Passivhaus and Covid-19: ventilation issues

- Introduction (Hands, Face, Space…)
- Covid Transmission
- Aerosols
- Ventilation mixing and displacement.
- Discussion

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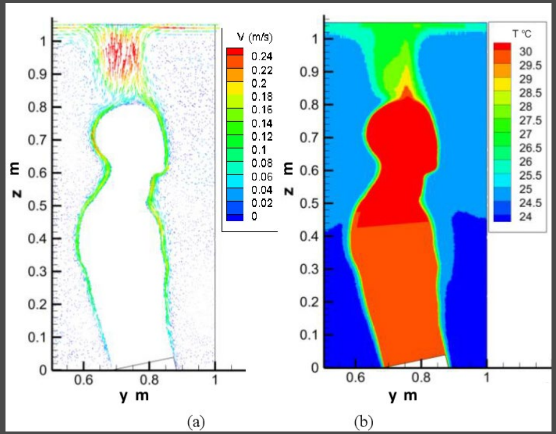
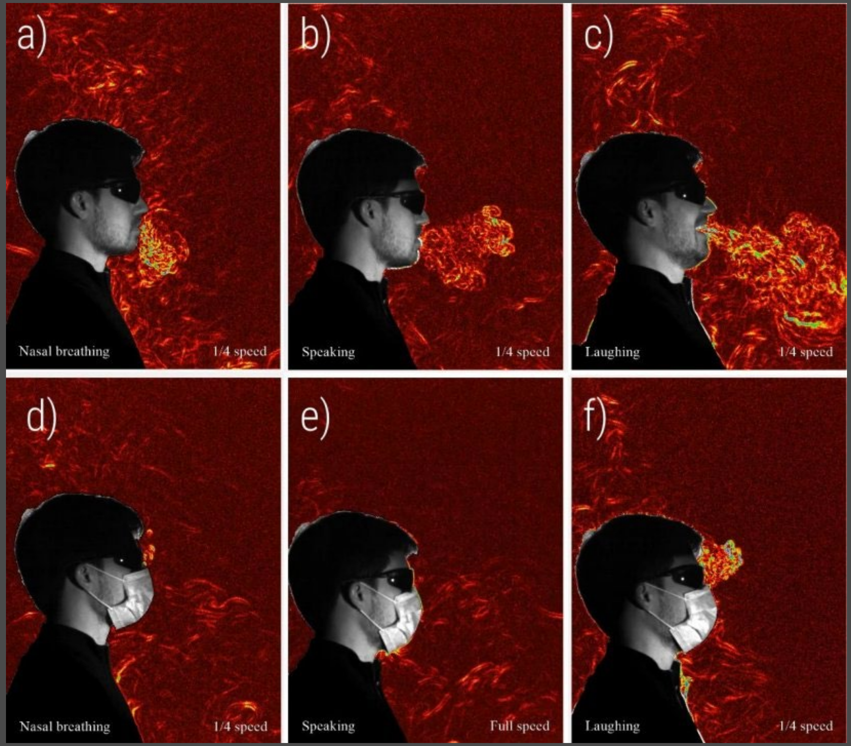
GREENGAUGE

THE RELATIVE SIZE
OF PARTICLES
From the COVID-19 pandemic to the U.S. West Coast wildfires, some of the biggest threats now are also the most microscopic.
A particle needs to be 10 microns (µm) or less before it can be inhaled into your respiratory tract. But just how small are these specks?
Here's a look at the relative sizes of some familiar particles ↘
HUMAN HAIR 50-180µm ›
FOR SCALE
FINE BEACH SAND 90µm ›
GRAIN OF SALT 60µm ›
WHITE BLOOD CELL 25µm ›
GRAIN OF POLLEN 15µm ›
DUST PARTICLE (PM10) <10µm ›
RED BLOOD CELL 7-8µm ›
RESPIRATORY DROPLETS 5-10µm ›
DUST PARTICLE (PM2.5) 2.5µm ›
BACTERIUM 1-3µm ›
WILDFIRE SMOKE 0.4-0.7µm ↘
CORONAVIRUS 0.1-0.5µm ↘
T4 BACTERIOPHAGE 0.225µm ↘
ZIKA VIRUS 0.045µm ›
Pollen can trigger allergic reactions and hay fever—which 1 in 5 Americans experience every year.
The visibility limits for what the naked eye can see hovers around 10-40µm.
Respiratory droplets have the potential to carry smaller particles within them, such as dust or coronavirus.
Wildfire smoke can persist in the air for several days, and even months.
SOURCES
COLLABORATORS
VISUAL CAPITALIST
/visualcapitalist @visualcap visualcapitalist.com

Thermal Plumes





Images Sourced: Bhagat et al., Journal of Fluid Mechanics 2020

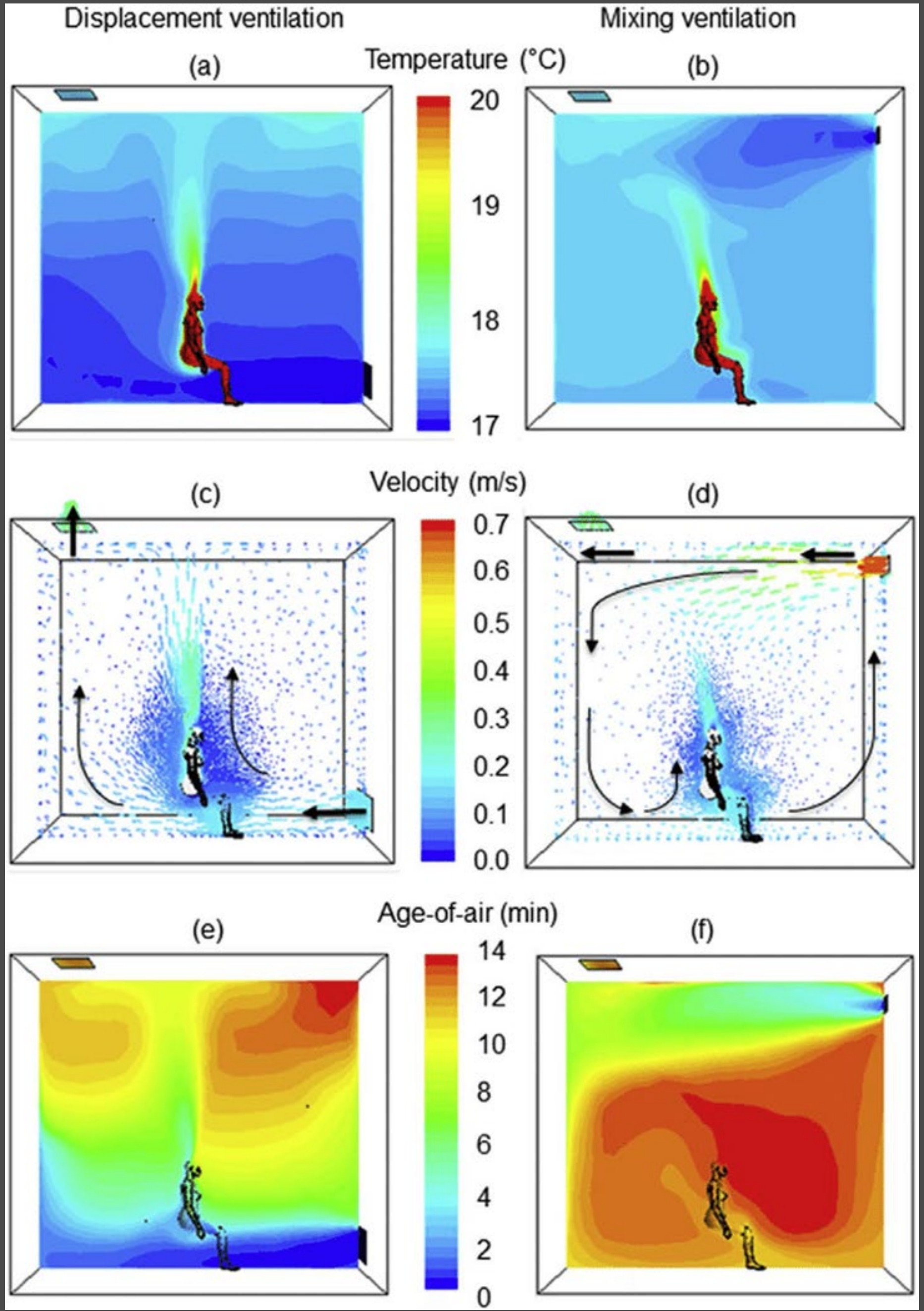
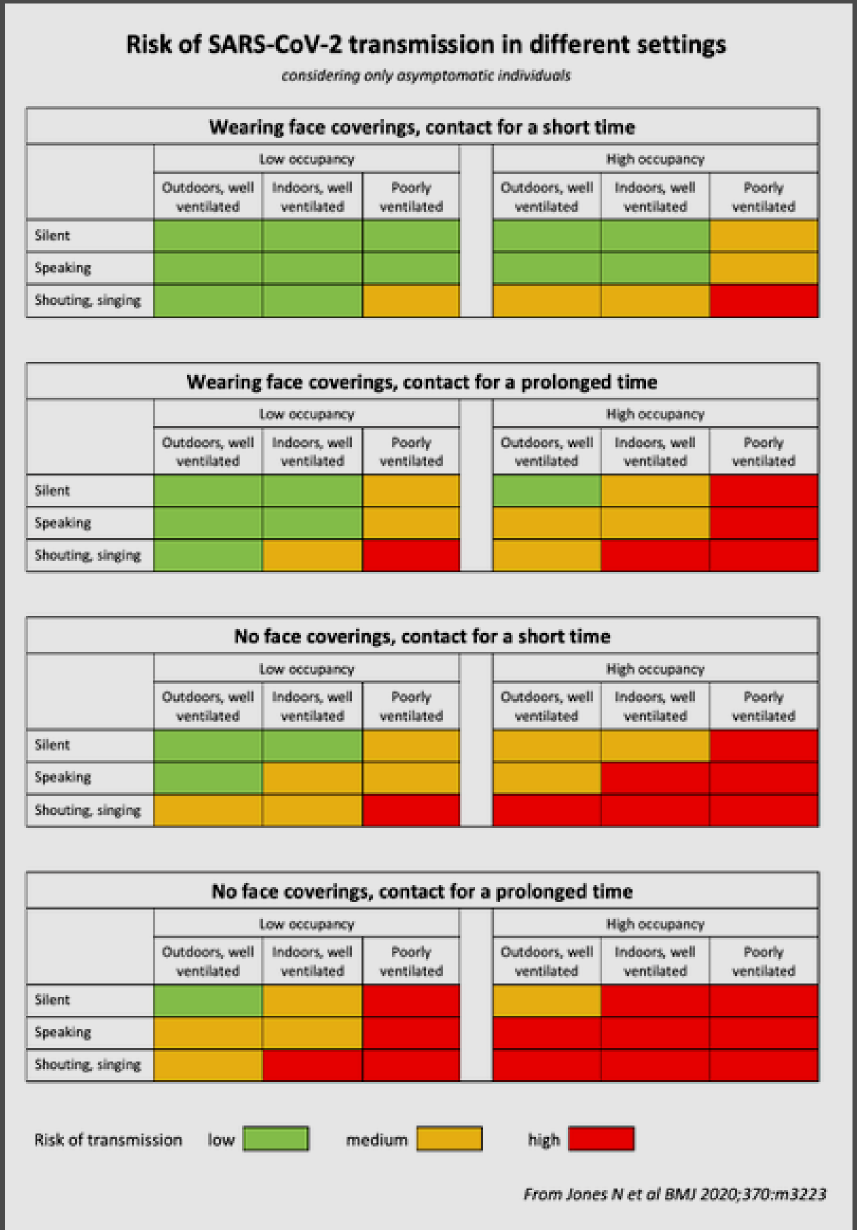


Image Source: Rim et al., Building and Environment (2018)

Risk



Risk of SARS-CoV-2 transmission in different settings
considering only asymptomatic individuals
Wearing face coverings, contact for a short time
Wearing face coverings, contact for a prolonged time
No face coverings, contact for a short time
No face coverings, contact for a prolonged time
Low occupancy
High occupancy
Outdoors, well ventilated
Indoors, well ventilated
Poorly ventilated
Silent
Speaking
Shouting, singing
Risk of transmission
low
medium
high
From Jones N et al BMJ 2020;370:m3223

Key Covid issues we need to apply to ventilation

- Removing virus from densely populated spaces is key
- Small aerosols can remain suspended for up to 3 hours
- The aerosol can become trapped or mixed in a volume of air which increases risk of infection
- The smaller the aerosol the deeper it can be taken into the lungs causing greater risks

Where do we ventilate

- New Build and Existing – existing buildings particularly poor
- Domestic and Non domestic – Domestic lower density, resident, Non domestic higher occupancy greater mixing.

- Greatest impact high occupancy public buildings, offices, schools, healthcare

Ventilation Rates

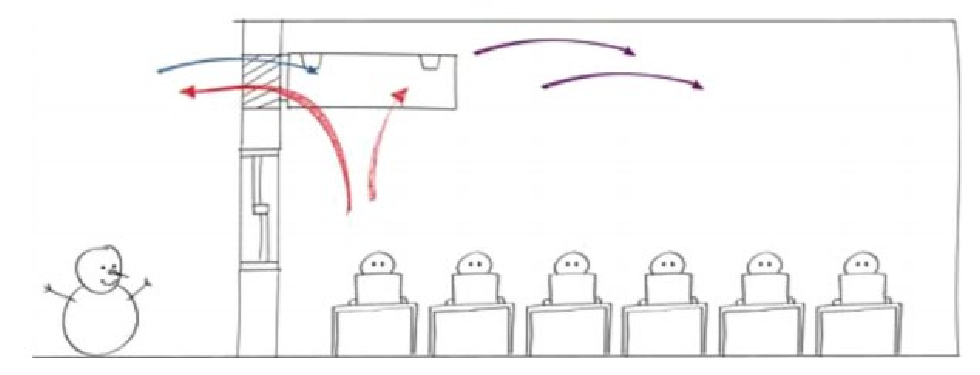
Table 2: Likely infections arising from airborne transmission (R-numbers) in an open-plan office (floor plan of 400 m^2 and floor-to-ceiling height of 3.5 m) occupied by 40 people for 8 hrs each day over a 5 day period that one pre/asymptomatic person remains attending work.

Scenario	Vent rate 4 l/s/p	Vent rate 10 l/s/p	Vent rate 20 l/s/p
Quiet desk work, q=1 quanta/hr	R = 0.84	R = 0.42	R = 0.24
Talking sedentary, q=5 quanta/hr	R = 4.0	R = 2.1	R = 1.2
Super-spreading events			
q=20 quanta/hr	R = 14	R = 7.6	R = 4.4
q=100 quanta/hr	R = 35	R = 26	R = 18

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/928720/S0789_EMG_Role_of_Ventilation_in_Controlling_SARS-CoV-2_Transmission.pdf

Ventilation Systems

https://bura.brunel.ac.uk/bitstream/2438/21585/1/FullText.pdf



Hybrid ventilation systems

T. Lipinski et al. / International Journal of Thermofluids 7–8 (2020) 100045

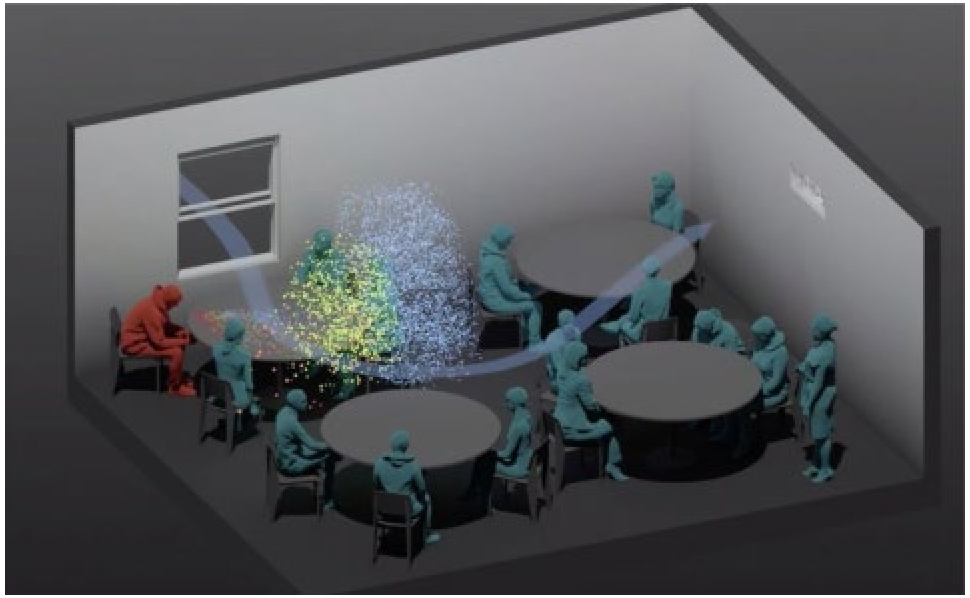
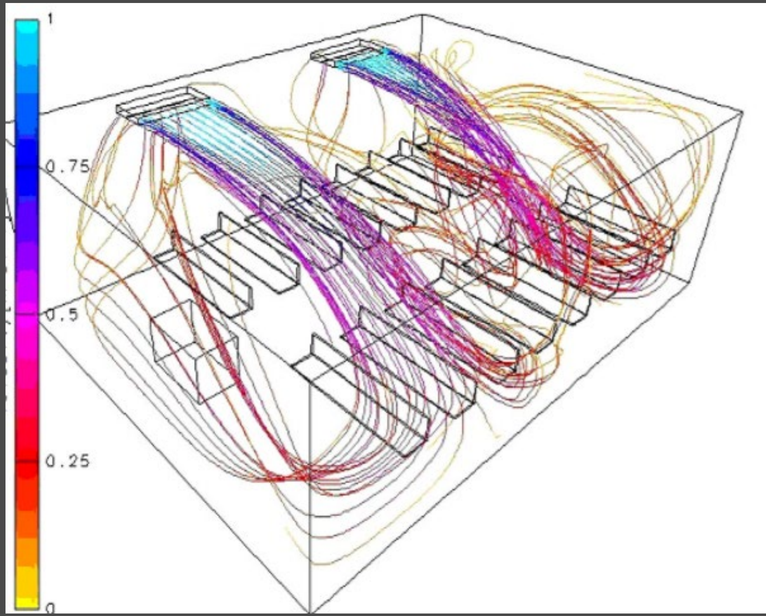


Fig. 17. The simulations showed how fresh air from an open window could carry the virus to a vent, University of Oregon [68].

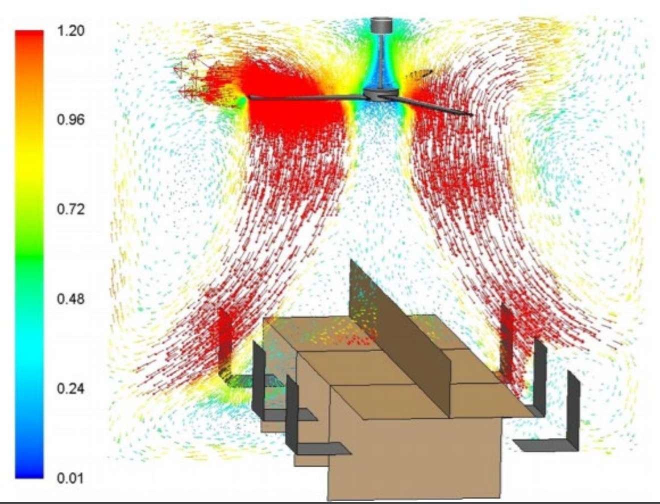
Mixed mode vent

- Mechanical supply/ Extract
- Openable windows

- High level of mixing
- Poor velocity control
- Potentially poor thermal comfort
- Potentially poor energy efficiency



Recirculating comfort systems (Air conditioning)

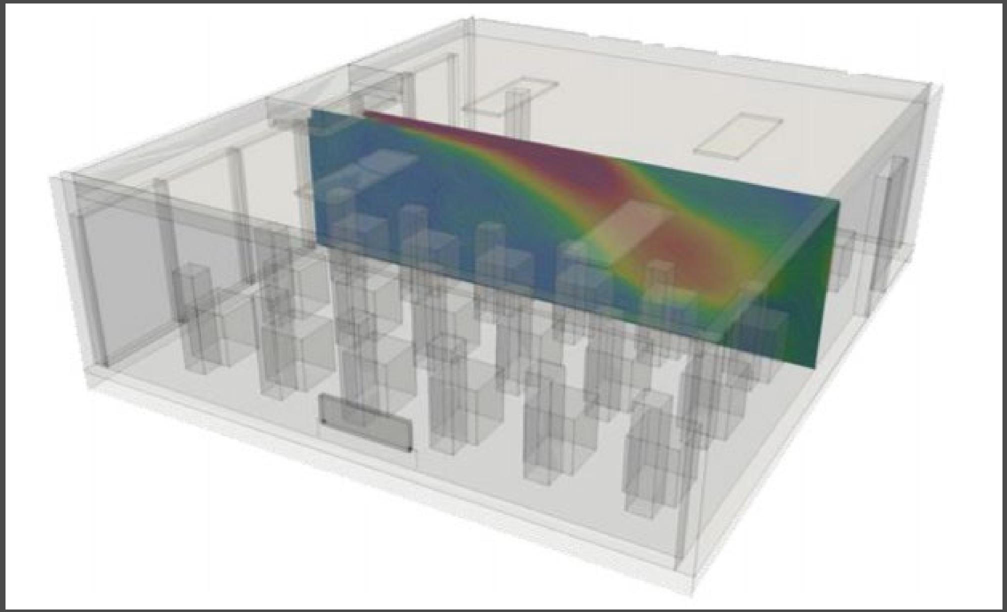


Recirculating ceiling fan

Images Sourced: T. Lipinski et al. / International Journal of Thermofluids (2021)

Air conditioning/Recirculation with some fresh air

- High level of mixing
- Often supply and extract is high level
- High velocity
- Poor fresh air ventilation rates and control of pollutants



MVHR (Mechanical ventilation with heat recovery)

Mechanical Ventilation with Heat Recovery

- Better fresh air supply
- Balanced system
- Can be zoned, multiple units
- Flow rate control possible
- Good energy efficiency possible
- Most installs will want to avoid stagnant areas and likely to look to provide mixing

Displacement Ventilation

- Low supply air velocity
- Less mixing than other systems
- Good control possible
- Temperature stratification and interaction with space heating system needed to maintain comfort
- Typically not always used with heat recovery but has potential

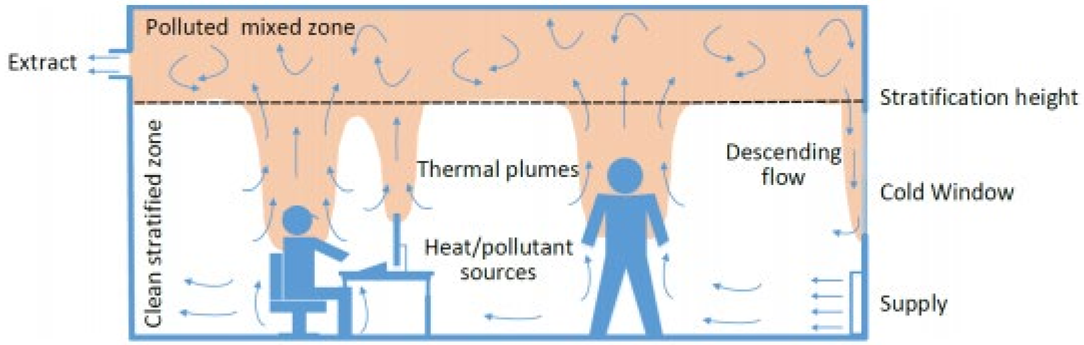


Figure 1. Illustration of displacement ventilation.

Article

Evaluating the Use of Displacement Ventilation for Providing Space Heating in Unoccupied Periods Using Laboratory Experiments, Field Tests and Numerical Simulations

Saqib Javed [1,*], Ivar Rognhaug Ørnes [2], Tor Helge Dokka [2], Maria Myrup [2] and Sverre Bjørn Holøs [3]

What to consider

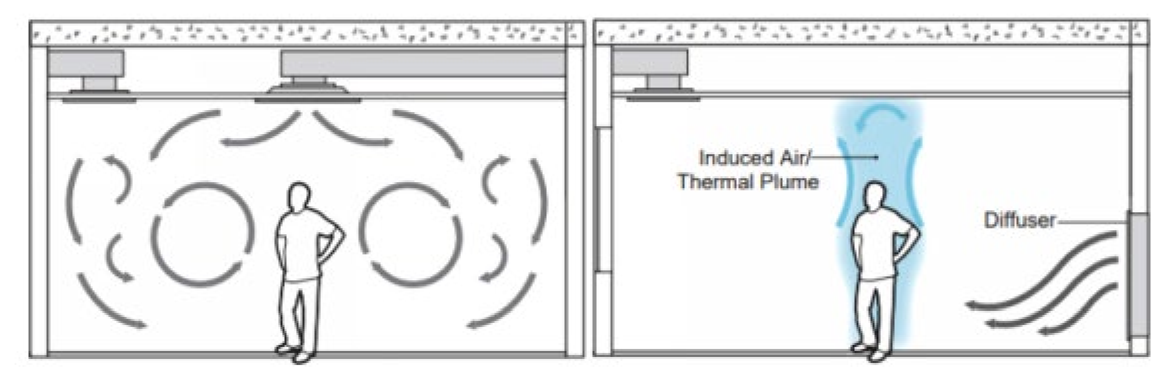


Fig. 15. Mixed vs. displacement ventilation system [63].

System Selection

- Must be manageable and maintainable – filters….
- Must be flexible and adaptable
- Must be able to reduce air supply velocity
- Must extract exhaust polluted air from high level and avoid mixing
- Must ensure thermal comfort and avoid stratification and large temperature differentials
- Energy efficiency – good building design can reduce over ventilation

Control

- Zoning of Ventilation units – multiple units, clean air areas
- Volume control and velocity control - Managing mixing during high occupancy
- Manual Alert – CO_2 sensors - location is important

Why Passivhaus can help good ventilation design

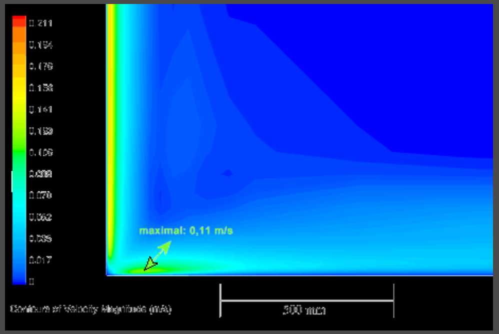
- Minimising temperature differentials across surfaces and internal and solar gains reduces the risk of these impacting your optimised ventilation design and plume removal

- Low space heating: Warm air heating?

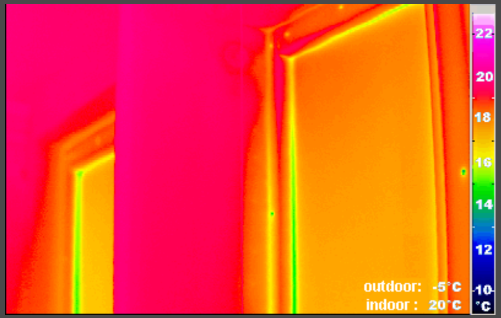
- Filtration is standard – can be improved

- Control flow rates to lower risk of mixing during occupancy and allow for purge vent out of hours.

- Optimisation of flow rate against good building design to allow the virus to be elevated above lock in zone. High ceilings are beneficial. Otherwise the flow rates will need to be elevated – particularly of importance in refurbishment which would likely lead to high flow rates.



Passipaedia velocity across a Passivhaus window
https://passipedia.org/basics/building_physics_-_basics/thermal_comfort/local_thermal_comfort



Passivhaus Ventilation Design

Passivhaus requires Mechanical Ventilation with Heat Recovery

- Modelling indicates typical MVHR could increase the level of mixing of pollutants
- Consider Displacement ventilation design with MVHR

Plan for

  - Requires large ductwork sizes to ensure low velocities
  - Requires ductwork to low level routing necessary
  - Requires positions for low level grilles which are not impeded
  - Higher ceilings to ensure the polluted zones remain away from head height
  - Consider integration of heating
  - Consider time and purge controls and integration of heating times to limit impact
  - Consider controls and alerts using CO2 sensors and humidity

Be Cautious about

  - Heavy reliance on filtration and UV
  - Consider multiple units to better zone systems – (energy vs improved control)
  - Consider heat exchanger selection

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ANY QUESTIONS

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