Thermal Performance of Prefabricated Modular Buildings in Australia: A Baseline Study

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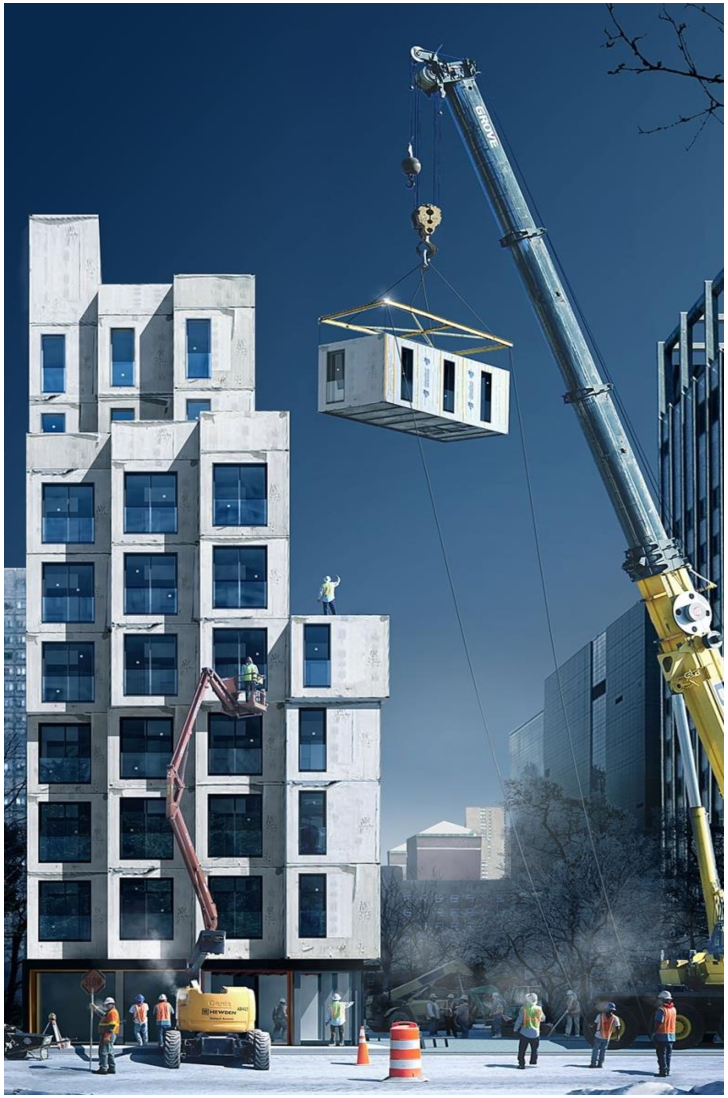


(https://www.dezeen.com/2015/10/21/narchitects-my-micro-ny-modular-residential-tower-affordable-housing-new-york-usa-adapt-nyc/)

Prefabricated Buildings Offer

- benefits to construction industry with reduction in time, cost and waste management.
- Improvements in environmental performance and building overall quality

(http://www.cimc-mbs.com/wm/index_115.aspx)

Cost	Quality	Environment
√Time saving	√Higher level of control	√Waste management

Life cycle costs?

IEQ?

Knowledge Gaps

- There is lack of knowledge on current baseline performance of prefabricated buildings.
- Thermal performance of modular houses is not well documented in the literature.
- The effects of building size and envelope on thermal performance of modular houses is not well documented.

Aim

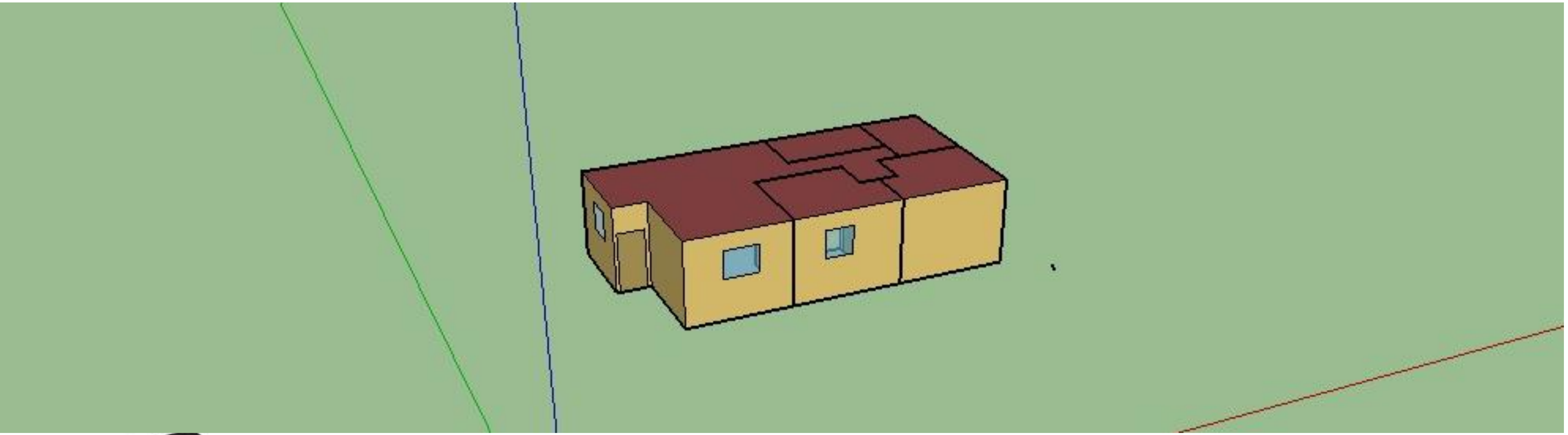
- To investigate the thermal performance of four prefabricated modular buildings in Melbourne, Australia

Objectives

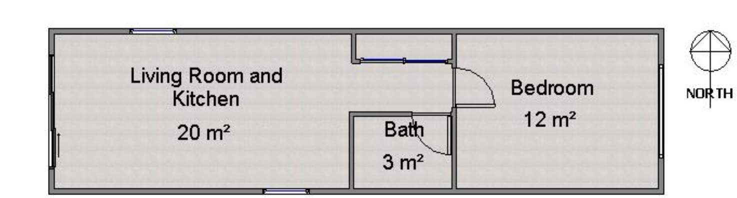
- To investigate the effects of building size on thermal performance
- To investigate the effects of envelope parameters on thermal performance

Method

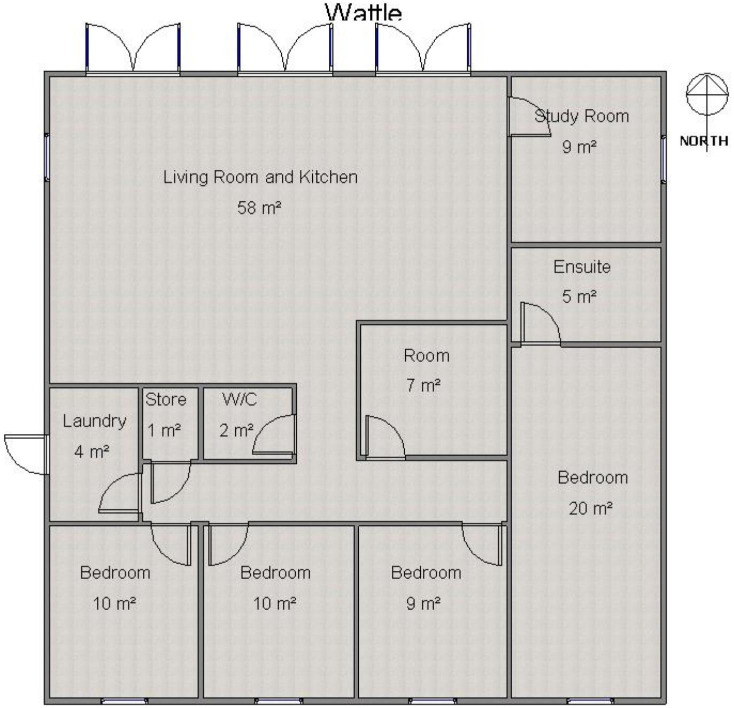
- OpenStudio plugins in Sketchup environment were applied.
- EnergyPlus engine was used for the simulations.
- Effects of window to wall ratio and floor area on cooling and heating loads were investigated.



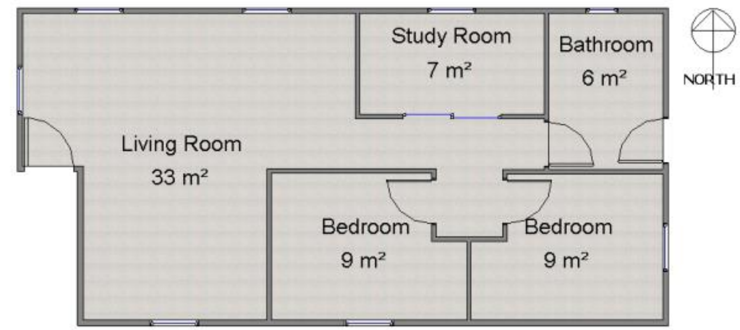
Buildings Investigated



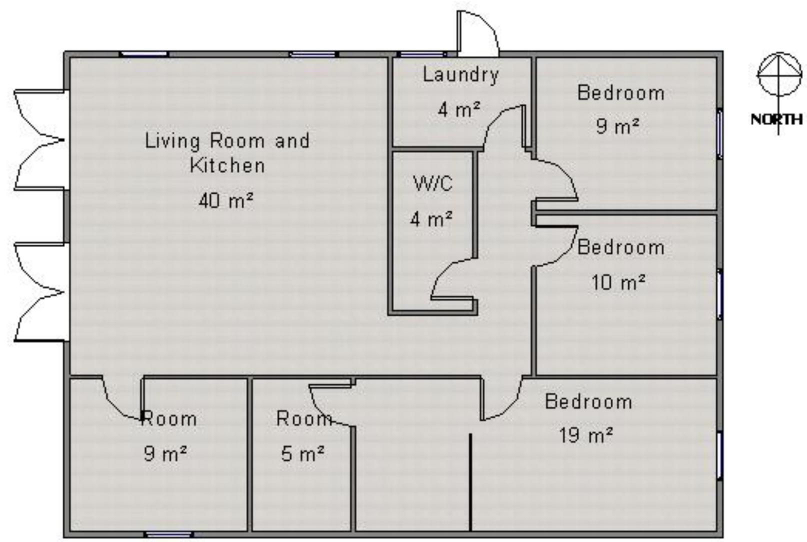
Wattle



Outback



Banksia

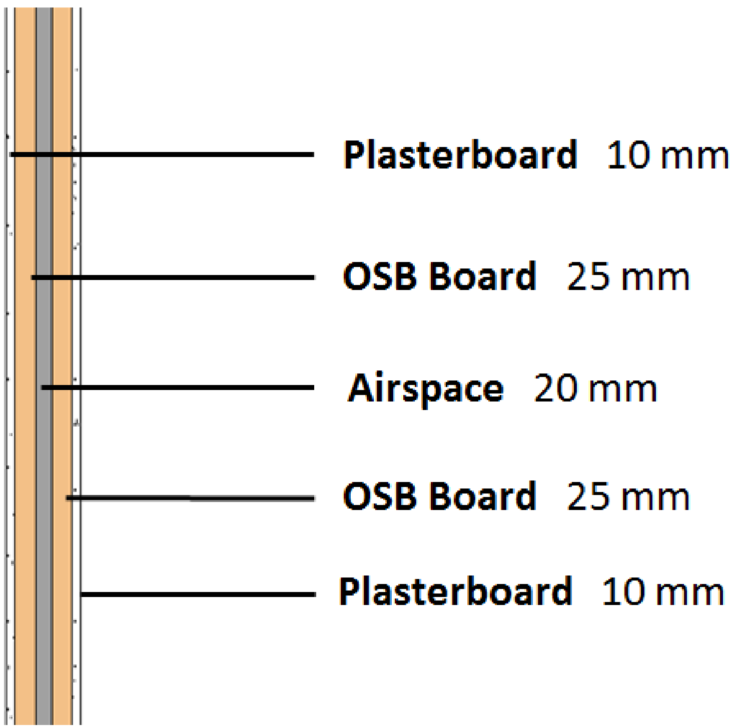


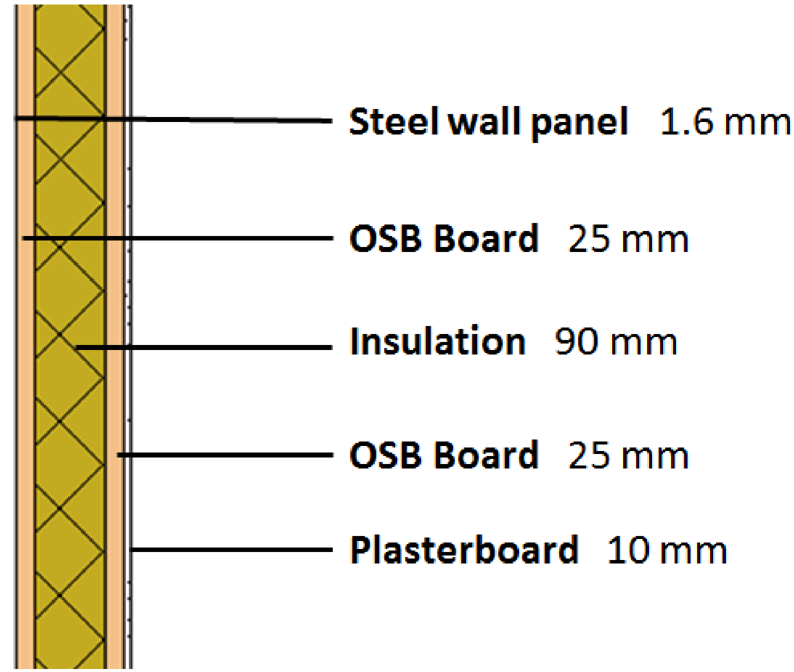
Territory

Fixed Parameters

Category	Item	Value
Location, Melbourne, Australia	Latitude [deg] Longitude [deg] Time Zone [h] Elevation above sea level [m] Site ground temperature [°C]	-37.817 144.967 10 38 18
Window glazing	U-Factor [W m^{-2} K^{-1}] Solar transmittance [-]	2.10 0.237
Thermostat settings	Heating set point Cooling set point	Day:21°C, Night:18°C 24°C
Space infiltration rate	Flow per space floor area [ms^{-1}]	0.0007
Design ventilation rate	Outdoor Air flow per floor area [ms^{-1}]	0.0003

Wall Components

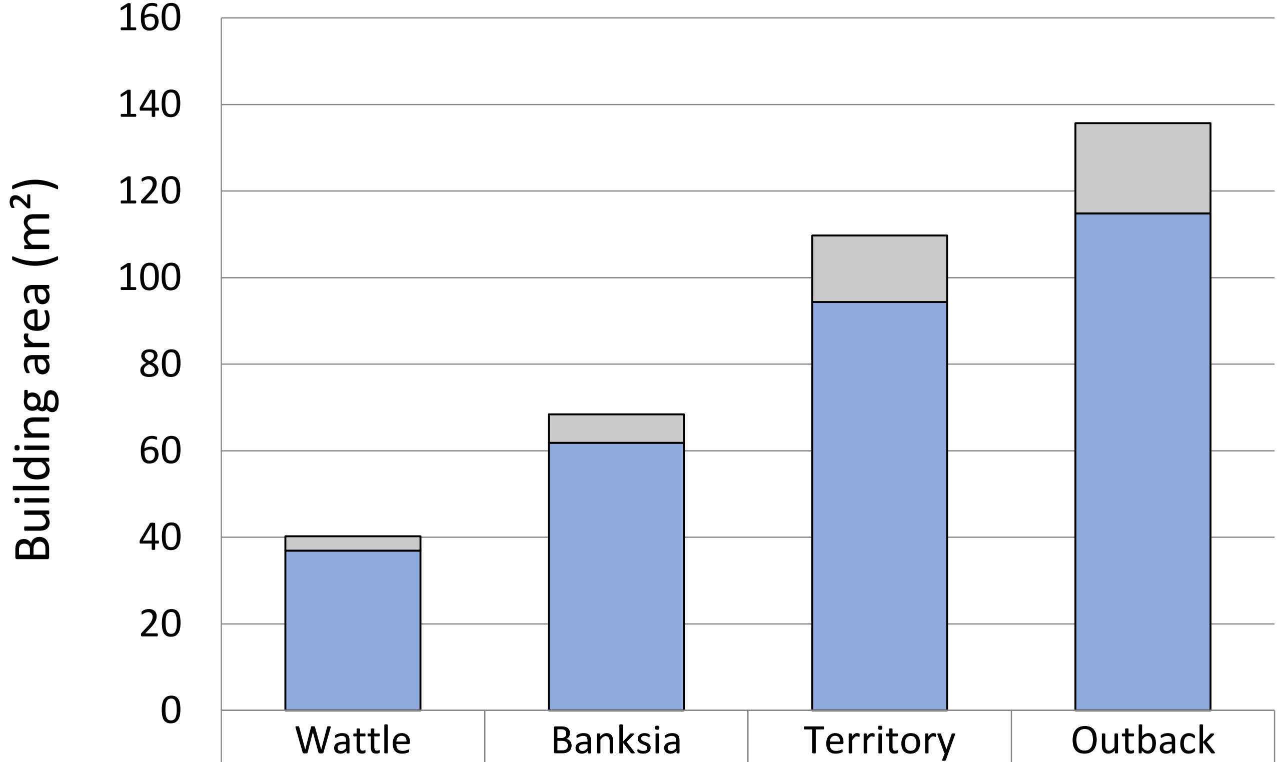




OSB = Oriented Strand Boards

Building Areas

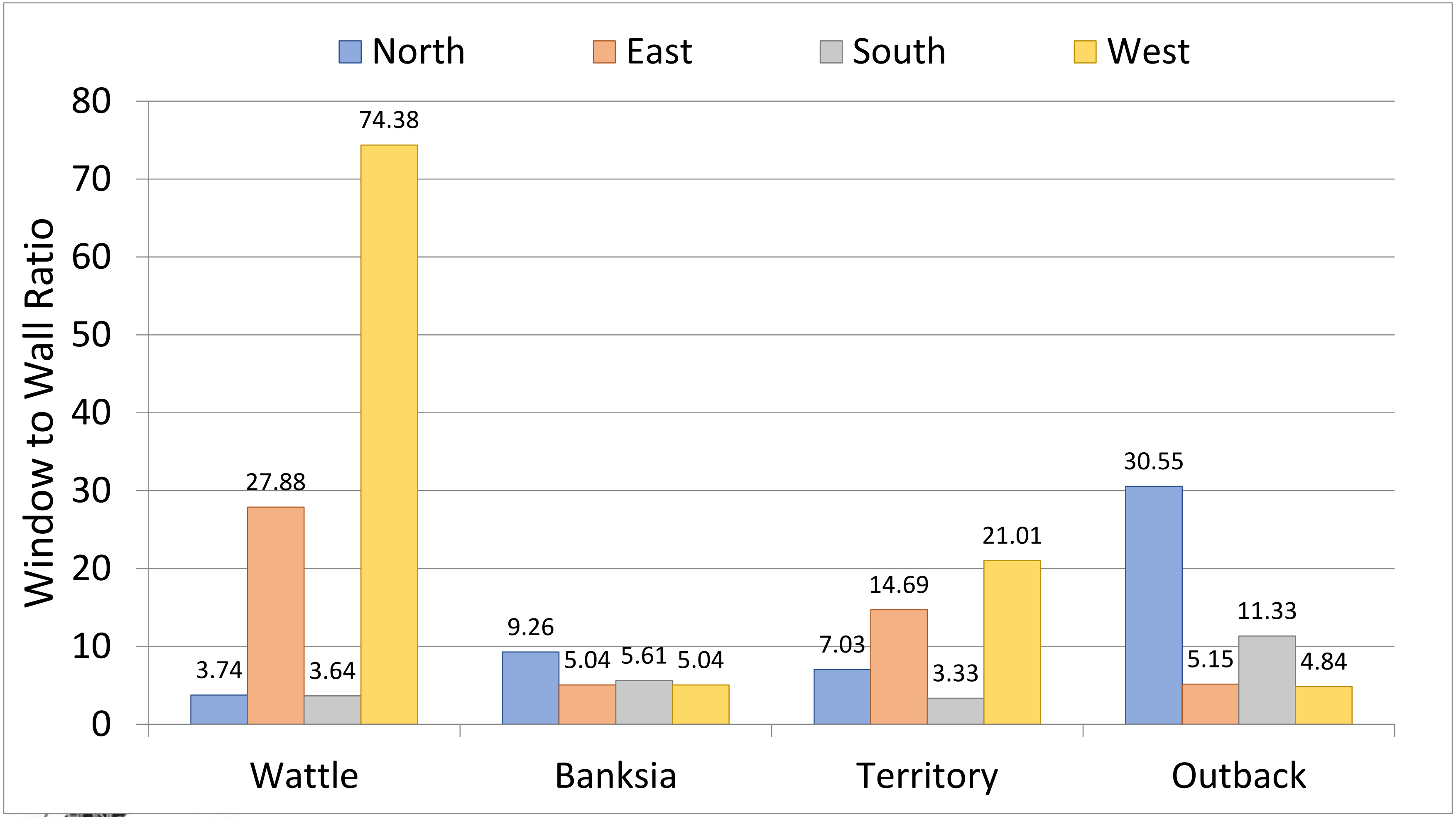
While 92% of the spaces in the Wattle building are conditioned, this percentage decreases to 85% in the Outback.



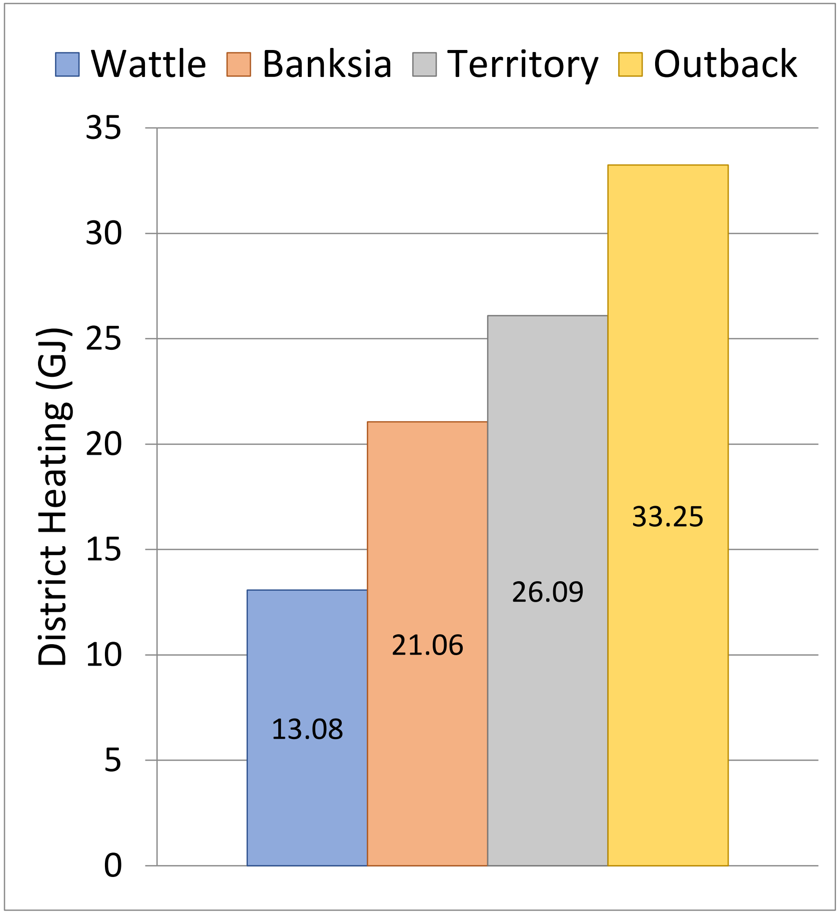
	Wattle	Banksia	Territory	Outback
Unconditioned	3.35	6.6	15.36	20.84
Conditioned	36.89	61.84	94.37	114.86

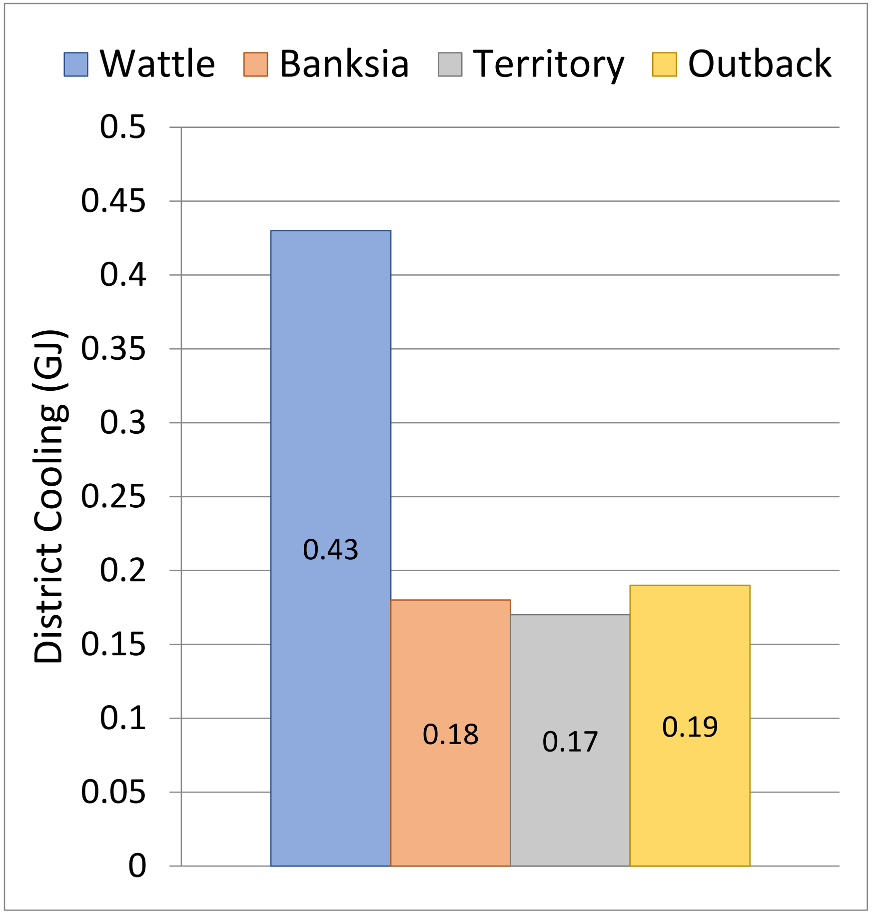
Window/wall Ratio

Regarding the fact that Wattle is the smallest building, the high value of window to wall ratio can be justified.

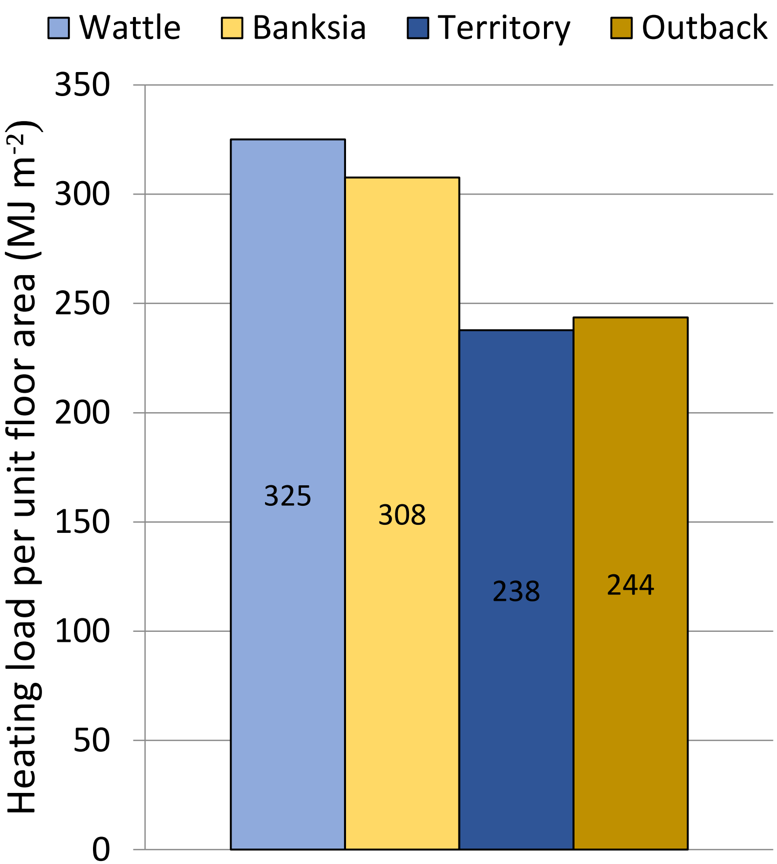


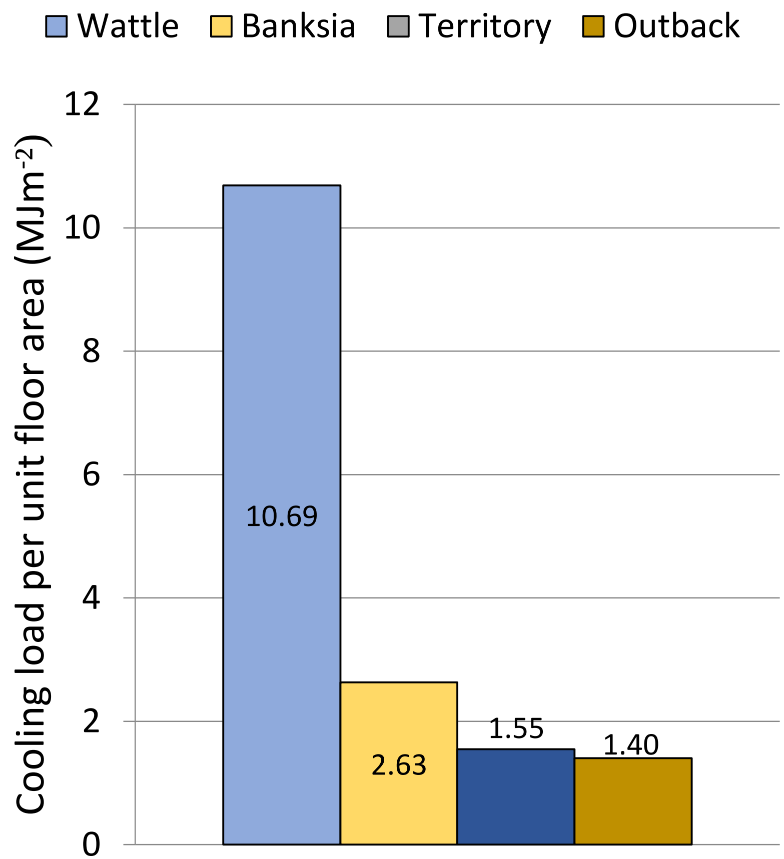
Annual Heating and Cooling load



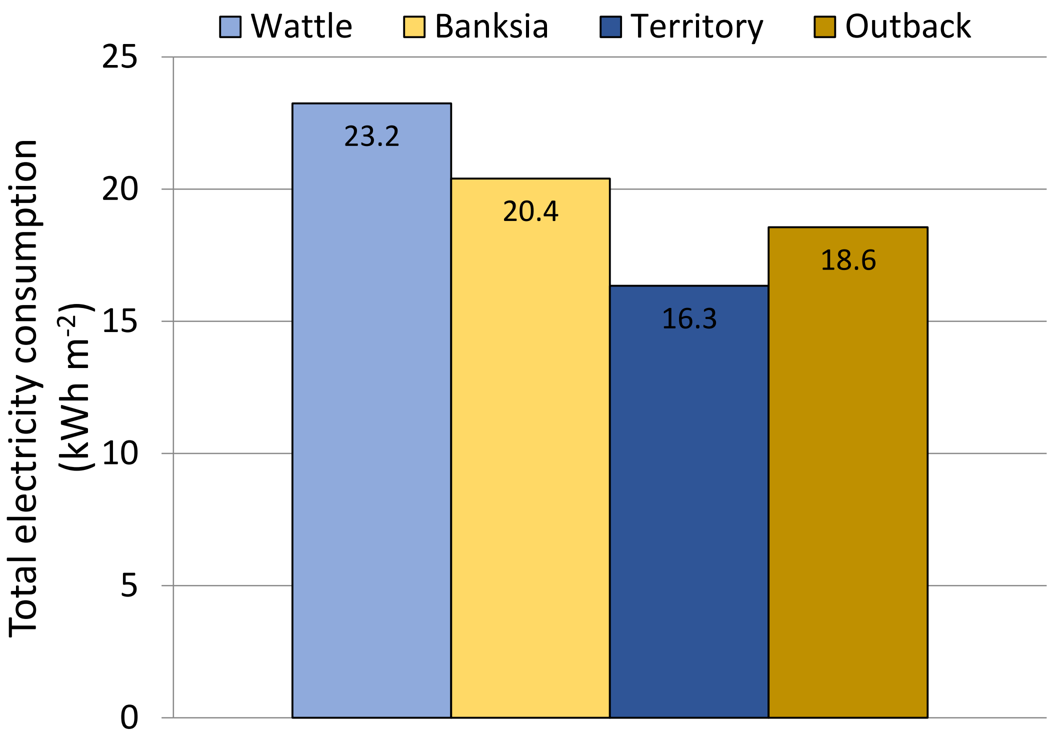


Heating and Cooling load per unit floor area





Annual Electricity Consumption



Building	Heat pump model	Heating (kW)	Heating COP	Cooling (kW)	Cooling COP
Wattle	Daikin FFQ25C2 / RXS25K3	3.2	4.00	2.5	4.46
Banksia	Daikin FTXM50P / RXM50P	6.0	4.23	5.0	4.24
Territory	Daikin FTXM60P / RXM60P	7.0	4.07	6.0	3.87
Outback	Daikin FTXS71L / RXS71L	8.0	3.67	7.1	3.41

Conclusions

- In this paper energy performance simulations of four prefabricated modular houses have been carried out using EnergyPlus interface with OpenStudio.
- The results reveal that heating and cooling load of the buildings highly depend on both floor area and window to wall ratio.
- While the energy required for heating showed increase in buildings with larger floor area, the cooling load followed a different pattern that indicated the impact of envelope parameters.
- The heating and cooling energy per floor area show a decreasing trend with increase of floor area.
- Results also indicate that window to wall ratio has higher impact on cooling load compared to heating load.

Thank you