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Adaptstar Model: A climate-friendly strategy to promote built environment sustainability

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Abstract

Building adaptive reuse plays a critical role in emissions reduction and supports global climate protection. Thus, the designing of future buildings with embedded adaptive reuse potential is a useful criterion for sustainability. This paper describes the development of a new rating tool known as *adaptSTAR*, which offers holistic and unified design criteria suitable for assessing the adaptive reuse potential of future buildings. 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. In addition, this paper reports on the first stage of the research methodology used in the initial development of the rating tool and concludes with some preliminary observations from twelve (12) selected successful case studies in New South Wales (NSW) and Melbourne, Australia. The use of *adaptSTAR* in designing future buildings will lead and help promote low carbon built environments.

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

Introduction

The built environment is the world's largest user of energy, emitter of greenhouse gases and has the largest potential for efficiency (UNEP, 2009). According to Balaras et al. (2004), the existing stock has the greatest potential to lower the environmental load of the built environment significantly within the next 20 or 30 years. This imperative encourages building professionals to produce more energy-efficient buildings and renovate existing stocks according to modern sustainability criteria (United Nations Environment Programme, 2007).

Building adaptive reuse is an alternative to traditional demolition and reconstruction; it is innately sustainable as it entails less energy and waste. It is defined as a significant change to an existing building function when the former function has become obsolete (Douglas, 2006). Adaptive reuse is relevant to the current climate change adaptation agenda due to its ability to recycle resources in place. Existing buildings that have been upgraded to achieve substantial cuts in greenhouse gas emissions (GGE) are considered a more climate-friendly strategy than producing new energy efficient buildings (TEC, 2008).

Adaptive reuse is a successful global strategy applied in many types of facilities around the world, including prestigious heritage buildings in most states in the United States, Australia and across the Asia Pacific region (Cantell, 2005; Langston et al., 2008; Department of Environment and Heritage, 2004; NSW Dept. of Planning, 2008; United Nations Educational Scientific and Cultural Organization, 2007). Moreover, building adaptive reuse has a major role to play in the sustainable development of communities, maintaining the social fabric whilst limiting potential demolition and reconstruction wastes (DEH, 2004). It also provides benefits of conserving green space, improving the micro-climate air quality, and maintaining habitat, ecosystem and water quality (Giles, 2005). This paper outlines the need for an adaptive reuse rating tool targeted to new design of buildings to support embedded adaptive reuse potential which will help promote built environment sustainability, and concludes on the initial development status of *the adaptSTAR* rating tool.

Literature Review

Adaptive Reuse, Sustainability and Sustainable Design Principles

The Urban Land Institute (cited in Tobias and Vavaroutsos, 2009) indicates that new construction accounts for merely 1 to 1.5 % of existing building stock each year in most developed countries. Naturally, the existing building stock represents the greatest opportunity for energy and carbon reduction. This is why adaptive reuse plays a critical role in reducing emissions from the built environment. UNEP (2009) 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 (2009) assert that there is no better example of the environmental benefits of effective sustainability in practice than the recycling of buildings. In addition, the Urban Land Institute (cited in Tobias and Vavaroutsos, 2009) 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.

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 (2000), 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. For Zushi (2005), 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 Zimmnicki (2004), sustainable design principles that encourage maximum reuse of 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 (2005) 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 architectural practice.

Adaptive Reuse Potential (ARP) Model

Until now experience and intuition are often the only guides to making decisions for adaptive reuse (Gorse and Highfield, 2009). However, through the ARP model (Langston et al., 2008) existing buildings can now be ranked on their adaptive reuse potential at any point in time. The ARP model is summarized in Figure 1 as firstly demonstrated by using a case study in Hong Kong (Langston and Shen, 2007).

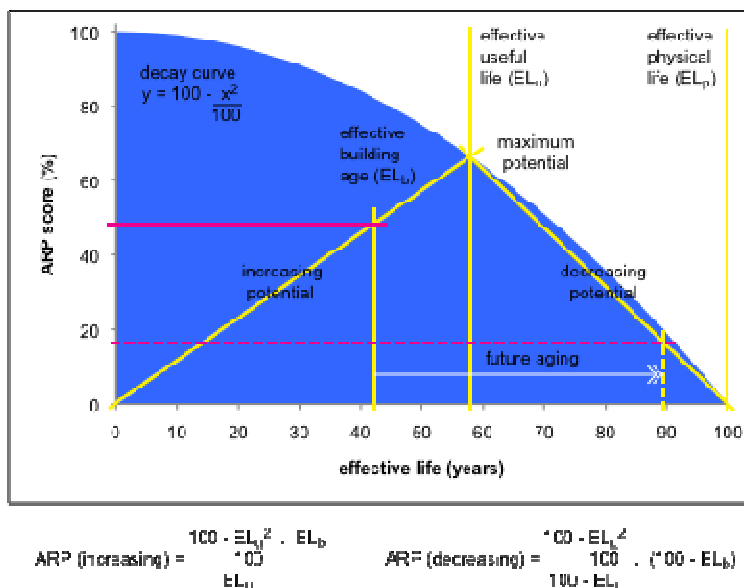


Fig. 1: Adaptive reuse potential model (Langston, 2008)

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). The ARP model predicts useful life as a

function of (discounted) physical life and obsolescence, and allows the calculation of the adaptive reuse potential at any point in 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 (Langston, 2008) and recently validated by a new multi criteria decision analysis tool called *iconCUR* (Langston, 2012).

Research Methodology

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 Langston's ARP model 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 that will 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 methodology.

This research is an explorative study and retrospectively analyzes existing successful adaptive reuse projects to establish a list of design factors (design criteria) that will be evaluated by members of the architectural profession. The methodological approach of this research is essentially in three stages and is a sequential mixed mode methodology (qualitative and quantitative). A combination of case study analysis, expert interview and practitioner survey is the approach selected to collect relevant data and enable the findings to be triangulated and validated. However, this paper reports on the results of the first stage of the research methodology since the other stages are in progress. Stage One is a qualitative approach that adopts a multiple case design to allow the researchers to fully understand the phenomenon of interest by using several independent case studies. A qualitative approach is most suitable for this type of exploratory research which encompasses theory building (Cresswell, 1998) and the use of evidence from multiple cases as they are deemed more compelling, which is essential to the overall study's robustness (Yin, 2009).

Stage One aims to identify an unweighted list of design criteria. Through the use of a qualitative approach, Australian practitioners involved in twelve successfully completed adaptive reuse case studies have been interviewed to solicit their views on key design criteria derived from analysis of their projects and underpinning literature. Fifteen key stakeholders who had expert case study knowledge were interviewed, and included representatives from the architectural team, developer, structural engineer, services engineer, quantity surveyor and facilities manager.

The twelve award-winning Australian adaptive reuse case studies are real life projects and demonstrate the successful blending of modern technology and design while respecting the building's historic character. They showcase rich and diverse architectural solutions in terms of conserving and adapting existing buildings to sustainable new uses. These selected case studies are adaptive reuse conversions throughout New South Wales, chosen among the over 20,000 heritage listed buildings in NSW because they represent different types of use and illustrate how the guidelines work in practice (NSW Department of Planning and RAI, 2008). In addition, a pilot study of the GPO Melbourne was also conducted. The following successful adaptive reuse case studies are summarised in Table 1 and presented in a photo collage (see Fig. 2).

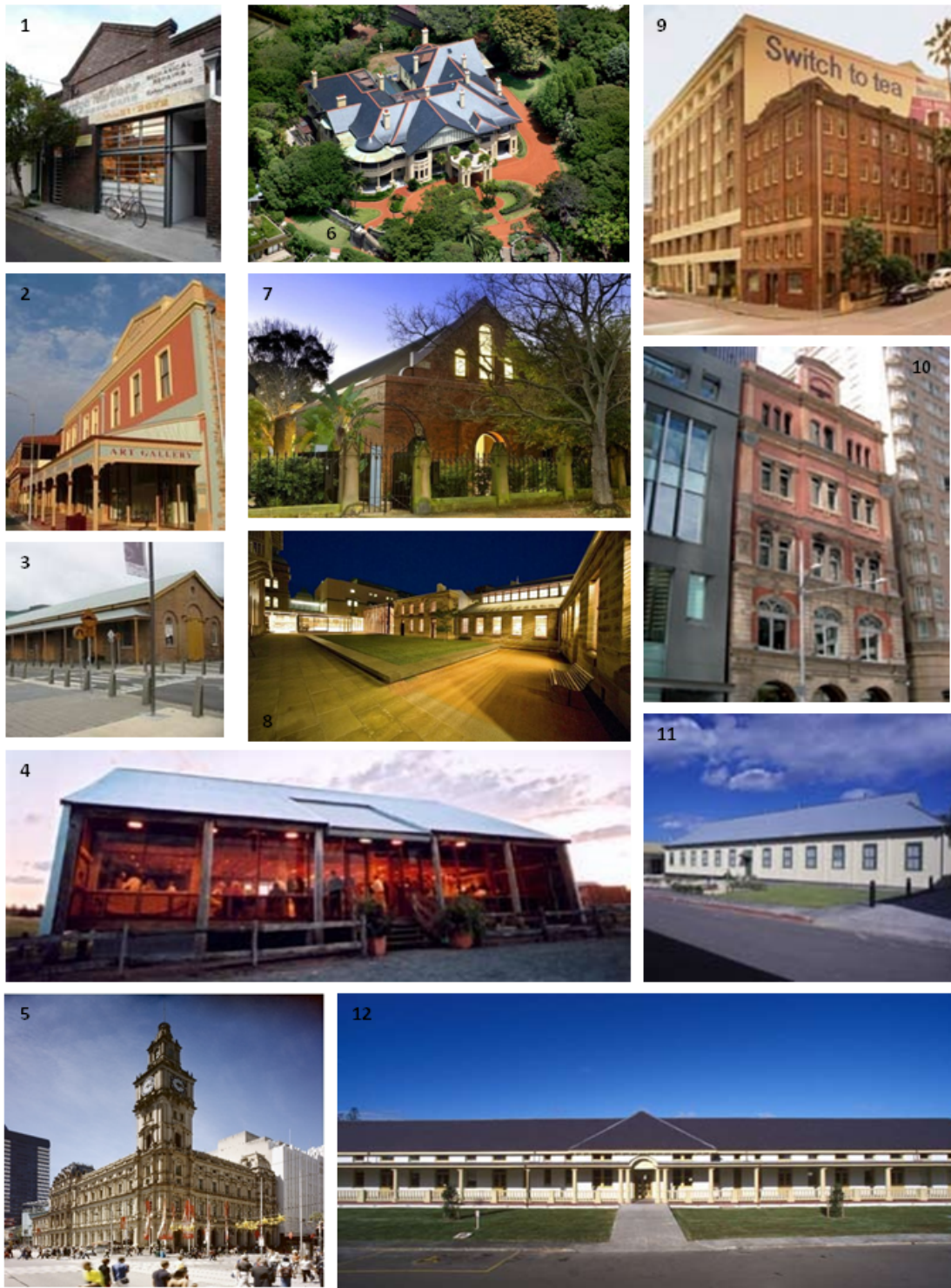
Table 1: The Twelve (12) Selected Successful Adaptive Reuse Case Studies

Case Study	Brief Description
1. Small scale industrial building converted to 4-Unit Residential Apartments, Egan Street, Newtown, NSW.	A small industrial warehouse was adapted to create three affordable contemporary apartments and a studio office space for a collective of architects, while retaining the heritage significance of the place. It is a representative example of a 1920s light industrial development and makes a positive aesthetic contribution to the streetscape. It is located in the O'Connell Town Estate Conservation Area. The project won the 2006 NSW Royal Australian Institute of Architects ESD/Energy Efficiency Award, the Multiple Housing Award, the President's Award and the 2006 National Trust Adaptive Re-Use Award.
2. Conversion of the Grand Babworth House to high-end apartments in Darling Point, NSW.	A grand 93-room Sydney mansion called Babworth House was adapted to five apartments, and ten new houses were constructed within its grounds. The house and its garden setting are listed on the State Heritage Register. Designed in the Federation Arts and Crafts style, the house displays an eclectic mix of Classical Revival, Arts and Crafts and Art Nouveau styles. Magnificent oak-panelled walls, decorative plaster work and an imposing timber stairway characterise the interior. The Babworth House adaptation was the recipient of the Woollahra Conservation Award in 2004 and was short-listed for the RAlA and National Trust 2004 awards.
3. Rural agricultural building into a tourist information and function centre in Tocal, NSW.	The Tocal Visitor Centre was adapted from an early 20th century hay shed within the State Heritage-listed Tocal Homestead precinct. It still maintains the appearance and feel of an Australian rural shed. It provides a multi-purpose visitor centre for both Tocal Homestead and Tocal Agricultural College. It is capable of seating 100 guests, has a 60 seat theatre and exhibition areas, and provides modern and comfortable amenities for visitors. The converted shed won the 2007 Ten Carat Award for Best Wedding Reception– Hunter Valley.
4. Local church and church hall into residential in Glebe, NSW.	A former church and church hall were adapted as two residences. The principal elevations, roofs and overall forms of the buildings were retained and conserved. The church and hall are located in the Toxteth Estate conservation area. The streetscape of predominantly Victorian houses has a mixed residential character, with single and two-storey terraces and some single dwellings. The conversion was a finalist for the Greenway Award in the 2007 RAlA NSW Chapter Awards.
5. Conversion of the Bushells building, an inner city industrial site into offices in the Rocks, Sydney, NSW.	This former factory building was adapted to modern offices in a way that preserves the structural clarity of the warehouse spaces, conserves and incorporates a number of significant artefacts, and provides a rewarding and unique work environment. The Bushells Building is a landmark within the historic Rocks area of Sydney and is listed on the State Heritage Register. The building is important because of its industrial character and its historical association with the Bushells Company, once synonymous with Australia's cultural identity through prolific and successful marketing campaigns over the last century. The project was awarded the Master Builders Association Excellence in Construction Merit Award for the Restoration or Renovation of an Historic Building and the UNESCO Award for conservation and adaptation in 2001 and was highly commended for both the Australian Property Institute Award for Best Development (heritage refurbishment) and the Property Council of Australia Rider Hunt Award for conservation and adaptation in 2002.
6. Defence buildings into mixed use development which include the Sydney Harbour Federation Trust Offices in Georges Heights, NSW.	A group of former WWI hospital buildings was adapted by the Sydney Harbour Federation Trust as part of an overall plan for a headland park extending from Rawson Oval to Middle Head. Three former hospital buildings were converted into a linked office space and headquarters for the Sydney Harbour Federation Trust. The former hospital buildings are on the Commonwealth Heritage List. They sit on a prominent knoll on the ridgeline, with excellent views to the east across Sydney Harbour. Two of the buildings were part of a 1915 Army Auxiliary hospital and are considered rare. All three buildings had been converted to other uses by the Army over time.
7. Commercial building into art gallery in Broken Hill, regional NSW.	The Broken Hill Regional Art Gallery was adapted from a near ruinous former mining hardware building in the main street of Broken Hill. The building now exhibits the extraordinary art of the Broken Hill region, including contemporary art and the local council collection, which dates from the council's establishment in 1886. Interpretation was added to tell the history of the building and the story of the development of Sully's Emporium as an important mining enterprise. It has become a unique visitor experience, enhancing Broken Hill's appeal as a tourist destination. Sully's Emporium is located within the Argent Street Conservation Area and is included on the State Heritage Register. The conversion won the Australian Property Institute Savills Heritage Award and the Corporate/Government category of the Energy Australia, National Trust of Australia (NSW) Heritage Conservation Award in the Built Heritage for projects over \$500,000 category in 2005.

Table 1: The Twelve (12) Selected Successful Adaptive Reuse Case Studies

Case Study	Brief Description
8. Conversion of the Mint Coining Factory to the Historic Houses Trust head office and library in Sydney, NSW.	The surviving structures of the sandstone Coining Factory buildings of the Royal Mint, Sydney (1855-1926) were adapted for use as the new head office of the Historic Houses Trust (HHT). There are two structures on the Mint site — the Mint offices on Macquarie Street (originally the south wing of Governor Macquarie’s General or ‘Rum’ Hospital, constructed from 1811-1816) and behind this, the Coining Factory (constructed in 1854 for the Royal Mint). Located in the most important civic precinct of Sydney, these buildings have a remarkable history of use and adaptation over nearly 200 years. The Mint project received both the Royal Australian Institute of Architecture’s Sulman Award and the Greenway Award in 2004. At the time the judges commented that ‘The whole ensemble is given cohesion through carefully modulated scale and proportion, juxtapositions of materials, light and shade, old and new, inside and out. A 19th century walled factory has been transformed into a 21st century campus.
9. Railway workshops into health and wellness centre in Newcastle, NSW.	An historic railway workshop building was adapted for The Forum Health and Wellness Centre, owned by University of Newcastle Sport. The building known as Civic Railway Workshop Block A (the former Permanent Way Store or Perway Building) is on the State Heritage Register. It is located between Workshop Place and Harbour Square at Harbourside in Newcastle. It appears as a combination of heritage railway and contemporary buildings within the Honeysuckle urban regeneration area’s contemporary streetscape. The project won the Babc Construction Heritage Award and the Andrews Neil Peoples Choice Award in the 2007 RAI A Lower Hunter Urban Design Awards.
10. Conversion of the George Patterson warehouse to a hotel complex in Sydney, NSW.	Two buildings - substantially damaged by two simultaneous fires on 2 January 1996 - have been retained, conserved and adapted for a hospitality venue, including a boutique hotel in the CBD. The building was adapted to accommodate a series of bars and function spaces accessible from George Street, a boutique hotel in the former warehouse section off Tank Stream Way, and a nightclub in the lower ground and basement levels. The building was designed in the Queen Anne Revival style and built between 1892-1895 for Holdsworth MacPherson & Co. hardware merchants and ironmongers, as a conjoined showroom and warehouse with a water tower at the junction. At the time of its construction it was considered the grandest emporium of its period. The project won an Interior Architecture Award in the 2001 RAI A NSW Chapter Awards.
11. Heritage-led urban regeneration, revitalisation of Prince Henry Hospital, a government health facility into mixed use development of residential, commercial and health facilities in Little Bay, NSW.	As recipient of numerous Australian awards for heritage and sustainability, the Prince Henry redevelopment project contributes to a sustainable future by providing a model for redevelopment of similar heritage and environmentally sensitive areas in Australia. The Prince Henry site has been used by Aborigines for thousands of years and was formerly a dilapidated hospital site for quarantine of infectious diseases. The revitalization of the site balances the old and new developments while keeping 80% of the site in public ownership. Over 90% of demolition materials were reused and buildings comply with energy efficiency principles while the whole redevelopment is based primarily on environmentally sustainable design principles. The Prince Henry master plan starts with the premise of conservation and enhancement. Its principles derive from analysis and evaluation of the physical and cultural framework of the site and surrounding environment. They address ecological sustainability, urban design, heritage, amenity and accessibility. Noteworthy also to mention is that the Prince Henry redevelopment won the President’s Award from the Urban Development Institute of Australia in 2009, which was the highest accolade within the UDIA awards program both state-wide and nationally.
12. GPO Building, Melbourne, Victoria (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 RAI A 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.

Sources: NSW Department of Planning and RAI A, 2008; Langston, 2008; Conejos, 2011



Legend: 1. Small scale industrial building converted to 4- Unit Residential Apartments, Egan Street, Newtown, NSW; 2. Commercial building into art gallery in Broken Hill, regional NSW; 3. Railway workshops into health and wellness centre in Newcastle, NSW; 4. Rural agricultural building into a tourist information and function centre in Tocal, NSW; 5. GPO Building, Melbourne, Victoria (Pilot Study); 6. Conversion of the Grand Babworth House to high-end apartments in Darling Point, NSW; 7. Local church and church hall into residential in Glebe, NSW; 8. Conversion of the Mint Coining Factory to the Historic Houses Trust head office and library in Sydney, NSW; 9. Conversion of the Bushells Building, an inner city industrial site into offices in the Rocks, Sydney, NSW; 10. Conversion of the George Patterson warehouse to a hotel complex in Sydney, NSW; 11. Defence buildings into mixed use development which include the Sydney Harbour Federation Trust Offices in Georges Heights, NSW; and 12. Heritage-led urban regeneration, revitalisation of Prince Henry Hospital, a government health facility into mixed use development of residential, commercial and health facilities in Little Bay, NSW.

Fig. 2: The 12 Selected Case Studies

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.

Initial Development of the *adaptSTAR* Model

The collected data in Stage One were transcribed, collated, managed and analyzed through the use of the *NVivo* software. *NVivo* (QSR, 2008) is qualitative research software that helps manage, shape and make sense of a researcher's data collection. With *NVivo*, analysis includes data classification, reduction, data display, theme identification and drawing of meaningful conclusions. Through the use of the case study protocol as a guide and the creation of nodes in *NVivo*, the Stage One case study analysis was organized and presented in two steps:

1. *Construction of Each Case Study Profile*: individual and in-depth case profiles based on comprehensive documentation (such as published literatures, approved building plans and maps, architect's conceptual schemes, news clippings and articles, and public reports) that were written about the twelve case studies; and
2. *Addressing Research Objective*: the pattern coding of key design criteria identified based on the in-depth expert interviews of the selected professionals involved in the case studies' design and construction implementation. This also includes the coding of key design criteria informed by the experts' interview results and relevant underpinning literature.

In identifying the list of factors, semi-structured interview questionnaires with the following themes were prepared:

1. *History of the project*: a brief background of the project from its existing use to its new adaptive use or building function; what major decisions/ events lead to its reuse; major considerations before undertaking the project; latent conditions;
2. *Design and technical aspects*: impediments encountered during the design process, how modern and green design features (if any) were incorporated or blended to the existing facilities; structural and utility challenges; legal and building code considerations;
3. *Design process: design principles and criteria applied or implemented*; design consultations conducted with stakeholders; adaptive reuse strategies identified or applied; critical factors that affected the success of adaptive reuse projects.

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 list of design criteria identified by the case study experts and linked to 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 below:

Table 2: List of Design Criteria (based on Experts' interviews and underpinning literature)

Category	Criterion	Experts (n=15)	Relevant Research Study
Long Life (Physical)	Structural Integrity- structural design of the building to cater future uses and loads	8	Grammenos and Russell (1997); Russell and Moffat (2001); Davison, et.al. (2006); Osbourne (1985); Douglas (2006); Siddiqi (2006); Horvath (2010); Gorse and Highfield (2009); Yudelson (2010)
	Material Durability- durability of the building asset	8	Milne in UNEP (2007); Prowler (2008); Osbourne (1985); Douglas (2006);
	Workmanship- quality of craftsmanship of structure and finishes	7	Osbourne (1985)
	Maintainability- building's capability to conserve operational resources	5	Prowler (2008); Vakili-Ardebili (2007); Osbourne (1985); Douglas (2006); Horvath (2010)
	Design Complexity- various geometries associated with the building's design and innovation	4	Grammenos and Russell (1997); Russell and Moffat (2001); Browne (2006)
	Prevailing Climate- changing climatic conditions	2	Wilson and Ward (2009);
	Foundation- differential settlement and substrata movement	7	Milne in UNEP (2007); Osbourne (1985)

Table 2: List of Design Criteria (based on Experts' interviews and underpinning literature)

Category	Criterion	Experts (n=15)	Relevant Research Study
Location (Economic)	Population Density- location within major city, CBD, etc.	2	Langston et al. (2008);
	Market Proximity- distance to major city, CBD, etc.	3	Campbell (1996); Fealy (2006)
	Transport Infrastructure- availability and access	3	Prowler (2008); UNEP (2007); Heath (2001)
	Site Access-proximity or link to access roads, parking and communal facilities, etc.	2	Prowler (2008); UNEP (2007); Heath (2001)
	Exposure-views, privacy	2	Campbell (1996); Fealy (2006); Browne (2006)
	Planning Constraints-site selection, planning, neighbourhood and building design, etc.	4	Langston et al. (2008);
	Plot Size- built area, spatial proportions, enclosure, etc.	2	Campbell (1996); Heath (2001)
Loose Fit (Functional)	Flexibility-space capability to change according to newly required needs, plug and play elements, etc.	12	Russell and Moffat (2001); Arge (2005); Graham (2005); Prowler (2008); Vakjli-Ardebili (2007); Douglas (2006); Horvath (2010); Langston et al.(2008); Milne in UNEP (2007); Nakib (2010);
	Disassembly-options for reuse, recycle, demountable systems, modularity, etc.	4	Russell and. Moffat (2001); Graham (2005); Vakili-Ardebili (2007)
	Spatial flow-mobility, open plan, fluid and continuous	5	Davison, et.al. (2006);Zeiler et al. (2010); Horvath (2010)
	Convertibility-divisibility, elasticity, multi-functionality	5	Russell and Moffat (2001);
	Atria- open areas, interior gardens, etc.	5	Whimster (2008)
	Structural Grid- ideal and economical limit of span and fully interchangeable	5	Grammenos and Russell (1997); Russell and Moffat (2001); Arge (2005); Rabun and Kelso (2009)
	Service Ducts and Corridors- vertical circulation, service elements, raised floors, etc..	11	Grammenos and Russell (1997); Russell and Moffat (2001); Prowler (2008); Rabun and Kelso (2009)
Low Energy (Techno-logical)	Orientation-micro climate siting, prevailing winds, sunlight,	15	Prowler (2008); Douglas (2006); GBCA (2010); Park (1998); UNEP (2007); Dittmark (2008); Shaw et al. (2007)
	Glazing-sunlight glare control and regulate internal temperatures, etc.	15	City of New York Department of Design and Construction (1999); Douglas (2006); GBCA (2010)
	Insulation and Shading- thermal mass, sunshades, automated blinds, etc.	15	Osbourne(1985); Douglas (2006); GBCA (2010); Klein (2008)
	Natural Lighting-inclusion for natural daylight, efficient lighting systems, etc.	15	Osbourne (1985); Douglas (2006); GBCA (2010); Park (1998); Holborrow (2008); Shaw et al. (2007); Davison et al. (2006)
	Natural Ventilation-optimise airflow, quality fresh air, increase ambient air intake, etc.	15	City of New York Department of Design and Construction (1999); Wilson and Ward (2009); Osbourne (1985); Douglas (2006); GBCA (2010) ; Park (1998); Holborrow (2008); Shaw et al. (2007)
	Building Management Systems- monitor and control building operations and performance systems	3	Grammenos and Russell (1997); Russell and Moffat (2001); Levine, M. et al (2007); Prowler (2008); GBCA (2010); Langston and Shen (2007)
	Solar Access-measures for summer and winter sun	15	City of New York Department of Design and Construction (1999); Wilson and Ward (2009); Douglas (2006); GBCA (2010); Park (1998); Dittmark (2008); Shaw et al. (2007)

Table 2: List of Design Criteria (based on Experts' interviews and underpinning literature)

Category	Criterion	Experts (n=15)	Relevant Research Study
Sense of Place (Social)	Image/ Identity- social and cultural attributes, values, etc.	4	NSW Department of Planning (2008); Bond and Charlemagne (2009); DEH (2004); Curry (1995); Harmon et al.(2006); ICOMOS (1994); Jokilehto (1996); Marquis-Kyle and Walker (1994); UNESCO (2007 and 2009); Fournier and Zimnicki (2004)
	Aesthetics-architectural beauty, good appearance, proportion, etc.	4	Prowler (2008); Farrel (2010); GBCA (2010)
	Landscape/ Townscape-visual coherence and organization of the built environment	3	Davison, et.al. (2006); NSW Department of Planning (2008); Fournier and Zimnicki (2004); Zushi (2005); Shaw et al. (2007)
	History/ Authenticity-original fabric, timelessness, socio-cultural traditions, practices, historic character or fabric, etc.	4	Prowler (2008); NSW Department of Planning (2008); Bond and Charlemagne (2009); DEH (2004); Curry (1995); Harmon et al.(2006); ICOMOS (1994); Jokilehto (1996); Marquis-Kyle and Walker (1994); UNESCO (2007 and 2009); Fournier and Zimnicki (2004)
Sense of Place (Social)	Amenity-provides comfort and convenience facilities	2	Browne (2006); Zushi (2005); Fealy (2006)
	Human Scale- anthropometrics and fit to average human scale	2	Campbell (1996); Grammenos and Russell (1997); Russell and S. Moffat (2001);
	Neighbourhood-local and social communities	2	HMSO (1987); DEH (2004); Browne (2006)
Quality Standard (Legal)	Standard of Finish-provision for high standard workmanship	9	Holborrow (2008); Park (1998); Osbourne (1985)
	Fire Protection- provisions for fire safety	6	Davison, et.al. (2006); NSW Department of Planning (2008); Douglas (2006);
	Indoor Environmental Quality-provisions for non-hazardous materials, natural fabrics, etc.	11	Prowler (2008); City of New York Department of Design and Construction (1999);
	Occupational Health and Safety-special needs of occupants, health and safety risks, building hazard and risk management plan	2	Prowler (2008); NSW Department of Planning (2008); City of New York Department of Design and Construction (1999); Douglas (2006);
	Security- provision of direct and passive surveillance designs	3	Prowler (2008); NSW Department of Planning (2008); Osbourne (1985); Douglas (2006);
	Comfort- hygiene and clean environment, etc.	2	Prowler (2008); Osbourne (1985); Gilder (2010)
	Disability Access- provision for disability easement, facilities, etc.	6	NSW Department of Planning (2008); Douglas (2006);
	Energy Rating- environmental performance measures	3	NSW Department of Planning (2008); Douglas 2 nd ed. (2006);
	Acoustics- noise control, sound insulation, etc.	8	Osbourne (1985); Douglas (2006);
Context (Political)	Adjacent Buildings- adjacent enclosures, vertical and visual obstacles	1	Davison, et.al. (2006)
	Ecological Footprint- appropriate measure of human carrying capacity	15	Cantell (2005); Tobias and Vavatrous (2009); UNEP (2007); Langston and Shen (2007); Giles (2005); Gilder (2010); Balaras et al. (2004)
	Conservation- principles, guidelines, charters governing tangible and intangible heritage protection	8	Curry (1995); Harmon et al.(2006); ICOMOS (1994); Jokilehto (1996); Marquis-Kyle and Walker (1994); UNESCO (2007 and 2009); Fournier and Zimnicki (2004)
	Community Interest/ participation-Stakeholder relationship and support	12	Langston et al. (2008); HMSO (1987); Browne (2006)

Table 2: List of Design Criteria (based on Experts' interviews and underpinning literature)

Category	Criterion	Experts (n=15)	Relevant Research Study
	Urban Masterplan- integrated skyline, urban landscape, built environment design and management/ practice	8	Wilson and Ward (2009; Douglas (2006); Heath (2001)
	Zoning- land uses and land patterns	7	City of New York Department of Design and Construction (1999); Wilson and Ward (2009); Douglas (2006);Campbell (1996); Browne (2006)
	Ownership- collaborative commitment, sense of community or ownership, etc.	4	HMSO (1987)

Sources: Table showing building adaptive reuse design criteria from relevant research study in Conejos et al., 2011 and updated with the expert interviews results in Conejos, 2011.

As the research progresses, the identified list of design criteria will be evaluated to determine the weighted value of its associated and corresponding design elements and this will be done in Stage Two of the research methodology. 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). With regards to the outcome of Stage 1, the initial framework of the proposed *adaptSTAR* model is shown in Figure 3.

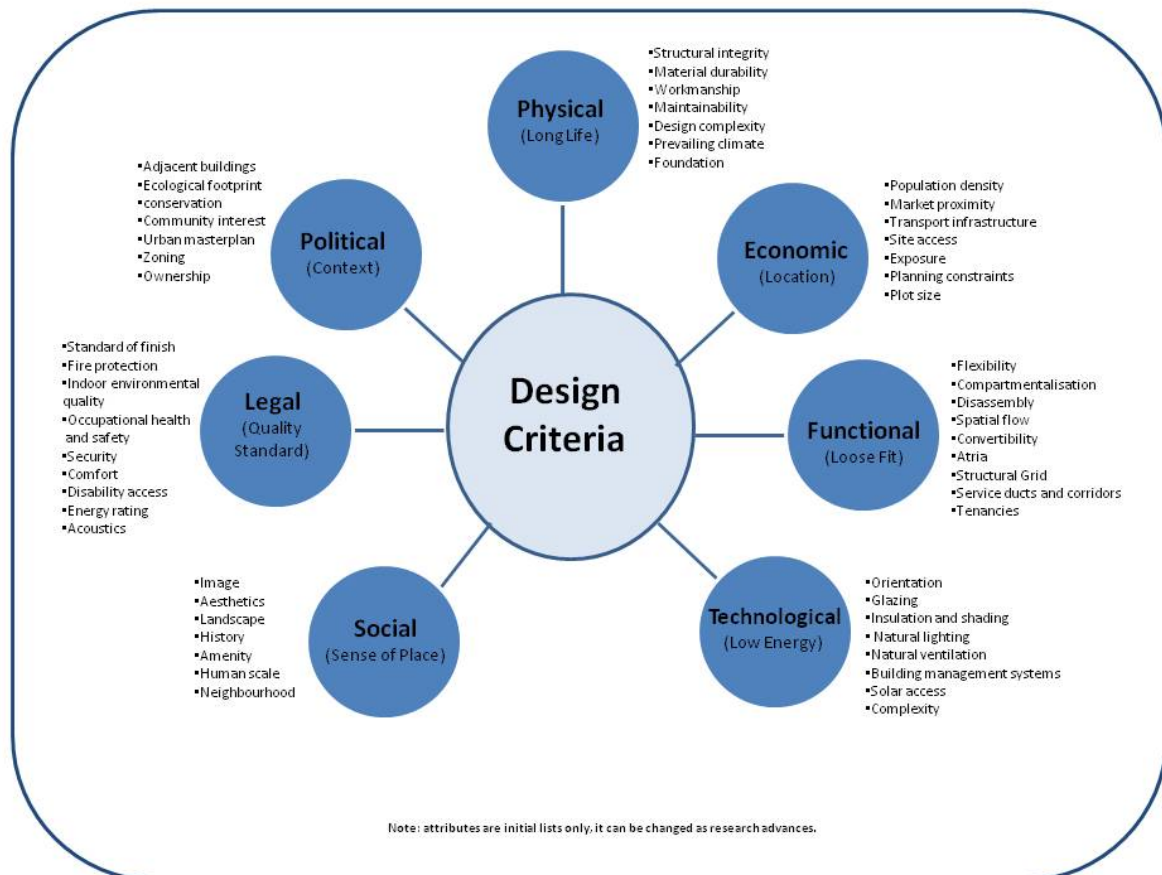


Fig. 3: Proposed *adaptSTAR* Model

Conclusion and Further Research

Amidst the diverse collection of design principles, strategies, approaches and solutions that have been in existence in the past, this research indicates a knowledge gap pertaining to the lack of clear design criteria for future adaptive reuse and the lack of consensus as to what design criteria would

best maximize the adaptive reuse potential of future buildings. This is a new field and this knowledge gap is expected.

Moreover, this research gives insights on how building designers approach the design process, solve problems, make decisions and address the potential complexity and value conflict in undertaking building adaptive reuse projects. Hence, this work leads to a better understanding of how designers can best be assisted in these activities in order to increase the likelihood of achieving design solutions that offer better future building adaptive reuse opportunities during the conceptualization process. Thus, when designing new buildings it is important to be concerned about maximizing the adaptive reuse potential of buildings later in their lives to help mitigate the effects of a changing weather climate plus the volatility of social, economic and environmental conditions. So, it is imperative that designers should fully understand the context of the existing built environment and consider the needs of new buildings through appropriate design technologies.

With the completion of the Stage One of this research, a list of design criteria have been identified to support the designing of future building adaptive reuse. Based on the interviews of selected expert professionals, they are geared towards the technological or environmental, physical and functional design criteria. Although there is less support for the socio-cultural design criteria, it must be noted that all selected case studies are heritage buildings and successful landmarks in NSW and Victoria. It is anticipated that the list of design criteria will be critically assessed once Stage Two of this research takes place.

The final development of the new *adaptSTAR* design rating tool is underway. Stage Two of the research will use a quantitative research methodology wherein a concise structured survey conducted electronically (and anonymously) to registered architects in Australia is used to rank and weight the list of design criteria by assessing the relative importance of each strategy and their contexts while Stage Three is the testing of the new *adaptSTAR* model against Langston's (2008) ARP model. This research paper has initially identified important design criteria needed for the sustainability and future adaptive reuse of new buildings. The research methodology outlined in this study is expected to assist in the reliability and validity of the new design rating tool. The outcome of this research and the application of the *adaptSTAR* model will be useful in the practical applications of adaptive reuse of the existing built environment as well as incorporation of adaptive reuse strategies for future buildings and help promote the development of sustainable built environments.

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