



**FLEXTECH
ENERGY EFFICIENT INDOOR AIR QUALITY STUDY
FINAL CONCLUSIONS REPORT**

**For
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Development Authority
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Joint Statement from NYSERDA and ASHRAE on the Energy Efficient Indoor Air Quality Study Conclusion Reports

The Energy Efficient Indoor Air Quality Study Conclusion Reports summarize the findings from individual studies conducted under the FlexTech Energy Efficient Indoor Air Quality Pilot. NYSERDA presented this offering in May 2020 in response to a two-fold call from commercial market building owners and managers of New York to better understand:

1. the energy impact of the COVID-19 response guidance that was emerging in the market between March and May of 2020, and
2. how energy efficiency goals could be achieved in conjunction with reducing the risk of building occupants transmitting and contracting COVID-19 in the built environment.

When reading these reports and contemplating the conclusions drawn, it is important to consider the context of the time period in which these studies were conducted and the uniform parameters by which the consultants were bound. NYSERDA directed the consultants to use the building readiness guidance that was in the market when the studies commenced in June 2020. The ASHRAE Epidemic Task Force (ETF) guidance available to the market at the time consisted of the following document versions:

Building Readiness v.5-21-2020
Commercial v.4-20-2020
Schools & Universities v. 5-5-2020
Healthcare v. 6-17-2020
Filtration & Disinfection v. 5-27-2020
ERV Practical Guide v. 6-9-2020

While a benefit of this approach is to allow for a comparative analysis across all the studies under the initiative to explore overarching conclusions applicable to the broader market sector, a drawback emerged when ASHRAE guidance evolved significantly while the studies were underway. As a result, some of the guidance that formed the basis of the studies is no longer advocated as best practices by leading authorities in the market, including the ASHRAE ETF. Current ASHRAE ETF guidance is summarized in its [Core Recommendations](#) (1/6/2021). The concise guidance in the Core Recommendations is reflected in more recent versions of the guidance documents noted in the table above. To provide the reader a side-by-side account of the changes to the ASHRAE ETF's guidance, the table below compares guidance available to the market at the time the studies commenced to the current ASHRAE Core Recommendations and the resulting energy implications.

ASHRAE Epidemic Task Force Guidance

	THEN Building Readiness Guidance version 5.21.2020 and/or Commercial Guidance version 4.20.2020	NOW Core Recommendations version 1.6.2021, Building Readiness version 4.27.2021, and/or Commercial Guidance version 3.22.2021	Energy Impact Takeaways
Outdoor airflow rate	<ul style="list-style-type: none"> • Increase system outdoor air ventilation as much as the system and or space conditions will allow to reduce the recirculation air back to the space during occupied hours • Open windows where appropriate during occupied hours. • For HVAC system that use Demand-controlled ventilation sequences we recommend disabling this feature for the duration of the crisis. 	<ul style="list-style-type: none"> • Provide and maintain at least required minimum outdoor airflow rates for ventilation as specified by applicable codes and standards • Maintain equivalent clean air supply required for design occupancy whenever anyone is present in the space served by a system • Evaluate the use of additional outdoor air as a mitigation strategy compared to other items, such as filters or air cleaners¹. • For HVAC system that use Demand-controlled ventilation sequences we recommend disabling this feature for the duration of the crisis² 	It is more energy and cost efficient to operate systems with less outdoor air
Filtration	Update or replace existing HVAC air filtration to a minimum of MERV 13 (MERV 14 preferred) or the highest compatible with the filter rack	Achieve MERV 13 or better levels of performance for air recirculated by HVAC systems by using a combination of filters and air cleaners ³	Depending on the performance of the current filtration system, higher MERV filter ratings might increase system pressure drop, leading to increased energy use and cost. Using carefully selected filters, or the appropriate combination of MERV filtration and air cleaners, could mitigate a negative energy impact.
Air Cleaners	<ul style="list-style-type: none"> • Where there can be a large assembly of people, consider air treatment, e.g. upper-room UVGI lamps. • Consider adding air treatment and cleaning devices such as UVGI in duct, plenums and air handling units and on the face of cooling coils⁴. • If an increase in filter MERV level cannot be accommodated using the existing air handling equipment fans and motors, consider using In Room portable HEPA filter units in high occupancy or high bioburden (such as the building entry) spaces. 	<ul style="list-style-type: none"> • Only use air cleaners for which evidence of effectiveness and safety is clear. Per the CDC, consumers should match any specified claims against the consumer's intended use, request efficacy performance data that quantifies a protective benefit under conditions consistent with the intended application of the technology, and look for multiple sources including independent, third-party sources that conclude the same performance data. • Consider adding air treatment and cleaning devices such as UVGI in duct, plenums and air handling units and on the face of cooling coils⁴. • If the outdoor air, filter or air cleaner in the HVAC system is not achieving the desired exposure reduction, consider adding In Room portable HEPA filter units¹. 	No impact in the context of these studies. Only air cleaners with a proven track record of safety and effectiveness were allowed in the NYSERDA studies. UVGI and HEPA filtration are considered safe technologies by ASHRAE if applied correctly and the appropriate safeguards are put into place.

¹ [ASHRAE ETF Core Recommendations, v.1.6.21, item 2.4](#)

² [ASHRAE ETF Core Recommendations, v.1.6.21, item 4.2](#)

³ ASHRAE ETF Building Readiness Guidance v.4.27.21, Equivalent Outdoor Air section

⁴ ASHRAE ETF Commercial Guidance v.4.20.20

	<u>THEN</u> Building Readiness Guidance <i>version 5.21.2020</i> and/or Commercial Guidance <i>version 4.20.2020</i>	<u>NOW</u> Core Recommendations <i>version 1.6.2021</i> , Building Readiness <i>version 4.27.2021</i> , and/or Commercial Guidance <i>version 3.22.2021</i>	Energy Impact Takeaways
Building Flush	Flushing sequence or mode may be implemented to operate the HVAC system with maximum outside airflows for two hours before and after occupied times.	When necessary to flush spaces between occupied periods, operate systems for a time required to achieve three air changes of equivalent clean air supply. Use the Equivalent Outdoor Air Calculator to determine the flush time required to achieve 3 equivalent changes of space volume based on the outdoor air levels, filtration levels, and/or efficacy of air cleaners in use OR use a 2-hour flush period.	<ul style="list-style-type: none"> Depending on the system configuration, achieving three air changes of equivalent clean air supply could be less energy intensive than conducting a two-hour flush. Performing only one flush between building occupancy will be more energy efficient than conducting a flush both pre- and post-occupancy of the building.
Air Distribution	Check that air handling systems are providing adequate airflow, there are no blockages in the duct system (for example – closed fire/smoke dampers) and air from the air handling system is reaching each occupied space.	Where directional airflow is not specifically required, or not recommended as the result of a risk assessment, promote mixing of space air without causing strong air currents that increase direct transmission from person-to-person	Both sets of guidance could have an increased impact on energy use if deficiencies in airflows levels require corrective action.
Contaminated Air Re-entry	<ul style="list-style-type: none"> Well-designed and well-maintained air-to-air energy recovery systems should remain operating in residences, commercial buildings and medical facilities during the COVID-19 pandemic. Heat wheels may continue operation if the unit serves only one space. 	<ul style="list-style-type: none"> Evaluate the operation of your energy recovery devices to determine that they are well-designed and well-maintained and fix them if there are issues⁵. Limit re-entry of contaminated air that may re-enter the building from energy recovery devices, outdoor air, and other sources, such as relief air from patient rooms to acceptable levels 	No substantial change in guidance
Setpoints	<ul style="list-style-type: none"> Maintain dry bulb temperatures within the comfort ranges indicated in ANSI/ASHRAE Standard 55-2017 Consider adjusting the space comfort setpoints to increase the system's ability to use more outside air. Maintain relative humidity between 40%-60% Prioritize increasing outside air over humidity⁶ 	Maintain temperature and humidity design set points	The current guidance will likely result in less energy use compared to the prior guidance.
System Performance	Verify that equipment and systems are properly functioning	Verify that HVAC systems are functioning as designed	No substantial change in guidance

⁵ [Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems](#)

⁶ ASHRAE ETF Commercial Guidance v.4.20.20

It is also important to understand the basis of the package groupings in these reports.

Pre-COVID energy use establishes the typical energy use baseline prior to any impacts resulting from COVID-19

ASHRAE guidance measures include the HVAC-related guidance from the ASHRAE Epidemic Task Force documents that are feasible in the subject building(s)

Energy Efficient measures include Ultraviolet Germicidal Irradiation (UVGI), air filtration strategies, and building operation optimization solutions that perform equally on the basis of COVID-19 risk of infection to the ASHRAE guidance package of measures

ASHRAE has recommended UVGI since the inception of the Epidemic Task Force as a potential mitigation strategy. NYSERDA chose to use UVGI in the Energy Efficiency package because of its potential to reduce the energy impact of risk mitigation.

One final note is that major mechanical capital improvements were intended for exclusion from analysis under these studies.

For more information, the NYSERDA-issued mini-bid for the Energy Efficient Indoor Air Quality studies can be found [here](#) and the current ASHRAE ETF Core Recommendations can be found [here](#).

Energy Efficient Indoor Air Quality Study

NYSERDA



Study Conclusion Report

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Study Approaches

Research Conducted

The initial stage of the project began with a review of project scope with the clients. Following that, observational site visits were conducted to assess site conditions and discuss current and historical building operation with facilities staff. Previous years utility data was gathered and analyzed. Research was conducted on the various proposed measures. Vendors were consulted on the application of specific products such as the UVGI devices. The results were then compiled into draft reports.

Study Methodology

This analysis reviews a range of opportunities for improving IAQ from an HVAC, energy, and safety perspective to provide a cost benefit analysis and a comparison of the risk of COVID-19 spread to enable the building to make an appropriate decision on next steps forward. It should be noted that the NYSERDA Program Opportunity Notice (PON) was designed only to cover technologies currently supported as effective in maintenance of IAQ by ASHRAE, so this excludes some options being promoted or being installed elsewhere.

Potential energy conservation measures (ECMs) are evaluated after the site survey. In order to assess savings associated with each measure, the baseline for consumption is compared individually to consumption totals calculated for each measure. Baseline consumption is determined based on current code requirements, information about existing base building equipment from observation or discussion with building staff, and utility consumption from the previous year. Results are then calculated using spreadsheet analysis.

Measures were modeled primarily using the bin method. The consumption associated with each measure is assessed based on the technical performance of new equipment, and compared to the baseline's energy usage to determine energy savings. Cost savings are determined using projected energy savings and typical utility costs for the previous year.

The analysis provides two broad range options for addressing the Covid crisis. The first option includes implementation of the full range of measures recommended by ASHRAE guidelines. Feasibility of these options, implementation costs, and associated energy impact are addressed in these measures.

Goldman Copeland provides an alternative that we believe will provide similar efficacy at a much-reduced energy and capital cost. Measure efficacy was demonstrated using ASHRAE's Equivalent Outside Air Calculator. Each measure was evaluated individually and then combined for the ASHRAE recommend and the Energy Efficient protocol. Increased outside air levels are reduced under this alternative, with UVGI at coils included. Further, humidification is eliminated as impractical, and having unclear implications on the future of the building.

Some measures, such as system balancing and increased filtration, are included in both categories as low cost and high value. Additional measures are included that could be considered on a case-by-case basis or for future development within the building. The tables below divide recommended measures into these three categories and summarize both up-front and ongoing energy costs for each measure.

Our reports review the following options for the building, with a summary of findings presented in the conclusion report below:

- Increased outside air rates and verifying performance of existing HVAC systems
- Improved filtration at AHUs
- UVGI at coils in AHUs
- Increased tenant awareness of ongoing IAQ projects – informing tenants of measures undertaken and installation of local HEPA units.
- Local filtration options within tenant space
- Retro-commission HVAC systems, with a focus on air-side testing and balancing
- Confirm air flow through toilet exhaust system
- Other strategies which may or may not be appropriate to this building are listed

Overall Findings

Below are the tables from the Overall Findings compilation of total results for each building.

WP#	Building	Pre-Covid Baseline									
		Energy Use Impact			Total Supply Air CFM	CFM Outside Air	Air Changes OA	eACH	Energy Cost Impact		
		kWh	kW	MMBtu					kWh	kW	MMBtu
WP-01	Manhattan Commercial Office Building #1	13,327,277.0	3,549.0	44,729.8	667,475	113,641	0.850	4.291	\$2,229,795.00	Not Available	\$1,466,038.00
WP-02	Manhattan Commercial Office Building #2	8,325,434.0	1,089.0	6,362.8	410,500	69,785	0.730	3.681	\$1,474,044.00	Not Available	\$263,640.00
WP-03	Manhattan Commercial Office Building #3	15,604,400.0	2,634.7	13,319.6	504,100	61,500	0.560	4.202	\$2,964,836.00	Not Available	\$365,563.00

Building	ASHRAE Measures Baseline									
	Measures Included	kWh	kW	MMBtu	CFM Outside Air	eACH	kWh	kW	MMBtu	Implementation Cost
Manhattan Commercial Office Building #1	MERV 14, Purge, Max OA, Humidification, T&B toilet exhaust and OA fans	14,673,013.0	4,625.9	87,406.9	667,475	4.976	\$2,641,142.34	Not Available	\$2,313,484.95	\$624,900.00
Manhattan Commercial Office Building #2	MERV 14, Purge, Max OA, Humidification, T&B toilet exhaust and OA fans	9,411,350.0	1,942.5	28,161.7	410,500	4.269	\$1,599,929.50	Not Available	\$5,069.10	\$1,428,700.00
Manhattan Commercial Office Building #3	MERV 14, Purge, Max OA, Humidification, T&B toilet exhaust and OA fans	16,694,713.0	2,738.0	14,852.7	82,000	4.414	\$3,171,995.47	Not Available	\$386,450.91	\$1,721,100.00

Building	Energy Efficiency Measures Baseline									
	Measures Included	kWh	kW	MMBtu	CFM Outside Air	eACH	kWh	kW	MMBtu	Implementation Cost
Manhattan Commercial Office Building #1	Reduce OA Ventilation, UVGI	13,606,031.0	3,665.9	49,442.5	113,641	4.956	\$2,449,085.58	Not Available	\$1,257,539.79	\$726,500.00
Manhattan Commercial Office Building #2	Reduce OA Ventilation, UVGI	8,409,026.0	1,112.6	9,257.1	69,785	4.268	\$1,429,534.42	Not Available	\$230,884.34	\$1,617,500.00
Manhattan Commercial Office Building #3	Reduce OA Ventilation, UVGI	16,507,605.0	2,637.0	13,530.7	61,500	4.589	\$3,136,444.95	Not Available	\$333,089.63	\$2,009,100.00

Study Comparisons

Measure recommendations for the two categories were determined from method effectiveness (primarily assessed per ASHRAE's Equivalent Outside Air Calculator), energy consumption, implementation cost, and feasibility. For each measure below, a brief valuation is provided for applicability across all commercial office buildings, with comment as appropriate on applicability at certain building typologies.

Recommended Measures

Increase Filter Efficiency to MERV 14

Increased filter efficiency reduces transmission through the building's ventilation system in addition to other wellness benefits beyond the reduction of viral transmission. Higher filtration levels are especially effective at reducing various VOCs contributing to an overall improvement in air quality. Implementation of this measure is relatively inexpensive and requires few modifications to existing operations and maintenance program. Static pressure and energy use is slightly increased, but as the systems reviewed are equipped with variable frequency drives, the energy impact is low. The baseline filter efficiencies were MERV-12 and MERV-13. While some building staff, in both the buildings reviewed in these studies, and in other buildings within our client base, expressed concern about the ability to distribute sufficient air with increased system static pressure, calculations and direct experience at participating buildings showed that sufficient air was able to be delivered in almost all cases. This measure should be applicable throughout commercial office portfolios of all building classes and all ventilation air delivery types. Further, viewed through ASHRAE's Equivalent Outside Air Calculator, the increase in filtration efficiency was the most impactful opportunity at the lowest cost. Finally, while buildings could consider higher filtration efficiency than MERV-14, material costs and static pressure loss continue to increase significantly while reductions in transmission show only limited increase. For this reason, MERV-14 filters were determined to be the sweet spot of most universal applicability.

Increase Ventilation Hours of Operation

Extended operation of air handlers for an additional two hours beyond normal operating hours will assist in purging the system of air pathogens and removal of airborne cleaning agents. Flushing between occupancy periods can be done on the basis of risk assessment. Before first occupancy and after last occupancy may not be necessary. Between uses of space by different groups may require a minimum clearance time. Clearance time recommendation currently is based on 3 equivalent air changes (outdoor air, filtered air, disinfected air) and may require much less than two hours. Goldman Copeland recommends this air not be conditioned unless required by extreme weather conditions to conserve energy. An increase in energy use is expected, but can be reduced by the deactivation of the cooling plant after hours. Findings regarding this measure are applicable to all commercial office buildings.

Test and Balance Toilet Exhaust Systems

The toilet exhaust system should be fully tested and balanced to assure appropriate flow from each floor in the building. Given that toilet exhaust systems are adjusted on a tenant-by-tenant basis, this

testing and balancing will likely provide benefit in all buildings. Typically, lower floors sustain a diminution of air flow over the years. Depending upon the results of this TAB process if airflows are not as per design, they should be adjusted as is done in many properties. During this Covid period the building could operate toilet exhaust fans extended hours to flush out the bathrooms. The energy impact is relatively low cost, as these fans are low horsepower. Typically, toilet exhaust fans are lower than 5 HP, resulting in a minimum impact on energy efficiency.

Test and Balance Supply Fans with Focus on Outdoor Air Levels

Assessing outside air flow to the building as a whole and to the individual floors will provide valuable information regarding the cost or impact on comfort conditions with excess outside air. Balancing will also enable the outside air setpoint to be targeted more effectively to meet the needs of the building. Cost and tenant impact for this measure is low. This measure is equally applicable to all buildings included within this review, as well as to all commercial office buildings.

Install UVGI lights at supply air coils

UVGI systems within air handlers have been shown to kill germs and bacteria on chilled water coils, reducing maintenance needs on cooling coils, improving heat transfer, and positively impacting air quality conditions. To this end, there is a demonstrable benefit to adding these systems into buildings. However, this will lead to a reduction in Covid transmission only if the virus is transmitted through the full air distribution system. Risks associated with the installation of these devices are minimal if building personnel properly follow operating procedures. Analysis of this measure in series with MERV-14 was performed.

Reduction of Outside Air Levels

While an increase of outside air to 100% provides a reduction in the likelihood of viral transmission through the ventilation system, the energy impact is high and that setpoint challenges the buildings capacities for conditioning. Older vintage commercial office buildings are often sized for higher outside air flow (in the range of 30%), giving them a better capability to condition 100% outside air, and all buildings with air-side economizer capability have the capacity to provide sufficient air. However, no buildings reviewed within this study had the design capacity to condition 100% OA under peak conditions. Buildings with water-side economizer and direct outside air supply (DOAS) were generally not capable of providing this level of outside air. ASHRAE no longer recommends that 100% outside air be provided for these reasons. Goldman Copeland recommended a reduction to a lower setpoint to balance energy savings with COVID mitigation strategies. This balance should be determined on a case by case basis for specific buildings based on their existing conditions.

Measures recommended for further consideration

Monitoring of Indoor Air Quality

The buildings could use Indoor Air Quality (IAQ) monitoring systems to implement multi-parameter demand control ventilation measuring VOC's, particulate matter, and CO₂. While CO₂ has been accepted as an indicator of air quality, the additional information is useful for categorizing potential issues, giving the building the ability to assess a range of conditions, including off-gassing from new

equipment and furniture as a part of tenant fit-outs, outdoor air conditions associated with neighboring construction projects, and other potential sources of a range of particulate matter. Monitoring of IAQ levels is useful in all building types. In older vintage buildings where outdoor air levels exceed current requirements, the potential to reduce these OA levels is especially high, but lower levels can be achieved on all building types with detailed reporting on a range of materials. Further white papers and studies beyond the current manufacturer's literature is required before full acceptance of this technology is recommended.

Local HEPA Filter Units

Along with other recommended practices such as masks, installation of portable HEPA filters will help trap some of the aerosols, particularly those attached to larger particles. As noted in the ASHRAE Position Document on Infectious Aerosols adding portable air cleaners for certain high-risk areas (lobbies, elevators, etc.) can mitigate some transmission of aerosols. Given the large tenant floor areas, it is impractical the use on the floors as an alternate to changing the purge time central filtration or amount of outside air. Installation of these units was found to be impractical economically in all buildings reviewed as a part of this project, and it appears that these issues will extend to all buildings. Where specific tenants are deeply engaged in the installation of this type of system, it may be plausible. These units can be used in conjunction with other methods and would be best utilized in select locations in the tenant space. Moreover, given the typical NYC landlord/tenant lease, the tenant would be responsible for the installation of these when located in their space and removal at end of lease.

Add Upper Room UVGI for Tenant Spaces

In addition to options that can be implemented within the base building space, additional measures could be implemented within the tenant space to further reduce chance of spread. As discussed in the specific building reports, the bulk of transmission of the virus occurs locally without transmission through the HVAC system. As such, local solutions for addressing potential spread of the Covid virus appear best suited to increase safety.

Many of these options are not within MEP design scope (sanitation and cleaning and personal equipment such as masks) and are thus not included within the scope of this project. However, the installation of local upper room UVGI solutions is an option that could be effectively deployed within commercial tenant spaces, although there are some concerns with both the efficacy and safety of this option.

While safe solutions have been developed for the installation of UVC lighting within tenant spaces, the efficacy of these solutions is still largely debated, and direct exposure to UVC lighting remains a safety concern. As such, we would only recommend this if other measures cannot be undertaken like some increase in outside air, purge cycles better filters, all of which are recommended throughout commercial office buildings considering opportunities to reduce Covid health concerns. Further, upper room UVGI can only remove Covid from air that passes in front of it, while particles of equivalent size to Covid tend to sink gradually rather than rise, further limiting efficacy. If applied comprehensively in the space, it can be highly effective at viral activation but the cost can be prohibitive.

That said, a wide variety of fixtures are available that lie within this category, and have the capability of neutralizing Covid particles which come within their path. A typical fixture has a name plate range of

150 – 250 SF, and draws in the range of 20 W, meaning they add approximately 0.1 W/SF to the lighting power density (LPD) of the building. With overlap to assure full coverage, this Wattage increases further. As new tenant fit-outs can easily achieve LPDs in the range of 0.5 W/SF, this substantially increases the energy footprint of commercial spaces. Further, operating hours for these fixtures is extended, further exacerbating this issue.

In addition, the fixtures must be installed visibly within tenant spaces, impacting architectural design and layout. The quantity of fixtures and electrical work required to power the fixtures makes this a relatively high cost measure, per the summary chart above. Because of typical leasing processes, we anticipate this measure will only be implemented by tenants with base building support, rather than directly by the base building throughout the facility.

Selection and location of the upper room UVGI fixtures would have to be completed on a floor-by-floor basis. Tenants could deploy the fixtures fully, with larger fixtures serving open floor spaces and smaller fixtures serving individual offices. Alternatively, fixtures could be selectively deployed, located only in high-risk areas such as pantries and conference rooms, and in larger open office areas. This would reduce costs while providing the bulk of the efficacy. Energy impact and cost estimates are based on full deployment through all tenant spaces in the facility.

Measures not Recommended

Increase Outdoor Air Levels to 100%.

While a major increase in outdoor air levels from setpoints typically between 15% and 20% to 100% can provide a reduction in viral particulate spread through a building's ventilation system, it will come with a significant increase in energy impact and cost, potentially doubling the cost relative to implementation of recommended measures. Additionally, this increase will challenge each building's ability to condition the increased quantity of outside air. Based on our report, buildings from the 1950s and 1960s were sized for significantly large OA quantities, enabling them to at least partially cope with this increased OA quantity. However, the bulk of buildings would not be able to condition this level of air changes. Comparison provided by the ASHRAE Equivalent Outdoor Air Calculator indicated that other measures such as installation UVGI at supply coil, provided a comparable equivalent outdoor air rate and were considerably less expensive to implement.

Add Interior Humidification.

Addition of interior humidification was considered for each of the three buildings. Studies have shown that low winter humidity levels (10-25%) can increase airborne transmission of viruses. However, with the construction of buildings of this vintage, a high humidity difference between the interior and exterior of the building can also lead to mold and interstitial condensation. The former mold could lead to other health issues while the latter in some buildings can compromise the structural integrity of the building. Also, in the NYC area there is a limited number of months where the humidity is this low given the weather and the amount of moisture produced by occupants and activities in buildings.

Additionally, the cost and implementation of this measure was determined to be high relative to other measures. Costly new equipment would need to be installed and intensive maintenance would have to be performed on an annual or semiannual basis. Humidifiers at each unit would typically have to be installed. In the case of steam heated buildings, a dedicated steam riser would be required to provide steam to these units throughout the building. In the case of electric humidification, unless the buildings has significant spare capacity on each floor, an additional electric riser would likely be required. These infrastructure upgrades would be quite costly. The ASHRAE Equivalent Outdoor Air Calculator does not provide a value for increased humidification so no comparison was available

Overarching Takeaways

Implementation of the recommended measures will have positive implications for the health of building occupants, during the COVID-19 pandemic and for the future. There are few deleterious effects, and as the Energy Efficiency Protocol measures demonstrate, health and safety of building occupants can be balanced with energy conservation. From the table above, the equivalent air changes achieved by the Energy Efficiency Protocol measures are comparable to those achieved by the ASHRAE Protocol.

Airside measures that require no additional investment in equipment such as increasing ventilation hours and best practice measures – balancing of various building systems will be easily applicable to other office buildings regardless of size and vintage, and should be implemented throughout buildings of this typology. Supply coil UVGI can be complementary to the measures addressed above, adding additional protection against transmission in addition to other energy savings and ongoing maintenance benefits.

Costs associated with other measures, such as interior humidification, may render these options infeasible for a significant percentage of New York City office stock, but may be applicable for new construction (where risers and equipment can be sized and selected appropriately at time of construction). Increasing outside air to 100% may also not be reasonable for most buildings to attempt. The buildings in this study had heating and cooling plants capable of managing increased loads, but were limited by their respective air handling systems. Cooling plants are supplied with redundant capacity, but heating and cooling coils do not have the same level of spare capacity. It is anticipated that tenants will be broadly resistant to implementation of installation of UVGI or other major work within their spaces, significant costs notwithstanding.

Bibliography

An Energy Saving, Indoor Air Quality & Sustainability Initiative, EFP Headquarters, Edmund Barton Building. Steril-Aire, October 2017.

An Energy Saving, Indoor Air Quality & Sustainability Initiative, Brisbane Entertainment Centre. Steril-Aire, 2016.

An Energy Saving, Indoor Air Quality & Sustainability Initiative, Redacted Report. Steril-Aire, March 2016.

An Energy Saving, Indoor Air Quality & Sustainability Initiative, Woolworth Paradise Centre. Steril-Aire, June 2017.

ASHRAE 2019 Handbook Chapter 62 Ultraviolet Air and Surface Treatment -Sections 4 and Section 5.

ASHRAE Building Readiness v.5-21-2020

ASHRAE Guide to Covid-19 Filtration/Disinfection v. 5-27-2020

ASHRAE Guide to Covid-19 Commercial v.4-20-2020.

ASHRAE Position Document on Infectious Aerosols. ASHRAE, April 2020.

COVID-19 Impacts and Risk Mitigation Strategies. Goldman Copeland, April 2020.

COVID-19 White Paper. Taylor Engineering, June 2, 2020.

Data-Driven Communication for a Healthier World. TBL Building Sciences.

Example Project Statement. Healthway.

Environmental Control for Tuberculosis: Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings. CDC

Healthy indoor air, For the public good. Healthway.

Healthway Indoor Air Quality Solutions. Gil-Bar Industries.

Healthway Intellipure Portable Air Purifiers, Brochure. Healthway, 2020.

Noti, J.D. et. al, Steam Humidification Plays an Essential Role in Minimizing the Transmission of the Corona virus. Mosto Technologies.

P.E. David, HUMIDIFICATION helps to protect your respiratory system and HUMIDIFICATION fights against bioaerosol infectivity. Armstrong International.

Proof Source Test (Statement of Conditions), Microbial Analysis and Airflow Uniformity Report. Steril-Aire, June 2013.

Reed N. G. (2010). The history of ultraviolet germicidal irradiation for air disinfection. *Public health reports (Washington, D.C. : 1974)*, 125(1), 15–27.

Statement of Condition & Plan for Improvement, Sacramento Hospital, Sacramento, CA 95823, AHU-2 & AHU-3. Steril-Aire, 2015.

Ultraviolet C (UVC) Light System Installation. TBL Building Sciences.

Understanding the Touchless World. TBL Building Sciences.

Yousef Al horr, et. al., *Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature*, International Journal of Sustainable Built Environment, Volume 5, Issue 1,2016