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Load resilience in high performance buildings

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Abstract

In the past 15 years there has been a sea change in the performance of the base building services of office buildings in Australia, particularly in the upper echelons of the market, with achieved efficiency levels far exceeding what had previously been considered possible. This has been achieved through innovations in control and operation of existing HVAC system types and the emergence of newer HVAC types. At the same time, there have been changes in how we occupy office buildings, with changes in computing loads and adoption of new work practices such as "agile working". With these changes it is worthwhile to re-examine the fundamental assumption that underlies the NABERS base building rating, being that the performance of the base building is sufficiently independent of occupancy to enable the rating to be formulated without significant reference to the operations of the tenancies.

In order to test this, a computer simulation model in IES has been developed and tested against a range of equipment and occupant density scenarios representing the traditional and agile workplaces to determine the extent to which the base building performance is sensitive to these factors.

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Keywords: Office building; NABERS; Base building; HVAC load; energy consumption

1. Project Overview & Objectives

The original work underlying NABERS Energy for offices [1] dates from the late 1990s. Since then, there have been many changes to office workplaces and workplace technology. Furthermore, during the intervening period, the issue of the impact of tenancy loads on base building ratings has been raised several times as a potential issue with the rating. Work undertaken in response to this has generally identified very limited impacts of tenancy loads.

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Recently, a number of workplaces have adopted activity-based work practices, which eliminate the traditional one-desk-one-person approach and as a result create higher occupant densities. Indeed, proponents of activity-based work practices suggest that a decrease in floor area requirement of 25-50% can be achieved through hot-desking approaches, equating to an increase in occupant density of 30-100%. Conversely, activity based working tends to be associated with the use of laptops and by implication reduced overnight loads (because the desktop equipment is packed away each night) which would significantly reduce consumption.

Therefore the purpose of this study was to address the following questions:

- Does activity based working produce significant changes in occupancy loads; and
- Do such changes produce a significant effect upon the base building rating beyond that envisioned under the design of NABERS?

2. Methodology

2.1. Data Gathering

Two activity-based workplaces in Sydney were used to collect data for this study, each consisting of an entire floor; for purposes of anonymity these will be designated Site A and Site B throughout this paper. At each site an hourly count of the computers/occupancy was taken for an entire working day, lighting and equipment counts were taken as well. This site-measured data was then compared with time interval electricity metering data to develop an occupancy profile, equipment density and lighting profile.

2.2. Occupancy Profile

At Site A an hourly occupancy count was performed between the hours of 9am till 6pm for a single day. The data from the count was used as the basis for the occupancy profile. 20% occupancy was assumed for 8am-9am and 5% occupancy was assumed for 6pm to 7pm. For all other hours occupancy was assumed to be 0%.

An hourly occupancy count was also performed for Site B. However for this site there was also data available from the building's security gate control system. This data was compared to the occupancy counts (based on laptop presence) made during the site visit in order to validate its accuracy.

The comparison (Fig. 1) showed that the data from the security system closely matched the occupancy observed on site, with the following exceptions:

- Between the hours of 12:00 and 14:00 the security system data shows lower occupancy compared to the computer count. This is due to people leaving the building for lunch, but leaving their laptops at their desks
- Between 19:00 and 23:00 the security system data shows a small residual occupancy. This is due to people 'tailgating' others out of the building without swiping their cards through the gate. Therefore the system thinks these people are still inside the building because they didn't sign out. However the effect of tailgating on the data is minimal (typically less than 10 people per night) and was ignored for the purpose of this study.

The data from the security system was considered reliable enough to use for the study. Five weeks of security logs were used to build an average weekday occupancy profile for Site B.

2.3. Lighting and Equipment Power Profile

Interval data from the sub-metering systems in both tenancies were used to establish the profiles for both the lighting and general power. Energy from the computer server rooms was included in the equipment profiles. Five weeks of interval data were used to compile average weekday profiles.

A summary of the data collected is displayed in Table 1 below.

Using this data, two activity based scenarios were used for the simulation, a high density scenario (based on Site B densities and profiles) and low density scenario (based on Site A densities and profiles).