FUTURE-PROOFING BUILDINGS: OPTIMISING FACILITY MANAGEMENT IN BUILDING DESIGN TO ACHIEVE HIGH PERFORMANCE FOR OCCUPANTS

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Abstract

Buildings in general are large contributors of global greenhouse emissions and environmental deterioration. Climate adaptation of existing and new buildings is crucial in reducing their impact on climate change. In order to achieve this, efficient performance evaluation and operational management of buildings is required for future proofing buildings and other built environment assets. In particular, owner occupied buildings, including educational buildings offer unique opportunities. To meet legislative requirements and offer sustainable built environments, universities are now striving to be 'Green Star Education' enterprises or of an equivalent standard. This paper reports on the performance evaluation of two Green Star rated educational buildings in Victoria, Australia providing a best practice model based on the learnings from the respective case study buildings. Evaluation of the building case studies were undertaken using a mixed method research approach. Post occupancy evaluations (POE) were carried out in each of the two buildings to measure occupant satisfaction, complemented by internal stakeholder interviews and energy performance data. Analysis of the data highlights the importance of creating a link between building performance measurement and performance management of buildings. The paper recommends strategies to assist facility managers to analyse the gap between the actual and expected building performance for better and more efficient management of buildings.

Keywords: *Post-occupancy evaluation, Indoor Quality, Performance Management, Facilities Management, Environment Comfort*

1 Introduction

Climate change is a major global problem faced today due to the increasing greenhouse gas emissions. Buildings are responsible for emissions throughout all the stages of procurement and use, i.e., construction, operation, maintenance and demolition. However, the operation stages account for 80-90% of emissions contributing significantly to climate change [21]. Many building design professionals are now involved in "green" building design or "sustainable design" in response to expressed interest or requirements from clients, regulations, or their

own intention to reduce human impacts on the environment. Despite the low direct energy use during the construction phase, such buildings become high consumers of finite resources on completion and operation. Enhancing the overall performance, climate adaptation and effective management of buildings are highly crucial for facility managers.

The global trend towards environmental protection is gaining public support and momentum due to which many commercial and residential buildings have taken the lead of creating sustainable models for rest to follow. With this aim in mind, academic institutions are now striving towards sustainability and advocating efficient green designs. Universities, being owner-occupiers, generally manage extensive property and building portfolios. In Victoria, Australia, tertiary level academic institutions own approximately a combined land area of 23 million hectares [20]. Under pressure from communities and industry alike, these universities have a wide range of campus buildings (built or refurbished) that are designed and constructed to be green-rated buildings serving as industry best practice models. This commitment ensures ecological sustainable design (ESD) principles are considered and implemented at all stages of any building development works. After the implementation of these green building principles (for project design and delivery, performance targets, energy usage, water consumption and operating costs), the management of the building operation and performance of throughout its life cycle are essential to optimise design outcomes.

One of the widely used and accepted method to evaluate the actual performance of buildings is to measure the occupant's satisfaction. The feedback from the building users becomes an integral indicator for management to understand actual building performance relative to the original design intent. This performance metric allows the measurement of users' level of satisfaction assisting facility managers to manage the buildings efficiently and effectively.

The construction industry worldwide is now incorporating green and clean energy mechanisms into their designs for long term sustainability of buildings. Following similar trends, universities in Australia are also aiming for overall sustainability. Sustainable design frameworks are incorporated in the portfolio management aimed at setting key performance indicators to be "Green Star" building enterprises. Green Star sustainability rating system developed by the Green Building Council of Australia (GBCA) *is one of the rating tools used to evaluate sustainability outcomes. The Green Star – Design & As Built is a specific tool under this rating system which is used to evaluate such outcomes for the design and construction of all types of buildings.* This paper reports on the indoor environmental parameters and the interaction (as a performance metrics) with building occupants in two 5-star Green Star [22] academic institutions in Victoria. Following a background analysis of the principles, the POE methods used are evaluated. The discussion includes analysing the benefits of using the POE techniques to measure occupant satisfaction and how respective POE results assist building managers in the management of facilities.

2 Green Star - Design & As Built rating tool

Green Star – Design & As Built assesses the sustainability performance of the design and construction of buildings. It provides rigorous and holistic guidance for stakeholders in

managing building operations across nine impact categories namely: (1) management, (2) indoor environment quality, (3) energy, (4) transport, (5) water, (6) materials, (7) land use & ecology, (8) emissions and (9) innovation [22].

Green Star is a highly regarded green building certification system. With more than 428 projects certified to date, it assesses and rates against a range of categories with the aim to encourage leadership in environmentally sustainable design and construction, showcase innovation in sustainable building practices, and consider occupant health, productivity and operational cost savings [22]. The GBCA 'Value of Green Star' report of 2013 also stated that on average, Green Star-certified buildings produce 62% fewer greenhouse gas emissions, use 66% less electricity than and use 51% less potable water than average Australian buildings [17].. The report also found that Green Star - As Built certified buildings recycled 96 per cent of their construction demolition waste, compared with the average recycling rate for new construction projects of 58 per cent [17].

Green Star – Education v1 is a tool that assesses the attributes of newly build or refurbished educational facilities in Australia. The eligibility criteria is based on specific time frames (different for new build and refurbished), specific NABERS energy rating (different for each building type for example at least 4.5 energy rating for commercial buildings), not located on or in close proximity to sustainable sites, having a distinct boundary and carbon credits [23].

3 General aspects and methodology of Post Occupancy Evaluation (POE)

A review of the literature suggests that there is a lack of knowledge of the connection between the building user's outlook, how buildings are operated and managed, and the appropriate techniques for evaluating building performance. Evaluating the performance of buildings should be considered as an iterative practice, which acts as an ongoing process and extends to the upgrading and refurbishment of buildings in occupation [3]. One such effective tool for monitoring building operations is Post Occupancy Evaluation (POE). POE over the years has progressed from a one dimensional feedback process to a multidimensional process that acts as an integrated element driving the building procurement process further [7].

By carrying out an evaluation of the building's performance after completion, commissioning and period of use helps to find 'whether the buildings actually performed as they were supposed to' [2]. POE assists in assessing occupant satisfaction and reactions to using the building. It has been defined as a 'process of systematic data collection, analysis and comparison with explicitly stated performance criteria pertaining to occupied built environments' [6]. This process of perception involves the notion of an accumulative database of knowledge, which is continually fed by information garnered from specific successes and failures of particular building types and configurations, using the POE process. POE assists in improving the commissioning of buildings and management procedures, targets areas of specific needs for refurbishment, provides knowledge for design guides and regulatory processes and is a widely applicable and comprehensive methodology [7].

One of the major criterion used to evaluate building performance is to measure Indoor Environment Quality (IEQ). Building occupant's reactions and responses assist in

understanding various aspects of indoor environment quality. These responses can be evaluated by using POE methodologies. Constructively utilised evaluation results assist facility managers (FM) to effect change effectively that benefits all users. Measuring occupant's satisfaction levels using POE methodologies and providing FMs with the respective results enables overall performance management. This is because using longitudinal building evaluations rather than one-off snapshots assist in the knowledge development of quality building designs as well as effective use, building management and operation.

POE in general can be a mix of both quantitative and qualitative techniques. The quantitative techniques are supplemented by environmental monitoring, i.e., measurement of indoor environmental quality and energy. Qualitative techniques are the most commonly used methods which include monitoring occupant satisfaction and feedback through questionnaires/surveys, interviews and focus groups. This study used both quantitative and qualitative techniques and the two results were cross referenced to triangulate and measure the outcomes.

4 Management Framework

The main objective of this paper is to report on the investigation of the role of user feedback in assisting the facility managers to evaluate performance and manage a building as per original design strategies. Decisions are often based on different considerations such as emotions, intuition, judgements and prejudices, social ideals and norms and values. The role played by these considerations is as important as that played by rational argument and available information [3].

The evaluation of decision making processes in facility management can lead to a better understanding of the motives underlying the decisions on management frameworks, the roles of the various stakeholders, and use of data and information. Such an understanding is also important for interpreting the result of the building evaluation and the guidelines and recommendations derived from it.

Management takes place within a structured organisational setting with prescribed roles. It is directed towards the achievement of aims and objectives through influencing the efforts of others. Over time, facility management systems have changed to an approach involving group decision-making and concern for individuals designed to satisfy physical, psychological needs and self-actualization. This approach is aimed at encouraging individual employees to take responsibility for their work and participate in decisions as employees seek responsibility, intellectual potential and obtain satisfaction from work. Higher management also play an important role by motivating (extrinsic motivating sectors such as rewards and punishments) employees to maximise their potential and achieve satisfaction, which in return advances organisational goals. For participative management to work, facility managers must have the knowledge and ability to effectively participate and the company's culture must support the approach. This framework is often adopted in the management of Australian academic institutions and campuses involving, monitoring and reporting at each phase of building's lifecycle (planning, analysing, construction and operation).

5 Method and analysis

This paper reports on the study conducted in two (2) Victorian university buildings of roughly similar gross floor area; referred to as Building A and Building B (Table 1). Both Green Star buildings have delivered exemplary sustainability outcomes. While being recognised for the contributions as leading examples for the construction industry and delivering sustainable outcomes, the performance evaluations of these buildings are not known and the design outcomes have not been validated.

Tab. 1 *Key features for both case study buildings*

Key Features	**Building A**	**Building B**
Year Completed	2012, New Build Certified: 1 Feb 2012	2013, New Build Certified: 14 Aug 2013
Green Star Rating	5 Star Green Star (Australia GBCA) Education Design V1 *(Score – 65 points)*	5 Star Green Star (Australia GBCA) Education Design V1 *(Score – 63 points)*
Gross Floor Area	25,000 m^2	22,000 m^2
Number of Floors	Eleven	Ten
Types of Staff Offices	Open Plan Offices	Open Plan Offices
Types of Rooms	Teaching and Learning (interactive and lecture areas), Research, Student Amenity, Meeting and Office Spaces	Lecture Theatres, Laboratories, Seminar and Group Study Rooms, Meeting and Office Spaces.

Two POE methods were used to evaluate the performance the case study buildings: (1) user satisfaction surveys (questionnaires) and (2) stakeholder interviews and walk in discussions. The satisfaction survey administered were the *Building Use Studies (BUS)* (paper-based survey) for Building A and *Survey Monkey* (online survey) for Building B. The BUS methodology was developed in the 1990s in United Kingdom and is one of the most accurate and extensively used tools for POE. The Survey Monkey online survey is a cloud based survey that helps users with free access to customizable surveys and paid back-end programs. Questions in the surveys are designed using the 5 point Likert scale rating in order to carry out analysis using common indices and compare the results. The surveys were distributed to all staff in the two buildings via email followed up with a reminder. The response rates were 20% and 32% for Building A and Building B, respectively. These surveys provided the building occupants the opportunity to rate the features and functions of the buildings. The respondents were also asked to provide additional feedback/comments regarding things that are working well, not working as desired or lacking, and whether the building helped or hindered them to work effectively and efficiently.

Semi-structured interviews were carried out with the key stakeholders of the two educational buildings to understand the original design intent, the drivers for building construction and the motivation for continuous building improvement. Walk-in discussions were also carried out with the building occupants to get their feedback on the building features and functions. It was also used by the researcher to triangulate the outcomes.

The interviews and discussions were undertaken with 18 key internal and external stakeholders each from both buildings involved in the design, operation and occupation of the

two buildings including the users, project managers and building facility managers. Interviewees were identified as key people who are and/or continues to be, involved in the buildings operation and ongoing maintenance. The interview questions focussed on building aspects that worked well, the major challenges faced and the lessons learned. Care was taken throughout the interview to reduce weaknesses of interviews such as interviewer bias and conducting study under appropriate ethics approval.

Finally, results from the survey and stakeholder interviews were cross-referenced with the energy performance data provided by the facility managers of the two buildings to triangulate the outcomes.

6 Results and Discussion

The technical performance of the case study buildings and the results of the BUS surveys will be presented first, followed by the outcomes from the interviews with a focus on the role of management in achieving sustainability outcomes. Building A and Building B are Green Star certified, each with a rating of 5 stars (Green Star Design & As Built v1). As explored in the interview analysis, this was a standard driven by senior management and integrated into the development from the conception stage. The surveys confirmed occupant satisfaction with the buildings in terms of performance and function. The survey results also show that the buildings performed excellently in three categories: overall comfort (63 % for Building A and 67% for Building B), design (72 % Building A and 64% Building B) and image to visitors (69%) Building A and 67% Building B), but poorly in two categories: perceived health (54% Building A and 49% Building B) and overall noise (57 % Building A and 71% Building B). The survey results placed the buildings in terms of satisfaction levels at 64% for Building A and at 52% for Building B, suggesting that both buildings are in the top percentile compared to the equivalent Australian building benchmark data. These preliminary results indicate that achieving improved environmental sustainability performance has not compromised occupant satisfaction.

Building aspects that worked well for the users and stakeholders are the design of the building, exceptional teaching and learning spaces and student study areas. Aspects that did not work well were basic design faults or technical issues, such as open plan office spaces, no control over temperature monitoring and ventilation etc. However, the main concern that were highlighted in the surveys was not such issues but the dissatisfaction of the building occupants. As the key users of the buildings and spending most of their daily hours in the respective offices, the staff felt that they were not consulted in the original design brief of the buildings. They had complaints regarding the design and decisions being entirely senior management driven. Building occupants also felt that in order to achieve the green building certification, the focus was only on the sustainability outcomes by integrating environmental performance targets and the indoor environmental quality (space, noise etc.) was ill-considered and compromised. This is reflected in the following comments by the building occupants:

> *"Shared office spaces are a disaster. It impedes work, prevents research, restricts and problematizes student/staff interaction". (*Occupant 4, Building B*)*

*"Need better thermal management. Winter is terribly cold."(*Occupant 23, Building B*)*

*"We were never consulted or briefed about the design intent and progress of the project, we were just shown the final result and asked to move". (*Occupant18, Building A*)*

Other design-related issues identified by the building occupants are as follows:

1. Temperature fluctuations – usually extreme in some specific areas/levels as compared to others
2. Noise – no sound proofing from internal and external noise
3. Lack of enough power points/ faulty power points
4. Less storage in office spaces
5. Cleanliness in toilets
6. Elevators being slow

As observed from the building occupants (staff) feedback and comments, it is quite clear that they are highly dissatisfied with the open office plan spaces and noise and a few other issues such as temperature control, storage space. The occupants were unhappy about lack of consultations at each stage of the project and complaints not being timely acknowledged. This shows lack of internal feedback mechanisms and appropriate frameworks for managing a building.

6.1 Interviews

The interviews with key stakeholders found a number of challenges, successes and learnings. A summary of the key findings are presented in this section, with a focus on the role of management in ensuring sustainability outcomes. Some of the key questions asked during the interviews are the following:

1. What was the driver that led to construction of the building and striving to achieve a 'Green Star' rating?
2. Who was involved in the respective decisions? Were the building users (staff and students) consulted for their requirements and feedback at the design phase of the project?
3. What was the original design intent? Has the building met all the original requirements in terms of its design and energy performance?
4. Were the key internal stakeholders involved during each phase of building construction and operation?
5. What procedures are in place to maintain the building performance on a regular and overall basis? Was building commissioning done at any stage?

Results from the semi-structured interviews show that there were two key elements introduced in the conception phase of the development of both case study buildings which had significant impact across the sustainability outcomes which were driven by senior management. The first was the objective to achieve 5 Star Green Star Educational Design v1 and set improvement targets as desired performance outcomes. The environmental performance targets were added in the design brief to ensure that the design architects and other construction stakeholders integrated these performance objectives. However receiving

Green Star Educational Design v1 rating also has provided the management with a number of challenges itself.

The lessons learned from the study have given the facility managers the opportunity to integrate a number of outcomes into the revision of their design guidelines and modify future projects accordingly. For example, key learnings were mainly on indoor conditions and space planning. Therefore, these key features (listed below in Table 2) assisted the FM to understand the drawbacks of their design and the potential areas to focus on for future projects.

Tab. 2 *Key features for both case study buildings*

Building A	Building B
Extreme temperature fluctuations in the office, mainly corners	Not enough sound proofing from internal and external noise – extremely disturbing
Insufficient storage spaces in the offices	Unsatisfactory office spaces
Meeting rooms arrangements dissatisfactory	Insufficient open learning spaces
Insufficient plug-in points	Temperature fluctuations in winters

Another key decision made by senior management and the design architect was to push the innovation in the design of the teaching and learning spaces. While not all the innovative teaching spaces and elements were successful such as white board location and distance to students in certain project rooms, lack of enough electricity sockets etc., the majority achieved the objectives (such as student study areas, luminance levels, lecture theatres and group work areas). These design innovations support the success of the buildings.

"*The utilisation stats from* [2014] *were 20% more attendance in the classes in the building than the rest of the university*." (Stakeholder 9, Building A)

"A gap from other buildings had been that while the building technically had been delivered very well, the actual occupation and transition into the building was something which was sometimes a bit lacking". (Stakeholder 5, Building B)

Overall, the development of the two educational buildings has been very successful from an environmental sustainability perspective with Building A performing slightly better overall (12 percent approx.) as compared to Building B. However, both case study buildings performed poorly in terms of occupant satisfaction. The evaluation of the buildings highlighted learnings which can be drawn upon for future developments to improve building outcomes.

7 Summary

The study presents an analysis of the gap between actual and expected performance in two 5-star Green Star institutions in Victoria, Australia and how POE generated results can assist in achieving building performance objectives. The outcomes include the development of clear assessment mechanisms for establishing link between performance measurement and performance management with an understanding of how occupants view its value on

achieving better performing buildings. The comparison was carried out on how well the building has been managed (in conjunction with the annual energy targets), improved (where required) and reported.

As suggested by analysis of POE results of both case study buildings, the building users (mainly academic and non-academic staff) are not satisfied and their needs have not been considered in the initial design brief. However, after triangulating the outcomes and looking at the broader context, both the buildings have met their key objective in terms of green building certification and energy performance. What worked well for both buildings have been exceptional teaching and learning spaces, student study areas and establishing institutional reputation. Aspects that did not work well were the lack of consultations with building occupants and design faults or technical issues. This preliminary analysis of the evaluation of two education buildings indicate that focussing on issues of building sustainability is not sufficient for achieving overall building success in terms of performance management. Being green" is only one important feature of building success, but other aspects (user needs, satisfaction, etc.) of the building are prime considerations. It would seem that the focus on the "green" aspect has distracted the construction industry from other equally important design issues. The research outcomes intend to be significant for case study areas and benefit market audiences seeking new knowledge about performance development.

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