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ONE-SIZE-FITS-ALL HOUSING

An Exploration of 6-Star Requirements in the Volume Builder Sector

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Abstract. Energy consumption attributed to the residential sector makes up around 8% of the total consumption in Australia. Roughly a third of all houses built in Victoria are done so by the largest 20 builders. These volume builders keep costs down by offering a selection of 'clone' designs from which the client can choose, however they lose the site-specific customisation which is required for effective passive design in favour of a one-size-fits-all approach where designs are developed to a point where they can satisfy just the minimum requirements in a range of orientations and site locations. The Australian government has implemented regulations regarding the minimum efficiency standards for housing and these initiatives to limit the carbon emissions have brought the question of energy use to the table, yet are they enough? This paper will explore the concept of cloned house designs in terms of energy efficiency and optimal siting and through computer simulation, evaluate how a cloned house design performs under different site conditions in Victoria.

Keywords: six-star housing, passive design, FirstRate, volume builders, building cloning.

1. Introduction

It is widely accepted that global warming is the biggest environmental concern facing the world at present. Construction sector makes up 40% of the total energy use in Australia with 8% a direct contribution from the energy requirements of the residential sector. Residential energy consumption, though not the largest contributing sector, is one of the fastest growing. This can be partially attributed to the increase of disposable income amongst the population coupled with the increase in ownership of energy consuming appliances (Gatersleben, 2002). However, a large portion of household energy consumption comes from the heating and cooling of a house in order to maintain a comfortable indoor climate. The construction of large, often inefficient housing has proliferated around Australia contributing to Australia's position as number one in the world in terms of house size. Adding to this the house size rose even though the occupancy level in each was falling (Johanson, 2011); the significance of the residential sector's energy consumption is hard to ignore. In order to combat the energy consumption of the residential sector, the Australian government has implemented regulations which govern the minimum requirements of a house in terms of energy use for heating and cooling and lighting, and in Victoria, water usage. The Nationwide House Energy Rating Scheme (NatHERS) awards a rating to new houses according to their performance in terms of passive thermal comfort and energy use. The requirement for new houses and renovations in Victoria is 6 stars. In Australia the low to medium density construction of houses make up the majority of the buildings (ABS, 2011). Not only are these the least thermally efficient dwellings with the current housing stock achieving an average of just 2 stars (Wang et al., 2011), this construction sector is majorly driven by volume builders. For the purpose of this paper the term volume builder represents a company which constructs mass amounts of housing based on 'clones' of a selected number of house designs. This paper will explore the concept of cloned house designs in terms of energy efficiency and optimal siting and through computer simulation, evaluate how a cloned house design performs under different site conditions in Victoria.

2 NatHERS Star Rating

The NatHERS Star Rating is the primary home-efficiency rating tool adopted in Australia. It provides a common language for all construction in Australia and ratings for construction which are easily identifiable and comparable to one-another. The NatHERS awards stars to a building depending on its performance – zero stars means it provides no protection from the outside thermal conditions and 10 stars representing a house in which almost no energy is used for heating and cooling. As of May, 2011 the minimum Star rating for any new residential dwellings, renovations and additions in Victoria has been 6 Stars (Rajagopalan and Leung, 2012) and applies to the thermal performance of the envelope – roof, walls, flooring and openings. Other factors such as gas hot water services, lighting and appliances are not taken into consideration as they are continuously replaced throughout the life of the house and would therefore affect the rating at a later date (Dept of Climate Change and Energy Efficiency, 2010); however the Building Code of Australia (BCA) dictates the minimum efficiency standards for gas hot water services and lighting (Miller & Buys, 2012) though it is still majorly up to the owners and occupants to select appliances which run the most efficiently, which is only governed by their conscience and the financial burden of inefficient appliances, factors which are often outweighed by the savings from using cheaper, inefficient appliances (Gatersleben et al. 2002). The first energy rating systems were developed in the 1990's with each state adopting their own approach the Victorian rating system being generally accepted as the most effective; however it failed to account for the energy efficiency requirements of other states with warmer temperatures and high humidity. The NatHERS was adopted in 1993 as a replacement for each state's individual energy efficiency rating system. Back in 2001 the minimum requirements for new houses was 3 to 4 stars and even then there was much discussion as to whether the calculated energy estimates were accurate enough in comparison to the real-world (Williamson et al., 2001). It is commonly understood that the current software has developed and can achieve a higher level of accuracy than was available in the previous decade. Given that today's new buildings require 6 stars and increase from 5 in the past two years it is reasonable to assume that as technology improves in the future the minimum requirements for energy efficiency will also increase.

3. Sustainability amongst volume builders

In spite of the wealth of information and regulations surrounding the design techniques behind sustainable architecture, not to mention the professed marketing potential, it still appears to have not penetrated the housing industry to any substantial effect. According to HIA's Housing 100 report (HIA, 2009) as of 2009, the top 20 home builders by number in Victoria are as shown in Table 1.

Table 1. Top 20 Builders in Victoria by Volume (taken from HIA Housing 100, 2009)

No.	Builder	Starts in 08/09	GBCA	Sustainability
1	Metricon Homes	1,794		
2	Simonds Group	1,606		
3	Porter Davis Homes	1,342		
4	Hickory Developments Pty Ltd	1,114	X	X
5	Henley Properties (s)	1,050		X
6	Dennis Family Homes	873		X
7	Burbank Homes	869		X
8	JG King	828		X
9	L.U. Simon Builders	702		
10	Devine Group	466	X	X
11	Carlisle Homes Pty Ltd	422		
12	Hamlan Homes	309		
13	Multiplex Ltd	297	X	X
14	Orbit Homes Group	288		
15	Hotondo Homes	277		
16	Frenken Homes	225		
17	Hometec Industries	216		X
18	Hermitage Properties Pty Ltd	215		X
19	Zuccala Homes P/L	202		
20	GJ Gardner Homes	187		X

The total number of houses constructed by these 20 builders accounted for 32% of all houses constructed in the 2008-2009 financial year. As can be seen in Table 1, only 3 builders are members of the Green Building Council of Australia (GBCA) and just half make any reference to sustainability, carbon emissions or energy use on their websites. Interestingly of the 3 largest builders, who make up just over 11% of the total house construction in Victoria, none make any reference to sustainability at all and the majority of those that do make mention simply explain that their house designs are 6-Star rated. Additionally, though *innovation* is invariably listed, no form of sustainable innovation is mentioned in the core values section of any of the builders' websites. These builders are still required to adhere to the six-star regulations; however there is a noteworthy lack of communication and build options surrounding the potential for more energy efficient designs. However Buys et al. (2005) argue that the power to make the change is with the builder who has the opportunity to promote sustainable housing, believing that it's a lack of knowledge which leads to the choices of housing arguing that they are in the position to promote that it isn't just the economic savings but also the comfort, quality and liveability which come from an energy efficient house.

Even with the regulations in place, the majority of houses volume builders pay barely lip service to the idea of sustainable design, using it more of a marketing technique rather than an area of any serious development (Osmani et al. 2009), furthermore loopholes such as unrestricted floor areas and improper installation can be difficult to police retrospectively and contribute to higher energy consumption (Martin, 2012). The cloned designs are a cost-saving technique where the time and cost involved in designing customised houses is removed by implementing the same designs on a range of sites in a development. Either the client selects a house from a catalogue for their site or the sites have built on them the predetermined design from a volume builder's range.

The design cloning system gives the ability for a volume builder to produce a large amount of standardised dwellings at a relatively lower cost by speeding up construction through repetition, lowering design costs and speeding up the permit application and planning processes. This scheme, though cost effective lowers the potential for customisation and adaptation to the site, and more specifically, utilising the climatic conditions in order to maximise passive heating and cooling. One aspect of sustainable design is the customisation of each design in order to develop one which will be the most effective for its specific location. Morrissey et al. (2011) states that anecdotally the volume builders develop these clone designs so they will be adaptable to a selected range of sites and orientations. This approach may provide housing which does satisfy the 6-star requirements however it is extremely unlikely that the design will reach its full potential in terms of efficiency. Not only that, the time spent on designing a *one-size-fits-most* house could also be put towards the design of a house which exceeds the minimum requirements and therefore consumes less energy. Morrissey et al. (2011) argues that the cost of customisation is the single factor which determines the use of these cloned designs and that any extra cost in construction would then be passed on to the consumer making housing less affordable however they also add that the broader cost implications of these adaptable houses should be explored specifically with the required passive design changes.

The appeal of these houses to the Australian market is that the house is able to be bigger or large enough for the client at a relatively low cost however what is often overlooked is the running cost of such houses in terms of heating and cooling, especially once the increased size is taken into account. A potential cause may be that the majority of information provided by the governing bodies implementing the regulations regarding 6 star ratings focus on the positive effects financially, highlighting the eventual savings on heating and cooling with only minimal comment on the potential environmental effects indicating the overriding factor for any home builder, additionally there is no mention about any compromise in dwelling size or material choice in order to achieve a higher Star rating.

4. Methodology

The design “Essex house” at Waverly park development by Mirvac - one of the leading volume builder is selected as the case study. Orientation is the major difference between sites amongst the examples of the Essex at the Waverly Park development. Hence the FirstRate program was used to determine how the design performs at a range of orientations. The program uses the AccuRate simulation engine, developed by the CSIRO. Figure 1 shows the layout of the units in the site and Figure 2 shows the floor plan of “essex” with street frontage to the south. The 2-storey, 3-bedroom townhouse has a total floor area of $162.2m^2$ of which $133.27m^2$ is deemed to be conditioned. The remaining is made up of garage and porch areas. The living area is located to the North of the building with a large sliding glass door and windows allowing direct sunlight inside. This design was assessed at 8 different orientations at 45^o intervals and the rating calculations performed at each.

Figure 1: Waverly park Development Plan

Figure 2: Floor Plan of the Essex design

FirstRate splits the floor plan into zones which are determined by the usage times and requirements for conditioning. For instance living areas are deemed to be conditioned from 7am until 12am. The insulation and construction materials determine the R-value of the envelope as well as the envelopes of each zone. Other factors such as orientation, openings, wall height and occupancy are also considered to calculate the energy required to maintain a comfortable indoor temperature. The systems makes certain assumptions about the occupancy activities of the inhabitants in order to calculate which zones are to be conditioned at which times and heat gains from internal activities such as cooking and use of appliances. Unlike previous calculation models the software assess the potential for alternatives to heating and cooling rather than assuming mechanical conditioning begins once the temperature leaves the comfort zone. For instance, in the event of overheating, the simulation will take into account the prevailing winds, house orientation and any operable windows as well as the physiological effects of air movement within the house to determine whether a window can be opened in place of air conditioning (Sustainability Victoria, 2012). This does make assumptions about the occupancy but errs in favour of the occupant and the level of programming to obtain a perfect simulation is too complicated to be feasible.

5. Results and Discussion

NatHERS suggest that the heating and cooling contributes approximately 80% and 20% respectively to the total conditioning of the house for the given climatic zone. Table 2 shows the heating and cooling energy of the house for different orientations. The figures suggest that the heating load makes up a slightly higher proportion of the total energy usage indicating that the house may have more heating load than what has been determined for the zone however in a majority of the cases this stays within 3% of the 80/20% split with the most extreme case only moving to 6% away from NatHERS' estimate indicating that the house is fairly well suited to the climate zone.

Table 2. FirstRate Energy Consumption Calculations

Facing	**Total (MJ/m2)**	**Heating (MJ/m2)**	**% Heat**	**Cooling (MJ/m2)**	**% Cool**	**Rating (stars)**
North	132.6	113.4	86%	19.2	14%	5.7
Northeast	131.9	110.9	84%	21.0	16%	5.8
East	129.4	105.4	81%	24.0	19%	5.8
Southeast	124.3	101.4	82%	22.9	18%	6.0
South	118.6	98.2	83%	20.4	17%	6.1
Southwest	120.3	98.3	82%	22.0	18%	6.1
West	128.5	104.8	82%	23.7	18%	5.9
Northwest	134.6	112.5	84%	22.1	16%	5.7

Table 2 indicates that the most effective orientation is South with a star rating of 6.1. However the calculations also show that in other orientations, particularly those where the larger windows face towards the south, the star rating falls below the 6-star level with an increase in energy consumption from 118.6MJ/m^2 to 134.6MJ/m^2, a 13.5% increase. Interestingly in the section of the Waverly Park development, of the 26 examples of the Essex house only two are orientated in such a way that remotely resembles the orientation which these calculations have deemed the most thermally efficient. The actual orientations and number of the Essex design houses are given in Table 3.

Table 3: 'Essex' Locations and Orientation

Street Name	**No.**	**Orientation**
Bernie Smith Street	2	South-Southwest
Bernie Smith Street	6	West-Northwest
Excelsior Circuit	4	East-Southeast
Excelsior Circuit	6	West-Northwest
Excelsior Circuit	4	West-Northwest
Hoddle Circuit	4	East-Northeast
Total	26	

Furthermore in order to comply with the 6-star requirements the worst case orientation for this design – the Northwest facing house must have a decrease in energy use of more than 20MJ/m^2. This kind of increase is assumed to have been made through improved insulation, windows and eaves would also lead to a reduction of energy use in the best-case orientation (south) from 118.6MJ/m^2 to 100.5MJ/m^2. This means an increased star rating from 6.1 to 6.6 stars. The full results of these improvements are given in Table 4.

Table 4. Improved Energy Rating

Facing	Total (MJ/m2)	Heating (MJ/m2)	% Heat	Cooling (MJ/m2)	% Cool	Rating (stars)
North	112.31	96.04	86%	16.26	14%	6.3
Northeast	111.71	93.93	84%	17.79	16%	6.3
East	109.60	89.27	81%	20.33	19%	6.4
Southeast	105.28	85.88	82%	19.40	18%	6.5
South	100.45	83.17	83%	17.28	17%	6.6
Southwest	101.89	83.26	82%	18.63	18%	6.6
West	108.83	88.76	82%	20.07	18%	6.4
Northwest	114.00	95.28	84%	18.72	16%	6.2

A better designed house which is able to comply with the 6 star regulations is obviously a positive however it does limit the potential of the design if not implemented in the most beneficial orientation. This potential is, as we have seen at the Waverly Park development, commonly wasted therefore should it not be the responsibility of the designer to ensure the house is placed at the most advantageous orientation for its design? Or could the rating system take into account the designs potential for efficiency and penalise designs which fail to reach that potential? Obviously in some cases the site doesn’t allow for this, however in large developments such as Waverly Park it is in the hands of the volume builder to plan the roads as they see fit, giving them the opportunity to plan with the orientation of the lots in mind.

6. Conclusion

This research has looked at the concept of sustainable architecture as a way of mitigating the energy use and subsequent CO_2 emissions associated with the heating and cooling of Australian houses. It is evident through the literature that there are a number of effective and well-tested techniques which are commonly known to reduce the energy consumption of a house as well as continuously improving technologies for thermal performance and alternative energy production. Globally, building rating systems have become the standard for building design assessment prior to construction. Mass production of houses by relatively few companies within the industry makes up the majority of houses built in Australia. These companies, we have seen, manage to keep housing affordable by the use of cloned designs which, as shown, have a negative effect on the energy efficiency of the house when not oriented in the most advantageous direction. Through use of the FirstRate 5 software it is clear that an inappropriate orientation of Mirvac's 'Essex' can have an effect on the energy consumption of up to 13.5%. This also highlights the responsibility of the volume builders to plan developments in such a way that they are able to orient their houses in order to maximise energy efficiency and though they may still comply with the 6-star regulations the potential for higher energy efficiency is often wasted.

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