Development and initial trial of a tool to enable improved energy & human performance in existing commercial buildings

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A B S T R A C T

Green Building has been a large focus for the construction industry, with Green Star certified commercial buildings becoming the new standard for commercial office buildings. However there has been little focus on the improvement of existing buildings, and many of Australia's capital cities have ageing building stock that is not operating efficiently and contributing to the nation's growing greenhouse gas emissions.

Retrofitting existing buildings for energy efficiency is receiving more attention across Australia, with grants and funding to incentivise owners to find energy efficient solutions for buildings. However it is important that optimising performance of these buildings considers the impact on occupants. Australians spend the majority of their day indoors and the quality of the indoor environment can have a major impact on the health and productivity of workers.

This paper covers the development of a tool for a project sponsored by the Sustainable Built Environment National Research Centre to assist building stakeholders identify key energy performance issues with their buildings. The tool explores 5 key areas in buildings that influence energy performance: design elements, building management, occupant experience, agreements and culture and indoor environment quality.

The paper explains the development of the tool and some surprising results from the first trial on the tenancy for a 28 year old commercial building in the Perth CBD that underwent a Green Star interiors fit-out.

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1. Introduction

The role of cities in climate change has become increasingly evident with 60% of the world's population predicted to be living in cities by 2030, consuming around 60—80% of the world's energy production, and approximately an equal share of greenhouse gas emissions [8]. Within cities the demand for space will continue to grow, requiring existing buildings to house more residents and workers and new-buildings to be constructed. A large focus of the green building movement has been on new-builds with programs such as Green Star, LEED and BREEAM encouraging changes to the business as usual construction of buildings to become more sustainable. It is important that the existing building stock is also brought under focus.

The Intergovernmental Panel for Climate Change (IPCC) 2007 report [10] brought attention to the level of GHG emissions which come from commercial buildings and it has since been identified that a significant proportion of these are easily targetable for

reductions, emphasising the need to improve the energy efficiency of existing buildings. There is also growing concern over the working environment inside buildings and how this impacts health, which was largely driven initially around Sick Building Syndrome in the late 1980s.

Occupant health and productivity is complex and has remained largely researched on a building by building scale but a combined approach is fundamental for sustainability, the people and the environment both need to be considered in a whole systems approach to improving the built environment for the long term benefit of economies. The term green building brings with it many expectations, from reduced energy, water and waste to improved indoor environments for occupants, but the outcomes are often variable [13] and there is still no large scale research that proves the productivity improvements from green building as this is difficult to quantify. The cost of human resources to a building is much higher to an organisation than energy expenditure on operation and just small improvements to productivity can offset costs to improving the office [6].

These new 'green' buildings will become part of the existing stock in the next ten years and it is important the long term impacts

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on both the environment and occupants are considered. There is not yet a rating tool or performance appraisal that encompasses the many complexities of commercial buildings. This paper reviews the development of a tool that attempts to weave these areas together and enable green building in lower grade existing buildings. This paper will share the findings from the first trial of the tool. This research forms part of a project by the Sustainable Built Environment National Research Centre titled 'Greening the Built Environment' completed in 2012.

1.1. The existing building challenge

There are a number of reasons that existing buildings need to be targeted for improved efficiency that weave together multiple disciplines and require a more holistic view.

The primary driver for sustainably retrofitting existing buildings has been based around improving energy efficiency. This cannot be underestimated with the rising electricity process that is forecast and the increasing temperatures that are resulting in peak demand growth [3]. With air-conditioners being the most energy intensive component of a commercial building it is an unrelenting contribution to climate change, and use will continue to grow as temperatures continue to rise, which is not expected to cub anytime soon considering that Australia saw the hottest temperatures on record in 2013 [1].

The loss of productivity for an entire city to go off the grid during business hours is epic. Peak demand may only occur for a few hours a month is summer seasons but it is a main driver for infrastructure growth and development as it is essential to meet those peak demand days. There is over $46 billion planned for electricity network infrastructure development to manage both the increased demand for electricity and peak demand pressure which is resulting in consumer tariffs climbing [9].

There is the issue of wasted energy of this new infrastructure is essentially feeding into buildings that do not operate as efficiently as possible. Often over time commercial buildings drift from the original design intent and undergo multiple fit-outs over their lifetime. The Australian Low Energy High Rise (LEHR) study showed that most commercial buildings can operate at a 4 Star NABERS rating with minimal investment [17], a US [11] study also showed the older commercial buildings can make a 16% improvement in energy use through commissioning. The facts are solid that buildings need and can improve, but there seems to be limited uptake in the market for voluntary retrofits.

The barriers to retrofitting are often addressed as the up-front capital required to invest as well as split incentives that are experienced between the various stakeholders [2]. The industry is very disjointed and buildings have become increasingly complex with more and more services integrated that require an increased number of stakeholders in design and delivery [14]. Over time these communication break downs tend to manifest as deficiencies in the buildings that can impact energy performance, the indoor environment and comfort for occupants [12].

The issues started to emerge from the literature showing the building management and design elements in a building are highly influential on the energy consumption, and that these impact the indoor environment and occupant experience. However there are also factors that need to be considered such as lease agreements in place, mandatory energy ratings and other influences that the tenant or owner's organisational culture has in regards to sustainability that can impact the performance of the building. Although post-occupancy evaluations are implemented on some buildings there is no an industry wide uptake, and once buildings are in operation information is not fed back to the design teams limiting the ability for continual learning and improvement.

What has become quite apparent from this research is the need to re-brand energy efficiency in a way that appeals to the key stakeholders. The research, in essence, has largely indicated the necessity to link occupants as the economic imperative. Although energy efficiency is the ultimate goal the market is not responding as well as it would to health and productivity which is largely impacted by the way people work. The energy savings may not be enough to convince the CFO, but the health implications of improving the indoor environment and working area in a way that boosts health and productivity may be the new drivers for sustainability.

2. Materials/methods

The project used a mixed method approach of qualitative and quantitative action based research including a comprehensive literature review and development of discussion papers, stakeholder engagement workshops, stakeholder interviews and the development and trial of a cross-disciplinary post-occupancy evaluation.

The tool was tested on two commercial buildings. The first was a pre- and post-occupancy study an interior retrofit to a tenancy applying for Green Star accreditation. Following this trial the tool was expanded and re-tested on another commercial building. This paper will cover the findings from the first trial and how further research needs to be directed to improve the ability of such a tool to capture information from these five areas.

2.1. Workshops

The stakeholder workshops were run with a mix of industry and government representatives across a range of disciplines in both Perth and Brisbane. The results showed that there is still some confusion as to how to actually measure the performance of a building and that it is necessary for a clear and standardised methodology to be used that can feed into policy. There is not an internationally recognised standard for conducting POE's [4]. The most frequently used occupancy surveys for green building are the Building In Use Studies (BUS) and the Indoor Environment Survey by Centre for Built Environment at University of Berkeley, California. There are also many other individual and smaller scale surveys but these surveys have been used widely in research around the world in order to compare different buildings.

The outcome from the workshop showed that 'green' does not necessarily equate to a high performing buildings across multiple areas and that there really is limited understanding and practice as to how reducing energy demand in buildings actually effects the indoor environment and productivity. The reason is that it is complex and addressing the relationship between multiple areas of a building requires addressing multiple stakeholders.

2.2. Designing the tool

The evaluation tool was designed to draw on linkages between existing tools and research (Hargroves [7]). The Green Building Council has transformed the top end of the market through the introduction of Green Star, and the voluntary NABERS ratings are also targeting mainly the A and Premium Grade buildings. But there are many buildings out there that may not even be obtaining NABERS ratings, or not declaring ratings as they are too low. This was kept in mind during the design stage, with these buildings as the target, to be low cost low complexity tool that could enable stakeholders to identify issues present in the building.

After reviewing best practice research a set of questionnaires were developed that asked a series of questions linking five key areas identified as impacting building performance. Table 1 summarises