Quick Indoor Air Quality & Ventilation Study: BCIT Architectural Science Studio

Background:

- The Architectural Science studio room is a large space that can house up to about 40 students comfortably. The BCIT Architectural Science program has 3 such rooms
- Students in the Architectural Science program tend to stay in the studio working on projects for extended hours until early in the morning
- Their studio-project work habits of students do not match the HVAC system operation work schedule
- The students are complaining about poor air quality in the architectural studio. Particularly when they stay working overnight
- Context – The studio is located in a ≈ 50 year old building.

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Methods:

- Historic data from the Building Automation System (BAS) was collected
- Three CO2 data loggers were placed in room 302 in opposite room locations
- Monitoring duration: about 1 month (October 3rd to November 9th, 2018)
- HVAC air system operation was analyzed
- Room Indoor Air Quality (IAQ) was assessed using CO2 concentration as an indicator
  - Acceptable IAQ: $CO_2 < 1000\ PPM$
  - Poor IAQ: $1000\ PPM \leq CO_2 \leq 2000\ PPM$
  - Very poor IAQ: $CO_2 > 2000\ PPM$
- Note. CO2 is not a contaminant itself. It is used as an indicator of poor indoor air quality risk: low ventilation rates for the occupancy

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Summary findings:

- Room 302 is served by an air handler (AHU2) that also serves several other rooms
- The air handler (AHU2) operates as intended according to schedule to maintain required indoor temperatures and ventilation levels, while conserving energy
- AHU2 operation schedule: 6:00 to 22:00, 7 days a week
- AHU2 is disabled from 22:00 to 6:00
- During operation, system airflows and temperatures are maintained according to set points
- Room CO2 readings indicate occasional poor indoor air quality levels (i.e. CO2 > 1000 PPM) during HVAC operating hours (i.e. at certain room high occupancy times).
- However, recurrent poor indoor air quality levels, lasting about 4 hours each, were measured 8 times, when AHU2 was disabled (i.e. unoccupied hours). This happens presumably when students remain in the room working on their projects until early in the morning.

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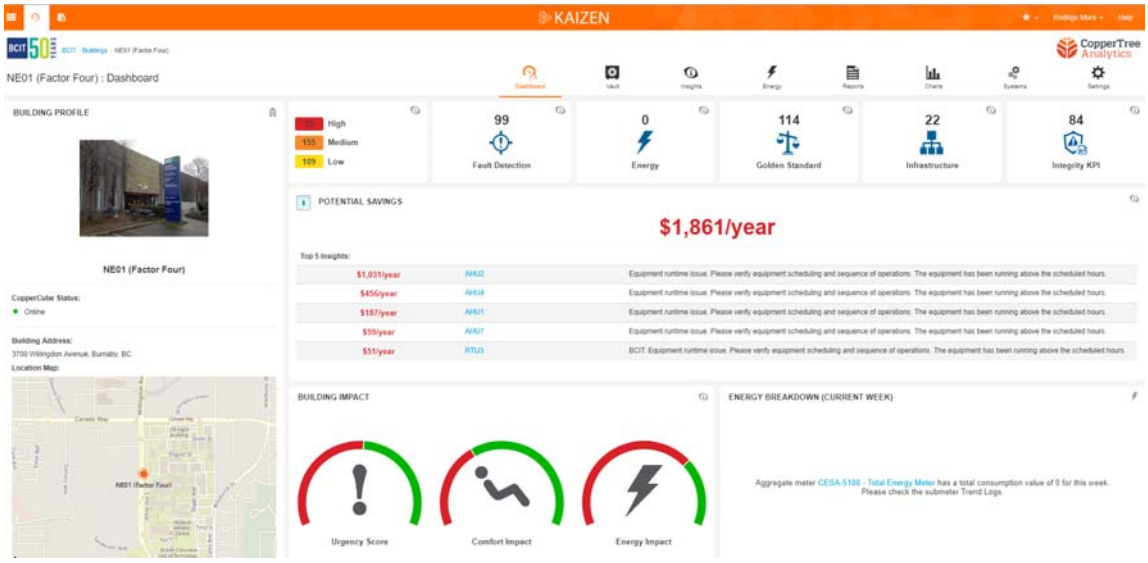
Recommendations:

- In principle AHU2 is able to maintain satisfactory room thermal and air quality during expected operating hours. At AHU2 operating times, occasional CO2-level exceedance hours are expected because the system does not operate on demand controlled ventilation (CO2 based).
- However, the more recurrent CO2-level exceedances are due to the mismatch between AHU2 operating hours and students' late project working hours.
- Possible solutions:
  - Extend AHU2 Schedules – Extend AHU2 operating hours according to the planned room occupancy
  - Retrofit AHU2 with CO2 demand-controlled ventilation (DCV) – In addition to the cost of the retrofit itself, this would require a sophisticated control algorithm to run the AHU2 fan according to individual room ventilation demands (recall AHU2 serves several rooms).
- Eventually, for optimal IAQ and energy conservation, it would be convenient to have all classrooms at BCIT with DCV. However, this requires extensive capital retrofits.

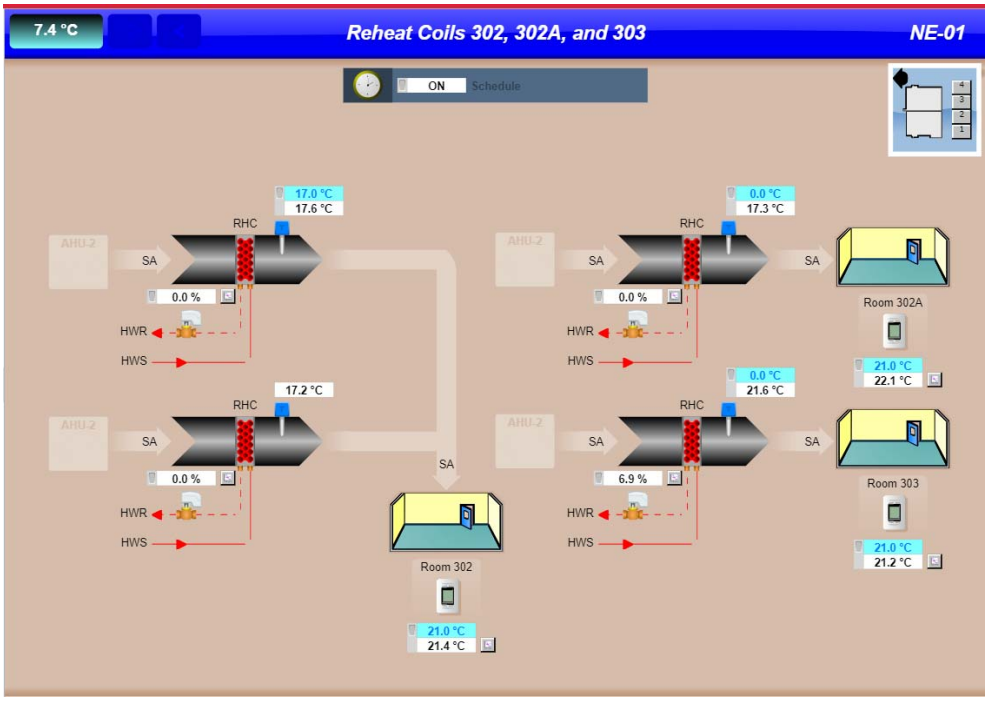
Building Automation System (BAS)

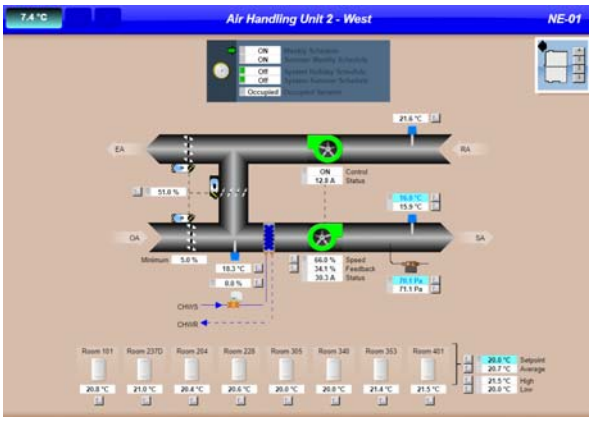


- HVAC is being monitored for fault detection, energy conservation, and thermal comfort

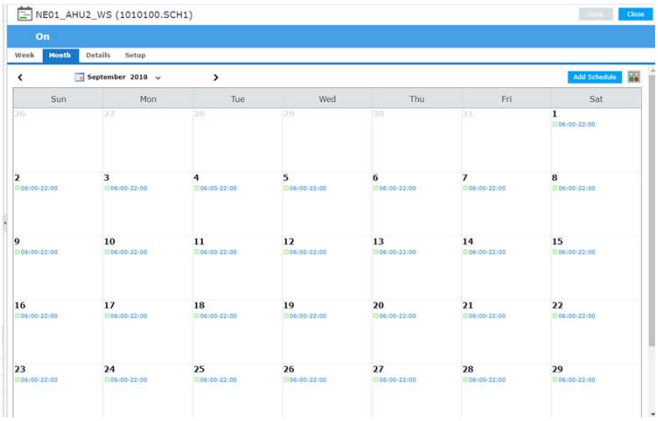
- Air handling unit 2 (AHU2) provides cooling and ventilation for rooms 302 and 303, plus several other rooms
- AHU2 has a cooling coil to provide uniform cooling to all rooms
- For heating, rooms 302 and 303 include terminal reheat coils

- Terminal reheat coils for rooms 302 and 303 maintain comfort temperatures in heating season

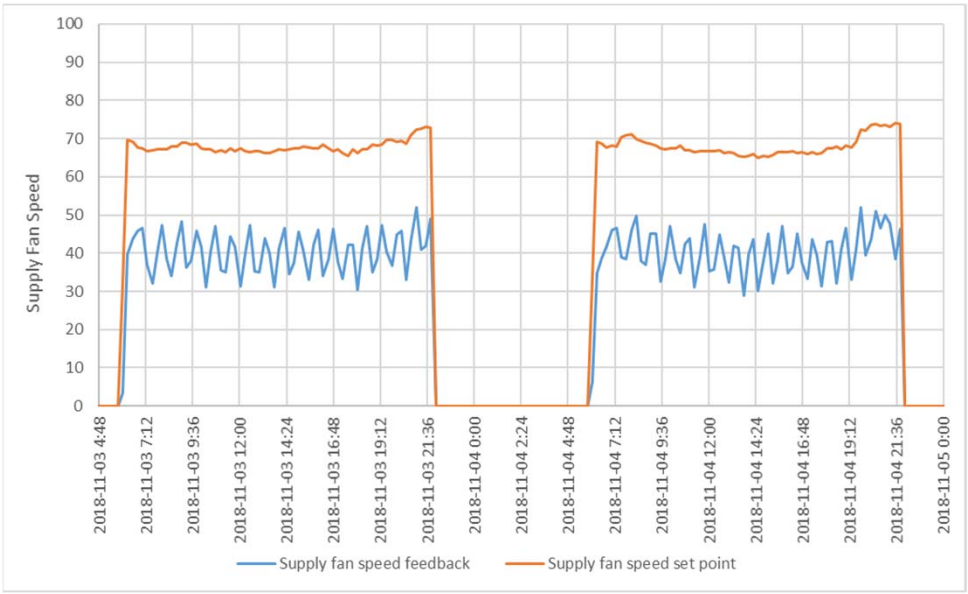




- AHU2 serves several rooms

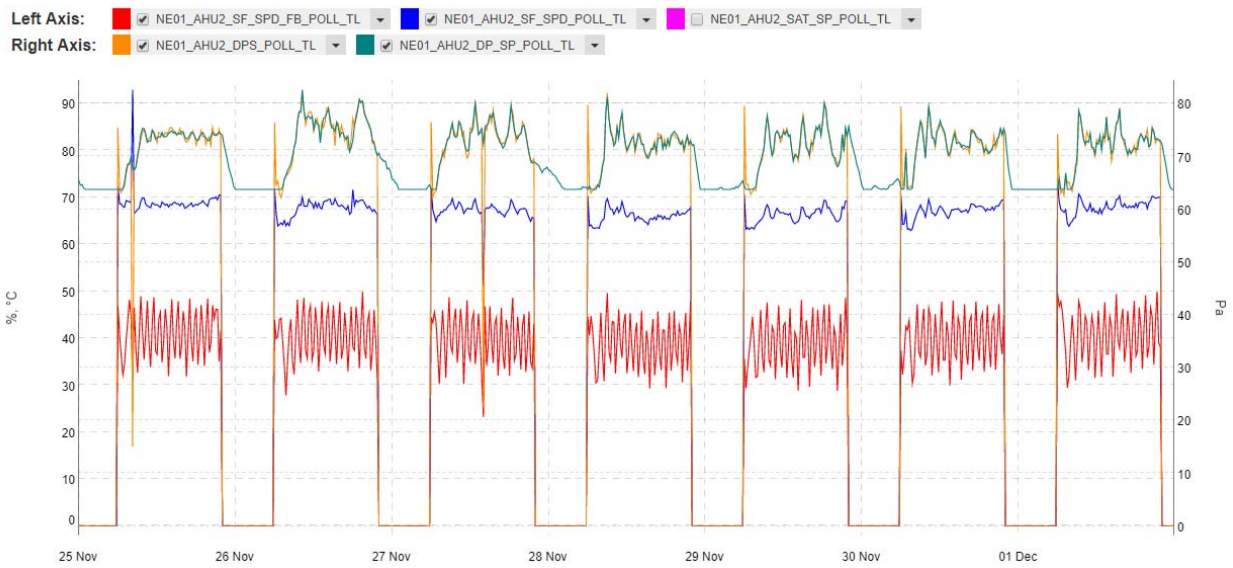


- Fall season AHU2 operating schedule
- Enabled seven days a week between 6:00 and 22:00
- Demand Controlled Ventilation (DCV)? … Not implemented

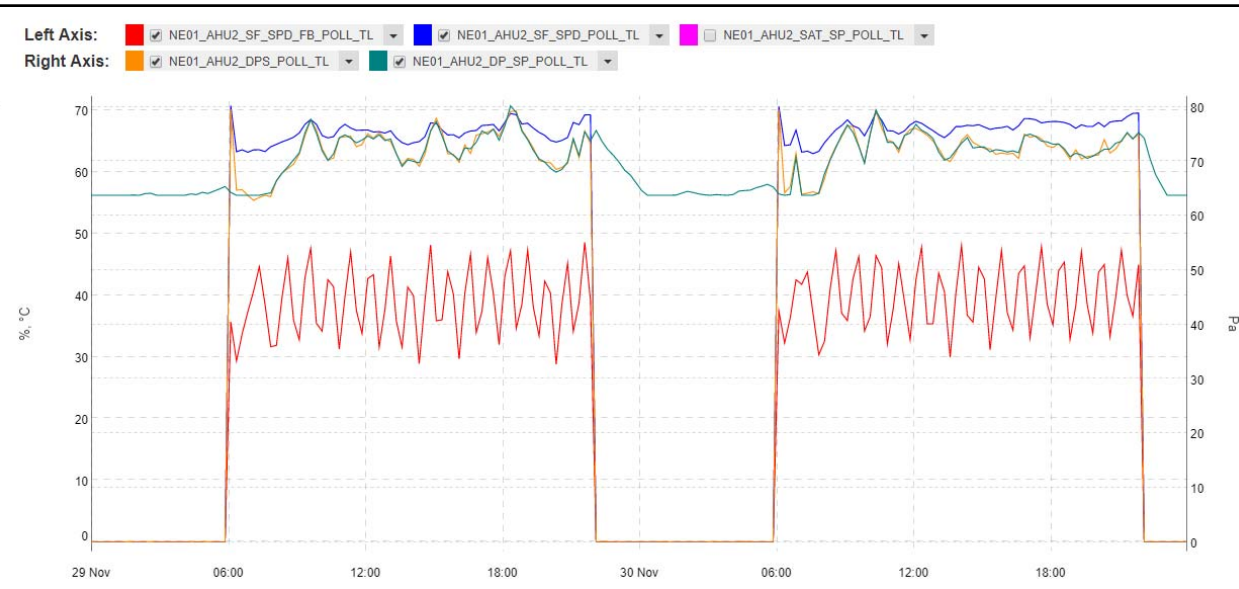


- AHU2 typical air supply fan operation
- Air supply fan enabled according to schedule
- Supply fan speed is below set point

Supply Air System Pressure is maintained at about 70 Pa during occupied hours



- System static pressure is maintained, but the fan speed is low compared to set point
- However, having low fan speed is not a problem, as long as the system static pressure is adequate to maintain air flow without starving any rooms of air… Needs further investigation…



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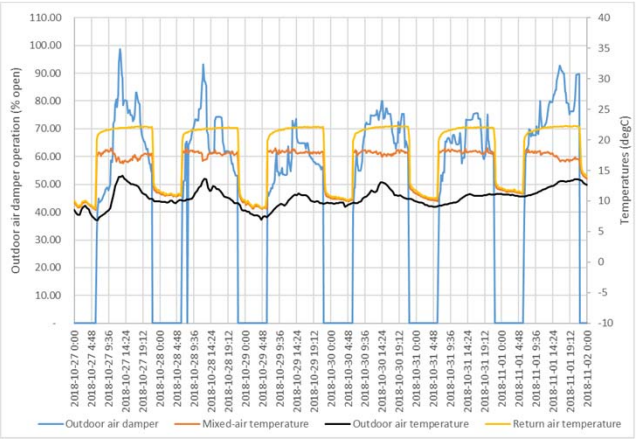
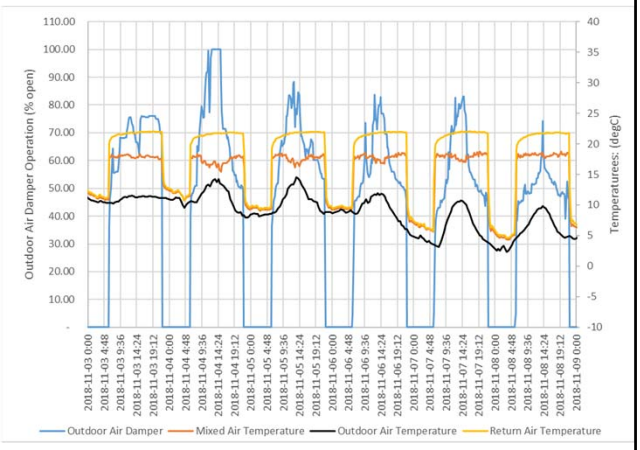
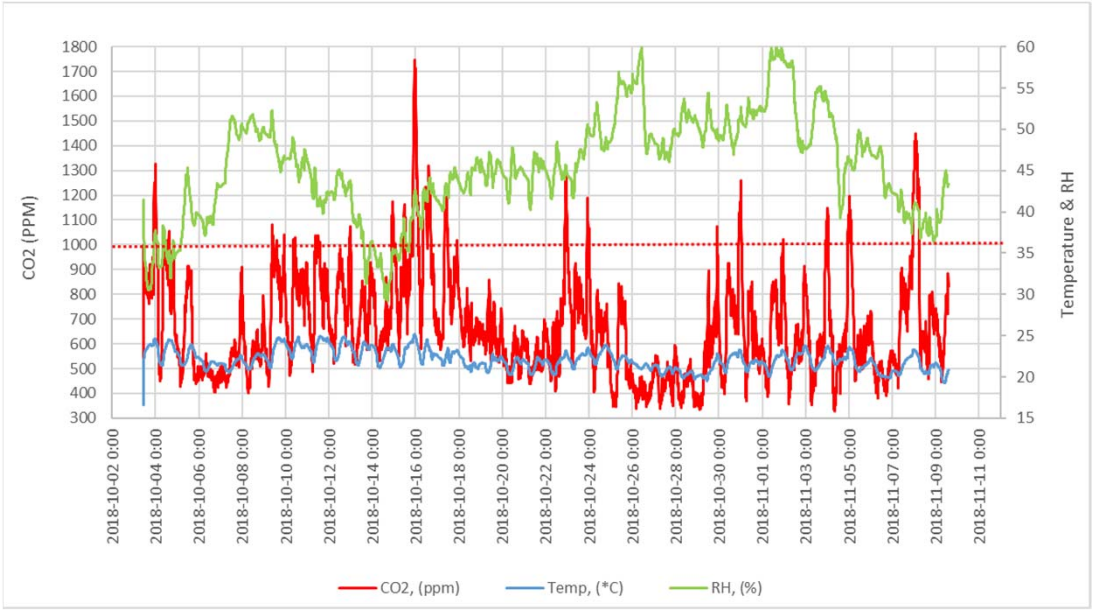
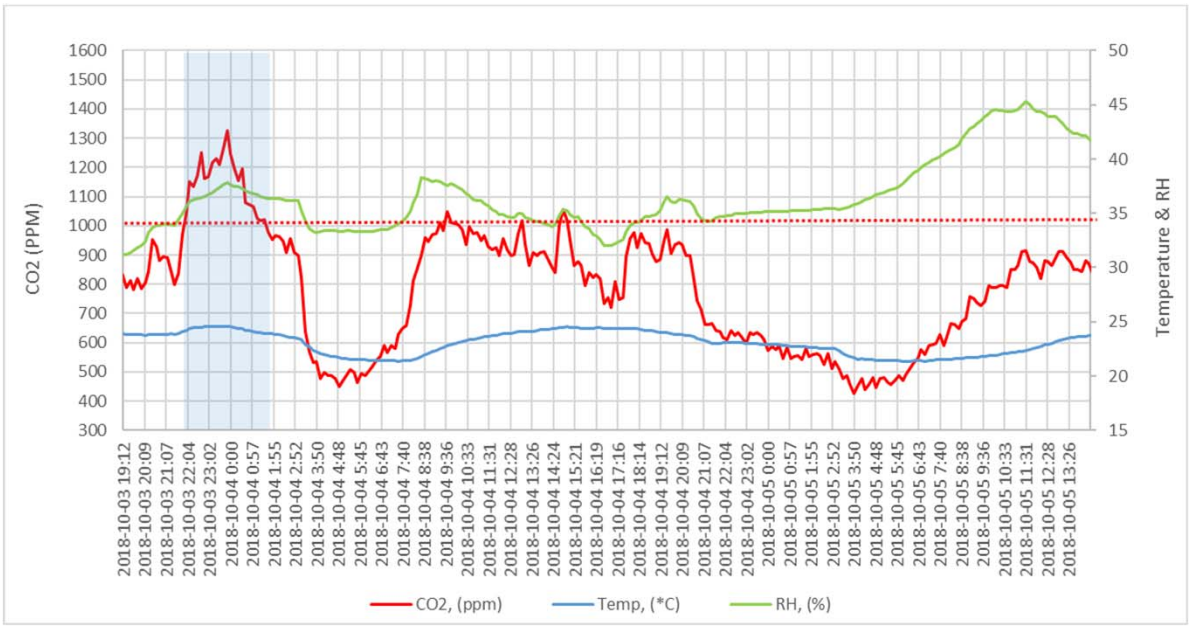




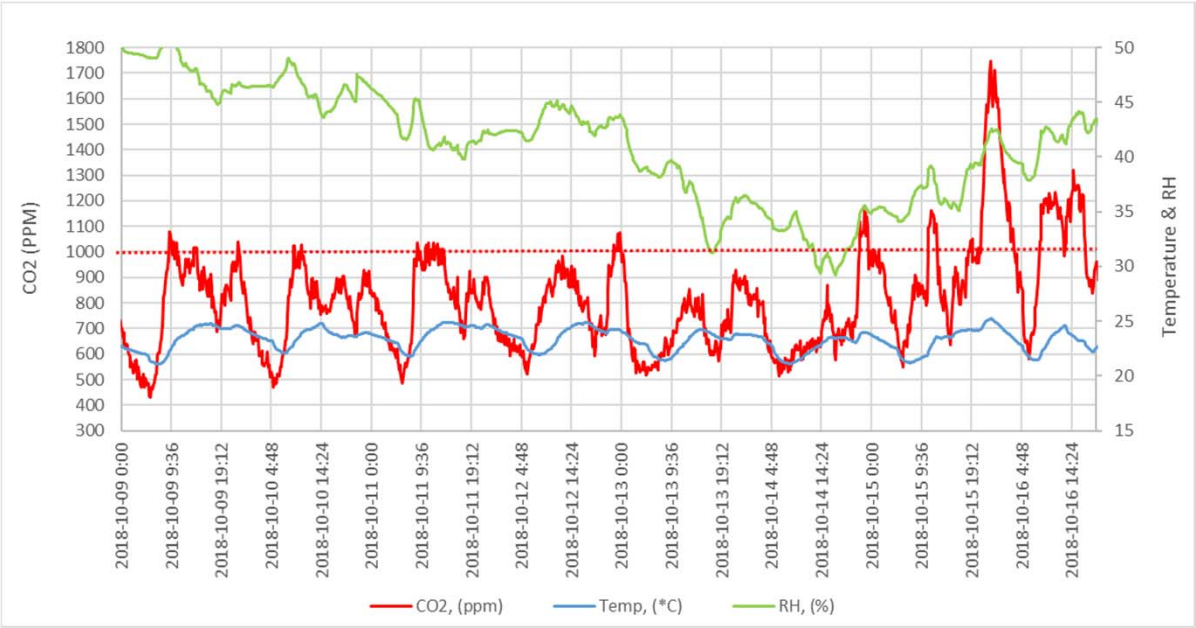
- Fall season outdoor air damper (OAD) operation enabled according to schedule
- AHU2 operates dampers: OAD (outdoor air damper) , MAD (mixed-air damper), EAD (exhaust air damper)
- Dampers operation is based on energy conservation (versus outdoor air temperature: OAT) and proper ventilation air intake criteria
- To conserve energy, OAD opens further at moderate outdoor air temperatures, and reduces opening at cooler outdoor air temperatures

Indoor Environmental Monitoring





- Continuous red line indicate CO2 levels and dotted red line 1000 PPM limit
- Notice when CO2 levels exceed 1000 PPM concentration



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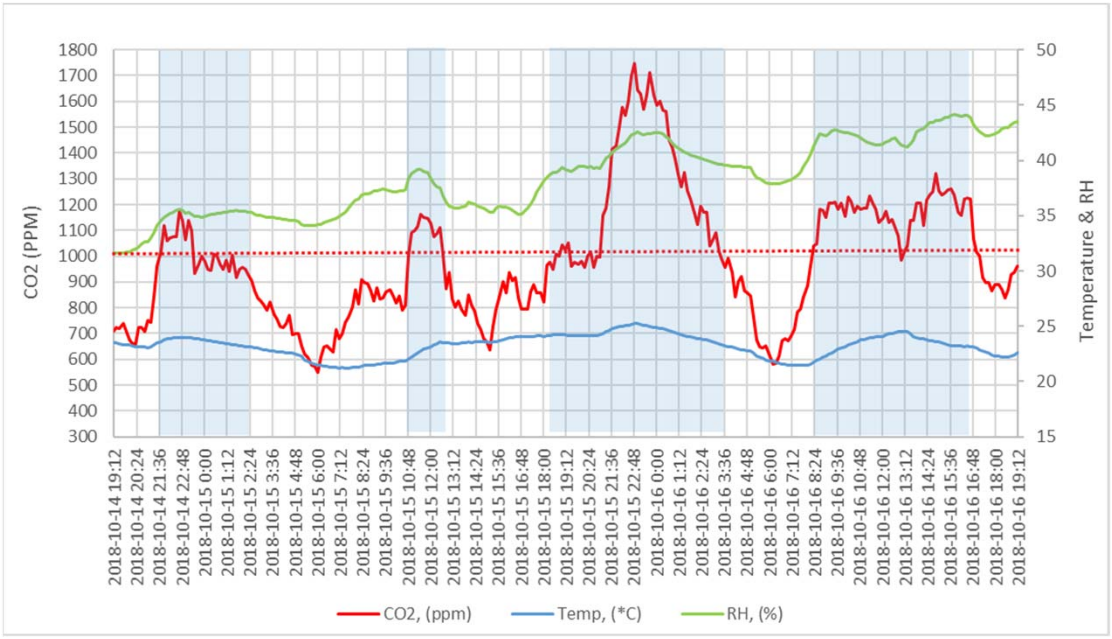

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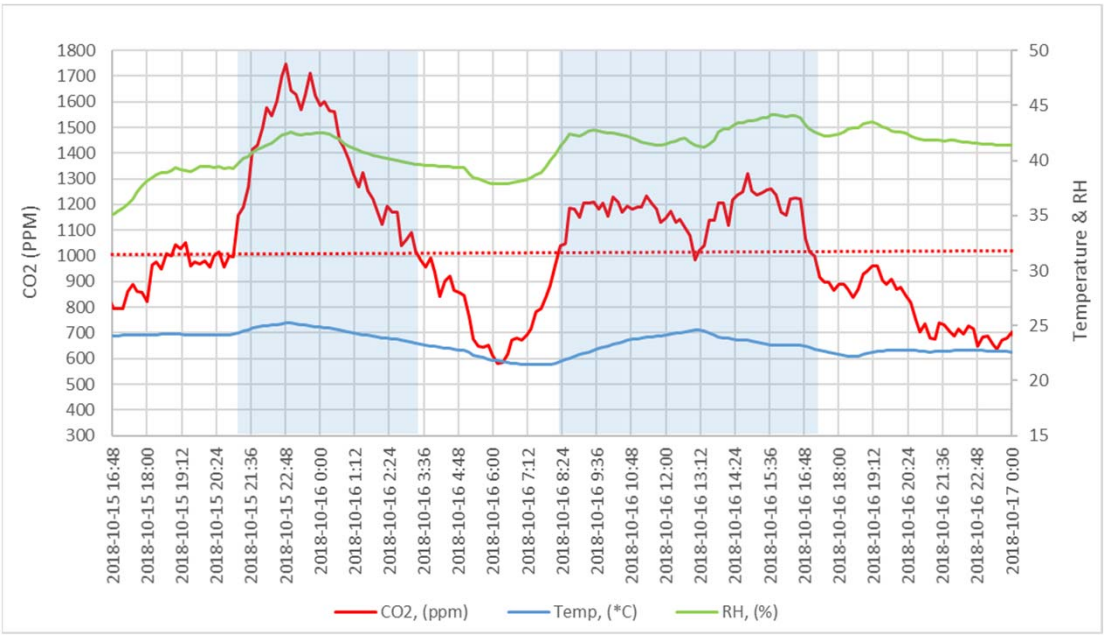

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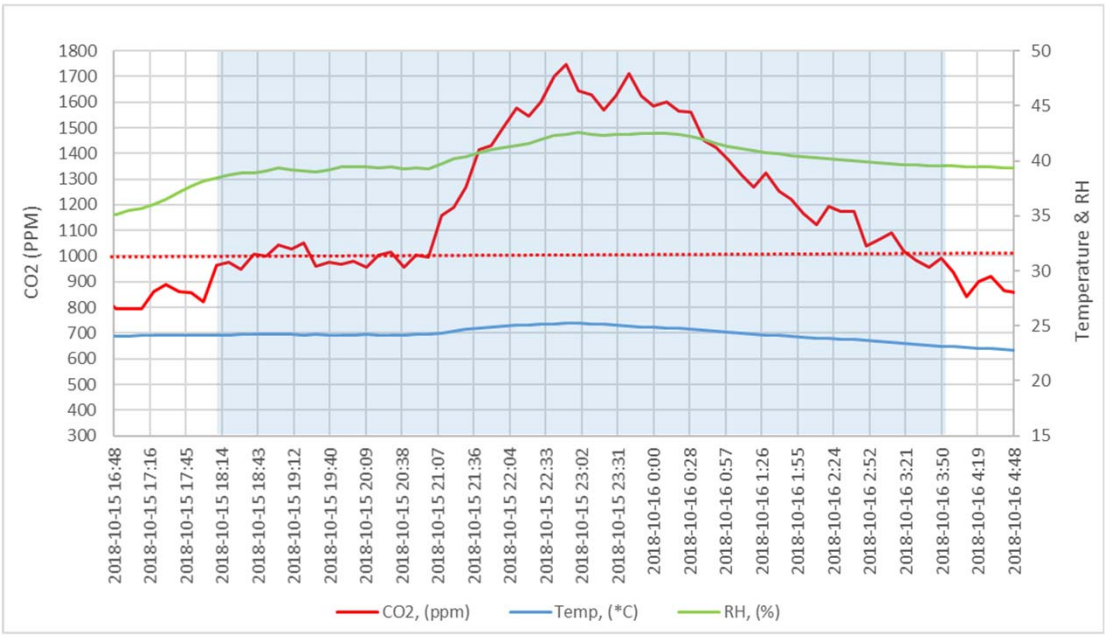

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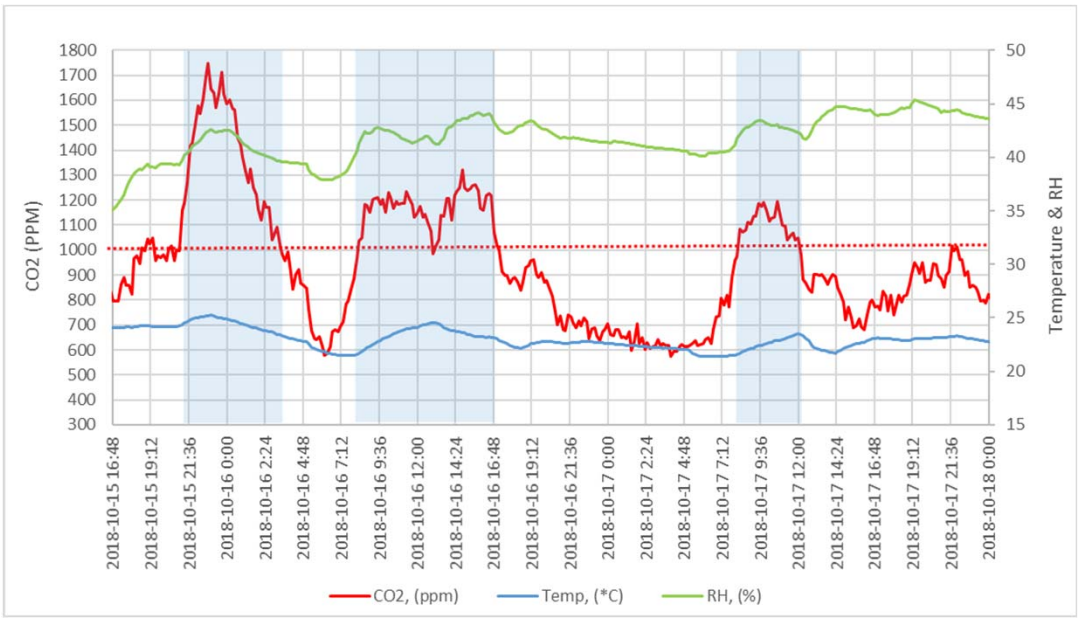

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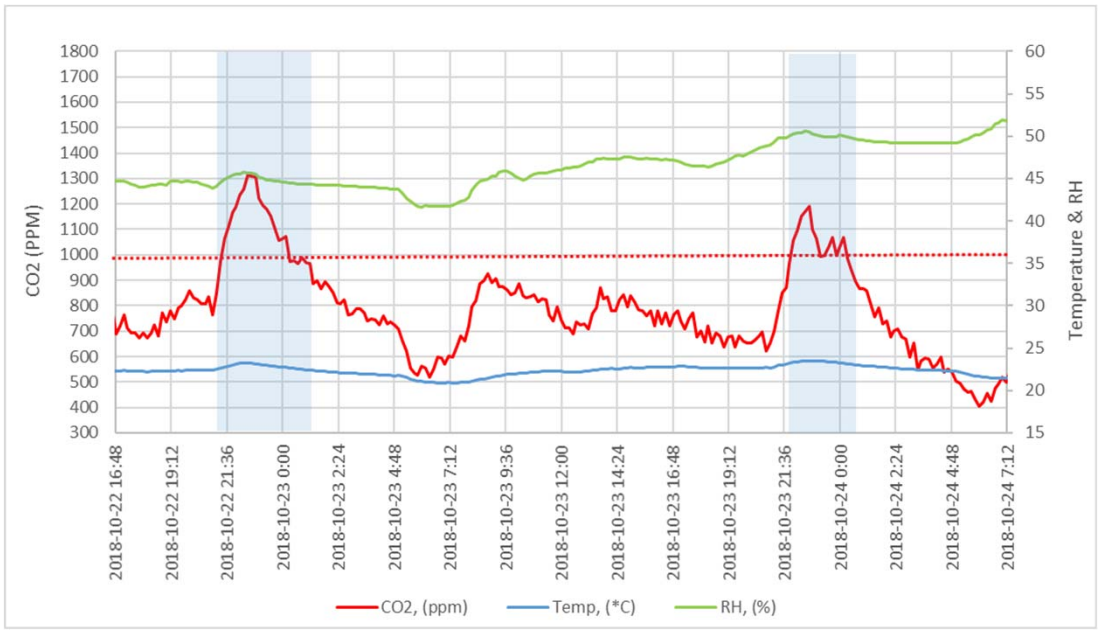

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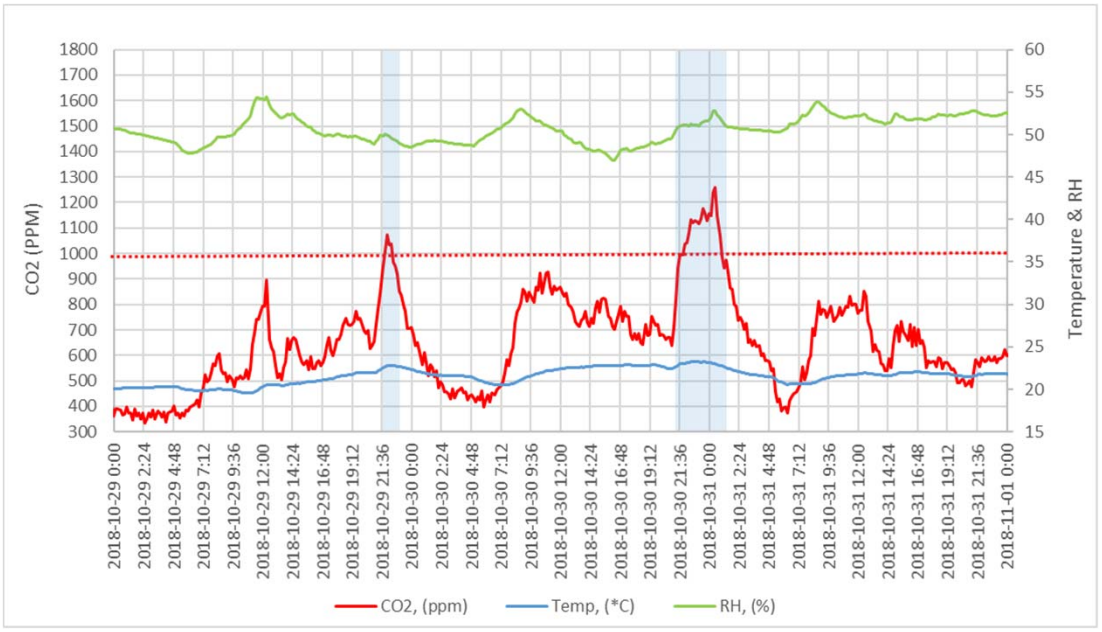

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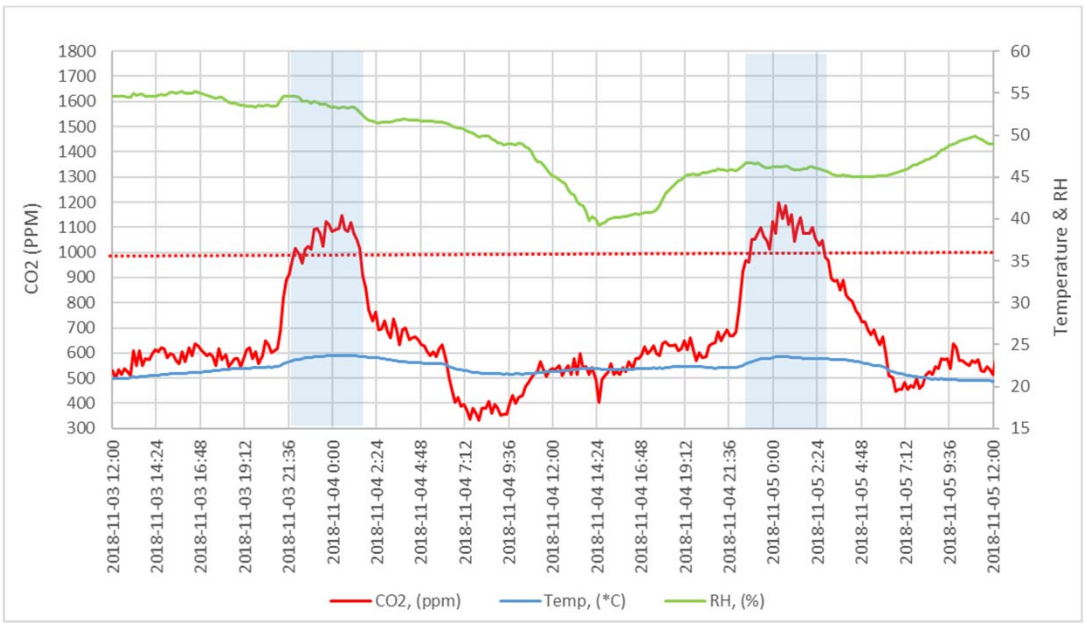

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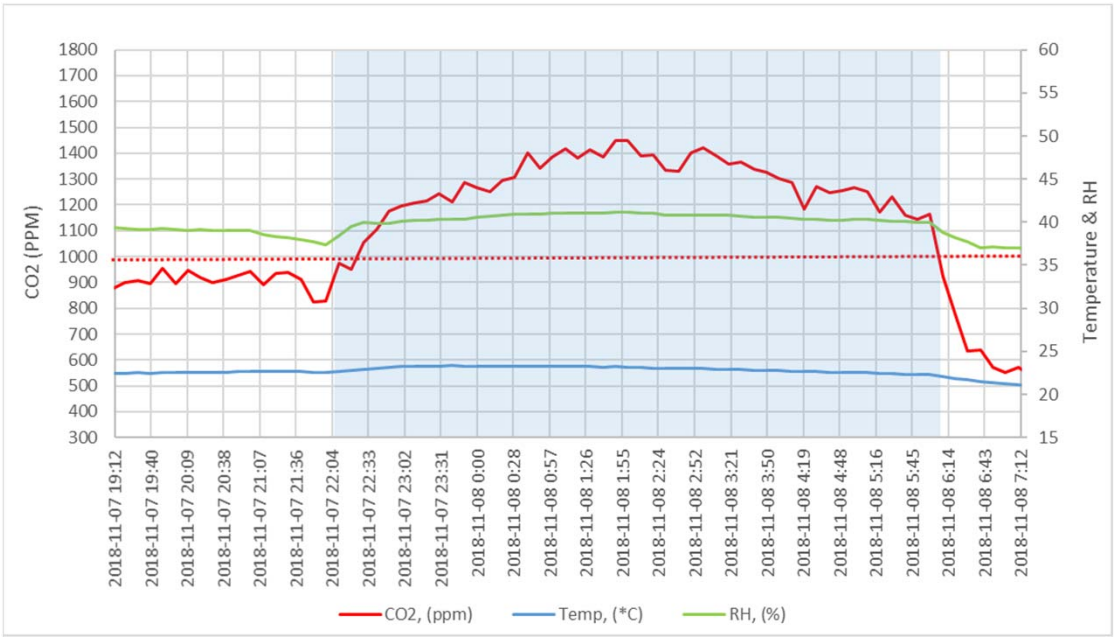

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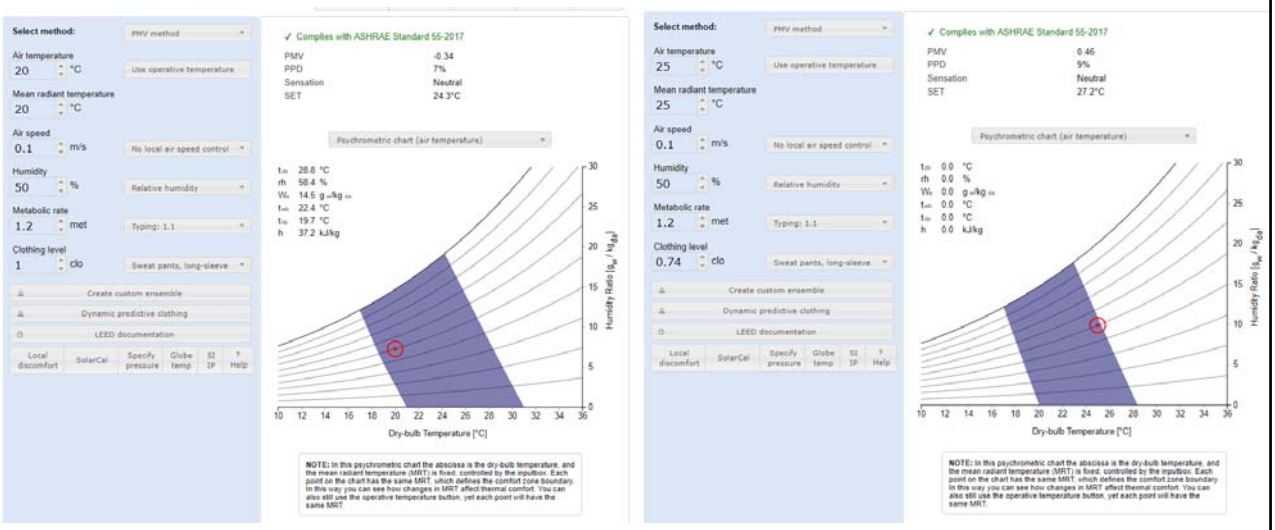
Quick Thermal Comfort Analysis



- Comfort analysis at lowest and highest recorded temperatures
- Within comfort zone…
- Clothing adjustments are sufficient to maintain comfort…

Conclusions

- BCIT Facilities suggested that extending the schedule when needed could be an option. The problem is that the air handler that serves studio rooms 302 and 303 also serves several other rooms. So running it extended hours could be very wasteful (it is a large unit with a big fan).
- Another solution proposed by facilities is adding a small ventilation system just for those Architectural Science rooms. It may draw air from the corridor (which has plenty of fresh air) and operate on demand based on CO2 concentrations.
- To be continued…