SAMSUNG

Climate Solutions

# Whitepaper Enhanced Indoor Air Quality for Office Buildings

Using Air Purification Panels to mitigate the adverse effects of Particulate Matter.

Redefine Tomorrow
Redefine Indoor Climate

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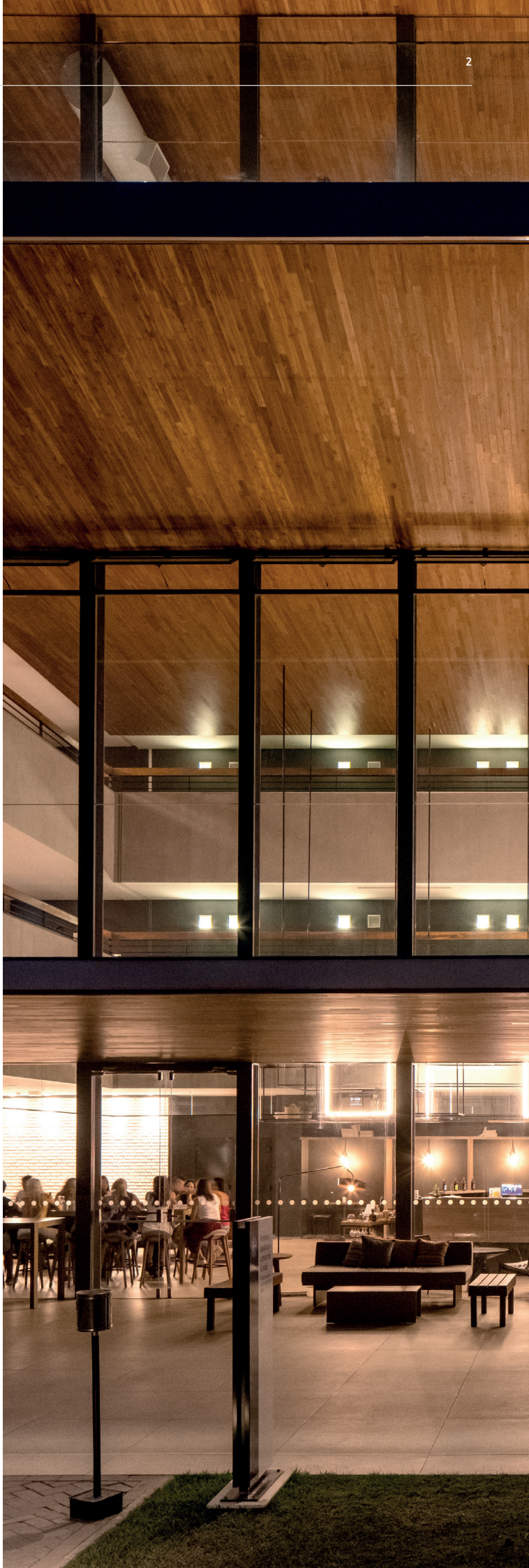


# Abstract

This whitepaper aims to explain the importance of Indoor Air Quality (IAQ) in office buildings, with special focus on airborne Particulate Matter (PM) that is harmful for human beings, and offers possible solutions to help mitigate the presence of PM in the air we are exposed to for the greater part of our day to day lives.

The whitepaper begins by explaining what IAQ entails, the important elements that contribute to IAQ and the consequences of bad IAQ for inhabitants of closed spaces such as modern office buildings. It provides clear insights into the importance of filtering out potentially harmful PM from the air we breathe in, and the ways in which that may be done. In conclusion, the whitepaper also sheds light on Samsung's product offerings that address the issue of dealing with PM.

## Keywords

Indoor Air Quality (IAQ)
Particulate Matter (PM)
PM1.0 Filter
Air Purification
Air Filtration
Air Purification Panel
Air Conditioning
Office building

# About Us

Since introducing its first air conditioner in 1974, Samsung Electronics has been redefining indoor climate comfort for tomorrow's society. For every space where people create memorable experiences together, be it commercial spaces or residential homes. At Samsung, we go beyond convention, through a relentless focus on pushing the boundaries of technology, innovation and design.

Samsung Electronics entered the European market of commercial air conditioning in 2005. Due to rapid growth and in support of its long-term commitment to the European market, Samsung Electronics Air Conditioner Europe B.V. (SEACE) was opened in 2017 in Amsterdam, the Netherlands. This European headquarters aims to harmonize the activities across more than 30 European countries. SEACE offers ongoing technical training in climate and smart building solutions; after sales and technical support for its industry partners; backed by Samsung's quality reputation and leading-edge innovation, including digital connectivity solutions. SEACE thrives to fulfil the needs of its European markets including for both the commercial and residential market with innovation cooling, heating, domestic hot water, refrigeration and smart building solutions.

# Importance of Indoor Air Quality

Millions of European citizens spend more than 90 % of their time indoors, with two thirds of this time spent in their homes and the remaining at workplaces, schools, or public spaces[1] (Sarigiannis, 2013). Despite increased awareness and ongoing attempts to improve the quality of indoor environments over the years, a range of health risks continues to exist, including indoor air pollution, humidity, noise, mold growth or inadequate indoor temperature. Many of these risks can be linked either directly or indirectly to the quality of the building, therefore, risking the quality of health of those who inhabit in these buildings.

Indoor Air Quality (IAQ) refers to the quality of air within and around buildings and structures that affects the health and comfort of occupants[2] (U.S. EPA, 2019). Research shows that the air within the walls of our homes, schools, offices, and factories can be up to five times more polluted than outdoor air[2] (U.S. EPA, 2019). This means that those responsible for designing, building and maintaining our buildings have an important role to play when it comes to the health of the people in it. The importance of IAQ is being increasingly acknowledged and extensively studied. The World Health Organization (WHO) has stressed the importance of IAQ and the potential danger of pollutants, thus IAQ has become one of the main determinants of our overall health.

**Europeans spend more than 90% of their time indoors[1].**

**Indoor air is up to five times more polluted than outdoor air[2].**

## Typical sources of air pollutants


While air pollution can originate from natural phenomena, the contribution from human activities far exceeds the natural sources. The air pollutants that are considered to have the strongest evidence of adverse health effects are Particulate Matter (PM), Ozone ($O_3$), Nitrogen Dioxide ($NO_2$) and Sulphur Dioxide ($SO_2$)[2] (U.S. EPA, 2019). Outdoor ambient air pollutants can penetrate indoor spaces through natural or mechanical ventilation routes, and also via infiltration through building fabric.

But there are also air pollutants that are produced inside a building environment. These include Volatile Organic Compounds (VOCs) that are given off by painted wall coverings, carpets, furnishings or appliances. Also emissions from office equipment play a role as well as occupants themselves, who breathe out $CO_2$ and by that can spread colds and viruses[2] (U.S. EPA, 2019).

[1] Source: Sarigiannis, D.A. (2013), 'Combined or multiple exposure to health stressors in indoor built environments', World Health Organization.
[2] Source: U.S. EPA (2019), Indoor Air Quality (IAQ) | Available at: https://www.epa.gov/indoor-air-quality-iaq. Introduction to Indoor Air Quality, United Status Environmental Protection Agency.

# Effect of Indoor Air Quality in Office buildings

Most studies on IAQ have primarily been confined to homes and schools, while that of modern office buildings has been less subject to studies. Although this seems to be increasing in the last years and expects to continue to increase further in the coming years. Understanding and analysing IAQ in offices is important as it may affect the cognitive performance and productivity of employees, alongside their general health. Needless to say, modern office buildings are usually highly controlled environments with sophisticated ventilation and air conditioning systems. The last few decades have witnessed an increase in the air tightness of modern office buildings. Although air tightness is a good step towards ensuring energy efficiency, the downside is that it makes it more difficult for polluted air to escape, thus negatively impacting the IAQ in workspaces.

Building-related illness syndromes are generally referred to as Sick Building Syndrome[3].

Across European office buildings various indoor pollutant concentrations are higher than the WHO air quality guideline values[5].

Building-related illness syndromes are generally referred to as Sick Building Syndrome (SBS), introduced by WHO in 1983[3]. Several health-related symptoms can be associated with SBS, varying from general symptoms such as allergies, dizziness, or the inability to concentrate, to mucous symptoms such as irritation in the eyes and throat, and dermal symptoms such as itchiness in the skin, face, or hands[4] (Ghaffarianhoseini *et al.*, 2018). The negative effects of sick buildings can also translate to costs incurred in the form of absence from work, lower productivity, remedial expenses, or an increase in the building's energy consumption[4] (Ghaffarianhoseini *et al.*, 2018). Recent research shows that various indoor pollutant concentrations in office buildings across Europe are higher than the WHO air quality guideline values, while also noting seasonal variations in IAQ levels in modern office buildings[5] (Mandin *et al.*, 2016). The indoor pollutants that were studied also included airborne Particulate Matter particles, and that calls for major concern.

[3] SBS is defined as 'a collection of nonspecific symptoms including eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritations, which seem to be linked with occupancy of certain workplaces'
[4] Source: Ghaffarianhoseini A. *et al.* (2018), 'Sick building syndrome: are we doing enough?', in: Architectural Science Review.
[5] Source: Mandin C. *et al.* (2016), 'Assessment of indoor air quality in office buildings across Europe – The OFFICAIR study', in: Science of the Total Environment.

# Role of Particulate Matter

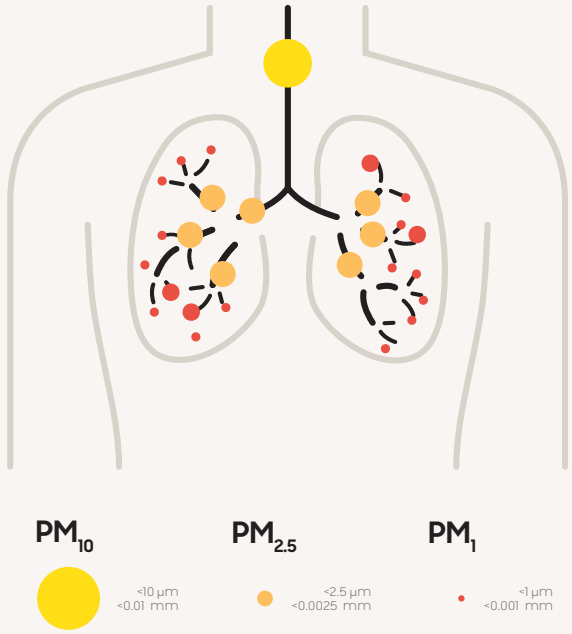
**In 2016, long term exposure to $PM_{2.5}$ concentrations resulted in about 412,000 premature deaths in Europe alone[8].**

Particulate Matter (PM) is an air pollutant produced by a combination of suspended solid and liquid particles in the air. It can either be emitted directly into the air by vehicles, trucks or heavy machinery (called primary PM) or formed by Sulfur Dioxide, Nitrogen Oxides or Ammonia (called secondary PM)[6] (WHO, 2006) in the atmosphere. Such airborne particle concentrations are used as key quality indicators of indoor environments.

Scientific evidence shows that exposure to fine particles can cause adverse cardiovascular effects, including heart attacks and strokes resulting in hospitalisations and, in some cases, premature death[7] (U.S. EPA, 2007). A number of studies have also linked exposure to fine particle to respiratory issues, including the exacerbation of asthma (short-term exposure) and the impairment of lung development (long-term exposure)[7] (U.S. EPA, 2007).

The common technical classification of fine PM is based on particle sizes, according to the areas where they are deposited in the human respiratory system (figure 1).

Leading health organisations classify $PM_{10}$, $PM_{2.5}$ and $PM_1$ fine dust fractions as dangerous and harmful for humans[8] (EEA, 2019). Today, concentrations of PM continue to exceed set limit values in Europe. In 2017, 44 % of EU-28 urban population was exposed to $PM_{10}$ concentrations exceeding the WHO air quality guideline value.




**$PM_{10}$** – thoracic Particulate Matter, particles with a diameter <10 µm (micron) in size, that can be stopped as they enter the throat. Examples: pollen, desert dust, beach sand and human hair.

**$PM_{2.5}$** – fine thoracic Particulate Matter, particles with a diameter <2.5 µm in size, that may be filtered by the lungs and alveoli. Examples: pollen, mold spores and toner dust.

**$PM_1$** – sub-micrometre Particulate Matter, particles with a diameter <1 µm in size that can remain in the atmosphere for weeks. When inhaled, $PM_1$ particles travel to the deepest area of the lungs, where a significant part of them enter the bloodstream, damage the inner walls of arteries, penetrate tissues in the cardiovascular system and potentially spread to organs. Examples: nanoparticles, exhaust gasses and viruses.

Figure 1. Classification of Particulate Matter

For $PM_{2.5}$, approximately 77 % of the population was exposed to concentrations exceeding the guideline. Estimates indicate that $PM_{2.5}$ concentrations in 2016 were responsible for about 412,000 premature deaths originating from long term exposure in Europe[8] (EEA, 2019).

[6] Source: WHO (2006), 'Health risks of particulate matter from long-range transboundary air pollution', World Health Organisation.
[7] Source: U.S. EPA (2007), 'Particulate Matter Concentrations', United Status Environmental Protection Agency.
[8] Source: EEA (2019), 'Air quality in Europe - 2019 report', European Environment Agency.

# Removing Particulate Matter

In completely closed spaces, such as in office buildings, air pollutants remain and accumulate in the room, which in turn could impact the wellbeing and health of people in their working environment. Air filtration plays an important role in maintaining healthy indoor air by eliminating potentially harmful PM dust from the passing air, while also improving the climate system and its hygienic and efficient operation.

In 2005, the WHO published the well-established and widely accepted guideline of thresholds for concentrations of PM in the air we breathe. These thresholds are intended to achieve the lowest possible PM concentration. The WHO guidelines recommend the following limits to be followed when choosing the correct types of air filter classes:

| Pollutant | Average Period | Concentration |
|---|---|---|
| $PM_{10}$ | 24-hour mean | < 50 µg/m³ |
| | Annual mean | < 20 µg/m³ |
| $PM_{2.5}$ | 24-hour mean | < 25 µg/m³ |
| | Annual mean | < 10 µg/m³ |

*At the time being, there are no recommendations set by WHO for $PM_1$ concentration. The WHO air quality guidelines are currently under revision with an expected publication date in 2020.*

The importance of adhering to these thresholds should not be undermined. When (office) buildings are newly designed and/or renovated, it is imperative to ensure that sufficient equipment and technology is used in order to ensure effective air filtration for retaining the threshold limits of indoor air pollutants. This is where the implementation of Air Purification Panels comes into play.

# Air Purification of Particulate Matter

Most air filters that are mounted in air conditioning systems for commercial applications such as office buildings are not designed for filtering particles up to $PM_1$. But with the recent introduction of the concept of Air Purification Panels for cassette units, which contain a series of pleated air filters including a PM1.0 Filter, a solution is now made available to filter harmful PM particles from the airstream.

By recirculating air within a room and catching particles using electrostatic charge, Air Purification Panels clean the air and improve IAQ. They also prevent contaminants from building up in the equipment and damaging it, and essentially serve as an air purifier in the air conditioning system.

The Air Purification Panels contain two types of filters to enhance the mitigation of PM, aimed to keep the indoor air fresh all day long (figure 2).

The cleaning of filters is also an integral part of maintaining good IAQ, and elevation panels can make this process easier. An Auto Elevation Panel[9] is a panel that provides quick and comfortable access to dust filters for cleaning, facilitating extra convenience with the 4 metre elevation advantage with a single remote click. Thus, a ladder is no longer required when cleaning panels. This makes it easier and safer for end users or service engineers to access filters for cleaning[9].

It is generally advised to use Air Purification Panels for circulated air in combination with a sufficient supply of fresh outside air.

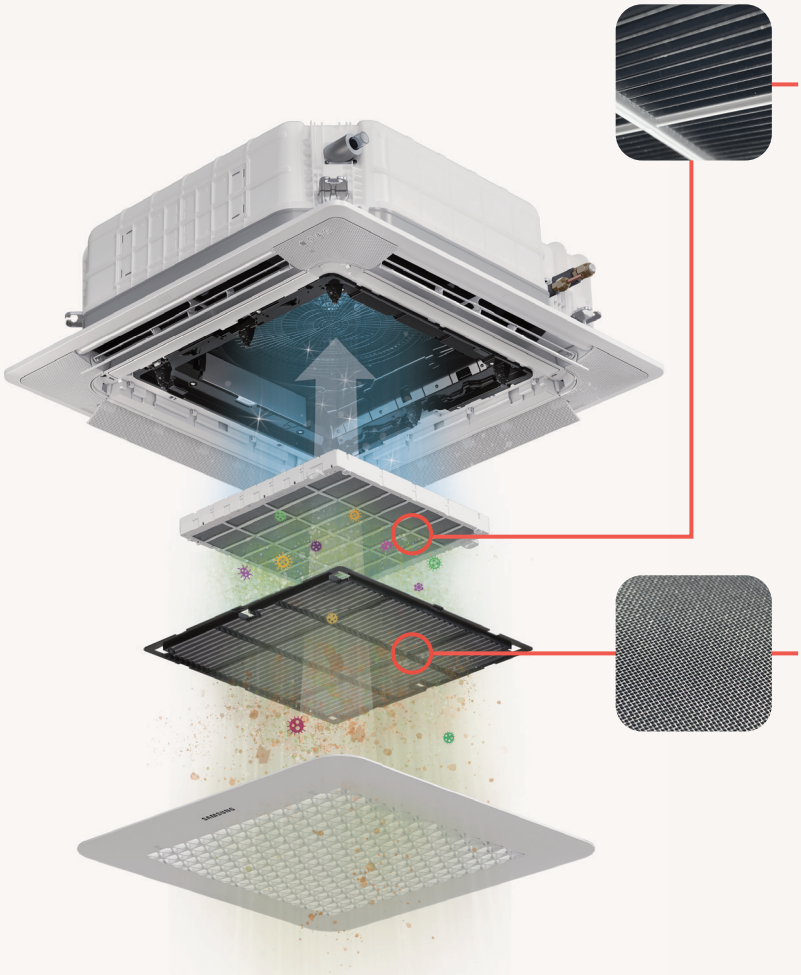


Figure 2. The Concept of Air Purification Panels

## PM1.0 Filter

The PM1.0 Filter not only effectively captures ultrafine dust up to 0.3 µm but also inactivates certain types of bacteria that are captured, using an electrostatic precipitator[10]. It has two main parts that charge and collect dust and certain types of bacteria[10]. The brush discharger generates negative ions. And these give the dust particles and certain types of bacteria[10] a negative charge, so they become strongly attached to the ground electrode due to the electrostatic force of the collector. An added advantage is that this filter is also semi washable, thus saving the purchase and maintenance cost of replacing the filter.

## Pre-Filter

The Pre-Filter captures larger dust particles, stopping them from entering the air conditioning unit.

[9] It is not possible to install the Auto Elevation Panel and Air Purification Panel on the same air conditioning unit.
[10] Certain types of bacteria referred too are Escherichia coli and Staphylococcus aureus. Certified by Intertek, Report Number RT20E-S0010-R, Issue Date:17 April 2020

# Filter Purification Test[11]

In order to measure the efficiency of the Air Purification Panels, a field test was conducted in an empty classroom setup, with one 12 kW Samsung Wind-Free™ 4-Way Cassette, fitted with an Air Purification Panel.

## Objective

The purpose of the test was to evaluate the filtration performance of the Air Purification Panel on $PM_{2.5}$ dust particles.

## Hypothesis

The filter removes at least 90 % of $PM_{2.5}$ dust particles in 30 minutes in a closed classroom.

## Test Method and Measurement

1. Inject ultra-fine test dust in a concentration of 100 µg/m³ into the classroom. Dimensions of the classroom: 8.8 m (Length), 6.7 m (Width), 2.5 m (Height).
2. Operate the Samsung Wind-Free™ 4-Way Cassette with Air Purification Panel and Fan mode on, in order to recirculate the air inside the room.
3. Measure ultra-fine dust by time.

## Test Result[12]

| Fine dust concentration ($PM_{2.5}$) | Operations (Fan mode) | Removal rate | | |
|---|---|---|---|---|
| | | 10 Min. | 20 Min. | 30 Min. |
| 100 µg/m³ | On | 58 % | 81 % | 91 % |
| | Off | 3 % | 6 % | 9 % |

After the classroom was injected with the test dust, the air conditioning system was activated with the Air Purification Panel and Fan mode on. In the first 10 minutes, 58 % of the fine dust particles was removed. In 20 minutes, 81 % of the fine dust particles was removed. At the end of 30 minutes, 91 % of the 100 µg/m³ ultra fine dust was removed from the classroom.

[11] Tested on the AC110JN4DBH1 model under specific testing conditions and may vary depending on specific factors and use.
[12] The test results were carried out by Samsung and may vary depending on the situation.

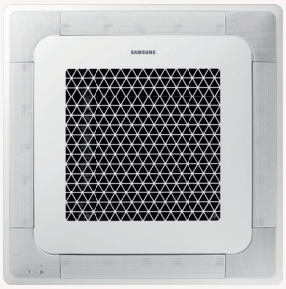
# Conclusion and Recommendation

Legislations and the increased awareness of good IAQ in the context of the next normal are driving innovations in the area of air purification.

Despite improvements made in the quality of indoor environments in the previous decades, a range of health risks still exists. Health organisations around the world have tried to sound the alarm when it comes to $PM_{10}$, $PM_{2.5}$ and $PM_{1}$ fine dust fractions as they pose a serious and insidious threat to humans. It has been proven that health effects may show up years after exposure has occurred or only after long or repeated periods of exposure to $PM_{10}$, $PM_{2.5}$ and $PM_{1}$ fine dust fractions. These effects, which include respiratory diseases, heart disease and cancer, can be severely debilitating or even fatal[13] (U.S. EPA, 2019). Awareness regarding the different categories of pollutants affecting IAQ, how this may differ per space and the exact consequences of PM, are all key factors that contribute to reaching optimum IAQ and mitigating adverse health effects.

Legislations and the increased awareness of good IAQ in the context of the next normal are driving innovations in the area of air purification, amongst others to mitigate the adverse effects of PM on humans. Hence, it is prudent to try to improve the IAQ in workspaces, even if symptoms are not easily noticeable.

Samsung is constantly innovating and educating its partners to help improve indoor climate comfort and wellbeing. Samsung's 360 Cassette, Wind-Free™ 4-Way Cassette and Wind-Free™ 1-Way Cassette (figure 3), for example, can be fitted with an Air Purification Panel[14] made of multiple filters to help maintain PM concentrations level. The Wind-Free™ 1-Way Cassette has an additional third filter known as the deodorization filter to filter unpleasant odours. Furthermore, the Auto Elevation Panel makes it easier for the end user and service engineers to access the dust filters for cleaning.



Wind-Free™ 4-Way Cassette

Wind-Free™ 1-Way Cassette

360 Cassette

Figure 3. Availability of Samsung Air Purification Panels

[13] Source: U.S. EPA (2019), Indoor Air Quality (IAQ) | Available at: https://www.epa.gov/indoor-air-quality-iaq. Introduction to Indoor Air Quality, United Status Environmental Protection Agency.
[14] Air Purification Panels are applicable for Multi Split (FJM), Commercial Split (CAC) and VRF (DVM). The Air Purification Panel is available for the Wind-Free™ 1-Way Cassette, Wind-Free™ 4-Way Cassette and 360 Cassette as per November 2020. Availability may differ per model and market.

# More information

If you are interested in receiving more information, please contact your Samsung representative. To learn more about Samsung Climate Solutions, please visit: **samsung.com/climate**

To achieve the optimum situation of an energy-efficient system that simultaneously provides high IAQ and comfort, a building typically requires both circulation of indoor air and supply of fresh outside air through ventilation. As the focus of this whitepaper is on optimising IAQ by means of filtration of PM from circulated indoor air, the general principles of ventilation have not been discussed in this whitepaper. For specific recommendations on ventilation systems, we recommend consulting guideline documents published by industry bodies - such as REHVA (the Federation of European Heating, Ventilation and Air Conditioning Associations).

In alignment with BREEAM (Building Research Establishment Environmental Assessment Methodology, launched in 1990) and its accompanying certification, builders need to produce an IAQ Plan to manage the contaminants within new buildings. Samsung's Accredited Professionals can provide support in understanding the BREEAM assessment standard to achieve the highest BREEAM score for creating sustainable buildings, simultaneously securing the best possible IAQ in the design phase.



Samsung's products have not been tested for their effect on the COVID-19 virus. Therefore, Samsung does not make or give any express or implied claims or guarantees with regard to the COVID-19 virus. Samsung recommends building owners and facility managers to always closely follow the guidance given by their local authorities.

Learn more about Samsung Climate Solutions at:
**www.samsung.com/climate**



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