Implementing ESD in Architectural Practice –
An Investigation of Effective Design Strategies
and Environmental Outcomes

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ABSTRACT: The implementation of ecologically sustainable design (ESD) is relatively low in the Australian building market, despite the availability of technical information and rating tools. A detailed case study of the architectural design process and building performance is undertaken to analyse how decisions are made for ESD and what strategies work best. The study findings highlight the importance of client commitment and awareness regarding ESD, a carefully considered briefing and design team selection process accompanied by tangible environmental criteria, and an integrated design approach that is cognisant of user needs. Further, post occupancy evaluation of the building demonstrates the importance of extending the integrated approach to responsive management of the building during its occupancy to ensure successful realisation of ESD objectives.

Conference Topic: 2 Design strategies and tools
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1. BACKGROUND

The ongoing emphasis on energy efficiency and ecologically sustainable design (ESD) in recent years in Australia has resulted in the development, and recognition of some buildings that are designed to limit their impact on the environment. However, the wider implementation of ESD has remained relatively low particularly in the non-residential sector. This continues despite the availability of technical information and literature describing the architectural arrangement of various ESD features, and the introduction of environmental performance rating tools in Australia. Further, the scope of most ESD projects is restricted to those efficiency measures that are compatible with existing practice. Australian building design professionals identify uncertainties concerning the practicability and technological riskiness of sustainable design initiatives, lack of client demand, perceptions of greater financial cost, and lack of information (RAIA, 2000) as perceived barriers to the implementation of ESD.

In this context, a study underway at the University of Technology, Sydney, uses the methodology of a detailed case study to study specific experiences and strategies as a means of understanding what enables some project teams to implement ESD initiatives. It seeks to analyse what factors influence ESD initiatives and the extent and scope of such measures. While it is widely accepted that ESD be included at the inception of the design process, this study aims to uncover interrelationships between the strategies adopted for ESD within the design process and the consequent outcomes that are achieved in the architectural end product. In doing so, it seeks to identify what strategies are needed to encourage the wider adoption of an environmentally sustainable approach to building design.

This paper will discuss the findings in the context of a case study building. It provides a brief description of the multi-methodological approach and background to the selected building. This is followed by an exploration of factors influencing the implementation of ESD in order to elicit relevant drivers and strategies. The paper also discusses the realisation of ESD objectives through an evaluation of case study performance and presents lessons and conclusions to improve ESD in practice.

2. CASE STUDY METHODOLOGY

The study was undertaken in the context of a selection of recently built medium and large scale public, institutional and office building projects that have been recognised as producing examples of best practice in ESD. Using a detailed case study, factors that affected the architectural design process (from design brief formulation and conceptual design through to final design development) were analysed retrospectively. In addition, the building was examined using environmental assessment rating tools and post occupancy evaluation evaluate the extent to which it bears evidence of the attention to environmental design.

Table 1 provides the sources of information and the questions that the research sought to address, and the rating tools referred to in this document.
The building is located in the temperate climatic context of Sydney and is one of a very few buildings designed in recent years that adopts a mixed mode environmental control strategy. Significantly, a previous study [5] showed that it is possible to

Table 1: Table of Data Sources to Investigate Environmental Design Technical and Social Issues

<table>
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<tr>
<th>Data Sources</th>
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<th>Project documentation including</th>
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Technical aspects investigated
- Understanding of different knowledge bases of ESD
- Responsibility and interaction of players to form decisions
- Validation of interviews and source of new interview questions.
- Articulation of design and environmental criteria.
- Design development through competition and design reports.
- Understanding design actions leading to environmental performance
- Comparison of potential and actual performance
- Understanding how the building environmental systems work and conformity to design expectations

Social aspects investigated
- Understanding of power relationships and history of each actor.
- Validation of power relationships and how needs were defined.
- Occupants evaluation of comfort, health productivity and building functionality
- Comparison of occupant perceptions of comfort to theoretical understanding.

The BUS (Building Use Survey) is a standard Post Occupant Evaluation that surveys the building occupants experience of the building developed by Building Use Studies, UK. [1]

**The NABERS (National Australian Building Environmental Rating System) developed by the Dept of Environment and Heritage, is a performance based rating system that measures an existing building’s performance during operation. It includes assessment of occupant satisfaction and is currently in its pilot version [2]**

***Green Star developed by the Green Building Council of Australia uses information from the design process to rate the environmental potential of buildings. Current versions are Office Design and Office As Built for commercial office buildings [3].

****ABGR is an energy rating system with separate protocols for Commitment Agreement (by simulation) at design stage as well as Performance Rating (energy monitoring) for post occupancy assessment [4]. It is also cross referenced for “Energy” aspects within the Green Star and NABERS rating tools above. A 5 star rating (less than 135kg of CO2/m²/annum for Sydney) represents the current top rating for greenhouse gas emissions in Australia.

The quantitative and qualitative information provided a multilayered and complex description of the factors influencing the building design. It must be noted that the approach of the detailed case study, relies upon and acknowledges the willingness of the owner and building team to share information, while allowing examination of the design process and built product. This contribution is noteworthy, in a scenario where a number of clients and design teams are reluctant to participate for fear of commercial sensitivity or exposure to public scrutiny.

2.1. CASE STUDY BUILDING A

Building A was selected because it had won a number of architectural and environmental awards, many of which cited its innovative approaches to integrating environmental and structural design. The project arose primarily from the need to collocate this arm of the institutional department with other administrative functions in a central location within the city. The building was designed over a five-month design phase, which followed the selection of a “design and construct” consortium after a two stage competitive design and tendering process. The project was governed by important constraints on project budget and timeline.

The resulting building (approx 2000m²) adopts a shallow building form (15.0m depth) with its glazed elevations facing north and south, and predominantly open plan office accommodation over four floors for 120 occupants. Figure 1 shows the passive component of the mixed mode strategy. The solar stacks to the north and the bank of inlet louvres in the south are located within the paired blades of the structural columns. Additional openable windows are provided on all floors. An external screen of cor-ten steel louvres makes up the external skin of the building on both facades. The integrated design is discussed in further detail in section 3.3.3 of this paper. The air-conditioning system comprises of a ducted variable refrigerant volume system along the perimeter of the open plan ceiling.

Figure 1: Environmental control strategy for Building A (sourced from project's architects)
achieve comfort without mechanical systems for approximately 80% of the year in a free running office building with typical internal load levels in Sydney, and concluded that the acceptability of a climate interactive approach would hinge on the success with which the residual period of discomfort was alleviated.

At the time of brief formulation (2001), protocols for assessing greenhouse gas emissions using the Australian Building Greenhouse Rating Scheme (ABGR) were well established. In addition, although there was a broader and operational definition of ESD recognised through high profile projects such as the Sydney Olympic Games, currently available rating tools such as Green Star and NABERS, were not available. (refer to Table 1 for details of rating tools)

3. FACTORS INFLUENCING THE IMPLEMENTATION OF ESD

A number of themes or factors influencing the implementation of ESD may be drawn from the detailed study of the design process and development seen in the case study.

3.1. THE CLIENT’S COMMITMENT TO ESD

The architects interviewed were unanimous about the importance of client commitment and consistent leadership. They believed this was necessary not only to guarantee that sustainability was brought to the foreground via the design brief, but also in ensuring it was supported throughout the process of design development and implementation. In Australia, such commitment is only forthcoming from institutional clients and/or owner-occupiers who are willing and able to appreciate the long term benefits of their initiatives. This was indeed true of the case study building.

In the current project, members of the design and project management teams saw the owner developer’s role of initiating the ESD targets as crucial to their inclusion. While this can be traced to the client’s commitment to ESD as one of the foundational principles for the organisation, it was articulated as an explicit objective to “encourage integrated design, that as an outcome will set new standards as a benchmark low energy facility” in the Functional Design Brief for the project. The brief committed the design and construct team to deliver energy performance of 505MJm²/annum and an independent energy and greenhouse gas performance rating based on Australian Building Greenhouse Rating Scheme (ABGR). The prescribed target equates to 4.5 to 5.0 stars (assuming all electricity use) under ABGR.

From the perspective of the building owner, the focus on energy can be understood to be a reflection of the importance with which energy is viewed in response to established environmental debates on global warming and the Kyoto Protocol. This was translated into a willingness on the part of the owner to develop a passive designed building with mixed mode ventilation, which was considered a major improvement on current industry practice. In addition, attention to energy efficiency brought with it more tangible benefits of the ability to recoup any additional costs and achieve recurrent cost savings. It was also noted that at the time of brief formulation there was less information and expertise available to the project managers to articulate requirements for other ESD issues such as water, waste and materials.

3.1.1. Towards a more holistic consideration of ESD

The case study highlights the positive impact of regulatory frameworks (such as ABGR energy star rating) and informed owner-developers in influencing the inclusion of performance criteria for energy efficiency. Clearly if owners and developers are to be encouraged to demand attention to broader issues of ESD for their buildings, then regulatory frameworks, incentives and education of owners, developers and key personnel charged with brief development and project management must be extended to these aspects of ESD. It is anticipated that the recent development and introduction of holistic ESD rating tools such as Green Star (launched 2003) and NABERS (pilot launched 2003) will influence the uptake of these aspects in future projects in Australia.

It is also worth noting that the owner-developer of the Building A has gone on to use the experience gained from the building to incorporate more detailed requirements for ESD in its subsequent projects.

3.2. THE ROLE OF FUNCTIONAL DESIGN BRIEF (FDB) AND PROJECT MANAGER

In the project studied, the guiding principles were encapsulated for the client in the form of a Functional Design Brief (FDB). The document provided the vision and intent for the new building and detailed requirements for programmatic and spatial requirements, as well as criteria for collocation with a 2 storeyed heritage sandstone building. As noted, energy requirements were carefully detailed in the brief to include specific energy targets and passive design subsections on thermal comfort, natural ventilation, solar protection/access, daylighting and thermal performance.

The appointment of an external specialist Project Manager with its own ESD consultant to advise and manage brief development, design evaluation and implementation through the various project phases on the behalf of the client, is seen as a crucial strategy in ensuring successful implementation of the brief. Further, the stipulation of performance targets rather than prescriptive design solutions for energy gave the design team the freedom to meet functional targets in a number of different ways. Significantly, this strategy transfers the risk to the design and construct team, engaged on the basis of the recognition of their experience and the knowledge. The FDB document also served as an instrument of negotiation and evaluation within and amongst the various stakeholder groups at competition and design development stage.

The case study provides evidence of how a carefully structured brief with effective management strategies to monitor design development and decision-making can translate into positive outcomes in terms of energy efficiency. In situations where a definitive FDB is handed down to the design team at the beginning of the design process there is also the
potential risk of excluding those criteria not envisaged at the time of brief development. Clearly, a good briefing process and communication strategy between stakeholders is essential for the successful implementation of any design aspect and this applies to ESD strategies.

3.3. THE DESIGN PROCESS

A number of insights and lessons can be gained from the various aspects of the design development process as discussed below.

3.3.1. Nature of the design competition and project commission

In the project studied, the ability of the winning team to meet the energy targets within project budget was one of the influential factors in their selection. The architects noted that the design competition approach gave the architectural design process an increased level of intensity and momentum, together with the freedom to explore a design to a stage where a more complete design concept could be presented to the client. Nevertheless, this freedom also brought with it the risk of being unable to gauge client expectations until the judging process.

Design decisions were also influenced by the "design and construct" nature of the tender. The obligatory partnership of architect and builder meant that buildability and concerns for cost efficiency had to be considered and negotiated on an equal footing with design aesthetics and functional issues within the bidding partners. The risk of negotiation in this case was passed on to the design team.

3.3.2. The integrated design process and the role of the architect

An integrated design process in which a multidisciplinary team including architect, builder, heritage consultant, environmental engineer and structural designer worked together from the inception of the building concept until its commissioning was adopted in this project. This is contrary to a linear process where the design is passed down the "food chain" typically from the architect to the various consultants and then the builder, with limited interaction between the members of the design team.

Although some of the impetus for the integrated design approach came from the need to make the design and construct partnership work, there was also a fundamental recognition of the need for a multidisciplinary team approach to satisfy the ESD requirements of the brief by the bidding partners.

In addition to the energy directives of the brief, the architects suggested that the basis for attempting a passive/mixed mode approach to the design arose from precedents and some experience in passive designs for educational buildings in Australia as well as examples drawn from international practice. Through the design of Building A, they sought to extend this approach to commercial buildings in the climatic context of Sydney. They also stated that they adopted environmental performance as a major design theme to be fully integrated into the architectural fabric of the building rather than allow it to be added on at the end.

The outcome of an integrated design approach can be seen at a number of different levels:

At a tectonic level, a lot of attention was paid to seamless integration of architectural design elements, which often served more than one purpose. For example there was a deliberate overlap of the environmental and structural systems in the case of Building A. The solar stacks and inlet louvres were integrated into the space between the paired blades of the structural column with the depth of the blade columns being used to align with the inner glazing skin and external louvered screen. The screen of corten oxidised steel louvres served as both sunshading devices and security screens. Its latter function ensured the acceptability of separate openable windows that were provided. The rusted appearance of the screen was intended to deliver an aging patina as a contemporary response to the neighbouring heritage sandstone buildings. Further, the rust layer of the cor-ten steel provided a protective layer to prevent further oxidation and therefore reduces the need for ongoing maintenance.

Significantly, the resolution of such design approaches requires integration at a disciplinary level amongst the members of the design team. In the project studied, the solutions were a direct consequence of the manner in which the design and construct team operated. While design 'rules of thumb' and past experience form the starting point for synthesis of the numerous issues and constraints in any project, this study demonstrates the value of introducing specialised knowledge at an early stage to develop design concepts. In addition this expertise can reduce the risk of non-performance by modelling the design and providing feedback before key decisions are 'locked in' and detailed.

3.3.3. The role of the occupants

This project saw the owner play the role of both developer and occupant. In this particular project, input of the actual occupants was sought to configure and tailor user needs such as spatial allocation and work layouts during the formulation of the brief.

On the other hand, there was no direct interaction between the design team and the occupants during the competition phase of the design when much of the conceptual design, including ideas of natural ventilation and mixed mode operation were introduced. In some ways this approach is similar to that of many market built "speculative" buildings where the known tenant plays only a selected role in the design development. In such instances, some assumptions about occupants are based on research and past experience of the design team.

However, once the design team was selected, the occupants were again consulted during the design development phase. For example, a sample workstation was developed to gain feedback of occupant work needs. In addition to manuals and plaques outlining ESD strategies in the building, occupants were also given detailed induction as to environmental management of the building prior to occupancy. Further, the case study building offers some interesting insights, which are discussed in results of the post occupancy evaluation in section 4.
3.3.4. Knowledge, power, risk, and ESD

In a series of case studies, on energy use in the built environment Guy et al [6] argue that the adoption of technical information needs to consider the particular context of a practitioner, the many objectives pursued and the opportunities for introducing technical knowledge at various points in the development process.

This view finds resonance in the current project. For example although value engineering suggested that the performance of the solar stacks could perhaps be substituted through efficient lighting and air-conditioning systems, they were retained as analysis demonstrated that the solar stacks improved the potential greenhouse Star rating of the building. Moreover, from the designers’ point of view, the tactic of integrated design ensured that the key element serving more than one function (structural and environmental) was not easily designed out.

The juxtaposition of the financial power and knowledge within the team is not uncommon in any design development process. Nevertheless it is important to realise how cognisance of the need to satisfy varied and conflicting criteria can lead to creative solutions that have a positive impact in maintaining design intent.

The case study also demonstrates the importance of understanding social aspects such as power, accountability, and risk, in tandem with the technical aspects of knowledge, skill and design. Further, it demonstrates that the degree to which ESD is perceived as an additional risk determines how the actors work together in terms of power and knowledge and the ‘level’ of sustainability achieved.

4. EVALUATION OF BUILDING AS BUILT

A post occupancy evaluation of the building using the BUS survey has recently been completed. Preliminary analysis points to some interesting results. Occupants rated the building better than or close to benchmark buildings for aspects of their physical work environments such as space at desk, furniture, suitability of storage, and availability of meeting rooms. Significantly, these were all aspects of the building design for which the occupants had been engaged in a consultative process, thereby validating the effectiveness of user participation.

With the exception of overall lighting which received positive responses, the occupant responses to aspects of comfort (temperature, ventilation, and noise) in the work environment are close to or just below midpoints of the 7 point scale of the BUS survey instrument (1=unsatisfactory, 7=satisfactory) and in this respect the results could be perceived as disappointing.

Through open ended comments, occupants complained of a lack of adequate airflow, and erratic temperature controls. However it must also be noted that the BUS survey only elicits questions about summer and winter performance, and feedback for mid season performance is not separately elicited.

The occupants were also critical of noise in their workplace. In open-ended comments under noise, comfort and productivity, a number of respondents reported unacceptably high levels of noise and interruptions to their work from colleagues and phones. Others were concerned about insufficient privacy in their open plan offices.

Based on monitored data for the first 12 months, energy consumption for all lights, power and air-conditioning was calculated by the projects’ engineers at 508MJ/m²/annum which suggests that the building will meet its energy targets. A formal ABGR Star Rating is awaited. Although energy is metered and logged in the building, monitored data of temperatures was not available for the period of the study. Further study that includes monitoring of internal temperatures, airflow rates and noise would be useful to elicit where and why the problems occur.

It is envisaged that a subsequent paper will discuss issues of post occupancy evaluation in detail.

4.1. DESIGNING IN RESPONSE TO USER NEEDS

The emerging results confirm some interesting issues. The open plan concept for offices is now the norm for its space efficiency and potential to increase communication. In terms of a passive design it is often promoted for its ability to afford unobstructed air flow across the floor plate. However, partitions and other forms of fixed furniture can become impediments. As seen, the open plan configuration also results in break out noise, a problem that is further intensified by the hard reflective surfaces in the office interior as a consequence of exposed thermal mass. There are also a number of occupant related issues such as privacy, control over the shared aspects of the work environment (openable windows and blinds). This study confirms the challenges [7] of designing appropriate open plan offices. Designers [8] have used under-floor air delivery systems to combat some of the problems relating to air distribution and individual control, but despite its potential, they are still viewed as non standard and expensive. Others [9] promote varied functional configurations including break out spaces as a means to combat issues of privacy and noise.

Notwithstanding the design fixes, the observations of Bordass et al [10] at the conclusion of the post occupancy PROBE studies are worthy of note. They suggest that while mixed mode buildings “can bring the best of both worlds” (natural ventilation and air-conditioning) … “they require effective integration in both design and management”. They note that occupants tend to be more sensitive to the shortcomings of advanced natural ventilation systems (such as stack ventilation seen in the case study) and warn that such buildings must have the ability to respond quickly and satisfactorily if problems arise.

Without doubt, good and robust environmental design begins with an integrated design approach that is cognisant of user needs and expectations. However it can only be fully realised when there is an equal commitment to an integrated and responsive management of the building during its occupancy both in terms of technology and human factors.
4.2. EVALUATION OF ENVIRONMENTAL PERFORMANCE

Retrospective self-assessments using Green Star Office Design tool, indicate that the case study would gain high credits in the area of Management, Transport and Energy based on its commitment to the use of ESD professionals, building commissioning processes, environmental management plans, proximity to public transport services and predicted energy consumption. On the other hand, the aspects of ESD that were not focussed upon in the design brief such as Pollution, Land Use and Ecology, Materials and Water were estimated to receive lower credits using the tool. In terms of Indoor Environmental Quality, the building design received full credits for its potential for daylighting, external views, and 100% outside air, but did not satisfy criteria for individual control of ventilation, or reduction of noise reduction and indoor air pollutants.

The methodology of assessing both the “design” potential of the building using Green Star and the “post-occupancy” outcomes using NABERS and the BUS survey is expected to yields some interesting comparisons. A preliminary outcome in the case study building relating to Transport is noteworthy. Based on the Green Star design evaluation, the building has the potential of gaining the full credits awarded for the “Commuting Public Transport” criterion based on proximity to and frequency of public transport services. However, preliminary analysis of the NABERS Transport survey data for the building, suggests a high use of private vehicles (more than 50% of those surveyed use cars for over 75% of their journeys to work), despite the excellent public transport services available to the site. This is a result of the free parking available on the campus.

Nevertheless, the difference between potential and actual environmental performance, points to a matter of universal relevance - it demonstrates the crucial need for indicators at both ends of the design and building process. At the design stage, they influence design decisions and enable owners and designers to evaluate their proposals. Equally important is the requirement to “close the loop” following the occupancy of the building. The latter enables owners, designers and policy makers to evaluate what is actually achieved, where barriers to ESD lie and what measures can be implemented to overcome them.

5. CONCLUSION

This paper demonstrates the value of studying the design process in its context, as a means for understanding how decisions for ESD are made and what strategies work best. Through analysis of the case study it highlights some important lessons. These include the importance of client commitment and awareness regarding ESD, a carefully considered briefing and design team selection process with tangible environmental criteria, and an integrated design approach that is cognisant of user needs.

From the perspective of the practitioner, it also highlights the value of considering ESD at the inception of the design process, the need for a multidisciplinary team approach to design, the willingness to learn from past experience and the ability to synthesise the conflicting needs of the building program and stakeholders. Further, the post occupancy evaluation of the building demonstrates the importance of extending the integrated approach to responsive management of the building during its occupancy to ensure successful realisation of ESD objectives. Design insights gained from evaluating the design process and building performance will also be useful to optimise the design and integration of emerging technologies such as mixed mode air-conditioning systems and stack ventilation in open plan offices. Finally, it demonstrates the potential for design and post occupancy rating tools to influence market behaviour, and confirms the importance of wider dissemination and research into the social and technical aspects of implementing ESD.

6. ACKNOWLEDGEMENT

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7. REFERENCES