Chapter

Highlighting the Design and Performance Gaps: Case Studies of University Buildings

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Abstract

Buildings are one of the highest emitters of greenhouse gases globally. To reduce the detrimental effects of buildings on the environment and recognise their potential for emissions reductions, a transition towards sustainable building solutions has been observed globally. This trend and the associated benefits have been discussed and argued for more than three decades now. However, the impacts of sustainable buildings are yet to be demonstrated at macro, meso, and micro levels in the community, as the actual versus expected performance of such buildings are still being questioned. Consequently, this entry discusses the concepts underpinning sustainable buildings outlining the drivers and practices to achieve sustainable built environment solutions from the design to operation stage using university buildings as a case study. The chapter also recommends evidence-based solutions on understanding the actual and perceived gaps to achieve expected performance using "Green Star" rated academic buildings in Australia.

Keywords: facility management, green academic buildings, green construction, green star, post-occupancy evaluation, sustainable buildings

1. Introduction

Globally, it is a critical time to act on climate change either through developing appropriate policies, focused research or implementing sustainable and green strategies across various sectors. The report by United Nations Environment Programme (UNEP) and International Energy Agency (IEA) [1] indicates that by 2056, globally, there is going to be a rapid increase by five-fold in the economic activity and by three-fold in energy consumption compared to the current numbers. Furthermore, there would be a population increase by 50% and a drastic rise in global manufacturing activities imposing further pressure on the resources and planet. Buildings alone are responsible for 40% of the GHG emissions [2, 3]. As a consequence of the rapid growth in economic activities, urbanization, and growing population, the impact of the built environment sector on the planet is anticipated to worsen further. The building industry's exhaustively growing consumption of energy through the construction to operation phase is considered as a major contributor to environmental pollution, producing an enormous amount of waste [4–8].

However, the building industry also demonstrates high potential and has capabilities to contribute towards significant emissions reduction [9–10]. As stated by the United Nations Environment Programme [2], "the solution that sits at the intersection of urbanisation and climate change which can cut carbon emissions, boost productivity, and enhance the health and wellbeing of people is a green building." The outcomes and commitments of the built environment sector have also been recognized as a critical sector at COP26 at Glasgow demonstrating leadership, resilience, and social inclusiveness for climate action [11]. However, a "sustainable" or "green building" is a broad and complex concept, which is still quite perplexing for the building industry. Sustainability is a concept that is built upon three key aspects, namely environmental, economic, and social sustainability. These three aspects need to be incorporated collectively and cannot be targeted individually to achieve expected results [4, 6, 7]. Jenson [12] states that it is when all these aspects fit together in the planning and governance strategies, one can deliver buildings that perform as desired and are truly sensitive to our environment. This is a challenge continually encountered by design, construction, and building management practitioners. The objectives primarily established are mostly only incremental changes; however, what is required is a step-change in these design and management approaches being currently followed to acknowledge the veritable potential of buildings.

Supporting this concept, many recent studies have argued the potential of buildings for delivering significant cuts in emissions at no cost or little extra cost, reducing harmful environmental effects, and acting as the backbone of any economy [3, 6, 8]. There is immense potential for this as the building industry employs more than 10% of the global workforce [1, 3, 6, 10], resulting in gains in social outcomes as well. Underpinned by this argument, this chapter discusses the key concepts of sustainability in buildings and recommends a best practice model to close the gap between actual versus expected performance taking "Green Star" rated tertiary education institutions in Melbourne, Australia as case studies. Green Star is the internationally recognised sustainability rating and certification of the Green Building Council of Australia (GBCA). This is cross-referenced in Section 2 – Background (p4) with further information. The results of the study presented assists the design community to deploy strategies that not only meet a building's energy and savings targets but also respond to occupants' requirements of space comfort and use, creating an overall efficient system for users and building managers alike, thus achieving all three components of sustainability – reduction of environmental impacts, increased social outcomes, and reduced economic costs.

2. Background

The two aspects of the overall building purpose and operation are not necessarily always in sync as has been demonstrated to date by the way the industry has approached this problem in the form of split incentives [13]. Many organisations feel that just complying with the environmental norms or national regulations is enough to meet user needs, and their work is completed once they manage to deliver a building as per such guidelines. Examining the performance of a building is also mostly restricted to evaluating the operation of a building with respect to energy consumption and energy efficiency. Most initiatives taken by facility managers and senior management are to ensure that the utilities, that is, electricity, gas, and water consumption of the building meet the standards overlooking other key concepts of performance management, such as incorporating the occupant's perception and outlook in building management, performance evaluation through a building's life cycle, and other such social considerations beyond the environmental. However, a building in operation is a complex system and its management should not be restricted only to the knowledge of facility managers. It should focus on more integrated and holistic approaches, where the organisational objectives, knowledge of facility managers, review by the external stakeholders, and occupant perceptions should all be considered together to be satisfactory and present optimum results for these stakeholders.

As indicated earlier with green buildings, the assessments have generally been restricted to the measurement of energy being the key focus for most organizations when aiming to reduce the emissions or overall carbon footprints. When including other aspects of building performance, many studies [14–19] have discussed the significance of monitoring design and other internal building features, with a focus primarily on indoor environmental quality (IEQ) and thermal comfort conditions. However, not much focus and practical exploration have been undertaken to consider occupant satisfaction for evaluating overall building performance and closing the loop between the occupants and building management to achieve holistic green outcomes [20, 21].

Tertiary education institutions have a critical role in the current decade to innovate, excel, and set an example in meeting the needs of the changing environment [22]. The strategic vision of universities needs to be one that accounts for the rapidly changing world, and to be flexible enough to recalibrate and refresh as conditions around them change. Universities globally are investing billions of dollars into building construction that showcases their sustainability commitment [23] designed for being used as science laboratories to incubate innovative green technologies facilitating academic and research activities. Universities are constantly upgrading to sustainable standards leading through design, innovation, and adapting to new reforms and requirements by the industry around the globe. Such reforms are formulated to cultivate a population that is knowledgeable and active towards their crucial role in sustainable development and combating climate change.

Over the last several years there has also been a shift away from a prescriptive approach to sustainable design towards the evidence-based evaluation of actual performance through life cycle assessments (LCAs). While LCAs are not yet a consistent requirement of green building rating systems and codes, there is a trend towards requiring LCAs and improving the methods for conducting them [24]. Here is where green building assessment tools play a role in guiding the design professionals towards green approaches and eliminating bad performing buildings from the building industry. Building assessment tools are in a continuous state of evolution and continue to be refined to reflect new standards and goals for achieving ever-higher levels of sustainability [24, 25]. Therefore, it is essential to investigate the most current versions of these tools to gain an understanding of the requirements that must be met to achieve optimal results.

Globally, sustainable building rating systems started about 30 years ago after the development of Building Research Establishment Environmental Assessment Methodology (BREEAM) in 1990. Since then, there is an emergence of several environment rating tools for buildings, such as Leadership in Energy and Environmental Design (LEED) in the U.S.A, Eco-Quantum in the Netherlands, Promise in Finland, Eco-Pro in Germany, Haute Qualité Environnementale (HQE) in France, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan, and Athena in Canada, to name a few. The assessment methods for these rating tools vary from the perspective of scope, structure, format, and complexity. Apart from the most commonly used rating tools, such as LEED and BREEAM, other assessment tools fall into the category of qualitative and life cycle assessments, including the Sustainable Building Tool; Green Star, Hong Kong Building Environmental Assessment Method (HK BEAM) or tools adapted to specific countries, such as LEED adapted for Canada and Australian Green Star adapted for New Zealand and South Africa. In some instances, the tools have developed into a new tool, for example, the Building Assessment Tool (SBAT) influenced by BREEAM and LEED.

Although most of the existing building rating systems are voluntary, in some countries, such as Australia, it is a mandatory requirement for minimum energy requirements of new office buildings and major refurbishments as per the National Construction Code Building Code of Australia maintained by the Australian Building and Construction Board [26]. Development and uptake of such rating schemes are promoted in Australia at a national level, as the detrimental effects of buildings account for approximately a quarter of the nation's greenhouse gas emissions and two-thirds of electricity consumption [27]. Currently, two voluntary national accreditation programs exist to measure and report on the environmental performance of office tenancies and assist in guiding best practice office fit-outs. These Australian building rating systems are mandatory requirements for minimum energy requirements of new buildings and major refurbishment [28]. The two rating systems, that is, NABERS and Green Star, currently available in Australia promote sustainable building development in the commercial space. Green Star is Australia's only national, voluntary, holistic rating system for sustainable buildings and communities [29]. The Green Building Council of Australia (GBCA) developed Green Star, which is a design-based rating system that provides no guarantee of, or commitment to, a specific level of performance and confines itself to the intent of the design and to some extent the provision of the process to achieve that intent [30, 31]. The Green Star rating system is a much broader rating scheme than NABERS and assesses both environmental and liveability factors throughout a building's lifecycle [29]. Green Star has now achieved sufficient market penetration and may be considered to be part of procurement practice by industry.

This study used Green Star rated buildings. Green Star started with three rating classifications, that is, "As Design," "As Built," and "Green Star Communities." Recently a fourth component of "As Performance" [32] has been added to the rating system, with each classification having versions as and when updated.

There are several versions of each Green-Star tool that have been updated since the tool was first created. Rating buildings as per the design and built outcome to interiors, performance, and communities, Green Star supports deploying innovative practices to optimise sustainability outcomes through an array of options [33]. All the versions of the Green Star rating scheme started with a pilot version to understand the limitations and continued refinements based on changing global, national, and industry requirements. As the evaluation of the case study buildings were conducted over the period 2014–2019, the buildings used were all Green-Star buildings certified for As Design (v1) at the start of the data collection period. A total of 86 academic buildings/projects in Australia were certified As Design (v1). Of which, 35 projects were in Victoria. 37 buildings/projects were certified following As Built (v1) with 6 projects located in Victoria.

Concurrently, what is also required is to constantly upgrade university governance models for long-term sustainability. The governance strategies for most universities are focused on shaping their respective campuses, creating innovative learning spaces, and a student precinct, which supports a rich and rewarding student experience. Universities aim at developing teaching and research facilities, which by their very nature, encourage interdisciplinary collaboration and industry engagement, and explore options for campus development to accommodate increasing scale in both teaching and research. Formulating appropriate strategic plans to incorporate such outcomes is crucial and provides a framework within which to develop, implement and modify practices, associated investments, and action plans.

3. Method

For the purpose of selecting study buildings for the research, a detailed evaluation of four recently constructed Green-Star rated academic buildings in Australia was carried out to observe their performance and management structure in reality. Four tertiary academic institutions were selected in Melbourne, Australia as case study buildings, incorporating post-occupancy evaluation techniques and appropriate project management strategies. The buildings were completed within the 2010–2014 period. The key features (Building Type, Academic Faculty, Green Star Certification Score, Volume, Area, and number of Floors) of the study buildings are described in **Table 1**. The buildings are denoted as Buildings A, B, C, and D. The results provide a model framework for design stakeholders to achieve desired building performance targets for green buildings, as they are designed to perform as per specific standards but can be applicable to conventional or non-green buildings as well, drawing upon lessons learned from this study.

The study has adopted a mixed-methods approach utilizing both quantitative and qualitative techniques. For quantitative data, survey research has been deployed. Surveys have been used to evaluate occupant satisfaction levels in the case study buildings.

Currently, Building User Survey (BUS) and Building Occupants Survey System Australia (BOSSA) are the only two officially accredited post-occupancy evaluation (POE) instruments within the National Australian Built Environment Rating System (NABERS) for commercial buildings used in Australia [34]. These surveys are robust and accessible Australian alternatives to other surveys currently in use by NABERS and

Study Buildings	Building Type	Faculty	Green Star Certification (Education Design v1)	Volume	Gross Floor Area	No of Floors
Building A	New Build, Refurbished	Architecture and Design	Certified – 5 Star Green Star, 2011	16,040 m^2	13,000 m^2	10
Building B	New Build	Design and Manufacturing	Certified – 6 Star Green Star, 2013	21,000 m^2	10,000 m^2	11
Building C	New Build	Construction	Certified – 5 Star Green Star, 2014	17,500 m^2	11, 861 m^2	3
Building D	New Build	Architecture and Design	Certified – 6 Star Green Star, 2014	17,673 m^2	14,528 m^2	7

Table 1.
Description of case study buildings.

Green Star Performance rating tools [35]. However, BOSSA has wider applications, BUS surveys were used in this study due to the narrower scope, more-wider presence globally and acceptance of the respective survey, and the license rights available with or for the case study buildings [28, 34]. Apart from the BUS itself, an online survey deployed through Survey Monkey (cloud-based interface) was used by one of the case study buildings. Although the survey used was different for one building, their project managers allowed the researcher to add or modify survey questions as required before they were finally deployed. Hence, to ensure comparative study across all the buildings, their questionnaire was modified, and questions were added or removed to match the themes of the BUS format. So, four buildings used BUS and one building used an additional online survey as well as the standard BUS. BUS is available as hard copy survey and online; the buildings used the online survey rather than hard copy.

The surveys were used to evaluate the feedback of case study buildings, focusing on staff rather than staff and students. This was because staff spend more hours in a building either for teaching, research, or undertaking other professional activities. The BUS surveys used a 5-point Likert scale for measurement with 1 rating the highest dissatisfaction to 5 being the highest level of satisfaction. Statistical analysis of the occupant satisfaction survey data was carried out using SPSS Statistics (version 26) analysing via one-way ANOVA. Many studies [36–38] have proved that the Likert scale data can be analysed using parametric tests, as the analysis can vary based on how the responses are formulated. For example, in this research, the distance between each item category is considered "equivalent," and when a Likert scale is assumed to present symmetry of variables and is equidistant, it behaves more like an interval-level measurement in practice, being suitable for parametric tests [37, 38]. In this study, the distance between each item category is "equivalent" and the Likert scale was used to run parametric tests on the data collected. The other key primary criteria were to assess if the data were normally distributed within all groups. Hence, the Descriptive and Levine's Test for Homogeneity of Variances was carried out for all variables [36, 37]. The output displayed normal distribution using the mean values as the measure of central tendency, that is, the probability distribution. Correspondingly, as the data represented a Gaussian population (normally distributed), one-way ANOVA was used to determine the statistical significance of data [36, 37].

In addition to the surveys, qualitative tools in the form of walk-in discussions, stakeholder interviews with the building facilities department and design stakeholders, and focus group discussions were undertaken. The walk-in discussions assessed occupant's (including building's staff and students) responses in a more informal

Figure 1.
Data collection approach.

manner, followed by the outcomes from the stakeholder interviews, assessing the role and responses of management and finally the focus group results. The focus group discussions were conducted to share the preliminary results and discuss preliminary results of the actual versus expected outcomes with key management stakeholders. These qualitative results assist in understanding and validating the occupant survey findings and facility management perspectives concerning sustainable and green building concepts. The study hence adopted an "Action Research" framework for data analysis. The steps involved in the data collection are summarized in **Figure 1**.

4. Results and discussion

The categories and sub-categories of the Green-Star As Design (v1) rating tool were used. Each sub-category has certain scores available that when combined form the maximum score available for that Green-Star category. The specific scores attained and statements made by the study buildings in the original Green Star application documents assist in determining the original design intention by a building.

Green-Star performance of case study buildings was analysed by utilising the Green-Star applications submitted by the respective institutions as an expression of interest for creating these buildings. The scores achieved by each building assists in understanding the commitments of the respective institutions. The mixed-method techniques deployed assisted in evaluating and validating how well these case study buildings performed in relation to the targets they laid out in their respective applications. The scores achieved by each case study building against the nine categories of the Green-Star As Design (v1) rating system are shown in **Table 2**.

As shown in **Table 2**, all the case study buildings scored high under the first five categories, namely – (i) Management – achieving score on factors, such as external and internal building commissioning, delivering appropriate management practices, evaluating user satisfaction, technical and physical performance; (ii) IEQ – for improved technologies for providing better IEQ services; (iii) Energy – achieving

Green Star As Design v1 Categories	Available Points	Points scored by Building A	Points scored by Building B	Points scored by Building C	Points scored by Building D
Management	14	12	12	13	14
IEQ	25	13	11	16	17
Energy	29	14	14	18	14
Transport	13	12	12	13	12
Water	13	10	10	16	14
Materials	20	12	12	14	14
Land use and ecology	7	4	4	2	4
Emissions	13	9	9	6	8
Innovation	5	0	0	0	10
Total	140	65 – 5 Star	63 – 5 Star	76 – 6 Star	83 – 6 Star

Table 2.
Scores achieved by each case study building across the nine Green-Star As Design (v1) categories.

Building Name	Total no. of staff	No. of responses
Building A	54	37
Building B	42	30
Building C	60	42
Building D	131	60

Table 3.
Case study building sample size.

energy efficiency, carbon footprint reduction; (iv) Transport; and (v) Water – using water-efficient technologies. The buildings scored moderate on materials, land use, ecology, and emission and no score on innovation, except Building D, which attained double the maximum score available for innovation, due to commitment in design and technologies promised.

The BUS surveys used to assess the staff responses towards these newly built Green Star rated buildings evaluated user comfort, indoor environment quality, wellbeing and productivity, and communication with management. In relation to the surveys, the effective population size (N) for each case study building is described in **Table 3**.

The key findings to emerge from the surveys were occupant responses towards three main themes – (i) impact of various design and work environment conditions (office/desk design, thermal comfort, acoustics, personal control, etc.) on their overall behaviour; (ii) their overall comfort and perceived productivity; and (iii) dissatisfied engagement levels from the management level

The user's perspective towards the impact of various design and work environment conditions on overall behaviour showed that 69% of users in Building A, 66% in Building B, 55% in Building C, and 58% in Building D rated the conditions in the building affected their behaviour personally (with colleagues) and professionally (in terms of work and productivity). Most users commented that the overall comfort or productivity was drastically affected, leading to changes in the work schedule and activities. Using Pearson (r) statistical test, significant at $p < 0.01$, the highest correlation was the variable 'building meets user needs and comfort', followed by 'overall comfort and perceived productivity', and 'perceived productivity and perceived health. The correlation results are presented in **Table 4**.

On rating the engagement of management, the mean of responses on the satisfaction scale of 1–5 for Building D for two variables were – 4.25 for: (i) facilities meet user needs, and (ii) speed of response for staff complaints, and 3.24 for the effectiveness of response. The results for Building D were the highest when compared to other

Variables	Correlation between variables			
	Building A	Building B	Building C	Building D
Building meets user needs and comfort	0.821	0.786	0.705	0.993
Overall comfort and perceived productivity	-	0.904	0.775	-
Perceived productivity and perceived health	0.913	0.747	0.863	0.797

Table 4.
Pearson correlation coefficient (r) between work environment variables in case study buildings.

Variables	Correlation between variables	
	Building B	**Building D**
Facility meeting user needs and effectiveness	0.955	0.738
Facilities meeting user needs with speed of response	0.929	0.681

Table 5.
Pearson correlation coefficient (r) between stakeholder engagement focused variables in case study buildings.

buildings, stating the highest level of satisfaction for the occupants of Building D. The other buildings also had mean scores close to or more than 3 on facilities meeting user needs and effectiveness of the response, demonstrating moderate levels of satisfaction. The occupants for all buildings rated lowest on the speed of response to a request to change, demonstrating lower levels of satisfaction. This particular aspect was also observed in the open-ended comments, where the occupants (average of 42% in study buildings) expressed their discontent towards the attitude of the facilities for not acting upon their requests or complaints on time. When the variables under this category were compared, a high correlation between two variables in each building was observed. The highest correlation (significant at $p < 0.01$) was observed in Building B followed by Building D demonstrating a high positive relationship. This suggests that for the users in Buildings B and D, the positive response for one variable affected the other directly. The correlation results are presented in **Table 5**.

On completion of occupant feedback survey analysis, it was observed that the occupants of the study buildings had mixed feelings about the facility. As primary occupants of the buildings, the staff were reasonably satisfied with the overall building, but not fully satisfied that it met their expectations specifically in relation to their office space and comfort. However, as per the occupant's perspective, the facilities were designed very efficiently and effectively for its students, with management's key focus being on providing a comfortable and desirable environment for the students over the staff.

Nonetheless, for all four buildings, the occupants on average showed high satisfaction (87%) towards the building design and Green Star attainment, medium/neutral satisfaction (57%) towards maintained temperature conditions, lighting levels, and comfort, and low satisfaction (42%) towards noise levels, office space, perceived productivity and health, and personal control over physical factors. This level of lower rating can be associated with several factors, including a shift to open-plan offices, sustainability initiatives not working well, and a lack of appropriate occupant engagement by the management, as per the occupant's open-ended comments provided in the surveys. Upon comparison between the four buildings, it was observed that Building D outperformed all other study buildings with the highest occupant satisfaction (89%) and Building C rating the lowest levels of occupant satisfaction towards most measured variables (54%).

Summarizing the responses, the quantitative results assisted in understanding the extent to which the study buildings met their occupant's needs and expectations, and how well have the facility managers succeeded in providing the building services to the occupants. On an average (43%), the results implied an overall low satisfaction of occupants with respect to their workspace environment and factors, demonstrating that the study buildings lack the ability to meet the primary objective of fulfilling occupant needs and improving their comfort and productivity. These quantitative results were triangulated with the qualitative results to eliminate any bias and understand the occupant-management relationships, and management's perspective in the study buildings for arriving at the final recommendations and conclusions.

The qualitative results obtained via walk-in discussions, stakeholder interviews, and focus group discussions re-emphasized the "missing link" or lack of communication loop between building occupants and the management, ultimately affecting the overall building performance. The management's priority is to achieve the University targets, whereas the occupants want a good indoor space to work, in addition to being able to express their needs and wants. Both managers and occupants' perspectives are individually valid and justified but do not complement due to low or negligible stakeholder prioritization and engagement in the management strategies. Hence, this chapter highlights the learnings from the case study buildings and develops a model using the best practices for improved execution in future projects.

The stakeholder interviews and focus group further assisted in triangulating the study's outcomes in correspondence to Green Star aspiration results. The results demonstrated that buildings could achieve certification, but the operation can still be poor in terms of low occupant satisfaction levels towards their workplace productivity and comfort. Major concerns observed in the walk-in discussions and stakeholder interviews were the lack of occupant engagement and consultations by the facility management officials during the building design and construction phase; none to extremely low involvement of design officials after building in use; and the limited focus on short term benefits over life cycle performance. The discussions with facility and building managers reiterated the key aspiration for the building's senior management was to achieve overall energy efficiency and make student-friendly facilities, rather than creating a productive workplace for the staff. The results also demonstrated that although the buildings scored high against the "management" and "energy" categories of the Green Star applications, most sub-categories were not satisfied in the operation phase. The management and design stakeholders primarily associated this non-functionality with technical defaults or cost-related issues.

The analysis reported in this chapter demonstrates that the development of the case study buildings has some success from an environmental, sustainability, and financial perspective. However, lacked drastically from an occupant (social) perspective. There are lessons that can be drawn upon for future developments to improve outcomes further. The analysis of survey responses and interviews highlights that it is crucial to close the loop between the performance measurement and performance management of buildings to achieve sustainability. Moreover, it is recommended to integrate stakeholder engagement and management at each phase of any project, to optimize the potential for all the stakeholders, and create an output beneficial and satisfactory for all.

The best practice model hence recommended by the study serves as a guidance document, providing structure and direction for the design professionals, and facility and building managers to prepare and implement their actions strategically, to achieve the desired performance of their buildings along with building occupant satisfaction. The model is represented in **Figure 2**.

Figure 2 demonstrates the structure of the key factors of the "best practice model" recommended by the study, based on the gaps identified earlier on and learnings from the study findings. It represents a continuing sequence along with the direction flow of the stages, tasks, or events in a circular flow, with each stage having the same level of importance, to ultimately achieve project success and performance management throughout the life cycle. This model has been derived based on the analysis of green-rated tertiary education buildings; however, it can be adopted by all commercial building types as it informs a general structural change required in an organization's

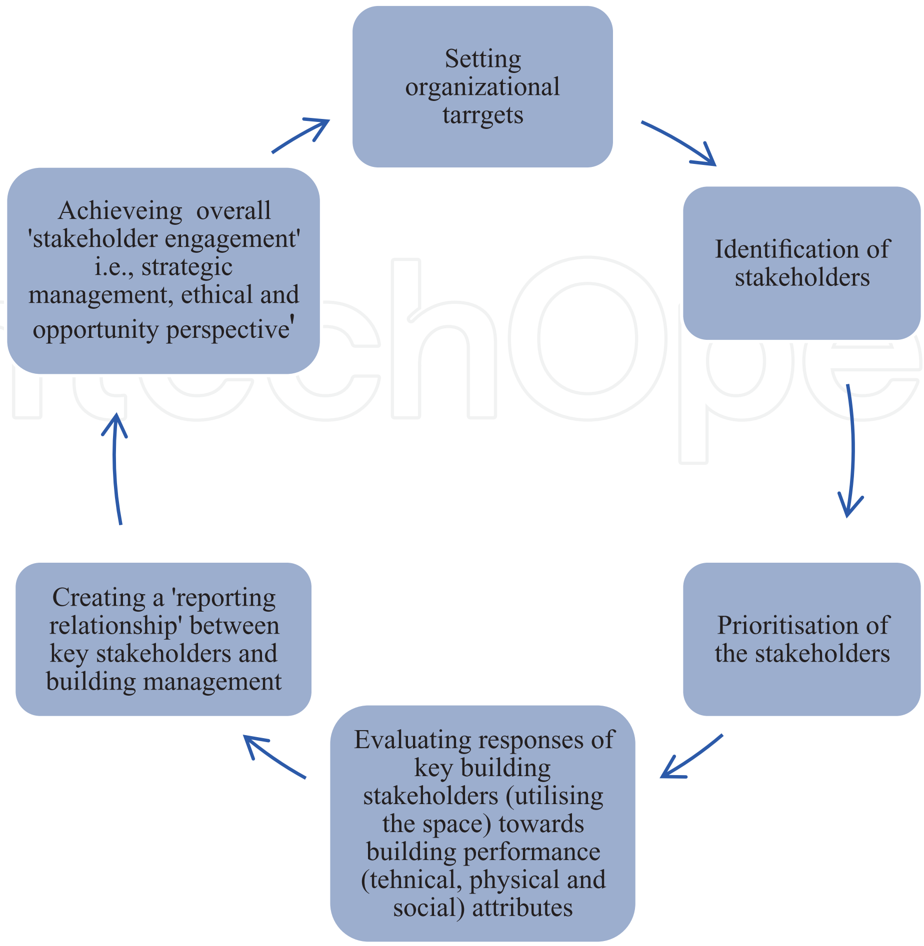

Figure 2.
Recommended 'Best Practice Model' for achieving sustainable building outcomes. Source: Authors.

management practice, to deliver required and appropriate governance strategies achieving all business outcomes and creating productive workplaces for the users. The key recommendations of the model can be summarized as a model that includes:

1. Identification and prioritization of key building stakeholders

2. Mapping the effects of building performance on different stakeholder groups and measuring the satisfaction of occupants (annually) using and being affected the most by building operation and function

3. Closing the loop of communication between the design team (internal and external) and building users by raising information

4. Collaboration across different organizations and agencies. This is because organizations or agencies often collect and manage their own data/research and have little or no incentive to share it with others. Without a culture of collaboration and knowledge sharing, attempts to understand and analyze interrelated building performance and sustainability issues are unlikely to succeed

5. A strong government mandate and institutional frameworks can provide a much-needed push

6. Routine (half-yearly or annually) performance monitoring of buildings as per the national guidelines for non-green or rating systems if certified to become mandatory for buildings. For example, the case study buildings were Green-Star rated (As Design) which does not mandate the buildings to evaluate performance once the certification is received, even when applying for re-certification. The recent version of the standard has been updated to mandate such assessments but the buildings previously certified are exempted, creating a gap in performance evaluation. This is a gap that needs to be closed by making evaluation techniques mandatory for buildings as per the desired or required standards

7. Appropriate incentive structure and practical arrangements for handling the information generated so that it becomes attractive and feasible to develop a set of good practices

Retaining and sharing the knowledge and lessons learned, then capitalizing and converting this to insights for future projects will be challenging, considering the flux in many organizations in these increasingly uncertain times. Nonetheless, incorporating ongoing performance evaluation, stakeholder engagement practices and understanding the need for reporting and getting the reporting relationship right in any organization becomes an important consideration.

The framework defined in this chapter is primarily based on the stakeholder engagement principles and is a three-step pyramid process. At the lower level or the base, the framework determines "Strategic Management" perspective, which simply means identifying organisational targets and priorities, enhancing decision-making processes, and ensuring stakeholder identification, prioritization, and engagement towards design, processes, and outcomes, followed by "Ethical" perspective illustrating maintaining harmony between stakeholder groups and identifying socio-behavioural aspects, and the higher level or apex constituting the "Opportunity" perspective illustrating knowledge sharing. The contribution of the research (based on the framework) to the knowledge will be the development of a best practice model for the built environment sector (applied/inspired from the academic sector) using a "holistic" or "integrated design" approach. Hence, the paper intends to recommend that being energy conservers and managing financial sustainability, the organization still needs to focus on engaging with all the stakeholders constructively.

Finally, the paper discusses the strategies to ensure replication of the respective best practice model to develop a supporting policy framework and build up capacity of building managers. The outputs generated by the paper are consistent with and instrumental to the achievement of the objectives that contribute to creating enabling environments for integrated sustainability strategies into building design and management.

5. Conclusions

The chapter presents an analysis of the gap between actual and expected performance in four Green Star institutions in Melbourne, Australia, and how POE generated results assisted in achieving this objective. Outcomes include the development of clear assessment mechanisms for establishing links between performance measurement and performance management with an understanding of how occupants view its value and description of a better performing building as compared to the others. The comparison was carried out on how well the building has been managed in conjunction with the sustainable building targets.

As observed by analysis of POE results of the case study buildings, it has been clearly indicated that 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 studying the broader context, all four buildings have met their key parameters in terms of Green Star certification utility targets. What worked well for all buildings have been exceptional teaching and learning spaces, student study areas and institution image. Building variables that did not work well were lack of consultation with end-users and basic design faults or technical issues. This signifies that it is important to realize that the organizational facilities function cannot exist in isolation if the organization is to effectively exploit its entire asset base to best support the delivery of core services. Making constructive use of performance measurement results is critical if the organization is to improve the performance of its assets. At both individual and organisational levels, a better understanding of the relationship between what is being done and how well the organization succeeds needs to be developed. Based on the analysis, senior management and facility managers are seen to have a direct impact on building operations and performance. They can also adjust or redirect their strategies or identify new strategies for the organization.

Following the lead by the European Union since early 2021, there is a global momentum that is currently shifting towards Nearly Zero Energy Buildings, that is, high performing buildings utilising nearly zero or extremely low amounts of energy being met by renewable sources. While new commercial buildings in the US and Canada are now required to follow these principles, Australia is taking initiatives in the residential sector as well to achieve the same. Significantly, understanding the applications and potential of the building sector to effectively achieve overall sustainable outcomes. The outcomes of this study highlight that focusing on issues of building sustainability are not sufficient for a building's success. Being "green" is only one important feature of building success, but other aspects of building performance (user needs and engagement) must be considered as well. The focus on the green or sustainability aspect has detracted the construction industry from other equally important design issues relative to overall building performance. Understanding and taking the triple bottom line approach of being economically viable, environmentally responsible, and socially inclusive is important rather than simply aiming to be rated as "green" or sustainable. Furthermore, being sustainable and green should be translated to high-performance buildings for optimal benefits. Supporting this argument, the outcomes of this study are noteworthy for individual buildings be they academic or otherwise, and benefits wider government, non-government and market audiences seeking new knowledge about performance development.

Zero-energy programs often build on these frameworks supporting a variety of non-energy benefits relative to standard buildings, such as improved comfort, improved occupant health and productivity, enhanced indoor environment quality, and higher occupancy rates. Therefore, this study concludes that in making building codes, policies and management approaches more stringent, prioritisation and engagement of building stakeholders, and increased interest in decarbonisation, would assist in encouraging and assisting buildings that are truly zero-energy and zero-energy-ready.

Acronyms and abbreviations

ANOVA	Analysis of Variance
BREAM	Building Research Establishment Environmental Assessment Methodology
BOSSA	Building Occupants Survey System of Australia
BUS	Building User Survey
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
COP	Conference of Parties
GBCA	Green Building Council of Australia
GHG	Greenhouse Gas
HK BEAM	Hong Kong Building Environmental Assessment Method
HQE	Haute Qualité Environnementale
IEA	International Energy Agency
IEQ	Indoor Environmental Quality
LCA	Life Cycle Assessment
NABERS	National Australian Building and Energy Rating Scheme
LEED	Leadership in Energy and Environmental Design
NZEB	Nearly Zero-Energy Buildings
POE	Post Occupancy Evaluation
SBAT	Sustainable Building Assessment Tool
SPSS	Statistical Package for the Social Sciences
UNEP	United Nations Environment Programme

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