

Building Construction Phase Commissioning Case Study - Building B

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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 B. 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, 2]. In essence, commissioning is a quality control process for buildings to ensure optimal performance of building systems and equipment, as well as to 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 amenities
Building GFA	19,000 m ²
Building Height	14 storeys
Residential Suites	240
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, submetering systems
Cx Project Completion	January 2018
Total Utility Cost Savings*	\$17,000 or 4% of annual utility costs
Cx Project Payback Period	< 3.5 years
GHG Emissions Reductions [3]	7,500 kg CO ₂ e or 5.5% 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 56 commissioning deficiencies were identified through the construction phase of this project. Over 40% of deficiencies were related to ventilation systems, while heating and cooling accounted for 18% of deficiencies each. Other categories of deficiencies included hydronic piping systems, system water, submetering systems, and controls. In total, Cx deficiencies identified amounted to the following utility savings, cost savings, and GHG emissions reductions.

Table 1 - Building B Whole Building Cx Results

	Estimated Savings		Savings per m ² GFA		Savings as Percentage
Electricity	77,046	kWh	4.0	kWh / m ²	3.3 %
Natural Gas	19,827	m ³	1.0	m ³ / m ²	15.8 %
Energy	286,613	ekWh	14.9	ekWh / m ²	7.9 %
Domestic Water	168	m ³	8.7	L / m ²	0.8 %
Greenhouse Gases	7,540	kg CO ₂ e	0.4	kg CO ₂ e / m ²	5.5 %
Utility Costs	17,003	\$	0.88	\$/ m ²	3.8 %

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. Savings percentages were calculated based on total building consumption estimates determined through energy modeling and LEED documentation.

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 ^[4, 5, 6]:

- 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 construction phase Cx at Building B 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 B 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 B is primed for higher performance and smoother operation. The results of this case study and others like it support the inclusion of commissioning as a significant value-add in new construction projects.

Works Cited

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Table 2 - Building B Cx Deficiency Impacts



Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Service Calls	Equipment Service Life	Life Safety	Environmental Waste
Deficiency Impact Totals		17	11	25	4	3	41	10	19	1	1
Heating Systems											
Heat Exchanger	The secondary side of air handler heating coil heat exchanger should be equipped with pressure gauges as shown on design drawings. Provisions for the pressure gauges have not been installed at the time of site visit.						•				
Heat Exchanger	The primary side of air handler heating coil heat exchanger should be equipped with a three-way control valve with bypass.	•	•	•			•				
Heat Exchanger	Heat exchanger insulation incomplete.	•	•								
Boilers	Boiler condensate has not been piped to the floor drain.						•				
Boilers	Set boiler local display dates/times such that trend data can be read at local boiler display screens.						•				
Fan Coil Unit	Amenity fan coil units observed to be running but control valve actuators have not been wired and thermostats have not been installed. Fan coil units are constantly blasting hot air into the common area spaces.	•	•	•							
Fan Coil Unit	Amenity fan coil unit heating control valve actuator does not respond to call from thermostat.			•			•				
Fan Coil Unit	Amenity fan coil unit heating control valve actuator does not respond to a call for heating from the thermostat; wiring/programming to be corrected.			•			•				

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Service Calls	Equipment Service Life	Life Safety	Environmental Waste
Fan Coil Unit	Suite fan coil unit heating discharge air not hot enough to heat space - check control balancing valve.			•							
Misc. Heaters	Building supervisor to be instructed on how/where to isolate miscellaneous ground floor and parking level hydronic heating units (unit heaters, force flow heaters) during the cooling season.	•	•				•				
Cooling Systems											
Air Handler	Air handling unit cooling coil return control valve not yet installed.	•	•	•			•				
AC Unit	Mechanical penthouse CCU room AC unit does not discharge cooled air when thermostat setpoint is lowered.			•			•				
Fan Coil Unit	Amenity fan coil unit condensate drains have not been piped.						•	•	•		
Fan Coil Unit	On a call for cooling, amenity fan coil thermostat displays "System Wait" and cooling does not enable. Contractor to correct to enable cooling.			•			•				
Fan Coil Unit	Amenity fan coil hydronic cooling coil control valve actuator does not respond to a call for cooling at the thermostat. The position of this valve bypasses the coil.			•			•				
Condensing Unit	Amenity fan coil DX cooling condensing units are not operational. Hydronic cooling coil freeze protection safeties not installed.			•			•		•		
Condensing Unit	Condensing units serving fitness room fan coils and the west-most lobby fan coil were enabled at the time of the cooling season site visit. Ensure that all condensing units are disabled during the cooling season and that amenity and common space fan coil cooling is supplied by system water.	•	•						•		•

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Service Calls	Equipment Service Life	Life Safety	Environmental Waste
Pumps	Condenser pump is defective (leaks) - to be repaired/replaced.	•							•		
Pumps	Pump damage to be repaired - replacement housing ordered.						•		•		
Piping and Accessories	Chilled water piping insulation and labeling incomplete.						•				
System Water											
Tanks	System water expansion tank sight glass indicates tank is almost full - to be drained.						•				
Fan Coil Unit	Amenity fan coil unit aquastats have not been installed.	•	•	•			•				
Ventilation Systems											
Air Handler	Air handling unit heating and cooling coil supply and return pressure gauges not installed and no ports provided on piping.						•				
Air Handler	Air handling unit interior lights have no power – 120V power has not been provided/connected to the unit.						•				
Air Handler	Air handling unit drain trap has not been installed.						•	•	•		
Air Handler	Air handling unit end switch has been jumpered – freezestat is not operational until end switch is installed.						•	•	•		

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Service Calls	Equipment Service Life	Life Safety	Environmental Waste
Air Handler	Bypass damper on top of cooling coil has not been balanced.						•	•	•		
Air Handler	Air handling unit pre-filter is dirty – to be replaced.	•	•		•				•		
Air Handler	Air handling unit pre-filter magnehelic gauge is not working. Correct to show pressure difference across filter and thereby indicate filter dirty/clean status.						•		•		
Fan Coil Unit	Suite fan coil unit running with no filter. It is recommended that fan coil units are not run unless construction filters are installed in order to protect equipment.								•		
Fan Coil Unit	Suite fan coil unit manual fan speed adjustment at thermostat is programmed backwards - command for high speed results in low speed at fan and vice-versa.	•	•	•				•			
Fan Coil Unit	Level 7 suite fan coil unit thermostats are programmed for fan ON/AUTO only - should be three-speed.			•							
Fan Coil Unit	Amenity fan coil unit is not powered/not operational. Coil replacement required.			•			•				
Fan Coil Unit	Amenity fan coil unit installation incomplete.			•			•				
Fan Coil Unit	Amenity fan coil unit motherboard is fried; to be replaced.			•			•				
Fan Coil Unit	Lobby fan coil unit thermostat indicates that a filter replacement is required.	•	•		•				•		

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Service Calls	Equipment Service Life	Life Safety	Environmental Waste
Energy Recovery Ventilator	Suite ERV switch not powered / not functional.			•	•			•			
Energy Recovery Ventilator	Suite ERV does not run on low continuously.			•	•			•			
Energy Recovery Ventilator	Suite ERV makes whistling noise while enabled.					•		•			
Fan	Exhaust fan serving level P1 CCU room makes excessive noise while running.					•			•		
Fan	P1 CCU room AC unit fan does not ramp up/down on command from controller.			•			•				
Fan	Fan producing loud rattling noise when enabled. Contractor to investigate - could be indication of misalignment or bearing issue.					•	•		•		
Fan	Fan thermostats wired backwards; exhaust fan enables on heating call, disables on cooling call.	•	•	•			•				
Fan	The parking garage exhaust fans should be equipped with VFDs as per mechanical equipment schedules. VFDs were not installed at the time of site visit.						•		•		
Dehumidifier	Amenity whirlpool dehumidifier wall controller not operational.			•			•				

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Service Calls	Equipment Service Life	Life Safety	Environmental Waste
Hydronic Piping Systems											
Piping and Accessories	Pipe penetrations in the wall behind the P1 CCU room exhaust fan and ductless split AC unit are not fire-stopped. Piping penetrations through the floors in this room are fire-stopped. Architectural drawings show that this room should be fire-stopped; fire-stopping to be completed.									•	
Piping and Accessories	Piping insulation and identification are incomplete.						•				
Piping and Accessories	Pressure and temperature gauge installations are incomplete (chiller, boilers, pumps).						•				
Piping and Accessories	Isolation valve is leaking causing rust formation on flanged pipe connection below.	•					•	•	•		
Metering Systems											
Meters	The thermal meter in the P1 mechanical room leaks when the bypass is open to allow water through the meter; to be repaired.	•					•				
Meters	The bypass for the gas meter located in the mechanical penthouse remains open due to a leak at the meter. To be repaired/replaced as required such that boiler gas consumption can be read.						•				

Equipment	Description of Cx Deficiency	Utility Consumption	GHG Emissions	Occupant Comfort	Occupant Health	Noise	Ongoing Operations	Service Calls	Equipment Service Life	Life Safety	Environmental Waste
Controls											
BAS	Building automation thermowells and control valves are not installed on any of the bare element heating loops; only the circuit balancing and shutoff/isolation valves were installed at the time of site visit.	•	•	•			•		•		
BAS	½” ball valve for EMS system water pressure sensor on system water VFD pumps is missing. To be installed on the drainer/filter line for BAS monitoring and pump VFD control.	•	•	•			•		•		
BAS	Low zone domestic hot water control valve actuator wiring is incomplete.			•			•	•			
Standalone Controller	Glycol heating control valve for air handler does not respond to commands at the controller.	•	•	•			•				
Pumps	Control strategy for condenser water pumps TBD. These pumps are meant to operate in lead/lag configuration. Currently the building super is rotating the lead pump manually with the disconnect switches. Will these pumps be controlled by the chiller controller or by the BAS, or continue to be rotated manually?						•		•		