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Continuous Optimization for Commercial Buildings Program

Recommissioning Report

Version	Updated on	Phase
1	12 July, 2022	Investigation phase. Draft for client review.

Prepared for:

School District 69

Kwalikum Secondary School

266 Village Way

Qualicum Beach, BC

Project: BCH-07831

Prism Project: 2021300

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TABLE OF CONTENTS

1.0 Introduction

Prism Engineering is pleased to present the results of the Investigation Phase that was conducted as part of BC Hydro's Continuous Optimization for Commercial Buildings Program for Kwalikum Secondary School. The objective of an Investigation is to identify deficiencies and improvements in the operation of a facility's mechanical equipment, lighting, and related controls, and determine opportunities for corrective action that reduce energy consumption and preserve the indoor environmental quality.

This document is a complete record of the work performed at this facility, including the in-depth investigation of the building systems and the implementation of selected measures to optimize building performance.

The Recommissioning Investigation Report provides an overview of the recommendations for the implementation of measures. This information is not considered a specification or detailed sequence of operations. The intent is to provide an overview of the recommendation that can be built upon during the implementation phase as part of any detailed design that may be required. Certain measures may require further investigation and specification for the correct implementation by the owner or the DDC contractor.

Eight recommended retrofits were identified as a part of this investigation. The proposed measures will be reviewed in a meeting with SD69 and Prism Engineering representatives to determine which measures will be implemented.

Recommended retrofits for implementation include:

- Measure #1: Air handler heating control valves passing
- Measure #2: Boiler setpoint optimization
- Measure #3: AHUs running overnight
- Measure #4: Weekly schedule
- Measure #5: Night Setback
- Measure #6: Reheat coils passing or blocked
- Measure #7: HV-7 and HV-8 Outdoor Dampers
- Measure #8: Broken sensors

These measures are presented in the Investigation Summary Table (see Appendix A).

While the investigation focuses on low-cost improvements with short paybacks, some capital improvement opportunities may also be identified. Major retrofit measures are beyond the scope of this program, but other BC Hydro and FortisBC programs provide a variety of incentives to complete the retrofits. Retrofits were identified as a part of this investigation that could potentially qualify for other BC Hydro and FortisBC programs, these measures are described in Section 6.

Retrofits include:

- Measure #9: Four ASHP Hot Water RTUs
- Measure #10: Central Air Source Heat Pump

2.0 Project Overview

Project Information

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RCx Project File #	**BCH-07831**
Date of Workbook Update	12-Jul-2022
Organization	School District 69
Building Name	Kwalikum Secondary School
Building Type	Large School
Location (City)	Qualicum Beach, BC
Owner Contact	Phil Munro
Investigation Phase start date	01-Feb-2022
Participated in previous BCH RCx program?	No
Previous RCx File #	
Previous RCx completion date	

Building Information

Facility Area (ft2)	105,206		
Annual elec consumption (kWh)	676,432	6.4	kWh/ft^2
Annual elec costs ($)	$ 66,547	$ 0.10	Avg. $/kWh
Fuel type	Natural Gas		
Annual fuel consumption (GJ)	6,866	18.1	$ekWh/ft^2$
Annual fuel cost ($)	$ 83,237	$ 12.1	Avg. $/GJ
Total GHG emissions (tCO2e/yr)	350		
Total Energy Cost	$ 149,784	$ 1.42	$\$/ft^2$
Energy Use Intensity (ekWh/ft2)	24.6		
Year for energy data above	2021		

3.0 Savings Summary

Savings Summary	Previous, still working	New + Previous, rectify + Previous, documented					
		Identified		Selected		Implemented	
# of measures	0	10		8		8	
	Re-claim Savings	Total Savings	% Savings	Total Savings	% Savings	Total Savings	% Savings
Electrical savings (kWh/yr)	-	76,672	11.3%	194,307	28.7%	194,307	28.7%
Fuel savings (GJ/yr)	-	4,779	69.6%	3,407	49.6%	3,407	49.6%
Cost savings ($)	$ -	$ 65,480	43.7%	$ 60,420	40.3%	$ 60,420	40.3%
GHG reduction (tCO2e/yr)	-	239.2	68.4%	172.0	49.2%	172.0	49.2%
# of Abandoned measures	**0**						

4.0 Brief Description of Existing System

This section contains a brief description of the existing HVAC and Controls system. The information is intended to provide a general overview only.

4.1 Facility Description

Kwalikum Secondary School consists of two buildings. The original two-storey South Block was built in 1981 and expanded around 1987, with a major retrofit of HVAC systems in 2002. The South Block contains classrooms, workshops, and gym. The two-storey North Block was built in 2002 and contains classrooms and admin offices. The total area of the school is 105,207 sqft.

4.2 Heating System

A boiler plant with eight IBC 399 MBH condensing boilers (Figure 1 and Figure 2) is the main source of heating to both blocks. The primary loop is connected through a low loss header to secondary loops serving heating coils in air handlers, reheat coils, convective heaters and fan coils in entrance ways, radiant panel, and unit heaters. Distribution loops and pumps are shown in Figure 3 and Table 1.

Figure 1: Four of the IBC boilers

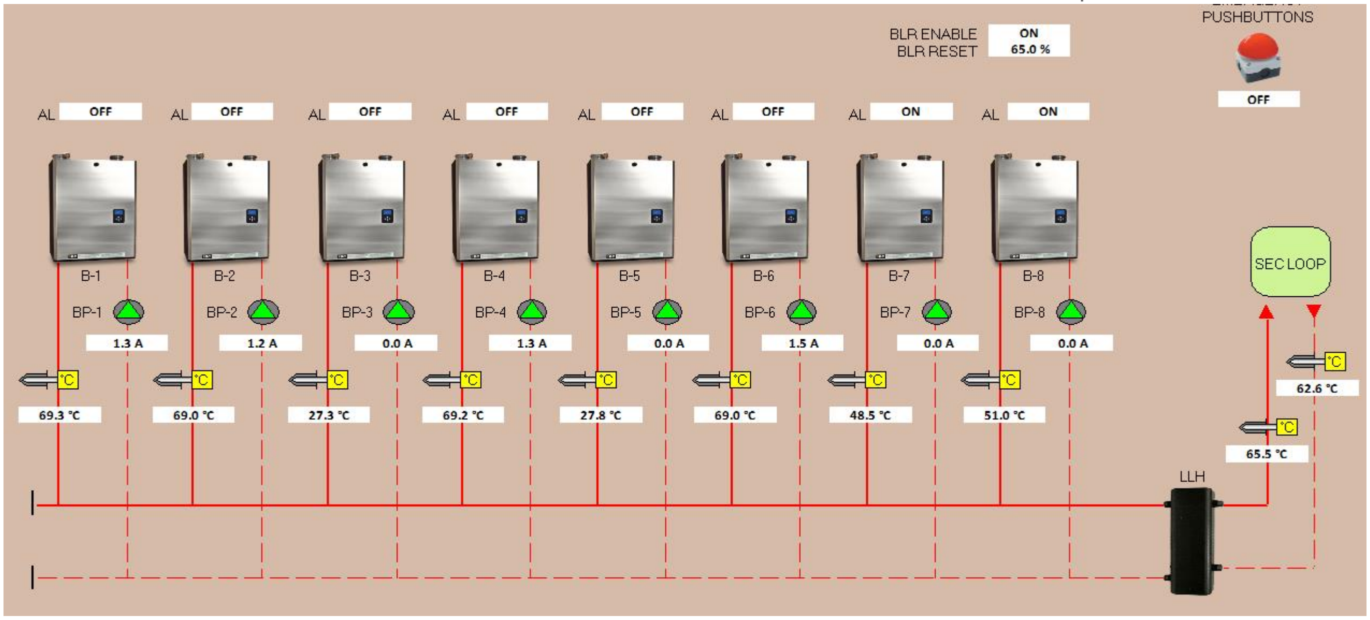


Figure 2: Boiler Plant DDC Graphic

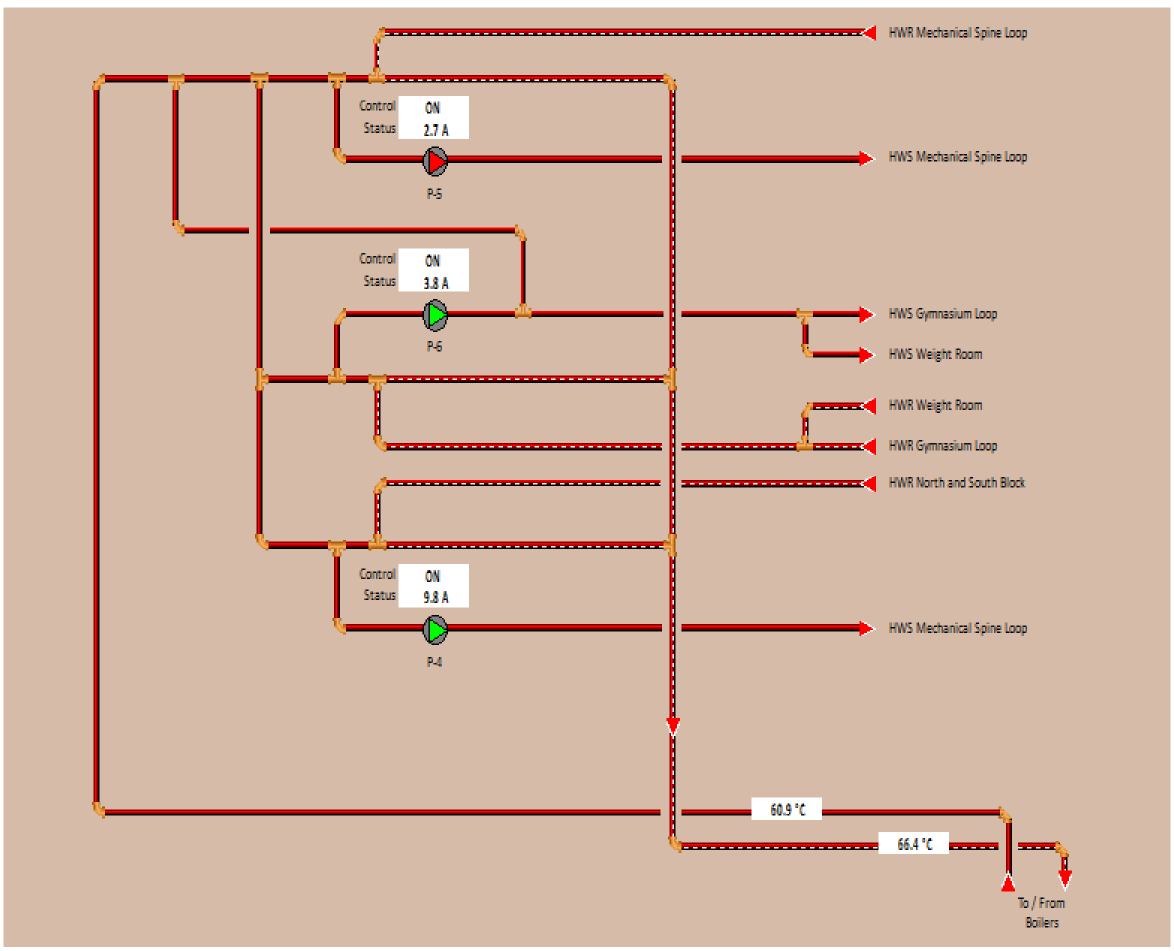


Figure 3: Secondary heating water loops

Table 1: Heating Water Pumps

Tag	Serves	Size	Flow (GPM)	Head (Ft)
P-3	DWH recirc (South)	179 W	Unknown	Unknown
P4	Mech Spine Secondary loop	5 HP	220.8	51
P-5	Mech Spine, A Secondary loop	1.5 HP	90.6	33
P-6	Gym/Weights Secondary loop	1 HP	82.3	30
P-7	North Block Loop (not shown in DDC)	2 HP	112.4	39
P-8	AC-4 Coils	1/3 HP	38	30
P-9	DHW recirc (South)	1/25 HP	Unknown	Unknown
BP-1 to BP-8	Boilers Primary Circulation	189W each	Unknown	Unknown

4.3 Cooling System

Cooling is provided by DX coils and condensing units in AC-1 to AC-5.

4.4 Ventilation System

There are five rooftop units on the North Block, and 7 rooftop units and an indoor air handler (AC-4) on the South Block, all listed in Table 2.

Table 2: Air handling units

Tag	Service	Supply Flow	Supply Fan	Return Fan	Heating Coil	Cooling Coil	Mix/OA
North Block (2002)							
AC-1	Technology Class and Workroom	3,440 CFM	5 HP	2 HP	Hydronic	DX 9 Tons	Mix Min 20%
AC-2	Staff Room, Admin, Counseling	4,500 CFM	5 HP	2 HP	Hydronic	DX 11 Tons	Mix Min 10%
HV-1	Music Room and Practice	10,560 CFM	7.5 HP	5 HP	Hydronic	-	Mix

Tag	Service	Supply Flow	Supply Fan	Return Fan	Heating Coil	Cooling Coil	Mix/OA
							Min 20%
HV-2	North Block Ground and Upper Classrooms	17,065 CFM	10HP	7.5HP	Hydronic	-	Mix Min 20%
HV-3	Multi-purpose Room	12,000 CFM	7.5 HP	5 HP	Hydronic duct reheats	-	Mix Min 20%
South Block (1981/1987)							
AC-3 (2002)	Multimedia Comms and Research	6,435 CFM	7.5 HP	3 HP	Hydronic	DX 18 Tons	Mix Min 20%
AC-4	Admin, Computers Science and Art	20,788 CFM	20 HP	N/A	Hydronic	DX 60 Tons	Mix Min 20%
AC-5 (2002)	South Class: Textiles, Food, Art	7,865 CFM	7.5 HP	3 HP	Hydronic	DX 21 Tons	Mix Min 10%
HV-4 2002	Metal Shop	6,500 CFM	5 HP	N/A	Hydronic	-	Mix Min 20%
HV-5 (2002)	Power and Automotive Shop	6,000 CFM	5 HP	N/A	Hydronic	-	Mix Min 20%
HV-6 (2002)	Wood Shop	7,695 CFM	5 HP	N/A	Hydronic	-	Mix Min 20%
HV-7 (2002)	Admin and Drama	7,300 CFM	5 HP	5 HP	Hydronic	-	Mix Min 20%
HV-8 (2002)	Gym and Change Rooms	42,035 CFM	25 HP VSD	15 HP VSD	Hydronic	-	Mix Min 20%

The two buildings have approximately 30 exhaust fans.

Table 3: Exhaust fans

Tag	Service	Airflow	Fan	Control
EF-1	Washroom. Ground Floor	312 l/s	1/4 HP	DDC / HV-2
EF-2	Staff Washrooms	94 l/s	100 W	DDC / AC-2
EF-3	Staff Room	283 l/	1/4 HP	DDC / AC-2
EF-4	Office N108	154 l/s	Unknown	DDC / AC-2
EF-5	Home Economics N121	1312 l/s	1/2 HP	DDC
EF-6	Storage N131	195 l/s	1/10 HP	-
EF-7	Elevator Mech Room N217	200 l/s	1/10 HP	Thermostat
EF-8	Fume Hood	378 l/s	1/4 HP	Manual
EF-9	Fume Hood	1034 l/s	1/4 HP	Manual
EF-10	Fume Hood	378 l/s	1/4 HP	Manual
EF-11	Fume Hood	378 l/s	1/4 HP	Manual
EF-12	Science 256	800 l/s	1/4 HP	DDC / AC-4
EF-13	Science 258	900 l/s	1/4 HP	DDC / AC-4
EF-14	Physics 202	900 l/s	1/4 HP	DDC / AC-4
EF-15	Biology 264	900 l/s	1/4 HP	DDC / AC-4
Ef-16	Chemistry 201	Unknown	Unknown	DDC / AC-4
EF-17	Washroom, Ground Floor	Unknown	Unknown	DDC / AC-4
EF-18	Welding Hood	1228 l/s	5 HP	Manual
EF-19	Heat Treatment 241	236 l/s	1/4 HP	Thermostat.
EF-20	Finish Room 232	455 l/s	1/3 HP	Switch (light)
EF-21	Foods 255	Unknown	Unknown	DDC / AC-5
EF-23E	Change Room	1025 l/s	1/3 HP	DDC / HV-8
EF-24	Gym Storage 144	Unknown	Unknown	DDC / HV-8
EF-25	Weight Room 145	566 l/s	1/3 HP	Manual
EF-26	Storage 124	71 l/s	161 W	DDC
EF-27	Rooms W246 W247	457 l/s	1/3 HP	DDC / AC-5
EF-28	Medical Room N106	154 l/s	100 W	Manual
EF-29	Elevator Machine Room	94 l/s	100 W	-
EF-30	N142A	306 l/s	Unknown	-
EF-31	Electrical 108	958 l/s	3/4 HP	-

4.5 Domestic Hot Water System

Each building has its own domestic hot water (DHW) system, shown in Table 4.

Table 4: Domestic Hot Water

Block	Heaters	Heating capacity	Storage	Recirculation Pump
South Block	Electric DWH heater	12 kW	404 liter	Fractional
North Block	Two atmospheric gas-fired heaters	2 x 400 MBH (input)	2 x 80 US Gal	1/25 HP

4.6 Controls System (includes Lighting Controls if Applicable)

The HVAC system is controlled by a Delta Controls DDC system, using ORCAView 3.40 software. Remote access to the system is available. DHW is not on the DDC. Trend data is seldom available for more than a day.

4.7 Others

The school has a 40.8 kW solar PV system on the roof of the South Block. It was installed in 2017 and produces approximately 47,000 kWh electricity annually.

5.0 Measures Selected for Implementation (Under C.Op. Program)

This section provides an overview of each measure, recommendations for implementation, and update after implementation.

5.1 Measure 1: Air Handler Heating Control Valves Passing

5.1.1 Description of Finding

Several air handlers appear to have passing heating coil control valves, based on the rise in temperature between mixed air temperature and supply air temperature, with the heating valve closed. During conditions when the boilers were disabled, the temperature rise was confirmed to be approximately 1°C (or less) which is what is expected from just the fan.

HV-2

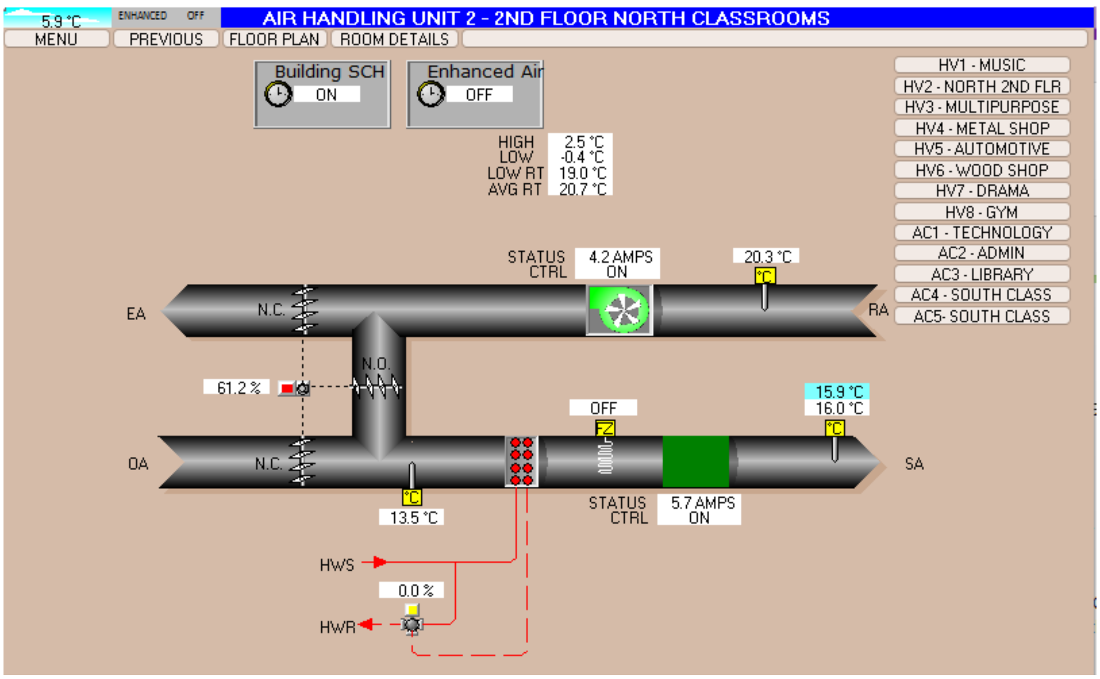


Figure 4: Heat rise across the AHU-2 heating coil is 3.5°C with its control valve closed

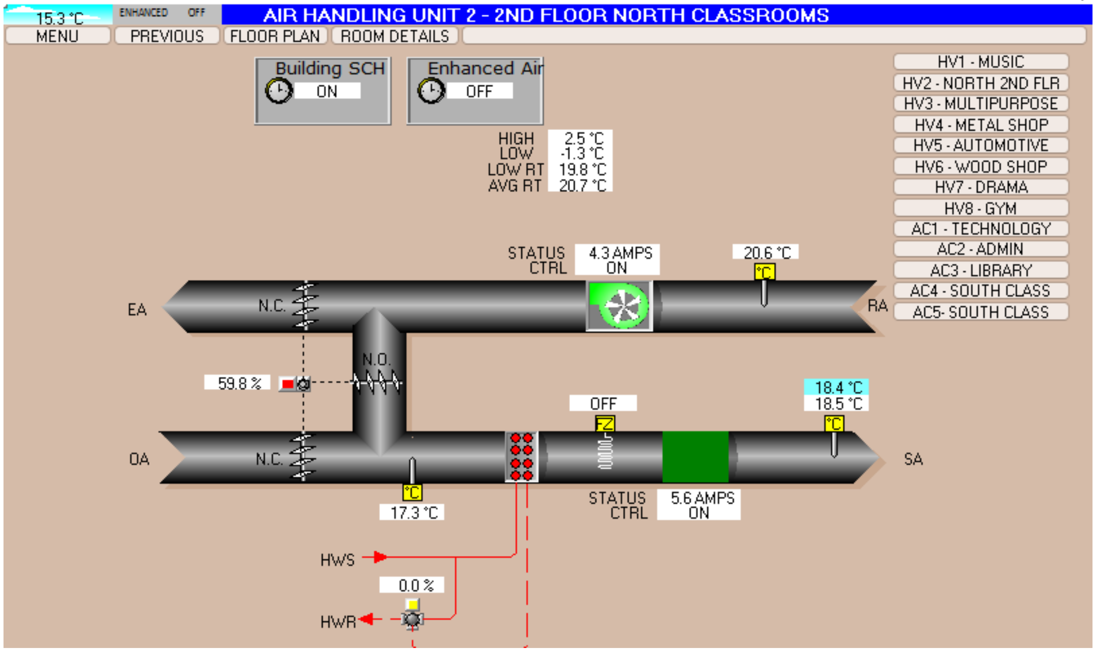


Figure 5: AHU-2 Heat rise across the heating coil drops to 1.2°C when the boilers are disabled and the coil is cold.

HV-3

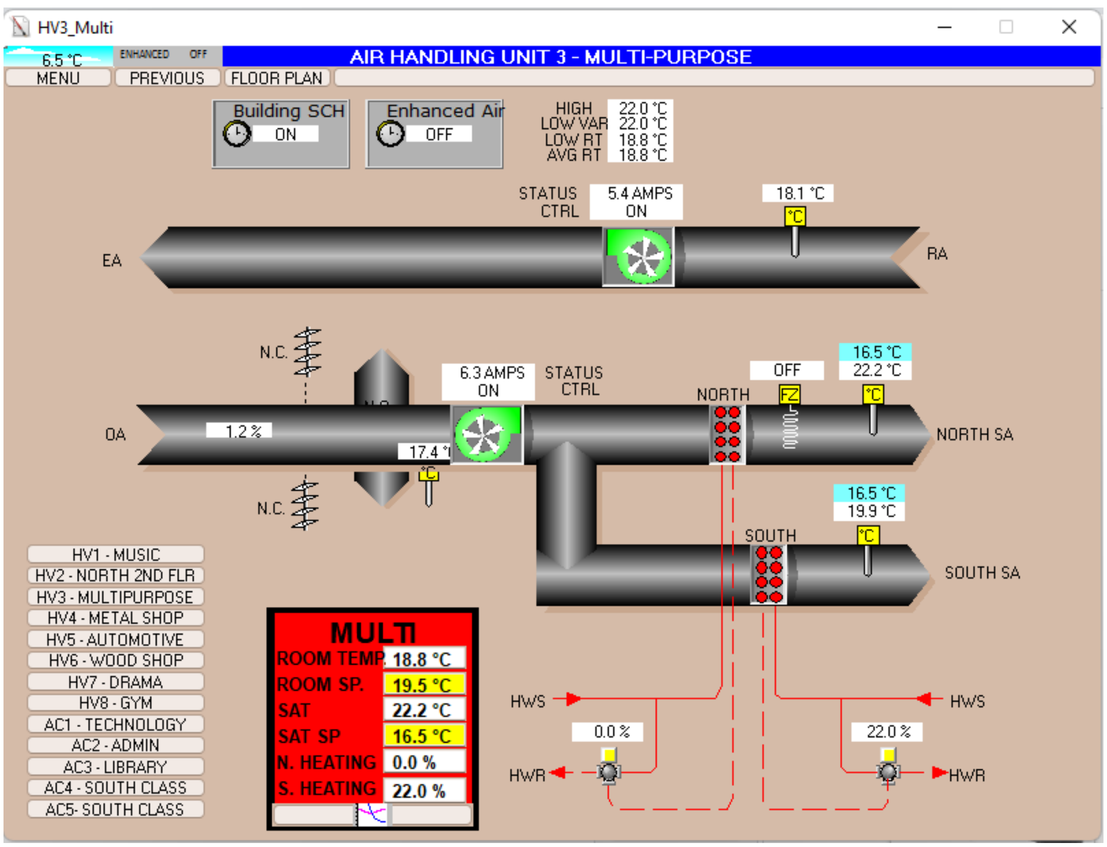


Figure 6: Heat rise of 4.8°C across the AHU-3 north supply air heating coil

HV-4

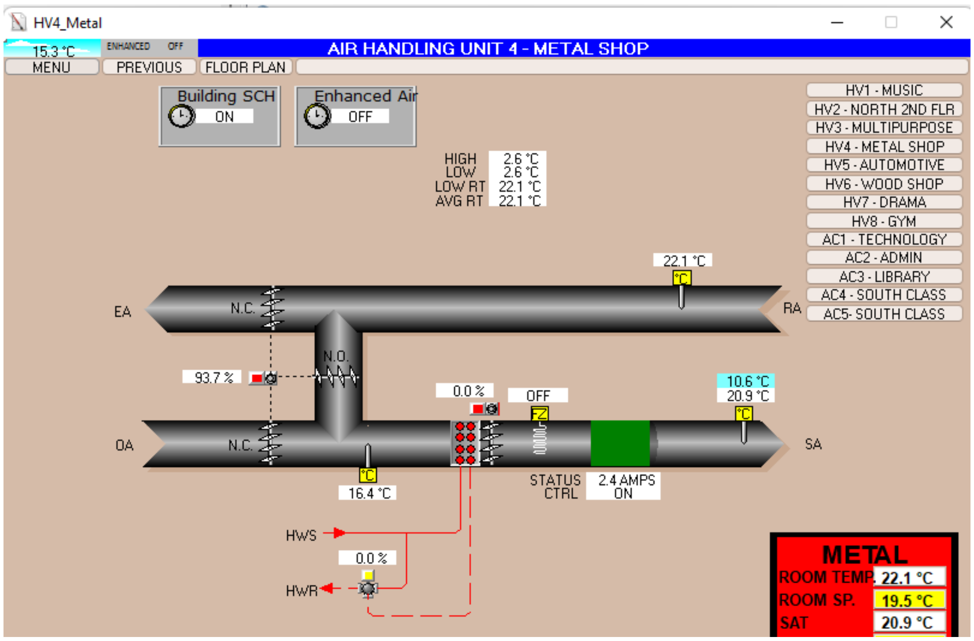


Figure 7: Temperature rise across the heating coil is 4.5°C with the control valve closed.

HV-6

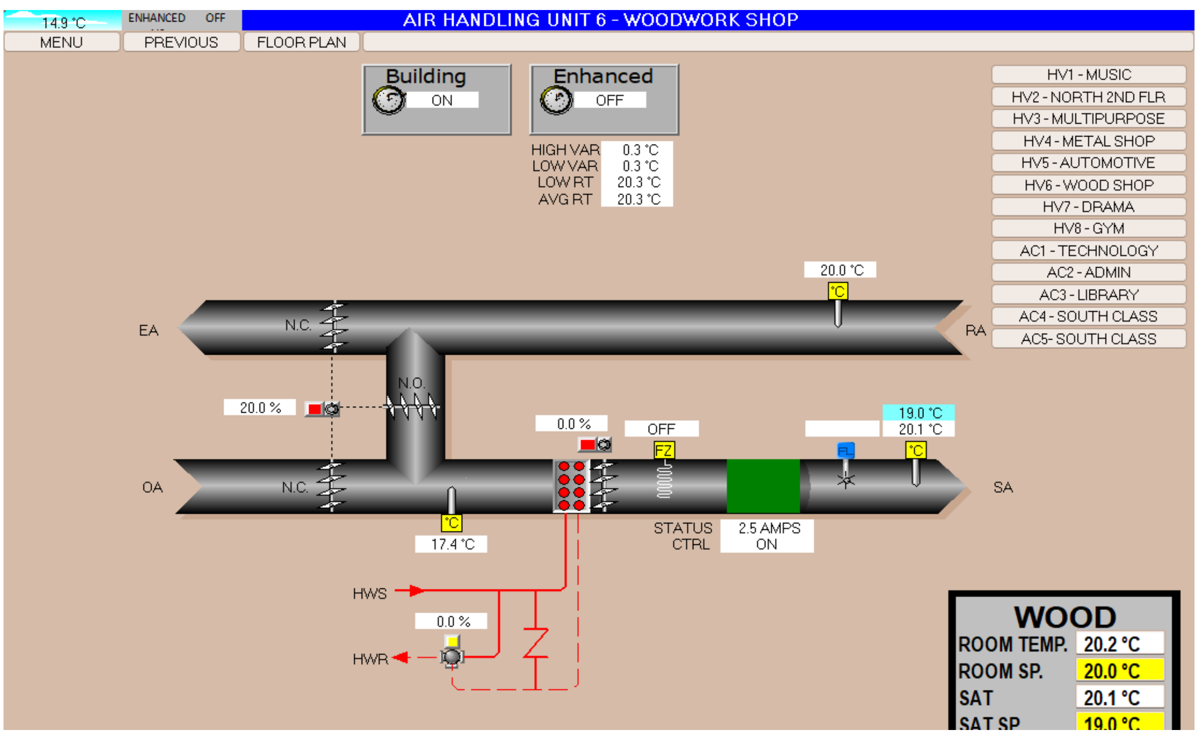


Figure 8: Temperature rise of 2.6°C across the heating coil with the control valve closed.

HV-8

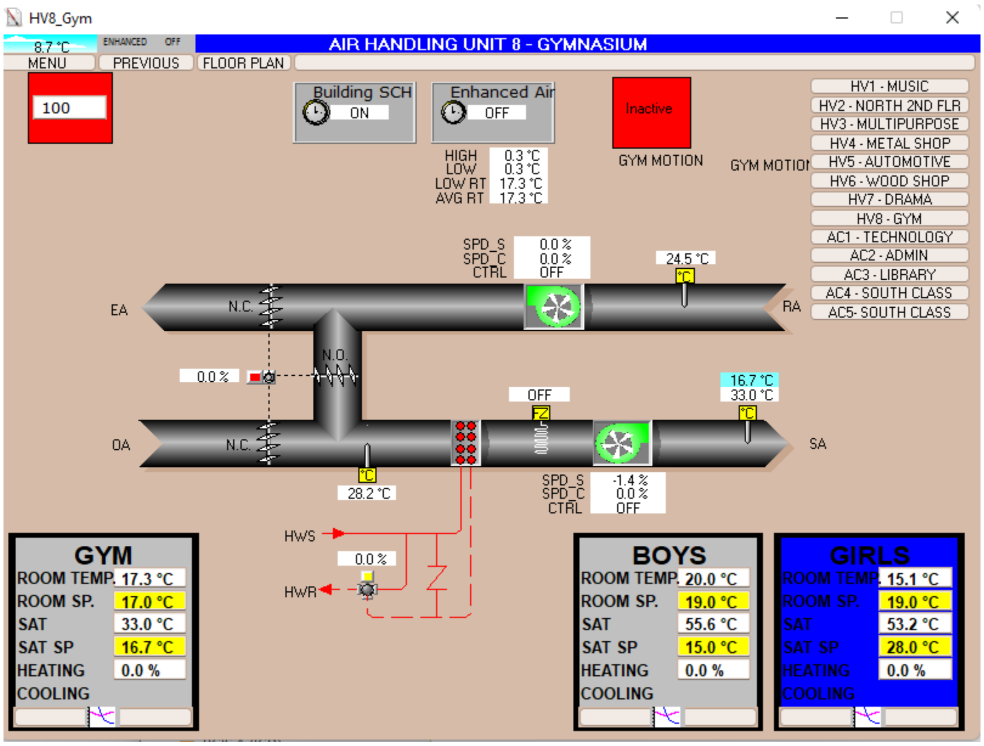


Figure 9: HV8 has a temperature rise of 7.5°C across the heating coil

AC-2

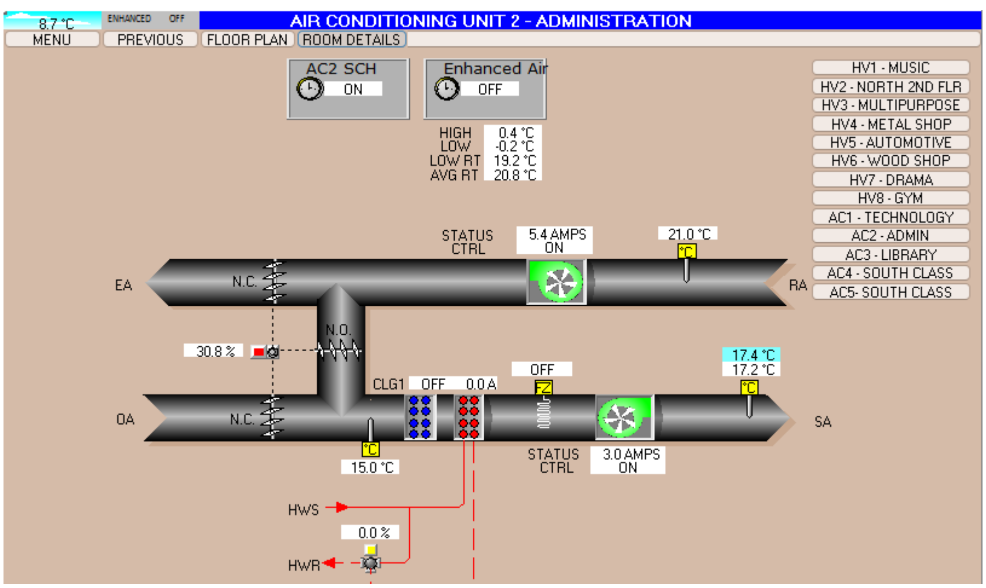


Figure 10: AC-2 showing a rise in air temperature across the heating coil with its control valve closed.

5.1.2 Measure Description

Validate heating valve issues with manual temperature readings in the field:

Operate the mentioned air handlers with the supply fan enabled and the heating coil control valve commanded fully closed (0%). Manually measure the air temperature at the coil inlet and outlet. A temperature rise indicates a passing valve. Furthermore, the heating coil inlet and outlet pipes should be cold after the control valve is closed for several minutes. Diagnose the valve issue as required, including replacing the valve, or repairing control parts.

Since this issue has affected multiple units, there may be an issue with heating loop water. Water quality should be tested and water treatment processes should be reviewed.

5.1.3 Measure Implementation Update

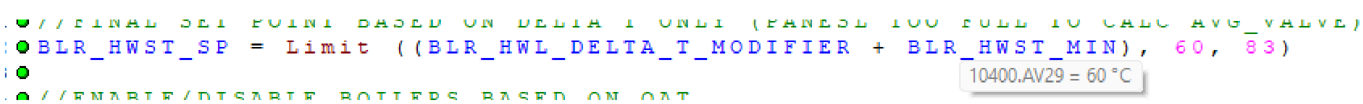
[Provide confirmation details **AFTER** the measure is implemented and verified]

5.2 *Measure 2: Boiler Setpoint Optimization*

5.2.1 Description of Finding

The boiler control program resets the boiler supply water temperature setpoint when heating demand is low. Heating demand is determined by the temperature difference between supply and return water.

However, regardless of the load, this setpoint is not allowed to drop below 60°C. The efficiency of condensing boilers increases as loop temperatures drop and operating the boilers at higher temperatures does not take advantage of their higher efficiency.



We observed the boilers operating in several conditions, with outdoor temperatures down to 7°C, and the setpoint did not rise above 60°C. We were not able to observe the boilers in any conditions in which the building required higher heating water temperatures.

5.2.2 Measure Description

We recommend updating the boiler supply temperature reset logic to use trim and respond logic based on zone feedback (i.e., the position of heating valves required to maintain the room temperature). This will reduce the boiler temperature to the lowest that keeps all zones comfortable, operate the boilers at highest possible efficiency, and reduce distribution losses.

The algorithm also identifies which zones require the highest loop temperature. There may be issues with equipment in these zones, for example blocked or passing heating coil valves (see ECM 5.1 and ECM 5.6) which should be corrected first, or it may just be due to the selection of coils/equipment in these zones.

We also recommend enabling long term trending for the heating system, including water supply and return temperatures, and heating valve positions and room temperatures, will provide important insights for future electrification of the heating system.

5.2.3 Measure Implementation Update

[Provide confirmation details **AFTER** the measure is implemented and verified]

5.3 Measure 3: AHUs Running Overnight

5.3.1 Description of Finding

HV-1, HV-2, and AC-1 are programmed to operate for normal operation whenever the variable CLASS_SCH_BV is ON. This variable is always on and appears to have no Control Source (e.g., schedule). Therefore, these AHUs operate continuously in occupied mode, causing unnecessary fan energy use and gas consumption (for ventilation heating).

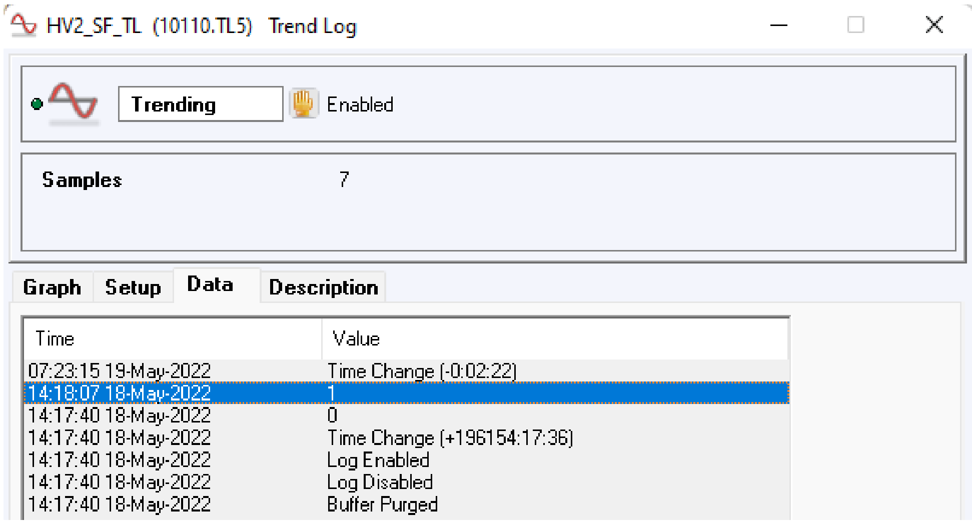


Figure 11: HV-2 supply fan trend show it turned on for the last several months.

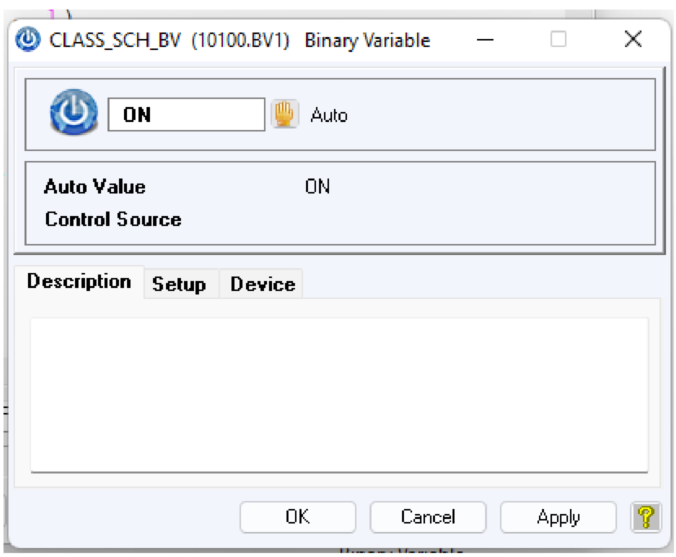


Figure 12: CLASS_SCH_BV has no "Control Source" program changing it

```
     HV1_LOW_RT = Min (RMN122_RT_AV, RMN130_RT_AV)
     HV1_AVG_RT = Average (RMN122_RT_AV, RMN130_RT_AV)
     HV1_OCC = Max (CLASS_SCH_BV, HV1_OS_BV)

End Do

---
//SYSTEM START-UP MODE
If (HV1_OCC = On) Or (BUILDING_FLUSH_BV = On) Or (Enhanced_Air_Ad
     HV1_RFC = On
     HV1_NSB_BV = Off
Else
```

10106.BV21 = ON

Figure 13: HV-1 is enabled in occupied mode due to the value of CLASS_SCH_BV

```
 HV2_LOW_RT = Min (RMN206_RT_AV, RMN208_RT_AV, RMN
 HV2_AVG_RT = Average (RMN206_RT_AV, RMN208_RT_AV,
 HV2_OCC = Max (CLASS_SCH_BV, HV2_OS_BV)
End Do
```

Figure 14: HV-2 enabled by the value of CLASS_SCH_BV

```
AC1_AVG_RT = Average (RMN214_RT_AV, RMN215_RT_AV)
AC1_OCC = Max (CLASS_SCH_BV, AC1_OS_BV)
```

Figure 15: AC-1 enabled by the value of CLASS_SCH_BV

5.3.2 Measure Description

The occupancy mode logic for HV-1, HV-2 and AC-2 should be updated to refer to the main building operating schedule (KSS_CLASSROOM_SCH)

5.3.3 Measure Implementation Update

[Provide confirmation details **AFTER** the measure is implemented and verified]

5.4 Measure 4: Weekly schedule

5.4.1 Description of Finding

Kwalikum Secondary's main operating schedule (KSS_CLASSROOM_SCH) starts at 4am Monday to Wednesday, and 7am Thursday and Friday. The later start on Thursday and Friday indicates that the school typically warms up in time even with a later start.

In addition, the schedule includes one hour of occupancy from 6-7pm Monday to Friday. It is unclear what this is for.

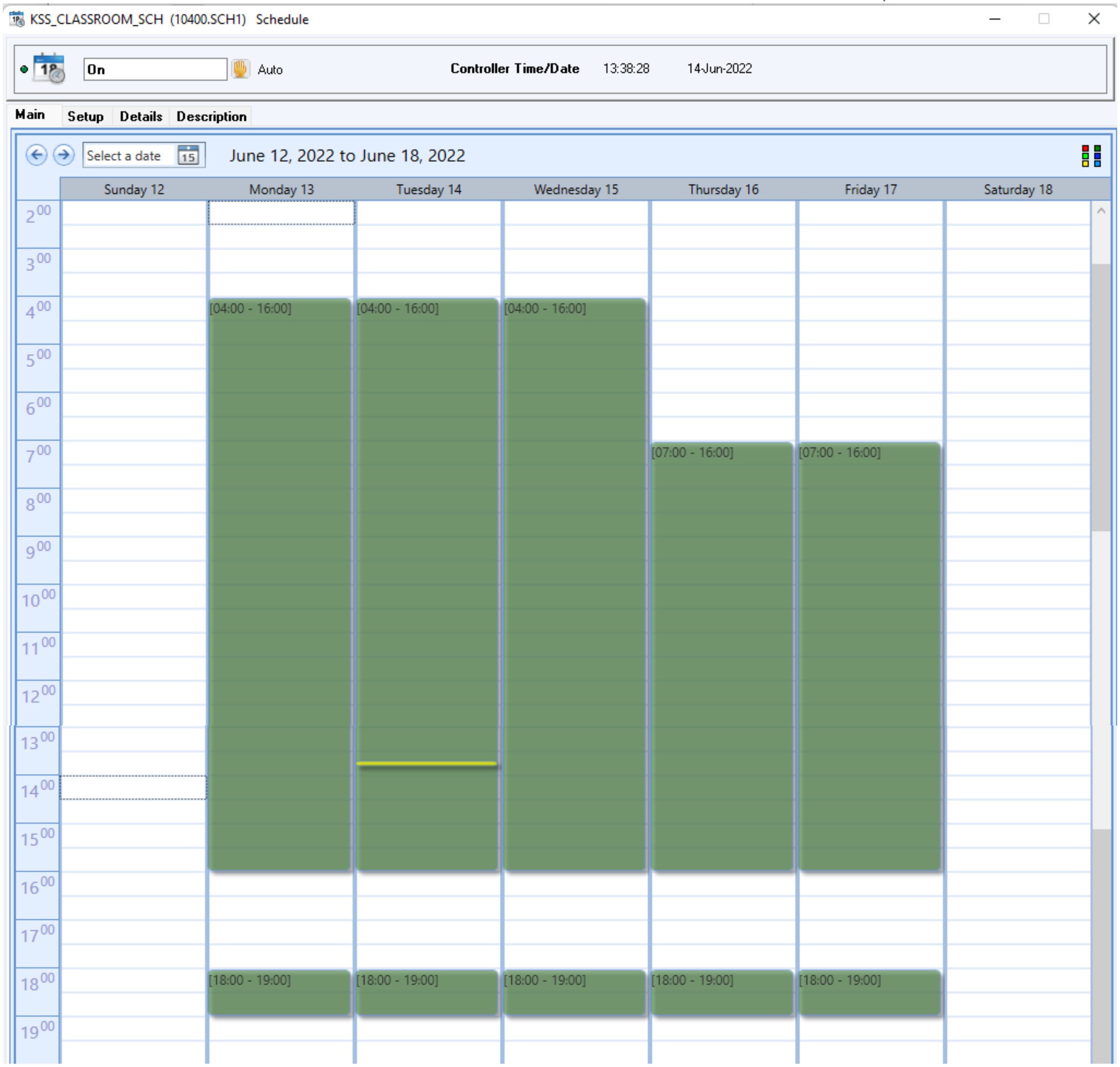


Figure 16: Main operating schedule

5.4.2 Measure Description

Program the DDC to adjust start times based on outdoor air temperature and room temperatures, since it takes more time to warm up the building on a cold morning than on a warmer day when the building has retained most of the heat from the previous day. This is commonly known as "optimal start". The start time should be calculated separately for each air handler, since they have different occupancy times

5.4.3 Measure Implementation Update

[Provide confirmation details **AFTER** the measure is implemented and verified]

5.5 Measure 5: Night Setback

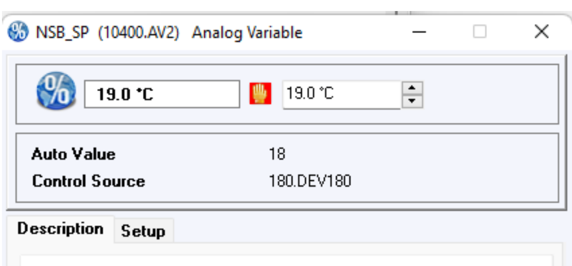
5.5.1 Description of Finding

Lowering the building temperature at night, commonly known as "night setback", reduces the heating required. The school DDC already has logic to do this, but the night setback temperature is between 19°C and 20°C for most zones per Table 5, which is too high to provide any significant savings.

Table 5: Current night setback temperatures

Unit	Night setback
HV-1, HV-2, HV-3	19.9°C
HV-4 to HV-7	19°C
HV-8	14°C
AC-1, AC-2	19.9°C
AC-3, AC-4, AC-=5	19°C
Radiators	19°C
Fan coils	No setback

Some units follow the global night setback variable. This has been overridden to to 19°C.



The night setbacks for other units are calculated using various equations. In some cases, the logic refers to undefined values which may result in unpredictable results.

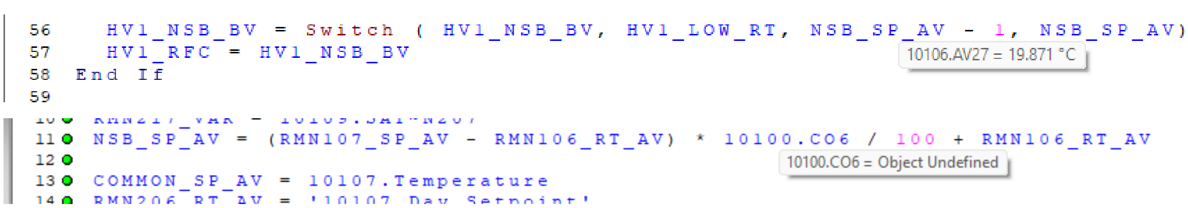


Figure 17: NSB calculations for HV3 refers to undefined values

5.5.2 Measure Description

Change the night setback for all zones and equipment to 15°C. Link all zones to the global night setback temperature setpoint.

Where available, enable terminal units including radiators and fan coils before AHUs during unoccupied periods. This will reduce AHU operating hours, saving fan energy use while still heating the zones.

5.5.3 Measure Implementation Update

[Provide confirmation details **AFTER** the measure is implemented and verified]

5.6 Measure 6: Reheat Coils Passing or Blocked

5.6.1 Description of Finding

Several reheat coils were found to be operating incorrectly. Some appear to be blocked: they did not provide any heating even when commanded open. This indicates an issue with the control valve sticking closed, the coil obstructing water flow, or a lack of air flow through the coil.

Other coil control valves appear to be passing: the coils provided heat when the control valves were commanded closed. This indicates an issue with the control valve mechanism, wiring, or programming.

Both issues cause comfort issues in the space served by the coil. They can cause the associated air handler to raise or lower supply air temperature which can affect comfort in other. Both issues can increase energy use.

A summary of problem reheat coils is provided in Table 6.

Table 6: Reheat coil issues

Air handler	Blocked Coils	Passing Coils
HV-1	RM129, RM125, RM126	
HV-2	RM113, RM115, RM204, RM207	RM208, RM210, RM114
HV-7	RM220, RM225	
AC-1		RM214
AC-2	RM101, RM104, RM106, RM134, RM137, RM102 (also passing?)	RM102
AC-3	RM215	RM211E, RM211W
AC-4	RM101, RM105, RM114, RM204A, RM257, RM258	RM103C, RM104,
AC-5	RM251, RM255	RM208

Examples of issues are shown in Figure 18 and Figure 19.

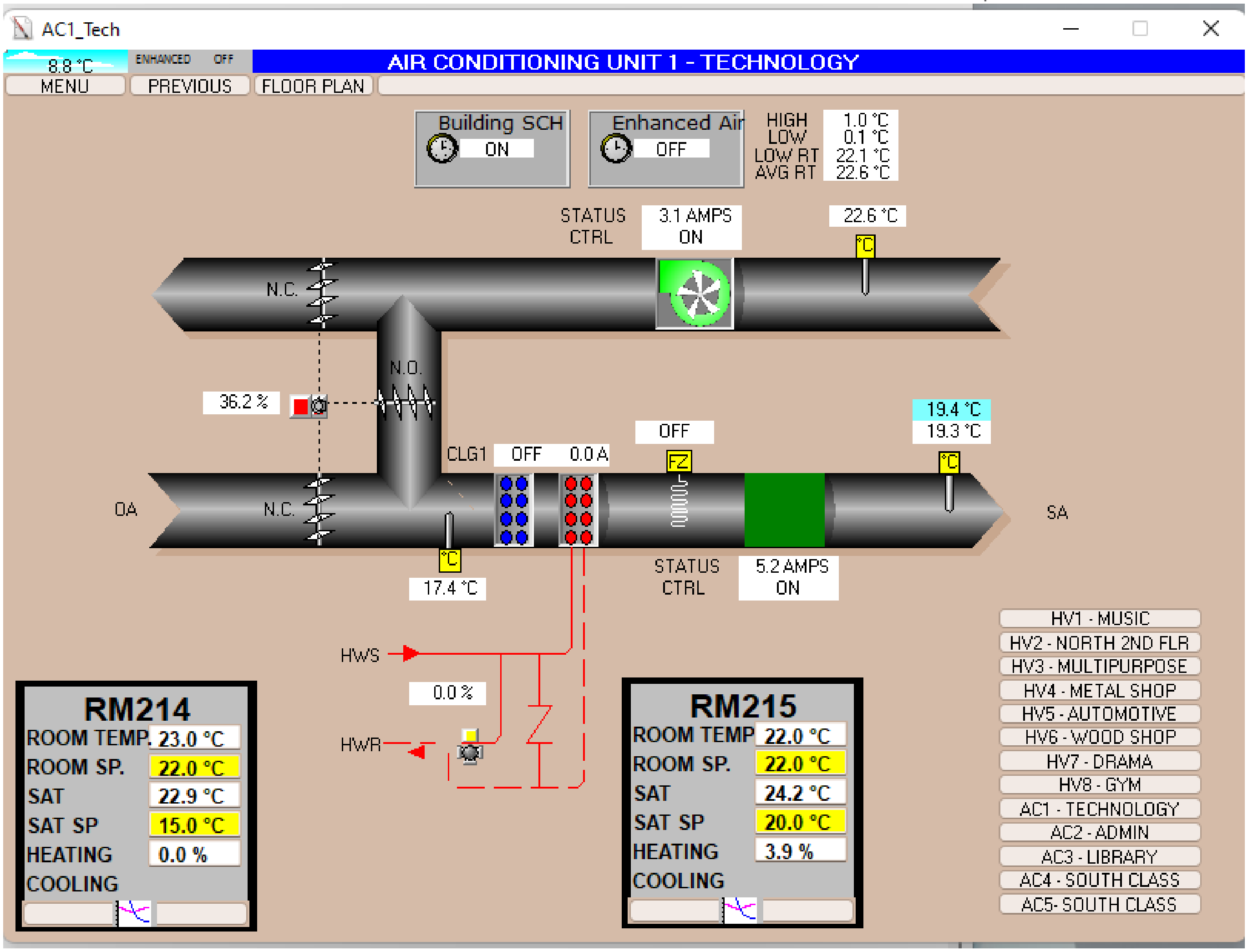


Figure 18: RM214 supply air temperature is 3.5°C hotter than provided from AC-1, even with reheat coil control valve closed.

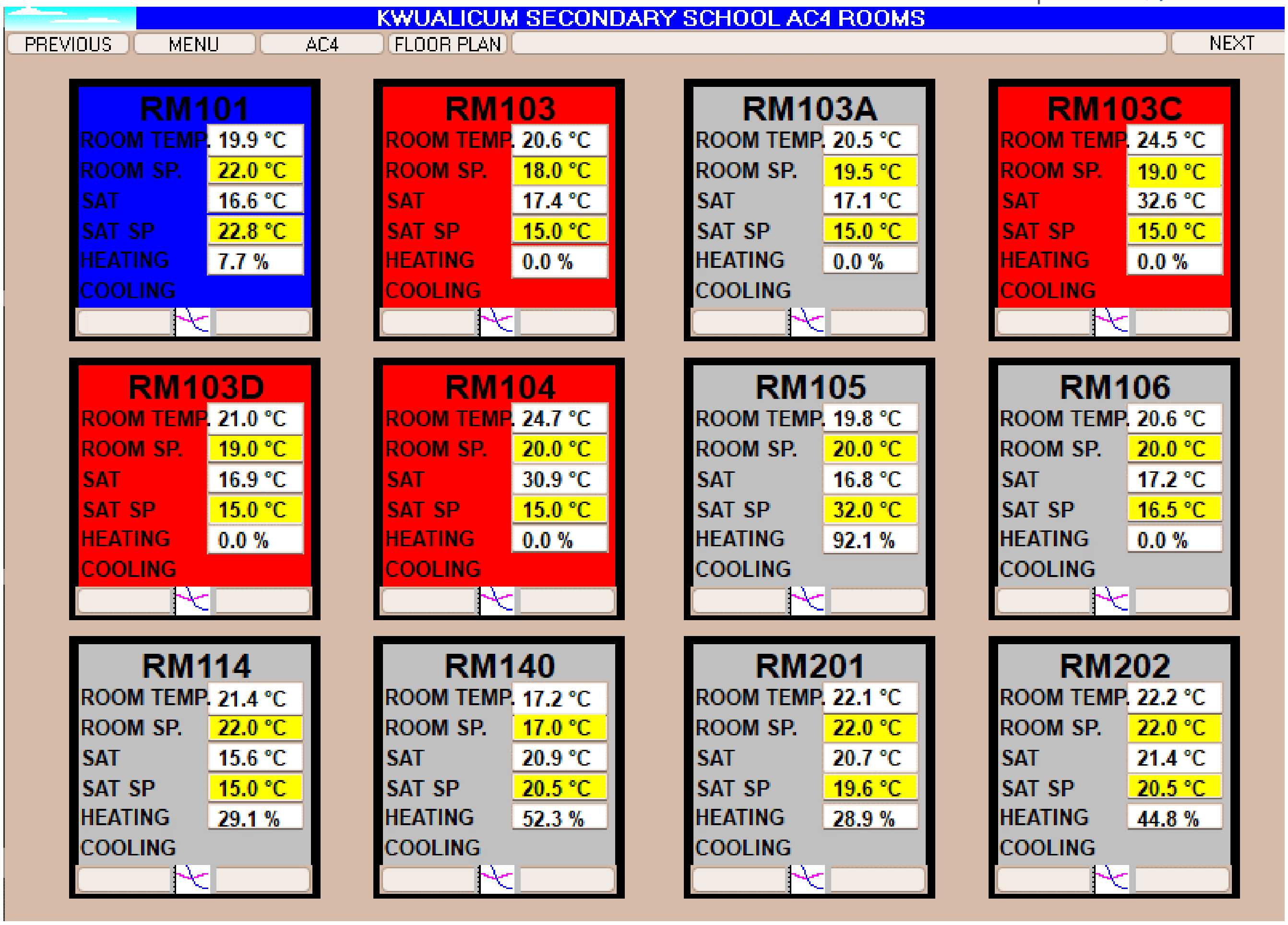


Figure 19: AC-4 reheat coils. The supply air from the air handler was 17.2°C. RM103C and RM104 have much higher supply air temperature with no reheat. RM105 has no heat increase with its heating coil control valve 92% open.

5.6.2 Measure Description

Each problem reheat coil should be diagnosed and repaired. This may include repairing or replacing the valve, control components, or even the coil itself. Our costing estimates that approximately half of the identified coils need new valves, and that the rest of the issues can be resolved with simple repairs (recalibrating actuators, cleaning coils, etc.). If any reheat coils are replaced, they should be sized for 45°C or less entering heating water at design conditions to accommodate future efficiency projects.

5.6.3 Measure Implementation Update

[Provide confirmation details **AFTER** the measure is implemented and verified]

5.7 Measure 7: HV-7 and HV-8 Outdoor Dampers

5.7.1 Description of Finding

HV-7

The control logic for HV-7 fully closes the outdoor air damper because Enhanced_Air_Mode is commanded off. This stops HV-7 from cooling its zones with outdoor air. Furthermore, the lack of outdoor air ventilation reduces indoor air quality.

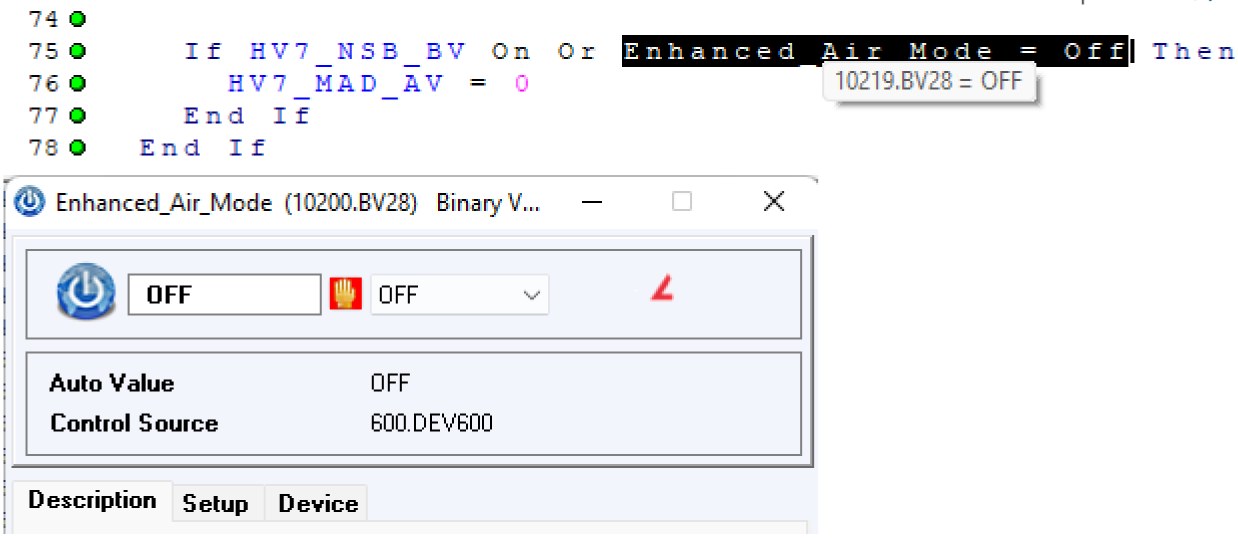
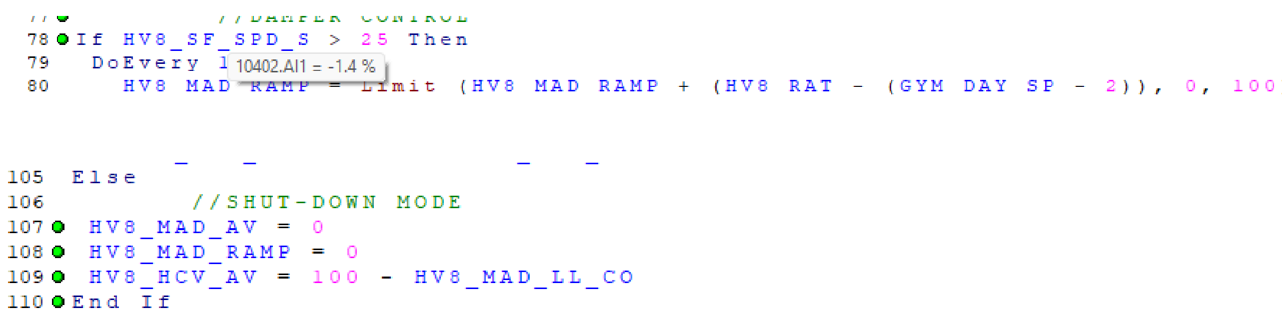


Figure 20: HV-7 MAD closes since Enhanced_Air_Mode is off

HV-8

The HV-8 supply fan feedback sensor returns -1.4%, which is interpreted as the fan has failed. The control logic thus activates HV-8's "shutdown" mode. This keeps the mixed air dampers closed, leading to indoor air quality and comfort issues.



5.7.2 Measure Description

Remove the reference to Enhanced_Air_Mode in the HV-7 logic mixed air damper logic.

Confirm if the HV-8 feedback sensor matches actual fan status and replace if necessary.

There are no energy savings associated with this measure.

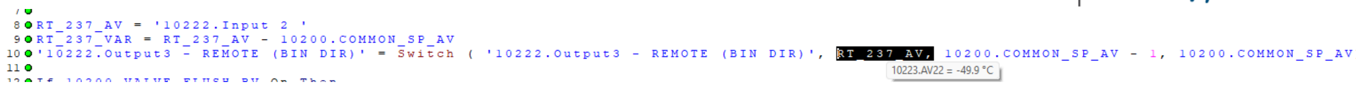
5.7.3 Measure Implementation Update

[Provide confirmation details **AFTER** the measure is implemented and verified]

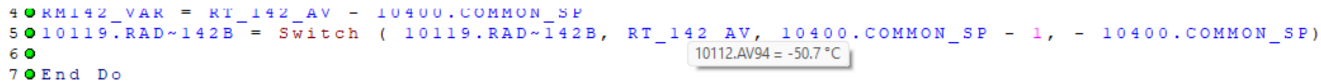
5.8 *Measure 8: Broken Sensors*

5.8.1 Description of Finding

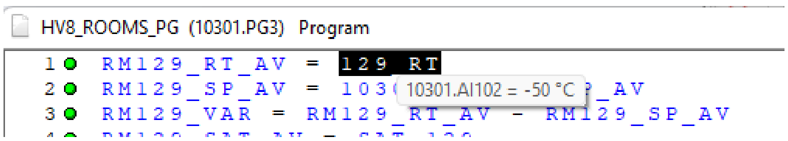
The Corridor 237 room temperature sensor reads -49.9°C. This causes the associated convective heater to operate continuously.

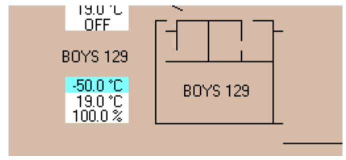


North block Sprinklers 142B room temperature sensor is reads -50.7°C, causing the radiator to be enabled continuously.



The boys change room (Room 129) room temperature sensor reads -50.0°C, causing the reheat coil serving the space to stay at 100%, heating continuously.





Operating heaters continuously overheats spaces, reducing comfort and wasting energy.

5.8.2 Measure Description

Ensure the room temperature sensors are properly connected to the DDC. Replace the sensors where broken.

5.8.3 Measure Implementation Update

[Provide confirmation details **AFTER** the measure is implemented and verified]

6.0 Measures to be considered for Future Implementation

This section provides an overview of each measure (that was identified but **was not selected** as part of this C. Op. project, but maybe considered for future implementation), recommendations for implementation, and the most suitable method for providing evidence of implementation. See Appendix A - Investigation Phase Summary Table for more details.

6.1 Measure 9: Four Dual-Fuel Roof Top Units

Four of Kwalikum Secondary's air-conditioning rooftop units (AC-1, AC-2, AC-3 and AC-5)[1] are 20 years old and nearing the end of typical useful service life. Their DX cooling systems use R-22 refrigerant, which is obsolete.

When the units need to be replaced[2], we propose selecting dual-fuel rooftop units equipped with reversible air source heat pumps in place of the existing DX systems. Air source heat pumps provide efficient low-emission heating as well as cooling. The retrofit units would retain heating coils for supplementary heating from the central boilers plant. The heating coils should be compatible with low entering heating water temperature (<50°C at design conditions).

Measure costs assume all four units are replaced.

6.2 Measure 10: Central Air Source Heat Pump

The gas-fired heating plant can be supplemented with an air source heat pump. This can achieve significant gas (and emissions) reduction, even with a unit sized for only part of the full heating load, since it can often meet all heating requirements at mild temperatures and supplement the existing gas boilers during colder periods.

The heating loop is currently operated above 60°C heating water supply temperature continuously. This is too high to be served by commercially available air source heat pumps. However, analysis of the DDC indicates that it would be possible to reduce the loop temperature, while providing adequate heating, at least in milder conditions.

We recommend a feasibility study during the next heating season, after implementing logic to reduce the loop temperature (see ECM 5.2). The investigation will identify the required upgrades to the distribution equipment (mainly the heating coils) required to operate the building at loop supply temperatures at 50°C for a significant part of the heating season. This equipment can be upgraded as part of regular replacement cycle, or on a more aggressive schedule. Note that any reduction in loop temperature will provide immediate gas (and emissions) savings as the system efficiency is improved. Heat pump capacity can be added incrementally, as the system is adapted to operate at low loop temperatures at colder temperatures.

Reversible heat pump can also provide chilled water, and it should be explored whether this is a practical and economical method for providing cooling in any of the existing units. As an example, we've explored cost and energy savings from replacing the aging condensing unit in AC-4 with a 60T reversible air-to-water heat pump. During heating season, the unit can produce hot water for the heating loop. During cooling season, it can produce chilled water piped to a new cooling coil in AC-4. The calculated savings assume the heating loop can be operated at temperatures of 50°C (or below) when the outdoor temperature is 6°C or warmer.

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[1] A fifth air conditioning unit, AC-4, is located inside in the mechanical penthouse and likely has a different replacement schedule and options. The condensing unit for AC-4 is due for replacement and has been considered in ECM 6.2.

[2] If the units are in good condition, an alternative strategy is to replace only the DX coils and serve these with external VRF units which provide both heating and cooling.

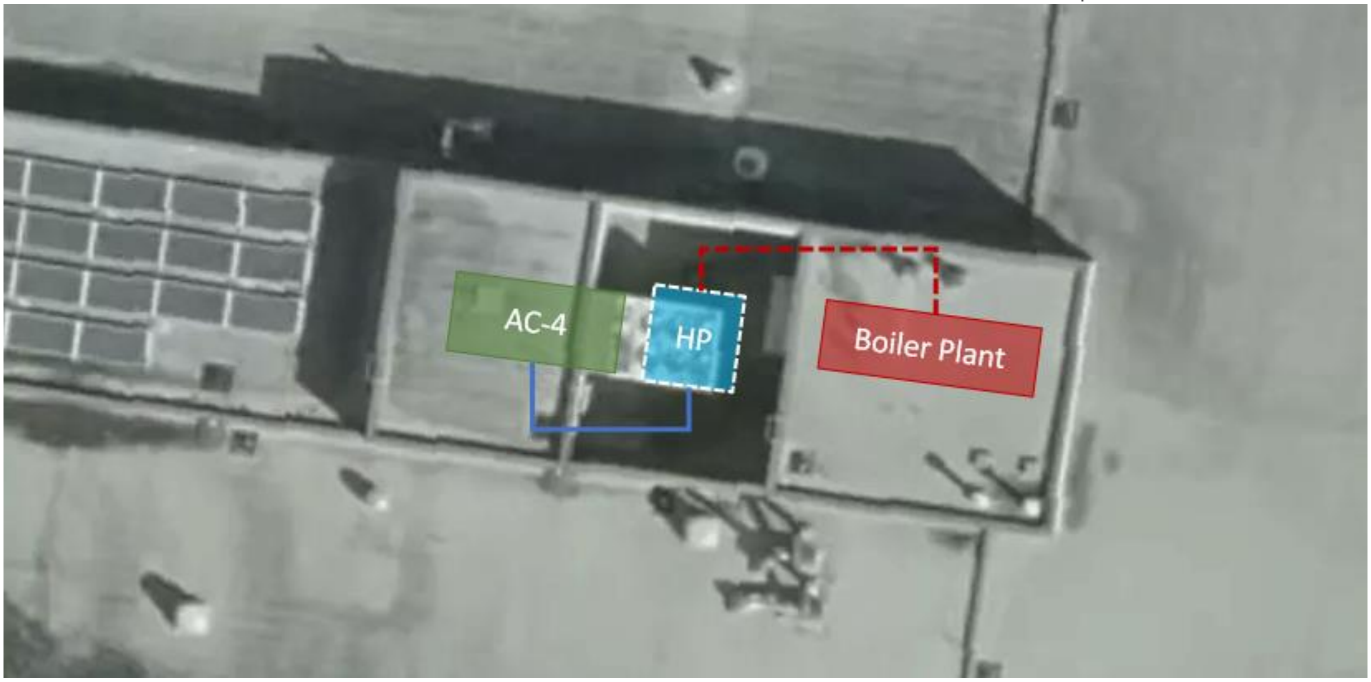

Figure 21: Possible location for an air-source heat pump serving both AC-4 and the central heating loop

7.0 Next Steps – Implementation Phase and Completion Phase

7.1 Implementation Phase

To continue in the program, the owner is responsible for implementing the selected bundle of measures that pay back in two years or less. Using the *Recommissioning Report* for implementation allows flexibility in how the selected measures are implemented. Options include: utilize in-house building staff, hire the C.Op Provider to implement or provide technical assistance, contract with outside service contractors, or any combination of the above.

7.2 Completion Phase

C.Op Service provider will follow up after implementation of the selected measures and **update** this *Recommissioning report and Recommissioning Workbook*.

The updated report for the implemented measures includes but not limited to: date of completion of each measure, new or improved sequences of operation, the energy savings impact of the measures, the requirements for ongoing maintenance and monitoring of the measures, and contact information for the service provider, in house staff, and contractors responsible for the implementation. When feasible, verification data should include trends or functional test results, though other methods, such as copies of invoices, site visit reports, and before/after photos, may be acceptable.

The C.Op Service Provider will conduct an in-house (teleconference) session for the Applicant and the appropriate building operations personnel covering the new documentation, measures that were implemented, and requirements for ongoing maintenance and monitoring. Document the attendance of the building operations staff.

The *updated Recommissioning Workbook* and *updated Recommissioning Report* will be submitted to the owner and the program for review. See Appendix B: Completion Phase Summary Table for more details on implemented measures.

Appendix A: Investigation Phase Summary Table

Investigation Phase Summary				Investigation Phase							
				Energy Savings			Cost Savings	Financial		Est. GHG Reduction	
ECM #	Measure Title	Measure History	Include cost	Demand (kW)	Electrical (kWh/yr)	Fuel (GJ)	Total ($/yr)	Estimated Measure Cost ($)	Simple Payback (yrs)	tonnes CO2e/yr	Enter "x" if DESELECT for implementation
ECM-1	Air Handler Control Valves Passing	New	1	-	-	1,164	$ 14,116	$ 2,900	0.2	58.1	
ECM-2	Boiler Setpoint Optimization	New	1	-	-	182	$ 2,209	$ 6,000	2.7	9.1	
ECM-3	AHUs running overnight	New	1	-	147,432	311	$ 18,272	$ 400	0.0	17.1	
ECM-4	Weekly schedule	New	1	-	46,876	308	$ 8,351	$ 600	0.1	15.9	
ECM-5	Night Setback	New	1	-	-	709	$ 8,593	$ 700	0.1	35.4	
ECM-6	Reheat valves and coils	New	1	-	-	732	$ 8,878	$ 24,300	2.7	36.5	
ECM-7	HV-7 and HV-8 Air Dampers	New	1	-	-	-	$ -	$ 800	#DIV/0!	-	
ECM-8	Broken sensors	New	1	-	-	-	$ -	$ 1,400	#DIV/0!	-	
ECM-9	Four ASHP Hot Water RTUs	New	1	-	- 21,091	253	$ 993	$ 563,600	567.4	12.4	x
ECM-10	Central Air Source Heat Pump	New	1	-	- 96,545	1,119	$ 4,066	$ 427,500	105.1	54.8	x
TOTAL (Previous, still working):				-	-	-	$ -	n/a	n/a	-	
TOTAL (All potential measures for Implementation):				-	76,672	4,779	$ 65,480	$ 1,028,200	15.7	239.2	
TOTAL (Selected measures only):				**-**	**194,307**	**3,407**	**$ 60,420**	**$ 37,100**	**0.6**	**172.0**	
						Implementation cap @$0.25/ft2		$ 26,302			

Appendix B: Completion Phase Summary Table

[Paste image of Completion Summary Table from the RCx Workbook **AFTER** Implementation]

Appendix C: Sample Training Outline

[Completion Report AFTER Implementation]

The Commissioning Provider (C.Op Provider) may customize the outline for the training and developing the training materials. Before preparing the training outline and materials, the C.Op Provider should assess the related level of knowledge of the building operators, to set up the training accordingly. For reference, the Program provides the following sample outline for the training:

- Background on the energy use of this particular building
  - Present Energy Utilization Index
  - Describe Operating Schedules and Owner's operating requirements
- RCx investigation process used in this building
  - Describe the methods used to identify problems and deficiencies
  - Review the RCx Workbook
- Implementation process in this building
  - Describe the measures that were implemented and by whom
  - Walk around the building to look at any physical changes or step through the new control sequences at the operator workstation
  - Provide as many details about implementation as necessary to describe what was done
  - Describe improved performance that these measures will create (show trends if available)
- O&M requirements
  - Describe the O&M requirements needed to keep these improvements working
  - Describe how the staff can be aware of energy efficiency opportunities and begin looking for additional savings potential

The C.Op Provider should follow the outline to prepare materials, as necessary, to hand out at the training session.

Appendix D: Training Completion Form

Project ID

Facility Information

Company Name	Building Name(s)	
Facility Address	City	Province

Training Details

Location	Date
Commissioning Provider/Trainer	

Materials Attached

☐	Agenda
☐	Materials used for training
☐	List of individuals who attended

COMMISSIONING PROVIDER SIGNATURE

By signing this Training Completion Form, I verify that this training took place with the listed attendees.	
Commissioning Provider (print name):	
Signature:	Date:

FACSIMILE/SCANNED SIGNATURES: Facsimile transmission of any signed original document, and the retransmission of any signed facsimile transmission, shall be the same as delivery of the original signed document. Scanned original documents transmitted to BC Hydro as an attachment via electronic mail shall be the same as delivery of the original signed document. At the request of BC Hydro, C.Op Provider shall confirm documents with a facsimile transmitted signature or a scanned signature by providing an original document.

Targeted Documentation

O & M Manual

O & M Manual updated ☐	Describe updates below and attach copies of new or amended portions
O & M Manual not updated ☐	Province reasons below
Building has no O & M Manual ☐	

Building Plans ("as-builts")

Building Plans updated ☐	Describe below
Wiring diagrams updated ☐	Describe below
No plans or diagrams updated ☐	Describe below

EMS Programming

New sequences of operation on file ☐	Specify location of file and attach copy
Printed screenshots on file ☐	Specify location of file and attach copy

Equipment Manuals

Manuals for new equipment are on file ☐	Describe below (attach copy if applicable)

Checklist of subjects discussed at training

Explain investigation process and how measures were identified	☐
Describe implemented measures, and how they are reducing energy usage	☐
Building walkthrough to show implemented measures	☐
Describe methods for monitoring and maintaining optimum system performance related to implemented measures	☐
Describe scenarios where system setting changes would be required, and how to maintain optimum energy efficiency, e.g., seasonal-based manual adjustments to setpoints.	☐

List of Individuals Who Attended

Name	**Title**	**Building (address or name)**	**Contact information (e-mail and/or phone number)**