



Te Tāhuhu o
te Mātauranga
Ministry of Education

COVID-19 RESPONSE

Ventilation Guidance for New Zealand Schools

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Foreword

This document summarises the guidance developed by the Ministry of Education *COVID-19 Response: Ventilation in Schools programme during 2021-2022*.

It explores how ventilation can minimise and mitigate the spread of COVID-19 and by nature, other airborne illnesses, within New Zealand school environments. It may be of interest for schools, teachers, school leadership, Ministry staff and other stakeholders to support them in improving indoor air quality (IAQ) and ventilation ongoing.

In October 2021 the Ministry formed the Ventilation Technical Advisory Group (VTAG) comprised of experts on ventilation and indoor air quality from the Ministry of Health, the University of Canterbury, Victoria University of Wellington, Massey University, GNS Science, BRANZ, and the National Institute of Water and Atmospheric Research (NIWA).

This group has worked collaboratively with the Ministry to provide scientific and technical input and advice, on which the Ministry's ventilation guidance was developed. At time of publication and to the best of our ability, this document accurately reflects the advice that has been provided by the VTAG to the Ministry and aligns to the current online guidance published by the Ministry.

The global COVID-19 situation will continue to evolve with successive variants, an increasing understanding of the disease and transmissibility, and the development of more effective mitigation strategies and solutions including ventilation. Due to this, the guidance summarised in this document may not be applicable in future years.



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Section one: Context

In New Zealand there are more than 2,500 state, state-integrated and private schools. The Ministry of Education owns approximately 15,000 buildings containing 25,000 teaching spaces for the 2,100 state schools. This is one of the largest property portfolios in New Zealand, and an estimated 90% of these buildings are designed to be naturally ventilated using openable windows.

This document summarises the guidance developed by the *Ministry of Education COVID-19 Response: Ventilation in Schools programme* (the programme) during 2021-2022. It explores how ventilation can minimise and mitigate the spread of COVID-19 (and by nature, other airborne illnesses) within New Zealand school environments.

This document has been prepared towards the end of the programme to record the guidance, for future reference and in a consolidated format. At time of publication it aligns to the [current online guidance](#) provided by the Ministry and may be of interest for schools, teachers, school leadership, Ministry staff and other stakeholders to support them in improving indoor air quality (IAQ) and ventilation ongoing.

Response to the COVID-19 pandemic

From May 2021 it became widely accepted that COVID-19, the disease that is caused by the SARS-CoV-2 coronavirus, can spread through respiratory airborne droplets and smaller aerosols in the air (airborne transmission).

Internationally, there are a number of public health measures recommended to decrease the chance of catching or spreading COVID-19. Global public health authorities have identified that the risk of COVID-19 transmission is greater in crowded and poorly ventilated spaces. Maintaining good ventilation in indoor spaces has been proven to contribute to a lower risk of infection between people who spend time in these spaces, by diluting or removing the airborne particles which transmit COVID-19 from person to person.

From December 2021 to September 2022, New Zealand's COVID-19 response was managed under the COVID-19 Protection Framework. This framework provided guidance about the health measures that should be adopted based on the current level of COVID-19 risk. Under this framework, schools and kura (i.e., a state school based on Māori culture and values) remained open for face-to-face teaching with various public health measures in place depending on the current risk and framework settings.

Making sure indoor spaces were well ventilated was recommended for schools at all levels of the COVID-19 Protection Framework along with the use of face coverings, physical distancing, good hygiene and other measures.

Although the framework was removed by the Government in September 2022, COVID-19 and other airborne illnesses will continue to require a health and safety response from schools to minimise the risk of transmission.

The Ministry's advice to schools continues to be to ensure ventilation capabilities are adequate, maintained and used effectively while maintaining comfortable indoor temperatures to reduce the risk of airborne transmission.

COVID-19 ventilation experts and authorities

This section summarises the relevant authorities and their advice that has informed the Ministry's COVID-19 ventilation response. The Ministry and its advisors also regularly considered COVID-19 ventilation guidance being provided for schools in other jurisdictions, especially the United Kingdom and Australia.

Ventilation Technical Advisory Group (VTAG)

VTAG is the advisory group formed by the Ministry to collaboratively provide scientific and technical input and advice, on which the Ministry's ventilation guidance was developed and associated support activities were determined. The VTAG members have also contributed to the development of critical work within the programme including the ventilation calculator tool, literature reviews and rapid studies.

VTAG is comprised of experts on ventilation and indoor air quality including representatives from the University of Canterbury, Victoria University of Wellington, Massey University, the Ministry of Health, GNS Science, BRANZ, and the National Institute of Water and Atmospheric Research (NIWA).

Ministry of Health (Manatū Hauora)

During a pandemic the Ministry of Health is responsible for formation and delivery of public health messages to communities, testing and reporting on case data information, contact tracing, providing care to patients and those in isolation, and supporting other Government agencies with tailored pandemic response strategies for their relevant sectors.

The Ministry of Health provided the programme with direct support and was an active member of the VTAG, contributing health advice and updates to allow the Ministry of Education to respond appropriately, and to ensure approaches were aligned between both Ministries.

The Ministry of Health has also provided the general public with fundamental ventilation advice to reduce the risk of COVID-19 infection and recommends that ventilation be used alongside other health measures, such as vaccination, physical distancing, wearing masks, and staying home when sick.

World Health Organisation (WHO)

In 2007, WHO first recognised ventilation as an effective measure to control airborne infection (Natural Ventilation for Infection Control in Health-Care Settings). In 2021, WHO advised that indoor ventilation and improving air quality should be a part of a comprehensive package of prevention and control measures to help limit the spread of respiratory viral diseases such as COVID-19.

For schools, WHO recommends a minimum ventilation rate per person directly linked to a space's occupancy and suggests adjusting a building's maximum occupancy if adequate ventilation is not possible. WHO encourages cross ventilation, the assistance of portable fans placed close to open windows¹, and purging the air for 15 minutes before and after rooms are occupied.

¹In its studies the Ministry confirmed residential-style portable fans provided negligible improvements and could at times impede airflow. They can also be a safety hazard in a busy classroom environment. As a result, the Ministry does not recommend the use of portable fans to improve natural ventilation.

If natural or mechanical ventilation cannot provide good ventilation, WHO recommends the use of stand-alone air cleaners with a high-grade air filter, noting that filtered and recirculated air does not replace ventilation in any circumstances.

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

In March 2020, ASHRAE developed a task force to deploy technical resources addressing the challenges of the COVID-19 pandemic and future epidemics as they relate to the effects of heating, ventilation and air-conditioning systems on disease transmission.

ASHRAE has developed and published a standard for *Ventilation and Acceptable Indoor Air Quality* (Standards 62.1-2022). This states that there must be a good supply of outdoor air to dilute indoor contaminants as a first line of defence against aerosol transmission of COVID-19.

ASHRAE's guidance for schools, in addition to the above standard, recommends that the condition of Heating, Ventilation and Air Conditioning (HVAC) systems be assessed and maintained, bringing systems up to current ventilation standards and (if possible) installing the highest rated filters. Pre- and post-occupancy purge cycles are recommended to flush school buildings with clean air.

Centers for Disease Control and Prevention (CDC)

The CDC's research on ventilation in schools and childcare programmes emphasises that ventilation is one component of maintaining healthy environments to prevent COVID-19 transmission.

CDC recommends that windows and doors should be fully or partially opened, and that child-safe fans should be placed by windows to increase the effectiveness of blowing out potentially contaminated air and pulling in new air².

CDC states that filtering and/or cleaning the air improves air quality, and portable high-efficiency particulate absorbing (HEPA) air filters should be considered if there aren't systems in place that can offer air filtration. Portable air cleaners can also enhance air cleaning in higher-risk areas such as a nurse's office or in sick/isolation rooms.

United States Environmental Protection Agency (EPA)

The EPA's strategy emphasises indoor air quality for maintaining healthy indoor environments in schools. EPA's recommendations are focused on ducted mechanical ventilation given this the most common type of ventilation in US schools.

EPA suggests assessment of HVAC systems to ensure they are operating properly, are capable of bringing in more outdoor air, and meet the ASHRAE ventilation standards. EPA also recommends that maintenance programmes should be put in place for HVAC systems to allow for repair, modification, or replacement of equipment.

Research commissioned by the Ministry of Education

A range of international studies about ventilation have been, and continue to be, undertaken to support our universal understanding of and response to COVID-19. Building upon this research, the Ministry worked with VTAG to undertake and publish several rapid studies and literature reviews to further understand ventilation in the New Zealand context and inform the programme's approach to supporting New Zealand schools.

Refer to footnote¹

Ventilation and Air Quality in 18 School Classrooms — A Rapid Study

In November 2021, NIWA led a rapid study on ventilation practises and behaviours in New Zealand schools, observing 18 occupied classrooms and one vacant control classroom. Levels of carbon dioxide (CO₂) in the air were measured to evidence how well each space was ventilated.

The study found that good ventilation was achieved in most classrooms when doors and/or windows were opened, with the best results associated with when there was crossflow between multiple openings.

The Effectiveness of Natural Ventilation: A Case Study of a Typical New Zealand Classroom with Simulated Occupation

In March 2022 a further study was undertaken to inform the Ministry's winter COVID-19 ventilation guidance for schools. The aims were to assess how ventilation was impacted by different opening areas, by differing indoor and outdoor temperatures, and by supplementary measures such as portable air cleaners and fans.

The study showed that, as a rule of thumb, opening windows by 5cm can provide good ventilation while maintaining comfortable temperatures when it is colder outside. It also confirmed the degree by which additional measures such as fans and portable air cleaners can improve ventilation.

The study also found that HEPA air cleaners can provide a consistent reduction in particulate levels, even when used in conjunction with natural ventilation. In the simulated 75m² classroom environment, operating a single large air cleaner at maximum fan speed provided 4.0 effective air changes per hour (eACH), while operating a single medium air cleaner at maximum fan speed provided 2.7 eACH. These findings were pivotal to developing the Ministry's guidance for the use of air cleaners in New Zealand schools.

The Impact of Natural Ventilation During Winter on Thermal Comfort (Literature Review)

This paper reviewed the available literature on the impact of natural ventilation during winter on thermal comfort. Findings in the literature were that natural ventilation is most effective in winter due to buoyancy-driven airflow, and that partially opening windows in classrooms can achieve adequate airflow while maintaining thermal comfort. Also, if indoor and outdoor temperatures are the same, airflow from wind is required to provide ventilation.

The Performance of Portable HEPA Air Cleaners in Naturally Ventilated Classrooms (Literature Review)

This paper reviewed the current research on the performance of portable HEPA air cleaners used in naturally ventilated classrooms for the purpose of COVID-19 mitigation.

Findings in the literature included that air cleaners can achieve an effective rate of 5.0 – 6.0 eACH and having the potential to reduce the COVID-19 infection risk by 70 – 85% if there is one infected person in the room, with additional air cleaners required for more protection.

One study showed that HEPA air cleaners with a flow rate of 6.0 eACH can achieve a similar level of reduction in infection risk compared to natural ventilation, but that opening windows is more effective than two air cleaners with flow rates of 2.5 eACH.

Most notably, multiple studies informed and reinforced the Ministry's guidance, which recommends using HEPA air cleaners as an effective supplementary measure in classrooms where natural

ventilation is inadequate or not possible. Air cleaners are not a substitute for good ventilation as they do not move fresh outdoor air inside, and do not reduce CO₂ levels.

Classroom Ventilation: The Effectiveness of Preheating and Refresh Breaks

From May 2022 the programme initiated a temporary monitoring regime through the winter season of CO₂, temperature and humidity in 169 spaces at 43 schools nationwide. This study analysed the data with a focus on investigating how preheating rooms and taking refresh breaks (i.e. deliberate opening of multiple doors and windows, preferably while vacating the room) impacted CO₂ and temperature levels.

The findings generally showed that for most of the monitored teaching time, the CO₂ levels were largely less than 800ppm (67% of the time) and were within the adaptive comfort temperature range of 18-25 °C (70% of the time). While the indoor air temperatures were similar in all Climate Zones, CO₂ levels were higher in colder climates.

A warmer temperature when teaching started in the morning may have played a positive role in lowering CO₂ levels throughout the day, and indoor air temperature drop was likely to be limited when breaks and refresh breaks occurred.

Applicable design standards and building regulations

New Zealand Building Code (NZBC)

The purpose of the NZBC G4 Ventilation clause (G4 Ventilation) and the associated acceptable solutions and verification methods (4th edition, effective on 27 June 2019) is to *safeguard people from illness due to lack of fresh air*. G4 Ventilation requires adequate ventilation that is consistent with the intake of outdoor air to maintain air purity. Buildings with mechanical ventilation should be constructed and maintained to remove pollutants from the spaces in which they are generated including airborne particles and bacteria, viruses or other pathogens, among poisonous fumes, moisture and cooking odours.

The guidance summarised in this document provides options for schools to improve ventilation and reduce the risk of COVID-19 transmission that often exceed the requirements of G4 Ventilation and its acceptable solutions.

Designing Quality Learning Spaces (DQLS)

The DQLS series of documents is a Ministry of Education set of guidelines and requirements to assist architects, designers and engineers to create quality physical learning environments. The requirements focus on the main internal environment quality factors of acoustics, lighting and visual comfort, indoor air quality and thermal comfort.

The DQLS series was first released by the Ministry in partnership with the Building Research Association of New Zealand (BRANZ) in 2007. The second version was released in 2017 and the most recent version in 2022.

Complying with DQLS requirements is mandatory for all new school builds, new prefabricated modular school buildings and refurbishments or significant alterations of existing school buildings that are starting their design phase after 1 July 2022. DQLS requirements often exceed NZBC requirements, including G4 Ventilation.

DQLS recognises CO₂ as a good indicator of indoor air quality and for CO₂ levels to be used as a proxy to determine how well a space is ventilated. DQLS mandatory requirements prefer natural or mixed-mode ventilation, with full mechanical ventilation systems able to be considered if other ventilation methods have been explored and are not appropriate.

COVID-19 ventilation strategy for New Zealand schools

The Ministry's approach to ventilation as part of its COVID-19 response has been to encourage behaviours that promote good ventilation, such as opening windows, improving awareness of the importance of ventilation in classrooms, and better enabling schools to self-assess and improve ventilation performance. Support was provided to urgently remediate ventilation-related property issues, and to utilise CO₂ monitoring and portable HEPA air cleaners.

Working collaboratively with the VTAG and other Government agencies, from late 2021 the Ministry adopted a COVID-19 ventilation layered intervention strategy as illustrated in Figure 1.1.

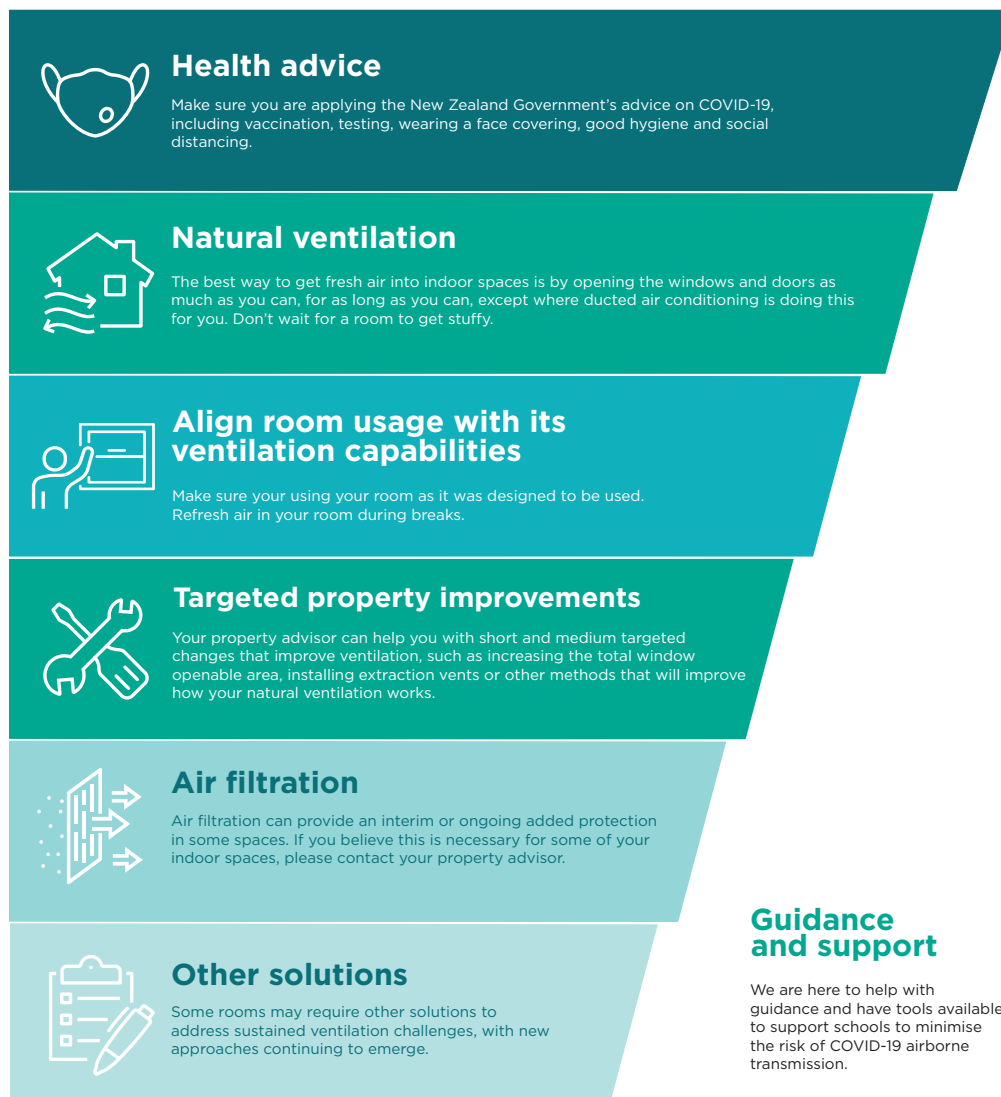


Figure 1.1: Ministry of Education layered intervention strategy for COVID-19 ventilation in schools.

Section two: Assessing ventilation

Good ventilation and indoor air quality in schools has a positive impact on teachers and students, supporting them to work and learn safely and comfortably in classrooms. Good ventilation removes stale air and replaces it with fresh, clean air while maintaining a comfortable temperature and humidity levels. It is important to regularly assess and maintain good ventilation to lessen the risk of transmission of airborne illnesses, including COVID-19.

This section provides guidance on the methods schools and Ministry property advisors can use to assess the ventilation performance in a space, which will help to identify areas for improvement.

Course of action following an assessment are outlined later in this document.

Start by using your senses

As an initial assessment, your senses can help you ascertain how the ventilation is currently performing in occupied spaces. If a room feels stuffy, has lingering smells, or doesn't appear to have any open windows or doors to create airflow, it may not be well ventilated and deserves a more structured assessment.

You can then verify this using a carbon dioxide (CO₂) monitor or other assessment methods.

Assessing property condition and behavioural factors

In the Ministry's experience, in most cases ventilation challenges can be addressed by behavioural change or minor property remediation.

Where this is not possible it typically involves spaces that have been converted, renovated or refurbished and the method of ventilating the space has not remained in place, or the condition of the ventilation system has deteriorated over time.

When investigating ventilation challenges, initial lines of enquiry should include:

- » How was the building designed to provide good ventilation?
(e.g., openable windows, ducted HVAC)
- » Are building users doing the correct things to make good use of this?
(e.g., opening the windows, turning on HVAC systems)
- » Do building users know how to adjust and maintain any installed systems?
(e.g., how the HVAC system is controlled, and what settings to use or change)

- » Are there any deferred or other minor maintenance issues impacting ventilation that should be remediated?
(e.g., windows jammed, painted shut, mechanisms need servicing)
- » Has the space been reconfigured in a way that is impeding ventilation?
(e.g., windows removed or disabled, spaces subdivided, openings blocked)

If property condition or behavioural factors are impeding good ventilation these should be addressed. Further assessment methods, such as CO₂ monitoring or using the classroom ventilation calculator, are not always required to further validate or quantify the issues being experienced.

Comparing the current ventilation capability to original design intentions

NZBC G4 Ventilation and the associated acceptable solutions provides minimum ventilation standards for all buildings to meet including natural, hybrid and mechanical systems. There is an obligation on building owners and operators to ensure that ventilation systems continue to work as designed, including if alterations are made or if the primary use for a building changes.

The current ventilation capability of a space should be compared to how it was originally intended to be ventilated, and in reference to the current G4 Ventilation acceptable solutions. For example:

- » For naturally ventilated spaces, ensure windows and doors operate (open) as they were originally designed to do. Under G4 Ventilation, the openable area of windows or other openings to the outside should not be less than 5% of the floor area³.
- » For spaces with mechanical ventilation that has been classified under NZBC as a specified system and is therefore subject to Building Warrant of Fitness (BWF), ensure that the BWF is current, and the system is operating as specified.

A space for which the current, functioning ventilation system is not achieving its original design intentions should be remediated as a priority. It is however possible for a space to meet NZDB G4 and its original design intentions, but still experience ventilation issues which can be quantified by monitoring CO₂ levels.

Measuring indoor air quality using carbon dioxide (CO₂) monitors

CO₂ as a proxy for COVID-19 airborne transmission risk

Monitoring CO₂ levels in occupied spaces will help assess whether a space is well ventilated. A regular routine of checking CO₂ and temperature levels will gauge how well the supply of fresh air is meeting the needs of the room's occupants and is being balanced with maintaining comfortable indoor temperatures.

CO₂ is a naturally occurring gas that is constantly breathed out by a room's occupants. Ventilation will remove CO₂ concentrations and replace it with fresh air. The level of CO₂ in the air, measured in parts per million (ppm), is a balance between these processes and is a good indicator of whether the ventilation is adequate and effective. However, as CO₂ levels do not necessarily reflect the presence of other pollutants, it is not an overall or definitive indicator of indoor air quality.

³An example calculation is for a classroom measuring 10 x 10m, the floor area is 100m². 5% of this is 5m², therefore under G4 Ventilation, the area of the windows and doors that are able to be opened in this classroom should meet or exceed 5m². The Ministry notes this is a rudimentary test that does not consider the degree by which the window is able to open or the environment they open into, which will have a considerable bearing on ventilation performance and air quality; and that DQLS requirements exceed G4 Ventilation in this regard.

An occupied space that maintains CO₂ levels under 800 ppm is generally considered to be well-ventilated. When CO₂ levels start to climb above this, pollutants and airborne particles including viruses will be staying in the room for longer, increasing the risk of airborne transmission and infection. CO₂ levels can therefore be used as a proxy for COVID-19 infection risk. Elevated CO₂ levels also impact health and learning outcomes and can cause drowsiness and concentration issues for the people in the room.

In 2022 the Ministry distributed portable CO₂ monitors to all state and state-integrated schools, to help them assess CO₂ levels as part of their COVID-19 response and mitigation activities. If schools are purchasing CO₂ monitors, the programme recommends devices that utilise a nondispersive infrared (NDIR)-type CO₂ sensor.

Interpreting CO₂ levels

Short, intermittent peaks in CO₂ levels are common. Very frequent peaks, or persistently elevated CO₂ levels for a sustained period of time (e.g. over an hour or more) indicate that fresh air isn't flowing into a space quickly enough to meet the needs of the room's occupants.

Action to improve ventilation should be taken if CO₂ levels stay above 800ppm for an hour or more, or are very frequently peaking in the higher CO₂ ranges. Actions should progressively increase if CO₂ levels are sustained or continue to rise, as presented in Figure 2.1 below⁴.

	PPM level	Actions to consider
	Under 800	Your space is well ventilated for its current number of occupants and their level of activity, continue with the current approach.
	800 to 1,250	Open windows more if this can be done while maintaining comfortable indoor temperatures. Consider lowering the level of activity, briefly vacating the room and/or regularly purging and refreshing the air in the space (a "reboot").
	1,250 to 2,000	Take further action to introduce more fresh air, for example: <ul style="list-style-type: none"> » Open all windows and doors as much as possible, and whenever it is practical to do so while maintaining comfortable indoor temperatures. » Reboot the room by fully opening all windows and doors for a short time (e.g. 5-10 minutes), preferably while vacating the room, to purge and refresh the air in the space. » Reduce the level of vigorous activity performed in the room or lower the total occupancy. » Consider utilising other protective measures such as face coverings and increased physical distancing.
	Over 2,000	If you have followed the above advice and still have persistent CO ₂ levels over 2,000ppm for a sustained period of time (e.g. over the course of an hour), or have very frequent CO ₂ peak levels exceeding 2,000ppm, or please contact your Ministry property advisor. In addition, instigate at least four refresh breaks through the school day where you reboot the room with all windows and doors open for a few minutes, and preferably with the room unoccupied.

Figure 2.1 CO₂ levels and associated actions to take to improve ventilation

⁴A limitation of the portable CO₂ monitors distributed is they can only display three CO₂ thresholds indicators on the device's screen (green, yellow, red). The Ministry suggests associating these with the 1,250 (orange) and 2,000ppm (red) thresholds to emphasise the need to progressively take more action should sustained CO₂ levels exceed these higher thresholds. This should not be interpreted as advice that no action should be taken when CO₂ levels are in the 800-1,250ppm range.

The following charts presented in Figure 2.2a and 2.2b below, illustrate example typical, persistently elevated and frequent peaks CO₂ levels that may be experienced in a classroom environment through a school day, and the benefit of adopting a successful “reboot” or refresh break strategy to lower persistent CO₂ levels.

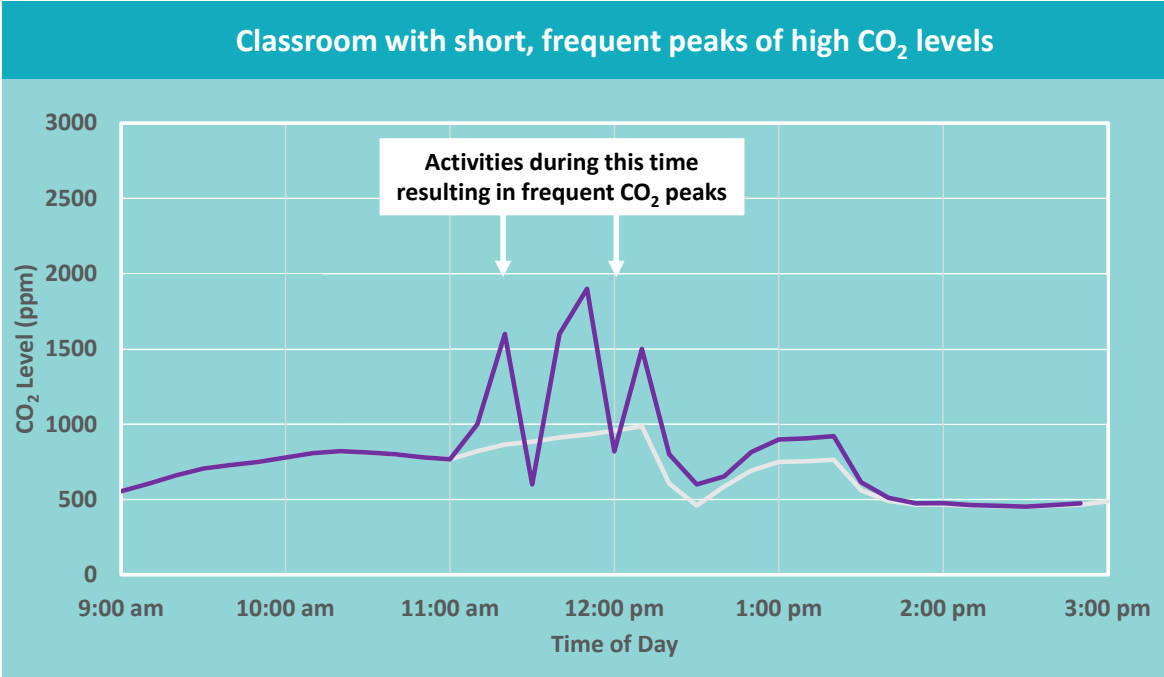
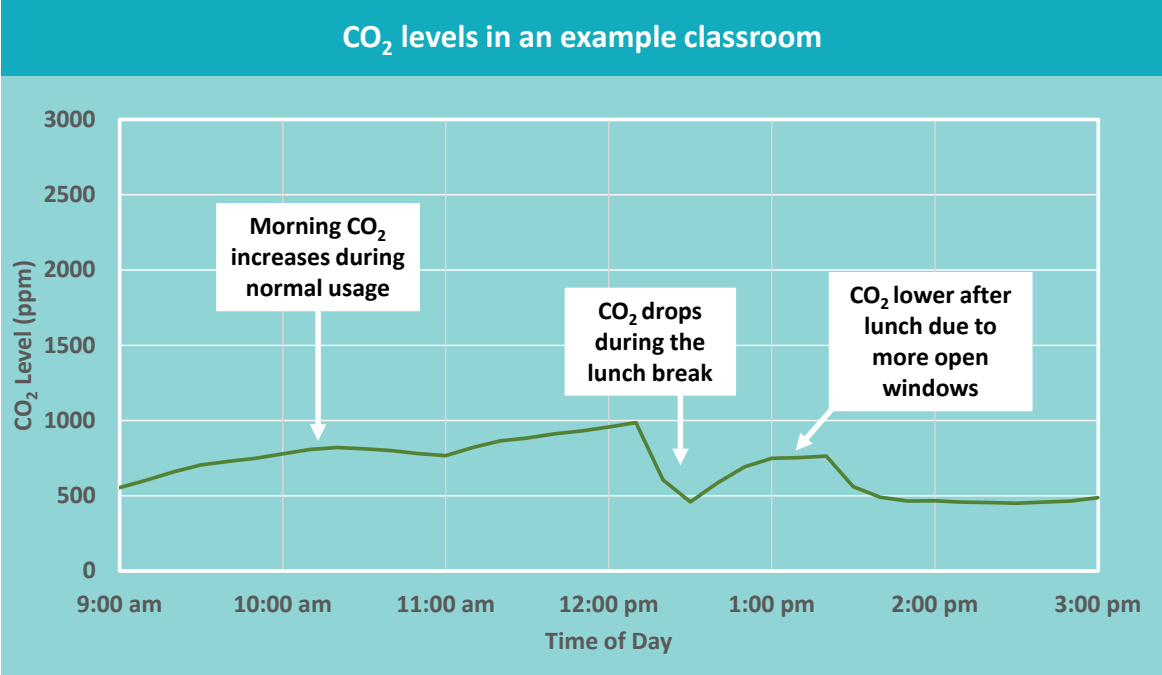


Figure 2.2a An illustration of the relationship between typical, persistently elevated, and frequent peaks of CO₂ levels and the benefit of adopting refresh breaks.

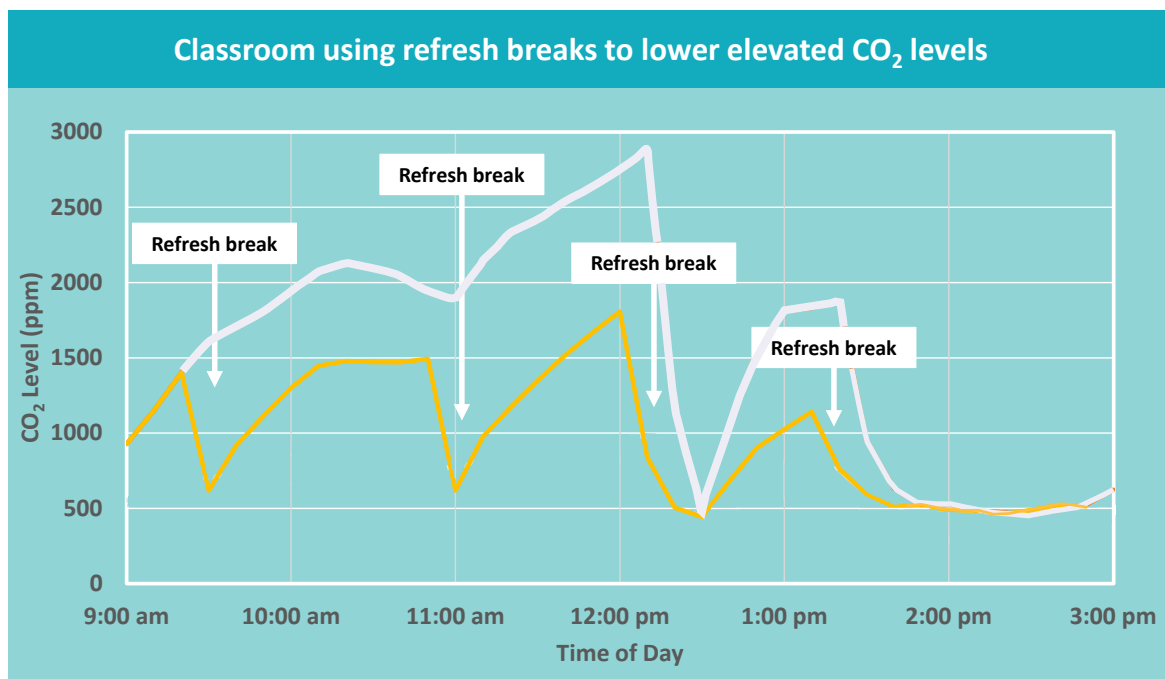
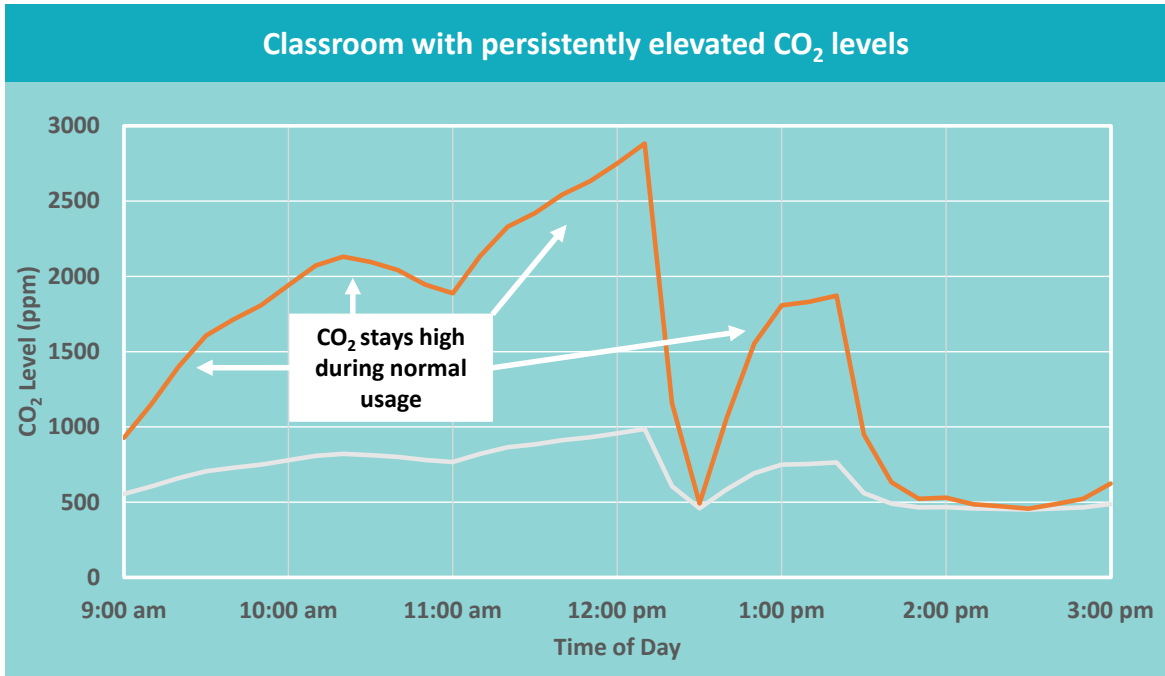


Figure 2.2b An illustration of the relationship between typical, persistently elevated, and frequent peaks of CO₂ levels and the benefit of adopting refresh breaks.

Using a CO₂ monitor to perform spot checks

Spot checks provide an immediate indication of current CO₂ levels and can be used to ascertain if further assessment or CO₂ monitoring is appropriate. If the spot-check levels are high, follow our guidance to try to lower CO₂ levels by increasing ventilation.

As spot checks only provide a snapshot of the current CO₂ level, they may not represent peak or sustained levels. Spot checks are best carried out toward the end of a teaching period while the space is fully occupied and in use, to provide the most representative spot-check readings.

For a more accurate assessment of the ventilation for a space, carry out a full or multi-day check as explained below.

Follow the steps below to carry out a spot check on any space:

1. Take the CO₂ monitoring device to the space and place it somewhere around student head height, away from doors and windows, out of direct sunlight, and at least 1m away from the closest people. Please note that breathing directly into or over the device will cause it to report high CO₂ levels.
2. Leave the device in the room for at least 5 minutes before checking the CO₂ levels reported on its screen. If temperature readings are also required, extend this to 30 minutes to allow the device to report this accurately.
3. Repeat this process in a selection of representative spaces, or all spaces on a regular basis (e.g. fortnightly). Look for patterns and relationships between CO₂ levels, who is in the room, doing what, and with windows and doors open or closed.

Using a CO₂ monitor to perform full or multi-day checks

For a more accurate assessment, a portable CO₂ monitor should be left in the space for a longer period for it to automatically gather its readings. This will provide a more representative picture of ventilation compared to performing spot checks. The supplied devices typically store 3-7 days data that can then be downloaded using a smartphone.

Follow the steps below to carry out full- or multi-day checks:

1. Take the CO₂ monitoring device into the space and place it somewhere around student head height, away from doors and windows, out of direct sunlight, at least 1m away from the closest people and in a place where it will not be disturbed or moved.
2. At the end of the day or days, use the smartphone app to connect, view and download the CO₂ readings from the device. After downloading the data, ensure you only review the data associated to that space on that or those days. Take note of how CO₂ levels change based on who is in the room, doing what, with windows and doors open or closed at different times through the day.
3. Use the downloaded data to support conversations with other people including staff, Ministry Property Advisors and ventilation technicians to confirm what changes in behaviour or property improvements may be required to address any ventilation challenges.

Classroom ventilation calculator

The Ministry has developed a ventilation calculator estimation tool to help assess ventilation and identify if improvements need to be made, for unoccupied spaces. This Excel-based tool can be used when CO₂ monitoring is not possible, and to model how the ventilation may perform under different scenarios.

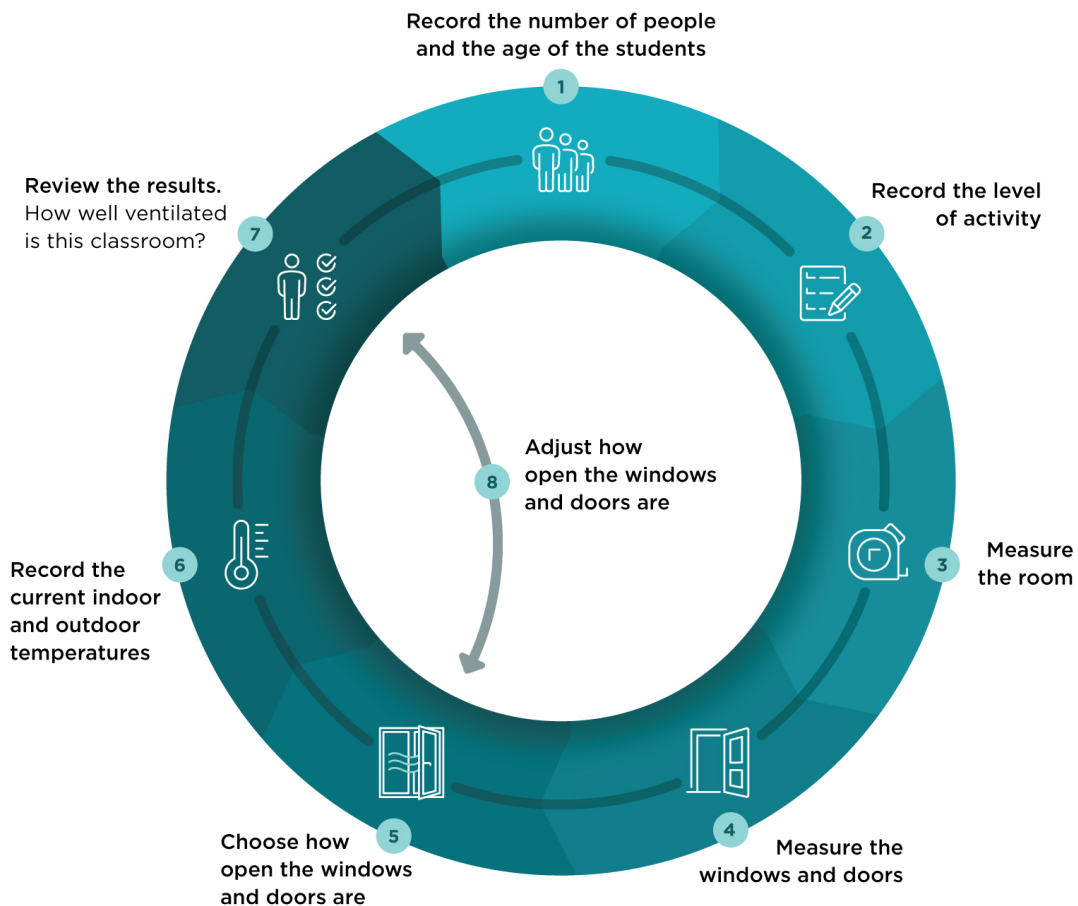


Figure 2.3

The calculator is a useful tool to determine whether additional ventilation is required in a space, potential remedies if action needs to be taken, and helps to build understanding of how the various factors impact ventilation in classrooms.

The tool estimates how well a classroom's natural ventilation will perform considering room usage, size, percentage of window openings, and inside and outside temperatures. The tool also reports whether the percentage of openable area is consistent with the current NZBC G4 Ventilation.

The tool allows users to enter variables and review the results. Users are then able to go back and update the variables to understand how different aspects (such as opening or closing a window) impact the room's ventilation performance.

Longer-term strategy for internal environmental monitoring in schools

The Ministry's Te Haratau programme is a multi-year, staged initiative which aims to support the quality of school learning environments, and will measure a range of variables including acoustics, lighting, temperature, relative humidity, and CO₂ levels. As part of this, Internal Environment Monitoring devices (IEMs) will be installed in all schools over a multi-year period.

Portable CO₂ monitors are complementary to other environment monitoring strategies, including Te Haratau, as they give schools an immediate understanding of CO₂ levels and ventilation needs.

Schools may also consider implementing other non-portable CO₂ monitoring solutions and systems if they wish to have their own CO₂ monitoring in place.

Section three: Ventilation solutions and strategies

In New Zealand we generally have very good outdoor air quality. The Ministry's approach to ventilation during the COVID-19 pandemic has been to encourage solutions and behaviours that take full advantage of this to improve indoor air quality.

Minimum ventilation standards apply to all New Zealand buildings, as outlined in the current NZBC G4 Ventilation. The Ministry has also developed DQLS which stipulate further ventilation design standards and requirements for New Zealand schools.

All New Zealand schools are designed to be well ventilated either naturally by opening windows and doors, or mechanically with a ducted mechanical HVAC system. Schools can improve air quality, reduce CO₂ concentrations and reduce the risk of COVID-19 and other airborne illnesses by ensuring spaces are well ventilated.

This section summarises the three types of ventilation commonly found in New Zealand schools, associated design requirements, and strategies that can be used for each to improve air quality.

Natural ventilation

Overview of natural ventilation

Natural ventilation is any way in which outside air can be brought into a building or space without using a machine, system or appliance. It generally relies on the occupants to open windows and other openings to achieve adequate ventilation. Natural ventilation is the Ministry's preferred ventilation strategy, with the vast majority of school property designed to be naturally ventilated (i.e., with openable windows).

Natural ventilation relies on internal/external air pressure differentials, or on vertical thermal differentials within building spaces (the stack effect), to drive air movement. Typically, natural ventilation could provide more air changes per hour (ACH) than mechanical or hybrid ventilation methods, but its performance is much more susceptible to the ambient conditions.

At times, natural ventilation strategies may introduce unwanted noise or create challenges with maintaining a comfortable temperature in the indoor spaces. In these instances, it might not be practical to fully or consistently open windows or doors.

Natural ventilation systems need to be well maintained to ensure they operate as intended and continue to provide good ventilation over time. This can be significantly impacted by property changes and deferred maintenance. Addressing common maintenance issues, such as ensuring windows that were designed to open are still able to do so, will improve ventilation.

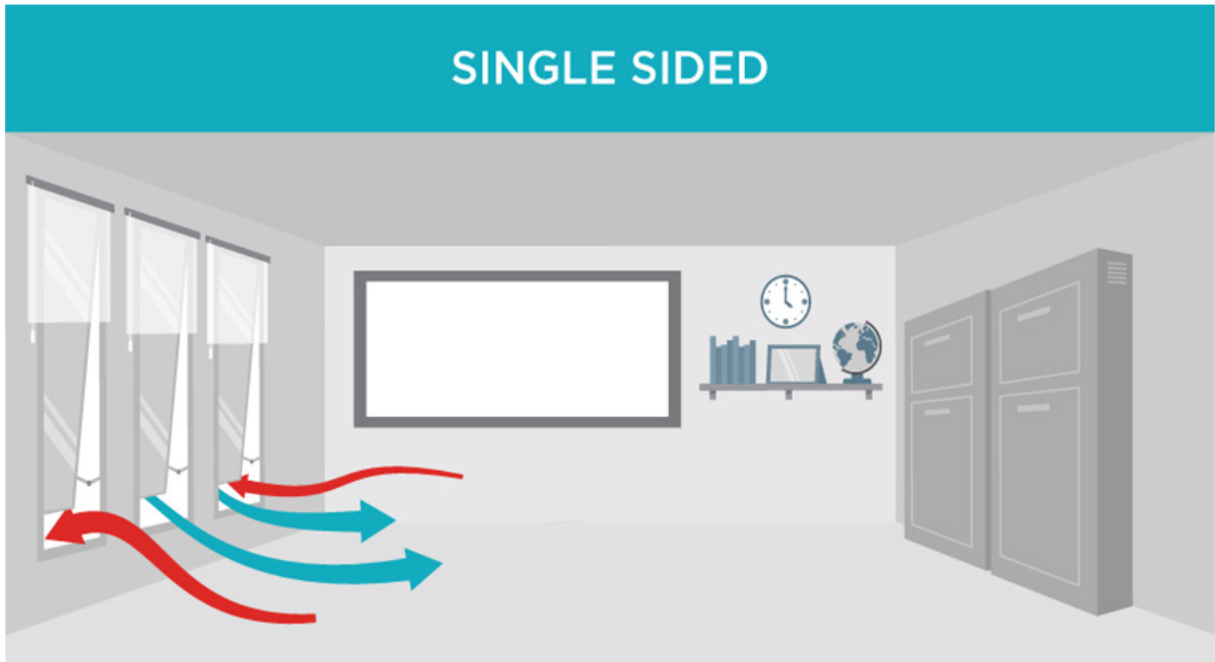


Figure 3.1: Single-sided ventilation whereby air is introduced into a space and vented from the same side. This is typically less effective than double-sided ventilation.

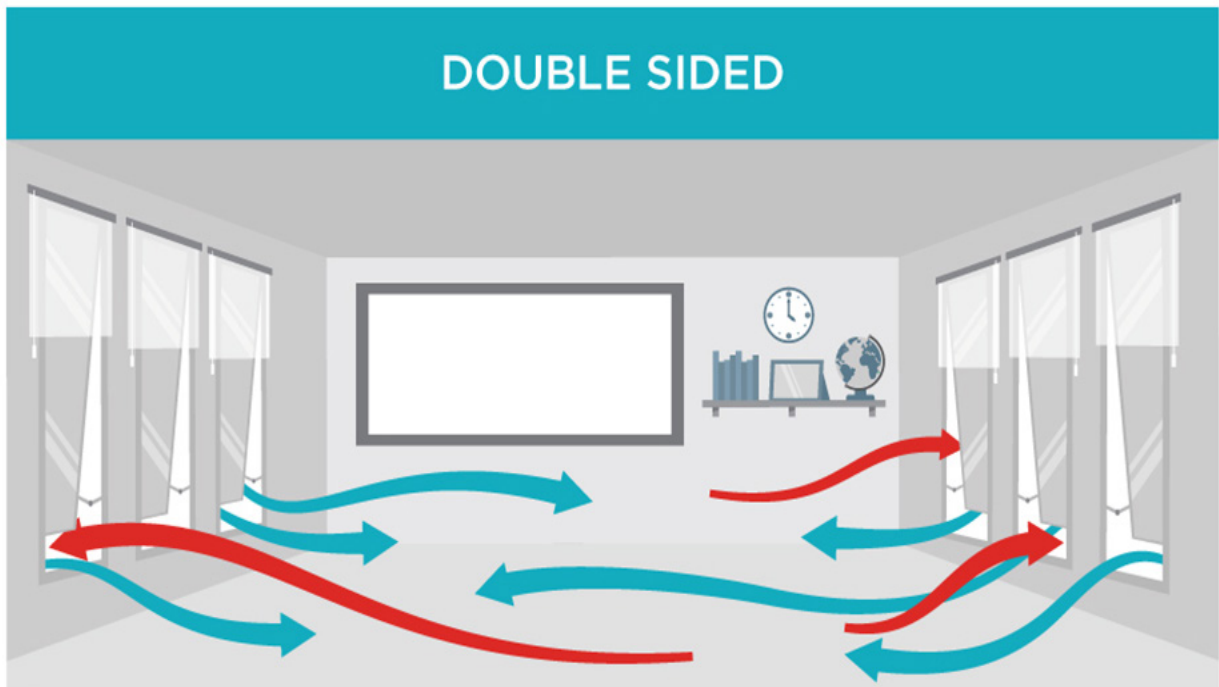


Figure 3.2: Double-sided (crossflow) ventilation whereby air is introduced into a space on one side by positive air pressure and then drawn across the space and vented from the other side by negative air pressure. Natural cross ventilation utilising wind and local air movements is a common and effective ventilation strategy, particularly in small, spatially simple enclosures.

Maximising indoor air quality in naturally ventilated spaces

There are several strategies to make the most of natural ventilation. These broadly fall into two categories: behavioural strategies and property improvements/maintenance.

Behavioural Solutions



- » Opening windows and doors as much as practical while balancing thermal comfort. If it is impractical to open windows or doors fully due to outdoor conditions, occupants can consider partially opening windows (e.g., as a rule of thumb, by 5cm).
- » Opening upper windows first, and more than other windows. This helps to keep the room warm inside by keeping draughts away from occupants, and helps to move warm air back down.
- » Opening windows and doors on one side is known as single-sided ventilation (refer Figure 3.1).
- » Opening windows or doors on either side of a room will create double-sided, or crossflow ventilation (refer Figure 3.2). This enables an entry and exit point for airflow to help flush out contaminants and reduce CO₂ concentrations more effectively than single-sided ventilation.
- » For spaces that only have external windows and doors on one side of the building, consider also opening doors that connect the space to internal corridors to assist with airflow. If doing this, the adjoining space should be well-ventilated and have its external windows open.
- » Ensuring teachers and staff know how to (and are able to) open windows in all spaces throughout the school, and regularly checking to ensure windows are not being temporarily blocked by classroom furniture, student artwork or teaching materials.
- » Adjusting the room layout so that there are not any obstructions in front of windows and doors to affect airflow, and that occupants are further away from cold draughts.



- » Pre-heating classrooms before the start of the day and continue heating throughout the day while windows are at least partially open (even when it is colder outside) to maintain a comfortable indoor temperature.



- » Taking refresh breaks to flush a space with fresh air by fully opening windows and doors for a short time – for example, 5-10 minutes. If this does not resolve the stuffiness and quickly reduce the CO₂ levels, the windows and doors may need to be open for a longer period of time.
- » The air in the room will also be refreshed more quickly if the space is unoccupied during the refresh break.
- » Schools can check whether a refresh break was effective by using a CO₂ monitor.

Property maintenance and improvements for naturally ventilated spaces

Schools should regularly check for any property issues that could be impeding good ventilation, such as:

- » Ensuring any window or door that was originally designed to open, can still open easily without undue effort, and without compromising safety.
- » Unsticking windows which may have been fixed or painted shut.
- » Replacing or repairing missing or broken window winders, hinges, catches, handles, security stays and closers.
- » Ensuring windows are able to be used as originally intended and are not blocked, covered over, disabled, made inaccessible or otherwise changed so that they cannot be opened.
- » Removing artwork or decoration which may be obstructing windows that are designed to open, or the presence of which may denote that that the window should not be opened.
- » When a room's use has been changed or altered, ensuring it still meets minimum ventilation requirements in the current NZBC G4 Ventilation and DQLS, and that it has appropriate ventilation for its purpose and layout.

Summary of natural ventilation design requirements

Natural ventilation design requirements

New Zealand Building Code (NZBC) G4 Ventilation

Natural ventilation is an acceptable solution to G4 Ventilation, along with mechanical ventilation or a combination of the two, depending upon the needs of the space. G4 Ventilation states that ventilation of spaces within buildings is required to maintain air purity, either naturally or with mechanical assistance.

G4 Ventilation states that an occupied space must have a net openable area to the outside of no less than 5% of the spaces floor area to meet the minimum requirement for natural ventilation. Openable building elements such as windows must be constructed in a way that allows them to remain open to ventilate the space while avoiding injury or damage from a sudden closure due to wind or other forces

Designing Quality Learning Spaces (DQLS)

DQLS design requirements prefers natural ventilation and mixed-mode ventilation to improve indoor air quality. Natural ventilation can be achieved through single-sided ventilation where the depth of the space is no more than twice the floor to ceiling height at its lowest point (in accordance with CIBSE: AM10, 2005), and the total opening area is more than 10% of the floor area.

Natural ventilation can be achieved with double-sided cross-ventilation when all parts of the enclosure are within 7m of an openable window, complying with AS1668.4:2012 Section 3.5 or a total opening area greater than or equal to 5% of the floor area distributed across at least two sides.

In spaces greater than or equal to 600m², a fully modelled design is required. This needs to show that the ventilation system means that the space will not exceed the maximum CO₂ levels in the DQLS table of indoor CO₂ concentration design criteria.

Ducted mechanical ventilation

Overview of mechanical ventilation

Ducted mechanical ventilation systems source, filter, heat/cool, circulate and recirculate air within a building, commonly using Air Handling Units (AHU) and vents fitted into the ceiling to transfer air. These systems are collectively referred to as Heating, Ventilating and Air Conditioning (HVAC) systems, excluding heat pumps.

Heat pumps are often mistaken for ducted mechanical ventilation, however they only heat or cool recirculated air and do not bring fresh air in or extract air out of a space. The Ministry supports the use of heat pumps for heating and cooling, used in conjunction with an effective method of ventilation.

One way to identify if your space has a ducted mechanical ventilation system is to look for vents in the ceilings or walls that bring in fresh air or extract stale air.

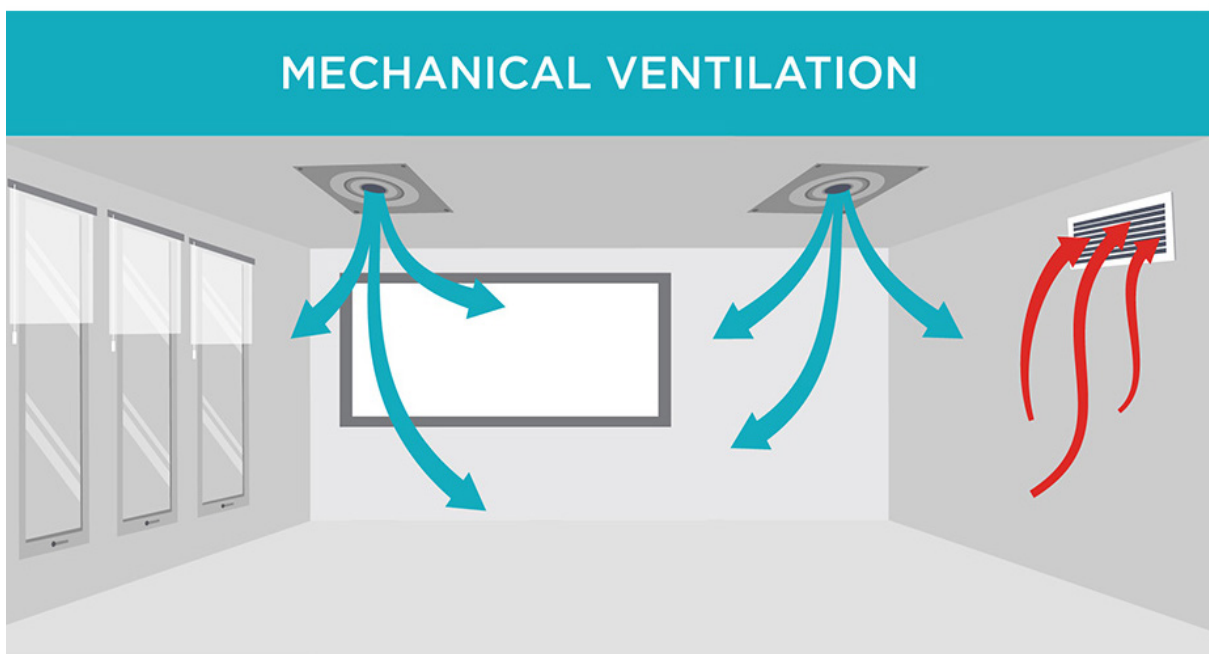


Figure 3.3: Ducted mechanical ventilation.

Maximising indoor air quality in mechanically ventilated spaces

Schools fitted with ducted mechanical ventilation systems should ensure these systems are well-configured and maintained by an appropriate HVAC technician to provide good ventilation while managing indoor temperatures.

Where ducted mechanical ventilation systems are fitted, the advice for naturally ventilated spaces doesn't apply unless the system has specifically been designed to work in conjunction with windows and doors being open. If not, windows and doors should remain closed to allow the system to work as designed.

Mechanical ventilation is designed to meet a specific occupancy rate. If there are too many people in a space, the system may not perform as intended and will not provide enough fresh air for the occupants.

Many systems will automatically adjust to warmer or colder weather, but it may be possible for the HVAC technician to change the amount of fresh air brought in as the seasons change. The performance of a system can be best maintained by ensuring that the systems are routinely serviced, and air filters regularly cleaned.

Strategies for maximising mechanical ventilation include:

- » Ensuring the system is checked, cleaned and maintained by an appropriately skilled HVAC technician in accordance with the system's warranty and maintenance specifications and meeting any associated Building Warrant of Fitness (BWOFF) requirements for specified systems.
- » If possible, consider upgrading the filters to a higher grade.
- » If possible, being configured to achieve an air change rate of at 6.0 ACH or more.
- » Configuring the system to turn on at least two hours before and stay on for at least two hours after the school day, to refresh the air before students arrive and once they have left for the day.
- » Reduce or eliminate the recirculation of air (i.e. setting the system to "once through" or "full fresh air" mode) including running the full fresh air setting at its maximum rate, for as long as is practicable, where this can be done while maintaining comfortable outdoor temperatures.
- » Disable any Demand-Controlled Ventilation (DCV) controls that reduce air supply based on occupancy or temperature. If the DCV controls are driven by CO₂ monitoring, ensure they are set to try and achieve sustained CO₂ levels under 800ppm.
- » Closing windows and doors when mechanical ventilation is on, as most systems are designed to work in a closed room.

It is preferable for these systems to be activated by CO₂ thresholds, enabling them to identify when they need to ensure more fresh air is supplied into the space. You can also use CO₂ monitors to assess whether the system is working effectively.

If CO₂ levels become too high in mechanically-ventilated spaces, schools can also employ refresh breaks where they purge the room of old air by opening windows that can be opened (if there are windows in the space), or by having occupants leave the room and turning the system on full until CO₂ levels drop.

Schools that are not able to achieve acceptable CO₂ levels, despite employing all strategies to improve mechanical ventilation, should work with their Ministry Property Advisor to identify other solutions.

Summary of mechanical ventilation design requirements

Natural ventilation design requirements

New Zealand Building Code (NZBC) G4 Ventilation

Mechanical ventilation is an accepted method of ventilation within the NZBC G4 Ventilation. All buildings designed with mechanical ventilation should adhere to strict New Zealand industry standards for compliance regarding the following:

- » Outdoor air supply designed, and equipment installed to comply with NZS 4303 to provide outdoor air to occupied spaces at the specified flow rates.
- » Air-handling systems installed and maintained to the requirements of AS/NZ 3666.1 and AS/NZS 3666.2.
- » Extract ventilation constructed so any products listed in Clause G4.3.3 are removed, collected or diluted by ventilation rates and methods set out in AS 1668.2.
- » Outdoor air intakes to be located to avoid contamination from any local source in accordance with AS 1668.2 Clause 4.3.1 and NZS 4303 Clause 5.5.
- » Recirculated air systems to comply with AS 1668.2 Clause 4.5.
- » Contaminated air discharge systems to discharge contaminated air in a way that complies with AS 1668.2 Clause 5.10.
- » Filtration to comply with AS 1668.2 Clause 4.4.
- » Commissioning to comply with CIBSE Code Series A.

Designing Quality Learning Spaces (DQLS)

DQLS guidelines state that mechanical ventilation can be used in learning spaces if natural ventilation is not appropriate or possible.

A filtered mechanical outdoor supply ventilation system must provide a minimum flow rate of 10 l/s per person, and with filtration to grade G4 or higher (meeting specific references for the space in the NZS4303: Ventilation for acceptable indoor air quality, or AS1668.2: Mechanical Ventilation in Buildings).

Mechanical ventilation systems that filter more than 500 litres per second must automatically modulate air flow rates in response to internal CO₂ concentrations, measured by CO₂ monitors. This is in order to maintain the concentration limits set out in the DQLS table of indoor CO₂ concentration design criteria.

Mechanical ventilation systems of greater than 500 litres per second must include a heat recovery by counter-flow heat exchanger or run-around coil in specific climate zones. Heat recovery systems including a summer bypass mode must be subject to an airtightness test.

Mixed-mode (hybrid) ventilation

Overview of mixed-mode ventilation

Mixed-mode or hybrid ventilation systems combine natural and mechanical methods, using both ducted mechanical and openable windows to provide ventilation.

Mixed-mode ventilation allows schools to account for colder outdoor temperatures by enabling them to switch to mechanical options when opening windows or doors isn't practical. It helps to manage

CO₂ levels by allowing windows or doors to be opened or a mechanical system to be turned on to achieve adequate air change rates when CO₂ peaks occur.

This ventilation strategy is a low-cost energy solution and is the most flexible out of the three strategies given it can be changed throughout the day to suit conditions. However, the performance of these systems can depend strongly on weather conditions.

Maximising indoor air quality in spaces with a mixed-mode ventilation system

Mixed-mode ventilation allows occupants to use their judgement in a space and adjust to the ventilation requirements. As mixed-mode ventilation uses both natural and mechanical ventilation methods, the school should ensure both are maintained well as summarised in the previous sections.

The Ministry recommends schools continue to monitor CO₂ levels to assess whether solutions are working effectively, or whether they need to be adjusted by opening windows, turning on mechanical ventilation and/or employing refresh breaks.

Summary of mechanical ventilation design requirements

Mixed-mode (hybrid) design requirements

[New Zealand Building Code \(NZBC\) G4 Ventilation](#)

Mixed mode ventilation must meet G4 Ventilation requirements for both natural and mechanical ventilation systems, as outlined in the sections above.

[Designing Quality Learning Spaces \(DQLS\)](#)

The DQLS states that schools don't need to be designed with a one-size-fits-all ventilation strategy. Mixed-mode ventilation is generally suited to a larger building or spaces that can accommodate a larger number of occupants and buildings in colder climates. Mechanical ventilation systems, including hybrid systems, must comply with G4 Ventilation.

In terms of CO₂, mechanical systems >500 litres per second must automatically modulate air flow rates in response to internal CO₂ concentrations, measured by CO₂ monitors in the space.

Section four: Seasonal considerations

Air flow behaves differently at different temperatures – for example when it’s cold outside and the bigger the temperature difference to the inside, the more efficiently fresh outside air is drawn in. Ventilation solutions and strategies need to be adjusted during warmer and cooler weather to balance good ventilation with maintaining comfortable indoor temperatures.

Schools will need to adjust their ventilation strategies based on current outdoor temperatures to ensure they can effectively balance good ventilation with thermal comfort.

During colder weather and especially during the winter season, it can be less practical to fully open windows and doors in naturally ventilated environments. But on cold days good ventilation can still be achieved by partially opening the windows.

Thermal comfort is not just related to air temperature – it also relates to relative humidity, the temperatures of surrounding surfaces, air movement, occupant activity levels, and the clothing worn by occupants.

Ventilation advice all year round

- » Don’t wait for a space to get stuffy. Open all windows and doors, partially or fully as conditions allow, whenever you can.
- » Open windows and doors on opposite sides of a room where possible to enable cross flow of air.
- » Take regular refresh breaks where everyone leaves the room and windows and doors are fully opened, to flush out the space with fresh air.

In colder weather	In warmer weather
<ul style="list-style-type: none">» Open windows by a small amount (e.g. 2-5cm) to draw fresh air in when its cooler outside, then increase openings as it gets warmer during the day.	<ul style="list-style-type: none">» Open windows fully to make the most of natural ventilation
<ul style="list-style-type: none">» Increase the heating if needed, to offset the impact of having windows partially open.	<ul style="list-style-type: none">» Continue to use cooling systems like heat pumps to reduce indoor temperatures.
<ul style="list-style-type: none">» Relax uniform rules and dress codes to allow warmer clothing to be worn on the coldest days.	<ul style="list-style-type: none">» Reset the temperature of the room by briefly vacating the space, closing all windows and doors and running the cooling system on its highest setting, and then reverting to windows fully open.

Natural ventilation during cooler weather

During colder weather and especially during the winter season, it can be less practical to fully open windows and doors. However, airflow works better when it's colder outside, and the bigger the temperature difference between outside and inside, the more efficiently fresh outside air is drawn in through open windows even if the actual opening size is quite small. Doing this means that it is possible to achieve good ventilation even by only partially opening windows and results in minimal temperature loss compared to fully opening windows.

On colder days, take these additional steps to help ventilate your space while balancing comfortable indoor temperatures:

- » **Heat:** Heat the room before the start of the school day, which will allow people to open windows earlier in the day. Keep heating on throughout the day to stay warm, with windows partially opened whenever possible.
- » **Open:** Open windows by at least a crack or as much as you can while staying warm. Opening lots of windows a little can be more effective in colder weather. If the weather is bad outside, close what you need to stay comfortable.
- » **Reboot:** Take refresh breaks to clear the air at different times during the day by fully opening all the windows and doors, preferably while having everyone exit the room. Aim to do this at least four times each day, for 5-10 minutes each time.
- » **Fine-tune** the approach throughout the day as the weather changes. Fully opening windows still achieves the best ventilation, so increase window openings if it warms up outside later in the day or whenever this can be done while maintaining a comfortable indoor temperature.

You can use CO₂ monitors to check that these strategies are working and identify whether adjustments need to be made.



HEAT

the room so windows can be opened earlier in the day

OPEN

windows by a crack while staying warm, and by more whenever you can. Every little bit helps!

REBOOT

and refresh the room at different times during the day, by fully opening all the windows and doors

Help Slow COVID-19

and other illnesses using the power of fresh air. If CO₂ levels stay high for an hour or more, follow these tips to refresh the air:

Fresh air, let's keep it that way!



<800 ppm

It's getting stuffy in here, time to open more windows or reboot soon...



1250+ ppm

Let's get some fresh air in here... ASAP!



2000+ ppm

Figure 4.1: This poster was issued in July 2022 as part of the Ministry's support for schools in response to the COVID-19 Omicron variant nationwide resurgence at that time. It advises schools to heat rooms, open windows while staying warm and to regularly refresh the air at all times. It also presents tips to further refresh the air if CO₂ levels are elevated for a sustained period at 800, 1250 and 2000ppm thresholds to demonstrate increasing risk, and therefore the increasing importance of mitigations when sustained CO₂ levels are over 800ppm. The Ministry's guidance is that schools should be taking action to improve ventilation when CO₂ levels are persistent/sustained above 800ppm. A three-point colour scale is used to communicate this, aligning to the capability of the portable CO₂ monitors distributed which allow three CO₂ alert thresholds to be set. A Te Reo Māori version of the poster was also issued.

In addition to the tips above schools can also adopt other, more specific ventilation strategies, such as:

- » Opening high-level windows first and wider than low level windows, to reduce cold draughts in the room and help push warm air down.
- » Opening lots of windows a little, rather than a few windows a lot. Close the doors before beginning to close windows and reduce or close any windows directly facing the worst weather conditions (e.g. wind, rain or snow).
- » On a wet day, try to keep wet clothes out of the classroom as bringing them in will make the classroom more difficult to heat.
- » Adjust the classroom layout to move students away from open windows, and other areas that may have cooler air or draughts.
- » Relax uniform rules/dress codes and allowing warmer clothes to be worn on the coldest days.

Air cleaners can also be used in spaces that are challenging to ventilate while maintaining comfortable indoor temperatures, noting they are not a substitute for good ventilation.

Natural ventilation during warmer weather

When it is warmer, schools should fully open windows and doors whenever possible to make the most of natural ventilation while still maintaining comfortable indoor temperatures.

When hot weather outside is making it too warm inside, schools should use their cooling systems (for example, heat pumps) to reduce the indoor temperature. This may require windows and doors to be open less at the warmest times during the school day.

Schools can also consider resetting the temperature of the room to a comfortable level by having all occupants leave the room, open all the windows and doors fully for a short period to air the space, and then close them and run the cooling system on its highest setting before re-occupying the room and re-opening windows.

Air cleaners can also be used in spaces that are challenging to ventilate. During warmer months air cleaners will also help remove dust, pollen and other outdoor allergens from the indoor air.

Portable and ceiling fans can provide additional comfort to occupants in the warmer months by moving air and creating a breeze within the room, noting their use is not a replacement for opening windows. Portable fans should only be positioned where they do not present a health and safety risk.

Use of heating and cooling solutions

Many schools are fitted with heat pumps which are used to heat or cool spaces efficiently. Heat pumps only recirculate existing air within the space and do not bring in outside air. The Ministry recommends schools continue to use heat pumps and other tempering solutions in conjunction with their ventilation strategies to balance good ventilation and thermal comfort. The use of any tempering solution should not impede the designed ventilation system for a space.

Heat pumps and other tempering solutions can continue to be used even when windows and doors are open. This will be less energy efficient and may incur some additional energy costs but may be necessary to ensure there is a sufficient flow of fresh air through a space.

Tips for effectively using heat pumps and other heating systems in conjunction with natural ventilation include:

- » On colder days, pre-heat the space to a comfortable temperature before the school day to improve the draw of fresh air through partially opened windows.
- » Increase indoor heating or cooling during the day, if you need to, to offset the impact of having the windows open.
- » Reset the temperature of the room to a comfortable level after it has been vacated and aired out, by briefly closing all windows and doors and running the heating or cooling system on its highest setting before re-occupying the room and re-opening windows.

Heat pumps and tempering solutions should be checked and serviced regularly, and especially ahead of the start of the winter school terms, to ensure the systems are able to heat rooms efficiently. Servicing should also include cleaning of a heat pump's mesh dust filters. Regular maintenance should also be carried out year-round to keep systems running at their best.

Section five: Portable air filtration

Air filtration, performed as part of a mechanical system, or by using portable air cleaner devices, removes contaminants from the air to improve indoor air quality. In naturally ventilated environments, portable air cleaners are a useful supplementary solution but do not replace good ventilation practices as they do not supply fresh air or reduce CO₂ levels.

Throughout 2022 the Ministry distributed more than 13,000 portable HEPA air cleaners to all state and state-integrated schools to supplement their existing ventilation capabilities, as part of each school's COVID-19 response and mitigation activities.

The programme's literature review and studies regarding HEPA air cleaners informed the Ministry's COVID-19 ventilation layered intervention strategy. This research confirmed that air filtration is a useful supplementary measure to natural (and other) ventilation systems, and to mitigate the risk of COVID-19 airborne transmission in school environments. However, air cleaners are not a replacement for good ventilation strategies and systems as they do not reduce CO₂ levels or supply fresh air.

The content in this section provides information on the relationship between ventilation and the use of portable HEPA air cleaners for air filtration, including how to use air cleaners, where they should be placed, and scenarios for their use.

As ducted mechanical systems are not prevalent in New Zealand schools, it is outside the scope of this document to discuss the relationship between COVID-19 airborne transmission, and air filtration functions within ducted mechanical systems.

What air cleaners do

Air cleaners can reduce the airborne transmission of illnesses including COVID-19, by filtering and recirculating the air within a space. The degree of improvement achieved is generally less than can be achieved by adopting other ventilation strategies, such as refresh breaks or partially opening windows.

Air cleaners filter out tiny viruses, fungi, bacteria and airborne particles, including ones that have been breathed out by the room's occupants, from the air in the room. A fan inside the air cleaner pulls in the air and passes it through a filter, then recirculates it back into the room. Air cleaners also offer benefits in terms of reducing pollen, dust and other airborne particles. They do not filter or reduce gaseous pollutants from the air.

The effectiveness of air cleaners and the volume and type of pollutants they can remove is dependent on the unit being correctly sized for the room, running on a high fan speed, and having a quality HEPA filter.

Air cleaners can offer a modest improvement to air quality in spaces and can help improve air quality where there is limited airflow, and in spaces that are challenging to ventilate well (e.g. where airflow is low, the air is stale, or CO₂ levels are persistently elevated) and when it is impractical to sufficiently open windows to flush the space with fresh air.

The process of removing and filtering the air is measured as effective air changes per hour (eACH). The air changes are considered 'effective' (eACH) rather than 'actual' (ACH) because they don't introduce any fresh air. Fresh air is important for a space as it is the best way to dilute contaminants and CO₂ concentrations in the air. As a result, the use of HEPA air cleaners will not reduce CO₂ levels and are not a substitute for ventilation in any circumstances.

The Ministry recommends running air cleaners on their highest fan setting throughout the day. If the air cleaner is too loud or blowing out cold air, it should be relocated in the space to minimise disturbance.

Running air cleaners on low or auto settings are unlikely to make a significant difference to reducing COVID-19 or other airborne illness transmission risk. For auto settings this is because the sensor may not be triggered by the small particles which carry many common airborne illnesses.

Using portable air cleaners

Air cleaners were distributed to schools to use at their discretion in spaces that may have a higher risk of COVID-19 airborne transmission or are otherwise challenging to ventilate. Spaces that have a large number of occupants, rigorous activity levels or are used for prolonged periods of time are generally considered to be higher risk.

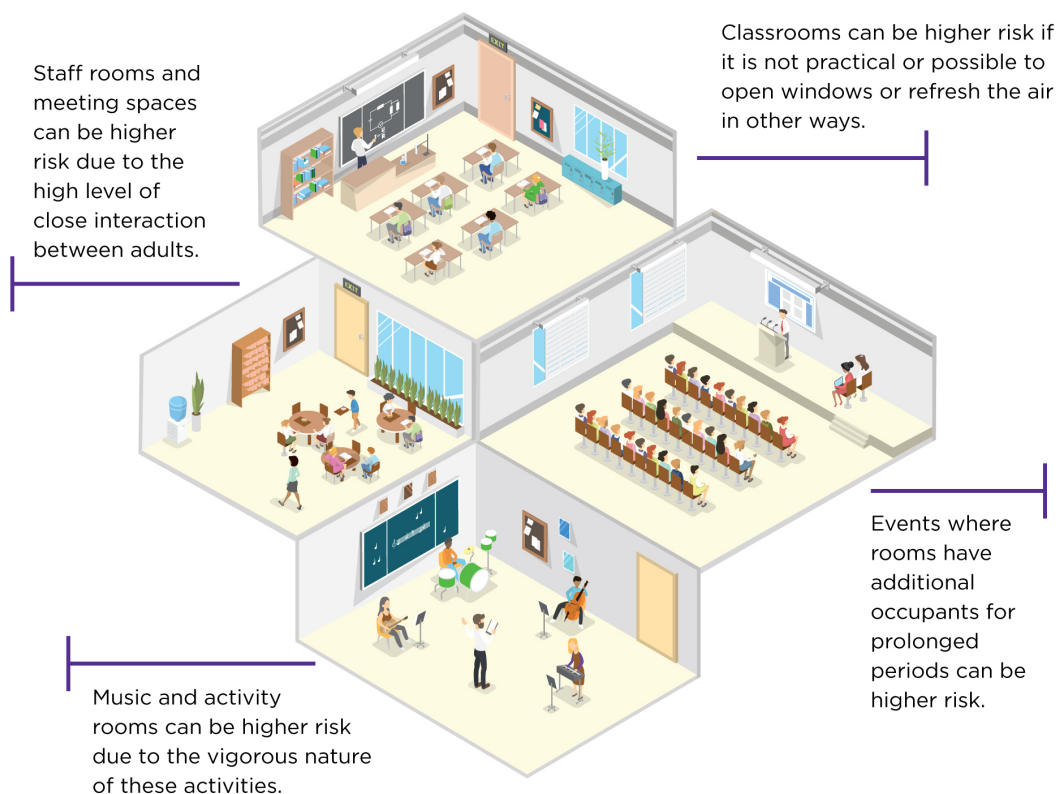


Figure 5.1 presents some examples of where air cleaners can be utilised within a school

Where and when to use air cleaners

The following spaces may benefit from the use of air cleaner(s) to supplement the ventilation system, to varying degrees.

Breakout and quiet spaces are often smaller rooms, some of which were not originally designed to house a larger number of people for a prolonged period. Doors between the breakout room and the main teaching space are often closed to provide a quiet and separated environment. These spaces can become under-ventilated when used in this way for a prolonged period.

Event in larger spaces can involve larger numbers of people congregating in rooms or halls for prolonged periods, and the more active the types of activities, the higher the demand on the space's ventilation system. Air cleaners can offer some supplementary benefits during such events.

Learning spaces (classrooms) are generally designed with good ventilation in mind, to suit a large number of occupants doing classroom-based activities through the school day. There is no substitute for fresh air in these spaces, however there may be times such as during very bad weather, or when doing more vigorous activities, that ventilation becomes challenging.

Meeting rooms are often smaller rooms, used intermittently and for short periods by a group of people. If it's a private or sensitive discussion, windows and doors can tend to be closed. This can result in the room becoming under-ventilated very quickly.

Music and activity rooms are spaces where the activity type causes people to move and breathe more, increasing the possibility of airborne transmission should one of the room's occupants have COVID-19 or another illness.

Reception areas are typically well ventilated due to the entry/exit doors, with rarely many people present for prolonged periods. Air cleaners are likely to offer very little benefit in these spaces.

Sick rooms are spaces that may be higher risk due to illness being present, however noting people should not remain at school for a prolonged period if showing signs of illness, and those around them should consider face masks and other measures to reduce the risk of infection.

Staff offices that are used by multiple adults in close proximity, especially if not originally designed to have that number of adults in it concurrently, can present a ventilation challenge.

Staff rooms are spaces that have close interaction between adults, and where masks are not a practical option because they are eating or drinking. The number of adults in the room can increase quickly at break times, resulting in the room becoming under-ventilated very quickly.

Air cleaners can be used in classrooms and other spaces when adverse weather conditions make it less practical to open the windows. In addition to general space type and usage considerations, also consider using an air cleaner when:

1. There are minor ventilation issues being remediated, such as fixing windows that cannot open. Air cleaners are a good short-term mitigation when while longer-term ventilation solutions are put in place.

2. It is not practical to sufficiently open windows or doors, for example during adverse weather.
3. There is heightened viral risk in the community and therefore within the school, for example during a COVID-19 variant resurgence event.

For effective air changes to occur, portable air cleaners should be placed in a central location within the space, or furthest away from your other mechanical ventilation methods, and turned on to their highest setting. As demonstrated in Figure 5.2, they should also be placed far away, or on the opposite side of the room, to any open windows and doors, and at least one to two metres away from occupants. There should also be 20-30 cm of space around the device to ensure its airflow isn't blocked by walls or other objects.

Where to place air cleaners in a room

Air cleaners should ideally be placed in a central location within the space, away from other mechanical or natural ventilation openings or vents (including windows and doors), at least one-to-two metres away from occupants and with 20-30 cm of space around the device to ensure its airflow isn't blocked by walls or other objects.

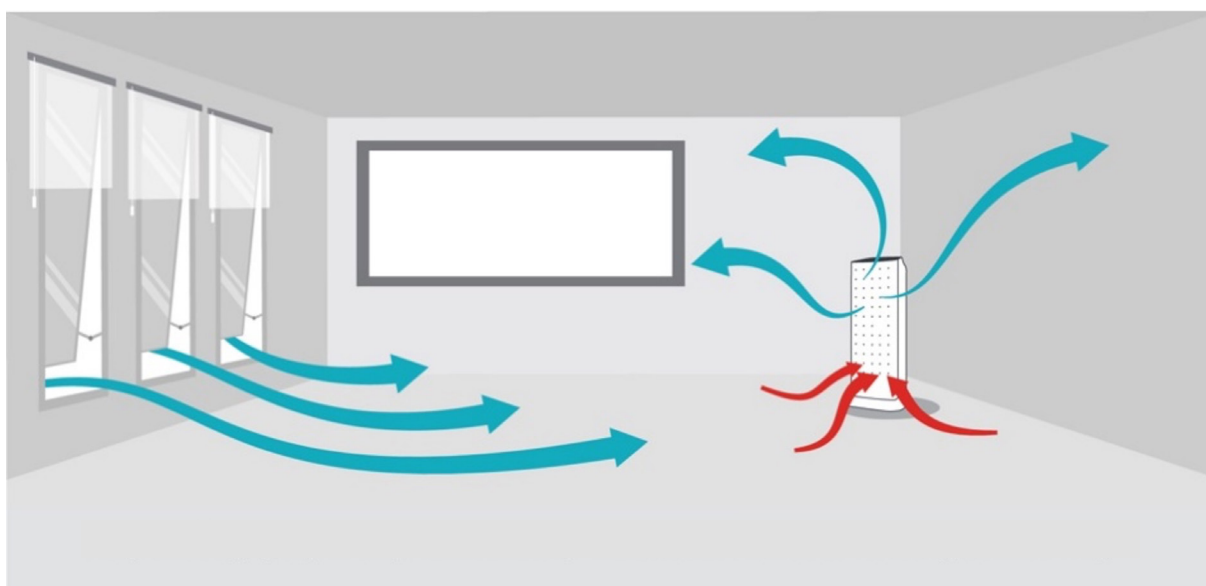


Figure 5.2: Ideal air cleaner placement within a room

The Ministry notes, however, that placement options are often very limited in classrooms, which can decrease the effectiveness of the device(s).

Air cleaner specifications and maintenance

The following recommendations were formed in consultation between the Ministry and the VTAG.

- » Air cleaners should use H13-14-grade HEPA filters, have a Clean Air Delivery Rate (CADR) greater than 400 m³/hour, operate at less than 60dB (under 45dB preferred).
- » Air cleaners should not employ emerging technologies that emit any substances into the air – for example ionisers, plasma discharge, ozone generators, photocatalytic oxidation or hydrogen peroxide. There is insufficient research and independent peer reviewed evidence on

the use of emerging technologies in public spaces, and the impact of long-term exposure to the substances they emit. There are also no internationally recognised standards that define a safe implementation for emerging technologies.

- » Portable air cleaners being deployed into classrooms, that are within the reach of children, should not utilise UVC irradiation (UVC) or ultraviolet germicidal irradiation (UVGI) technologies. These technologies are not recommended due to concerns in a school environment the device's enclosure could get damaged, causing the technologies to pose as a health risk for people.

Air cleaners should also be maintained to ensure they can filter particles effectively. Any pre-filter screens should be vacuumed then washed with detergent and lukewarm water every 4-6 weeks, and the HEPA filter should also be replaced every 6-12 months in accordance with the manufacturer's recommendations.

Section six: Actions summary for teachers, principals and property

This section summarises the different roles school leadership and teachers play in managing and implementing ventilation at schools. The strategies in this section are best practice and can also be applied to other buildings or indoor spaces.

Schools are governed by Boards which represent the views of the school community when making decisions for all aspects of school strategy and operations. In doing so, schools are required to undertake these activities within the appropriate legal parameters, including putting in place appropriate health and safety measures to mitigate the risks from COVID-19 and other infectious illnesses.

School leadership teams are responsible for heating strategies, adjusting uniform policies for the comfort of students in colder weather, identifying ventilation issues and working alongside the Ministry to resolve problems. School leadership teams are also encouraged to consider how good ventilation strategies, solutions and checking regimes are employed ongoing, for example as part of new staff induction, health and safety and regular property maintenance processes.

For teachers, the key consideration is how to manage ventilation in classrooms during the school day, and what actions to take if CO₂ levels are high for a sustained period of time.

Teachers and principals are encouraged to understand how to monitor CO₂ levels, what they mean and what actions they should take in response to particular readings. Generally:

- » If CO₂ levels are between 800 - 1,250 ppm, open windows and doors as much as possible.
- » Short peaks of over 1,250 ppm throughout the day are common, however, if they are sustained for over an hour or more then take other actions such as refreshing the room.
- » If levels of CO₂ very frequently peak or are persistently elevated over 2,000 ppm despite employing ventilation strategies, further investigation of the space is required in order to understand how best to improve ventilation.

Support available for schools

In addition to the Ministry's published ventilation guidelines and resources, the Ministry developed a range of support mechanisms for schools. This included access to expert advice from the programme team, downloadable resources and other useful tools to help schools follow guidance, the distribution of more than 13,000 portable air cleaners and 12,500 portable CO₂ monitors free of charge, and capital funding to support urgent ventilation-related property improvements⁵.

⁵ A capital fund for schools to carry out urgent property improvements over \$5,000 that is required to achieve good ventilation. Schools can access this fund by speaking to their Property Advisor, with submissions currently accepted until 30 June 2023. If eligible, the Ministry will cover the entire cost of the project.

For teachers

Teachers can take the following actions to monitor and improve ventilation:

- » Use your senses
- » Open windows for as much, and for as long, as practical while staying warm
- » Open windows on opposite sides of the room to create a crossflow of air
- » Implement refresh breaks

For school leaders

Principals and school leaders need to work alongside teachers to find solutions for ventilation challenges

- » Encourage CO₂ monitoring
- » Review ventilation capabilities as part of regular health and safety planning
- » Ensure property maintenance is up to date
- » Encourage good ventilation practices, such as opening windows
- » Adjust uniform policies if needed
- » Inform Ministry of Education Property Advisor of any concerns

Property

Schools also need to carry out necessary property maintenance to ensure they can take advantage of the ventilation systems they were designed with. This includes:

- » Prioritising work to fix windows that have been painted or sealed shut, and any window that has been designed to be opened that no longer does so.
- » If rooms have been repurposed as learning spaces, following the G4 Ventilation to ensure spaces have at least 5% of openable area, based on floor area, and making the necessary infrastructure changes.
- » Undertaking regular maintenance of heating and mechanical ventilation systems.
- » Using air cleaners and air conditioners to assist with air flow in classrooms, as needed in the interim while other improvements are made.
- » All window alterations and remediation need to comply with the [DQLS](#) and the [Ministry's Window Replacement Requirements](#) for existing buildings.

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