Healthier Buildings: Energy Efficiency Strategies for Implementing CDC & ASHRAE COVID-19 Guidance

75F

Energy Efficiency and CDC/ASHRAE COVID-19 Guidance

1. Science: Updated Recommendations
2. Review CDC & ASHRAE guidelines
3. Science: Is Dilution Ventilation Effective?
4. What Guidelines Mean for Energy Efficiency
5. Strategies for Energy Efficiency
6. Guest Presenter: Dr. Mark Modera
7. Q&A

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CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

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CDC: How COVID-19 Spreads

The virus is thought to spread mainly from person-to-person.

- Between people who are in close contact with one another (within about 6 feet).
- Through respiratory droplets produced when an infected person coughs, sneezes, or talks.
- These droplets can land in the mouths or noses of people who are nearby or possibly be inhaled into the lungs.

The virus may be spread in other ways.

- Touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes. This is not thought to be the main way the virus spreads.

source: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html

Read our COVID-19 research and news.

Hard lessons

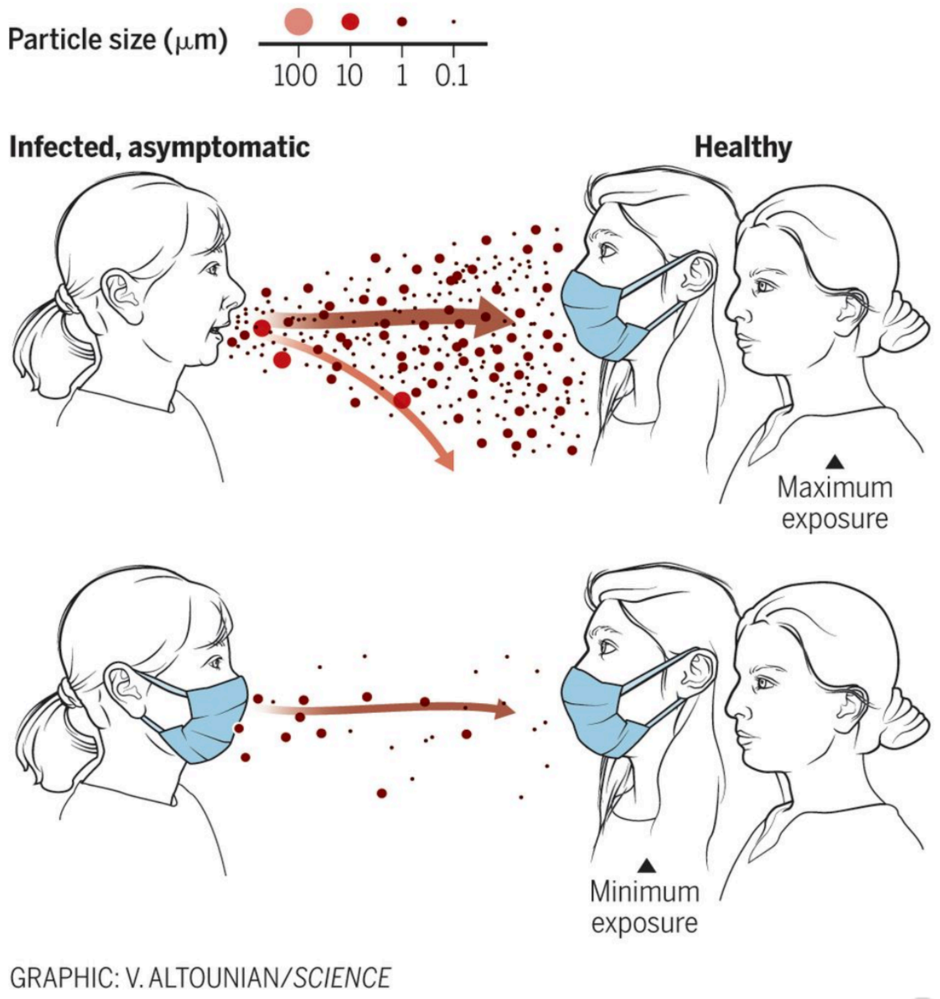
Carlos Castillo-Chavez trained a record number of minority mathematicians—but his tough-love approach took a toll

MATT LE

Science Magazine: Viral Particles Linger in Air

An article published in Science Magazine indicates six feet of distance indoors may not be enough and highlights the importance of ventilation.

- Aerosols can accumulate in the air as asymptomatic people talk, remain infectious in indoor air for hours, and be easily inhaled deep into the lungs.
- “Calculations predict that in still air, a 100-µm droplet will settle to the ground from 8 ft in 4.6 seconds, whereas a 1-µm aerosol particle will take 12.4 hours.”
- “Ultimately, the amount of ventilation, number of people, how long one visits an indoor facility, and activities that affect air flow will all modulate viral transmission pathways and exposure.”



Graphic source: Science Magazine

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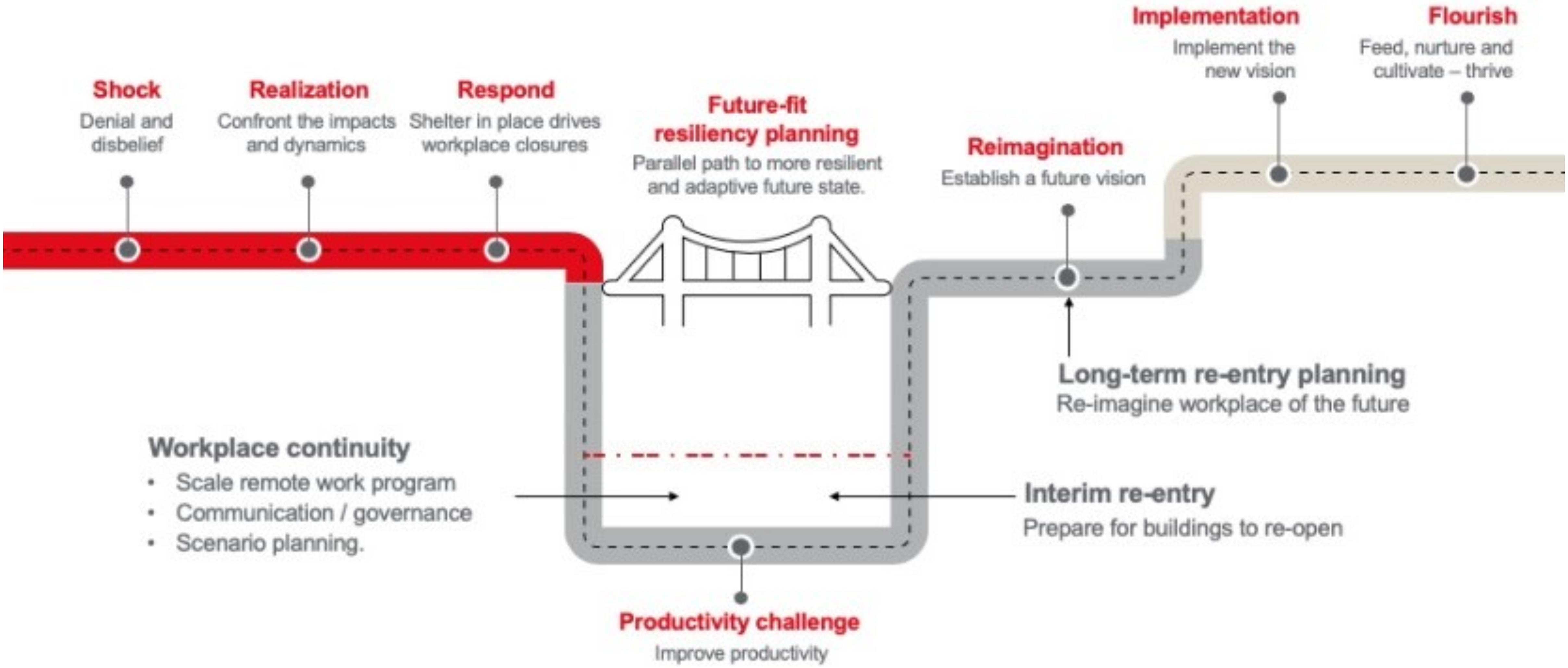
COVID-19 experience journey



Graphic source: JLL

CDC: Maintaining a Healthy Work Environment

As states start to reopen businesses, the Centers for Disease Control and Prevention currently recommends increasing ventilation rates and the percentage of outdoor air (OA) indoors.

- Keep systems running longer hours, 24/7 if possible, to enhance air exchange.
- Increase outdoor air ventilation, using caution in highly polluted areas.
- Disable demand-controlled ventilation (DCV) – a CO_2-based outside air sequence
- Open outdoor air dampers as high as 100 percent to reduce or eliminate recirculation.
- Improve central air filtration to the MERV-13 or highest compatible with the filter rack. Seal edges of the filter to limit bypass.

CDC: Reopening After Prolonged Shutdown

In addition to guidance for increasing ventilation while occupied, the CDC has issued guidance for re-opening buildings after a prolonged shutdown. The portion of this guidance pertaining to HVAC addresses mold awareness, monitoring, and remediation.

- During the shutdown, keep humidity levels as low as possible, not exceeding 50%.
- Before re-opening, conduct a mold assessment by trained professionals and remediate as needed.
- If HVAC system has not been active for a prolonged period (can be as short as a few days), flush the air for 2-3 days before occupancy with outside air at the highest level that can maintain desired temperatures.

ASHRAE: Reopening Guidance and Building Readiness

ASHRAE warns that "transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.." ASHRAE Commercial Building COVID-19 Guidance is given at their Web site:

ASHRAE > COVID-19 > Buildings > Commercial

- Flush the air in a building for two full hours before and after occupancy.
- Open Outside Air (OA) to the maximum possible while maintaining acceptable indoor conditions
- Disable Demand Control Ventilation
- VAV systems: Increase discharge air temperature to max to encourage open VAV terminal unit dampers

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CDC Examination of Outbreak in South Korean Call Center

Bob covered in previous webinar why the built environment can pose a considerable risk.

- One infected employee managed to infect 94 other people on a single floor of this call center.
- “Indicates that the duration of interaction was likely the main facilitator for further spreading of COVID-19."

Figure 2

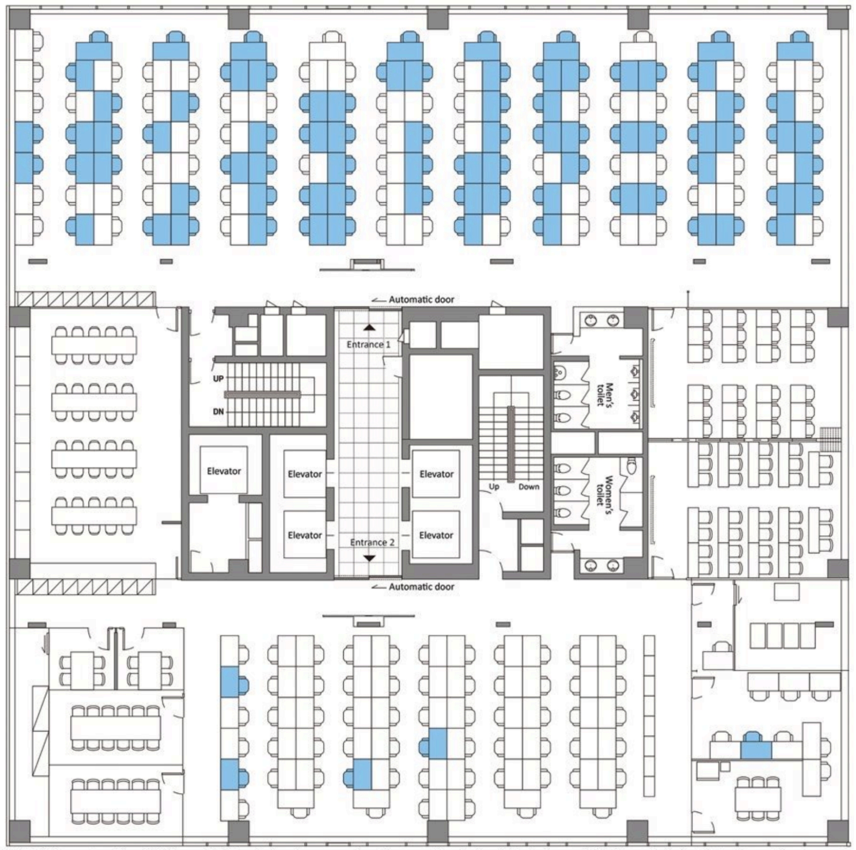


Figure 2. Floor plan of the 11th floor of building X, site of a coronavirus disease outbreak, Seoul, South Korea, 2020. Blue coloring indicates the seating places of persons with confirmed cases.

Graphic source: CDC

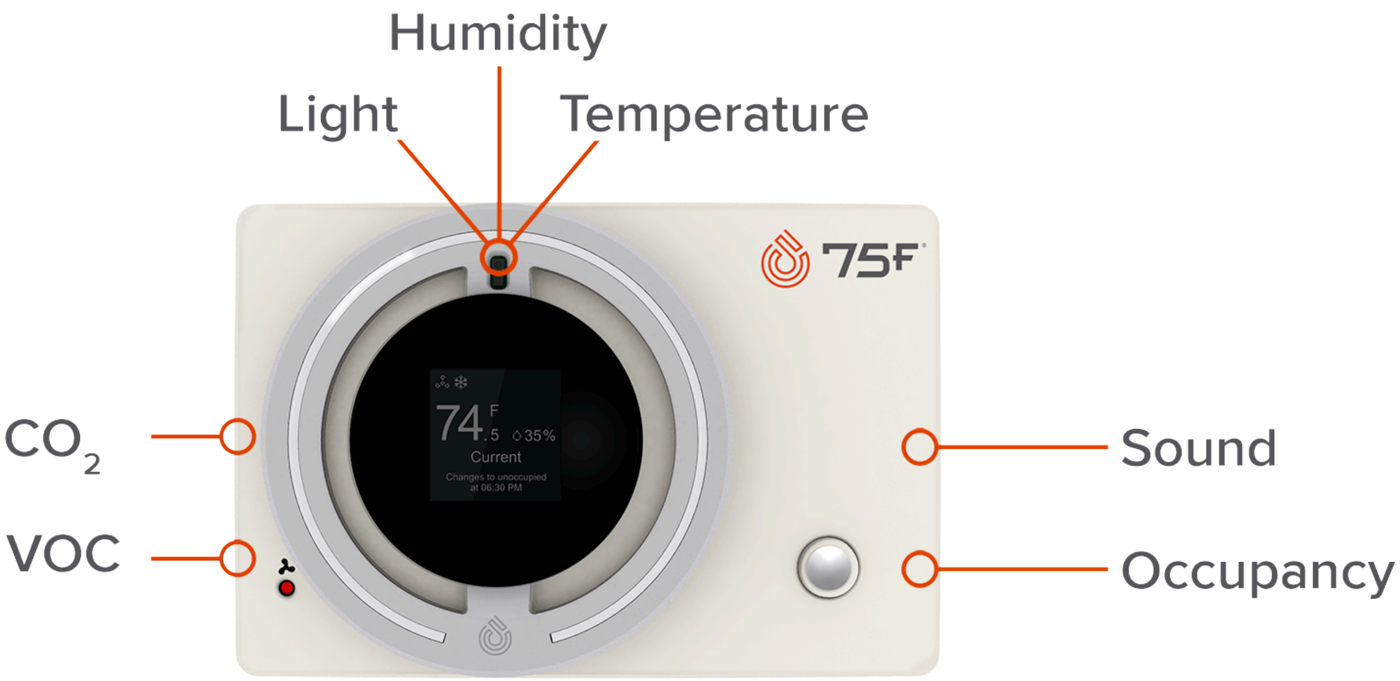
Viral Load

Since duration of interaction was likely the main facilitator of spreading, there is a measure of “viral load” or the concentration of virus particles per cubic foot of air.

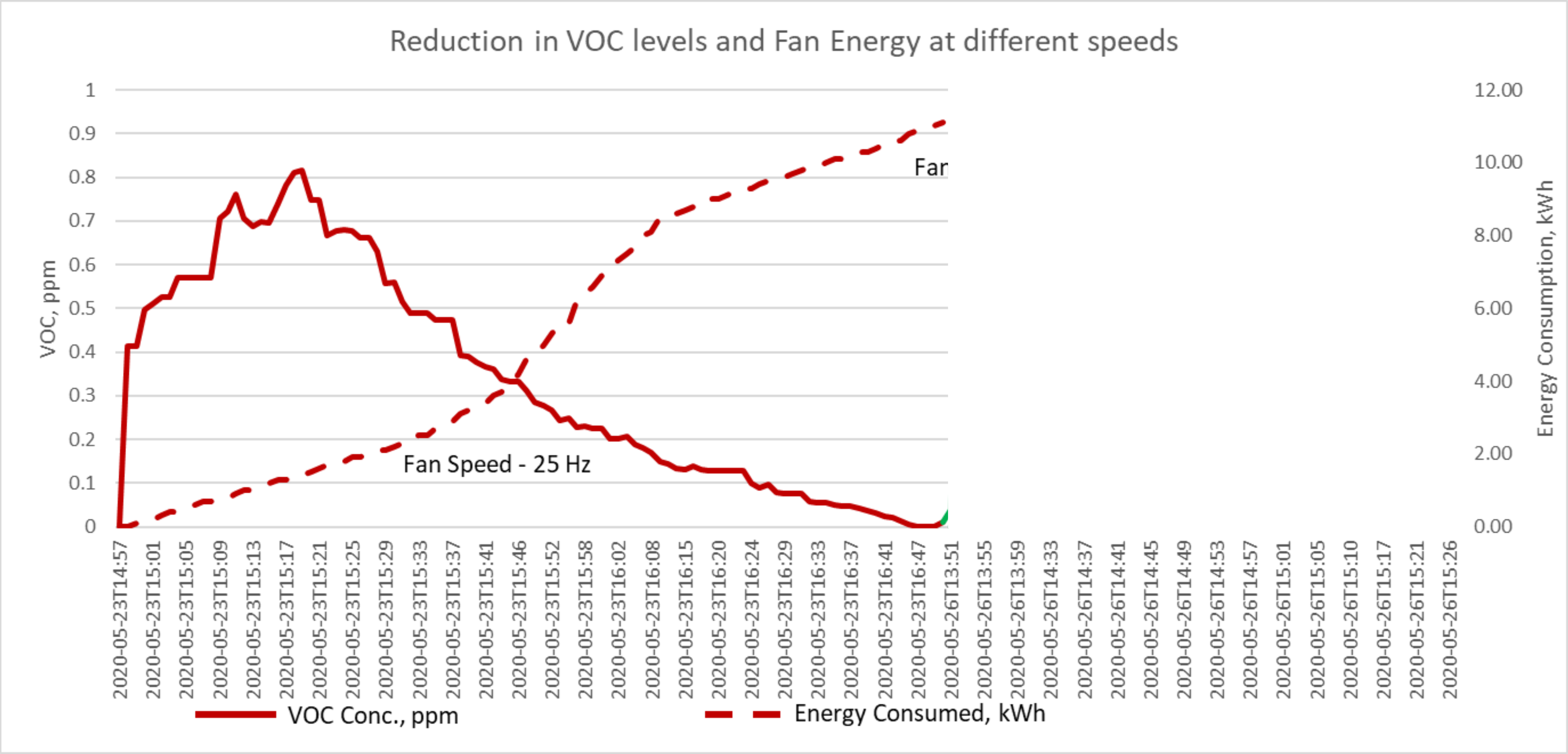
- Reducing the viral load reduces the number of particles a person is exposed to in a given time period.
- Increasing outside air (OA) reduces the viral load by dilution ventilation.

An illustration of coronavirus particles
Maurizio De Angelis/Science Photo Library

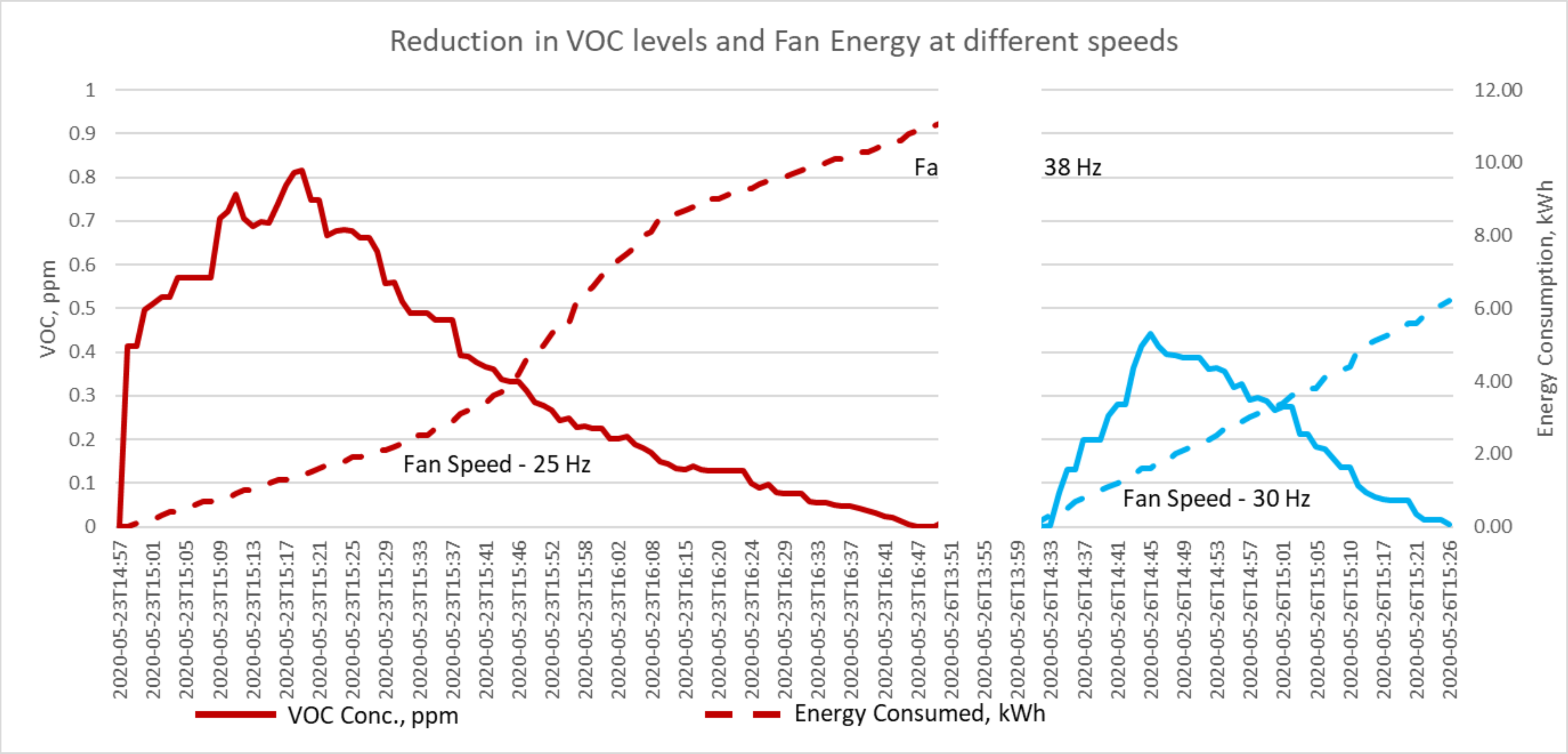
75F Sensing


Humidity
Light
Temperature
CO2
VOC
Sound
Occupancy
75F
74 F .5
35%
Current
Changes to unoccupied at 06:30 PM

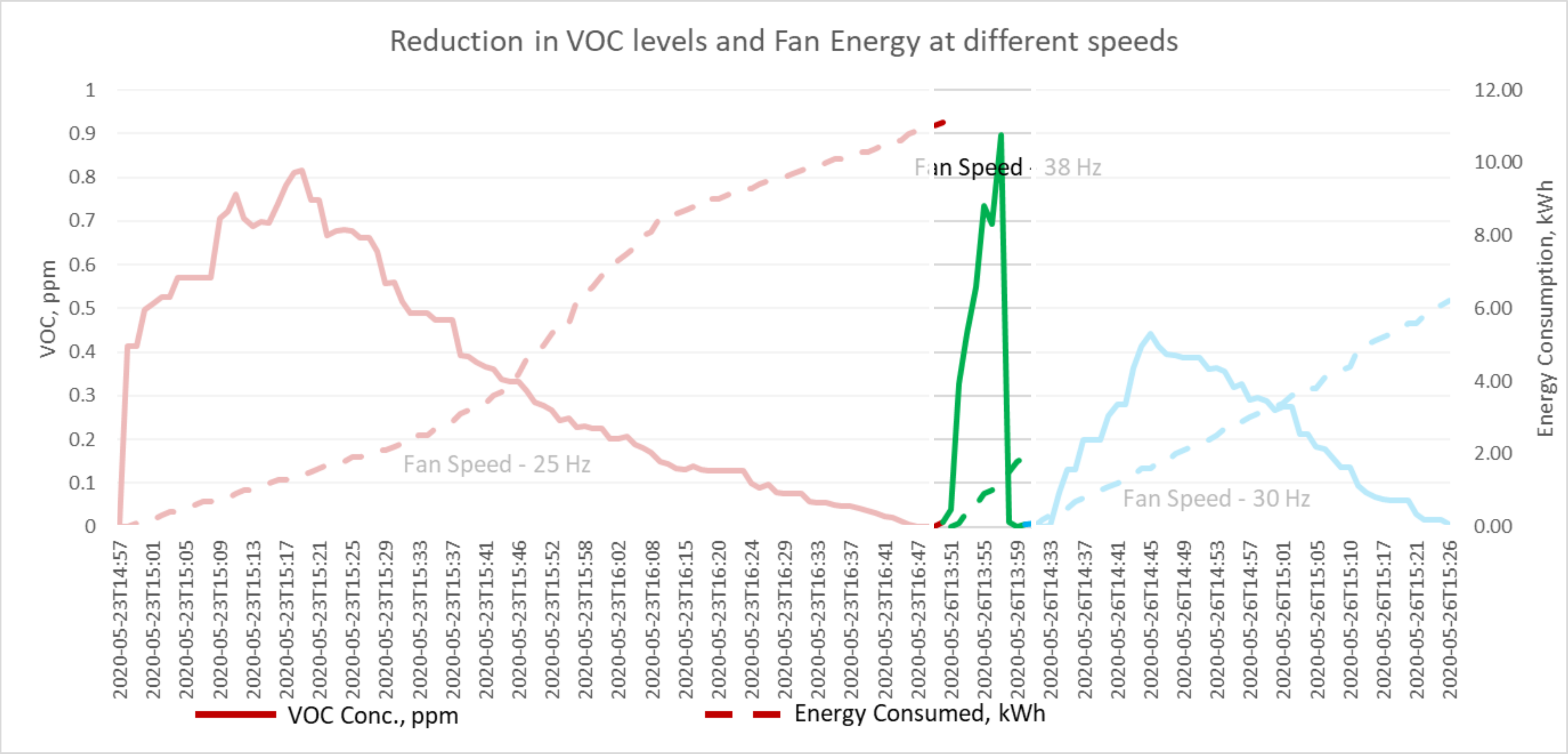
Fan Speed vs Dilution Effect – 75F



Fan Speed vs Dilution Effect – 75F



Fan Speed vs Dilution Effect – 75F



Energy Usage for purge vs non-purge

Description	Standard	Purge	Enhanced
EM Start	2201.8	2214.3	2222.8
EM End	2213	2216	2229
Energy, kWh	11	2	6
Time Taken, hours:min	1:53	0:09	0:55
Speed, Hz	25	38	30

Q&A

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Sequences of Operation – Pre and Post Purge

The guidance to purge the building for 2 hours before and after occupancy can be accomplished these ways:

– **Thermostat**: If you have a programmable thermostat, change your program to start 2 hours before occupancy and end 2 hours after occupancy.

– **Pneumatic Controls**: You likely don’t have any control over the VAVs but might be able to change your schedule to start 2 hours before occupancy and end 2 hours after occupancy.

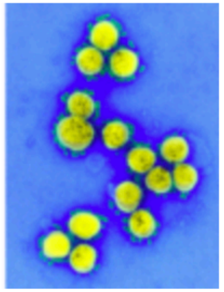
– **Typical BAS**: Edit the fan setting to cover 2 hours before and after occupancy. If not possible, adjust the occupied schedule.

COVID-19 is an emerging, rapidly evolving situation.
Get the latest public health information from CDC: https://www.coronavirus.gov .
Get the latest research from NIH: https://www.nih.gov/coronavirus.

PMC

PubMed Central® (PMC) is a free full-text archive of biomedical and life sciences journal literature at the U.S. National Institutes of Health's National Library of Medicine (NIH/NLM).

COVID-19 INITIATIVE
Expanding access to coronavirus research



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Energy Implications of Increased Ventilation

A 2015 study published in the National Center for Biotechnology Information evaluates the economic impact of increased ventilation in humid, dry, and temperate locations.

- At the higher levels of tested ventilation, all locations demonstrated higher energy costs, as demonstrated in corresponding graphic.

Table 2

Change in energy cost per occupant per year compared to conventional.

Ventilation Rate	Austin	Charlotte	San Francisco	Baltimore	Albuquerque	Boston	Boise
Variable Air Volume							
20 cfm/person	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
27.6 cfm/person	$7.14	$7.29	$4.58	$10.42	$4.16	$12.03	$6.57
27.6 cfm/person + ERV	−$0.58	$0.42	$6.59	−$1.53	$3.77	−$0.82	$0.15
40 cfm/person	$23.07	$23.24	$15.73	$32.36	$14.34	$37.27	$20.78
40 cfm/person + ERV	$9.37	$10.55	$17.44	$11.21	$10.05	$14.06	$7.83
Fan Coil Unit							
20 cfm/person	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
27.6 cfm/person	$7.31	$8.63	$8.69	$12.35	$7.77	$15.19	$9.19
27.6 cfm/person + ERV	−$0.18	−$3.46	−$0.05	−$7.29	−$0.72	−$8.35	−$6.77
40 cfm/person	$19.20	$22.70	$22.94	$32.42	$20.41	$39.87	$24.13
40 cfm/person + ERV	$8.32	$5.18	$10.22	$4.01	$7.88	$5.81	$1.00

Increased ventilation rates and the associated cost in seven different U.S. cities.

Graphic source: NCBI

ASHRAE: Energy Implications of Increased Ventilation

The concern over the capability for a coil to provide additional capacity was evaluated using a typical cooling coil at various percent of outside air. This evaluation shows the additional required cooling capacity and gpm required[1] if the same exact coil experiences the different entering air conditions. The following shows the impact of increasing the percent of outside air

- Increasing ventilation from 20% outside air to 90% outside air doubles the required chilled water, triples the coil pressure drop and requires just over twice the amount of cooling source from the chiller.

Percent OA	EAT DB / WB	CHW GPM	Coil Pressure Drop (Ft H2O)	Total Capacity (MBH)	Sensible Capacity (MBH)
20	77.64 / 66.64	73.66	5.04	443.49	282.78
30	78.95 / 68.55	83.4	6.32	510.68	297.83
40	80.26 / 70.39	94.27	7.90	582.09	312.93
50	81.56 / 72.15	104.17	9.49	651.46	327.99
60	82.86 / 73.84	114.6	11.3	720.81	343.1
70	84.15 / 75.47	125.87	13.43	790.57	358.15
80	85.44 / 77.03	135.5	15.37	857.15	373.26
90	86.72 / 78.54	149.73	18.48	929.1	388.3

Graphic source: ASHRAE

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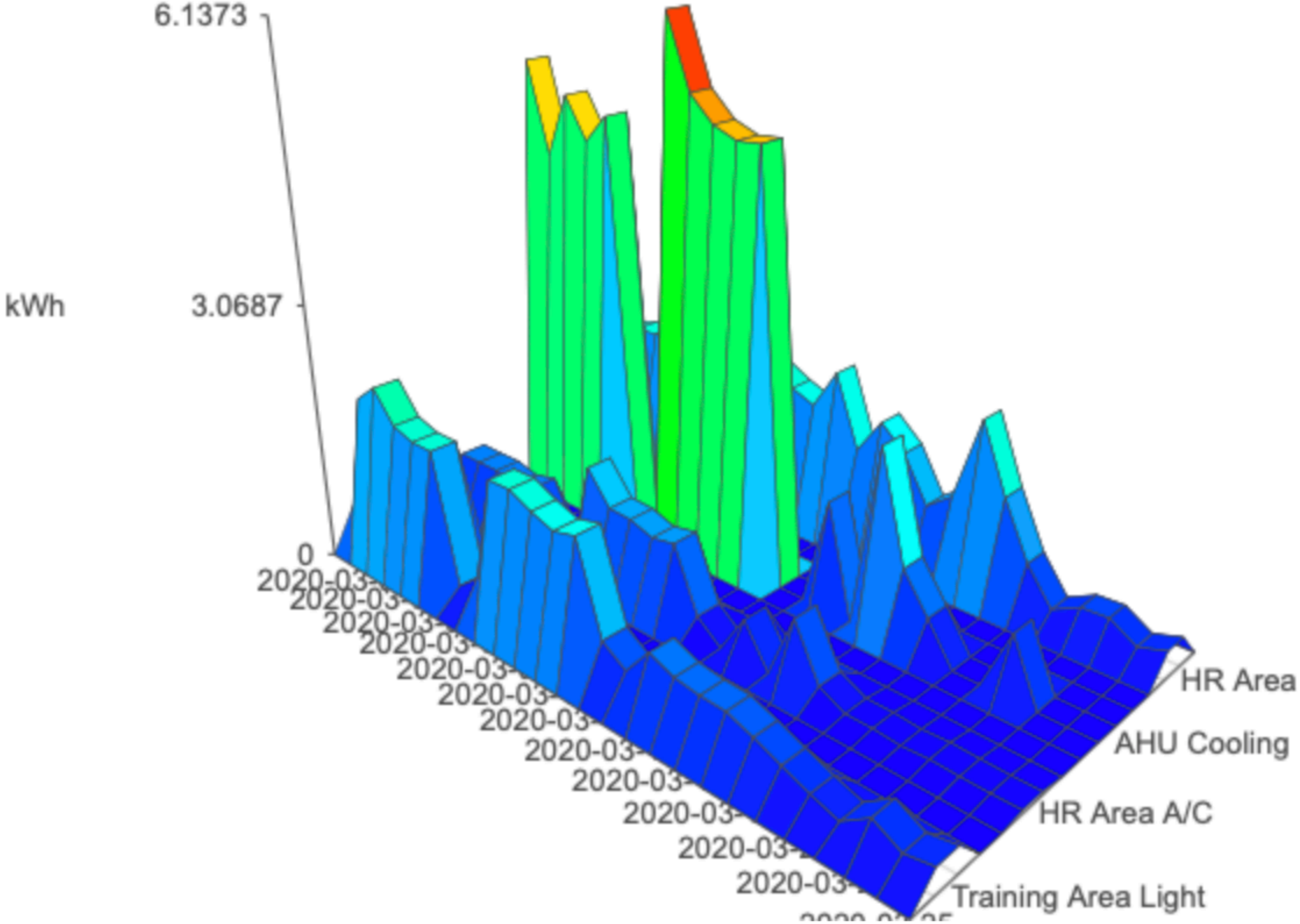
Energy Impact during shutdown



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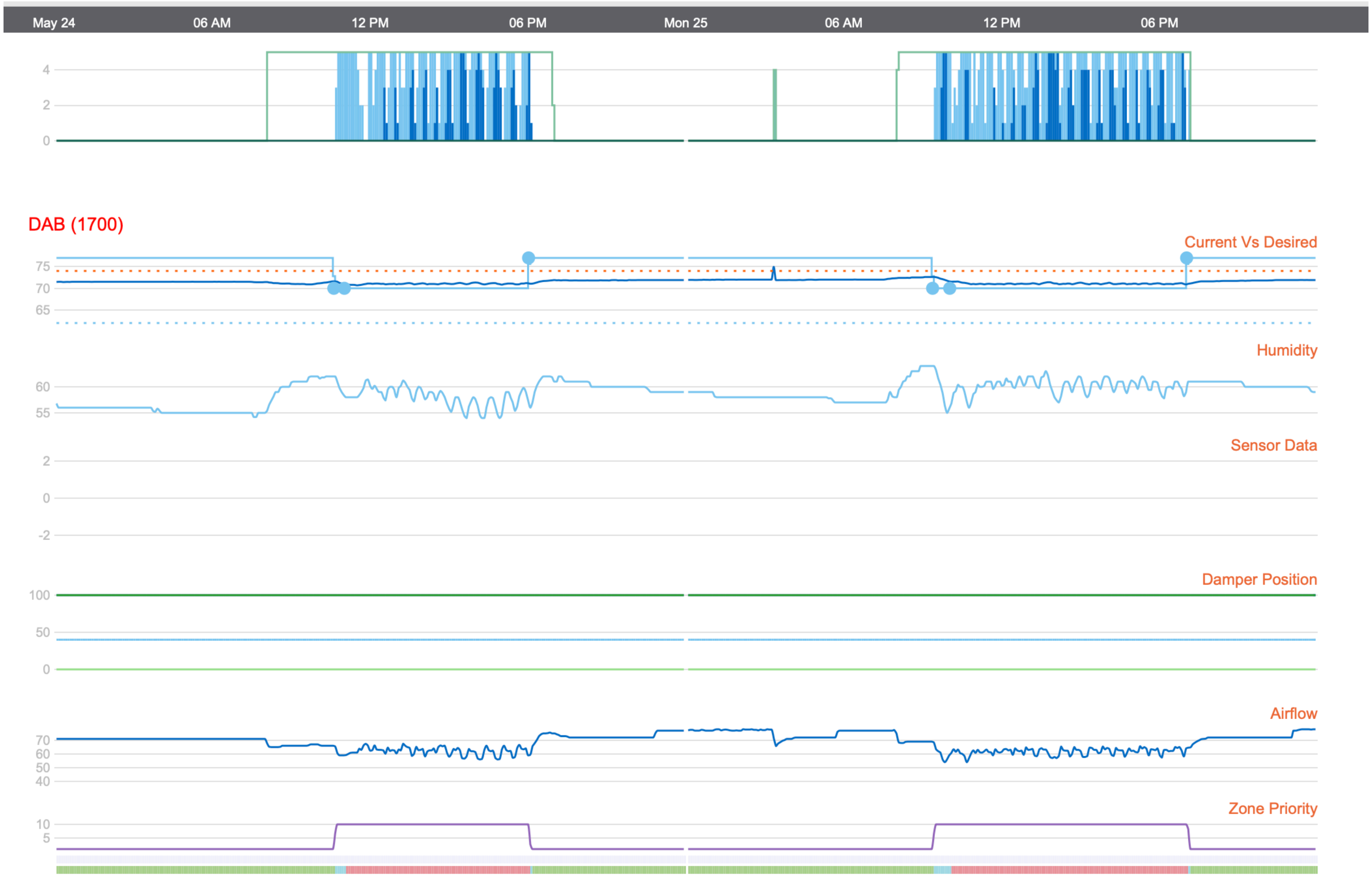
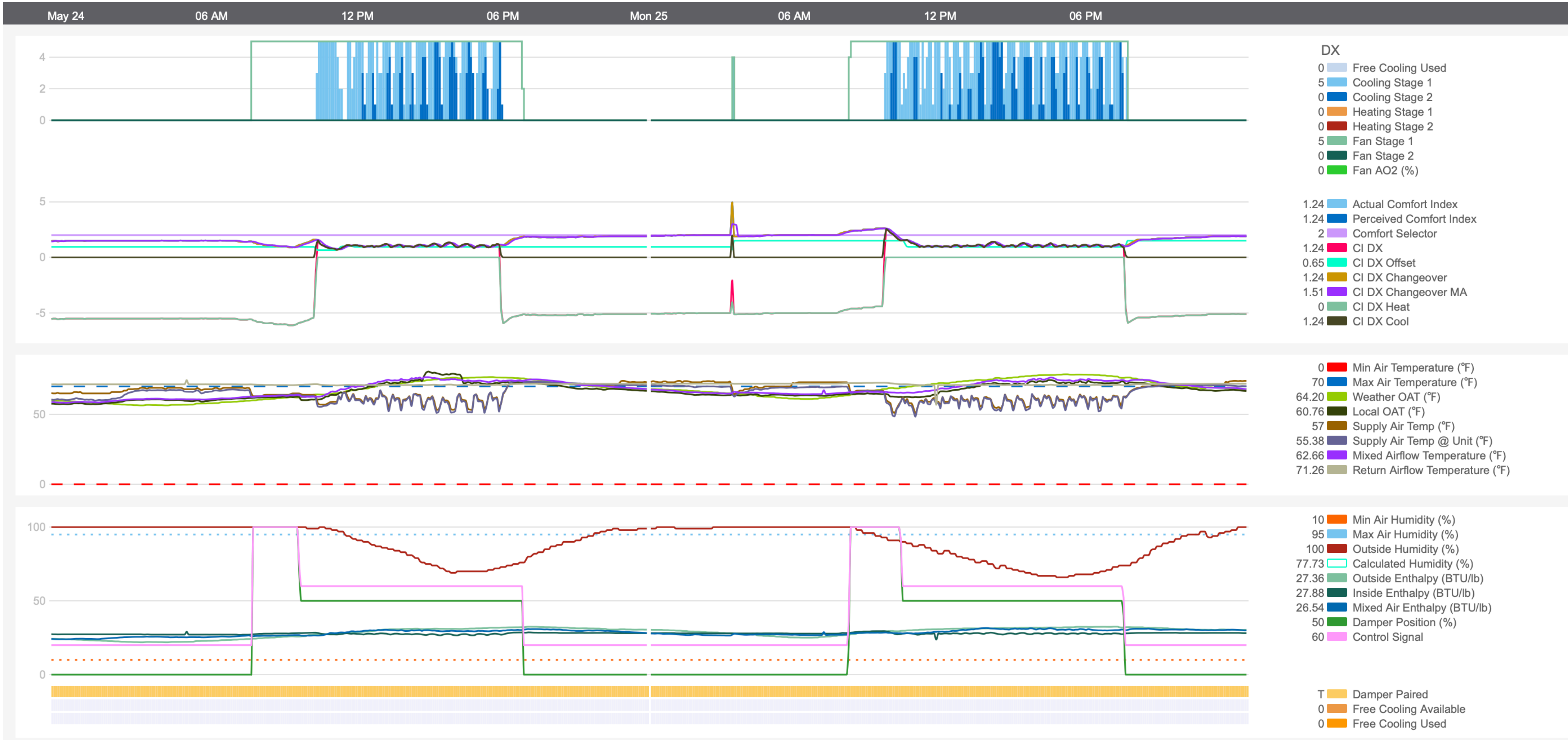
Suggested sequence

- Pre occupancy purge
  - During unoccupied period
  - 100% OA damper
  - Temperatures are in setback
  - Run the fan – at speed
- Enhanced ventilation during occupied period
  - OA damper varies based on equipment capacity and weather
  - Ensure space temperatures of 72-78°F and humidity between 40-60%
- Direct the ventilation to parts of the building that are occupied
- In zone where ventilation is needed, open up the dampers to reduce the pressure losses



May 24
06 AM
12 PM
06 PM
Mon 25
06 AM
12 PM
06 PM
DAB (1700)
Current Vs Desired
Humidity
Sensor Data
Damper Position
Airflow
Zone Priority



May 24
06 AM
12 PM
06 PM
Mon 25
06 AM
12 PM
06 PM
DX
0 Free Cooling Used
5 Cooling Stage 1
0 Cooling Stage 2
0 Heating Stage 1
0 Heating Stage 2
5 Fan Stage 1
0 Fan Stage 2
0 Fan AO2 (%)
1.24 Actual Comfort Index
1.24 Perceived Comfort Index
2 Comfort Selector
1.24 CI DX
0.65 CI DX Offset
1.24 CI DX Changeover
1.51 CI DX Changeover MA
0 CI DX Heat
1.24 CI DX Cool
0 Min Air Temperature (°F)
70 Max Air Temperature (°F)
64.20 Weather OAT (°F)
60.76 Local OAT (°F)
57 Supply Air Temp (°F)
55.38 Supply Air Temp @ Unit (°F)
62.66 Mixed Airflow Temperature (°F)
71.26 Return Airflow Temperature (°F)
10 Min Air Humidity (%)
95 Max Air Humidity (%)
100 Outside Humidity (%)
77.73 Calculated Humidity (%)
27.36 Outside Enthalpy (BTU/lb)
27.88 Inside Enthalpy (BTU/lb)
26.54 Mixed Air Enthalpy (BTU/lb)
50 Damper Position (%)
60 Control Signal
T Damper Paired
0 Free Cooling Available
0 Free Cooling Used

75F Epidemic Mode™

- **Smart Purge™** automatically flushes the air in the building prior to occupancy
- Maximize outside air intake based on equipment and weather
- Open up zone dampers or VAV boxes
- Sequences are automatically updated as CDC and ASRAE guidelines change, or to meet state or federal regulations.

ASHRAE® CDC

Enhanced IAQ Monitoring and Management:

- Monitor the temperature, humidity and occupancy and indoor air quality of each zone independently.
- Maintain space setback temperatures during unoccupied periods along with emergency building heating so relative humidity does not rise above critical levels.

Built-In Occupancy Sensors Track Building Utilization Rates:

- Dynamically rebalance airflow from partially occupied or unused spaces to increase outside air ventilation in all high occupancy areas.
- Reduce operating expense and equipment and maintenance costs from ventilating or cooling unoccupied indoor spaces.
- Review granular occupancy data for each building or office at a zone level to comply with policies or regulations.

Q&A

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INTERACTIONS BETWEEN DUCT LEAKAGE AND COVID-19 MITIGATION

MARK MODERA

PROFESSOR AND DIRECTOR – WCEC/UC DAVIS

TECHNICAL CONSULTANT – AEROSEAL

JUNE 2, 2020

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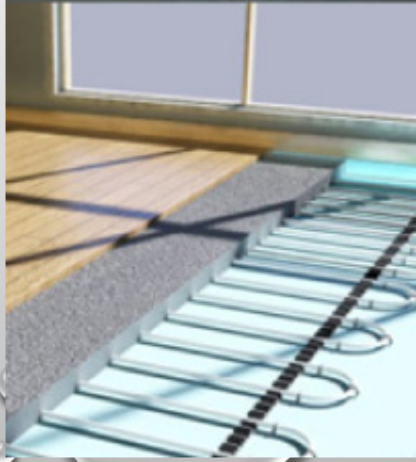


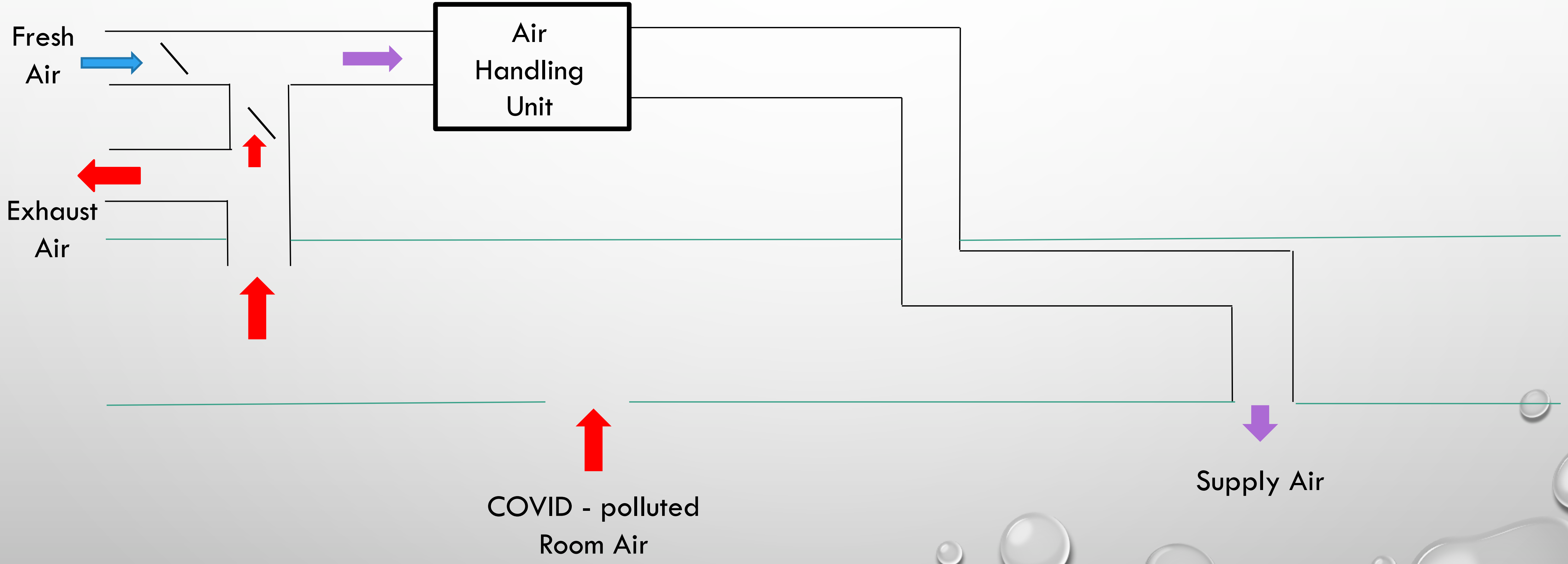
MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

FOCUS OF THIS TALK: THE AIR WE BREATHE

- VIRUS CONCENTRATION REDUCTION
  - FILTRATION
  - DESTRUCTION
  - **DILUTION**

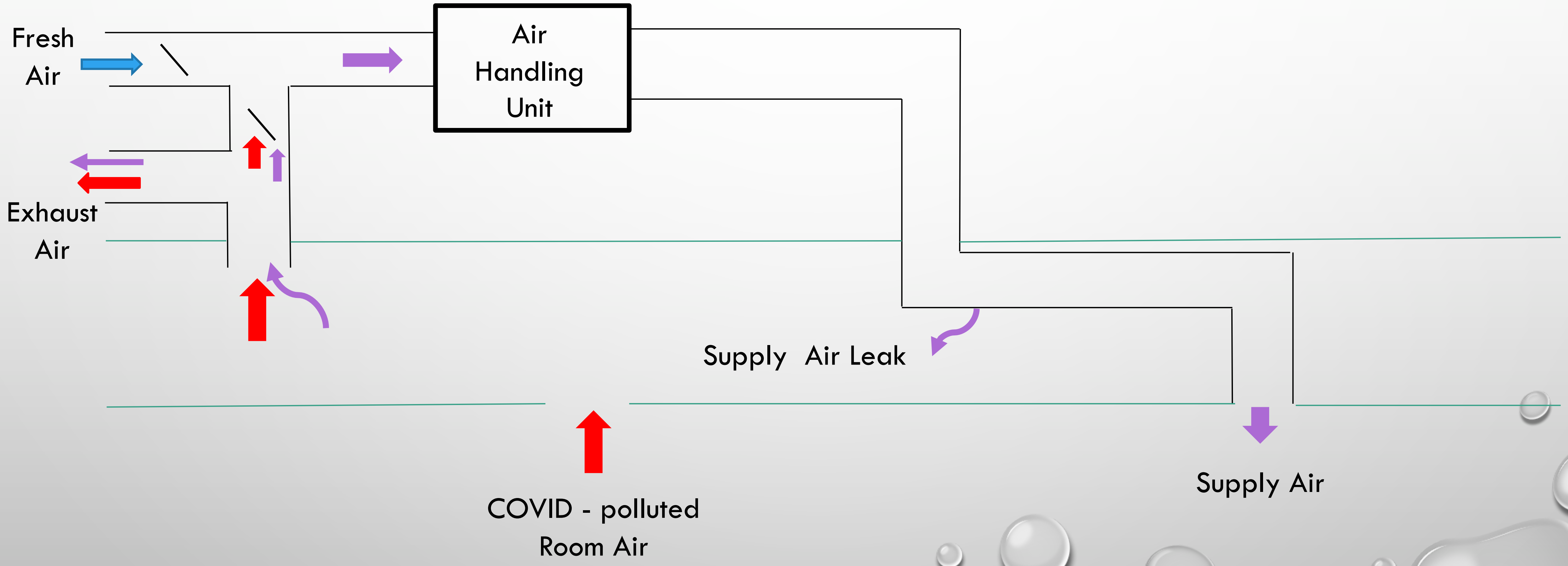
MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

OFFICE BUILDING SUPPLY AIR



MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

OFFICE BUILDING SUPPLY AIR WITH DUCT LEAKAGE



MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

IMPLICATIONS OF SUPPLY DUCT LEAKAGE

- SHORT-CIRCUITING OF FRESH AIR TO RETURN/EXHAUST AIR
- A FRACTION OF SUPPLY AIR LEAKED NEVER GETS TO CONDITIONED SPACE
  - SHORT CIRCUITED AIR IS SENT BACK TO SUPPLY FAN OR EXHAUSTED FROM THE BUILDING
  - FRACTION EXHAUSTED DEPENDS UPON OUTDOOR AIR FRACTION AND/OR NEED FOR BUILDING PRESSURIZATION/DEPRESSURIZATION
- VIEWED ANOTHER WAY, DUCT LEAKAGE **REDUCES THE CONCENTRATION OF COVID-19 IN THE EXHAUST AIR**

MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

IMPLICATIONS OF SUPPLY DUCT LEAKAGE – EXAMPLE CALCULATION

- **ASSUMPTIONS**
  - **20% DUCT LEAKAGE** AT FULL LOAD (10% UPSTREAM OF VAV BOXES, 10% DOWNSTREAM)
  - **UPSTREAM LEAKAGE FLOW IS CONSTANT** (ΔP IS CONSTANT)
  - **DOWNSTREAM LEAKAGE FRACTION IS CONSTANT** (LEAKAGE ~$\Delta P^{0.6}$, FLOW ~ $\Delta P^{0.5}$)
    - ⇨ 30% AT 50% LOAD (I.E. 50% FLOW)
  - **FIXED VENTILATION AIR FLOWRATE** - 20% OUTDOOR AIR AT FULL LOAD
    - ⇨ 40% OUTDOOR AIR AT 50% LOAD

MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

IMPLICATIONS OF SUPPLY DUCT LEAKAGE – EXAMPLE CALCULATION

- FRACTION OF OUTDOOR AIR REACHING THE SPACE

  (1-LEAK FRACTION) * (1+(LEAK FRACTION)(1-OUTDOOR-AIR FRACTION))

- ANALYSIS – **FULL LOAD**

  = (1-0.2) * (1+(0.2)(1-0.2)) = 0.8*(1+0.2(0.8)) = **93% OF OA REACHES ROOM**

- ANALYSIS – **50% LOAD**

  = (1-0.3) * (1+(0.3)(1-0.4)) = 0.7*(1+0.3(0.6)) = **83% OF OA REACHES ROOM**

MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

IMPLICATIONS OF SUPPLY DUCT LEAKAGE – ENERGY

- ANALYSIS – **FULL LOAD**

  93% OF OA REACHES ROOM ⇨ NEED TO MOVE (1/0.93-1) = 8% MORE AIR ⇨

  20% MORE FAN ENERGY TO GET SAME OUTDOOR AIR AS AIRTIGHT SYSTEM

- ANALYSIS – **50% LOAD**

  83% OF OA REACHES ROOM ⇨ NEED TO MOVE (1/0.83-1) = 21% MORE AIR ⇨

  58% MORE FAN ENERGY TO GET SAME OUTDOOR AIR AS AIRTIGHT SYSTEM

MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

IMPLICATIONS OF SUPPLY DUCT LEAKAGE

- FRACTION OF VENTILATION AIR REACHING THE SPACE IS LOWER AT PART LOAD
- FRACTION OF VENTILATION AIR REACHING THE SPACE IS LOWER AT HIGHER OUTDOOR AIR FRACTIONS
- ACHIEVING THE DESIRED OUTDOOR AIR FLOWRATES TO THE SPACES REQUIRES MOVING MORE AIR AT THE FAN
- MOVING MORE AIR REQUIRES MORE ENERGY CONSUMPTION
- ALTERNATIVE IS TO EXPERIENCE HIGHER COVID-19 CONCENTRATIONS

MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

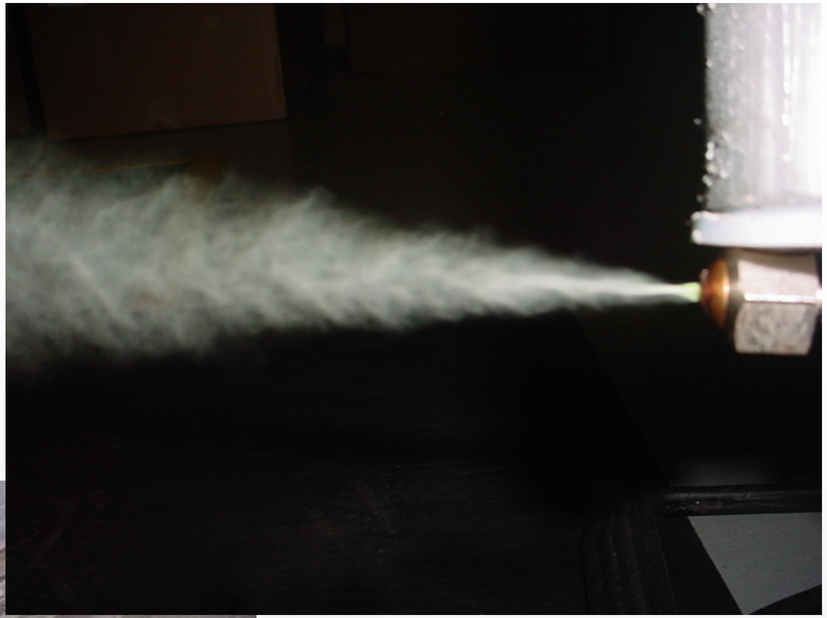
IMPLICATIONS OF EXHAUST DUCT LEAKAGE

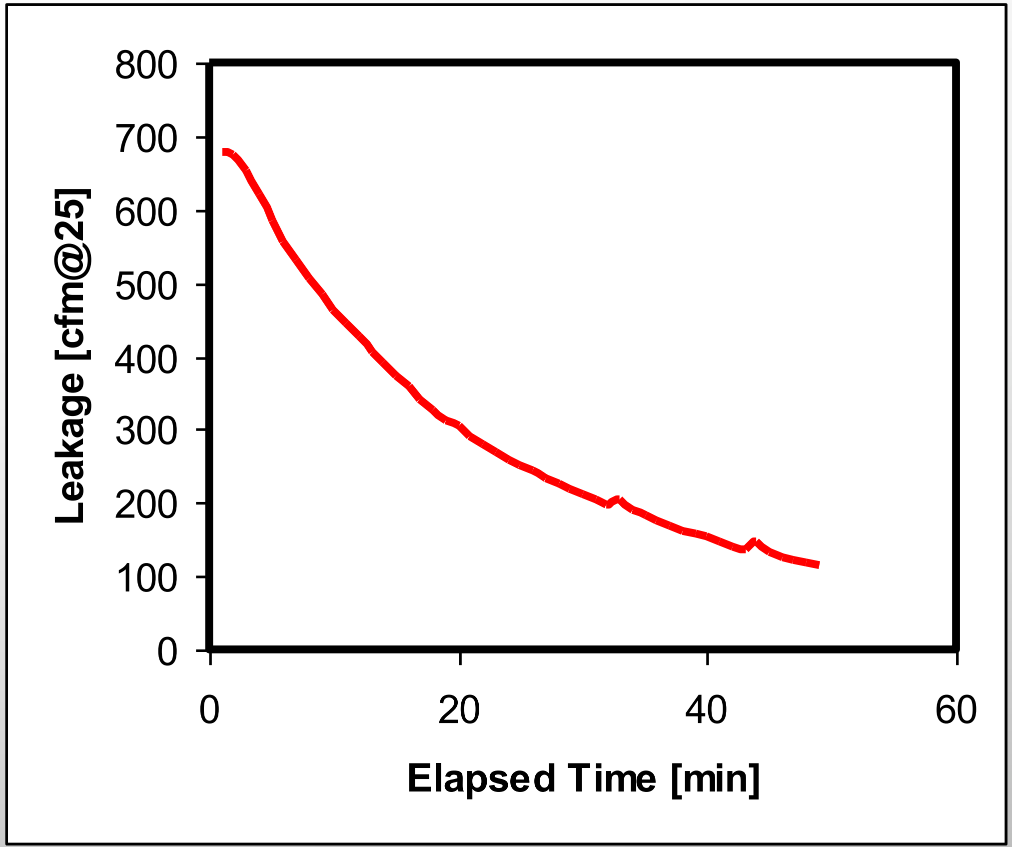
- **EXHAUST DUCT LEAKAGE REDUCES EXTRACTION OF COVID-19 FROM RESTROOMS**
- NEED TO INCREASE FLOW AT FAN TO GET SAME EXTRACTION
- FAN POWER GOES WITH CUBE OF FLOW RATE
  - **20% LEAKAGE** MEANS 25% MORE FLOW ⇨ **95% MORE FAN POWER**
- MOST OF THE TIME THIS ENERGY IMPLICATION WILL NOT BE REALIZED
  - FAN CANNOT KEEP UP
  - EXTRACTION IS LOWER

MEASURED EXHAUST SYSTEM LEAKAGE LEVELS

Building	Fan Flow [cfm]	Leakage [%]	Notes
Condominium (40-Story)	950	74%	Building-Cavity Bathroom Exhaust
NYS University Dorm (10-story)	2,300	70%	Bath/Shower Exhaust
NYS University Dorm (7-story)	2,050	54%	Bath/Shower Exhaust
Navy BEQ (10-story dorm)	6,300	18%	Ducted Supply w/heat wheel
Navy BEQ (10-story dorm)	6,470	54%	Building-Cavity Exhaust w/heat wheel
Barracks (8 3-story buildings)	20,000	20%	Bath/Shower Exhaust
Office Toilet Exhaust (3-story)	8,700	9%	No pre-qualification of leakage
Hospital Exhaust (9-story)	8,200	19%	Sterilization room riser
Seven NYC Apartment Exhausts	**2,450**	**36%**	**Kitchen/Bath Exhausts**
AVERAGE		**39%**	

ONE EXISTING-BUILDING OPTION - REMOTE SEALING WITH AEROSOLIZED SEALANT





REMOTE SEALING WITH AEROSOLS

CONCLUSIONS

- **Supply Duct Leakage** either reduces COVID dilution or results in larger energy use (or some of each)
- **Exhaust Duct Leakage** either reduces COVID dilution or results in larger energy use (or some of each)
- **Duct Leakage** can be addressed in existing buildings

Energy Efficiency and CDC/ASHRAE COVID-19 Guidance

1. Science: Updated Recommendations

2. Review CDC & ASHRAE guidelines

3. Science: Is Dilution Ventilation Effective?

4. What Guidelines Mean for Energy Efficiency

5. Strategies for Energy Efficiency

6. Guest Presenter: Dr. Mark Modera

7. Q&A

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