Energy Performance of New Project Homes, Perth, Western Australia

Elizabeth Karol

The design of new project homes constructed in Perth since 2003 is not always creating a stock of energy efficient houses for future generations. This paper discusses the relationship between project home design, domestic energy consumption and the aim of the energy efficiency requirements in the Building Code of Australia (2006) to reduce greenhouse gas emissions from housing.

1.0 Introduction

Efforts are being made at the State Government level in Western Australia to reduce greenhouse gas emissions from housing. Western Australia published a State Sustainability Strategy (Government of WA, 2003), which included intent to reduce greenhouse gas emissions, and in 2003 WA adopted the Building Code of Australia (ABCB, 2003) amendments which aimed to reduce greenhouse gas emissions through energy efficiency in housing. In addition, Landcorp, the State Government body charged with providing development land for housing in Western Australia, currently refers to the need to reduce local contributions to greenhouse gas emissions from housing in new subdivisions.

Are these efforts delivering energy efficient new housing? This paper describes the energy consumption performance in new project homes in a new Landcorp subdivision in Perth based on a recently completed pilot study. Two aspects of performance are taken into account – the design features of homes related to energy efficiency and domestic energy consumption. In addition, one typical project home design is theoretically assessed to demonstrate the poor relationship between the aim of the BCA to reduce greenhouse gas emissions and compliance with the current energy efficiency requirements in the BCA (ABCB, 2006).

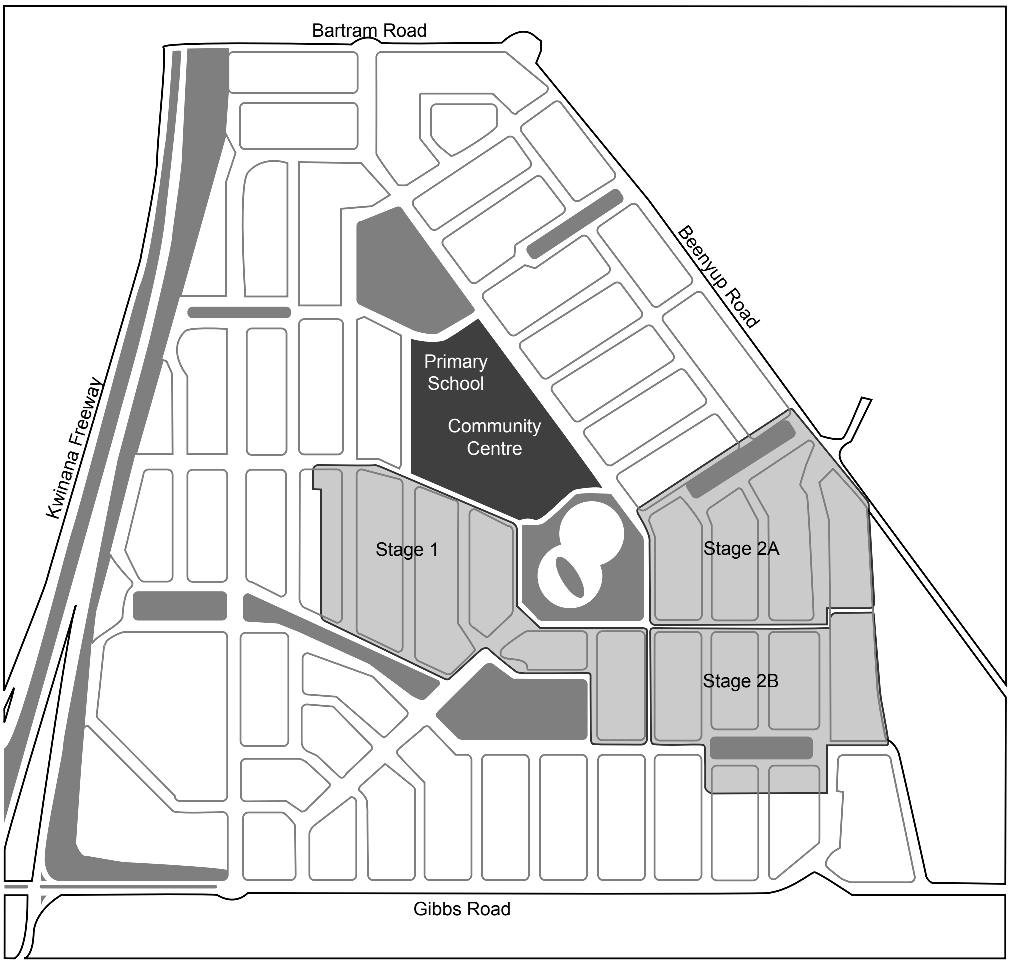


Figure 1. Plan of subdivision at Harvest Lakes

2.0 Energy Performance of Project Homes

2.1 Background of Case Study Subdivision

The subdivision considered in this study, Harvest Lakes, is a multi-award winning estate recognized for its sustainable development practices. It is a 1000-lot estate (refer Figure 1) on 115 hectares in Atwell which is 22 km south of Perth CBD. More than half the building lots have been developed and when fully developed Harvest Lakes will house approximately 3500 residents.Building lots at Harvest Lakes have been released in stages with slightly different 'sustainable building design' requirements applied at each stage of release.

The houses constructed at Harvest Lakes represent a cross section of typical project homes available in the Perth market. A typical street view of the subdivision is shown in Figure 2. The homes are mostly double brick construction on a concrete slab on ground with metal deck or tile roofs. In addition to complying with the BCA, homes are required to comply with energy efficiency features stipulated by the land developer. These include roof ventilation, indoor cross ventilation, north facing living areas, door and window seals or additional wall insulation, minimum east and west facing glazing or energy efficient glass or summer protection of glazing, and energy efficient fixtures. Solar water heaters are now also mandatory, although they were not mandatory for homes built in the early stages of the subdivision.

2.2 Pilot Study

A pilot study of nine homes at Harvest Lakes was carried out in early 2006. Part of the pilot study focused on energy consumption in households. According to the Sustainable Energy Development Office, a West Australian household produces around six tonnes of greenhouse gases every year from usage of energy in the home, with up to 57% of the energy used attributed to space heating and cooling and water heating. Thus the pilot study looked at design features of the home that could contribute to a reduction in energy use for space heating and cooling and water heating.

The potential for a reduction in energy use can be assessed by considering certain attributes of a house including size, design of the house in relation to solar orientation and shading of windows for solar control and cross ventilation, the type of space heating and cooling installed and the type of water heating provided. In addition to the building attributes for reducing energy use, the behaviour of occupants impacts on energy use. Occupants' behaviour related to energy use was assessed by examining electricity and gas bills for the preceding year.

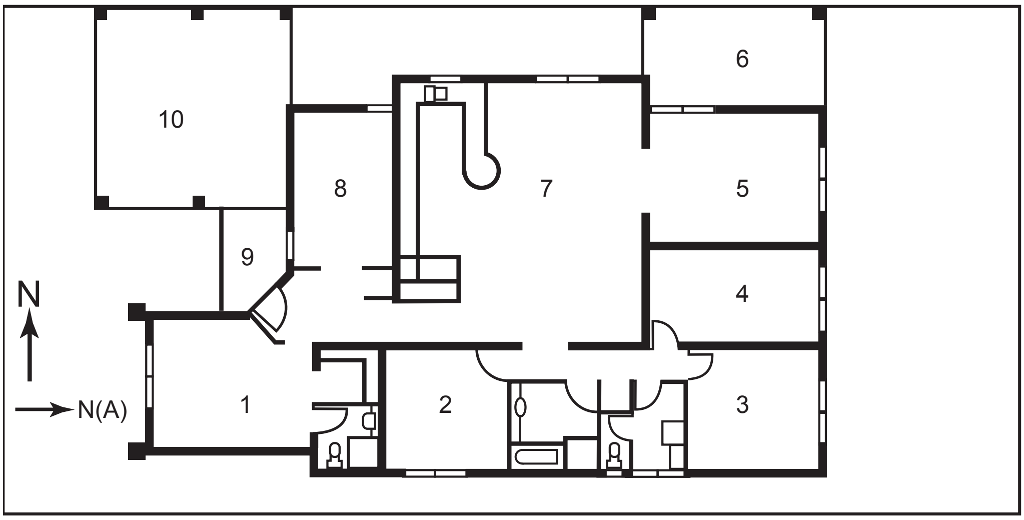
Each of the nine homes was assessed in relation to the main features of housing design that could impact on space heating and cooling and the type of water heater. Energy efficient housing design features included:

1. Building orientation to benefit internal room layout
2. Window placement, sizing and shading to maximise solar control and manage heat transfer through the building envelope
3. Use of insulation to manage heat transfer through the building envelope
4. Ventilation to enable effective cross ventilation in summer
5. Draught proofing to reduce uncontrolled heat gains and losses
6. Use of heat absorbing building materials internally to stabilize indoor temperatures
7. Landscaping to create appropriate micro climate.

2.3 Theoretical Assessment of Project Home

The main aim of introducing energy efficiency provisions into the BCA was to reduce greenhouse gas emissions from buildings. It is pertinent in this paper to consider how the BCA (2006) could impact on energy efficient design of a typical project home built at

Figure 2. Typical street view at Harvest Lakes



1. Main bedroom 2-4. Minor bedrooms 5. Games room 6. Patio 7. Living/dining/kitchen 8. Home theatre
9. Entry porch 10. Carport

Figure 3. Plan of typical single storey project home with two alternate north points shown

Harvest Lakes. In regard to energy efficiency, one means of complying with the BCA (2006) is for the building to achieve "… an energy rating of not less than 5-stars determined using a thermal calculation method that complies with the ABCB Protocol for House Energy Rating Software" (BCA Volume 2, Regulation V2.6.2.1).

To determine whether a typical single storey project home on a 500m² site complied with BCA (2006) and was likely to pass the special energy efficiency criteria at Harvest Lakes, the home shown in Figure 3 was modelled using First Rate (Version 4.0) with two different orientations. The home is 229 square metres[1], similar in design to two homes in the pilot study and similar in design to a number of homes advertised in the low to medium price range in the Western Australian Newspaper New Homes supplements in 2005. The general specifications of the home used for the purposes of modelling were:

- concrete floor slab on ground with carpet in bedrooms, a floating timber floor in the theatre and games room and ceramic tiles elsewhere
- brick cavity external walls and internal block walls
- one layer of reflective foil and R3 insulation in the ceiling space
- single glazing throughout in standard aluminium frames
- eaves of 100 millimetres in length
- a poor level of cross ventilation
- in regard to infiltration, large gaps around the entry door, small gaps around windows and no draught proofing.

3.0 Results and Discussion

3.1 General

Although the number of houses considered in the pilot study was too small to use for reliable statistical analysis, the study at Harvest Lakes provides an insight into design trends in new subdivisions in Perth. All homes were constructed by project home builders. The majority of homes (five) had a floor area of between 150 and 250 m² whilst one home was less than 150m² in area and three homes were more than 250m². This finding is compatible with ABS data relating to the average size of new homes in Perth.

The number of occupants varied from one to five. Four households had one or two occupants whilst five households had between three and five occupants. There was no apparent correlation between the number of occupants and energy bills. It is likely that the lack of correlation between gas usage and number of occupants reflects the fact that 80% of the households with more than three occupants had solar water heaters.

3.2 Energy Efficient Design

The study showed that two of the nine homes would need to be constructed at an angle that was not parallel to the allotment boundary in order to achieve northerly orientation[2]. None of the homes had walls that were not parallel to the allotment boundary. This situation will inevitably arise in a subdivision, so to enable energy efficient design on all allotments in a new subdivision, land developers should create non-northerly oriented blocks of appropriate proportions. This will allow for standard project homes to be placed at an angle to the boundary on those sites. Also home owners should be made aware of the issue if their particular block does not

1 The average size of new housing in WA in 2003 was 229m² (ABS 2005)
2 In this paper 'northerly' orientation refers to 22.5° east or west of true north as defined in BCA 2006.

have a northerly orientation, so they can direct the builder to accommodate a northerly orientation for living areas.

In regard to creating an advantageous microclimate around the house, all of the houses were constructed on totally cleared sites. Only one of the home owners was in the process of creating a planned landscape around the house that responded to the seasonal needs within the house.

In regard to solar access, two of the houses did not have living rooms with substantial areas of northern glazing accessible to winter sun whilst five of the houses had significant areas of sunlight entry in summer. When considering heat transfer through the building envelope, none of the houses had insulation in the external walls and only one household had installed insulated curtains. All houses had ceiling insulation to comply with regulatory requirements[3] current at the time when these homes were obtaining building approval.

Typically summer cross ventilation was poorly addressed. If cross ventilation was possible at all, it was dependant on leaving doors open between living areas and bedrooms. In some homes not even this was possible. None of the homes had been designed with a secure means of providing cross ventilation at night. Lack of security was mentioned as a reason why three of the householders did not open windows and doors for cooling on summer nights. Another reason was mosquitoes and midges coming inside. None of the homes had door seals to restrict air infiltration.

As all of the houses were of cavity brick construction on a concrete slab, there was adequate indoor heat absorbing material to store solar radiation and the cooling effects of night ventilation.

Six of the nine homes had solar water heaters installed, as that had become a mandatory requirement for building at Harvest Lakes in the later stages of the subdivision. The remaining three homes, built in the early stages of the subdivision, had gas storage water heaters.

3.3 Energy Consumption

Questions related to occupants' knowledge and behaviour related to energy use showed limited understanding of ways of reducing greenhouse gas emissions. None of the interviewees were aware of the availability of 'green power'[4].

It was found that eight of the nine householders had installed mechanical space cooling and all nine volunteers had installed mechanical space heating. Four of the eight space coolers were evaporative coolers whilst the remaining cooling systems were either ducted or stand alone reverse cycle air conditioners. With regard to space heating, five of the nine homes had gas heating either in the form of stand alone heaters or ducted gas heating while the remainder were either ducted or stand alone reverse cycle air conditioners.

In order to establish the energy consumption of households, a tabulation of average annual electricity and gas consumption was collated (Table 1). For purposes of comparison, three other sets of data are provided. One point of comparison is the average energy consumption figures for the suburb, incorporating the Harvest Lakes subdivision, as a whole. Another set of data is for the Perth metropolitan area whilst the third set of data is from a similar pilot study of 12 volunteers living at another housing subdivision at Ellenbrook[5].

Due to the small number of homes examined and energy bills collected, it is not possible to establish any statistical correlation between house designs at Harvest Lakes and energy bills although two trends are evident. The trends relate to the impact of solar water heating and floor area.

Table 1 shows the impact of solar water heaters on gas consumption. The average annual gas consumption at Harvest Lakes[6] is 62% of the consumption for the Perth Metropolitan area and 55% of the consumption at Ellenbrook, where none of the householders had solar water heaters. Also, at Harvest Lakes only those households with solar water heaters had gas bills in the lowest percentile of consumption.

	Average annual electricity consumption / premise (kWh/a)	Average annual gas consumption / premise (kWh/a)
Harvest Lakes pilot study	6113	3428
Atwell suburb	5810*	Not available
Perth Metro	5724*	5556**
Similar pilot study at Ellenbrook	6596	6238

* 2004/2005 data provided by Synergy, Perth electricity provider; July 2006
** Data provided by Alinta Asset Management, Perth gas provider; 16 August 2006

Table 1. Annual energy consumption per household

3 The regulatory requirements were based on BCA (1996) Amendment 13.

4 'Green power' refers to electricity that has been generated by the electricity provider from a renewable source such as wind power or solar power. It may be purchased on request.

5 A pilot study, similar to that conducted at Harvest Lakes, was carried out at Ellenbrook in early 2006. Ellenbrook housing estate has been under development since 1994 and the volunteers involved had been living at the estate in project builder designed homes for between 3 and 7 years. Ellenbrook is 24 km north east of Perth CBD.

6 At Harvest Lakes six of the nine households examined had solar water heaters

For floor area, the results are less conclusive but indicate a trend. At Harvest Lakes all three houses that were more than 250m² in floor area had either gas or electricity bills in the highest percentile of consumption. A similar trend was seen at Ellenbrook where only those houses greater than 250m² had both gas and electricity bills in the highest percentile of consumption. No houses less than 150m² at Harvest Lakes or at Ellenbrook had either gas or electricity bills in the highest percentile of consumption.

3.4 Relationship between Design, Energy Consumption and BCA Compliance

One way of examining the design of project homes for energy efficiency was to simulate a typical project home that complies with the BCA (2006). The home shown in Figure 3, with two alternate orientations (N and N(A)), achieved a 5-star rating. However the home does not comply with five of the seven features of energy efficient design mentioned previously.

For example, with orientation N shown in Figure 3, living areas have very limited exposure to northerly winter sun as the main living area is 2m from the lot boundary, so in winter, solar access will inevitably be blocked by a house on the adjacent allotment. Alternatively a games room and two bedrooms will have northerly winter sun (orientation N(A)).

In addition, nearly all windows will be exposed to summer sun as the eaves are 100mm long and the majority of glazing has no external shading[7]. Also there will be significant heat transfer through the windows in both summer and winter as the windows are not protected internally with insulating curtains or blinds. Cross ventilation is poorly addressed in the three minor bedrooms and in the main living area. High levels of infiltration can occur as no draught proofing is required to achieve a 5-star rating. Finally there is no requirement to create a micro-climate around the house to try to minimize the need for mechanical heating and cooling.

4.0 Directions for the Future

It is of concern that new homes do not appear to be using less energy than older homes and that sub-optimal designs can readily comply with BCA (2006). However a more extensive study of energy consumption in new homes is required to confirm the indicators appearing from this pilot study. Thus a comprehensive longitudinal study of new housing is currently being developed which will provide a benchmark for energy consumption in new project homes in Western Australia.

Given that future generations will be living with the consequences of designs now being constructed, it may be appropriate to reconsider the approach taken to energy efficiency in housing both in terms of policy decisions, regulations and public education. Considerably higher standards of climatic design are required for new housing to try to provide comfort conditions without the need for mechanical space heating and cooling, particularly in mild climates. Not only can energy efficient design significantly reduce the need for mechanical space heating and cooling, but, as stated by McChesney, Smith & Baines (2006, p.v) in their study of household energy efficiency in New Zealand "...setting high standards in new homes will have a positive spill-over into energy saving products that can have application in existing homes".

References and Further Reading

ABS Australian Bureau of Statistics, 2005, *Australian Social Trends - Housing Stock: supply of housing*, Cat. No.4102.0, ABS Canberra

Australian Building Codes Board (ABCB), 2003, *Building Code of Australia 1996 – Amendment 13*, CCH Australia, Canberra

Australian Building Codes Board (ABCB), 2006, *Building Code of Australia*, SAI Global

Dodson, Jago, & Sipe, Neil, 2006, *Shocking the suburbs: urban location, housing debt and oil vulnerability in the Australian City*, Griffith University Urban Research Program [accessed August 2006 http://www.griffith.edu.au/centre/urp/urp_publications/research_papers/URP_RP8_MortgageVulnerability_Final.pdf]

Government of Western Australia, 2003, *Hope for the future: The Western Australian State Sustainability Strategy,* Department of Premier and Cabinet, Perth Sept 2003 [accessed July 20 2006 http://www.sustainability.dpc.wa.gov.au/docs/Strategy.htm]

Holloway, D., Pullen S., Randolph, B. and Troy, P., 2005, *Draft -Water and energy profiles of selected Landcom residential developments*, City Futures Research Centre, UNSW.

McChesney, I., Smith, N. & Baines, J., 2006, *The impact on housing energy efficiency of market prices, incentives and regulatory requirements.* Centre for Housing Research, Aotearoa New Zealand.

Smith, Peter, 2005, *Architecture in a climate of change* – Elsevier - Oxford – 2nd edition

Sustainable Energy Development Office (SEDO) (n.d) (http://sedonewsbyemail.vivid-design.com.au/print.asp?id=251 accessed 16 December 2005)

Biography

Elizabeth Karol BArch, BEng, PhD is a Senior Lecturer at Curtin University of Technology, Western Australia.

e karol@curtin.edu.au

7 In order to achieve a 5 star rating when North (N) was to the side boundary, external blinds were required on east windows.