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Existing Building Commissioning (EBCx) Case Study

Recommissioning of a B-class, low-rise office building in Richmond, BC

PROJECT SUMMARY

Building Name/Type: Airport Executive Park #14, 2 storey office building, 9,170 sq. m., year built in 1981. This facility is one building of a low-rise office park.

Location: Richmond, BC

Project: BOMA BC (Building Owners and Managers Association) Building Tune-Up Program: an existing building commissioning program primarily targeting the building automation systems (BAS) of B & C class properties.

Commissioning Scope (see legend on page 4 for list of acronyms)**:** Revisions to the HVAC equipment sequencing through the building's DDC system, covering the whole building's central HVAC equipment (AHUs, rooftop units, boiler plant, chiller plant, heat pumps and zone HVAC equipment (fan-coil units, VAV boxes, induction units)). Building assessment and sequencing recommendations were undertaken by BOMA's selected Building Tune-up contractor and implementation was then completed by the building manager's own preferred contractor.

The project was initiated in August 2019; and the project was completed (with testing verifications) in November 2019.

Size of Commissioned Area: 9,170 sq. m. (representing 100% of the building's total floor area)

Total Commissioning Investment: *$13,189 (BOMA BC / NRCan covered $13,000 of the cost)*

Energy Cost Savings: $11,090 (and 7%) per year for electricity & gas combined (cost savings were based on the BC Hydro Large General Service Rate, and an assumed average natural gas cost of $10/GJ).

Payback: simple payback (implementation costs/energy savings) = 0.2 yrs; full project payback (assessment + verification + implementation/energy savings) = 1.2 yrs.

Energy Savings: 266 MWh/yr.

GHG Emission Reductions: 37 tonnes (and 19%) per year

Quantified annual non-energy benefits: N/A

PROJECT OVERVIEW AND BACKGROUND

Airport Executive Park (AEP), Building 14 is a 2-storey office building; one of 14 buildings that comprise a suburban office park located in Richmond, BC. The building qualified for the Building Tune Up program given its age, size, and its DDC system which controls central HVAC equipment (Air-Handling Units, Rooftop Units, Boilers and Cooling Towers serving water-source heat pump system); Zone HVAC equipment (Heat Pumps, AC units).

A new property management firm took over management in 2019 after the park was sold. The new ownership and property management firm recognized none of the buildings had been significantly recommissioned for many years and so they chose #14 as (one of the largest and oldest buildings within the office park) for a retro-commissioning project, in order to learn from the experience and consider if the identified opportunities might be transferable to the remaining buildings with the office park. While the building has a controls contractor, the building operator had made modifications to scheduling along with further adjustments to accommodate maintenance of the mechanical systems. The system had not been optimized to account for those changes for many years.

The building management did not enter into the project with any specific objective other than their desire to share the learnings and opportunities from the project with their other buildings in the office park.

10711 Cambie Rd. Richmond, BC

PROJECT SCOPE OF WORK

ESC Automation Inc. was engaged by BOMA BC to provide recommissioning investigation and verification services for AEP 14 as part of the Building Tune Up program.

The project's investigation phase took approximately six weeks and involved a thorough review of the BAS settings, sequences and trend logs to identify and assess optimization opportunities (a list of the identified opportunities are detailed below under Investigation and Opportunities Identified). ESC then prepared a report for the building owner and manager outlining these recommendations.

The project's implementation phase saw the building manager asking their existing controls contractor (Controls Solutions) to put into place the recommended adjustments and re-sequencing. This took approximately 10 weeks (from August to October 2019).

Finally, ESC revisited the site to measure and verify the adjustments and re-sequencing, as well as train the building operator. The project's verification phase lasted two to three weeks and concluded with a final building verification report.

WHAT IS COMMISSIONING?

Building commissioning is a systematic and documented process of ensuring that building systems perform according to the design intent and the owner's operational needs.

Existing Building Commissioning (EBCx):

- *Provides a better environment for occupants*
- *Reduces indoor air quality problems*
- *Reduces occupant complaints*
- *Reduces contractor call-backs and warranty issues*
- *Reduces energy consumption and operational costs*

PROJECT MANAGMENT

As mentioned, AEP 14 took part in the Building Tune-Up Program shortly after it was purchased. The new owners recognized recommissioning the building's systems was long overdue. The building's mechanical and controls systems maintenance is contracted to third party firms. The operations staff was not trained to undertake systems repairs nor did they know the extent of the building's systems' inefficiencies.

ESC was granted full access to the building and its systems. They also developed the systems reprogramming report and Controls Solutions (the building's existing BAS service provider) undertook the reprograming.

Budgeting was predetermined by BOMA BC for the assessment and verification phase of the project (at $10,500) after a formal RFP process and selection of ESC at their proposed bid rate. Implementation costs for the project were $2,689.

Building operator training is included in BOMA BC's Building Tune-Up program. It ensures the building staff is comfortable with the changes and inspires them to maintain the building in its newly optimized state.

INVESTIGATION AND OPPORTUNITIES IDENTIFIED

The key opportunities identified during the assessment of AEP 14 were:

1. Reduce AHU3 operation during building unoccupied hours
2. Revise MUA unit schedules to align with occupancy
3. Reduce MUA unit SAT setpoints
4. Reduce heat pump unoccupied run-times and short cycling
5. Reduce heat pump loop operations during unoccupied hours

LEGEND

AHU – Air Handling Unit

BAS – Building Automation System

DDC – Direct Digital Controls

HVAC – Heating, Ventilation, Air Conditioning

MUA – Make-Up Air (unit)

SAT – Supply Air Temperature

VFD – Variable Frequency Drive

VAV – Variable Air Volume

IMPLEMENTATION AND RESULTS

ESC visited AEP 14 one month after implementation of the recommendations to verify the work and energy savings results. The following chart details the recommended actions and the resulting savings:

Facility Improvement Measure (FIM)	Energy savings (MWh/yr)	CO2 savings (tonnes)	Energy cost savings ($/yr)	Implementation costs ($)	Implementation payback (years)	Full project costs*	Full project payback (years)
Reduce AHU3 operation during building unoccupied hours	41	7.1	$1,470	$0	0.0	-	-
Revise MUA unit schedules to align with occupancy	35	5.8	$1,350	$0	0.0	-	-
Reduce MUA unit SAT points	104	22.2	$2,500	$0	0.0	-	-
Reduce heat pump unoccupied run-times and short cycling	37	1.0	$2,500	$2,420	0.97	-	-
Reduce heat pump loop operations during unoccupied hours	49	1.3	$3,270	$270	0.08	-	-
TOTAL RECOMMENDED FIMs	**266**	**37.4**	**$11,090**	**$2,690**	**0.2**	**$13,189**	**1.2**

*Full project costs include: EBx assessment fee, EBx implementation fee & EBx verification fee. Full project payback = full project costs/energy costs savings. Implementation payback = implementation costs/energy costs savings.

PROJECT BENEFITS

ESC identified these benefits once the recommended changes were implemented:

1. **Reduce AHU3 operation during building unoccupied hours, achieving an annual energy savings of $1,400**

   Prior to recommissioning AHU3 was sequenced to operate at a lower speed (50%) during unoccupied hours of operation (6 PM to 5:30 AM Monday to Friday, and 24/7 on weekends). Based on feedback from the operations team, constant ventilation was not required during unoccupied hours and the unit could be shut off. Accordingly, the sequencing was revised to allow AHU3 to stop running during unoccupied hours.

   This measure principally reduced heating energy use as the unit was continuously maintaining an 18°C supply air temperature after hours, year- round.

Graphic Showing AHU3 disabled from 6PM to 5:30AM and VFD speed changed from 50% to 0%

2. **Revise MUA unit schedules to align with occupancy, achieving an annual energy savings of $1,290**

   As these units provide fresh air for occupants, they are not required to operate until the building's specified occupancy period (6 AM to 6 PM Monday to Friday). Therefore, reducing the equipment run-times reduces unnecessary ventilation, decreasing fan electrical energy use and make-up air heating energy.

3. **Reduce MUA unit SAT points for an annual energy savings of $2,710.**

   Based on an analysis of trend data, the building was switching from heating dominant to cooling dominant operation at an outside air temperature of 13.5°C. In addition, many heat pumps were located at the building interior and operating in cooling mode year-round.

   Reducing the SAT setpoints of all MUAs to 10°C. reduces unnecessary heating of fresh air, which is then delivered to zones in cooling mode (a form of simultaneous heating and cooling). This measure reduces make-up air heating (offset somewhat by increased zone heating loads in perimeter areas) and reduces cooling loads and heat pump electrical use.

   Reducing the MUA heating setpoint to 10°C also reduces the annual heating load at the MUAs by 73%, and shifts some of that load from the inefficient MUA furnaces (<80% efficient) to the condensing boiler (~95% efficient).

4. **Reduce heat pump unoccupied run-times and short cycling for an annual energy savings of $2,490.**

   The supply fans were running outside of scheduled occupancy hours and short cycling (rapidly turning on and off) during that time. The reversing valve and compressor were also short-cycling. This was resulting in some simultaneous heating and cooling as the heat pumps switched between heating and cooling modes, energy waste during the unoccupied period, as well as putting excessive wear and tear on the heat pumps (potentially resulting in premature failures).

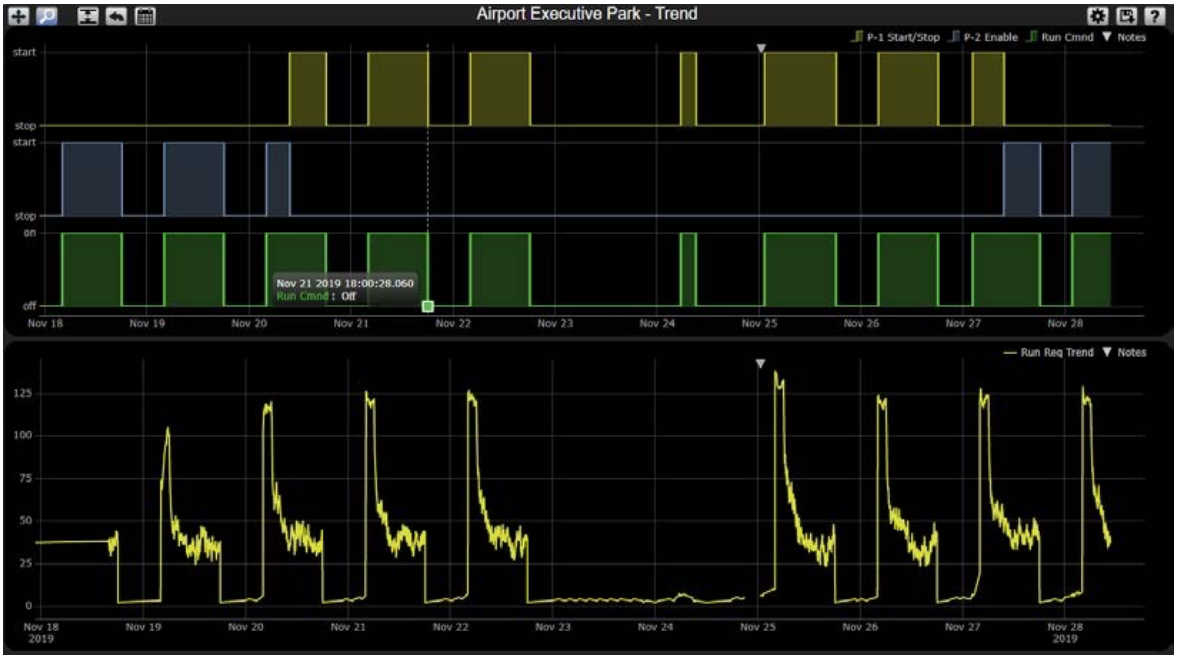
   The issues were resolved by tuning the zone heat pump control settings, including expanding the heating and cooling deadband. The changes resulted in a reduction of unoccupied heat pump operation (reducing fan and compressor energy), a reduction in simultaneous heating and cooling, a reduction of short cycling, and an increase of occupant comfort by resolving deficient units.

5. **Reduce heat pump loop pump operations during unoccupied hours for an annual energy savings of $3,270.**

   The heat pump loop pumps were operating 24/7 due to a control programming issue. The pumps are not required to run after-hours as the heat pumps are programmed to remain off if the pumps are not running, and no area of the building requires 24/7 operation.

The programming issue was addressed and the loop was set to enable if more than 8 heat pumps are requesting to run. This resulted in significantly reduced energy use by the loop pumps, which were consuming almost 250,000 kWh annually. A 20% run-time reduction was conservatively estimated.

Graphic: Heat pump run requests (yellow, bottom), resulting in demand-based enabling of the heat pump loop pumps (green shows the overall loop enabling command)



FUTURE OPPORTUNITIES

As a complement to their recommissioning efforts, building management chose to invest in the CopperTree Kaizen analytics software program for AEP 14. This software functions by connecting the building's automation system to Kaizen's cloud-based software. Kaizen then continuously monitors and analyzes the building's systems' data to identify energy anomalies and resulting savings opportunities. The program also creates on-demand reports for the building operations team to review and share with building ownership and management.

The building automation system is integrated with the cloud-based software through a data acquisition device (Delta CopperCube, for BACnet systems, CopperTree Edge device for non-BACnet) which collects trend data from the automation system

controllers and regularly exports the data to the Kaizen cloud servers.

In the coming months and years, AEP 14 will essentially have a 'built-in recommissioning program' attached to their DDC system.

LESSONS LEARNED

1. During the building's verification phase some of the recommended measures experienced minor 'slippages' out of their reprogrammed modulations (for instance temperature adjustments by a degree or two). While minor, these measures showcase how quickly a sophisticated BAS system could become compromised; minor slippages can add up and potentially result in an inefficient or challenged system.

   Fortunately, the energy software program quickly identified these 'slippages'. However in a building without such a system, the building operations team must be especially knowledgeable about the intent and value behind the ideal modulations. The team must also check the BAS daily to identify slippages. If one system slips, it can throw off associated systems, in a domino-like effect. Hence, if not checked and attended to daily, it becomes increasingly more challenging to identify the prime mover in this domino effect.

PROJECT PARTNERS/TEAM:

Building Manager:	Colliers International
Commissioning Provider:	ESC Automation
Project Sponsor:	BOMA BC
Controls contractor:	Controls Solutions