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Beyond buildings: holistic sustainable outcomes for university buildings

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The impact of climate change and adaptation pose huge challenges to the built environment. Educational institutions in particular, are faced with not just management of their built assets, but also future proofing their assets from a climate change and adaptation perspective as well as a learning and teaching perspective. While there are recent examples of educational institutions joining the wave of building iconic Green Star buildings across Australia, there still remains the question of whether the physical building, facilities management and occupancy patterns provide realistic triple bottom line (TBL) outcomes. Very little post occupancy studies, if any, are undertaken particularly capturing key experiences to further improve future new building development and refurbishment. Using the experience of an iconic building that has won numerous awards in Australia, this paper captures the learning from the perspective of educational institutions as owner-occupiers of built assets. A case study was undertaken using a mixed method research approach. Interviews were undertaken with the project team, both internal and external to the educational institution, complemented by post occupancy evaluation (POE) examining energy and water use of the building. In addition, a Building User Satisfaction survey was also undertaken. While the data set was evaluated using various frameworks, this paper focuses on the role of the management style in ensuring TBL sustainability outcomes. The paper highlights the importance of senior management support in achieving TBL outcomes and presents some guidelines for other educational institutions wanting to future proof their assets.

Keywords: Case study, Green Star, Post Occupancy Evaluation, interviews, triple bottom line.

Introduction

Buildings are significant contributors to environmental deterioration accounting for 40% of the world's energy consumption and one third of global greenhouse gas emissions (Cooper, 2001) throughout their life cycle and contribute 15– 45% of the total environmental burden for each of the eight major life cycle assessment inventory categories' (Levin, 2009). The total overall energy consumption of buildings is affected by climate change as weather patterns impact the energy use in buildings to regulate internal comfort conditions for occupants. Attempts to mitigate adverse environmental effects through the adaptation of existing and new buildings are becoming crucial as we transition to a sustainable low carbon future. What is required is a focus towards enhancing architectural design by using efficient and low embodied energy construction materials in order to save resources. Architects and other built environment professionals are striving to incorporate more sustainable design aspects and technologies to achieve better design outcomes, but also due to increased demand from clients to include sustainability considerations in the design. In doing so, it becomes important to close feedback loops so that monitoring of the building performance is supporting the original design intent.

This is increasingly being undertaken within a triple bottom line (TBL) framework, a predominant model of sustainability in which the environmental, social and financial outcomes are taken into account (Elkington, 1997) and where improving social outcomes and ensuring value for money becomes equally as important as improving environmental outcomes. The approach is in contrast to the finance first approach which saw social and environmental outcomes pushed down the list of priorities. Further, sustainability thinking within the TBL framework has expanded with the integration of ecological thinking into all social and economic planning (Lowe, 1996).

Educational facilities generally manage extensive property and building portfolios and share a considerably high amount of land. For instance in Victoria, the total rateable value of land as at June 2012 is valued at $1,047 billion and covers approximately 23 million hectares. Of this approximately 3.4 percent is covered by academic institutions (ABS, 2012). Although the land coverage may appear small, in terms of the total built up area, the value is significant. Furthermore, there is a high number of direct users associated with educational facilities. While educational facilities provide benefits to society, they have many direct and indirect environmental impacts associated with them which are required to be addressed. Direct impacts include use of land, materials and energy; this use in turn leads to greenhouse gas emissions and the production of other wastes. Indirect impacts depend on a range of factors including location, the use of the building throughout its life span and the urban form created through construction (ABS, 2003). Educational facilities throughout the world are large energy consumers (GBCA, 2013). Despite the low direct energy use by the construction industry, educational buildings become high consumers of energy and other resources on completion. Hence, the overall performance and effective management of buildings is important for facility managers and universities more broadly.

Once operational, the performance of buildings needs to be constantly evaluated and monitored in order to achieve utility targets. Although governments throughout the world have been proactive in instituting policies and measures aimed at halting climate change, focus on adaptation is still not emphasised. The potential impacts of building adaptation are now being addressed (GBCA, 2013). Both the functionality of the existing built environment and the design of future buildings are likely to be altered by climate change impacts, hence commitment for improving the energy performance of buildings should be considered as a strategic objective (ürge-Vorsatz, Harvey, Mirasgedis, & Levine, 2007). This paper provides an overview of the challenges confronted by educational facilities and implications of preparing these facilities for climate change.

Emerging Examples

The design and structure of educational facilities will shape the ways we think about education for the future (Radcliffe, Wilson, Powell, & Tibbetts, 2009). In the 21st century, the educational leaders are expected to understand how technologies can contribute to incorporation of sustainability elements in the design. In Australia and worldwide, technologies are promoted as a means of transforming teaching and learning, so pedagogies become more innovative, and by default create innovative students (ALP, 2007; DECS, 2006; DET, 2000; OPRI, n.d.; Williamson & Payton, 2009). This requires the management structures and framework to be aligned with the organisational setting in order to support the design intention and overall infrastructural, psychological, social and philosophical objectives. There are many leading examples in the literature showing such innovation and the Swanston Academic Building (SAB) at RMIT University explored in this paper is one such example, although this innovation has been more in the commercial building sector rather than the academic sector to date. Other notable recent examples in the non-residential sector in Melbourne, Australia, which have also undergone post-occupancy evaluations, include Council House 2 (Paevere & Brown, 2008) and ANZ office Docklands (Alessi, Heywood, & Drake, 2014).

In addition, academic institutions in Australia are strategically aligned to national policies and frameworks (Universities Australia, 2014), among which, is the promotion of the value of higher education and enhancing productivity.

Post Occupancy Evaluation (POE)

Across the past decade, POE has become an increasingly important tool for major infrastructure projects and efforts continue to both broaden the use of POE across all building projects and in refining the methodology of undertaking POE (Candido, Kim, de Dear, & Thomas, 2015; Menezes, Cripps, Bouchlaghem, & Buswell, 2012). The literature also points out to particular aspects of thinking and personality that differ between the people who build models and those who use them and the need to close the gap between predicted and actual performance (Azar & Menassa, 2012; de Wilde, 2014). It is necessary to pave the way to the broad adoption of POE in the design and building industry so that building can be managed according the key parameters and original design intent. More collaboration is needed between the architects, building designers and the construction professionals particularly those involved in building facility management and building performance evaluation. This is a gap that this study intends to address.

POE acts as a useful snapshot of user's views and 'assists in better understanding of the use and re-use of buildings over long life-cycles' (Whyte & Gann, 2001). POE can be explored architecturally, within realms of psychology, sociology and technology (largely for mechanical concerns). Previous literature has contributed to the significance of POEs and involving user satisfaction to evaluate a building's performance, and has recommended various ways to create a link between performance measurement and performance management. The objective of this research is to put theory into practice, and use the available knowledge and ideas to develop strategies for enhancing the link between levels of user satisfaction and management of the respective building by quantifying obtained results. Appropriate management or decision-making have a significant impact on implementation of POE and highlights its success within the facility management framework.

People in organisations and the assets used to support them achieving their goals or targets needs to be considered. Systems theory (Boulding, 1956) works on the premise that individuals in organisations seek more than just a "job". They seek satisfaction in their day to day work, and this is the primary basis around which management in universities are structured. Therefore, organisations, and in particular owner occupied organisations are able to have a greater control over their built assets such that they can optimise returns on their investments. These returns are both in the built assets as well as in their human resources so that rewards may be maximised.

Method

RMIT University is committed to improving sustainability across all areas of activities. This is most acutely demonstrated by a commitment to reduce greenhouse gas emissions by 25% by 2020, from a 2007 baseline. A significant pathway to achieving sustainability goals across the university is through the development (or improvement) of sustainable built environment assets. RMIT University has a number of innovative new buildings, which have been designed to deliver exemplary sustainability outcomes, and enhanced teaching and learning experiences for staff and students.

While recognised for their sustainability outcomes from a theoretical perspective, there have been no evaluations of these buildings to see how they were performing in reality. A proposal was developed to undertake a detailed evaluation of a recently constructed building: the SAB with funding support from the RMIT Sustainability Committee. The aim of the evaluation was to identify Triple Bottom Line (TBL) learnings and opportunities.

SAB is a $182 million, 12 level, 35,000m^2 innovative learning and teaching facility with capacity for 6,000 students and office accommodation for 850 staff. Some key highlights of the building and process include:

- Engaging future generation of teaching, learning and students,
- Creating a vertical campus,
- Achieving a 5 star Green Star Education Design v1 rating,
- Using a design and construct guaranteed maximum price contract,
- Early building completion; 108 days ahead of schedule,

- Innovative IT development across the university, and the southern hemisphere, and
- Innovative design and materials.

The evaluation was undertaken through two main methods: a Post Occupancy Evaluation (POE) and stakeholder interviews. The POE provides largely quantitative outcomes on the metrics of energy and water use, whereas the stakeholder interviews focused more on the process and role of management in the design, construction and operation of the SAB.

SAB Post Occupancy Evaluation

The POE analysed the building performance data (electricity, gas, water, temperature and occupancy rates) for the period August 2012 (when the building opened) to December 2014. This data was collected from the SAB's Building Management System (BMS), through the use of the research teams own monitoring equipment (e.g. Hobo temperature and humidity data loggers) and data provided by RMIT Property Services. This allowed for a triangulation of data to check for accuracy. Collected data was compared to initial Green Star Educational Design v1 utility performance aspirations as determined by the Green Building Council of Australia in the educational design rating tool and the wider RMIT City Campus building stock to assess the performance of the building. The collection and analysis of utility performance data, occupation/utilisation rates and temperature data followed techniques which have been applied across building research internationally (e.g. Ridley et al., 2013).

In addition, an international standardised Building User Satisfaction (BUS) survey was conducted for staff and higher degree by research students located in the building in March 2014. The BUS has been applied in numerous research projects across the world for both residential and non-residential buildings (Arup, 2015; Leaman & Bordass, 2001). It is a three page survey containing sections on thermal comfort, noise, air quality, space and general amenities and takes approximately 10 minutes to compete. The survey was distributed to all staff in the SAB via email and then followed up one month later with a paper based reminder. The response for the BUS survey was 150 completed (and useable) surveys out of 689 staff and full time higher degree by research students, a response rate of 20%. Data from the survey was also cross-checked with the performance analysis and stakeholder interviews to triangulate outcomes.

Stakeholder interviews

Interviews were undertaken with 17 key internal and external stakeholders involved in the design, construction and/or occupation of the SAB including the project manager, builder, architect, Environmentally Sustainable Design (ESD) engineer, building facilities manager, and senior managers, advisors, directors and student representatives from within RMIT University Property Services and the School which predominantly occupies the building. Interviewees were identified for the evaluation by RMIT University Property Services as key people who had been, or continued to be, involved in the SAB development.

The semi-structured interviews took about one hour and were conducted from April 2014 to February 2015 at the interviewee's place of work or at RMIT University. Interview questions focused on what worked well during the project, what the challenges were and what they thought the lessons for future projects were. Interviews were audio recorded and transcribed. Care was taken to reduce weaknesses of interviews such as interviewer bias, through techniques such as repeating key questions in different ways throughout the interview to allow answers to be correlated. The research was conducted under approval from RMIT University ethics. Participants have been anonymised as per ethics requirements.

Results and discussion

This section presents the results and discussion from the evaluation of the SAB. The technical performance of the building and BUS survey will first be presented, followed by the outcomes from the interviews with a focus on the role of management in achieving TBL sustainability outcomes.

SAB Building Performance

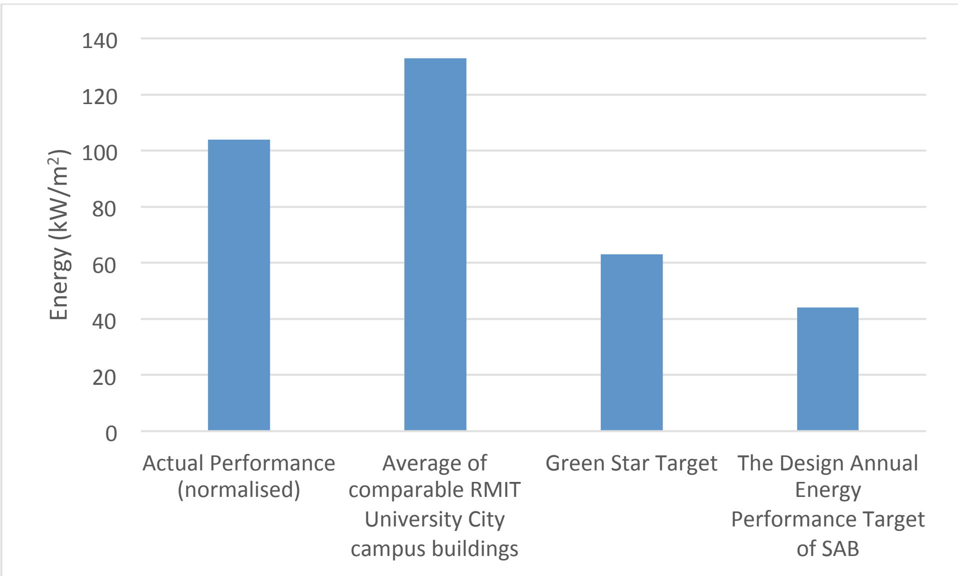
For the environmental element of the TBL approach, the SAB achieved a Green Star certification rating of 5 stars (v1). As explored in the interview analysis, this was a standard driven by senior RMIT management and integrated into the development from the conception stage – in fact it was decided that the SAB should have an aspirational target to use 30% less energy, and water than the current Green Star standard to push design and performance outcomes for the University. To achieve a 5 star rating a Bench Mark University Building should have the following annual energy intensities in kWh/m^2 of usable floor area (Table 1)**Error! Reference source not found.**. For the SAB, this equates to a target of total of 57.8 kWh/m^2/year (electricity and gas). The aspiration target therefore was 44.1kWh/m^2/year (electricity and gas).

Table 1: Green Star Educational Design (v1), 5 Star Performance Energy Criteria.

	Total Electricity kWh/m^2/year	Total Gas kWh/m^2/year
Teaching / Classroom Spaces	68.6	14.3
Office / Administrative Spaces	69.5	1.5
Common Spaces	39.3	0.8

Analysis of two years of utility consumption data found that the energy usage in the SAB was higher than both the 5 Star Green Star Educational Design (v1) target and the aspirational targets at 104 kWh/m^2/year (normalised for hours of operation and occupancy numbers). However, the usage is 50% lower than comparable RMIT University campus buildings (Figure 1). In part these results are impacted on by a significantly higher occupancy rate in the SAB than predicted in initial modelling. Analysing for a kWh/m^2/occupant based upon actual occupation, the SAB utility consumption is 98% lower than comparable buildings within the university. From a greenhouse gas emissions perspective, the building is performing at 3.5 times higher than the predicted rate, again in part due to the higher utilisation of the building.

Figure 1: Comparison of actual and target/predicted energy performance.



In terms of water consumption, the building was found to have 61% lower water consumption to other RMIT buildings when adjusted for floor area. When rainwater and recycled water is considered, actual potable water consumption of the building was 92% lower than comparable RMIT buildings.

From a comfort perspective, internal temperatures were within the comfort range (18-26°C) 97% of the time. The building contains elements of mechanical heating and cooling as well as natural ventilation which the data shows is working well; in fact, the temperature settings for the SAB have been revised to reflect occupants being comfortable at higher/lower temperatures across the year.

The BUS survey confirmed occupant satisfaction with the building in terms of performance and function. The survey found that the building performed excellently in three categories: overall comfort, design and image to visitors, but poorly in two categories: Perceived health and overall noise. The survey results placed the building in terms of satisfaction levels in the 64% top percentile compared to the Australian benchmark data. This indicated that achieving improved environmental sustainability performance has not compromised occupant satisfaction.

From a management perspective the above analysis demonstrates a significant improvement on utility consumption and occupant satisfaction of the SAB in comparison to other RMIT University comparable buildings addressing elements of the TBL approach (i.e. improved environmental performance, improved social outcomes and lower operating costs). However, whilst there was a clear aim to achieve certain targets (e.g. 5 Star Green Star Educational Design v1), it is clear that actual outcomes are not (yet) matching predictions. Issues such as occupancy numbers and longer operational times of the building are impacting on the performance of the SAB, but are also a reflection on how well liked and utilised the building is for staff and students. These and other challenges will be explored below.

Interviews

The interviews with key stakeholders found a number of challenges, successes and learnings - a summary of key outcomes are presented below, with a focus on the role of management in ensuring TBL sustainability outcomes. Further analysis will be presented in forthcoming articles.

There were two key elements introduced in the conception phase of the development of the SAB which had significant impact across the TBL sustainability outcomes, both of which were driven by senior RMIT Property Services management. The first was to set both the 5 Star Green Star Educational Design v1 and 30% aspiration improvement targets as desired performance outcomes. This was guided by a wider governance approach to address sustainability across the university as evidence by the commitment to reducing greenhouse gas emissions by 20% from 2007 levels by 2020. It was recognised by senior management that new buildings therefore had a significant role in achieving such outcomes and the development of the SAB arrived at an opportune time to solidify this approach.

By including the requirement for the environmental performance targets in the design brief, it allowed the architect and other key stakeholders to integrate this approach from the beginning. This meant that environmental considerations were not added on, but informed the philosophy of the design. The use of the Green Star Educational Design v1 framework meant that a broader consideration of all elements of sustainability was required, rather than just whatever were the key strengths of the stakeholders involved. However, SAB was one of the first educational buildings to seek a Green Star Educational Design v1 rating which also provide a number of challenges in and on itself. Property Services have learnt from this experience and are in the process of integrating a number of outcomes regarding design into the revision of the RMIT University Design Guidelines.

> *[The architects] culture and approach to design is one where they do put sustainability upfront within the design process…From a sustainability engineers perspective, that works in our favour as you know you are going to get that engagement early in the process and buy in.* (Stakeholder 2)

> *If you don't get the design right the operational impacts are huge, they're massive.* (Stakeholder 3)

The second key conception phase decision by senior RMIT Property Services management was to undertake the project through a maximum price design and construct contract which was not common within the academic sector at the time. This allowed the design phase to be extended by six months at the request of the architect. As there was no impact on this in terms of cost to RMIT, the university was happy to allow this. The additional design time was used to properly consider, test and design the building. It allowed time for the development of a virtual time table to test out various room and space requirements and occupancy predictions for the new building. Through the use of the virtual time table, 10% of internal floor space was saved in the final design, resulting in tangible economic savings for the university again contributing to the TBL approach of the project. At the time the use of virtual time tabling for building design was innovative in the Australian academic sector, but is now common across Australian Universities.

> *At $6,000 per m^2, if you can save a couple of classrooms that saves you a lot of money.* (Stakeholder 9)

Another key decision made between senior management and the architect was to push the innovation for the teaching and learning spaces. While not all the innovative teaching spaces and elements are successful, the majority of them are, and this is a testament to the success of the building and the drive from across the project team to achieve this.

> *The utilisation stats from last year was 20% more attendance in the classes in the building than the rest of the university*. (Stakeholder 9)

Furthermore, the external stakeholders interviewed were very clear in stating that a key point of difference in this development was the buy-in and governance set by senior management at RMIT University and that this flowed through all stakeholders involved in the project allowing for innovation around sustainability, social improvement and finances. Despite this, there were challenges throughout the project to engage staff to participate in the project and prepare for moving into the building, especially as the building was promoting cultural change.

> *It's good to allow people the opportunity to comment and 'allow buy-in…especially when you are using architecture to drive cultural change, which this building is doing.* (Stakeholder 4)

The preparation of staff for the cultural change was one area where contestation was identified between management and other stakeholders. The interviews identified that this transition process became an internally championed process from within the Schools moving into the building. This was in recognition that there seemed to be no clear approach to preparing staff from the project management team; although the project management team disputed this to some degree stating they allocated resources and developed a pathway to facilitate the transition. It often fell upon individuals to shoulder the burden and pursue for the benefit of all staff.

> *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)

An area for improvement is facility management of the building itself. This was overlooked in the design phase. The facility management was outsourced initially for the SAB. Due to the timing of the appointment of the facility manager, hand over post occupancy was not done well, which led to issues over the commissioning of the building. The facility manager handed over the management to the owners almost 2.5 years post occupation. Documentation alone in the hand over process back to RMIT is not enough, it was essential to ensure that the owner understood the reasons why certain parts of the building was commissioned the way it eventually was.

> *I just think that if they just spend a bit more time closing out these things and making sure the monitoring is correct and ensuring the commissioning is done properly and doing sustainability more holistically it will be a brilliant building for the next 20 years. (Stakeholder 1)*

Overall the development of the SAB has been very successful from an environmental sustainability perspective, occupant perspective and financial perspective. However there are lessons which can be drawn upon for future developments to improve outcomes further. The evaluation of the SAB has shown that amongst the various criteria for success within a TBL approach, there is need to:

- Ensure top-down buy-in from all levels of management at the university.
- Establish environmental sustainability criteria upfront to shape design and outcomes rather than be seen as add on.

- Include an as-built rating requirement (i.e., performance), not just a design requirement to ensure that outcomes align with targets.
- Address disconnect between predicted and actual building performance across academic buildings.
- Allow sufficient time for a detailed design phase.
- Allow adequate resources to prepare staff for cultural transition.
- Have a more formalized pre and post development evaluation, including a strategy for adoption of lessons learned.

Conclusion

In terms of energy and water consumption, the SAB did not achieve its Green Star Educational Design v1 targets. However, it did perform significantly better than other RMIT buildings in the same city campus. Part of the reason why the building did not achieve Green Star Educational Design v1outcomes were the utilisation of the building itself, which was underestimated in the assumption regarding utilisation and patterns of use.

The underlying philosophy of participation and consultation with various stakeholders can be attributed to the success of the SAB and a key driver of improving TBL outcomes compared to previous RMIT building developments. This took longer in the lead up to the design process, however, this brought reward at the end, in the form of early completion. The one area that was highlighted post occupancy was hand over to the facility manager of the building. The relationships built between the various team members during the design process not only benefited the SAB, it has also been taken to other buildings such as the New Academic Street, currently under development at RMIT. Whilst not overtly stated, individuals did take their roles seriously, and demonstrated that they were committed to ensuring that the building itself was successful within a TBL framing. They took it upon themselves to ensure that the goals of the wider project team were met.

To enable success of buildings for TBL outcomes (e.g. sustainable through lower energy and water use, social through improved student and staff connection and use of the building and financial through a building that provides good value for money now and into the future) these elements need to become part and parcel of the brief of the building. To meet the design intent, performance measures must be set and monitoring must take place, so that disconnect between design and performance no longer exists. It does require that additional resources are allocated post occupancy for design intent to be met. Ultimately, occupiers of the building are part of the performance outcomes of the building. Therefore, staff training is required so they understand the building and their behaviours are aligned to the stated goals of performance. Formal documentation of lessons learnt will allow owner occupiers to learn from the experience and fast track better TBL performance for other buildings in their portfolios.

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