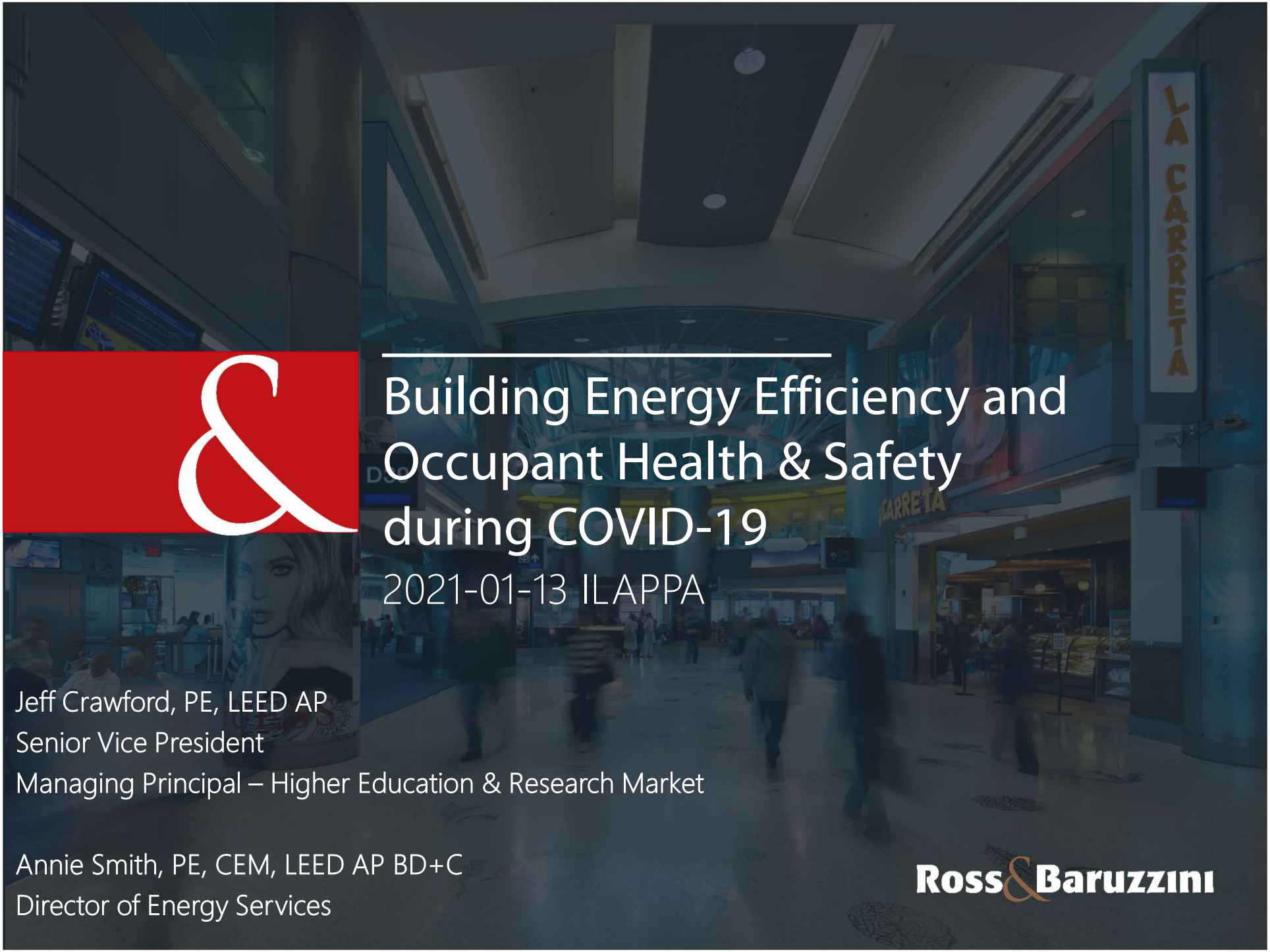

Building Energy Efficiency and Occupant Health & Safety during COVID-19

2021-01-13 ILAPPA

Jeff Crawford, PE, LEED AP
Senior Vice President
Managing Principal – Higher Education & Research Market

Annie Smith, PE, CEM, LEED AP BD+C
Director of Energy Services

Ross & Baruzzini

Who We Are

- Design & Consulting Engineers
  - Mechanical, Electrical, Plumbing, Fire Protection Engineering
  - **Energy Services**
  - Commissioning
  - AV, IT, Comm, Security Engineering
- 380 people across 14 offices
- Focus on Higher Education, Science & Technology, Healthcare, and Government Markets

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Today's Presenters

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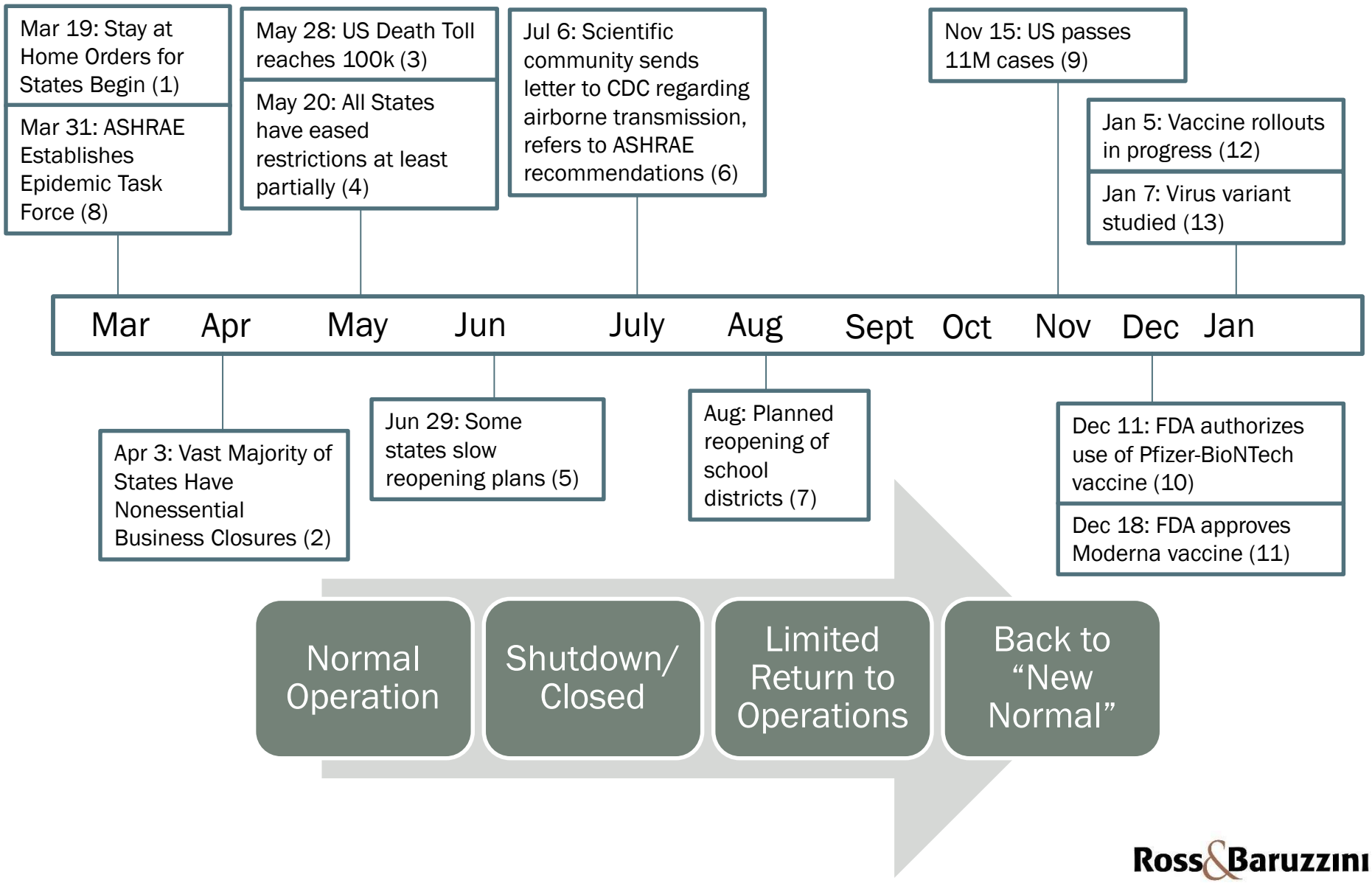
Learning Objectives

1. Learn about the Unoccupied Mode Best Practices Checklist to guide facility managers through proper building maintenance during a shutdown.
2. Understand the factors in successfully re-opening facilities that have been shut-down.
3. Learn the key considerations for operating an occupied building during a pandemic.
4. Learn about modifications that can be made to HVAC systems to reduce risk of virus transmission.
5. Understand ASHRAE's position on infectious aerosols and recommended response for HVAC system operation.

Agenda

- Recap of the Past Year
- Shutdown/Closed Operation
  - Unoccupied Mode Best Practices
  - ASHRAE Recommendations for Building Shutdown
- Limited Return to Operations
  - Effects of COVID on Design & Operations
  - ASHRAE Recommendations for Pandemic Operations
  - Energy Impacts of the ASHRAE Recommendations
- Looking Forward: the "New Normal"

Some Perspective…



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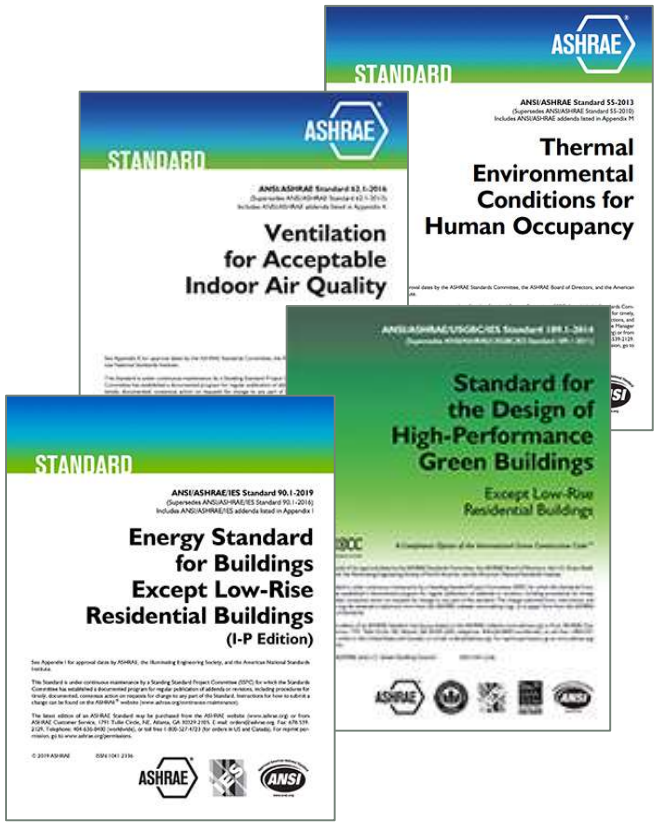
A Quick Note On ASHRAE Recommendations

- ASHRAE = American Society of Heating, Refrigerating, and Air-Conditioning Engineers
- Established Epidemic Task Force in March 2020
  - Under preexisting Environmental Health Committee

Reopening Buildings Filtration/Disinfection

Transportation Resources



With more than 57,000 members from over 132 nations, ASHRAE is a diverse organization dedicated to advancing the arts and sciences of heating, ventilation, air conditioning and refrigeration to serve humanity and promote a sustainable world.

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ASHRAE Epidemic Task Force (ETF)

ASHRAE issues Emerging Issue Brief April 17, 2020:

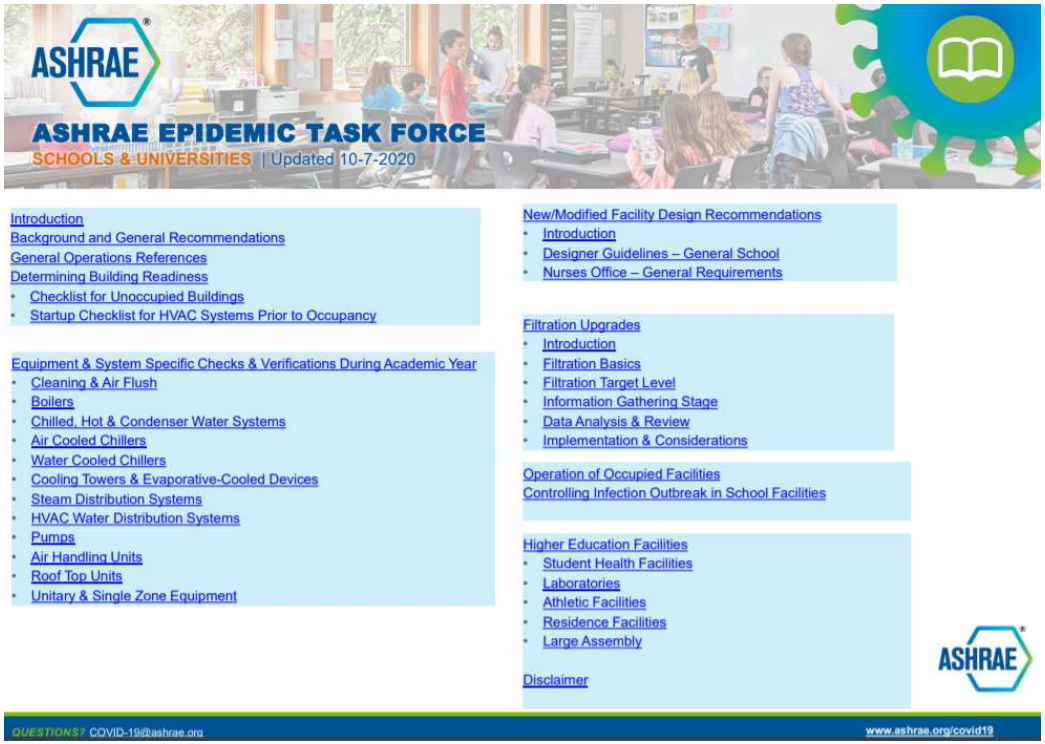
- Compared the 2002-2003 SARS pandemic to the current situation
- Noted concern for possibility of airborne transmission
- Established role of ASHRAE to assist the global community

Two important questions that urgently require answers include:

1. What are the engineering interventions that may be applied to minimize the spread of the disease through the air?
2. How effective are those engineering interventions at minimizing the spread of disease?

Source Link: https://www.ashrae.org/file%20library/technical%20resources/covid-19/eiband-airbornetransmission.pdf

ASHRAE Recommendations



Schools & Universities Guidance

https://www.ashrae.org/technical-resources/reopening-of-schools-and-universities

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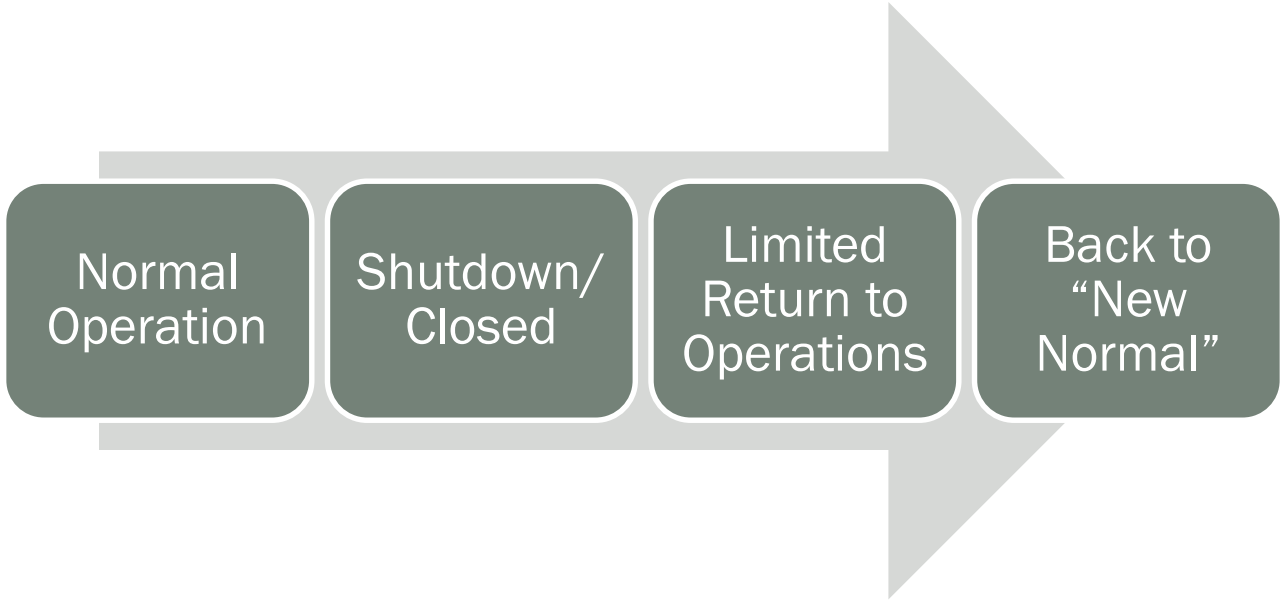
Mode of Operation Determines FOCUS



	Normal Operation	Shutdown/ Closed	Limited Return to Operations	Back to "New Normal"
FOCUS	- Optimize energy performance - Optimize occupant experience - Prepare for capital projects - Business as usual	- Reduce energy because building is unoccupied - Reduce transmission (more cleaning, minimize HVAC effects)	- Occupant safety is #1 priority - Energy is secondary - Simple operational changes - Remote virtual communications - Testing, tracing, quarantine	- Vaccine available - Lower occupant densities - Higher ventilation rates - Higher filtration - Changes to HVAC design approach

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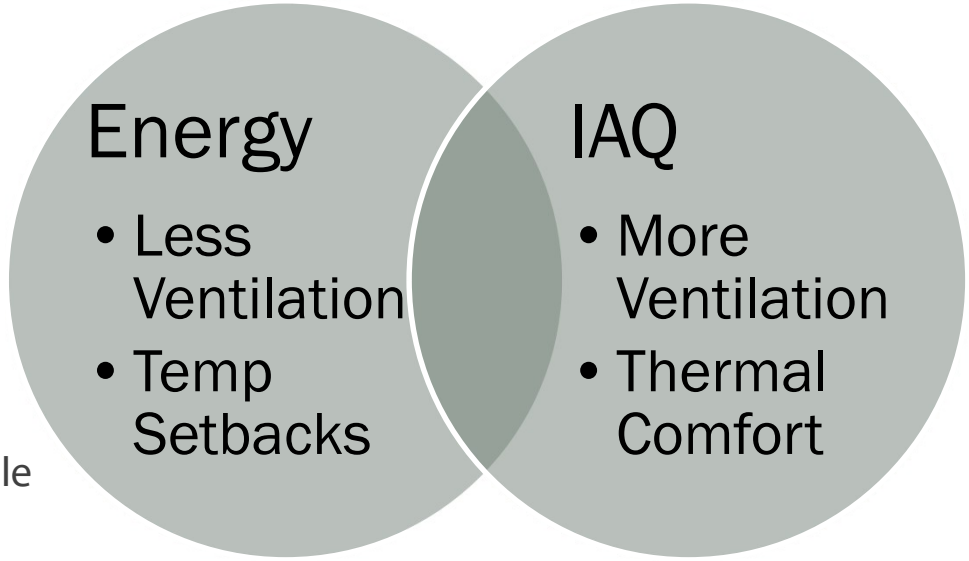
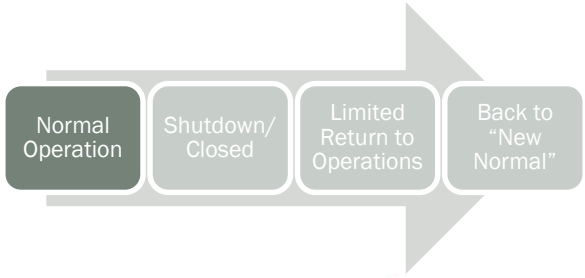
Normal Operation

Focus is to…

- Optimize energy performance
  - Operate equipment less, at lower loads
  - Vary speed / pressure to reduce power draw
  - Reduce ventilation air when possible to reduce heating/cooling loads
  - Increase setpoints when possible
- Optimize occupant experience
  - Maintain setpoints when occupied
  - Provide minimum ventilation
- Prepare for capital projects
- Meet business needs as usual





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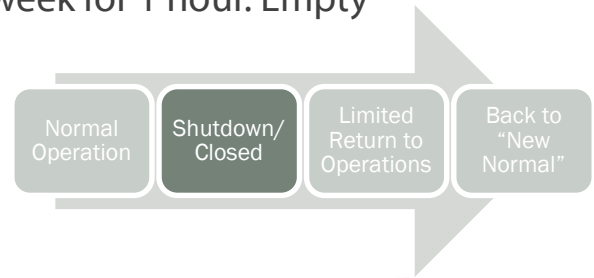
During Shutdown

* Don't just turn off equipment and shut the door! *

Focus: Minimize energy because building is unoccupied.

- Remote BAS Monitoring: humidity, temperature
- Minimal Equipment Operation: "unoccupied mode" settings, keep exhaust fans off, cycle AHUs for humidity control rather than temperature, cycle on with OA dampers at minimum, Temperature setbacks (80°F, 60% RH is reasonable)
- Keep OA dampers closed unless for free cooling
- Walk-Throughs: observe equipment when operating, close all windows (keep out people, critters)
- Plumbing: Turn on water once per week to avoid stagnant water. Operate drinking fountains, lavatories, showers, sinks. Keep U-traps filled with water. Circulate and fire water heaters to keep water above 140°F
- Electrical: disconnect non-essential appliances and lighting, keep lighting off except security
- Maintain Plant Equipment: Fire and cycle boiler systems once per week for 1 hour. Empty steam traps and condensate receiver. Circulate hydronic loops.



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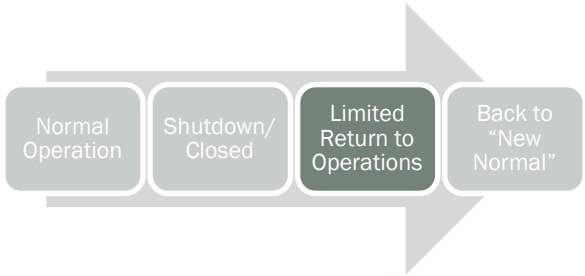
Limited Return to Operations

Effects of COVID on Design & Operations

- "Pandemic Operation Mode"
- Reduced building occupancy due to new occupancy mandates and employee choice
- Modifications to HVAC Systems
  - More ventilation air – more fan & cooling/heating energy
  - Higher level of filtration – more fan energy
  - Addition of UV-C lighting – increased power consumption
- Increased level of disinfection
- Maintenance of social distancing
- Barriers (plexiglass)
- Testing, Tracing, and Quarantine
- Wireless Bandwidth and IT Upgrades for Remote Communications



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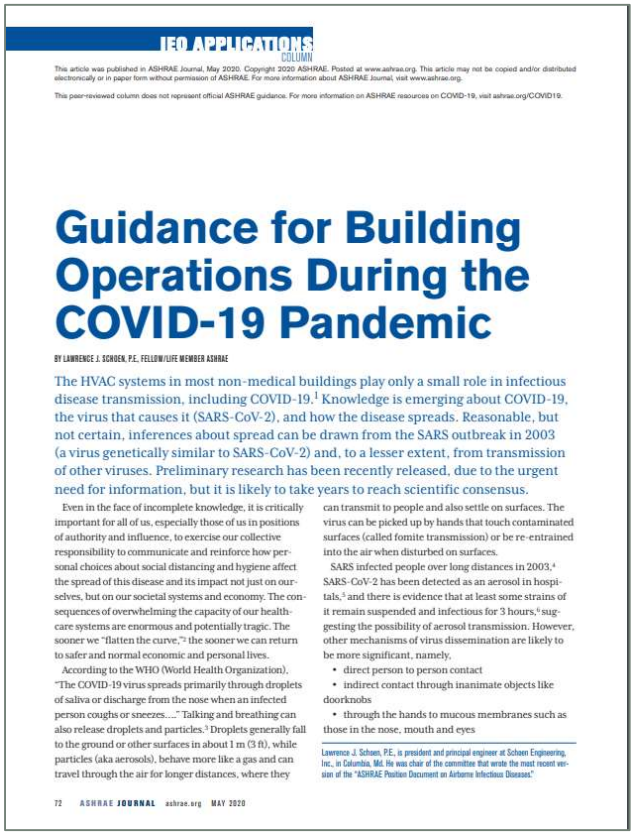
Limited Return to Operations – Recommendations

- "**Increase outdoor air ventilation** (use caution in highly polluted areas); with a lower population in the building, this increases the effective dilution ventilation per person.
- **Disable demand-controlled ventilation** (DCV).
- Further **open minimum outdoor air dampers**, as high as 100%, thus **eliminating recirculation** (in the mild weather season, this need not affect thermal comfort or humidity, but clearly becomes more difficult in extreme weather).
- Improve **central air filtration** to the MERV-13 or the highest compatible with the filter rack, and seal edges of the filter to limit bypass.
- Keep systems **running longer hours**, if possible 24/7, to enhance the two actions above.
- Consider **portable room air cleaners** with HEPA filters.
- Consider **UVGI (ultraviolet germicidal irradiation),** protecting occupants from radiation, particularly in high-risk spaces such as waiting rooms, prisons and shelters."



IEQ APPLICATIONS COLUMN

This peer-reviewed column does not represent official ASHRAE guidance. For more information on ASHRAE resources on COVID-19, visit ashrae.org/COVID19.

Guidance for Building Operations During the COVID-19 Pandemic

BY LAWRENCE J. SCHOEN, P.E., FELLOW/LIFE MEMBER ASHRAE

The HVAC systems in most non-medical buildings play only a small role in infectious disease transmission, including COVID-19.[1] Knowledge is emerging about COVID-19, the virus that causes it (SARS-CoV-2), and how the disease spreads. Reasonable, but not certain, inferences about spread can be drawn from the SARS outbreak in 2003 (a virus genetically similar to SARS-CoV-2) and, to a lesser extent, from transmission of other viruses. Preliminary research has been recently released, due to the urgent need for information, but it is likely to take years to reach scientific consensus.

Even in the face of incomplete knowledge, it is critically important for all of us, especially those of us in positions of authority and influence, to exercise our collective responsibility to communicate and reinforce how personal choices about social distancing and hygiene affect the spread of this disease and its impact not just on ourselves, but on our societal systems and economy. The consequences of overwhelming the capacity of our healthcare systems are enormous and potentially tragic. The sooner we "flatten the curve,"[2] the sooner we can return to safer and normal economic and personal lives.

According to the WHO (World Health Organization), "The COVID-19 virus spreads primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes…." Talking and breathing can also release droplets and particles.[3] Droplets generally fall to the ground or other surfaces in about 1 m (3 ft), while particles (aka aerosols), behave more like a gas and can travel through the air for longer distances, where they can transmit to people and also settle on surfaces. The virus can be picked up by hands that touch contaminated surfaces (called fomite transmission) or be re-entrained into the air when disturbed on surfaces.

SARS infected people over long distances in 2003.[4] SARS-CoV-2 has been detected as an aerosol in hospitals,[5] and there is evidence that at least some strains of it remain suspended and infectious for 3 hours,[6] suggesting the possibility of aerosol transmission. However, other mechanisms of virus dissemination are likely to be more significant, namely,

- direct person to person contact
- indirect contact through inanimate objects like doorknobs
- through the hands to mucous membranes such as those in the nose, mouth and eyes

Lawrence J. Schoen, P.E., is president and principal engineer at Schoen Engineering, Inc., in Columbia, Md. He was chair of the committee that wrote the most recent version of the "ASHRAE Position Document on Airborne Infectious Diseases."

Source: *Guidance for Building Operations During the COVID-19 Pandemic* by Lawrence J. Schoen, PE, Fellow/Life Member ASHRAE, ASHRAE Journal, May 2020

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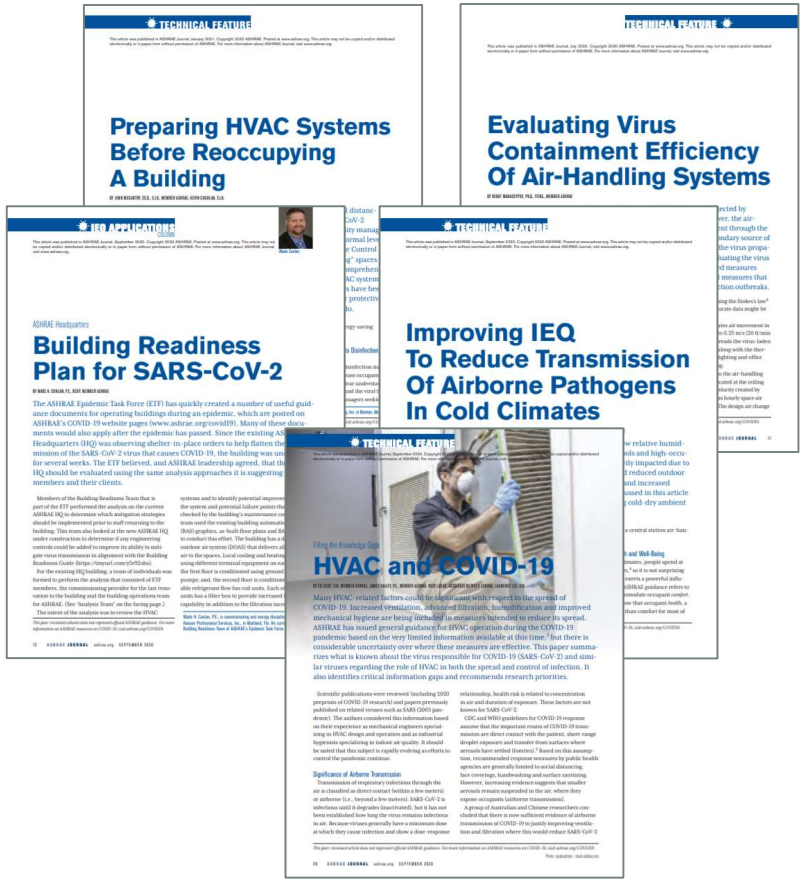
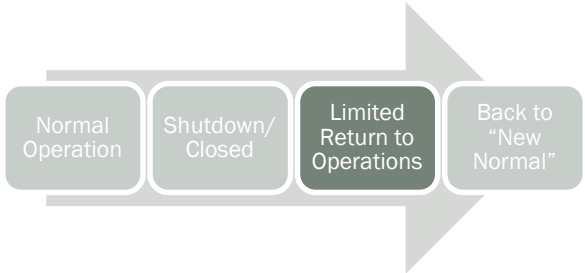
Limited Return to Operations – Recommendations

Recommendations for Occupying Buildings

- Technical Resources (Central Hub of Info)
  - https://www.ashrae.org/technical-resources/reopening-of-schools-and-universities
- Owners should evaluate their building(s) for current readiness:
  - https://www.ashrae.org/technical-resources/building-readiness#epidemic
- Owners should consider changes based on ASHRAE recommendations.





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Limited Return to Operations – Recommendations

See Checklists No. 1 and No. 2

Building Readiness Check

- Review controls sequences to verify systems operating to maintain code-minimum ventilation, temperature, and humidity.
- Trend and monitor temperature and humidity in BAS, if possible.
- Consider having airflow and system capacities reviewed by a professional to determine if additional ventilation can be provided within existing system capacity.
- Verify all filters installed correctly. Develop plan for filter type and frequency of replacement.
- Disable Demand-Controlled Ventilation sequence (CO_2 controls).
- Perform initial air flush of all spaces prior to occupant re-entry (1 week in normal occupied mode).
- Flush domestic water systems with all fixtures on a branch open for 5 minutes minimum (cold water) and 15 minutes minimum (hot water).

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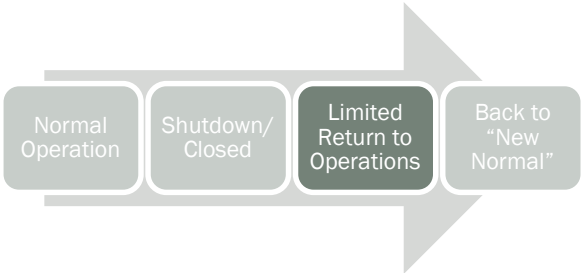
Limited Return to Operations – Recommendations

Ongoing Equipment and System Checks During Occupancy

- Daily Flush Prior to Occupancy: Operate in Occupied Mode (with peak OA rate) for minimum 2 hours prior to occupants re-entering building.
- Daily Cleaning: all areas that were occupied since last cleaning efforts.
- Monthly Equipment Checks: boilers, chilled/hot/condenser water systems, air/water-cooled chillers, cooling towers/evaporative devices, steam distribution
  - AHUs/RTUs: Replace filters as-needed, replace UV bulbs as needed, check VFD operation, verify damper operation, coil cleanliness, check OA damper for particle accumulation
  - Terminal Equipment: Replace filters as-needed, verify damper operation



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ASHRAE Recommendations

ASHRAE Journal Articles

- Evaluating Virus Containment Efficiency of Air-Handling Systems (July 2020)
  - https://www.ashrae.org/file%20library/technical%20resources/covid-19/17-23_manassypov.pdf
- Building Readiness plan for SARS-CoV-2 (September 2020)
  - https://www.ashrae.org/file%20library/technical%20resources/covid-19/72-75_ieq_conlan.pdf
- Improving IEQ to Reduce Transmission of Airborne Pathogens in Cold Climates (September 2020)
  - https://www.ashrae.org/file%20library/technical%20resources/covid-19/30-47_graef.pdf
- HVAC and COVID-19 Gaps (September 2020)
  - https://www.ashrae.org/file%20library/technical%20resources/covid-19/20-29_light.pdf
- Preparing HVAC Systems Before Reoccupying a Building (January 2021)
  - https://www.ashrae.org/file%20library/technical%20resources/ashrae%20journal/2021journaldocuments/january2021_022-027_mccarthy.pdf

Limited Return to Operations - Recommendations

- Increase Ventilation
  - Increasing ventilation will reduce "viral load" by reducing the recirculated air sent back to the space.
  - Experts still don't know how much ventilation air is enough to diffuse virus particles as the dose of infection is unclear.
  - Changes should be evaluated by a professional so additional issues are not created.
  - Limiting Factor: Maintain space conditions for temp, humidity
    - Occupant comfort may be impacted if system cannot handle increased ventilation
    - 40-60% RH decreases infectivity of airborne viruses

Checklist

- Disable DCV (CO_2 controls)
- Increase ventilation rates to system capacity when occupied
- Building flushout prior to occupancy

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Limited Return to Operations - Recommendations

- Improve Filtration
  - Increase MERV rating of filters from MERV-6 or 8 to MERV-13 to trap more particles carrying the virus.
  - Effectiveness in reducing particle concentrations depends on: efficiency, airflow rate, particle size, filter location

Std. 52.2 Minimum Efficiency Reporting Value (MERV)	Application Guidelines: Typical Controlled Contaminant	Typical Applications and Limitations	Typical Air Filter/Cleaner Type
16	**0.30 to 1.0 µm Particle Size**	Hospital inpatient care	**Bag Filters**
	All bacteria	General surgery	Nonsupported (flexible) microfine fiberglass or synthetic
15	Most tobacco smoke	Smoking lounges	media. 300 to 900 mm (12 to 36 in.) deep, 6 to 12 pockets.
	Droplet nuclei (sneeze)	Superior commercial	**Box Filters**
14	Cooking oil	buildings	Rigid style cartridge filters 150 to 300 mm
	Most smoke		(6 to 12 in.) deep may use lofted (air laid) or paper (wet laid)
13	Insecticide dust		media.
	Copier toner		
	Most face powder		
	Most paint pigments		
12	**1.0 to 3.0 µm Particle Size**	Superior residential	**Bag Filters**
	Legionella	Better commercial	Nonsupported (flexible) microfine fiberglass or synthetic
11	Humidifier dust	buildings	media. 300 to 900 mm (12 to 36 in.) deep, 6 to 12 pockets.
	Lead dust	Hospital laboratories	**Box Filters**
10	Milled flour		Rigid style cartridge filters 150 to 300 mm
	Coal dust		(6 to 12 in.) deep may use lofted (air laid) or paper (wet laid)
9	Auto emissions		media.
	Nebulizer drops		
	Welding fumes		
8	**3.0 to 10.0 µm Particle Size**	Commercial buildings	**Pleated Filters**
	Mold	Better residential	Disposable, extended surface, 25 to 125 mm
7	Spores	Industrial workplaces	(1 to 5 in.) thick with cotton-polyester blend media,
	Hair spray	Paint booth inlet air	cardboard frame.
6	Fabric protector		**Cartridge Filters**
	Dusting aids		Graded density viscous coated cube or pocket filters,
5	Cement dust		synthetic media.
	Pudding mix		**Throwaway**
	Snuff		Disposable synthetic media panel filters.
	Powdered milk		
4	**>10.0 µm Particle Size**	Minimum filtration	**Throwaway**
	Pollen	Residential	Disposable fiberglass or synthetic panel filters
3	Spanish moss	Window air conditioners	**Washable**
	Dust mites		Aluminum mesh, latex coated animal hair, or foam rubber
2	Sanding dust		panel filters
	Spray paint dust		**Electrostatic**
1	Textile fibers		Self charging (passive) woven polycarbonate
	Carpet fibers		panel filter

Note: A MERV for other than HEPA/ULPA filters also includes a test airflow rate, but it is not shown here because it has no significance for the purposes of this table.

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Limited Return to Operations - Recommendations

- System-Level Disinfection Solutions
  - UV-C lighting can kill the virus particles in the air within ductwork or within a room.
  - UV-C LED options are available but limited.
  - Types
    - In-duct air disinfection
    - Upper-air disinfection
    - In-duct (AHU) surface disinfection
    - Portable room decontamination
  - Can cause eye/skin damage! Requires special PPE for installation

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Limited Return to Operations - Recommendations

- In-Room Disinfection Solutions – next level of protection
  - Portable HEPA (countertop, plug-in)
  - Fixed UV-C (wall-mounted options)
  - Bipolar ionization (JCI unit in fan coil unit)
  - Plasma – relatively new technology
  - Hydrogen peroxide (Synexis Blade)

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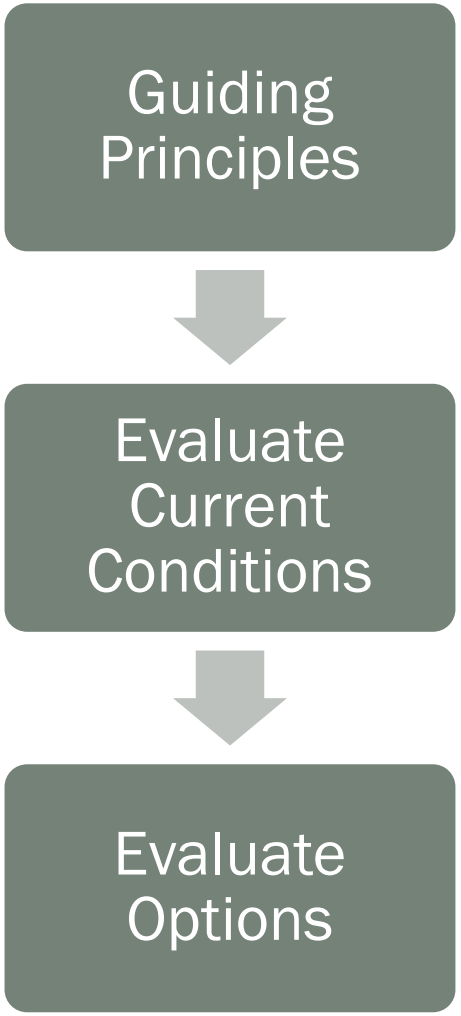
Case Study

Washington University - St. Louis – COVID Study

- Scope: 55 residence halls
- Purpose: How to re-open residence halls for fall classes?
  - Present current condition of the buildings related to each building's capability to re-open to student occupancy
  - Recommend options to improve the current status of the existing residence halls
- Approach
  - Guiding Principles established: Filtration, Ventilation, Humidification, Potential for Cross-Contamination
  - Systematically investigate all 55 buildings
  - Rate buildings risk level: red, yellow, green
  - Evaluate applicable options: in-room, system-level
    - Goal: improve the building's rating



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Case Study

Washington University - St. Louis – COVID Study

Guiding Principles

		Bedrooms/Suites				
	Initial Grade	Bedroom Filtration	Bedrooms Have Ventilation Air	Ability to Increase Ventilation Rates	Humidification	Community Bathroom
Building	Red/Yellow /Green	MERV Rating	Yes/No	Yes/No	Yes/No	Yes/No

Common & Office Areas (Served by Same AHUs)				Dining			
Filtration	Have Ventilation Air	Ability to Increase Ventilation Rates	Humidification	Filtration	Have Ventilation Air	Ability to Increase Ventilation Rates	Humidification
MERV Rating	Yes/No	Yes/No	Yes/No	MERV Rating	Yes/No	Yes/No	Yes/No

Strategies

Add UV-C Lighting	Increase Filtration Level	Add Humidifiers	Revised Grade
			Red/Yellow/ Green

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Case Study

Washington University - St. Louis – COVID Study

Model	Technology	Description	Mat'l & Labor Cost Notes	Total Unit Costs	Lead Time
Novaerus Protect 900 Portable Air Disinfecting System	Plasma Technology	No filter; small fan Designed for continuous air dis-infection and odour control in medium indoor spaces, the Novaerus Protect 800/900 (NV800/900) uses patented filter-free ultra-low energy plasma technology with a 2-speed fan. Can be wall-mounted or placed on a stand and plugs into any outlet. Safely kills viruses like influenza, norovirus, measles and coronavirus	900: $2700 (up to 1200 sf) 200: $1600 (up to 120 sf) *does not include bulk discount *includes 1-yr warranty	$1,600	Some in inventory and can ship stat; will need to place order quickly to ensure delivery by move-in date of Sept 4th
AtmosAir FC400	Bipolar Ionization	Can be installed in fan coil units Ions in the air kill the virus out of the air	M1000 model: $1195 FC400 model: $695 *doesn't include freight, taxes, or installation *original pricing from JCI was $560 + 1-3 hrs labor	$945	
Grainger GPS-FC4B-AC	Bipolar Ionization	Comes in fan coil unit mounted or duct-mounted Smaller unit is good up to 3200 cfm Larger unit is good up to 4800 cfm	Need pricing, dimensions		
Aerus Solutions Air Scrubber	Dry Hydrogen Peroxide	Produces dry hydrogen peroxide, Installed for Chris' Electric Have in-duct model (probe) and portable plug-in model (but no wall-mount) Mount these in-duct for Millbrooks? Craig understands installation to be fairly simple: wire to 24V leads?	$1,000 each		
Synexis	Dry Hydrogen Peroxide (Photocatalytic Oxidation)	Comes in-duct (have them in stock) or wall-mounted (mid-Sept) Have to change UV packets etc. every quarter			
Vortex VI-3500 Room Ionic Air Purifier	Ionization	Helps purify the air of dust, allergens, viruses, mold spores, odors and smoke. For rooms up to 800 square feet (40' x 20'). Easy setup and filterless. Can help fatigue, eye strain, irritability and headaches. Airflow output exchange rate of 150 feet per minute. Outputs 3.4 trillion ions per second. Specifically designed to not interrupt computer systems. Absolutely silent, fanless- no motor noise		$199.95	
RamAir	UV-C Lighting	SLX - Single Lamp High Output Fixture Duct-mounted Clear selection guidelines from Vince	$1408 + tax and freight (for a 24x16 duct)	$1,649	6 weeks
EMS-UV UV-C Air Sanitizer	UV-C lighting No filter	24/7 Room Air Sanitizer. Perfect for Ambulances, Waiting Rooms, Exam Rooms, Offices, Labs... EMS-UV™ is the most advanced 24/7 air sanitizer on the market. Utilizing ultraviolet lamp technology, this product kills up to 99.9% of airborne bacteria, viruses, black mold and fungal growth, reduces odors and respiratory allergens and reduces airborne transmission of influenza, colds, and viruses. Wall mount or table top, Self-cleaning with no filters to replace. Rooms can be fully occupied. Low power consumption, Detachable power cord, 13.8" x 5.1" x 4" (350 x 130 x 100mm), Wt. 4.4 lbs. (2 kg.) Long lasting germicidal UV-C bulb (10,000 hours) and inexpensive to replace. Bulbs sold here. 350 sq. ft. room.	$495	$495	
Purafil Purashield 500	Molecular ion technology, HEPA filter	Portable Air Purifier Four-layer filter includes: pre-filter, patented molecular filtration, PuraWard filter (protected from many viruses, bacteria, and mold using copper and silver ions), and HEPA final filter.	Initial cost: $800 Replacement filters: $150	$800	Availability is good

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Case Study

Washington University - St. Louis – COVID Study

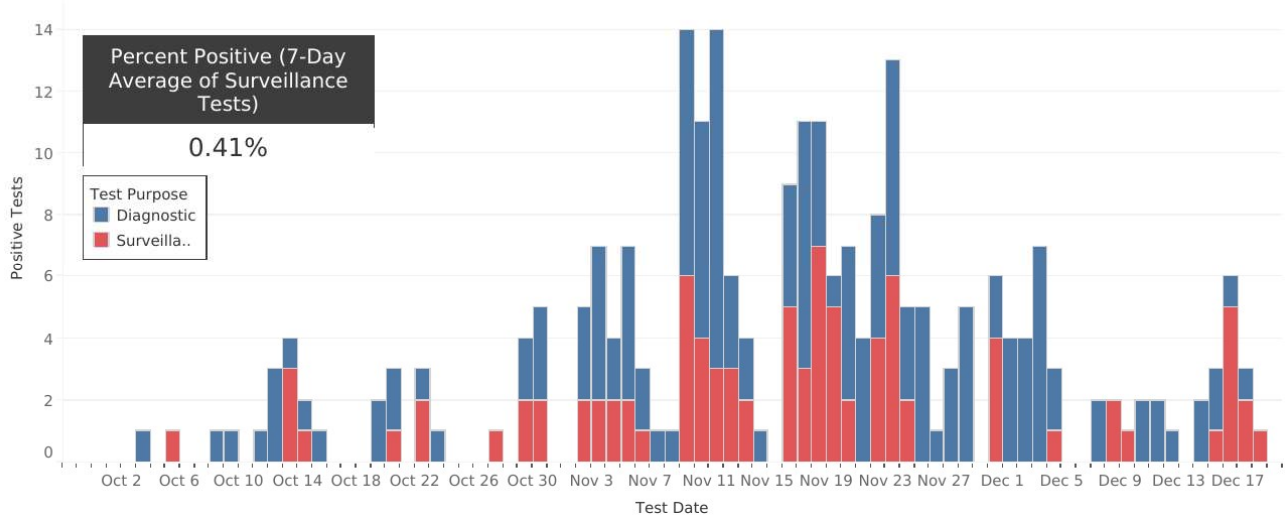
- Provided options to mitigate risk: plasma, bipolar ionization, dry hydrogen peroxide, UV-C lighting, HEPA filters
- Matrix of options and weighed factors: technology type, unit price, efficacy, safety, lead time, ongoing maintenance
- Dorm-Specific Strategies
  - Replace MERV-7,8,10 with MERV-13 filters wherever possible.
  - Install UV-C lighting devices in bedrooms and common areas (duct-mounted or wall-mounted).
  - Install in-room plug-in humidifiers in bedrooms.
  - Add portable HEPA filters in common areas
- Ultimate decision to use portable HEPA filters based on feedback on the various options from public health and aerosols experts in the campus community.
- Individual Requirements: mandatory masks, distancing, daily self-screening, personal hygiene, community pledge & acknowledgement, limited gatherings, undergrad testing every 2 weeks
- University Requirements: cleaning, quarantine/isolation, contact tracing, testing upon arrival and periodically, alert level system (Red, Orange, etc.), hybrid learning, single bedrooms for all on-campus housing residents
  - Provided mask kits with thermometer, outdoor tents with 600 seats, FDA-approved saliva test with 24-36 hr results, revised spring calendar (no Spring Break – 3 wellness days off)

Case Study

Washington University - St. Louis – COVID Study

Active Cases (all testing sources)		Total Cases (since Aug. 1)	
Faculty/Staff	13	Faculty/Staff	120
Graduate Students	0	Graduate Students	65
Undergraduate Students	10	Undergraduate Students	208

Positive Tests through WashU & BJC (since Sep. 28)



Final Entry Testing Statistics

	Tests	Positives	% Positive
Graduate	2,714	1	0.04%
Undergrad	5,708	11	0.19%

Data last updated: 12/14/20 10:39 PM

Questions? Email us at covidquestions@wustl.edu

% Positive rate for STL County as of 1/12 is 14.3%

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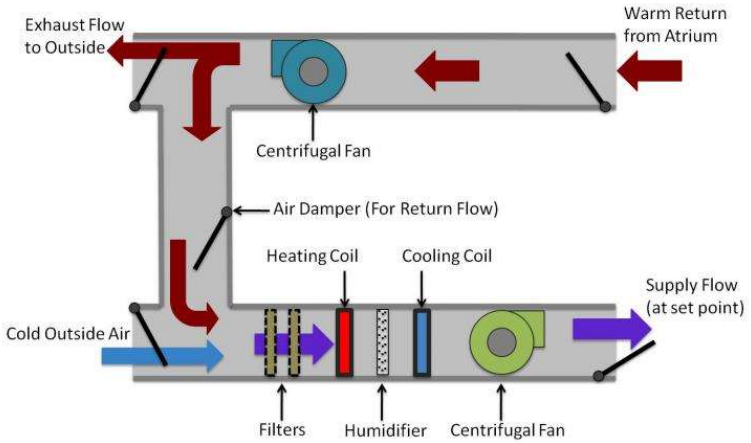
Limited Return to Operations - Recommendations

How will energy be impacted?

- Increase Ventilation
  - Higher ventilation rates require more energy to condition and move the air through the building.
- Improve Filtration
  - Increased filter efficiency leads to increased pressure drop and more fan power used.
- System-Level Disinfection Solutions
  - Added plug load of new UV-C installation
- In-Room Disinfection Solutions
  - Added plug loads and additional electrical energy



Normal Operation → Shutdown/ Closed → **Limited Return to Operations** → Back to "New Normal"

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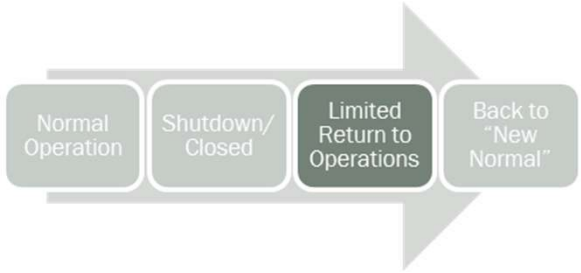
Limited Return to Operations – Recommendations

Strategies to Counteract Energy Increases

- Allow building space temperature & humidity to setback upward during unoccupancy
  - Reduced airflows help negate increases to fan energy and cooling energy
- Dramatically reduce or shut-off airflow to spaces that are no longer in use
  - Reduced airflows help negate increases to fan energy and cooling/heating energy
- Utilize MERV-13 filters in lieu of higher level of filtration (i.e. HEPA)
  - Studies have shown minimal additional benefit from higher levels of filtration



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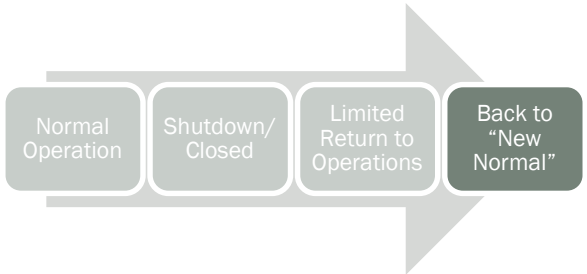
The "New Normal" in the Future

- What is the "New Normal"?
  - Lower occupant density
  - Greater % of work-from-home employees and virtual learning
  - Buildings that can adapt to future pandemics
    - Fans sized for higher pressure (can swap in higher MERV filters)
    - Additional zoning to allow for space subdivision/flexibility
  - Building systems that inherently mitigate virus transmission rates
    - Incorporate strategies previously discussed



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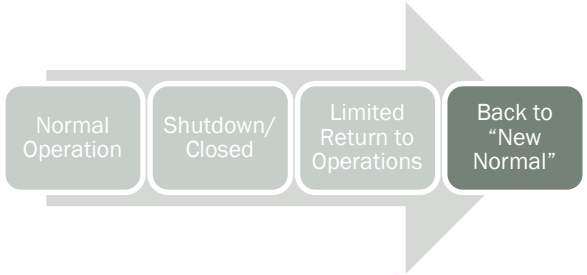
The "New Normal" in the Future

- Changes to HVAC Design Approach
  - Focus on less air recirculation throughout a building
    - Once-thru dedicated outdoor air systems (DOAS)
    - Localized cooling/heating with active chilled beams or local fan coil units (with EC Motors)
    - Added benefit of reduced overall building ventilation air requirement
  - AHU Sizing based on reducing coil/filter face velocities & pressure drop
    - Added benefit of making UVC more effective – longer contact duration
  - Greater emphasis on exhaust air energy recovery
  - Higher level of focus on occupancy controls to match energy consumption to occupancy
  - Extra built-in capacity to provide flexibility to respond to another pandemic
- Changes to Other Areas of Building Design
  - Larger, flexible, sub-dividable spaces with movable furniture
  - Greater focus on building envelope
  - Higher level of lighting control
  - Office Hoteling – reduction in assignable office SF
  - AV Upgrades to promote virtual meetings/presentations



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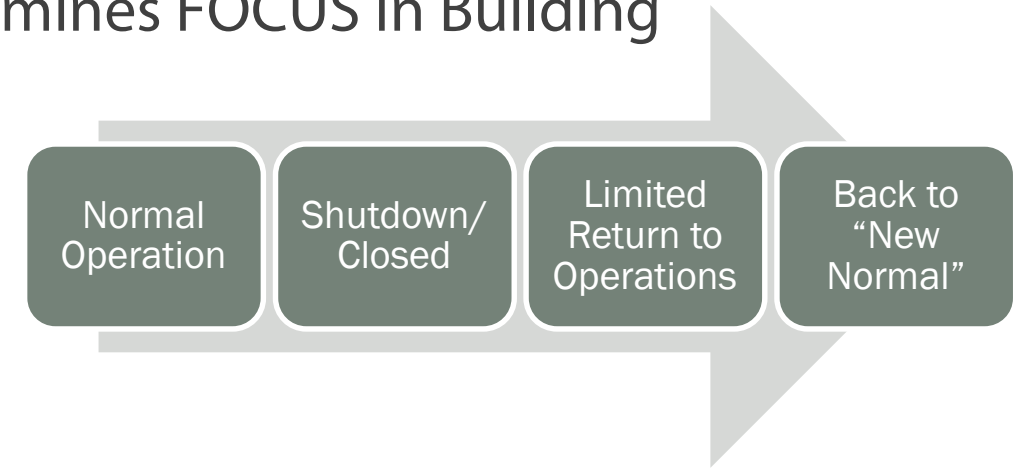
Conclusions

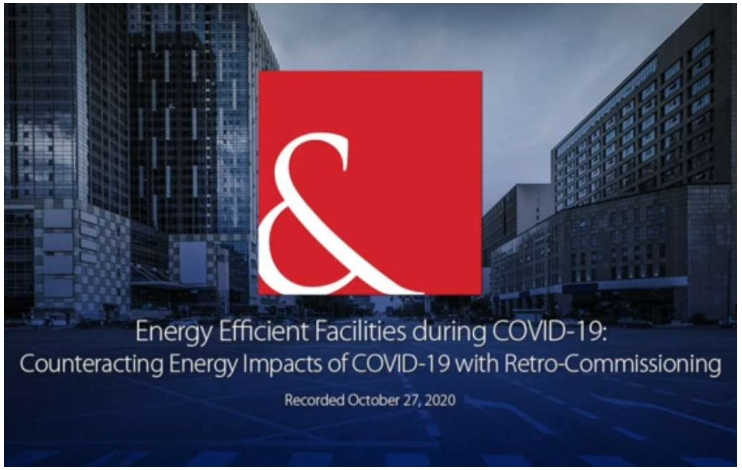
- Mode of Operation Determines FOCUS in Building Operations
- Recommendations
  - Increase Ventilation
  - Improve Filtration
  - Install UV-C Lighting
  - Install In-Room Decontamination



- Most "pandemic best practices" will likely incur an energy penalty.
  - Retro-Cx Studies or Energy Audits can help find other opportunities to offset energy penalties!

Resources

- ASHRAE Guidance for Reopening Schools and Universities: https://www.ashrae.org/technical-resources/reopening-of-schools-and-universities
- 3-Part Webinar Series



Thank you!

Questions?

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