Clean indoor air for health and sustainability

The term 'Indoor Air Quality' is much used but not always considered carefully. For people to live and work happily inside a building they should have a comfortable environment and as part of that the air should be at the optimum temperature, humidity and cleanliness to allow them to carry on with their daily activities efficiently. Air for people to breathe should be sufficiently clean for them to inhale without risk to health. New buildings need flexible and efficient air systems.

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Today there is an overriding need for people to breathe clean healthy air in both residential and commercial buildings. Many buildings may be located in polluted industrial city locations or maybe in relatively clean rural settings. There is an increasing trend for many people to work from remote locations or from their place of residence.

Buildings in use by people can also vary greatly in age, size, type of construction, the materials used, and also the air leakage rate of the building envelope. Other variables to be considered include location, building orientation and climate.

Even from the North to the South of the UK there are local climate variations and this is further emphasized if we consider the differences between climates in mainland European countries such as Spain, Portugal and Italy and compare them to the Nordic countries such as Norway and Sweden.

The central European countries share the bulk of the recent population growth and where there is a larger concentration of people and more industrial activity the problem of increased levels of air pollution will almost certainly result.

There are many types of air pollution particle as the chart shows and they are spread over many different sizes. The particles that can most easily penetrate into the lungs are those below 2.5 microns in diameter they consist of a mixture of toxic traffic emissions and also bio-particles such as airborne spores, pollen, bacteria and virus that can cause allergic reaction, asthma, disease and infection.

Studies such as the US six cities survey and the more recent studies at University of Edinburgh by Anil Shah and Nicholas Mills have shown the main threat to public health is from fine combustion particulate matter 2.5 microns diameter and below in size, known as $PM_{2.5}$ These particles are composed of a mixture of carbon, heavy metals, Volatile organic compounds (VOC's) and a toxic cocktail of numerous other combustion products. They are able to make deep lung penetration and thus enter the bloodstream causing infections, cancers and heart disease.

The recently completed European HealthVent project considered in detail the Burden of Disease (BoD) that could be attributed to outdoor sourced pollution that ends up indoors, as opposed to indoor sourced air pollution. The BoD was about a 2:1 ratio weighted towards outdoor sourced pollution. A result surprising to many but showing the need for action to remove the $PM_{2.5}$ that is responsible for a large part of the outdoor sourced BoD. Of the strategies considered by the project use of air filters to remove 50% of $PM_{2.5}$ was the main intervention action that was advised as the most effective. Long term aims such as reducing emissions at source would be difficult to achieve because $PM_{2.5}$ comes mainly from burning of fossil fuels in transport systems, power stations and heating systems. There is a lack of political impetus to make difficult policy decisions regarding limiting $PM_{2.5}$ emissions at the current time. This type of air pollution is closely linked to the level of economic activity in each country.

Many designers and engineers advocate use of ventilation methods that utilise naturally occurring air currents in buildings. Broadly these design solutions can be grouped under the name of passive ventilation. The great attraction of these types of solution is that they have low levels of energy use but the main drawback is that they are usually unsuitable for use in locations with high levels of air pollution.

Where air pollution is a problem it is usual to have a mechanically ventilated building to not only reduce carbondioxide (CO_2) levels and replenish oxygen (O_2) but also to clean the air and remove air pollution. Air filtration by mechanical means is the usual method employed to remove airborne particles and where necessary also gas phase and molecular airborne contaminants.

The rising cost of electrical energy has increased the focus of national governments on ways to improved energy efficiency in buildings. Heating ventilating and air conditioning (HVAC) systems can use as much as 50% of the energy consumed in buildings. The opportunity and challenge is clear and if energy efficiency is to be achieved then clear performance benchmarking is needed for assessment of energy using components such as air filters.

Theoretical costing models such as Life Cycle Costing (LCC) or Total Cost of Ownership (TCO) will give a good indication of energy use benchmarked against working performance but they will only get you so far towards assessing real life performance.

Working performance in the case of air filters is gauged by particle removal efficiency. Unfortunately this particle removal efficiency varies greatly between the artificial conditions of a laboratory test and the real life working conditions in a city centre based Air Handling Unit system used for ventilating or full air conditioning.

Another problem with air filter particle removal efficiency is that it can, with some products, vary greatly over the life of the filter. This is not ideal if we are relying on a consistent high particle removal efficiency to remove as much toxic $PM_{2.5}$ as possible and thereby protect the health of people in buildings.

There is an increasing trend towards direct measurement of airborne particles in buildings to make an assessment of how clean the air is and how it compares to the limits set for commonly experienced health damaging pollutants such as $PM_{2.5}$.

Readings taken with a particle counter at several key locations inside and outside a building are useful in constructing a comparative graph of the numbers of fine airborne particles and their sizes. The data from the readings taken can be used to construct a profile diagram to determine the effectiveness of the building envelope plus the air filter system in maintaining a reduced level of particles compared to the outside air. This diagram is a useful tool in determining whether improved air filtration is required in the HVAC system or improved air sealing at weak points in the building envelope.

As previously mentioned many people are now working from home or in small buildings where there is no large HVAC system supplying clean air on demand. What can be done in this situation? One solution that is gaining increased consideration and acceptance is the use of standalone air purifiers.

These are air filter units that combine High efficiency particulate air (HEPA) filtration to remove $PM_{2.5}$ and NO_2 as well other commonly experienced pollutants. These air purifiers or air cleaners if they remove just particles are used in residential situations or healthcare applications. Removing *aspergillus* spores to protect vulnerable children and pollen removal to prevent asthma attacks are two recent needs that have been met.

Using a standalone air purification unit that delivers clean air at point of need if often a quicker more effective IAQ solution than trying to get a large unmanageable centralised HVAC system to service a small area in a large building with air. It can also save energy if the main HVAC system can be stepped down.

Sick building syndrome is often encountered in new or newly refurbished buildings and if often due to poor IAQ due off-gassing of molecular contaminants. This can often come from new carpets, varnishes, wall coverings or cleaning fluids. There are diagnostic kits available that can test for these emissions and identify the problem.

Bodies responsible for research and advice on public health such as the WHO are responding to demands for improved information on the health damaging effects of exposure to monitored levels of air pollution. They have recently included $PM_{2.5}$ and NO_2 as Group 1 carcinogens as they are a major part of diesel engine traffic emissions. Also pressure from the EU on national governments is leading to improved levels of city air monitoring network information being made available. This is a virtuous circle of communication, information, education and research that is putting pressure on governments to reduce airborne pollution at source, where possible, but also introduce firm legislation to improve air indoor air quality.

The challenge for engineers is to come up with an easy to understand test methods that can deliver clean IAQ with minimal energy use and running costs. These aims can all be reached with practical measurements and use of the solutions available.

Adopting the principals in ISO 50001 and motivating everybody in the building concerned to take an interest in IAQ as well as energy efficiency is a good start. ■