Continuous Optimization for Commercial Buildings Program

Retrocommissioning Investigation Report

March 28, 2013

Prepared for:

Thompson Rivers University

Campus Activity Centre

BC Hydro #:COP10-354

Prism Project #: 2012100

Prepared by:

Prism ENGINEERING

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Introduction

Prism Engineering Ltd is pleased to present the results of the Investigation Phase that was conducted as part BC Hydro's Continuous Optimization for Commercial Buildings Program for the Campus Activity Centre of the Thompson Rivers University Kamloops Campus. 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 implementations 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.

Nine retrofits were identified as a part of this investigation. The proposed measures were reviewed in a meeting with Thompson Rivers University, BC Hydro and Prism Engineering representatives to determine which measures will be implemented.

Retrofits approved for implementation include:

- Add chilled Water Temperature Reset;
- Repair RTU-4 Outdoor Damper Control;
- Implement Night Shutdown for Heating Water Pumps;
- Lower Rooftop Night Setback Temperatures;
- Add Occupancy Control to Third Floor Addition;
- Remove Override on Unit FC-1;
- Add DDC control to Vestibule Forced Flow Heaters;
- Add Lighting Controls to Independent Centre.

The following retrofits were not considered for implementation under the C Op program but are recommended for further analysis and implementation for addressing comfort or operational issues:

The following retrofits were not considered for implementation due to the long payback periods:

1.0 Project Overview

Project Information	
Project/Building Name	Campus Activity Centre
Building Owner	Thompson Rivers University
Building Location	Kamloops, BC
Project Start Date	3/13/2012
Project Completion Date	3/15/2013

Contact List		
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Task	Date Completed
RCx investigation kickoff meeting	20/Jun/2012
EMIS installation date (Electricity)	11/Apr/2011
EMIS installation date (Fuel)	11/Apr/2011
Master List of Findings submitted	28/3/2013
Master List of Findings approved	
Master List of Findings meeting with owner	
Measures selected for implementation	
RCx Investigation Report submitted	

Estimated Project Implementation Start Date	August 1, 2013

Building Energy Usage Summary	
Building Size (gross sq. meters)	7,200
Building Size (conditioned sq. meters)	7,200
Annual Electric Consumption (kWh/yr)	1,559,370
Annual Electric Cost (with applicable taxes)	$103,891
Bulk cost per kWh (with demand charges)	$0.067
Utility Rate Tariff	1611
Fuel Type	Natural Gas
Annual Fuel Consumption (GJ)	3,105
Annual Fuel Cost (with applicable taxes)	$29,558
Fuel Cost per gigajoule	$8.50
Total Energy Cost (with applicable taxes)	$133,450
Electric Energy Use Intensity (EUI) (kWh/sq. meters)	217
Building Energy Use Intensity (EUI) (ekWh/sq. meters)	336

RCx Costs & Savings	
Implementation Cap	$17,258
Implementation Cost	$21,200
Annual Electric Usage Savings (kWh)	28,902
Annual Electric Usage Savings - Avg. of Year 1&2 ($)	$2,535
Savings as % of Total Electric Usage	1.9%
Annual Electric Demand Savings ($)	$0
Annual Fuel Savings (GJ)	1,016
Annual Fuel Savings ($)	$8,634
Savings as % of Total Fuel Usage	32.7%
Total Energy Cost Savings - Avg. of Year 1&2 ($)	$11,169
RCx Project Simple Payback	1.9
Savings as % of Total Energy Cost	8.4%

Implementation cost includes engineering and project management. It is our intent to provide accurate pricing; however, the measure implementation costs provided should be used as budgets only and not fixed prices. Pricing assumes that all measures will be implemented. Implementation costs for individual measures will likely increase if measures are excluded from the scope of contracted services.

1.1 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.

Boilers

The heating plant consists of four (B1 to B4) 1,160 mBH Weil-McLain LGB-12-W atmospheric hydronic boilers. The rated efficiency of the boilers is 80%.

Hot Water Distribution

Boiler pumps P-1 and P-2 provide primary heating loop circulation through the boilers. Hot water circulation for the secondary loops is achieved as follows:

- a hot water heating loop serving reheat coils, radiant panels and fan coil heating coils, using circulation pumps P-8/9. Loop temperature is controlled by DDC via a 3-way valve;
- a loop serving the hot water/glycol heat exchanger. Hot water temperature in the heat exchanger is controlled by DDC via a 3-way valve; and
- a glycol heating loop feeding AHU-1 heating coil using pumps P3/P4.

A summary of the heating distribution pumps is included in Table 1.

Table 1: Summary of Heating Water Distribution Pumps

Tag	Description	Hp
P1	Boiler primary loop	3
P2	Boiler primary loop	3
P3	Glycol loop	3
P4	Glycol loop	3
P8	Secondary heating loop	3
P9	Secondary heating loop	3

Unit Heater (Hot Water)

The mechanical room and crawl space, where the condenser water sumps are located, are heated by hot water unit heaters with line voltage thermostats.

Forced-flow Heaters

The hallways/entrances have a total of nine hot water forced-flow heaters with built-in thermostats.

Cooling Systems

The building is cooled by a chilled water plant located in the mechanical room. The plant consists of a180-ton Multistack chiller, a chilled water pump, a condenser water pump and a cooling tower.

Chilled water from the chiller is pumped by circulating pump P-2 to AHU-1 cooling coils CC-1 to CC-4. P-2 is a Bell & Gosset series 1510-4AC with a 3 hp motor. Condenser water is circulated by a 5 hp Bell & Gosset pump (P-1)

A Marley Primus dry sump cooling tower is located outside the building, on grade level, on the North side. Two sumps, located in the crawl space, are used for storage of the condenser water.

Air Handling Units

Air handling unit AHU-1, located in the ground floor mechanical room, provides ventilation to the original building. AHU-1 supplies a VAV system with terminal reheat; fan speed is controlled by VSDs. AHU-1 comprises two parallel 40 hp supply fans with a rated capacity of 15,350 l/s and two parallel 15 hp return fans. AHU-1 is equipped with a mixing section, glycol heating coil and chilled water cooling coil.

The centre court is also served by air handling unit FC-1, located in the rotunda crawl space. FC-1 is equipped with a 5 hp supply fan motor and a heating coil. Both AHU-1 and FC-1 are interfaced to the DDC system.

Ventilation to the third floor addition is provided by two Heat Recovery Ventilators (HRV-1 & HRV-2). Each unit is equipped with a 1.5 hp fan and is rated at 1900 CFM.

Rooftop Air Conditioning Units

HVAC to the Independent Centre is provided by four Lennox rooftop units. The units comprise a mixing section, gas fired furnaces, DX cooling coils and integral condensers.

Units RTU-1 and RTU-2 are equipped with terminal bypass boxes and electric reheat coils.

All units are interfaced to the DDC system. A summary of the units is provided in Table 2.

Table 2: Summary of Independent Centre Addition Rooftop Units

Tag	Service Area	Model	Fan HP	Cooling Capacity (Ton)	Heating Stages	Cooling Stages
RTU-1	Main floor offices	LGA072	3	6	2	1
RTU-2	Second floor offices and club room	LGA120	5	10 ½	2	2
RTU-3	Multi-purpose room West	LGA360	10	30	Mod	3
RTU-4	Multi-purpose room East	LGA360	10	30	Mod	3

Mechanical Room Ventilation

Five supply fans are installed in the building to provide ventilation and free cooling to the building's service and mechanical rooms. The units are controlled by line voltage thermostats. A summary is presented in Table 3.

Table 3: Summary of Supply Fans

Tag	Description/Service Area	Hp	l/s
SF-2	Electrical room	½	1,050
SF-3	Telephone room	0.4	260
SF-4	Elevator machine room	¼	260
SF-5	Combustion air	½	850
SF-6	Mechanical room	¾	1,440

Exhaust

Washroom exhaust fans EF-3 and EF-4 are DDC controlled, exhaust from the pub, including the kitchen hood and dishwasher exhaust are controlled by a local manual switches. A summary of the exhaust fans serving the building is included in Table 4.

Table 4: Summary of Exhaust Fans

Tag	Description/Service Area	Hp	CFM
EF-01	Photocopy	0.40	230
EF-02	2nd floor WR North	¼	440
EF-03	Main floor WR	0.40	275
EF-04	2nd floor WR	$^{1}/_{3}$	800
EF-05	Grant hall storage	¼	320
EF-06	Pub	1	2,000
EF-07	3rd floor WR	¼	330
EF-08	Atrium	¾	800
EF-09	Kitchen WR	0.16	145
EF-10	Kitchen storage	0.30	185
EF-11	Pot wash area	¼	250
EF-12	Dishwasher	¼	560
EF-13	Baking hood	1.5	1,120
EF-14	Hot prod. Hood	5	3,190
EF-15	EF short order	3	2,000
EF-16	EF janitor storage	0.40	230
EF-01	IC addition EF lower photocopy	0.10	120
EF-02	IC addition EF lower meeting	0.10	120
EF-03	IC addition EF Main floor WR	$^{1}/_{3}$	780
EF-04	IC addition EF meeting room #1	¼	120
EF-05	IC addition EF club room	¼	120
EF-06	IC addition EF meeting room #2	¼	120
EF-07	IC addition EF meeting room #3	¼	120
EF-08	IC addition EF electrical room	0.10	120

Third Floor Addition

Heating and cooling to the third floor addition is provided by nine fan coil units (FC-1 to FC-9) Each unit is equipped with a DX coil and additional heating is provided by electric duct heaters.

Building Management/Automation System (BAS)

The mechanical systems in the building are controlled from a BAS controlled with Direct Digital Control (DDC). The system is a Siemens Insight, version 3.11.

The third floor addition is controlled by an Automated Logic (ALC) system installed in 2011. Remote access is available via web connection.

2.0 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).**

2.1 Measure 1: Optimize AHU-1 Controls

Overview

Air handling unit AHU-1, located in the ground floor mechanical room, provides ventilation to the original building. AHU-1 is a VAV system with terminal reheat; fan speed is controlled by VSDs. AHU-1 comprises two 40 hp supply fans in parallel with a rated capacity of 15,350 l/s and two parallel 15 hp return fans. AHU-1 is equipped with a glycol heating coil and a chilled water cooling coil. A graphic representation from the DDC system is presented in Figure 1.

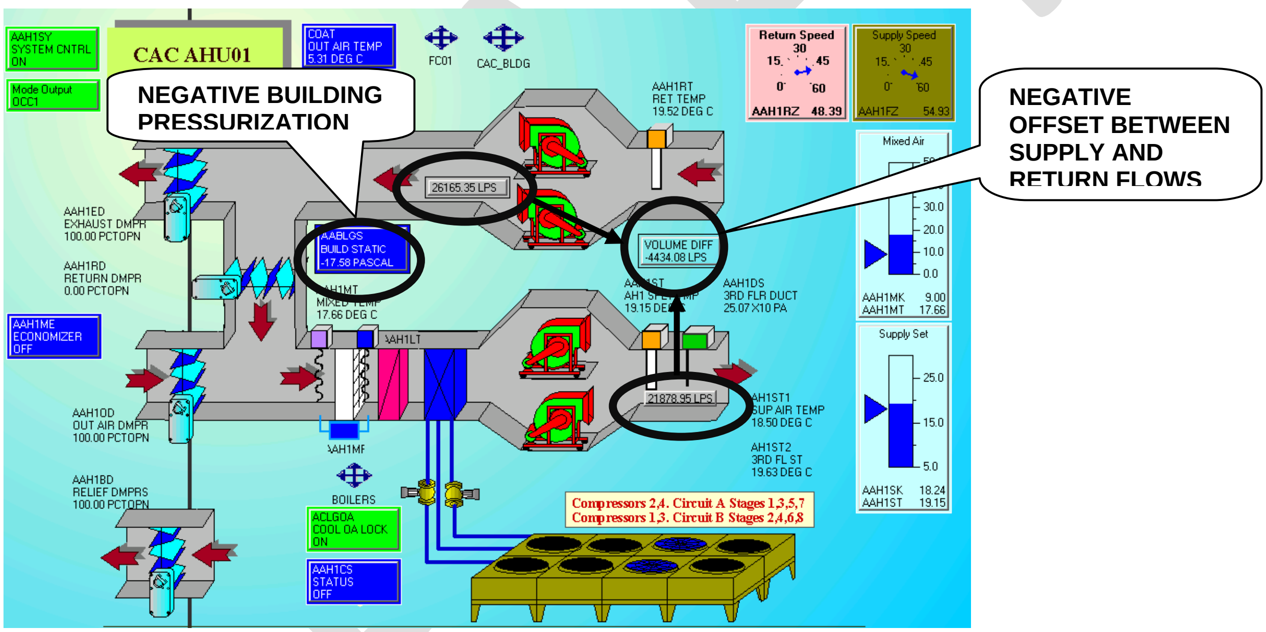

Figure 1: Air Handling Unit AHU-1

The Supply fans speed is modulated to maintain supply static pressure setpoint. The return fan is modulated to maintain a flow differential between supply and return air. The flow differential setpoint is reset by the control program from 4,000 to 13,300 l/sec depending on the number of exhaust fans running. However, the return fan speed is controlled in such way that maintains a negative flow differential pressure between supply and return (Supply Fan Volume – Return Fan Volume) as can be seen in Figure 1. This control is causing the building to be negatively pressurized, while the desired effect is to maintain a positive pressure in the building.

The outdoor, return, relief and exhaust air dampers are controlled in unison to maintain a mixed air temperature setpoint. However, the setpoint is rarely met.

Recommendations for Implementation

We recommend controlling the return air fan speed to maintain a positive differential volume between supply and return. Recommission the mixing dampers and actuators and verify flow sensors.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by setting trends showing damper position, mixed air temperature and setpoint and flow differential.

2.2 Measure 2: Add chilled Water Temperature Reset

Overview

The building is cooled by a chilled water plant located in the mechanical room. The plant consists of a180-ton Multistack chiller, a chilled water pump, a condenser water pump and a cooling tower.

The chilled water plant is operating at a constant chilled water temperature setpoint. Even though the chiller panel has the option for remote chiller water temperature reset, this is not implemented. There is and output from the DDC panel for chiller reset and there is a chiller reset in the program code that has been abandoned.

The chiller efficiency increases with an increase in the chilled water temperature, as shown in data from the chiller's shop drawings, Table 5 .

Table 5: Multistack Water Cooled performance at 75°F Entering Condenser Water Temperature

Leaving Chilled Water Temperature °C	Output Tons	Input kW	Efficiency kW/Ton
6.5	70.6	47.4	0.67
7.7	73.3	48.0	0.65
9.0	76.2	48.6	0.63
10.0	79.1	49.2	0.62

Recommendations for Implementation

We recommend resetting the chiller supply water temperature based on cooling demand. A control loop would vary the setpoint from 6.5 to 10°C to maintain AHU1 cooling coil valve about 90% open.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by setting trends showing the chilled water temperature, reset signal and commanded cooling coil valve position.

2.3 Measure 3: Repair RTU-4 Outdoor Damper Control

Overview

Rooftop unit RTU-4 serves the East part of the Multi-purpose room. The unit is equipped with a mixing section controlled by the DDC system (see Figure 2). The DDC system overrides the minimum damper position if the CO2 switch installed in the return duct (not shown in the DDC graphic) is switched on. DDC observations and trend reviews showed that the outdoor damper position was continuously at 100% open during conditions when it should be at minimum, indicating that the CO2 switch is out of calibration.

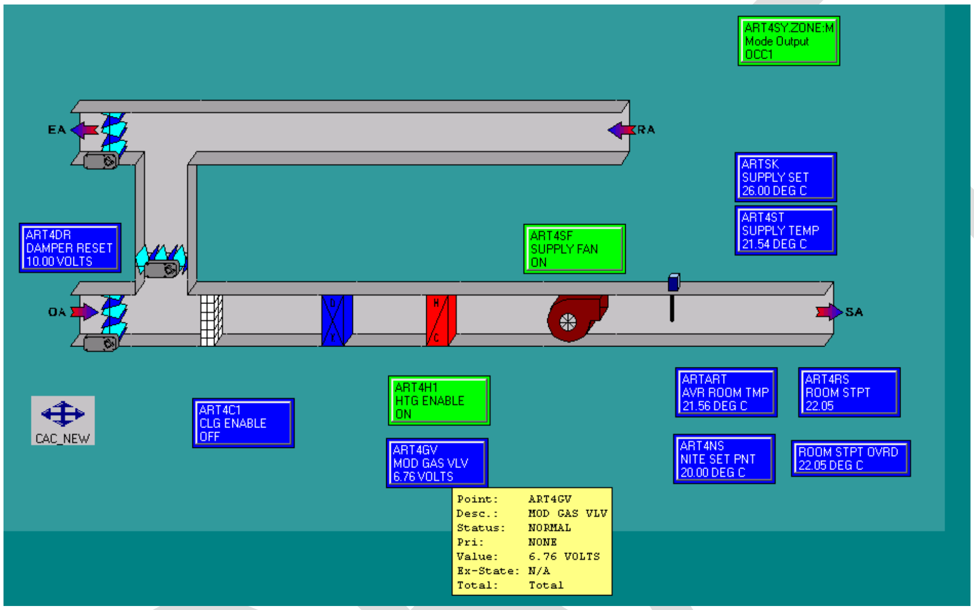

Figure 2: RTU-4 DDC Graphic

Recommendations for Implementation

We recommend replacing the RTU-4 CO_2 switch. The CO_2 switch of unit RTU-3 is recommended for calibration/replacement.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by trend logs for fan status and damper position.

2.4 Measure 4: Implement Night Shutdown for Heating Water Pumps

Overview

The heating plant is enabled for outdoor temperatures below 15°C. The primary loop supply water temperature setpoint is reset from 75°C to 85°C as the outdoor temperature varies from 20°C to -25°C. The boilers (B1 to B4) are fired in sequence to maintain the primary loop setpoint.

The glycol loop is enabled for outdoor temperatures below 5 °C.

During unoccupied periods the heating plant can be shutdown when heating is not required to maintain unoccupied space temperatures. Energy savings can be achieved by shutting down the radiation pumps at 15°C during occupied periods.

Recommendations for Implementation

We recommend the program code to be revised to allow the radiation heating pumps (P8 and P9) to shutdown during unoccupied periods. Pumps would start if at least three temperature sensors fall below 15ºC and stop when all zones are above 17ºC. For outdoor temperatures lower that 5°C, the radiation pumps would cycle on for 10 minutes if the pumps have been off for two hours continuous.

During unoccupied periods the boilers and primary loop pumps would be switched to standby mode. During standby mode the boiler plant would cycle on when the supply water temperature reaches 75°C and run until 85°C at which time the pumps and then boilers would be disabled. Standby mode would be disabled when operation of the radiation or glycol pumps is required.

When AHU1 is off pumps P3/P4 would cycle to maintain a minimum mixed air temperature.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by reviewing trends of the room temperatures, heating water temperature and heating pump status during unoccupied periods.

2.5 Measure 5: Lower Rooftop Night Setback Temperatures

Overview

HVAC to the Independent Centre is provided by four Lennox rooftop units. The units operate to a weekly schedule. During unoccupied mode the units cycle to maintain unoccupied temperature setpoint.

The unoccupied setpoints are presented in Table 6.

Table 6: Rooftop Units Night Setback Setpoints

Tag	Service Area	Heating Setback Setpoint
RTU-1	Main floor offices	22
RTU-2	Second floor offices and club room	22
RTU-3	Multi-purpose room West	20
RTU-4	Multi-purpose room East	20

Recommendations for Implementation

Lower the night setback setpoint to 16 °C.

Evidence of Proper Implementation

The recommended method for verifying that this measure is reviewing night setback setpoints in the DDC system.

2.6 Measure 6: Add Occupancy Control to Third Floor Addition

Overview

The third floor addition is served by fan coil units equipped with a DX coil and auxiliary electric duct heaters. The fan coils are controlled by the ALC DDC system with a weekly schedule from 6:00AM to 10:00 PM, Monday to Friday.

Some areas such as The Great Room and the classrooms are not continuously occupied. Energy savings can be achieved by installing occupancy sensors in areas with intermittent occupancy

Recommendations for Implementation

Install occupancy sensors in The Great Room and Classrooms #1 to #3. The fan coils serving these rooms would operate in "standby mode" when the spaces are not in use. The standby heating and cooling setpoints will be drifted one and a half degrees from the occupied setpoint. In standby mode the supply fan would cycle as required to maintain standby setpoint. A brief (15 minute) flush would be provided if a fan coil does not operate for 2 hours.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by setting trends showing the room temperatures and fan status.

2.7 Measure 7: Remove Override on Unit FC-1

Overview

Fan coil unit FC-1, located in the rotunda crawl space, serves the centre court. FC-1 is equipped with a 5 hp fan motor and a heating coil.

During a site visit, FC-1 was found running after 11:00 PM; a trend review revealed that the unit is operating continuously.

The program code enables FC-1 when the variable "AAHSY" is ON. AAHSY is overridden ON, hence the unit is running continuously. AAHSY is linked to a weekly schedule. However, the main air handling unit AHU-1 is not running continuously.

Recommendations for Implementation

We recommend linking unit FC-1 to the same schedule that is controlling unit AHU-1.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by setting trends showing the FC-1 unit status.

2.8 Measure 8: Add DDC control to Vestibule Forced Flow Heaters

Overview

Vestibules in the building are heated by forced flow heaters controlled by local thermostats (Figure 3). The vestibules are heated to a constant setpoint of 20°C, as recorded on a site visit at night.

Figure 3: Forced Flow Heater in Vestibule

Recommendations for Implementation

Add DDC control to the forced flow heaters located in the vestibules and in the kitchen receiving (three units). During occupied periods the heaters would be controlled to maintain a temperature of 15°C and a night setback temperature of 10°C.

Evidence of Proper Implementation

The recommended method for verifying this measure is by reviewing trend logs including vestibule temperature and forced flow heater status.

2.9 Measure 9: Add Lighting Controls to Independent Centre

Overview

Lighting in the foyer is primarily composed of compact fluorescent down lights. Lights are on regardless of occupancy (Figure 4).

Figure 4: Independent Centre Mezzanine

Nights in the Independent Centre are on at night (see Figure 5).

Figure 5: Independent Centre at Night

Recommendations for Implementation

Add occupancy sensor control to the lighting in the mezzanine. Add the independent centre and the third floor addition lighting to the existing Douglas Panel lighting system.

Evidence of Proper Implementation

The recommended method for verifying this measure is by a physical inspection of the controls installation.

3.0 Measures to be considered for Future Implementation

The following measures include findings that were investigated but not selected for implementation under the BC Hydro Continuous Optimization program. These measures have longer than the 2 years payback considered in the BC Hydro C. Op program or are capital measures.

3.1 Add a Kitchen Demand Controlled Ventilation System for the Pub

Overview

Exhaust from the Pub's kitchen is provided by EF-14, serving the kitchen hood (5 hp) and EF-13 serving the short order (3 hp). There is no dedicated makeup air unit for the kitchen. Electricity and natural gas savings can be achieved by installing a demand controlled ventilation system in the hood exhaust fans.

A typical demand controlled ventilation system comprises the following components:

- a sensor to detect kitchen usage (temperature, smoke or a combination);
- a variable frequency drive controlling the exhaust fan speed; and
- an electronic control panel.

The control panel modulates the exhaust fan flow depending on the cooking load, as detected by the sensor(s). In case of a dedicated make up air unit, it is equipped with a VFD to match the exhaust rate.

This measure is not recommended under the C Op program due to the high cost and payback period.

3.2 Lighting Retrofit on Independent Centre

Overview

Lighting in the Independent Centre multi-purpose room is provided by metal halide luminaires, as shown in Figure 6.

Figure 6: Heating Plant DDC Graphic

The lights are controlled by a schedule. According to the energy manager, lighting levels in the seating area are practically the same when sun light is present. However, sun light control is not recommended for this type of luminaires. A lighting retrofit to fluorescent lighting is recommended before considering daylighting control.

3.3 Boiler Retrofit

Overview

The heating plant consists of four (B1 to B4) 1,160 mBH Weil-McLain LGB-12-W atmospheric hydronic boilers. The rated efficiency of the boilers is 80%. The boilers were installed in 1992.

Recommendations for Implementation

A separate engineering study is recommended to replace the existing boiler plant with energy efficient options such as condensing or near condensing boilers with dedicated boiler pumps. This measure is not recommended under the C Op program as it is a capital project.

3.4 Revise Heating Plant Graphics

Overview

The heating plant graphic screen, shown in Figure 7, does not accurately represent the system configuration.

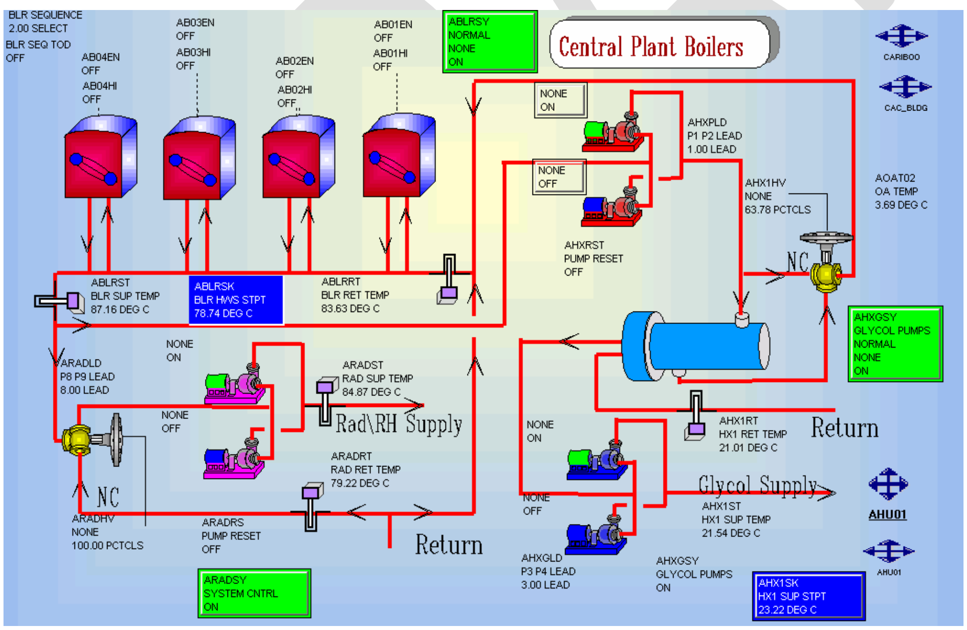

Figure 7: Heating Plant DDC Graphic

Graphic screen for unit AHU-1 also has several deficiencies such as some variables not properly labeled (SAT setpoint and SAT low limit), glycol coil control not included in the graphic, etc.

Other issues with the system graphic screens include units RTU-3 and RTU-2 not showing CO2 control and some equipment having more than one graphic screen as obsolete graphics were not deleted.

Recommendations for Implementation

Revise graphic screens to represent the actual equipment installation.

4.0 Next Steps – Implementation and Hand-off Phases

4.1 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 2014.

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*.

4.2 Hand-off Phase

The Program provides an incentive payment to Prism Engineering Ltd. 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 Prism Engineering Ltd., in-house staff and contractors responsible for implementation.

Appendix A: Investigation Summary Table

BC Hydro Continuous Optimization for Commercial Buildings Program
Campus Activity Centre

#	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 (%)
1	Optimize AHU-1 Controls	1,096	$96	$0	32	$269	$365	$2,200	6.0	5.0	$ (530)	17%
2	Add chilled Water Temperature Reset	2,440	$214	$0	0	$0	$214	$2,200	10.3	5.0	$ (1,220)	10%
3	Repair RTU-4 Outdoor Damper Control	2,448	$215	$0	818	$6,952	$7,167	$1,400	0.2	5.0	$ 31,421	512%
4	Implement Night Shutdown for Heating Water Pumps	5,611	$492	$0	31	$265	$757	$3,100	4.1	5.0	$ 366	24%
5	Lower Rooftop Night Setback Temperatures	928	$81	$0	46	$387	$469	$800	1.7	5.0	$ 1,347	59%

BC Hydro powersmart

BC Hydro Continuous Optimization for Commercial Buildings Program
Campus Activity Centre

#	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 (%)
6	Add Occupancy Control to Third Floor Addition	2,669	$234	$0	0	$0	$234	$4,500	19.2	5.0	$ (3,428)	5%
7	Remove Override on Unit FC-1	11,693	$1,025	$0	36	$309	$1,335	$800	0.6	5.0	$ 5,312	167%
8	Add DDC control to Vestibule Forced Flow Heaters	411	$36	$0	53	$452	$488	$3,900	8.0	5.0	$ (1,663)	13%
9	Add Lighting Controls to Independent Centre	1,608	$141	$0	0	$0	$141	$2,300	16.3	5.0	$ (1,654)	6%
		28,902	**$ 2,535**	**$ -**	**1,016**	**$ 8,634**	**$ 11,169**	**$ 21,200**	**1.9**			

BC Hydro Continuous Optimization for Commercial Buildings Program
Campus Activity Centre

#	Measure	Description of Finding	Implementer	Recommendations for Implementation	Recommended Evidence of Implementation Method	Implement without incentives as part of <2 year simple payback bundle? (Y or N)
1	Optimize AHU-1 Controls	Air handling unit AHU-1, located in the ground floor mechanical room, provides ventilation to the original building. AHU-1 is a VAV system with terminal reheat; fan speed is controlled by VSDs. AHU-1 comprises two 40 hp supply fans in parallel with a rated capacity of 15,350 l/s and two parallel 15 hp return fans. AHU-1 is equipped with a glycol heating coil and a chilled water cooling coil. The Supply fans speed is modulated to maintain supply static pressure setpoint. The return fan is modulated to maintain a flow differential between supply and return air. The flow differential setpoint is reset by the control program from 4,000 to 13,300 l/sec depending on the number of exhaust fans running. However, the return fan speed is controlled in such way that maintains a negative flow differential pressure between supply and return (Supply Fan Volume - Return Fan Volume). This control is causing the building to be negatively pressurized, while the desired effect is to maintain a positive pressure in the building. The outdoor, return, relief and exhaust air dampers are controlled in unison to maintain a mixed air temperature setpoint. However, the setpoint is rarely met.	DDC contractor	Control the return air fan speed to maintain a positive differential volume between supply and return. Recommission the mixing dampers and actuators and verify flow sensors.	Trends showing damper position, mixed air temperature and setpoint and flow differential.	Y
2	Add chilled Water Temperature Reset	The building is cooled by a chilled water plant located in the mechanical room. The plant consists of a180-ton Multistack chiller, a chilled water pump, a condenser water pump and a cooling tower. The chilled water plant is operating at a constant chilled water temperature setpoint. Even though the chiller panel has the option for remote chiller water temperature reset, this is not implemented. There is and output from the DDC panel for chiller reset and there is a chiller reset in the program code that has been abandoned. The chiller efficiency increases with an increase in the chilled water temperature.	DDC contractor	Reset the chiller supply water temperature based on cooling demand. A control loop would vary the setpoint from 6.5 to 10°C to maintain AHU1 cooling coil valve about 90% open.	Set trends showing the chilled water temperature, reset signal and commanded cooling coil valve position.	Y
3	Repair RTU-4 Outdoor Damper Control	Rooftop unit RTU-4 serves the East part of the Multi-purpose room. The unit is equipped with a mixing section controlled by the DDC system. The DDC system overrides the minimum damper position if the CO2 switch installed in the return duct is switched on. DDC observations and trend reviews showed that the outdoor damper position was continuously at 100% open during conditions when it should be at minimum, indicating that the CO2 switch is out of calibration.	DDC contractor	Replace the RTU-4 CO2 switch. The CO2 switch of unit RTU-3 is recommended for calibration/replacement.	Trend logs for fan status and damper position.	Y
4	Implement Night Shutdown for Heating Water Pumps	The heating plant is enabled for outdoor temperatures below 15°C. The primary loop supply water temperature setpoint is reset from 75°C to 85°C as the outdoor temperature varies from 20°C to -25°C. The boilers (B1 to B4) are fired in sequence to maintain the primary loop setpoint. The glycol loop is enabled for outdoor temperatures below 5 °C. During unoccupied periods the heating plant can be shutdown when heating is not required to maintain unoccupied space temperatures. Energy savings can be achieved by shutting down the radiation pumps at 15°C during occupied periods.	DDC contractor	Revise the program code to allow the radiation heating pumps (P8 and P9) to shutdown during unoccupied periods. Pumps would start if at least three temperature sensors fall below 15ºC and stop when all zones are above 17ºC. For outdoor temperatures lower that 5°C, the radiation pumps would cycle on for 10 minutes if the pumps have been off for two hours continuous. During unoccupied periods the boilers and primary loop pumps would be switched to standby mode. During standby mode the boiler plant would cycle on when the supply water temperature reaches 75°C and run until 85°C at which time the pumps and then boilers would be disabled. Standby mode would be disabled when operation of the radiation or glycol pumps is required. When AHU1 is off pumps P3/P4 would cycle to maintain a minimum mixed air temperature.	Review trends of the room temperatures, heating water temperature and heating pump status during unoccupied periods.	Y
5	Lower Rooftop Night Setback Temperatures	HVAC to the Independent Centre is provided by four Lennox rooftop units. The units operate to a weekly schedule. During unoccupied mode the units cycle to maintain unoccupied temperature setpoint. The unoccupied setpoints are: RTU-1 - 22°C RTU-2 - 22°C RTU-3 - 20°C RTU-4 - 20°C	DDC contractor	Lower the night setback setpoint to 16 °C.	Review night setback setpoints in the DDC system.	Y

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6	Add Occupancy Control to Third Floor Addition	The third floor addition is served by fan coil units equipped with a DX coil and auxiliary electric duct heaters. The fan coils are controlled by the ALC DDC system with a weekly schedule from 6:00AM to 10:00 PM, Monday to Friday. Some areas such as The Great Room and the classrooms are not continuously occupied. Energy savings can be achieved by installing occupancy sensors in areas with intermittent occupancy	DDC contractor	Install occupancy sensors in The Great Room and Classrooms #1 to #3. The fan coils serving these rooms would operate in "standby mode" when the spaces are not in use. The standby heating and cooling setpoints will be drifted one and a half degrees from the occupied setpoint. In standby mode the supply fan would cycle as required to maintain standby setpoint. A brief (15 minute) flush would be provided if a fan coil does not operate for 2 hours.	Set trends showing the room temperatures and fan status.	Y
7	Remove Override on Unit FC-1	Fan coil unit FC-1, located in the rotunda crawl space, serves the centre court. FC-1 is equipped with a 5 hp fan motor and a heating coil. During a site visit, FC-1 was found running after 11:00 PM; a trend review revealed that the unit is operating continuously. The program code enables FC-1 when the variable "AAHSY" is ON. AAHSY is overridden ON, hence the unit is running continuously. AAHSY is linked to a weekly schedule. However, the main air handling unit AHU-1 is not running continuously.	DDC contractor	Link unit FC-1 to the same schedule that is controlling unit AHU-1.	Set trends showing the FC-1 unit status.	Y
8	Add DDC control to Vestibule Forced Flow Heaters	Vestibules in the building are heated by forced flow heaters controlled by local thermostats (Figure 4). The vestibules are heated to a constant setpoint of 20°C, as recorded on a site visit at night.	DDC contractor	Add DDC control to the forced flow heaters located in the vestibules and in the kitchen receiving (three units). During occupied periods the heaters would be controlled to maintain a temperature of 15°C and a night setback temperature of 10°C.	Review trend logs including vestibule temperature and forced flow heater status.	Y
9	Add Lighting Controls to Independent Centre	Lighting in the foyer is primarily composed of compact fluorescent down lights. Lights are on regardless of occupancy. Nights in the Independent Centre are on at night	Electrical contractor	Add occupancy sensor control to the lighting in the mezzanine. Add the independent centre and the third floor addition lighting to the existing Douglas Panel lighting system.	Physical inspection of the controls installation.	Y