

# White Paper

## *What is Fresh Air and is it Really Fresh?*

Covid-19 is a highly contagious disease and to mitigate the spread of the virus especially indoors, the common refrain is to make sure the space is well ventilated with fresh air. But what exactly is fresh air? Fresh air is typically defined as cool, unpolluted air in natural surroundings. But as there is no agreed parametric definition of what fresh air is, how can you determine if the air indoors is really fresh?

Although the World Health Organisation (WHO) has not formally confirmed that COVID-19 is spread by airborne transmission, it is probably only a matter of time as other similar viruses such as norovirus and the flu are acknowledged to be spread in this way. In the case of COVID-19, it is believed that ventilation plays an important part in reducing transmission by dilution and removal of infected particles and droplets.

Ventilation is the intentional introduction of fresh air into a space while the stale air is removed. It is done to maintain the quality of air in that space. According to The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), acceptable interior air quality is where there are no known harmful contaminants in harmful concentrations. But what constitutes harmful contaminants in harmful concentrations is left to individual States to define, such as the Title 14 California code of regulations, which stipulates for example maximum permissible levels of CO<sub>2</sub> in a building.

In the UK, there are guidelines such as the Building Regulations 2010 for manufacturers, architects and engineers involved with building design and services to assist in the process of reducing poor air quality and ensuring there is enough fresh air ventilation. The *Health and Safety at Work etc Act 1974* is the primary piece of *legislation* covering occupational *health and safety*. It states that employers have a duty of care to ensure there is a safe and healthy work environment. New and revised workplace exposure limits (WELs) came into force from January 2020 under the auspices of the Health and Safety Executive EH40/2005 containing a updated list of maximum exposure limits and occupational exposure standards for specific gases as required by the Control of Substances Hazardous to Health (COSHH) Regulations.

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However, there are currently no regulations on what constitutes 'good quality' indoor air. Although there have been calls on the Government to make measuring and monitoring of indoor air quality a legal requirement in commercial buildings and schools especially in urban locations, legislation has not yet been forthcoming.

The established benchmark test for indoor air quality is to assess CO<sub>2</sub> levels. Ignoring particulate matter, VOCs and other contaminants, it is generally understood that indoor CO<sub>2</sub> levels are a good proxy for the amount of pollutant dilution in densely occupied spaces and can therefore be used as a good indicator for fresh air.

So how do CO<sub>2</sub> levels equate to fresh air? The amount of carbon dioxide in a building is usually related to how much fresh air is being brought into the building. In general, the higher the concentration of carbon dioxide in the building in comparison to outdoors, the lower the amount of fresh air exchange. The background level of CO<sub>2</sub> outdoors is generally considered to be in the range of 350-450 parts per million (ppm). CO<sub>2</sub> is a by-product of normal human activity and is removed from the body via the lungs in the exhaled air. Unless an indoor space is adequately ventilated, CO<sub>2</sub> will naturally build up over time. CO<sub>2</sub> levels in a well managed indoor space are generally 350-1,000ppm. Above 1,000ppm and most people will begin to complain about the stuffy atmosphere or poor air quality. High levels of CO<sub>2</sub> indoors are also associated with headaches, sleepiness, poor concentration, and loss of attention and in extremely high concentrations, CO<sub>2</sub> is harmful to life due to oxygen deprivation.

CO<sub>2</sub> sensors along with temperature and humidity sensing are often used as part of automatic ventilation control systems. But what if the building or school does not have such a sophisticated environmental control setup?

Ample natural ventilation is considered to be the best method to prevent the Sars-CoV-2 virus from spreading indoors. The amount of fresh air that needs to be supplied is a matter of conjecture, but good practice is to ensure ventilation is capable of keeping CO<sub>2</sub> levels below 1,000 ppm or even lower. Assuming monitoring of CO<sub>2</sub> levels is a good proxy for fresh air, CO<sub>2</sub> sensors can be used to check if there is enough ventilation in the building and if not, to trigger a response. At its simplest, this can be as simple as setting a CO<sub>2</sub> alarm level to prompt opening a window in the room.

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Most high-performance ambient level CO<sub>2</sub> sensors use a measurement method called Non-dispersive *Infrared (NDIR)*, where the CO<sub>2</sub> level is determined using the Beer-Lambert law. Beer-Lambert's law states that the loss of light intensity when it propagates in a medium is directly proportional to intensity and path length. CO<sub>2</sub> molecules absorb infrared radiation at a wavelength of around 4.25 microns.

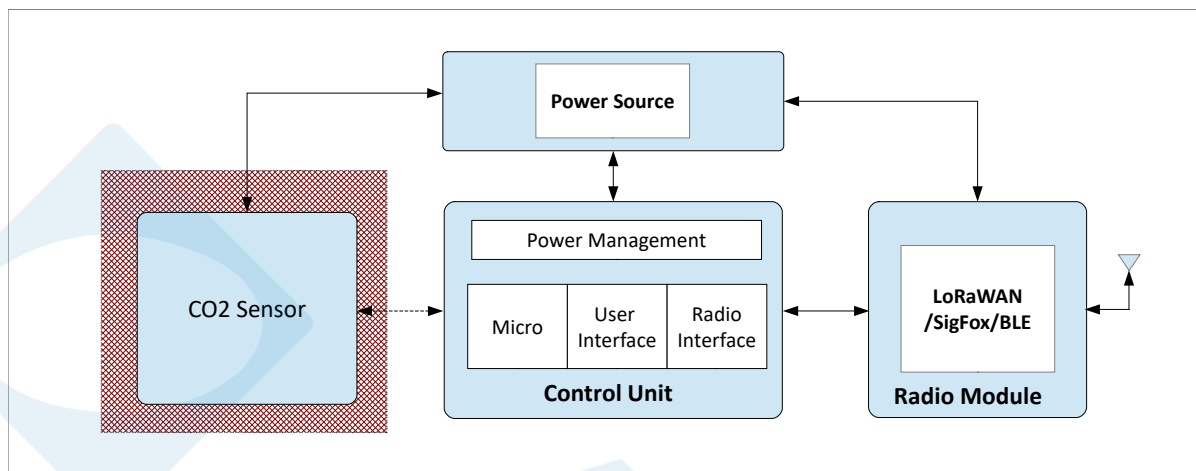
CO<sub>2</sub> monitoring systems often need to be installed in locations where access to mains power is limited, or its provision is costly. The ability to be able to power the CO<sub>2</sub> sensor for long periods of time from a battery or from energy generated using harvesting techniques is highly desirable. To reduce maintenance costs, users want the ability for the CO<sub>2</sub> sensor to operate autonomously for many years without user intervention.

Conventional CO<sub>2</sub> sensors use an incandescent light source. However, these mid-IR light sources consume lots of power during a lengthy warm-up phase and during operation, making them unattractive especially for retrospective installations, where there is often a lack of an easily accessible power source.

All GSS sensors use an in-house designed ultra-efficient LED light source. LEDs are much more efficient in converting electrical power into light than conventional light sources and they do not need the long warm up times suffered by incandescent light sources. The length of time the light source is active is a major contributor to how much power is consumed by the sensor. In a power sensitive application, a GSS CO<sub>2</sub> sensor is typically pulsed on and off to minimise overall power consumption.

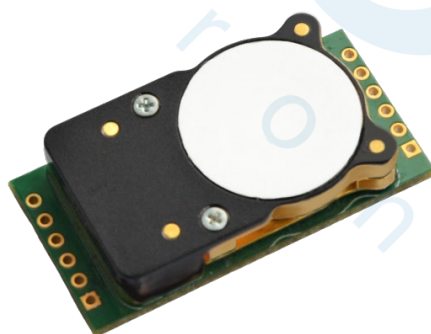
Depending on installation requirements, a CO<sub>2</sub> monitor can range from a simple display on the wall with a programmable alarm to sophisticated systems with wireless interfaces sending data up to the cloud.

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**Figure 1: Wireless CO<sub>2</sub> Sensor**

The latest GSS sensors such as the CozIR<sup>®</sup>-Blink are designed to operate in battery powered units so they can be easily installed and deployed. They are designed to be power cycled, where the whole device is powered down after a CO<sub>2</sub> reading has been made. A typical installation might be pre-programmed to take one reading every few minutes. Depending on the required CO<sub>2</sub> measurement accuracy, if the sensor is configured to take a reading every minute, the power consumed by the CozIR<sup>®</sup>-Blink can be as low as **26uW** per reading. Whilst obviously dependent on what other electronics are in the sensor, CO<sub>2</sub> monitors using the CozIR<sup>®</sup>-Blink are often designed to last for two or more years on a single battery charge.



**Figure 2: CozIR<sup>®</sup>-Blink CO<sub>2</sub> Sensor**

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All GSS sensors can also be pre-programmed to run an automated background 'reference-setting' routine where CO<sub>2</sub> levels are monitored over time. The reference value is the lowest concentration to which the sensor is exposed over an extended period such as a week and is typically considered to be the fresh air minimum ambient level. This scheme allows users to set an alarm threshold that is relative to a fresh air reference value, which takes account of changing outdoor ambient CO<sub>2</sub> levels. The sensor programmable alarm can easily be used to drive a "traffic light alert" indicating it is time to open the window

Ultra-low power sensors such as the CozIR®-Blink open-up new installation possibilities in a wide range of offices, workplaces and schools. Used correctly, this type of CO<sub>2</sub> sensor can be employed as a simple and cost-effective tool to help avoid catching the virus indoors.