

Building Construction Phase Commissioning Case Study - Building A

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This case study presents the analysis and quantification of the results of whole-building commissioning (Cx) services provided by EQ Building Performance Inc. (EQ) through the construction phase for a single project - Building A. The analysis described herein and in other such case studies informs on the overall value of building commissioning in terms of utility consumption, cost, and greenhouse gas (GHG) emission reductions.

Commissioning is one of the most cost-effective and low-risk strategies for reducing utility consumption, utility costs, and GHG emissions for both new and existing buildings [1]. In essence, commissioning is a quality control process for buildings to ensure optimal performance of building systems and equipment as well as maximize occupant comfort. Although building commissioning is rising in popularity in the Canadian construction industry, gaining intuitive recognition as beneficial to the building construction process, and meriting inclusion in local and international green building standards, quantifying its benefits has only been undertaken in a limited capacity.

Cx Project Description and Results Summary

Building Location	Toronto, Ontario
Building Occupancy Type	Multi-unit residential with associated amenities and light retail
Building GFA	35,000 m ²
Building Height	13 storeys
Green Building Certifications	LEED 2009 NC, Toronto Green Standard v2 Tier 2
Cx Scope of Work	New construction commissioning for heating, ventilation, and air conditioning (HVAC) systems and controls, domestic water systems and controls, building automation system, energy submetering systems, solar PV system
Cx Project Completion	August 2018
Total Utility Cost Savings	\$79,500 or 12% of annual utility costs
Cx Project Payback Period	< 1 year
GHG Emissions Reductions [2]	29,450 kg CO ₂ e or 14% of annual emissions

*Note: Reported utility and cost savings and GHG emissions reductions represent the first year of building operations only.

Energy, Water, and Greenhouse Gas Implications

A total of 49 commissioning deficiencies were identified through the construction phase of this project. Nearly one third of deficiencies were related to controls, (standalone or automated). Half of the total deficiencies were related to heating, cooling, and ventilation (18%, 10%, and 22%, respectively). Other categories of deficiencies included domestic water systems, energy submetering systems, and administrative related deficiencies. In total, Cx deficiencies identified amounted to the following utility savings, cost savings, and GHG emissions reductions.

Table 1 - Building A Whole Building Cx Results

	Estimated Savings		Savings per m ² GFA		Savings as Percentage
Electricity	520,731	kWh	14.9	kWh / m ²	17%
Natural Gas	20,721	m ³	0.59	m ³ / m ²	6%
Energy	739,749	ekWh	21.2	ekWh / m ²	11%
Domestic Water	216	m ³	6.2	L / m ²	1%
Greenhouse Gases	29,451	kg CO ₂ e	0.84	kg CO ₂ e / m ²	14%
Utility Costs	79,558	\$	2.27	\$ / m ²	12%

Note that all results presented in this case study are for the first year of building operations post-commissioning. No conclusions have been made beyond the first year, as there are many factors that influence operational utility consumption and cost savings including fluctuating utility prices, equipment degradation, control logic adjustments, building staff operational practices, maintenance practices, and changes to building occupancy patterns.

Cx Deficiencies

In addition to utility, greenhouse gas, and cost results like those presented above, commissioning has many benefits that are more difficult to quantify. These include, but are not limited to [3, 4, 5]:

- design phase document reviews resulting in fewer change orders and site instructions;
- smoother start-up of building equipment;
- extended equipment life;
- reduction of unnecessary site visits by subcontractors/vendors/manufacturers;
- improved occupant comfort and avoided occupant complaints;
- improved building operations staff training process;
- fewer deficiencies at substantial completion;
- improved building documentation;
- smoother building turnover at occupancy; and
- support in pursuing voluntary green building certifications.

The table attached to this case study presents all of the deficiencies found during the construction phase Cx at Building A and the impacts of their correction in terms of qualitative benefits. This table showcases both the breadth and depth of the commissioning approach for Building A as well as the specific types of issues that can be discovered through commissioning.

Between the quantitative and qualitative impacts of the whole building commissioning process, Building A is primed for higher performance and smoother operation than it would have been without. The results of this case study and others like it support the inclusion of commissioning as a significant value-add in new construction high-rise residential projects.

Works Cited

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- [5] NOVA Commissioning Services Ltd., "Benefits of Building Commissioning," 2020. [Online]. Available: <https://novacommissioning.ca/howithelps.htm>. [Accessed 14 October 2020].

Table 2 - Building A Cx Deficiency Impacts



Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Required Service Calls	Equipment Service Life
Heating Systems									
BAS Sensor	BAS sensor point is missing on the high temperature heating supply piping. Sensor point to be used to control heating boilers firing rates.	•	•				•		•
BAS Sensor	Hydronic underslab bare-element heating loops should have BAS temperature sensors on the supply and return piping for control.	•	•	•					
Boilers	Boiler condensate neutralizer not installed and piped to drain.						•		•
Pressure Gauges	Heating pump pressure gauge range is too narrow - reading over max pressure on supply side gauges.						•		
BAS Control Valve	Retail heating control valve wiring not yet complete.	•	•	•					
Underslab Heating	Underslab heating system and piping incomplete.			•					
Unit Heaters	Multiple unit heaters did not respond to heating calls from associated thermostats.			•					
Boiler	Boiler serving high temperature heating to four-pipe fan coil system is locked out in alarm; investigate and resolve.						•		•
Boiler	Boiler serving low temperature heating to four-pipe condominium fan coils is locked out in alarm; investigate and resolve.						•		•
Pool Heating Controls	There is no temperature control for pool heating. Recommended to add a two-way or three-way valve to control on the primary side of the heat exchanger so that once the pool temperature setpoint has been reached the valve can be modulated to stop or bypass flow to the heat exchanger. This system should be connected to the BAS for control and monitoring.	•	•	•					

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Required Service Calls	Equipment Service Life
Cooling Systems									
BAS Sensor	Chilled water pump duplex is missing a pressure sensor port right after pumps. Port to be used for differential pressure control.	•	•	•			•		•
Cooling Tower	Cooling tower is leaking from a bolted connection; to be repaired.	•							•
Suite Fan Coil Units	Several of the fan coil units tested did not deliver enough cooling on a call from the thermostat. Discharge temperatures in cooling mode were approximately equal to space temperature, indicating that chilled water is not being delivered through the coil and room temperature air is being recirculated without conditioning.			•				•	
Condenser Pumps	Condenser water pumps are running simultaneously - these pumps are intended to run duty/standby. Controller programming to be implemented.	•	•						•
Heating & Cooling Systems									
Amenity Fan Coil Unit	Amenity fan coil unit delivers heated air on a call for cooling from the thermostat.	•	•	•				•	
Amenity Fan Coil Unit	Amenity fan coil unit does not provide cooling on a call from the thermostat - recirculates tempered air.			•				•	
Suite Fan Coil Unit	Suite fan coil unit does not deliver heated or cooled air to the space - recirculating air only.			•				•	
Suite Fan Coil Unit	Suite fan coil unit delivers heated air in cooling mode.	•	•	•				•	
Suite Fan Coil Unit	Suite fan coil unit does not deliver heated air to the space, coil not heating up on call from thermostat.			•				•	

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Required Service Calls	Equipment Service Life
Domestic Hot Water Systems									
BAS Sensor	BAS temperature sensor point is missing on the return piping to domestic hot water boilers. Sensor point to be used to control DHW boilers' firing rates.	•	•				•		•
BAS Sensor	Domestic hot water tanks are missing BAS temperature sensor points. These points will be used to control DHW boilers firing rates.	•	•				•		•
DHW Boiler	DHW boiler alert prevents boiler from firing.						•		•
Mixing Valve	The amenity DHW mixing valve is set to discharge water at 109°F; tenants have complained that the water is not warm enough. Increase the temperature setting.			•					
Hydronic Systems									
BAS Sensor	All VFD pumps require pressure sensors the BAS control before and after pumps; all missing.	•	•	•			•		•
BAS Sensor	1/2" ball valves to be provided for BAS pressure sensors for heating, cooling, and system water pumps differential pressure control.	•	•	•			•		•
Hydronic Piping	Piping identification incomplete.						•		
Pumps	Pump duplex disconnect lights do not turn on to indicate when a pump is running.						•		
Ventilation Systems									
BAS Sensor	Make-up air unit cooling coil BAS temperature sensor point located downstream of the 3-way valve on the chilled water return line is missing. Sensor point to be used to control make-up air unit cooling.	•	•	•			•		
Make-Up Air Unit	Make-up air unit supply ducts not yet insulated (typical for all).	•	•						

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Required Service Calls	Equipment Service Life
Exhaust Fan	Exhaust fan serving bike room squeaks while running. Check alignment and belt tension.					•		•	•
Suite ERVs	Several of the suite energy recovery ventilators (ERVs) tested were found to be running constantly on high speed and did not ramp down when switched to low.	•	•	•	•	•		•	•
Suite ERVs	Several of the suite energy recovery ventilators (ERVs) tested were found to not be running constantly on low (off unless enabled at wall timer switch).			•	•			•	
Suite Fan Coil Unit	Diffuser above thermostat is loud even on low fan speed (turbulence in duct/at diffuser).			•		•		•	
Suite ERV	Suite energy recovery ventilator duct rattling on high speed. Check alignment and for presence of obstructions.			•	•	•		•	•
Suite Air Distribution	No bedroom diffuser in suite - provide duct and diffuser per mechanical drawings.			•	•			•	
Make-Up Air Unit	Make-up air unit cooling coil control valve actuator movement is backwards - closes on a call for cooling and opens upon removal of call for cooling.	•	•	•					
Amenity Fan Coil Units	Amenity fan coil unit filters are dirty; to be replaced.	•	•		•			•	•
Amenity Fan Coil Unit	When switching between heating and cooling in AUTO mode at the thermostat, amenity fan coil unit fans don't ramp up. Verify programming.			•	•			•	
Make-Up Air Unit	Make-up air unit heat wheel bypass damper actuator not yet installed.						•		•
Make-Up Air Unit	Differential pressure sensing across the filter has not yet been completed/enabled.				•				•
Make-Up Air Unit	Make-up air unit return air temperature sensor not yet installed.	•	•				•		

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Required Service Calls	Equipment Service Life
Make-Up Air Unit	Make-up air unit variable frequency drive trips when speed exceeds 40 Hz - voltage alarm.	•					•		
Make-Up Air Unit	Make-up air unit glycol tanks are full. Glycol hose leaks.						•		
Make-Up Air Unit	All make-up air unit cooling coils have coil bypass dampers installed but no means to control. Install motorized actuator or advise building operations staff that bypass dampers will have to be manually opened/closed seasonally.						•		•
Electrical Submetering									
Electrical Meter	Several electrical metering points have not yet been picked up. These meters are required for rate setting and LEED M&V purposes.						•		
Electrical Meter	Electrical meter for pump duplex is not reading. This meter is required for heating/cooling system rate setting.						•		
Electrical Panel	Retail panel is missing current transformer labels for loads.						•		
Administrative Issues									
Plumbing O&M	Plumbing O&M manual review comments: include general warranty; include flushing and cleaning reports; include piping pressure test results; include boiler IOMs; include boiler ventilation systems.						•		
Ventilation O&M	Ventilation O&M manual review comment: include general warranty.						•		