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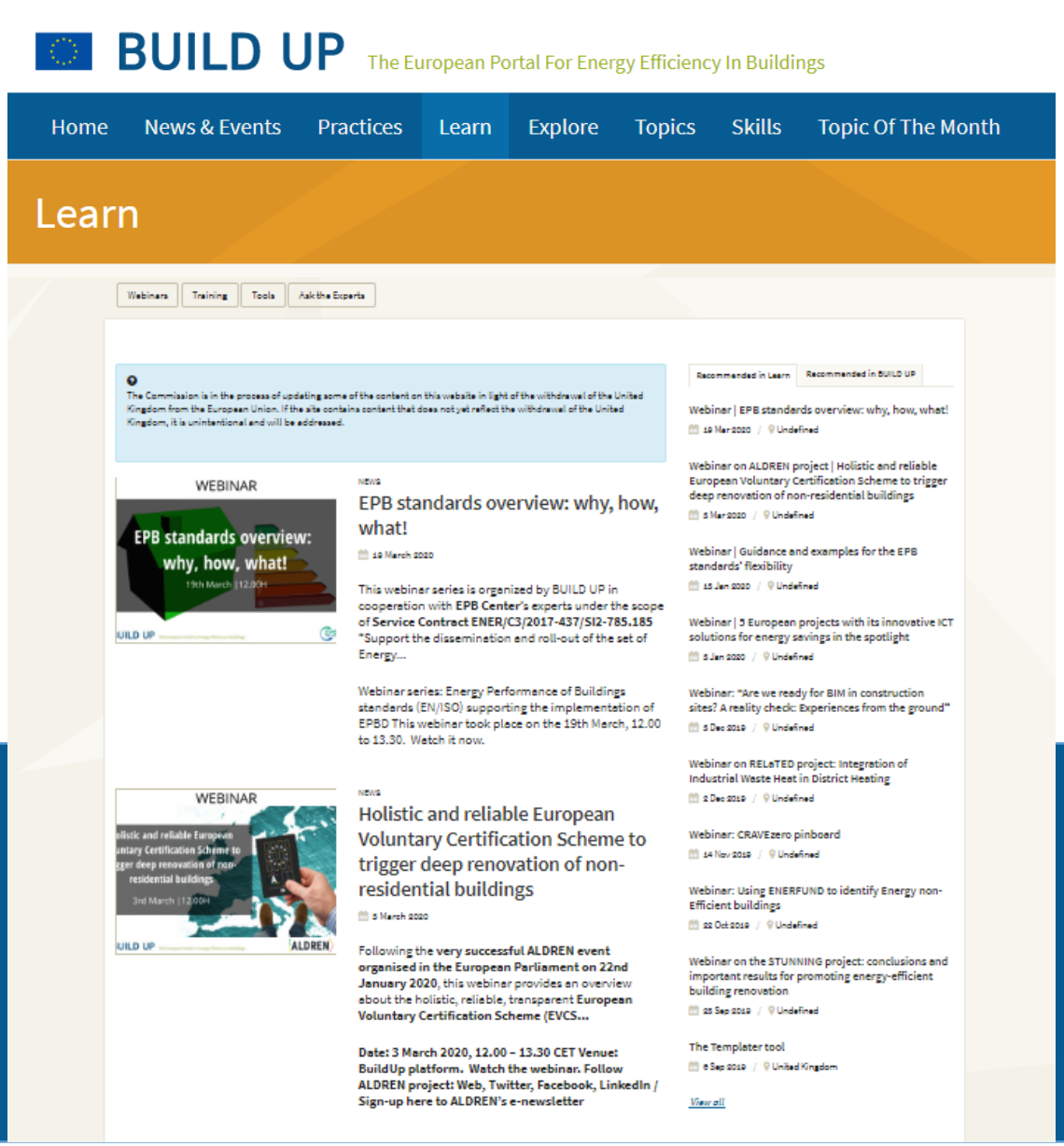

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REHVA

WEBINAR

BUILD UP The European Portal For Energy Efficiency In Buildings

Indoor Air Quality (IAQ) Concepts Case Study COVID-19

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University of Coimbra

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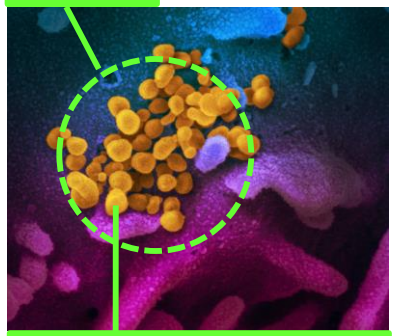
Dimension of Sars-CoV-2 vs Airborne Particles

1 μm X 1000 = 1 mm



80-140 nm ≈ 0.1 μm

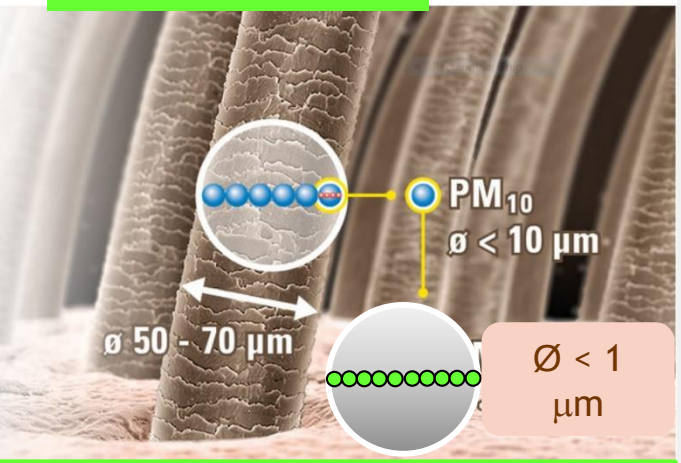
HEALTH

This Is What The COVID-19 Virus Looks Like Under The Microscope

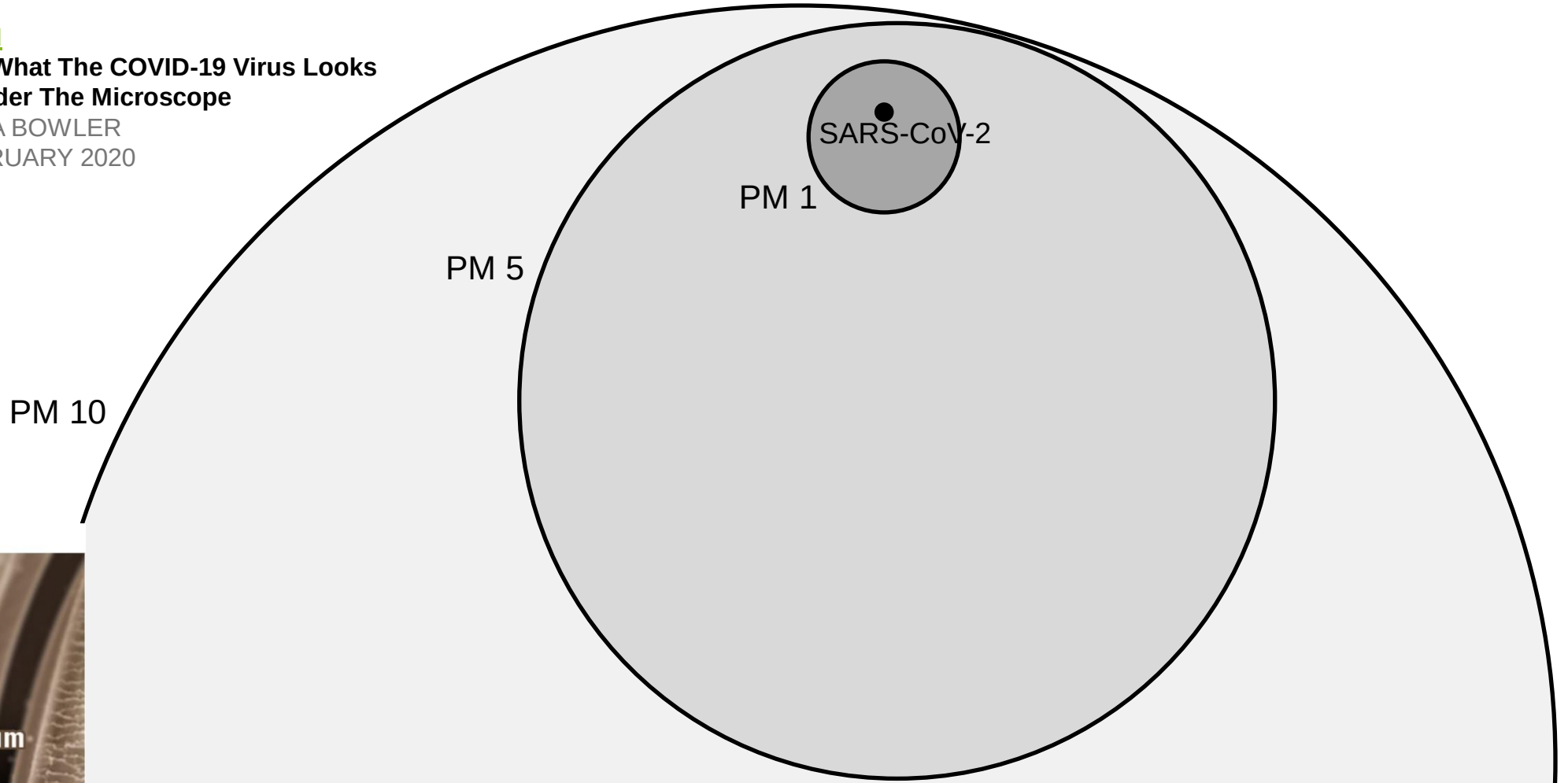
JACINTA BOWLER

14 FEBRUARY 2020

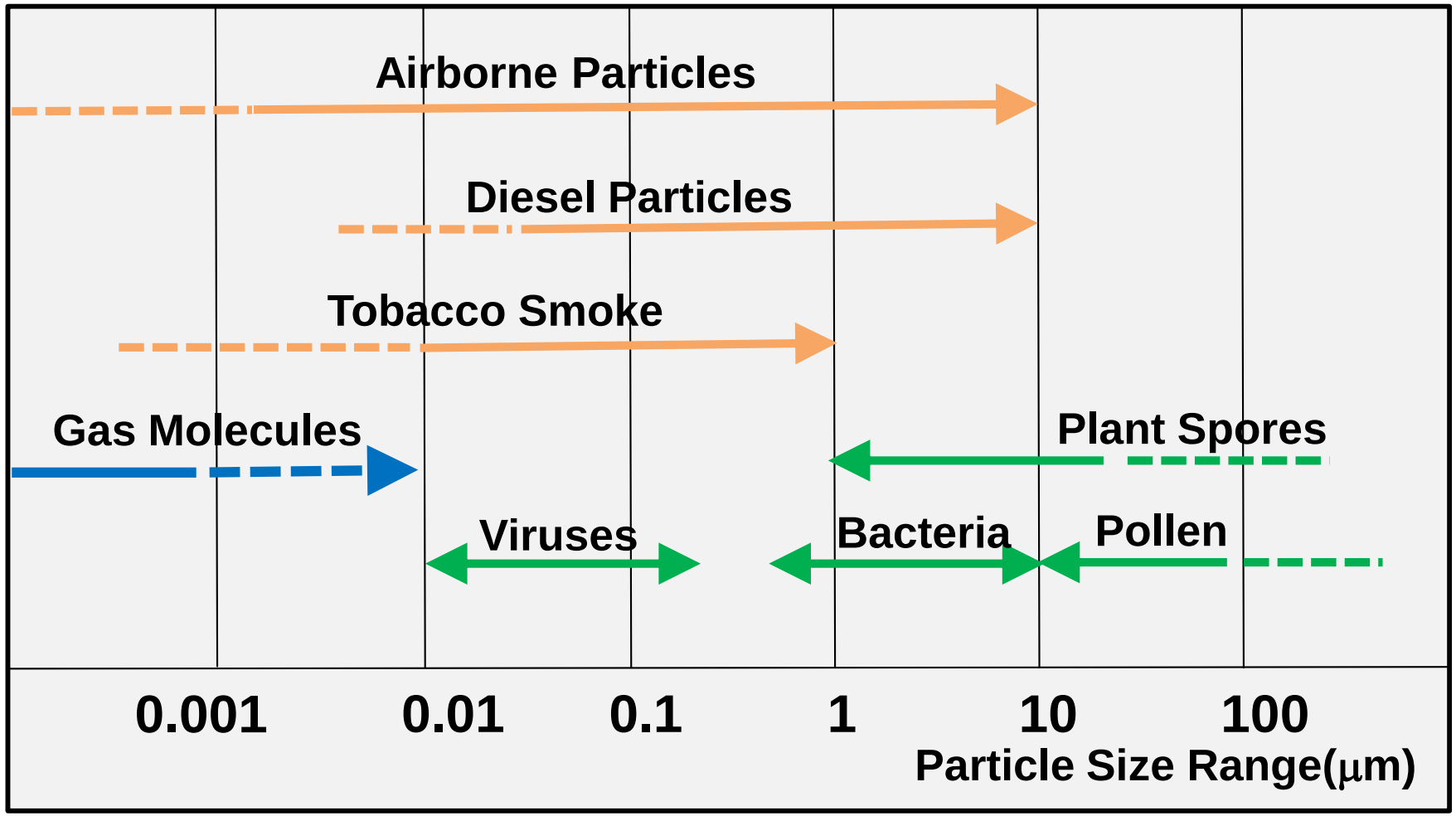
Virus is about 300 times bigger than the molecules of Nitrogen and Oxigen (≈ 0.000300 μm)



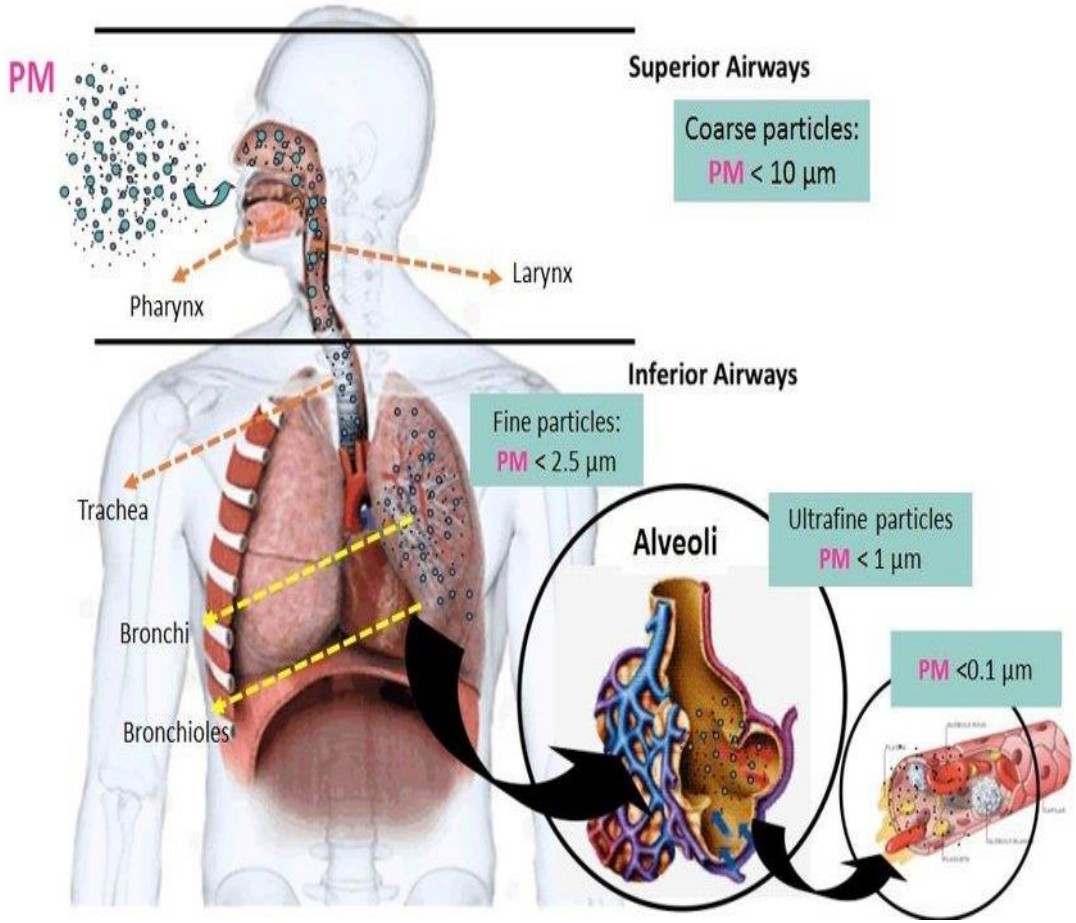
Virus is 600 times thinner than a hair



Particle Size Ranges in the indoor air



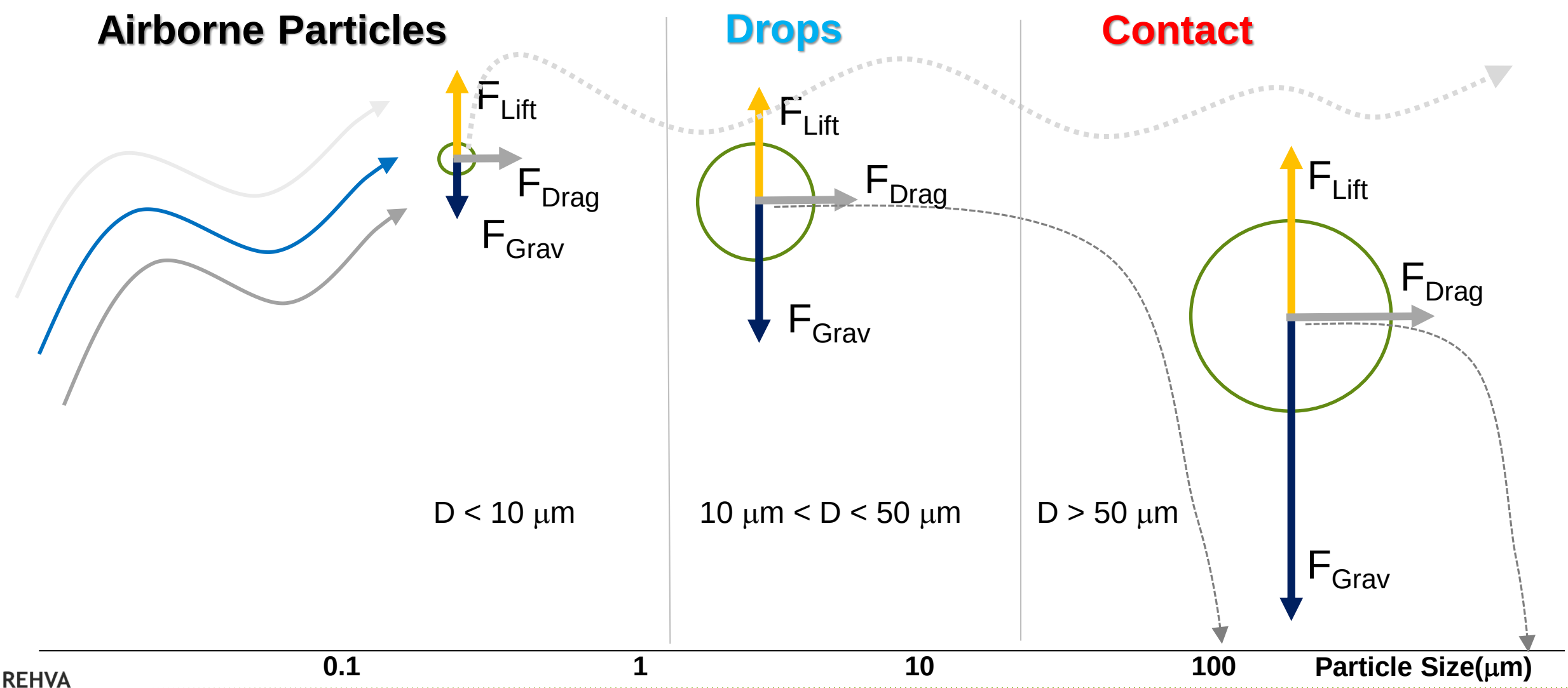
Airborne Particles



Diameter (µm)	**Nível de Penetração**	**Classificação**
> 7	Oral and Nasal Cavities	Inhalable
4.7 – 7	Larynx	
3.3 – 4.7	Trachea and Bronchi	Thoracics
2.1 – 3.3	Secondary Bronchioles	
1.1 – 2.1	Bronchioles	Breathable
0.65 – 1.1	Alveoli	

Smaller particles have a higher hazard index, can cause alveolar obstruction and impede respiratory function.

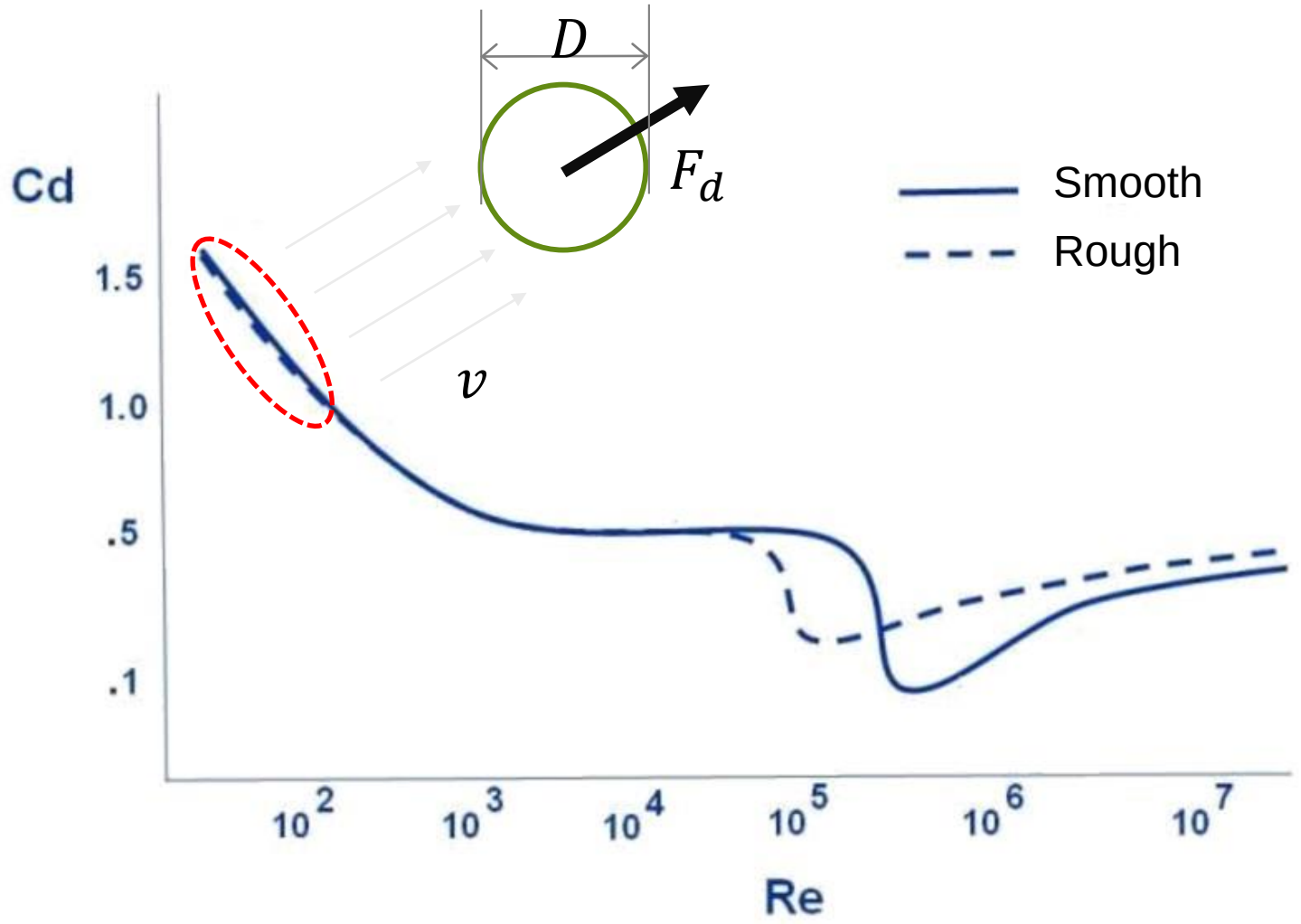
Balance of Forces on Particles in the Air



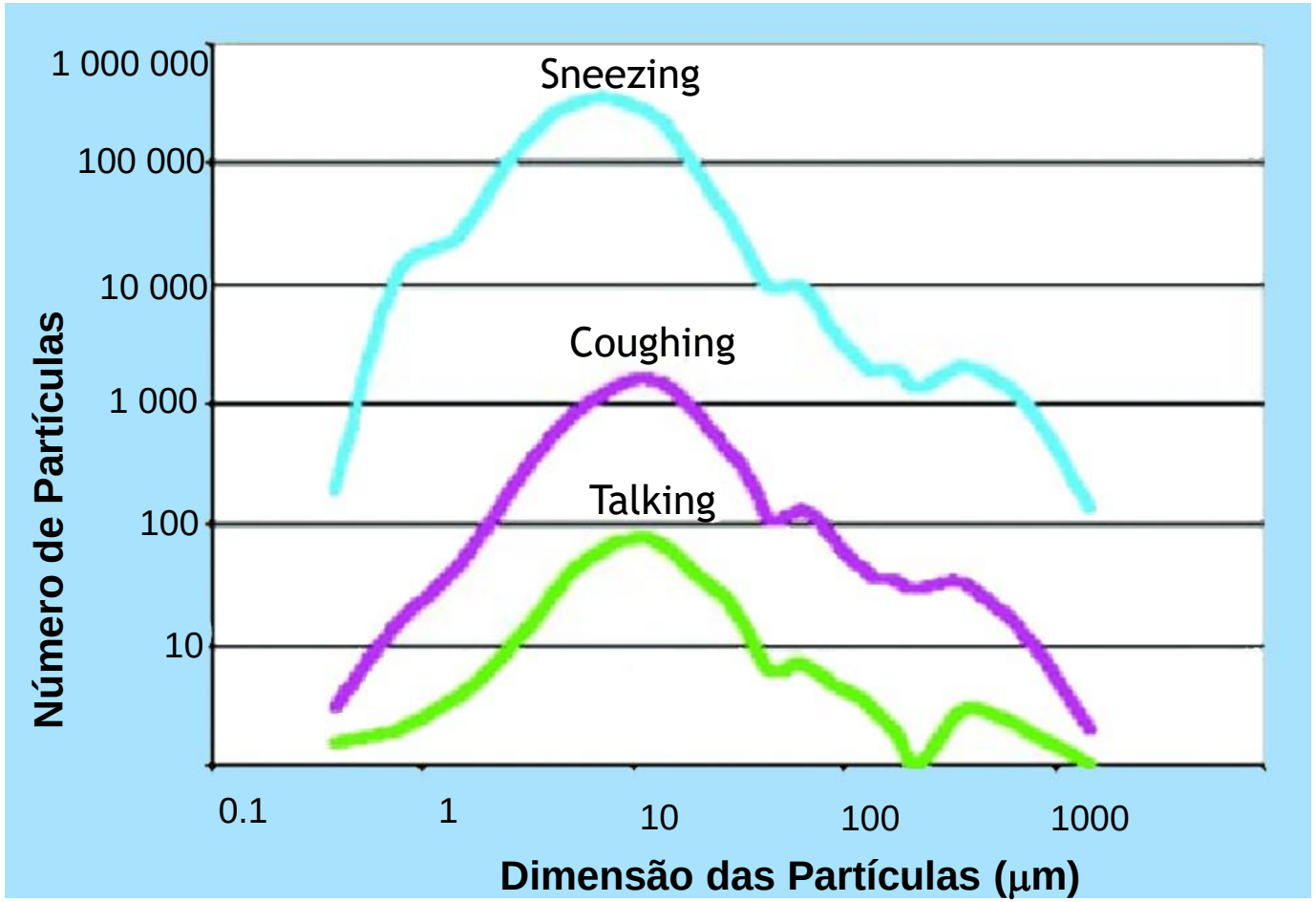
Aerodynamic Resistance Coefficient of a Sphere

$$Cd = \frac{F_d}{\frac{1}{2}\rho v^2 A} \qquad Re = \frac{\rho v D}{\mu}$$

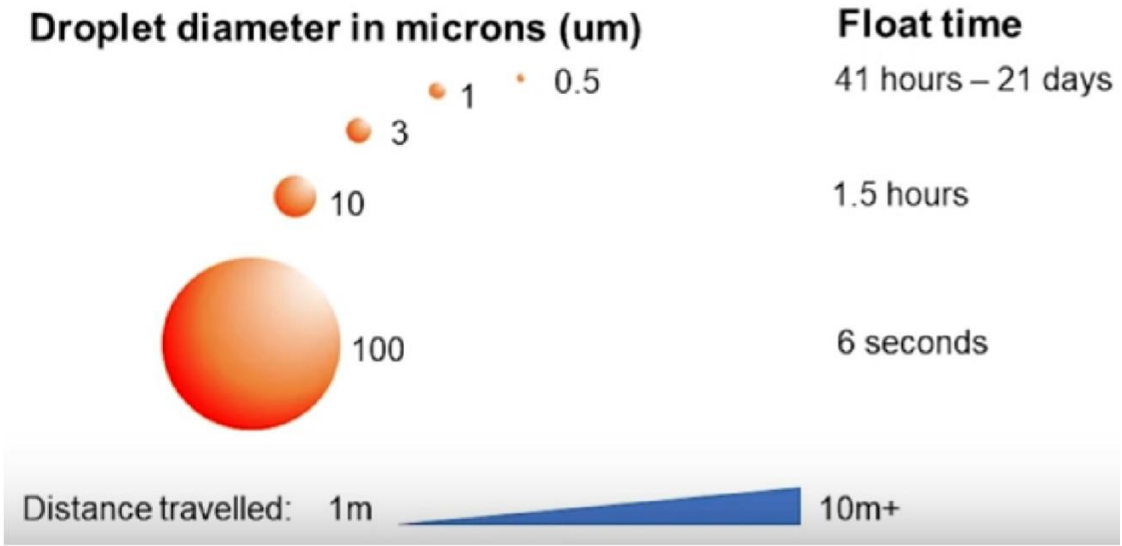
F_d	Aerodynamic drag force(N)
ρ	Air specific mass(kg.m^{-3})
v	Air Velocity(m.s^{-1})
A	Front Area(m^2)
D	Characteristic dimension(m)
μ	Air Dynamic Viscosity(kg.m^{-1}.s^{-1})



Emission of Exhaled Droplets



Farhad Memarzadeh, "Figure 1 Particle generation by sneezing, coughing and during talking," [https://www.researchgate.net/publication/234076687_Improved_Strategy_to_Control_Aerosol Transmitted_Infections_in_a_Hospital_Suite]

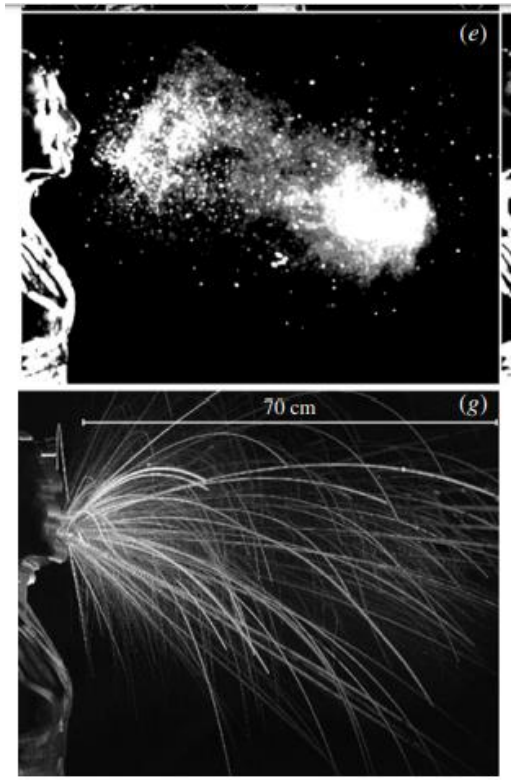


Stephanie Taylor, "Optimize Occupant Health, Building Energy Performance and Revenue through Indoor-Air Hydration," 19 November 2019, Atlanta: ASHRAE.

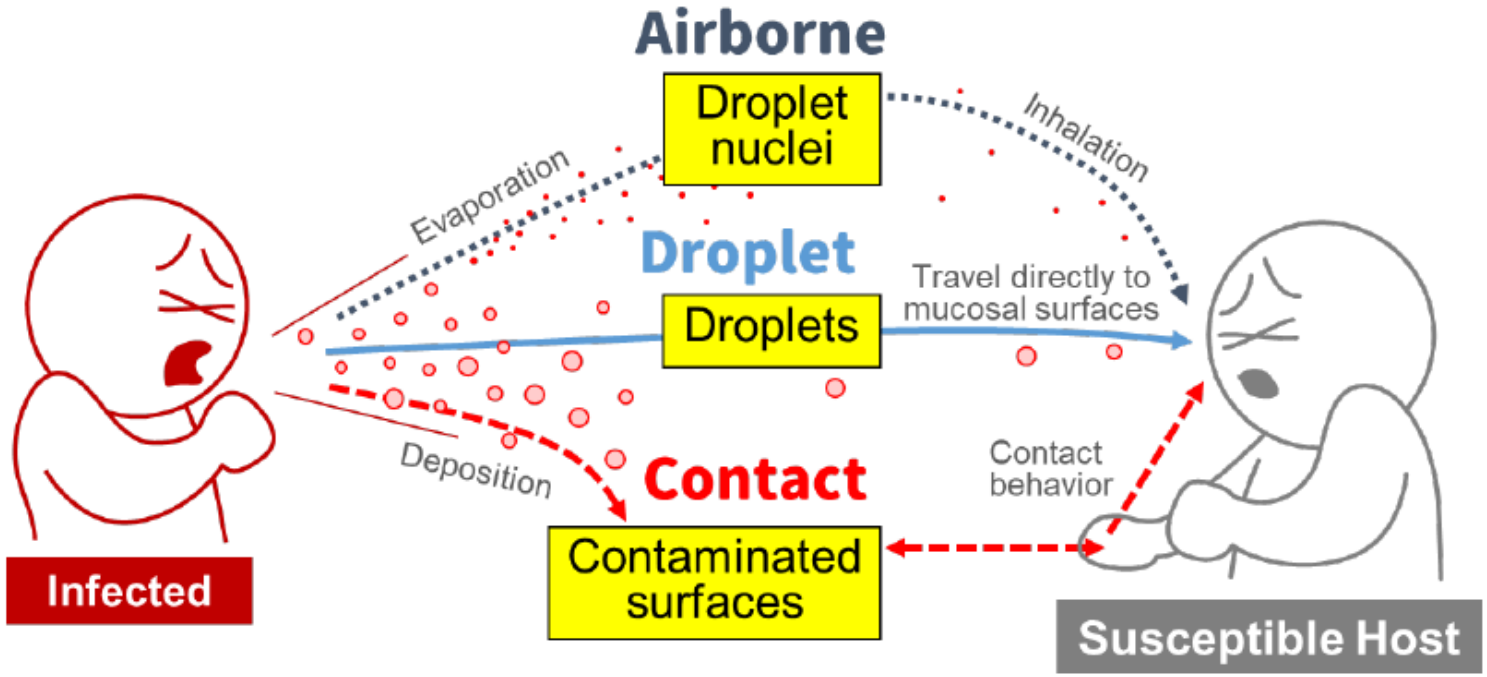
Aerodynamic Resistance Coefficient of a Sphere

Lydia Bourouiba et al, MIT

J. Fluid Mech. (2014), vol. 745, pp. 537–563. c Cambridge University Press 2014 doi:10.1017/jfm.2014.88



Transmission/Contamination Modes



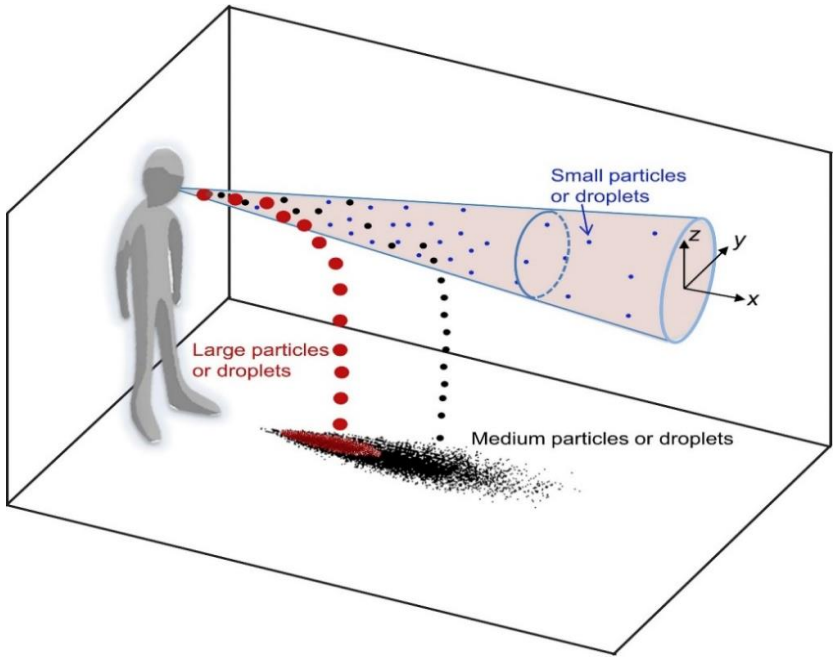
Role of ventilation in the control of the COVID-19 infection: Emergency presidential discourse SHASE, March 23, 2020.

Mode	PM Size	Measures
Airborne	< 10	Mask, Face Shield, Ventilation
Droplets	10<D<50	Confinement, Social Distancing
Contact	> 50	Hygiene, Disinfection, Behavior

Enhanced spread of expiratory droplets by turbulence in a cough jet

Jianjian Wei; Yuguo Li

Building and Environment
Volume 93, Part 2, November 2015, Pages 86-96
https://doi.org/10.1016/j.buildenv.2015.06.018



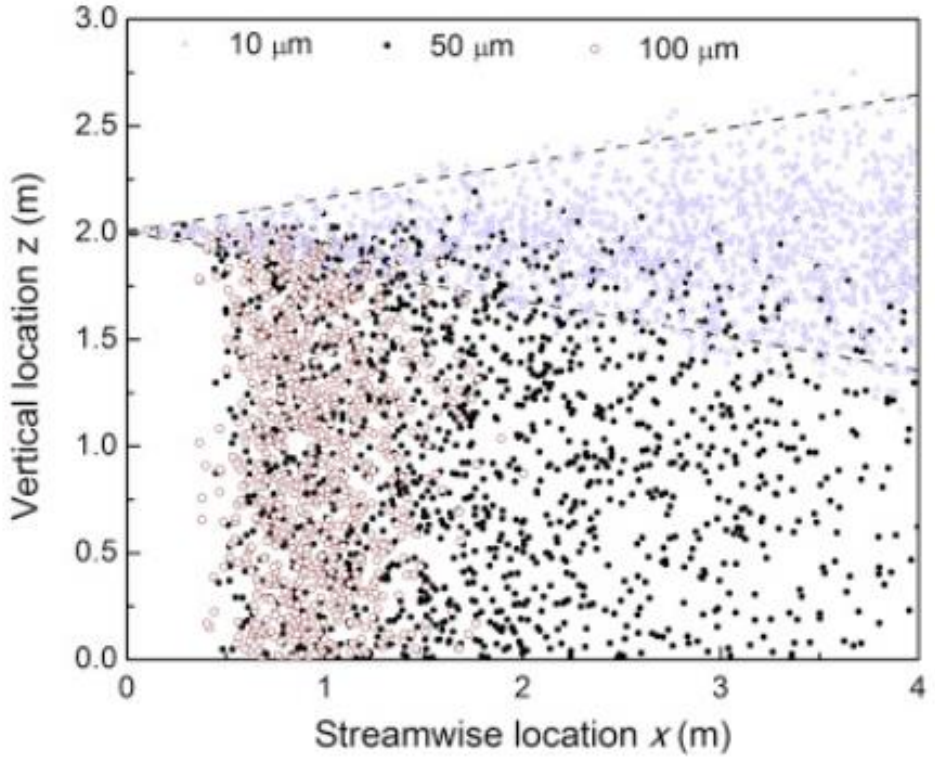
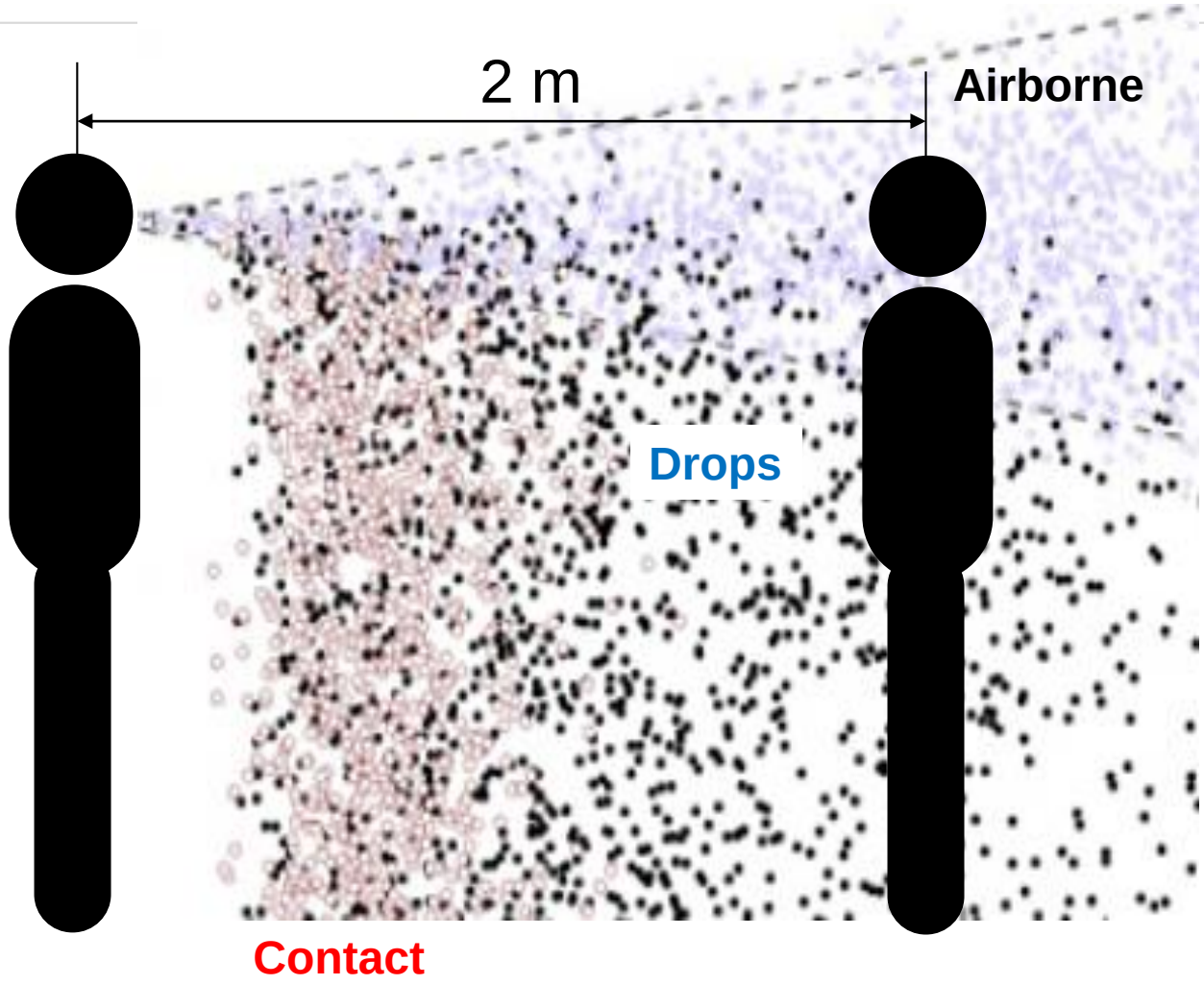


Fig. 5. Instantaneous dispersion pattern of particles (t = 100 s) in the buoyancy-neutral jet (mouth opening diameter D = 2 cm, initial velocity u_0 = 10 m/s, T_{amb} = 25°C). Particles are continuously released from t = 0. The top-hat width of the jet is indicated by the dashed line, which collapses with the visible boundary of the jet.

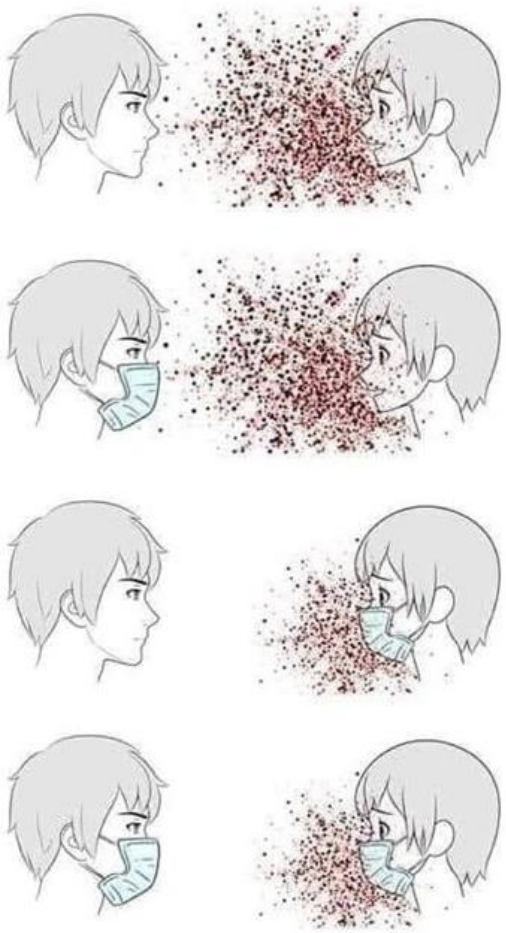
Does it exist a safety distance?

Conclusion

- The safety distance of 2 m between people, regarding the risk of COVID-19 infection, **is a myth**
- The Mode of Transmission through Airborne Particles (Aerosols) is possible, because the virus remains viable and infectious for at least 3 hours.
- These particles, remain in suspension, follow the internal flows and their deposition rate is residual.



Masks Effects



Effect of Protective Measures

Three countries with 10 millions inhabitants

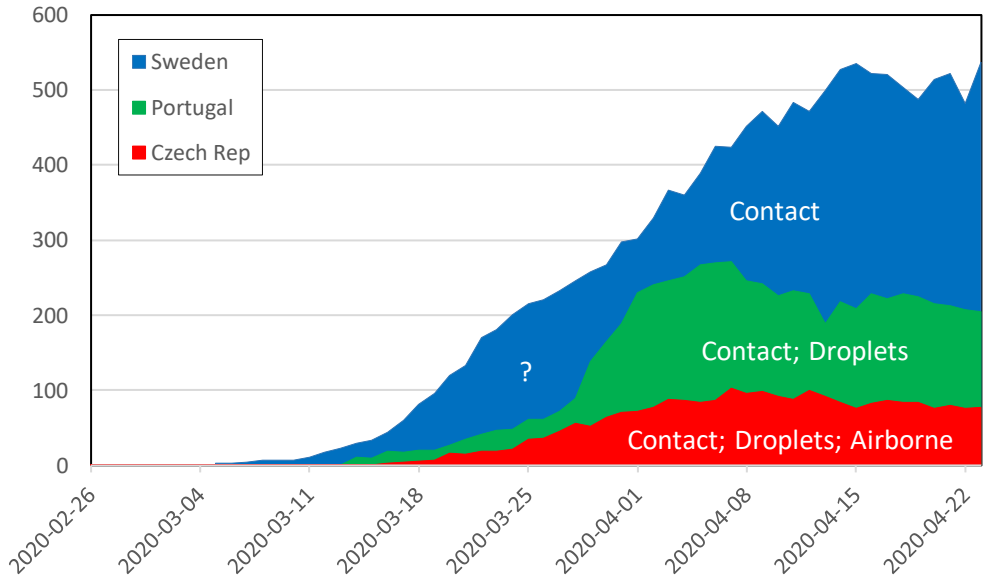
	Population	Age Median	Life Espectancy	Population Density	Urban Pop (%)
Cz	10 708 982	43.2	79.8	138 (p/km^2)	73.5
Pt	10 196 707	46.2	82.7	112 (p/km^2)	65.9
Sw	10 092 270	41.1	83.3	25 (p/km^2)	87.9

Country	Transmission Modes Protection	Protective Measures
Czech Rep	Airborne, Droplets, Contact	Masks, Ventilation, Confinement, Distancing , Hygiene, Disinfection, Behavior
Portugal	Droplets, Contact	Confinement, Distancing , Hygiene, Disinfection, Behavior
Sweden	Contact	Hygiene, Disinfection, Behavior

Effect of Protective Measures

Country, Other	Total Cases	New Cases	Total Deaths	New Deaths	Total Recovered	Active Cases	Serious, Critical	Tot Cases/ 1M pop	Deaths/ 1M pop	Total Tests	Tests/ 1M pop	Cases /Tests
Czechia	6,914	+14	196	+2	1,597	5,121	75	646	18	178,617	16,679	0.038
Portugal	20,863		735		610	19,518	215	2,046	72	235,878	23,133	0.088
Sweden	14,777		1,580		550	12,647	521	1,463	156	74,600	7,387	0.198

Interned in ICUs vs Protection for Transmission Modes



Breakdown of the Probabilities of Transmission Modes

- **Airborne: 64%**
- **Droplets: 21%**
- **Contact: 15%**

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Conclusion

- Face-to-face meetings, during the epidemic crisis, should not be held.
- Indoor spaces with human occupancy must be heavily ventilated, exclusively with fresh air, to decrease virus concentrations, in the event of possible contamination by suspended particles, and to reduce the risk of infection.
- When planning an exit, to crowded spaces, you should wear a mask and, if possible, a visor. Normal masks are not completely effective in preventing the smallest particles. The visor substantially increases the prevention effectiveness.
- Those who work in public places should wear a mask and visor to protect the airways.

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Questions

https://www.researchgate.net/publication/340435784_An_analysis_of_the_transmission_modes_of_COVID-19_in_light_of_the_concepts_of_Indoor_Air_Quality

April 2020
DOI: 10.13140/RG.2.2.28663.78240

https://www.researchgate.net/profile/Manuel_Gameiro_da_Silva

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Thank you very much for your attention

REHVA

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

April 28, 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

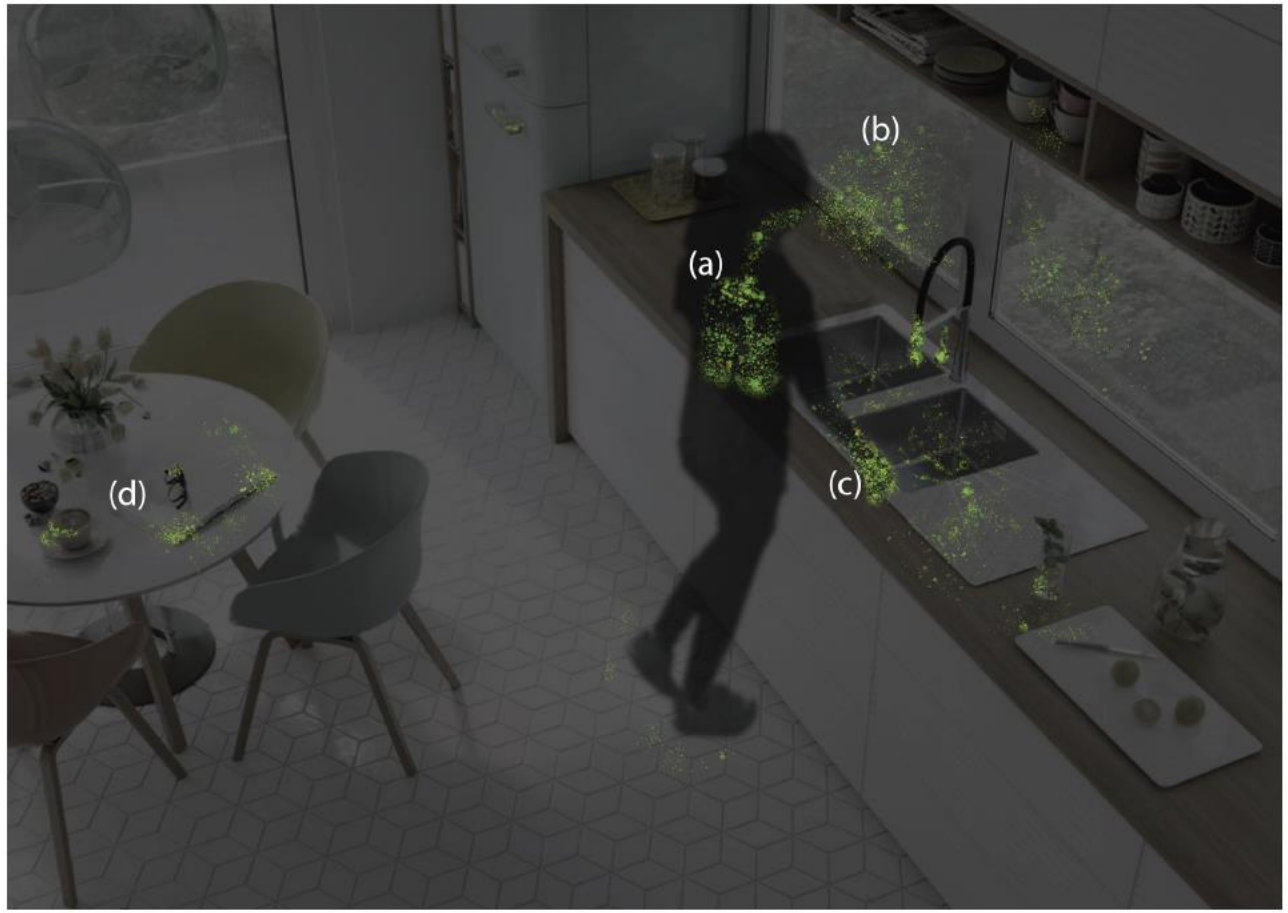
Transmission routes

(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



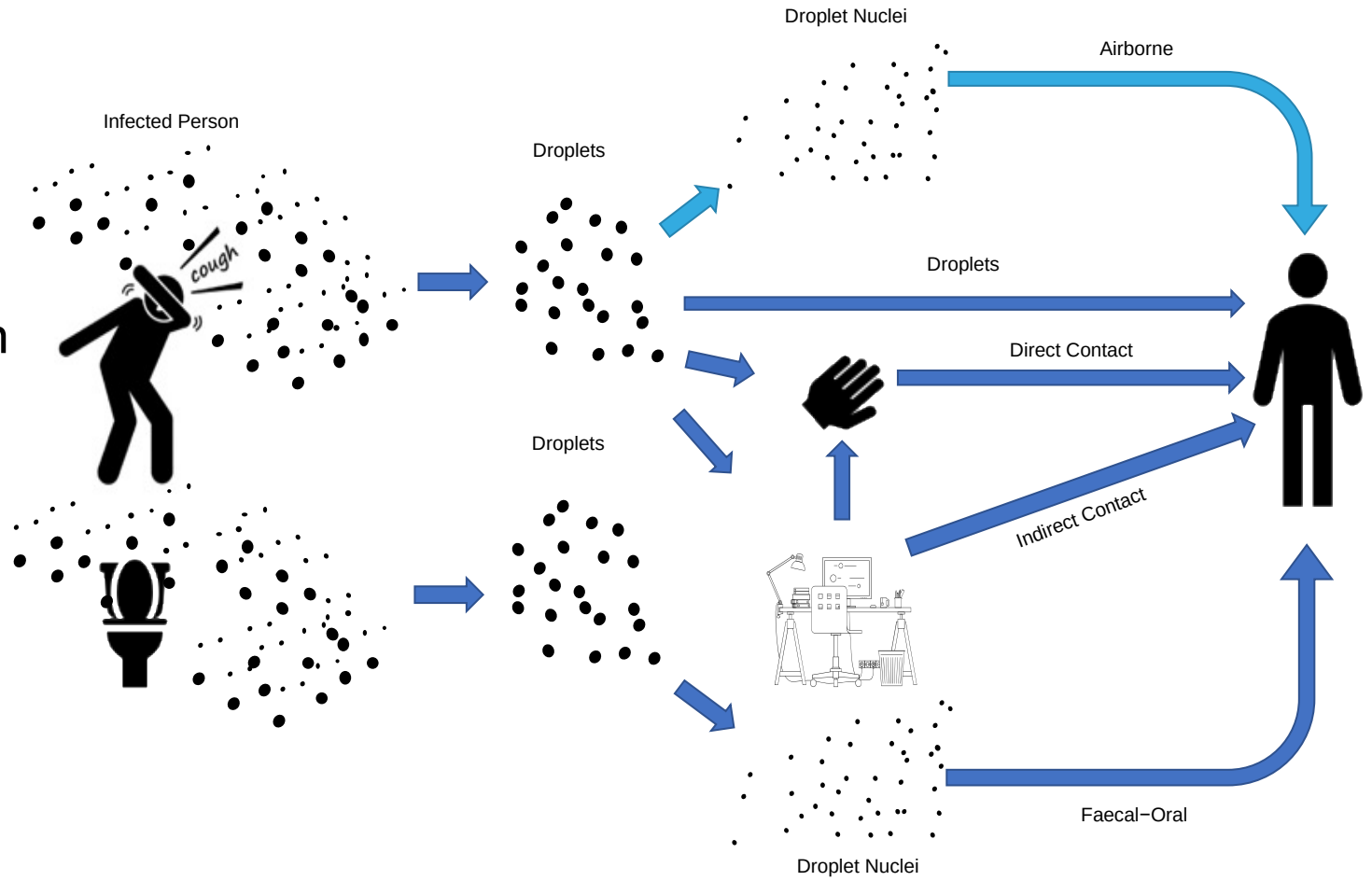
Leslie Dietz et al, 2020 Novel Coronavirus (COVID-19) Outbreak: A Review of the Current Literature and Built Environment (BE) Considerations to Reduce Transmission

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

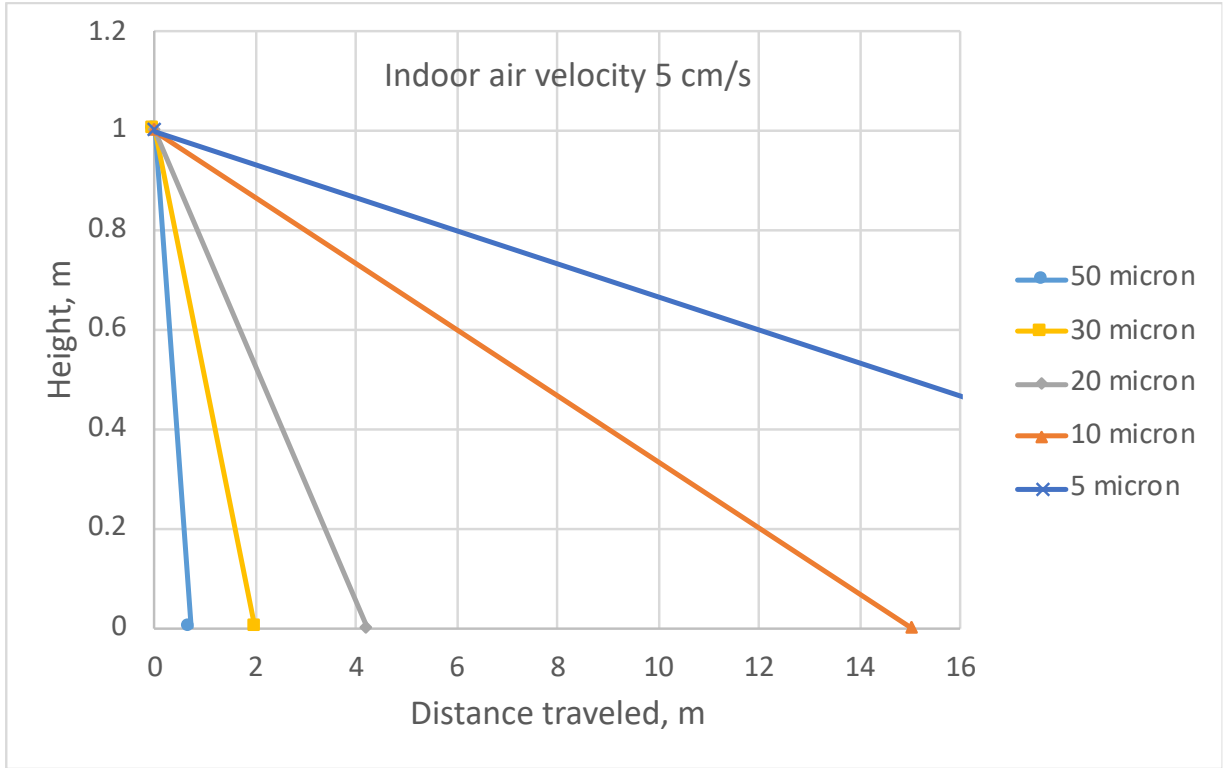
Dark blue: evidence exist

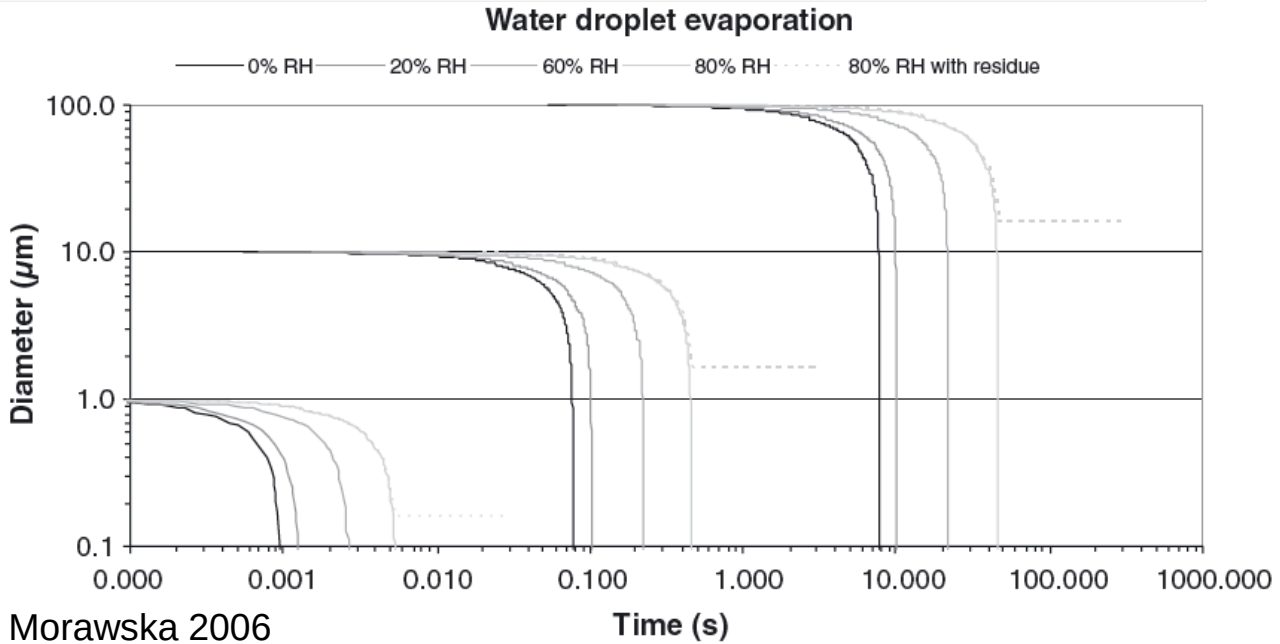
Light blue: evidence for SARS-CoV-1



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)





Morawska 2006

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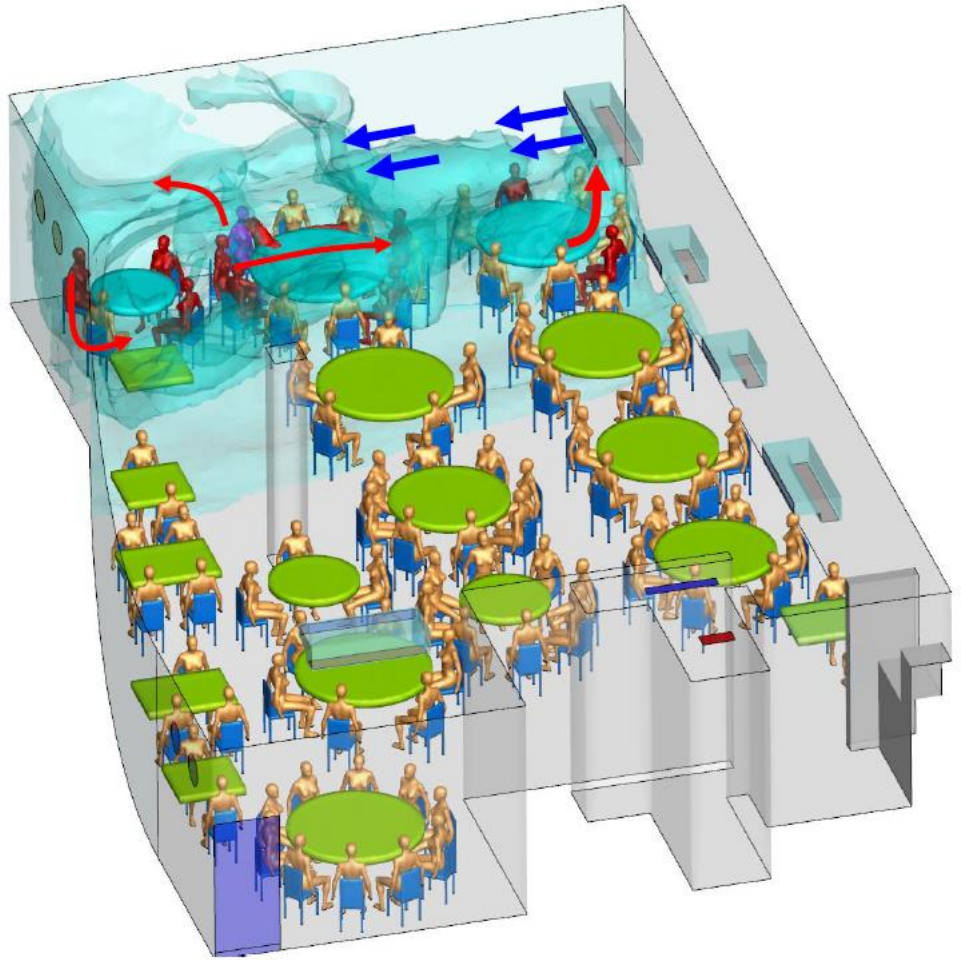
Airborne transmission indication

- 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

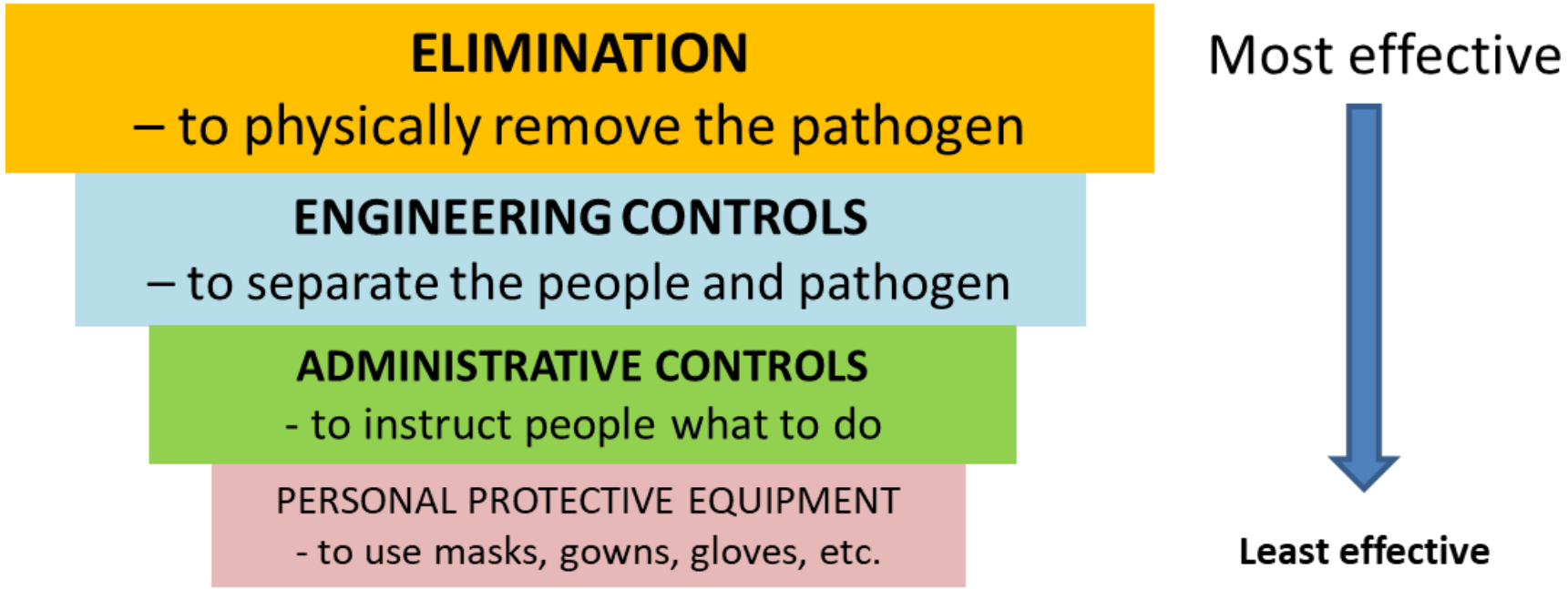
→ Good justification to take a set of preventive mitigation measures and to apply ALARA principle (As Low As Reasonably Achievable) that help to also control the airborne route in buildings (apart from standard hygiene measures as recommended by WHO)

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 viru 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
  - CO_2 measurement allow to estimate ventilation at least 36 L/s per person



Ventilation and building services guidance



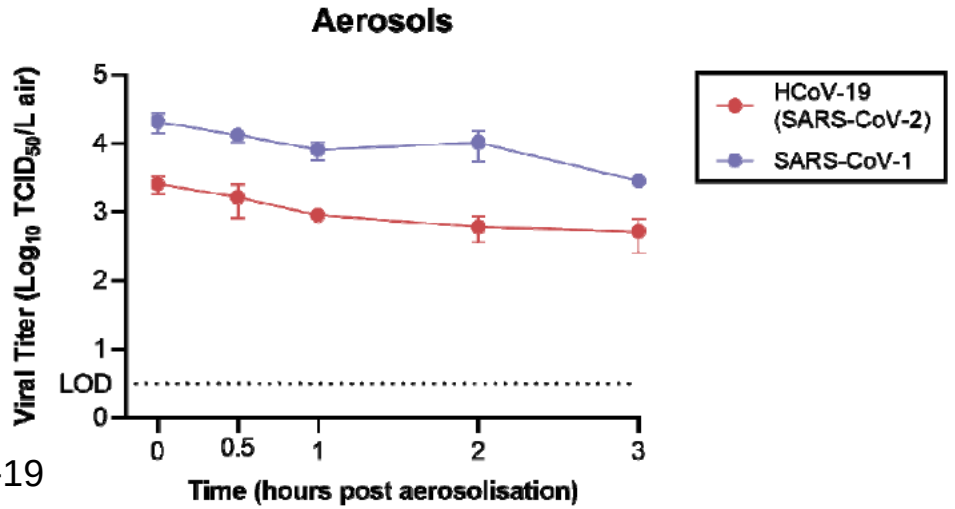
- Traditional infection control pyramid adapted from the US CDC (CDC 2015)
- Until vaccine and medicaments are not available, ventilation is No 1 infection control measure

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

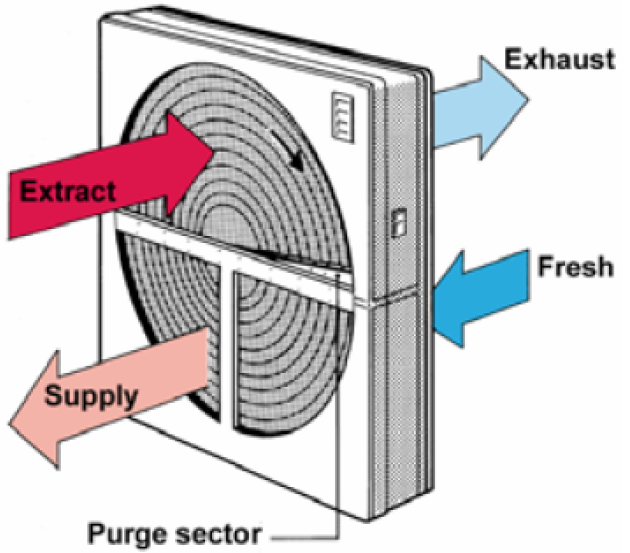
- SARS-CoV-2 stability (viability) has been tested at typical indoor temperature of 21-23 ℃ and **RH of 65% with very high virus stability** at this RH. Together with previous evidence on MERS-CoV it is well documented that humidification up to 65% may have very limited or no effect on stability of SARS-CoV-2 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 ℃; 37 ℃ for one day and 56 ℃ 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-6 2) compared to SARS-CoV-1 (RH 65%)

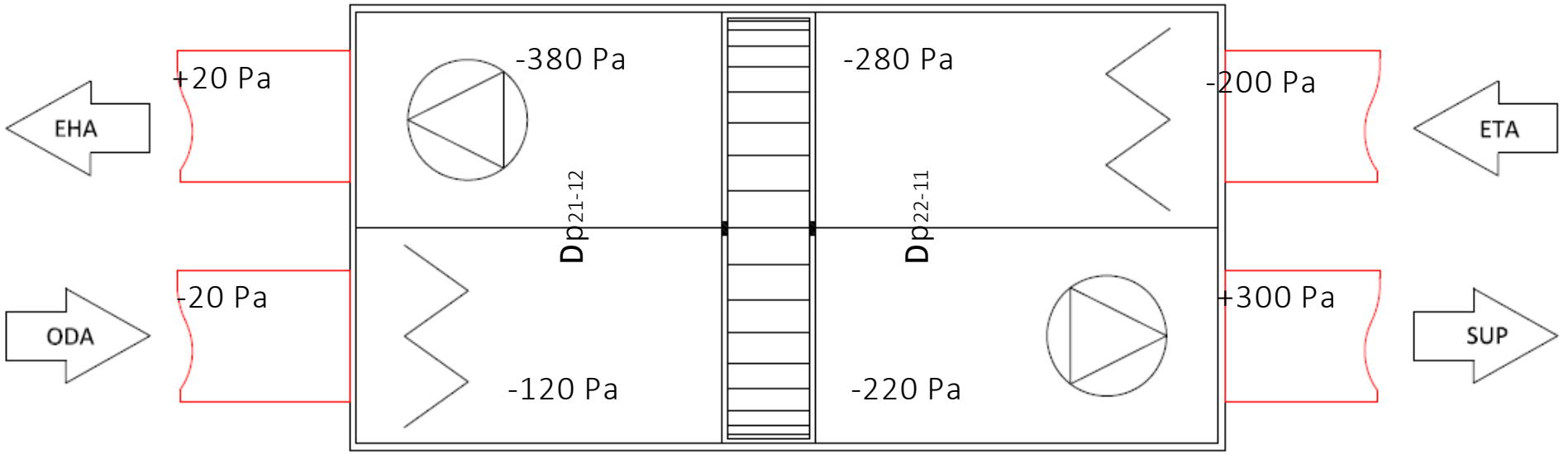
Safe use of heat recovery sections

- 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 m^2 – 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:

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Cultura e Tecnica per Energia Uomo e Ambiente

(Culture and Technique for Energy, Humans and the Environment)

How to operate and use building services during the COVID-19 crisis

Build Up WEBMINAR, 28th April 2020

Cultura e Tecnica per Energia Uomo e Ambiente

(Culture and Technique for Energy, Humans and the Environment)

Showcasing the Italian COVID-19 guidance for reducing the diffusion risk of SARS-CoV-2

Livio MAZZARELLA,
Prof., Politecnico di Milano, REHVA Fellow

AiCARR Activity for COVID-19

20/03/2020 – 1st Short position paper on HVAC system operation (Italian only, short version REHVA doc)

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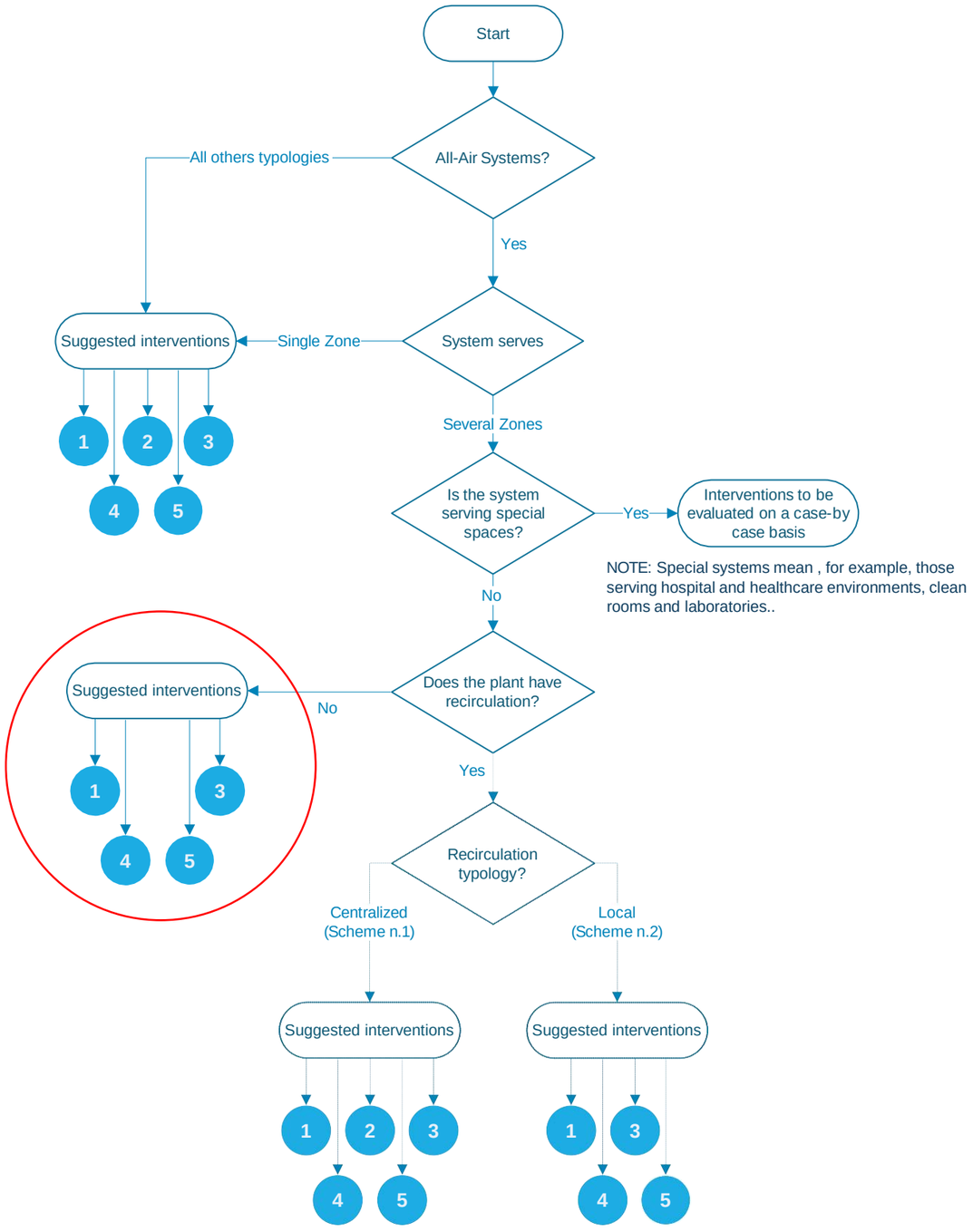
Cultura e Tecnica per Energia Uomo e Ambiente

PROTOCOL FOR RISK REDUCTION OF SARS-CoV2-19 DIFFUSION WITH THE AID OF EXISTING AIR CONDITIONING AND VENTILATION SYSTEMS



NOTE: Special systems mean , for example, those serving hospital and healthcare environments, clean rooms and laboratories..

PREMISE

AiCARR deemed it necessary to produce a second document after that already published on 13 March 2020 on the association's website entitled HVAC PLANTS AND DIFFUSION OF SARS-CoV2-19 IN THE WORKPLACES.

This document is addressed to HVAC technicians for giving indications on how to operate existing systems, with the exception of special systems, such as those serving hospital and healthcare environments, clean rooms and laboratories.

Starting from the principle, widely shared by bodies responsible for supervising human health, that:

- the best action to limit any risk of COVID-19 infection by air is to ventilate indoor environments with outdoor air as much as possible;

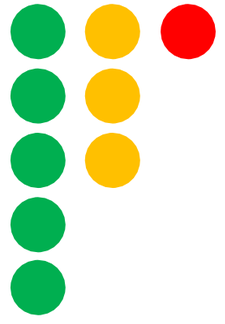
and by the fact that

- mechanical ventilation systems and air conditioning systems, which also provide ventilation, can perform this function more effectively than simply opening the windows, also because they improve the quality of the outdoor air with filtration;

AiCARR suggests some management operations that allow to maximize external air introduction into internal spaces according to existing systems specific type.

SUGGESTED INTERVENTIONS

1. INCREASE AIR FLOW
2. FORCE DAMPERS TO INTRODUCE OUTDOOR AIR ONLY
3. DEACTIVATION OR BY-PASS OF THE HEAT RECOVERY UNIT
4. KEEP THE RELATIVE HUMIDITY SETPOINT ABOVE 40%
5. VENTILATION CONTINUOS OPERATION (H24)



LEGENDA

- INTERVENTIONS THAT REQUIRE ACTIONS ON CONTROL SYSTEMS
- INTERVENTIONS THAT REQUIRE MAINTENANCE STAFF ACTIONS
- INTERVENTIONS THAT REQUIRE ORE MAY REQUIRE PLANT MODIFICATIONS

NOTE

Suggested corrective actions are those to be implemented on properly maintained and managed systems. At present there is no evidence that extraordinary plant sanitation should be carried out. It is recommended instead that maintenance and sanitation interventions, if carried out, always follow well-defined procedures and are performed by qualified personnel, equipped with suitable Personal Protective Equipment. Any intervention carried out incorrectly and / or without the use of PPE could result not in reduction, but in increase in risks.

PROTOCOL FOR RISK REDUCTION OF SARS-CoV2-19 DIFFUSION WITH THE AID OF EXISTING AIR CONDITIONING AND VENTILATION SYSTEMS

Cultura e Tecnica per Energia Uomo e Ambiente

DESCRIPTION OF SUGGGESTED INTERVENTIONS

1 INCREASE AIR FLOW

It can be done by increasing the fan speed. In particular:

1) In fans equipped with inverters, increasing the supply frequency.

2) In fans equipped with belt and pulleys, changing the diameter of the pulleys.

Obviously, the intervention must concern both the external air supply fan and the exhaust air return fan, being careful to keep the pressure difference in the individual rooms unchanged (if in overpressure, they must remain in this state. The operation in depression mainly concerns special systems, which must be examined on a case-by-case basis).

In any case, care must be taken that the actual fan motor power input do not exceed the maximum allowed power input.

2 FORCE DAMPERS TO INTRODUCE OUTDOOR AIR ONLY

For the sole purpose of increasing the external air flow, it is advisable to close the recirculation damper and at the same time open the outdoor air and exhaust air dampers, taking care not to alter the pre-existing overpressure conditions.

For systems designed to be able to operate with all external air, for example free-cooling (Scheme n.1), only external air mode is recommended, providing for total closure of the recirculation damper and simultaneous opening of both outdoor and exhaust air dampers.

For systems that do not provide free-cooling (Scheme n.1), it is still advisable to close recirculation damper and simultaneously open both outdoor and exhaust air dampers. The fan flow rate will be reduced, but it will consist of only outdoor air. Care must be taken avoiding that fan is going to work at points of instability. In such case, fan speed must be lowered, either by acting on inverter frequency, if present, or by varying the pulleys diameter.

For packaged direct expansion systems with partial free-cooling, for example roof tops, it is necessary to carefully check what are the minimum allowed flow rates and outdoor air percentage to be introduced to avoid blocking the refrigerant circuit operation.

3 DEACTIVATION OR BY-PASS OF HEAT RECOVERY UNIT

The rotary heat exchangers must always be stopped, to avoid a possible, however improbable and remote, contamination of the air introduced. Upon restarting, the wheel must first be sanitized.

For the same reason, any other type of **membrane based** enthalpy heat exchangers must be by-passed. For cross-flow heat exchangers, it is advisable to evaluate by-pass' opening in order to increase the outdoor air flow. If there is a calibration damper on the outdoor air by-pass line, designed to produce the same the pressure drops of the heat exchangers, such damper must be opened as much as possible, without exceeding the maximum allowable motor input power.

4 KEEP RELATIVE HUMIDITY SETPOINT ABOVE 40%

It is well known that low relative humidity values make mucous membranes dry, reducing their barrier function to viruses.

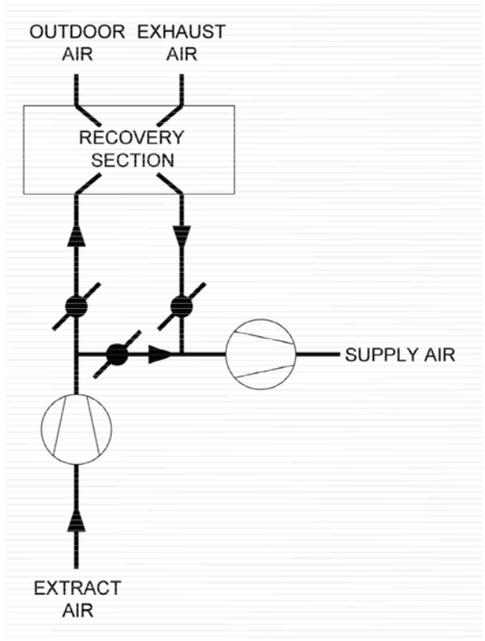
Therefore, in winter operation, air must be kept at least 40% relative humidity. If humidification is needed and the system is not equipped with a humidification system, use of local humidifiers must be evaluated taking into account the climatic conditions.

In summer, the problem of low relative humidity should never arise. Should this occur, it is advisable to act by increasing the minimum saturation temperature, that is, the temperature set-point of cooling coil outlet fluid. In general, in hydronic systems it is appropriate to adjust the set-point temperature of the water leaving the refrigeration unit; in direct expansion systems, the evaporation temperature should be appropriately adjusted.

5 VENTILATION CONTINUOUS OPERATION (H24)

Although there is no evidence that introducing outdoor air even during off-hours helps reduce the risk of contracting the virus, the precautionary principle suggests doing so. Continuous operation on a daily basis ensures that indoor air is at outdoor air conditions when the premises are reopened.

NOTES TO SCHEMES 1 AND 2

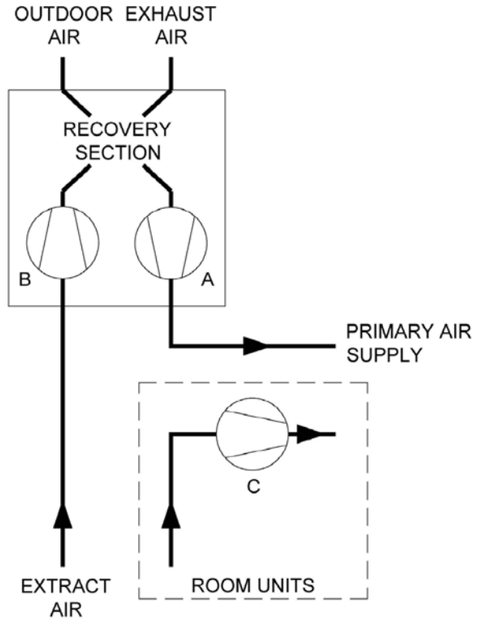


ALL-AIR SYSTEMS WITH CENTRALIZED RECIRCULATION (SCHEME N.1)

This is the typical case of many large all-air systems with recirculation. The return fan is located upstream of the recirculation connection. There are two configurations:

1)Systems designed taking into account a possible operation in free-cooling mode: sizing of exhaust and extract air ducts is made on the maximum system air flow; dampers are always conjugated and motorized.

2)Systems designed without operation in free-cooling mode: sizing of outdoor and extract air ducts is carried out on the outdoor air flow rate only. In older systems, dampers are manually calibrated and non conjugated to each other. In more recent systems, dampers may be motorized and conjugated, to allow variation of outdoor air flow according to actual occupancy, but they may have a manual lock to prevent the complete closure of the recirculation by-pass. This block must be removed, to carry out what is suggested in intervention n. 2.



PRIMARY AIR SYSTEMS WITH ROOM OR ZONE UNITS (SCHEME N.2)

This is the typical case of new VMC systems built according ERP 2016 or ERP 2018 prescriptions.

Outdoor air flow rate depends only on the two fans present in the heat recovery unit, A and B in the diagram.

The third fan, C, is used only for system operation and does not contribute in increasing the external air flow rate.

HOTELS - Rooms (for common use spaces see Restaurant)

Mechanical Ventilation	System Type	What to do	Possible virus cross contamination	System impact on infection risk	Changes in system performance
NO	Single room (A)	Open windows as much as possible when customers are not in the room	NO	none	unchanged
YES	Single room (A+C)	Increase outdoor air flow rate*	NO	REDUCTION	unchanged

RESTAURANTS, BARS, SHOPS

Mechanical Ventilation	System Type	What to do	Possible virus cross contamination	System impact on infection risk	Changes in system performance
NO	Single room (A)	Open windows and doors as much as possible	NO	bone	1
	Several rooms (B)	Open windows and doors as much as possible	YES	INCREASE	1
YES	Single room (A+C)	Increase outdoor air flow rate*	NO	REDUCTION	unchanged
	Several rooms (B+C)	Increase outdoor air flow rate*	YES	LIGHT INCREASE**	unchanged
	Multi-zone All-Air System (D)	Increase outdoor air flow rate and close recirculation dumpers*	NO	REDUCTION	unchanged

1 system may malfunction because it is designed on the assumption that doors and windows remain closed

SUPERMARKETS

Mechanical Ventilation	System Type	What to do	Possible virus cross contamination	System impact on infection risk	Changes in system performance
YES	Single-zone All-Air System (E)	Increase outdoor air flow rate and close recirculation dumpers*	NO: locale unico	REDUCTION	unchanged

CINEMAS, THEATRES

Mechanical Ventilation	System Type	What to do	Possible virus cross contamination	System impact on infection risk	Changes in system performance
YES	Single-zone All-Air System (E)	Increase outdoor air flow rate and close recirculation dumpers*	NO: locale unico	REDUCTION	unchanged

OFFICES

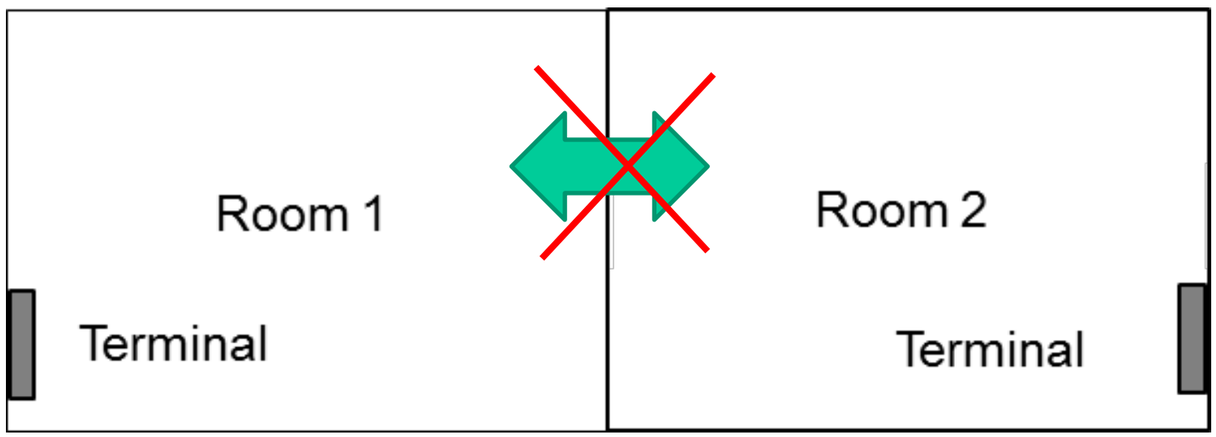
Mechanical Ventilation	System Type	What to do	Possible virus cross contamination	System impact on infection risk	Changes in system performance
NO	Single room (A)	Open windows and doors as much as possible	NO	bone	1
	Several rooms (B)	Open windows and doors as much as possible	YES	INCREASE	1
YES	Single room (A+C)	Increase outdoor air flow rate*	NO	REDUCTION	unchanged
	Several rooms (B+C)	Increase outdoor air flow rate*	YES	LIGHT INCREASE**	unchanged
	Multi-zone All-Air System (D)	Increase outdoor air flow rate and close recirculation dumpers*	NO	REDUCTION	2

1 system may malfunction because it is designed on the assumption that doors and windows remain closed
2 depend on system design

A. H&C System without air mixing between individual rooms

There is no any ventilation system and therefore outdoor air intake can occur only opening windows.

Terminals recirculate air only in the room where they are located, so viruses cannot pass from one room to another. Terminals can be of any type and placed anywhere in the room: radiators , radiant systems, fan coils, air conditioners (even those ducted, provided they are serving only one room).

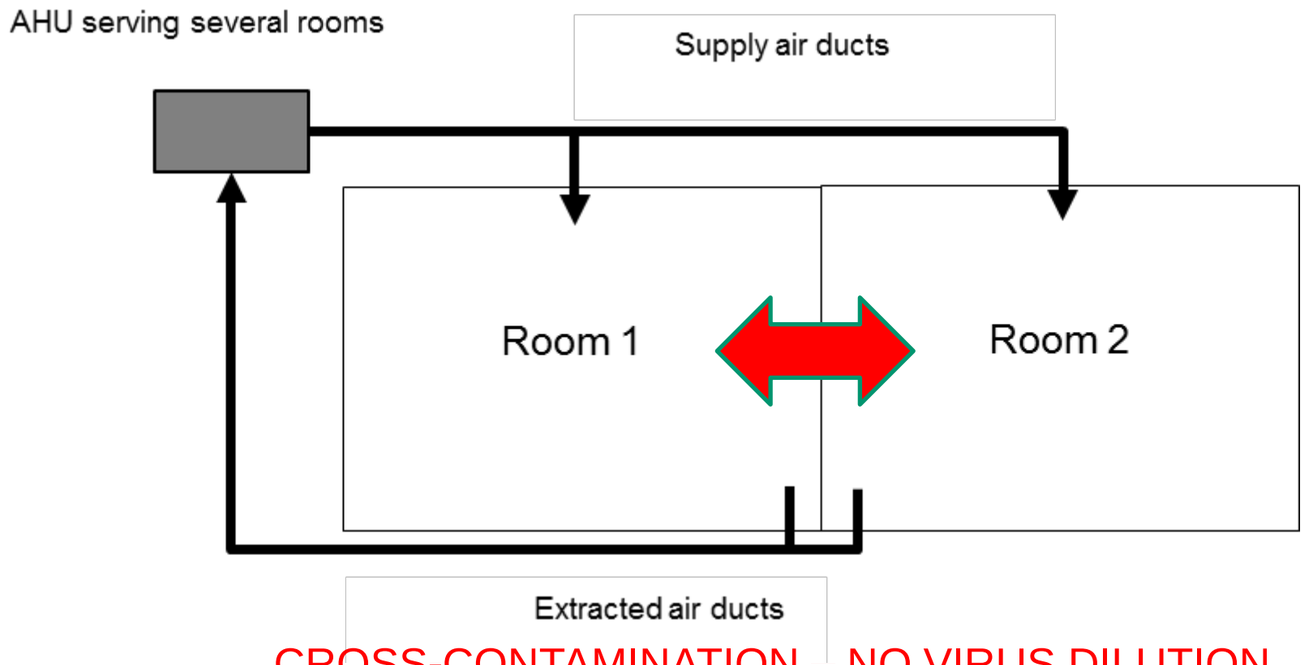


NO CROSS-CONTAMINATION – NO VIRUS DILUTION

B. H&C System with air mixing between individual rooms due to RECIRCULATION

There is no any ventilation system and therefore outdoor air intake can occur only opening windows.

A single AHU supplies air to all individual rooms recirculating all extracted air.
With this type of system, it is possible that viruses pass from one room to another if not absolute filtering is made.

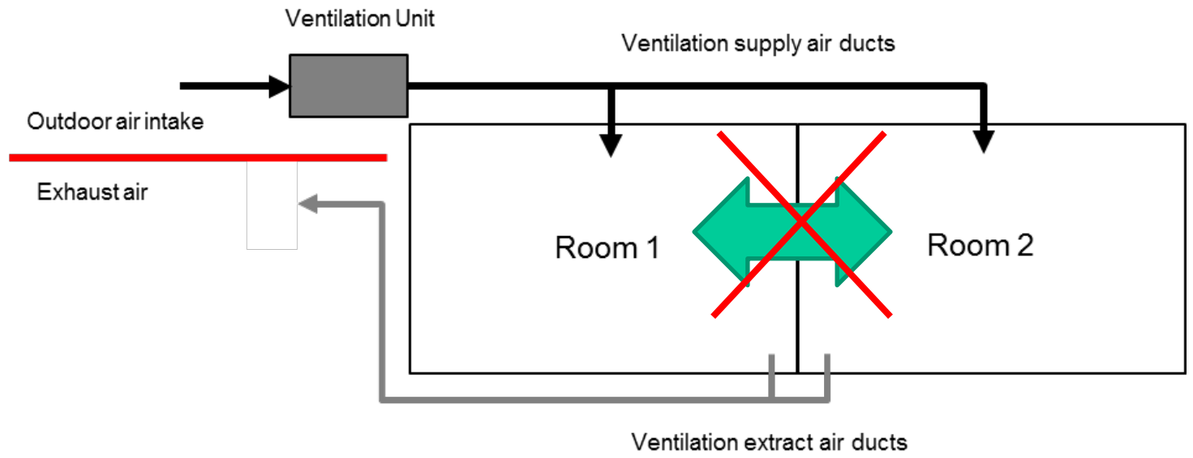


CROSS-CONTAMINATION – NO VIRUS DILUTION

C. Mechanical ventilation system

Supply outdoor air is provided to each room , is extracted and expelled outdoor, so viruses cannot pass from one room to another. But, mainly, possible virus concentration in any room is reduced through dilution with provided outdoor air.

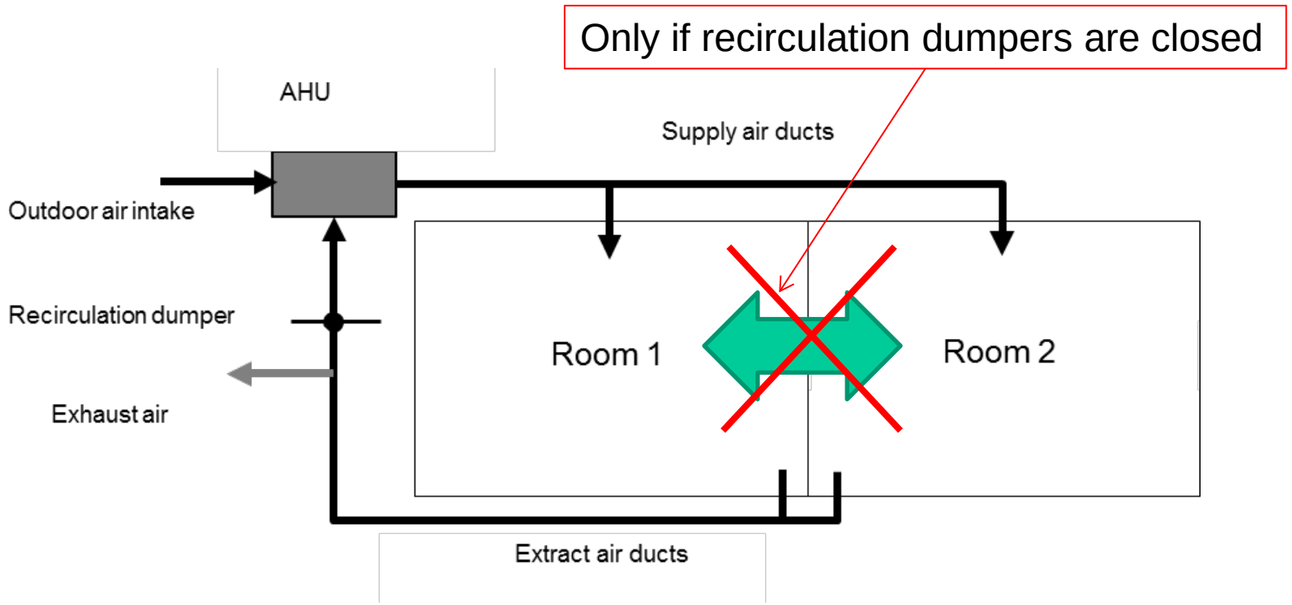
A mechanical ventilation system can be added to type A or type B H&C system, with different results.



NO CROSS-CONTAMINATION AND VIRUS DILUTION

D. All-Air HVAC System

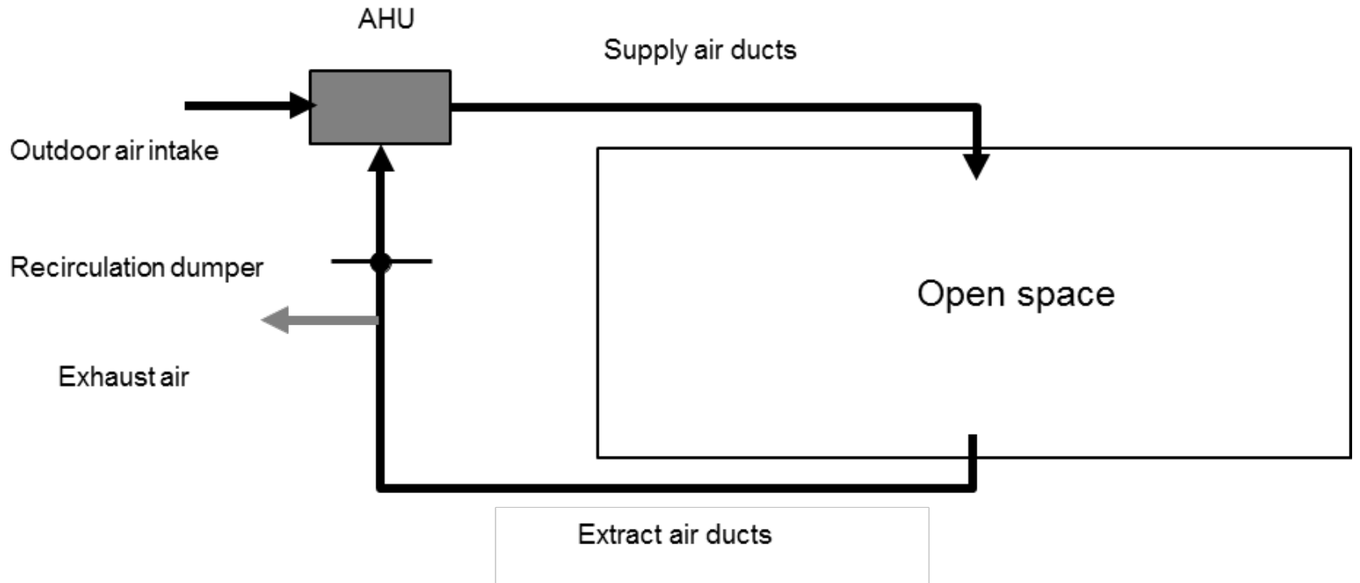
A single AHU supplies air to all individual rooms as mixing of outdoor and extract (recirculation) air.
With this type of system, it is possible that viruses pass from one room to another if not absolute filtering is made on recirculation air or recirculation is completely avoided closing recirculation dumpers.
If recirculation dumpers are closed cross-contamination is avoided and virus dilution is achieved.



POSSIBLE CROSS-CONTAMINATION IF RECIRCULATION IS ALLOWED BUT VIRUS DILUTION

E. Single Zone All-Air HVAC System

Single zone All-Air Systems are used in large commercial open spaces as supermarkets, cinemas and theatres.
Recirculation damper is always present, but such systems are generally designed to be able to supply only outdoor air. Therefore, in emergency conditions it is ALWAYS necessary to CLOSE the RECIRCULATION DAMPER, in order to dilute eventually introduced viruses.



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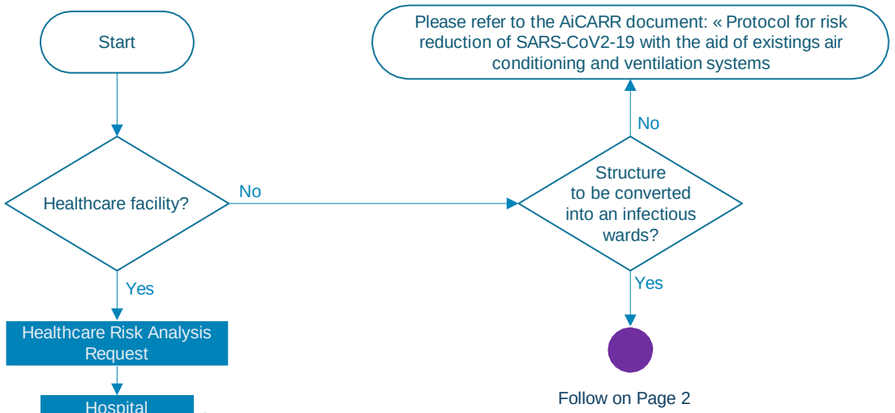
PROTOCOL FOR RISK REDUCTION OF SARS-CoV2-19 DIFFUSION IN HEALTHCARE FACILITIES WITH THE AID OF AIR CONDITIONING AND VENTILATION SYSTEMS



PREMISE

On March 18th AiCARR has published on its web site the document «Protocol for risk reduction of SARS-CoV2-19 diffusion with the aid of existing air conditioning and ventilation systems". This new protocol is intended to complement the previous one for aspects relating to healthcare environments.

This document is addressed to HVAC technicians and Healthcare Departments to provide indications on how to operate on existing systems or how to design and operate new systems when adapting existing spaces to healthcare facilities .

Starting from the basic principle that in the hospitalization of highly infectious patients the actions to be taken are:

- segregation both in terms of architectural layouts (for example air-lock) and in terms of systems (actions to maintain adequate pressure differences between different spaces in order to avoid cross contamination);
- airborne virus concentration dilution through high air changes rates, especially for intensive care units;
- outdoor environment contamination control through absolute filtration of the exhaust air.

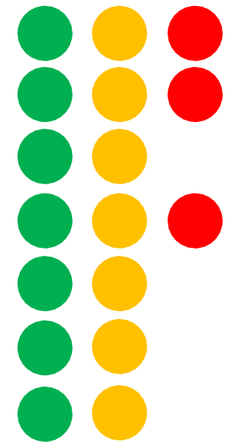
should be previously authorized by the Health Department.

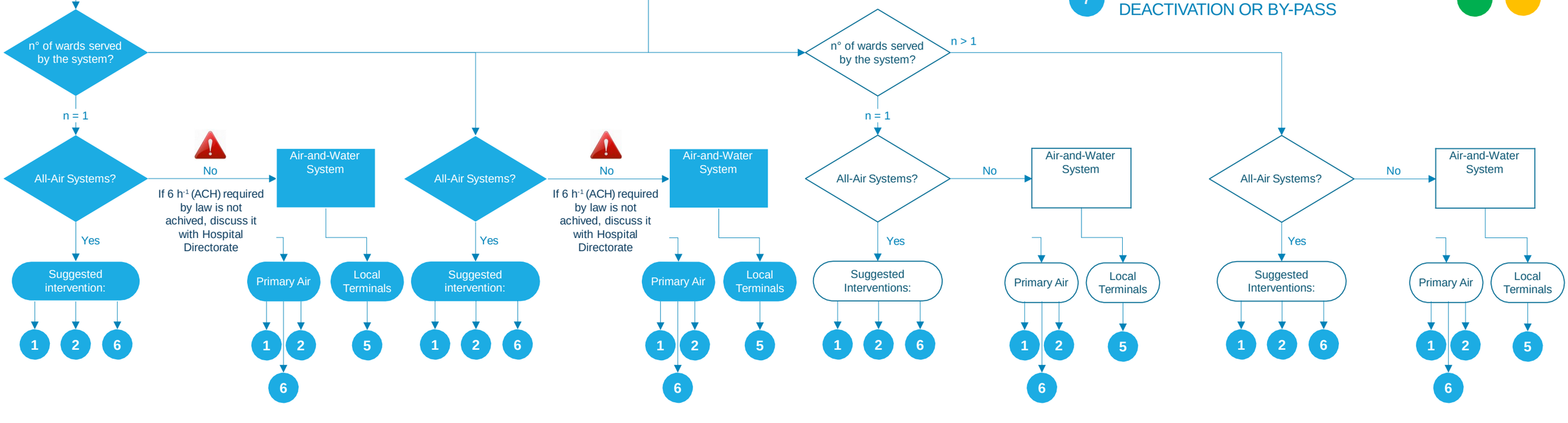
WARNING

- Please note that pursuant to the Italian Presidential Decree of 14 January 1997, in intensive care units supply air flows are only external air without recirculation with a minimum of 6 h^{-1} air changes rate.
- To achieve an effective virus charge dilution in the ambient air not only the outdoor air fraction in the supply air must be maintained but it must be increased as much as compatible with the system capacity.
- It is recommended to check that the distance between the external air intake and the exhaust outlet is not less than 10 m to avoid recirculation.
- Relationships with healthcare facility managers are essential to establish with them:
  - designed spaces suitability, minimum standards to be achieved, every exceptions to current regulations and legislation, compatibility between required intervention work time and emergency needs, level of functional reliability of devices/supplies to ensur e patients lives.

SUGGESTED INTERVENTIONS

1. SPACES DEPRESSURIZATION
2. EXHAUST AIR MANAGEMENT
3. INDOOR AIR RECIRCULATION
4. INTENSIVE CARE UNIT
5. TERMINALS CLEANING
6. ABSOLUTE FILTERS REPLACEMENT
7. HEAT RECOVERY UNITS DEACTIVATION OR BY-PASS





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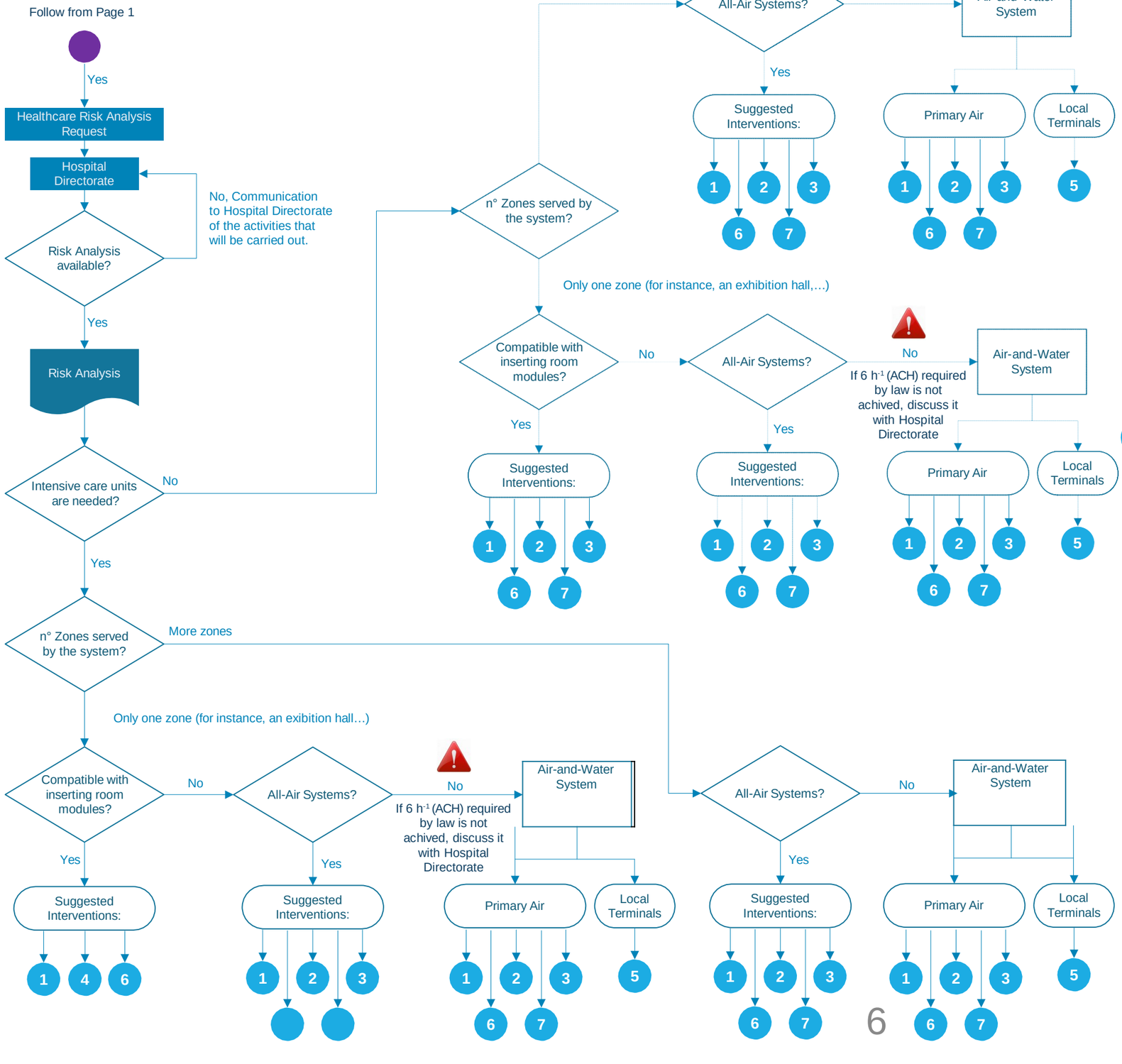


LEGENDA

- INTERVENTIONS THAT REQUIRE ACTIONS ON CONTROL SYSTEMS
- INTERVENTIONS THAT REQUIRE MAINTENANCE STAFF ACTIONS
- PLANT OR ARCHITECTURAL MODIFICATIONS

SUGGEESTED INTERVENTIONS DESCRIPTION

1 SPACES DEPRESSURIZATION

To transform existing ordinary hospital stays into infectives hospital stays, first of all it is necessary to increase the extract air to maintain these rooms in depression compared to other departments and or spaces for non-infected, it is therefore recommended to:

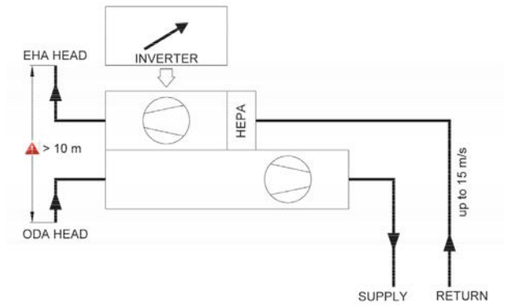
a. do not decrease the supply air flow but rather force the supply fan to provide the maximum possible flow by feeding its motor through inverter in order to increase its round speed remaining below its maximum allowed absorbed power;

b. feed exhaust air fan motor through inverter in order to increase its round speed as much as possible below its maximum allowed absorbed power (scheme 1) and insert an absolute filter on the exhaust outlet, after checking the available head; despite noise increase, in these situations it is possible to increase the air speed in return ducts even up to 15 m/s;

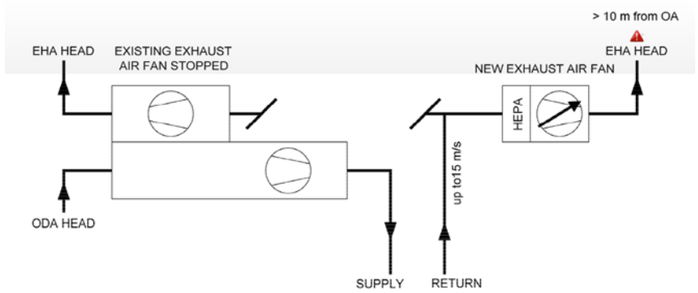
c. if applying a) and b) an effective depression, verified by smoke test, is not achieved, examine the possibility of replacing the existing exhaust air fan with a new appliance of adequate power and head (scheme 2) ; despite noise increase, in these situations it is possible to increase the air speed in return ducts even up to 15 m/s;

d. if still insufficient, it is necessary to install an autonomous extraction system (see schemes 3a and 3b) with fan and absolute filter block located in the corridor outside the healthcare unit. In the first case (3a) it is possible to keep the corridor in overpressure with a limited risk of cross-contamination, in the second case (3b) there is risk of uncontrollable infiltrations.

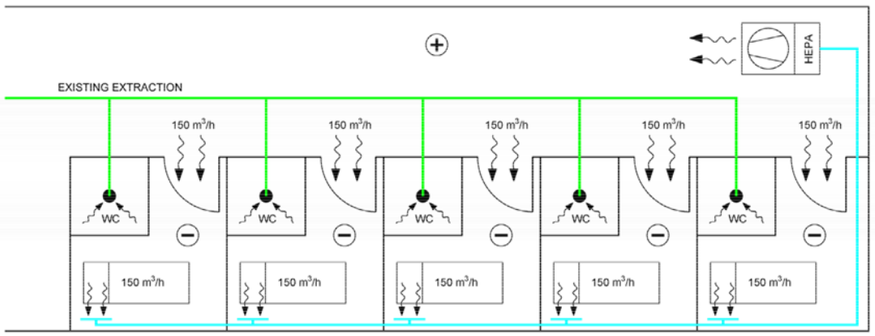
SCHEME N.1 – Insertion of inverter on exhaust air fan motor and of HEPA filter



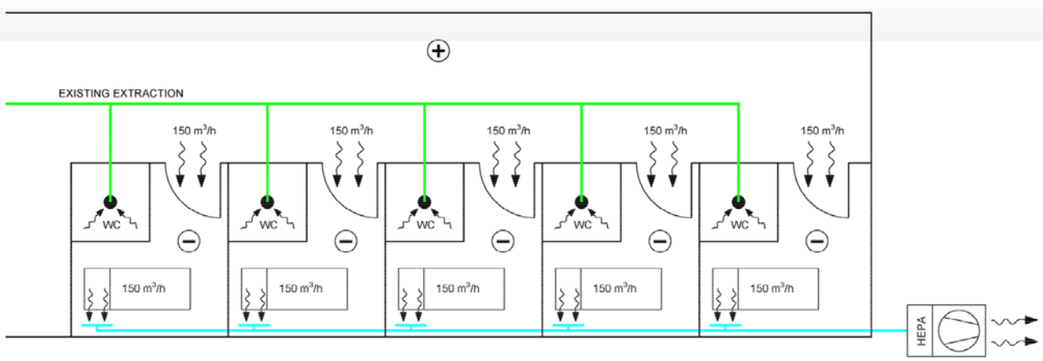
SCHEME N.2 – New block with HEPA filter and exhaust air fan with inverter



SCHEME N.3a – Internal extraction fan in the department corridor



SCHEME N.3b – Extraction fan outside the department



Note to schemes 3a e 3b: to maintain a minimum depression, an extraction flow rate of about 150 m³/h is recommended for invectives hospital stay of about 25 m².

It should be remembered that isolation of infected spaces respect to other healthcare spaces is an essential provision and the principles expressed above must be applied according to the intended use and the existing systems typology; specifically:

A. In the presence of **local terminals with primary air system**, space transformation into intensive care unit is strongly discouraged; indeed:

- The supply air flow rate (usually about 2 h^{-1}):
  - is too low, compared to a recommended flow rate of 10-12 h^{-1} and a regulatory minimum of 6 h^{-1};
  - cannot be diminished to create depression;
  - compatibly with the existing situation, it should be forced to the maximum.
- The extract air sometimes:
  - is allowed to flow out naturally due to the overpressure in the rooms;
  - occurs from the dedicated toilet, if any, with extraction fan (fixed at 6 h^{-1}, or intermittent with 12 h^{-1}), however not adaptable to new requirements;
  - occurs from the corridor and should be decreased as much as possible to keep it in overpressure in respect of hospital stays.

In conclusion, major renovations would be needed.

In the event that the emergency forces this type of use, it is necessary to introduce an autonomous air extraction system as described in (2) that maintains the healthcare unit in a strong depression by recovering air from other rooms, excluding the toilet, and agreeing with the Hospital Directorate the non-compliance with the minimum ventilation level required by law.

B. In the presence of a **All-Air system**, space transformation into intensive care for infected patients is subject to:

- compliance verification with the project data agreed with the responsible Hospital Directorate;
- enhancement of the supply air flow rates in the intensive care area both by acting on fan motor as described at point (1), and by recalibrating the supply ducts network in favour of the intensive care area;
- enhancement of air extraction and expulsion.

2 EXHAUST AIR MANAGEMENT

The expulsion of the exhausted air from hospital stays or infectious departments must be subjected to absolute filtration (filters H13 or H14):

1) If you can use the existing systems, check for air expulsion that:

- it is possible to install HEPA filter before exhaust air fan (with canister if available, in the alternative, if not available, provide for replacing the filter with suitable PPE following the instructions of the RSPP), and to maintain it according to the instructions of hygienist;
- a short circuit with the outdoor air intake must be avoided, thus try to have a minimum distance between the exhaust outlet and the intake of 10 meters, placed upwind of exhaust outlet respect to predominant winds;
- it is possible to connect easy with the control system center, if not, install clogged filter luminous-acoustic alarm as visible/audible as possible.

2) If it is necessary to provide new independent auxiliary extraction duct:

- where applicable, the recommendations/provisions of the previous point apply;
- create a new air intake duct from the rooms concerned, even inside them, providing it with : intake terminals possibly positioned behind the head of the infectious bed (s); extraction air fan with absolute filtration (with canister if available, in the alternative, if not available provide for the operation of replacing the filter with suitable PPE following the instructions of the RSPP) with soundproofed box, placed in inspectable position and maintainable safely for both patients and heahlthcare operators;
- if possible introduce a duct silencer.

PROTOCOL FOR RISK REDUCTION OF SARS-CoV2-19 DIFFUSION IN HEALTHCARE FACILITIES WITH THE AID OF AIR CONDITIONING AND VENTILATION SYSTEMS

Cultura e Tecnica per Energia Uomo e Ambiente

3 INDOOR AIR RICIRCULATION

Since the virus can survive in air for several hours, it is necessary to prevent possible contamination of indoor air by eliminating air recirculation, when it exists and in case of intervention on non-healthcare structures, (recirculation in healthcare environments is prohibited due to risk of cross contamination independently of SARS-CoV2- 19).

Local terminals - such as split units, fan coils and VRF systems for heating and cooling - only recirculate air of space used as healthcare facility and represent a low risk of spreading the virus, in nearby wards, especially if they are subjected to continuous and accurate cleaning and sanitizing. However, their presence is not compatible with infectious intensive care unit stays.

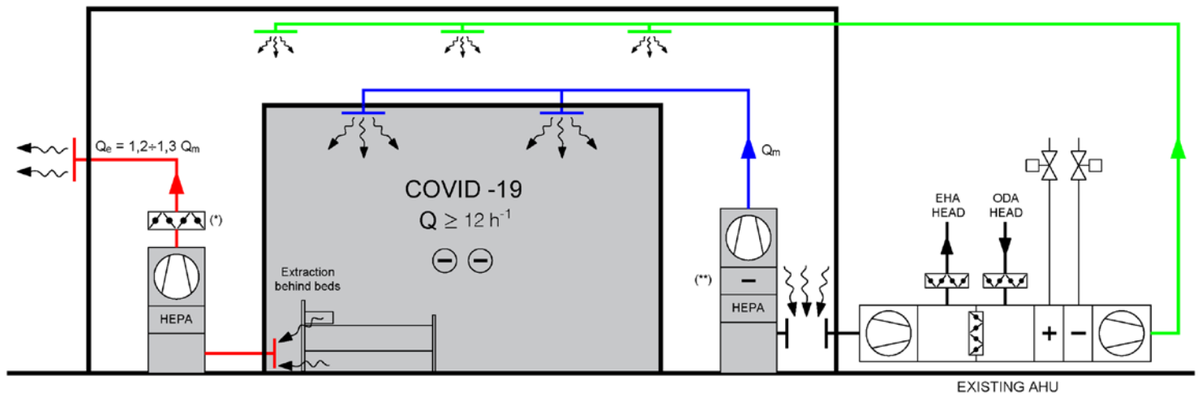
In hospitals, indoor air recirculation is allowed only in the operating theatres; in case of interventions on SARS-CoV2-19 patients, it is recommended not to modify HVAC systems but it is sufficient to have post-intervention decontamination period lasting to be defined with Hospital Directorate.

4 INTENSIVE CARE UNIT

When setting up temporary intensive care units within large already air-conditioned existing structures, such as exhibition centres, gyms, warehouses, etc. (scheme 4), it is suggested to take into account thermal load for the new built environments of about 60 W/m^2, so identified:

- Reference area for intensive care unit bed: 15 m^2/bed;
- Equipment: 600 – 800 W/bed about 50 W/m^2;
- Lighting: 5 W/m^2;
- People: 5 W/m^2;
- Minimum outdoor air flow ≥ 10/12 h^{-1} with a minimum of 6 h^{-1} as required by Italian decree DPR 14/01/1997;
- Supply air temperature ≥ 18 °C;
- Relative humidity between 40 e 60 % as required by Italian decree DPR 14/01/1997.

SCHEME N.4 - COVID-19 intensive care unit layout



(*) Calibration dumper or variable flow fan (EC motor).
(**) Direct expansion post cooling coil.

5 TERMINALS CLEANING

Droplets and an important fraction of the aerosol precipitates on horizontal surfaces and therefore it is necessary to clean and sanitize them with adequate equipment at least once a day.

For correct cleaning of system terminals (radiators, fan coils, vents, etc. ...) only qualified personnel, equipped with suitable Personal Protective Equipment (PPE) and following well-defined procedures, must be used.

Any intervention carried out incorrectly and/or without using PPE would result in not reduction but in risk increase.

Equipment: vacuum cleaner with HEPA micro filter (filter capable of retaining 99.9% of micro particles) and telescopic rod, cloth and color-coded bucket.
Products: multipurpose detergent for surfaces cleaning .
Operating technique:

- Clean the surfaces with a vacuum cleaner with telescopic rod.
- Wash with cloth soaked in detergent solution.
- Leave to dry.

6 ABSOLUTE FILTERS REPLACEMENT

Absolute filters must be inserted in workmanlike manner to avoid leaking contaminated air; thus, penetration test must be carried out on terminals of air conditioning system to check the filtration efficiency, including the correct sealing of the filters and the correct sealing of their frame to channels and vents to avoid bypass of unfiltered air through leaks.

If possible, use suitable canisters for the absolute filters (safety filter holder containers or alternatively use of suitable PPE when removing them) that guarantee maximum containment, protection of the environment and of maintenance operators, which watertight seal is certified in class 3 according to ISO 10648-2 at +/- 6000 Pa.

7 HEAT RECOVERY UNITS DEACTIVATION OR BY-PASS

Rotary heat exchangers must always be stopped, to avoid a possible, however improbable and remote, contamination of outdoor air with exhaust air. Upon restarting, wheels must first be sanitized.
For the same reason, any other type of membrane based enthalpy heat exchangers must be by-passed.
In case of cross flow heat exchangers, instead evaluate opening of by-pass damper in order to increase the outdoor air flow. If there is a calibration damper on the outdoor air by-pass line giving the same pressure drops of the heat exchanger, the damper must be opened as much as possible, always compatibly with the fan motor electrical absorption.

PROBLEMS RELATED TO ACTIVITIES OF OPERATORS IN CHARGE OF PLANTS MANAGEMENT AND MAINTENANCE

In any modification/enhancement of HVAC systems serving COVID-19 departments or in any case areas where patients affected by COVID-19 are treated, operators must be specifically trained on the risks and, in particular, operations must be implemented considering every possible precaution that protects their health, such as:

- surface disinfection prior to all operations, taking care to follow instructions for products used;
- adoption of all PPE suitable for required operations with control of this use by foremen of cleaning companies;
- correct transfer and safety isolation of all removed parts, taking into due consideration virus survival time on their surfaces;
- posting, where necessary for risk prompt identification, of signs identifying plant parts subject to potential SARS-CoV2-19 infection (for example, identification of ducts and expulsion grids of the AHUs serving the COVID-19 areas);
- recording (date, operation carried out, etc.) of maintenance operations and/or plants upgrading/modification, for example to allow interpretation of any statistical evidence or identification of any anomalies.
- check at least 2 times a day medical oxygen production and distribution plant functioning and correct feeding to departments of as well as, even several times a day, its distribution manifolds to check the absence of lamination phenomena due to the high demand of the oxygen itself with consequent freezing and interruption of the service; this malfunction is in fact potentially lethal, especially for patients affected by SARS-Cov2-19.

THANK YOU
for your attention

People-centric approach: create lasting habits for threat mitigation

Motivating end-users behavioral change
(energy use, indoor environment, health and lifestyle)

BUILD-UP Webinar

28th April 2020, 12.00 to 13.30.

EU wide

Jure Vetršek
IRI UL

Ana Tisov
HIA

MOBISTYLE ENERGY HEALTH INDOOR ENVIRONMENT

Let’s change perception from

‘Buildings consume energy’…

Let's change perception from

'Buildings consume energy'…

…to the fact that

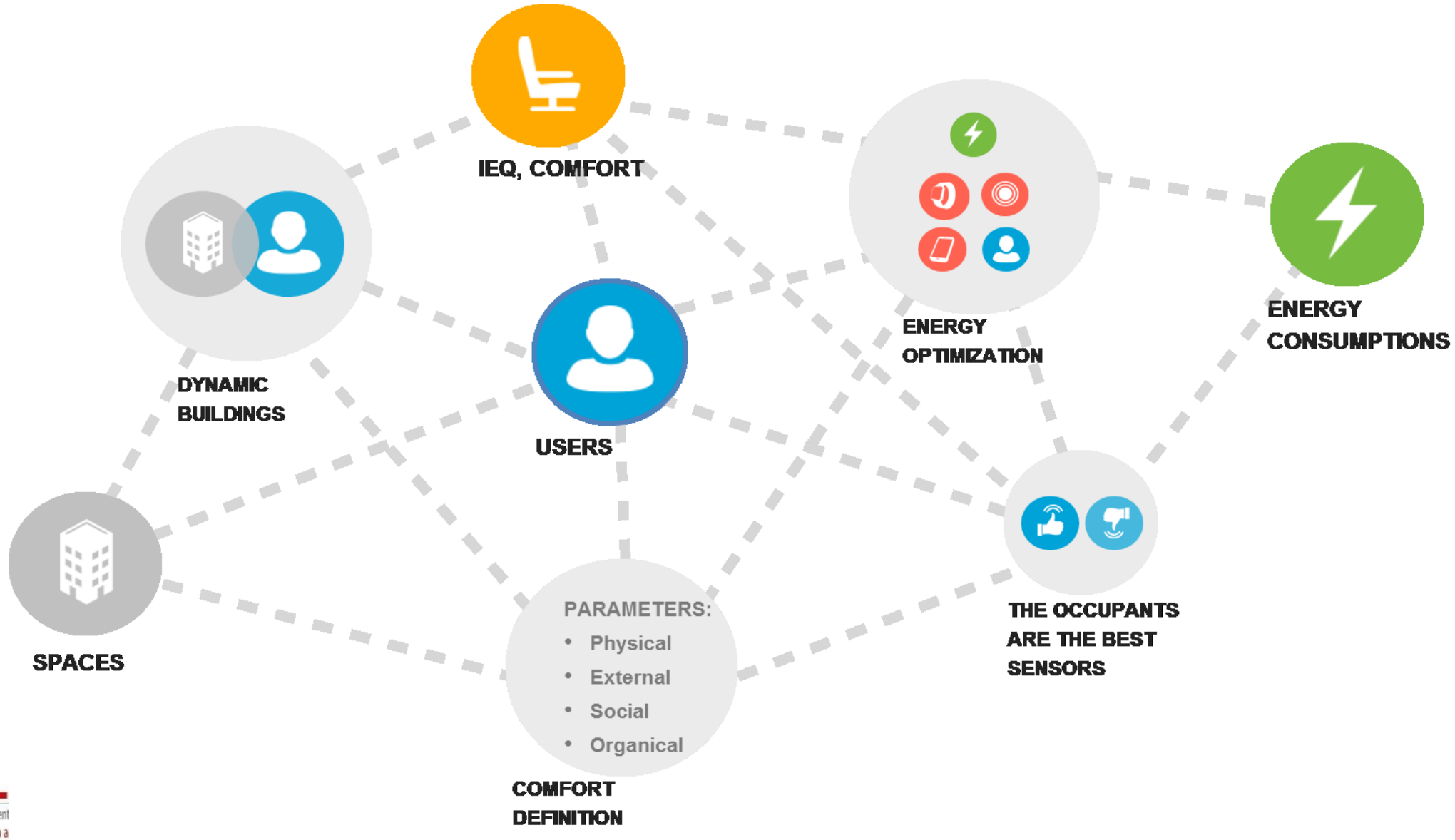
'People use energy.'

IRI UL
Institute for Innovation and Development of University of Ljubljana

MOBISTYLE

Human building interaction

Building ecosystem is efficient if all the components are mutually conscious.



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YLE

Changed behavior – elevators use

MOBISTYLE aim is to persuade people to change behavior **one step at the time.**

- Open windows more;
- Take stairs more often.

Elevator	X kitchen	FKKT large	FKKT small	X panoramic	FRI
Change of moves per day in %	+4	-7,4	-13,2	-10,1	-14,6

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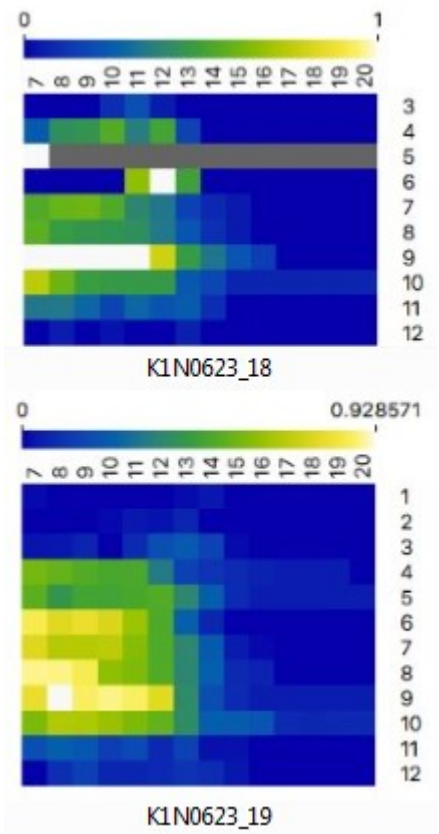
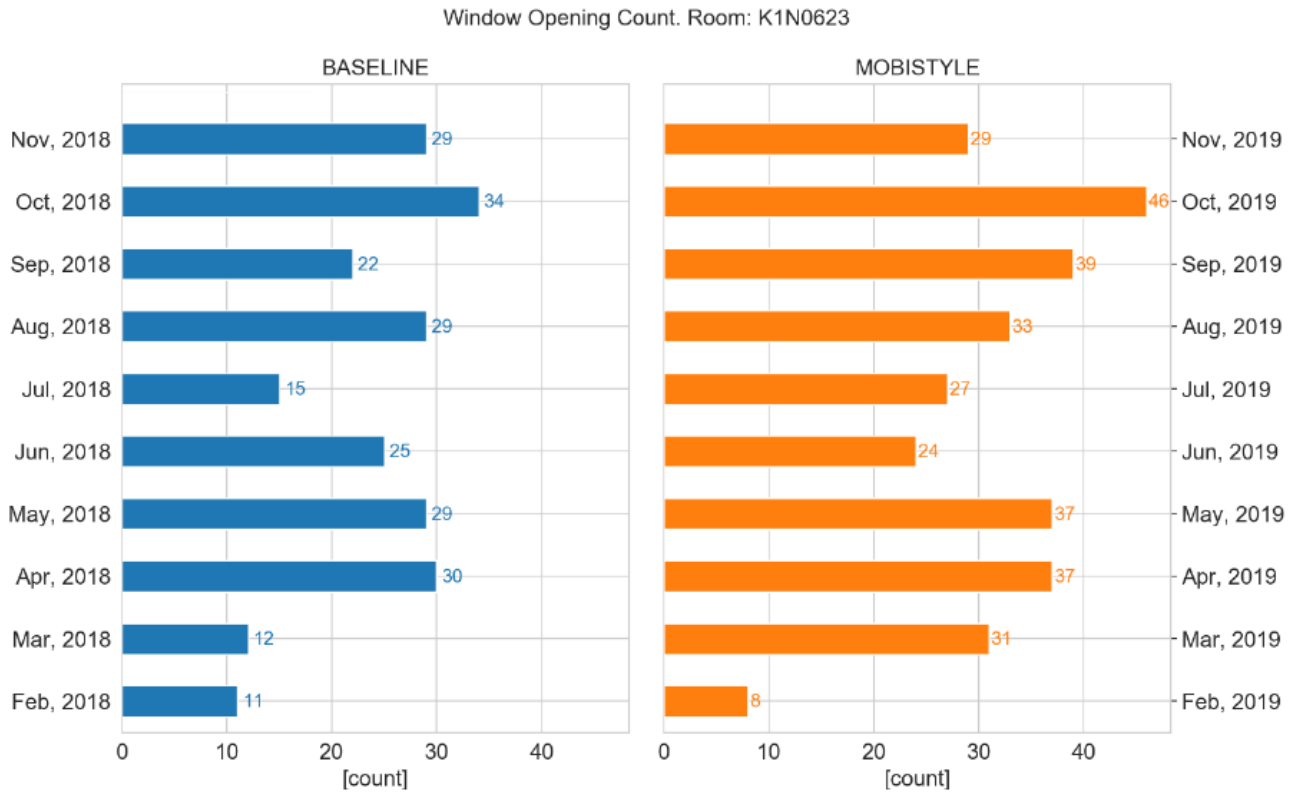
MOBISTYLE

Changed behavior – window opening

More window opening (not necessary better IEQ)





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MOBISTYLE

Changed behavior -> big VS thick data

„LED red often, I don’t trust it… „

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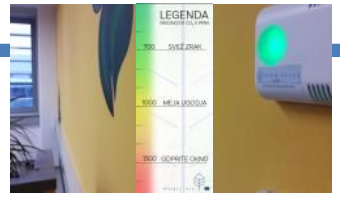
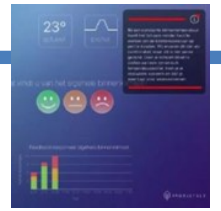
MOBISTYLE

Changed behavior -> big VS thick data

„LED red often, I don’t trust it… „
Gown used in lab…

MOBISTYLE people centered development





IDENTIFICATION

Who are we solving for ?

ANALYSIS

What do people want?

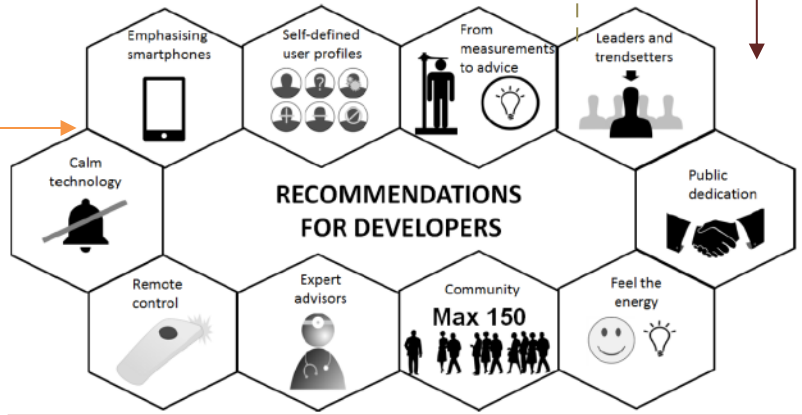
INTERPRETATION

What and how will be created to serve the user needs?

TESTING

How will we improve solutions to serve people?

Improvements



Identification and analysis methods:
Interviews, focus groups, participant observation...

Testing and interpretation methods:
Prototypes, scenarios, focus groups…

For more information on the developed MOBISTYLE Approach & Methodology…

- Look at the MOBISTYLE deliverables on the website: LINK
- Summary presentation of the work developed within the first 24 months: LINK
- Watch our previous BUILD-UP Webinar where the methodology behind the MOBISTYLE ICT tools is presented: LINK

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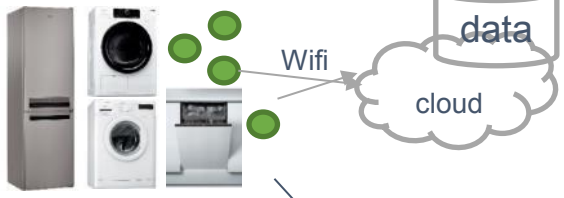
MOBISTYLE



White goods

Energy
IEQ
Health

Methodologies
(Algorithms, models)

API

API

Wearables

M2M

MOBISTYLE
Database

API

Energy, IEQ sensors

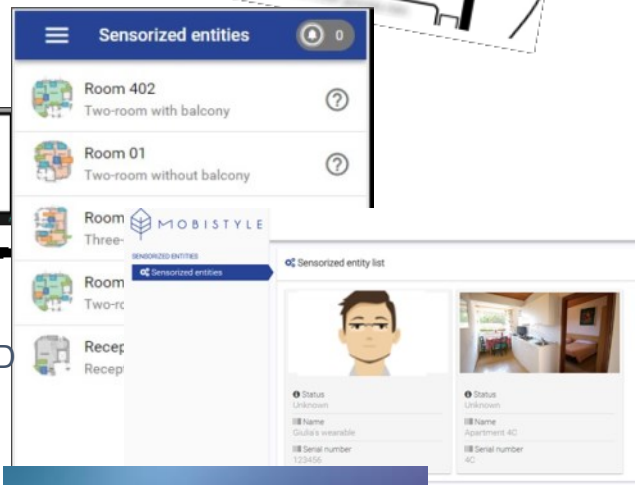
Digital authentication

M2U

MOBISTYLE
Users Platform

MOBISTYLE
Expert Tool

GAME



DASHBOARD

OFFICE APP

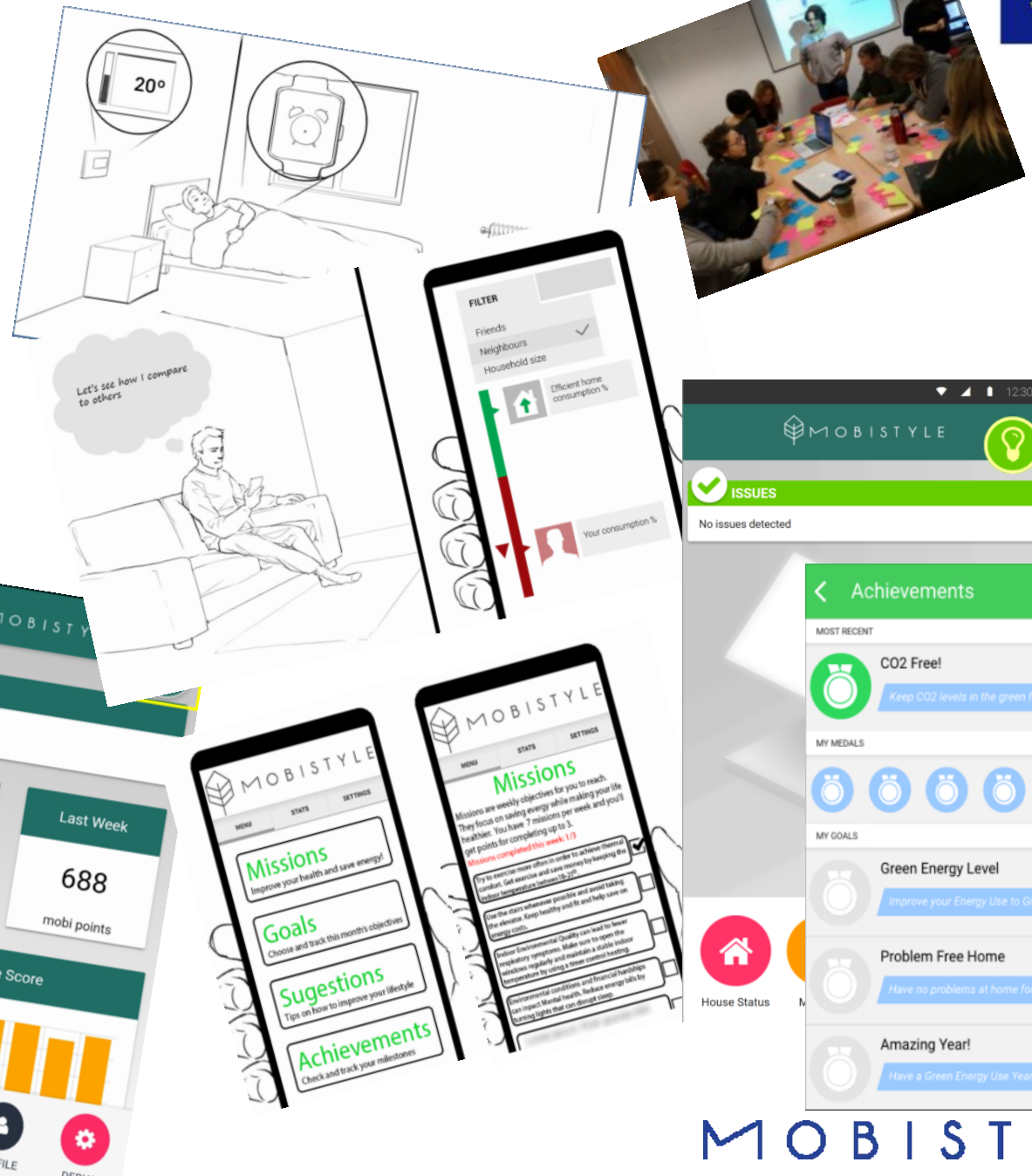
IRI UL
Institute for Innovation and Development of University of Ljubljana

MOBISTYLE

MOBISTYLE Game

Mobile application:

- Used in homes.
- Uses “nudges”, complemented by “tips”.
- Using data from energy-IEQ sensors.
- Triggers missions & detects their completion.



→ **Game developer:**

HIGHSKILLZ
HIGHLY PERSONALIZED LEARNING EXPERIENCES

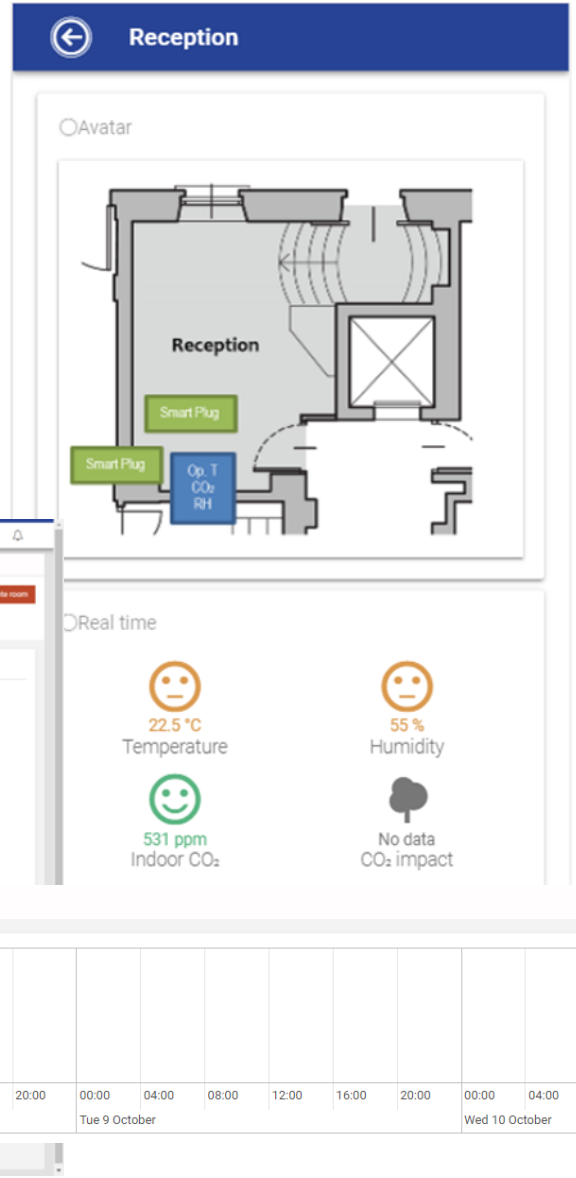
MOBISTYLE

MOBISTYLE Dashboard

Desktop and Mobile application:

- Used in university & hotel demonstration cases.
- Aimed to both consumers & company managers.

→ **See the MOBISTYLE Dashboard video**: LINK

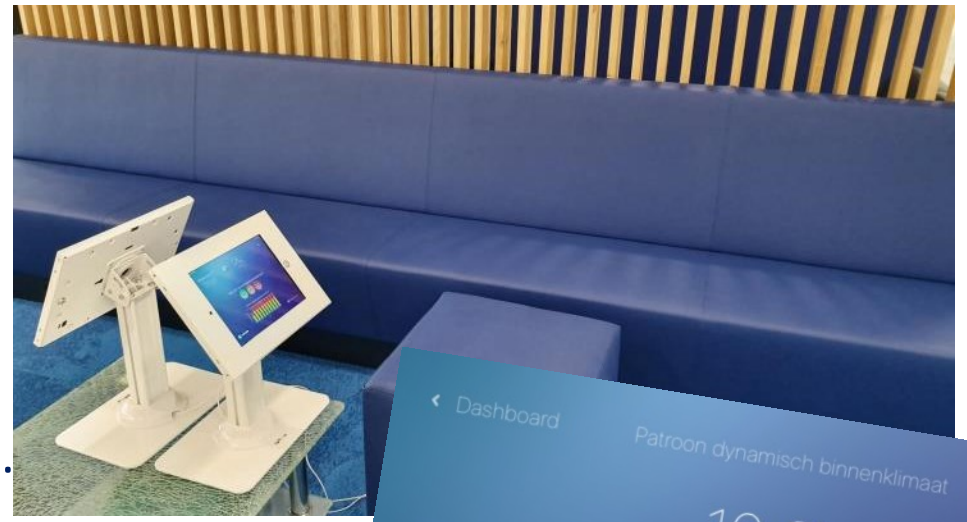


→ **Dashboard developer:**

HOLONIX
BRING THINGS TO LIFE

MOBISTYLE

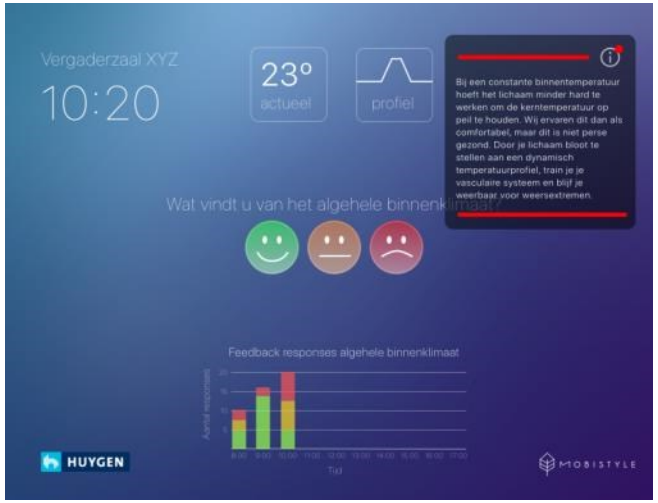
MOBISTYLE Office App



Desktop application:

- Aimed for employees & company managers.
- Used primarily to encourage dynamic indoor conditions.

→ **See the MOBISTYLE Office App video**: LINK



→ **Office App responsible:**

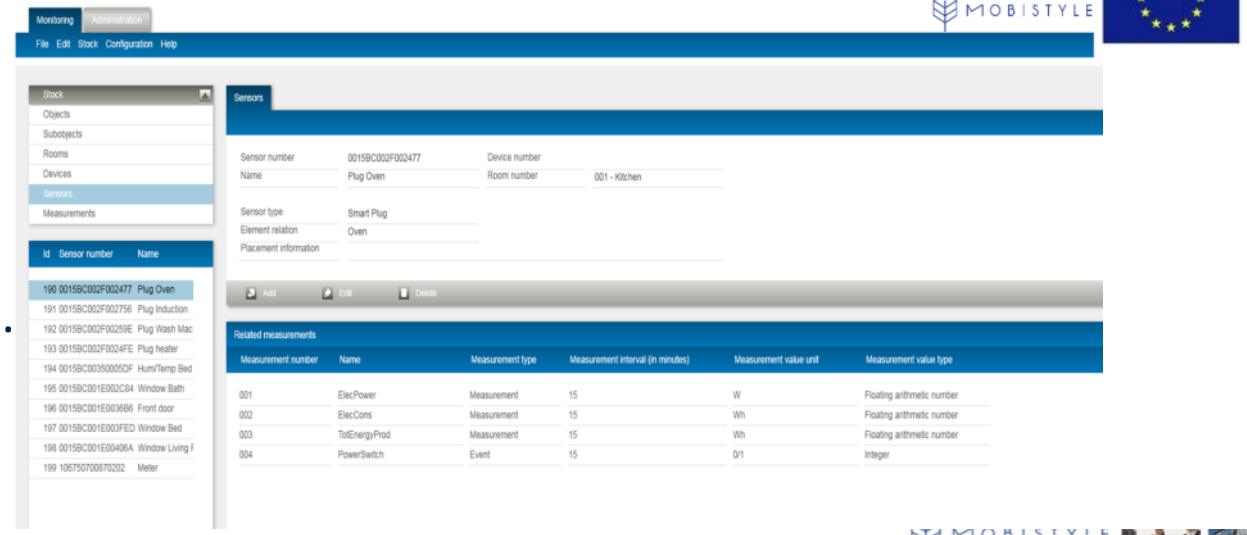
HUYGEN
INGENIEURS & ADVISEURS

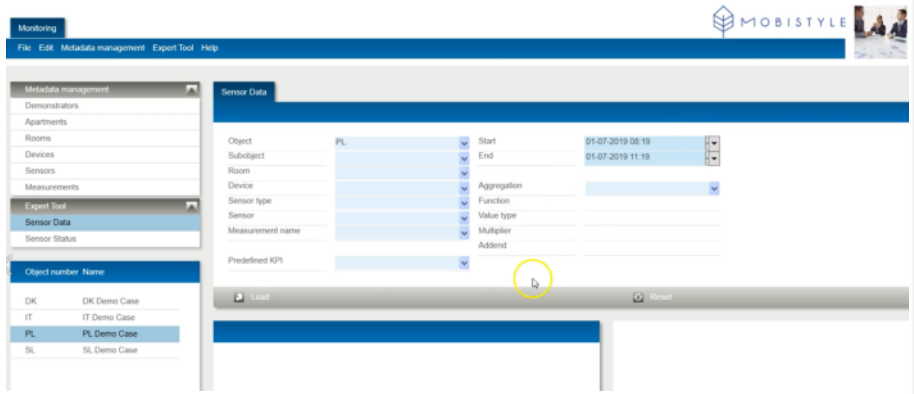
MOBISTYLE

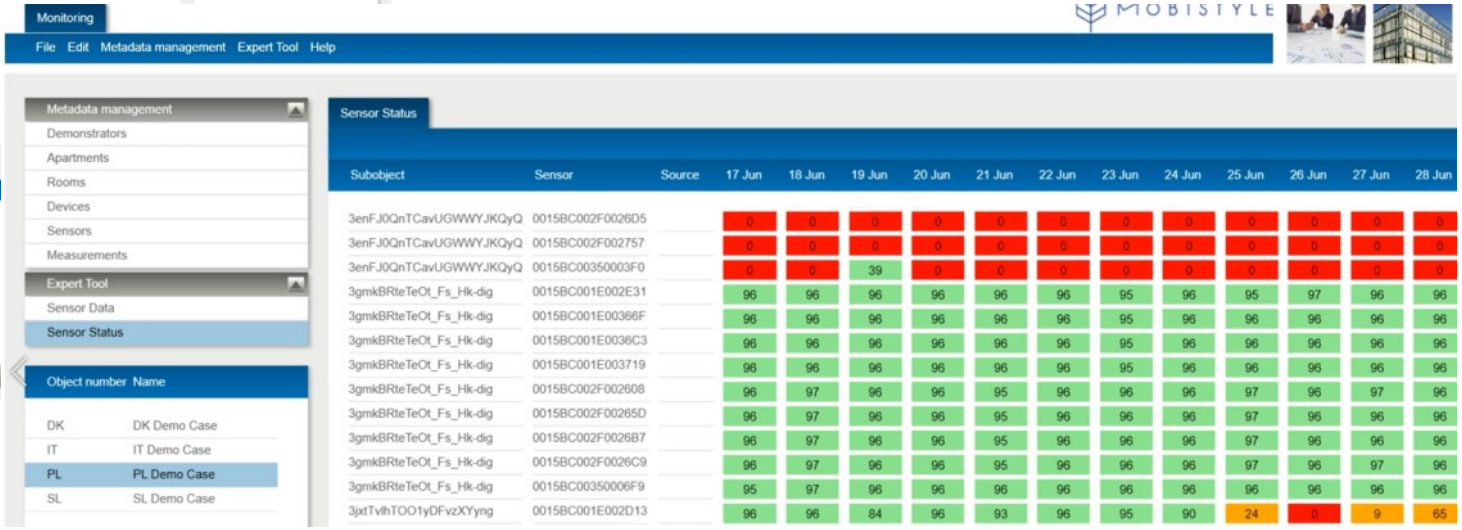
MOBISTYLE Expert tool

Desktop application:

- Primarily for building managers and experts.
- Allowing:
  - Data management;
  - KPI calculation;
  - Interoperability.







→ **Expert tool developer:**

DEMO CONSULTANTS

MOBISTYLE

Hero at Home – example of people friendly communication

How to stay energy-efficient, healthy and productive in times of lockdown LINK

#HeroAtHome is the new social campaign launched by MOBISTYLE, Utilitee, TripleA and eTEACHER

@Hero_atHome

@Hero_At_Home

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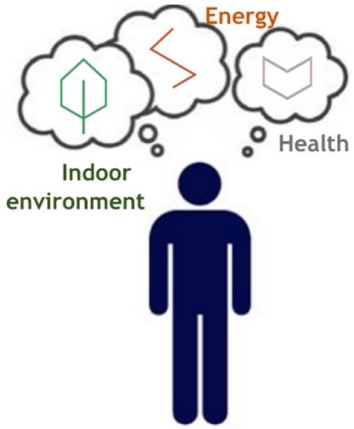
MOBISTYLE UTILITEE Triple A-reno eTEACHER Empowering Energy Education

Conclusions – take away

- In the past (Before Corona - **BC**) it was difficult to change habits.
- In MOBISTYLE we used **health** as a trigger to change building use.
- Now it is similar time as when opening a newly constructed building: **new habits** (human-building interaction) will be formed.
- If nudged/ communicated well, it can bring lower energy use and improved IEQ/productivity while health will really become new wealth.

- We can choose to make new habits in respect to much greater threat than Covid19 – **climate change** or we wait for government decrees,

  but at that time it will be **to late**.



Thank you for your attention.

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COLOPHON

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Q&A

Submit your question!