CONFERENCE THEME - INTERNATIONAL INNOVATION

Case Study

GREENSMART HOUSING VILLAGE – INNOVATIONS AND LESSONS

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ABSTRACT

Three innovative residential houses built in Springfield Lakes 28 km SW of Brisbane have succeeded in setting a new benchmark for project house construction. Innovation, through passive design for small lots, rainwater capture and use, energy and water efficiency and inclusion of many simple design initiatives that improve social outcomes, have all set these project homes at the leading edge. This case study paper describes the design processes of the houses and their cost / benefit assessments for their key energy and water initiatives and social inclusions (safety, security and universal design) as well as the lessons learnt from the design and construction processes.

Keywords: residential houses, small lots, rainwater tanks, smart housing, cost / benefit assessment

1. INTRODUCTION

Three display houses at Summit Drive, Springfield Lakes were constructed on lots of varying area (332m2, 415m2 and 785m2) and were completed in early March 2004. They were the result of approximately 14 months of planning and construction and were to include passive design, “off the shelf” products, water and energy efficiency, minimum site disturbance and good site management. The houses were to also incorporate new and appropriate technologies (e.g. smart wiring, smart meters, and a solar ventilator)

The houses are the second HIA GreenSmart Village in Queensland with the first being completed in 2002 at North Lakes, 25 kilometres north of Brisbane CBD. This Springfield Lakes project was the result of a partnership team consisting of:-

- WESLEY MISSION under their “Homes for Hope” program - Project Manager
- HOUSING INDUSTRY of AUSTRALIA (HIA) – GreenSmart initiative
- DELFIN LEND LEASE - Developer
- CIVIC STEEL HOMES – Designer and Builder of all 3 houses
- DEPARTMENT OF HOUSING, ENVIRONMENTAL PROTECTION AGENCY and DEPARTMENT OF FAMILIES – State Government sponsorship
- IPSWICH CITY COUNCIL – Local Government Authority
- CRC-CI (Cooperative Research Centre for Construction Innovation) – scholarship support for research of the GreenSmart housing village
- CSIRO – technical support
- SUPPLIERS & TRADES – products and services were donated or substantially discounted

2. DESIRED OUTCOMES

Each of the houses strived to achieve the following outcomes and employed where possible, the detailed strategies to meet this end:-

2.1 Overcoming summer heat

Strategies – addressing house orientation to true north – insulation (roof, ceilings, walls) – eaves and overhangs – shading (external structures, other buildings) – windows (location, size, treatment, protection) – roof and external wall colours and materials – ventilation – room zoning – thermal mass

2.2 Overcoming winter cold

Strategies – addressing house orientation to true north – insulation (roof, ceilings, walls) – eaves and overhangs – windows (size, location, treatment, protection) – weatherproofing – room zoning – thermal mass

2.3 Achieving energy efficiency

Strategies – compact fluorescent lights – efficient 12 volt task lights – dimmers – smart sensor lights – natural day-lighting – high star rated whitegoods – smart meters to show energy use – solar or instantaneous gas hot water systems

2.4 Achieving water efficiency

Strategies – 3A or 4A rated whitegoods, shower roses and tap-ware – dual flush toilets – mixer taps in showers and baths – well mulched native plants – limited lawn – rainwater tank(s) for house and garden use incorporating water quality design – smart meters to show water use

2.5 Minimise long-term maintenance costs

Strategies – use of good quality materials, paint and finishes – hardwearing floors and coverings – use of galvanized steel framing and light organic solvent preservative (LOSP) treated timbers

2.6 Adaptability for changing needs

Strategies – level door entries – hobless showers – location and size of power points and light switches – wider door and hall ways – lever or D-shaped handles – rounded bench tops – availability of communication points – open plan living – areas for home office or bedrooms – safety and security inclusions

2.7 Achieving good air quality

Strategies – non-toxic paint – low formaldehyde carpentry – non-toxic timber finishes – natural product blended carpets – good ventilation

It was anticipated that all the above outcomes and strategies, when compared to current housing approaches, would result in –

- Better comfort and quality of life (without retrofits)
- More disposable income for the occupant(s) each year due to reduced operational and retrofit expenses
- Adaptable homes that are "easier to sell"
- Future proofed homes that will increase in value above the current average

NOTE - All future Queensland houses are likely to require energy and water efficient features as standard and so, like cars, resale houses will most likely need a "house-worthy certificate" before listing. Energy ratings are already required for resale in Canberra. Victoria has adopted 5 star rating for all new housing (http://www.buildingcommission.com.au/asset/1/upload/media_release_5_star_30_June_04.pdf) and New South Wales are introducing a legislated building approval environmental and social checklist for all future houses (http://www.iplan.nsw.gov.au/basix/).

3. COSTS OF DESIRED OUTCOMES INITIATIVES

A summary of some key costings for the three houses is given below. The results should be considered indicative and it must be emphasized that this information is based on these particular house designs, their inclusions and current pricing –

- The average cost of the passive design elements (insulation, glazing, higher ceilings and shading) was 2.4% or $6,250 of the total house costs. Offsetting this were annual savings of $523 compared to conventional approaches, if adopted for the houses
- The average cost of the energy efficiency elements (lighting, fans, appliances and water heating) were 1.0% or $2,610 of the total house cost. This did not include the photo-voltaic cells which cost an additional 2.2% or $7,350 of the largest house cost

- The average cost of the "smart housing" design elements was 0.2% or $582 of the total house costs
- The cost of rainwater tanks, water quality devices, and pumps for whole of house supply was 2.3% or $6,300 of the total cost of the 2 houses on which they were placed. The quality of water supply can be maintained at safe levels with currently available devices and minimum maintenance
- The payback periods for
    - passive design (insulation, glazing, higher ceilings, shading) – 12 years
    - Energy efficiency (lighting, fans, whitegoods) – within the first year
    - Water heating (2 x solar, 1 x instantaneous gas) – 7 years
    - Water efficiency (AAA shower roses & taps, dual flush toilets, AAA+ whitegoods) – making savings from day 1
    - Water supply for the whole house (i.e. tanks, water quality devices, pump, irrigation) – does not currently have a payback period
    - All combined initiatives including rainwater supply systems – 12 years
- Insulation was 5 times more cost effective than glazing treatments (i.e. tinting, "low-e" glass and films)
- Annual predicted reduction of 4.3 tonnes of Greenhouse Gas (GHG) for operational costs from each house
- Good site and waste management during construction saved $100 per house
- There was no additional cost for superior air quality as a result of using non-toxic paint and very low toxicity floor and timber finishes

4. PROJECT INNOVATIONS

4.1 DESIGNS ON SMALL LOTS

Orientation for two of the lots (areas and widths being – 332m2 and 10m – 415m2 and 12.5m) was rotated to within 20 degrees of true north, thereby giving better solar access. Fortunately this was possible before the final survey plans were lodged at Council by the developer. For narrow lots, a north-south orientation is usually the optimum because it allows for northern zoning of living areas and uses the close proximity of adjoining housing as summer shade for the eastern and western walls. It is generally less feasible to incorporate northerly solar access along the longer side boundary due to the close proximity of the adjoining house.

For small narrow lots, the influence of adjoining housing is huge and if not known at the design stage needs to be predicted. Adjoining lot widths, identified zero lot line boundaries and the developer covenants were influential in these small lot house designs. Insulation, glazing, through-flow ventilation and the installation of fans in the living area and bedrooms were all critical elements for achieving good thermal comfort. The house design on one lot incorporated a covered double car garage in a tandem formation with 50% of one side being open to the entry courtyard for the house

The sloping land (1:8, 12% or 4m drop over 33m) resulted in the design adoption of a small amount of concrete slab combined with elevated floors, to minimise earthworks and site disturbance. The elevated floors provided space below for the location for rainwater tanks and possible future storage.

4.2 ACHIEVING WATER EFFICIENCY

A 74% saving of an average home's water requirements are predicted through the combination of rainwater tanks, efficient devices and appliances and appropriate landscaping.

4.2.1 Rainwater tanks

Two of the display houses (lot 894 and lot 895) have 12,000 litres of rainwater storage each, in two 6,000 litre squat polyethylene tanks located under their back "summer room" decks. This tank water is pressure pumped for all internal and external house uses. This is *UNIQUE* for any residential display home in Queensland.

Four main issues needed to be addressed:-
Water Quality - There were several components involved in maintaining water quality:-

- Pre-painted steel roofing and guttering, being stable inert provided a safe collection surface
- Gutter guards and rain heads on downpipes provided filtering of most objects and the rain heads included screens to keep out mosquitoes
- First flush devices to remove small impurities which would build up on the roof and in gutters between rain events. These were sized to allow for about 1mm of rain to flush the roof and gutters. The first flush devices were placed underground thereby creating "dry systems" – this was made feasible because of the sloping lots
- Drinking quality standard and chemically stable polyethylene tanks
- A carbon filter was placed on the cold water tap in the kitchen to provide better tasting drinking water
- On-going maintenance would include "bottom of tank" flushing (every 10-15 years), regular checking of gutter guards, rain head screens, first flush device outlets and pump operation with the replacement of pump when necessary

Guarantee of supply – the unique pumping system uses a seamless switching process to allow pressured town water to bypass the tank water system when there is a power failure, pump problem or the level in the tank reaches a pre-set low threshold. The system returns to tank water once the level rises above the minimum threshold. This guarantees supply as well optimizing tank water use

Local Authority approval – the unique pump switching system incorporates a backflow prevention device but the Ipswich City Council also requested another backflow prevention device (dual check valve) at the property boundary.

Council considers tank water as a low hazard (class A) quality as they have a large number of households in their jurisdiction for which stored rain water is their only supply.

Costs – there are two main costs – the initial system components and the on-going pump energy, system maintenance and replacement costs. The system components were $6,300 (gutter guards, rain heads, first flush devices, tanks, pump, switching device and additional labour) with predicted annual electricity and maintenance costs of $98 and water cost savings of $81. Obviously, significant subsidies and mandating by governments and/or developers are required to support broad-based introduction of effective rainwater tank systems.

4.2.2 Devices and Appliances (internal features)

The first two of these are essentially standard in all new houses:-

- AAA shower roses and taps
- Dual flush 3/6 litre toilets -
- Flow restrictors and aerators for selected taps and mixer taps for long flow situations
- 3A or 4A whitegoods (washing machines and dishwashers)

4.2.3 Appropriate landscaping

- Well mulched native gardens with little or no lawn
- Pumped sub-surface irrigation with an automatic controlled irrigation system.

NOTE - it was envisaged that selected greywater (showers, basins and washing machine) would be kept available for sub-surface use when legislation allowed. Plumbing for this direct dispersal was incorporated in each of the houses and so remains an option for the future.

4.3 "SMART HOUSING" DESIGN FEATURES

(responsive to people's housing needs during their life – "ageing in place")

Each of the three display homes incorporate these simple, minimal or zero additional cost initiatives:-

- Wider door and hall ways
- Level thresholds (floor), where possible
- Hobless showers
- Lower light switches and higher power points (both large rocker style)
- Lever or D style door handles for doors and drawers
- Logical layouts with kitchens not used as thoroughfares
- Outside venting of range-hood and refrigerator
- Compact fluorescent lighting and efficient 12 volt task lighting where appropriate
- Water and energy efficient appliances and whitegoods

- For SAFETY & SECURITY – large visible street number, well lit and street visible door entrances, security glass and visitor viewing at a solid core front door, locks on windows and doors – keyed alike, catches for swing doors, hard wired smoke detectors with battery backups, lockup cupboards for poisonous products, adequate storage to prevent clutter, visible children's play areas away from driveways, no poisonous landscaping, sturdy, narrow and vertical balcony railings

Lot 896 was specifically designed to be accessible for people with a range of abilities (wheelchair). Key additional design elements for this house were:-

- a ramp from the street (accessible paths)
- easy access from the garage into the house – special wide sliding door
- easy access to main toilet
- reinforcement in the bathrooms for future grab rails
- lower benches and vanities with access under for sitting position

The Queensland Department of Housing's web site is available for a comprehensive list of all universal design, safety and security inclusions (http://www.housing.qld.gov.au/builders/smart_housing/index.htm).

5. LESSONS LEARNT

5.1 Possibly the most significant yet subtle lesson – there is no perfect house for a particular block -
There are always conflicting design elements to rationalize (e.g. shaded outdoor living and solar access – views and glazing exposure — car access and house zoning – ventilation and privacy). There are many variables to balance but an open minded, ethical, educated, "do the best you can" approach is going to lead to a great outcome, from which one will no doubt still learn.

5.2 Preparation of a simple "services plan" would have identified problems -
This was not done for the display houses but would have been an ideal tool to draw attention to the locations, linkages and then possible problems for installing the smart meters, rainwater systems, hot water systems, photo-voltaic cells and landscaping. It would have focused all those concerned on the concepts and interconnection seeking to be achieved. Most sub-contractors (plumbers, electricians, and landscapers) literally construct to or modify the plan or system on site as they go. With any new process there are always challenges and better planning via a services plan would provide the shortcut and minimise problems

5.3 Car access onto sloping lots needs a conservative approach -
The car access onto lot 896, while complying with the statutory code, appears or feels too steep. In hindsight, the floor level of the house could have been raised for minimal additional cost. It should be noted that the design was based on engineering design levels as the road was not constructed when the design was substantially completed but a conservative slope calculation would have overcome this steep access problem

5.4 Various passive design elements were considered a high priority for thermal performance but additional simulations showed their interrelated importance was mixed -
After completion of the houses, many subsequent thermal simulations showed that some marginal improvements in annual energy use could be achieved by changes contrary to the normal passive design strategies. All houses were well insulated and ventilated to combat summer heat but insufficient passive solar heating was available during winter. Each house required significantly more winter heat energy than summer cooling energy and removal of some glazing treatments to northern facing windows would have improved passive winter heating. Not venting eaves would have reduced the energy required during winter. Annual energy use would have reduced slightly with use of dark roofs and external walls in some instances. Reductions in the large expanses of living area windows would have certainly reduced the need for expensive glazing options to achieve low annual energy use. This would be a compromise with architectural and aesthetic decisions. For project home builders it is not practical to carry out simulations of the countless inter-related options for every house but achieving an honest 4 or 5 star rating would ensure a good thermal result

5.5 Windows and glazing treatment impacts and costs need to be carefully monitored -
Window treatments are expensive and could be offset with different window sizing, placement and additional external shading. There was a premium paid for the glazing treatments ("low-e" glass and films and tinting) which positively assisted the energy ratings for the three display houses. A significant price reduction could have been achieved if there was some reduction of the large window areas, glazing treatments were applied to selected windows only and additional external protection was added to some windows.

5.6 Adjoining buildings are influential on house design and need to be taken into account -
Having three houses adjoining gave control over their relationships but the designs on either side were not known. Shading influences and privacy issues from adjoining buildings need to be predicted and planned for in each house design

5.7 New products are continuously appearing in the marketplace and need investigation -
Time to thoroughly investigate some new products would have allowed some better results from different product selection. Sponsorship restricted some choices

5.8 The size, style (wet or dry system), supply requirements and location of rainwater tanks and first flush devices should be included with the early house design -
This was not the case with the display homes as the rainwater tanks were an evolutionary process but it would have been beneficial. Initially the tanks were to be for garden use but this was upgraded to whole house use. With the end in mind, planning and integrating a rainwater system would present minimal problems, especially with a plumber's early involvement

5.9 Sloping sites provide the opportunity of "dry systems" for roof water -
The three display houses initially had "wet systems" (water remaining in underground piping after rain). These were converted to "dry systems" with the

first flush devices being placed underground at the tanks and ultimately being drained to the rear of the properties. This was only possible because of the sloping sites. This "dry system" reduced the amount of water needed to be flushed

5.10 Rain-heads on downpipes should be placed for easy cleaning and inspection -
This was the case for a few of the rain heads but many could have been located close to ground level for practical future maintenance

5.11 Non standard landscaping elements need close supervision -
Landscaping detention ponds were placed within the rear gardens of each of the three houses but their effectiveness was compromised because the contouring did not focus overland storm water towards the ponds. The landscaper and the plumber both needed to fully understand the proposed concept before its construction. Time pressure to complete the landscaping was also an influence

5.12 Signage is important to convey the education message -
The signage in and around the display homes appears to be limited given the background information and new products included in the houses. Additional signage may have been appropriate

5.13 Energy and water efficiency inclusions are becoming standard while universal design elements need to be further promoted -
Talking to product suppliers and trades people during the construction process revealed a reasonable understanding of energy and water efficiency products and their purpose but "smart" housing and universal design elements were not well understood or appreciated. This is probably indicative of the general public's perception of these initiatives and shows that more education is required for their better acceptance

5.14 Good communication leads to better understanding and less problems -
This is an obvious statement but with the new processes and products involved in the three display homes many problems were discovered and solved early but many could have been avoided with more initial communication. The construction process occurred during "boom" conditions and so many other pressures also hampered communication. For new products and processes there is a process of education which is one of the main purposes of the houses

5.15 The most cost effective additions were -

- Passive design elements – solar orientation, window size and location, external shading (eaves), insulation
- solar hot water
- resource efficiency elements – water (3A & 4A products and appliances, flow restrictors); energy (lighting, fans, 4 & 5 star rated appliances)
- smart housing elements (wider doors and hallways, level entry thresholds (all doors and showers), lever door and tap handles, safety and security design approach)
- non-toxic paint and timber and floor finishes

5.16 The least cost effective additions were -

- Window treatments – low emissivity glass or films or tinted windows. These products do become useful if large expanses of glass are desired or if direct summer sun on windows, especially western, can not be avoided. Special glazing treatments can be avoided or minimised with careful window design and external shading
- Rain water tank systems – given present water pricing, the additional $6,300 for this whole of house system will not be adopted by choice. Government, developer or even builder incentives (rebates, subsidies, covenants, policies, legislation) are required to instigate the broad scale adoption of rain water tanks. For effective use, storage of at least 10,000 litres should be adopted and a system installed to ensure the water gets used.
- Photo-voltaic roof panels – this product could be greatly reduced in price via a corresponding increase in its demand, which could be government and/or developer driven.
- Automatic irrigation systems – use of controllers to automatically trigger pumping to the underground dripper system could have been replaced by a manual system incorporating a self timer. This would also require the occupier to remain in-tune with the garden status
- Higher ceilings – with a current additional cost of $30/m2, this element may questionably be deleted with minimum decrease in thermal comfort but attention to through-flow ventilation becomes critical. In two of the display homes, higher ceilings were an integral part of their design

5.17 Site management success is directly related to builder attitude -
Site management was an important element that did not have a significant financial return but rather environment and social returns. The intent of the site management plan was for 80% of building waste to be recycled, the three sites to remain clean, tidy and safer during construction, silt and erosion to be managed and delivery locations and site entries to be used and monitored. These were all addressed with varying degrees of success with the conclusion being that their effectiveness and success is directly related to the attitude of the builder.

5.18 There are no official indicators for assessing how good or bad a house may be relative to an agreed benchmark and the marketplace needs the feedback for effective change -
There are national energy rating tools and various recommended strategies for residential house design to move towards sustainability but Queensland does not have a legislated measuring indicator to consider the environmental and social impacts of houses. The Sustainable Housing Code (SHC) is an on-going draft option which is taking a long time to evolve and which appears to have thresholds that are set too low

6. CHECKLIST - INDICATOR

An assessment of each display home using the Sustainable Housing Code version 8 (SEQROC 2004) criteria was completed with results shown below (Table 1). All of the display homes satisfied the “graded points” requirement (Table 2) such that the ultimate level set for 2013 was easily reached. This fact may indicate that the scale of the assessment has been set too low for conventional project housing.

LOT	LOT AREA m2	HOUSE GFA m2	REQD POINTS	SOCIAL (blue)	ENVIRO (red)	TOTAL
894	785	271	18	25	36	61
895	415	218	14	16	23	39
896	332	154	14	36	19	55

Table 1 – Display home results for the Sustainable Housing Code (version 8)

SUSTAINABLE HOUSING CODE MINIMUM POINTS REQUIRED			
		GFA OF HOUSE	
YEAR	<130M2	< 260M2	> 260M2
2005 – 6	10	14	18
2007 - 8	12	16	20
2009 – 10	14	18	22
20011 - 12	16	20	24
2013 +	18	22	26

Table 2 – Sustainable Housing Code (version 8) graded points requirements

Department of Housing’s “Smart Housing” and the HIA’s “GreenSmart” criteria are guidelines and do not result in a points assessment or measurable indicator. As such they do not give any feedback on “how good” the house may be in its resource efficiency and minimizing its impacts.

There is an urgent need for an indicator for Queensland houses. At present there are only the lowest standard Building Code of Australia (BCA) requirements which relate to minimum building materials, processes and initial energy efficiency standards. To lift Queensland’s new residential housing towards a “Smart” status, a tool is required which can at least give an indication of a building’s environmental impact, resource efficiency and livability.

7. CONCLUSION

The main conclusion derived from the three display homes is that incorporating all the above described inclusions and resource efficiencies does have additional cost (average 6.7% over the three houses) but pays for itself within 12 years. This additional cost and payback period could be substantially reduced with elimination or modification of the more expensive elements.

Good house design that reduces environmental impacts and resource consumption is more a matter of common sense and commitment to a better result, than technical know-how. Project houses can achieve 4 or 5 star ratings with relatively small additional cost which would payback in a few years. The creation of these resource efficient houses will be a result of public education, government prodding and critically, industry will.

The three Springfield Lakes display homes are good examples of thermally comfortable, energy and water efficient project housing in the middle to upper price range, constructed on sloping land in sub-tropical south-east Queensland.

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