Continuous Optimization for Commercial Buildings Program

Retrocommissioning Final Report

April 30, 2015

Prepared for:

University of Victoria

Clearihue

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TABLE OF CONTENTS

Introduction

Through the BC Hydro Continuous Optimization for Commercial Building Program, 5 measures were implemented at Clearihue resulting in an estimated annual energy savings of $56,419. To ensure that these savings persist over time, it is vital that the facilities staff and service contractors, current and future, are aware of the implemented measures and the actions that need to be taken in order to support and maintain each measure.

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

CES Engineering Ltd provided the professional services for this project and any questions related to this document can be directed to:

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1.0 Project Overview

Building Energy Usage Summary	
Building Size (gross sq. meters)	16,395
Building Size (conditioned sq. meters)	14,530
Annual Electric Consumption (kWh/yr)	3,524,719
Annual Electric Cost (with applicable taxes)	$268,573
Bulk cost per kWh (with demand charges)	$0.076
Utility Rate Tariff	1611
Fuel Type	Campus Hot Water
Annual Fuel Consumption (GJ)	10,737
Annual Fuel Cost (with applicable taxes)	$157,502
Fuel Cost per gigajoule	$14.67
Total Energy Cost (with applicable taxes)	$426,075
Electric Energy Use Intensity (EUI) (kWh/sq. meters)	243
Building Energy Use Intensity (EUI) (ekWh/sq. meters)	448

RCx Costs & Savings	
Implementation Cap	$44,103
Implementation Cost	$43,375
Annual Electric Usage Savings (kWh)	177,280
Annual Electric Usage Savings - Avg. of Year 1&2 ($)	$17,414
Savings as % of Total Electric Usage	5.0%
Annual Electric Demand Savings ($)	$0
Annual Fuel Savings (GJ)	2,659
Annual Fuel Savings ($)	$39,005
Savings as % of Total Fuel Usage	24.8%
Total Energy Cost Savings - Avg. of Year 1&2 ($)	$56,419
RCx Project Simple Payback	0.8
Savings as % of Total Energy Cost	13.2%

2.0 Project Results

The primary objective of the project at this facility was to identify deficiencies in the operation of a facility's mechanical equipment, lighting, and related controls, and determine opportunities for corrective action and other operational and maintenance improvements that reduce energy consumption and demand.

To perform the investigation, CES Engineering Ltd. assessed the facility's equipment and operations. Functional performance testing was used to verify the intended operation of individual components and systems under various conditions and modes of operation, and analysis of system data occurred either through trends from the building automation system or by the use of portable data logging equipment.

A complete list of findings was provided after the investigation at the meeting between the Owner, CES Engineering Ltd., and the BC Hydro Program Representative to select measures for implementation.

Once the RCx investigation was complete, 5 measures were selected for implementation, listed below:

Measure Number	Measure Description
1	Demand Based AHU SAT Reset and Adjusted Min Damper Positions
2	Dual Zone Temperature Setpoints and Setpoint Optimization
3	Optimize System Schedules and Enabling Controls
5	AHU DCV and DCE Controls
7	Reduced Corridor Lighting Schedule

Note that based on the setup of data in the original Findings Workbook, measure 4 and 6 were not implemented, and the numbering has been maintained to keep consistency.

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3.0 Implemented Measures

The following section provides information about the implementation of these measures and documents the actions that need to be taken in order to maintain each measure.

3.1 *Measure 1: Demand Based AHU SAT Reset and Adjusted Minimum Damper Positions*

Overview

Nine Clearihue AHUs were found to use proportional SAT reset sequences that in general, result in lower than necessary supply air temperatures to meet zone cooling demands. These low supply air temperature setpoints resulted in the use of the economizer in cool weather when there was no cooling demand, increasing zone heating loads due to the colder than necessary supply temperatures. All AHU zones had heating elements (typically reheat coils or perimeter convectors) that reheat this cool supply air. Since the zone heating maintained the zone heating setpoints, there was no signal to the AHUs for the setpoint to increase and for the economizer to close.

Measure Implemented

Demand based AHU SAT reset with dual zone setpoints for heating and cooling operation.
Zone temperatures are now compared to dual setpoints using PID loops, one for cooling and one for heating. All zone setpoints are individually adjustable and not specified by building-wide global variables. This method of operation is integrated with economizers, heat recovery coils, heating/cooling coils, and coil pumps accordingly. The measure listed above is applicable to the following air handling units: AHU-1, TRA, TRB, BAH, AHE, AHC, TRD, TRL and TRP.

Air-handling units that have a means of heating or cooling use a demand-controlled SAT reset strategy, whereby the AHU SAT setpoint is reset between a maximum and minimum setpoint based on actual zone heating and cooling demand.

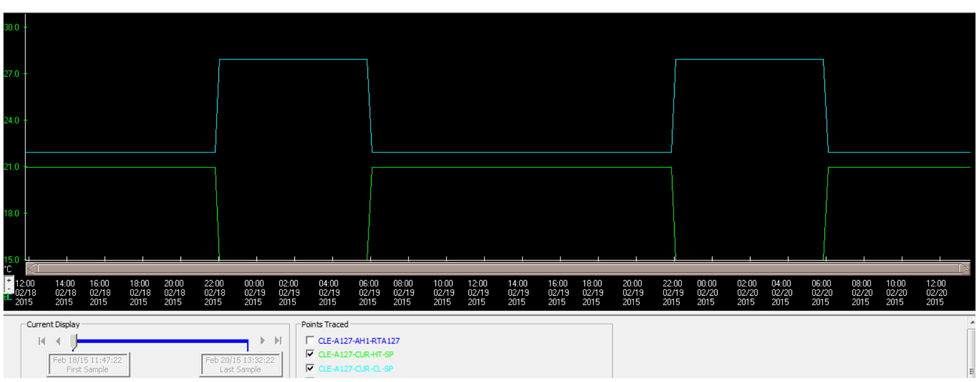

Figure 1: Heating and Cooling Setpoints with Setback for AH 1

SAT is reset based upon heating and cooling demand as shown above.

The implementation information for this measure is summarized in the table below:

Completion date	February 20, 2015
Estimated Implementation cost (note that actual cost cannot be determined by University of Victoria)	$10,625
Projected energy and cost savings per year.	-346 kWh electricity, or -$34 2,153 GJ Gas, or $31,583

Measure Maintenance

- Periodically check temperature sensors are properly calibrated
- ensure PID settings still represent system properly (settings may change if actuators age, are replaced etc.)

3.2 *Measure 2: Dual Zone Temperature Setpoints and Setpoint Optimization*

Overview

All DDC zones essentially had a single temperature setpoint for both heating and cooling. Certain zones had a setpoint that controlled zone level equipment, and another setpoint imposed at the system level that controlled the system SAT setpoint, HCV, and MAD. Deadbands were (for some systems) imposed at the system level SAT control, but as an adjustment to a SAT reset (sometimes based on average zone temperature, sometimes max/min). As a result, systems were either using economizers excessively or overheating the zone.

Measure Implemented

Dual Zone Temperature Setpoints and Setpoint Optimization

Unique heating and cooling setpoints exist for each air handling unit (AHU-1, TRA, TRB, BAH, AHE, AHC, TRD, TRL and TRP).

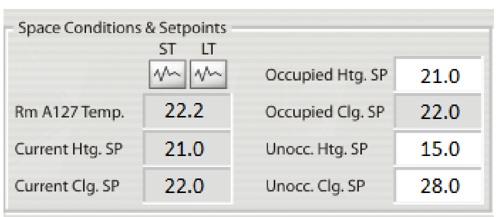

Figure 2: AH 1 Heating and Cooling Setpoints

All AHU zone setpoints are individually adjustable and not specified by building-wide or global variables. A minimum deadband of 1°C is used to separate heating and cooling setpoints (e.g. 21.5°C for heating and 22.5°C for cooling).

The implementation information for this measure is summarized in the table below:

Completion date	February 20, 2015
Implementation cost	$3,000
Projected energy and cost savings per year	845 kWh, or $83 180 GJ, or $2,640

Measure Maintenance

- Ensure deadband is realistic and there are periods of time without heating and cooling

3.3 *Measure 3: Optimize System Schedules and Enabling Controls*

Overview

All systems ran on fixed weekly schedules with no holidays, and a few systems we allowed to run after-hours based on zone temperatures.

A-Wing Classroom systems TRA and TRP have zone occupancy sensors which could be used to enable/disable systems, based on a combination of zone occupancy and zone temperatures. TRA had a programming error which resulted in 24/7 operation. TRP had excessively high ventilation rates due to a zone CO_2 setpoint that was too low at 900 ppm.

The C-Wing basement system BAH was also running 24 hours based on a lack of enable/disable controls.

AHU-C305 has zone occupancy sensors but they were only used to trigger after-hours operation.

Measure Implemented

Optimize System Schedules and Enabling Controls
A combination of scheduling and occupancy sensors enable air handling while CO_2 sensors for each zone allow for demand-controlled ventilation through reset of outdoor air damper. The measure listed above is applicable to AHUs TRA, BAH, TRP and AH-C305.

AHU TRA cooling enabling sequence of requiring cooling at all times is corrected, and the unit no longer runs 24/7.

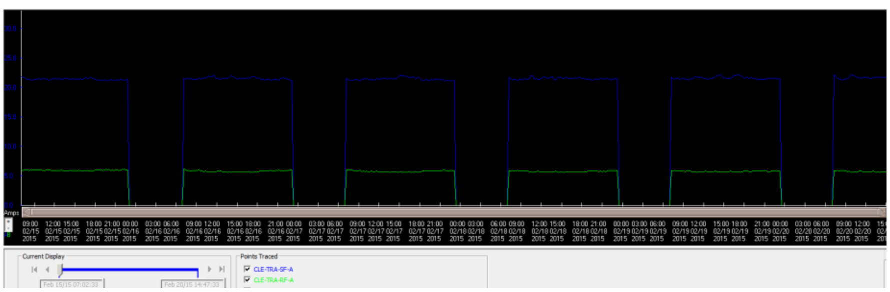

Figure 3: AH TRA Supply and Return Fan Amperage

Demand controlled enabling sequences based upon heating/cooling demand and feedback from occupancy sensors are implemented for AH TRA and TRP. Time delays for enabling/disabling of fully occupied mode shall be user adjustable and clearly specified.

AHU-C305 fixed schedule has been reduced in length to align with typical occupancy. Additionally, zone occupancy sensor feedback controls enabling/disabling of the unit during unoccupied periods.

Mon	Tue	Wed	Thu	Fri
05:00	07:00	07:00	07:00	07:00
21:00	21:00	21:00	21:00	21:00

Figure 4: AH C305 Current Operation Schedule

Holiday and weekly schedule enabling/disabling are implemented for AHU BAH.

The implementation information for this measure is summarized in the table below:

Completion Date	February 20, 2015
Implementation Cost	$1,500
Projected energy and cost savings per year	79,158 kWh, or $7,775 131 GJ, or $1,922

Measure Maintenance

- check for abnormal runtime periods or CO2 sensor readings
- check that AHUs run based upon occupancy sensors, and are not manually overridden on

3.4 *Measure 5: AHU DCV and DCE Controls*

Overview

As mentioned in Measure 3, most systems ran on a fixed schedule. Systems typically also had fixed outside air damper positions, which are in some cases resulted in more airflow than the ASHRAE 62 design requirement, and in some cases less.

Measure Implemented

AHU DCV and DCE Controls

Demand controlled enabling and ventilation controls were applied to the following unit: AHUs TRA, TRP, CLEA004, AHU-1, BAH, AHE, AHC and TRL. Implementation details are as follows:

Air-handling units with CO2 sensors in all zones use a demand-controlled ventilation strategy where minimum OAD position is reset between the design minimum (the position that provides sufficient ventilation for full occupancy), and a closed position.

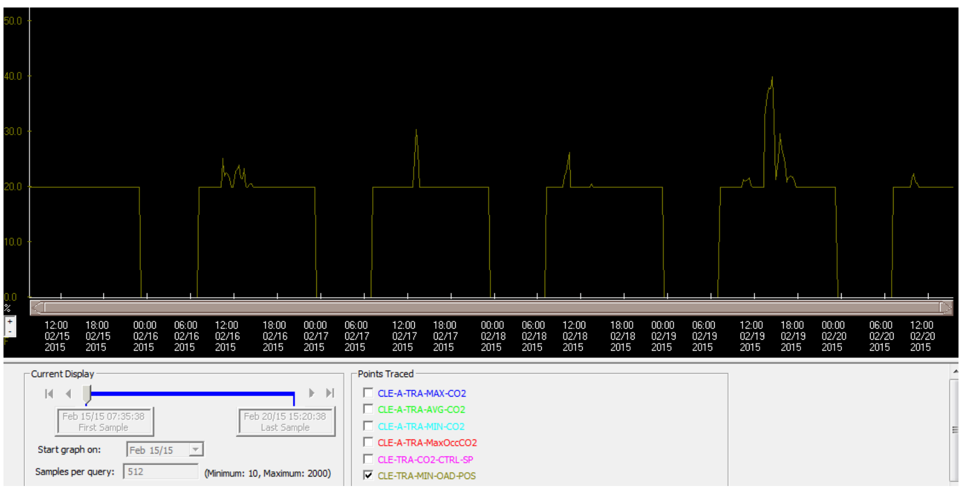

Figure 5: AH TRA Minimum Outside Air Damper Position Reset

Overall zone ventilation demand is represented by a variable that are user-adjustable to be representative of the PID outputs.

Demand controlled ventilation is implemented for AHU TRA and TRP. Current CO2 setpoints are at 1025 ppm, increased from 900 ppm based on ASHRAE 62.1

DCV is implemented on CLEA004 based on the duct return-air CO2 sensor.

DCE and DCV are implemented on AHU-1 (A127) based on 2 zone CO2 and occupancy sensors;

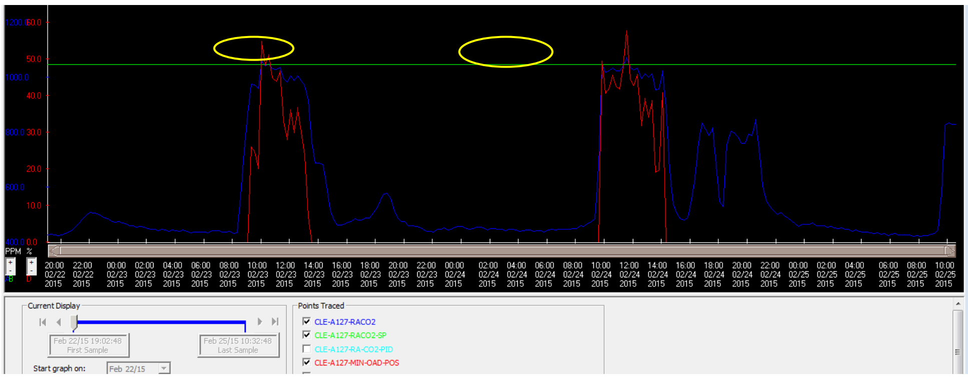

Figure 6: AH1 RA CO2 Sensor and OAD Reset

RA CO2 is used to reset the OAD and is maintained below setpoint of 1050 ppm.

DCE is implemented on BAH, with a hybrid demand/scheduled approach based on 3 zone occupancy sensors.

DCE is implemented on AHE, with a hybrid demand/scheduled approach based on 2 zone occupancy sensors.

DCE and DCV are implemented on AHC based on 7 zone occupancy and CO2 sensors in the 1stfloor classrooms.

DCE and DCV are implemented on TRL based on 1 zone occupancy sensors and 1 RA CO2 sensor.

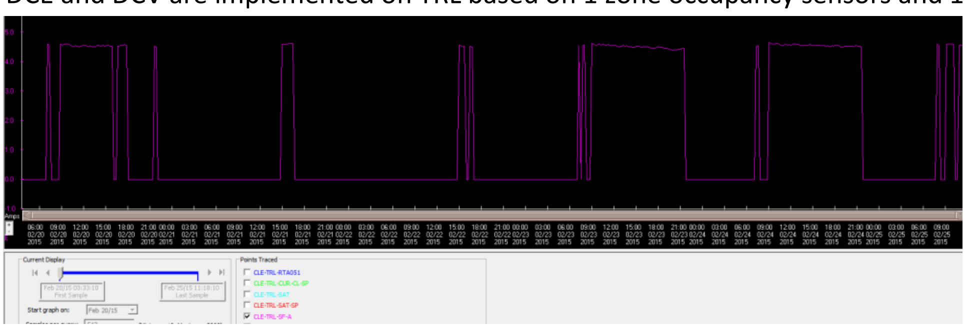

Figure 7: TRL Operation Based on Occupancy Sensor

The TRL unit operation is enabled by one occupancy sensor.

The implementation information for this measure is summarized in the table below:

Completion Date	February 20, 2015
Implementation Cost	$27,750
Projected energy and cost savings per year	30,004 kWh, or $2,947 392 GJ, or $5,750

Measure Maintenance

- ensure proper modulation of VFD and that the speed is not fixated near max capacity
- check CO2 levels to ensure adequate ventilation and proper outdoor air damper modulation

3.5 *Measure 7: Reduced Corridor Lighting Schedule*

Overview

Common area and corridor lighting ran from approximately 4 am to 12 am daily. During the investigation, the programmed lighting schedule was not determined, but this schedule was estimated based on an analysis of daily electrical consumption profiles.

Measure Implemented

Reduced Corridor Lighting Schedule

General Space lighting such as corridor lighting is now controlled by lighting relays on a reduced set schedule.

Corridor Lighting runs from 5:00 am to 1:00 am
Office Corridors runs from 5:00 am to 7:00 pm
First Flr. Classrooms run from 5:00 am to 10:00 pm

The implementation information for this measure is summarized in the table below:

Completion Date	February 20, 2015
Implementation Cost	$500
Projected energy and cost savings per year	67,619 kWh, or $6,642 -197 GJ, or -$2,890

Measure Maintenance

- Monitor lighting and ensure reduced operation after hours

4.0 Updated Building Documentation

The following building documentation was updated:

Sequence of Operations: The building BAS sequence of operations was updated to incorporate the various control sequence modifications to satisfy the energy saving measures. For a full list of updates, refer to UVic Phase II – Sequence of Operations document created by Syscor R&D Inc.

5.0 Contact Information for Implementer / Contractor

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Electrical Contractor:

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ATTACHMENT A: Implementation Summary Table

#	Finding	Measure	Updated Annual Electric Savings (kWh with interactions)	Updated Annual Electric Energy Savings ($)	Updated Annual Electric Demand Savings ($)	Updated Annual Gas Savings (gigajoules with interactions)	Updated Annual Gas Savings ($)	Updated Annual Total Savings ($)	Updated Implementation Cost ($)	Updated Simple Payback (years)	Implementer	Scheduled Completion Date	Actual Completion Date	Implemented Measure	Updated Evidence of Implementation Method	Evidence of Implementation Results	Recommendations for Future Persistence of Measure	Implement without incentives as part of <2 year simple payback bundle? (Y or N)
1	AHU proportional-only reset sequence results in lower than necessary SATs (through economizer use) and excess reheat.	Demand based AHU SAT reset and adjusted min damper positions	-346	-$34	$0	2,153	$31,583	$31,549	$10,625	0.3	Syscor	30/Jun/2015	20/Feb/2015	Demand based AHU SAT reset and adjusted min damper positions	Refer to CES Engineering Functional Test Form CLE1 for details.	Refer to CES Engineering Functional Test Form CLE1 for details.	• Periodically check temperature sensors are properly calibrated • ensure PID settings still represent system properly (settings may change if actuators age, are replaced etc.)	Y
2	DDC zones have a single temperature setpoint for both heating and cooling	Dual zone temperature setpoints and setpoint optimization	845	$83	$0	180	$2,640	$2,723	$3,000	1.1	Syscor	30/Jun/2015	20/Feb/2015	Dual zone temperature setpoints and setpoint optimization	Refer to CES Engineering Functional Test Form CLE1 for details.	Refer to CES Engineering Functional Test Form CLE1 for details.	• Ensure deadband is realistic and there are periods of time without heating and cooling	Y
3	Fixed schedules are programmed longer than necessary. Existing occupancy sensors can be used for enabling/disabling. TRA and BAH are running 24/7.	Optimize system schedules and enabling controls	79,158	$7,775	$0	131	$1,922	$9,697	$1,500	0.2	Syscor	30/Jun/2015	20/Feb/2015	Optimize system schedules and enabling controls	Refer to CES Engineering Functional Test Form CLE2 for details.	Refer to CES Engineering Functional Test Form CLE2 for details.	• check for abnormal runtime periods or CO2 sensor readings • check that AHUs run based upon occupancy sensors, and are not manually overridden on	Y
5	Systems have fixed outside air damper positions, and run on fixed schedules	Add controls for DCV and demand-enabling	30,004	$2,947	$0	392	$5,750	$8,697	$27,750	3.2	UVic and Syscor	30/Jun/2015	20/Feb/2015	AHU DCV and DCE Controls	Refer to CES Engineering Functional Test Form CLE3 for details.	Refer to CES Engineering Functional Test Form CLE3 for details.	• ensure proper modulation of VFD and that the speed is not fixated near max capacity • check CO2 levels to ensure adequate ventilation and proper outdoor air damper modulation	Y
7	Common area and corridor area lighting is running longer than needed	Reduce corridor lighting schedule	67,619	$6,642	$0	-197	-$2,890	$3,752	$500	0.1	UVic	30/Jun/2015	20/Feb/2015	Reduced Corridor Lighting Schedule	Confirmation with UVic Building Operations	Confirmation with UVic Building Operations	• Monitor lighting and ensure reduced operation after hours	Y