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Continuous Optimization for Commercial Buildings Program

Retrocommissioning Investigation Report

March 21, 2013

Prepared for:

Thompson Rivers University

Trades & Technology Centre

BC Hydro #:COP10-350

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 the Trades and Technology Building 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.

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:

- Optimize Chilled Water Setpoint Reset;
- Add Weekly Schedule to Infrared Heaters Control;
- Shutdown Heating Pumps at Night;
- Remove Overrides on VAV's;
- Add Programmable Timers to TV Monitors;
- Add DDC control to Vestibule Forced Flow Heaters.

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:

- AHU's Supply Air Temperature Setpoint Reset

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

1.0 Project Overview

Project Information	
Project/Building Name	Trades and Tech Building
Building Owner	Thompson Rivers University
Building Location	Kamloops, BC
Project Start Date	3/13/2012
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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Building Engineer	Tom O'Byrne
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BC Hydro Program Representative	Graham Henderson
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phone	(604) 453-6471

Task	Date Completed
RCx investigation kickoff meeting	20/Jun/2012
EMIS installation date (Electricity)	11/Apr/2012
EMIS installation date (Fuel)	4/Nov/2012
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	
Task	**Date Completed**

Building Energy Usage Summary	
Building Size (gross sq. meters)	10,500
Building Size (conditioned sq. meters)	10,500
Annual Electric Consumption (kWh/yr)	898,924
Annual Electric Cost (with applicable taxes)	$59,890
Bulk cost per kWh (with demand charges)	$0.067
Utility Rate Tariff	1611
Fuel Type	Natural Gas
Annual Fuel Consumption (GJ)	7,192
Annual Fuel Cost (with applicable taxes)	$68,470
Fuel Cost per gigajoule	$8.50
Total Energy Cost (with applicable taxes)	$128,360
Electric Energy Use Intensity (EUI) (kWh/sq. meters)	86
Building Energy Use Intensity (EUI) (ekWh/sq. meters)	276

RCx Costs & Savings	
Implementation Cap	$27,787
Implementation Cost	$18,000
Annual Electric Usage Savings (kWh)	25,157
Annual Electric Usage Savings - Avg. of Year 1&2 ($)	$2,206
Savings as % of Total Electric Usage	2.8%
Annual Electric Demand Savings ($)	$0
Annual Fuel Savings (GJ)	183
Annual Fuel Savings ($)	$1,555
Savings as % of Total Fuel Usage	2.5%
Total Energy Cost Savings - Avg. of Year 1&2 ($)	$3,762
RCx Project Simple Payback	5.7
Savings as % of Total Energy Cost	2.9%

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 six (B1 to B6) 3,560 mBH Burnham atmospheric hydronic boilers arranged in parallel. The boilers are equipped with electronic ignition. The firing sequence of the boilers is DDC controlled. Each boiler has a dedicated 1/7 hp boiler circulation pump that is operated in conjunction with the boiler.

Hot Water Distribution

The piping configuration is primary-only; there is no secondary loop or 3-way valve. Heating water circulation is achieved by two 5 hp circulation pumps (P-1 & P-2) arranged in parallel that operate in duty/standby fashion.

Heating in rooms is provided by DDC controlled hot water reheat coils. The entrances and lobbies have hot water forced flow heaters controlled by local thermostats. The boiler room and mechanical rooms are equipped with hot water unit heaters controlled by local thermostats.

Unit heaters

A total of seven Reznor model SCB125 unit heaters are installed in the workshops, one in the automotive, three in carpentry, one in electrical, two in tech transfer and one in the tool room. The units are enabled by the DDC system and controlled by local thermostats.

Infrared Heaters

There are 15 Gordon Ray HB model BH-60-20 and BH-80-30 gas fired infrared heaters in the automotive shop. All heaters are enabled by the DDC system and controlled by local thermostats.

Cooling Systems

The building is cooled by a 240 Ton, air-cooled Trane chiller located outside the building, west of the welding shop. The chiller is interfaced with the DDC system.

Chilled water from the chiller is pumped to the mechanical room where the air handling units are located. The chilled water pump, P-3A, is a Bell & Gossett series 80 with 10 hp motor, software interlocked with the chiller through the DDC system.

Ventilation Systems

Air Handling Units

Classroom areas, common areas and offices are served by three air handling units (AHU-1 to AHU-3). All units are equipped with cooling coils, indirect gas fired burners and mixing section. The supply fans speed is controlled by a VSD. Units supply VAV boxes with reheat coils.

The telecommunications room has a dedicated air handling unit (FC-1) with a cooling coil and a mixing section.

The welding shop has a makeup air unit with direct gas fired heating. The two-speed fan is controlled by DDC.

A summary of the units is provided in Table 1.

Table 1: Summary of TTC Air Handling Units

Tag	Service	HP	CFM	Flow Control	Heating Stages	Cooling Coil
AHU-1	Classrooms, storage	25	19,000	VSD	Modulating	Yes
AHU-2	Second floor South	40	26,800	VSD	Modulating	Yes
AHU-3	First and second floors East end	20	13,000	VSD	Modulating	Yes
FC-1	Computer room	3	3,800	None	Modulating	Yes
MAU-1	Welding shop	15	20,000	2-Speed	2 Stage	No

Transfer Fans

The workshops are supplied with conditioned air from the central corridor by 19 transfer fans. Transfer fans 7 to 16 are DDC controlled. A summary is presented in **Error! Reference source not found.**.

Exhaust

Exhaust from washrooms is provided by three fans, located on the roof. Exhaust from the shops is provided by 26 exhaust fans, controlled by local switches and monitored in DDC.

A dust collector system is installed in the carpentry shop; dust collector (DC-1) is controlled by a manual switch.

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	Washrooms EF	¾	1,640
EF-2	Washroom 288C EF	Frac.	55
EF-3	Washroom EF	¼	220
EF-4,5&6	Stairwell EF	¼	1,130
EF-7	Comm Veh shop EF	5	2,270
EF-8	Automotive shop EF	5	1,700
EF-9	Automotive shop EF	2	950
EF-10	Marine engine shop EF	2	685
EF-11	Commercial transport shop EF	2	1,130
EF-12	Heavy duty Mechs shop EF	1.5	850
EF-13to16, 25,27to31	shops general EF	1	3,000
EF-17,18	Welding booth exhaust	5	1,980
EF-19 to 22	Welding booth exhaust	3	1,415
EF-23	EF welding shop	1 ½	3,800
EF-24	Welding booth exhaust	2	2,270
EF-26	Elevator machine room	Frac.	212
EF-32	EF Computer room	1/3	1,000
EF-33	Welding booth exhaust	5	2,360

Compressed Air Systems

Two 35 hp Gardner Denver air compressors located in the compressor room provide compressed air for the building.

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: Optimize Chilled Water Setpoint Reset

Overview

The chiller plant is enabled when the outdoor temperature is above 16 °C, disabled at 14°C. The supply water temperature setpoint is linearly reset by the DDC from 12.7 °C to 7.2 °C as the return water temperature varies from 7.2 °C to 12.7 °C.

The chiller efficiency increases at higher supply water temperatures. A rise in chiller efficiency can be achieved by using a reset that can meet the building's cooling load and keep the supply water temperature as high as possible.

Recommendations for Implementation

We recommend resetting the chilled supply water temperature setpoint based on the cooling demand as indicated by the chilled water coil valve positions. The chilled water temperature would be reset to maintain at least one valve about 90% open.

The chiller plant would be enabled by the offset between supply air temperature and setpoint for operating fan systems.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by setting trends showing chilled water temperature, setpoint and cooling valve positions.

2.2 Measure 2: Add Weekly Schedule to Infrared Heaters Control

Overview

The infrared heaters in the automotive shop (Figure 1) are enabled by the DDC system and controlled by local thermostats.

According to the program code, the heaters are enabled if the outdoor temperature is below 15 °C., regardless of occupancy.

Figure 1: Infrared Heaters in the Automotive Shop

Recommendations for Implementation

We recommend adding a weekly schedule to control the infrared heaters. The heaters would be enabled continuously during scheduled occupancy periods if the outdoor temperature is lower than 15°C. A newly added temperature sensor in the shop would enable/disable the heaters to maintain night setback temperature. An optimum start algorithm would enable the heaters before the schedule time to bring the shops temperature to occupied setpoint at the schedule start time.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by trend logs for infrared heaters enable and outdoor temperature.

2.3 Measure 3: Shutdown Heating Pumps at Night

Overview

Heating water circulation is achieved by two parallel 5 hp circulation pumps (P-1 & P-2) that operate in duty/standby fashion. The hot water system serves DDC controlled VAV reheat coils and forced flow heaters installed in the entrances and lobbies, controlled by local thermostats.

The heating pumps are enabled when the outdoor temperature is lower than 18°C. The supply water temperature setpoint is reset by an outdoor temperature schedule from 60°C to 85°C as the outdoor temperature varies from 15°C to -10°C.

Recommendations for Implementation

We recommend the program code to be revised to allow the heating water pumps to shutdown during unoccupied periods. Pumps would start if any air handling unit (AHU-1 to AHU-3 and FC-1) is running in night setback or morning warm-up mode.

Pumps would run continuously if the outdoor air temperature is below 3ºC.

Evidence of Proper Implementation

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

2.4 Measure 4: Remove Overrides on VAV's

Overview

Occupancy control was added in 2011 to the VAV's serving the classrooms. The VAV's are controlled by Terminal Equipment Controller (TEC). With the current controller configuration, the VAV's switch to "Night Mode" when no occupancy is detected for 10 consecutive minutes. VAV's revert to DAY mode when occupancy is detected for more than 2 minutes.

All VAV's were overridden to "Day" mode; hence the occupancy control was not in effect. The mechanical systems coordinator advised the controllers were overridden to DAY mode due to temperature and ventilation problems.

However, ventilation issues cannot be resolved by overriding the VAV's to DAY mode. According to the TEC's control schedule, VAV's in heating mode operate at minimum flow, regardless of DAY/NIGHT mode.

Recommendations for Implementation

We recommend creating a routine to reset the night cooling/heating setpoints to +/- 1.5 °C from occupied setpoint during scheduled occupancy periods and revert the setpoints for unoccupied periods back to 27°C cooling and 18 °C for heating.

The allowable drift from day mode would be adjustable from the DDC graphic screen, to allow for adjustments during cold temperatures. Remove the overrides from the VAV's.

Evidence of Proper Implementation

The recommended method for verifying that this measure is implemented properly is by running a Panel Point Log report to confirm that there are no overrides in the VAV's and an application sub-point report including unoccupied setpoint.

2.5 Measure 5: Add Programmable Timers to TV Monitors

Overview

There are two TV monitors installed in the lower and upper cafeteria/luncheon areas that are continuously ON, as shown in Figure 2.

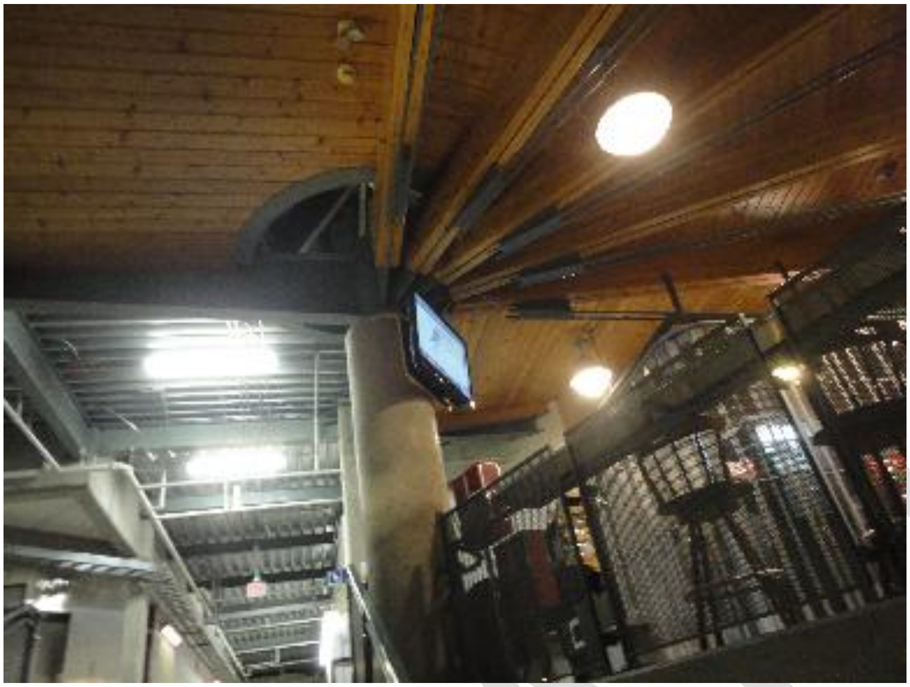

Figure 2: Upper Floor Monitor at Night

Recommendations for Implementation

Install programmable timers to turn off the TV monitors when the building is unoccupied.

Evidence of Proper Implementation

The recommended method for verifying this measure is physically inspecting the installation of the timers.

2.6 Measure 6: Add DDC control to Vestibule Forced Flow Heaters

Overview

Vestibules in the building are heated by forced flow heaters controlled by local thermostats. The vestibules are heated to a constant setpoint of 18°C, as recorded by a site visit at night.

Recommendations for Implementation

Add DDC control to the forced flow heaters located in the vestibules (four 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.

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 AHU's Supply Air Temperature Setpoint Reset

Overview

The supply air temperature (SAT) reset of the air handling units serving the building, AHU-1, AHU-2, AHU-3 and FC-01 is reset by the outdoor temperature. The reset schedules are presented in Table 3.

Table 3: AHU's Supply Air Temperature Reset

Tag	Service	Outdoor Air Temperature °C	Supply Air Temperature Setpoint °C
AHU-1	Classrooms, storage	10	18
		28	16
AHU-2	Second floor South	10	18
		28	14
AHU-3	First and second floors East End	5	19
		28	18
FC-1	Computer room	-2	23
		2	16

The VAV controllers are equipped with occupancy sensors, when occupancy is not detected in an area for 10 minutes, the controller switches to unoccupied mode; this means that the VAV operates on unoccupied heating and cooling setpoints. If occupancy is detected by the sensor, the controller switches back to occupied operation.

Reheat energy savings and comfort improvements may be achieved by resetting the SAT based on cooling demand.

Recommendations for Implementation

We recommend the resetting the SAT based on cooling demand. The DDC system would reset the SAT based on the maximum offset between space temperature and a neutral setpoint of 22.5 °C. Only VAV's in occupied mode would be considered for the reset.

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
Trades and Tech Building

#	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 Chilled Water Setpoint Reset	4,997	$438	$0	0	$0	$438	$2,900	6.6	5.0	$ (893)	15%
2	Add Weekly Schedule to Infrared Heaters Control	0	$0	$0	44	$376	$376	$3,700	9.8	5.0	$ (1,976)	10%
3	Shutdown Heating Pumps at Night	4,210	$369	$0	0	$0	$369	$2,900	7.9	5.0	$ (1,209)	13%
4	Remove Overrides on VAV's	14,470	$1,269	$0	52	$439	$1,708	$3,300	1.9	5.0	$ 4,522	52%
5	Add Programmable Timers to TV Monitors	1,182	$104	$0	0	$0	$104	$400	3.9	5.0	$ 75	26%
6	Add DDC control to Vestibule Forced Flow Heaters	297	$26	$0	87	$740	$766	$4,800	6.3	5.0	$ (1,292)	16%
		25,157	$ 2,206	$ -	183	$ 1,555	$ 3,762	$ 18,000	4.8			

Prepared by
Prism Engineering
3/21/2013

BC Hydro Continuous Optimization for Commercial Buildings Program
Trades and Tech Building

#	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 Chilled Water Setpoint Reset	The chiller plant is enabled when the outdoor temperature is above 16 °C, disabled at 14°C. The supply water temperature setpoint is linearly reset by the DDC from 12.7 °C to 7.2 °C as the return water temperature varies from 7.2 °C to 12.7 °C. The chiller efficiency increases at higher supply water temperatures. A rise in chiller efficiency can be achieved by using a reset that can meet the building's cooling load and keep the supply water temperature as high as possible.	DDC contractor	Reset the chilled supply water temperature setpoint based on the cooling demand as indicated by the chilled water coil valve positions. The chilled water temperature would be reset to maintain at least one valve about 90% open. The chiller plant would be enabled by the offset between supply air temperature and setpoint for operating fan systems.	Set trends showing chilled water temperature, setpoint and cooling valve positions.	Y
2	Add Weekly Schedule to Infrared Heaters Control	The infrared heaters in the automotive shop are enabled by the DDC system and controlled by local thermostats. According to the program code, the heaters are enabled if the outdoor temperature is below 15 °C., regardless of occupancy.	DDC contractor	Add a weekly schedule to control the infrared heaters. The heaters would be enabled continuously during scheduled occupancy periods if the outdoor temperature is lower than 15°C. A newly added temperature sensor in the shop would enable/disable the heaters to maintain night setback temperature. An optimum start algorithm would enable the heaters before the schedule time to bring the shops temperature to occupied setpoint at the schedule start time.	Trend logs for infrared heaters enable and outdoor temperature.	Y
3	Shutdown Heating Pumps at Night	Heating water circulation is achieved by two parallel 5 hp circulation pumps (P-1 & P-2) that operate in duty/standby fashion. The hot water system serves DDC controlled VAV reheat coils and forced flow heaters installed in the entrances and lobbies, controlled by local thermostats. The heating pumps are enabled when the outdoor temperature is lower than 18°C. The supply water temperature setpoint is reset by an outdoor temperature schedule from 60°C to 85°C as the outdoor temperature varies from 15°C to -10°C.	DDC contractor	Revise the program code to allow the heating water pumps to shutdown during unoccupied periods. Pumps would start if any air handling unit (AHU-1 to AHU-3 and FC-1) is running in night setback or morning warm-up mode. Pumps would run continuously if the outdoor air temperature is below 3ºC.	Trends of the room temperatures, air handling unit status and heating pump status for unoccupied periods.	Y
4	Remove Overrides on VAV's	Occupancy control was added in 2011 to the VAV's serving the classrooms. The VAV's are controlled by Terminal Equipment Controller (TEC). With the current controller configuration, the VAV's switch to "Night Mode" when no occupancy is detected for 10 consecutive minutes. VAV's revert to DAY mode when occupancy is detected for more than 2 minutes. All VAV's were overridden to "Day" mode; hence the occupancy control was not in effect. The mechanical systems coordinator advised the controllers were overridden to DAY mode due to temperature and ventilation problems. However, ventilation issues cannot be resolved by overriding the VAV's to DAY mode. According to the TEC's control schedule, VAV's in heating mode operate at minimum flow, regardless of DAY/NIGHT mode.	DDC contractor	Create a routine to reset the night cooling/heating setpoints to +/- 1.5 °C from occupied setpoint during scheduled occupancy periods and revert the setpoints for unoccupied periods back to 27°C cooling and 18 °C for heating. The allowable drift from day mode would be adjustable from the DDC graphic screen, to allow for adjustments during cold temperatures. Remove the overrides from the VAV's	Run a Panel Point Log report to confirm that there are no overrides in the VAV's and an application sub-point report including unoccupied setpoint.	Y
5	Add Programmable Timers to TV Monitors	There are two TV monitors installed in the lower and upper cafeteria/luncheon areas that are continuously ON.	Electrical contractor	Install programmable timers to turn off the TV monitors when the building is unoccupied.	Physical inspection of the installation of the timers.	Y
6	Add DDC control to Vestibule Forced Flow Heaters	Vestibules in the building are heated by forced flow heaters controlled by local thermostats. The vestibules are heated to a constant setpoint of 18°C, as recorded by a site visit at night.	DDC contractor	Add DDC control to the forced flow heaters located in the vestibules (four 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