton: *One ton is 12,000 BTUs per hour.*

U

Up flow Furnace: *A furnace that pulls in air from the bottom and releases it through the top.*

V

Vacuum: *A space where the pressure is significantly below that of standard atmospheric pressure.*
Variable Speed Blower Motor: *A motor that is able to run at capacities between 20% and 100% based on pre-programmed algorithms in the circuit board of the furnace. This blower motor converts A/C current to D/C current that enables the blower motor to run at a lower cost to operate. The benefits of a variable speed blower motor are, 1/3 of the cost to operate the fan, quieter operation, fan ramps up and down slowly, continuous air supply into the home at lower speeds.*
VAV: *Variable Air Volume. A type of HVAC system that varies airflow at a constant temperature*
VFD: *Variable Frequency Drive*
Volt: *A unit of electro-motive force.*
Voltage: *The force pushing electrical current along wires and cables.*

W

Watt: *The unit of electrical power equal to the flow of one amp at a potential difference of one volt.*
Wet Bulb Thermometer: *A thermometer that measures the relative humidity in the air.*

Z

Zoning: *A system that divides a home, office, or space into different regions in order to better control the temperature and effectiveness of a heating and cooling system.*

12 APPENDIX C: ENERGY CONVERSION FACTORS

All energy saving calculations have been calculated in accordance with the requirements of FortisBC Energy Studies Guides and requirements.

For consistency and adherence to the FortisBC Energy Study Guides, the following Energy conversation factors have been used:

Table 63: Energy Conversion Factors

Electricity	Natural Gas	Other
1 HP = 0.746 kW	1 GJ = 277.78 kWh	1 m3 = 35.31 ft^3
kW = 3,412 Btu/hr	1 GJ = 26 m^3 of natural gas	1 boiler HP** = 33,480 Btu
1 Lux = 0.93FC	1 GJ = 947,817 Btu	1 boiler HP** = 34.5 lb/hr
	1 GJ = 9.47817 therms	1 GJ = 0.05 tons CO^2e

** Based on 1,000 Btu per ft^3.*
*** From and at 100°C (212°F).*

13 APPENDIX D: ACCEPTABLE INDOOR SPACE TEMPERATURES AS PER ASHRAE

Type of Heated Rooms	Temperature	
	°F	°C
Bars	64	18
Bathrooms	72	22
Bedrooms	64	18
Changing rooms	72	22
Churches	64	18
Cloakrooms	61	16
Classrooms	68	20
Corridors	61	16
Dining rooms	68	20
Dressing rooms	70	21
Exhibition halls	64	18
Factories, sedentary work	64	18
Factories, light work	61	16
Factories, heavy work	55	13
Gyms	59	15
Halls, assembly	64	18
Halls, entrance	61	16
Hotel rooms	70	21
Laboratories	68	20
Lecture rooms	68	20
Libraries	68	20
Living rooms	70	21
Museums	68	20
Offices	68	20
Operating theaters	75	24
Prisons	64	18
Recreation rooms	64	18
Restaurants	64	18
Shops	64	18
Stores	59	15
Swimming baths	81	27
Waiting rooms	64	18
Wards	64	18
Warehouses	61	16