ADVANCEMENTS IN SUSTAINABLE HOUSING PRACTICES IN AUSTRALIA

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Abstract: Australian housing industry practices, especially in the single and low to medium density housing development sectors are predominantly driven by the volume builders. Here the term, volume builders, refers to a practice of high volume of cloning. Individually designed owner builder house are very limited in Australia. Within such an industry environmentally unsustainable practice could multiply significantly at much faster rate. Australian living standard is resource intensive and the life style is high on the consumption of water and energy. For example living space, energy consumption, water consumption and embodied energy usage per capita are, relatively, at a much higher level. It is therefore envisaged that the positive influence on the sustainable practices can be affected efficiently through policy innovations and regulatory measures. Since early 2000, the topic of sustainable housing has been a very active area of discussion. Therefore, over the last ten years, notable progress was made in this sphere. Attention was drawn by the media through public debates and significant improvements have been observed in policy improvements, R&D activities and in engineering curricula. This paper presents the positive outcomes of current practices, policy innovations, research and education.

Keywords: Sustainable housing, Policy and practices, Engineering education

Introduction

Housing industry is a culturally sensitive practice which has established over many generations. It is acknowledged that influencing such a practice to change its course requires a concerted and coordinated response from the stake holders. It also needs to have a well informed customer base and a sustained leadership.

The housing industry generates about 15% of the GDP in Australia. Australia is expected to have 1.1 million new houses built between 2002 and 2011[1]. Minnery [2] identifies the present pattern of Australian metropolitan development as low density housing; an observation supported by the Australian Bureau of Statistics [3] reporting that 73% of all Australian housing was comprised of single dwellings. Current domestic construction is predominantly site-built, timber-framed, brick-veneered construction with tiled roof. This method has been utilized to great effect and the industrial infrastructure in place is vast. Any attempted shift to a fundamentally different approach is often met with strong resistance, frequently due to questions of its viability.

The energy efficiency practices in the building industry introduced some ten years ago. However, this was primarily limited to condition of minimum insulation requirements, a deem-to-comply approach specified in the Building Code of Australia (BCA) [4]. The objective was to minimize the energy losses through building's envelope and roof in order to increase the efficiency of heating and cooling system. More quantifiable mandatory sustainability benchmarks were set out to regulate the industry towards an environmentally sustainable practice in 2005. As given in Table 1, although there are some disparities among the standards adopted in different states of Australia, an encouraging positive trend is clearly evident (Refer Table 1). Most commonly adopted mandatory requirements are the provision of rainwater tank per house hold and also achieving a minimum energy star rating. As can be seen from Table 1, the state of Victoria is providing leadership in forcing industry towards a more sustainable practice in which RMIT University has become a proactive stakeholder over the last ten years.

Sustainable hosing practices in Australia, 2000 - 2010

Among developed nations, Australia has progressed well in sustainable housing sector during this period. The areas where progress has been achieved include a number of good examples of sustainable houses, development of rating tools to administer mandatory requirements, legislative and financial incentives, institutional capability development and sustainable technologies and products.

Sustainable housing practices in early 2000 were isolated rather than in the mainstream. There were example houses of best practice [5, 6]. Technical guidelines of best practices were also being developed and at their preliminary stages [7, 8]. Relatively higher cost of off-the-shelf products was a barrier to uptake of technologies, particularly solar PV panels, given the marketing potential was limited at the early stages, and no government subsidies were made available. However, public awareness, industry readiness and media discussion towards sustainable practices were on a high, which subsequently drove changes to policy and legislation. There are a number of good case studies of sustainable houses in Australia [9, 10]. Many of the example homes were part of research projects. In other words, their performances are evaluated and measured in terms of energy and water efficiency, ecological footprint etc.

A number of rating tools are available in Australia currently being use to evaluate energy efficiency of house design. Top tier rating tools include *FirstRate*, *BERS* and *AccuRate*. These are widely used rating tools in Australia. Some other rating tools include *NABERS*, *BASIX*, *ABGR* and *Greenstar*.

There are a number of key organizations promoting sustainable housing in Australia. Australian Greenhouse Office (AGO) is a statutory body responsible for GHG emissions inventory. AHURI (Australian Housing and Urban Research Institute) conducts research on social and economic aspects of housing. CSIRO (Commonwealth Scientific and Industrial Research Organization) developed the *AccuRate* rating tool. Landcom in NSW and VicUrban in Victoria play a special role by developing master planned sustainable communities. Department of Housing in Queensland actively promotes sustainable housing through the 'smart housing' project. Similar state bodies in other states are also actively promoting sustainable housing. Green Building Council of Australia (GBCA) developed the 'Greenstar' rating tool. Sustainability Victoria is a statutory body in Victoria promoting sustainability among local government, schools and community groups.

Currently 5 star standards are mandatory in ACT, Victoria, South Australia and Western Australia. Table 1 summarizes the current status according to Building Commission [9]. Rebates are available for solar photovoltaic panels, solar hot water systems and rainwater tanks in most of the States and territories. Australia is currently tradeoff incandescent light bulbs with energy saving compact fluorescent bulbs at no cost to the house hold.

A comprehensive on-line guide *Your Home Technical Manual* [11], managed by Australian Greenhouse Office, made available to public which is also a great resource for educational institutions. This technical manual is a great resource for professionals, students, researchers and members who are interested in the current trends in sustainable housing. It includes major issues such as passive design, energy use, materials use, water use, site impacts and other impacts. It also includes a comprehensive discussion of case studies around Australia. A growing market of sustainable products available for buildings include solar PV panels, solar hot water systems, rainwater tanks, insulation products, plantation timber, evaporative coolers, energy efficient bulbs, energy and water efficient home appliances to name a few.

Table 1: *Energy rating regulations across Australia*

State	5 star building fabric	5 star building fabric plus renovations and alterations
Victoria	Yes from 2005	Yes from 1 May 2008
ACT	Yes from 2006	Yes from 2006
Western Australia	Yes from 2006	Yes from 2006
South Australia	Yes from 2006	Yes from 2006
New South Wales	NSW uses BASIX	NSW uses BASIX
Queensland	4 star energy rating	-
Tasmania	4 star energy rating	4 star energy rating

Methods and tools available in measuring sustainability

The practice of measuring sustainability is a recent development and the housing industry is rapidly getting adjusted to the task and should be treated as work in progress. Methods of measurements, tools and skilled personnel are at the developing stage. Minimum energy ratings and use of rainwater tanks became mandatory in 2005 and 2006 respectively as discussed. Industry response is really encouraging as some volume builders are now promoting their products achieving 7.5-8 energy star ratings. Also, it is noteworthy that much innovative water conservation devises and apparatus are currently flooding the market. Through such industry participation and competition the products and processes can only improve to better serve the course. However, it is important in ensuring that the current limited capabilities in assessing sustainability is not over rated and over used for purposes other than the set objective.

In true sense sustainability rating tools of the housing industry must be capable of assessing a green rating encompassing,

1. Solar and water sensitivity of the subdivision/plot within which the house is located
2. Energy sensitivity based on, both, embodied energy and operational energy of the house
3. Water sensitivity based on conserving potable water, harnessing rain water and recycling gray and black water

In this light the current status of the commercially available rating tools, despite exceptional progress within a relatively short period, can only be described as at their early stages of the development. The three key elements of sustainability mentioned above are currently being treated as standalone independent parameters which are not necessarily true. For instant, when a tool classifies the home having a five star energy rating; it means that rating is based only on the operational energy component. Widely used commercially available energy rating tools indicated above calculate star energy rating only using operational energy. Also, each of the above elements must be assessed not only at the development and occupancy stage of the house but over the full life cycle. The LCA tools currently in use only focus on maintenance intervention. This is a potential future research area where very little work has been done to date.

Concept of Bill of Embodied Energy (BEE)

As mentioned before a full evaluation of energy efficiency of a domestic building should include, both, embodied energy and operational energy. Embodied energy is a measure of environmental impact, which can be quantified and optimised through proper selection of materials and construction processes during the planning stage. Embodied energy is defined here as the cumulative energy embedded in the process of bringing a domestic unit into being. This includes the energy embedded in the processing and manufacturing of materials, transporting and handling and construction [12]. Figures 1(a) and 1(b) illustrate the distribution of embodied energy within a typical single dwelling in Australia and a comparison between embodied energy and operational energy breaking even.

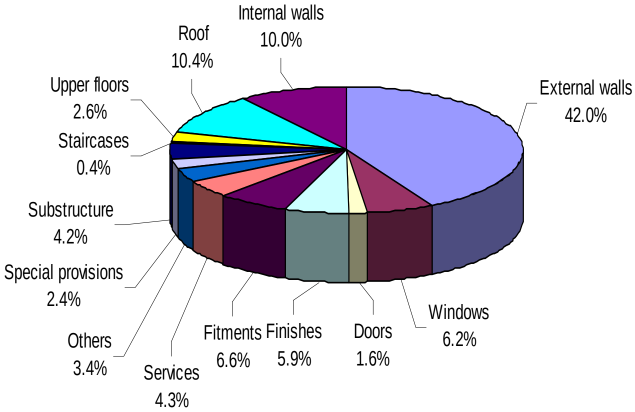

Figure 1(a): *Embodied Energy (EE) distribution of a single dwelling*

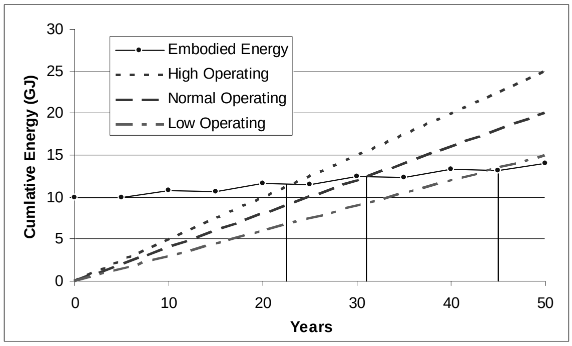

Figure 1(b): *Comparison of EE and operational energy breaking- even during life cycle*

Objective of estimating embodied energy can be beneficial in two ways. Firstly, in practice, achieving a better carbon foot print of the final product. Secondly, in research, it has the capacity to highlight the energy intensive elements of the building and the materials which are contributing to that outcome. For example, as Figure 1(a) illustrates, 42% of the embodied energy reside in the building envelope. The typical single dwelling assessed above has a building envelope which comprises a timber load bearing frame, brick venire, and 10mm internal plaster board finish with standard insulation. Out of all these products used to construct the building envelope the brick venire contributes the most. Obviously, production of kiln baked brick venire is highly energy intensive. Such measures and observations of environmental impact can influence the brick manufacturing industry to improve their production processes to be more environmentally friendly. As a result, less embodied energy bricks and smarter wall paneling systems are starting to emerge.

BEE

Components	***Material/Dimension/Methods of Construction***	***Unit***	***Qty***	***Cost ($)***	***Embodied Energy(GJ)***
Sand	50mm thick	m^2	180	547.20	2.340
Membranes	200um	m^2	180	486.00	0.522
Stiffened Raft Slabs	300mm deep x 300mm wide @ 7.0 meter spacing; F11TM3 and F72 mesh	m^2	180	13,114.80	41.472
Clay Brickwork	Walls - 110mm thick	m^2	344	24,668.78	374.070
Upper Floor Framing - Hardwood F8	200 x 50mm @ 450mm C/C	m^2	180	4,951.80	20.232
				TOTAL COST	**$xxxxxx.xx**
				TOTAL EMBODIED ENERGY	**xxxxxx GJ**

Figure 2: *Sample of Bill of Embodied Energy (BEE) output*

To further leverage the embodied energy measurements toward a more sustainable construction industry, including housing, the concept of Bill of Embodied Energy (BEE) was introduced. The initiative stemmed from extending a traditional practice widely adopted by the industry. It is an age old practice to produce a Bill of Quantities (BOQ) prior to commencement of a project to estimate the optimum cost. The idea was to develop and test a web based decision support tool [web link], which has embodied energy data presented next to bill of quantities. The embodied energy unit rates were aligned to the items and unit rates of the standard building cost guides. Figure 2 gives a part of a report generated by this tool to illustrate the idea. The reason for developing a web base tool was to disseminate this knowhow to a wider community at no cost. Full account of this research undertaking, development of web based tool and research outcomes can be found in reference [12] which was conducted under the supervision of the author.

It is envisaged that such tools would not only assist the developers and the home owners to understand and appreciate their environmental duty of care but also the planning authorities and local governments to make informed decisions with respect to carbon foot print within their constituencies.

Influencing volume builders market

As mentioned at the beginning, especially in Australia, the key is to positively influence the volume builders market towards a more sustainable practice. This section briefly outlines couple of recently concluded research projects conducted at RMIT University supervised by the author [10, 13].

5.1 EcoHome, Cairnlea, Victoria, Australia

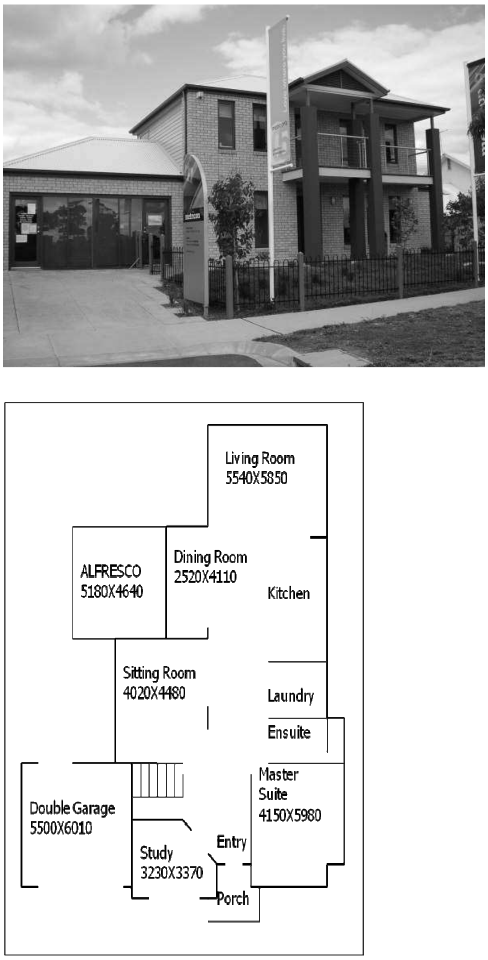

Figure 3: *EcoHome, Cairnlea, Victoria, Australia*

This project is the fist-of its kind in Australia. A standard 280 m^2 floor plan from the volume builder, Metricon Homes, was selected and improved with state-of the art sustainability features including full assessment and against passive design principles. Project was a joint collaboration between the industry stakeholders, two Universities which was partly funded by the Australian Research Council. Project duration was 2002-2007. The project is strongly supported by a consortium of industry partners including the Urban and Regional Land Corporation, Metricon Homes, Building Commission, Origin Energy, City West Water, Melbourne Water, Sustainable Energy Authority of Victoria and Hassell Architects. The main objective was to investigate the sustainability outcomes that are possible in outer suburban project homes using current building and design technologies, and the barriers to the uptake of these technologies more broadly in outer suburban project home developments. Building was designed and constructed incorporating instrumentation to measure and monitors its performance during first two years of occupancy. Water and energy usage was zoned for monitoring purposes. Full account of this research undertaking, development of web based tool and research outcomes can be found in reference [10].

Key findings were,

1. The cost overshoot due to the incorporation of state-of-the art sustainable features were around 15% of the total construction cost of the house.
2. Use of passive design principles (solar orientation) in the design and proper orientation of the house paid dividends in terms of maintaining thermal comfort with notable energy savings especially during winter time.
3. Based on the comments during display period and the occupant's comments (over two years of occupancy) no negative perceptions were noted.

5.2 Sustainability of pre-fabricated modular construction

This project investigated the feasibility of the use of pre-fabricated modules replacing the traditional and current practice of on-site construction. The investigation took into consideration not only the direct benefits in achieving better environmentally sustainable housing but also the secondary benefits such as affordability, speedy response to shortage of housing, better quality control, measurement and certification of sustainability. Study revealed the modular construction, for volume builders market, was not only found feasible but attractive.

Layout flexibility and avoiding repetitiveness of external façade identified as the deterrents needing innovative thinking. This is because home is perceived as a way of expressing individuality and there is a stigma attached to living in community housing environments.

So the key is the ability of the modular system to produce an adequate number of different floor plans. Obviously this is possible when utilizing stick construction, because the components are small enough that they can be combined in any number of possible ways. In practice of course houses look similar, regardless of their technical uniqueness. Many trends and standards exist in home design; for example 80% of Australian homes have 2-4 bedrooms. This and other trends provide a useful framework and benchmark from which new designs can be formulated. This fact allows high-volume builders to produce a finite number of house designs for a development and then build them repetitively, making sure to spread them out so no one homeowner gets the feeling of living in a carbon copy home. This same method is applicable to a modular approach. If one set of modules can be designed in such a way that they can be arranged into several different designs, then the system utilises the benefits of replicate construction while providing a developer and homeowner with the necessary range of different designs.

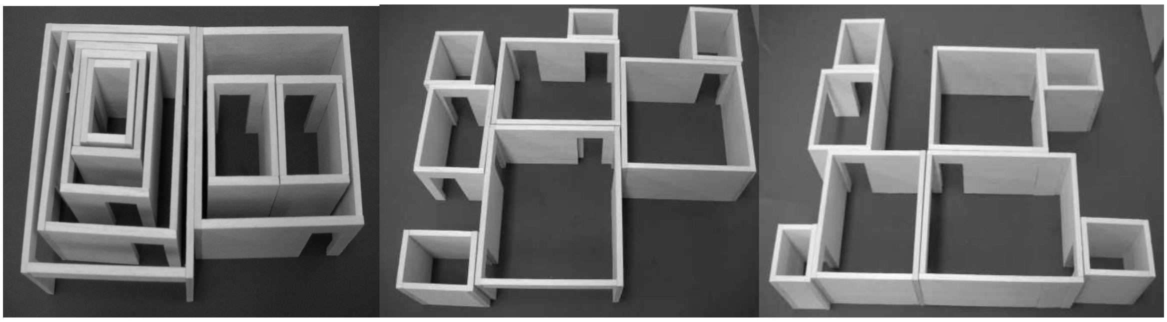

Figure 3: (a) Modules (b) Layout option 1 (c) Layout option 2

Table 2: *Module sizes and numbers in set*

Unit	Size (m)	#
A	1.5 x 1	1
B	2 x 1.5	3
C	3 x 2	1
D	4 x 3	1
E	4 x 4	1
F	5 x 4	1

Initial investigations into the potential flexibility of modular systems indicate the necessary performance is achievable. Simple single-bedroom floor plans have been developed demonstrating that a single eight module set (which contains six distinct module sizes) is capable of delivering twenty or more different layouts of varying uniqueness. Table 1 provides the sizes, which are also compatible with current volume builders' product range, and number of modules that the set contains. Full account of this research undertaking, development of web based tool and research outcomes can be found in reference [13].

Conclusions

Promotion of sustainability in the housing industry requires the commitment and proactive participation of the stakeholders. Effectiveness of the process cannot be driven from top nor could it be expected to spring from the grassroots. An informed concerted effort from community, industry and research community can only be expected if the need is felt. This requires a significant effort in education and capability development. From a technical and commercial view point, sustainable housing industry is viable. It is imperative to develop measurable outcomes to ensure opportunities are not carried away to become a promotional and propagandist style campaign. No environmentally sustainable measure can be regarded as independent. Each measure is part of an interwoven system which must be treated as an eco system in balance where one measure feeds from the other. In this light, current rating tools and methods of measurement has a greater potential for research, innovation and development.

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Acknowledgements
This paper is based on three post graduate research project outcomes conducted by Dr. S. M. S. Rhaman, Miss. S. K. Ting and Mr. David Oxley under the supervision of the author.

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