ALEXANDER MACDONALD LODGE

Recommissioning Investigation

Prepared by:
Johnson Controls Canada L.P.
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EXECUTIVE SUMMARY

This report summarizes the results of a recommissioning investigation report for the Alexander MacDonald Lodge located at 636 Fifth Ave Box 310, Dawson City, YT. In September 2019, the Government of Yukon and Johnson Controls Canada LP entered into an agreement for recommissioning services, to be delivered in five phases. Recommissioning is a process that seeks to re-optimizes the operation of existing equipment and systems. It provides a rigorous investigative approach to identifying problems and system integration issues. This project is funded in part by Natural Resources Canada's Office of Energy Efficiency to promote the value of commissioning for existing buildings.

The objectives of this mandate are the following:

- Resolve operational issues and reduce energy use;
- Assess the building automation system to identify deficiencies;
- Implement identified low-cost/no-cost energy saving opportunities and operational deficiencies through coordination with the current service provider, Johnson Controls;
- Produce a case study report documenting the recommissioning process;
- Client comfort has to be maintained at current level or improved.

The Johnson Controls team, supported by Prism Engineering, conducted site visits in November 2019. We met with representatives of Alexander Macdonald Lodge review the operation of the building. We also met with the Johnson Controls service technician to discuss findings. The retrocommissioning process also involved obtaining available technical documentation on the building HVAC equipment and its operation. Documentation such as as-built mechanical drawings, commissioning reports, DDC installation record drawings including points list, sequences of operation, trend logs, operational graphic screenshots were obtained for review of existing HVAC system operation.

AML staff report HVAC-related problems at AML, including offices and nursing stations being too hot, and preheat coils freezing. This report proposes operational, maintenance, and control measures to rectify these issues. There are opportunities to reduce energy consumption at AML. The two heating loops are variable flow, and VFDs can be installed on the circulation pumps to reduce pumping energy. AHU-101 serves zones that are unoccupied at night, but the unit currently runs continuously. AML currently buys all electricity and heat from the adjacent Dawson City Hospital. Heat is not metered but is billed at a flat monthly rate. All the sensors already exist in the DDC to meter heat used by AML. It is recommended that totalizers be set up in the DDC to record monthly AML heat use to help identify savings opportunities and examine the current cost of heating.

The next steps consist of implementating the recommendations for energy savings opportunities and operational deficiencies. Seasonal checks on the operation of the cooling plant should also be performed. A monitoring plan is provided as part of the report to ensure a seamless integration of the recommendations within this report.

1.0 SUMMARY OF RECOMMENDATIONS

A detailed recommissioning investigation at Yukon College located in Whitehorse was completed. Table 1 shows the the recommendations for the energy savings opportunities and operational deficiencies.

Table 1: List of Recommendations

#	ECM Recommendation	Est. Energy Savings ($)	Budgets ($)	Priority	Notes
1	Install VFDs on circulation pumps	$ 5,176.00	$ 52,000.00	1	Includes on site time and separate travel
2	AHU-101 scheduling	$ 6,098.00	$ 1,500.00	2	Estimated as 100% remote.
3	Heating plant optimization	$ 1,960.00	$ 1,100.00	2	Estimated as 100% remote.
4	Trend BTU meters	-	$ 1,100.00	2	Estimated as 100% remote.
5	Clean, replace or remove humidifiers	-	Remove $ 4000.00 Clean $ 6000.00 Replace $15,000.00	2	Estimated as 100% remote.
6	Integrate AHUs with DDC	-	$ 35,000.00	2	
7	Fix heating near resident room 4	-	$ 2,000.00	2	
8	Revise heating staging	-	$ 2,000.00	2	
9	Prevent preheat coils from freezing	-	$ 12,000.00	1	Estimated as 100% remote.
TOTAL		**$ 13,234.00**			

Notes:

- We estimate the accuracy for ECM 1, 6 and 9 to be in the +/- 5% accuracy level
- We estimate the accuracy for the remainng ECMs to be in the +/- 15% accuracy levels
- ECMs 2, 3, 4
- The operational benefits are excluded from the estimated savings noted above.
- The engineering fees required to finalize the scope of work for the recommendations above is excluded

- Due to recent COVID-19 events, the timelines for implementation of the recommendations should be discussed further
- “Priority” is defined as the following
    - 1 – Low Cost and/or High Priority
    - 2 – Low Cost and/or Medium Priority
    - 3 – Low Priority
- Combining the implementation of ECMs could generate cost savings
- Proposed sequences of operation will be provided for approved recommendations, as required.

2.0 UTILITY ANALYSIS

2.1 Utility Rates

Electricity is provided by the adjacent Dawson City Hospital. AML's electricity use is submetered and billed at a predetermined rate through two accounts. Table 2 states the rate used for electricity savings calculations.

Table 2: Rates used for Electricity Savings Estimates

Vendor	In effect	Consumption ($/kWh)
Yukon Hospital Corporation	Mar 2019	$0.2012

Hot water for heating and DHW is also provided by the adjacent Dawson City Hospital. It is not metered but is billed at a monthly flat rate. AML does not have its own fuel or gas service. Table 3 states an assumed rate used for heating savings calculations, based on what the hospital pays for heating oil.

Table 3: Rates used for Heating Savings Estimates

Utility	Vendor	In effect	($/GJ)
Hot Water	Yukon College Corporation	Jan 2019	$31.17

2.2 Energy Use and Cost Summary

Electricity use for one year is presented in Table 4.

Table 4: Electricity Use Summary, 2018

		2018
Electricity	Use (kWh)	408,598
	Cost ($)	$82,210
	BEPI (kWh/m^2/yr)	324.3
	BECI ($/m^2/yr)	$65.25

Cumulative monthly electricity use for the two meters at AML is shown in Figure 1. Although

electricity use varies from month-to-month, there is no sign of weather dependence.

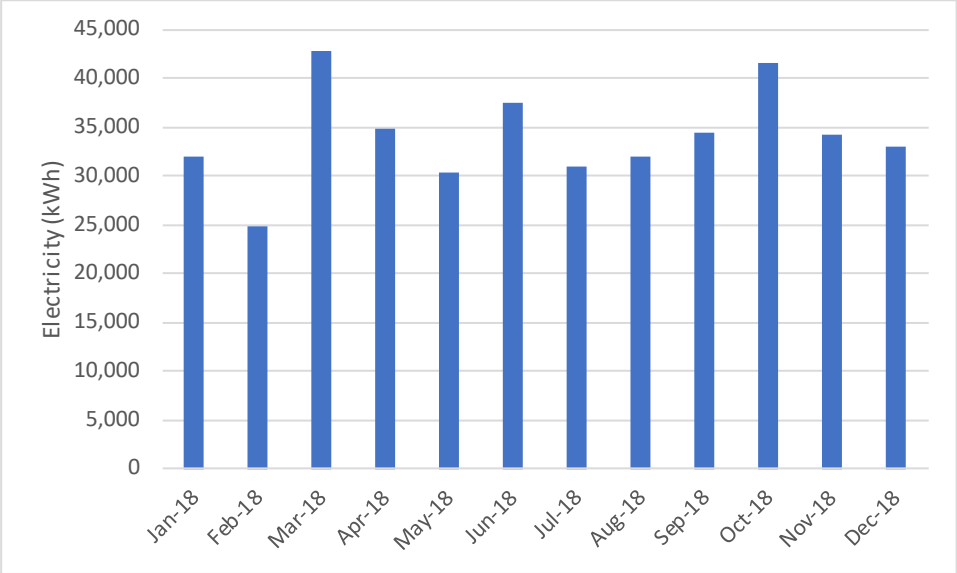

Figure 1: AML Monthly Electricity Use, 2018

3.0 BUILDING AND SYSTEM DESCRIPTIONS

3.1 General Building Description

AML was constructed in 2016. It is a one-storey extended care home with 15 beds. The total floor area of the building is 1,260 m^2. The building has not been renovated since construction.

AML's bedrooms and nursing stations are continuously occupied. Its offices and kitchen are occupied roughly 6am – 6pm daily.

AML is attached to the Dawson City Hospital, from which it obtains heating water.

3.2 Mechanical Systems Description

General Overview

Heating is provided by hydronic systems. Air handling units on the roof provide ventilation, cooling, and additional heating.

Heating Systems

The heating system is shown in Figure 2. Dawson City Hospital, adjacent to AML, provides heating water for all space heating requirements. Two glycol loops connect the buildings. Heat exchangers HE-101 and HE-102 separate the hospital glycol from AMLs two heating loops. HE-101 (396 kW) serves a heating water loop serving reheat coils and radiant ceiling panels. HE-102 (572 kW) serves a glycol loop serving forced flow heaters near exit doors, unit heaters in the basement crawlspace, and the air handling units. Both AML heating loops are variable flow.
A summary of the heating distribution pumps is included in Table 5.

Table 5: Summary of Heating Water Pumps

Tag	Description	HP	Flow (US gpm)	Head (ft)
P-101/102	HE-101	5	90	65
P-103/104	HE-102	5	130	65
P-105	AHU-101 Preheat	1.5	22	45
P-106	AHU-102 Preheat	1.5	39	45

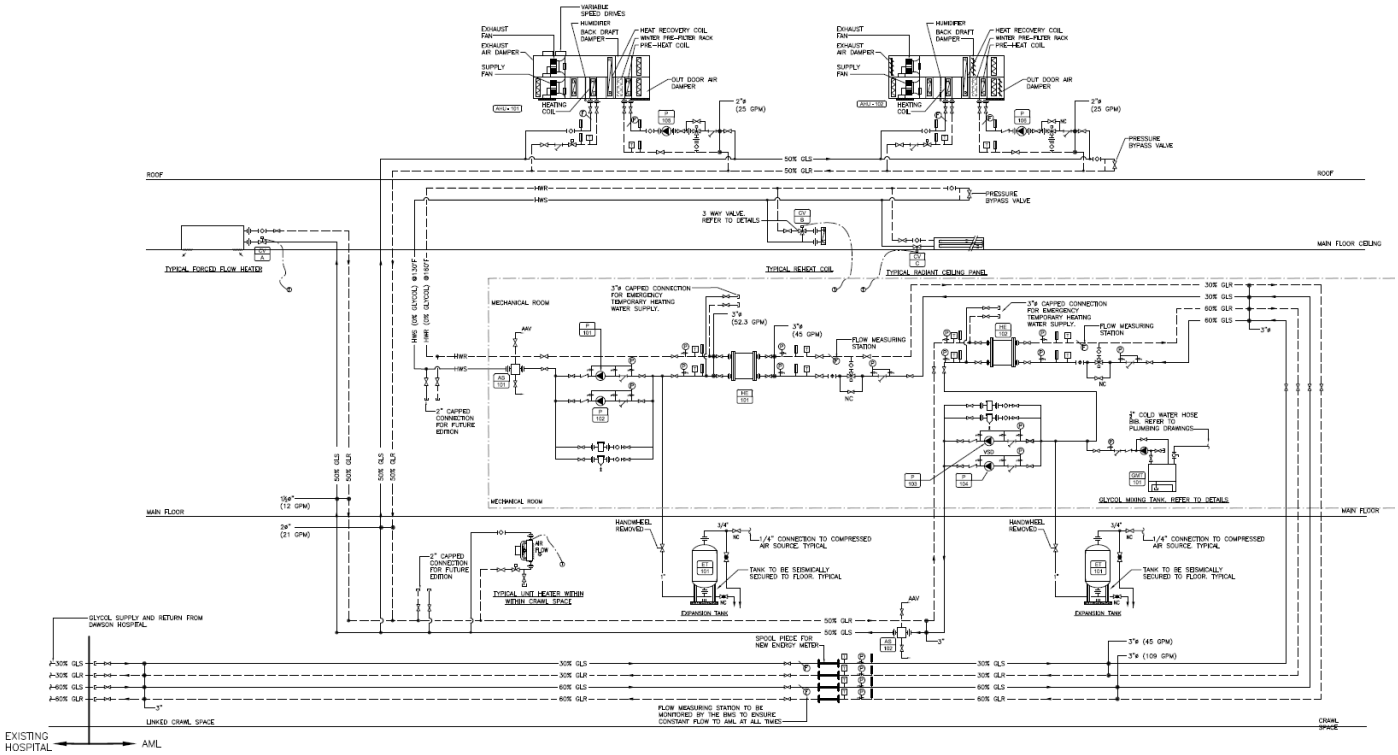

Figure 2: AML Heating Schematic

Ventilation Systems - Air Handling Unit(s)

Two air handling units located on the roof provide ventilation, cooling, and additional heating to the building. A summary of the units is provided in Table 6.

Table 6: Summary of Air Handling Units

Tag	Service	Description	Flow Control	Fan Powers (HP)	Supply Flow (cfm)
AHU-101	Kitchen/ lounge/ offices	Variable volume, 100% outdoor air unit with supply fan, exhaust fan, heat recovery wheel, humidifier, preheat and heating coils, and DX cooling.	VFDs	7.5 / 3.0	4,260
AHU-102	Bedrooms/ Nurses Station	Constant volume, 100% outdoor air unit with supply fan, exhaust fan, heat recovery wheel, humidifier. preheat and heating coils, and DX cooling.	None	15 / 7.5	7,450

The kitchen has a dedicated exhaust fan (EF-01, 1.0 HP, 2,400 cfm).
There is a split air-conditioning unit for the LAN room (AC-101, 24 MBH)

Central Building Controls

The mechanical systems in this building are controlled from a BAS controlled with Direct Digital Control (DDC). The system is manufactured by Johnson Controls.

3.3 Domestic Water

Domestic Cold Water

Domestic water is distributed throughout the building with available city water pressure.

Domestic Hot Water

Domestic hot water is provided by Dawson City Hospital.

4.0 PROPOSED MEASURES

4.1 Install VFDs on Circulation Pumps

Pumps 101 through 104 serve heating water and glycol loops. These loops are variable flow, but the existing pumps have constant speed motors. Under most conditions, heating water/glycol flow is much less than design flow, so the pumps are effectively throttled by heating valves in the loop. This is less efficient than modulating the pump speeds with variable frequency drives (VFDs), as shown in Figure 3.

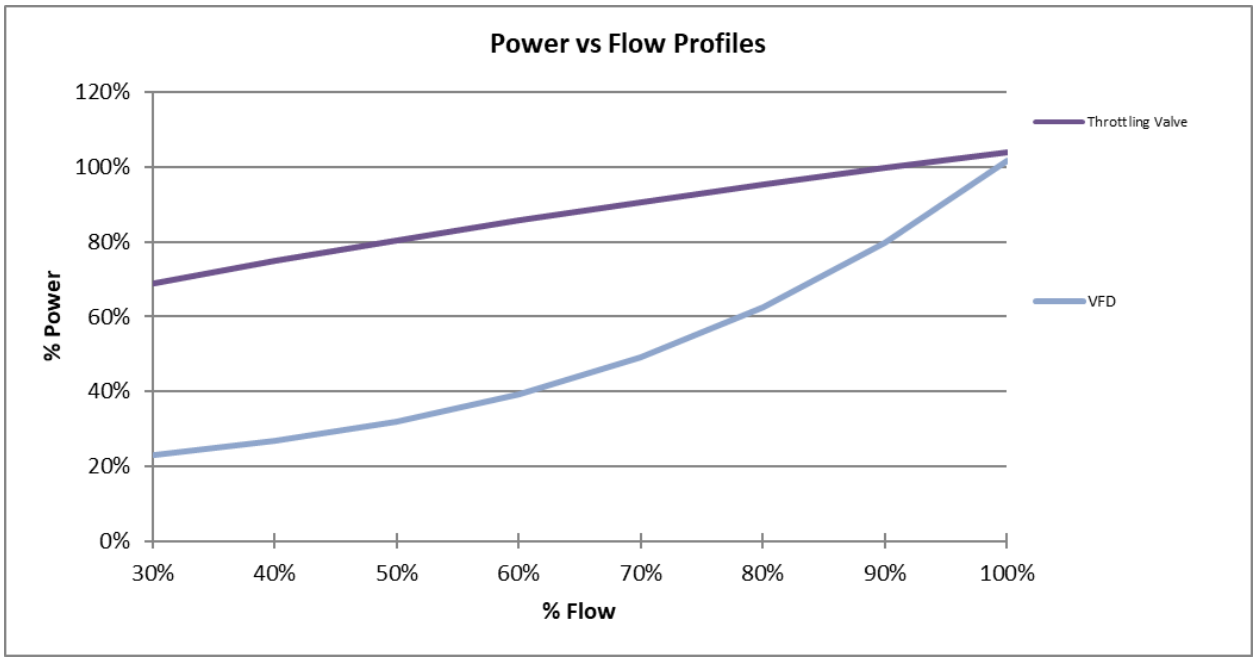

Figure 3: Performance of Flow Control Technologies

It is recommended that VFDs be installed on all four pumps, and pressure sensors be installed across each heating loop. The VFD speeds would be modulated to ensure sufficient differential pressures across the heating loops.

Figure 4: P-103 and P-104

4.2 AHU-101 Scheduling

Per fan speed trends shown in Figure 5, AHU-101 is currently running continuously. This 100% outdoor air unit serves the kitchen, lounge, and offices. These spaces are unoccupied at night.

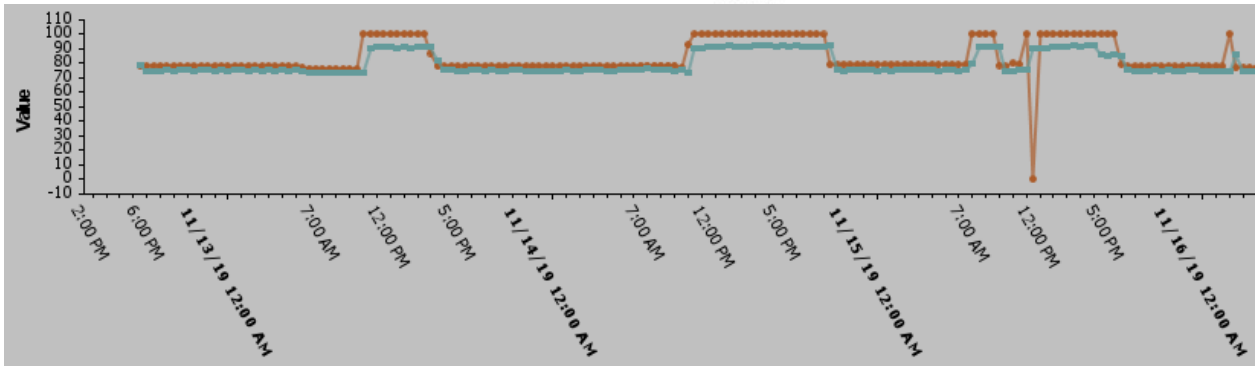

Figure 5: AHU-101 Supply and Exhaust Speed Command Trends

It is recommended that AHU-101 be enabled by a weekly operating schedule. Outside of regular operating hours, radiant panels should provide the first stage of heating for the zones. Night setbacks would be implemented to allow zone temperatures to fall during unoccupied hours. AHU-101 would be configured to start to provide supplemental heating if the radiant panels are unable to maintain night setback temperature setpoint. Optimal starts should be implemented to ensure occupied temperature setpoints are met at the start of occupied periods.

It is important to avoid freezing AHU-101 when shut down or tripping upon restart. In cold weather preheat and heating coils in the unit would be opened to prevent freezing. Fans need to ramp up slowly and coil valves ramped towards closure at start-up to avoid nuisance trips.

4.3 Heating Plant Optimization

The higher the heating loops supply temperatures, the greater the distribution losses in AML, and the greater the heating required from the hospital. Therefore, the heating loops should be disabled or maintained at low supply water temperatures as much as possible while still meeting zone heating requirements.

The heating loops are configured to run if outdoor air temperature is less than 15°C. It is proposed that the heating plant only be enabled if zones require heating (subject to existing ambient lockout).

Currently the heating loops supply temperatures are reset per outdoor air temperature. It is proposed to have the DDC reset the heating supply temperature based on demand from space sensors and AHU heating coil requirements, in addition to the existing outdoor air temperature reset.

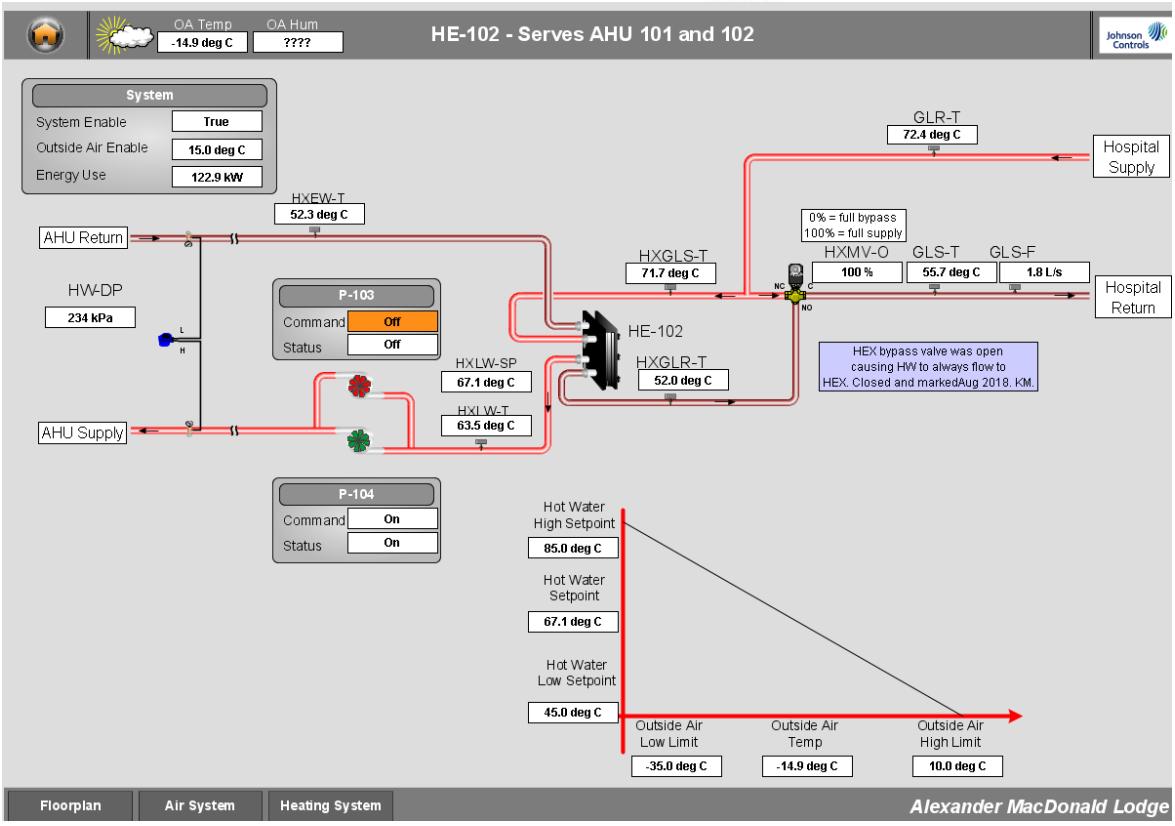

Figure 6: HE-102 Heating Loop DDC Graphic

4.4 Trend BTU Meters

AML is provided with glycol for space heating from Dawson City Hospital next door. It is not metered, and AML is billed a fixed amount each month regardless of consumption. It is unknown if this rate is comparable to what AML would pay operating its own plant, and it is difficult to detect if there is a heating system malfunction resulting in an increase in heat use.

Both heating loops have DDC system inlet and outlet temperature and flow sensors. These sensors are sufficient to measure the heat provided to AML by Dawson City Hospital. It is recommended that totalizers be set up in the DDC to measure the monthly heat provided to each of AML's heating loops.

4.5 Clean, Replace or Remove Humidifiers

Humidity levels at AML are very low. Figure 7 shows AHU-101 reporting 10.1% return air relative humidity. AHU-102's return air relative humidity was 4.3% at the time. Relative humidity should be maintained between 40 and 60% to maximize occupant comfort and health.

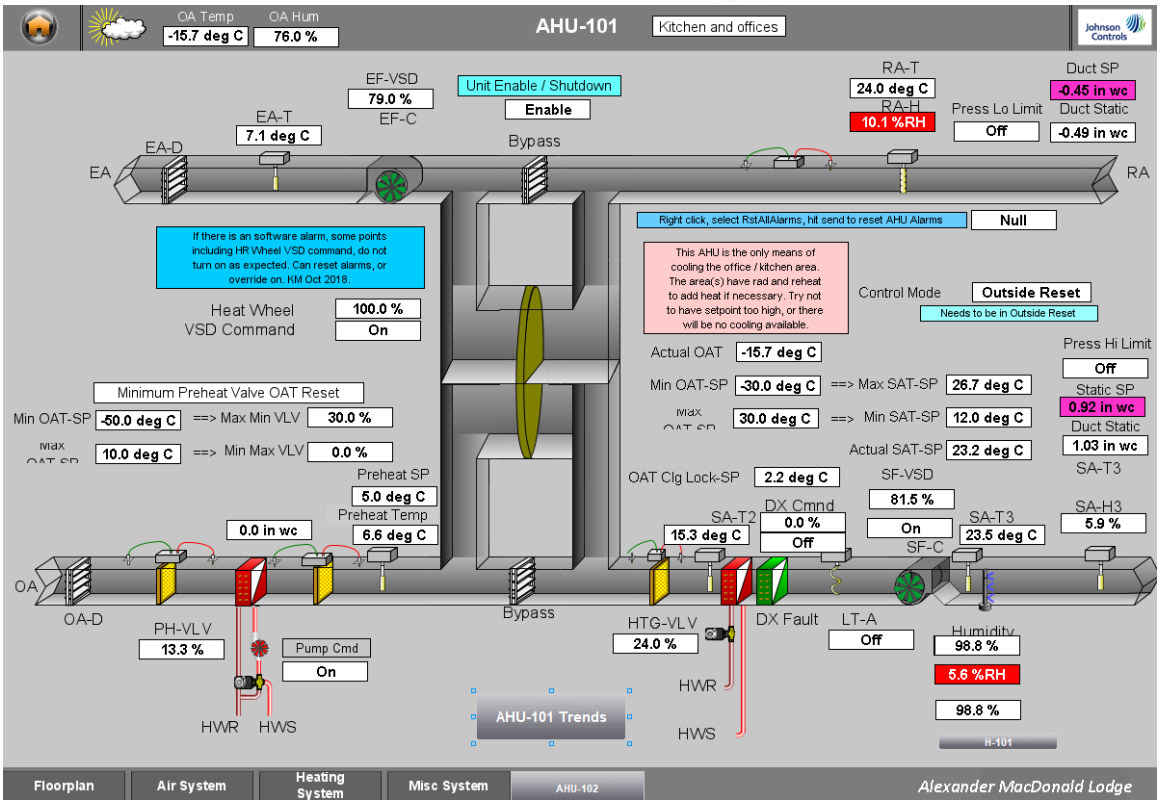

Figure 7: AHU-101 DDC Graphic

Figure 7 shows the controls are functioning properly, commanding the humidifier to operate at 98.8%. However, the humidifiers have failed (both for AHU-101 and AHU-102). On-site we were told that attempting to run the humidifiers was tripping breakers.

Figure 8: Humidifier H-102

Humidifiers of this design need to be cleaned frequently. The manufacturer's literature states that cleaning may be required every 1000 hours of operation. This is less than two months of continuous operation.

Alternatively, the humidifiers could be replaced with a design that uses replaceable canisters. Instead of having to clean the evaporation chamber, these humidifiers have a component that can be replaced every few months. The DDC could be configured to alert the operators when humidifier maintenance was required based on humidifier feedback or operating hours.

4.6 Integrate AHUs with DDC

The air handling units, AHU-101 and AHU-102, are on local controls. The JCI Metasys DDC system only enables/disables the units, sets supply air temperature setpoint, and reads sensors and commands. It does not directly control VFD speeds or valve positions.
This makes it difficult to troubleshoot issues with nuisance trips and coils freezing, like for Measure 5.9. Logic to slowly ramp up a unit during a cold weather start-up cannot be directly implemented without control of fans and heating valves (Measure 5.2).
It is proposed that direct control of the AHUs be given to the building DDC system.

4.7 Fix Heating near Resident Room 4

No heat was observed from the forced flow heater or radiant panel adjacent to the exterior door near Resident Room 4. The temperature at the time was 19°C and below setpoint.

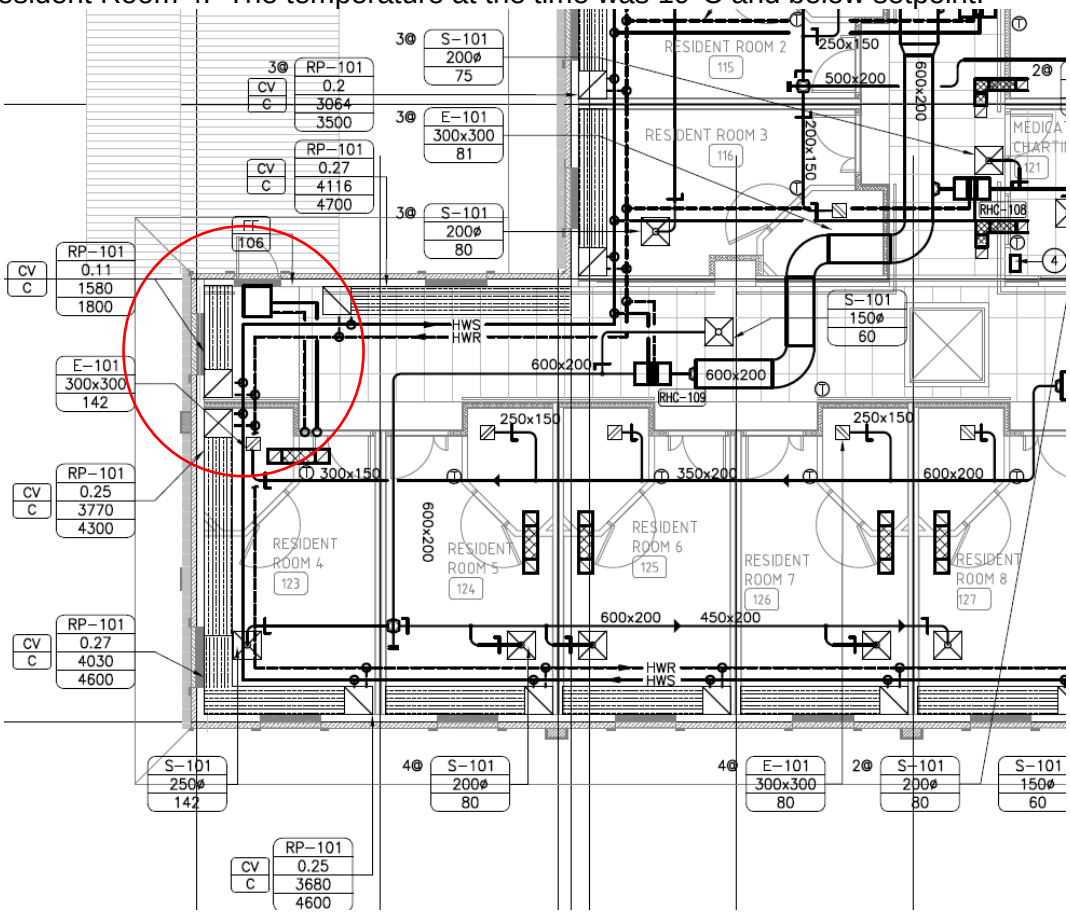

Figure 9: Main Floor HVAC Drawing near Resident Room 4

Possible causes of the lack of heat are controls mapping or one or both systems may be air-locked. It is not known which temperature sensor controls the radiant panel by the exterior door. The forced flow heater is at the end of the heating water supply line and may be air-locked.

We recommend ensuring there is no air-lock and checking that the radiant panel is controlled by the closest temperature sensor.

4.8 Revise Heating Staging

Nursing management stated that the nursing station and administration offices are often too hot, even in winter months.

Most zones in AML have three heat sources. AHUs have heating coils and DX cooling (the only source of cooling for the building) and can adjust their supply air temperature setpoint. Currently, the supply air temperature setpoint is reset with outdoor air temperature. Reheat coils provide additional heat, but often serve 4-5 resident rooms each. Zones are equipped with radiant panels or forced flow heaters.

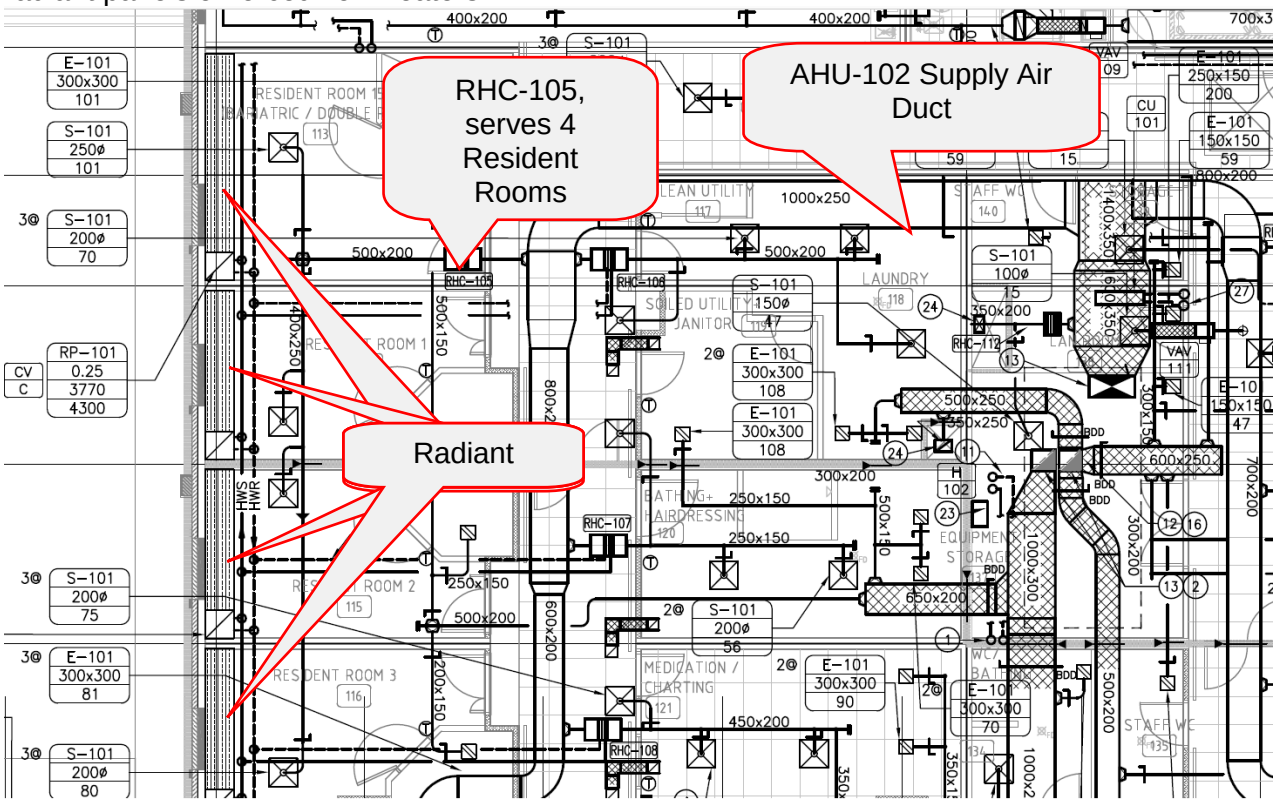

Figure 10: AML Heating System Stages

Ideally the radiant panels would modulate as required to meet individual zone temperature setpoints. The reheat coils would provide supplemental heating if any zone was below heating setpoint, but no zone was too hot. The AHUs would provide cold enough air to ensure all zones do not overheat.
DDC screenshots suggest the reheat coil control is correct. To rectify the nursing station and offices being too hot, the AHUs should control the supply air temperature setpoints to meet these spaces' cooling setpoints.

4.9 Prevent Preheat Coils from Freezing

Operations staff indicated that AHU-101 and AHU-102 preheat coils keep freezing. This causes equipment downtime, reducing indoor air quality and occupant comfort.

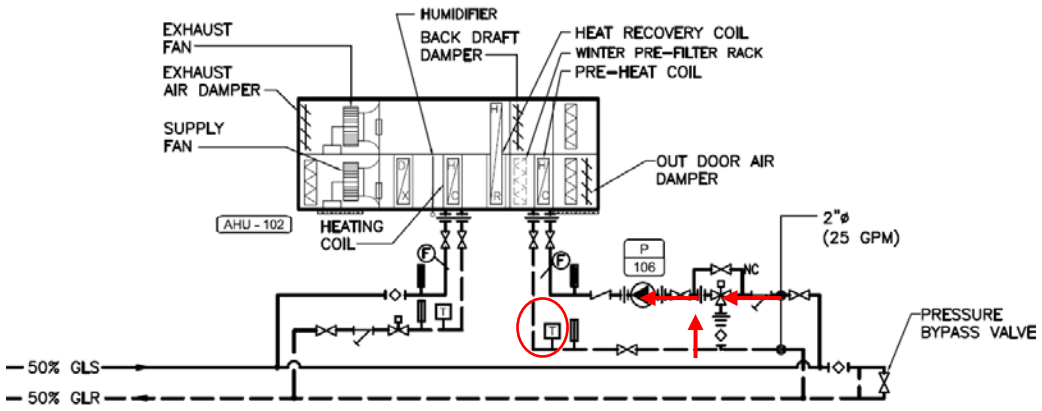

Figure 11: AHU-102 Schematic (AHU-101 is similar)

This is an unexpected problem. The AHUs heating loop contains 50% glycol. The preheat coil has a dedicated circulation pump, P-106, to ensure a constant flow through the coil.

The 3-way control valve was installed incorrectly. It needs to be a mixing valve, with flow directions as shown in Figure 11, for P-106 to provide constant flow through the preheat coil. However, it was installed as a diverting valve with the common ("AB") port attached to the heating water supply pipe. The valve should be reversed or replaced. A pressure bypass valve, as shown on the bottom-right of Figure 11, should be installed if it does not already exist.

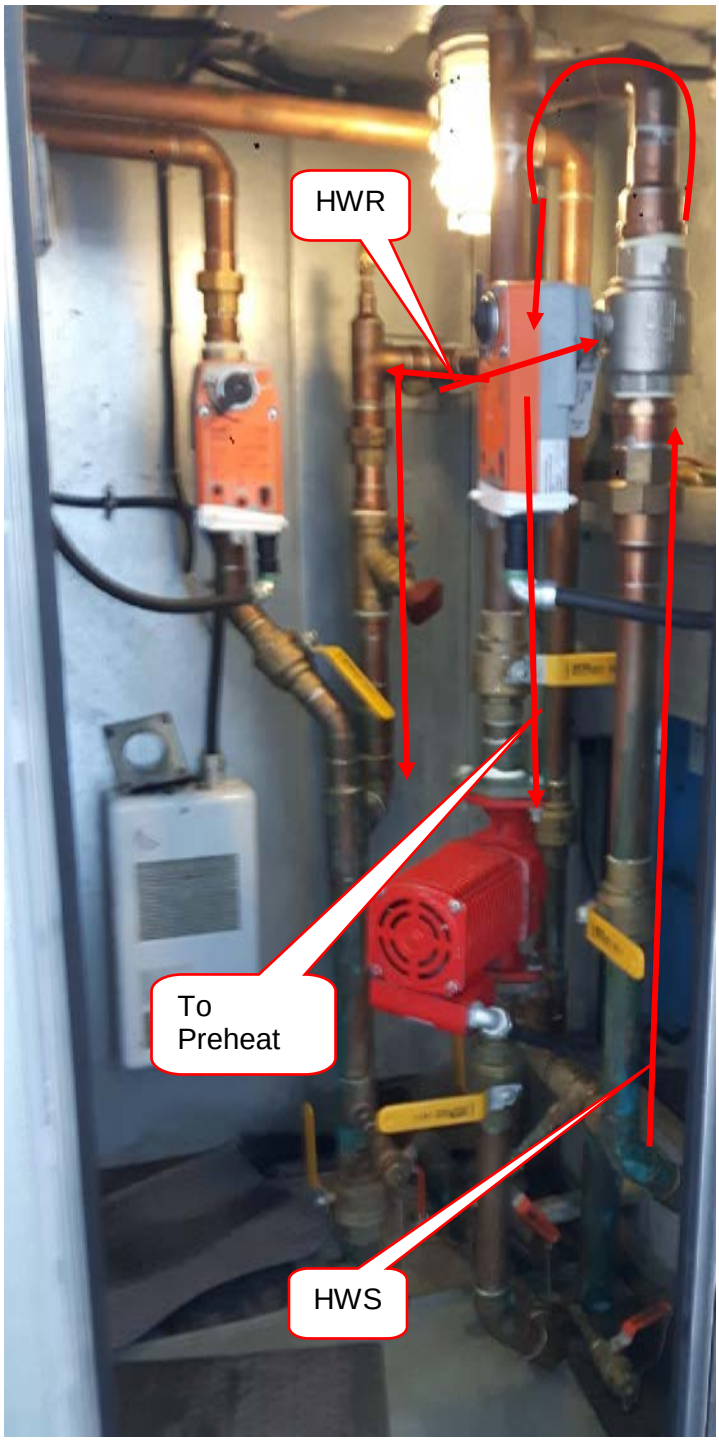

Figure 12: AHU-101 Preheat Coil Piping

The temperature sensor identified with a circle in Figure 11 on the preheat coil return water line could not be found and is not shown in the DDC. It is recommended that one be installed in this location. The control valve would maintain return water temperature high enough to prevent freezing.

4.0 SENSORS REQURING RE-CALIBRATION

At the time of this recommissioning investigation, we did not find sensors that were either giving no readings or faulty readings. This is explained by the fact the facility was constructed in 2016.

5.0 MONITORING PLAN

The table below shows the monitoring plan to document project results from the approved ECM recommendations. The list of recommended parameters to be trended at BAS will be provided for each approved ECM.

Table 7: Monitoring Plan To Document Project Results

#	ECM Recommendations	Resolution Status	Resolution Description	Recommended BAS Trends	Seasonal Check
1	Install VFDs on circulation pumps (P-101, 104)			☐ TBD	☐ Heating
2	AHU-101 scheduling			☐ TBD	☐ Heating ☐ Cooling
3	Trend BTU meters			☐ TBD	☐ Heating
4	Heating plant optimization			☐ TBD	☐ Heating
5	Clean or replace humidifiers (AHU-101,102)			☐ TBD	
6	Integrate AHUs with DDC (AHU-101,102)				
7	Fix heating near resident room 4			☐ TBD	☐ Heating
8	Revise heating staging			☐ TBD	☐ Heating
9	Prevent preheat coils from freezing			☐ TBD	☐ Heating

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