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DESIGNING FOR FUTURE BUILDING ADAPTIVE REUSE USING adaptSTAR

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ABSTRACT

Designing future buildings with embedded adaptive reuse potential is a useful criterion for sustainability. Adaptive reuse is an emerging and significant design strategy that supports global climate protection and emissions reduction. Building adaptive reuse is a viable alternative to demolition and replacement; 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 rating tool known as **adaptSTAR**, suitable for assessing future adaptive reuse potential at the time a building is designed. This paper reports on the methodology used to develop this rating tool and the practical issues concerning its application. The findings show that criteria can be identified and weighted according to physical, economic, functional, technological, social, legal and political categories to calculate an adaptive reuse star rating.

KEYWORDS

Adaptive Reuse, Sustainability, Built Environment, Climate Change, Architecture.

INTRODUCTION

The building sector is a large source of domestic greenhouse gas (GHG) emissions and has a significant potential as a source of cost effective emissions reduction. Buildings are responsible for 40-50 percent of total energy use worldwide, with approximately 80-90 percent of the energy a building uses during its entire life cycle being devoted to heating, cooling, lighting and other appliances (Cheng et al., 2008). The remaining 10-20 percent is embodied energy implicated during the mining, material manufacture, transport and construction, but can increase to higher proportions where useful building life is too short. This urges building professionals to produce more energy-efficient buildings and renovate existing stocks according to modern sustainability criteria (UNEP, 2007).

The recycling of buildings, known as adaptive reuse, came into 'mainstream architectural parlance during the 1960s and 1970s in the US due to the growing concern for the environment' (Cantell, 2005). Although, the protection and maintenance of existing buildings especially ancient monuments, had been encouraged through conservation, preservation and adaptation since 1882. These practices have evolved under different heritage laws such as UK's Ancient Monument Act in 1882 (Curry, 1995), US Antiquities Act in 1906 (Harmon et al., 2006), Hague Convention in 1954 (ICOMOS, 1994), Venice Charter in 1960 (Jokilehto, 1996), Australia's Burra Charter in 1979 (Marquis-Kyle and Walker, 1994) and lately Asia's Hoi An Protocols in 2005 (UNESCO, 2009).

Existing buildings that have been upgraded to achieve substantial cuts in GHG emissions are considered a more climate-friendly strategy than producing new energy efficient buildings (TEC, 2008). It has been said that the greenest buildings are the ones that we already have (Jacobs, 1993). Adaptive reuse is an emerging and significant design strategy that supports the Kyoto Protocol's objectives for global climate protection and emissions reduction. Building adaptive reuse is a viable alternative to demolition and replacement in order to minimize energy and the cost of new construction works (Langston, 2008).

Adaptive reuse has been successfully applied in many types of facilities, including defence estates, airfields, government buildings, industrial buildings, and 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 (Langston et al., 2008). 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 (DEH, 2004; NSW Department of Planning and RAIA, 2008; UNESCO, 2007).

The purpose of this paper is to outline the need and the philosophy for an adaptive reuse rating tool targeted to new design, and the approach taken by the researchers to develop and validate it. Contemporary literature pertaining to obsolescence and adaptive reuse potential 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.

BUILDING OBSOLESCENCE

Buildings are major assets and form a critical part of facility management operations. Although buildings are long lasting, they require continual maintenance and restoration. Eventually, buildings can become inappropriate for their original purpose due to obsolescence, or can become redundant due to change in demand for their service. It is at these times that change is likely: demolition to make way for new construction, or some form of refurbishment or reuse (Langston and Lauge-Kristensen 2002).

Buildings, like other assets, can become obsolete over time. Buildings both deteriorate and become obsolete as they age. A building's service life, which may be interpreted as its structural adequacy (i.e. structural safety), and is effectively reduced by obsolescence, resulting in a useful life somewhat less than its expected physical life. The useful (effective) life of a building or other asset in the past has been particularly difficult to forecast because of premature obsolescence (Seeley, 1983). Obsolescence may be described as constituting one or more of the following attributes:

1. Physical
2. Economic
3. Functional
4. Technological
5. Social
6. Legal
7. Political

Attempts to assess building obsolescence based on these attributes were initially developed by Langston and Shen (2007), illustrating the application of surrogate estimation techniques to help quantify each obsolescence category. This model has been shown to reasonably simulate reality based on a large number of case studies (see Langston, 2008); and the surrogates for each obsolescence category have been shown to be both measureable and practical. There is still opportunity for improving this approach in terms of adjusting category scales and weighting, especially to better cater for different building typologies, and this work is ongoing. The seven categories are used in this research as the underpinning framework for a design evaluation framework and to enable subsequent cross-referencing to this earlier work. They are summarized below.

Physical obsolescence can be measured by an examination of maintenance policy and performance. Useful life is effectively reduced if building elements are not properly maintained. A scale is developed such that buildings with a high maintenance budget receive a 0% reduction, while buildings with a low maintenance budget receive a 20% reduction. Interim scores are also possible, with normal maintenance intensity receiving a 10% reduction.

Economic obsolescence can be measured by the location of a building to a city center or central business district or other primary market or business hub. Useful life is effectively reduced if a building is located in a relatively low density demographic. A scale is developed such that buildings sited in an area of high population density receive a 0% reduction, while buildings sited in an area of low population density receive a 20% reduction. Interim scores are also possible, with average population density receiving a 10% reduction.

Functional obsolescence can be measured by determining the extent of flexibility imbedded in a building's design. Useful life is effectively reduced if building layouts are inflexible to change. A scale is developed such that buildings with a low churn cost receive a 0% reduction, while buildings with a high churn cost receive a 20% reduction. Interim scores are also possible, with typical churn costs receiving a 10% reduction.

Technological obsolescence can be measured by the building's use of operational energy. Useful life is effectively reduced if a building is reliant on high levels of energy in order to provide occupant comfort. A scale is developed such that buildings with low energy demand receive a 0% reduction, while buildings with intense energy demand receive a 20% reduction. Interim scores are also possible, with conventional operating energy performance receiving a 10% reduction.

Social obsolescence can be measured by the relationship between building function and the marketplace. Useful life is effectively reduced if building feasibility is based on external income or if the service for which the building is intended is in decline. A scale is developed such that buildings with fully owned and occupied space or with an increasing market presence receive a 0% reduction, while buildings with fully rented space or with a decreasing market presence receive a 20% reduction. Interim scores are also possible with balanced rent and ownership or steady market presence receiving a 10% reduction.

Legal obsolescence can be measured by the quality of the original design. The rationale for this is that higher quality leads to higher compliance levels against future statutory requirements. Useful life is effectively reduced if buildings are designed and constructed to a low standard. A scale is developed such that buildings of high quality receive a 0% reduction, while buildings of low quality receive a 20% reduction. Interim scores are also possible, with average quality receiving a 10% reduction.

Political obsolescence is a less publicized concept, can be measured by the level of public or local community interest surrounding a project. Useful life is reduced if there is a high level of (restrictive) political interference expected. A scale is developed such that buildings with a low level of interest receive a 0% reduction, while buildings with a high level of interest receive a 20% reduction. Interim scores are also possible, with normal public and local community interest receiving a 10% reduction. Where a project can receive a significant benefit from political interference, rather than a constraint, it is feasible to extend the assessment scores into the positive range (i.e. -20% to +20%). In this case, should the potential interference is seen as an advantage, it may extend a building's useful life and help offset other obsolescence considerations, which are all negative or neutral. Examples of a positive influence include government funding opportunities or enhanced tax concessions that can be accessed when pursuing an adaptive reuse strategy (Gardner, 1993).

In addition to the above, environmental obsolescence is obviously relevant to today's society and arguably deserving of individual assessment. But in this study environmental issues are subsumed within technological obsolescence given the choice of an energy intensity surrogate. As the marketplace continues to become more sustainability–conscious, social, legal and political obsolescence will increasingly reflect the environmental agenda.
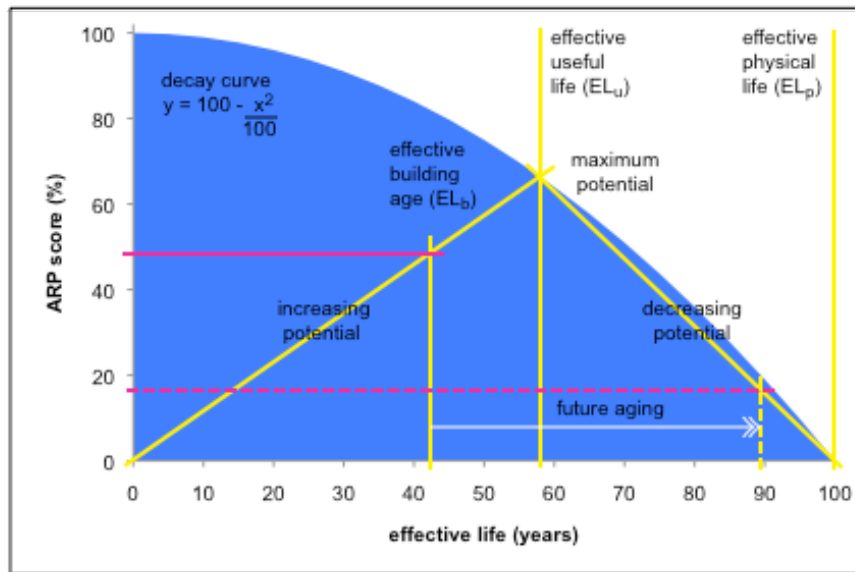
ADAPTIVE REUSE MODEL

The adaptive reuse model (see Langston, 2008) identifies and ranks adaptive reuse potential (ARP) in existing buildings, and therefore can be described as an intervention strategy to ensure that collective social value is optimized and future redundancy is planned. 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. This work has been widely published.

Obsolescence is advanced as a suitable concept to objectively reduce the expected physical life of a building to its expected useful life. A discounting philosophy is adopted, whereby the annual obsolescence rate across all criteria is the "discount rate" that performs this transformation. An algorithm based on a standard decay (negative exponential) curve produces an index of reuse potential (known as the ARP score) and is expressed as a percentage. Existing buildings in an organization's portfolio, or existing buildings across a city or territory, can therefore be ranked according to the potential they offer for adaptive reuse at any point in time. 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.

The ARP model is summarized in Figure 1. Its application was first demonstrated for a real case study in Hong Kong in Langston and Shen (2007). It provided a conceptual framework for the assessment of adaptive reuse potential in existing buildings at a strategic management level.

Figure 1: Adaptive reuse potential model (Langston, 2008)

The ARP model has been shown as robust. The ultimate goal of the current research is to reverse engineer this evaluation so that building designers can produce new proposals knowing the expected useful life of the project, and where high ARP scores apply, develop plans for adaptive reuse at the outset. In other words, where useful life is expected to be well short of physical life (i.e. a high ARP score likely to result), then future adaptive reuse plans must be considered as part of the original design process. The alternative, of course, is to construct buildings with an expected physical life sufficient only to support expected useful life, but the outcome of this strategy may be unacceptable when considered at a macro social or environmental level, despite the economic benefits that may be ascribed through such short-term or myopic behaviour.

RESEARCH METHODOLOGY

Designing future buildings with embedded adaptive reuse potential is a useful criterion for sustainability. By extension, planned adaptive reuse is advanced as an emerging and fundamental design consideration for all new projects in the context of national climate change and emission reduction strategies. The reuse of obsolete buildings without extensive demolition or destruction provides a significant benefit to the conservation of resources and the associated energy embedded in new material manufacture and assembly. It is important that the provision for future building adaptive reuse be taken into consideration in new-build schemes. There is a need for an evaluation tool to help architects maximize future adaptive reuse potential of their buildings at the time they are designed.

The significance of this research lies in understanding the long-term impacts of initial decisions, and so be better placed to strive for solutions that contribute to ecological sustainability. Further, the innovation of this research lies with the reverse engineering of the adaptive reuse potential model developed by Langston (2008) so that design pathways can be readily evaluated to optimize building proposals and be more aligned to long-term national interests. Therefore this research, for the first time, aims to develop an assessment process for adaptive reuse potential for proposed new buildings, similar in concept to the Green Building Council's Green Star or LEED evaluation methodology. The objectives of the research are to:

1. Translate the adaptive reuse model (Langston, 2008) into a set of contemporary design strategies that describe a pathway to future optimal adaptive reuse opportunity.
2. Discover and apply individual design criteria and appropriate weightings for each strategy informed by a combination of case study analysis, expert interview and practitioner survey, and
3. Develop and validate a star rating system (known as **adaptSTAR**) aligned to best practice that describes predicted adaptive reuse performance at the outset.

The main deliverable of the research is the creation and validation of the **adaptSTAR** tool, which is essentially a weighted checklist of design decisions that lead to best practice outcomes. Performance is assessed using a standard five-star rating methodology.

The adopted research plan (see Figure 2), while open to modification as the work progresses, provides an underpinning explanation of intent. It clearly shows the logic of the approach. It identifies the knowledge gap (lack of consensus on design criteria for future adaptive reuse success) and proposes a methodology for filling this gap (mixed mode: qualitative and quantitative). Two hypotheses are proposed that will validate the work using triangulation. The contribution of the research will be evidenced through its ability to influence the level of sustainability performance of our built environment over time via an increased propensity to reuse rather than destroy and reconstruct. When validated, the **adaptSTAR** tool will be made available to design practitioners through a future commercialization arrangement.

A mixed mode research methodology comprising a combination of case study analysis, expert interviews and practitioner survey is the approach selected to collect relevant data and enable the findings to be triangulated and validated. The role of each method is explained separately below.
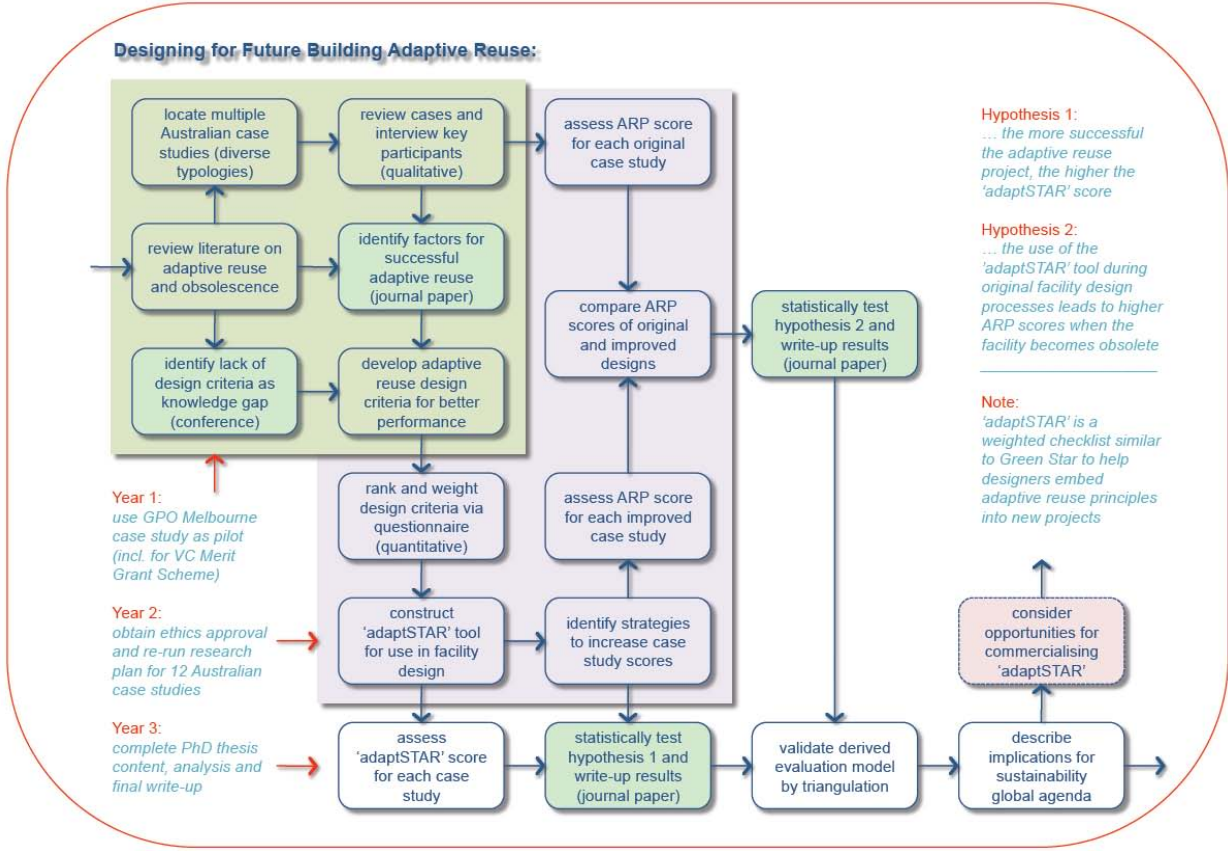

Figure 2: Research Plan Logic

Stage 1 (based on pilot study of Melbourne's GPO Building in 2010):

From review of the literature on adaptive reuse and obsolescence, it is clear that there is a lack of consensus about which design criteria lead to successful future adaptive reuse projects. Even more importantly, the relative weighting of criteria in various contexts is unknown. Using a qualitative research methodology, Australian practitioners involved in twelve successfully completed adaptive reuse case studies will be interviewed to solicit their views on key design criteria derived from analysis of their projects and underpinning literature. Case studies will be drawn from the joint publication of the Heritage Council of New South Wales and the [then] Royal Australian Institute of Architects (NSW Department of Planning and RAIA, 2008) listing eleven award winning adaptive reuse conversions (varied typologies) throughout New South Wales, plus a further (pilot) study of the GPO Melbourne project in Victoria. The main outcome of Stage 1 is an unweighted list of design criteria

suspected to contribute to better performance in adaptive reuse applications. The pilot is supported by an internal Bond University research grant to be completed by the end of 2010.

Stage 2 (to be undertaken in 2011):

Using a quantitative research methodology, a concise structured survey conducted electronically (and anonymously) to registered architects in Australia shall be used to rank and weigh the list of design criteria by assessing the relative importance of each strategy and their context. The Australian Institute of Architects will be approached in this endeavour by advertising the survey to its members as they have done for other research projects on previous occasions. A response rate of at least 30% is the target. A 5-point Likert scale is to be used to elicit opinion, with respondent judgement based on issues of practicality, potential for success and (where relevant) architectural merit. *SurveyMonkey* will be used to administer the survey instrument.

From the data discovered through this process, a weighted list of design criteria will be constructed using *Microsoft Excel*. The ARP model considers the seven obsolescence categories as equally weighted, and so too shall this research. However, for each obsolescence category, design strategies shall be weighted directly from the discovered Likert scores. Statistical analysis of the data will show the level of confidence in the weights and their robustness. Strategies that contribute less than 1% of the overall performance score will be discarded, and the remainder revalued so that each obsolescence category equals one-seventh (14.29%). Points shall be used to define a user-friendly star rating scheme similar to that used currently in *Green Star*, where 4 stars indicate best practice, 5 stars indicate Australian excellence and 6 stars indicate world leadership. The main outcome of Stage 2 is the **adaptSTAR** 'engine' and forms the heart of this research project. Each of the twelve case studies will be assessed using **adaptSTAR** to determine their performance and using the ARP model to determine their potential at the time of their redevelopment. *Green Star* is effectively acting as the conceptual framework for the **adaptSTAR** tool.

Stage 3 (to be undertaken in 2012):

Based on the earlier expert interviews and reflections with the benefit of hindsight, theoretical improvements to each of the twelve case studies will be proposed. These will be assessed as above to determine alternate performance and potential scores. Two hypotheses flow from this study:

> 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

The hypotheses are objective and relational. They are suitable for statistical testing and correlation. Only if both of these hypotheses are supported will the **adaptSTAR** tool be validated and of practical merit.

The case study improvements relate not to the adaptive reuse conversion but to the original design. It raises a number of questions. What could have been done then to make the current process more effective? How could the philosophy of 'long life, loose fit, low energy' have been enhanced at the outset? How can combined economic, social and environmental performance be maximized? In this regard the views of experts having detailed knowledge of the case studies through their engagement with the conversion process are extremely valuable. Given each case study has a completely different set of experts, their views are combined to form the list of unweighted design criteria and the consensus of other Australian architectural practitioners in ranking and weighting criteria leads to a tool that is far from self-serving. What the case study experts consider as architectural merit may not necessarily lead to higher **adaptSTAR** scores since the ranking and weighting process is independent.

By comparing the change in ARP score with the change in **adaptSTAR** score, the use of **adaptSTAR** as a strategy to realize more successful adaptive reuse outcomes can be validated. The innovative mix of methodologies, comprising case studies, expert interviews and practitioner survey, enables triangulation of results. Only through a validated tool can further commercialization opportunities be pursued and realized. The main outcome of Stage 3 is the validation of the **adaptSTAR** tool and its dissemination. In particular, the application of **adaptSTAR** in mitigating the effects of a changing climate needs to be clearly articulated in the context of global sustainability targets for the built environment professions. A significant benefit to the nation will result from this knowledge and its adoption in practice over time.

DISCUSSIONS

Progress to date

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 RAIA 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.

| Figure 3: GPO Building Facade | Figure 4: GPO Building Mall Interiors |

Initial Development of the adaptSTAR Model

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 was also informed by the relevant literature on existing and recent design strategies that pertains to the adaptation of heritage buildings (NSW Department of Planning and RAIA, 2008; UNESCO, 2009) together with other building adaptation concepts/guidelines (Douglas, 2006; Grammenos and Russel, 1997; City of New York Department of Design and Construction, 1999; Russel and Moffat, 2001; Graham, 2005; Arge, 2005; Davison et al., 2006; Shaw et al., 2007; Prowler, 2008; Vakili-Ardebili, 2007; Wilson and Ward, 2009; Wilkinson et al., 2009). As the research progresses, it is anticipated that the initial list will be substantially modified given the different interviews and field surveys of the stakeholders/experts of the other eleven selected case studies used in the full project.

The proposed **adaptSTAR** 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.
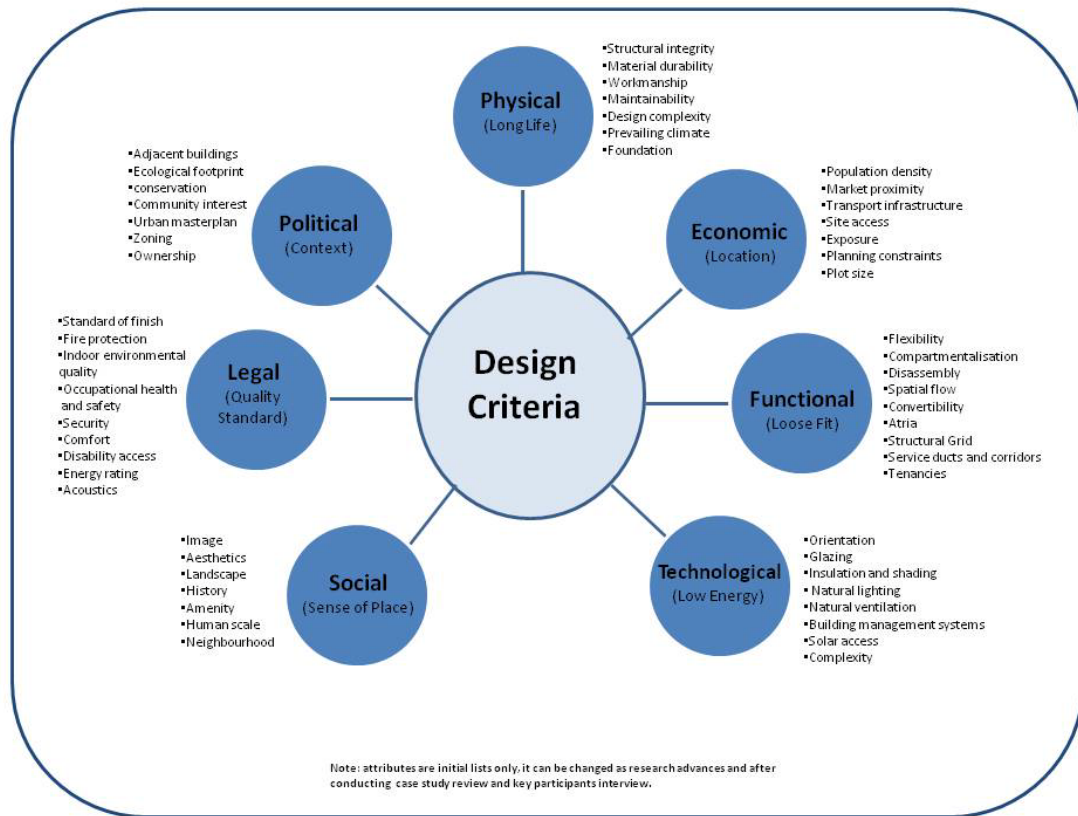
Figure 5: Proposed **adaptSTAR** Model

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:

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

1.2 *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.

1.3 *Workmanship* - pertains to the quality of craftsmanship applied to the building's structure and finishes.

1.4 *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.

1.5 *Design complexity* - this element consists of various geometries associated with the design and innovation of the building.

1.6 *Prevailing climate* - this element addresses designing for changing climatic conditions that determine appropriate solutions for warm or cold temperature areas.

1.7 *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).

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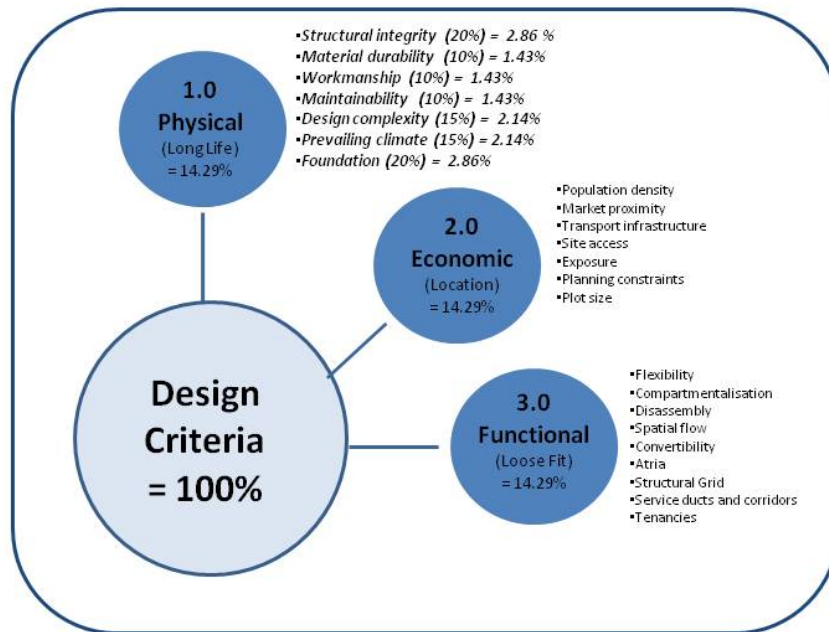
Figure 6: *Proposed **adaptSTAR** Model: sample application*

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.

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