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## The New NABERS Indoor Environment tool – the next frontier for Australian buildings

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### Abstract

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In our ambition to improve the environmental performance of office buildings, it is easy to lose sight of their real purpose – to accommodate people. To understand the future of sustainable buildings, it is important to recognise that services such as HVAC and lighting are provided to create suitably comfortable conditions for staff to be productive.

Providing a good quality indoor environment has been shown to increase staff productivity from improved comfort, health and wellbeing. Productive staff are essential for creating competitive businesses. The Property Council of Australia has estimated for offices that a 1% improvement in productivity would be equivalent to the whole energy cost of a building or, nationally \$2 billion annually.

The indoor environment quality (IEQ) of an office is complex and determined by many factors, including the layout of the space, lighting, air quality, thermal conditions and noise levels. These are influenced by the building characteristics, maintenance practices, tenant equipment and behaviour. The new NABERS Indoor Environment (IE) tool measures these IEQ factors and compares their performance against a set of benchmarks that reflect industry standards, scientific research and current market performance of office buildings.

NABERS IE converts this complex information into a score on a six star scale – providing a direct measure of the overall IEQ for the office. This star rating provides a common language which can assist in coordinating multiple parties in setting goals, evaluating performance and recognising market achievements in occupant comfort and wellbeing.

A high NABERS IE rating will help attract and retain tenants with excellence in indoor air quality and thermal comfort identified by tenants as significantly more important than other building attributes [14]. While for businesses, a high NABERS IE tenancy rating will identify you as an employer of choice – helping you to attract and retain staff.

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## 1. Introduction

Office buildings are designed to provide suitable conditions for occupants through the provision of services such as lighting, heating, ventilation and air conditioning (HVAC). The Australian office sector is globally one of the most active and engaged in sustainability today [1]. Since 2010, NABERS rated office buildings have decreased their energy use by 10 per cent, which is around \$60 million per year in energy savings [2]. However, with the focus on energy efficiency, it is easy to lose sight of the real purpose of office buildings – to provide suitable conditions for occupants. As Joseph Allen, Assistant Professor of exposure assessment science, Harvard Chan School of Public Health said “*We have been ignoring the 90%. We spend 90% of our time indoors and 90% of the cost of a building are the occupants, yet indoor environmental quality and its impact on health and productivity are often an afterthought*” [3].

There are currently two streams of thought around energy efficiency and the indoor environment quality. The first is that decreasing energy consumption negatively impacts indoor air quality. The basis for this idea is that as three quarters of an office building’s energy consumption is used to provide a suitable indoor environment for occupants [4], reducing the energy inputs to these systems will have a detrimental impact to occupants.

The second stream of thought is that energy efficiency will lead to a good indoor environment, because highly efficient buildings are well managed and are more likely to be in tune with occupant comfort and satisfaction. This paper presents the findings from analysis of the NABERS Indoor Environment ratings for the 35 base building ratings listed on the NABERS website in June 2016. They include buildings across five states in Australia. The analysis compared the NABERS Indoor Environment rating with the NABERS Energy rating for the same building to assess, in practice, these two streams of thought.

### Nomenclature

|        |   |
|--------|---|
| NABERS | National Australian Built Environment Rating System |
|--------|---|

## 2. Importance of energy efficiency and indoor environment quality in the office sector

Staff costs, including salaries and benefits, typically account for about 92 per cent of business operating costs [4]. With office workers spending an average of 7 hours a day inside, the quality of the indoor environment can have a significant impact on employee health and productivity. A recent study found that people who work in well-ventilated offices with below average levels of indoor pollutants and carbon dioxide have significantly higher cognitive-functioning scores than those in offices with typical levels [3].

The study tested participants under four stimulated conditions [3]:

- elevated levels of VOCs, to represent emissions emitted from common office materials (classed as ‘conventional’ building);
- elevated levels of carbon dioxide to represent higher, but not uncommon levels found in an office environment that typically has the minimum required ventilation;
- low levels of VOCs (class as ‘green’); and
- enhanced ventilation (classed as ‘green+’).

The results show that the cognitive performance for participants who worked in green+ were, on average, double those of participants who worked in the conventional environment, while the scores for those working in green buildings were 61 per cent higher [3]. The study found that the most significant difference between the ‘green’ and ‘conventional’ building conditions was experienced for crisis response, information usage, and strategy, which are indicators of higher levels of cognitive function and decision-making abilities (Table 1).

Table 1. Results for three cognitive function areas linked to cognitive function and decision making for green buildings and green+ buildings in comparison to ‘conventional’ buildings [3]

| Cognitive function area | Green building | Green+ building |
|-------------------------|----------------|-----------------|
| Crisis response         | 97%            | 131%            |
| Information usage       | 172%           | 299%            |
| Strategy                | 183%           | 288%            |

The results from the study demonstrate that even modest improvements to indoor environmental quality can have a profound impact on the cognitive-functioning of employees.

This issue is also important, because commercial buildings (including office buildings) account for approximately 10 per cent of overall energy consumption in Australia [5]. Around three quarters of an office building’s total energy consumption is used to provide a suitable indoor environment for occupants from the provision of heating, ventilation and air conditioning (HVAC) and lighting. HVAC is generally responsible for a significant proportion of total building energy consumption - a typical system accounts for approximately 40 per cent of the total building consumption [6]. The pie graph in Figure 1 shows the typical energy consumption breakdown of an office building:

- HVAC ~ 39 per cent,
- Lighting ~ 25 per cent,
- Equipment, such as computers ~ 22 per cent,
- Lifts ~ 4 per cent,
- Domestic hot water ~ 1 per cent, and
- Other uses not covered ~ 9 per cent [6].

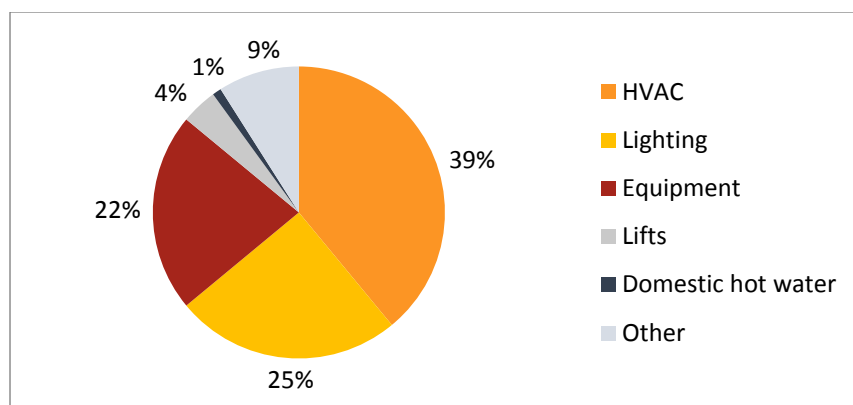


Fig. 1. typical energy consumption breakdown in an office building [6]

### 3. Background to the NABERS Indoor Environment (IE) rating

The new NABERS Indoor Environment (IE) tool for offices tool was released in October 2015 with the goal to improve occupant comfort and wellbeing in the office sector [7]. It is a national tool for Australian office buildings, designed to be used in conjunction with the other NABERS rating tools (energy, water and waste) to deliver a comprehensive measure of the operational performance of an office building that takes into account the occupant comfort and well-being, as well as the resource efficiently and environmental impact of the building. The NABERS IE tool is managed by the NSW government on behalf of the other state and territory governments and the Australian government and is a voluntary rating.

The NABERS IE tool benchmarks the performance of a building or tenancy on 1 to 6 star rating scale. The highest rating of 6 stars represents market leading performance, while 3 stars represents average performance within the market.

The NABERS IE tool measures the five indoor factors; thermal comfort, air quality, noise, lighting and the office layout to assess the level of comfort or wellbeing and ultimately satisfaction in a building. NABERS uses two measurement approaches - an occupant satisfaction survey and the collection of on-site quantitative data [7]. These two approaches allow the tool to measure to what extent the building characteristics, maintenance practices and tenant equipment impact the quality of the indoor environment. The occupant satisfaction survey assesses how a building is performing from the perspective of its occupants, while the on-site quantitative measurements capture data on specific parameters that are indicators of overall building performance.

NABERS IE benchmarks the quality and performance of the indoor environment for a building or tenancy against the Australian office market – the only tool worldwide that uses the combination of qualitative and quantitative data to benchmark performance.

### 3.1. Ratings reflect split responsibilities within the building

The NABERS IE rating reflects the split of responsibilities within a building, so that building owners and tenants can separately measure and report on the environmental impact from the part of the building for which they are responsible (Figure 2). There are three different rating types; base building, whole building and tenancy [7]. Separate rating types enable the different stakeholders within a building including, building owners, managers and tenants to benchmark how well their indoor environment is performing and identify opportunities for improvement.

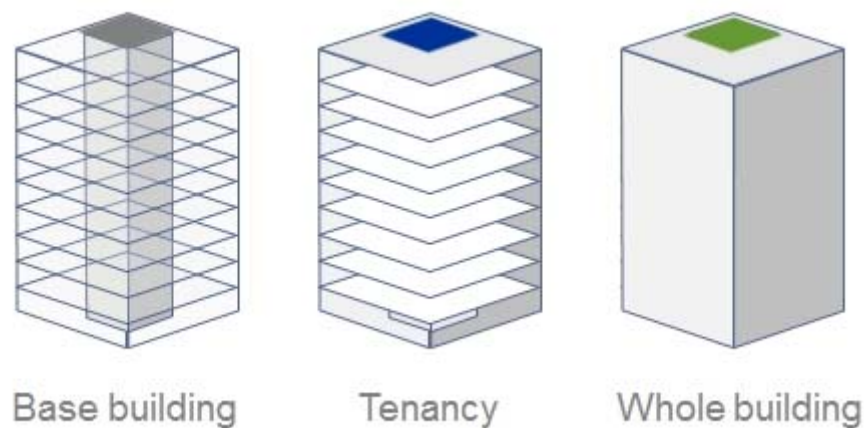


Fig. 2. an illustration of the NABERS IE building coverage [7]

### 3.2. The indoor environmental factors measured by NABERS IE

NABERS measures five key indoor environment factors (thermal services, acoustic comfort, indoor air quality lighting and office layout) to measure the level of comfort, wellness and ultimately satisfaction in a building. Each factor is scored separately, to help identify areas where the building and/or tenancy is performing well and area where performance can be improved. The factors are also weighted differently depending on their impact on occupants (Table 2).

The number of floors to sample and the sampling locations required is based on the size of the building or tenancy. The maximum number of floors required for a NABERS rating is 6 and the maximum number of samples per floor is 5. The majority of the site measurements can be taken within one to two working days, with measurements taken during the morning and afternoon. To ensure the site visit does not influence the occupant survey results, the occupant satisfaction survey must be completed before conducting the measurements.

The occupant satisfaction survey measures the level of satisfaction with various aspects of the indoor environment and is used with the quantitative measurements taken on-site to calculate the final rating. NABERS currently allows three occupant satisfaction surveys for use in a certified rating – Center for Built Environment (CBE), Building Use Studies (BUS) and BOSSA administered by Sydney University. The occupant satisfaction survey is used for whole building and tenancy ratings and account for 50 per cent of the final rating score for thermal services, acoustic comfort, indoor air quality and lighting and 100 per cent for the office layout parameter.

### 3.2.1. Thermal Services

Thermal services is very important for occupant comfort and wellbeing. Under NABERS it is measured by the air temperature, radiant temperature, relative humidity and air speed provided to the space and compared against the international standard ASHRAE 55:2013 *Thermal Environmental Conditions for Human Occupancy* [8]. It is measured for base building and whole building ratings only, as tenants typically have no control over these services [7]. The percentage of samples that meet ASHRAE 55:2013 ('optimal conditions') is then compared to the NABERS benchmark to determine the final quantitative score, which is used for base building ratings. For whole building ratings the thermal services score is calculated from the final quantitative score and the occupant satisfaction survey result.

### 3.2.2. Acoustic Comfort

Noise levels in an office are a key factor to occupant satisfaction, with one study finding that over 50 per cent of occupants in office cubicles think that noise levels interfere with their ability to get their job done [9]. Acoustic comfort is measured for all NABERS IE rating types as noise levels can be attributed to the mechanical systems and façade insulation in the base building, as well occupant behaviour in the tenancy [7]. The average result from the on-site samples are compared to the NABERS benchmark to determine the final quantitative score, which is used for base building ratings. For whole building and tenancy ratings the acoustic comfort score is calculated from the final quantitative score and the occupant satisfaction survey result.

### 3.2.3. Indoor Air Quality

Research shows a strong relationship between good indoor air quality and people's performance at work [3] [10]. It is not a simple, easily defined concept but a constantly changing interaction of factors, including the maintenance and operation of building ventilation systems, pollutant sources from office materials, and occupant perceptions and susceptibilities. NABERS measures the ventilation effectiveness provided (using carbon dioxide as a proxy) and the levels of pollutants (carbon monoxide, particulate matter (PM<sub>10</sub>), formaldehyde and Total Volatile Organic Compounds (TVOCs)) [8]. To reflect their individual importance, the quantitative indoor air quality result is calculated from the individual weighted scores for these five variables based on their potential impact to occupant satisfaction, health and wellbeing. The average result from the on-site samples are compared to the NABERS benchmark to determine the final quantitative score.

For whole building and tenancy ratings the indoor air quality score is calculated from the final weighted average of the on-site quantitative measurements and the occupant satisfaction survey results. Formaldehyde and TVOCs are the result of tenant activities and equipment or materials used and are measured for tenancy and whole building ratings only. Carbon monoxide is measured for base building and whole building ratings only because it generally comes from external sources and is heavily influenced by the building design and the location of the air intake ducts.

### 3.2.4. Lighting

Lighting accounts for around 25 per cent of the energy used in an office building [6]. The quality of the office lighting is critical, with employees spending, on average 7 hours every weekday in the office. Studies have shown that light and glare can impact staff productivity and general wellbeing [11].

NABERS measures the level of horizontal illuminance at the occupant’s desk level to provide an indication of the potential for eye strain, and therefore the occupant’s ability to work effectively. Lighting is only measured for tenancy and whole building ratings because the tenant has the greatest control over the light levels within the tenancy [5]. The lighting score is calculated from the final quantitative score and occupant satisfaction survey result.

### 3.2.5. Office layout

As the office layout is difficult to quantitatively measure, the data used in the NABERS IE rating is based on the results from the occupant satisfaction survey to provide information on the level of satisfaction with the general office layout [7].

Scores are calculated based on how the responses compare to the Australian IEQ NABERS benchmark [7]. For example, if results for office layout are better than 70 per cent of buildings, the score obtained will be 70 per cent.

Table 2. Data required according to the NABERS IE rating type and weighting [8]

| Indoor environment factor | Base building rating |           | Tenancy rating |           | Whole building rating |           |
|---------------------------|----------------------|-----------|----------------|-----------|-----------------------|-----------|
|                           | Data                 | Weighting | Data           | Weighting | Data                  | Weighting |
| Thermal services          | M                    | 40%       | -              | -         | M, S                  | 30%       |
| Indoor air quality        | M                    | 40%       | M, S           | 40%       | M, S                  | 30%       |
| Acoustic comfort          | M                    | 20%       | M, S           | 25%       | M, S                  | 15%       |
| Lighting                  | -                    | -         | M, S           | 25%       | M, S                  | 15%       |
| Office layout             | -                    | -         | S              | 10%       | S                     | 10%       |

Where: M represents on-site measurements; S represents occupant satisfaction survey; - represents no measurements.

## 4. Analysis: Can we have a highly efficient building and an excellent indoor environment?

To assess, in practice, whether it is possible to operate a highly efficient building while at the same time delivering an excellent indoor environment, the NABERS IE and Energy base building ratings for 35 office buildings around Australia were analyzed. This represents the total number of buildings with a NABERS IE and Energy base building rating listed on the NABERS website in June 2016.

The analysis demonstrated a correlation ( $R^2=0.3346$ ) between energy efficiency and good indoor environment quality, with 94 per cent of buildings achieving good performance (4 stars and above) for both (Figure 3). Only two out of the 35 ratings had a NABERS IE rating below 4 stars (both achieved 3 stars, representing market average performance). One of the two buildings had a NABERS Energy rating of 3.5 stars, while the other had a NABERS Energy rating of 5 stars.

The numbers inside each bubble in Figure 3 represents the total number of buildings analyzed. The linear trend line has also been included.

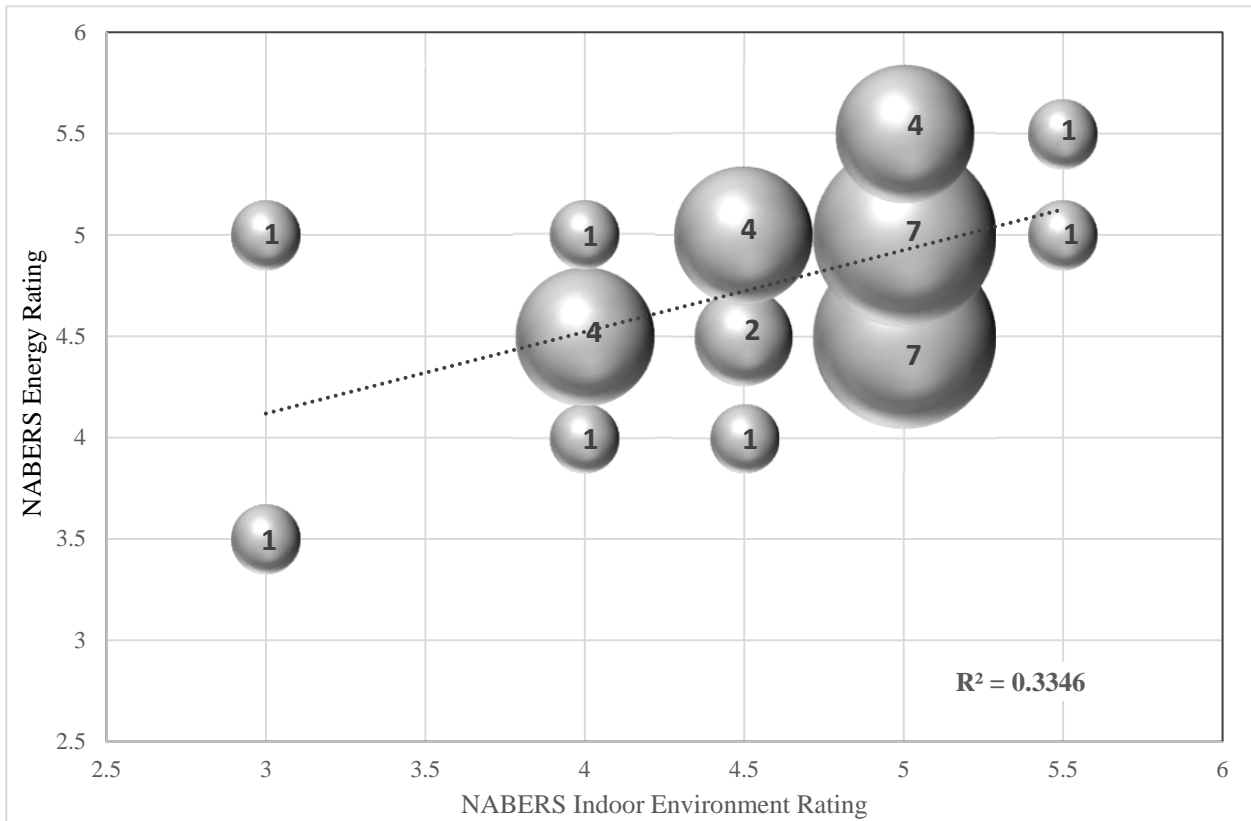


Figure 3. NABERS Indoor Environment and Energy ratings for the 35 office buildings in Australia.

This correlation between energy efficiency and good indoor environment quality is further demonstrated when comparing the NABERS IE rating and the average NABERS Energy rating, particularly as the NABERS IE rating improves (Table 3).

Table 3. NABERS IE rating and the corresponding average NABERS Energy rating

| NABERS IE rating | Average NABERS Energy rating |
|------------------|------------------------------|
| 3                | 4.3                          |
| 4                | 4.5                          |
| 4.5              | 4.7                          |
| 5                | 4.9                          |
| 5.5              | 5.3                          |

## 5. Discussion

The results from the study support the theory that high energy efficiency will lead to a good indoor environment with highly efficient NABERS rated buildings demonstrating excellent indoor environment quality by achieving a 4 star NABERS IE rating and above. It is likely that these highly efficient buildings are well managed and are therefore more in tune with occupant comfort and satisfaction.

Independent research by the Investment Property Databank has shown buildings with high NABERS ratings have higher returns and less vacancies, leading to a higher market valuation [12]. These efforts have been recognised in many international sustainability indices, and as a result, the Australian property market took out the top spot as the world's leading region in the Global Real Estate Sustainability Benchmark (GRESB) in 2014, far outperforming buildings in Europe, Asia and North America [1].

This research is supported by a separate study into the value of buildings with excellent indoor environment, equivalent to a NABERS IE rating 5 stars and above. This study found that the value of buildings with excellent indoor environment compared to standard buildings is 10 per cent higher, while the occupancy rate is approximately 10 per cent higher and rent is 5 per cent higher [13] (Table 4). The results for 5 star and above NABERS Energy ratings correlate well with the results for excellent IEQ rating and support the findings from the study of the 35 NABERS rated buildings that show high NABERS Energy correlates with excellent IEQ.

Table 4. Investment returns for buildings with a 5 star NABERS Energy rating and excellent IEQ [12] [13]

|                      | 5 star and above NABERS Energy Rating [12] | Excellent IEQ [13] |
|----------------------|--|--------------------|
| Building asset value | 10.6% higher                               | +10%               |
| Occupancy rate       | Not reported                               | +10%               |
| Vacancy rate         | -1.4%                                      | Not reported       |
| Rental return        | +10.8%                                     | +5%                |

Of the 35 office buildings rated using NABERS IE, 21 building (60 per cent) achieved NABERS 5 stars or above for NABERS IE ('excellent' and 'market leading') and 19 buildings (54 per cent) achieved NABERS 5 stars or above for NABERS Energy. 14 out of the 35 buildings achieved NABERS 5 stars or above for both NABERS IE and Energy (40 per cent).

The potential financial return from buildings that are achieving environmental excellence is supported by a recent survey by Colliers International that showed that 95 per cent of tenants want to be in a green building [14] and results from Jones Lang LaSalle's research that found that 92 per cent of the 143 top-level corporate real estate leaders surveyed internationally consider sustainability when making their location decisions [15]. Importantly, of those surveyed, just under half said they would pay up to a 10 per cent premium for sustainable office space [15].

This study analyzed buildings rated under the new NABERS IE tool and while these buildings represent a range of geographical locations, with different climatic conditions (for example, Queensland in comparison to Victoria), these buildings, are most likely, A Grade buildings – representing the premium building market. This assumption is based on a knowledge of the buildings rated and previous experience with new NABERS ratings which saw initial uptake in the premium building market. Based on the 35 buildings assessed, it is clear that buildings can be managed to provide an excellent indoor environment and be highly energy efficient. As the market matures, and NABERS IE ratings become an established performance assessment of a building's IEQ it will be interesting to re-analyze the results to assess these two theories in the less-premium building market.



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