Continuous Optimization for Commercial Buildings Program

Retrocommissioning Investigation Report

March 15, 2013

Prepared for:

Thompson Rivers University

Arts and Education Building

BC Hydro #:COP10-356

Prism Project #: 2012100

Prepared by:

Prism ENGINEERING

saving you energy

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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 Arts and Education building at 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.

Six 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:

- Remove Heat Pump Overrides;
- Install Occupancy Sensors in Classrooms;
- Optimize SF-1 Supply Air Temperature Setpoint;
- Implement Heat Pump Loop Pumps Night Shutdown;
- Optimize Boiler Firing and Heating Coil Sequence;
- Lower Heat Pumps Night Setpoints.

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:

BC hydro
powersmart

1.0 Project Overview

Project Information	
Project/Building Name	ARTS and EDUCATION
Building Owner	Thompson Rivers University
Building Location	Kamloops, BC
Project Start Date	4/11/2012
Project Completion Date	3/15/2013

Contact List	
C.Op Provider	Ken Holdren/Juan Mani
C.Op Firm	Prism Engineering
email	ken@prismengineering.com
phone	(604) 298 4858
Building Owner Representative	Jim Gudjonson
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phone	(250) 852-7253
Building Engineer	Tom O'Byrne
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phone	(250) 371-5866
BC Hydro Program Representative	Graham Henderson
email	Graham.Henderson@bchydro.bc.ca
phone	(604) 453-6471

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	15/Mar/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)	6,100
Building Size (conditioned sq. meters)	6,100
Annual Electric Consumption (kWh/yr)	911,474
Annual Electric Cost (with applicable taxes)	$60,726
Bulk cost per kWh (with demand charges)	$0.067
Utility Rate Tariff	1611
Fuel Type	Natural Gas
Annual Fuel Consumption (GJ)	1,051
Annual Fuel Cost (with applicable taxes)	$8,934
Fuel Cost per gigajoule	$8.50
Total Energy Cost (with applicable taxes)	$69,659
Electric Energy Use Intensity (EUI) (kWh/sq. meters)	149
Building Energy Use Intensity (EUI) (ekWh/sq. meters)	197

RCx Costs & Savings	
Implementation Cap	$15,235
Implementation Cost	$22,100
Annual Electric Usage Savings (kWh)	82,490
Annual Electric Usage Savings - Avg. of Year 1&2 ($)	$7,235
Savings as % of Total Electric Usage	9.1%
Annual Electric Demand Savings ($)	$0
Annual Fuel Savings (GJ)	211
Annual Fuel Savings ($)	$1,795
Savings as % of Total Fuel Usage	20.1%
Total Energy Cost Savings - Avg. of Year 1&2 ($)	$9,030
RCx Project Simple Payback	2.6
Savings as % of Total Energy Cost	13.0%

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.

Heat Pump Loop

The main source of heating and cooling for the Building is via a series of water source heat pump units connected by two independent water loops of piping, one serving the East wing and one for the West, through which water is continuously circulated.

To keep the water loop temperature within a specified range, the loops are equipped with evaporative fluid coolers (one per loop) for heat rejection and two gas-fired boilers for heat addition.

Boilers

The Building is served by two Brian model CL120-W-FDG forced draft boilers rated at 1,200 mBH. The boilers have a rated efficiency of 80% . The boilers are piped in parallel; water is circulated through the boilers using two 2 hp Taco pumps model 1638 (P-2 & P-102).

Heat Pump Loop Water Distribution

Two pumps, P-1 and P-101, serving East and West water loops respectively, circulate water in the heat pump loops. The pumps are both Taco model VL3008, rated at 7 ½ hp each. The pumps operate continuously.

Fluid Coolers

Two fluid coolers, one per loop, located on the roof provide heat rejection for the heat pump loops. The fluid coolers are Evapco model F1-742-K, equipped with two fan motors rated at 10 and 3 hp in a main/pony fashion and a 1 hp spray pump.

Heat Pump Units

There are 63 water source heat pumps (WSHP) installed in the Building's ceiling space and mechanical closets that provide heating, cooling and air circulation. The units are controlled by DDC. A summary of the units is presented in **Error! Reference source not found.**.

Table 1: Summary of WSHP

Make	Model	Quantity	CFM	Capacity (TON)	
				Cooling	Heating
Water Furnace	VS015	3	530	1 ¼	1 ½
Water Furnace	VS019	5	650	1 ¾	2
Water Furnace	VS024	9	800	2	2 ½
Water Furnace	VS030	8	1,000	2 ½	3 ¼
Water Furnace	VS036	13	1,250	3	3 ½
Water Furnace	VS042	1	1,500	3 ½	4 ½
Water Furnace	VS048	7	1,700	4	4 ¾
Water Furnace	VS060	17	2,000	5 ¼	6 ¼

Make-up Air Unit

An Engineered Air model LM-15C makeup air unit provides ventilation for the Building. The unit is located in the penthouse mechanical room and is equipped with a 7 ½ hp fan motor and two heating coils each with a three-way valve and a ½ hp circulator pump. The makeup air unit is DDC controlled.

Exhaust

Washroom exhaust fans EF-1 and EF-101and EF-6 are DDC controlled; the remaining fans are locally controlled. A summary of the exhaust fans serving the building is included in Table 2.

Table 2: Summary of Exhaust Fans

Tag	Description/Service Area	Hp	l/s
EF-1	East washroom	2	2,831
EF-2	Elevator mach room	3/5	236
EF-3	Student lounge	1/8	425
EF-4	Staff lounge	1/8	425
EF-5	ECED	1/8	378
EF-6	Anthropology	3/5	274
EF-101	East wing WR Exhaust	5	3,575
EF-102	Electrical room	½	520

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.

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: Remove Heat Pump Overrides

Overview

The heat pumps serving the building are controlled by Siemens configurable Terminal Equipment Controllers (TEC). The DDC system switches the operation mode from day to night via a weekly schedule.

During day mode, the supply fans run continuously and the heat pump compressors cycle as required to meet occupied setpoint; when in night mode, the supply fans cycle with the compressor and the TEC switches to night setback/setup heating and cooling setpoints.

During a site visit, all the heat pumps serving the East wing (HP101 to HP131) were found operating outside the weekly schedule. This observation was confirmed with a trend review. A panel point log report showed that all the East wing heat pumps and heat pump HP010, from the West loop, are manually overridden to day mode, hence the supply fans have been running continuously and units operate to maintain day setpoints.

Recommendations for Implementation

Remove the Day Mode overrides for heat pumps HP101 to HP 131. Add an indication on the existing floor plan graphics of day mode override.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by running a panel point log report for variables with operator priority.

2.2 Measure 2: Install Occupancy Sensors in Classrooms

Overview

Heat pumps serving classrooms operate under a weekly schedule from 7:00 AM to 9:00 PM, seven days a week. The classrooms and other areas are not continuously occupied during weekly scheduled hours. In addition, during some periods such as professional days or reading week, the building is open for the staff but the classrooms are unoccupied.

Energy savings can be achieved by installing occupancy sensors in areas with intermittent occupancy

Table 3: Areas Recommended for Occupancy Control

Floor	Room Number	Area	Heat Pump
1st	101	Classroom - Anthropology	HP007
1st	104	Classroom	HP004
1st	108	Classroom	HP002
1st	162	Classroom	HP105
1st	164	Classroom	HP109
1st	166	Classroom	HP108
2nd	200	Computer lab	HP030
2nd	208	Classroom	HP013
2nd	212	Classroom	HP011
2nd	260	Classroom	HP115
2nd	262	Classroom	HP119
2nd	266	Classroom	HP118
2nd	268	Classroom	HP117
3rd	304	Classroom	HP023
3rd	308	Classroom	HP022
3rd	312	Office	HP021
3rd	360	Computer lab	HP124
3rd	362	Classroom	HP123
3rd	366	Classroom	HP127

Recommendations for Implementation

Install occupancy sensors in the rooms included in Table 2. The heat pumps serving these rooms would operate in "standby mode" when the spaces are not in use. The standby heating and cooling setpoints will be drifted two degrees from the occupied setpoint. The supply fan will be off and cycle with the compressor as required to maintain standby setpoint. A brief (15 minute) flush would be provided if a heat pump 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, supply fan and compressor status.

2.3 Measure 3: Optimize SF-1 Supply Air Temperature Setpoint

Overview

An Engineered Air model LM-15C makeup air unit provides ventilation for the building. The unit is located in the penthouse mechanical room and is equipped with a 7 ½ hp fan motor and two heating coils each with a three-way valve and a ½ hp circulator pump. The makeup air unit is controlled by the DDC system.

The Supply Air Temperature (SAT) is reset by the DDC system based on an outdoor temperature schedule. The SAT setpoint is reset from 17°C when the outdoor temperature is 15°C to 20°C when the outdoor temperature is 0°C.

Figure 1 shows the graphic screen for SF-1. During the observation the SAT setpoint is 19.47°C and the outdoor temperature is 2.84 °C. At the time of the observation, 26% of the 61 heat pumps in the building were operating in cooling mode. Furthermore, 75% of the room temperatures were higher than the heating setpoint.

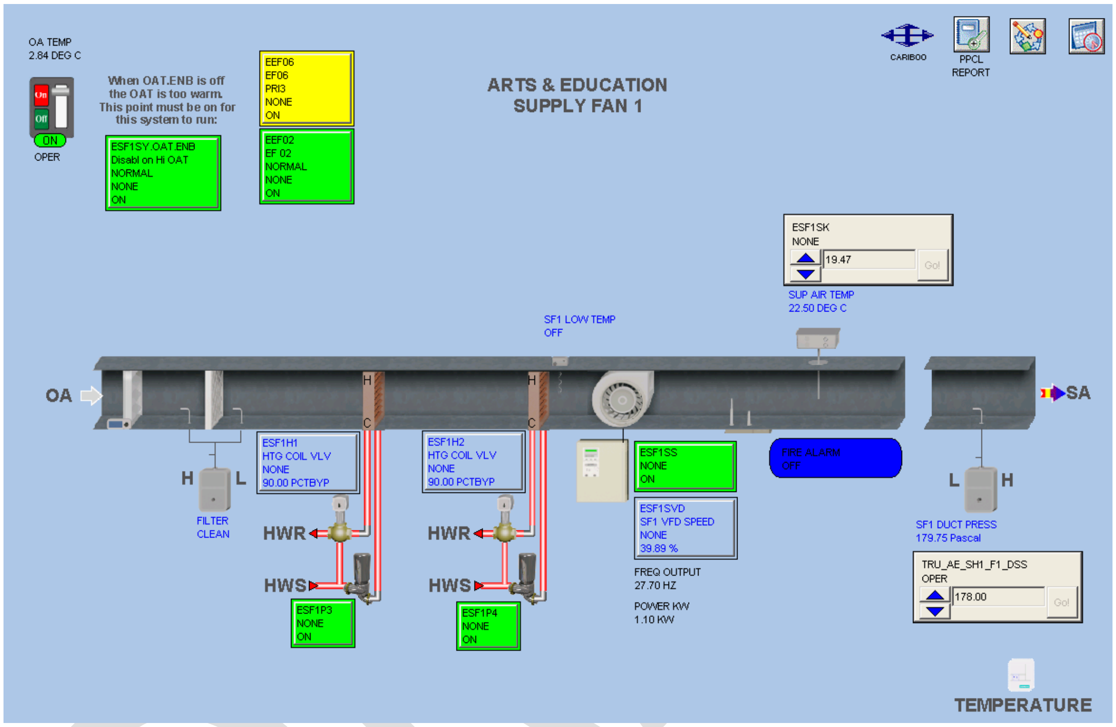

Figure 1: Makeup Air Unit SF-1 DDC Screen

Energy savings can be achieved by lowering the SAT setpoint based on the heat pumps cooling demand. Energy savings would be realized with heat pumps in cooling mode due to a lower makeup air temperature. The heat pumps in heating mode can meet the ventilation heating load more efficiently since, in some cases, the heat pumps in heating take heat from the loop that is rejected by the heat pumps in cooling mode.

Recommendations for Implementation

We recommend modifying the SAT reset based on heating demand as follows:

The high limit would be the existing SAT reset schedule

The low limit would be the outdoor temperature, limited to 12°C.

The DDC system would ramp down the SAT setpoint if the majority of heat pumps have a cooling demand, as indicated by the temperature differential across the loops (Return Temp > Supply Temp).

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by reviewing the new programming code.

2.4 Measure 4: Implement Heat Pump Loop Pumps Night Shutdown

Overview

The building is equipped with two independent heat pump loops to provide heating and cooling. Each heat pump loop uses a 7 ½ HP circulating pump operating continuously. An energy retrofit in 2011 was implemented to shut down the loop pumps at the end of the occupied periods. The pumps were programmed in the DDC code to start if any heat pump in the loop they serve was required to start, once the pump was started, the pump would run until the end of the following occupied period.

The heat pump shutdown was abandoned due to some heat pumps tripping on low pressure.

Recommendations for Implementation

We recommend investigating the reason of the heat pumps tripping. Provided that the loop flow is established prior to enabling of heat pump compressors and loop flow is maintained for a few minutes after all compressors have shutdown, shutting off the loop pumps will not result in tripping of the units. Once the problem is solved, restore the heat pump loop pump night shutdown.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by trend logs for pump status

2.5 Measure 5: Optimize Boiler Firing and Heating Coil Sequence

Overview

There are two boilers in the building, each serving a heat pump loop. Each boiler serves a heat exchanger which provides heat to the loop, as well as a heating coil installed in the makeup air unit.

The boiler primary loop pumps are enabled when the outdoor temperature is lower than 15°C. The heating coil pumps, P3 and P4, are enabled when the outdoor is lower than 15°C and the makeup unit, SF1, is in operation. Coil pumps run continuously if the outdoor temperature is lower than 3°C.

The boilers are enabled when their respective loop temperature is 4°C lower than the loop temperature setpoint and disabled when the loop temperature is 4°C higher than setpoint.

The primary loop supply water temperature setpoint is reset by an outdoor temperature reset schedule.

The makeup air unit is served by two heating coils, one from each boiler system. The 3-way heating coil valves for the heating coils are controlled by a control loop to maintain a supply air temperature setpoint.

Heating coil valves operate in unison based on the same DDC output, as a result, both valves are usually almost closed, as can be seen in Figure 2.

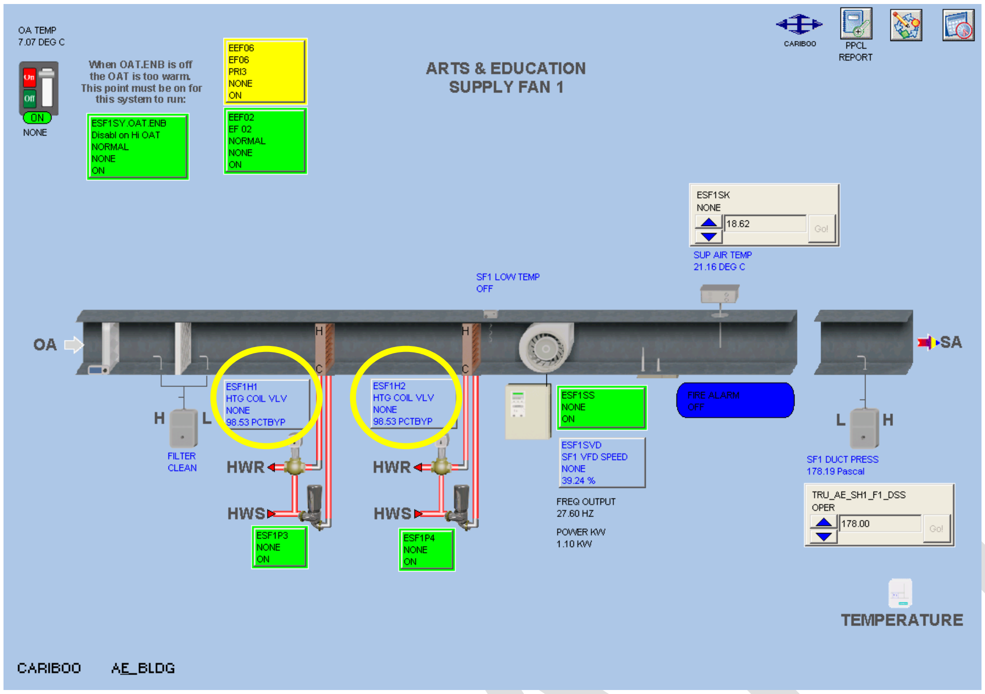

Figure 2: Makeup Air Unit SF1 DDC Graphic

Energy savings can be achieved and the operation of the heating valves improved if the sequence of operation is optimized to operate the heating coils in sequence,

Recommendations for Implementation

We recommend revising the existing sequence of operation as follows:

Occupied mode:

The boilers would operate in a lead/lag fashion to provide heating to the makeup air unit. The boiler serving the upstream coil will be the lead boiler.

Lead boiler would be enabled when the outdoor temperature is lower than 15 °C .

Heating coil valves would be controlled in sequence using split range control. Lead coil pump would be enabled with the lead boiler.

Lag boiler would be off unless enabled by the heating coil control loop or upon heating demand from the heat pump loop. Lag coil pump would be enabled by the heating coil loop or upon failure of the upstream coil pump.

Lag boiler, and the boiler pump, would be enabled when the respective loop temperature is 4°C below setpoint; disabled at sepoint plus 4°C.

Existing outdoor temperature reset would only apply to lead boiler. Lag boiler would operate at the minimum setpoint within the existing range.

Both boilers would be enabled if the outdoor temperature is -5°C or lower.

Unoccupied mode:

Boilers would be enabled when the respective loop pump is operating and loop supply temperature is 4°C below setpoint; disabled at setpoint plus 4°C or upon loop pump shutdown.

When the outdoor temperature is 3°C or lower the lead boiler would be enabled and both heating coil pumps would operate continuously.

Existing heating coil valve and pump coil freeze protection provisions would remain.

Evidence of Proper Implementation

The recommended method for verifying that this measure is reviewing trends including boiler, boiler pump and heating coil pump status.

2.6 Measure 6: Lower Heat Pumps Night Setpoints

Overview

The heat pumps serving the building are controlled by Siemens configurable Terminal Equipment Controllers (TEC). The DDC system switches the operation mode from day to night mode via a weekly schedule; when in night mode, the controllers switch to night heating and cooling setpoints.

The night mode heating setpoints on the controllers is between 18°C to 20°C, but in some cases as high as 23°C. The cooling setpoint is between 27°C and 28°C

Recommendations for Implementation

We recommend setting the night setpoints to 15 °C for heating and 28° for cooling.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by reviewing a report of TEC controller settings for the building and reviewing trends showing the space temperatures.

3.0 Next Steps – Implementation and Hand-off Phases

3.1 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*.

3.2 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
Arts and Education

#	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	Remove Heat Pump Overrides	34,200	$2,999	$0	0	$0	$2,999	$500	0.2	5.0	$ 13,237	600%
2	Install Occupancy Sensors in Classrooms	21,772	$1,910	$0	0	$0	$1,910	$10,800	5.7	5.0	$ (2,055)	18%
3	Optimize SF-1 Supply Air Temperature Setpoint	-2,134	-$187	$0	145	$1,229	$1,042	$2,900	2.8	5.0	$ 1,873	36%
4	Implement Heat Pump Loop Pumps Night Shutdown	14,294	$1,254	$0	0	$0	$1,254	$3,800	3.0	5.0	$ 1,941	33%

BC Hydro Continuous Optimization for Commercial Buildings Program
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#	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 (%)
5	Optimize Boiler Firing and Heating Coil Sequence	2,091	$183	$0	67	$566	$749	$3,400	4.5	5.0	$ 30	22%
6	Lower Heat Pumps Night Setpoints	12,267	$1,076	$0	0	$0	$1,076	$700	0.7	5.0	$ 4,227	154%
		82,490	$ 7,235	$ -	211	$ 1,795	$ 9,030	$ 22,100	2.4			

BC Hydro Continuous Optimization for Commercial Buildings Program
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#	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	Remove Heat Pump Overrides	The heat pumps serving the building are controlled by Siemens configurable Terminal Equipment Controllers (TEC). The DDC system switches the operation mode from day to night via a weekly schedule. During day mode, the supply fans run continuously and the heat pump compressors cycle as required to meet occupied setpoint; when in night mode, the supply fans cycle with the compressor and the TEC switches to night setback/setup heating and cooling setpoints. During a site visit, all the heat pumps serving the East wing (HP101 to HP131) were found operating outside the weekly schedule. This observation was confirmed with a trend review. A panel point log report showed that all the East wing heat pumps and heat pump HP010, from the West loop, are manually overridden to day mode, hence the supply fans have been running continuously and units operate to maintain day setpoints.	DDC contractor/building operator	Remove the Day Mode overrides for heat pumps HP101 to HP 131. Add an indication on the existing floor plan graphics of day mode override.	Run a panel point log report for variables with operator priority.	Y
2	Install Occupancy Sensors in Classrooms	Heat pumps serving classrooms operate under a weekly schedule from 7:00 AM to 9:00 PM, seven days a week. The classrooms and other areas are not continuously occupied during weekly scheduled hours. In addition, during some periods such as professional days or reading week, the building is open for the staff but the classrooms are unoccupied. Energy savings can be achieved by installing occupancy sensors in areas with intermittent occupancy	DDC contractor	Install occupancy sensors in the rooms served by Heat Pumps HP002,4,7,11,13,21,22,23,30,105,108,109,115,117,118,119,123,124&127. The heat pumps serving these rooms would operate in "standby mode" when the spaces are not in use. The standby heating and cooling setpoints will be drifted two degrees from the occupied setpoint. The supply fan will be off and cycle with the compressor as required to maintain standby setpoint. A brief (15 minute) flush would be provided if a heat pump does not operate for 2 hours.	Set trends showing the room temperatures, supply fan and compressor status.	Y
3	Optimize SF-1 Supply Air Temperature Setpoint	An Engineered Air model LM-15C makeup air unit provides ventilation for the building. The unit is located in the penthouse mechanical room and is equipped with a 7 ½ hp fan motor and two heating coils each with a three-way valve and a ½ hp circulator pump. The makeup air unit is controlled by the DDC system. The Supply Air Temperature (SAT) is reset by the DDC system based on an outdoor temperature schedule. The SAT setpoint is reset from 17°C when the outdoor temperature is 15°C to 20°C when the outdoor temperature is 0°C. Energy savings can be achieved by lowering the SAT setpoint based on the heat pumps cooling demand. Energy savings would be realized with heat pumps in cooling mode due to a lower makeup air temperature. The heat pumps in heating mode can meet the ventilation heating load more efficiently since, in some cases, the heat pumps in heating take heat from the loop that is rejected by the heat pumps in cooling mode.	DDC contractor	Modify the SAT reset based on heating demand as follows: The high limit would be the existing SAT reset schedule. The low limit would be the outdoor temperature, limited to 12°C. The DDC system would ramp down the SAT setpoint if the majority of heat pumps have a cooling demand, as indicated by the temperature differential across the loops (Return Temp > Supply Temp).	Review the new programming code.	Y
4	Implement Heat Pump Loop Pumps Night Shutdown	The building is equipped with two independent heat pump loops to provide heating and cooling. Each heat pump loop uses a 7 ½ HP circulating pump operating continuously. An energy retrofit in 2011 was implemented to shut down the loop pumps at the end of the occupied periods. The pumps were programmed in the DDC code to start if any heat pump in the loop they serve was required to start, once the pump was started, the pump would run until the end of the following occupied period. The heat pump shutdown was abandoned due to some heat pumps tripping on low pressure.	DDC contractor	Investigate the reason of the heat pumps tripping. Provided that the loop flow is established prior to enabling of heat pump compressors and loop flow is maintained for a few minutes after all compressors have shutdown, shutting off the loop pumps will not result in tripping of the units. Once the problem is solved, restore the heat pump loop pump night shutdown.	Trend logs for pump status	Y

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BC Hydro Continuous Optimization for Commercial Buildings Program
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#	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)
5	Optimize Boiler Firing and Heating Coil Sequence	There are two boilers in the building, each serving a heat pump loop. Each boiler serves a heat exchanger which provides heat to the loop, as well as a heating coil installed in the makeup air unit. The boiler primary loop pumps are enabled when the outdoor temperature is lower than 15°C. The heating coil pumps, P3 and P4, are enabled when the outdoor is lower than 15°C and the makeup unit, SF1, is in operation. Coil pumps run continuously if the outdoor temperature is lower than 3°C. The boilers are enabled when their respective loop temperature is 4°C lower than the loop temperature setpoint and disabled when the loop temperature is 4°C higher than setpoint. The primary loop supply water temperature setpoint is reset by an outdoor temperature reset schedule. The makeup air unit is served by two heating coils, one from each boiler system. The 3-way heating coil valves for the heating coils are controlled by a control loop to maintain a supply air temperature setpoint. Heating coil valves operate in unison based on the same DDC output, as a result, both valves are usually almost closed. Energy savings can be achieved and the operation of the heating valves improved if the sequence of operation is optimized to operate the heating coils in sequence,	DDC contractor	Revise the existing sequence of operation as follows: Occupied mode. The boilers would operate in a lead/lag fashion to provide heating to the makeup air unit. The boiler serving the upstream coil will be the lead boiler. Lead boiler would be enabled when the outdoor temperature is lower than 15 °C . Heating coil valves would be controlled in sequence using split range control. Lead coil pump would be enabled with the lead boiler. Lag boiler would be off unless enabled by the heating coil control loop or upon heating demand from the heat pump loop. Lag coil pump would be enabled by the heating coil loop or upon failure of the upstream coil pump. Lag boiler, and the boiler pump, would be enabled when the respective loop temperature is 4°C below setpoint; disabled at sepoint plus 4°C. Both boilers would be enabled if the outdoor temperature is -5°C or lower. Unoccupied mode. Boilers would be enabled when the respective loop pump is operating and loop supply temperature is 4°C below setpoint; disabled at setpoint plus 4°C or upon loop pump shutdown. When the outdoor temperature is 3°C or lower the lead boiler would be enabled and both heating coil pumps would operate continuously. Existing heating coil valve and pump coil freeze protection provisions would remain.	Review trends including boiler, boiler pump and heating coil pump status.	Y
6	Lower Heat Pumps Night Setpoints	The heat pumps serving the building are controlled by Siemens configurable Terminal Equipment Controllers (TEC). The DDC system switches the operation mode from day to night mode via a weekly schedule; when in night mode, the controllers switch to night heating and cooling setpoints. The night mode heating setpoints on the controllers is between 18°C to 20°C, but in some cases as high as 23°C. The cooling setpoint is between 27°C and 28°C	DDC contractor/building operator	Set the night setpoints to 15 °C for heating and 28° for cooling.	Review a report of TEC controller settings for the building and reviewing trends showing the space temperatures.	Y