



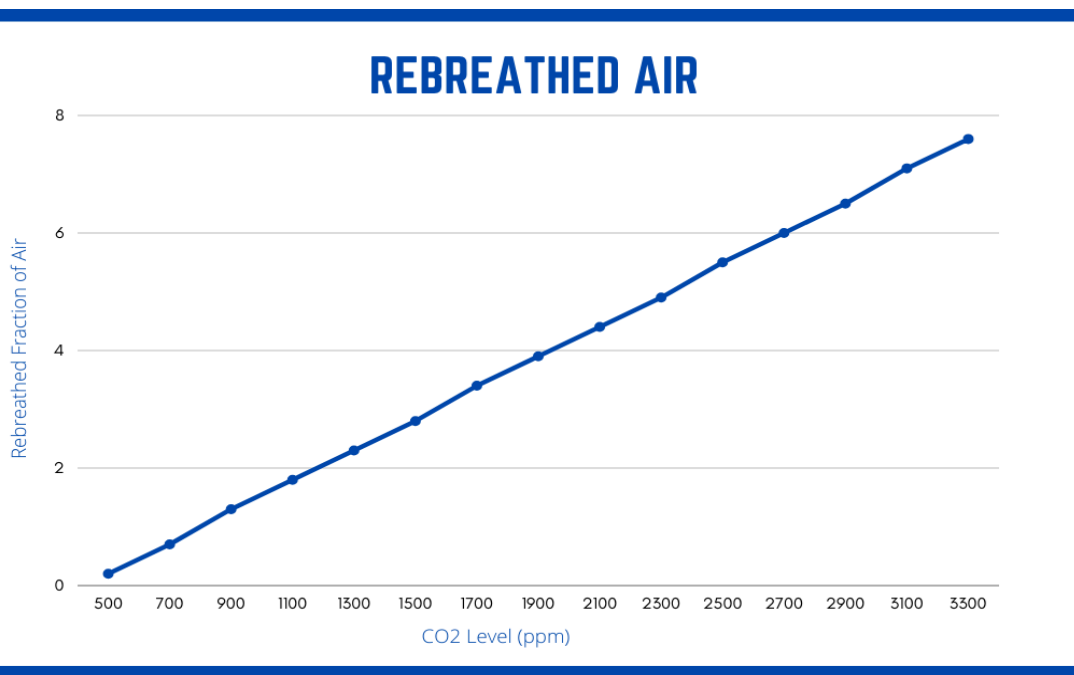
## Masks4Canada Room Ventilation/Filtration Guide and Tip Sheet

Protect yourself and your family from more contagious strains of the virus. We do not endorse any particular company and receive no funding or royalties from, and have no ties to any of the listed products. You can [contact us here](#) if you want to suggest changes, or reach out to [@kashprime](#), [@lisa\\_iannattone](#) or [@davidelfstrom](#) on Twitter.

Improving ventilation has been one of the biggest missed opportunities in this pandemic, especially with [greater](#) and [greater](#) recognition that Covid is airborne. We have long advocated this position, with our [open letters](#) and vocal advocacy in the media, together with an international group of scientists. Below we will explain basic terms and give you the tools you'll need to secure your office or classroom and protect everyone better.

### CO2 Monitoring



Generally room CO2 can be used as a rough marker of fresh air in a given room. The higher the count, the more chances you are rebreathing air from another person. If that person has Covid-19, you will inhale infectious particles that will give you the disease. [This neat spreadsheet](#) from [@davidelfstrom](#) does the math, also described by [Dr. Richard Corsi](#). Many classrooms in older buildings can have CO2 levels as high as 3000 ppm, in which 7% of the air in every breath you take comes directly from other people in that room.




You can use commonly available devices to measure your room CO2 levels. These are best done when the rooms are occupied. Generally you want levels to be as low as possible, as low as 700 ppm or lower.

Health Parameter Guide					
PM2.5	PM10	CO2(ppm)	Levels of Health Concern	HCHO(mg/m³)	Displayed Contents
0.0-12.0	0-54	0-700	Good	0-0.1	Healthy
12.1-35.4	55-154	701-1000	Moderate	>0.1	Unhealthy
35.5-55.4	155-254	1001-1500	Unhealthy for Sensitive Groups		
55.5-150.4	255-354	1501-2500	Unhealthy		
150.5-250.4	355-424	2501-5000	Very Unhealthy		
≥250.5	≥425	≥5001	Hazardous		

CO2 Monitors that we have used:

Manufacturer	User Notes
<p>Temtop M2000</p> 	<ul style="list-style-type: none"> <li>Relatively heavy and noticeable but well-suited for handheld use</li> <li>Several models available, some add particulate matter sampling (PM) and logging capabilities</li> <li>Reading response time is slow, it takes a few minutes to stabilize.</li> <li>Unit is calibrated monthly by bringing outdoors and completing a 30 minute calibration cycle.</li> </ul>
<p>Aranet 4 Home</p> 	<ul style="list-style-type: none"> <li>Very small and lightweight, can slip into a mesh side pocket on a backpack</li> <li>Runs off alkaline batteries good for several months depending on logging interval</li> <li>Access data and settings with smartphone app over bluetooth</li> <li>Storage is 3 days of logging, at 1 minute intervals</li> <li>Recommend calibrating to outdoor air on a regular basis</li> </ul>
AirQ	<ul style="list-style-type: none"> <li>Powered off standard USB charger. Rechargeable version is also available.</li> </ul>

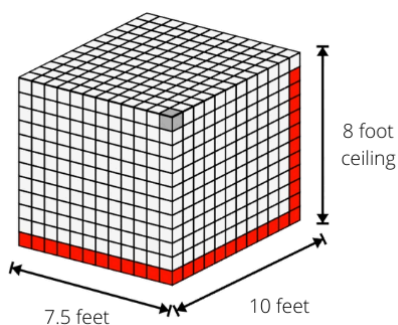
	<ul style="list-style-type: none"> <li>• Dual-beam NDIR sensor is very repeatable over long-term (very little drift)</li> <li>• Logs data in 1 minute intervals</li> <li>• Touch screen interface</li> <li>• Fast reading response, values stabilize within seconds.</li> </ul>
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## HEPA Filters

You can use HEPA (High Efficiency Particulate Air) filters to remove infectious particles from the air in rooms where you can't improve with outdoor ventilation. These are measured with the CADR (Clean Air Delivery Rate). This is given in units of CFM or Cubic Feet per Minute.

Let's take a typical medical clinic office. It is usually about 75 square feet, with 8 foot high ceilings, which is typical for a home or small office. With a small HEPA filter with a CADR rating of 50, you can get 5 air changes per hour on the highest speed setting. Add to the 1 ACH you get in a badly ventilated room and you get close to the standard of 6 ACH used in most hospital settings. Here's the math:

## HEPA How-to Guide



75 square foot office means:  
 $75 \times 8 \text{ foot ceiling} =$   
 600 Cubic feet total volume

+



HEPA Filter CADR of  
 50 Cubic Feet/Min =  
 3000 Cubic Feet/Hour

=

**5 ACH**  
 (Air Changes  
 per Hour)

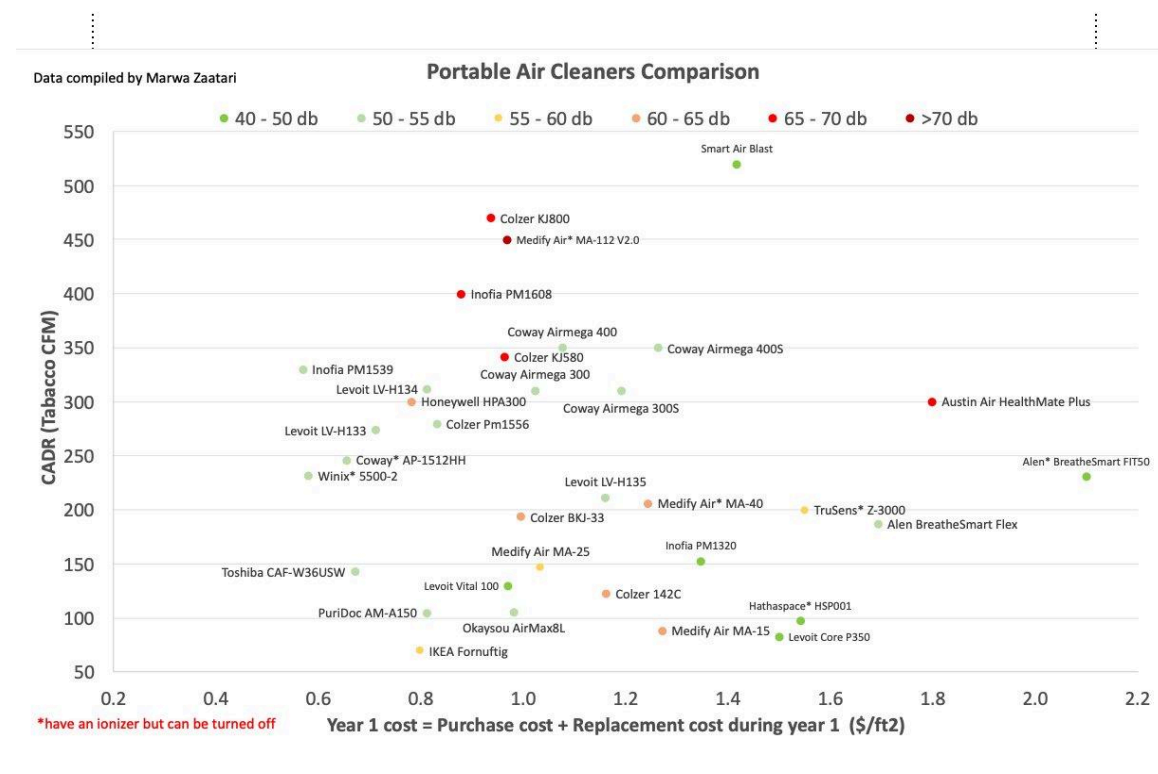
The Filter will go  
 through all of the air  
 in the room 5 times  
 (3000 Cubic  
 Feet/Hour in a 600  
 Cubic Foot room).  
 This means:



## Reducing Noise

One issue is noise; the CADR rating is usually measured at the filter's highest setting, which can be quite loud. This unit in the picture makes 60 dB at its highest setting, about the same as a conversation. This would be distracting in a classroom or office setting. You can mitigate this by placing 2-3X as many filters and running them on a low or medium setting, and running them on the highest setting during meal times.

This is an excellent graph created by [@marwa\\_zaatari](#) that compares various commercially available HEPA filters, charts them by cost and the noise they generate at their highest settings.



## How to Choose a Good Filter

1. High CADR (Clean Air Delivery Rate)
2. Low noise level on the highest setting
3. Relatively low velocity fan, preferably directed upwards
4. High energy efficiency - try to get one Energy Star rated if possible
5. Carbon filters don't matter (meant to stop odours), and can actually make the fan blow harder
6. UV filtration probably not useful, better used by specialists and in 'upper rooms'
7. Ionization is possibly not a great technology. It adds cost with questionable health impacts, maybe some issues from the Ozone that's generated as a byproduct. If present, it should be turned off.

## For Classrooms

[Harvard Healthy Buildings](#) has a number of resources that can be used to calculate the ventilation needs in a large classroom. [This spreadsheet](#) can help you calculate this (make a copy so that you can enter your own data)

SIMPLE TOOL FOR SCHOOLS FOR SELECTING PORTABLE AIR CLEANER FOR ROOMS (input fields are bright yellow)					
<b>STEP 1 HOW BIG IS THE ROOM?</b>					
Select units of preference	feet				
How big is your room?	500	Input your room size here in square feet			
How tall are your ceilings?	10	Input your room size here in feet			
<b>STEP 2 WHAT IS THE 'CLEAN AIR DELIVERY RATE' OF THE AIR PURIFIER? (you get this from the manufacturer)</b>					
What is the clean air delivery rate of the air cleaner?	300	Find the CADR from the manufacturer in units of cubic feet per minute, or cfm; if they report mult			
<b>STEP 3 HOW MUCH OUTDOOR AIR VENTILATION DO YOU HAVE?</b>					
How is the ventilation in my school?	Low ventilation	Good ventilation	3 ACH	This is the approxin	
		Enhanced ventilation	4 ACH	Select this only if yc	
		Typical school	1.5 ACH	This is an approxim	
		Low ventilation	1 ACH	Select this if your sc	
<b>STEP 4 COMBINING AIR CLEANING AND VENTILATION, IS YOUR ROOM MEETING THE TARGET?</b>					
Air changes from outdoor air ventilation	1	<b>TARGET IS AT LEAST 5 TOTAL AIR CHANGES PER HOUR</b>			
Air changes from air cleaner	3.6	Ideal (6 ACH)			
<b>Total air changes in the room per hour</b>	<b>4.6</b>	Excellent (5-6 ACH)			
		Good (4-5 ACH)			
		Bare minimum (3-4 ACH)			
		Low (<3 ACH)			
<b>STEP 5 WHAT SIZE ROOM WILL WORK FOR THIS PORTABLE AIR CLEANER?</b>					
Cubic feet per minute (cfm) of clean air from cleaner	300	This is from the manufacturer (see cell 'c10')			
Cubic feet per minute (cfm) of outdoor air from ventilation	83	This is calculated from air changes per hour and volume of room			
Total cfm of air cleaning and ventilation	383				
<b>Recommended room size for this air cleaner (in square feet)</b>	<b>460</b>	This is the recommended maximum size of the room for this air cleaner to achieve 5 total ACH			

## Improvised HEPA Filters

Understandably, demand for filters has exploded in the last year, and supply might become an issue. You can improvise an air filter using [MERV](#) 11 or 13 grade furnace filters sealed to a portable fan. The simplest version attaches one filter to the face of the fan. You can improve the efficiency by increasing the surface area of the filters: 1 thicker filter (2 inch instead of 1), 2 filters in a wedge shape or 4 filters in a cube, dubbed the 'Corsi Box.' [This article](#) goes in more detail. More [details here](#), and this article [discusses a modification](#) that you can use to improve the efficiency of the filter by directing the air through the middle of the fan. Box fans are in short supply these days, but you can use cardboard to fit most fan shapes, as [@ladyscorcher](#) does here:





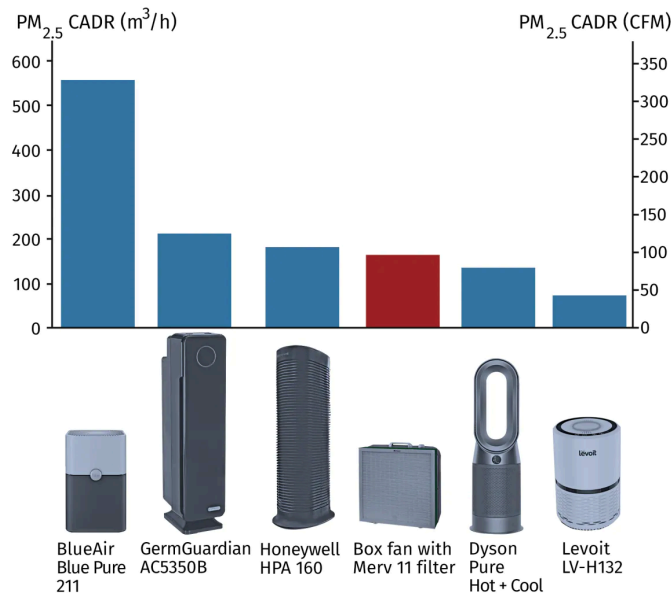
Here's a single 2 inch filter sealed to a box fan and another example of the 2 filter wedge design:



These improvised fans can be quite effective, one tested by [CBC Marketplace](#) produced a Clean Air Delivery Rate (CADR) of 100 CFM, in line with commercial filters that cost hundreds of dollars.

### How 5 different air purifiers and a DIY one performed in a test

A higher CADR rating can help you choose the best air purifier



CADR: Clean Air Delivery Rate, the most important metric in choosing an air purifier  
 PM<sub>2.5</sub>: Mass of all particles 2.5 microns and smaller (smoke)

M<sup>3</sup>/h: Cubic metres per hour CFM: Cubic feet per minute

CBC NEWS

Source: University of Toronto

## Examples

### 1) Classroom with very poor ventilation -

- Your CO<sub>2</sub> detector shows >700 ppm with people inside
- 800 sq.ft. 25' x 32' with 10 foot ceilings = 8000 cubic feet.
- You will need air filters that total a CADR (Clean Air Delivery Rate) of 800 CFM (cubic feet per minute to exchange the air 6 times an hour ( (8000 cu.ft. x 6) / 60 minutes )
- Assume the room itself provides only 1 air change an hour (which is terrible)
- You can buy 2 of [these models](#), which each provide a CADR of 323 CFM each to get close to that number (323 x 2 = 646 CFM). You can also use 3 [improvised home-made Corsi Boxes](#) (each has a CADR of around 200 CFM)
- Plug these numbers into this spreadsheet, the filters bring it up to 5.8 air changes an hour (ACH). This is very close to hospital grade (which is 6 ACH).
- For \$600 (~\$25 per student) you have protected them incredibly well from an airborne virus. Filters are good generally for one year.
- You can buy 4 of them (twice as many as required) and run them at lower settings if you want to limit noise (these ratings above are when the filter is running at full speed)

SIMPLE TOOL FOR SCHOOLS FOR SELECTING PORTABLE AIR CLEANER FOR ROOMS (input fields are bright yellow)					
<b>STEP 1 HOW BIG IS THE ROOM?</b>					
Select units of preference	feet	▼			
How big is your room?	800		Input your room size here in square feet		
How tall are your ceilings?	10		Input your room size here in feet		
<b>STEP 2 WHAT IS THE 'CLEAN AIR DELIVERY RATE' OF THE AIR PURIFIER? (you get this from the manufacturer)</b>					
What is the clean air delivery rate of the air cleaner?	646		Find the CADR from the manufacturer in units of cubic feet per minute, or cfm.		
<b>STEP 3 HOW MUCH OUTDOOR AIR VENTILATION DO YOU HAVE?</b>					
How is the ventilation in my school?	Low ventilation	▼	Good ventilation	3 ACH	Th
			Enhanced ventilation	4 ACH	Se
			Typical school	1.5 ACH	Th
			Low ventilation	1 ACH	Se
<b>STEP 4 COMBINING AIR CLEANING AND VENTILATION, IS YOUR ROOM MEETING THE TARGET?</b>					
Air changes from outdoor air ventilation	1		<b>TARGET IS AT LEAST 5 TOTAL AIR CHANGES I</b>		
Air changes from air cleaner	4.8				
<b>Total air changes in the room per hour</b>	<b>5.8</b>				
				Ideal (6 ACH)	
				Excellent (5-6 ACH)	
				Good (4-5 ACH)	
				Bare minimum (3-4 ACH)	
				Low (<3 ACH)	
<b>STEP 5 WHAT SIZE ROOM WILL WORK FOR THIS PORTABLE AIR CLEANER?</b>					
Cubic feet per minute (cfm) of clean air from cleaner	646		This is from the manufacturer (see cell 'c10')		
Cubic feet per minute (cfm) of outdoor air from ventilation	133		This is calculated from air changes per hour and volume of room		
Total cfm of air cleaning and ventilation	779				
<b>Recommended room size for this air cleaner (in square feet)</b>	<b>936</b>		This is the recommended maximum size of the room for this air cleaner to achieve		

## 2) Medical Office with poor ventilation

- Your CO2 detector shows >700 ppm with people inside
- 75 sq.ft 7.5' x 10' room with 8 foot ceilings = 600 cubic feet.
- You will need air filters that total a CADR of 60 CFM ((600 cu.ft. x 6) / 60 minutes)
- Assume the room itself provides only 1 air change an hour
- You can buy one of [these models](#) which provides a CADR of 50 CFM
- Plug these numbers into [the spreadsheet](#) to find that you can bring your room circulation up to 6 air changes an hour (6 ACH), which is hospital grade.

SIMPLE TOOL FOR SCHOOLS FOR SELECTING PORTABLE AIR CLEANER FOR ROOMS (input fields are bright yellow)					
<b>STEP 1 HOW BIG IS THE ROOM?</b>					
Select units of preference	feet	▼			
How big is your room?	75		Input your room size here in square feet		
How tall are your ceilings?	8		Input your room size here in feet		
<b>STEP 2 WHAT IS THE 'CLEAN AIR DELIVERY RATE' OF THE AIR PURIFIER? (you get this from the manufacturer)</b>					
What is the clean air delivery rate of the air cleaner?	50		Find the CADR from the manufacturer in units of cubic feet per minute, or cfm.		
<b>STEP 3 HOW MUCH OUTDOOR AIR VENTILATION DO YOU HAVE?</b>					
How is the ventilation in my school?	Low ventilation	▼	Good ventilation	3 ACH	
			Enhanced ventilation	4 ACH	
			Typical school	1.5 ACH	
			Low ventilation	1 ACH	
<b>STEP 4 COMBINING AIR CLEANING AND VENTILATION, IS YOUR ROOM MEETING THE TARGET?</b>					
Air changes from outdoor air ventilation	1		<b>TARGET IS AT LEAST 5 TOTAL AIR CHANGE</b>		
Air changes from air cleaner	5.0				
<b>Total air changes in the room per hour</b>	<b>6.0</b>				
				Ideal (6 ACH)	
				Excellent (5-6 ACH)	
				Good (4-5 ACH)	
				Bare minimum (3-4 ACH)	
				Low (<3 ACH)	
<b>STEP 5 WHAT SIZE ROOM WILL WORK FOR THIS PORTABLE AIR CLEANER?</b>					
Cubic feet per minute (cfm) of clean air from cleaner	50		This is from the manufacturer (see cell 'c10')		
Cubic feet per minute (cfm) of outdoor air from ventilation	10		This is calculated from air changes per hour and volume of room		
Total cfm of air cleaning and ventilation	60				
<b>Recommended room size for this air cleaner (in square feet)</b>	<b>90</b>		This is the recommended maximum size of the room for this air cleaner to achieve		

- For ~\$90 you can protect yourself and your patients much more effectively




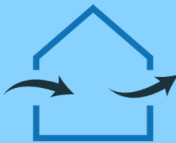



- h) You can buy two or three of them and run them at a lower setting if you want to minimize noise

### General Advice

This pandemic will be over for most of us soon. This is some general advice for you to follow to make things safer for unvaccinated family members (i.e. kids <12) to keep safe until then.

## FIVE WAYS TO FIGHT AN AIRBORNE VIRUS



<p><b>Wear high quality masks, like an N95 when indoors</b></p>  <p>@kashprime</p>	<p><b>Open windows where possible. Fresh air is good!</b></p> 	<p><b>Use a CO2 monitor to assess ventilation. Goal: &lt;700 ppm</b></p> 	<p><b>Use HEPA filters if CO2 levels are high</b></p> 	<p><b>Avoid eating lunch indoors, move outdoors</b></p> 
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