Thermal Performance of the Metricon Ecohome during Preoccupation Period

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ABSTRACT

The current pattern of low density housing in Australia is not sustainable. Australian homes are currently responsible for about 20% of its energy consumption. A significant gain in energy savings and green house gas emissions reduction can be achieved through incorporating sustainability in new homes construction. The sustainability features related to energy that can be included in new homes are insulation in the building envelop, solar access, orientation, efficient gas heating, heat recoverable ventilation system, solar hot water system, photovoltaic panels for electricity generation, use of low embodied energy materials in construction of new homes etc. As part of the research, an eco-friendly demonstration home called "the Ecohome" was constructed by Metricon Homes, one of the industry partners. The Ecohome is located at a suburban housing project at Cairnlea in Melbourne. The Ecohome is planned to be monitored for three years. Monitoring includes air temperature, air quality, humidity and rainfall at strategic locations. So far the baseline data have been collected for the period June 2004-May 2005 prior to occupation. Since the home was not occupied, only air temperature data are relevant at this stage. In this paper, the thermal performance of the Ecohome is reported for selected periods.

KEY WORDS

Sustainable housing, thermal performance, Ecohome.

Preferred Presentation Format: oral

1. Introduction

The pattern of metropolitan development in Melbourne is one of spreading low-density suburbs, which is relatively affordable but environmentally unsustainable [1] though stochastic urban accretion has been addressed to some degree since the early 1990's by encouraging higher density urban renewal, improved urban stormwater management on new estates etc. Housing sector now constitutes about 20% of Australia's green house gas (GHG) emissions [2]. Hence a great emphasis is given to improve housing sector performance mainly through volume house developments. The State of Victoria has already implemented a 5 star energy rating requirement from July 2004 for all new homes constructed in Victoria [3].

In Melbourne, the mainstream housing stock is provided in the form of project homes through major home developers. The advantage of this type of housing is that it is relatively easier to achieve sustainability outcomes such as passive solar design, common facilities, landscaping, water sensitive urban design principles, minimum appliance rating, water and energy conservation requirements through master planning [4]. A great potential exists to build new homes sustainably through legislative measures implemented with consultation and support of local governments and the housing industry.

Substantial research is being carried out in Australia on sustainable housing. This includes the "Smart Housing" project in Queensland [5] and the AHURI (Australian Housing and Urban Research Institute) research centres throughout Australia. In Victoria, as part of this research a model home called "the Ecohome" was constructed in 2003 at the Cairnlea Estate, Deer Park in Melbourne. The Ecohome is a typical dwelling but added with additional features such as solar panels, gas boosted solar hot water system, rainwater tank, grey water recycling, hydronic heating, compost bin and separate chutes in the kitchen enabling the separation of organic waste and recyclables. The Ecohome is intended for the mass housing market and only realistic solutions have been incorporated in the design.

The climate of Australia is characterised by four seasons: autumn (March-May), winter (June – August), spring (September – November) and summer (December – February). In this paper, partial performance data of two representative months representing two seasons are reported. They are October 2004 (spring) and February 2005 (summer).

2. Instrumentation and Monitoring

Instrumentation and monitoring strategies of the Metricon Ecohome have been reported elsewhere (S Rahman and others at RMIT, article accepted for presentation at the ISEC-03 conference in Japan in September 2005). The Ecohome is being monitored for air temperature, air quality, humidity and rainfall. Since the house is not occupied yet, only the air temperature data are relevant at this stage. The air temperature is being measured at eight significant locations and the frequency of data recording is 10 minutes. Air temperature data are being measured and recorded at outdoor, four locations in the ground floor (entry, kitchen, living room and master bed) and three locations (upstairs, family room and bed room 4) in the upper floor.

Data measurements and recording began in June 2004 and since then at least 12 months baseline data is being collected. At the moment the home is being sold and is expected to be occupied in 3-6 months time. Remote data logging is in the process in anticipation of the house being occupied to avoid inconvenience to the occupants. The home is planned to be monitored for two years from the start of the occupation.

3. Thermal Performance

Thermal comfort in a built environment is related to, among others, air temperature, relative humidity, air velocity, activity rate, clothing level etc. Since the Ecohome was not occupied in the study period, humidity and air quality data are irrelevant and only the air temperature data are important.

In measuring the thermal performance of the Ecohome, the authors are interested in the ability of the house to retain heat in cold periods and obstruct heat in hot periods. Melbourne weather is characterised by mostly cold periods and few hot days specially in the summer. Hence design strategies included getting more passive solar energy and retaining the energy cleverly through good insulation, heat exchanger in the ventilation system etc. Table A in the Appendix summarises the insulation and materials used in the building envelope to realise greater thermal comfort.

The partial data obtained from monitoring of the Ecohome are presented below in the form of thermal response curves. The performance has been evaluated qualitatively. In this report ‘comfort zone’ has been defined as temperatures between 17.5-24.5 degrees Celsius. Anders in 2003 reported in a similar format the thermal performance during winter months of the ETC (Environmental Technology Centre) buildings located at Murdoch University in Perth, Australia [6]. The authors are of the opinion that there is a lack of standard methods in presenting such thermal response curves or converting them to measurable parameters.

Previously during 22-25 February 2005, the Mobile Architecture and Built Environment Laboratory (MABEL) of Deakin University conducted a performance assessment of the internal environment for this home that included thermal performance, among others.

3.1. Thermal Performance in October 2004 (spring)

Partial data of the thermal performance of the Ecohome during October 2004 (spring) is presented in the following figures 1-2 and tables 1-2. Each graph contains 9 data series but only the outside air temperature and the average indoor air temperature (bold curve in the middle) are of most interest.

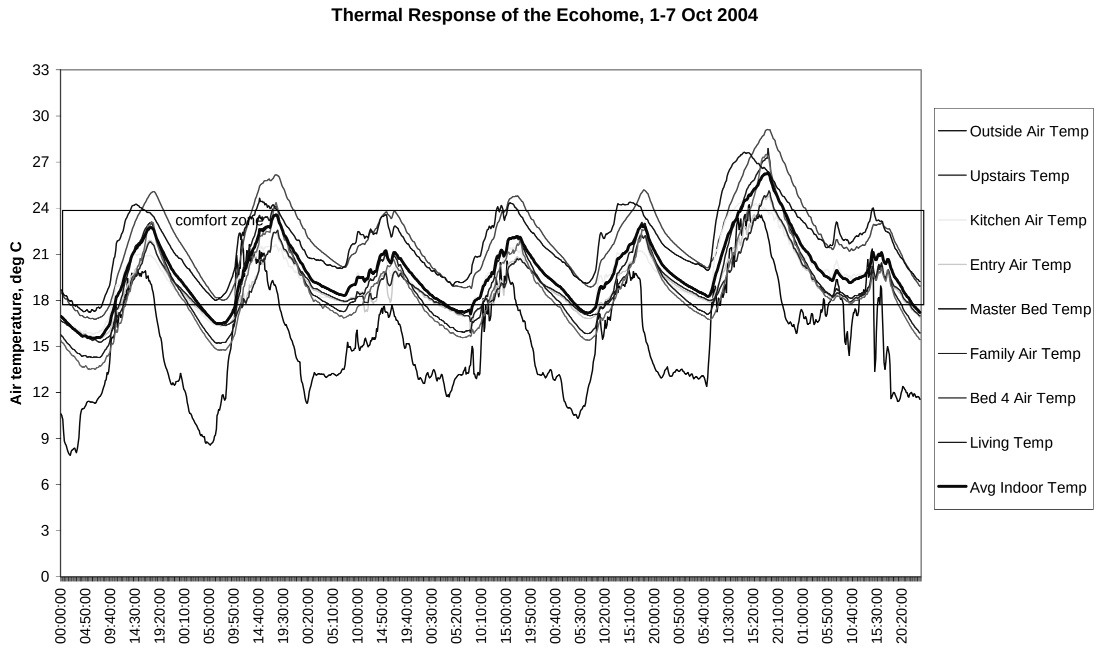

Figure 1: Thermal Response of the Ecohome, 1-7 October 2004 (spring)

3.1.1 Thermal performance during 1-7 October 2004

The outdoor air temperature during this period ranged from 7.9-24.2 deg C while the average indoor temperature ranged from 15.5-26.3 deg C (figure 1 and table 1). It is noticed that at lower temperature level (typical of Melbourne weather), the performance is very good. The insulation in the building envelope is performing well in retaining the heat and minimising the temperature extremes in the outside.

At upper temperature level (not typical of Melbourne weather), the performance is not good. The house tends to heat up easily. This overheating is related to lighter structural frame of the house. This is more evident in the thermal response curves in the summer periods (figures 3-4).

During this period, 81% of the time, the average indoor temperature remained in the comfortable zone (17.5-24.5 deg C) while only 29% of the time, the outdoor temperature stayed within the comfortable range. At warmer periods, thermal comfort can be maximised by naturally ventilating the house which is expected when the house will be occupied. Approximately 15% of the time space heating was required and only 4% of the time cooling was required.

Table 1: Performance summary

October 2004	Outdoor Air temp, deg C		Inside avg Air temp, deg C		% time space heating required	% time cooling required
	Min	Max	Min	Max		
1	7.9	20.0	15.5	22.8	43.8	0
2	8.6	22.0	16.5	23.6	27.1	0
3	11.3	17.7	18.3	21.2	0	0
4	11.7	20.6	17.1	22.2	17.4	0
5	10.3	20.0	17.2	22.9	13.2	0
6	12.4	24.2	18.3	26.3	0	27.8
7	11.4	21.3	17.2	22.0	3.5	0

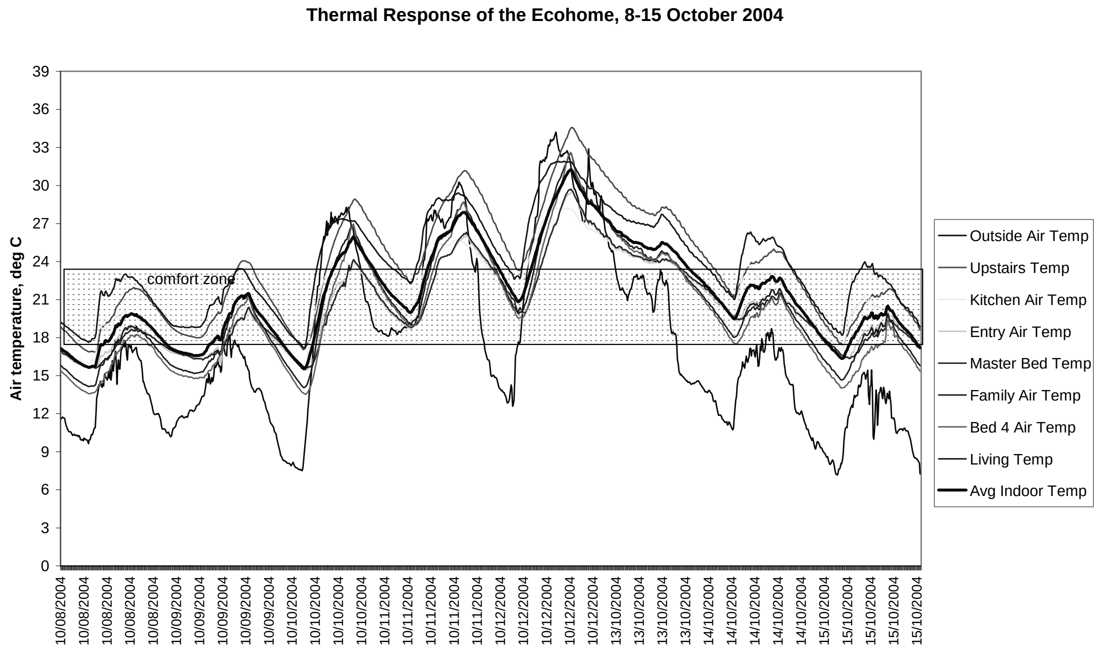

Figure 2: Thermal Response of the Ecohome, 8-15 October 2004 (spring)

3.1.2 Thermal performance during 8-15 October 2004

The outdoor air temperature during this period ranged from 7.2-34.2 deg C while the average indoor temperature ranged from 15.5-31.3 deg C (figure 2 and table 2). Here also, it is noticed that at higher temperature level, the performance is not good. The house tends to warm up easily. However, at lower temperature level (typical of Melbourne weather), the house was keeping warm inside.

During this period, 57% of the time, the average indoor temperature remained in the comfortable zone (17.5-24.5 deg C) while only 21% of the time, the outdoor temperature stayed inside the comfortable range. Again here, at warmer periods, thermal comfort can be maximised by naturally ventilating the house which is expected when the house will be occupied. In terms of the energy demand of the house, 17% of the time space heating would be required and 26% of the time cooling would be required during this period.

Table 2: Performance summary

October 2004	Outdoor Air temp, deg C		Inside avg Air temp, deg C		% time space heating required	% time cooling required
	Min	Max	Min	Max		
8	9.6	17.8	15.6	19.9	41.7	0
9	10.2	18.8	16.6	21.5	39.6	0
10	7.5	28.3	15.5	26.0	28.5	21.5
11	15.6	30.3	20.0	27.9	0	54.2
12	12.6	34.2	20.8	31.3	0	59.0
13	13.7	29.2	22.2	28.0	0	74.3
14	9.9	18.7	19.0	22.8	0	0
15	7.2	15.5	16.4	20.5	24.3	0

3.2. Thermal Performance in February 2005 (summer)

Partial data of the thermal performance of the Ecohome during February 2005 (summer) are presented in the following figures 3-4 and tables 3-4.

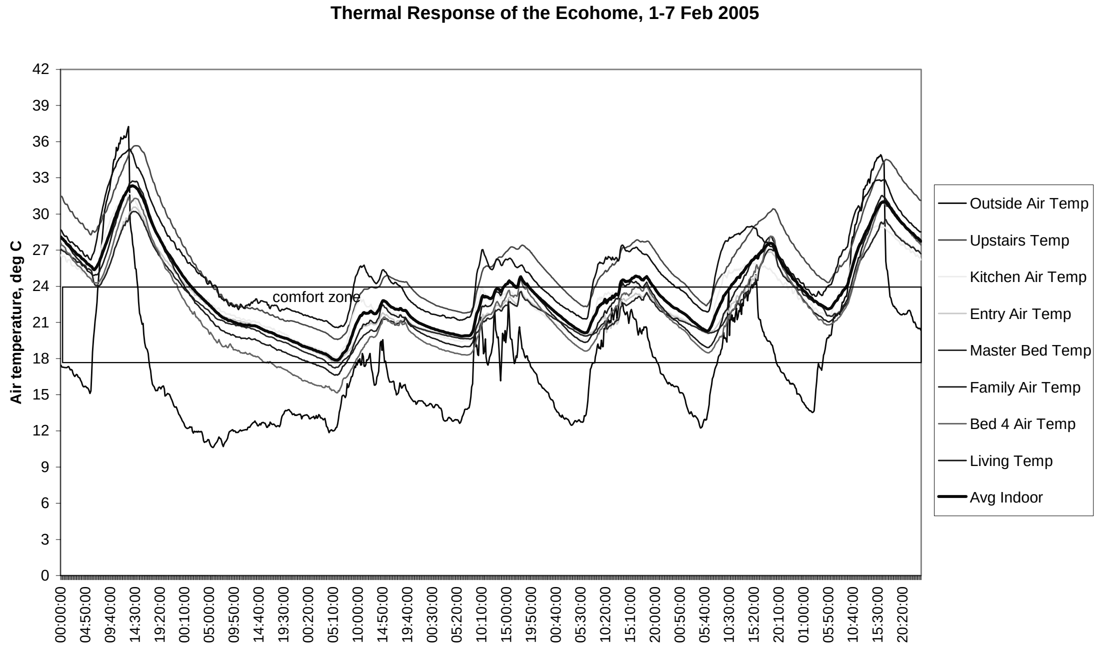

Figure 3: Thermal Response of the Ecohome, 1-7 February 2005 (summer)

3.2.1 Thermal performance during 1-7 February 2005

The ambient air temperature during this period ranged from 10.6 to 37.3 degrees Celsius and the indoor average temperature ranged from 17.9 to 32.3 degrees Celsius (figure 3 and table 3). There was no space heating requirement during this period but cooling was required as about 33% of the time the indoor average temperature went above the upper limit of the thermal comfort. Periodic ventilation during warm periods could minimise the cooling requirement.

During this period, 67% of the time the indoor average temperature stayed within the comfortable zone while for the outside air temperature it was only 32% of the time.

Table 3: Performance summary

February 2005	Outdoor Air temp, deg C		Inside avg Air temp, deg C		% time space heating required	% time cooling required
	Min	Max	Min	Max		
1	12.8	37.3	24.8	32.3	0	100
2	10.6	13.8	19.0	24.7	0	2.1
3	11.8	19.6	17.9	22.8	0	0
4	12.6	22.9	19.9	24.7	0	2.8
5	12.5	23.0	20.1	24.9	0	16.7
6	12.2	25.0	20.3	27.6	0	47.9
7	13.5	34.9	22.1	31.1	0	59.0

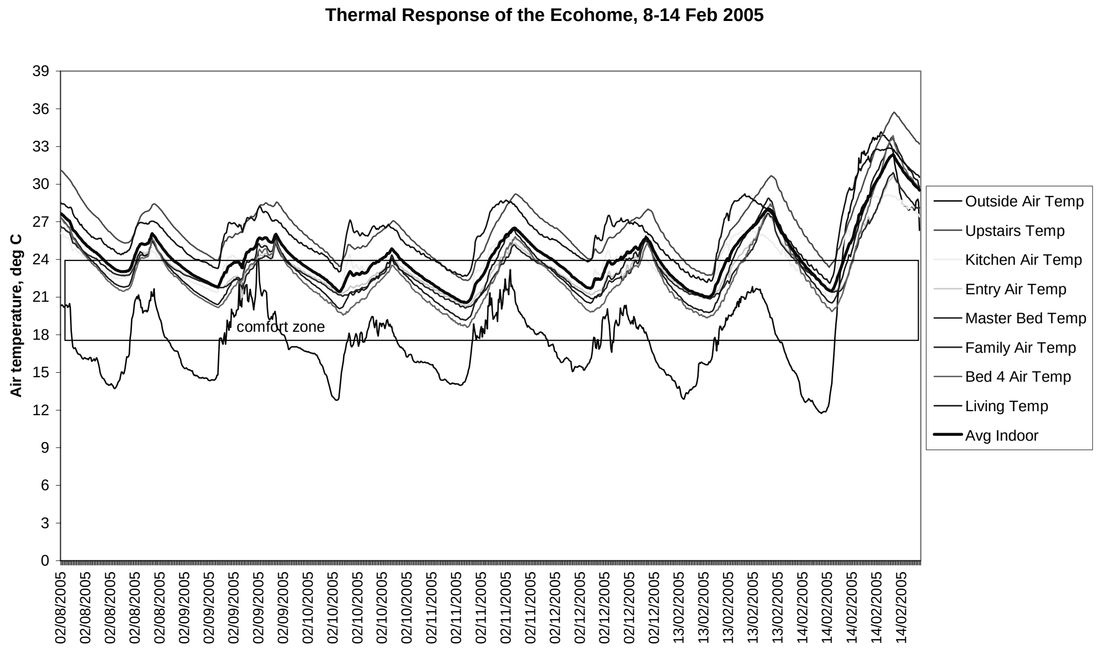

Figure 4: Thermal Response of the Ecohome, 8-14 February 2005 (summer)

3.2.2 Thermal performance during 8-14 February 2005

The performance results are presented in figure 4 and table 4. The outside air temperature during this period ranged between 11.7 to 34.2 deg C and the inside average temperature for the same period ranged between 20.6 to 32.4 deg C. Again here, there was no space heating requirement. However, significant cooling would be required to keep the temperature in the comfort range (39% time).

About 61% of the time, the average indoor temperature stayed in the comfortable zone while about 41% of the outside was in the comfortable zone in the same period.

Table 4: Performance summary

February 2005	Outdoor Air temp, deg C		Inside avg Air temp, deg C		% time space heating required	% time cooling required
	Min	Max	Min	Max		
8	13.7	21.6	23.0	27.6	0	54.9
9	14.3	24.6	21.8	26.0	0	34.7
10	12.8	19.5	21.4	24.9	0	5.6
11	14.0	23.2	20.6	26.5	0	39.6
12	14.3	20.3	21.7	25.7	0	22.9
13	12.9	21.8	21.0	28.0	0	52.8
14	11.7	34.2	21.5	32.4	0	60.4

4. Conclusion

Thermal performance data of the Metricon Ecohome indicate that good to excellent performance has been achieved for most of the periods. During cold periods the home is performing very well in retaining the heat energy primarily due to good insulation and heat exchanger in the ventilation system. However, in hot periods the home experiences overheating due to lack of external shading, light building structure and heat exchanger in the ventilation system. A bypass in the ventilation system and cross ventilation by occupants in hot periods can minimise such overheating.

The performance results reported here will be beneficial to other researchers for comparative study of thermal performance.

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APPENDIX:

Table A: Ecohome specifications- materials and insulation

Items	Description
External	Nubrik clay brickwork with natural raked mortar joints Colorbond metal roofing Colorbond fascia, downpipes and quad gutter Colorbond weatherboard cladding to first floor side and rear elevations Corinthian tempered hardboard flush panel front entry door with glazed panels and aluminium entry frame Aluminium powder coated balustrade and timber decking to balcony
Slab Floor	Concrete with recycled content and Polystyrene (CO_2 blown) insulating waffle pod
Windows	A&L windows aluminium improved with timber reveals Double glazed awning windows to front elevation Sliding windows to side and rear elevations
Framing	Prefabricated wall and trussed roof framing (plantation materials only)
Weather wrap	R1.3 foil (includes taping of joints and around window and external door frames)
Weather seals	Raven door seals as per standard specification
Insulation	Ceiling: R3.5 (recycled polyester batts) External walls: R2.0 (recycled polyester batts)
Ventilation	Venmar advanced ventilation system (heat recoverable)
Flooring	Ceramic floor tiles to entry (through to kitchen), kitchen, dining, living, linen and wet areas- natural fibre carpet to remaining areas
Wall tiling	Ceramic tiles with acrylic tile trim to bath hob