WHAT IS AFFORDABLE GREEN HOUSING? ANALYSIS OF A COMPETITION

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ABSTRACT

The range and invention of architects' proposals for more 'sustainable' modes of medium-density urban housing can be seen in entries to a design competition for 'affordable green housing'. The paper examines the attitudes and judgments about design that they represent, and how the winning entry has been modified for construction. An appendix provides a list of features claimed to promote the 'sustainability' of entries. The results present a picture of current thinking on the nature of affordable green housing, and provide a useful comparison for architects approaching their own projects and competition entries.

KEYWORDS

sustainability, ESD, competition, housing, water management, waste management, heating, cooling, passive, active, materials, energy, economy

INTRODUCTION

Calls for architects to design more 'sustainable', 'green', 'ecological' or 'environmental' housing have become commonplace in recent years. Entries to an Australian competition for the design of 'affordable green housing' provide an opportunity to examine the range and invention of architects' proposals for more 'sustainable' modes of medium-density urban housing. We discuss corresponding perceptions of the nature of 'sustainability' and the potential benefits of this kind of competition as a way of promoting interest and understanding in sustainability.

The competition[1] invited proposals for medium (or higher) density apartments for a corner site located about a kilometer from the centre of the city of Adelaide, South Australia. The winning design was to be used as the basis for the development of affordable housing for low income city workers who were unable to afford currently available rental housing. The objectives (City of Adelaide 2004) were to:

- challenge architects, engineers and environmentalists to propose innovative collaborative solutions to develop green affordable housing;
- demonstrate that a comfortable living environment and a reduction in operational costs can be achieved at an affordable price using sustainable design;
- demonstrate a reduction in energy and water consumption plus on-site waste compared to average Adelaide residential benchmark data;
- demonstrate that sustainable housing is also responsive to lifestyle by the use of innovative and aesthetic design;
- increase public awareness of sustainable issues by promoting the results of the competition and building affordable green housing.

Entry was open to members of the national institute of architects currently practising in Australia and 45 submissions were received, ranging from well-known national firms to small groups of individuals. The $A20,000 ($US15,000) first prize was credited towards the fees due to the appointed architect. Competitors were required to submit four A2 sheets with plans, sections, elevations and three-dimensional view(s). One sheet was to show the ways in which the proposed design responded to the key requirements of the competition brief including text, diagrams and sketches as appropriate. In addition, a concise report (A4 sheet) giving an opinion of probable building costs to assist the Jury and the quantity

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surveyors was to be attached but would not form part of any public exhibition. To submit a researched, developed and clearly presented entry was therefore a considerable undertaking.

A report of the competition in the professional journal *Architecture Australia* (Loo 2005) soon after the judging describes it as important both as genuinely open competition for a to-be-built project, rare in Australia, and as a statement about ecology. The author, Stephen Loo, comments on the 'red and blue arrows of cross ventilation paths, winter sun penetration and summer sun exclusion angles, sciagraphics showing the effect of north light, rain water reticulation and other water management diagrams, banks of solar cells, et cetera.' Yet behind these predictable expressions of greenness in architects' competition drawings are a myriad of architects' perceptions and judgments about what attributes of a building constitute contributions towards sustainability. The purpose of this paper is to report an examination of all of the entries, not just the award winners, in order to establish the range of ideas and claims that are made. This is important because it illustrates the extent of well-justified and poorly-justified conceptualisations about what genuinely constitutes a way to produce a more sustainable mode of building. The Appendix provides a consolidated list of all features that were claimed (justifiably or not) by one or more entrant to demonstrate or enhance sustainability. This can be compared with the extensive advice on and examples of Australian house design provided by the Australian Government's Australian Greenhouse Office (2005).

The winning scheme (figure 1; see pp. 132 and 133) was described by the competition jury as 'exemplary in achieving a 'balance' given the competing demands of reduced building cost to produce an affordable product and a high level of environmental performance and quality' (City of Adelaide 2004). Designed by the Adelaide office of Troppo Architects, a local office, it demonstrated knowledge of passive energy and environmental design without recourse to unproven devices. It also placed in the forefront a sense of community and resident enjoyment of their homes, the social aspects of sustainability, showing such details as a labelled 'dog bowl' on the plans. The brief stated that the 'proposed projects should contribute towards a socially friendly, community-focused development where people will enjoy healthy, safe and inclusive lifestyles and where a sense of belonging is promoted; the development should attract a mix of income entries predominantly made up of low and moderate income city workers and students'. The majority of applicants did not address this to any great extent, and the overt concern with how people might live in and enjoy both private and public spaces was a major part of the winning scheme's appeal.

TRADEOFFS AND MULTIPLE DISCOURSES

What is a competition such as this trying to achieve? A principal competition objective was to demonstrate that a comfortable living environment and a reduction in operational costs could be achieved at an affordable price using sustainable design.[2] In *Understanding Sustainable Architecture* (Williamson, Radford and Bennetts 2003) the authors argue that 'sustainable design' is a 'creative adaptation to ecological, socio-cultural and built contexts (in that order of priority), supported by credible cohesive arguments'. It is essentially a revised conceptualisation of design in response to a myriad of contemporary concerns about the effects of human activity. Sustainable—or more sustainable—design decisions must then be based on both an ethical position and a coherent understanding of the objectives and systems involved. There are several interlinked discourses that provide the context and motivation for such decisions. Currently the most prominent is climate change, for which the global objectives are to reduce lifecycle greenhouse gas emissions, create carbon sinks and to mitigate the effects of possible climate change. Designers are directly concerned with the first and third of these objectives. Their decisions need to be soundly based on an understanding of the whole system, particularly lifecycle effects (including production and disposal) rather than merely operational effects, and the 'opportunity costs' of adopting one design strategy rather than another (for example, the relative benefits of spending $X on solar panels or planting trees). For architects these decisions are still very hard to make. In the available information there is a disproportionate focus on operational effects rather than life-cycle effects, and very little reference to opportunity costs. The competition entries reflect this focus, with little examination of the tradeoff between environmental costs of production, maintenance and disposal of features compared with the operational environmental benefits in reducing energy use. Other environmental discourse issues are pollution, resource use and depletion (including water), biodiversity, and the preservation of indigenous flora and fauna. These lie alongside discourse issues of social and cultural relevance, occupants' health and comfort, cost effectiveness, and building longevity (see the appendix to (Williamson, Radford and Bennetts 2003 for an elaboration of how architects can respond to these issues). The competition alluded to many of these discourses, advising that 'submissions that perform highly on environmental factors, affordability, and design and comply with the planning instrument' would be 'well considered'. 'Greenness' was therefore to be achieved alongside the social objective of 'affordability' and the cultural objective of 'design' (not elaborated), all subject to the constraints of the 'planning instrument' that imposes limits on plot ratio, building heights, parking and other matters. But there was no explicit discussion of the tradeoffs between these criteria or how overall environmental performance would be assessed. This is not surprising; tradeoff decisions are notoriously difficult to make or justify.

In the following sections we comment on some of the main categories that relate to the discourses set out above, before returning to the issues of justification and tradeoff.

IMAGES OF SUSTAINABILITY

'Sustainability' is commonly made visible in designs through natural, cultural or technological images (Williamson, Radford and Bennetts 2003, based on Guy and Farmer 2000). A common concept is that a structure should 'look green' as well as 'be green', that it should display a 'natural' image. Few entries appeared to shout 'look at me, I'm green!' One entry did respond directly and obviously to seasonal movement of solar paths with a stepped design, but this was an exception amongst a majority that adopted a

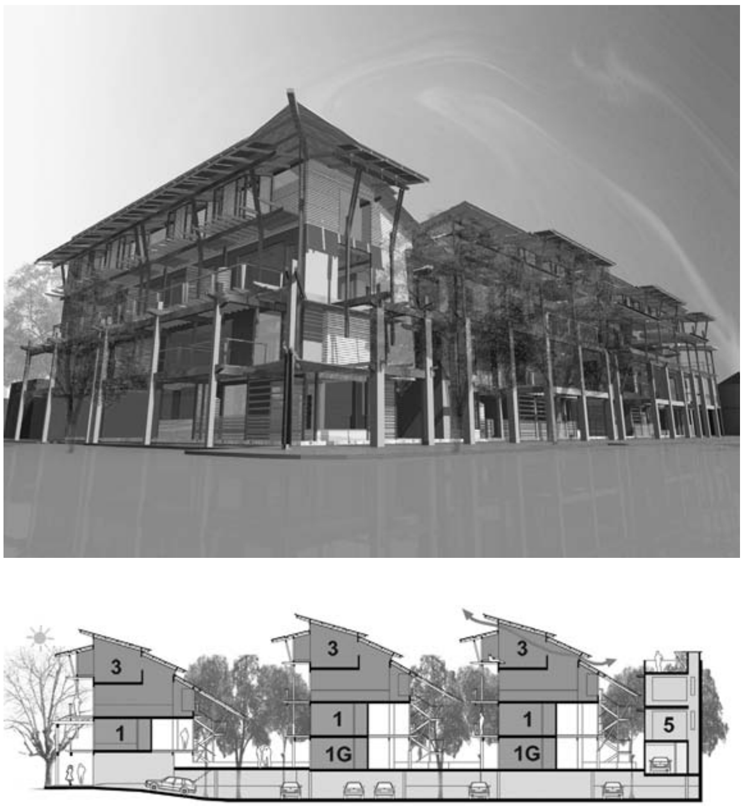
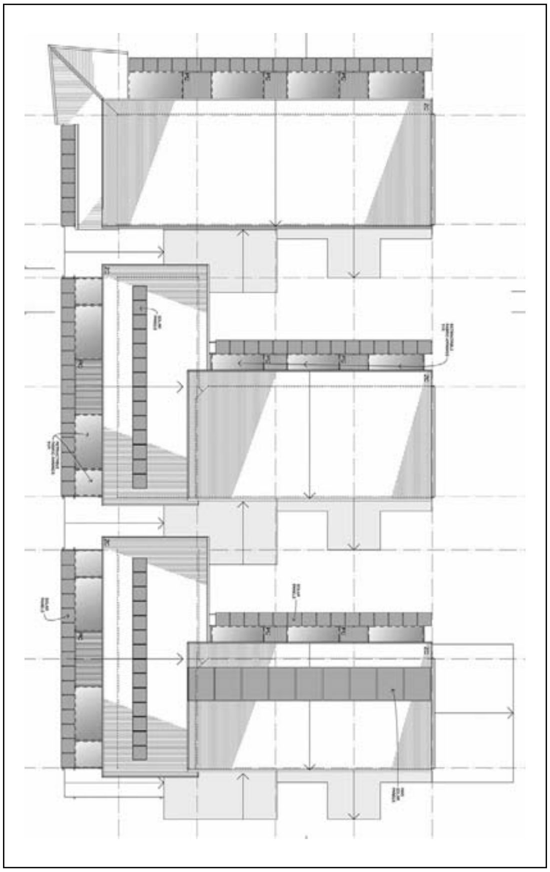
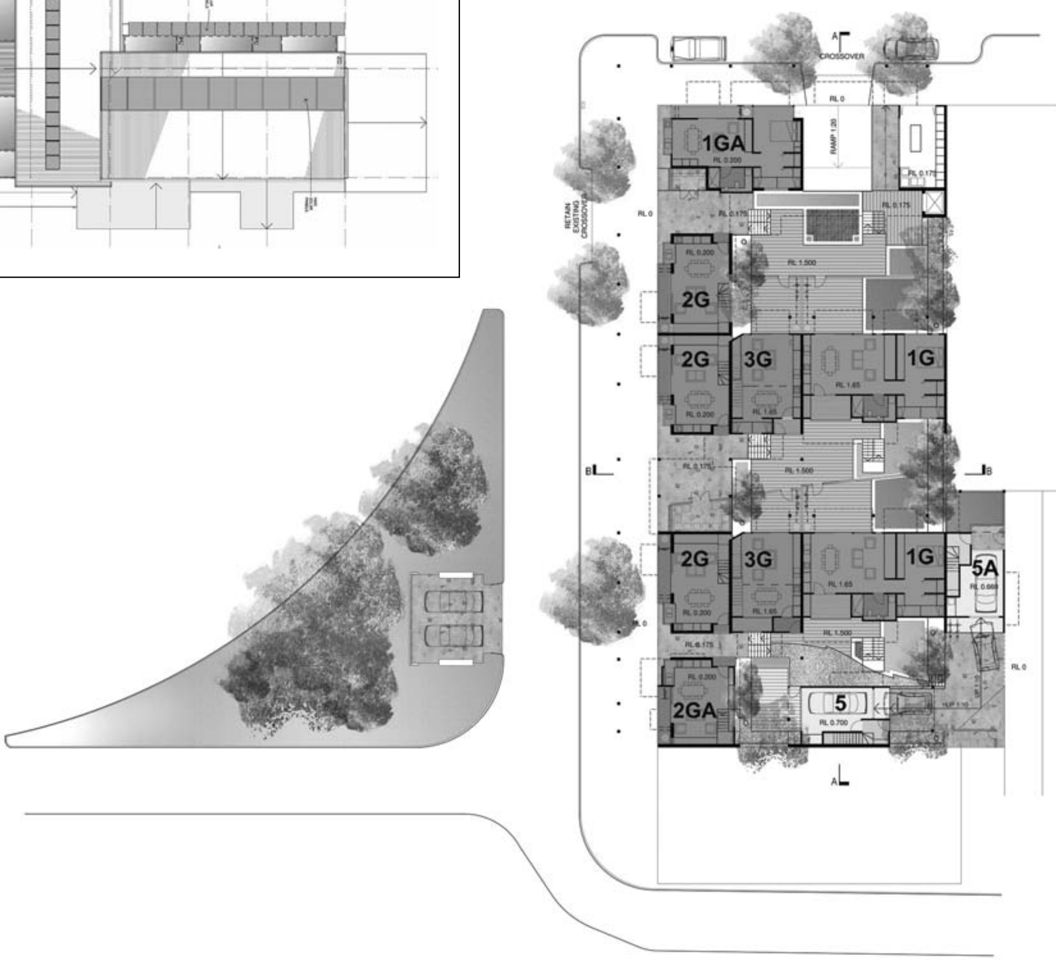


FIGURE 1. Winning entry by Troppo Architects. This page, above: perspective. This page, below: section. Facing page, above: roof plan. Facing page, below: plan.



contemporary architectural language without obvious ‘green’ labeling. Amongst smaller visually obvious features, ‘green walls’ softened the hard edges of built envelopes, ‘fin walls’ directed airflow, and water sculptures functioned as cooling elements or aerated retained stormwater.[3] Amongst other symbols was the emphasis of rainwater heads and downpipes as a symbolic expression of water, ‘public art’ made from waste materials, and buildings in varying colours to suggest community and being ‘eco-friendly’. Similarly, few designs obviously pursued a ‘cultural’ image that followed the traditional building form and materials of the locality. The statement on an entry that the use of overhanging balconies was ‘characteristic of the porch language established in the precinct’ was a rare overt reference to local style.[4] Some, including the winner, adopted recognisable indicators of



Australian-ness (corrugated steel, verandas, pitched roofs) within a contemporary language. Features associated with a technological image of sustainability were more common, such as breeze catching or hot air ventilating 'climate towers', solar hot water or electricity generating rooftop panels, and complex water capture and recycling systems.

WATER MANAGEMENT

South Australia is known as the driest state in the driest continent on earth. Only 3.3% of the land area receives a mean annual rainfall above 500 mm, while about 83% receives less than 250 mm (Atlas of South Australia 1986). The competition brief dictated that 'the entry shall demonstrate how it will achieve a reduced demand for potable water of at least 50 per cent using annual average Adelaide residential water consumption as a benchmark'. In their report, the jury drew attention to the response of entrants to 'water sensitive design—use, re-use and management'.

Recycling water was a common strategy. Entries proposed stormwater harvesting, grey water retention, black water retention and rainwater collection. Water storage was most commonly achieved in concrete underground tanks. One entry proposed to collect and store storm water in pre-cast concrete water pipes, built into concrete columns, and another proposed a hybrid wall and water storage system that would provide thermal mass (as long as there is water stored) to moderate internal temperatures. Stored water was most often used for toilet flushing. After a period of low rainfall, an automated valve would switch to mains water. The South Australian State Government has since introduced this feature as a requirement in new dwellings in Adelaide. Over half the entries also referred to low water use fixtures and equipment. They proposed water-efficient and/or flow restrictive plumbing fixtures such as taps, spouts and showerheads (3A-4A rating in the Australian scale of 1A-5A), dual flush WCs (common in Australia), 5A rated front loading washing machines, and selecting water efficient planting and landscaping. A more controversial water-saving measures suggested in one entry was to provide only a single water-saving mixing tap for each apartment. For the landscape, automatic watering systems with either a rain or soil moisture sensor were proposed. Water management before and during the construction period was also a common strategy, selecting materials that eliminated water-intensive trades and reduced dependency on high water use machinery, or recycling the water they used.

The winning scheme collects all rainwater that falls on roofs in basement tanks and for use in hot water pipe runs, avoiding duplication of cold water pipe runs and overcoming South Australian Health issues of potability of collected rainwater. Rainwater that falls on the ground is directed to soakage pits and detained on site. Grey water is only to be used for irrigation.

WASTE MANAGEMENT

Waste management can be divided into two categories: waste produced during pre-construction/ construction, and waste produced during occupation of the building. The competition brief stated 'the entry shall demonstrate the techniques to be used to achieve a reduction in waste generated in the construction process by at least 90 per cent. This may be achieved by efficient design, material selection and on site construction processes'.[5] Responses included factory pre-fabrication, designing to use materials in uncut manufactured sizes, agreement that suppliers take back non-recyclable packaging material during construction, and the use of recycled timber, specified by almost all entrants (timber waste also breaks down to produce a composting mixture).

The recycling of domestic waste has become common in Adelaide in recent years, with containers provided to householders for the separation of recyclable, composting and 'land fill' waste elements. One Adelaide suburb has tested the provision of biodegradable waste bags for kitchen scraps for composting. Amongst the competition entries, most made provision for designated receptacles for glass, metal, paper, organic/bio-degradable and unrecyclable waste, sometimes with 'chutes' to bins.

PASSIVE HEATING/COOLING

The competition website provided a link to the Australian Bureau of Meteorology website. It is often assumed that Adelaide has a 'Mediterranean' or a 'temperate' climate, yet its location and sporadic weather extremes make such a classification misleading: the latitude is comparable to northernmost Africa rather than southern Europe. Adelaide is subject to several sequential days of temperatures in the high 30s °C or low 40s °C each year, long enough to make smoothing by thermal mass difficult. Breezes and lower overnight temperatures can help. The greatest need in achieving 'passive cooling' is to stress the importance of ventilation to the occupants themselves, as they are the drivers behind any venting program.

The competition brief stated 'entries should provide a sustained temperature between 17 and 25 degrees Celsius throughout the year'. Many entries mentioned the need for 'cross-ventilation' or 'natural ventilation' in the design. A myriad of ventilation diagrams showed the anticipated movement of air by annotating lines with arrows, often implying that breezes automatically follow planned paths and that ventilation would occur if a design simply had a greater possibility for aeration.

Adjustable solar shading, particularly louver systems ('Venetian blinds'), credited for their ability to restrict/allow sun admittance during the changing seasons of the year, were popular. Other strategies included the use of 'green walls', ventilation stacks, plenums, water features and Trom(b)e walls. 'Green walls' accomplish a similar moderation of sun and light as louvers but with a random, dappling effect on sunlight during the warmer months of the year. While a design may dictate the density and estimate the effectiveness of green walls, it would have to take into account the long growth period before they achieve the desired effect and successful green wall implementation relies on a sufficient level of user interaction. Ventilation stacks took a wide variety of forms, all implying an ease of evacuation of excess heat in summer months. One entry realistically acknowledged that since their system of 'climate towers' was 'untried', further cooling towers might have to be implemented, but without detail of how this could be achieved.

A few entries included 'sun rooms', intended to act as glasshouses during winter or balconies/patios during summer. One entry proposed 'loggias', a variation on the same theme but using long, narrow balcony areas that could be enclosed or opened as desired, managing passive cooling principles in a confined area.

Passive heating took second place to cooling in this competition, although many entries mentioned confidence in the thermal mass properties of their load-bearing and partition walls. It is difficult to assess the thermal mass capabilities of a particular wall, as micro-climatic impacts are rarely seriously taken into account. Success depends on the direct sunlight the mass receives and the thickness of the wall. Too thick, and a wall cannot radiate a day's heat in time; too thin, and it cannot delay the radiance of heat to discharge during night hours. Only three entries showed climatic/air temperature charts or graphs to illustrate the variations in climate, one plotting simulated room by room air temperatures to demonstrate the expected microclimatic response.

ACTIVE HEATING AND COOLING

No entry proposed air conditioning and few proposed any from of heating to supplement passive solar spatial heating. One entry proposed gas space heaters. With the use of photo-voltaic (PV) arrays and wind generators, all entrants experimented with alternative power systems. Gas-boosted solar hot water systems were most often proposed for water heating. One entry advocated providing only one hot water unit to three apartments, but given that they used the same hot water system as other entrants, such rationing may lead to conflict. Ceiling fans were common. Fans are one of the most energy-efficient appliances for air movement, if used in conjunction with aerated spaces. In complementary up draught and down draught modes, they can assist air movement and occupant comfort levels greatly. Updrafts are stronger when running near to walls, but many of the entries simply showed fans in the centre of rooms, implying that symmetry was more important than optimum airflow.

Waste heat and energy were identified as possible issues for entrants to confront in the design brief, yet only a few suggest possible means of using this resource. Several entries proposed to capture heat generated from communal laundries, radiating it back through a network of metal coils embedded in concrete walls. One showed a bio-diesel/gas cogeneration plant, an alternative to providing hot water via a PV system, but reliant on sufficient bio-waste refuse—a dubious proposition for a central city site.

The winning scheme provided for community pre-heating of hot water (rainwater) by direct solar panels, with individual boosting of this pre-heated water when necessary using continuous flow natural gas heaters.

MATERIALS

The brief asked entrants to 'consider the balance between the use of materials with low embodied energy, low VOC (Volatile Organic Compounds), low long term maintenance and the potential for recycling and reuse'. 'Natural' materials, such as plantation timber, rammed earth, bamboo, strawboard and stone, typically require less energy to produce than manufactured materials. Many entries did include materials that are associated with a high-embodied energy or entail a high environmental cost to be manufactured, but also specified the use or inclusion of recycled material. Justifications for using materials that were neither low in embodied energy nor recycled were economics, aesthetics, efficiency in heating and cooling, structural load bearing efficiency, ease of maintenance, fabrication or transportation, ease of disassembly and disposal, and the reduction of toxic pollution during manufacture.

Interestingly, pre-cast reinforced concrete was used in most entries, as concrete requires less energy to produce than most non-natural building materials and off-site production in factory conditions lowers waste and facilitates the recycling of water used in the process. Adelaide has good production capacity in pre-cast concrete. Roughly half of these entries detailed the use of fly ash or slag in the concrete to add to the recyclability of the structure and lower energy use in its production. Other than precast concrete, structural walls were proposed that partly used recycled local bluestone and sandstone, as well as more conventional hollow core concrete blocks.

Many different cladding materials were selected. Choice was explained by recyclability, aesthetics and material life, beside obvious thermal and acoustical benefits. The most popular cladding material was 'ecoply', a product made from renewable plantation pine that claims to use less toxic glues and create less dust and waste when cut than most plywoods. Corrugated 'custom orb' and 'mini-orb' steel sheeting were also used in both an aesthetic and cultural statement, corrugated steel being strongly identified with traditional South Australian vernacular building. Corrugated steel was the most common roofing material, in one entry to be coated with 'intelligent nanotechnology paint' that would selectively reflect unwanted sun (no details were provided). Where specified, window frames were almost equally timber or aluminium, with a few entries choosing a combination of both. Timber window frames are aesthetically pleasing and can be made from recycled timber, but require maintenance. Aluminium requires enormous amounts of energy in its initial production but is totally recyclable and in the Adelaide climate requires minimal maintenance. Double glazing, tinted, white and frosted glasses were all proposed.

Applied floor surfaces were chosen in the majority of entries as an alternative to simply using polished concrete flooring. For wet areas these included recycled stone tiling, ceramic, terra cotta, recycled rubber, plastic laminate and linoleum. Other generic flooring materials included recycled cork, marmoleum, parquetry, wood veneered particleboard, laminated bamboo and sisal flooring. A few entrants chose carpet, highlighting low VOC properties and a recycled PET underlay. For kitchen bench tops, carbon fibre cement (CFC) coated with beeswax/turpentine was adopted in one entry, while others specified reconstituted stone. Another proposed low mud brick walls for kitchen 'peninsula' bars, claiming benefits in storing and radiating heat from appliances.

Many schemes showed no painted finish for interior spaces. Where a painted surface was proposed it was specified as based on acrylic and water-based pigments without volatile chemicals (no VOC). No colours were mentioned in any entries.

LIGHTING

The brief stated that 'all entries shall demonstrate the strategies to achieve a reduced energy demand by a minimum of 50 percent for lighting fixtures using average Adelaide residential consumption as a benchmark'. It asserted that an efficient and effective lighting system would provide a high level of visual comfort with 'the best light for the task', make use of natural light, provide controls for flexibility, and have low energy requirements.

To achieve effective day light, entries proposed light shafts, clerestories, and glass block arrays. Reflected light was achieved through the use of angled walls, 'light shelves', curved profiles that avoided sharp shadowed edges and reduced glare, and reflective wall and roof finishes. For artificial lighting, a third of the entries proposed the use of fluorescent lamps (including tubular and compact types) and light emitting diodes (LEDs). Dimmers, time delay switches, low voltage timers, time and motion sensors and building management systems are other ideas mentioned to reduce the need for lighting energy.

ECONOMY AND ADAPTABILITY

The jury commented that 'economical construction techniques and systems were to prove of paramount importance' in their assessment. Entries proposed a diverse range of ideas and claims for achieving economy, including such simple strategies as minimizing construction excavation and fill. Many entries adopted a 'modular' approach, keeping the structure of their buildings simple and allowing for later rearrangement of interior layout. Most schemes utilised a single, centrally located elevator for upper floor access, with stair access to outdoor areas and pathways between building envelopes, acting as spatial mediators. In two-bedroom, two storey units many entries chose to keep one bedroom per storey, thereby retaining similar floor areas and retaining a similar structural envelope on upper floors.

DESIGN DEVELOPMENT OF THE WINNING SCHEME

Troppo Architects, designers of the winning scheme, were commissioned to develop their design for construction, scheduled for 2007. This process has been a combination of responding to the City's developing aims for the project, cost control and value management, and design refinement.

The model of 'affordable' housing that became espoused by the City gave preference to two bedroom dwellings that could be shared by two unrelated single people, with two bedrooms that were equal in size and amenity, although a single bathroom would be shared and there would be only one parking space for each apartment. During design development what was originally a broad range of apartment sizes and types was reduced to variations of this common pattern, plus one 'equal access' (meaning readily usable by a wheelchair-bound person) apartment.

Other changes have responded to budget constraints. For example, most of the car parking became a half level below ground level rather than a full basement, reducing costs. The number of photovoltaic cells was cut back to be around 20-30% of what could actually fit on the available space. The architects have been keen to reserve a part of the budget for photovoltaic cells, arguing that the symbolism is important as well as the significant reduction in external power supply requirements. Phil Harris of Troppo Architects accepts that a process of informed value management is inevitable:

> A green approach to architecture does have to be affordable. I know we're talking about life cycle costings, but you've still got X dollars to spend at the outset. . . (Harris 2005)

Despite cost savings, social facilities were retained. A community stores/workshop area, essentially work benches with little stores underneath them, and a 'green laundry' were retained. Although all the apartments had space for a washing machine, a common facility would serve as a meeting place as well as allowing residents to avoid the cost of purchasing their own machine. It would also become a small commercial activity, attracting other people to the site.

> [T]hese people are sharing in a community title and as a group they need to manage it, and it's kind of fun to have things to manage. Things to worry about together, brings people together. [I]t's a green laundromat, so they will be water efficient. (Harris 2005)

There was provision for bicycles:

> Every dwelling unit has [a] porch, which is dimensioned to get a bike into, because a lot of people like to take their bikes up to their apartments. But if they don't, then there's bike parks. (Harris, 2005)

Along with these responses to client requests and budget, the environmental performance of the design was improved. For example:

> [A] lot of the work was actually done to optimise solar access. . . . [E]very verandah deck, every roof overhang, the arrangements of living areas lifted up [above the surrounding ground level], the distance between here and there, all that's worked over, making sure you

> get solar access into all the living areas. So [changes have] not just been a prompt of affordability, it's been . . . tightened up in relation to achieving solar access. (Harris 2005)

DISCUSSION

The competition sought to broaden the knowledge of sustainability principles, received an encouraging response from a nationwide field of entries, and was won by an entry that has been justly praised as good contemporary urban architecture. Such competitions are a means for questioning and developing the development of a national built identity that recognises today's concern for sustainability.

The entries displayed broad and inventive ways to seek a more sustainable kind of urban development than usual, and also displayed widespread awareness of current approaches to designing-in sustainability. Some, notably the second prize winner which provided a careful and detailed articulation of a sustainability time line, took great care in the justification of their decisions. But there is still a gap between common perceptions of materials and devices that promotes sustainability and the actual impacts of their production and maintenance and benefits of their use. For example, Williamson and Beauchamp (2006) question the rationale for South Australian regulations requiring the installation of 1 kilolitre water tanks to new residences in the state, connected to at least one toilet, laundry cold water outlet or hot water supply. While the aim of water conservation is admirable and the strategy initially appears well-founded, the actual cost-benefit is dubious given more environmentally beneficial ways of using the considerable additional costs involved. Similarly, a life-cycle energy analysis of domestic hot water systems illustrates the need to take production, maintenance and replacement into account (Crawford and Treloar 2006). Where, as in Adelaide, natural gas is available, instantaneous water flow heaters that heat water only when it is needed appear to perform better than electric boosted solar panels in terms of energy use when the full cycle is considered, with greater reliability and lower cost (gas instantaneous boosted solar systems were not analysed in the study).

The *Architecture Australia* review of the competition praised the winning architects' use of 'cypress pine' timber as 'the only type produced through a sustainable forest industry in South Australia' (Loo 2005), a claim quickly questioned in a letter published in the following issue which asked 'on whose authority is the cypress pine industry sustainable?' (Gunn 2005). Cypress pine has fine properties as a timber—it has attractive grain and colour, weathers exceptionally well, is termite resistant. "By virtue of its durability, Grade 1, and aesthetic (soft, silvery) ageing qualities, it is beautifully suited to an application where 'nil finish' (no paints, no pollution, no maintenance) timber is required" (Harris 2005). Most of the cypress pine used in South Australia is imported from natural forests in inland areas of southern Queensland or northern New South Wales. It is a relatively rare timber, worth using (because of its properties it is the timber of choice for work in the National Parks of South Australia) but not an icon of sustainability in its present availability. But this may change. Troppo are aware of a variety that has been successfully forested (planted) in the Top End (far north) of Australia and is harvestable after thirty years. There is an argument that demand will encourage the forestry and timber wholesale industries to develop the resource.

This is a problem with a competition such as this, and with the state of architects' attempts to create green architecture. There are a few principles that are uncontroversial, clearly better to follow than not follow. These are well known: passive solar design (in Adelaide this is north, shaded, aspect and windows and some thermal mass), provision for through ventilation catching available breezes, above all keeping things small so that less material is used and there is less space to heat or cool. Most of the rest is debatable, with highly questionable relationships between the environmental impact of provision, the lost opportunity to use the often significant money involved to promote environmental well-being in other ways, the ongoing maintenance of sophisticated systems, and any long-term environmental gain. There was no shortage of 'techno-gadgets', and many entries appeared to suggest innovation without fully balancing the potential environmental costs and benefits when production and maintenance are included. If we widen the parameters and ask, say, whether the money spent in installing a laundry heat capture system would have a greater environmental benefit if used to plant trees, then many of the features in the list in the Appendix appear to be more moves in a game than of real benefit. Even the installation of PV panels, often advocated, can be justified more convincingly as desirable to encourage an industry that might one day provide products with clear environmental benefits than as an obvious environmental benefit at this time. Sustainability is, anyway, a property of lifestyles, not buildings. In Adelaide, the amount of water a typical person uses inside the home appears to be (very roughly) similar to the amount used in watering pasture for their milk and red meat,[6] although irrigation water has admittedly not been treated like domestic water to a level suitable for human consumption. This does not mean that the architecture does not matter. By their design buildings can enable and support a sustainable lifestyle by their environmental performance, and (following Alain de Boton's (2006) eloquent exposition about the architecture of happiness) speak to us about our aspirations and attitudes.

The winning Troppo scheme 'does not overtly advertise its eco-credentials' and 'communicates an everyday-ness in the design of elegant and graceful living conditions' (Loo, 2005). It is an attractive and contextual contribution to the streetscape of Adelaide that provides flexible and enjoyable homes for its inhabitants. Its details are well considered. There are straightforward, sensible choices about solar aspect, shading, thermal mass and ventilation to enable comfortable living conditions. It speaks to its occupants and passers-by about attitudes to living and the natural and urban environments. All this is reassuring; a scheme that wins by being good architecture within a re-conceptualisation of architecture that encompasses sustainability, not by being the most demonstrative or outlandish in pursuing questionable environmental-icon gadgets and eco-features.

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NOTES

1. Jointly sponsored by the Adelaide City Council, the Government of South Australia, and the Royal Australian Institute of Architects.
2. The brief asserted: 'A minimum of 30 dwellings should be proposed with each unit costs of up to $A240,000 ($US180,000) at 80sqm, with however possibilities to accommodate some larger apartments'. This budget included construction costs, additional environmental features, land cost, contingencies and fit-out. The brief advocated maximising the development potential of the site in order to reduce the land cost component for each apartment.
3. Positioning the water feature or redesigning the building envelope to capture and utilise natural breezes maximises its intended effect, though too much exposure would evaporate the water faster. Evaporative cooling would not be desired during winter, so the water feature would only be active during hotter months.
4. The Adelaide City Council's Plan Amendment Report (Government of South Australia 2006) sets the generic criteria for a corner site in the City without reference to a specific building 'style':

   New development on major corner sites should define and reinforce the townscape importance of these sites with appropriately scaled buildings that:
   (a) establish an architectural form on the corner;
   (b) abut the street frontage; and
   (c) address all street frontages.
5. Construction waste is a significant issue. For example, according to the New South Wales (state) Environmental Protection Authority waste census data (1997), 2 per cent of total waste quantity produced is plasterboard, yet most of this is not recycled. Plasterboard disposed of in landfills produces poisonous hydrogen sulphide, accompanied by a foul odour.
6. This comment is based on figures in Newton 2001 and ACF 2007, assuming consumption of 1 liter of milk and 3 serves of 150gms of meat each week. It does not include water used in household gardens, which in Newton 2001 are recorded as approximately 55% of typical household water use. Irrigation—whether in agriculture of domestic gardens—is a use of water that tends to dominate other uses.

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APPENDIX: A LIST OF STRATEGIES FOR ACHIEVING 'AFFORDABLE GREEN HOUSING' PROPOSED BY ENTRANTS

Building Planning

- Car park spaces provided on grade, so no cost for underground parking.
- Open deck car parking.
- Eliminating/reducing need for lifts—lifts are costly and need maintenance, use of electricity is reduced.
- Minimal construction excavation, reducing costs for digging and filling soil.
- Modular design to allow for ease of removal, for example non-structural internal walls that are removable panels.
- Stairs, balconies, and other systems intrinsically separate from base building structure to be more efficient in terms of usable floor area.
- Maximise accessibility with provision of disabled access apartments.
- Each apartment has its own separate storage area.
- Shared laundry.
- Clothes drying deck/area.
- Lockable drying pens to secure different occupant's laundry.
- Use stairs instead of lifts.
- Solar access and the optimum balance of light admittance during the year.
- Ease of accessibility.
- Ventilation and possible 'breeze paths'.

Environmental Systems and Energy Use

- Elimination of ventilation systems by designing for natural ventilation.
- Longevity of products and materials reduces need for replacement and maintenance.
- Minimise lifecycle costs by ensuring continual opportunity for both extending lifespan of building and providing for more efficient systems design.
- Allocation for future PVC arrays.
- Light shafts, clerestories, 'light shelves' and glass block arrays. Reflected light through angled walls, curved profiles that avoid sharp shadowed edges to reduce glare and help maximise the effectiveness of daylight, and the use of reflective wall and roof cladding/finishes.
- Rainwater storage for toilet flushing. If there is low rainfall throughout a period, an automated valve would switch over to mains water.
- Water management before and during the construction period, selecting materials that eliminate water-intensive trades and reduced dependency on high water use machinery, or recycling the water they use.
- Automatic watering systems with either a rain or soil moisture sensor.
- Hot washes in Laundromat priced more than cold.
- Using a single water-saving mixing tap for each apartment.
- Photovoltaic Air Vents. This entry proposed a method through which air could be flushed out from under-floor vents, using PV-powered fans.
- Solar Laundry. This entry devised a means of passing heated air through a top-floor laundry space by connecting it with under-balcony vents. Air drawn into the vents would be heated by the thermal mass of the balcony concrete, pass

through the laundry area then exit through roof vents.
- Water Storage Walls. This entry proposed a hybrid walling system that, although being thicker, was also acting as thermal mass.
- 'Nanotechnology paint'. This entry planned to coat the corrugated iron roofing with 'intelligent' paint to reflect the sun's rays, although no details were provided.
- Collecting façade runoff through use of bioswales.
- Locating planter boxes directly under water tanks to prevent evaporation of water and shorten the time taken to transport it.
- Directing collected water through a system of interconnected garden beds, then reusing the excess.

Recycling

- Maximise ease of refurbishment and re-use.
- Minimise ongoing operational cost and change required for reuse, for example emphasising low maintenance, efficient products.
- Maximise the potential for future disassembly and material reuse.
- Use of recycled and recyclable materials that are both low in cost and reduce waste.
- Re-use of existing site topsoil and substrate.
- Mechanical fixtures with screws or bolts replace chemical anchors and glues.
- Recycling of domestic waste
- Designated receptacles for glass, metal, and paper, organic/bio-degradable and un-recyclable waste, sometimes with 'chutes' to the bins.
- Restricting the number of bins per unit.
- Easy-access composting worm farms.
- Sieve site soil, to separate rocks from soil; rocks are used in walls, soil used in core-filled internal walls.

Economy and Cost Recovery

- Elimination of cost of underground car parking.
- Elimination of use of sprinkler and ventilation systems.
- Avoidance of water and ventilation costs by designing buildings that use natural ventilation with appropriate materials and technology.
- Use of common construction methods.
- Use of existing site materials.
- Buying in bulk and use of standard material sizes.
- Using factory pre-fabrication of modular elements.
- Modular systems used for in-situ concrete.
- Designating waste receptacles for recyclable materials such as timber and steel.
- Designing to use materials in uncut manufactured sizes.
- Minimising timber required for formwork.
- Requiring that rejected defect materials were reused on return to manufacturer.
- Agreement that suppliers take back non-recyclable packaging material during construction.
- The use of recycled timber, specified by almost all entrants. Timber waste also breaks down to produce a composting mixture.
- Exposed unlined slab ceilings.
- Eliminating/reducing need for lifts—lifts are costly and need maintenance, use of electricity is reduced.
- Lease of unused car park spaces to local businesses at market rates.
- Access Government subsidies for solar hot water heaters.
- Gain possible grants/additional funding from organisations such as commercial tenants.
- Hire-out community room.
- Highlight the affordability of the house by showing ways of investing with different banks.

Social and Community Involvement

- Bike hire schemes and car share clubs/ carpooling to promote community interaction and reduce transport costs.
- Keep occupant levy low; if the cost to maintain building is low, then fees to occupants will be reduced.
- A commercial unit could double as (for example) a coffee shop and meeting facility for residents.
- Roof decks, gardens providing outdoor common spaces.
- 'Urban art'.
- Exercise area.
- Take advantage of amenity of the immediate area.
- A 'community room'.
- BBQ Area.
- Café and convenience stores.
- Children's play area.

- Prominent display of resource systems to provide information and knowledge.
- A display board providing a learning experience on sustainable lifestyles, linked to a website.
- Portals to reinforce formal access.
- Access circulation via shared spaces to encourage day to day interaction.
- Apartments share common stairs to increase opportunity to know neighbors.
- Shared spaces with specific uses located along circulation routes.
- Mix of apartment types to offer a 'socially just' development with wider than normal demographics.
- Individual garden plots in a communal garden.
- Location of letterboxes provides a focal point at entry to the site.

Landscape

- Gardens spill over podium and out onto street sidewalk.
- 'Edible landscape'.
- Low maintenance landscaping.
- Subtle hierarchy of public and private spaces.
- Permeable surface; 'grass-pave and gravel-pave' reduce water runoff and eliminate glare.
- Glasshouses/Greenhouses for hydroponics and permaculture.
- Planter boxes (under water tanks).
- 'Summer canopy' in courtyard to increase air moisture by pre-cooling low-humidity incoming air (in turn lowering temperature).
- Perennial native planting to encourage native birds and insects and reduce water use.
- Areas for vegetation on all levels.
- Low level greenery to temper microclimate conditions.
- Vegetation screening to reduce street noise.
- Car park surface perforated, composed of pavers set into a compacted earth bed, allowing grass to grow in openings; paving material is reduced and offers greener surroundings.
- Traffic 'calming' achieved through raised paving to street.
- Aim for zero net CO_2 production by planting a sufficient number of trees.

Security

- Secure tenant access via key cards and intercom at each stairway and lift with individual 'keys' for residents. Careful consideration for provision of individual 'keys' is needed as it would reduce interaction between residents, as they will not be able to access other buildings easily.
- Apartment entries provided as separate spaces 'removed' from walkways.
- Secure and overlooked bicycle parking.
- Material selection to reflect security.
- Eliminating the 'back end' of the development.
- Privacy screening / security fences.
- Closed-circuit TV security monitoring.
- Courtyard seating located to provide surveillance.
- Openness of vertical circulation routes.
- A superintendent manages the facility.