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Preliminary Findings Report No. 3

NYSERDA Energy Efficient Indoor Air Quality Analysis

September 18th, 2020

Executive Summary

Syska has been engaged by NYSERDA to evaluate the engineering feasibility, energy usage and operational cost impact of making indoor air quality (IAQ) improvements to existing buildings and spaces. The overall effort is split across two separate studies: a commercial office tenant in Manhattan and a commercial office building operator/occupier in Westchester. The studies focus on assessing COVID-mitigating improvements to building systems and operations that also incorporate energy efficiency without sacrificing safety or indoor air quality.

Existing Conditions

Below is a summary of the existing building characteristics and building systems for each project.

Study 1 – Manhattan Commercial Office Tenant			
Number of Floors	6	Peak Occupants (pre-COVID)	800
Project Gross Floor Area	186,000 Square Feet	Typical Operating Hours	8am through 8pm
Location	Midtown Manhattan	Current Occupancy %	2%
Heating System(s)	The tenant's floors are heated by a perimeter fin-tube radiator system outfitted with new control valves supplied by the landlord. Hot water is supplied by the landlord's boilers and routed through risers located at the perimeter columns.		
Cooling System(s)	The tenant's floors are cooled using base building supply air from two main air risers located at the buildings core. Cooling air is supplied to these floors from two variable volume AHUs. These AHUs with VFDs each provide approximately 67,000 CFM and are the main source of cooling for half the building. Chilled water is produced by 3 Chillers located in the basement totalling approximately 2,700 Tons. This chilled water is split between the AHUs that serve the lower levels and upper floor AHUs.		
Ventilation System(s)	Ventilation air is introduced via the main AHUs providing supply air to the tenant floors. The actual amount of outside air varies depending on outside conditions, but the landlord estimates the OA rate to be approximately 4,500 CFM per floor.		
Domestic Hot Water System(s)	DHW is provided by the landlord to the main core restrooms. Additional DHW for the pantries and additional tenant restrooms is provided by the tenant under-counter instantaneous water heaters and above ceiling storage type water heaters.		
Building Management System / HVAC Controls	All landlord and tenant equipment is connected to the base building BMS which is a Reliable Controls system and maintained by the landlord's automated controls contractor. Each tenant has visibility to the BMS for their HVAC terminal unit setpoints, leak detectors, CRAC/AC unit failures, etc		

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Study 2 – Westchester Commercial Office Facility			
Number of Floors	3 & Parking Garage	Peak Occupants (pre-COVID)	2,828
Project Gross Floor Area	627,000 Square Feet	Typical Operating Hours	5am – 6pm Mon-Fri
Location	Westchester	Current Occupancy %	10
Heating System(s)	The site is heated by (3) 300 HP boilers which provide steam and hot water to heating and reheat coils in the central air handling units and VAV/FPBs throughout the office spaces. The perimeter is heated with supplemental constant volume fans and steam coils.		
Cooling System(s)	The site is cooled via water-cooled chiller plant, with (3) 800-ton cooling towers and a total 2,100 tons of chiller capacity. The chiller plant provides chilled water to the cooling coils of all air handing units. The perimeter is cooled as needed with supplemental constant volume fans and chilled water coils.		
Ventilation System(s)	Supply and ventilation air to the occupied areas is provided by large central air handlers, some variable volume some constant volume.		
Domestic Hot Water System(s)	DHW is generated via heat exchangers on the steam supply from the space heating boilers which is stored in a domestic hot water tank which then supply the plumbing fixtures.		
Building Management System / HVAC Controls	The ventilating and air handling units are controlled via a central BMS which monitors status of all fans and coils as well as other setpoints, including OA damper open %, fan power, supply pressure and supply and return air temperatures.		

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Progress Summary

Study 1 – Commercial Office Tenant – 186,000 GSF (Manhattan, NY)		Study 2 – Large Commercial Office Facility – 627,000 GSF (Westchester, NY)	
Current Project Stage:	*Data Collection and Site Surveys*	Current Project Stage:	*Data Collection and Site Surveys*
	IAQ Measure Feasibility Analysis		*IAQ Measure Feasibility Analysis*
	Energy and Cost Impact Analysis		*Energy and Cost Impact Analysis*
	Draft IAQ and Energy Study Report		*Draft IAQ and Energy Study Report*
	Final IAQ and Energy Study Report		*Final IAQ and Energy Study Report*
	Overarching IAQ Report and Key Findings Slides		*Overarching IAQ Report and Key Findings Slides*

Study 1

- Client provided additional utility bills and the baseline energy use has been revised.
- Received technical information from manufacturers needed to complete energy use calculations.
- Currently waiting for technical information from the manufacture to continue review of IAQ sensors to be installed for permanent monitoring.
- IAQ sensors are also being assessed for a control strategy to reduce energy usage (e.g. only turn on conference room air cleaning equipment if CO2 is above a certain ppm threshold)
- Received answers to our follow up questions sent to base building engineers regarding filtration OA and COVID measures to survey and report back, in lieu of surveying base building mechanical rooms and air handlers directly
- Energy calculations for IAQ improvement measures deemed feasible from an engineering perspective (see August Report) are in progress.
- Currently investigating ASHRAE approved tools to be used to calculate the effectiveness of the COVID prevention measures that are being installed. Tools will be able to assist in calculations for reduction in airborne concentration, airborne exposure, and surface loading.

Study 2

- Energy calculations for IAQ improvement measures deemed feasible from an engineering perspective (see August Report) are in progress.
- The exact specifications, airflows and installation locations of the sorbent-based air scrubbers were received.
- Analysed results of IAQ testing and will incorporate in energy efficiency IAQ improvement recommendations made to the building. See ***IAQ Results*** in the Appendix below for further information.
- Not able to measure existing pressure drop across the filters in a typical AHU due to building operator not providing access at time of testing because system was running in an atypical, over-cooling, setting for the day. Will be proceeding with estimates based on equipment specs and BMS readings, will need to return to site if measurement is critical to decision making.
- Currently investigating ASHRAE approved tools to be used to calculate the effectiveness of the COVID prevention measures that are being installed. Tools will be able to assist in calculations for reduction in airborne concentration, airborne exposure, and surface loading.

New Findings to Date

Study 1 – Manhattan Commercial Office Tenant	Study 2 – Westchester Commercial Office Facility
• Specifications and operational information about the base building systems serving the tenant spaces was received: ○ <u>Current Filtration:</u> MERV 15 Filters ○ <u>Current % OA</u>: 17.6% OA at peak conditions ○ <u>Maximum % OA:</u> 100% ○ <u>OA Control Strategy</u>: Air side economizer controlled by enthalpy and outside dry bulb temperature ○ <u>Total Supply CFM</u>: 429,000 cfm total from the unit that serves the 28th through the 44th floor. ○ <u>Static Pressure</u>: 7" w.c. supply and 2-1/2" w.c. return ○ <u>Motor HP</u>: 100 horsepower for the supply and 40 horsepower for the return ○ <u>Changes in response to COVID-19</u>: UVGI systems to be installed in 2-4 weeks. Extend the occupied mode of operation by 2 hours on either end of the schedule. The building is currently reviewing a potential ventilation flush out pre-occupancy (OA air conditions permitting)	• The project space was found to have high existing indoor air quality but may have some over-cooling issues: ○ Based on average temperatures and relative humidity (cold and humid), the office areas were found be outside of ASHRAE 55 thermal comfort thresholds for a summer conditions during occupied hours. This may be due to over-cooling operation during zero to low occupancy. ○ PM2.5 (particulate matter) levels were found to be very low during occupied hours, within "high performance" limits for a commercial interior space as defined by the RESET standard (<12 µg/m3). ○ CO2 (cardon dioxide) levels found to be relatively constant and within "high performance" limits for a commercial interior space as defined by the RESET standard (< 600 ppm). ○ CO (carbon monoxide) concentration was found to be zero which is well below the "high performance" limits for a commercial interior space as defined by the RESET standard (<9 ppm)

- Several clarifications and additional energy efficiency IAQ strategies were presented at by ASHRAE at their recent SARS-CoV-2 seminar which will be taken into account in both IAQ studies:
  - The recommendation to run 2 hours before/after occupancy is a rule of thumb based on achieving 3 air changes. ASHRAE estimates that after 3 air changes, 95% of aerosoled particles will be cleaned out. If a building's systems operating in flush-out mode allow it to achieve 3 air changes faster than 2 hours, the off-hours operations can end once 3 complete air changes is achieved to save energy.
  - ASHRAE does not recommend that HVAC systems should be operated 24/7, unless there is a 24/7 occupancy. Only during occupied hours and the pre/post occupancy flushouts.
  - Given that 60% Relative Humidity leads to faster decay times in the air (per the DHS calculator, see the **Resources** section in the appendix below) a potential energy saving IAQ measure is to dehumidify only to a 60% RH setpoint in summer instead of 40% or 50% RH.

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Barriers Encountered

Study 1 – Manhattan Commercial Office Tenant

- Base building response time has been slow, and working with a tenant-level project adds an additional layer to the communication which also slows overall coordination as compared to working to a building owner/operator directly
  - Why is this a barrier?
    When attempting to implement IAQ upgrades at a tenant level, some engineering and operational info is required from the base building since they provide many relevant central services, chiefly ventilation air, to commercial tenant spaces that directly impact the IAQ and energy usage of the tenant floors.
  - Resolution/workaround
    Consistent, frequent, and clear email follow up and pushing from the tenant in addition to the consultant on the base building to provide requested information.

Study 2 – Westchester Commercial Office Facility

- Now that it is better understood, the atypical building operation makes it more difficult to use existing energy bills to establish a pre-COVID baseline
  - Why is this a barrier?
    The building reducing outside air supply due to air scrubbers reduced energy uses but this is not 100% equivalent to the air quality provided by keeping outside air supply at elevated levels and is a poor baseline case for "typical office operation" for the space.
  - Resolution/workaround
    Requested 2017 energy data (prior to the air scrubbers were installed) to establish an energy baseline under operations that are more typical for commercial office buildings.

Lessons Learned

Study 1 – Manhattan Commercial Office Tenant

- No additional lessons learned to report at this time

Study 2 – Westchester Commercial Office Facility

Proposed Work Plan Adjustments

Study 1 – Manhattan Commercial Office Tenant

- No new adjustments to work plan

Study 2 – Westchester Commercial Office Facility

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Next Steps

Study 1 – Manhattan Commercial Office Tenant	Study 2 – Westchester Commercial Office Facility
• Schedule follow up site visit to assess feasibility and scope of air scrubber installation • Complete initial energy calculations for ASHRAE baseline scenarios and IAQ improvement scenarios • Perform calculations using the NIST tool to understand relative airborne biohazard mitigation effects of various MERV and outside air CFM values for the project • Anticipated final IAQ report submission date: 11/27/20	• Complete initial energy calculations for ASHRAE baseline and proposed IAQ measure scenarios • Perform calculations using the NIST tool to understand relative airborne biohazard mitigation effects of various MERV and outside air CFM values for the project • Investigate the causes of the operational issues and anomalies as discovered in the IAQ testing. • Collect sample previous IAQ reports • Anticipated final IAQ report submission date: 11/27/20

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Appendix

Resources

As introduced and endorsed by ASHRAE in the September 9th Webinar titled "Reopening Commercial Buildings: Evaluating Your HVAC System's Readiness to Mitigate the Spread of SARS-CoV-2, the following free online tools allow for additional calculations regarding the airborne spread and survivability time of SARS-CoV-2 under varying airflow, outside air, MERV filtration, temperature and relative humidity conditions:

- NIST (National Institute of Standards and Technology) has developed an online simulation tool to compare the virus mitigation effectiveness of various filters and outside air rates:
  - https://pages.nist.gov/CONTAM-apps/webapps/FaTIMA/
- The DHS (US Department of Homeland Security) has developed calculators to estimate the time it takes SARS-CoV-2 to decay in the air and on surfaces based on UV, Temperature and RH:
  - https://www.dhs.gov/science-and-technology/sars-airborne-calculator
  - https://www.dhs.gov/science-and-technology/sars-calculator

IAQ Testing Results

As part of Study #2 for the Westchester Commercial Office Facility, IAQ testing was performed to spot check the temperature, relative humidity, CO2, CO and particular matter levels (PM2.5 = particulate matter that is 2.5 microns in diameter or smaller) in each type of occupied space, as well as perform continuous monitoring over the course of a few days to better map the effects of building operations.

It is important to note that the building is currently under a nightly "flush-out" mode, where all outside air dampers are set to full open, the supply CFM on the main air handlers is set to maximum and the exhaust fans are run at maximum airflow. VAV/FPB airflow is still controlled via setback indoor air setpoints during this time. Additionally, during the day the current building occupancy is low and the office area in which the sensors were places experienced minimal occupancy during the testing period (0-20%) The sensors that gathered the data were set up in the middle of a typical open office space on the 3rd floor and left to continuously sample the surrounding air quality in 1-minute intervals, for 3 days.

Conclusions

The results demonstrate that a small amount of additional particulate matter is being introduced to the space during the nightly flush outs with additional ventilation, however once the additional OA is reduced and more recirculation occurs, the existing MERV 16/15 filters successfully reduce the concentration of PM2.5 in the air during occupied hours, in some cases to down to zero (Fig. 1). The CO2 levels in the space stayed constant at relatively low levels (<1000 ppm, which is industry benchmark beyond which CO2 begins to has negative cognitive effects), despite additional outside air provided during non-occupied times (Fig 2.). This may be due to a lack of a significant number of occupants to introduce additional CO2 into the space and/or because the ambient level of CO2 in the outdoor air is close to the existing indoor levels of CO2, thus no dilution of CO2 occurs. Upon reviewing the data and comparing conditions at the various locations sampled we were able to draw the following conclusions:

- The conditions of each space type in comparison to each other is as would be expected; (Fig.3) the spaces that require more ventilation air as per NY Mechanical Code have lower levels of CO2 compared to the spaces that require additional air. This implies the relative distribution of outside air between various space types is well balanced per code ventilation requirements.
- The top floors have very slightly more effective supply air delivery as evidence by the lower air temperature and CO2 (Fig.4).
- The spaces are being slightly overcooled, average temperature was 67-68 in some spaces. This is most likely a result of either poor turndown efficiency or not considering the reduced load from a lack of people. Project team will follow up with building operators to investigate further.
- Overall CO2 in the open office area was relatively constant over the course of the 3 days and stayed 0-8% higher than the ambient outside air CO2, which was about 550ppm on average (Fig. 2). This is likely due to minimal sources of CO2 within the building though the reasons at to why the CO2 levels did not drop further during the nightly flush outs require further investigation.
- At night, the PM2.5 detected increased. This could be a result of PM2.5 being resuspended into the air from cleaning methods (i.e. vacuum) or from the increased exhaust and supply fan CFMs from the nightly flushout. Project team will be recommending establishing a more frequent cleaning protocol of supply and exhaust grills and ductwork and usage of additional HEPA filtration on cleaning devices such as vacuums (Fig. 5)
- During flush-out, the AHUs operate at 100% OA. However, once the set-point (74F at night) is reached, the VAVs turn down to minimum airflow to prevent overcooling. However, there may unnecessary re-heating or excessive heat gain occurring during the overnight operation because the outside air dropped below 70F for several hours on two consecutive nights, but this did not appear to significantly lower the space temperature. (Fig. 6)

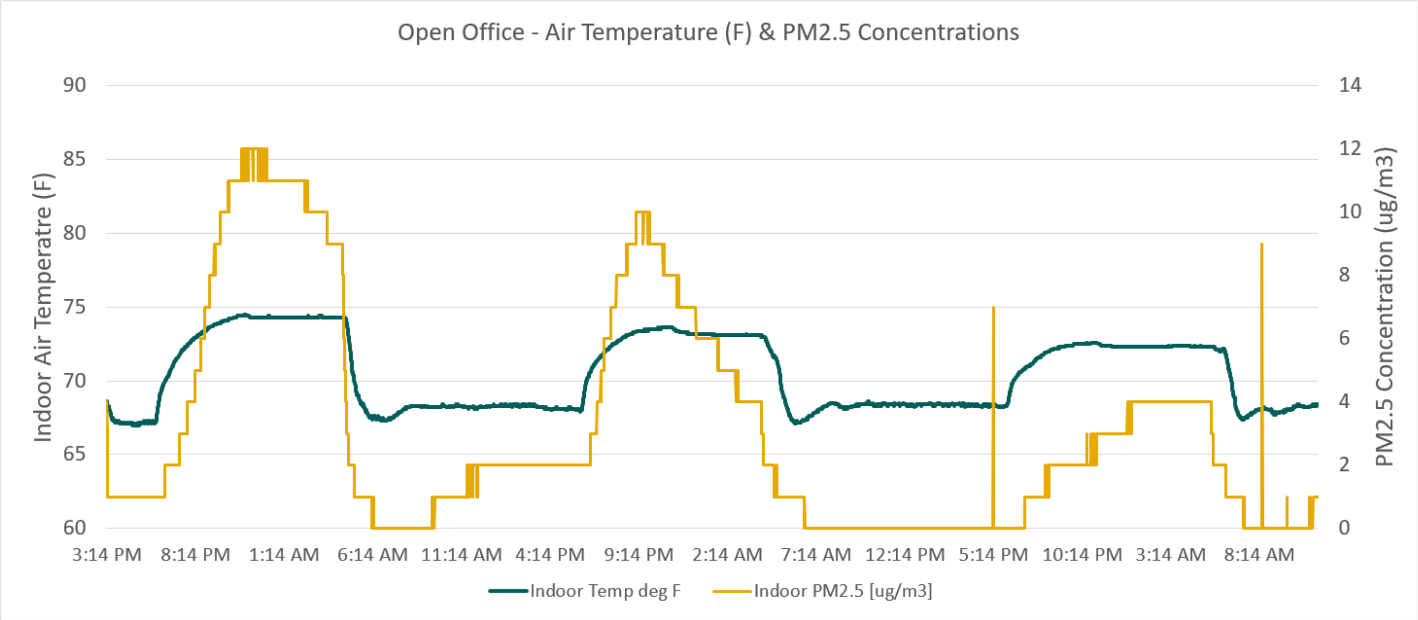

Fig. 1 – Air Temperate & PM2.5 over 3-day period in typical open office area.

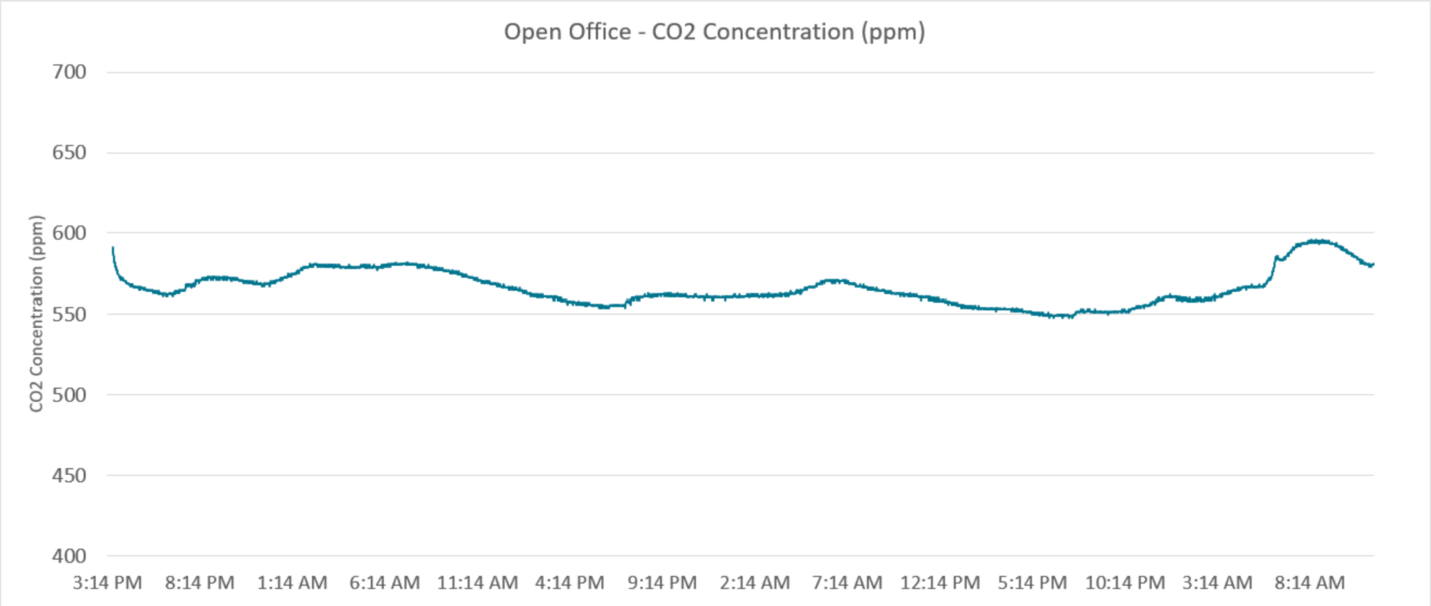

Fig. 2 – CO2 concentration over 3-day period in typical open office area
Min = 548 ppm, Average = 566 ppm, Max = 596 ppm

Space Type	Average Air Temperature (F)	Average % Relative Humidity	Average CO2 Concentration (ppm)	Average CO Concentration (ppm)
Fax/Storage	68.90	67	621	0
Enclosed Office	69.42	65	602	0
Pantry	70.50	64	599	0
Conference Room	70.20	62	594	0
Open Office	70.13	64	591	0
Lobby	67.80	63	586	0
Gym	70.70	63	583	0

Fig. 3 – Average IAQ conditions per space type

Floor	Average Air Temperature (F)	Average % Relative Humidity	Average CO2 Concentration (ppm)	Average CO Concentration (ppm)
1	70.65	64	601	0
2	69.92	65	599	0
3	68.60	62	587	0

Fig. 4 – Average IAQ conditions per floor

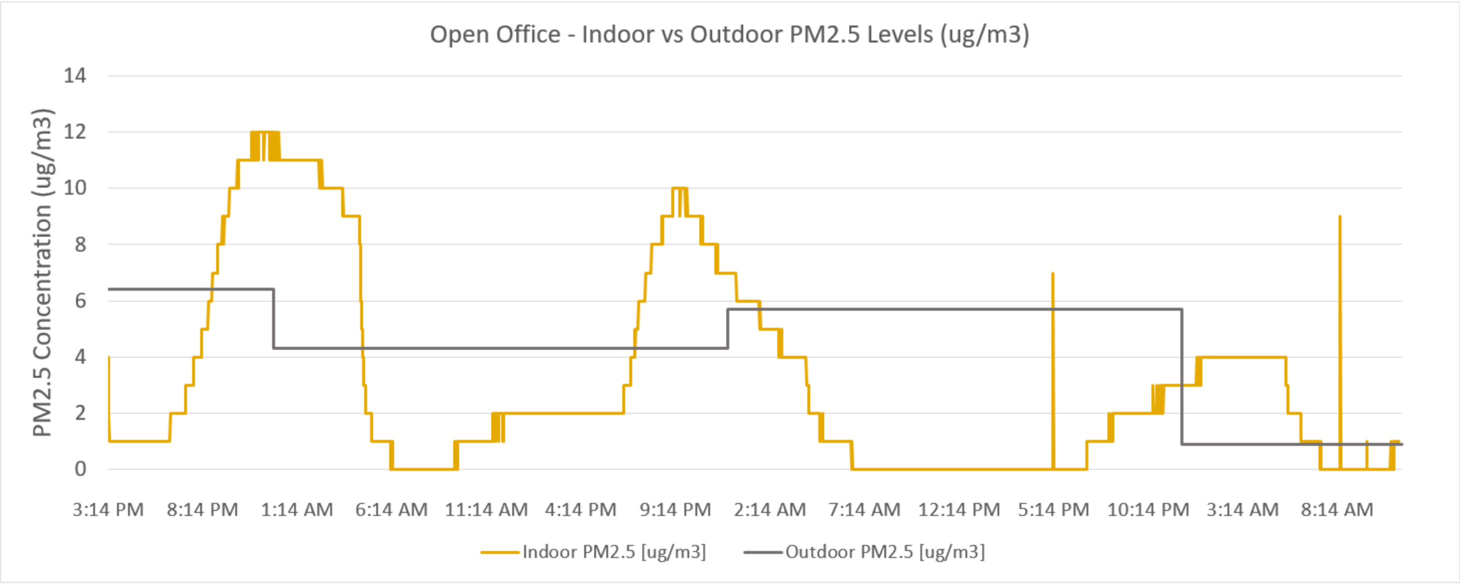

Fig. 5 – Indoor and outdoor PM2.5 over 3-day period in typical open office area

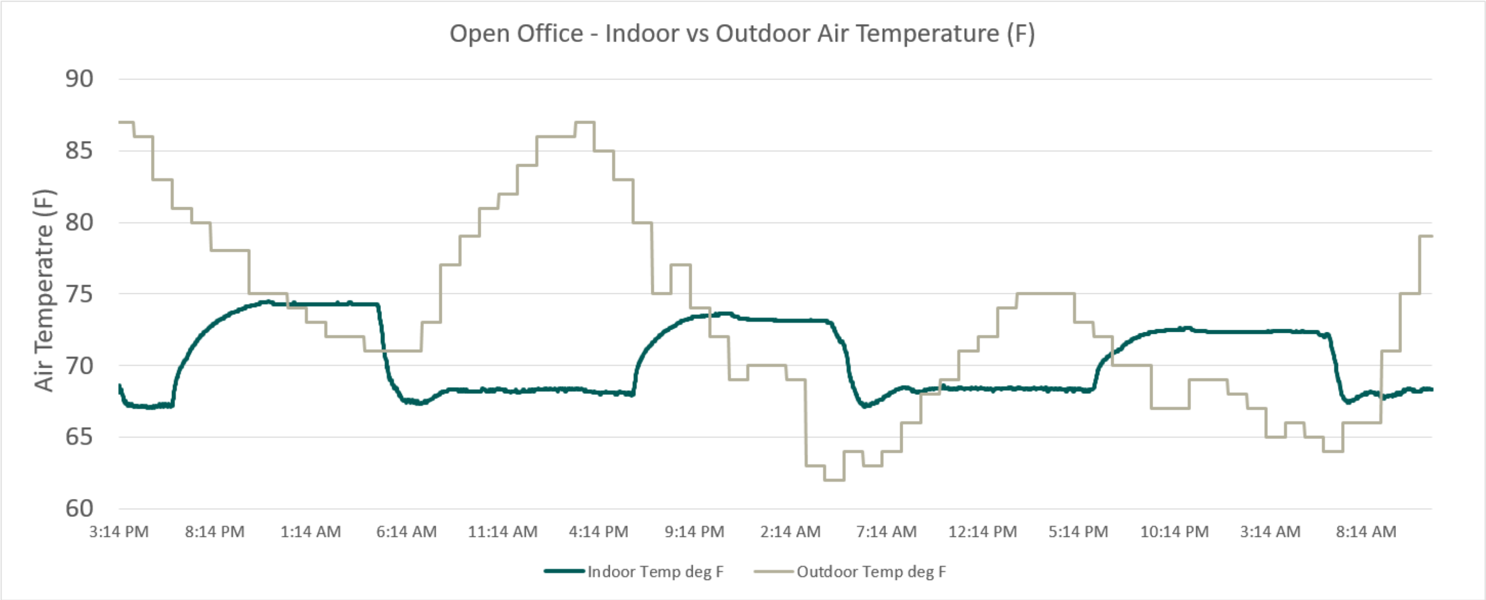

Fig. 6– Indoor and outdoor Air Temperature over 3-day period in typical open office area