



BREATHE EASY

AN EXPERT GUIDE TO INDOOR AIR QUALITY (IAQ) AND HEALTH



Introduction: Clean Air Expertise

Thank you for taking the time to download this Camfil IAQ guide. Our aim in preparing the document has been to give you an insight into IAQ, why it matters for your people and your business.

IAQ has a serious impact on human lives.

Prolonged exposure to indoor pollutants contributes to chronic health conditions, such as heart disease, stroke, obstructive pulmonary disease, cancer and pneumonia.

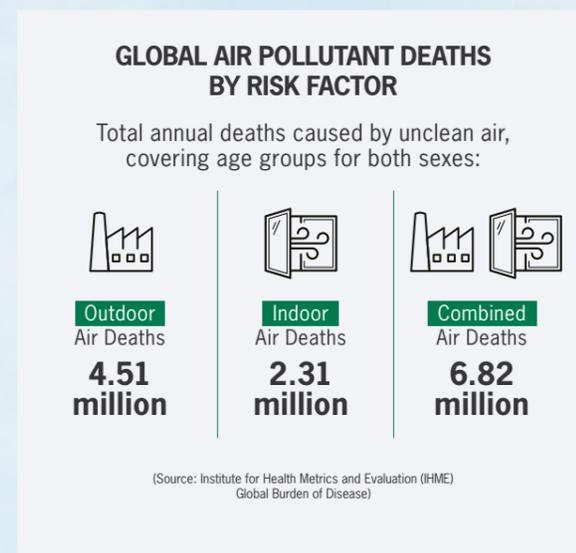
The World Health Organisation states the combined effects of ambient air pollution and household air pollution are associated with 6.8 million premature deaths annually (2020)

The EPA Science Advisory Board's (SAB) research ranks indoor air pollution as a top five environmental public health risk.

These globally researched findings lay clear the impact that substandard IAQ is having on the lives of people in almost every sector at work and at home. Poor IAQ impacts short-term performance and comfort and long-term, it shortens and ends lives.

We associate being indoors with safety. We see bright surroundings and clean architectural lines in a building

designed to protect our well being from exhaust fumes and industrial pollutants that clog the arterial roads surrounding where we live and work.



But indoor air pollution poses serious risk

The first step to tackling any problem, is to understand it. This guide aims to do just that, allowing you to understand the negative impact poor air quality has on people & businesses and how it can be mitigated.

I hope you find it useful on your journey to better IAQ.



Peter Dymont
Camfil IAQ Expert

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EVERYTHING YOU WANTED TO KNOW ABOUT **INDOOR AIR QUALITY**

1

What Is Indoor Air Quality?

Air quality is the term we use to describe how clean the air we breathe is. Indoor Air Quality is important because we spend up to 90% of our time in buildings.



When air quality is poor, contaminants in the air create an array of health hazards, especially concerning for people with existing lung or heart conditions.

Clean air is a basic requirement for a healthy environment and should be considered a human right in the context of “Everyone has the right to a standard of living adequate for their health and well-being”. We need clean air in the areas we spend most of our time and this includes our working environment and the places we raise our families.

Indoor air quality is everything. Clean air is as close to nothing as possible, this means free from contaminants.

Why Does It Matter?

Particulate matter is fine particles in the air that can act as an irritant once exposed to the human respiratory and cardiovascular system.

Particulate Matter comes in many different sizes but the two most prominent ranges, PM2.5 and PM1. These are based on size i.e. 2.5 and 1 micron in size. 1 Micron is equivalent to 1% of the width of a human hair.

The smaller the particles, the further they can penetrate into our body's natural filtration systems. Smaller particles get further into the body and can cause significant short and long-term illnesses.

When these particles reach the heart and the brain, poor IAQ becomes a short term irritant, and in long term cases, an invisible killer.

PM1 has been recorded penetrating further, with particulate crossing the blood brain barrier where it causes short term mental disruption and long term degenerative problems.

This minute threat, does not bring with it minute problems and facility managers and building staff hold a duty of care over those who work, clean and patronise their facilities. The obligation to protect through the provision of clean air is equal with other health and safety provisions such as fire protection and clean water provision.



Why Air Changes Per Hour Matter

Air Changes per Hour, or ACPH, is the number of times that the total air volume in a space is cleaned each hour.

ACH is calculated by dividing:

Airflow rate (Q) - cubic meters per minute
by
Total volume (V) of the space being cleared.

For example, to calculate changes in an hour, we multiply Q by 60 minutes and divide it by V.

$$60Q/V = ACPH$$

A unit with an airflow rate of 3.6m³ per minute, in a 5x5x2m room (50m³), will go through 4.32 changes per hour.

$$(3.6 \cdot 60) / 50 = 4.32$$

The effectiveness of an indoor air purifier is directly related to ACH, combined with the continued filtration efficiency of a filter.

When an air filter can maintain a high level of filtration performance and high air volume to impact of the unit can perform 2-3 times better than a unit that has a high airflow with a low filtration efficiency.

Filtration Efficiency

1

2000



When using H14 HEPA filters 1 particle for every 20,000 gets through the filter.

If this filter efficiency drops by 10%, 2000 particles get through the filter

Certified HEPA filters catch more particles and last longer, creating longer term safety.



How Is Indoor Air Quality Tested?



The Key Parameters Particles and gases from both

				
18 – 22°C	40-60% RH	415ppm	88µg/m ³	10µg/m ³
Temperature	Humidity	Carbon Dioxide	Sulphur Dioxide	Nitrogen Dioxide

1. Temperature (Comfort range is typically 18 – 22°C)
2. Humidity (Comfort range typically 40 – 60% RH)
3. Carbon Dioxide (Ambient outdoor 415 ppm over 1000 ppm becomes 'stuffy')
4. Sulphur Dioxide (Ambient volume of lowest safe exposure below 88µg /m³)
5. Nitrogen Dioxide (Recent WHO limit factor for NO₂ is 10 µg/m³ annual mean)

The Sources Of Indoor Air Pollution

The most common sources of Indoor Air Pollution:



Mechanical

- Fuel-burning
- Central heating / Air-conditioning
- Cooling systems
- Humidifiers



Organic

- Smoking (tobacco and vapes)
- Spores (bacterial, fungicidal)
- Viruses

Less obvious, but equally pervasive:



Artificial

- Fumes from cleaning products
- Particulate microplastics
- Personal care products



Organic

- Mould spores
- Pet dander
- Dust mite allergens

Other sources that can contribute to substandard IAQ:

- Building materials and furnishings.
- Deteriorated insulation containing asbestos.
- Newly installed flooring, carpets, or upholstery.
- Cabinetry or furniture made of certain pressed wood products.
- Radon gas can permeate through rock in some areas under building foundations.
- Indoor source mould spores bacteria and virus.
- Pesticides.
- Outdoor air pollution – from vehicles and industry.
- Natural allergens such as pollens, outdoor spores, bacteria and virus.



What Causes Poor Indoor Air Quality?

There are four key influencers on IAQ you need to be aware of. These are: Ventilation, Particulate Matter, Acidic gases and Aldehyde levels, and Total Volatile Organic Compounds (TVOCs).

1. Ventilation and CO₂



In 2021, The Harvard Healthy Buildings Program published a report examining clean air frequency needs to create sufficient levels of clean air to keep occupants in a space safe.

They found that 5 refreshes of the air per hour, once every 12 minutes, was optimal for creating clean air.

When we exhale, a significant amount of what we breathe out is Carbon Dioxide, CO₂, a waste product. When occupancy levels in a space are high, and ventilation substandard, the build-up of this waste gas not only impedes the body, causing headaches and accelerated heart rate amongst other conditions, but it can also impact mental acuity. Clumsiness, mental fatigue and greater emotional sensitivity have all been observed as results of CO₂ saturation.

2. Particulate Matter



Airborne fine combustion particles from burning of fossil fuels and traffic emissions are the most common encountered, outdoor sourced, air pollutants in urban locations. Traffic combustion particles have been classed by the WHO as a group one carcinogen (cancer causing).

The WHO states there is no safe level of exposure to these particles.

Also, studies have shown some of these particles known as Magnetite have been linked to early onset of dementia and premature mortality in young people. Hence the recent government policy for Ultra Low Emission Zones in major cities to discourage use of polluting cars.

3. Total Volatile Organic Compounds

As with particulate matter discussed earlier, TVOCs are responsible for a variety of short term health issues such as headaches, dizziness and nausea, while long term exposure can lead to organ damage and significant disruption to the central nervous system.



The source of VOCs are often the result of human products and activities, effective removal from the air requires molecular filtration to ensure the gaseous particles are captured.

The Clean Air Data is Greater than the Myths

These three myths, or misconceptions, come to us frequently:

Myth One: Outdoor air is more polluted, therefore it's safer inside

The circulation of air outside contributes to more of a churn in the air, and your ability to move from area to area means you encounter differing levels of air pollution. Indoors, occupancy rates and low standards of ventilation or circulation mean you are trapped in an area with poor, unchanging, IAQ. Sometimes for many hours at a time.



Myth Two: A focus on energy-efficient construction means IAQ is unlikely to be that bad

While energy efficiency is a noble goal (and when it comes to carbon output, reduction helps with air quality and sustainability) the flow of air within a building has a far greater impact on the health of the building and its occupants. If air isn't circulating and being purified, energy efficiency will not change the sources of unclean air detailed on page 5.



Myth Three: It's not easy to improve IAQ

There are many basic steps that can be taken to improve your IAQ. From the installation of air purification systems, that once properly sized and positioned, can often run establish clean air without direct human involvement to the basic upgrades of air filtration in your ventilation system. Once you understand your environment IAQ improvements are easier to target.



Erik Lans
Clean Air Data Expert



What does Indoor Air Quality mean for... Offices

It's now been proven that poor workplace IAQ can decrease the productivity of your team, and ultimately your business.

Studies suggest significant impacts on employee cognitive function, including response times and ability to focus. The National Center for Biotechnology Information (NCBI) has recorded that the impact on office work performance appears to be as high as 6-9%, with the higher value being obtained in field validation studies. Research concludes that it's usually more energy-efficient to eliminate sources of pollution than to increase outdoor air supply rates. While the high cost of labour per unit floor area ensures that payback times will usually be as low as 2 years.



Significant impact on employees' cognitive function, including response times and ability to focus has been shown by a one-year study, by Harvard T.H. Chan School of Public Health.



Participants were studied in offices across six countries working in a variety of fields, including engineering, real estate investment, architecture, and technology. The study found that increased concentrations of PM2.5 and lower ventilation rates - measured using CO2 levels as a proxy - were associated with slower response times and reduced accuracy on a series of cognitive tests.



Researchers also noted observations of impaired cognitive function at concentrations of PM2.5 and CO2 that are commonly recorded within indoor environments.



A \$40 investment in clean air technology per person in a commercial setting equates to average savings of \$6,500 through improved efficiency, productivity and attendance.



Citation: Harvard Study

Schools

Research shows that the air quality in an exam hall influences student performance. Studies show that cognitive scores are 61% higher across nine functional responses when air quality is high. The EPA reports that nearly one in 13 children of school-age has asthma, identifying this as the leading cause of school absenteeism due to chronic illness. Children who stay at home then have issues in keeping up with their classmates.

There is substantial evidence that indoor environmental exposure to common allergens in schools - dust mites, pests, and moulds - helps trigger these asthma symptoms. In addition to student attendance, this negatively impacts comfort and performance, as well as that of teachers and staff. This also creates broader issues such as reducing equipment efficiency, creating negative publicity that affects community trust, and potential liability problems.

The EPA reports that nearly one in 13 children of school-age has asthma, identifying this as the leading cause of school absenteeism due to chronic illness.



Communal Healthcare Spaces

Research suggests the quality of air directly influences a patient or visitor's quality of life.

Poor air quality in healthcare environments can have a disastrous effect on the health and wellbeing of residents. Failing to capture and filter out airborne contaminants can exacerbate and even cause chronic conditions, as well as lead to deadly outbreaks of infectious disease – such as at the height of the Covid-19 pandemic.



A study by Cambridge University found air filtration significantly reduces presence of airborne diseases such as SARS-CoV-2

The WHO attributes a number of non-communicable diseases such as lung cancer, stroke, ischaemic heart disease and chronic obstructive pulmonary disease (COPD) solely to indoor air pollution.

One 2017 study found that women living in highly polluted environments were almost twice as likely to develop dementia.

Hospitals

Research by the WHO suggests that air pollution affects every single cell in the body and is responsible for more health problems than previously believed. Improving IAQ in hospitals is essential to prevent new illnesses in patients, and to avoid exacerbating existing symptoms.

Air purification in hospitals results in better patient outcomes. According to NIOSH, 10-24% of non-epidemic nosocomial infections spread through the air. Clean air can prevent MRSA, Norovirus and other pathogens. The CDC acknowledges antibiotic resistance as one of the biggest public health challenges of our time, so infection prevention is key. As well as protecting patients, it keeps critical staff safe and avoids absenteeism.

Clean air also serves to reduce downtime (or fallow time) between appointments, increase operating capacity and allow for a higher patient intake.

Improving IAQ in hospitals is essential to prevent new illnesses in patients, and to avoid exacerbating existing symptoms.



THE TECHNOLOGY THAT CREATES CLEAN AIR AND BETTER INDOOR AIR QUALITY

2



Understanding the Air Purity Differentiators

Marketing claims are not always their best. Exaggeration, and misdirection, play a part in selecting any product.

- Ensure you have independent insights into a products performance.
- Find independent guidance on standards and legislation that affect the clean air provision in your jurisdiction.
- Aim to compare like for like, domestic products do not compare to those needed in commercial or industrial spaces.
- Look at total cost of ownership, what does a unit cost in application, as well as your initial investment.



Important Questions You Should Be Asking

1. Has the IAQ ever been tested in a significant way?
2. If so, is it possible to see the results and what actions were taken?
3. What is our IAQ like vs the OAQ of the surrounding area?
4. Do we know what creates good IAQ, what are we doing to achieve that?
5. Does IAQ and air pollution form part of regular risk assessments?
6. Are there any recorded incidents of a building occupant suffering from poor IAQ?
7. What is the building's ventilation system?
8. What role does technology play in ventilating our building?
9. Other than the built-in ventilation, what other provision is given to IAQ in the spaces in our building?
10. Who is responsible for the air in the building?

Crucial Considerations When You Buy An Air Purifier

When it comes to tackling poor indoor air quality, the machines you choose need to meet not just the immediate health concerns, but the commercial and sustainability concerns of any modern business.

1 How much of the air does the unit clean?

Completely cleaning the air within a room is a significant challenge. Air cannot be cleaned in the local area around a machine, the whole space needs to benefit from the deployed unit.

Otherwise the risk is of creating pockets of clean air that are cited and referenced as safe, while air within the same space still poses a health threat.

Page 13 explains in more detail the calculation and need for cleaning the air in the entirety of a space.



2 How long do the filters last?

A lot of airborne dust is invisible to the naked eye. This makes it doubly important that air drawn into the air purification unit is effectively filtered.

HEPA filters meet the defining standard for air filtration, focussing as they do on particulate matter as small as 0.18 micron. But not all HEPA filters are built equally.

Those filters with a higher media content in them, that are larger, not only have a significant advantage over smaller filters in terms of capture and replacement cost, their longer lifetime ensures a stable pressure drop over time, meaning greater protection, for longer, without the need for replacement.

Molecular filters contribute a further layer of safety to air purification, tackling gaseous contaminants such as VOCs.

3 Do you need anything more than filtration?

Research demonstrates that HEPA filtration is the most efficient air filtration technology. While COVID has brought HEPA 14 to a broader social consciousness, the technology of this type of filtration has been in use, and keeping people safe, for decades.

Recommendations for HEPA by CDC, SAGE and WHO stem from practical deployment and results tracking across a wide spectrum of use cases. All such agencies recommend an approach where subtractive technologies are used, taking something out of the air, rather than additive technologies.

When HEPA removes so much, and is so highly regarded, other technologies that do not have the same pedigree, that add to air, only create confusion.



4 Don't be distracted by noisy, hot air!

When sound is literally the disturbance of air, it's impossible to pursue complete silence. But when substandard components are used such as axial fans, the noise that resonates from a purifier unit can be loud, and the pitch uncomfortable for those within the space.

When you see noise settings that aren't aligned with different levels of operation, ask for a more suitable breakdown, what's the noise factor at each level of operation.

When you want to reap the benefits of better attention, and clearer thinking, the distraction that comes from a noisy product, loudly humming and whirring away, works counter to that aim.

5 Manufacturing process that is robust and materials that last.

It takes a lot to clean all the air in a space. Precision parts, focused engineering, research and development, all play a significant part in the unit that ends up in your space.

An air purifier is more than just a fan in a box.

Avoid units that can't be moved around a space, or aren't robust enough to be moved repeatedly. Also consider the energy consumption of the unit, how does it compare to HVAC systems and the ongoing costs of air purification.

Research demonstrates that HEPA filtration is the most efficient air filtration technology.

For more details see "Further Reading" on pg32

■ IAQ Quotes

“

“People spend around 90% of their time indoors, and human exposure to indoor air pollutants may occasionally be more than 100 times higher than outdoor pollutant levels”.

EPA United States Environmental Protection Agency

“

“Whilst outdoor air quality has improved significantly over the last 30 years, improved energy efficiency has led to increased airtightness levels and lower building ventilation rates, potentially deteriorating indoor air quality”.

defra.gov.uk

“

“Nearly 1 in 13 children of school-age has asthma, which is the leading cause of school absenteeism due to chronic illness. There is substantial evidence that indoor environmental exposure to allergens (such as dust mites, pests, and molds) plays a role in triggering asthma symptoms”.

EPA United States Environmental Protection Agency

“

“Pollutants such as carbon monoxide, which are diluted outdoors, can accumulate inside a room. In addition to pollution, respiratory pathogens, including coronaviruses and influenza

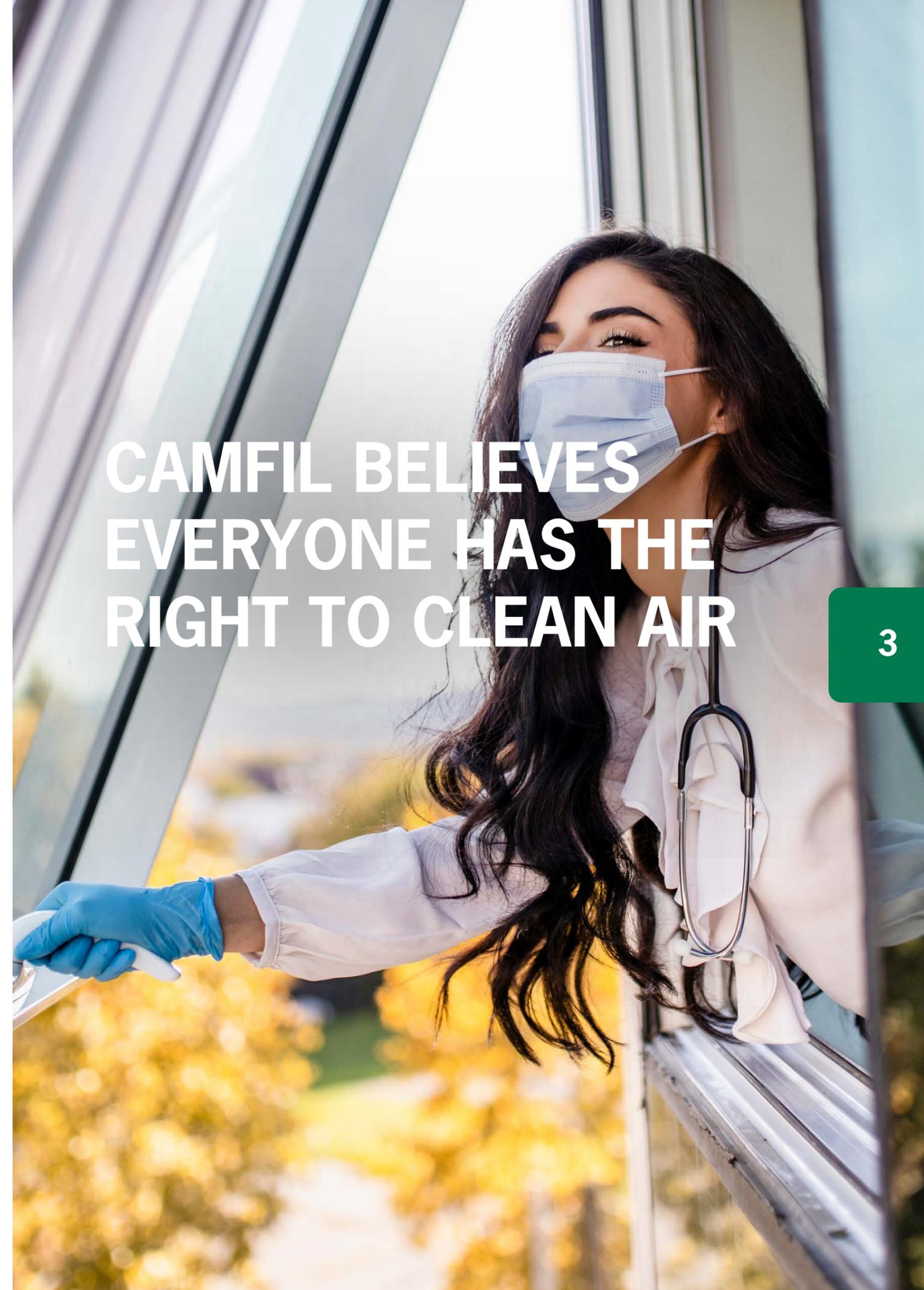
viruses, can build up and spread between individuals more readily indoors — as the COVID-19 pandemic and the latest flu outbreaks have demonstrated”.

Alastair C. Lewis, Deborah Jenkins & Christopher J. M. Whitty

“

“Ventilation system operation and maintenance play a major role in hospital IAQ and a plethora of studies exists to demonstrate that it is crucial towards controlling air-exchange rates, chemical and particle contaminants, excessive carbon dioxide levels and occupant comfort levels”

Frontiers (frontiersin.org)



**CAMFIL BELIEVES
EVERYONE HAS THE
RIGHT TO CLEAN AIR**

■ Clean Air that Protects Everyone, Enhancing Health and Lives

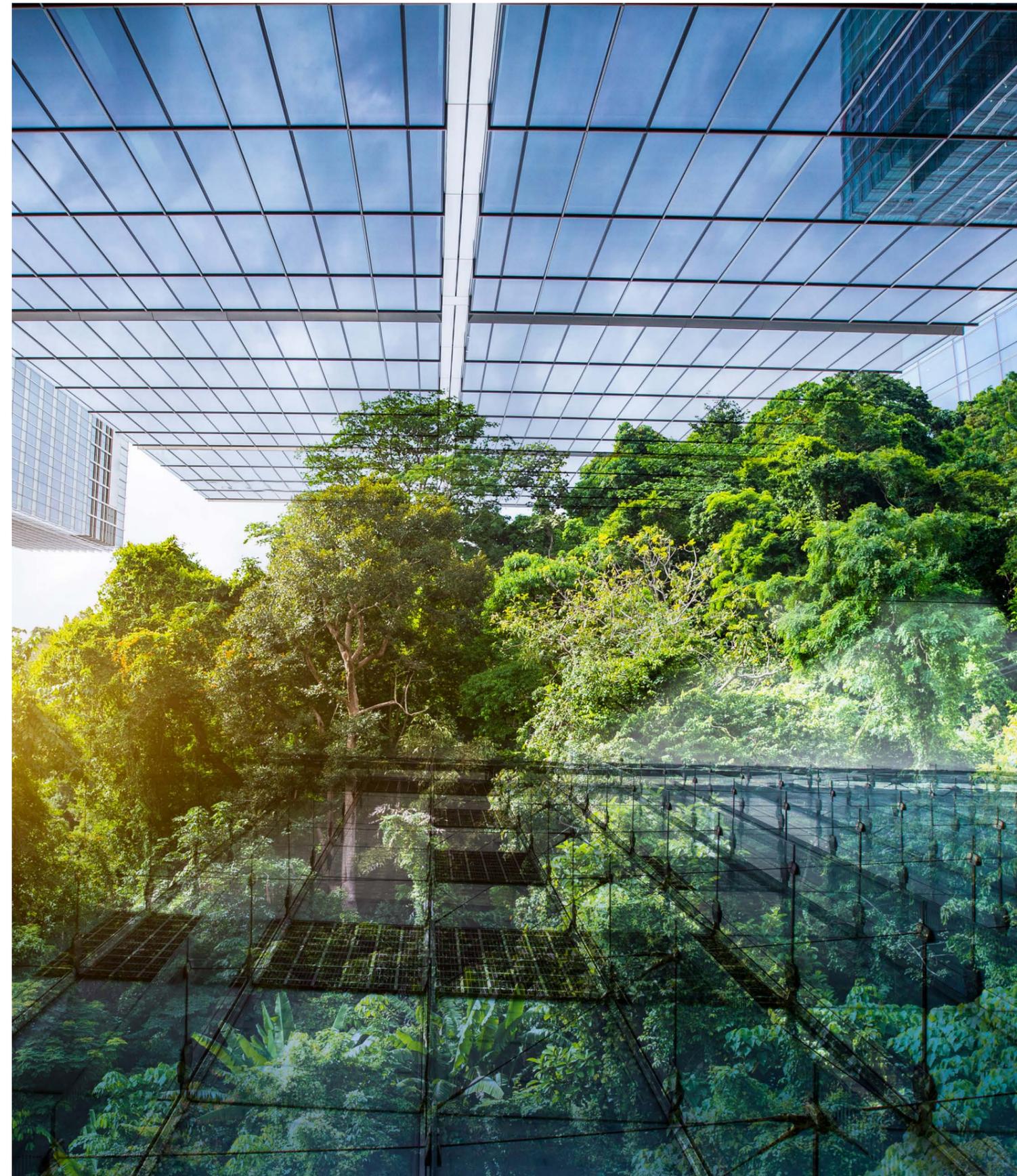
Camfil PROTECTS lives, promotes health and improves mental functioning with machines and units that filter air, removing debilitating particulate matter and other air pollutants.



Camfil ENHANCES the lives of all when clean air is established as a fundamental expectation of the spaces we spend our time in and is considered a human right, equal to clean water and healthy food.



Camfil PROTECTS businesses by keeping their staff healthy and in the office by reducing the contaminants that cause ill health, whether they stem from mechanical or organic sources.





■ A Little Bit About Camfil

As a leading manufacturer of premium clean air solutions, we provide commercial and industrial systems for air filtration and air pollution control that improve worker and equipment productivity, minimise energy use and benefit human health and the environment. We firmly believe that the best solutions for our customers are the best solutions for our planet, too.

Our mission is to provide clean air for every space - from offices to schools to healthcare, hospitality, retail and industrial spaces.

We strive for excellence in everything we do, from technological innovation to customer care. We aim for the highest standards in protecting health, enhancing wellbeing and driving productivity.

Our mission is to provide clean air for every space - from offices to schools to healthcare, hospitality, retail and industrial spaces.



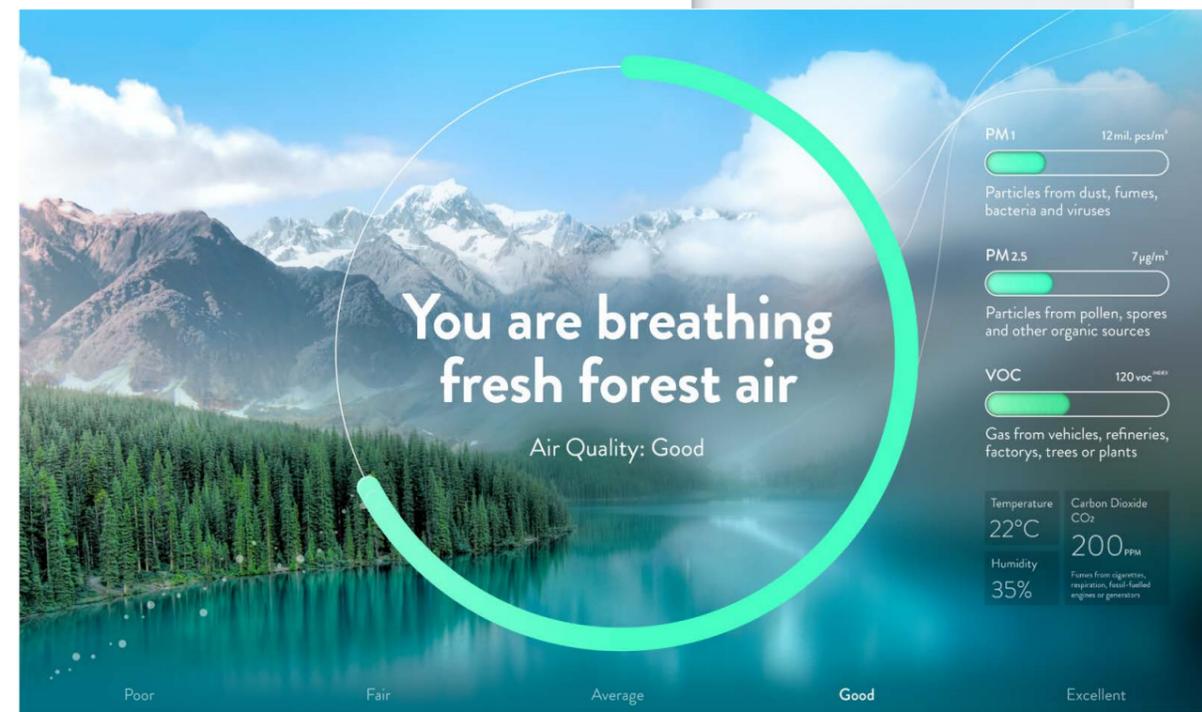
■ The Difference Between Labs and the Real World

It's always a concern isn't it, that the results that you get with a machine, or any piece of technology, is not reduplicated in the real world.

At Camfil, we believe in clean air as a human right, so we ensure that our machines don't just perform in the sterility of a lab setting, overseen by our experts, but that they make a real difference in the spaces and places they are deployed.

When we say our machine is the expert in your office, we mean it. Expertly designed, expertly built and capable of providing clean air change in the spaces you oversee. For complete peace of mind.

With the Camfil City L Connect we've even given you the tools to check the air quality, in real-time, on the unit or via the remote desktop app.



■ Why Our Customers Work With Us

Our customers benefit from air purification services, but no space, building or setup has exactly the needs of any other. In every element of what we do there is something bespoke that aids our customers to get the most from what we offer, whether that's technology, expertise or ongoing support.

Step 1: IAQ auditing covering areas such as:

- Existing ventilation and assessment against pre-eminent standards and regulatory requirements.
- What's in the air risk assessment alongside a discussion on the short, medium and long term results of detected unclean air.
- Estimated sustainability and energy improvements compared with current system or alternative methodologies.

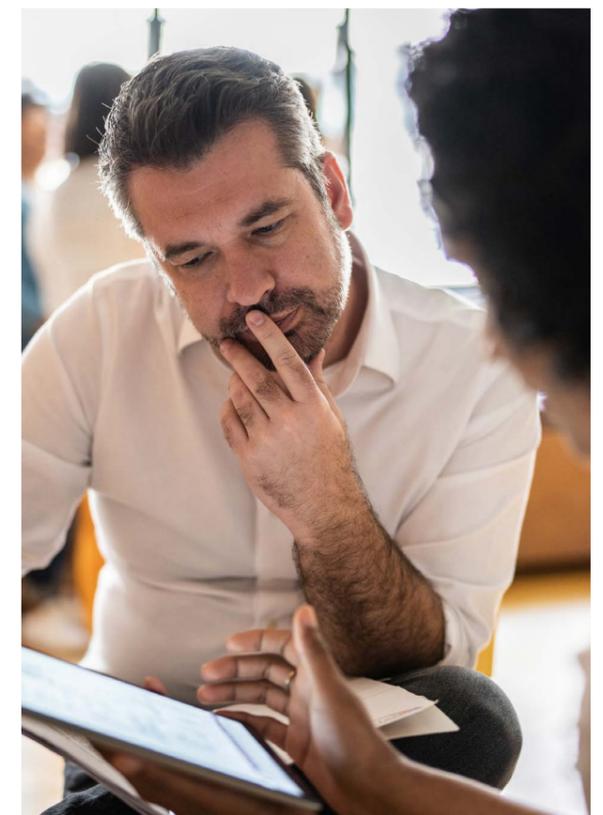
Step 2: We provide a comprehensive opportunity assessment report that can show the impact of good IAQ for your business.

This means you can see the needs of your spaces, understand what is going on and the level of action required to ensure the health of your employees and the long-term benefits to your business.

How can we help?

Our passion is clean air, we understand that it's a fundamental for good health, and as such a very functional parts our rights.

We welcome the opportunity to help any business implement the equipment and processes that ensure people get good clean air indoors, where they spend 90% of their lives.





■ The Right Air Purifier For You

Led by the City L Connect, the Camfil City Range of air purifiers meets the needs of different spaces with the expertise you would expect from Camfil machines. Each machine in the range comes with a double filtration packet as standard, combining certified H14 HEPA filter protection with activated carbon filtration to optimise the air you breathe.

City L Connect

The City L utilises real-time data visualisation of IAQ parameters on the device and via an IAQ dashboard available on any smart screen or device.

City L

The City L has been designed with higher airflow and low noise levels to ensure its the ideal solution for larger rooms in offices, hotels, waiting rooms and schools to ensure clean air quality for its occupants.

City M

The City M is a smaller unit for rooms up to 75m². Ideal as both stand alone system or as supplement to ventilation systems.



Arcangel Minguez
Machine Expert



City L Connect



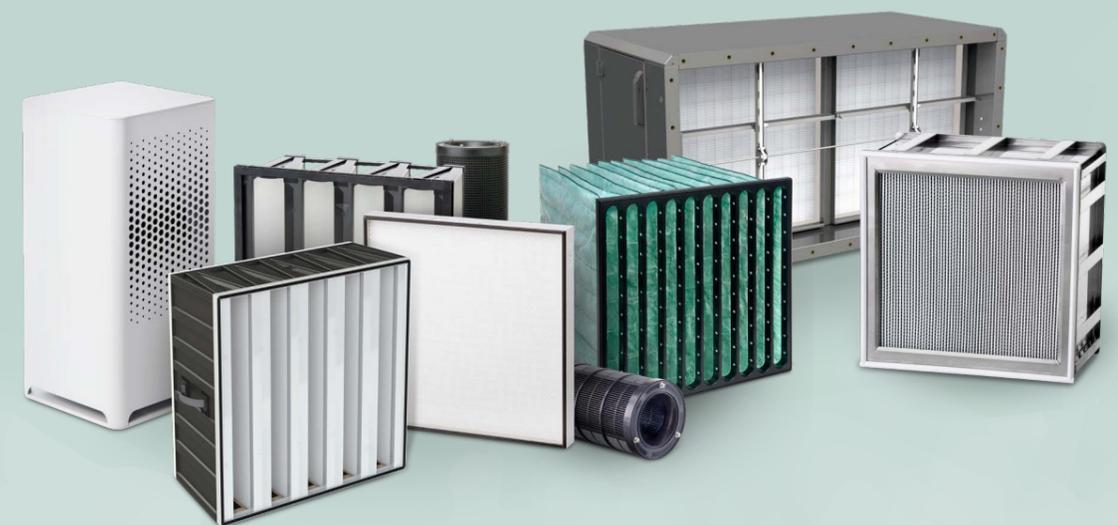
City L



City M



■ Extend Your Protection



In most buildings the ventilation systems are the source of "Fresh" air. At Camfil we offer a full range of HVAC filters that are aimed at improving air quality and reducing energy consumption.

Hi-Flo NG

The Hi-Flo range of bag filters are the most energy efficient bag filters on the market. These filters come in a full range of efficiencies and are ideal for most HVAC systems.

City-Flo

In towns and cities where molecular contaminants such as O₂, SO₂ and NO₂ are a concern the City-Flo is ideal as this range is designed to capture both particulate and molecular contaminants.

Further Reading

American Society of Heating and Air-Conditioning Engineers ASHRAE Standard 62.1 Ventilation for Acceptable Indoor Air Quality.

Department for Environment, Food and Rural Affairs DEFRA Air Quality Limits Eurovent 4/23 - Selection of EN ISO 16890 - Rated Air Filter Classes for General Ventilation Applications.

Ministry of Housing, Communities and Local Government MHCLG Approved Document F - Ventilation Health and Safety Executive HSE Radon in the workplace EH40/2005.

Workplace Exposure Limits National Air Quality Testing Services NAQTS Seminar- Monitoring Indoor Air Quality in 20 Schools Around the UK Pre- and Post.

COVID Restrictions World Health Organisation.

WHO Guidelines for IAQ – Selected Pollutants (2010) Air quality guidelines - For particulate matter, ozone, nitrogen dioxide and sulphur dioxide.

World Health Organisation (WHO) Air Quality guidelines 2021.

British Standards Institution BSI BS EN 16798-3 Energy Performance of Buildings. Ventilation for Buildings.

Eurovent 4/23 - Selection of EN ISO 16890 - Rated Air Filter Classes for General Ventilation Applications 2022.

COVID Restrictions World Health Organisation.

Global air quality guidelines - For particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide.

WHO Guidelines for IAQ – Selected Pollutants (2010) Air quality guidelines - For particulate matter, ozone, nitrogen dioxide and sulphur dioxide.

British Standards Institution BSI BS EN 16798-1 Health and Well-being in Building Services.

British Standards Institution BSI BS EN ISO 16890 Performance testing particle general ventilation air filters.

British Standards Institution BSI BS EN ISO 10121-2 Performance testing gas phase general ventilation air filters.

Further Reading

British Standards Institution BSI BS EN 1822 Performance testing HEPA, EPA, ULPA air filters (ref. ISO 29463 related global standard).

Energy Performance of Buildings. Ventilation for Buildings. Building Engineering Services Association BESA IAQ.

BESA A Beginner's Guide to Indoor Air Quality.

BESA H&W 002 Indoor Air Quality for Health and Wellbeing.

BESA SFG001 Air Filter selection to provide clean indoor air for city buildings.

BESA SFG004 Air filter selection to provide clean healthy indoor air quality for city buildings.

BESA VG002 Clean Indoor Air - Practical Measures for Building Services Operation.

Ministry of Housing, Communities and Local Government MHCLG Approved Document F - Ventilation Health and Safety Executive HSE Radon in the workplace EH40/2005.

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American Society of Heating and Air-Conditioning Engineers ASHRAE Standard 62.1 Ventilation for Acceptable Indoor Air Quality.

Chartered Institute of Building Services Engineers CIBSE TM40.

BESA TR19 - Guide to Good Practice TR/19 Internal Cleanliness of Ventilation Systems.

UK GOV Daily Air Quality Index

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