

SinBerBEST Recommendations for Singapore Buildings during COVID-19 Pandemic

Background

On 13 March 2020 World Health Organization (WHO) declared COVID-19 as a pandemic [1-2]. Individual hygiene, disinfection practice, isolation, and physical distancing measures have been advocated by the WHO and Singapore Ministry of Health as the main means to control the spread of COVID-19 [1-9].

With the intent to reduce the risk of COVID-19 virus spread further, [SinBerBEST](#) provides this Air Conditioning and Mechanical Ventilation (ACMV) expert recommendations document for Singapore commercial, institutional and residential buildings. This document is to provide guidance for:

- Building Owners and Facility Managers that operate buildings;
- Managers and Administrators for schools and childcare centers; and
- Homeowners of public and private residences.

This document follows the use of the precautionary principle to reduce potential risks associated with plausible routes of COVID-19 spread [10-11]. This document takes into account the context in Singapore [12-13]. These are made based on our professional judgment using imperfect data specific to COVID-19 [14-17], yet are grounded in many years of research in the field of indoor air quality, mechanical engineering and exposure science and evidence collected from studies of other infectious agents [18-33]. These recommendations should be used after the recommended primary measures, for example, individual hygiene, disinfection practice, isolation, and social distancing measures (SDM) [1-9].

How COVID-19 spreads

The WHO reports [1] that *“COVID-19 is transmitted via droplets and fomites during close unprotected contact between an infector and infectee. The airborne spread has not been reported for COVID-19 and it is not believed to be a major driver of transmission based on available evidence; however, it can be envisaged if certain aerosol-generating procedures are conducted in health care facilities. Fecal shedding has been demonstrated by some patients, and the viable virus has been identified in a limited number of case reports. However, the fecal-oral route does not appear to be a driver of COVID-19 transmission; its role and significance for COVID-19 remain to be determined.”*

We acknowledge that the airborne transmission route may not be the main pathway. Measures to reduce the potential airborne route may be secondary to others but should be applied if only small negative effects are caused by them or under some circumstances, particularly when ventilation is inadequate. Our recommendations are based on increasing ventilation rate [18-25] and enhancing air cleaning [26-28] as much as technically, environmentally, and economically feasible.

General recommendations for buildings

- **Set the outdoor air intake to the maximum setting in air-conditioned buildings.** In buildings with ACMV systems, outdoor air supply shall be set to the maximum setting to enhance dilution indoors. Outdoor air dampers should be opened to as high a percentage as possible with fans running in the high speed mode as indoor conditions permit. Operation times shall be extended to commence the system at least 2 hours before the first occupant arrives and switch off 2 hours after all occupants have left. For example, for office workers on staggered working hours with staff arriving as early as 7.30 am, leaving late at 7.30 pm, the recommended operation times will be from 5.30 am to 9.30 pm. Demand control ventilation and features that only turn on the supply air when the

occupants are in the room shall be disengaged. If a carbon dioxide sensor is present, the closer the indoor carbon dioxide concentration to the outdoor value (410 ppm), the better.

- **Minimise recirculation in air-conditioned buildings.** For air-conditioned buildings that have the capacity to operate with 100% outdoor air (no recirculation), they should be operated under such conditions. The return air dampers shall be closed and the outdoor air intake damper fully opened. The operator shall verify that acceptable conditions are maintained indoors. If full closing of the recirculation air is not possible to achieve adequate comfort (for example, air temperature above 27°C), the recirculation air shall be kept at a minimum level and treated with high-efficiency media-based filters in place in the AHU and/or the indoor space deployed with localized air cleaning using HEPA-based PACs in the office (see below).
- **Air purging in air-conditioned buildings.** For air conditioned buildings, an air purging system should be operated twice a day (before and after working hours), introducing outdoor air into the space and discharging indoor air outside of the building at a minimum rate of 2 air changes per hour [12].
- **Stop rotary exchangers in air-conditioned buildings.** Rotary heat exchangers or heat wheels shall be switched off, leaks identified and sealed to prevent exhaust/recirculated air from getting entrained (bypass) into the supply air.

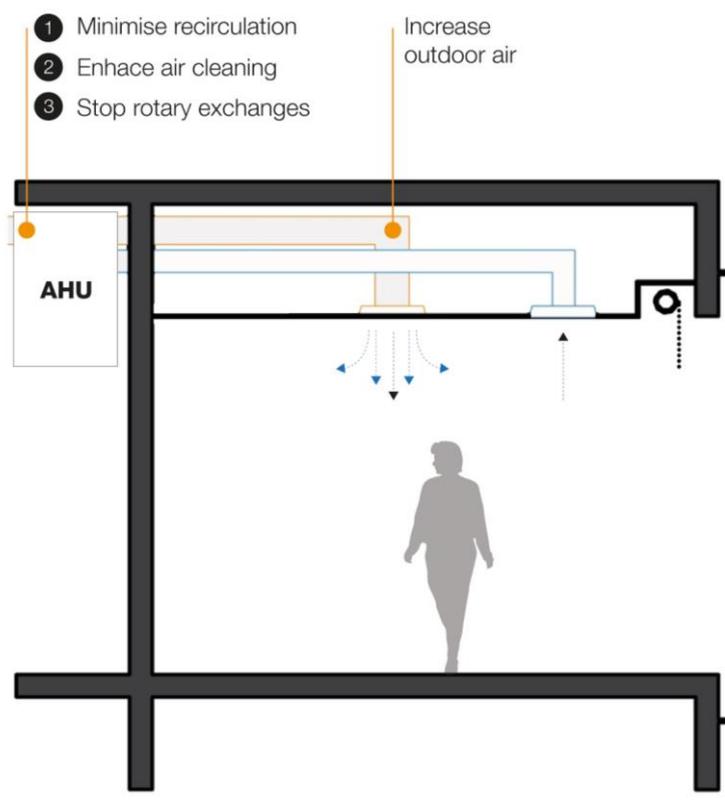


Figure 1. Diagram showing some of the recommendations given for air-conditioned buildings.

- **Maximise ventilation in toilets and common areas.** To avoid the possibility of fecal-oral transmission [32], the exhaust ventilation in the toilet shall always be kept on. Water seals in the plumbing system and use of toilet lid should be ensured to minimise the risks associated with under-pressure (lower pressure than outdoor). In common areas with a risk of crowd gathering, such as the entrance lobby, sufficient ventilation openings and air extraction/exhaust should be in place.
- **Consider the airflow pathway (air distribution) and occupancy layout.** Singapore Ministry of Manpower is enforcing safe distancing measures (SDM) in workplaces. As there have been reports on the association of airflows

and spread of the COVID-19 virus [14], it is recommended the occupancy layout for social distancing take into consideration the airflow patterns and pathways (e.g. staggered layout instead of linear placement of live workstations). It is also recommended that workstations be rearranged so that employees do not face each other, or establish partitions if facing each other cannot be avoided. If fans are used, ensure that air does not get blown from one person directly to another.

- **Open windows and turn off or use less often air-conditioning in naturally ventilated buildings.** For naturally ventilated buildings with operable windows, windows shall be fully opened to allow air to flow indoors without obstacles, ideally in the opposite side of a building. Ensure safety requirements and acceptability of outdoor noise and/or air pollution are met. Increased air motion, such as from a ceiling, desk or standing fans, can be used. In buildings designed to be naturally ventilated (such as residential buildings), if air-conditioning is used, it is recommended that sufficient outdoor air be provided by keeping the windows a bit open in every room. For rooms lacking windows, the internal doors may be kept open. Air-conditioning can be used to provide comfort but higher energy use may be expected.
- **Enhance air cleaning.** High-efficiency media-based filters, preferably MERV 14 (ASHRAE 52.2) [34] or F7 (EN 779 / EN 1822) [35,36] shall be installed and operated in the Air Handling Unit that serves the return and outdoor air. The filters shall be properly installed and well-sealed to prevent filter bypass. The filters shall be regularly inspected

to ensure no leakage and that it is not fully loaded. Adequate precaution shall be taken when changing the filters (done while the system is off, wearing personal protection equipment and gloves) and disposing of them.

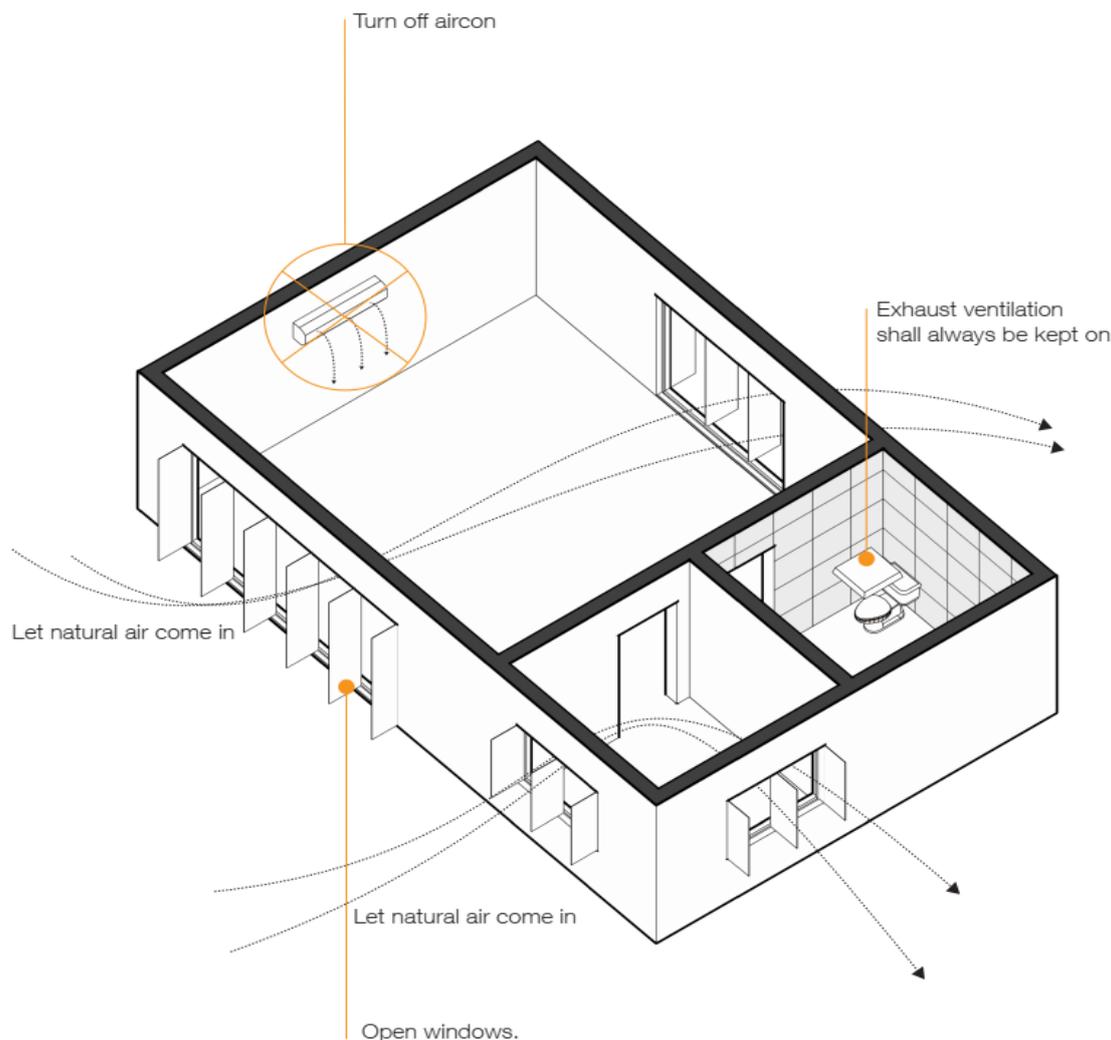


Figure 2. Diagram showing some of the recommendations given for naturally ventilated buildings.

- **Use Ultra-Violet Germicidal Irradiation (UVGI).** Other physical means of cleaning the air, such as UVGI (portable, upper room, AHU, and in the airstream) may be used [27]. Note that effective UVGI use will not be achieved for naturally ventilated spaces.
- **Use Portable Air Cleaners (PACs).** For mechanically ventilated buildings and air-conditioned schools and childcare centers, HEPA-based portable air cleaner may be deployed in a small room [28,37]. The selection of PACs depends on its performance (clean air delivery rates (CADR)). For larger indoor space, the numbers of PACs to be deployed shall be calculated on the performance of the PAC (CADR) and the space volume [37,38]. The use of PACs will have minimal impact in naturally ventilated spaces.

Recovering from Circuit Breaker [39] - associated building shutdown or operations

- **Address potential Legionnaire's bacteria colonization.** Waterborne pathogens, particularly Legionella bacteria, may colonize in stagnant water after an extended period of time in water mains, building plumbing lines, water heaters and cooling towers [40]. Building owners and operators shall assess and manage the risk of colonization, implement preventative measures and conduct remedial treatment if needed [40]. Prior to building re-entry,

operate water systems, toilets, faucets, etc. on a regular basis (3-5 days) to avoid the accumulation of biofilm and other bacteria.

- **Control indoor humidity to prevent dampness and mold growth.** Occupancy patterns that have changed as a result of social distancing associated situations may reduce a building's heat load and affect the ACMV's ability to control indoor relative humidity levels. This may create conditions favourable for moisture and mold damage on building surfaces. It is recommended that ACMV systems operate effectively to minimise and control indoor relative humidity to avoid dampness and mold growth in occupied spaces and ACMV systems.

Specific recommendations for residences with Person of Interest (POI)

- A person of interest in this document is defined as an individual issued with Stay-Home-Notice (SHN) [3], Leave of Absence (LOA) [4,5], or displaying COVID-19 like symptoms and not a confirmed case.
- All the room windows of the POI shall be opened without opening the door that links to the rest of the house. If the toilet attached to the POI room has an exhaust fan, it shall be turned on all the time. The door gaps of the POI room shall be sealed to ensure the air does not leak into the rest of the house.
- If doable, high-efficiency HEPA-based PAC is to be deployed in the room of the POI. Adequate precaution shall be taken when changing the filters (wearing personal protection equipment and gloves) and disposing of them. Additionally, portable UVGI (portable or upper room) may be installed in the room of the POI.

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