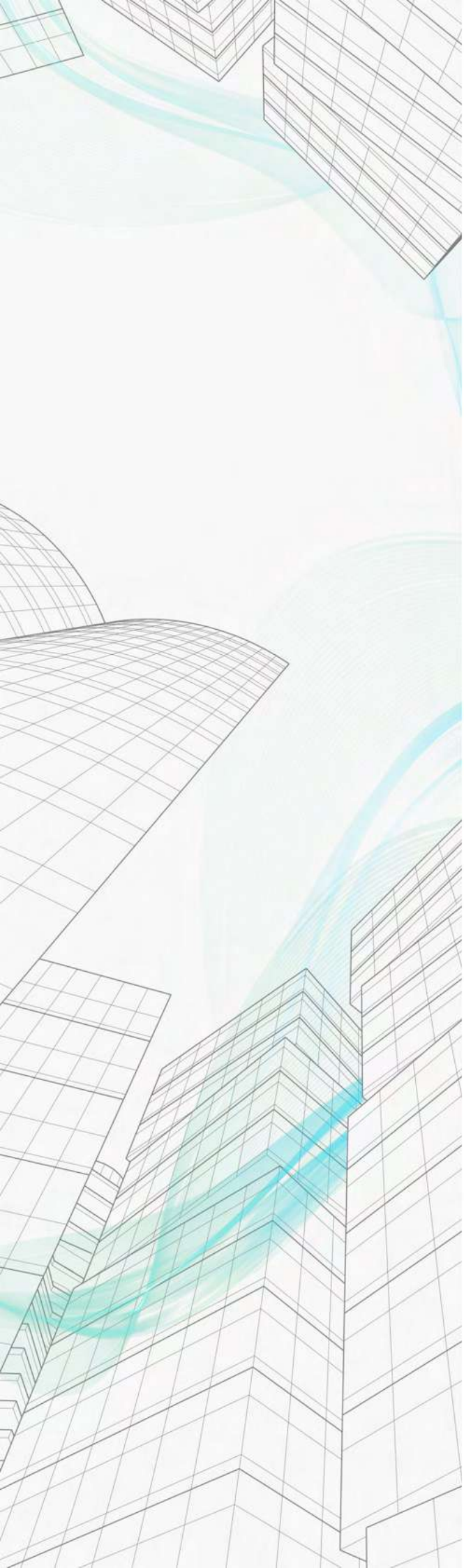

Creating Better
Indoor Air Quality

Stay fresh and stay healthy

Indoor Air Quality White Paper

Ahead of the Expected

01

Creating Better Indoor Air Quality

Introduction

Indoor air quality has become more important than ever before to the health, comfort, well-being, and productivity of the population. **Urban residents typically spend 90%[1] of their time indoors.** That figure is even higher for children, the elderly, and those with pre-existing health conditions, not to mention that time spent indoors increased even more during the COVID-19 pandemic. It could be argued that COVID-19 may have inadvertently acted as a strong advocate for healthy indoor air quality.

The EPA(Environmental Protection Agency) defines Indoor air quality (IAQ) as the air quality within and around buildings and structures[2]. IAQ is known to affect building occupants' health, comfort, and well-being.

IAQ in Numbers

Indoor air can be between **5 to 10 times more polluted** than outdoor air[1]

Indoor air pollution contributes to deaths due to the following afflictions[3]

- **34%** stroke
- **26%** ischemic heart disease
- **22%** genetic disorder
- **12%** acute lower respiratory infections in children
- **6%** lung cancer

An estimated **3.8 million deaths** were caused by indoor air pollution globally according to WHO's latest data as of 2021 referring to 2016[2]

people who spend ample time in poorly ventilated spaces have a **50% higher risk of developing allergies[4]**

25 to 30% of the population of industrialised countries are affected by allergies[5]

1) Source: http://leparticulier.lefigaro.fr/article/l-air-ambiant-du-logement-est-cinq-fois-plus-pollue-que-l-air-exterieur/
2) Source: https://ourworldindata.org/data-review-air-pollution-deaths
3) Source: https://www.who.int/news-room/questions-and-answers/item/air-pollution-indoor-air-pollution
4) Source: https://www.evia.eu/wp-content/uploads/EVIA-EU-MANIFESTO-2019.pdf
5) Source: https://www.ademe.fr/expertises/air-bruit/chiffres-cles-observations/chiffres-air-interieur

IAQ is partly affected by the outdoor air quality but primarily affected by indoor factors such as contaminants in the form of gases, dust particles, or microbes. If the concentrations exceed the limits suggested by the ASHRAE Standard 62, the air quality is considered poor and may affect occupants.

According to studies, exposure to high levels of air pollution can cause various adverse health issues. Under certain circumstances, it can trigger allergic reactions, asthma attacks, or have an even more severe health impact. Furthermore, poor indoor air quality can lead to sick building syndrome, which has negative impacts on cognition - reducing productivity, as well as impairing learning in schools.

This white paper is for HVAC professionals in charge of managing quality indoor air. This paper will provide information on the possible causes of poor IAQ, improvement measures, related standards and regulations, and **how IAQ can be optimized with HVAC systems.**

To meet market demands and address people's concerns on indoor air quality, LG Air Solution has specifically developed various technologies that can be applied to different types of HVAC equipment to either prevent the spread of large particles in the air or remove them. In the latter part of this white paper, you will find detailed information on our products and solutions to improve IAQ.

[References for this page]
1) Source: https://www.evia.eu/indoor-air-quality 2) Definitions from US EPA (Environmental Protection Agency).

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Creating Better Indoor Air Quality

HVAC Trends and IAQ

Over the years, the requirements for indoor air quality have evolved from basic climate control and functionality for comfort and **convenience to fully-integrated indoor air management with HVAC systems that are capable of inducing and maintaining a clean and healthy environment.**

In the 2000s, the focus of HVAC was primarily on providing comfort by managing indoor temperatures and airflow. With the advent of IoT ecosystems and smart technology, other factors came into play, and the focus shifted to providing comfort and user convenience. The implementation of smart features allowed users to operate their HVAC systems remotely, and smart sensors and smart technology made it possible for HVAC systems to control the climate in spaces only when it was needed.

Afterward, with the increasing awareness and impact of climate change on local air quality, **requirements for indoor air quality have changed to protect the environment while also improving quality of life – whether it be cooling and heating as a primary function, air purification, ventilation, and removal of harmful contaminants for enhanced management of health.**

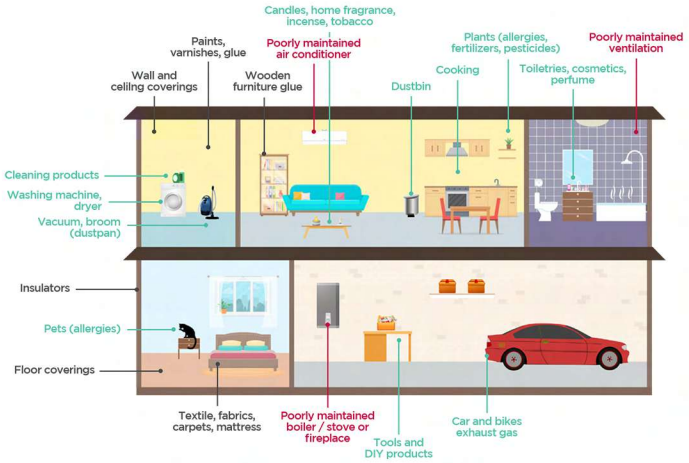
Since around 2020, we have observed an even more remarkable transformation in indoor environment trends. **The recent push to mitigate the effects of air pollution and harmful particles such as fine dust has been compounded by the need for effective indoor air management due to the COVID-19 pandemic. Air purification and ventilation have become some of the most critical issues facing our society today.**

Attention given to living spaces of those susceptible to diseases related to the environment has greatly increased, and the significance of IAQ for welfare facilities to improve overall well-being is slowly gaining more traction.

Creating Better Indoor Air Quality

What Causes Poor IAQ?

IAQ began garnering attention in the 1990s as people became aware of the impact that common household pollutants like mold and radon have on our health. Since that time, the importance of managing other indoor contaminants has grown while the house envelope has become much tighter and impermeable due to improvements in construction methods. Whereas, once indoor pollutants were once able to naturally seep out of buildings naturally and of their own accord, we now realize that a more proactive approach to ventilation is necessary to account for these changes.[1)]



Indoor air pollutants

- People, animals and their activities
- Heating, ventilation, air conditioning equipment
- Materials (construction, decoration, furnishings)

*Source : LG-Air-Solution-Europe-IAQ-White Paper
https://librairie.ademe.fr/cadic/1812/guide-pratique-un-air-sain-chez-soi.pdf?modal=false

The figure above shows three main sources of indoor air pollutants, such as activities of humans or animals, HVAC systems themselves, and building or furnishing materials. These risks to our well-being may be present in any building or space.

• The concentration of air pollutants

IAQ is affected by the concentration of pollutants in the air. Contaminants can be in various forms from gases, dust particles to microbes. **If the concentrations exceed the limits suggested by the ASHRAE Standard 62, the air quality is considered poor and may directly affect the health and quality of life of the building occupants.**

Gases	Dust Particles	Microbes	Viruses
· CO_2/CO	· PM10.0	· Mold	· SARS
· NO/NO_2	· PM2.5	· Bacteria	· MERS
· Radon/VOCs	· PM1.0		· COVID 19

Types of Air Pollutants

[References for this page]
1) Source: https://www.achrnews.com/articles/145754-experts-expect-interest-in-iaq-to-continue-after-covid

03

Creating Better Indoor Air Quality

What Causes Poor IAQ?

- **Gases**

CO_2 / CO

Carbon dioxide (CO_2) is one of the most common gases and its sources within a building include HVAC systems, washing machines, stovetops, and even crowded places. Prolonged exposure to high concentrations of CO_2 may cause a wide range of health complications, including headaches, difficulty breathing, increased heart rate, elevated blood pressure, and convulsions. ASHRAE sets the indoor carbon dioxide standard at 1,000ppm.[1)]

Carbon monoxide (CO) is also a colorless and odorless gas. It can come from gas heaters/stoves, gas water heaters, automobile exhaust, tobacco, etc. Symptoms of exposure may mimic influenza and include fatigue, cognitive impairment, and tachycardia.

NO / NO_2

The two most prevalent nitrogen oxides are nitrogen dioxide (NO_2) and nitric oxide (NO). Both are toxic gases, and NO_2 is a highly reactive oxidant and corrosive. Prolonged exposure to NO_2 can contribute to the development of bronchitis and low-level exposure may cause harmful effects to those suffering from asthma or other pulmonary diseases. These gases are most prevalently emitted from gas stoves, defective vented appliances, kerosene heaters, and tobacco.

Radon and VOCs[2)]

Radon is emitted from the breakdown of radioactive elements that occur naturally in soil and rocks. It is able to seep into buildings through cracks or gaps in a building's foundation and then become trapped indoors. Volatile Organic Compounds (VOCs) are a collection of chemicals that can be found in the products we use to construct and maintain buildings. Radon and VOCs can collect in a building and be harmful to the building's occupants, particularly when exposure is prolonged. The most common health effects of exposure to radon or VOCs are eye, nose, and throat irritation, headaches, loss of coordination, and nausea.

03

Creating Better Indoor Air Quality

What Causes Poor IAQ?

• Microbes

Mold

A WHO (World Health Organization) task force focusing on IAQ published guidelines in 2009 and 2010 designating dampness and mold as indoor pollutants and major contributing factors to poor IAQ.[3] Mold flourishes in environments where relative humidity levels are high. They produce allergens and irritants that can cause allergic reactions when inhaled or touched. Allergic responses to mold can include sneezing, runny nose, eye irritation, skin rash, and hay fever-type symptoms.

Bacteria

Bacteria are single-cell living organisms capable of surviving and reproducing on their own and they occur naturally in many different environments. While bacteria often play an important role in sustaining balance in an ecosystem, they can also be harmful to our health as airborne pathogens.

Viruses

Viruses are microscopic parasites and are much smaller than bacteria. They can be a severe threat to our health as they are known to cause contagion and spread easily between animals and humans. The COVID-19 pandemic is a prime example of the serious threat viruses pose to humanity, particularly when they can spread through direct contact with bodily fluids and the air in the form of droplet particles. Airborne viruses infect the respiratory system and spread easily in crowded spaces without proper ventilation.

[References for this page]
1) Source: ASHRAE POSITION ON CARBON DIOXIDE LEVELS IN SPACES
2) https://core.ac.uk/download/pdf/82058585.pdf
3) Source: https://apps.who.int/iris/handle/10665/164348
Source: https://www.epa.gov/sites/default/files/2014-08/documents/refguide_appendix_e.pdf

03

Creating Better Indoor Air Quality

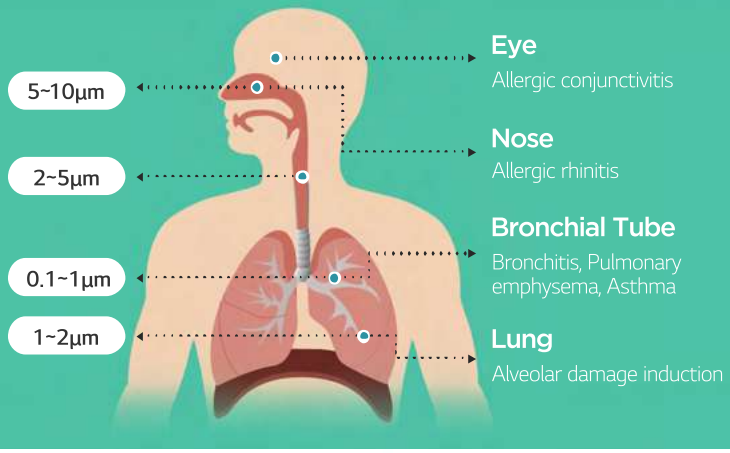
What Causes Poor IAQ?

• Dust Particles

Dust

Dust is made up of particles in the air that settle on surfaces. Large particles settle quickly and can be eliminated or significantly reduced by the body's natural defense mechanisms. Small particles are more likely to be airborne and pass through the body's defenses and enter the lungs.[1)]

▪ The Dangers of Particulate Matter to our Health



Particulate Matter

PM stands for particulate matter (also called particle pollution): the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope.[2)]

Particle Size Comparison

PM10 Coarse Particulate Matter	PM2.5 Fine Particulate Matter	PM1.0 Ultrafine Particulate Matter
PM 10	PM 2.5	PM 1.0
· PM10 includes all particles with a diameter of 10 μm or smaller.	· PM2.5 is defined as particulate matter with a diameter of 2.5μm or smaller.	· PM1.0 is tiny particulate matter with a diameter of 1 μm or smaller.
· **PM10 can still penetrate the lungs and cause irritation throughout the respiratory system and the eyes.**	· **It can reach deep into the lungs and even enter the bloodstream.**	· **PM1.0 is able to penetrate into the alveoli in the lungs and can have a more severe impact on our health.**
· This coarse particulate matter typically originates from construction, dusty roads, or natural dust storms.	· Fine particulate matter originates from sources such as vehicle exhaust, power plant emissions, and wildfires.	· PM1.0 generally consists of viruses and exhaust gas emissions from factories and vehicles.

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04

Creating Better Indoor Air Quality

The Pandemic Era [The Threat of Viruses]

The emergence of deadly diseases for the last two decades has greatly increased. In the last 40 years, 39 new infectious diseases such as SARS, SWINE FLU, and MERS have been discovered, and about 17 million people have died each year.

Although these viruses impacted society and influenced health measures to prevent airborne viruses, the emergence of the COVID-19 pandemic in early 2020 has particularly highlighted the need for effective preventative measures and IAQ management on a global scale.

Viruses spread through direct contact with bodily fluids and the air in the form of droplet particles. Naturally produced droplets from humans can be spread through breathing, talking, sneezing, or coughing. **To protect building occupants from infection of airborne viruses, experts say that airflow and ventilation in indoor spaces can play a significant role in mitigating the spread of airborne pathogens.**

• Airborne Dissemination

As mentioned previously, airflow and ventilation are essential in preventing the spread of airborne pathogens, and this is closely related to settling times by particle diameter in still air.

Particle Size	under 0.5 μm	0.5 μm	1 μm	3 μm	10 μm
Settling Time	over 41 hours	41 hours	12 hours	1.5 hours	8.2 minutes

Settling times by particle diameter in still air
[Source : ASHRAE.org]

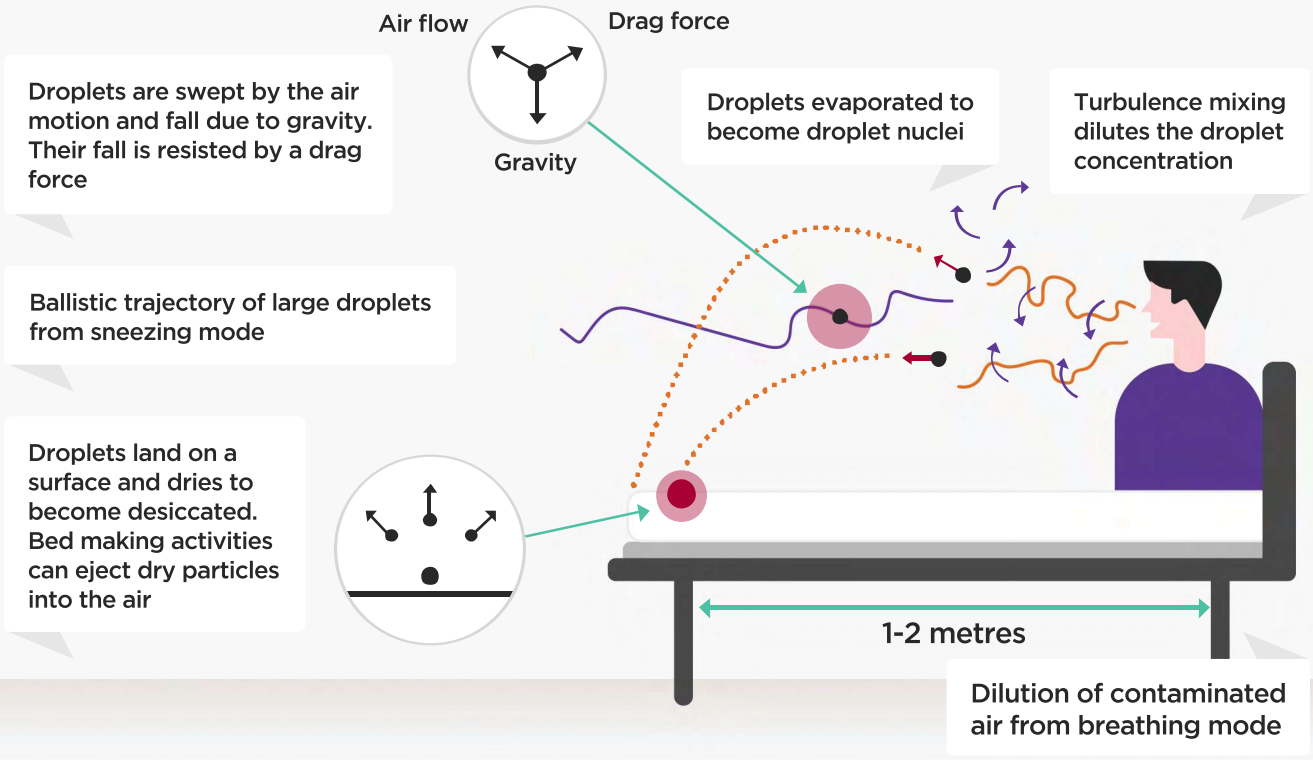
[References for this page]
*Source : ASHRAE.org

04

Creating Better Indoor Air Quality

The Pandemic Era [The Threat of Viruses]

Pathogens like SARS-CoV-2 spread more readily between people in an indoor environment in the form of droplets and aerosols. A lower concentration of viral particles makes it less likely to inhale these particles and lowers the risk of particles entering the nose and mouth or landing on surfaces. Larger droplet particles fall from the air due to gravity, but smaller aerosol particles can remain in the air for extended periods of time. It can take several minutes for viral particles 10 microns in size to settle, while **smaller particles may not settle for hours or even days.** Furthermore, larger particles may initially shrink due to evaporation before settling and becoming airborne aerosols.



[Source : ASHRAE.org]

Theoretical aerobiology of transmission of droplets
and small airborne particles produced by an infected patient

Effective strategies such as ventilation, air purification, directional airflow control, and zone pressurization can provide protection against the transmission of pathogens. **Adequate ventilation prevents bacteria from settling on surfaces where they can thrive longer than viruses. As for purification, the CDC recommends HEPA filters with a minimum filtration efficiency target of MERV 13 to curb the expansion of airborne infectious aerosols. Directional airflow can also be instrumental in controlling flow patterns of aerosols for them to be more easily captured or removed from an indoor environment.**[1)]

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- https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
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- https://imb.uq.edu.au/article/2020/04/difference-between-bacteria-and-viruses#:~:text=On%20a%20biological%20level%2C%20the,need%20a%20host%20to%20survive

05

Creating Better Indoor Air Quality

How Can IAQ Be Improved?

The international community is working to understand the effect of indoor air quality (IAQ) on our overall health, life expectancy, and more. With the rising concern for quality indoor air, best practices for operation and maintenance of HVAC systems to optimize indoor air quality while reducing risks are more important than ever before.

According to ASHRAE and REHVA guidelines, four main factors are involved in managing airflow and creating a healthy environment with minimal risk of infection.

Ventilation

- **Personalized Ventilation System**
- **100% Fresh Air / Avoid Recirculation**
  Provides highly filtered outdoor air to occupants

Air Purification & Filtration

- **Highly Efficient Particle Filtration in Centralized HVAC System**
- **Single-Space Particle filtration units**
  Can be helpful in reducing/lowering concentrations of infectious aerosols in single space

Hygienic Technology

- **UVGI (Ultraviolet Germicidal Irradiation)**
  Can inactivate microorganisms
  US CDC has approved UVGI as an adjunct to filtration for reduction of tuberculosis risk [1)]

Temperature & Humidity

- **Relative Humidity Between 40% and 60%**
  Microorganism unfavorably survive in RH 40 to 60%
  RH below 40% increases infections

<Disclaimer> This document is based on "ASHRAE Position Document on Infectious Aerosols" and "REHVA COVID-19 guidance document, April 3, 2020"
LG excludes any liability for any direct, indirect, incidental damages or any other damages that would result from, or be connected with the use of the information presented in this document.

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Creating Better Indoor Air Quality

How Can IAQ Be Improved?

Ventilation

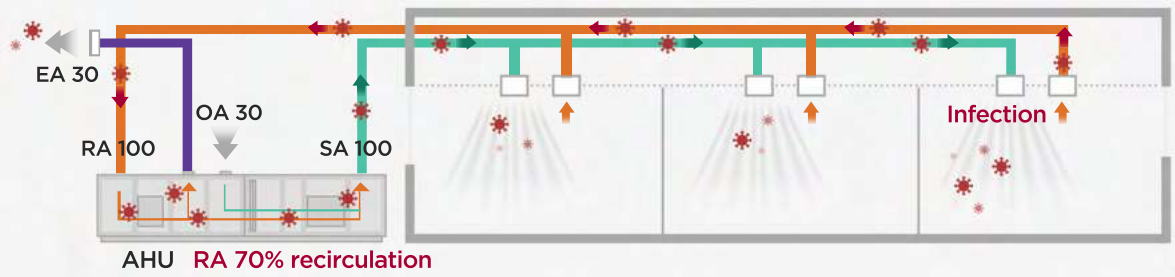
As mentioned earlier, indoor air contains various substances ranging from fine dust, pathogens, mold, and gases from building materials, interiors, and furniture. While air purification plays a critical role in filtering particles from indoor air, ventilation introduces fresh air to replace the indoor air. In particular, when it comes to CO_2 removal, ventilation is an effective method. To improve IAQ, active methods such as ventilation should be implemented along with passive IAQ improvement measures such as filtration.

The air that is brought in from outside can be filtered to remove pollutants from outdoor air before being provided indoors. Furthermore, airflow control and ventilation are crucial in mitigating the risk of infection caused by small airborne particles. ASHRAE Standard 62.1-2016 document shows optimal ventilation rate by the number and activity of occupants. Consultants can run ventilation rate calculations according to the ASHRAE standard.

ASHRAE and REHVA guidelines recommend HVAC systems with personalized ventilation that provide local exhaust of contaminated zones to prevent the spread of infection. These systems avoid recirculation of air and deliver highly-filtered, fresh outdoor air to occupants indoors.

The figure below shows that a general AHU operating with RA(return air) recirculation can increase the risk of infection from harmful pathogens. The Recirculation of air with AHUs and ducts allows infectious pathogens and pollutants to disseminate to other areas of a building. When particles are drawn into the ducts, they are distributed into adjacent rooms through the duct network and can cause infection of the building's occupants.

Not Recommended Ventilation Design



Recirculation type AHU system

[References for this page]
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ASHRAE Position Document on Infectious Aerosols
REHVA COVID-19 guidance document, April 3, 2020

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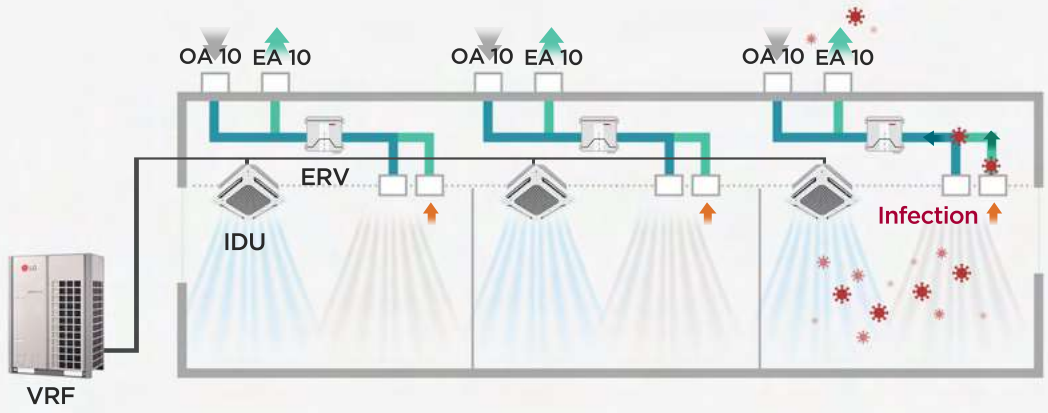
Creating Better Indoor Air Quality

How Can IAQ Be Improved?

Ventilation

Individual ventilation with ERV units effectively prevents the spread of infection to other spaces while saving energy. Individual ERV units implemented for each zone prevent the transfer of infectious pathogens and pollutants. Additionally, the ERV units and indoor air conditioning units can be fit with additional air purification capabilities that ensure clean air is supplied to each room.

Recommended Ventilation Design



Individual ventilation + Indoor unit system

*If several rooms are ventilated with one ERV unit, it is recommended to operate in bypass mode.

For safe and healthy indoor environments, recirculation of indoor air is not recommended to prevent the spread of infectious pathogens. Individual ventilation with ERV units or system ventilation with a DOAS system are optimal choices to ensure the safety of a building's occupants.

With a central air conditioning system, the air distributed to each space can be purified with the MERV filters. However, high volumes of air can present a challenge for filters in a central air conditioning system. Furthermore, due to the high possibility of contamination during transport through long ducts, individual air conditioning and individual ventilation are recommended.

ASHRAE and REHVA Guidelines for HVAC systems optimizing to mitigate infection recommend using highly efficient particle filtration within centralized HVAC systems while providing a local exhaust of infection sources across multiple spaces in a facility. Individual particle filtration units(ceiling mount or portable) can be helpful in reducing high concentrations of infectious aerosols across separate spaces.

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ASHRAE Position Document on Infectious Aerosols
REHVA COVID-19 guidance document, April 3, 2020

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Creating Better Indoor Air Quality

How Can IAQ Be Improved?

Air Purification and Filtration

Air purification through filtration is an effective method of removing harmful particulate pathogens from the air. There are two major filter evaluation standards, ASHRAE MERV and ISO. Both ASHRAE MERV and ISO standards can be used for filters that are applied to the HVAC products that supply outdoor air indoors. The ASHRAE MERV standard is primarily used in the United States and the ISO standard is a newer standard used globally.

MERV

One of the most recognized standards for filters is the ASHRAE MERV rating. ASHARE rates filters according to their efficiency at removing particles between 0.3 and 10 microns in size. The chart below provides a general outline of the MERV rating scale for filtration efficiency.

Filters with a MERV 13 rating provide a minimum filtration efficiency of 50% for removing PM1 pathogens such as bacteria and smoke. However, MERV 13 filters have also been found to reduce the risk of infection over HEPA filters in spaces with proper ventilation. While viruses are very small in size, they stick easily to droplets that are emitted from speaking, coughing, or breathing. Improved air purification with MERV 13 or higher helps mitigate the need for increased ventilation to remove aerosols from indoor air.

ISO Rated Filters

ISO 16890-1:2016 establishes an efficiency classification system of air filters for general ventilation based upon particulate matter (PM). [1)]

The ISO 16890 Standard classifies according to filter groups, evaluating a filter's performance by its ability to capture particles from 0.3μm to 10μm in size. [2)]

Unlike MERV and ISO, which indicate the performance of the filter itself, there are also indices of the actual product's air cleaning ability. MERV and ISO indicate filter performance according to the capacity to filter particles per unit of air that passes through the filter. On the other hand, CADR is mainly used as an indicator to evaluate the air cleaning ability of HVAC products with filters by considering factors such as air volume and filtration time. CADR is mostly used to evaluate the air cleaning performance of air purifiers and HVAC products with electrostatic filters.

CADR

While MERV is a filter efficiency rating that measures single path efficiency without recirculation, CADR (Clean Air Delivery Rate) measures air cleaning ability by circulating air for about 20-30minutes.

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Creating Better Indoor Air Quality

How Can IAQ Be Improved?

Air Purification and Filtration

Filter Type	Pre-filter	Medium Filter		HEPA Filter and ULPA Filter
Efficiency Rating	 Captures 75~85% of particles 3-10 microns in size	 Captures 50~75% of particles 0.3-1.0 microns in size	 Captures 95% of particles 0.3-1.0 microns in size	 Captures 99.97-99.9995% of particles 0.3 microns in size
Applications	General residential, and commercial	Day surgery, general surgery, smoking lounges		Low-level nuclear, clean rooms, laboratories
Air-pressure Requirement	Low-to-moderate air pressure required		Moderate-to-heavy air pressure required	Heavy air pressure required, using a stronger fan

Filter classifications by filtration efficiency

(Source: ASHRAE; CAMFIL; EMW.DE; MT Pinnacle; NAFAHQ; US Environmental Protection Agency)

HEPA

HEPA filters are efficient enough to remove 99.7% of dust, mold, bacteria, and other aerosols as small as 0.3 microns in size. The efficiency of HEPA filters for filtration of larger particles is even higher. ASHRAE (April, 2020) and REHVA (March, 2020) also advised that air purifiers with HEPA filters helped to reduce the concentration of infectious aerosols in the air.

ULPA

Ultra-Low Particulate Air (ULPA) filters have the highest efficiency of up to 99.9995%[1)] for particles as small as 0.12 microns. ULPA filters are the highest-quality filters available.

Air purification systems and filters require regular cleaning and replacement in order to maintain their prescribed filtration efficiency. It is recommended that users implement a regular maintenance schedule for the service of air purification systems.

People are unable to easily detect the concentration levels of fine dust in the air. Without the ability to detect air quality levels, it is difficult to determine whether operating a satisfactory filtration system is needed. In this regard, air quality detection technology, monitoring technology, and visualization functionality are considered equally as necessary as filters when it comes to air purification.

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Creating Better Indoor Air Quality

How Can IAQ Be Improved?

Hygienic Technology

• UVGI

A serious concern when ensuring improved IAQ is the hygiene of the HVAC units themselves. UVC is considered a very effective method to destroy bacterial DNA and RNA. Hospitals and sterile work environments have been using UV lights for decades due to their effectiveness in deactivating certain bacteria. Ultraviolet germicidal energy(UVC) has shown the ability to inactivate viruses, bacteria, and fungi[1].

Typical ultraviolet light has a wavelength of 10-400nm and is also known as actinic rays that create a powerful chemical reaction. Different wavelengths of UVC provide different effects in line with bacterial DNA and RNA removal and a UVC wavelength of 253.7nm is able to destroy a wide range of bacteria at the DNA level.[2]

LG's UVnano technology removes various harmful substances such as bacteria, and viruses in the form of droplets. In process of removing bacteria through UVnano, viruses parasitized on bacteria can be simultaneously dissipated. LG UVnano is certified to deliver 99.99% deactivation of bacteria and viruses.[2]

<Disclaimer>
*Currently, there is limited published data about the wavelength and duration of UVC irradiation required to inactivate viruses. In addition to understanding whether UVC irradiation is effective at inactivating a particular virus, there are also limitations to how effective UVC irradiation can be at inactivating viruses generally.
** UVnano™ is a compound word derived from the words UV and its unit nanometer.
***Based on TÜV Rheinland test conducted according to LG test method in compliance with ISO 20743, removing 99.99 of percent of Staphylococcus aureus, Staphylococcus epidermidis, and Klebsiella pneumoniae after being exposed to UV LED lights for 4 hours (Tested Models: PBM13M3UA0, PBM13M2UA0, PBM13M1UA0)
**** This result may differ in actual use conditions of the air conditioning system.

<Source>
1) https://www.esmagazine.com/articles/102047-hvac-upgrades-to-better-improve-your-iaq
2) https://ehs.lbl.gov/resource/documents/radiation-protection/non-ionizing-radiation/ultraviolet-radiation/

• Ionizer

The plasma ion from the ionizer deactivates bacteria and viruses in air passing through ERV or indoor units to provide cleaner air within a space. Active hydrogen and oxygen ions are released directly into the air to also minimize the impact of VOCs while active oxygen neutralizes toxic particles and generates H_2O.

Removes **over 99%** of adhering bacteria within 60 minutes

*TUV has verified to remove 99% of 3 kinds of adhering bacteria (Staphylococcus aureus, Escherichia coli and Pseudomonas aeruginosa).
** Intertek has verified that tobacco adhesive odor intensity is reduced from 3.6 to under 1.5 after 60 minutes.(Toluene, Ammonia, Acetic acid)

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Creating Better Indoor Air Quality

How Can IAQ Be Improved?

Hygienic Technology

Effects of Ions

Removal of Odors	Odorous gases are oxidized by binding reactive oxygen molecules as odors, and the sources of organic pollution are eliminated.
Removal of Dust	Dust particles and pollen in the air are bonded together by ionic bonds, and these charged particles quickly aggregate and increase in size to be easily removed by the filter. This process removes dust, mold spores, and other allergens from the air and relieves those who suffer from allergies.
Removal of Bacteria	Ions combine with moisture in the air to generate clusters and react with harmful substances like bacteria that bind to H+ ions.
Reduction of VOCs	Ions collide with volatile organic compounds and break the bonds of these compounds to remove them from the air.

• Antimicrobial Treatment

Antibacterial and hygienic technology is required to prevent the proliferation of viruses and bacteria that are collected in the filter. Some LG products are made with insulation materials that contain antimicrobial properties to suppress the growth of mold and bacteria.

Temperature and Humidity Control

In a low humidity environment, the human body is vulnerable to infection. According to a scientific study by Yale University, breathing air with a low humidity reduces our immune system's capability to fight off flu infections.[1)]

Mousavi(2019) reports that microorganisms unfavorably survive in RH 40 to 60%.[2)] Environments with excessively high or low humidity levels contribute to an increased rate of harmful or toxic chemicals in the air and exacerbate health conditions. High humidity creates favorable environments for dust mites to thrive. On the other hand, low humidity can increase the spread of airborne germs and intensify respiratory conditions such as asthma and bronchitis.

[References for this page]
1) Source: https://www.condair.co.uk/news/new-study-dry-air-is-flu-s-best-friend
2) Source: https://40to60rh.com/

06

Creating Better Indoor Air Quality

Product Line-up

■ Ventilation

Residential

Residential ERV

Commercial

ERV

FAU

DOAS

■ Purification with hygienic technologies

Residential

LG PuriCare™
360° Air Purifier

Wall Mounted

1 Way Cassette

Commercial

4 Way Cassette

Round Cassette

Air Purifier

1 Way Cassette

Ceiling Concealed Duct

06

Creating Better Indoor Air Quality

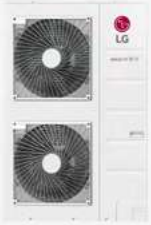
Product Line-up

■ Temperature and Humidity Control

Single Split

Multi Split

Multi V S



Multi V 5

Multi V Water

Chiller

Creating Better Indoor Air Quality

Energy Recovery Ventilation

■ Energy Saving Ventilation

Ventilation can reduce polluted indoor air by **ushering in the fresh air.** Natural ventilation causes a loss in cooling, heating energy, but with the heat exchanger, **ERV can supply fresh air with less energy loss.**

■ CO_2 Monitoring

The CO_2 level is monitored and displayed on the screen of the wired remote control. The ERV uses this information to automatically control fan speeds.

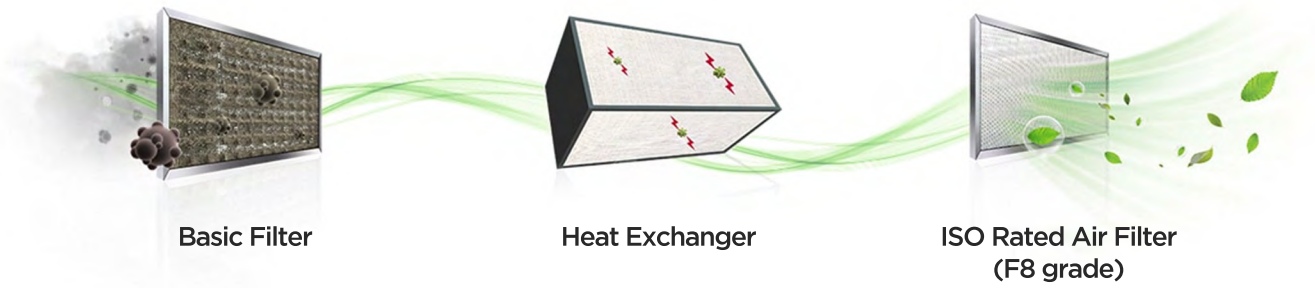
Creating Better Indoor Air Quality

Energy Recovery Ventilation

Clean and Fresh Air Ventilation

• Commercial

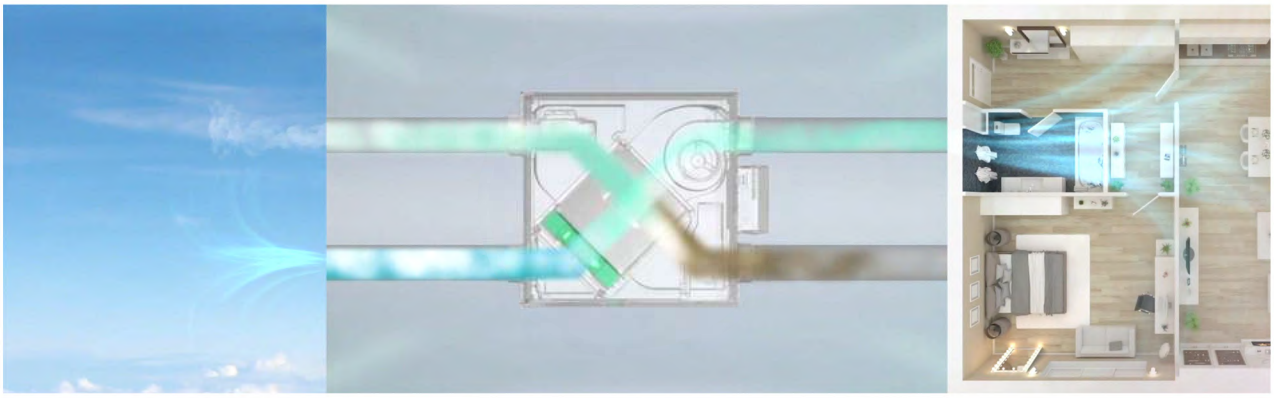
By installing a basic filter on the front of the total heat exchanger and an ISO grade filter behind the total heat exchanger, inflow of fine dust and pollutants from outdoors is reduced.



*ISO rate air filter is optional. ISO rating according to ISO 16890:2016. *The air filter (Model number : AHFT035H0) performance was tested by an ISO 16890-1:2016 Air Filter Test by using DEHS and KCl aerosol with the condition of air flow rate of 0.278 m³/s, air temperature of 23-24 ℃ and relative humidity of 44-49%. The result was an ISO rating of ePM1 75%. Results may vary depending on the environment.

• Residential

Fine dust filter (ePM1 95%) that filters over 95% of fine dust with a particle size of 0.3㎛. By applying UVnano technology, bacteria and viruses on pre-filters are removed by 99.99%. Preventing pathogens from festering, allows clean airflow into the room.



*The fine dust reduction performance of the air filter was tested by KCL. The test was conducted according to a test method in compliance with ISO 16890-1 : 2016 with test condition of 23±5℃, 45±10% RH (Model number 3330), and the result was 95% reduction of fine dust of 30 nm. The results may vary depending on the environment.

* Uvnano™ is a compound word derived from the words UV and its unit nanometer.
** Based on TÜV Rheinland test conducted according to LG test method with test condition of 25±2℃, 50±10% RH, removing 99.99 of percent of Staphylococcus aureus, Staphylococcus epidermidis, and Klebsiella pneumoniae from the pre filter. This had been measured after 2 hours of product opration. (tested models : Z-H0150B2SR).
The result value is measured at a specific point set in the experiment. *** This result may differ in actual use conditions of the air conditioning system

08

Creating Better Indoor Air Quality

DOAS [Dedicated Outdoor Air System]

LG DOAS enables building owners and facility managers to efficiently condition outside air for improved indoor air quality and comfort, without sacrificing flexibility, reliability or ease of integration.

• Innovative Energy Saving

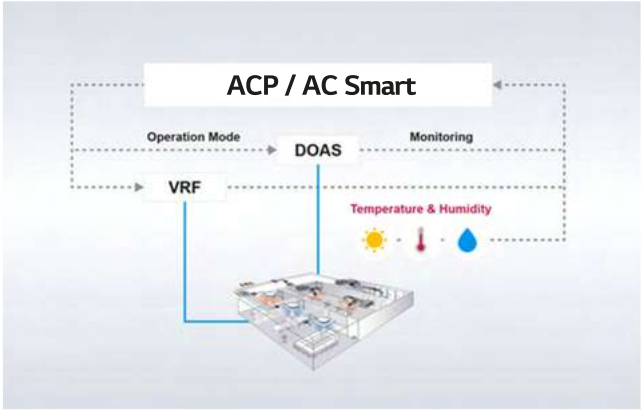
LG DOAS features inverter compressors that run efficiently at variable speed and double heat recovery coils, LG DOAS operates with reduced demand on energy use and compressor loads, leading to even more energy efficiency.

• Multiple IAQ treatments

LG DOAS maintains the best air quality for the building with the standard filters from MERV 8- to MERV 14 and the advanced filters for fine particles. It creates the best air conditions for various situations.

• Integration with Multi V 5 System

LG DOAS is configured for compatibility with LG's Multi V™ (VRF) outdoor units and integrates seamlessly with LG VRF controls. The integrated control logic embedded in ACP/AC Smart determines how the DOAS and VRF systems work based on the monitored indoor and outdoor air conditions. This interlocked operation enables the DOAS and the VRF system to collaborate to ensure a comfortable environment in energy-efficient



09

Creating Better Indoor Air Quality

Air Purifer

- LG PuriCare™

360° Purification

The innovative technology of the LG PuriCare 360˚ enables 360˚ degree purification. It thoroughly cleans the air from every corner, leaving no blind spot. Puricare 360˚ absorbs polluted air and discharges clean air 360˚ surround.

Filtration System

The LG PuriCare has a filter system that removes harmful substances.

Total Allergy/ Dust Collection Care

- **Step 1:** Large dust removal
- **Step 2:** Dust-storm / Ultra-fine dust removal
- **Step 3:** Allergy removal

Total Harmful Gas Care

- **Step 4:** Large dust removal (NH_3)
- **Step 5:** Sick building syndrome gases removal (VOCs)
- **Step 6:** Smog components removal (SO_x, NO_x)

Visualized Air Quality

- **Smart Sensor:** Automatic setting of airflow and operation according to the pollution level
- **Smart Display:** Smart lighting emits colors based on your pollution level.

Smart Solution

Easily access and control PuriCare 360˚ anywhere by LG ThinQ.

Residential

PuriCare 360°

Commercial

Air Purifier

Creating Better Indoor Air Quality

Indoor Cassette

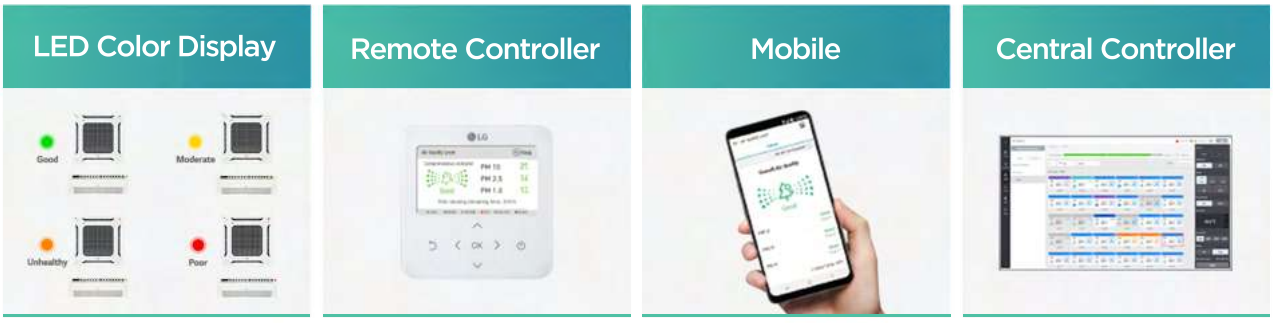
■ 5 Step Purification

A powerful 5-step air purification system removes odors, germs, and PM 1.0 fine dust. With indoor air cleaning, **99% of ultra-fine dust (size 50nm~ 100nm), bacteria and virus can be removed.** This filter can be cleaned with water, allowing semi-permanent usage.

*The fine dust reduction performance of the air purification kit was tested by TUV Rheinland by disposing Potassium chloride in a contaned area of 4m X 2.5m X 3m and kept the appliance (Model number PAH-TxPyMz, PTAHMP) running for ten (10) minutes, and the result was 99.9% reduction of fine dust of 50 nm and 100 nm (the test was based on the Korean experimental standard SPS-KACA002-132: 2018). The results may vary depending on the environment.
**The airborne bacteria removal performance was tested by TUV Rheinland by injecting Staphylococcus epidermidis (1×105 CFU) in a contained area of 60 m³ and kept the appliance (Model number PAH-TAP0MW) running for sixty (60) minutes, and the result was 99.9% reduction. The results may vary depending on the environment.
***The airborne virus removal performance was tested by TUV Rheinland by injecting Phi-X174 virus in a contaned area of 60 m³ and kept the appliance (Model number PAH-TAP0MW) running for thirty (30) minutes, and the result was 99.9% reduction. The results may vary depending on the environment.

■ Air Quality Monitoring

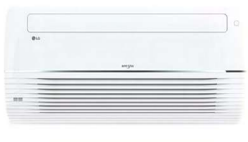
The PM 1.0 sensor monitors air quality and with the central controller or monitor units, the IAQ can be managed in real-time with a remote control, LED panel lamp, or smartphone.



■ Air Purification Kit Applicable Product Line-up

DUAL Vane 4 Way Cassette

Round Cassette

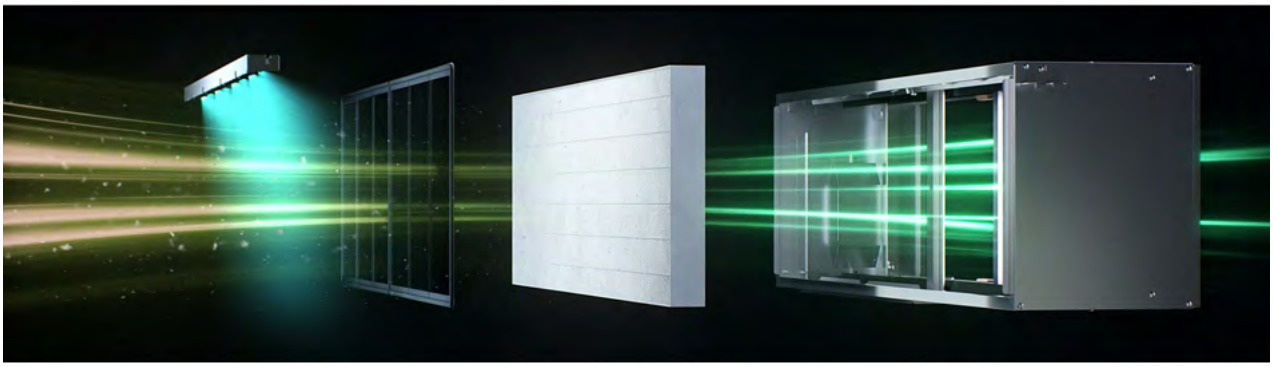


1 Way Cassette

<Disclaimer>
Round cassette air purification kit does not include ionizer.

Creating Better Indoor Air Quality

Ceiling Concealed Duct with UVnano Duct Filter Box



• Pre-filter

This filter traps large dust particles first when the indoor air enters the indoor unit.

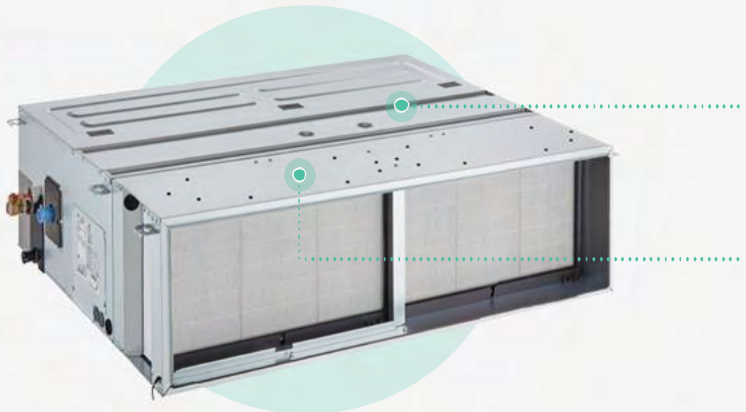
· Fine dust · Bacteria
· Viruses in the form of droplets

• UVnano

This UVC LED removes 99.99% of bacteria and viruses by irradiating ultraviolet rays which are trapped on the pre-filter.

• MERV 13 Filter

This MERV13 filter removes 1-3 μm particles over 85%, 0.3-1 μm over 50%



• High Static CCD

• UVnano Filter Box

<Disclaimer>
*Based on KCL test conducted in compliance with ASHRAE 52.2. ASHARE recommends MERV 13-equivalent filters for reducing airborne infectious aerosol exposure.

* UVnano™ is a compound word derived from the words UV and its unit nanometer.
** Based on TÜV Rheinland test conducted according to LG test method in compliance with ISO 20743 : 2007 removing 99.99 of percent of Staphylococcus aureus, Staphylococcus epidermidis, and Klebsiella pneumoniae from the air conditioner blower fan after being exposed to UV LED lights for 4 hours (tested models : PBM13M1UA, PBM13M2UA, PBM13M3UA). The result value is measured at a specific point set in the experiment.
*** This result may differ in actual use conditions of the air conditioning system.

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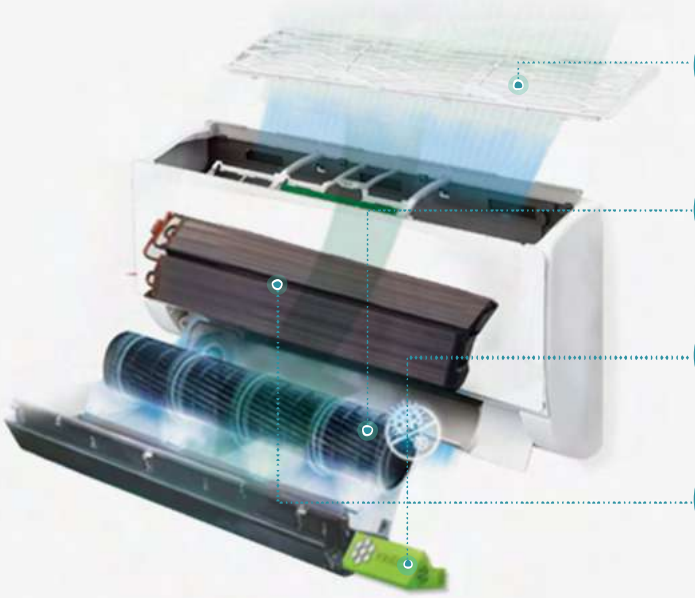
Creating Better Indoor Air Quality

Wall Mounted Units

AirCare Complete System™



- **Step 1: Pre-filter**
  Traps big dust particles from the start

- **Step 2: UVnano**
  Removes 99.99% of bacteria on the fan
  (Including 0.1~0.3 ㎛ in Size)

- **Step 3: Plasmaster Ionizer+**
  Removes more than 99.9% of bacteria
  (Included 0.1~0.3 ㎛ in Size)

- **Step 4: Auto Cleaning**
  Prevents bacteria and mold
  Drys the moisture inside the indoor unit
  to keep it clean

*TUV has verified that 99.99% of Staphylococcus aureus, Staphylococcus epidermids, and Klebsiella pneumoniae were removed from the the air conditioner blower fan after being ewposed to 4 hours of UV LED lights.

*TUV has verified to remove 99% of 3 kinds of adhering bacteria (Staphylococcus aureus, Escherichia coli and Pseudomonas aeruginosa).
** Intertek has verified that tobacco adhesive odor intensity is reduced from 3.6 to under 1.5 after 60 minutes.(Toluene, Ammonia, Acetic acid)

Creating Better Indoor Air Quality

LG Solution for Vertical Segments

Residential

A home is an important place to relax, unwind and regain energy. The critical components of a residential HVAC system certainly include comfortable heating and cooling, energy-saving, and convenience.

LG Multi V S offers a new level of comfort thanks to features such as Dual Sensing Control. By sensing both temperature and humidity, Multi V S quickly provides more comfortable environments. Multi Split and Multi V S can be combined with various indoor units to cover a wide range of capacities.

In addition, indoor cassettes are able to offer cleaner and healthier air due to the 5 step air purification. Also, ERV units with UVnano technology can remove polluted air and supply fresh air indoors. In addition, with LG ThinQ, residents can monitor air quality, control air purifiers, air conditioners remotely and even manage HVAC devices more conveniently.

Residential Apartment	· Multi V S · 1 Way Cassette (with Air Purification) · Wall Mounted (with Air Purification) · Residential ERV · PuriCare 360° · LG ThinQ

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Creating Better Indoor Air Quality

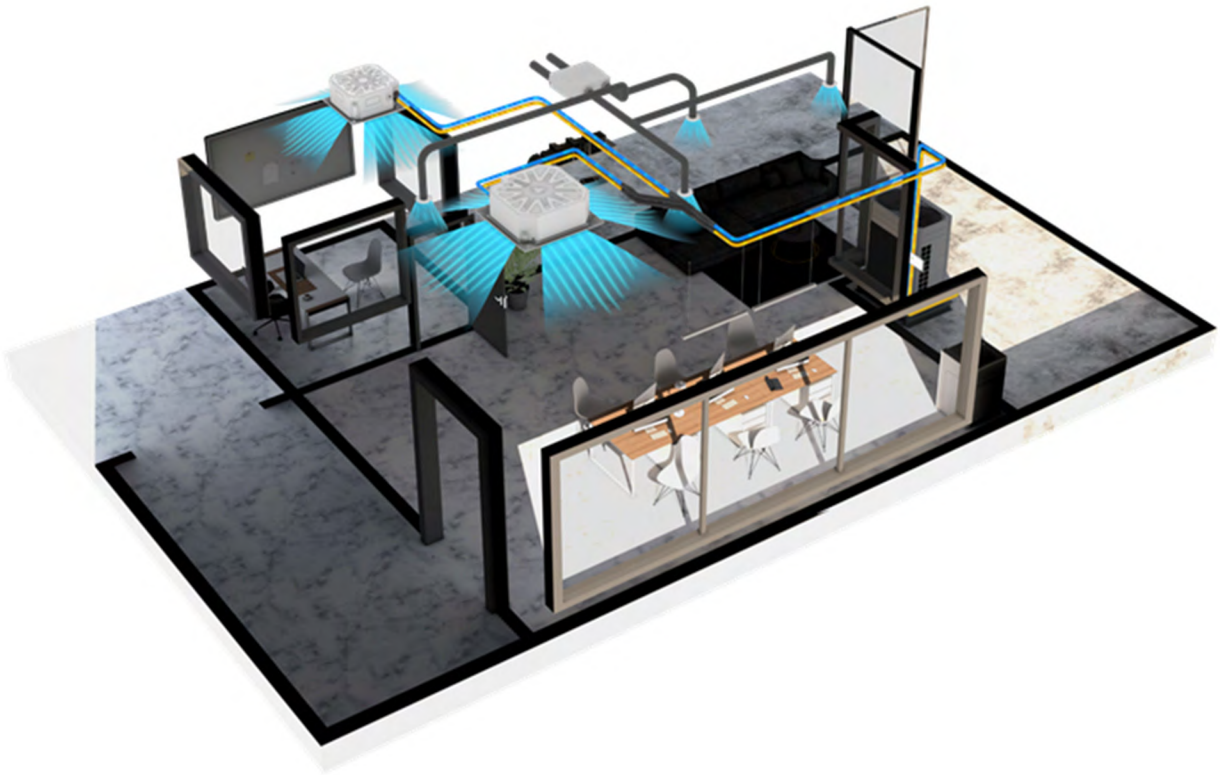
LG Solution for Vertical Segments

Office

Creating a comfortable environment for employees across a wide range of spaces in an office is a key ingredient in the success of the business since the environment is directly related to employees' health, job satisfaction, and productivity.[1)] A comfortable environment consists of adequate temperature, humidity, and clean air.

The 4 Way Cassette with Air Purification Kit supplies clean and pleasant air thorough filtration, as ERV units usher in fresh air to maintain optimal indoor air quality. By combining the Multi V 5 and ERV solutions, occupants can enjoy the fresh air at lower energy costs all year long.

1) Source: Harvard Business Review, The Human Era at Work



Office General	· Multi V 5 · ERV · 4 Way Cassette (with Air Purification) · AC Smart 5

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Creating Better Indoor Air Quality

LG Solution for Vertical Segments

Retail

Creating stylish and satisfying environments for customers is crucial to the success of a retail space. The overall temperature and atmosphere of a space is paramount to the comfort of a customer so that they enjoy their experience and are more likely to return to the shop in the future. With a sleek look and simpler piping, LG's round cassette blends in seamlessly and upgrades the interior design quality of a retail shop. Restaurants also require ventilation and IAQ control to prevent odors, smoke and fumes from moving from the kitchen or bathroom into the dining area.

A diverse range of indoor units like the 4-way Cassette and Round Cassette with Air Purification or a Ceiling Concealed Duct system with UVnano Duct Filter box allows retailers to design luxurious interiors while optimizing healthier indoor air. In addition, LG Multi V S provides a compact yet powerful VRF solution with high performance at low operation costs.

Retail	· 4 Way Cassette (with Air Purification) · Round Cassette (with Air Purification) · Ceiling Concealed Duct (with UVnano Duct Filter Box) · Multi V S

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Creating Better Indoor Air Quality

LG Solution for Vertical Segments

Hospital

Healthcare facilities require particularly unique set of requirements for installing HVAC systems. And even within a building, sections are divided by the characteristics of the residents, and the design requirements for each space varies. However, in general maintaining safe and hygienic conditions is highly important.

The major requirements for an HVAC system for hospitals are precise airflow and pressure control, temperature and humidity control, infection control with air purification and ventilation and reliable system design for 24-hour operation. LG HVAC solutions are capable of providing customized control for the unique requirements in any healthcare facility.

The 4 Way Cassette with Air Purification Kit can provide thoroughly filtrated and clean air in individual spaces. Furthermore, the DOAS makes it possible to avoid air recirculation and cross contamination between areas within a facility. DOAS or ERV systems effectively manage ventilation for each space and can reduce the risk of infection.

Hospital	· 4 Way Cassette (with Air Purification) · Ceiling Concealed Duct (with UVnano Duct Filter Box) · DOAS / ERV · Multi V 5

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Creating Better Indoor Air Quality

Standards and Regulations

- **ASHRAE Position Document on Infectious Aerosols**

  https://www.ashrae.org/file%20library/about/position%20documents/pd_infectiousaerosols_2020.pdf

- **REHVA COVID-19 guidance document, April 3, 2020**

  https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf

- **ASHRAE Standards for IAQ**

  https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20errata/standards/170_2017_a_20200901.pdf

- **ASHRAE Standards for IAQ in Healthcare Facilities**

  https://www.ashrae.org/technical-resources/standards-and-guidelines/standards-addenda/ansi-ashrae-ashe-standard-170-2017-ventilation-of-health-care-facilities

- **OSHA Standards for Commercial Buildings**

  https://www.osha.gov/sites/default/files/publications/3430indoor-air-quality-sm.pdf

- **EPA Standards for IAQ**

  https://www.epa.gov/sites/default/files/2014-08/documents/refguide_appendix_e.pdf

- **EPA Recommendations for IAQ by Building Type**

  https://www.epa.gov/indoor-air-quality-iaq/indoor-air-quality-building-type

- **NICE Guidance for IAQ (UK)**

  https://www.nice.org.uk/guidance/ng149/resources/indoor-air-quality-at-home-pdf-66141788215237

- **UK Regulation and Policy for IAQ**

  https://www.parliament.uk/globalassets/documents/post/postpn366_indoor_air_quality.pdf

- **WHO Guidelines for IAQ**

  https://www.euro.who.int/__data/assets/pdf_file/0007/78613/AIQIAQ_mtgrep_Bonn_Oct06.pdf

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