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IMPROVING THE IMPLEMENTATION OF ADAPTIVE REUSE STRATEGIES FOR HISTORIC BUILDINGS

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Abstract

Meeting the current needs of existing buildings and the designing of new buildings to ensure its sustainable adaptability in the future supports global climate protection and emissions reduction. The sustainable preservation of any historic building requires the blending of sustainable design and historic preservation principles. Building adaptive reuse is a viable alternative to demolition and replacement as it entails less energy and waste, and can offer social benefits by revitalizing familiar landmarks and giving them a new lease of life. This paper describes the development of a new design rating tool known as **adaptSTAR**, which offers holistic and unified design criteria for the successful implementation of adaptive reuse for historic buildings as well as for the measurement of embedded adaptive reuse potential of future buildings. The adaptive reuse design would be given an **adaptSTAR** star rating similar to a green building rating system. The findings show that criteria can be identified and weighted according to physical, economic, functional, technological, social, legal and political categories.

Keywords: Adaptive Reuse, Sustainability, Sustainable Preservation, Built Heritage, Architecture

1. Introduction

The built environment is the major contributor to global greenhouse gas emissions (GGE), where 45 percent of carbon dioxide emissions can be directly or indirectly connected to construction and building operation [1]. The demand for energy, land and materials resulting from new developments needs to be tempered with taking better care of existing buildings, extending their life expectancy and using less energy. This urges building professionals to produce more energy-efficient buildings and renovate existing stocks according to modern sustainability criteria [2].

Building adaptive reuse is an alternative to traditional demolition and reconstruction; but entails less energy and waste. It is defined as “a significant change to an existing building function when the former function has become obsolete” [3]. Adaptive reuse is relevant to the current climate change adaptation agenda due to its ability to recycle resources in place. It has been said that the greenest buildings are the ones that we already have [4]. Existing buildings that have been upgraded to achieve substantial cuts in GGE are considered a more climate-friendly strategy than producing new energy efficient buildings [5].

Adaptive reuse has been successfully applied in many types of facilities, including defence estates, airfields, government buildings, industrial buildings. Around the world adaptive reuse of historic buildings is seen as fundamental to sound government policy and sustainable development in countries such as United States Canada, Hong Kong, North Africa and Australia [6]. Noteworthy also are the prestigious projects of adaptively reusing heritage buildings in most states in the United States, Australia and across the Asia Pacific region [7-9]. The purpose of this paper is to outline the need and the philosophy for an adaptive reuse rating tool targeted to new design of buildings and the sustainable preservation of existing buildings most especially historic buildings, to support embedded adaptive reuse potential, and describe the approach taken by the researchers to develop and validate it. Contemporary literature pertaining to sustainability, architecture and adaptive reuse is reviewed and forms the basis for a proposed conceptual framework and detailed methodological approach. The paper concludes with some observations from a pilot study of the GPO Building in Melbourne, Australia.

1.1 Adaptive Reuse and Sustainability

The United Nations Environment Programme [10], identified the United States, Australia and Canada as the top three countries with the largest carbon dioxide emissions from buildings per capita. Yudelson [11] claims that about 75% of all buildings expected to be operating in the year 2040 are already built or renovated. He also mentioned that the pace of building energy retrofits and green

upgrades will accelerate dramatically in the next five years due to the fact that there are nearly 5 million existing buildings in the US and Canada that are ripe for retrofit into energy-efficient structures. Further, the Urban Land Institute [12] indicates that new construction accounts for merely 1 to 1.5 % of existing building stock each year in most developed countries. Thus, adaptive reuse or retrofitting plays such a critical role in reducing emissions from the built environment. UNEP [1] emphasizes that adapting and retrofitting of existing buildings to the optimal energy efficiency standard must be given more focus by the building sector. Gorse and Highfield [13] asserts that there is no better example of the environmental benefits of effective sustainability in practice than the recycling of buildings. In addition, the reuse of materials and assemblies salvaged from the building being adaptively reused or other buildings is a positive sustainable choice.

However, the Urban Land Institute [12] report that green building practices have underemphasized the importance of sustainable retrofits of existing building stock globally and that environmentally sensitive and energy efficient sustainable new construction by itself cannot significantly change the environmental impact of the built environment unless green design and construction technologies are applied to the existing building stock.

1.2 Adaptive Reuse and Sustainable Design Principles

An array of design principles, strategies, approaches and solutions have evolved from proven design solutions that have been in existence for decades [14]. However, there is still a lack of consensus as to what design criteria would best maximize the adaptive reuse potential of existing and future buildings. According to Kincaid [15], important change in the use of buildings and infrastructure arises because of the development of certain technologies, thus it is important to know how to meet these new needs in existing buildings and how new buildings are designed to allow sustainable adaptability to occur in the future. This is supported by Fournier and Zimnicki [16] in their formulated specific guidelines to provide information and guidance for adaptive reuse of buildings consistent with the goals of historic preservation and sustainable design. The guidelines integrate concepts of sustainability into the adaptive reuse of historical buildings in a way that will enhance the built environment while preserving the nation's cultural endowment.

For Zushi [17], successful adaptive reuse projects require not only good design for the building, but also careful planning that considers its surrounding environment. As for Fournier and Zimnicki [16], sustainable design principles that encourage maximum reuse of the existing building components, restoration of passive aspects of the original design and preservation of the micro climate created by historic plantings and site usage should also be included in the adaptive reuse of historic buildings. Snyder [18] also examines the potential of adaptive reuse projects in sustainable design and integrates "green design" into structures that were previously at odds with natural processes. He also pointed out that adaptive reuse and sustainable design have a significant role in the future of architecture. According to Langston [19], green adaptive reuse extends the lifespan of the building and reduces its carbon footprint while preserving its cultural heritage values.

1.3 Adaptive Reuse Potential (ARP) Model

Until now experience and intuition are often the only guides to making decisions for adaptive reuse [13]. However, through the ARP model [6] existing buildings can now be ranked on their adaptive reuse potential at any point in time. The useful (effective) life of a building or other asset in the past has been particularly difficult to forecast because of premature obsolescence [20]. In the ARP model, the seven obsolescence categories are based on Seeley [20] and are listed as physical, economic, functional, technological, social, legal and political. The ARP model predicts useful life as a function of (discounted) physical life and obsolescence, and allows the calculation of the adaptive reuse potential of a building's life cycle so that the right timing for intervention can be applied.

The model has generic application to all countries and all building typologies. It requires an estimate of the expected physical life of the building and the current age of the building, both reported in years. It also requires an assessment of physical, economic, functional, technological, social, legal and political obsolescence, which is undertaken using surrogate estimation techniques as no direct market evidence exists. The ARP model has been widely published and is considered robust as it has been tested in hindsight against 64 adaptive reuse projects globally [21] and recently validated by a new multi criteria decision analysis tool called iconCUR [19; 22]. The ARP model, summarized in Figure 1, was firstly demonstrated by using a case study in Hong Kong [23]. It provided a conceptual framework for the assessment of adaptive reuse potential in existing buildings at a strategic management level.

The decay curve can be reset by strategic capital investment during a renewal process by the current owner, or a future developer, at key intervals during a building's life cycle. ARP scores in excess of 50% have high adaptive reuse potential, scores between 20% and 50% have moderate potential, and scores below 20% have low value, representing about one-third of the area under the decay curve in each case. Potential means that there is a propensity for projects to realize economic, social and environmental benefits when adaptive reuse is implemented. ARP is conceptualized as rising from

zero to its maximum score at the point of its useful life, and then falling back to zero as it approaches physical life. Where the current building age is close to and less than the useful life, the model identifies that planning activities should commence.

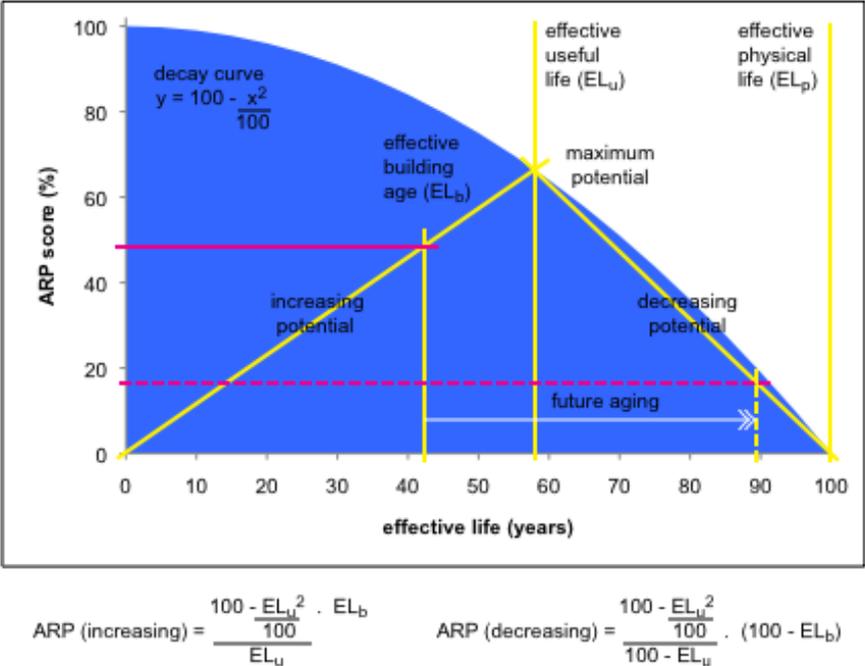


Fig. 1: Adaptive reuse potential model [21]

2. Research Methodology

Adaptive reuse is a well-documented strategy to breathe new life into obsolete buildings without unnecessary and premature destruction. The success of this activity is predicated on the particular context of the building and its original design. Most buildings are not designed to maximize future adaptive reuse, and hence the opportunity for doing so is serendipitous. Thus, the aim of this research is *to create and validate a design evaluation tool that will lead to making purposeful design decisions for future adaptive reuse at the time they are designed*, or put simply, planning for reuse as a key design criterion. As a proven indicator for identifying the potential for adaptive reuse in existing building stock, this research will use the ARP model [21] to validate a new design rating tool called **adaptSTAR**, which is a weighted checklist of design strategies that lead to future successful adaptive reuse of buildings. The development and testing of this checklist is the focus for this research. The main deliverable of the research is the creation and validation of the new **adaptSTAR** model, which is essentially a weighted checklist of design decisions that lead to best practice outcomes. It is similar in concept to the Green Building Council’s *Green Star* or *LEED* methodology where performance is assessed using a standard five-star rating scheme.

The methodological approach of this research study is essentially in three parts and relates closely to the planned three years of the project (see Figure 2). It is a sequential mixed mode research methodology (qualitative and quantitative), where the first stage explores 12 successfully completed Australian adaptive reuse projects to understand, with hindsight, what factors (related to the project’s original design) led to its adaptive reuse transformation. This step involves a detailed case study of each project supported by expert opinion from key stakeholders, including the architectural team, structural engineer, services engineer, quantity surveyor and facilities manager (as applicable). The case studies represent quite different building typologies. Given each case study will also have different latent characteristics, the list of factors is likely to be reasonably diverse. The assembly of these factors forms the base criteria to be used and scored in the **adaptSTAR** model. Factors will be collated into groups representing physical, economic, functional, technological, social, legal and political categories.

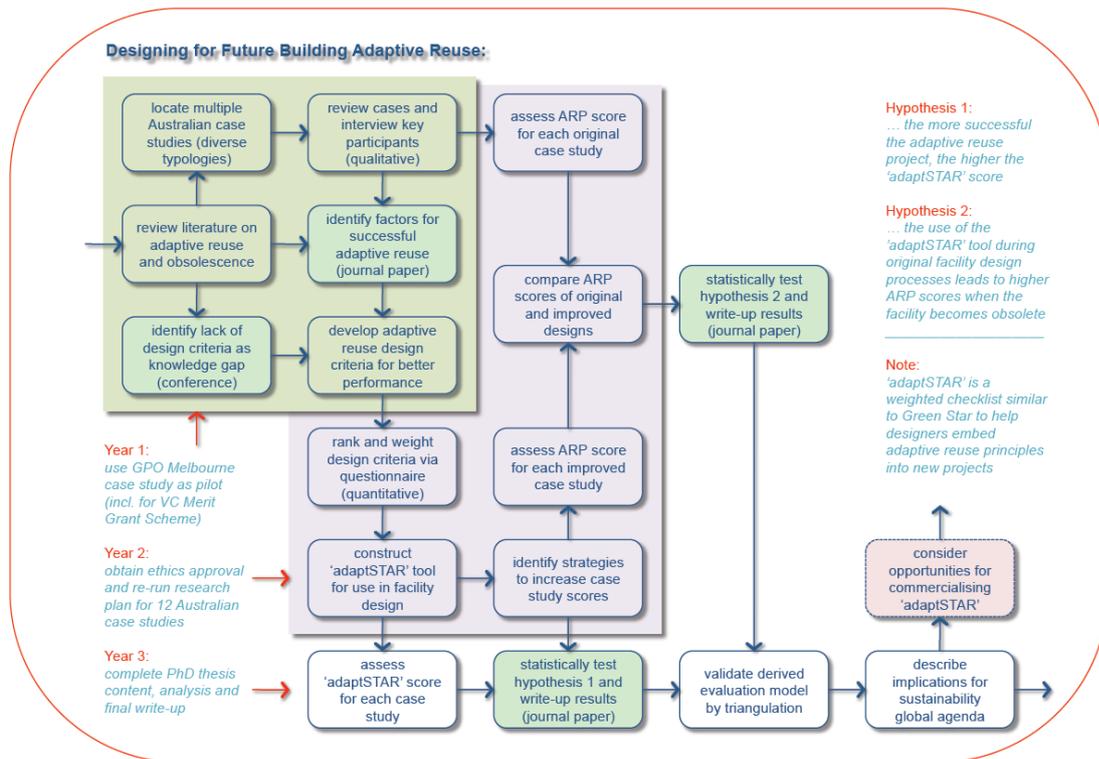


Fig.2: Research plan logic

The second stage takes this list of factors and assigns weights to them. This is achieved by an online questionnaire to the Australian architectural profession seeking the level of importance of each factor (via a 5-point *Likert* scale). It is unlikely that all factors are of equal importance. Some factors of low importance will be discarded. These judgements are independent of the 12 case studies and so the approach is not merely self-serving.

The third stage evaluates the performance of the derived model in a number of ways. The relationship between **adaptSTAR** and the **ARP** model [21] is tested to determine if the respective scores are correlated. From the data discovered through the previous stages, a weighted list of design criteria is constructed. The ARP model assumes the seven obsolescence categories are equally weighted, and so too does this research. However, for each obsolescence category, design strategies are weighted directly from the discovered Likert scores. Points are used to define a user-friendly star rating scheme similar to that used currently in green building evaluation. Each of the twelve case studies is assessed using **adaptSTAR** (to determine their performance) and the ARP model (to determine their potential at the time of their redevelopment). The hypotheses for the research are:

- H1: The more successful the adaptive reuse project, the higher the **adaptSTAR** score
- H2: The use of the **adaptSTAR** tool during original facility design processes leads to higher ARP scores when the facility becomes obsolete.

3. Initial Development of the adaptSTAR Model

The GPO Building in Melbourne (see Figures 3 and 4) was used as a pilot study. As one of the more prominent and well known adaptive reuse case studies in Australia, Melbourne's GPO building has been awarded with the RIAA National Award for Commercial Buildings and the Sir Osborn McCutcheon Commercial Architecture Award. Melbourne's GPO was constructed on the Bourke and Elizabeth Street corner site in 1859. Between 1859 and 1867, a much grander, two-level building was developed and underwent a few major renovations until it was completed in 1919 with its new sorting hall. In 1992, Australia Post announced plans to sell the building and end the GPO's major postal role in favour of decentralized mail centres. A shopping mall was proposed in 1993 but its permit later lapsed, while in 1997 a hotel proposal did not proceed. Again in early 2001 plans for a retail centre were announced but experienced a major setback when the building was almost gutted by fire in September of that year. Finally, the Melbourne's GPO building opened for trade as a retail centre in October 2004. As one of the CBD's premier boutique shopping destinations, the GPO building houses over 50 stores across its three floors.



Fig. 3: GPO Building Façade



Fig. 4: GPO Building Mall Interiors

From this pilot study, some of the possible design criteria have been identified. A preliminary unweighted list of design criteria was prepared based on interviews with the architectural team and a survey of relevant documentation. The purpose of the pilot was to demonstrate proof of concept for Stage 1 of the methodology. These discovered design criteria have been linked to the seven factors of obsolescence (physical, economic, functional, technological, social, legal and political) upon which the ARP model is based, and illustrate that this connection is possible.

The initial set of design criteria, informed by the relevant literature on existing and recent design strategies that pertains to the adaptation of heritage buildings together with other building adaptation and sustainable design concepts/guidelines, are presented in Table 1.

Table 1: Building Adaptive Reuse Design Criteria from Relevant Research Study

Category	Criterion	Relevant Research Study
Long Life (Physical)	Structural Integrity	[24-28]; [3]; [13]
	Material Durability	[2]; [30]; [27]; [3]
	Workmanship	[27];
	Maintainability	[29-31]; [27]; [3]
	Design Complexity	[24-25]; [32];
	Prevailing Climate	[33]
	Foundation	[2]; [27]
Location (Economic)	Population Density	[6]
	Market Proximity	[34-35]
	Transport Infrastructure	[2]; [30]; [36]
	Site Access	[2]; [30]; [36]
	Exposure	[32]; [34-35]
	Planning Constraints	[6]
	Plot Size	[34]; [36]
Loose Fit (Functional)	Flexibility	[2]; [25]; [29-31]; [41]; [36-38]; [3]; [6]
	Disassembly	[25]; [31]; [37]
	Spatial flow	[26]; [29]; [39]
	Convertibility	[25]
	Atria	[40]
	Structural Grid	[24-25]; [41-42]
	Service Ducts and Corridors	[24-25]; [30]; [42]
Low Energy (Technological)	Orientation	[2-3]; [30]; [43-46]
	Glazing	[3]; [43]; [47]
	Insulation and Shading	[27]; [3]; [43]; [48]
	Natural Lighting	[26-27]; [3]; [43-44]; [46]; [49]
	Natural Ventilation	[46-47]; [3]; [43-44]; [33]; [49]; [27]
	Building Management Systems	[23-25]; [30]; [43-44]
	Solar Access	[33]; [3]; [43-47]
Sense of Place (Social)	Image/ Identity	[7-9]; [16]; [50-51]
	Aesthetics	[30]; [43]
	Landscape/ Townscape	[26]; [8]; [16-17]; [46]
	History/ Authenticity	[7-9]; [30]; [50-51]; [16]
	Amenity	[32]; [17]; [35]

Table 1: Building Adaptive Reuse Design Criteria from Relevant Research Study

Category	Criterion	Relevant Research Study
Quality Standard (Legal)	Human Scale	[24-25]; [34]
	Neighbourhood	[52]; [32]; [7]
	Standard of Finish	[27]; [49]; [44]
	Fire Protection	[26]; [3]; [8]
	Indoor Environmental Quality	[47]; [30]
	Occupational Health and Safety	[3]; [30]; [8]; [47]
	Security	[3]; [30]; [8]; [27]
	Comfort	[27]; [30]; [53]
	Disability Access	[8]; [3]
	Energy Rating	[8]; [3]
Context (Political)	Acoustics	[27]; [3]
	Adjacent Buildings	[26]
	Ecological Footprint	[54]; [23]; [12]; [2]; [53]; [55]
	Conservation	[9]; [16]; [51]
	Community Interest/ participation	[6]; [52]; [32]
	Urban Masterplan	[33]; [3]; [36]
	Zoning	[47]; [3]; [33]; [36]; [34]
Ownership	[52]	

As the research progresses, it is anticipated that this initial list will be substantially modified given the planned interviews and field surveys with the stakeholders/experts of the other eleven selected case studies used in the full project. The design criteria will be evaluated to determine the weighted value of its associated and corresponding design elements. The set of design criteria reflect the obsolescence categories: Physical (Long Life); Economic (Location); Functional (Loose Fit); Technological (Low Energy); Social (Sense of Place); Legal (Quality Standard) and Political (Context). An example of this framework is shown in Figure 5.



Fig. 5: Proposed adaptSTAR Model

The design criteria will serve as the foundation for the evaluation of new designs using a scale of numerical scores from significant to not significant. An example of how this model will function is demonstrated in Figure 6 using the Physical (Long life) category as an illustration. The relevant design elements with its conditions may comprise:

- a. Structural integrity - pertains to the structural design of the building with strength to cater for different future building uses and loading scenarios.

- b. Material durability - the materials used for the building play a crucial role in the durability of the building asset; the more durable materials are used, the longer is the building's lifespan.
- c. Workmanship - pertains to the quality of craftsmanship applied to the building's structure and finishes.
- d. Maintainability - this element addresses the issues enhancing building performance over its lifespan, where maintainability attributes are defined as the capability of a building to conserve operational resources.
- e. Design complexity - this element consists of various geometries associated with the design and innovation of the building.
- f. Prevailing climate - this element addresses designing for changing climatic conditions that determine appropriate solutions for warm or cold temperature areas.
- g. Foundation - this element allows for potential vertical expansion of the building and the stability of the structure in relation to issues such as differential settlement and substrata movement.

Given the base assumption that the Physical category has a value of 14.29%, its corresponding design elements may have different values but must sum to 14.29%. For instance, the structural integrity and foundation may each have a weight of 20%, while the prevailing climate and design complexity may each be valued at 15%, and the rest of the elements may be scored at 10% each of 14.29 (see Figure 6).

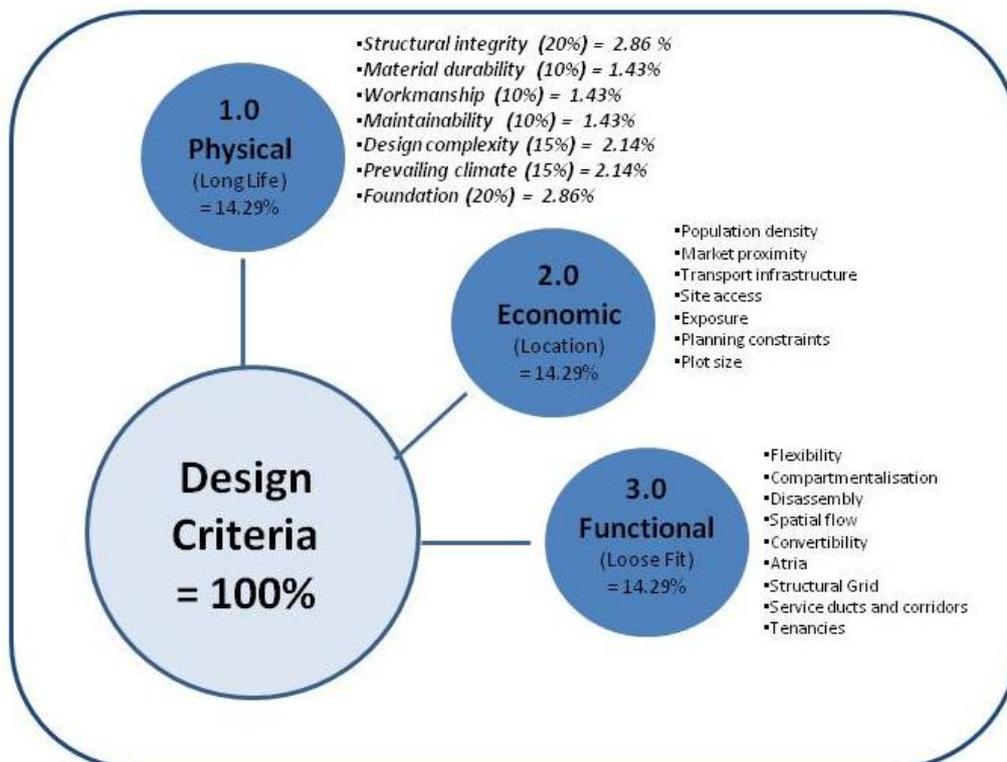


Fig. 6: Proposed **adaptSTAR** Model: sample application

The performance of any new design therefore is scored against these weighted criteria and used to assemble a total score or star rating for the future building. The higher this score, the better it is at addressing future adaptive reuse opportunities.

4. Conclusion

There is an increasing complexity and interplay between all of the issues associated with property portfolio decisions. This research further investigates the relationships between financial, environmental and social parameters associated with building adaptive reuse through providing a vehicle for strategic design advice at the very beginning of a project's life. The outcomes of this research have the potential to assist in the transformation of the building and property industry towards more sustainable practices, strategies and outcomes, and help mitigate the effects of a changing climate. Providing a means by which the industry can design new buildings that have high potential for adaptive reuse much later in their lives will clearly assist in this endeavour.

Premature destruction of built assets for economic (often profit-seeking) motives with minimal regard for social and environmental outcomes is a contemporary characteristic of the developed world. Reuse/adapt or renovate, preserve can be superior strategies where appropriate, and need proper consideration. This research is important to the national interest, as destruction and reconstruction brings with it higher energy impacts (evidenced principally as embodied energy) that collectively impact on Australia's ability to meet its emission obligations. But adaptive reuse can also exploit operational energy advantages often found in older buildings that did not have the option of mechanical conditioning solutions and conserve cultural and heritage values for the benefit of future generations. Indeed, adaptive reuse of existing built heritage and incorporation of adaptive reuse strategies in new buildings is economically, environmentally and socially responsible.

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