Air Cleaner and Air Purifier Technologies:

Compilation of Information and Recommendations from EPA, CDC, ASHRAE, Academia, and States

Air Cleaners vs Air Purifiers

Air cleaners remove airborne infectious and other particles and/or gaseous pollutants from the air using filters. Air purifiers (also called electronic air cleaners) inactivate or react with airborne infectious and other particles and/or gaseous pollutants to convert them to (ideally) harmless byproducts or remove them from the air. Some air purifiers also use filters.

The following are good resources for general information about air cleaners and purifiers:
Air Purifiers Fact Sheet from the University of Massachusetts Amherst
The website of the American Society of Heating, Refrigeration, and Air Conditioning (ASHRAE)
The California Air Resources Board

Guidance for Air Cleaner Technology

The technologies below are examples of air cleaners. Not all air cleaners are equally backed by evidence. Applicants are encouraged to review any guidance relevant to technologies listed in their applications.

a. Filters in an HVAC system
   The goal to strive for is MERV-13 rated filters. MERV filters range from 1-16. Upgrade to MERV-13 filters or filters with highest efficiency possible without having detrimental effects on overall HVAC performance.

b. Portable HEPA Air Filtration
   HEPA filters are very effective at filtering particles that can remain airborne for hours and are most associated with deep lung penetration, including human-generated infectious particles such as SARS-CoV-2 virus. HEPA filters are even more efficient at filtering infectious particles than MERV-16 filters. Portable HEPA air filters (appropriately sized for the room) can be effective technologies when adequate ventilation cannot be achieved via other means or the area has a potentially higher risk for spread of illness (such as a nurse's office).

c. Do-It-Yourself (DIY) Air Cleaners
   DIY air cleaners can be assembled from box fans and square HVAC filters. A commonly known type is the Corsi-Rosenthal Box with MERV-13 filters. Evidence suggests that well-build DIY air cleaners can be of comparable effectiveness to commercial air cleaners in reducing airborne particles (including viral particles). However, their performance varies based on the design, quality of the materials and the assembly. They can also be relatively noisy, which can be an issue depending on how the space is being used. Each time a DIY air cleaner is re-assembled after changing a filter, its performance may be different. EPA does not recommend routine use of DIY air cleaners as a permanent alternative to products of known performance (such as commercially available portable air cleaners). However, when commercially available portable air cleaners or other products of known performance are not available, using a DIY air cleaner does not worsen air quality and may offer benefits.

d. Gas Phase Air Cleaners

Air cleaners with adsorbent media filters such as activated carbon can be effective at removing gaseous pollutants or odors, including radon, from the air. These specialized media do not remove particles (including viruses). Adsorbent media do not remove all gaseous air pollutants equally, they have a finite capacity for adsorption, they must contain sufficient media for the size of the room and they must be replaced regularly. The effectiveness of gas phase air cleaners in removing radon has not been adequately evaluated. Some portable air cleaners have HEPA filters and adsorbent media filters.

The information regarding Air Cleaners was compiled from the following sources:

Connecticut DPH Guidance for School Systems for the Operation of Central and non-Central Ventilation Systems during the COVID-19 Pandemic

California Air Resources Board Fact Sheet

Center for Disease Control Coronavirus Ventilation Guidance

EPA Indoor Air Quality Page

EPA: Air Cleaners, HVAC Filters, and Coronavirus (COVID-19)

UCSD DIY Air Filter Poster

University of Washington DEOHS DIY Air Filter Infographic

EPA: Residential Air Cleaners Technical Summary

ASHRAE Position Document on Filtration and Air Cleaning, 2021

ASHRAE Website

Guidance for Air Purifier Technology

HVAC systems and portable air cleaners can use the technologies listed below as add-ons. The air purifying technologies listed below can also be marketed as stand-alone devices. Not all air purifiers are equally backed by evidence. Applicants are encouraged to review any guidance relevant to technologies listed in their applications.

a. Ionization (Ion generators)
   Examples of ionization include bi-polar ionization and hydrogen peroxide ionization (hydroxy generators). Systems that use ionization technology generate positive and negative electrically charged particles (similar to electrostatic precipitators) to facilitate removal of viruses and other particles. These products can generate ions, reactive oxidative species (ROS) such as hydrogen peroxide, hydroxyl radicals, and nitric (or nitrogen) oxide, or other chemicals into the indoor air. People in spaces treated by these technologies can be exposed to the ROS, ions and other chemicals. Some research has found that these exposures may be harmful, particularly if there are high concentrations generated or vulnerable populations present (such as children, the elderly, those with asthma and other respiratory conditions). These technologies also have the potential to generate ozone, a harmful indoor air pollutant. Ionization is an emerging technology with little research to evaluate its effectiveness and some research indicating it could cause harm.

b. Electrostatic Precipitators (ESPs)
Similar to ionizers, ESPs remove particles by an active electrostatic charging process. ESPs use electricity to charge particles that become attracted to and adhere to oppositely charged plates or other surfaces. Like ionization, ESPs have the potential to generate ozone and nitric oxide. ESPs can have high electric power requirements.

c. Ultraviolet (UV-C) Disinfection (UV Germicidal Irridiation, UVG)
UV-C uses UV light to kill or inactivate airborne microbes. UV-C can be effective at disinfection with high lamp intensity and sufficient contact time. UV-C can have high electric power requirements. Because UV-C does not remove viruses and other particles (only inactivates them), particles (such as dead fungal spores) remain in the air and can still cause exposure concerns to building occupants. UV-C has the potential to generate ozone. CDC recommends that UV-C should only be considered as a supplemental treatment if options for increasing ventilation and filtration are limited.

d. Ozone Generators
Any air purifying device that uses electricity during the air cleaning process has the potential to generate ozone. However, some air purifiers produce ozone by design to neutralize gaseous pollutants in indoor air. Ozone emission is always undesirable. Ozone is harmful for health and exposure to ozone creates risk for a variety of symptoms and diseases associated with the respiratory tract. The current science regarding the health effects of ozone strongly suggests that use of air cleaners or purifiers that emit ozone by design should not be used.

e. Photocatalytic oxidation (PCO)
PCO technology uses UV light along with a "catalyst" such as titanium dioxide that reacts with the light to destroy gaseous pollutants by converting them into (ideally) harmless products. PCO is not designed to remove viruses or other particles from air. This technology can generate harmful byproducts such as formaldehyde, ozone and acetaldehyde. PCO often has relatively low removal efficiency for many indoor gases and lacks studies demonstrating its performance and effectiveness.

f. Plasma
Electric current is applied to create an electric arc which ionizes gases to chemically transform them into (ideally) harmful products. There are a wide variety of types of plasma generation which has yielded confusion surrounding how the products actually work. Plasma technology has the potential to form harmful byproducts in indoor air (similar to those that can be created by ion generation, PCO and ESP).

The information regarding Air Purifiers was compiled from the following sources:

EPA: Air Cleaners, HVAC Filters, and Coronavirus (COVID-19)

California Air Resources Board Fact Sheet

Center for Disease Control Coronavirus Ventilation Guidance

CT DPH Ventilation Presentation

EPA: Residential Air Cleaners Technical Summary

University of Toronto: Air filtration and COVID-19: Indoor air quality expert explains how to keep you and your building safe

ASHRAE Position Document on Filtration and Air Cleaning, 2021

EPA: Guide to Air Cleaners in the Home

ASHRAE Website

CT DPH: Ozone Generators Fact Sheet

California Air Resources Board: Hazardous Ozone-Generating Air Purifiers

Air Quality Grant Requirements in Other States

The resources below give examples of how other states have applied evidence-based standards and best practices to their Indoor Air Quality funding programs.

a. Colorado's 2021 HVAC emergency grants program administered by the Colorado State Department of Education disallows supplemental disinfecting systems such as technologies using hydrogen peroxide or ionization.

b. The Environmental Law Institute is a highly regarded, impartial, non-partisan organization that provides policy analysis, objective data analysis and education on a wide range of environmental law and policy topics. In January 2023, they conducted a review of selected policies for state funding for school ventilation.

c. Chapter 5, Section E from the California Air Resources Board has requirements and criteria for schools applying for funding to cover air filtration systems.

d. California Schools Healthy Air, Plumbing and Efficiency Program (CalSHAPE) provides funding to upgrade HVAC systems in public schools and replace noncompliant plumbing fixtures and appliances that fail to meet water efficiency standards. Their website has information about the grant program guidelines and requirements. The contact person for this program is JonathonFong@energy.ca.gov