

EBC



Energy in Buildings and
Communities Programme

Building Energy Issues and the COVID-19 Response

May 5, 2020, 12:00 - 13:30 GMT

EBC Building Energy Codes Working
Group Webinar

Some Administrative Notes

- We are recording this webinar so that we can make it available to EBC members in the future. Your participation indicates your consent.
- We would like everyone to mute themselves to minimize extraneous noise.
- Please put questions in comments and we will go over as many as possible during the discussion section (see the chat function at the bottom of the screen).

Webinar Overview

- Goal: Discuss operational and construction issues related to energy use in buildings during the COVID-19 crisis
- Topics we will cover:
 - Safe operation of buildings and strategies countries are taking to maintain healthy indoor air quality (IAQ), including guidance from ASHRAE and REHVA
 - Broader issues facing the design and construction industry (e.g., compliance checking and leveraging opportunities for virtual assessments)
 - Opportunities/challenges for the building energy efficiency community, including opportunities for near- or long-term research

Agenda

- 12:00 Welcome and Introduction**
David Nemetzow, U.S. Department of Energy
Takao Sawachi, Building Research Institute, Japan
- 12:10 Infectious Aerosols and Impact of COVID-19 on HVAC Systems**
William Bahnfleth, Chair, ASHRAE Epidemic Task Force
- 12:25 Building Operations to Prevent the Spread of COVID-19**
Jarek Kurnitski, Chair, REHVA Technology & Research Committee
- 12:40 Global Perspectives: COVID-19 Challenges, Response, and Impact on Industry**
Paul Ruyssevelt, University College London
Jeremy Williams, U.S. Department of Energy
- 13:00 Open Discussion**
Moderator: Meredydd Evans, Pacific Northwest National Laboratory
- 13:25 Close**
David Nemetzow

Discussion Questions

1. What are the impacts of COVID-19 on building operations and construction across the EBC countries?
2. What are the opportunities and challenges for the building energy efficiency community of the current situation?
3. What do we know? What do we not know? How does this inform the specific research questions that are emerging as countries are trying to address COVID-19 in the building energy space?



ARCHITECTURAL
ENGINEERING

INFECTIOUS AEROSOLS AND IMPACT OF COVID-19 ON HVAC SYSTEMS

WILLIAM P. BAHNFLETH, PHD, PE, FASHRAE, FASME, FISIAQ
PROFESSOR OF ARCHITECTURAL ENGINEERING, PENN STATE
CHAIR, ASHRAE EPIDEMIC TASK FORCE

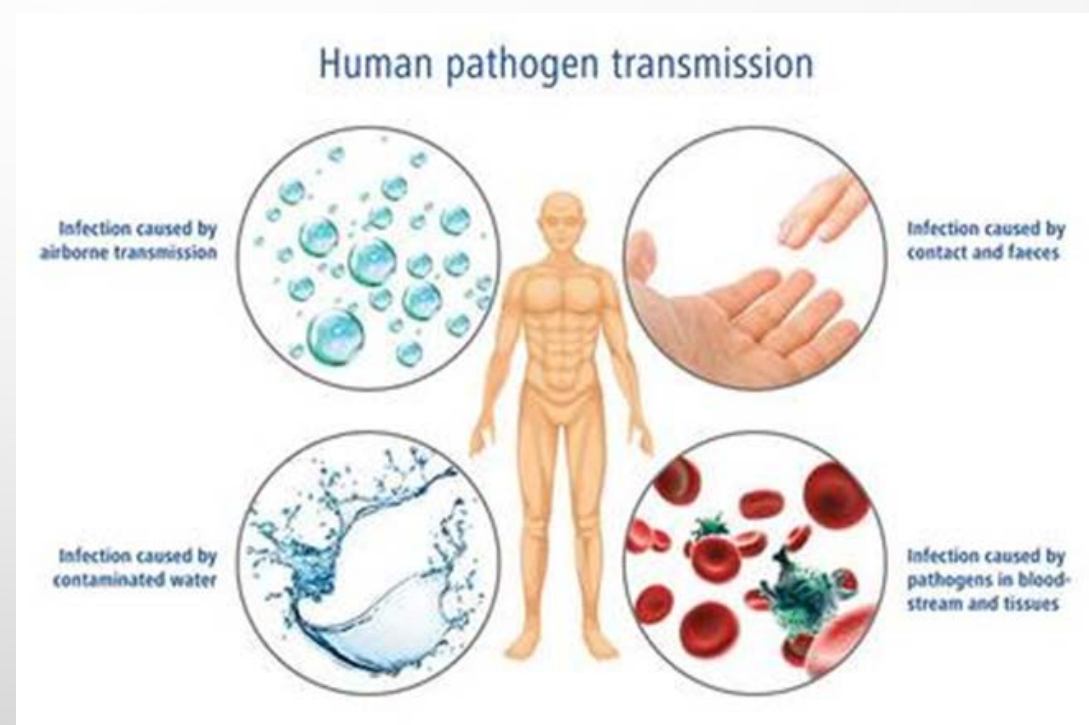
KEY POINTS

- Modes of infectious disease transmission
- Airborne/aerosol transmission of COVID-19
- HVAC systems and COVID-19
- HVAC systems and the future epidemics

INFECTIOUS DISEASE TRANSMISSION MODES

- Airborne
 - Large droplet/short range
 - Aerosol
- Fomite – intermediate surface
- Water/food
- Physical contact
- Insect/animal vector

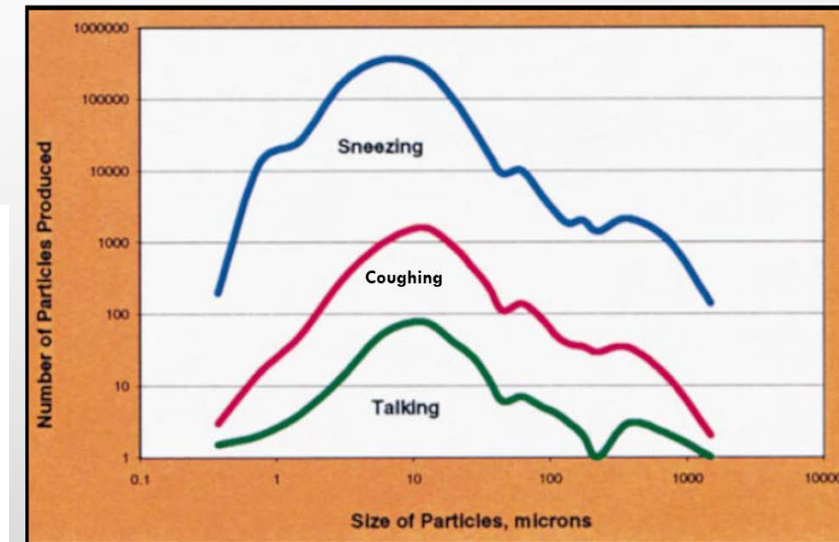
...HVAC mainly impacts aerosol and fomite transmission – only part of a solution



bode-science-center.com

PRODUCTION OF INFECTIOUS AEROSOLS

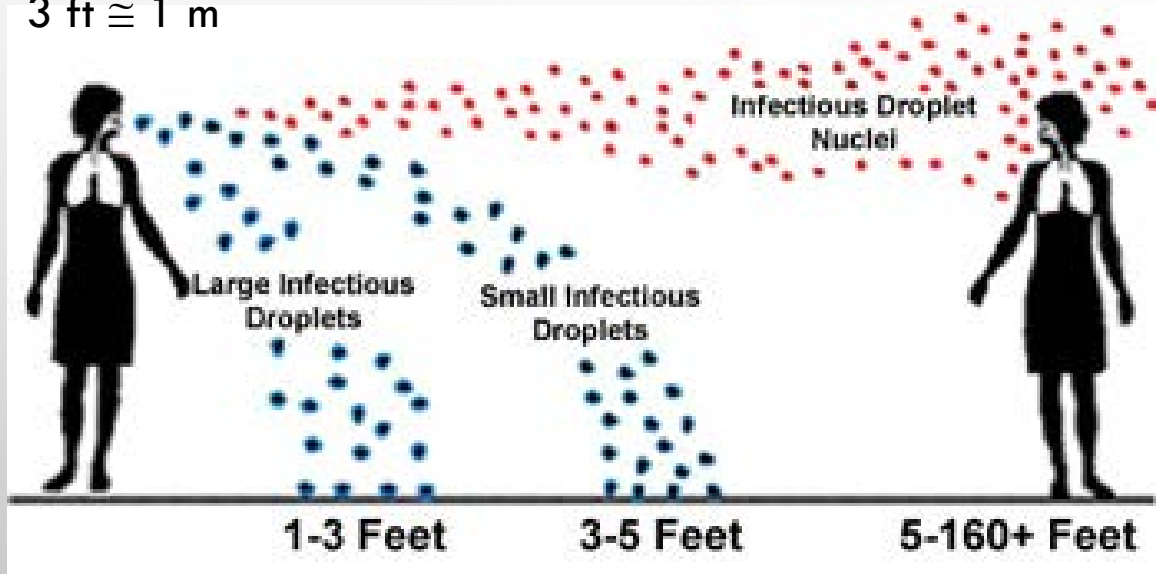
- Breathing, talking, singing, coughing, sneezing produce aerosols that may contain pathogens with a wide spectrum of sizes
- Although viruses like SARS-CoV-2 are very small ($O(100 \text{ nm})$), they typically exist in droplets and droplet residues
- Multiple recent studies find that more than 50% of shed viruses are in particles $<5 \mu\text{m}$



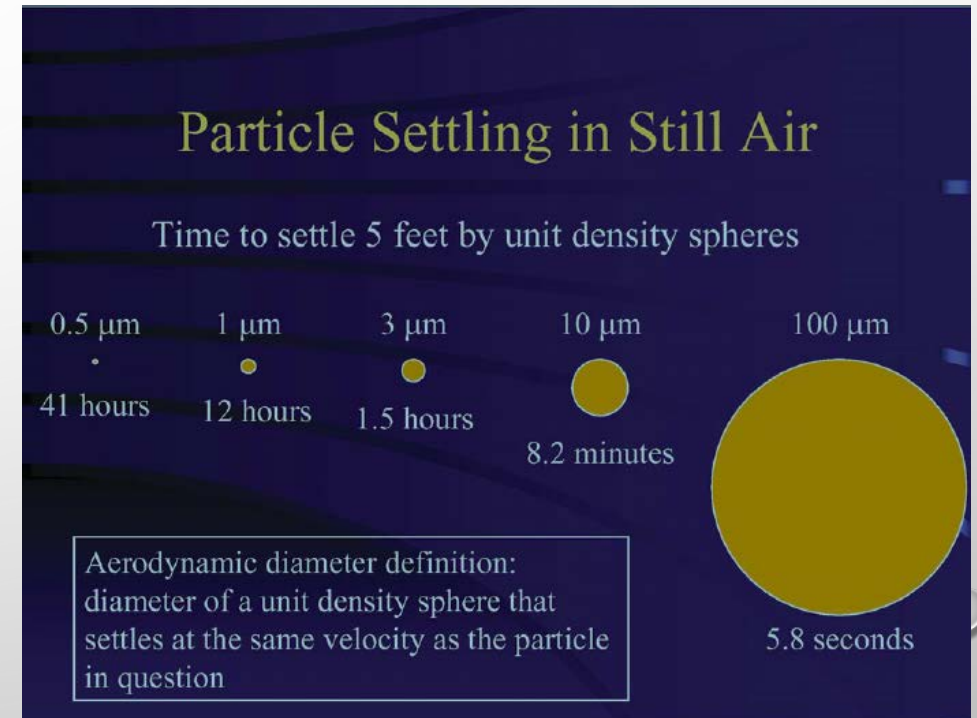
Duguid, et al. 1945

MANY RESPIRATORY PARTICLES CAN REMAIN AIRBORNE FOR HOURS, SARS-CoV-2 CAN SURVIVE FOR HOURS IN AIR

3 ft \cong 1 m



ASHRAE Position Document on Infectious Aerosols

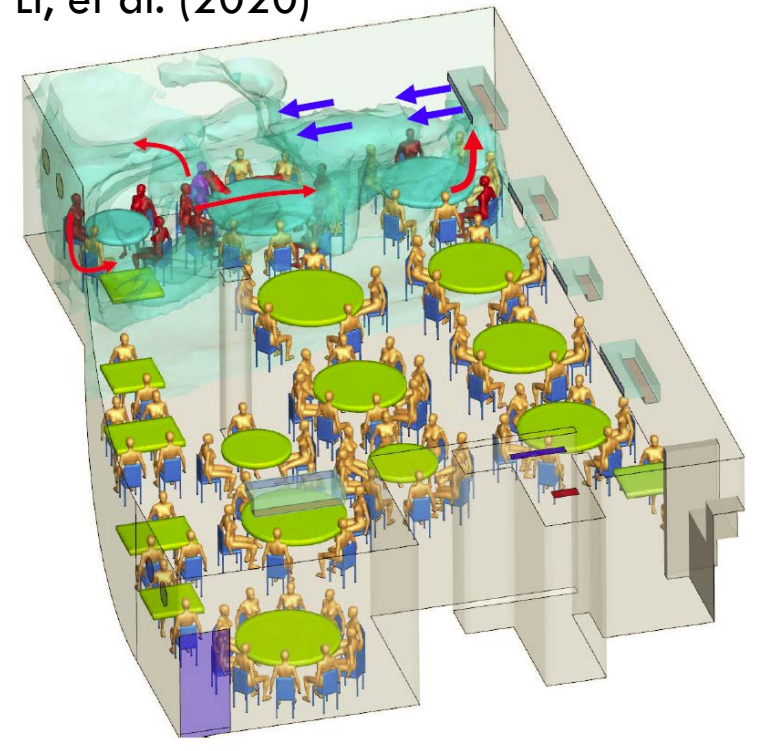


ASHRAE Position Document on Infectious Aerosols

CIRCUMSTANTIAL CASE FOR AEROSOL TRANSMISSION OF COVID-19 SEEMS STRONG, BUT PUBLIC HEALTH ORGANIZATIONS HAVE HIGH STANDARDS OF PROOF

- SARS outbreak associated with aerosol transmission through plumbing, within buildings, between buildings at Amoy Gardens
- Multiple “community spread” incidents with COVID-19, some investigated more thoroughly than others (e.g., Guangzhou restaurant)
- However, definitive data on source strength, infectious dose are not available yet
- If there is aerosol transmission, HVAC systems have potential to increase or decrease risk

Li, et al. (2020)



<https://www.medrxiv.org/content/10.1101/2020.04.16.20067728v1>

ASHRAE'S POSITION IS CONSERVATIVE

(LIKE MANY OTHER ORGANIZATIONS)

AIRBORNE TRANSMISSION

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.

OPERATION OF HVAC SYSTEMS

Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. *In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus.*

Source: [ashrae.org/covid19](https://www.ashrae.org/covid19)

IMPACTS OF COVID-19 ON HVAC

- “Healthcare” mindset suddenly applicable to all facilities...mostly not designed to implement it
- In the short term, limited repertoire of engineering/environmental controls to complement social distancing, hand hygiene, personal protective equipment
- Some measures...
 - increase energy use and cost
 - are expensive to implement
 - have potential to compromise operations or damage building and systems...implementation of high level guidance implies (demands) competent technical assistance

POSSIBLE HVAC OPERATIONAL CHANGES

- More outside air (ventilation)
 - Air flow control (pressurization -clean to less clean)
 - Enhanced filtration
 - Air disinfection (UVGI or?)
 - No recirculation (? – depends on multiple factors)
 - Humidification (? – mixed evidence, confirmation bias)
- Issues
 - Grasping at straws
 - The Devil is in the details – the problems of high-level/generic guidance
 - Lack of prioritization – must have vs. good to have
 - Today - protection is everything; Tomorrow – weighting of energy use, cost, cost-effectiveness will (should) increase
 - Still don't know what good IAQ is, especially with respect to microbial exposures

POST-PANDEMIC HVAC

- Changes to standards
 - Emphasis on health in non-healthcare standards
 - Higher bar for IAQ that presents challenges with respect to energy goals
 - Resilience as a fundamental design parameter
- Many research needs
 - IEQ criteria
 - Alternatives to ventilation that are less energy intensive
 - Flexible system operation
 - Monetization of benefits of infection control measures outside healthcare settings – epidemic response measures have every-day benefits



How to operate and use building services
in order to prevent the spread of the
coronavirus disease (COVID-19) virus
(SARS-CoV-2) in workplaces

May 5, 2020, Jarek Kurnitski
REHVA COVID-19 Task Force

Guidance for building services

- <https://www.rehva.eu/activities/covid-19-guidance>
- An addition to the general guidance for employers and building owners that is presented in the WHO document [‘Getting workplaces ready for COVID-19’](#).
- Intended primarily for HVAC professionals and facility managers
- The scope is limited to commercial and public buildings (e.g. offices, schools, shopping areas, sport premises etc) where only occasional occupancy of infected persons is expected
- Recommendations are based on best available evidence and knowledge, but in many aspects’ corona virus SARS-CoV-2 information is so limited or not existing that previous SARS-CoV-1 evidence needs to be utilized for best practice recommendations

Transmission routes

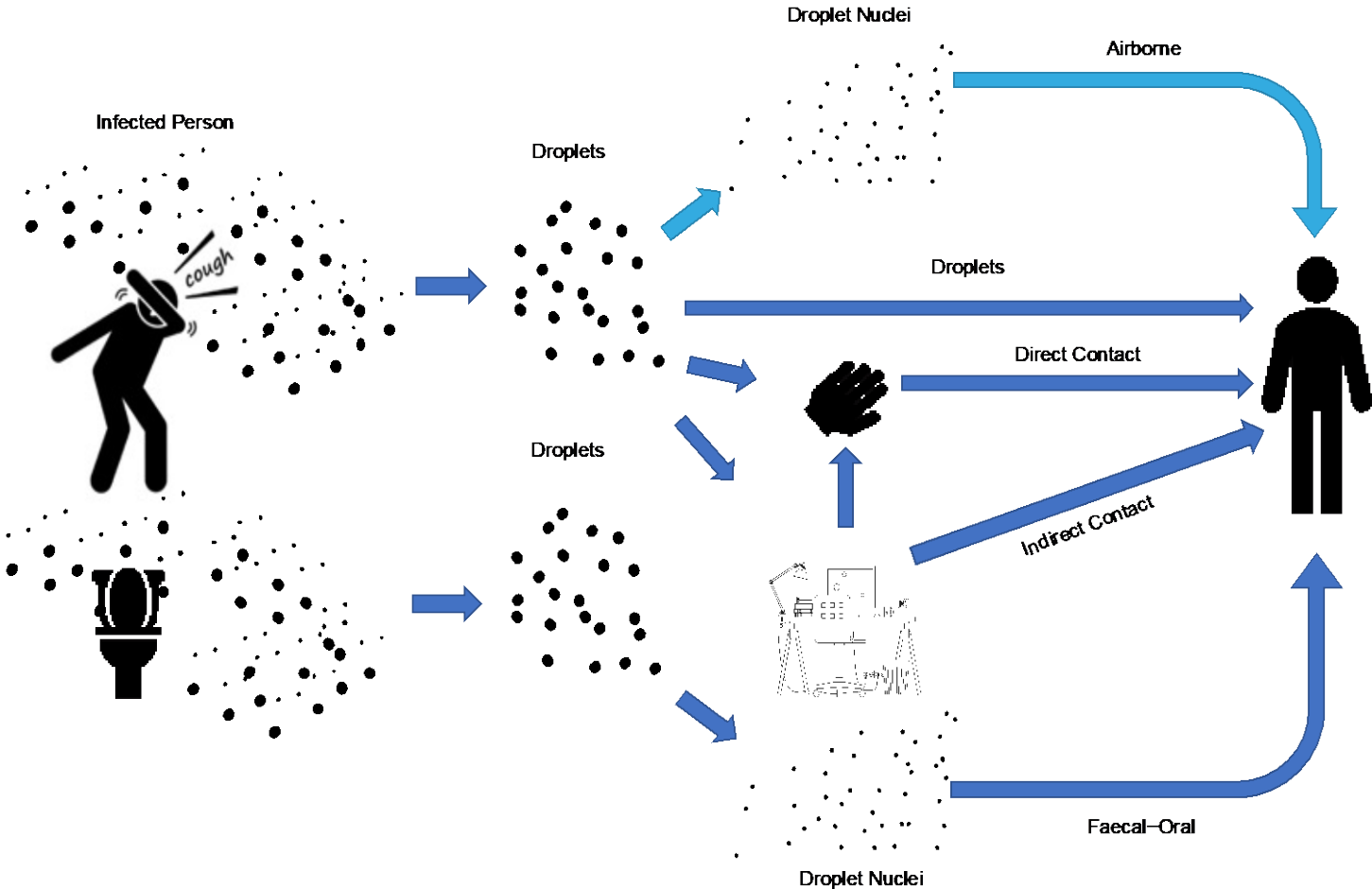
- (a) **viral particles** accumulate in the lungs and upper respiratory tract
- (b) **droplets and aerosolized viral particles** are expelled from the body through daily activities such as coughing, sneezing, talking, and non-routine events such as vomiting, and can spread to nearby surroundings and individuals
- (c) **Viral particles, excreted from the mouth and nose, are often found on the hands and**
- (d) **can be spread to commonly touched items**



Leslie Dietz et al, 2020 Novel Coronavirus (COVID-19) Outbreak: A Review of the Current Literature and Built Environment (BE) Considerations to Reduce Transmission

Transmission routes

- 1. Close contact, large droplets > 10 μm (<1 m distance), but rule of thumb 2 m
- 2. Airborne transmission, small particles, droplet nuclei < 5 μm stay airborne for hours
- 3. Via surface (fomite) contact
- 4. Faecal-oral route

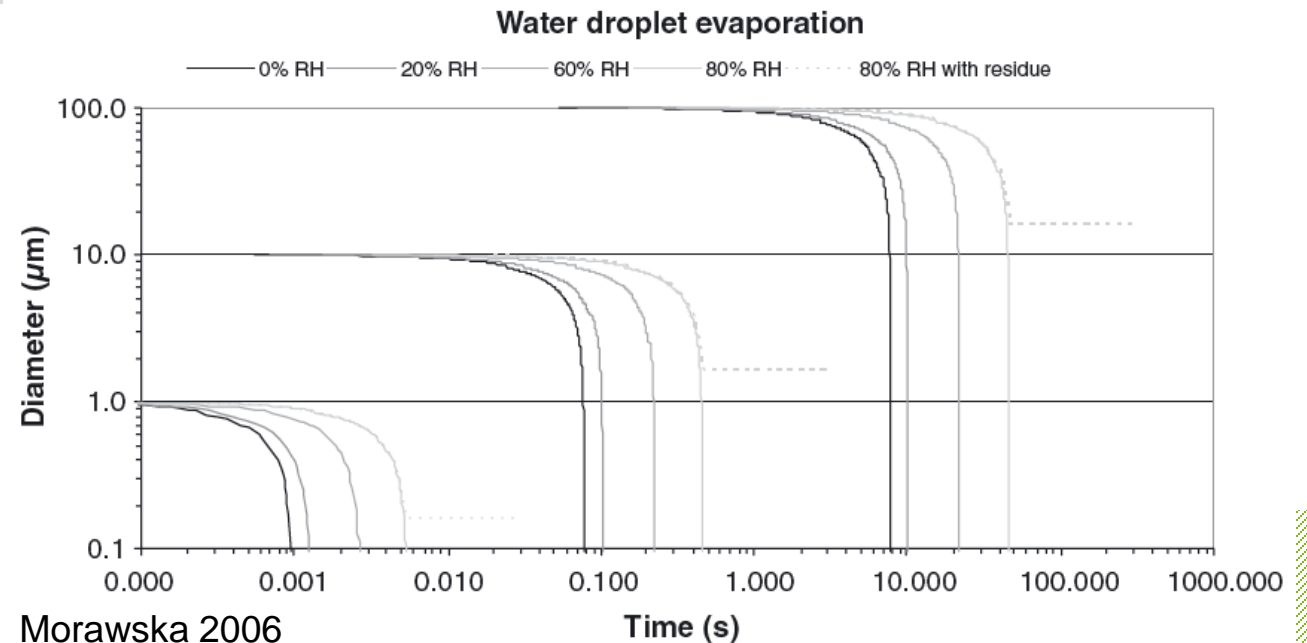
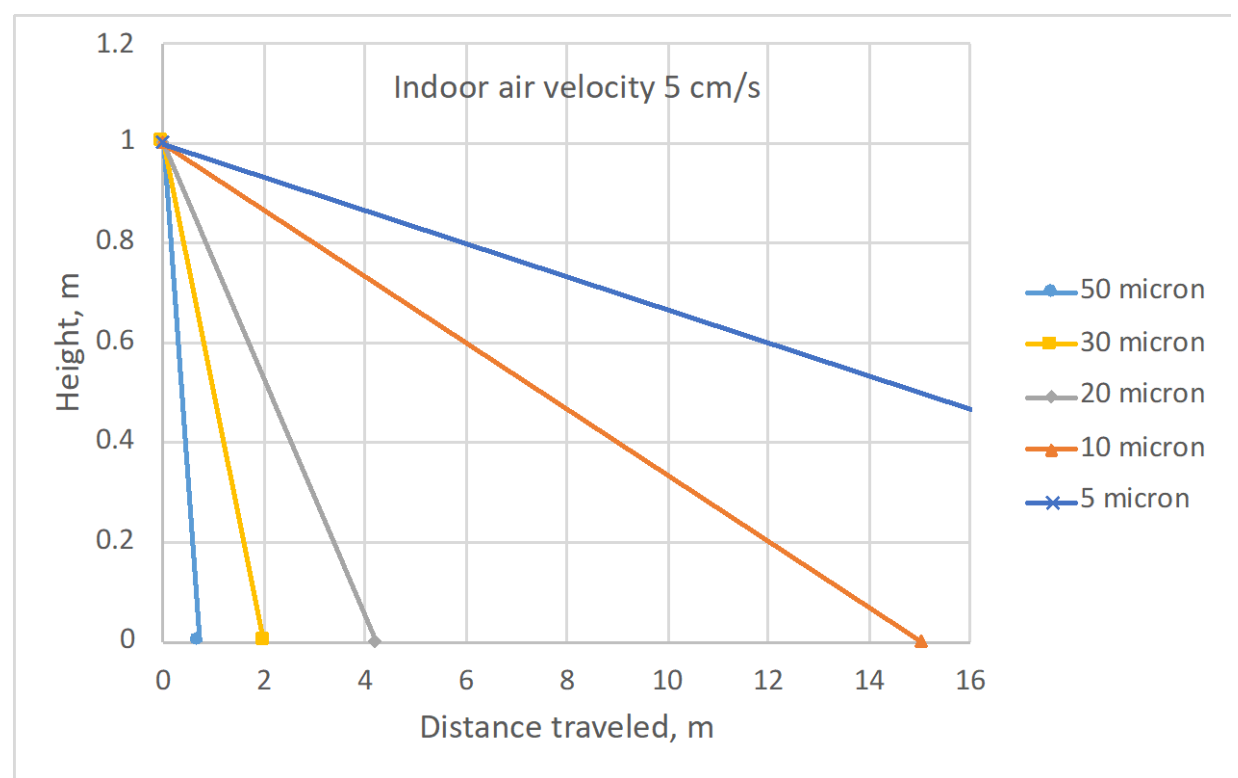


Dark blue: evidence exist

Light blue: evidence for SARS-CoV-1

Settling distance of droplets

- Small water droplets evaporate in milliseconds, even 10 μm in 0.2 s
- In the mixture of volatiles (mainly water) and nonvolatile substances the final diameter would be about half the initial diameter
- 1 μm to 100 μm range under interest, the rapid factor of 2 change in diameter often considered
- To estimate the settling distance of 1 m, low indoor air velocity 5 cm/s used (higher velocity will increase the distance)

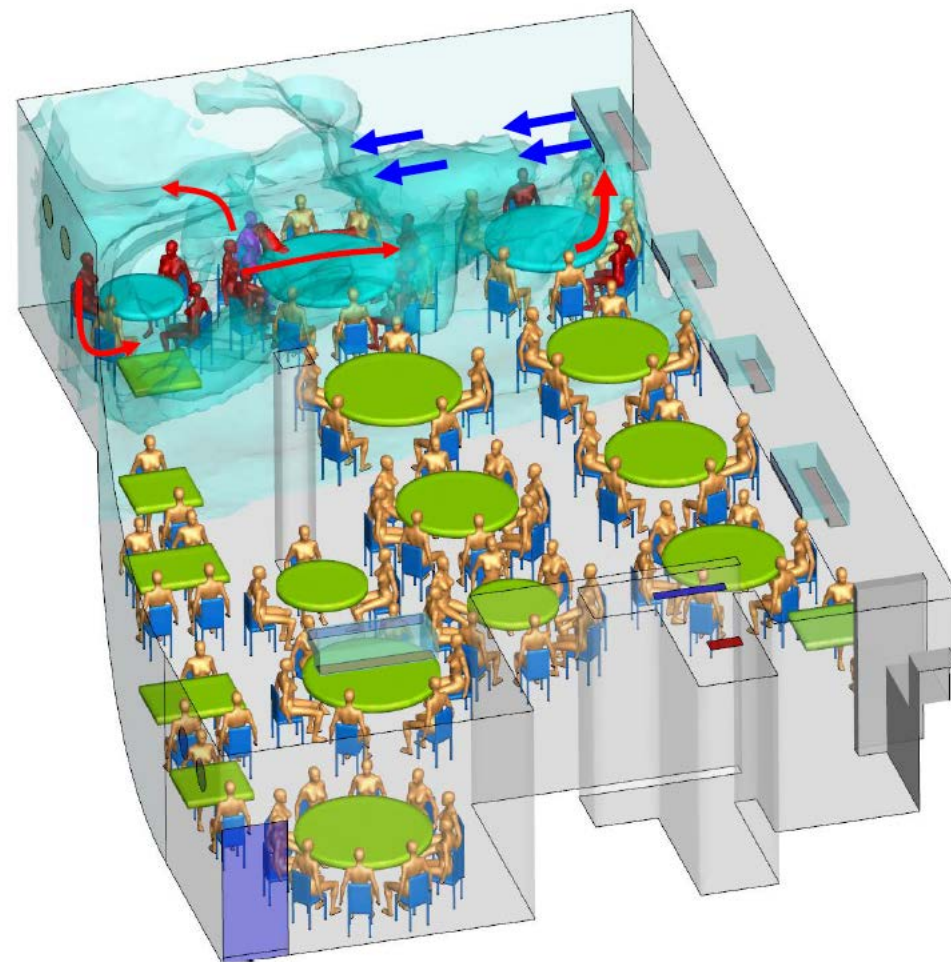


Airborne transmission indication

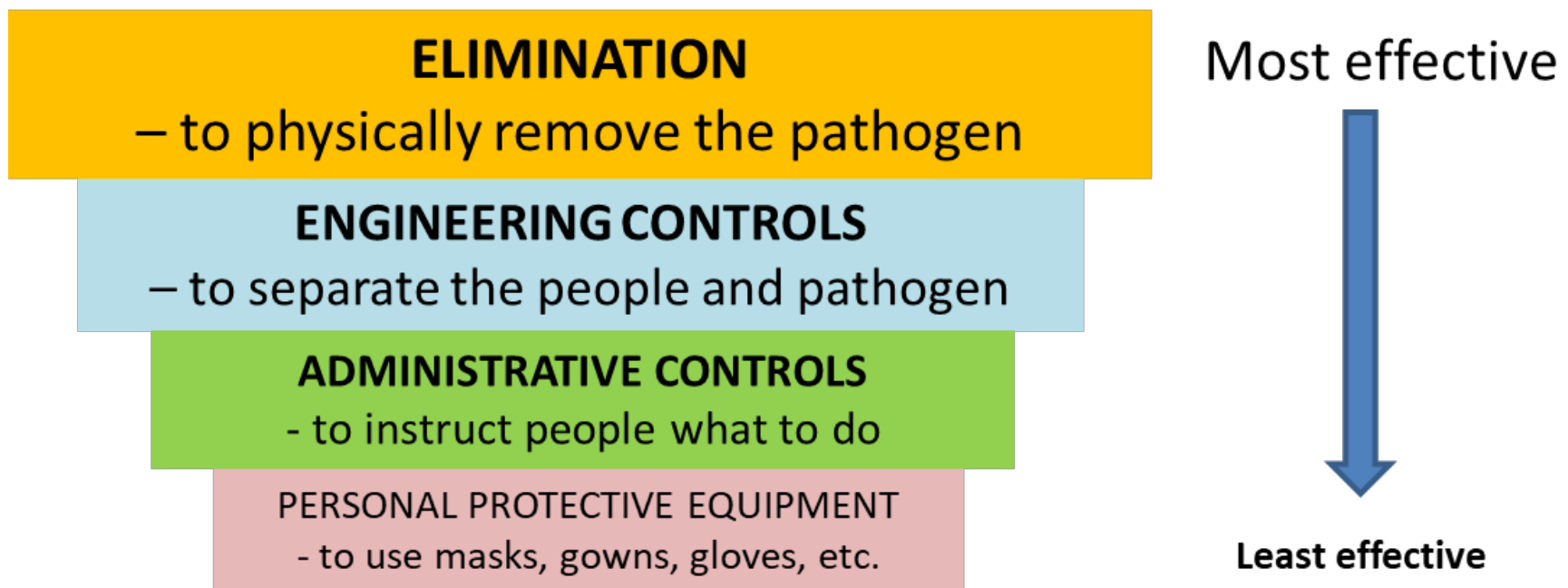
- Opportunistic airborne transmission of SARS-CoV-2 is seen plausible by Doremalen et al. 2020, but is generally currently recognized only in hospitals
 - Airborne transmission evidence for SARS in 2002/2003 for SARS-CoV-1 in Amoy Gardens, hospitals, hotels and residential homes
 - Nishiura et al. 2020 analyzed **superspreading events of SARS-CoV-2** and showed that **closed environments with minimal ventilation** strongly contributed to a characteristically high number of secondary infections
 - Allen and Marr 2020 conclude that evidence is emerging indicating that SARS-CoV-2 is also transmitted via airborne particles
 - Especially **crowded spaces with poor ventilation** need precautions
- Good justification to take a set of preventive mitigation measures and to apply ALARA principle (As Low As Reasonably Achievable) that help to also control the airborne route in buildings (apart from standard hygiene measures as recommended by WHO)

Example of a crowded space with poor ventilation

- Yuguo Li et al. 2020 preprint:
<https://doi.org/10.1101/2020.04.16.20067728>
 - Chinese restaurant, where ventilation about 1 L/s per person
 - An index patient infected 9 persons
 - Results show that the infection distribution is consistent with a spread pattern of exhaled virus laden aerosols driven by AC circulation airflow
- Hospital evidence: no infection risk at 2 m distance <https://doi.org/10.1016/j.scitotenv.2020.1384>
 - CO₂ measurement allow to estimate ventilation at least 36 L/s per person



Ventilation and building services guidance



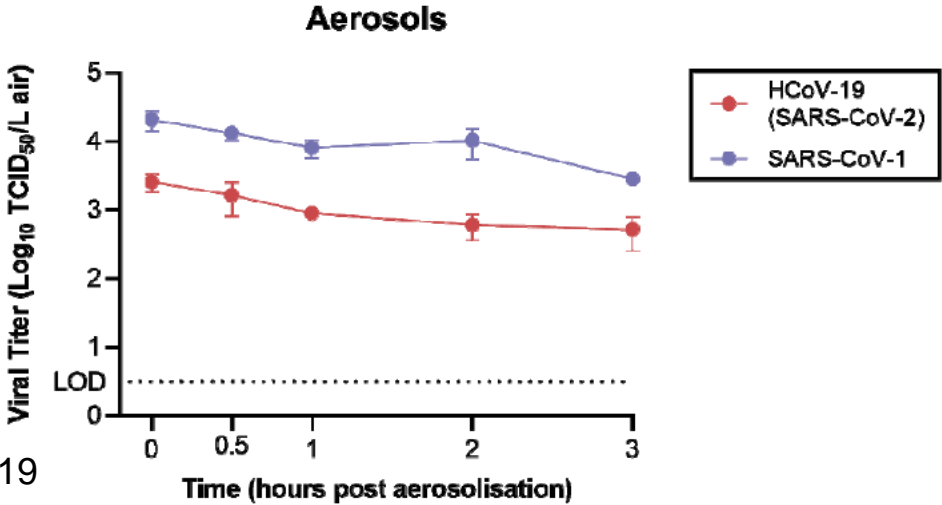
- Traditional infection control pyramid adapted from the US CDC (CDC 2015)
- Until vaccine and medicaments are not available, ventilation is No 1 infection control measure

Longer and continuous ventilation operation

- Extended operation times are recommended: Change the clock times of system timers to start ventilation at nominal speed at least 2 hours before the building usage time and switch to lower speed 2 hours after the building usage time
- Do not switch off ventilation at nights and weekends, but operate at lowered speed
- Extended ventilation will remove virus particles from air and also released virus particles from surfaces out the building
- The general advice is to supply as much outside air as reasonably possible. **The key aspect is the amount of fresh air supplied per person**
- Enlarge the spacing among employees (min physical distance 2-3 m between persons) in order to foster the ventilation cleaning effect
- Exhaust ventilation systems of toilets should always be kept on 24/7, and make sure that under-pressure is created, especially to avoid the faecal-oral transmission

Humidification and air-conditioning have no practical effect

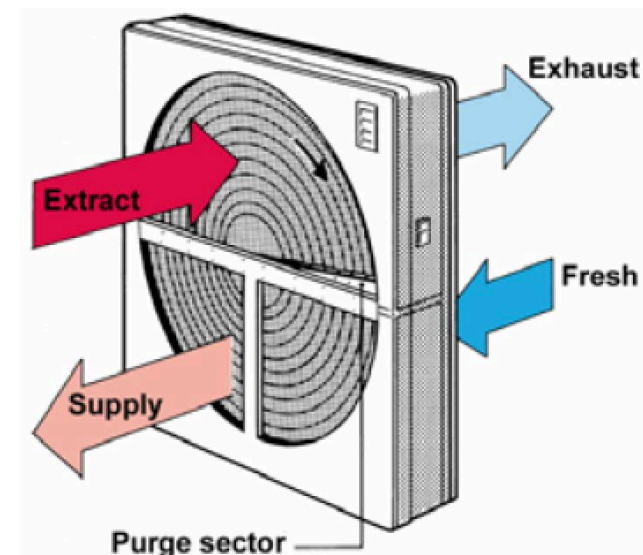
- SARS-CoV-2 stability (viability) has been tested at typical indoor temperature of 21-23 °C and RH of 65% with very high virus stability at this RH. Together with previous evidence on MERS-CoV it is well documented that humidification up to 65% may have very limited or no effect on stability of SARS-CoV-2 virus.
- Therefore, the evidence does not support that moderate humidity (RH 40-60%) will be beneficial in reducing viability of SARS-CoV-2, thus the humidification is NOT a method to reduce the viability of SARS-CoV-2.
- SARS-CoV-2 has been found highly stable for 14 days at 4 °C; 37 °C for one day and 56 °C for 30 minutes were needed to inactivate the virus (Chin et al, 2020)
- AC has no effect in this context (recirculation excluded)



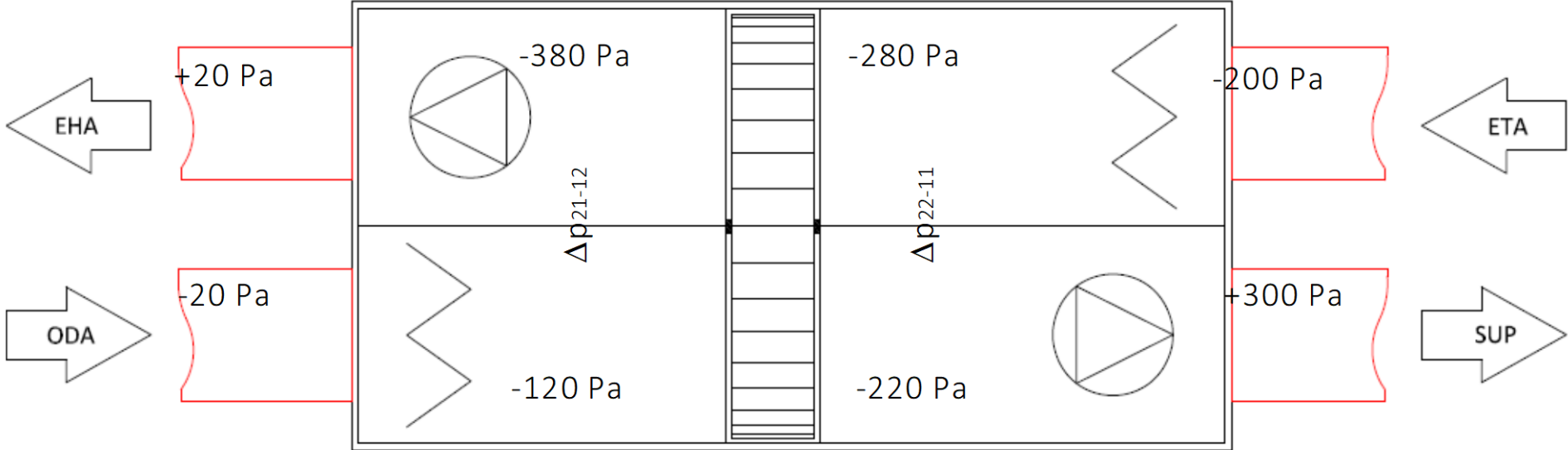
van Doremalen et al. 2020 Aerosol and surface stability of HCoV-19 (SARS-CoV-2) compared to SARS-CoV-1 (RH 65%)

Safe use of heat recovery sections

- Under certain conditions virus particles in extract air can re-enter the building. Heat recovery devices may carry over virus attached to particles from the exhaust air side to the supply air side via leaks.
- In the case of regenerative heat exchangers (rotors) the minimal leakage (seals + carry over) and correct pressure difference between exhaust and supply side are important
- The leakage, carrying over also particles, may increase from the 2% to 20% if fans create higher pressure on the exhaust air side
- Evidence suggest that rotors with adequate purge sector practically do not transfer particles, but the transfer is limited to gaseous pollutants (e.g. smells, tobacco smoke)
- Because the leakage does not depend on the rotation speed, it is not needed to switch rotors off. If needed, the pressure differences can be corrected by dampers or by other arrangements.



Safe use of heat recovery sections



Example of pressure measurement with correct pressure differences

Source: Eurovent Recommendation 6-15 (available/coming soon)

No use of recirculation

- Virus particles in return ducts can also re-enter a building when centralized air handling units are equipped with recirculation sectors (may be in use at least in older all-air heating and cooling systems)
- Recirculation dampers should be closed (via the Building Management System or manually)
- Recirculation air filters are not a reason to keep recirculation dampers open as these filters do not filter out particles with viruses effectively since they have standard efficiencies and not HEPA efficiencies
- When possible, decentralized systems such as fan coil units that use local recirculation, also should be turned off to avoid resuspension of virus particles at room level (esp. when rooms are used normally by more than one occupant)
- If fan coils cannot be switched off because of heating/cooling needs, it is recommended that their fans are operated continuously because the virus can sediment in filters and resuspension boost can follow when the fan is turned on

Filtration and air cleaners

- Outdoor air filters (filter class F7 or F8 or ISO ePM1) do not operate in the capture range of viruses - the size of a coronavirus particle of 80-160 nm (PM0.1) is smaller than the capture area of F8 filters (capture efficiency 65-90% for PM1)
- Outdoor air is not a source of viruses, thus no need to replace filters
- No need to clean ventilation ductworks as well
- In the case of air cleaners, to be effective, HEPA filter efficiency is needed
- Air cleaners with electrostatic filtration principles (not the same as room ionizers!) often work quite well too
- Because of limited airflow through air cleaners, the floor area they can effectively serve is normally quite small, typically less than 10 m² - to be located close to breathing zone
- Maintenance personnel needs to apply common protective measures when replacing filters including respirators, because filters may have active microbiological material on them

Summary of practical measures for HVAC operation

1. Secure ventilation of spaces with outdoor air
2. Switch ventilation to nominal speed at least 2 hours before the building usage time and switch to lower speed 2 hours after the building usage time
3. At nights and weekends, do not switch ventilation off, but keep systems running at lower speed
4. Ensure regular airing with windows (even in mechanically ventilated buildings)
5. Keep toilet ventilation 24/7 in operation
6. Avoid open windows in toilets to assure the right direction of ventilation
7. Instruct building occupants to flush toilets with closed lid
8. Switch air handling units with recirculation to 100% outdoor air
9. Inspect heat recovery equipment to be sure that leakages are under control
10. Switch fan coils either off or operate so that fans are continuously on
11. Do not change heating, cooling and possible humidification setpoints
12. Do not plan duct cleaning for this period
13. Replace central outdoor air and extract air filters as usually, acc. to maintenance schedule
14. Regular filter replacement and maintenance works shall be performed with common protective measures including respiratory protection

REHVA COVID-19 Task Force

Colophon

This document was prepared by a group of REHVA volunteers, the first version in the period March 6-15th 2020.
Members of the expert group are:

Prof. Jarek Kurnitski, Tallinn University of Technology, Chair of REHVA Technology and Research Committee

Atze Boerstra, REHVA vice-president, managing director bba binnenmilieu

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This document was reviewed by Prof. Yuguo Li from the University of Hongkong, Prof. Shelly Miller from the University of Colorado Boulder, Prof. Pawel Wargocki from the Technical University of Denmark and Prof. Lidia Morawska from the Queensland University of Technology.

TRANSFORMING CONSTRUCTION NETWORK PLUS



COVID-19 Construction Impact and Recovery in the UK

Professor Paul Ruyssevelt

Energy Institute

University College London

Agenda

- Impact
- Short term action and support
- Performance gap
- Recovery
- The future

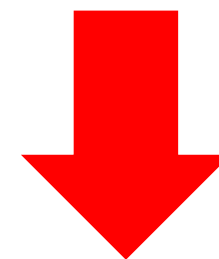
COVID-19 Impact

Coronavirus (COVID-19) continues to have a dramatic and unavoidable impact on businesses across the construction industry, many of them SMEs:

- Fastest downturn in UK construction output for almost eleven years
- Safe working practices such as social distancing, handwashing and additional PPE slow and in many case prevent project progress
- Contractual implications are uncertain
- Planning applications continuing with virtual committee meetings
- Building Regulations (codes) applications slowed and on-site checks restricted by application of new guidance

Total
Activity
Index

52.6



39.3

Lowest
for 11 yrs

Short-term action and support

Many contractors and employees without work:

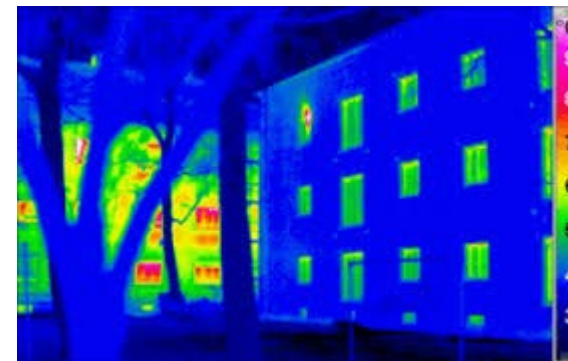
- Coronavirus Business Interruption Loan Scheme
- Coronavirus Large Business Interruption Loan Scheme
- Coronavirus Job Retention Scheme – employed staff furloughed with 80% salary support from government
- Self-employed scheme for sole-traders provides 80% of previous years monthly income



Implications for compliance?

Performance gap:

- Performance gap between design and operation already significant, with variations of +20% to +200% not uncommon
- Restricted working practices could make good quality construction difficult to achieve
- Reduced or restricted compliance checks may impact on quality
- Could result in increased performance gap for buildings constructed during lock-down and afterwards



Recovery?

Pre Covid-19:

- Major requirement for low carbon retrofit
- Major challenge to replace gas boilers (furnaces) with electric heat pumps to decarbonise heat
- Government commitment to level-up more deprived regions (mainly in the north)



Post Covid-19 lock down:

- Need to stimulate and grow economy
- Need to increase and enhance more advance skills
- Invest in infrastructure (but major projects such as HS2 are slow burn and focused in certain regions)
- Accommodate social distancing and other restrictions

The future?

New ways of working:

- Increased off-site manufacture
- Reduce manual operations on-site and increased automated construction
- Digital project progress monitoring
- Reduce waste
- Build-in guaranteed performance with IoT and operational BIM
- Mass customisation for retrofit

>>>Transforming Construction



TRANSFORMING CONSTRUCTION NETWORK PLUS

<https://www.ucl.ac.uk/bartlett/construction/about-us/transforming-construction-network-plus>

(Easier to google: UCL Network Plus)

Paul Ruyssevelt

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RENEWABLE ENERGY**

Impact of COVID-19 on Construction in the U.S.

Building Energy Issues and the COVID-19 Response

EBC Building Energy Codes Working Group

JEREMY WILLIAMS, U.S. Department of Energy



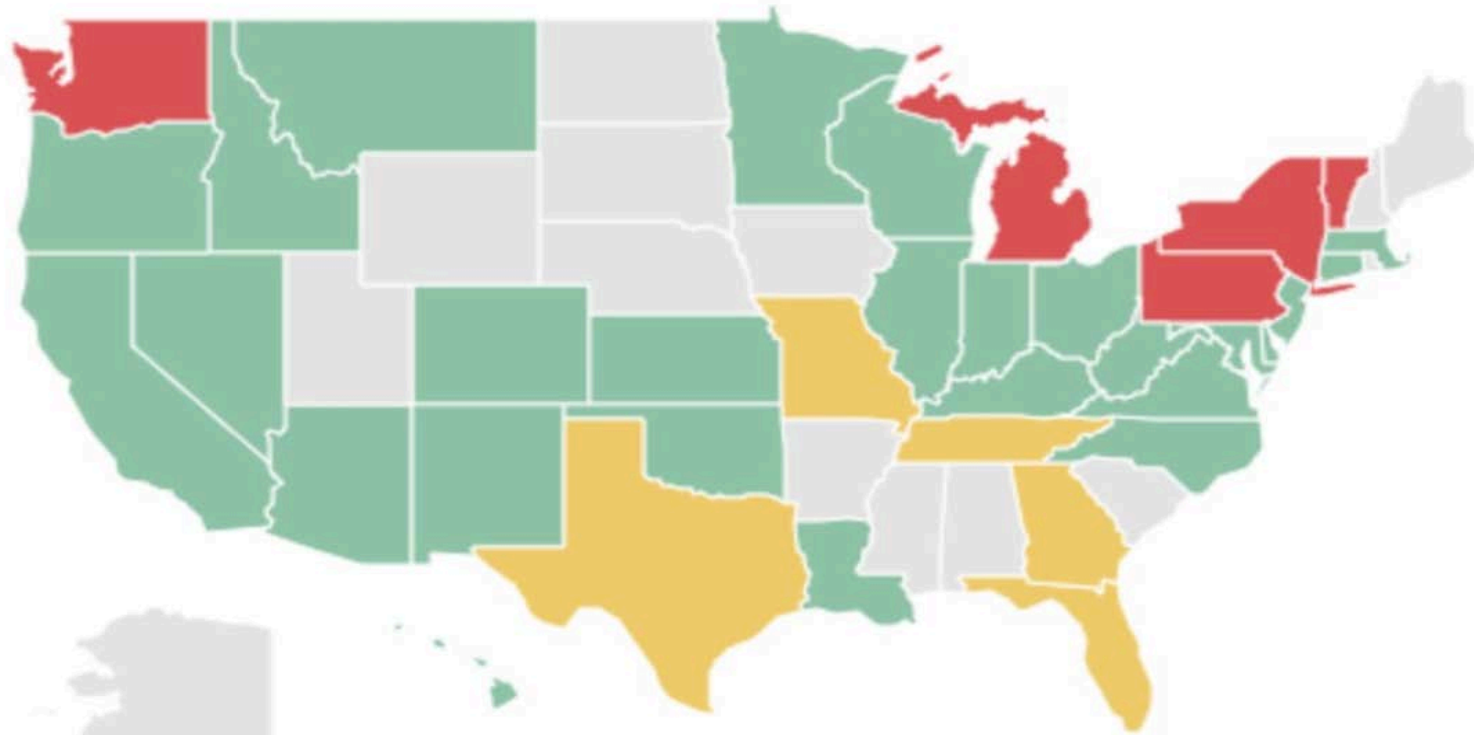
INTRODUCTION

Several important questions...

- + How has the design and construction industry in the U.S. been affected by COVID-19?
- + What is the impact on building energy codes?
- + Can virtual technologies help the industry continue to build and recover?

Construction is a major contributor to the U.S. economy—over **7 million workers** and **\$1.3T annually**

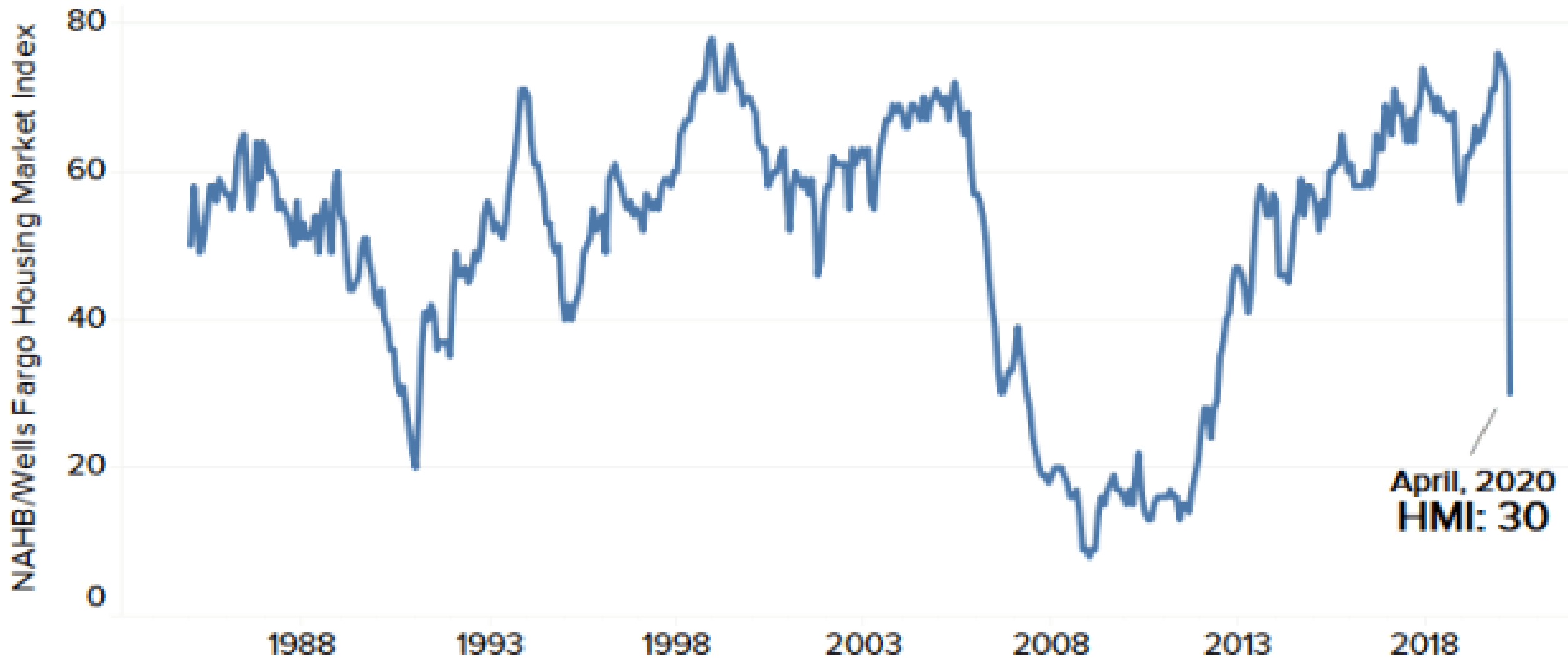
SOURCE: <https://www.agc.org/learn/construction-data>



- No Statewide Order
- No Statewide Order, But Local Order
- Statewide Order with Construction Exempted
- Statewide Order with Construction NOT Exempted

<https://www.nahb.org/Advocacy/Industry-Issues/Emergency-Preparedness-and-Response/Coronavirus-Preparedness/Stay-on-the-Jobsite>

Homebuilder sentiment plunges



April, 2020
HMI: 30

<https://www.cnbc.com/2020/04/15/coronavirus-homebuilder-confidence-takes-biggest-one-month-dive-in-history.html>

SOURCE: National Association of Homebuilders/Wells Fargo monthly survey



What does COVID-19 mean for code compliance?

International Code Council (ICC) survey of local building departments:

- + 1,158 respondents across all 50 U.S. states
- + Range in population from 1,000 to 4.6 million people

FINDINGS:

- + 93% of local building departments continue performing inspections—either remotely or in person
- + 65% said at least some inspectors are working remotely
- + 7% of jurisdictions use *all* electronic code formats
- + 40% do not have capability to do remote plan reviews
- + 26% have encountered requests to permit temporary facilities to combat COVID-19 (e.g., gymnasiums, hotels, outpatient clinics)

SOURCE: <https://www.iccsafe.org/wp-content/uploads/Code-Official-Survey-White-Paper.pdf>

Virtual and Remote Inspections

INTERNATIONAL CODE COUNCIL (ICC):

- + Determine a list of eligible project types and scheduling process
- + Determine which live video and other applications it will allow
- + Steps for conducting a virtual inspection process—many start at the curb or a nearby cross-street
- + Will an in-person follow-up site visit be necessary?
- + Determine whether a homeowner release will be needed
- + And some projects are simply not conducive to virtual inspection...

SOURCE:

https://www.iccsafe.org/wp-content/uploads/20-18670_GR_Building_Safety_COVID-19_Inspection_FINAL_HIRES.pdf

Virtual and Remote Inspections

Common tools used for virtual inspections:

- + **Mobile devices:** Tablets and phones with video chat capability to demonstrate various features (e.g., FaceTime, Skype, Zoom, WebEx)
- + **Photographs:** Email to building department (or traditional mail)
- + **Checklists:** Task-specific lists help guide the inspection
- + **Tools:** Be prepared to use jobsite tools to demonstrate particular attributes to the inspector (e.g., tape measure, level, electric tester)
- + **Drones:** Sometimes an option—can be operated by nearby inspectors

SOURCE:

<https://www.swenergy.org/how-building-departments-are-pivoting-with-the-covid-19-crisis>

[Southwest Energy Efficiency Project]

Virtual and Remote Inspections

Typical building components and systems allowed for virtual inspection:

- + HVAC and water heaters
- + Insulation, windows, doors
- + Pools and spas
- + Solar systems
- + Electrical panel changeouts
- + Roofing
- + Decks and patios

SOURCE:

<https://www.swenergy.org/how-building-departments-are-pivoting-with-the-covid-19-crisis>

[Southwest Energy Efficiency Project]

Virtual and Remote Inspections

Example jurisdictions currently using virtual inspection processes:

- + Tucson, Arizona
- + Los Angeles County, California
- + Boulder County, Colorado
- + Las Vegas and Clark County, Nevada
- + City of Austin, Texas
- + Arlington County, Virginia

SOURCE: [International Code Council and Southwest Energy Efficiency Project](#)

Also being relied upon currently by a range of above-code programs, including [RESNET HERS Ratings](#), [ENERGY STAR for Homes](#), [Zero Energy Ready Homes](#)

Is there a longer-term role for virtual inspections?

- + Jurisdictions are often constrained by financial/personnel resources—time and cost of performing inspections can be cumbersome
- + May be an option to increase capabilities for under-staffed agencies
- + Code compliance can suffer during times of increased construction activity (e.g., economic booms or rebuilding periods)
- + Quality can suffer due to limitations of the virtual format
- + Attractive option in many applications—particularly, re-inspections or other straight-forward inspections where little verification is required
- + Should focus on critical items (e.g., high-impact energy efficiency measures)
- + Anytime building departments are confronted with a threat to health or safety—due to the effects of COVID-19 or beyond

Additional Resources

International Code Council (ICC): Coronavirus Response Center:

<https://www.iccsafe.org/advocacy/coronavirus-response-center/>

+ [Considerations for Electronic Permitting and Plan Review](https://www.iccsafe.org/wp-content/uploads/20-18673_GR_Building_Safety_COVID-19_Permitting_Final_hires.pdf)

https://www.iccsafe.org/wp-content/uploads/20-18673_GR_Building_Safety_COVID-19_Permitting_Final_hires.pdf

+ [Considerations for Virtual and Remote Inspections](https://www.iccsafe.org/wp-content/uploads/20-18670_GR_Building_Safety_COVID-19_Inspection_FINAL_HIRES.pdf)

https://www.iccsafe.org/wp-content/uploads/20-18670_GR_Building_Safety_COVID-19_Inspection_FINAL_HIRES.pdf

ASHRAE: COVID-19 Technical Resources:

<https://www.ashrae.org/technical-resources/resources>

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JEREMY WILLIAMS

Building Technologies Office
U.S. Department of Energy
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Discussion Questions

1. What are the impacts of COVID-19 on building operations and construction across the EBC countries?
2. What are the opportunities and challenges for the building energy efficiency community of the current situation?
3. What do we know? What do we not know? How does this inform the specific research questions that are emerging as countries are trying to address COVID-19 in the building energy space?