PROJECT

ASSESSING THE ENERGY IMPACT OF PANDEMIC-RELATED VENTILATION UPGRADES ON WASHINGTON, D.C.-AREA COMMERCIAL BUILDINGS

CAPSTONE PRESENTATION: M.S. IN ENERGY POLICY & CLIMATE JOHNS HOPKINS UNIVERSITY

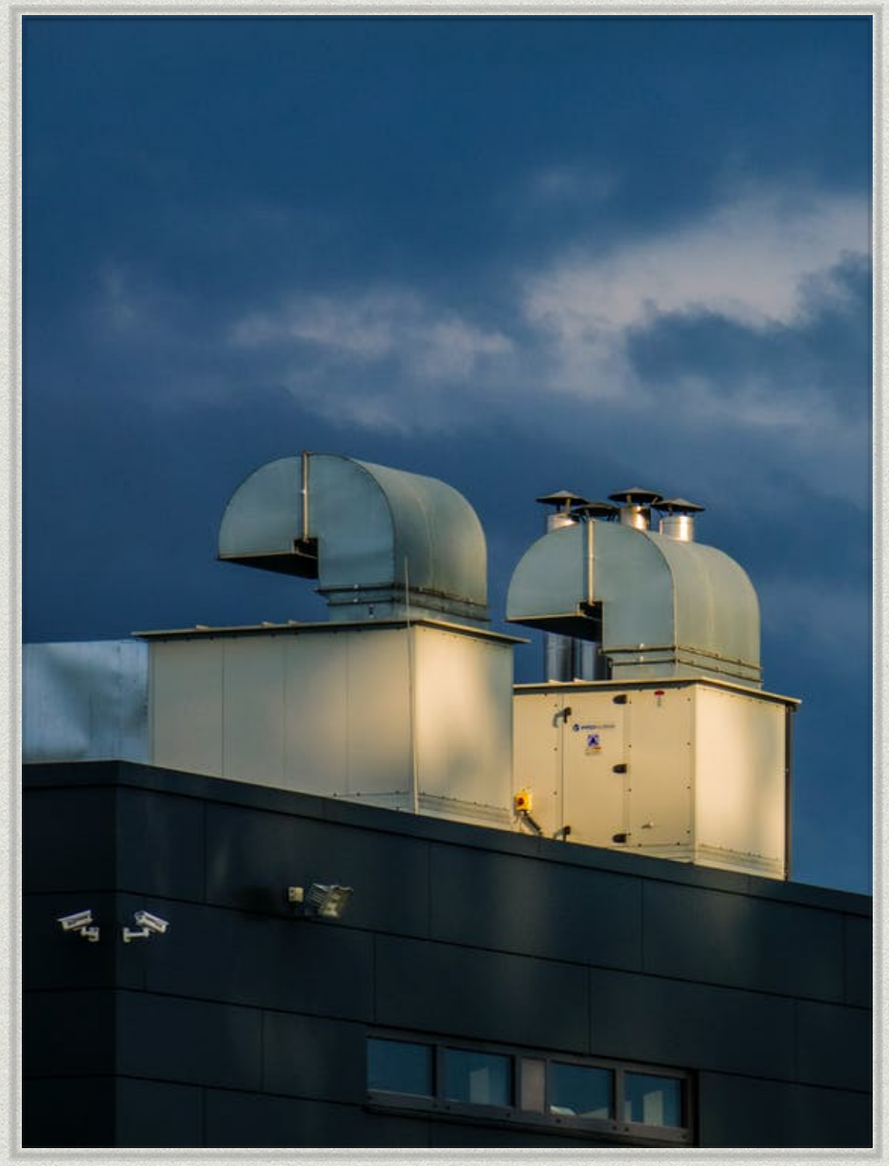
DATE **DECEMBER 2021**

PRESENTER **ROBERT OST**

Research Questions and Scope

1. *What are the notable changes in ventilation/filtration strategies implemented by Washington, D.C.-area commercial buildings in response to the COVID-19 pandemic?*

2. *What is the impact of the observed changes on the energy consumption of typical ventilation systems?*



Scope: Commercial Office Buildings in the Washington, D.C. metropolitan region

Ventilation Background

- Ventilation vs. Conditioning
  - Ventilation is the act of bringing outdoor air (OA) into a building
  - Conditioning is the act of treating OA prior to building dispersion
- Ventilation rate: the amount of outdoor air introduced into the building (cubic feet per minute, CFM)
- Airflow pattern: the efficiency at which external air is delivered throughout the building and that pollutants are removed
- Leading standard: *ANSI/ASHRAE Standard 62.1: Ventilation for Acceptable Indoor Air Quality*

Mechanical Filtration

- Minimum Efficiency Reporting Value (MERV)

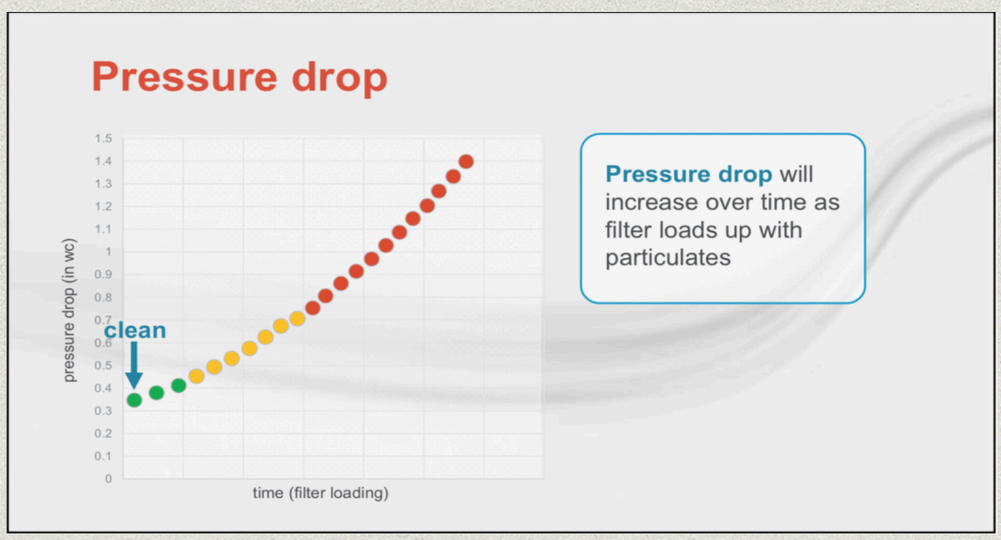


Figure 2. Pressure drop by filter use over time (Trane Technologies, Inc., 2017)

MERV Rating	Typical Contaminants	Particle Size
MERV 1-4	• Pollen • Dust mites • Textile/carpet fibers	≥10.0 microns
MERV 5-8	*Everything above, plus:* • Mold/spores • Dust lint • Cement dust	3.0–10.0 microns
MERV 9-12	*Everything above, plus:* • Legionella • Lead dust	1.0–3.0 microns
MERV 13-16	*Everything above, plus:* • Bacteria • Tobacco smoke • Auto fumes • Sneeze nuclei • Copier toner	0.30–1.0 microns
MERV 17-20 (HEPA filters)	*Everything above, plus:* • Virus carriers • Odor • Combustion smoke • Microscopic allergens	0.30 microns

METHODS AND RESULTS

Phase I: Property Surveys

Methods

PHASE I: PROPERTY SURVEYS

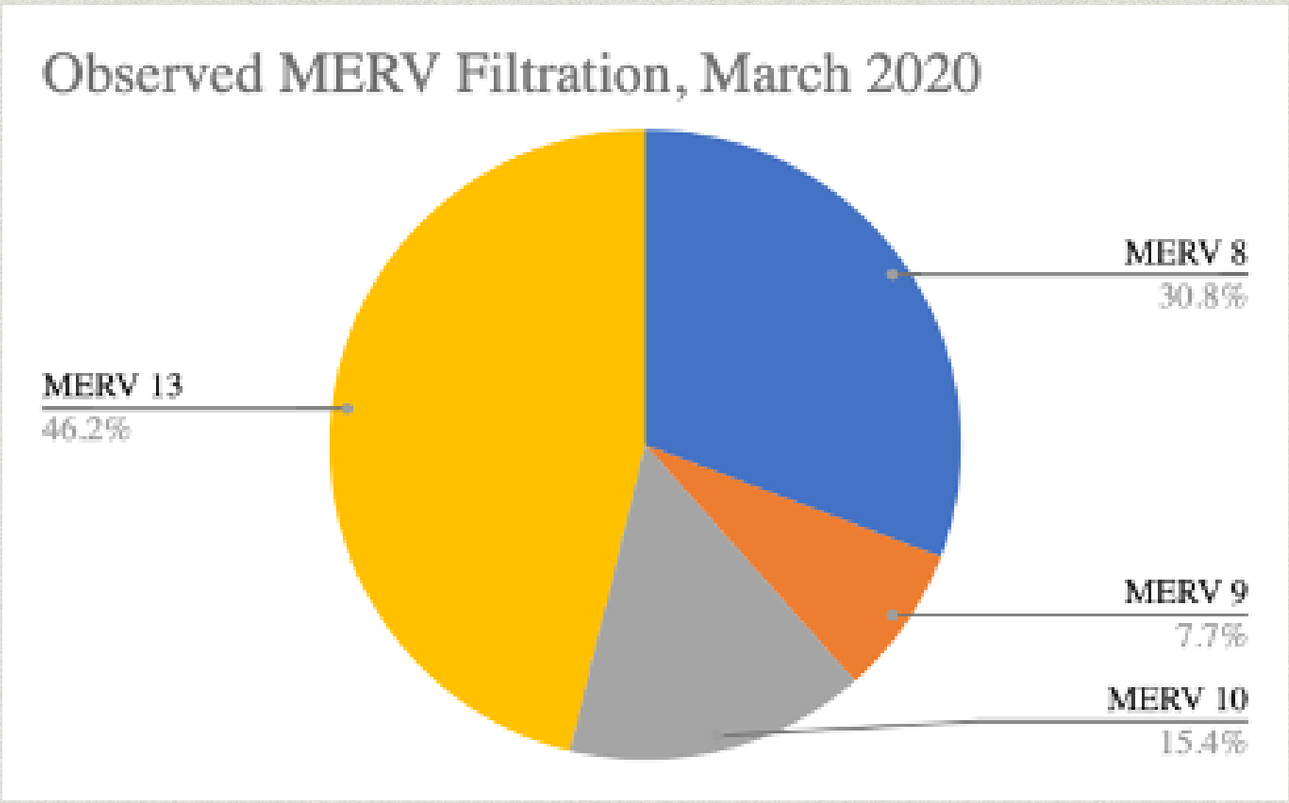
- 20 high-performance buildings (ENERGY STAR® score of ≥75)
- Period of comparison: March 2020 vs October 2021

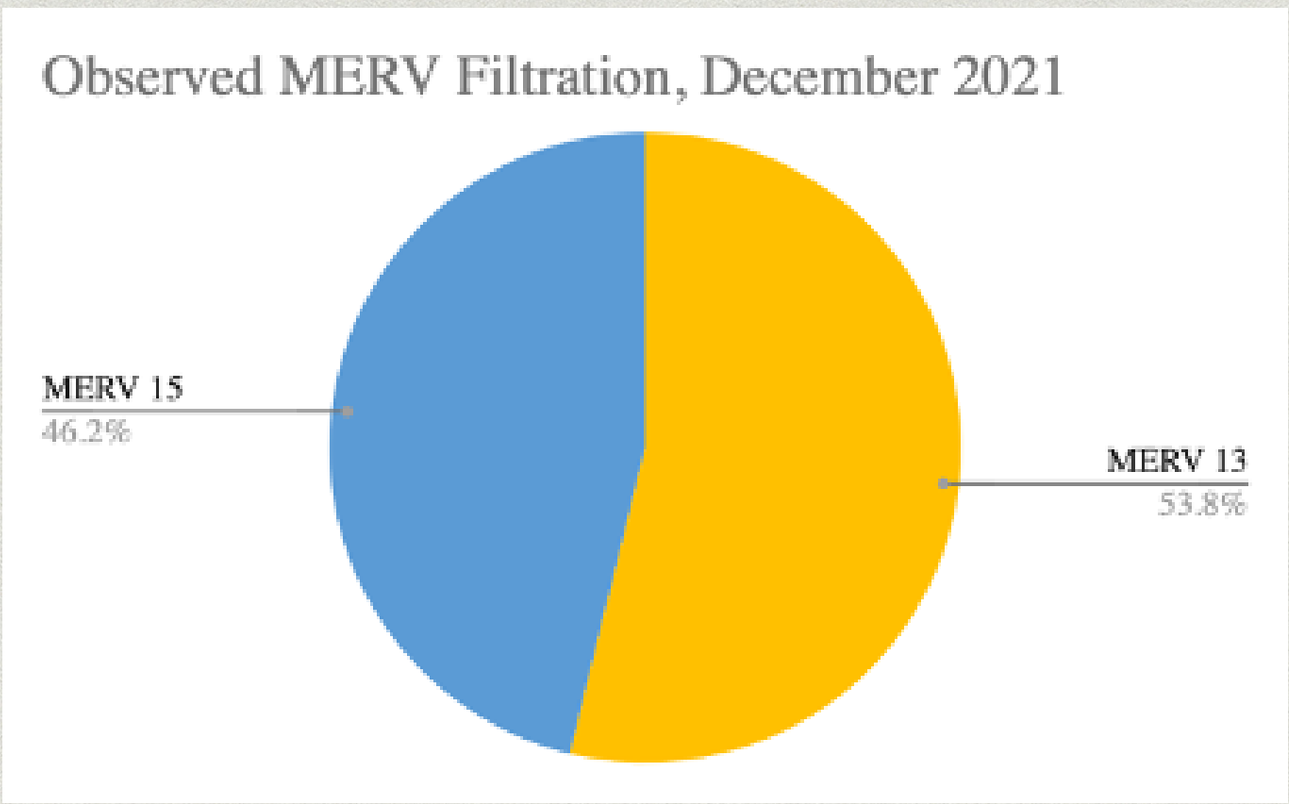
1. Hours of building occupation
2. Mechanical setup and outdoor air ventilation
3. Changes in ventilation practices (e.g., set-points, airflow rates)
4. Changes in filtration media
5. Changes in indoor air quality monitoring practices
6. Special technologies used (if any)
7. Authoritative standard or certification followed (if different than ASHRAE 62.1)
8. Special tenant requests/ conditions
9. Overall building vacancy rate

Results

PHASE I: PROPERTY SURVEYS

- Filtration efficiency upgrades
- Establishment of frequent, regular whole-building flush-outs





Phase II: Energy Analysis

Methods

PHASE II: ENERGY ANALYSIS

- **30-min. 100% OA flush-out:** Energy model simulations for 12 representative mechanical configurations (using standard technical operating conditions)
- **Filtration Upgrades:** Calculations to determine energy impact

$$BHP = (CFM * TSP) \div (6344 * faneff) \qquad InputPower = BHP \div (motoreff)$$

Variable	MERV 7 Filter	MERV 13 Filter
Airflow *(CFM)*	10,000 CFM	10,000 CFM
Total Static Pressure *(TSP)*	3.6	3.6
External Static Pressure	1.5	1.5
Internal Static Pressure	1.5	1.5
Filter Pressure Drop (400 fpm)	0.6	0.8
Fan Mechanical Efficiency *(fan eff)*	0.7	0.7
Fan Motor Efficiency *(motor eff)*	0.9	0.9

Energy Model Run Configurations

Config.	Cooling	Heating	OA Distribution
1	CHW - High Performance	Hot Water	DOAS
2	CHW - High Performance	Electric Resistance	DOAS
3	CHW - Low Performance	Hot Water	DOAS
4	CHW - Low Performance	Electric Resistance	DOAS
5	Water Cooled DX (direct expansion) - High Performance	Hot Water	Mixed Air
6	Water Cooled DX - High Performance	Electric Resistance	Mixed Air
7	Water Cooled DX - Low Performance	Hot Water	Mixed Air
8	Water Cooled DX - Low Performance	Electric Resistance	Mixed Air
9	CHW - High Performance	Hot Water	Mixed Air
10	CHW - High Performance	Electric Resistance	Mixed Air
11	CHW - Low Performance	Hot Water	Mixed Air
12	CHW - Low Performance	Electric Resistance	Mixed Air

Results

PHASE II: ENERGY ANALYSIS (FLUSH-OUTS)

- For all simulations, net increase in energy consumption
- Average increase was 1,130 kWh/1000 CFM.
- The energy models' annualized and normalized (per 1,000 CFM)

Config.	**Electric Usage** *kWh/1000 CFM (± 10%)*	**Gas Usage** *kWh/1000 CFM (± 10%)*	**Total** *kWh/1000 CFM*
1	582	732.5	1314.5
2	1167	N/A	1167
3	625	732.5	1357.5
4	1209	N/A	1209
5	317	937.6	1254.6
6	969	N/A	969
7	352	937.6	1289.6
8	1004	N/A	1004
9	263	791.1	1054.1
10	915	N/A	915
11	291	791.1	1082.1
12	944	N/A	944

Results

PHASE II: ENERGY ANALYSIS (FILTRATION)

- Upgrading from MERV 7 to MERV 13 resulted in an estimated net increase of 73 kWh consumed

Discussion

- **Key Assumptions**
  - Building managers are actively investigating and incorporating new strategies to prepare properties for re-entry
  - Enhanced ventilation and filtration tactics will be employed to protect occupants
  - Buildings within the scope of the study will utilize mechanical ventilation systems, powered by electricity and natural gas
- **Hypothesis:** *Buildings would demonstrate enhanced ventilation and filtration strategies as a response to the COVID-19 pandemic, resulting in an increase in energy consumption.*

Discussion (cont.)

- Competitive advantage from indoor air quality
- Prioritizing occupant wellness
- Selected strategies: filtration and flush-outs
  - Hesitancy towards substantial investments due to the pandemic's uncertainty
  - CO_2-eq of building flush-out configurations

Config.	CO2-eq (lbs. CO2)/1000 CFM
1	720
2	853
3	746
4	888
5	601
6	972
7	627
8	738
9	511
10	668
11	529
12	694

2021 RFCE emission rate for CO2 is 695.0 lbs/MWh.
Natural gas emissions rate is 11.7 lbs/therm.

CONCLUSION

Acknowledgements

- Charles Jackson (SBP)
- Dan Ferrante (SBP)
- Jake Torok (SBP)
- Phil Parrish (SBP)
- Jessica Cremen (SBP)
- John French (SBP)
- Bennett Heussler (SBP)
- Abhijit Narain (SBP)
- Jess Swaringen (SBP)
- Mike Babcock (SBP)
- Rachel Nicely (SBP)
- Dr. Daniel Zachary (Johns Hopkins)

References

- Abergel, Thibaut, Brian Dean, John Dulac, and International Energy Agency (IEA). 2017. “Global Status Report 2017.” Global Alliance for Buildings and Construction (GABC). https://www.worldgbc.org/sites/default/files/UNEP%20188_GABC_en%20%28web%29.pdf.
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). 2015. “ASHRAE Position Document on Filtration and Air Cleaning.” ASHRAE. https://www.ashrae.org/File%20Library/About/Position%20Documents/Filtration-and-Air-Cleaning-PD.PDF.
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). 2019. “ASHRAE Releases Updated Versions of Standards 62.1 and 62.2.” ASHRAE.org. https://www.ashrae.org/about/news/2019/ashrae-releases-updated-versions-of-standard-62-1-and-62-2.
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). 2021. “Guidance for Re-opening buildings.” ASHRAE.org. https://www.ashrae.org/file%20library/technical%20resources/covid-19/guidance-for-re-opening-buildings.pdf.
- Atkinson, J., Y. Chartier, and CL Pessoa-Silvia. 2009. “Natural Ventilation for Infection Control in Health-Care Settings.” World Health Organization. https://www.ncbi.nlm.nih.gov/books/NBK143277/.
- CBRE. 2021. “Washington, DC Office MarketView Q2 2021.” Washington, DC Office MarketView Q2 2021. https://www.cbre.us/research-and-reports/Washington-DC-Office-MarketView-Q2-2021.
- Clarke, Leon, Jiyong Eom, Elke H. Marten, Russell Horowitz, Page Kyle, Robert Link, Bryan K. Mignone, Anupriya Mundra, and Yuyu Zhou. 2018. “Effects of long-term climate change on global building energy expenditures.” Energy Economics 72 (May): 667-677. https://doi.org/10.1016/j.eneco.2018.01.003.
- Cushman and Wakefield. 2021. “MarkBeat Q2 2021.” U.S. Office MarketBeat Reports. https://www.cushmanwakefield.com/en/united-states/insights/us-marketbeats/us-office-marketbeat-reports.
- Dyer, Jan. 2020. “COVID-19 Forced Hospitals to Build Negative Pressure Rooms Fast.” Infection Control Today. https://www.infectioncontroltoday.com/view/covid-19-forced-hospitals-build-negative-pressure-rooms-fast.
- Government of the District of Columbia. 2020. “2017 District of Columbia Energy Conservation Code.” Government of the District of Columbia. https://eservices.dcra.dc.gov/DocumentManagementSystem/Home/retrieve?id=2017%20DC%20Energy%20Code.pdf.
- Grainger. 2020. “What Is MERV Rating? Air Filter Rating Chart.” Grainger KnowHow. https://www.grainger.com/know-how/equipment-information/kh-what-is-merv-rating-air-filter-rating-chart.
- Grant, Peter. 2021. “Return of Office Workers Reaches Pandemic High as Employees Trickle In.” The Wall Street Journal (October 13, 2021, print edition edition), October 12, 2021. https://www.wsj.com/articles/return-of-office-workers-reaches-pandemic-high-as-employees-trickle-in-11634031001?st=9wc2faka4rhe62d&reflink=article_gmail_share.
- International WELL Building Institute (IWBI). 2020. “International WELL Building Institute Launches WELL Health-Safety Rating for all Building and Facility Types.” WELL Press Releases. https://resources.wellcertified.com/press-releases/international-well-building-institute-launches-well-health-safety-rating-for-all-building-and-facility-types/.
- International Well Building Institute (IWBI). 2021. “Feature SA1: Assess Ventilation.” WELL Health-Safety Rating Q3 2021. https://v2.wellcertified.com/health-safety/en/air%20and%20water%20quality%20management/feature/1.
- National Institute for Occupational Safety and Health. 2015. “Indoor Environmental Quality: HVAC Management.” CDC.gov. https://www.cdc.gov/niosh/topics/indoorenv/hvac.html.
- Peplow, Mark. 2021. “Which air purification technologies can tackle COVID-19?” Chemical & Engineering News, March 12, 2021. https://cen.acs.org/biological-chemistry/infectious-disease/air-purification-technologies-tackle-COVID/99/i9.
- Schoen, Lawrence J. 2020. “Guidance for Building Operations During the COVID-19 Pandemic.” ASHRAE Journal, (May). https://www.ashrae.org/file%20library/technical%20resources/ashrae%20journal/2020journaldocuments/72-74_ieq_schoen.pdf.
- Trane Technologies, Inc. 2013. “Performance Climate Changer Air Handlers Indoor and Outdoor Units Application and Performance Information.” Trane. https://www.trane.com/content/dam/Trane/Commercial/lar/es/product-systems/Sistemas-de-agua-helada/Performance-climate-changer/CSAA/Catalogo/CLCH-PRC022-EN_092013_Performance%20Air%20Handler%20Catalog.pdf.
- Trane Technologies, Inc. 2017. “Trane Engineers Newsletter Live: High-Performance Air Systems.” Trane Technologies, Inc. https://www.trane.com/content/dam/Trane/Commercial/global/products-systems/education-training/continuing-education-gbci-aia-pdh/APP-CMC063-EN_booklet.pdf.
- U.S. EIA. 2021. “Carbon Dioxide Emissions Coefficients by Fuel.” EIA.gov. https://www.eia.gov/environment/emissions/co2_vol_mass.php.
- U.S. EPA. 2021. “Indoor Air Quality: What are the trends in indoor air quality and their effects on human health?” EPA.gov. https://www.epa.gov/report-environment/indoor-air-quality.
- U.S. EPA. 2021. “eGrid Power Profiler.” EPA.gov. https://www.epa.gov/egrid/power-profiler#/RFCE.
- U.S. Green Building Council (USGBC). 2021. “Minimum indoor air quality performance.” LEED v4 Credit Library. https://www.usgbc.org/credits/existing-buildings/v4/eq103?return=/credits/Existing%20Buildings/v4
- U.S. Green Building Council (USGBC). 2021. “Safety First: Managing Indoor Air Quality during COVID-19.” LEED v4 Pilot Credit Library. https://www.usgbc.org/credits/safety-first-138-v4.1?utm_source=usgbc-website&utm_medium=article&utm_campaign=leed-resources.
- U.S. Green Building Council (USGBC). 2021. “Strategies & Case Studies: Achieving LEED O+M during building re-entry and post COVID-19.” USGBC Education. https://www.usgbc.org/education/sessions/strategies-case-studies-achieving-leed-om-during-building-re-entry-and-post.