INDOOR ENVIRONMENT QUALITY, BUILDING DESIGN AND MANAGEMENT, AND OCCUPANT PRODUCTIVITY

BY VYT GARNYS, CETEC

After 30 years of research into the health effects of indoor environment on occupants, there is now extensive research and assessment of the effects of indoor environment quality (IEQ) on occupant performance and productivity.

Introduction

There is a European protocol that measures how organisations can financially benefit from improved IEQ. This work has shown that a two per cent office productivity gain can be worth as much as $270 per square metre, over the lifetime of the building. This protocol also involves integrating productivity into the life cycle cost analysis of building services. In broad terms, this can equate to savings of $2000 to $5000 per employee per annum.

Techniques now exist to estimate the effect that the indoor environment has on occupant wellbeing and productivity, and to rate or benchmark relative performance. This is a very active area of research internationally. Australia is leading the way in rating the built environment and has the opportunity to contribute with benchmarking.

Facility ecology is the study of the functioning of a building, with respect to the measurable interaction of the occupants and the built facility. Such studies allow us to optimise the wellbeing and productivity of the occupants, and the environmental performance of the building.

The elements of facility ecology include:

- building design and location
- occupant satisfaction and wellbeing
- facility and corporate management
- risk management
- indoor environment quality (IEQ).

CETEC's focus has primarily been on public and office buildings, where the occupants are typically office workers, or visitors to an office or public facility. CETEC creates a scientific framework based on measured data that shows if a building can, or is, delivering its primary function of improving the occupants' performance whilst minimising its environmental impact and costs.

Influences on office indoor environment

Many factors influence the measured, as well as the perceived, quality of indoor environments, including:

- noise and vibration
- ventilation effectiveness
- draughts
- temperature and air humidity
- airborne pollutants
- personal control of environment
- natural light and outside view
- lighting and glare
- space and privacy

- decor and furnishings
- pre-existing health and behavioural conditions
- job role
- worker and management relationships
- worker perceptions
- worker stress
- business demands.

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Why focus on the indoor environment?

Most working Australians now spend more than 70 per cent of their working lives indoors. Building design, use, and management influence the comfort, wellbeing and productivity of occupants. Building problems that go unrecognised or are neglected can lead to building, staff, business and regulatory problems.

In addition, tenants are increasingly demanding and specifying improved environmental quality; significantly affecting the design, construction and ongoing management and incorporation of IEQ elements in various Australian rating tools and publications. It is essential for the architect to design an office building, or public facility, so that a facility manager can effectively and efficiently control the critical IEQ elements affecting occupant wellbeing and productivity.

Research evidence in the current decade has increasingly confirmed strong links between the indoor environment, occupant wellbeing and comfort problems. There are a number of critical parameters that need to be measured to assess the indoor environment quality. These include:

- temperature
- ventilation
- volatile organic compounds (VOCs)
- particulates
- biological substances.

These parameters are discussed below.

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Temperature

The link between occupant comfort and temperature is well-understood. As a guide, the rule of thumb is that there is a reduction in performance of one per cent for every one degree celsius change in temperature above and below 22 degrees celsius. This performance drop is most evident as the temperatures move to high 20s and beyond.

Ventilation

The ventilation rate has also been found to affect performance. The performance increase per unit increase in ventilation is greatest in ranges below 20 litres per second per person of the air supply rate (from an 8L/s ventilation base rate), resulting typically in a 1.5 per cent increase in performance. These findings may not be appropriate for all facilities, as other factors may influence the relationship.

Chemical

Pollutants such as carbon monoxide (CO) or nitrous oxides (NOx) (from sources such as transport and tri-generation plants) reflect the level of outside contamination. On the other hand, carbon dioxide levels reflect the occupancy levels and the efficiency of the air ventilation system. Most other chemical pollutants are grouped into what is known as volatile organic compounds (VOCs).

The World Health Organization defines volatile organic compounds (VOCs) as organic compounds with boiling points between 50 degrees celsius and 260 degrees celsius, excluding pesticides. There are literally thousands of organic compounds, synthetic and natural, emitted into the atmosphere at room temperature from products used in buildings.

VOCs have widely varying toxicities, irritant and odour properties, and it is important to characterise them if a raised VOC level is detected. VOCs may cause irritation of mucous membranes and are associated with headaches, dizziness and nausea. It is also widely recognised that some VOCs are confirmed or suspected carcinogens

and mutagens. An example of this is formaldehyde.

Recent studies conducted showed that 96 per cent of the VOCs found in a large office building following construction resulted from the materials used to construct and furnish the building. Contributors included hard surface and carpet flooring materials, paints, adhesives and sealants, office furniture, computers, insulations, vinyl wall coverings, ceiling tiles, cabinetry, fireproofing, and textile furnishings.

Particulate

In the office environment, particulates can be generated from external dust, wear particles, and cleaning activities. Of greatest concern are the smaller respirable particles below 10 micron in diameter (PM10). Very fine particles can remain suspended for up to 72 hours. Consequently, effective ventilation and filtration is required in office environments. Furthermore, cleaning activities and poorly maintained flooring are major contributors to the remobilisation of indoor particulates.

Biological substances

Many biological substances are benign and do not necessarily indicate the existence of a hazardous work environment. However, some viruses, bacteria and fungi are capable of causing infections, while fungi, protozoa and dust mites may cause allergic conditions such as asthma.

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Microorganisms such as bacteria and fungi tend to become established and proliferate on wet surfaces and in humid conditions. For example, carpets damaged by local flooding often become the site of fungal growth. Non-living biological pollutants are associated with allergic conditions in susceptible individuals. They originate both inside and outside buildings. Those from outside, such as pollen, enter the airstream because of inadequate or damaged fresh air filtration systems. Many of those generated inside buildings, such as dead skin cells and other dander, may remain in circulation for some time, especially where filtration of recycled air is inadequate.

Productivity increases and savings

Some calculations reported show that the cost of deteriorated indoor environments is higher than both building maintenance and operational costs combined. With about 80 per cent of the annual cost of an office building being its staff wages, benefits, and salaries, small changes in occupant productivity (caused by inadequate IEQ) can have a significant cost impact. The costs from the additional capital expenditure involved to improve IEQ can result in the productivity gains being larger, and thus easily justify the investment.

It has been shown that in an office building, staff costs are 100 to 200 times the energy cost for the building, and can therefore be offset by a corresponding 0.5 to one per cent increase in staff productivity. Staff costs are also 20-44 times the HVAC running cost, and so a productivity increase of two to five per cent can offset this entire cost.

In recent productivity studies conducted by CETEC, a productivity gain of 13 per cent was measured at Umow Lai, a leading engineering consultancy. Based on CETEC measurement, the organisation was predicted to have a 13 per cent improvement potential, prior to their relocation; but ultimately this was validated as 12.5 per cent – translating to $5000 per person gain per annum, or a payback of lease four times over. Significant positive gains have also been shown at a range of government entities, including Sydney Water, with their recent office relocation to Parramatta.

Conclusion

With the knowledge accumulated from IEQ studies worldwide, there is a need to consolidate findings into a methodology that demonstrates tangible occupant wellbeing and productivity gains from facility ecology expenditure, effort and rating.

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CETEC has initiated a program to study these IEQ factors in a global trial by surveying and measuring a large sample of commercial buildings throughout the international arena and with the support of various national Green Building Councils. This study would ensure a standard methodology is used, thus allowing comparisons across the sample pool of buildings. Furthermore, there is the ability to benchmark your operation for sustainable performance.