Continuous Optimization for Commercial Buildings Program

Retrocommissioning Investigation Report

14 November 2014

Prepared for:

Thompson Rivers University
House of Learning
Kamloops
COP10-403

Prepared by:

SES Consulting
#401-55 Water Street
Vancouver, BC
604-568-1800

TABLE OF CONTENTS

Introduction

SES Consulting 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 TRU House of Learning. 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.

The measures selected for implementation are presented in the *Investigation Summary Table* (see Appendix A). To ensure each measure is implemented according to the C.Op Provider's specifications, the *Retrocommissioning Investigation Report* details the recommendations for implementation and the recommended verification method to show that each measure is implemented correctly. This information can be used by the owner to specify the corrective actions and what needs to be presented to show that the correction or improvement has been successfully implemented by those responsible (e.g. controls contractor) for the implementation.

While the investigation focuses on low-cost improvements with short paybacks, major capital improvement opportunities may also be identified. Major retrofit measures are beyond the scope of the Program but other BC Hydro programs provide a variety of incentives to complete the retrofits. Two retrofits were identified as a part of this investigation that could potentially qualify for other BC Hydro programs. Retrofits include a T8 relamping and LED lighting retrofit.

BC hydro powersmart

1.0 Project Overview

Contact List	
C.Op Provider	Christopher Naismith
C.Op Firm	SES Consulting Inc.
email	christopher@sesconsulting.com
phone	(604)568-1800 ext 115
Building Owner Representative	James Gudjonson
email	jgudjonson@tru.ca
phone	(250) 852-7253
Building Engineer	Tom O'Byrne
email	tobyrne@tru.ca
phone	(250) 371-5866
BC Hydro Program Representative	Tommy Yim
email	tommy.yim@bchydro.com
phone	(604) 453-9284

Building Energy Usage Summary	
Building Size (gross sq. meters)	**7,021**
Building Size (conditioned sq. meters)	**7,021**
Annual Electric Consumption (kWh/yr)	**850,941**
Annual Electric Cost (with applicable taxes)	**$59,748**
Bulk cost per kWh (with demand charges)	**$0.070**
Utility Rate Tariff	**1600**
Fuel Type	**Natural Gas**
Annual Fuel Consumption (GJ)	**863**
Annual Fuel Cost (with applicable taxes)	**$12,545**
Fuel Cost per gigajoule	**$12.87**
Total Energy Cost (with applicable taxes)	**$72,293**
Electric Energy Use Intensity (EUI) (kWh/sq. meters)	**121**
Building Energy Use Intensity (EUI) (ekWh/sq. meters)	**155**

RCx Costs & Savings	
Implementation Cap	**$22,800**
Implementation Cost	**$52,650**
Annual Electric Usage Savings (kWh)	**114,400**
Annual Electric Usage Savings - Avg. of Year 1&2 ($)	**$10,770**
Savings as % of Total Electric Usage	**13.4%**
Annual Electric Demand Savings ($)	**$1,340**
Annual Fuel Savings (GJ)	**250**
Annual Fuel Savings ($)	**$3,217**
Savings as % of Total Fuel Usage	**29.0%**
Total Energy Cost Savings - Avg. of Year 1&2 ($)	**$15,328**
RCx Project Simple Payback	**3.8**
Savings as % of Total Energy Cost	**21.2%**

2.0 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.

Facility Description

This 6,215 m^2, four level building was constructed in 2009. It houses a library, a tiered pit house / lecture hall (The Gathering Place), a library café, a writing center, instructional and study spaces, training labs, classrooms, the First Nation Business Faculty and office areas.

Heating System

The heating system consists of three water to water heat pumps, and two condensing boilers serving two AHUs, fan coils, wall fins, perimeter radiation and radiant slabs.

Chilled Water System

Chilled water is provided by the three water to water heat pumps and is circulated through fan coil units, air handling units and the perimeter slab radiation during the cooling season.

Ventilation System

Ventilation for the building is provided by two air handling units and several exhaust fans with pumped glycol heat recovery. The AHUs will re-circulate some portion of the total air volume when carbon dioxide levels permit

Domestic Hot Water System

Domestic hot water is generated using the boiler loop during the winter. In the summer, when the boiler is turned off, the DHW is heated using electric heaters.

Control System

A Johnson Controls Metasys DDC system is provided and can be accessed via the Internet.

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

This section provides an overview of each measure, recommendations for implementation, and the most suitable method for providing evidence of implementation. For each measure, costs, payback calculations and incentive amounts can be referenced in the *Investigation Summary Table* (see **Appendix A).**

3.1 Measure 1: Boiler OAT lockout and weather predictor

Overview

Currently heating cooling switchover is set to OAT of 12°C for the winter. The operator manually changes this based on the time of year. AHUs return air units with heat recovery. DHW is supplied by a supplemental electric heater when the boilers are disabled.

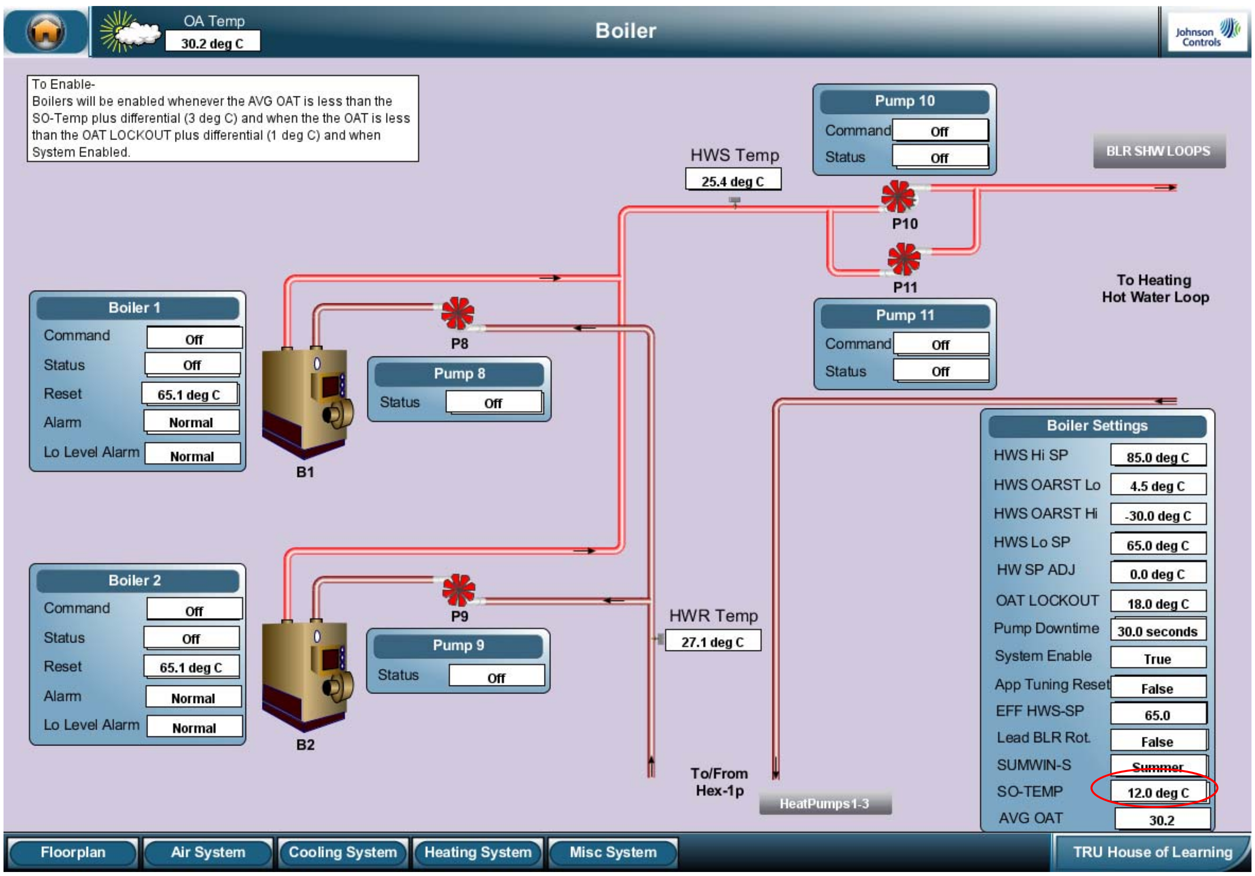

Figure: Switchover temp is 12°C in the cooling season and is reset manually be the operator

Recommendations for Implementation

Implement a seasonal reset for switchover temperature to eliminate manual reset. Apply weather predictor to lock out heating in mornings when the afternoon will be hot.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.2 Measure 2: Scheduling and Optimal Start

Overview

The current schedule for AHU 2 and fan coil units (FCUs) are frequently scheduled beyond typical occupied hours. Fan coil unit fans operate continuously when scheduled.

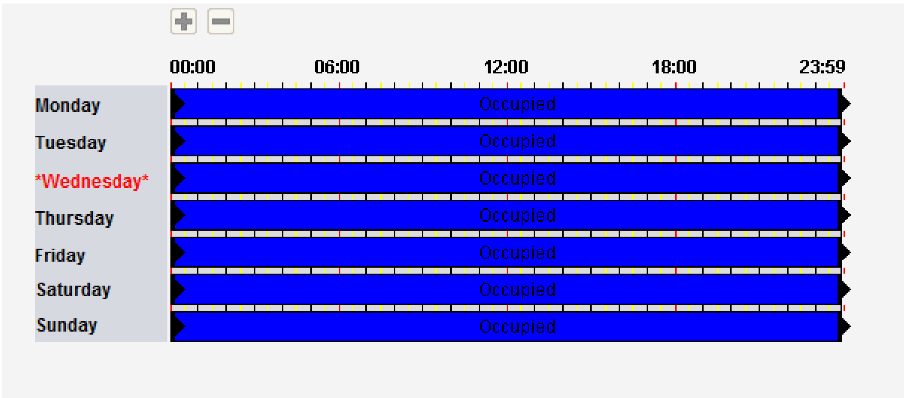

Figure: Fan coil unit schedule

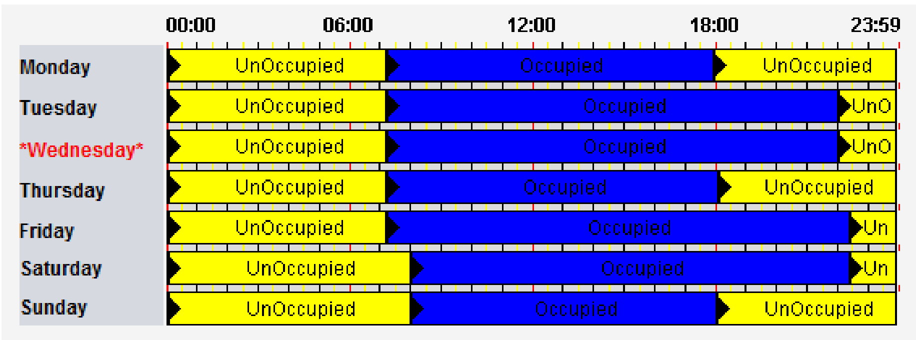

Figure: AHU2 schedule

Recommendations for Implementation

Reduce scheduled hours to match periods of dense occupancy. Implement optimal start routine using FCUs and radiation as the first stage of heating. This routine will ensure spaces are at an acceptable temperature at the start of the occupied period.

Maintain night time setbacks during the unoccupied period.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots from the DDC system.

3.3 Measure 3: Demand Controlled Ventilation Recommissioning

Overview

CO_2 setpoints are currently 500 ppm, which is very low. CO2 sensors are located in the majority of spaces, though there is no duct sensor to measure average space values. This may result in stuffiness complaints in unrepresented rooms and low overall setpoints. Many sensors are reading erroneous values, below atmospheric CO_2 levels.

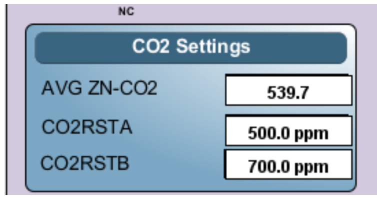

Figure: AHU2 CO_2 settings

Recommendations for Implementation

Install a duct CO_2 sensor in the return air duct of AHU 2. Raise individual space CO_2 setpoint to 1,000 ppm. Set return air CO_2 setpoint to 800ppm.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.4 Measure 4: SAT Reset

Overview

During the cooling season the average room temperature was observed to be 17°C. Under these conditions, the AHU 2 supply air temperature setpoint was 40°C, though heating was locked out. AHU 1 maintains a static SAT setpoint.

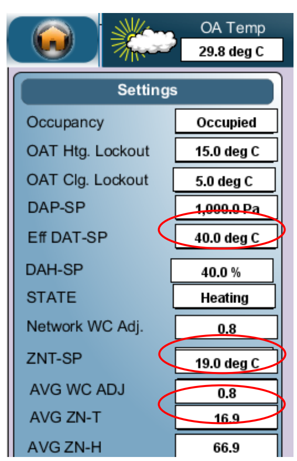

Figure: AHU2 SAT

Recommendations for Implementation

Reset SAT based on average space temperature and room temperature setpoint. This will reduce the potential for heating and cooling conflicts between the AHUs and FCUs. Set separate heating and cooling room temperature setpoints for all spaces.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.5 Measure 5: Atrium Occupancy Counter

Overview

The large atrium space has intermittent occupancy and is served by AHU 1, which is enabled 15 hours a day on average. No optimal start program in place. AHU 1 maintains a static SAT setpoint.

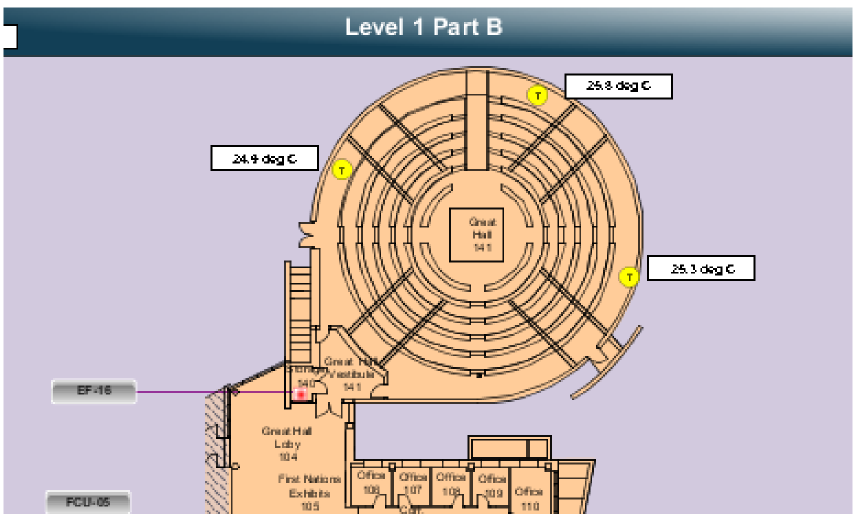

Figure: Large atrium served by AHU1

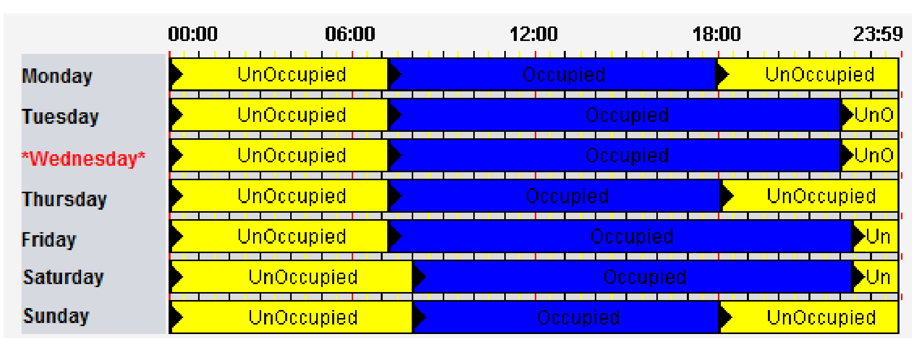

Figure: AHU 1 schedule

Recommendations for Implementation

Install an occupancy sensor and program a counter algorithm to set back temperature and airflow setpoints unless the space is densely unoccupied. Reduce the schedule and implement an optimal start routine to bring temperature to daytime setback temperature at the start of the occupied period.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.6 Measure 6: AHU 2 SAP Reset

Overview

Supply air pressure for AHU 2 is set to 1,000 Pa. The AHU 2 supply fan maintains 50 Pa at 100% Speed. Terminal units are a mix of variable and constant volume. VAV terminal units are not controlled by DDC.

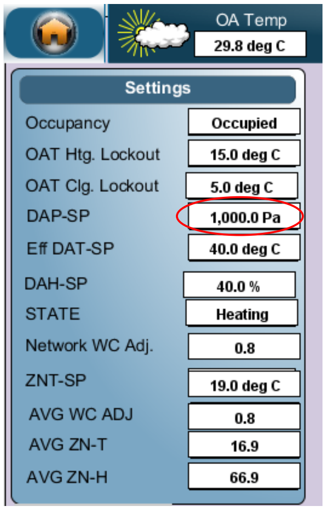

Figure: High duct air pressure setpoint for AHU 2

Recommendations for Implementation

Reset fan speed based on OAT and feedback interior space conditions. Minimize fan speed while maintaining air quality and occupant comfort standards.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.7 Measure 7: Boiler HWST

Overview

Currently the heating water supply temperatures (HWST) on primary and secondary loops are reset based on OAT. Boilers are condensing.

OA	HWS
-30^{0}C	85^{0}C
4.5^{0}C	65^{0}C

18/08/2014 , 1:13:43 PM

Figure: Current HWST reset strategy

Recommendations for Implementation

Reset Primary HWST based on demand for heating at the secondary loops. Reset Secondary HWST based on supply and return temperature differential on each loop.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.8 Measure 8: Heat Pump SWT Reset

Overview

Heat pump heating and cooling supply water temperatures (SWT) are reset based on OA. For the majority of the shoulder seasons (0°C to 18°C OAT) slabs are at 22-23°C, whereas the fan coil units are frequently in cooling when OAT is greater than 15°C.

SUMMER
HP-2 HP-3

OA	CHWS
6^{0}C	17^{0}C
28^{0}C	12^{0}C

WINTER
HP-2 HP-3

OA	HWS
-30^{0}C	40^{0}C
0^{0}C	27^{0}C

SUMMER
HP-1 Fan Coil Loop

OA	CHWS
6^{0}C	15^{0}C
20^{0}C	7.3^{0}C

WINTER
HP-1 Fan Coil Loop

OA	HWS
-30^{0}C	40^{0}C
0^{0}C	27^{0}C

18/08/2014 , 2:52:25 PM

Figure: Current heat pump supply water reset strategy

Recommendations for Implementation

Reset FCU supply water temperature based on average FCU control valve position.

Reset Slab SWT base on average mixing valve position. Eliminate heating and cooling conflicts between slabs and FCUs. Operate Heat Pumps at best efficiency point.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.9 Measure 9: DHW Tank Temperature Reset

Overview

The domestic hot water tank maintains a constant temperature. Recirculation pumps operate on an occupancy schedule

Recommendations for Implementation

The domestic hot water tank temperature may be reduced during the unoccupied and cycled to a purge temperature one hour before the start of the occupancy scheduled.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.10 Measure 10: AHU 1 heat recovery recommissioning

Overview

AHU 1 heat recovery pump was observed to be operating with a temperature differential of 0.5° C.

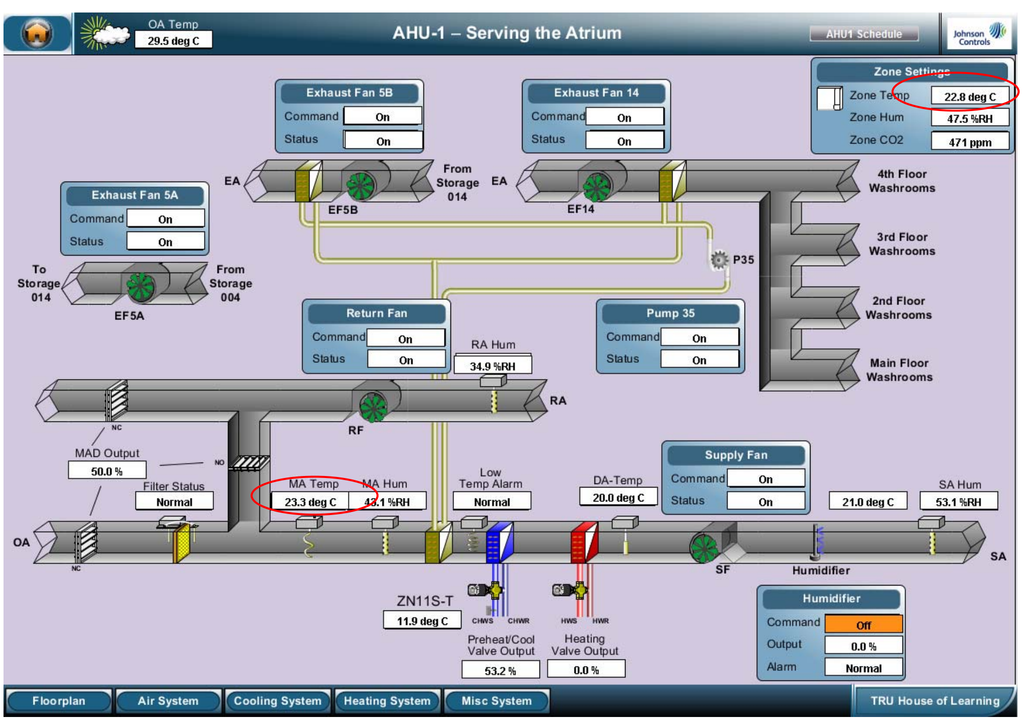

Figure: DDC screenshot of AHU1 heat recovery system

Recommendations for Implementation

Evaluate heat recovery potential in real-time. Shut off the heat recovery pump systems when potential is low.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.11 Measure 11: Reduce Force Flow Setpoints

Overview

Force flow heaters serve stairwells and common areas. Their setpoints are typically 22°C.

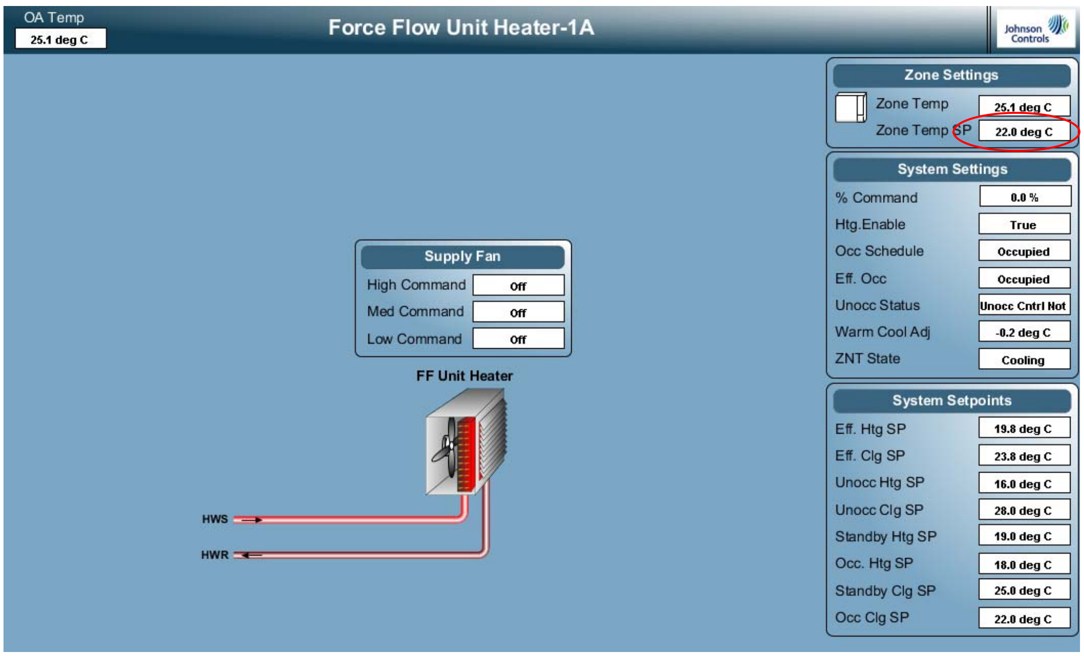

Figure: Typical Force Flow Heater

Recommendations for Implementation

Implement an OAT reset for forceflow heater setpoints to eliminate unnecessary heating in the shoulder and cooling seasons.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.12 Measure 12: Temperature Setpoint Review

Overview

There are frequent complaints from occupants about overheating and humidity. Occupants have the opportunity to offset room temperature by several degrees with the thermostats.

Recommendations for Implementation

Conduct and occupant survey to determine ideal working conditions for each regular resident. Set base temperature setpoints based on survey feedback. Reset occupant offsets to 0°C on a weekly basis.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.13 Measure 13: Atrium Relief Fan Recommissioning

Overview

Atrium relief air dampers are frequently at a very low position while the fan operates at a high speed.

Recommendations for Implementation

Operate the relief fan speed to maximize relief damper position. Install an atrium static pressure sensor and maintain building static pressure at an acceptable setpoint.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

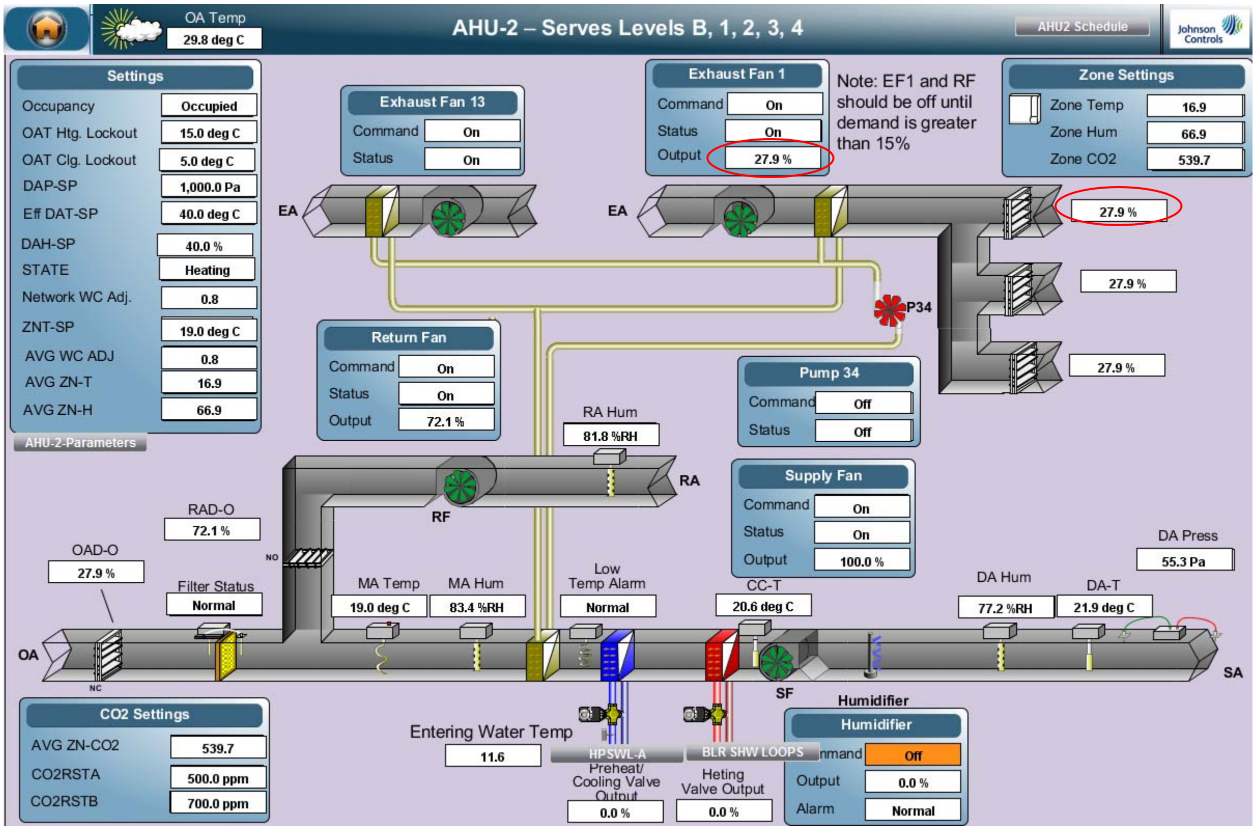

Figure: Relief fan damper position controlled to fan speed

3.14 Measure 14: Load Shedding

Overview

There are significant variable l loads in the building, including fan coil units and AHU fans.

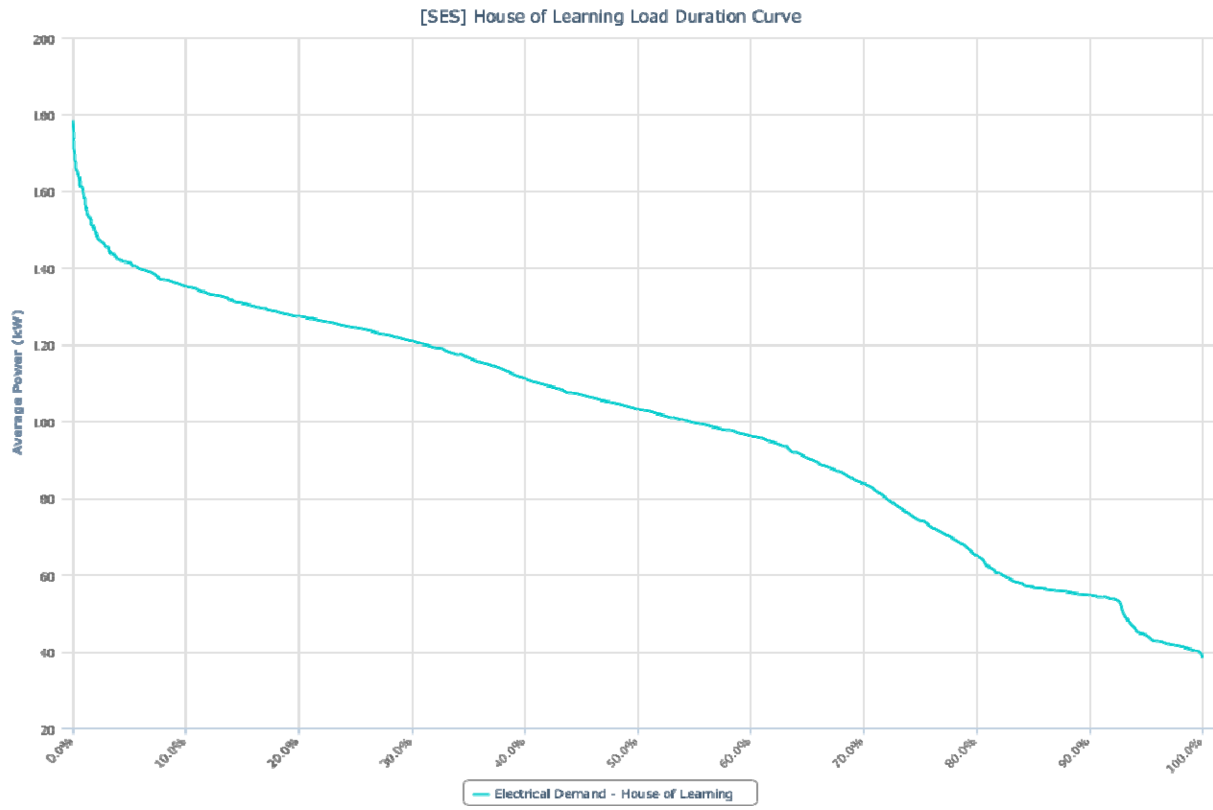

Figure: Pulse trend indicates demand may be limited to approximately 150 kW

Recommendations for Implementation

Integrate the electrical demand meter with the DDC and reduce non-essential loads during peak demand events.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

3.15 Measure 17: Integrate Lighting Control to DDC

Overview

Lighting is swept-on throughout the building by the Leviton lighting control system, early in the day.

Recommendations for Implementation

Integrate lighting control to the DDC system. Eliminate the sweep-on feature in all areas with locally controlled switching (non-public areas) Allow occupants to turn on lighting as necessary. Existing sweep-off functions should be maintained and used several times throughout the unoccupied period.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing screenshots of the DDC sequence of operation programming and trends.

4.0 Measures Selected for Implementation (Under Other Power Smart programs)

This section provides an overview of each measure, recommendations for implementation, and the most suitable method for providing evidence of implementation.

4.1 Measure 15: T8 Relamping

Overview

The majority of lighting in the Library are 32 watt T8 fixtures.

Recommendations for Implementation

Re-lamp 32 Watt lamps with 25 Watt replacements.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by written statement from lighting contractor.

4.2 Measure 16: LED Retrofit

Overview

There are a number of metal halide fixtures throughout the facility.

Recommendations for Implementation

Replace 250 W skylight flood light and 400 W pole light metal halide fixtures with LED replacements

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by written statement from lighting contractor.

5.0 Measures to be considered for Future Implementation

This section provides an overview of each measure, recommendations for implementation, and the most suitable method for providing evidence of implementation.

5.1 Measure 18: Replace Wireless Thermostats

Overview

Wireless thermostats are battery operated, and batteries must be replaced frequently.

Recommendations for Implementation

Replace battery powered thermostats hardwired or self powered models. New thermostats should be equipped with occupancy sensors and CO2 sensors.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by providing photographs and a written statement from the controls contractor.

6.0 Next Steps – Implementation Phase and Hand-off Phase

6.1 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 *Retrocommissioning Investigation 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. The *Retrocommissioning Investigation Report* and *Investigation Summary Table* should provide sufficient detail to specify accurate implementation of the measures if handled by in-house staff, contractors or a combination of both.

According to the program agreement, the time period allowed for the Implementation Phase is the "rest of fiscal year + additional year" as measured from completion of the Investigation Phase (could range from 13 to 23 months), with the proviso that the Energy Management Information System (EMIS) must have sufficient time to collect the required baseline data. Therefore for this project, the Implementation phase must be completed by March 31, 2016.

Once implementation is complete, the *Implementation Summary Table* will be submitted to the owner and the program (for approval) as part of the *Retrocommissioning Final Report*.

6.2 Hand-off Phase

The Program provides an incentive payment to SES Consulting to follow up after implementation of the selected measures to create the *Retrocommissioning Final Report (Final Report)*. The *Final Report* for the implemented measures includes, but is not limited to: a description of the new or improved sequences of operation, energy savings impact of the measures, requirements for ongoing maintenance and monitoring of the measures, the *Training Outline*, *Training Completion Form* and contact information for SES Consulting, in-house staff and contractors responsible for implementation.

BC hydro
powersmart

Appendix A: Investigation Summary Table

#	Measure	Estimated Annual Electric Usage Savings (kWh)	Estimated Annual Electric Usage Savings ($)	Estimated Annual Electric Demand Savings ($)	Estimated Annual Gas Savings (GJ)	Estimated Annual Gas Savings ($)	Estimated Annual Total Savings ($)	Estimated Implementation Cost ($)	Simple Payback (years)	Measure life (years)	NPV ($)	IRR (%)	Description of Finding	Implementer
1	Implement a seasonal reset for switchover temperature to eliminate manual reset. Apply weather predictor to lock out heating in mornings when the afternoon will be hot.	0	$0	$0	50	$643	$643	$1,900	3.0	10.0	$ 3,589	34%	Currently heating cooling switchover is set to OAT of 12°C for the winter. The operator manually changes this based on the time of year. AHUs return air units with heat recovery. DHW is supplied by a supplemental electric heater when the boilers are disabled.	Controls Contractor
2	Reduce scheduled hours to match periods of dense occupancy. Implement optimal start routine using FCUs and radiation as the first stage of heating. This routine will ensure spaces are at an acceptable temperature at the start of the occupied period. Maintain night time setbacks during the unoccupied period.	7,300	$687	$0	40	$515	$1,202	$3,500	2.9	10.0	$ 6,754	34%	The current schedule for AHU 2 and FCUs is from 7 am to 10 pm on average. Fancoil unit fans operate continuously when scheduled.	Controls Contractor
3	Install a duct CO2 sensor in the return air duct of AHU 2. Raise individual space CO2 setpoint to 1,000 ppm. Set return air CO2 setpoint to 800ppm.	2,000	$188	$0	40	$515	$703	$3,900	5.5	10.0	$ 2,097	18%	CO2 setpoints are currently 500 ppm, which is very low. CO2 sensors are located in the majority of spaces, though there is no duct sensor to measure average space values. This may result in stuffiness complaints in unrepresented rooms and low overall setpoints. Many sensors are reading erroneous values, below atmospheric CO2 levels.	Controls Contractor
4	Reset SAT based on average space temperature and RTSP. This will reduce the potential for heating and cooling conflicts between the AHUs and FCUs. Set separate heating and cooling room temperature setpoints for all spaces.	3,800	$358	$0	20	$257	$615	$2,400	3.9	10.0	$ 2,847	26%	During the cooling season the average room temperature was observed to be 17°C. Under these conditions, the AHU 2 supply air temperature setpoint was 40°C, though heating was locked out. AHU 1 maintains a static SAT setpoint.	Controls Contractor
5	Install an occupancy sensor and program a counter algorithm to set back temperature and airflow setpoints unless the space is densely unoccupied. Reduce the schedule and implement an optimal start routine to bring temperature to daytime setback temperature at the start of the occupied period.	32,700	$3,079	$0	10	$129	$3,207	$5,200	1.6	10.0	$ 22,159	62%	The large atrium space has intermittent occupancy and is served by AHU 1, which is enabled 15 hours a day on average. No optimal start program in place.	Controls Contractor
6	Reset fan speed based on OAT and interior space conditions.	19,800	$1,864	$0	0	$0	$1,864	$5,500	3.0	10.0	$ 10,401	34%	Supply air pressure is set for AHU 2 to 1,000 Pa. The AHU 2 supply fan maintains 50 Pa at 100% Speed. Terminal units are a mix of variable and constant volume. VAV terminal units are not controlled by DDC.	Controls Contractor
7	Reset Primary HSWT based on demand for heating at the secondary loops. Reset Secondary HSWT based on supply and return temperature differential on each loop	0	$0	$0	50	$643	$643	$3,400	5.3	10.0	$ 2,089	19%	Currently the heating supply water temperatures (HSWT) on primary and secondary loops are reset based on OAT. Boilers are condensing.	Controls Contractor
8	Reset FCU SWT based on average FCU CV position Reset Slab SWT base on average mixing valve position. Eliminate heating and cooling conflicts between slabs and FCUs. Operate Heat Pumps at best efficiency point.	5,900	$555	$0	0	$0	$555	$2,900	5.2	10.0	$ 1,838	19%	Heat pump heating and cooling supply water temperatures (SWT) are reset based on OA. For the majority of the shoulder seasons (0°C to 18°C OAT) slabs are at 22-23°C, whereas the fancoil units are frequently in cooling when OAT is greater than 15°C.	Controls Contractor
9	The domestic hot water tank temperature may be reduced during the unoccupied and cycled to a purge temperature one hour before the start of the occupancy scheduled.	400	$38	$0	10	$129	$166	$800	4.8	10.0	$ 619	21%	The domestic hot water tank maintains a constant temperature. Recirculation pumps operate on an occupancy schedule	Controls Contractor
10	Evaluate heat recovery potential in real-time. Shut off the heat recovery pump systems when potential is low.	2,200	$207	$0	0	$0	$207	$950	4.6	10.0	$ 817	22%	AHU 1 heat recovery pump was observed to be operating with a temperature differential of 0.5° C.	Controls Contractor
11	Implement an OAT reset for forceflow heater setpoints to eliminate unecessary heating in the shoulder and cooling seasons.	0	$0	$0	10	$129	$129	$950	7.4	10.0	$ 148	14%	Force flow heaters serve stairwells and common areas. Their setpoints are typically 22°C.	Controls Contractor
12	Conduct and occupant survey to determine ideal working conditions for each regular resident. Set base temeprature setpoints based on survey feedback. Reset occupant offsets to 0°C on a weekly basis.	1,500	$141	$0	20	$257	$399	$2,500	6.3	10.0	$ 900	16%	There are frequent complaints from occupants about overheating and humidity. Occupants have the opportunity to offset room temperature by several degrees with the thermostats.	Controls Contractor
13	Operate the relief fan speed to maximize relief damper position. Install an atrium static pressure sensor and maintain building static pressure at an acceptable setpoint.	1,800	$169	$0	0	$0	$169	$950	5.6	10.0	$ 496	18%	Atrium relief air dampers are frequently at a very low position while the fan operates at a high speed.	Controls Contractor
14	Integrate the electrical demand meter with the DDC and reduce non-essential loads during peak demand events.	0	$0	$1,340	0	$0	$1,340	$6,800	5.1	10.0	$ 4,634	20%	There are significant variable l loads in the building, including fancoil units, AHU fans, and potentially new pump VFDs.	Controls Contractor
17	Integrate lighitng contol to the DDC system. Eliminate the sweep-on feature in all areas with locally controlled switching (non-public areas) Allow occupants to turn on lighting as necessary. Existing sweep-off functions should be maintained and used several times throughout the unoccupied period.	37,000	$3,483	$0	0	$0	$3,483	$11,000	3.2	10.0	$ 18,714	32%	Lighting is swept-on throughout the building by the Leviton lighting control system, early in the day	Lighting Contractor
		114,400	$ 10,770	$ 1,340	250	$ 3,217	$ 15,328	$ 52,650	3.4					