

AIR CLEANING DEVICES FOR THE HOME

Frequently Asked Questions

Many types of indoor pollution problems are found in homes. The most effective approach to solving these problems is usually to remove or reduce the sources of indoor pollution. Ventilation also helps remove indoor air pollutants, but not as effectively as source reduction. Air cleaning devices can also be helpful when used along with source reduction and ventilation.

The best solution to the air pollution within your home will depend, of course, on the type and scope of the particular problem, your home's characteristics, and your family's specific health concerns and budget. The information below will help you decide if an air cleaning device would be useful as a part of your solution to indoor pollution, and if so, what type might best meet your needs. Many of the principles discussed here also apply to offices, schools, and vehicles.

Important Basics about Air Cleaning Devices

Air cleaning devices alone cannot adequately remove all indoor pollutants from homes. This is especially true when the sources emit a large amount of pollution, or when the pollutants settle rapidly on surfaces. The most common air cleaning devices will remove some of the particles from the indoor air, but will not effectively remove certain types of pollutants, such as very fine particles, bacteria and viruses, carbon monoxide, radon, odors, and some allergens such as those from roaches and pets. Specific types of filtration devices and air cleaners are needed for such pollutants: high efficiency filters and air cleaners, discussed further below, can remove very small particles, and devices with sufficient quantities of charcoal (carbon), Purafil, or similar sorbent materials can remove some odors and gaseous pollutants.

Air cleaning devices are available as portable, stand-alone appliances or as filters or air cleaners in a central air system. Portable units are usually best for single room use, rather than multiple room or whole-house use, because of their limited capacity to circulate large volumes of filtered air. Air cleaners and specialized filters designed for use in central heating and air conditioning systems, if properly configured and maintained, may have the greatest potential to improve your entire home's air quality because most can circulate very large volumes of filtered air throughout the home.

The health benefits of air cleaning devices are not clear, based on the limited scientific evidence that is currently available, but high efficiency filtration may be an effective strategy, and it is currently being studied by the California Air Resources Board (ARB) and others. However, it is clear that you should never use an air cleaner that deliberately produces ozone, sometimes called "ozone generators". Ozone generators cause indoor pollution and do not clean the air. The ARB has taken regulatory action to limit ozone emissions from portable air cleaners, as discussed later in this fact sheet.

How Is a Filter's Particle Removal Efficiency Rated?

Several standardized methods have been developed by trade groups or organizations to allow comparison of filters. These standards are designed to rate a filter's particle removal efficiency. No recognized standard has been developed to rate a filter's gaseous or chemical vapor removal rate. Currently, most filters are rated using the Minimum Efficiency Reporting Value (MERV) rating system that has been developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The MERV rating system ranges from a low of 1 to a high of 20, with each rating indicating the percentage of particles removed within a specific particle size range (measured in microns, where a micron is one millionth of a meter). For illustration purposes, the diameter of a human hair is about 40-50 microns wide. Particles smaller than 10 microns, especially those smaller than one micron, are of greatest concern to health because they penetrate farthest into the lungs. Generally, as the MERV rating increases, so does the filter's removal efficiency for smaller-sized particles. Table 1 summarizes each MERV rating's particle removal efficiency, based on specific size ranges.

Table 1. MERV Ratings*					
MERV Rating	Average Particle Size Efficiency (PSE), microns – % Removal			Typical Controlled Contaminant or Material Sources (ASHRAE 52.2)	Typical Building Applications
	0.3-1.0	1.0-3.0	3.0-10.0		
1-4			<20%	> 10 Microns Textile Fibers Dust Mites, Dust, Pollen	Window AC units Common Residential Minimal Filtration
5			20-35	3.0 to 10.0 Microns Cement Dust, Mold Spores, Dusting Aids	Industrial Workplace Better Residential Commercial
8			>70		
9		<50	>85	1.0 to 3.0 Microns Legionella, Some Auto Emissions, Humidifier Dust	Hospital Laboratories Better Commercial Superior Residential
12		>80	>90		
13	<75	>90	>90	0.3 to 1.0 Microns Bacteria, Droplet Nuclei (sneeze), Most Tobacco Smoke, Insecticide Dust	Superior Commercial Smoking Lounge Hospital Care General Surgery
16	>95	>95	>90		
17**	≥ 99.97			<0.3 Microns (HEPA/ULPA filters) Viruses, Carbon Dust, Fine Combustion Smoke	Clean Rooms Carcinogenic & Radioactive Matls., Orthopedic Surgery
18**	≥ 99.99				
19, 20**	≥ 99.999				

* Adapted from EPA 2009; originally from ANSI/ASHRAE Standard 52.2-2007. Not all levels are shown.

** Not part of the official ASHRAE Standard 52.2 test, but added by ASHRAE for comparison purposes.

How Do I Improve My Existing Air Filter in My Central Heating and Air System?

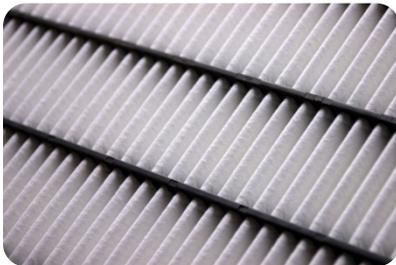
As a first step, you should check your central air system filter and upgrade to a higher MERV filter if possible. This may be all that is needed to provide clean air in your home. Central forced

air systems in homes usually accommodate a rectangular, one-inch thick fiberglass filter that slides underneath the furnace fan, or into a wall or ceiling register where the air returns to the furnace. These filters typically remove less than 20% of the particles that reach the filter and are usually rated at only MERV 1-4. They are disposable and typically cost \$2 to \$4.



Often, merely upgrading this filter to a medium- or high-efficiency filter will improve the air quality in your home. Medium-efficiency filters are typically pleated, woven material. Those that use synthetic media may help reduce bacterial growth on the filter itself, and recent research shows that synthetic filters may not emit formaldehyde as some fiberglass filters do. They are rated at 20% to greater than 70% efficiency for removing particles of 3 to 10 microns and carry a MERV 5 to 8 rating. Medium-efficiency, disposable one-inch filters cost about \$4 to \$9. Washable medium efficiency filters for residential use tend to carry a MERV 8 or lower rating, and an average size filter costs about \$20. Some medium-efficiency filters use static electricity created by air flow, but the effectiveness of such filters may decline as the static charge decreases over time.

Higher efficiency filters begin to remove much smaller particles and are rated at less than 50% to greater than 80% efficiency for removing particles 1 to 3 microns in size, and they carry a MERV 9 to 12 rating. They cost about \$10 to \$20 for disposable one-inch models. Before using a filter rated MERV 9 or higher, you may want to have an HVAC technician check your central system to be sure it can handle any added airflow resistance that higher efficiency filters may cause. Some higher efficiency filters are designed to avoid excessive airflow reduction (e.g. the filter is highly pleated, or has deeper pleats), so you may want to use one of those.



High efficiency filters remove very small particles and are rated as removing less than 75% to greater than 95% of particles 0.3 to 1 microns in size, and carry a MERV 13 to 16 rating. Premium one-inch, MERV 13 disposable filters are becoming more common and cost up to about \$25. Most high efficiency filters are typically two to five-inches deep (deeper filters are meant to prevent reduced airflow and typically have a longer service life), and may only be installed in central air systems designed or modified to accommodate them. High efficiency filters are sometimes mistakenly called HEPA or True HEPA (High Efficiency Particulate Air) filters. HEPA filters are 99.97% efficient for removing particles less than 0.3 microns, require correctly sized fans and central duct work, and are now becoming more readily available for use in home central forced air systems.



Note that many filters sold in retail stores and online do not show a MERV rating; you may have to check the manufacturer's website or contact the manufacturer to determine the MERV rating of the filter you wish to purchase. Sometimes other information is provided on the filter packaging that provides information similar to the information on the MERV table above; this can help you choose a suitable filter even if the MERV value is not specified.

Proper installation, operation, and maintenance are critical for effective operation of air filters:

- ✓ To maintain filter efficiency, make sure that the filter fits tightly in its seat or holder to prevent air from bypassing the filter.
- ✓ Check the filter for dust and debris buildup at least every month during heavy use. Replace or clean the filter as necessary, based on the manufacturer's recommendations, to maintain your system's efficiency and to reduce system strain caused by a dirty filter. Home filters usually require replacement several times a year, although a few models may last up to a year.
- ✓ Consider having an inexpensive pressure gauge installed to accurately show when a high-efficiency filter needs changing; the filter manufacturers recommend maximum pressure drops for each filter model. Some filters or air cleaners come with a sensor that indicates when filter replacement is necessary.
- ✓ To prolong the useful life of a HEPA filter, you may want to install a low-efficiency pre-filter upstream in order to prevent rapid overloading of the filter.

What Other Kinds of Air Cleaning Technologies are Available?

Even if you have taken actions to remove pollutant sources in and near your home, provided ventilation, and upgraded your central air filters, you may still have a problem with excess dust or odors. If so, you may benefit from an air cleaner. The information below will help you determine what type and size of air cleaner you need, and how to use it properly. You may also want to review ARB's Consumers' Air Cleaner Portal webpage at <http://www.arb.ca.gov/research/indoor/aircleaners/consumers.htm>.

Most air cleaners remove particles, a few remove gases (and odors), and some do both, as discussed below.

PARTICLE REMOVAL. Two basic types of air cleaners remove particles such as dust and allergens from the air: mechanical or physical-barrier air cleaners, and electronic air cleaners.

Mechanical air cleaners. These devices draw air through a fibrous or metal filter with different sized pores that trap particles. These devices should, at a minimum use medium-efficiency filters (see above), **but high efficiency or HEPA filter-equipped mechanical models are recommended because they remove more of the smaller particles of concern and do not emit ozone.** The filter will need to fit tightly in its seat, and be replaced regularly, although some units have filters that can be cleaned and re-used. These filters may be flat, round, or pleated.

Electronic air cleaners. There are three general types of electronic air cleaning technologies available for portable and central air cleaners: intentional ozone generators, electrostatic precipitators (ESPs), and ionizers. **Ozone generators produce substantial amounts of ozone by design, which can result in unhealthy indoor air quality and a pungent odor; these are not recommended for use in homes, schools, or other occupied locations.** Ozone generators are discussed further later in this fact sheet. ESPs use electrically charged plates to collect charged particles from air pulled through the device. Ionizers, or negative ion generators, charge particles which then causes them to deposit on materials near the ionizer (such as the carpet and walls). Hybrid air cleaners that have a combination of technologies also are available. ESPs, ionizers and hybrid electronic

technologies typically produce only very low amounts of ozone, but some produce sufficient amounts of ozone to cause unhealthful exposures. They should be used cautiously: to minimize ozone emissions, these devices need to be cleaned and maintained regularly, and operated only according to the manufacturer's instructions.

Before purchasing any portable air cleaner, be sure to check ARB's list of certified air cleaners, available at <http://www.arb.ca.gov/research/indoor/aircleaners/certified.htm>. ARB-certified air cleaners typically emit little or no ozone, and may not emit more than 0.050 parts per million (ppm) of ozone. (One ppm is equal to about one drop of water in 15 gallons of water). They also meet the applicable electrical safety standards of Underwriters Laboratories, Inc. Confirm the presence of an ARB-certified label on the device's packaging. In addition, ARB has published a list of potentially hazardous ozone generators sold as air cleaners that you should avoid; that list is available at <http://www.arb.ca.gov/research/indoor/o3g-list.htm>.

Sample Label



GAS AND CHEMICAL VAPOR REMOVAL. Residential air cleaning devices that effectively remove gases and odors are relatively costly, both to purchase and maintain. Gaseous pollutants are typically trapped or destroyed as the air is drawn through materials such as activated charcoal (carbon) or alumina coated with potassium permanganate. However, the filter material can quickly become overloaded and may need to be replaced often. These filters (usually charcoal) are offered as an option with some residential particle air cleaners. If you have very sensitive individuals in your home or odors that are difficult to remove, especially in just one area of the home, you may want to consider this option.

OTHER TECHNOLOGIES. Both portable and central air cleaners continue to incorporate newer types of technologies that may be combined with the electronic or mechanical technologies discussed above to remove particles, gases, and chemical vapors. Photocatalytic oxidation (PCO) air cleaners use ultraviolet (UV) radiation and a photocatalyst, such as titanium dioxide, to produce hydroxyl (OH) radicals that are purportedly generated to destroy gaseous contaminants. Ultraviolet germicidal irradiation (UVGI) air cleaners use UV radiation to neutralize airborne biological contaminants. Air cleaners with high-temperature heating elements (found in a few portable air cleaners) claim to inactivate biological contaminants and remove gaseous pollutants. "Air washers" or air cleaners that electrolyze water to produce OH radicals and hypochlorous acid claim to destroy biological contaminants. Some filters incorporate "nanofibers" into their media to capture smaller particles without increasing airflow resistance. These new technologies should be used only after careful consideration, as some may have potentially adverse health consequences, including ozone production or generation of unintentional pollutants. Many of these newer technologies are still being studied.

Portable or In-duct (Central) Air Cleaners: How Do I Choose?

Air cleaners are available in different configurations: portable units for single rooms, and larger central air cleaners for large rooms or the whole house. Smaller portable units typically cost between \$50 and \$200, while larger or more efficient portable models typically cost over \$300. Central air cleaners can cost on the order of \$250 to \$3,000, depending on the size and efficiency of the device.

PORTABLE AIR CLEANERS. Portable air cleaners are practical for existing homes where addition of a central air cleaner is too costly or not possible, and where air cleaning is primarily needed in a specific room or area of the house. Proper size, location, and maintenance are critical for portable air cleaners to be effective.

- ✓ Check the room size rating (in square feet of floor area) for the air cleaner, and use the appropriately sized unit for your situation. More information is provided under the *What Size Air Cleaner Should I Use* section below. The Appendix at the end of this fact sheet provides detailed guidance for determining size requirements.
- ✓ Install the unit(s) in the room(s) where your family spends most of their time or where air cleaning is needed most.
- ✓ Locate the unit away from doors, windows, and foot traffic, but not next to walls or corners, so that air may easily reach the air cleaner and it can effectively clean all the room air.

CENTRAL AIR CLEANERS. Central air cleaners using the technologies discussed above— such as ESPs, HEPA, PCO, and UVGI—can also be added to conventional forced air systems in new or existing homes to reduce airborne particle and chemical vapor pollution. However, a more powerful fan may be required to move sufficient air through some types of air cleaners that use HEPA or high efficiency filters. In addition, for continuously operating air cleaners, energy costs for constant fan operation can be significant. Alternatively, some manufacturers produce forced air systems that have a two-speed or variable speed fan, so that the system can operate at a lower fan speed when a lower rate of air cleaning or fresh air ventilation is needed. Access for maintenance also can be problematic. These systems do not normally come with an outdoor air supply.

For new homes or major remodels, "whole-house" or "fresh-air" ventilation systems, that may or may not provide filtration, can be installed separately from the central heating and cooling systems. These systems typically use small diameter ducts, a quiet energy-efficient fan, and an optional heat- or energy-recovery ventilator (HRV or ERV). HRVs and ERVs help save money on electricity costs associated with a ventilation system by using the exhaust air energy to heat or cool incoming fresh air. HRVs and ERVs provide energy savings in climate zones that experience more extreme temperatures, but may not provide savings in temperate areas. Installed costs are about \$700 to \$2,000 or more, depending on the system size and the type of air cleaning device used in the system. Fresh-air ventilation systems with filtration are recommended; it is important to install systems with filtration sufficient to remove incoming outdoor pollution.

For any central system air cleaner, contact a company or contractor that is experienced in designing and installing central filtration systems. Request a system that is low-leakage, easy and cost-effective to maintain, energy efficient, and ozone free.

What Size Air Cleaner Should I Use?

Test standards for particle removal by air cleaning devices have been developed by trade and engineering groups, but standards for gas removal have not been developed. The effectiveness of most portable air cleaners in removing particles is usually rated in terms of pollutant removal efficiency, or Clean Air Delivery Rate (CADR), measured in cubic feet per minute (cfm). The CADR equals the airflow (cfm) multiplied by the efficiency of particle removal; a larger CADR is better. Separate CADR ratings are provided for the removal of dust, pollen, and environmental

tobacco smoke. Larger air cleaners usually produce more noise and use more energy than smaller units do. For these reasons, you should avoid getting an air cleaner that is oversized for the room(s) you are cleaning.

PORTABLE AIR CLEANERS. Select an air cleaner that can replace the room air at least two or three times per hour, enough to rapidly reduce indoor pollutant levels. Most portable units will state on the package the unit's air flow rate (in cfm), the size room it cleans, and perhaps its particle removal efficiency and its CADR. The appropriate size for a portable air cleaner can then be calculated following the formula and example shown in the Appendix.

In addition, the Association of Home Appliance Manufacturers (AHAM) provides a searchable online database of certified CADR listings for many models at: http://www.ahamdir.com/aham_cm/site/pages/index.html?code=r.rac>AboutThisProgram. The search engine available at this website also offers a "room size calculator" that allows you to search for air cleaners that are recommended for your particular room size.

CENTRAL SYSTEM AIR CLEANER. Air cleaning systems or units designed for use as part of a central heating and air system should be designed and installed by an experienced, licensed mechanical contractor or heating and ventilating contractor. The air cleaner should be sized to handle at least 0.5 air changes per hour (see Appendix). This is the air exchange rate (AER) necessary to continuously ventilate a house under most conditions. To avoid major air flow (and energy) loss, have your system's ductwork pressure tested for leakage and then sealed and insulated as necessary.

What Types of Air Cleaners Are Not Effective?

OZONE GENERATORS. The California Air Resources Board, the California Department of Public Health (formally Health Services), and other government agencies advise the public not to use so-called "air purifiers" that are specifically designed to generate ozone indoors. These intentional ozone generators are sometimes erroneously marketed as emitting "trivalent oxygen," "activated oxygen," "allotropic oxygen," "saturated oxygen," "superoxygen," or "mountain-fresh air." These devices may also be combined with an ionizer, HEPA filter, or other technologies. However, these devices actually emit ozone, typically at unsafe levels.

Ozone is a harmful air pollutant that is the main component of ground-level smog. Breathing ozone can be harmful, especially for children, the elderly, and people with asthma, emphysema, bronchitis, or other respiratory diseases. Ozone irritates the nose and throat, and may trigger asthma attacks in those with asthma. Long-term exposure to ozone may permanently reduce a person's breathing ability. Studies show that use of an ozone generator can produce harmful levels of ozone in a home – over three times the State outdoor air quality standard of 90 parts per billion and at levels high enough to cause a Stage I smog alert if measured outdoors.

Ozone at safe levels does not clean the air. As summarized by an ARB 2007 staff report on ozone emissions from indoor air cleaning devices (see reference section, below), independent studies by the U.S. Environmental Protection Agency, the Consumers Union, and others have shown that these devices do not effectively destroy microbes, remove odor sources, or reduce indoor pollutants enough to provide any health benefits. Ozone reacts with certain indoor pollutants, but this can produce toxic byproducts, such as formaldehyde. Ozone is used effectively in water to destroy microbes, but ozone in air must reach extremely hazardous levels (50-100 times the outdoor air quality standard levels) to effectively kill microbes.

DESKTOP AIR CLEANERS. Small, desktop air cleaners have been shown to have very little effect on indoor pollutants.

DUCTLESS RANGE HOODS. Air filters in kitchen range hoods that exhaust air into the house (ductless hoods) trap much of the grease from cooking. However, they do not effectively remove the air pollutants and moisture produced by cooking or by cooking appliances that burn natural or propane gas. Only ducted hoods that exhaust to the outdoors should be used. For additional information on range hoods, see ARB's webpage on range hoods at http://www.arb.ca.gov/research/indoor/cooking/cooking_range_hoods.htm.

HOUSEPLANTS. Houseplants do not effectively remove indoor air pollutants in homes. A few researchers have reported that certain houseplants can remove significant amounts of indoor air pollutants. However, subsequent reviews and a study in office buildings and portable office buildings indicated that houseplants have minimal effect on indoor pollutant levels. Small effects might occur, but only with a very large number of houseplants present, which could easily cause other indoor pollution problems such as excess moisture, mold and harboring of gnats and other insects. In addition, the Consumers Union has evaluated a popular plant-based portable air cleaner and concluded that it did not help remove common pollutants from the indoor environment. Houseplants do remove a small amount of some chemicals from the air, as well as carbon dioxide, and they are aesthetically pleasing, so moderate use is generally beneficial, but houseplants are not a solution for polluted indoor air.

Has the Air Resources Board Taken Action To Limit Exposure From Air Cleaner-Generated Ozone?

Yes. ARB has adopted a regulation that limits ozone emissions from indoor air cleaning devices that are manufactured, sold in, or shipped to, California. Air cleaners must meet certain ozone emission and electrical safety standards, and be certified by ARB as meeting them. They must produce an ozone emission concentration less than 0.050 parts per million (ppm) of ozone. For more information on this regulation, please visit our aircleaner website at <http://www.arb.ca.gov/research/indoor/aircleaners/aircleaners.htm> and the Factsheet on *California's Regulation to Limit Ozone Emissions from Indoor Air Cleaning Devices* at <http://www.arb.ca.gov/research/indoor/acrfactsheet.pdf>. A list of certified air cleaners may be found at <http://www.arb.ca.gov/research/indoor/aircleaners/certified.htm>.

How Can I Shield My Home Interior From Outdoor Air Pollution?

Outdoor pollution from such sources as fires, wind-blown dust, pollen, motor vehicles, and industrial and commercial activities can contribute to indoor air pollution. Reducing the penetration of unfiltered air while minimizing indoor pollution sources can help shield your home interior during outdoor pollution episodes. Consider the following actions:

- ✓ Closing doors and windows and sealing up air leaks in a home's exterior shell and its central air ductwork can help reduce the rate of outdoor pollution entering your home.
- ✓ Care should be taken to minimize all sources of indoor air pollutants, including pollutants entering from attached garages.

- ✓ For short-term episodes of outdoor pollution, turning off mechanical ventilation equipment such as forced air systems and exhaust fans will reduce the penetration of outdoor pollutants into the home. Interior fans can be used for temporary cooling.
- ✓ For long-term or recurrent episodes of outdoor air pollution, permanent installation of a mechanical ventilation system that provides filtered outdoor air should be considered (see discussions above on central air systems and cleaners).
- ✓ In part to address indoor air quality issues, new California homes are now required to have mechanical ventilation under California's Energy Efficiency Standards for Residential Buildings [Title 24]. However, certain types of ventilation system installed in new homes, such as a continuously operating bathroom exhaust fan, do not filter the incoming air. Other types of mechanical systems that include high efficiency filtration should be considered.

Where Can I Obtain More Information?

The references listed below provide extensive, useful information on residential air cleaning devices. If you have questions or would like to receive a printed copy of ARB's Indoor Air Quality Guidelines and Supplements or other documents listed below, please contact us at:

Indoor Air Quality and Personal Exposure Assessment Program
Research Division
California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812
Phone: 916-322-8282, Fax: 916-322-4357

This document is also available on the Internet at the following URL:
<http://www.arb.ca.gov/research/indoor/indoor.htm>.



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APPENDIX

Estimating the Size of Air Cleaner Needed

Most manufacturers list the square footage rating for the floor area that would be effectively treated by their air cleaner, based on the CADR testing for removal of tobacco smoke, street dust, and common indoor allergens. If that rating is not available for an air cleaner, you can calculate what size of an air cleaner is appropriate for a given space in your home.

To calculate the size of the air cleaner you need, use the following formula and manufacturer specifications, as shown in the examples below. These examples assume a 50% efficient air cleaner and the Air Exchange Rates shown. (AER is the portion of the volume of indoor air replaced by outdoor air each hour). The AERs used below are typical values used only as examples; the appropriate AER will depend on the size and duration of the indoor pollutant sources, the amount of building ventilation with outdoor air, and the speed of pollutant removal that is desired.

$$\text{Air Flow Rate needed (cfm)} = \frac{A \times B \times C \times D}{E}$$

EXAMPLES FOR SIZING AIR CLEANERS

A Your Floor Area of room to be cleaned (square ft.)	B Ceiling Height of room (ft.)	C Air Exchange Rate (AER) desired (per hour)*	D Convert hours to minutes (constant)	E Cleaning Efficiency of the air cleaner (see product specs.)**	Air Flow Rate Needed = (A x B x C x D)/E (cfm; ft ³ /minute)
200 (room)	8	3	0.017	0.50	163
2000 (house)	8	0.5	0.017	0.50	272

* An AER of about 3 air changes per hour would be appropriate for quickly removing pollutants from an area with a large source of indoor air pollution, such as cooking activity. An AER of 0.5 air changes per hour is generally adequate to remove moisture and odors from a home that does not have a large source of indoor air pollution.

** This factor can vary from less than 0.1 to over 0.9, depending of the air cleaner.

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