Research on housing environment and energy consumption in Australia

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Introduction

In recent years, the energy demand has increased in the hot and humid regions of Asia, owing to its rapid economic development. Similarly, Australia, which also houses a vast hot and humid region, is a large economic power. Furthermore, because of its receptive immigration policies, population growth is expected in the future, along with the consequent increase in housing demands. However, in the home construction industry, no progress has been made toward the construction of environment-friendly housing that is adapted to the climate of each city.

Climatic conditions

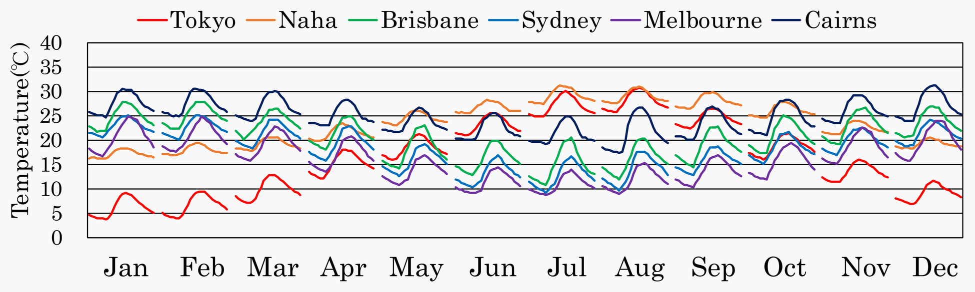

Figure 1 The monthly average of temperature of major cities in Japan and Australia

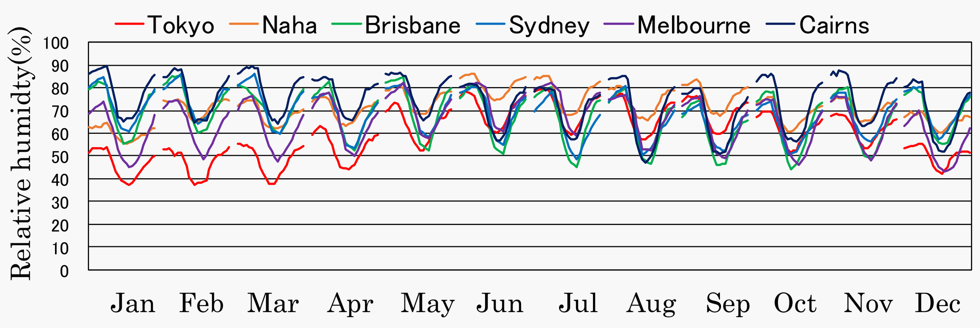

Figure 2 The monthly average of relative humidity of major cities in Japan and Australia

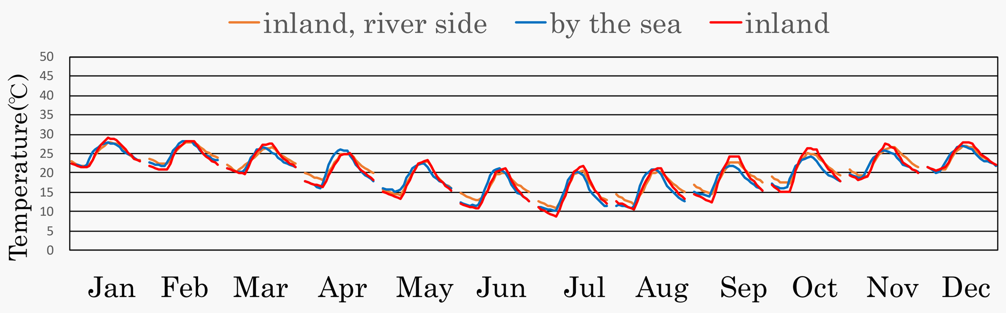

Figure 3 The monthly average of temperatures at various locations in Brisbane

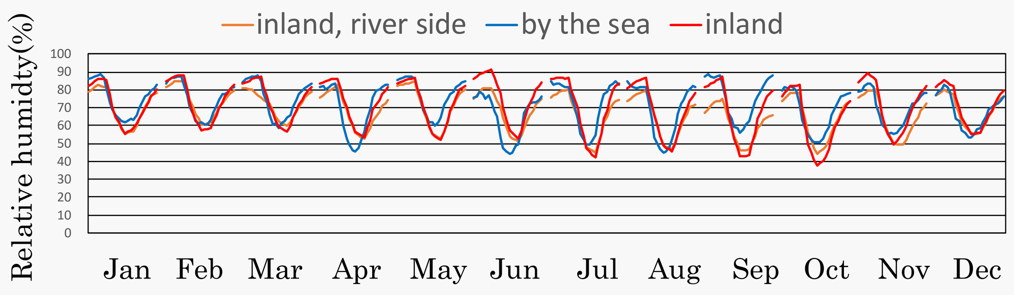

Figure 4 The monthly average of relative humidity at various locations in Brisbane

Table 1 Heating degree days in Japan and its regional zones

Heating Degree Days	Regional zones
4500 or more	1region
3500 or more and less than 4500	2region
3000 or more and less than 3500	3region
2500 or more and less than 3000	4region
2000 or more and less than 2500	5region
1500 or more and less than 2000	6region
500 or more and less than 1500	7region
less than 500	8region

Table 2 Heating degree days in the principal cities of Japan (and its regional zones) and Australia

Place name	Heating Degree Days	Regional zones
Tokyo 23 Wards	1511.3	6region
Melbourne	1109.2	7region
Sydney	636.9	7region
Brisbane	253.2	8region
Naha	127.9	8region
Cairns	0	8region

The monthly average of temperature during a day was calculated (every month for 12 months) and plotted along the x-axis, as shown in the figure 1.
The monthly average of relative humidity during a day was calculated (every month for 12 months) and plotted along the x-axis, as shown in the figure 2.
Table 1 shows heating degree days in Japan and its regional zones, and Table 2 shows heating degree days in the principal cities of Japan (and its regional zones) and Australia. The heating degree days shown in these tables were calculated using D18-18.

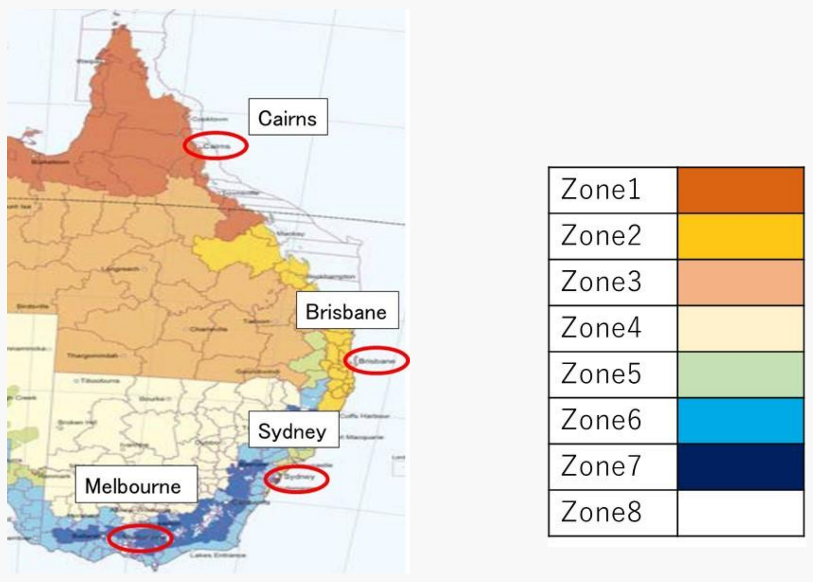

Figure 5 The climatic zones of Australia

Housing regulations

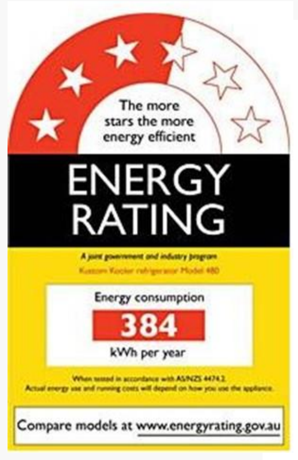

Figure 6
Energy rating label

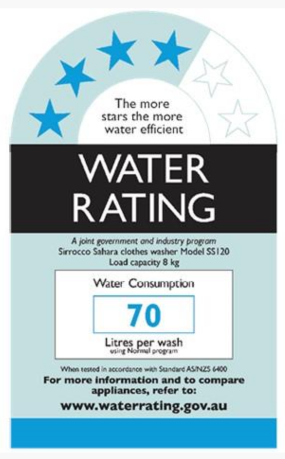

Figure 7
Water-efficiency rating label

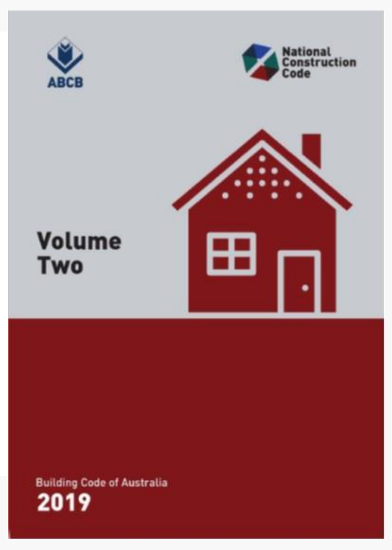

Figure 8 NCC Volume2

Energy performance information is offered to consumers when selling different products. In the water-efficiency labelling system, as shown in the figure 7, the quantity of water consumed for a single wash can be compared and evaluated using the situation, task, action, result (STAR) technique.
Australia has NCC (National Construction Code) technical provisions for building work and building regulations, as shown in the figure 8.
The NCC comprises volumes 1 to 3, with volume 2 including the technical provisions and building requirements for residential buildings.

Simulation

Thermal load simulations were carried out to investigate whether the performance of dwellings in Brisbane is suited to the local climate.
The model building and outside views of the dwellings for which drawings have been submitted by Brisbane House Building Company A are shown in the figure 9.

Figure 9 The model building

Figure 10 The floor plan

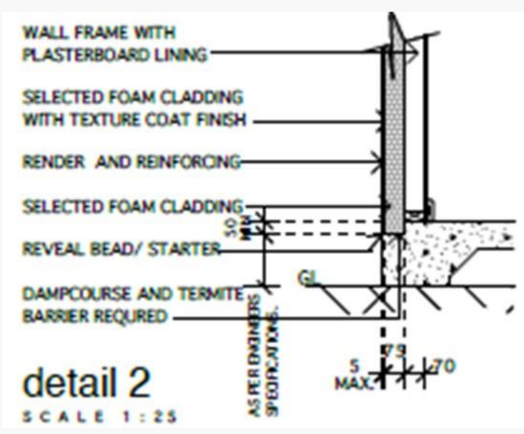

Figure 11
A drawing of the cross-section of the outer wall other than the front wall

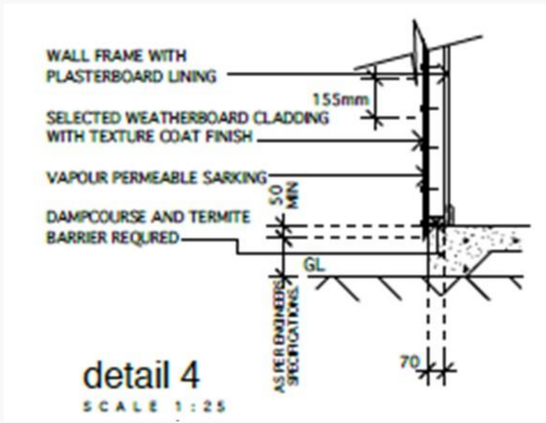

Figure 12
A drawing of the cross-section of the front outer wall

Table 3 The construction materials selected among BEST-H for the outer wall (other than the front wall)

No.	Material classification	Material name	Thickness(mm)
1	Non-wood-based wall and base materials	Gypsum board	10
2	Hollow layer	Unsealed hollow layer	70
3	Polystyrene foam insulation	Extruded polystyrene foam	75
4	Concrete material	Cement mortar	5

Table 4 The construction materials selected among BEST-H for the outer wall (the front wall)

No.	Material classification	Material name	Thickness(mm)
1	Non-wood-based wall and base materials	Gypsum board	10
2	Hollow layer	Unsealed hollow layer	70
3	Concrete material	Cement mortar	8

Table 5 The types of glazing in dwellings

	Melbourne	Sydney	Brisbane
single	80.0%	76.5%	100.0%
double	20.0%	23.5%	0.0%

Table 6 The types of frames in dwellings

	Melbourne	Sydney	Brisbane
aluminum	95.0%	82.3%	95.0%
timber	5.0%	11.8%	5.0%
uPVC	0.0%	5.9%	0.0%

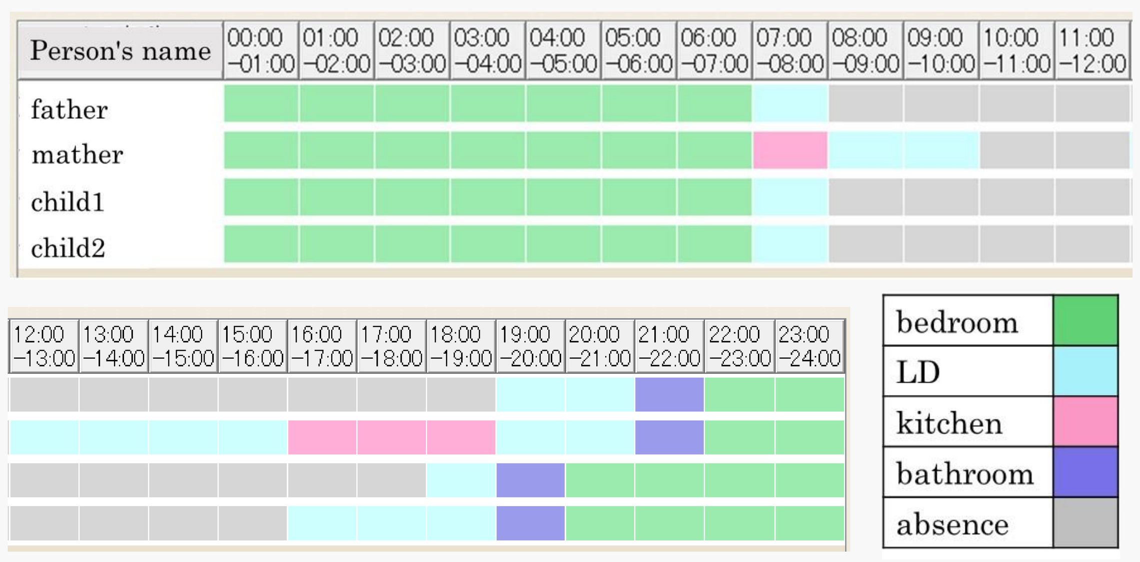

Figure 13 A schedule for room occupancy

Simulation result

Table 7 Total outer surface heat loss of the aforementioned dwellings and UA value.

	Total outer surface heat loss (W/K)	UA value(W/㎡K)
standard model	486.51	0.93
pattern1	840.12	1.61
pattern2	486.51	0.93
pattern3	438.85	0.84
pattern4	417.18	0.80
pattern5	369.52	0.71

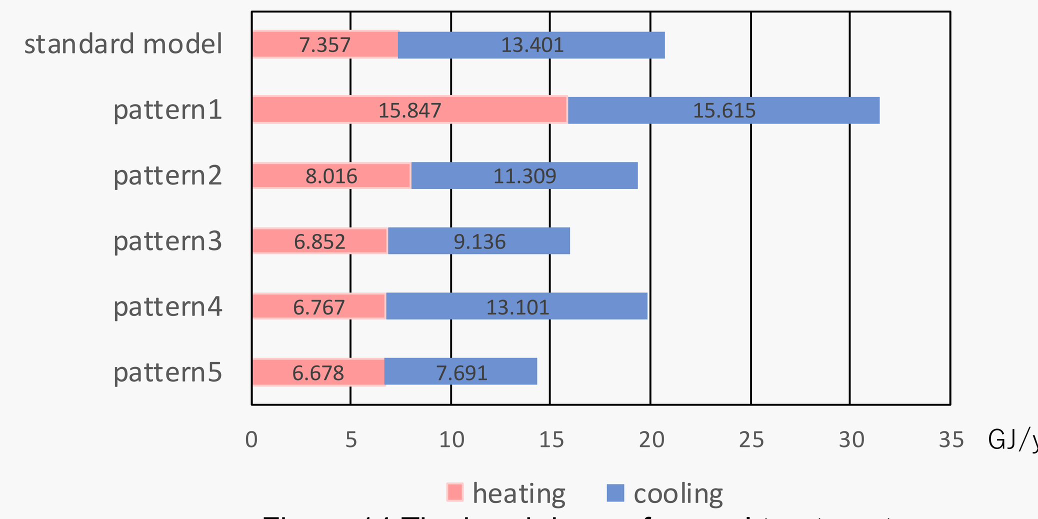

Figure 14 The breakdown of annual treatment thermal load for these dwellings

Table 8 The percentage increases and decreases relative to the basic model

	heating	cooling	overall
pattern1	＋115.4%	+16.5%	＋51.6%
pattern2	+9.0%	−15.6%	−6.9%
pattern3	−6.9%	−31.8%	−23.0%
pattern4	−8.0%	−2.2%	−4.3%
pattern5	−9.2%	−42.6%	−30.8%

With Pattern 1, the heating load was ca. twice that with the basic model and accounted for half of the overall thermal load: the total load was ca. 1.5 times that with the reference model.
With Pattern 2, in which the length of the roof overhang was doubled, the cooling load was increased by ca. 15%; however, the heating load increased, and the total load decreased by 7%.
The greatest decrease in cooling load was in the low-E double-glazing of the windows (Pattern 3) at 32%, with the total load also decreasing by 23%.
With Pattern 4, the surface area of the outer wall with the modified heat insulation was smaller, and there was little reduction.
The decreases in cooling and heating load were both greatest in Pattern 5, which adopted Patterns 2–4, with a total decrease of 30%.
It would also seem to be necessary to study combinations with intermittent air conditioning or passive methods from the point of view of lifestyle.

Conclusion

1) The heating degree day for Brisbane is ca. 253 (degree days), which is close to the value for Naha; however, the daily temperature variation in Brisbane is very high. Therefore, a detailed investigation of the heating load is considered necessary.
2) Some dwellings have a high level of heat insulation, and it can be interpreted that the spread of environmentally high-performing buildings is still a work in progress.
3) In the simulation results, a reference model with specifications of a house building company in the area in question resulted in a somewhat higher thermal load than the energy saving standard in regions 5–7 of Japan; however, the thermal load was ca. 1.5 times greater in the case of outer walls without heat insulation, which are assumed not to be uncommon among existing dwellings in the area in question. It was also confirmed that a decrease of the order of 30% in the thermal load is possible using low-E glazing for windows and improving the shelter from the roof overhang.

References

1) Isochronous data in epw format
https://www.ladybug.tools/epwmap/
2) NCC
https://ncc.abcb.gov.au/ncc-online/NCC
3) Australian Ministry of Environment and Energy
https://www.environment.gov.au/

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