Indoor Air Quality
The beginning of a new era

SENSIRION

Why clean indoor air is important – for all of us, in any place, at any time.

In recent years, a new demand for clean air has developed among many people who value healthy living. When it comes to air quality, most of them rightly are worried about atmospheric pollution, but tend to forget about indoor air pollution.

Being at home or in the office does not protect us from polluted air. The pandemic reminded us to take proper care of air quality in school, in the office, and at home. And with good reason: the air we breathe impacts how we learn, work, and relax. Given that we spend around 80 or 90 percent of our time in enclosed spaces, measuring and controlling indoor air quality (IAQ) should not be considered a side issue. According to calculations by the Centre for Research on Energy and Clean Air (CREA) and Greenpeace, air pollution is causing 4.5 million premature deaths worldwide each year. Besides the outdoor exposure to exhaust gases, ozone or pesticides (which have an impact on IAQ too), various sources can affect indoor air quality, including construction materials, stored chemicals, condensation, dust and paints. Unfortunately, in many parts of the world, the air quality indoors actually tends to be worse than outdoors. And this cocktail of polluted air affects our well-being, our daily activities, and our physical and mental health, resulting in less personal freedom.

Breathing clean air is essential; in fact, it should be a fundamental human right. Innovators like Sensirion have developed intelligent technological solutions that can be used in air purifying or air ventilation systems. Let's unleash the full potential of clean air – for a happy and healthy life!

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“ Source: World Bank Study

Today, air pollution is recognized as a major health risk. Exposure to air pollution, both ambient and household, increases a person’s risk of contracting a disease such as lung cancer, stroke, heart disease, and chronic bronchitis.

Rising aware-ness

In many countries all over the world, smoking in closed public spaces is forbidden. Our kitchens are equipped with fume hoods and we tend to close windows facing roads simply because of the noise emissions. In fact, well-being is often considered to be more important than cleanliness when it comes to indoor air. We tend to care most about unwelcome odors, the temperature and humidity levels when at home or in the office. Larger hotels and shopping malls scent their ventilated air to make customers feel more at ease.

However, the demand for clean indoor air is rising worldwide, although this varies by region. In China and South Korea, for example, people in cities tend to have a higher awareness of smog compared to those in Western countries.

The emerging rating systems for indoor air quality in public buildings and hotels is proof of this rising awareness. However, when it comes to regulations, building standards for heating, ventilation and air conditioning have only addressed the issue of energy efficiency – until now.

In recent years, new laws, regulations, and guidelines to govern indoor air quality in workplaces have been created – and regulators are introducing more. The WHO has issued guidelines as a template for regulation, and the EU is moving to develop laws for indoor air similar in scale to those for outdoor pollution. But these regulations vary from country to country and only concern employers or public authorities.

Some countries are introducing laws and eco-labels that regulate VOC emissions for products like furniture, building materials, electrical appliances and IT equipment. Regarding the regulatory aspect of health, well-being and productivity, we are at the beginning of a new era. This also concerns technological possibilities, which are constantly evolving from expensive instruments to accessible consumer devices. Thanks to affordable and continuous air quality measurements, expensive single-shot measurements by an IAQ specialist are becoming obsolete. Intelligent solutions connected to the Internet of Things will soon become standard for many people in digitalized countries. Not only will public buildings be equipped with technologies that provide data-driven insights to tenants, employees or guests, but private apartments and houses will employ these solutions in the near future too.

Source: Carbon Lighthouse Study

> Soon, building owners must not only ensure their buildings can adequately manage IAQ and implement the appropriate measures, but they will also have to communicate their efforts and resulting impact.

Important guidelines

The WHO Guidelines for Indoor Air Quality aim to protect public health from harmful pollution present in indoor air. For each substance, a chapter offers a general description, the sources and pathways of exposure, the indoor-outdoor relationship, kinetics and metabolism, the health effects, a health risk evaluation and guidelines for prevention.

The WELL Building Standard™ establishes requirements in buildings that promote clean air and reduce or minimize the sources of indoor air pollution.

The RESET Air Standard defines the requirements for collecting indoor air quality data via continuous monitoring of an interior space or building, with the goal of providing standardized indoor air quality data that is trusted, actionable, and relevant. Among other factors, it takes into consideration calibration requirements, data reporting and data platform requirements.

The Clean Air Act requires the US Environmental Protection Agency to set National Ambient Air Quality Standards (NAAQS) for lead (Pb) and five other harmful pollutants to public health and the environment (ozone, particulate matter, nitrogen oxides, carbon monoxide, and sulfur dioxide).

Several other indoor air standards regarding products intended for indoor use like the Greenguard Certification ensure that products meet standards for low emissions of volatile organic compounds (VOCs) into indoor air.

Simply measure it

As a leading manufacturer of environmental sensors, Sensirion offers a comprehensive portfolio of miniaturized solutions for measuring fine dust, carbon dioxide, nitrogen oxide, ozone, VOCs, pollen, aerosols, formaldehyde, and other pollutants. Our connected sensors are integrated into air purifiers, air conditioning systems, fume hoods, air humidifiers and dehumidifiers as well as into indoor air quality monitors, thermostats, cars and mobile phones.

For maximum comfort at home, it is recommended to not only measure temperature (T), humidity (RH) and carbon dioxide (CO_2), but also volatile organic compounds (VOCs) such as mold emissions, fine dust (penetrating from outside to inside) and formaldehyde (HCHO). The filter used for this can be monitored with a differential pressure sensor. For an employer, on the other hand, it is advisable to measure carbon dioxide in addition to temperature and humidity, since high CO_2 concentrations are associated with a higher risk of viral infections and lower work force productivity.

Our market-leading environmental sensor solutions enable precise monitoring and continuous control of your indoor air quality. In combination with a smart ventilation system, air purifiers, air quality monitors and manual ventilation routines, you will immediately improve air quality, well-being and productivity and reduce the risk of viral infection.

Dangers in indoor air

Due to high levels of humidity, ozone, smog or pollen, some people do not go out on certain days. But even at home or in the office, they are not protected from health risks. Depending on the location, the most polluted air we breathe can be indoors. Why? Because enclosed areas trap air pollutants. Indoor air might already contain dust, mold, germs, and chemicals. In addition, air pollution is caused by every day activities such as cooking, cleaning, using perfume or hair spray, burning candles or smoking. Once polluted air from outside is added, which penetrates the home through open windows or ventilation, the result is a cocktail of toxins floating around.

Since the mid-1970s, there have been increasing reports of health problems associated with being indoors – known as Sick Building Syndrome (SBS). Sufferers complain of eye, nose, respiratory, and oc casionally skin irritations, as well as general symptoms such as headaches, fatigue, malaise, dizziness, and difficulty concentrating. After leaving the affected building, the symptoms subside. Given that people spend around 80 to 90 percent of their time in enclosed spaces, measuring and controlling indoor air quality is the key to improving well-being and health.

Carbon dioxide is a trace gas. However, most of it is released by burning resources that contain carbon. CO_2 is a source of food for the flora that absorbs it and uses photosynthesis to produce oxygen. We (and animals) breathe in oxygen and exhale CO_2. Thus, in closed spaces, it correlates with human activity and occupancy. High concentrations may cause headaches, drowsiness, lethargy and poor performance.

Carbon monoxide is produced, among other things, during the incomplete combustion of carbonaceous substances. The main sources of carbon monoxide indoors are leaky stoves, tobacco smoking and indoor stoves without a vent (ethanol stoves), and also other combustion processes. Symptoms of mild poisoning include headaches, dizziness and flu-like symptoms. Higher doses have a significant toxic effect on the central nervous system and the heart.

Nitrogen oxides are produced by the combustion of fossil fuels and help create particle pollution. Cooking with gas stoves or polluted outdoor air entering from busy roads affect indoor air quality. However, nitrogen oxides are also produced due to natural atmospheric processes. Nitrogen oxides – especially nitrogen dioxide –

irritate and damage the respiratory system. Elevated concentrations in the air we breathe have a negative effect on lung function.

Formaldehyde is a gas with a strong odor and is typically found in new or renovated living spaces. It can be present as an adhesive component or solvent in wood-based materials, floorings or paints, such as building products and furniture. Higher concentrations in the indoor air have an irritating effect on the eyes and can even cause cancer.

VOCs (Volatile organic compounds) is the collective term for carbon-containing substances that evaporate at room temperature or higher. Volatile organic compounds are generated from very different sources and are in many ways not precisely defined. VOCs are emitted by living beings, natural sources, chemicals or combustion processes. Short-term exposure can contribute to eye, nose, and throat irritation, headaches, dizziness or worsening of asthma. Long-term exposure can lead to lung cancer, or damage to the liver, kidneys, or central nervous system.

Radon is a colorless, tasteless gas that forms naturally and can reside at dangerous levels inside buildings. Uranium in soil breaks down to form radium, which then turns into radon gas. Once formed, radon enters a home through cracks in the walls, basement floors, foundations and other openings. As radon decays, it releases radioactive byproducts that are inhaled and can cause lung cancer.

Ozone is a trace gas with a characteristic odor. The ozone layer protects humans and animals from damage caused by ultraviolet radiation from the sun. However, emissions from road traffic also indirectly form ozone, which can enter into buildings through windows and ventilation systems. Ozone is harmful to health even in low concentrations. It can cause irritation of the respiratory tract and the eyes, and promote respiratory diseases.

Particulate matter of different kinds like dust, fine dust, dust mites, molds or pollen can lead to allergic reactions and respiratory diseases. Besides other exhaust gases, particulate matter that is associated with insufficiently detoxified car engines is suspected of damaging the lungs, heart and blood vessels.

Temperature and humidity can affect our daily performance. Humans are most comfortable in the humidity range 40-60 % RH. While dry air irritates the respiratory tract, humid air leads to condensation, which in turn can be a trigger for mold infestation. Temperature and humidity can result in headaches or even migraines, especially for individuals who are vulnerable to weather conditions.

Source: Veolia Study

> In poorly ventilated homes, particulate concentration in smoke from domestic cooking can reach levels 100 times higher than acceptable limits

Source: Sensirion

> From dust to formaldehyde to VOCs invisible elements and fine particles in flats, houses and offices can lead to short- or long-term health problems.

Fine dust, molds and pollen

Whether outdoors or indoors, dust is found everywhere. Natural sources like plants, molds, sea spray, and forest fires emit dust. Wind erosion, for example, is quite common – desert sand transported by the wind, even over thousands of kilometers, is also considered dust.

While plant pollen can cause relatively harmless allergies, microorganisms like fungal spores can pose serious health risks: they can irritate the eyes, respiratory tract and skin. An irritation of the respiratory tract can lead to chronic bronchitis or asthma, and allergies can develop. Molds are particularly dangerous for people with weakened immune systems, as they can trigger infections.

Human-caused dust from combustion processes, mainly as ultra-fine and fine particles with diameters below 0.3 micrometers, is particularly dangerous to health. Tobacco smoke, wood-burning emissions and gases produced by cooking food emit fine dust as well. Asbestos and microplastics are also considered fine dust. Fine dust particles – PM2.5 – are only partially blocked by the nose and penetrate deep into our lungs. Depending on the source they come from, these can vary from symptoms like cough or asthma to serious illnesses like heart attacks, lung cancer and other respiratory diseases.

Dust mites

Mites are one of the most common cause of allergies and are found in homes all over the world. They love warm, humid climates and multiply during the warm season. Their life span is between 60 and 150 days, during which they excrete about 200 times their weight in dung. When this dries, it releases pollutants.

When the heating is switched on and the humidity decreases, many animals die and end up in our house dust. The heating whirls up the dust, the mite allergens combine with the air we breathe and get onto the mucous membranes of our eyes and nose, onto our skin and are inhaled. One gram of house dust contains up to 100,000 of the small eight-legged arachnids or their highly allergenic excrement pellets.

People who are allergic to dust mites particularly suffer during the cold season, when we spend more time indoors. Since the highest concentration of mite allergens is found in bed, allergy sufferers complain of the most severe discomfort at night and in the morning. Sneezing attacks, a blocked or runny nose, itchy, watery eyes, itchy skin rashes or breathing difficulties are the consequences of an allergic reaction. Dust mites can trigger asthma and allergic reactions like dermatitis and rhinitis.

Volatile organic compounds – VOCs

All living things – humans, animals, plants, microorganisms – emit organic compounds into the environment. Natural sources include animal hair and dander, substances from plant metabolism, decay and degradation processes as well as methane from swamps. Methane emissions from wet rice cultivation and cattle farming also constitute a significant source.

Man-made releases of volatile organic compounds are dominated by emissions of ozone-depleting and highly climate-warming refrigerants as well as substances generated by incomplete combustion, especially motor vehicle exhaust gases. A famous VOC is formaldehyde, a colorless and flammable gas that is used in chemical manufacturing processes as a preservative. It is used in paints, wood, laminate flooring and other materials. At high concentrations, formaldehyde vapors can cause cancer and respiratory diseases. VOCs are found in the atmosphere, groundwater and inside buildings and houses. Possible sources include residual solvents in plastics, building materials, furniture, carpets and decorative materials, cleaning products, paints, varnishes (lacquer), adhesives, auxiliaries such as plasticizers and fragrances, or flame retardants. However, cosmetic products like nail varnish or hair spray can also emit VOCs, as can tobacco smoke or cooking food.

Volatile organic compounds can cause odor nuisance, irritation, and other symptoms not directly attributable to diseases. As a consequence, many Western countries have now introduced laws and eco-labels requiring products intended for indoor use, such as furniture and fixtures, building materials, household electrical appliances and IT equipment, to first pass VOC emission tests before they can enter the market. For example, the Greenguard Certification (US) or the Blauer Engel label (GER) ensure that products meet standards for low VOC emissions.

Indoor sources of VOCs

- Paint, varnishes, caulks, adhesives
- Carpet, vinyl flooring
- Composite wood products
- Upholstery and foam
- Air fresheners, cleaning products
- Cosmetics
- Fuel oil, gasoline
- Smoking, burning wood
- Dry cleaning, photocopiers
- Cooking

Microplastics, pesticides and asbestos

Skin creams, peeling treatments, toothpastes, shower gels and shampoos all contain small plastic particles that pose risks to the environment and bodies of water. Microplastics of different kinds can also be released from building and furnishing materials, paints, solvents and detergents. However, today the main source of microplastics in the air is road traffic. Tires, brake pads, and road markings are made of plastics, among other things, which are rubbed off and stirred up in the air. Technically speaking, microplastics are small plastic particles with a diameter less than 5 millimeters.

Asbestos refers to a group of naturally occurring, fibrous minerals. The material was once widely used in building supplies and other consumer products. Research shows that asbestos fibers can cause major breathing problems and lung cancer. Old and brittle asbestos products can release tiny, even microscopic, fibers. These airborne fibers can remain suspended in the air and enter the lungs when inhaling. Like microplastics, asbestos is considered a fine dust.

New studies have shown that fertilizers and pesticides are not only found in soil, groundwater, and food, but also in the air. They not only can penetrate into homes near crop fields through open windows, but also can be transported over hundreds of kilometers by the wind.

> The use of CO_2 monitors serves as a rough measure of whether ventilation is adequate or not. As virus-carrying aerosols are exhaled, so too is CO_2. And when ventilation is poor, CO_2 accumulates along with the virus.

Source: Nature – "Why Indoor Spaces are Still Prime Covid Hotspots"

Bacteria and viruses

Most germs are harmless to humans. Only some of them are microorganisms or subcellular pathogens that cause harmful processes in other organisms. The pathogens that play a role in our daily lives and cause infections are bacteria and viruses.

Wherever people meet, they spread bacteria and viruses: at home, in the workplace, in schools, day-care centers, universities, hotels, shops and public transport. The SARS-CoV-2 pandemic, or more specifically the basic measures that need to be taken to avoid a COVID-19 infection, has revealed that we have neglected indoor air quality – and with it our well-being. It is incomprehensible how we simply accepted easily preventable colds before the pandemic.

A growing body of research indicates a link between COVID-19 cases and low humidity or poor indoor air quality. In addition, high CO_2 concentrations are associated with viral infections. The higher the percentage of CO_2 in a closed space, the higher the risk of inhaling aerosols that another person in there has exhaled before. The CO_2 concentration thus allows an indirect measurement of possible exposure to viral aerosols.

According to the Nature journal, COVID-19 infections spread most commonly through indoor air. It is rare for SARS-CoV-2 to pass from one person to another through contaminated surfaces. Since standard ventilation is mostly not good enough to reduce airborne transmission, it is necessary to improve ventilation in public buildings like schools, museums and offices.

The basis of a healthy life

Although children naturally build up internal defense mechanisms, there are dangers to which they must not be exposed. A crucial one is air pollution: children are more vulnerable to air pollution than adults, because their bodies do not yet have the protective mechanisms of an adult. In addition to that, they are physically more active, which means that they breathe faster and inhale more pollutants into still smaller lungs.

As far as the physical and mental development of a child is concerned, the first two years are particularly important. Especially during this period, the immune system and the brain are developing fast. So it is obvious that children grow up and learn better when they are surrounded by clean air. Breathing clean air makes it easier for them to concentrate, to think clearly and to process information and impressions. It is assumed that bacterial and viral infections, for example, can also temporarily hinder the development of a child. Those little ones who are constantly sick might be at a disadvantage. Therefore, it is essential to provide children clean air at home, daycare, kindergarten and school.

Parents all over the world are attaching more and more importance to the fact that children need to breathe clean air. Avoiding busy roads, banning chemicals from the home and buying certified furniture or toys is no longer considered to be over-cautious behavior. In some regions, air purifiers are gaining importance in family households. However, the awareness varies from country to country. In European cities, for example, the issue has not yet penetrated sufficiently: bicycles with child trailers positioning the child's head at exhaust level still are popular.

Source: UNICEF

> Children's exposure levels to toxicants and pollutants are much higher than adults as they have faster metabolic rates, proportionally consume more water and food and breathe more air.

Children's sleep

Regeneration during sleep is enormously important for children. It has to be considered that air pollution can impact their sleep quality and with this most probably also their development. Continuous non-recovery might increase the risk of a child suffering from asthma and pneumonia, which are the most common childhood respiratory diseases.

Where clean air is essential

At home

Despite the evolution from caveman to urban man, home is still our preferred retreat to close ourselves off from the outside world. It is the preferred place to make ourselves comfortable, relax and sleep. At the same time, we want our home to be inviting as possible when hosting family, friends and colleagues. Parents are increasingly recognizing the importance of clean air and are choosing to live in neighborhoods that have this. Since increasing numbers of people are now working – at least part of the time – from home, clean air within our four walls is gaining even more importance. Thanks to new smart solutions, indoor air quality can be optimized easily. Affordable consumer devices with multiple sensors enable air to be monitored, controlled as well as purified, making homes an even better place to spend time in.

In the UK, India, China, and South Korea, for example, many people already use air purifiers to ensure clean air in their homes. This occurs mostly at places where outdoor air pollution finds its way indoors through open windows or ventilation systems. In particular, people want to get rid of outdoor pollutants such as soot, car exhausts and pollen. However, often they do not realize that indoor air quality also can be worsened by existing chemicals from paint, textiles and cleaning products as well as cooking odors, or dust mites.

Improving optimal sleep quality

Home is the place where we sleep. Besides silence and lower temperatures, clean air can also improve sleep quality. Our physical and mental fitness requires deep sleep. Poor sleep leads to unease and can affect the immune system as well as increase the risk of diseases, especially in the long term.

In brand-new facilities

The smart building is no longer a future scenario. In fact, smart homes and other smart buildings can contribute to healthy living by managing indoor air quality. However, modern buildings are often too air-tight and lack sufficient ventilation. Thus, it is important to leave behind architectural concepts that have neglected indoor air quality because of the focus on energy efficiency.

But technological innovation demonstrates that one does not have to exclude the other. Demand-driven solutions allow air to be ventilated or purified only when needed in order to meet energy requirements and keep operating costs low. There is a large potential to be unleashed if the building-led approach of the last decades is replaced by smart, user-centered solutions. Properties are becoming more appealing for tenants and forming the basis for a higher productivity, which is also increasing their return of investment.

Today, systems that monitor indoor air quality can be installed and put in operation rapidly. Offering wireless communication and APIs, the reported information can be accessed remotely and be used in overall systems addressing heating, ventilation and air conditioning (HVAC).

At the workplace

Since we are at work for around one-third of the day, it makes sense to care about indoor air quality at the workplace. This particularly applies to employers: clean air in the office leads to clear thinking, better decision-making and less absences, resulting in higher productivity. Besides humidity and temperature, also air pollutants like CO_2, VOCs and particles can affect performance and well-being in the office. Moreover, as the measures against the COVID-19 pandemic showed, bacterial and viral infections can easily be reduced by following simple safety instructions. In other words: sick employees should stay away from healthy ones. A lot of people worry about the air quality in the office, because they do not have the possibilities to act against possibly polluted air. Commonly known problems are poor ventilation, windows that cannot be opened or printers standing too close to employees. In point of fact, all over the world there is a lack of regulations that forces companies to guarantee clean indoor air.

Optimizing the return on investment

Today, indoor air quality has become a performance indicator. For companies using multi-floor buildings, it is recommended to install an effective solution to monitor, regulate and ventilate or purify indoor air. This means that building owners and real estate providers need to discuss new equipment standards, which in turn brings a good return on investment. In brief: indoor air quality monitoring helps to create a better environment for businesses and allows cost savings in the long term.

“ Source: The Harvard Gazette

A Harvard University study from 2017 found that people working in “green” buildings with better ventilation had higher cognitive function, fewer symptoms of sickness and better sleep quality.

On the road

Exhaust emissions like NO_x as well as particulate matter from tire wear, dust swirl and brake pads can enter the driver cabin. In addition to that, a wide variety of other pollutants are already present inside cars: concentrations of chemicals emitted from components like the dashboard, interior panels, seat coverings, or flooring materials. Especially in new car cabins, VOCs are emitted by a wide array of materials, including natural or artificial leather, adhesives, paints, and plastics.

Concentrations of toxic pollutants are very high in urban areas, particularly near major roads and freeways. In many countries, on-road vehicles are the primary source of air pollution. Their emissions are transported from areas with very high concentrations to surrounding local environments. They can infiltrate both personal and public-transport vehicles, thereby increasing the exposure of passengers.

Subway systems can play a pivotal role in reducing outdoor air pollution in large cities by helping to reduce motor-vehicle use. However, in response to increasing scientific and public awareness regarding the importance of clean air, several studies have revealed unacceptably high levels of particulate matter in some subway systems. These dominantly iron-containing particles are sourced from rails, wheels, brake pads, as well as dust swirl.

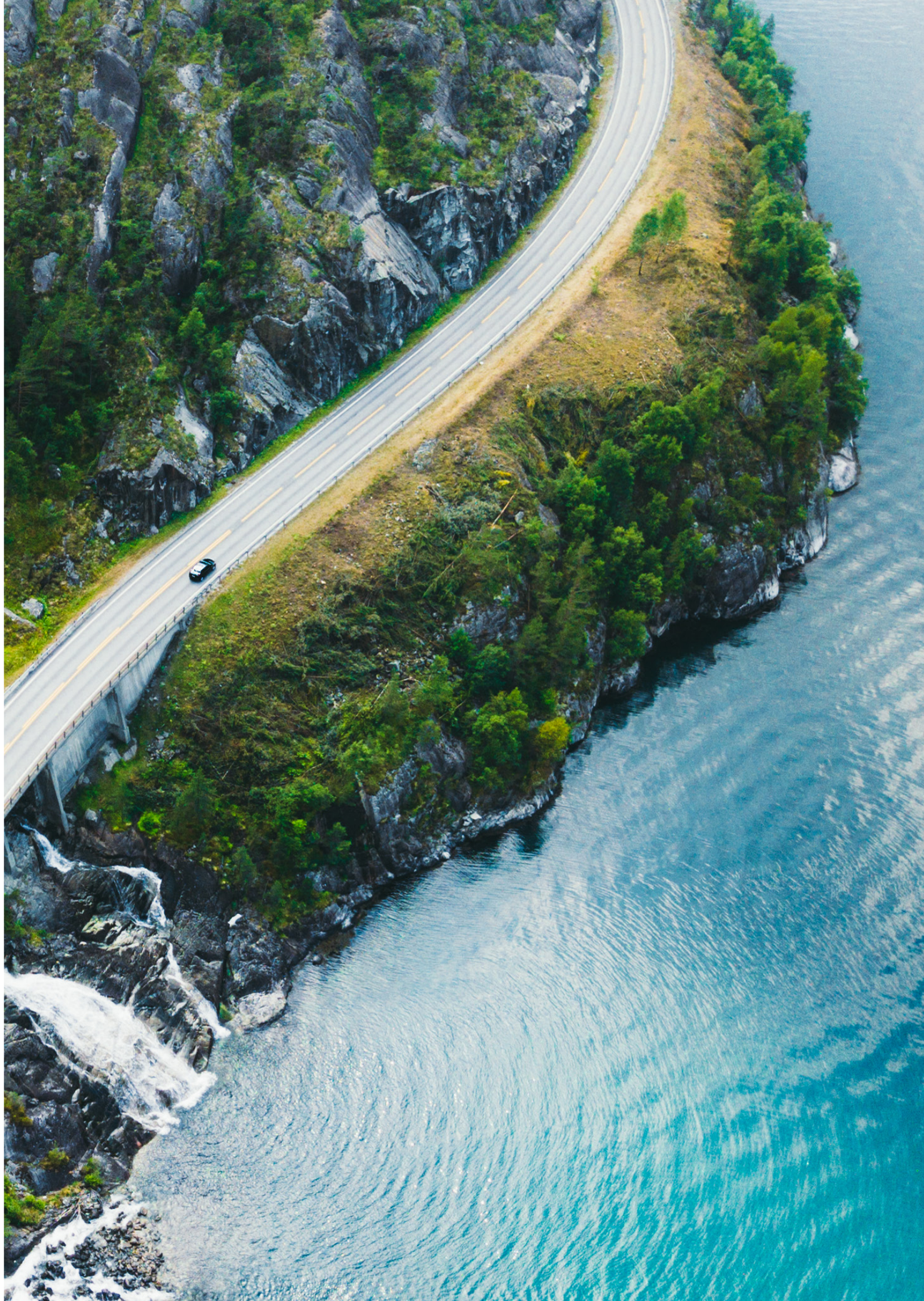
Whereas airplane pilots and locomotive drivers are provided with clean air in the cockpit, the situation of passengers looks quite different. Trains and airplanes are affected from outdoor air pollution and their own engine emissions. Additionally, they represent a hotspot for all kinds of bacteria and viruses. Ventilation systems in planes can be particularly affected by them, because the constant temperature changes provide the perfect conditions for germs.

However, the use and thus the exposure to air pollution in transport vehicles strongly depends on the level of air monitoring and control. The impact of the pandemic forced public transport operators to come up with new solutions regarding interior air quality in order to make traveling attractive for commuters once again.

Average time in the car

According to a study by the Harvard Health Watch, the average American citizen spends 101 minutes per day driving. That means that in a lifetime, they spend a whopping 37,935 hours driving a car (assuming that they start driving at 17 and drive until 78.7 years old). In that time, they will drive around 798,000 miles (1,284,256 kilometers), which is approximately the distance it takes to drive to the moon more than three times!

In addition, with 37,935 hours, we have spent an average of about 4.3 years of our lives behind the wheel. While driving, we are fully exposed to the air quality in the car. Thus, it is indisputable that the air quality in your car is very important and strongly influences our health and well-being.



In public buildings

Depending on their age and their job, human beings might spend a lot of time in public buildings. Clean air is important for them for different reasons: children in day-care centers, kindergartens and schools, as well as adolescents in universities, develop, learn and study better. The elderly in retirement homes, who are more likely to be suffering from diseases and having a weakened immune system, are more protected against respiratory illnesses. And people with responsibility such as doctors in hospitals need clean air to focus on their challenging tasks.

With COVID-19, feeling safe from infection in all public spaces has become a major issue. However, we also desire clean air as a comfort factor, for example in shops, train stations and hotels. Restaurants, for example, represent a special case because we want clean air to enjoy food. We choose restaurants with good air – at least with regard to its scent – because eating tastes better with clean air. Again, the situation is different for gyms, where people demand clean air because they breathe intensively when exercising.

The situation in …

Educational institutions > Whether in day-care centers, kindergartens, schools or universities, improving indoor air quality in classrooms increases the ability to concentrate and enables better processing of information. Clean air also reduces school absences due to respiratory infections or other sickness. With the COVID-19 pandemic, many educational institutions have begun with installing air purifiers.

Hospitals > Ventilation systems are used in operating rooms and must meet strict requirements; for example, their filters must be replaced on a regular basis. Measuring CO_2 levels could be beneficial here, as they indicate air usage (a high CO_2 value corresponds to a high proportion of air that has been used and contains various aerosols). Importantly, the risk of infection in the hospital should be kept low, which unfortunately is not the case today.

Restaurants > Ventilation systems are used to absorb cooking odors and gases emitting from frying oil. Establishments apply hygiene measures such as dusting and cleaning surfaces regularly in order to offer comfort and to avoid bacterial and viral infection. However, the use of toxic cleaning chemicals is a problem. In some countries even smoking in restaurants is still allowed.

Hotels > As many hotels lack satisfactory ventilation systems, they are introducing air purifiers as a value-added service in guest rooms, gyms and dining areas. These measures are mainly employed in order to optimize comfort – some larger hotels even scent the ventilated air to make guests feel at ease (hopefully without spreading chemicals). However, since rooms must be equipped with smoke detectors anyway, additional sensor technology to monitor indoor air quality could be easily integrated.

Gyms > Gyms have a high throughput of people. Due to heavy, deep breathing from exercising (people exhale CO_2 and aerosols), there is an increased risk of contracting a viral or bacterial infection as well as air pollution in these facilities. This is at odds with the fact that we visit gyms because we want to improve our health. In this regard, it must be considered that our physical performance is enhanced with clean indoor air.

How to improve air quality at home

While homes in rural areas tend to be surrounded by cleaner air, larger cities tend to have more polluted air. But most people are not aware of the fact that indoor air quality does not necessarily correspond to this image. In the first place, affected people need to be educated and made aware of the health risks caused by polluted indoor air.

Today, it is easy to measure and manage indoor air quality. Pollution sources can be identified and made less harmful. In some cases, a change of habits like opening the windows regularly might be enough to enjoy improvements. However, such actions do not improve the situation, the purification of indoor air is the obvious solution.

Basic measures

- **Ventilate regularly** (the easiest and most effective way, depending on the outdoor air quality level)
- **Use an air purifier or air conditioner** to filter pollutants (and change the filter regularly)
- **Install smart home devices** to monitor indoor air quality

Additional measures

- Dust and vacuum regularly
- Buy green products that do not emit VOCs
- Use the fume hood in the kitchen and make sure that it is working appropriately
- Use a bathroom exhaust fan
- Make sure that gases from the fireplace are extracted well and do not enter the room
- Do not smoke indoors
- For people allergic to dust mites:
  Take action to minimize growth like reducing places where they grow, dust regularly, wash bedding regularly in hot water, and reduce humidity below 50 percent
- In case of possible radon sources, check the emitting values
- In case the property is newly constructed or refurbished, check that new construction materials do not emit substances like formaldehyde or VOCs

Polluted indoor air: what to do?

Put simply, there are two ways: ventilation and purification. Ventilation by opening windows is the best option for homes or small closed spaces if the surrounding outdoor air is clean. If the location shows polluted outdoor air, it is recommended to purify indoor air. For larger buildings with a ventilation or air conditioning system, it makes sense to check that it works well. Measuring indoor air quality provides data that, ideally, would be used to configure the air purifying system.

monitor IAQ → gather IAQ data → understand IAQ data → ventilate / purify indoor air

Measuring IAQ data

As mentioned above, it is highly advisable to measure indoor air quality. The ideal scenario to get an overall picture is to compile environmental, metrological and medical data: environmental data regarding indoor air quality by means of smart sensors, metrological data concerning temperature and humidity and health data in the form of sicknesses (as an additional retrospective indicator). If data from these three sources are compared, it might be possible to identify more precisely the circumstances in which indoor air quality worsens in specific situations, thereby providing a solid basis from which it can be optimized.

Cutting-edge monitoring technology rapidly generates reports and insights about indoor air quality. Such smart building equipment serves as an essential basis for the improvement of health and well-being of users. It can boost productivity as well as the property value. Of course, cloud-connected remote monitoring and visualized dashboards also enhance usability for users as well as tenants, owners or real estate companies.

Connected sensors

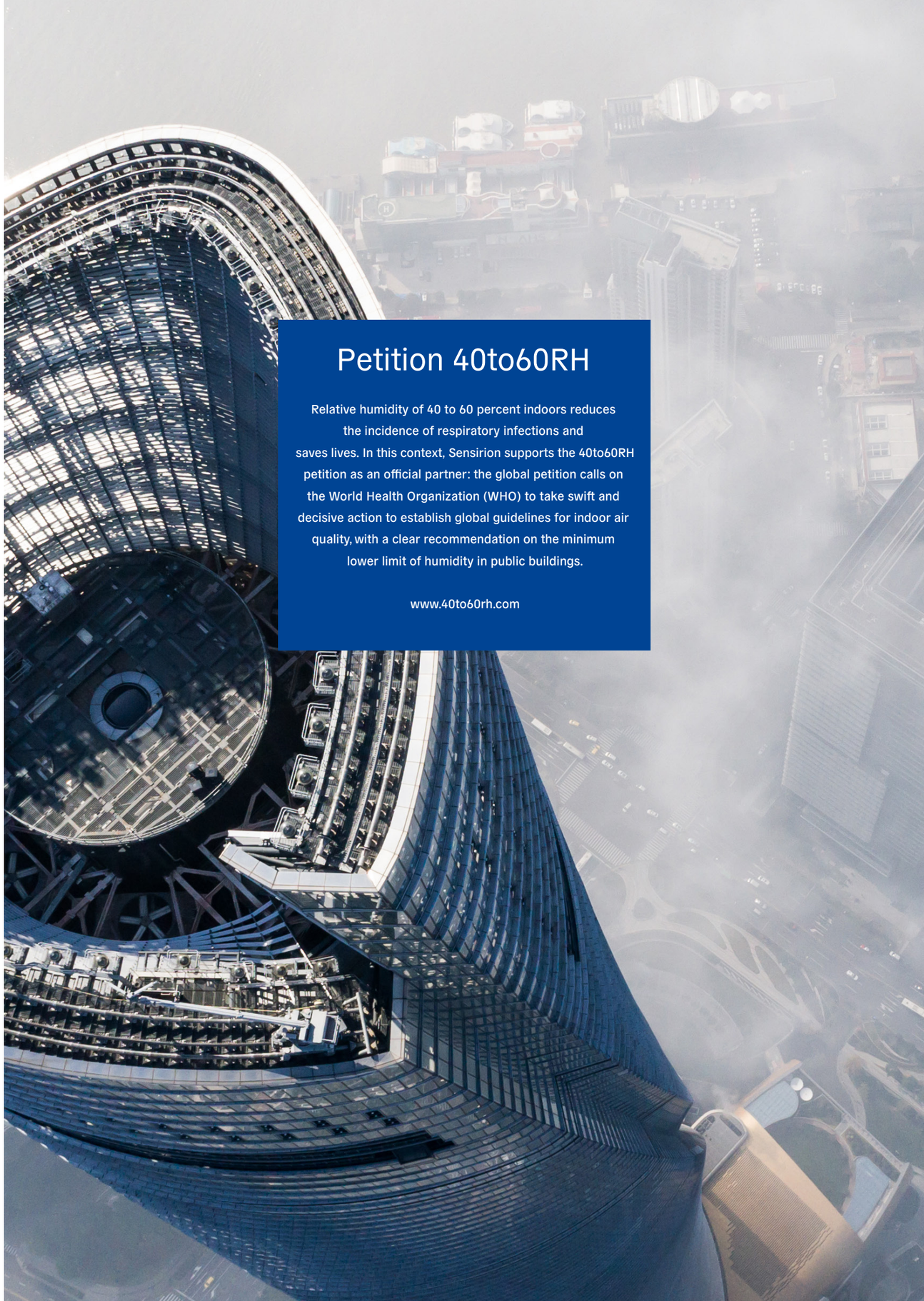
In a smart building, digitized sensors are mini heroes. Miniaturized, connected sensors of different kinds provide invaluable information that can be used to discover insights. Based on these, it is possible to identify immediate action to be taken. Today, indoor air quality monitors collect information about pollutants like formaldehyde, CO_2, VOCs, temperature, humidity and particulate matter – all factors, that might affect the performance and health of building users. The key to finding healthy building solutions is the reliability of the sensor data.

New rules and regulations

In many cases, architects are so busy with regulations and design aspects that they have neglected health aspects. As a result of this, modern buildings often show insufficient ventilation systems in terms of their design and operation. As a new standard feature, emerging monitoring systems can provide comprehensive data about indoor air quality. This will enable new insights to emerge that will help to guide the formation of new rules about building design and operation as well as new regulations about indoor air quality. The goal: implementing healthy building solutions without sacrificing on energy efficiency.

Air purifiers: no longer a luxury

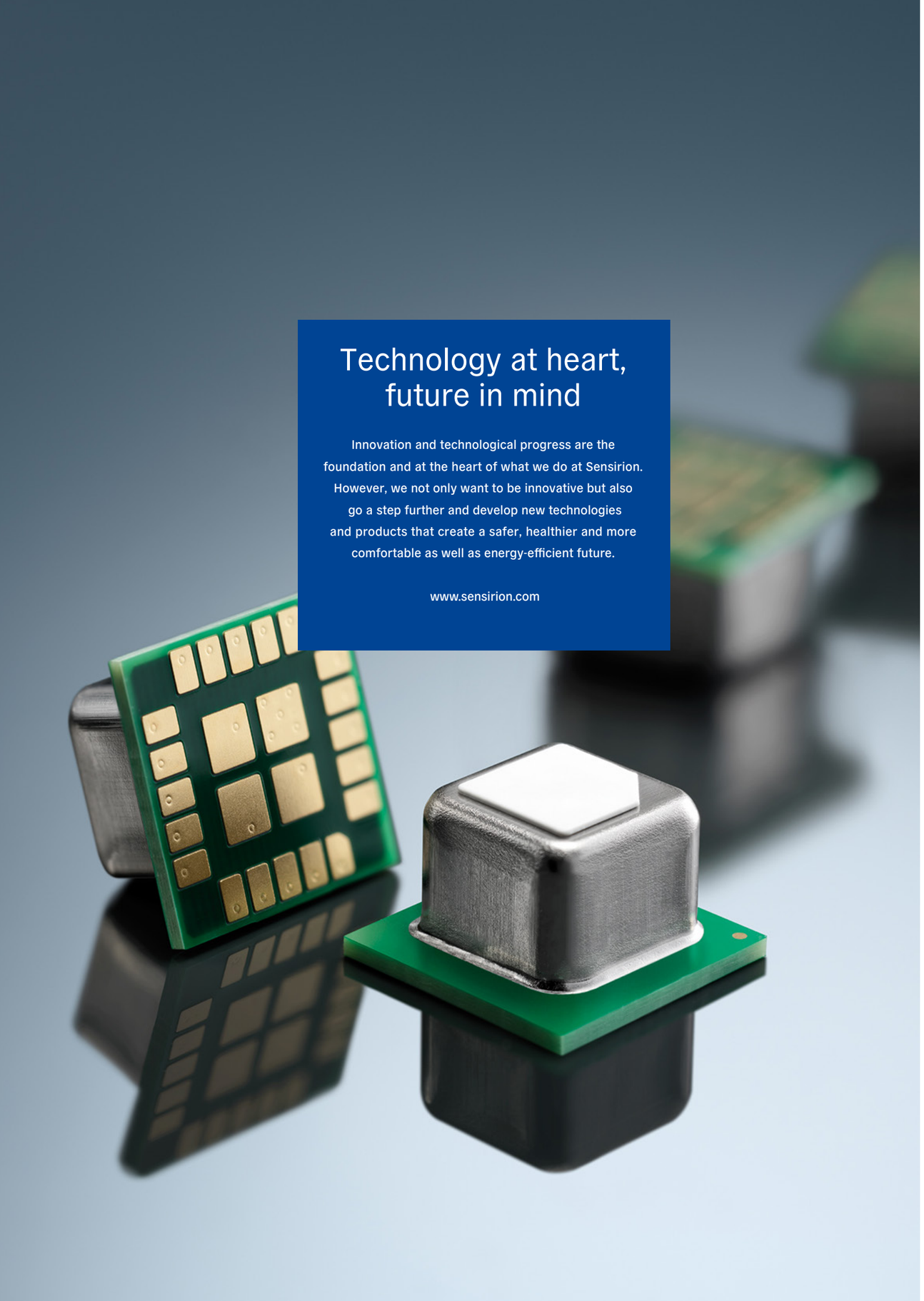
Wherever they are used, people benefit. The use of air purifiers can help to reduce exposure to common household pollutants like dust, cooking odors, or toxic chemicals as well as penetrating pollution from outdoors such as exhaust gases or pollen. In particular, air purifiers are helpful to people suffering from asthma or allergies. Even more important are high-performing systems for larger buildings such as offices, hotels or public buildings because they additionally remove bacteria and viruses from the air. Thus, the risk of picking up coughs and colds can be minimized, which is an advantage for working environments, hospitals or public transport.



Petition 40to60RH

Relative humidity of 40 to 60 percent indoors reduces the incidence of respiratory infections and saves lives. In this context, Sensirion supports the 40to60RH petition as an official partner: the global petition calls on the World Health Organization (WHO) to take swift and decisive action to establish global guidelines for indoor air quality, with a clear recommendation on the minimum lower limit of humidity in public buildings.

www.40to60rh.com



Technology at heart, future in mind

Innovation and technological progress are the foundation and at the heart of what we do at Sensirion. However, we not only want to be innovative but also go a step further and develop new technologies and products that create a safer, healthier and more comfortable as well as energy-efficient future.

www.sensirion.com

Sensirion environmental sensors

Each one specializes in something different and is ingenious in its own way: Sensirion's miniaturized environmental sensors are able to detect all kinds of pollution indicators to provide a complete picture of the indoor air quality situation. The sensors help to underline the need for a collective approach to the challenge of indoor air pollution.

Sensirion offers reliable and innovative solutions for comprehensive management of indoor air quality to be implemented in public or private spaces. These smart solutions are characterized by their high ease of use and digital connection in order to allow the information to be shared and presented visually.

Humidity & temperature sensor

When it comes to humidity and temperature sensing, Sensirion defined the market standard with its SHT sensor series 20 years ago. The industry-proven SHT4x humidity and temperature sensor series offers best-in-class performance and reliability and is offered with various accessories and variations to fulfill every customer's sensing needs.

Carbon dioxide sensor

Sensirion has a proven track record in CO_2 sensing. The SCD30 CO_2 sensor is a reliable dual-channel CO_2 sensor, perfectly suited for the most demanding applications. With the SCD4x, Sensirion breaks the size barrier in CO_2 sensing, offering a new miniaturized CO_2 sensor with SMD compatibility that enables space-saving integration with maximum design freedom. The integrated humidity and temperature sensor offers excellent on-chip signal compensation as well as additional relative humidity and temperature outputs.

PM2.5 sensor

The MCERTS-certified SPS30 particulate matter (PM) sensor represents a technological breakthrough in optical PM sensors. The measurement principle is based on laser scattering and uses Sensirion's innovative pollution resistance technology. Together with high-quality and durable components, this sensor enables precise measurements throughout its the entire service life.

Formaldehyde sensor

Based on Sensirion's electrochemical technology, the SFA30 offers excellent performance for formaldehyde measurements with a uniquely low cross-sensitivity to other VOCs. The module's integrated SHT sensor provides accurate humidity and temperature readings and allows for fully temperature- and humidity-compensated as well as factory-calibrated formaldehyde concentration output in ppb.

VOC sensor

The SGP40 digital VOC sensor for the detection of volatile organic compounds is designed for easy integration into air purifiers or demand-controlled ventilation systems. In combination with Sensirion's powerful VOC algorithm, the sensor signal can be used directly to assess indoor air quality, for example to drive the stepwise fan control of an air handling unit.

Multi-gas sensor

The SGP41 measures indoor pollutants (VOCs) and typical outdoor pollutants such as ozone and NOx. The sensor has a multi-pixel approach, is fully factory calibrated and boasts long-term stability due to its siloxane resistance.

Environmental sensor node

The SEN5x Environmental Sensor Node is an all-in-one sensor solution for accurate measurement of particulate matter, volatile organic compounds (VOCs), outdoor gases (NO_x and O_3), humidity and temperature. Thanks to proprietary algorithms, the module enables straightforward, simple and cost-efficient integration into various applications.

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Source: OECD

The OECD found that between 2000 and 2015, the decline in particulate matter concentrations by about 20 percent could explain 15 percent of the total GDP growth in the European Union.

An initial study (preprint) from the Harvard T.H. Chan School of Public Health found that an increase of just 1µg/m³ in PM2.5 was associated with an 8% increase in COVID-19 death rates.

Source: World Health Organization (WHO)

Publisher
Sensirion AG
Laubisrütistrasse 50 · 8712 Stäfa · Switzerland
Phone +41 44 306 40 00 · info@sensirion.com
www.sensirion.com

Concept and editorial
Sensirion AG

Design and implementation
Sensirion AG

www.sensirion.com