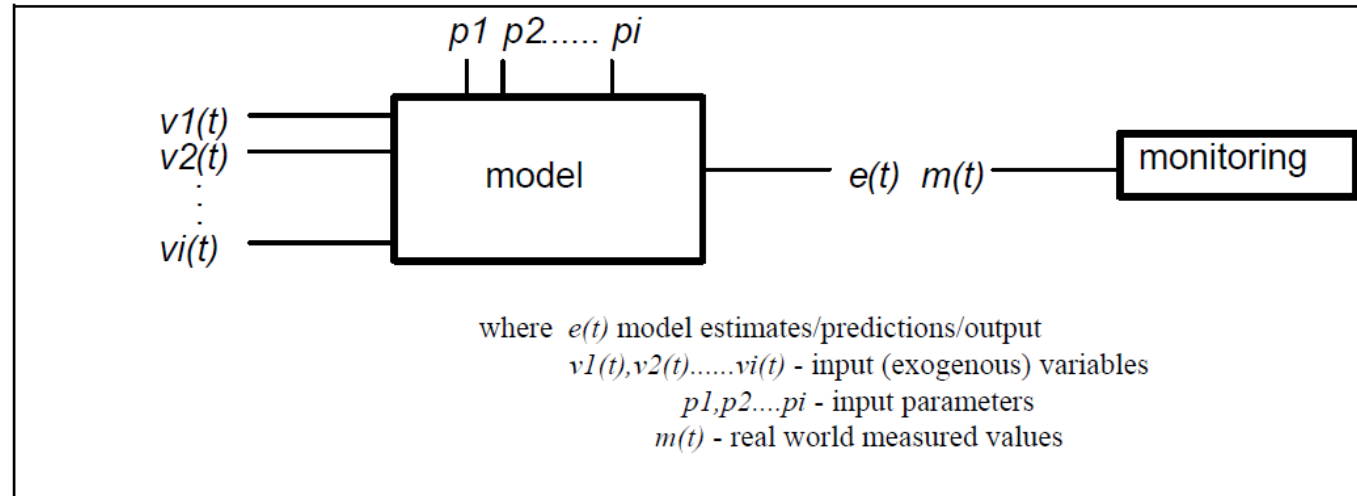


*Empirical validation of house rating  
software predictions and Darwinian's  
thermal comfort thresholds*

Terry Williamson  
The University of Adelaide

**Darwin Home Comfort Rating Forum – March 2023**

A thermal simulation program can be considered a black box model. The model is a computer code describing the complex physics of heat flow, air flow and the occupant use of the building, all of which can vary with time.



- The input parameters ( $pi$ ) include things like the dimensions of the building, the thermal properties of materials, thermostat settings, etc
  - The Input variables ( $vi(t)$ ) include the weather, the occupant use patterns, etc

**Validation is about seeing how close the output  $e(t)$  matches the measured data  $m(t)$**

# Field Validation of *Chenath/AccuRate* software

The question –

*“Can the NatHERS Chenath/AccuRate software reliably predict the temperatures in a range of building types in the Darwin?”*

# Monitoring

We are relying on data collected in Darwin houses during two PhD projects.  
(Sponsored by CSIRO)

- Daniel monitored 20 households (designed to be naturally ventilated) located in Darwin and surrounds including Palmerston and Howard Springs areas, from June 2013 to May 2014.
- During the period March 2020 to February 2021, Damiati, conducted a similar monitoring exercise in Darwin and surrounding areas, that included a number of houses in the Palmerston, Howard Springs and Wagait Beach areas. In this case 30 houses and 8 apartments were included in the study.
  - In each study the conditions in living rooms and main bedroom were monitored at 30 minute intervals. Included temperature (dry bulb & globe), humidity & air-speed.
- In each study the occupants completed thermal comfort surveys. In 2013/14 ,N=2415 and in 2020/21, N=4996.
- The 30 minute weather data for each study was taken from the BOM station closest to the house. Included temperature, humidity, wind & solar radiation.

# Monitoring Equipment & Comfort Surveys

2013/14



Occupant Identification: A  B  C  D

1. How do you feel?  
 Cold  Cool  Slightly cool  Neutral  Slightly warm  Warm  Hot

2. How would you like to feel?  
 Cooler  No Change  Warmer

3. Are you ...  
 Very Uncomfortable  Uncomfortable  Slightly Uncomfortable  Slightly Comfortable  Comfortable  Very Comfortable

4. What best describes the level of clothing you are currently wearing?

5. What best describes the activity you have been doing in the last 15 minutes?

6. Do you have any windows or doors open for ventilation?  
Yes  No

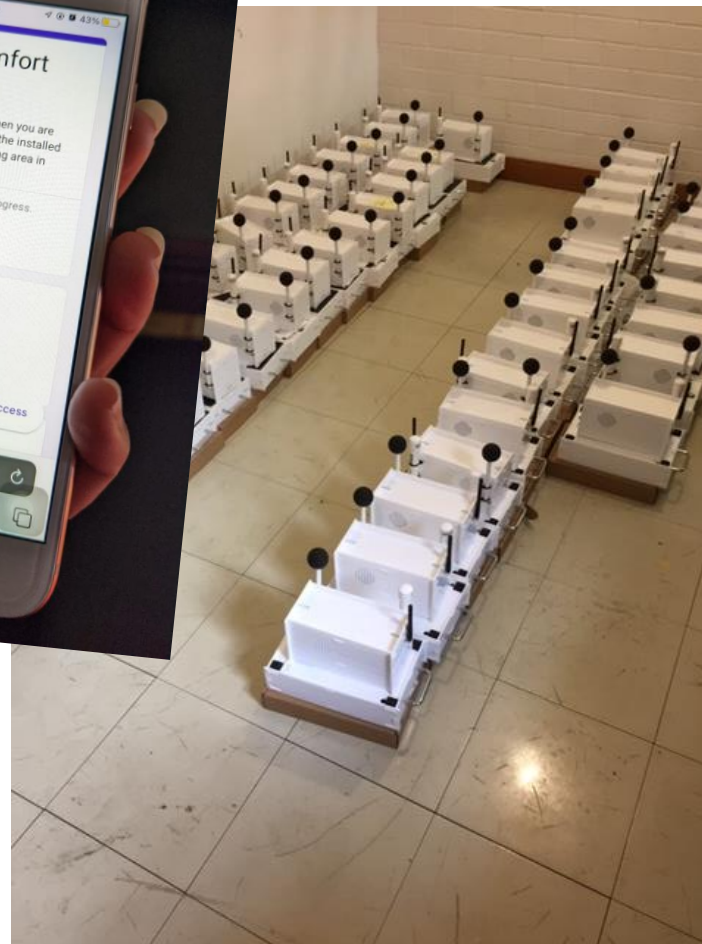
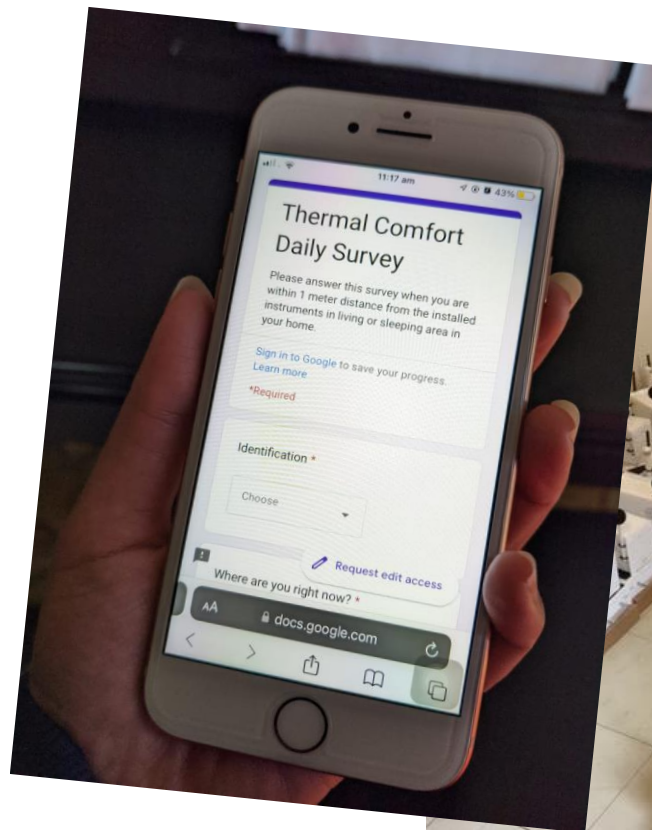
7. Do you have a portable or fixed fans operating?  
Yes  No

8. Do you have artificial cooling appliances operating?  
Yes  No

9. If you reported to be uncomfortable, how would you best describe the source of this discomfort?  
Too Drafty  Too Stuffy  Too Dry  Too Humid   
Other please explain \_\_\_\_\_

Date: / / Time: : am/pm Room:

2020/21





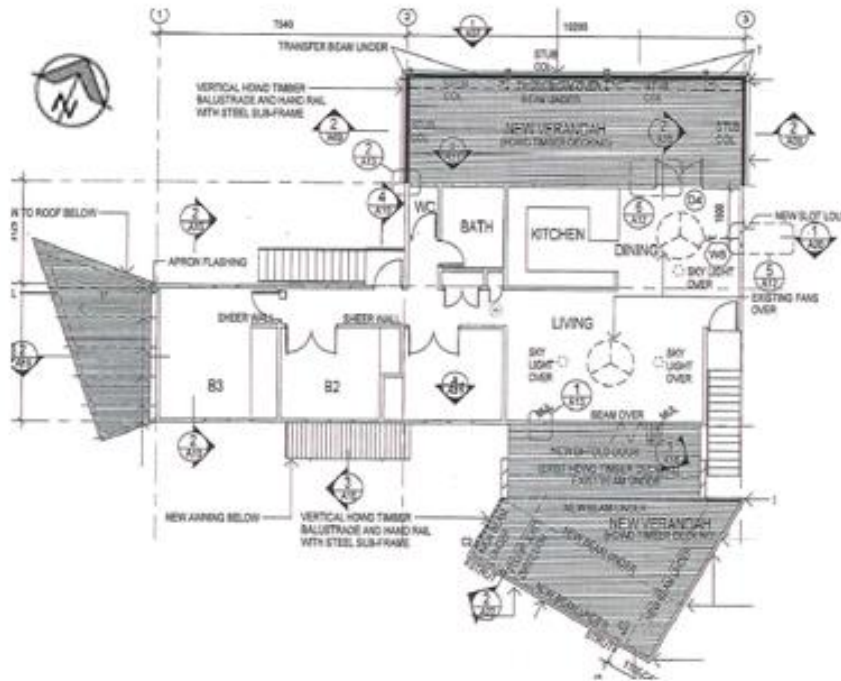
# Some of the Houses Monitored





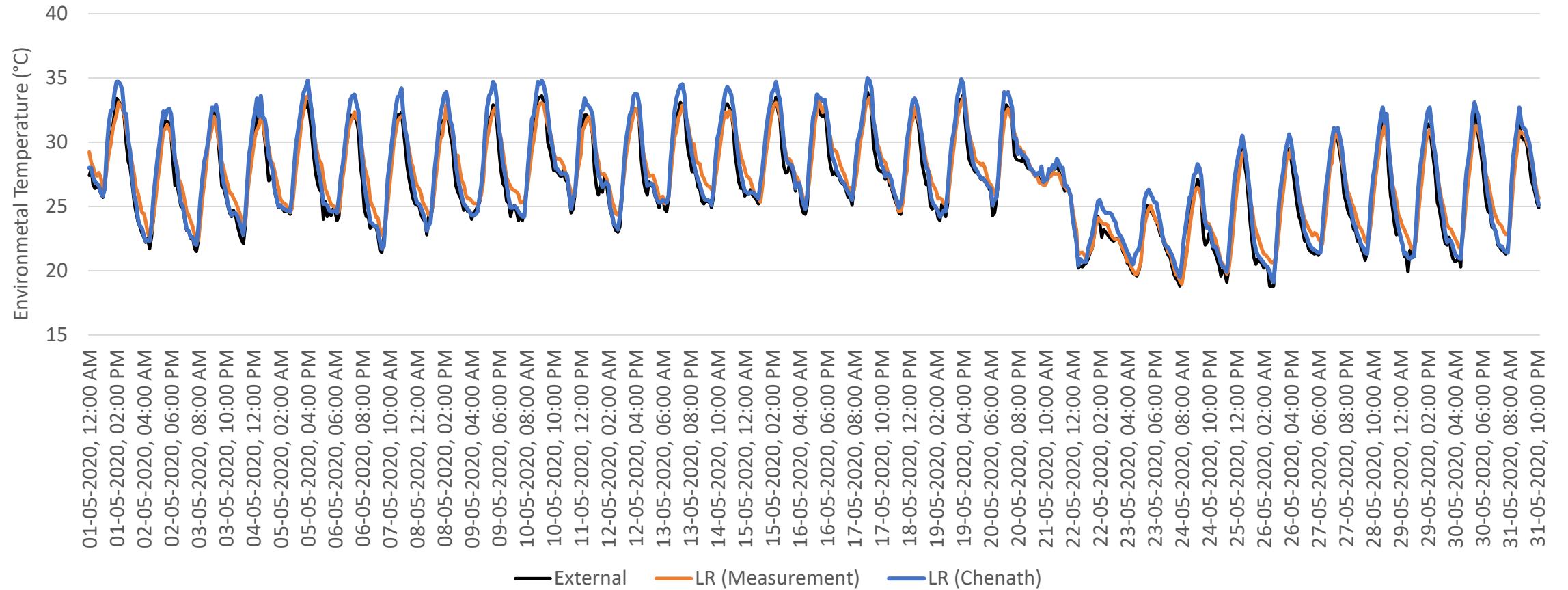
# House 38 – High-set Lightweight

A modified Northern Territory Housing Commission House Type H18. Lightweight construction, louver windows, timber floors. Houses built in this era typically had reflective foil, only, in their roofs and walls.



# House 38 – High-set Lightweight

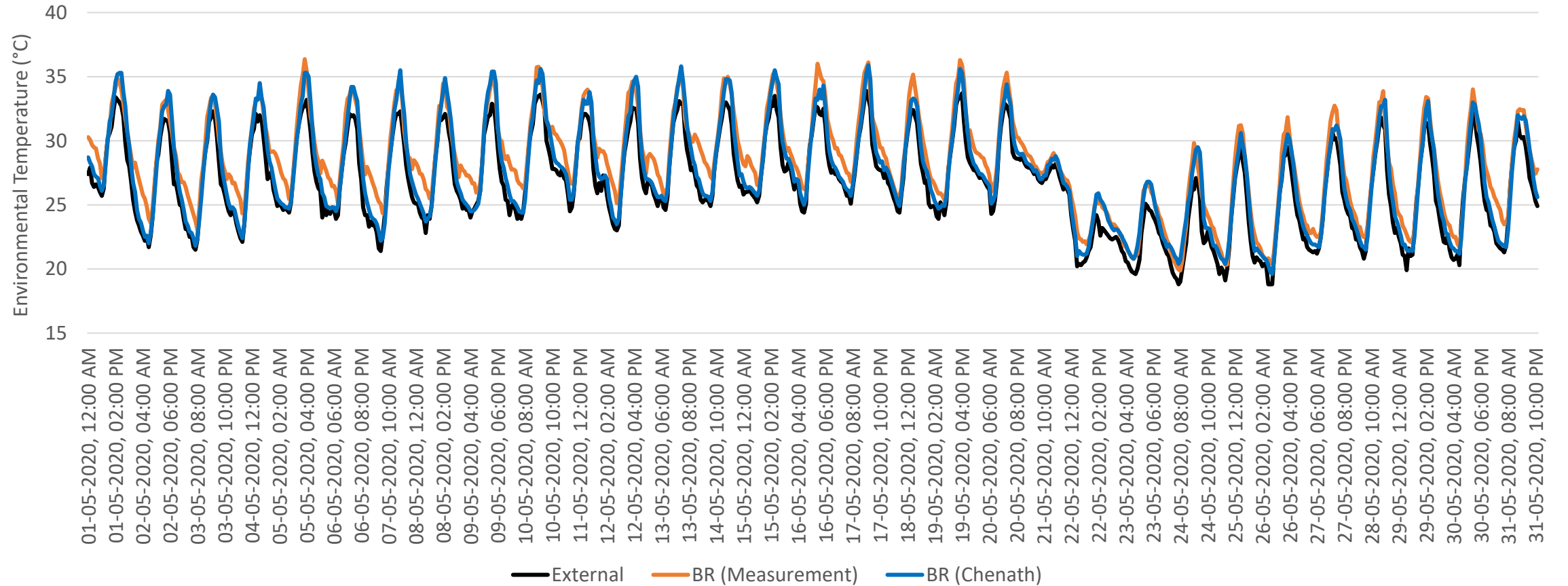
Lightweight - Living room





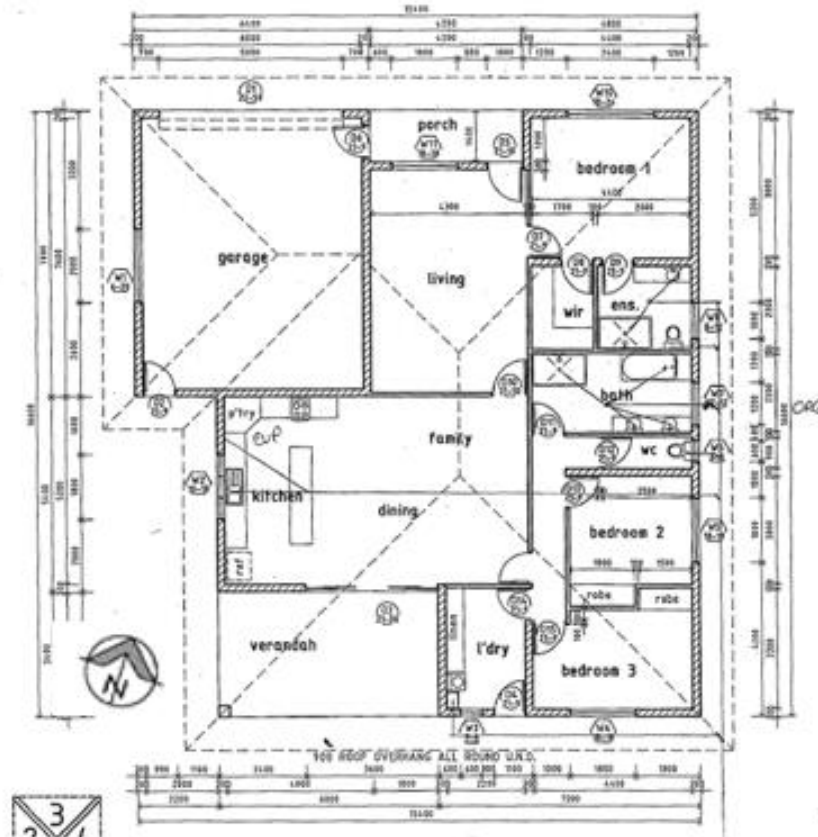
# House 38 – High-set Lightweight

Lightweight - Bedroom



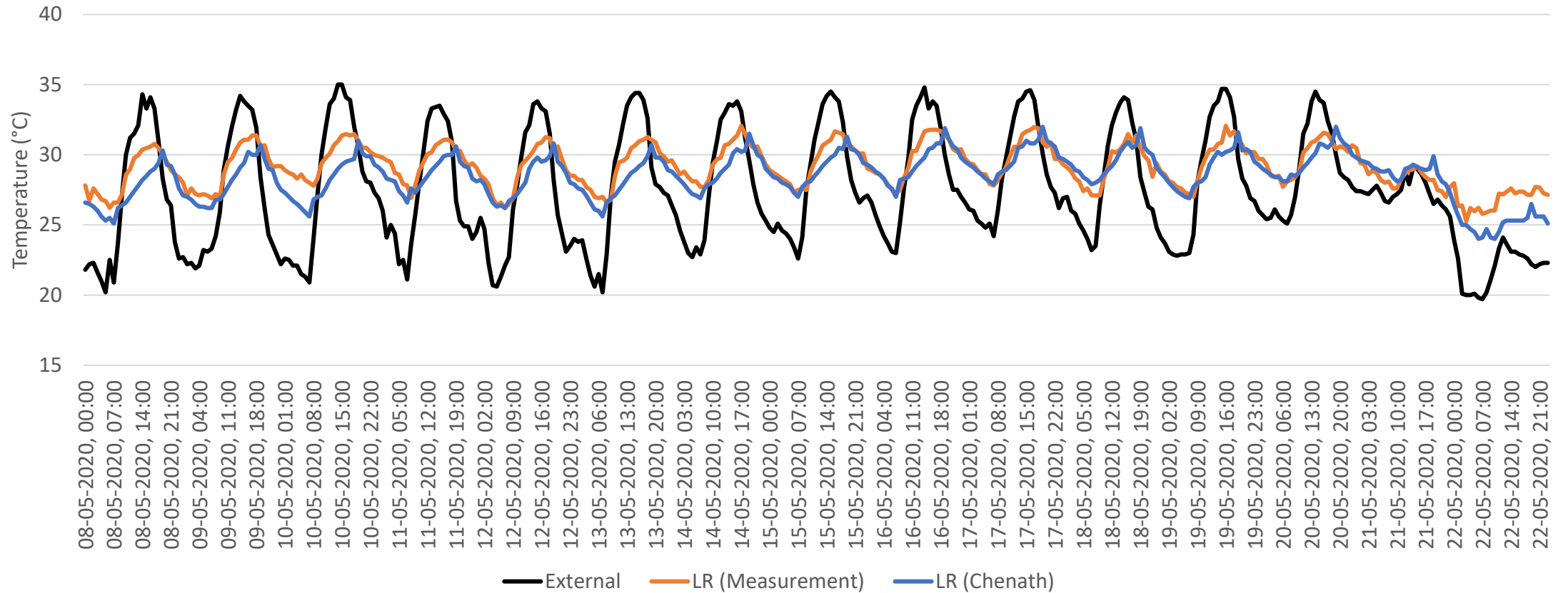
# House 23 – Slab-on-ground Heavyweight

Single level house floor area 162 m<sup>2</sup> (excluding garage and verandah), constructed in 2007 in accordance with BCA requirements. White colourbond steel roof with reflective foil. 190mm Blockwork with no insulation. Aluminium window single glazed tint. Plasterboard ceiling to roof space, no insulation. Concrete slab-on-ground floor.



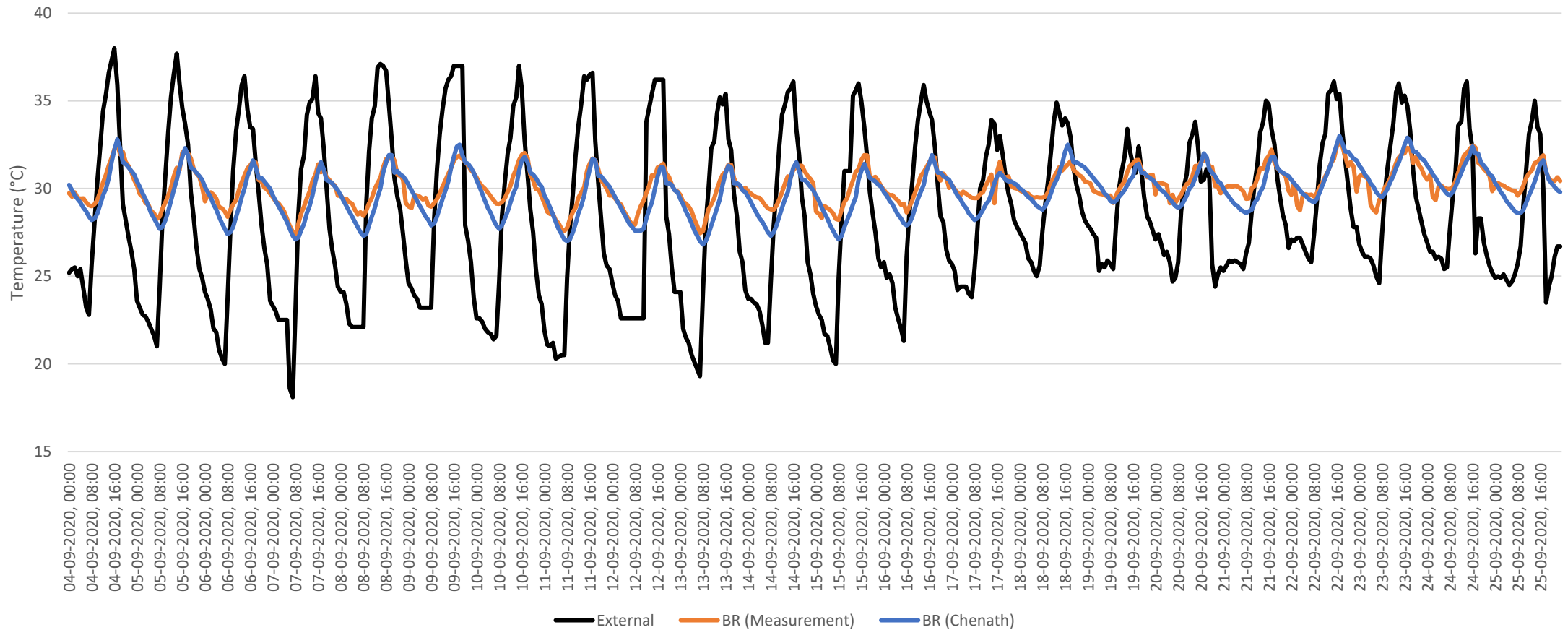
# House 23 – Slab-on-ground Heavyweight

Heavyweight - Living room



# House 23 – Slab-on-ground Heavyweight

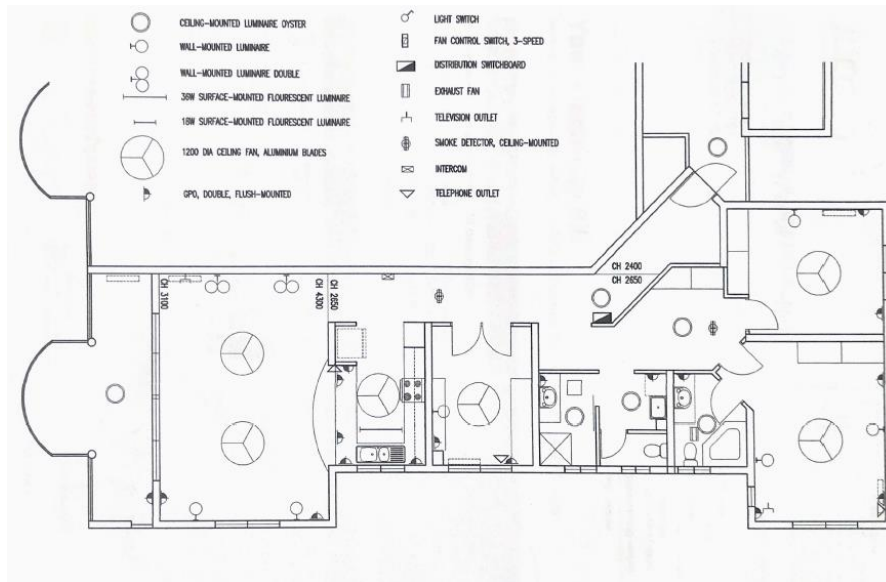
Heavyweight - Bedroom





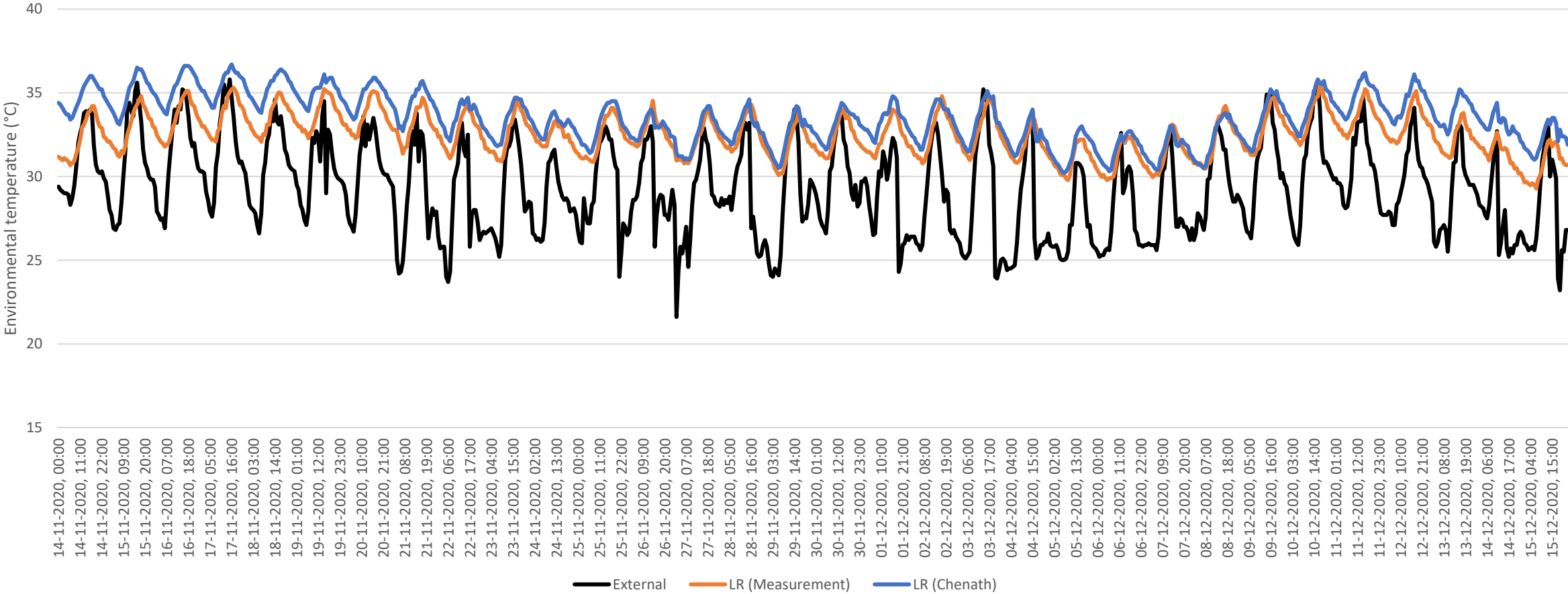
# House 21 – Apartment

The top floor of a 4-storey apartment complex with floor area 131 m<sup>2</sup> consisting of an open-plan kitchen-living area, two bedrooms and a home office. Construction is of concrete, with single glazed sliding door and windows and a North-facing balcony facing the sea. Most of the windows have casement-type internal shading of opaque louvres.



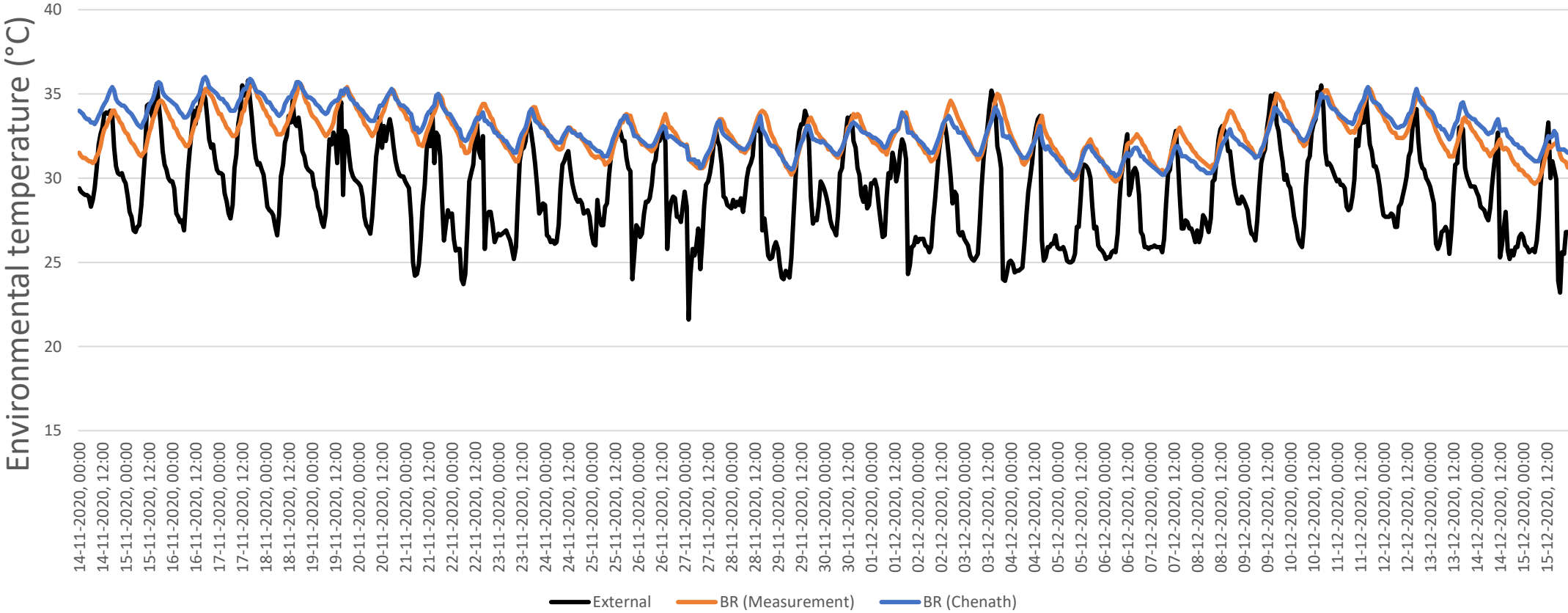
# House 21 – Apartment

Apartment (L4) - LR



# House 21 – Apartment

Apartment (L4) - BR



## Conclusion

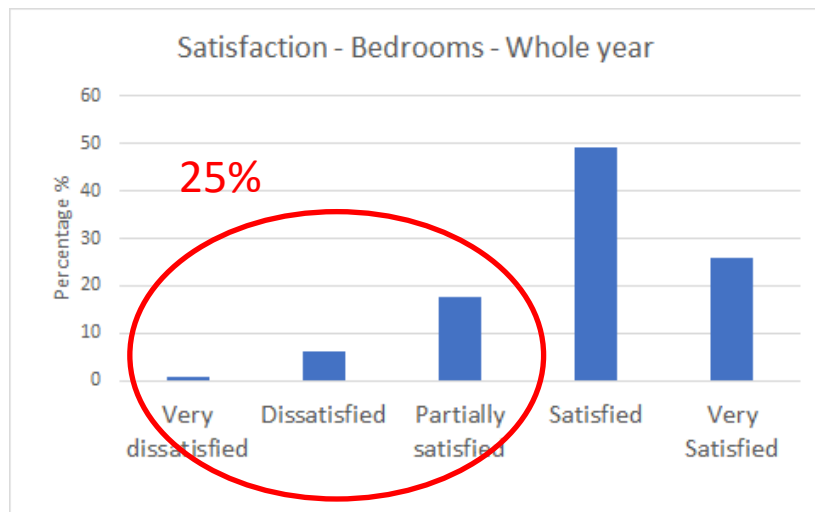
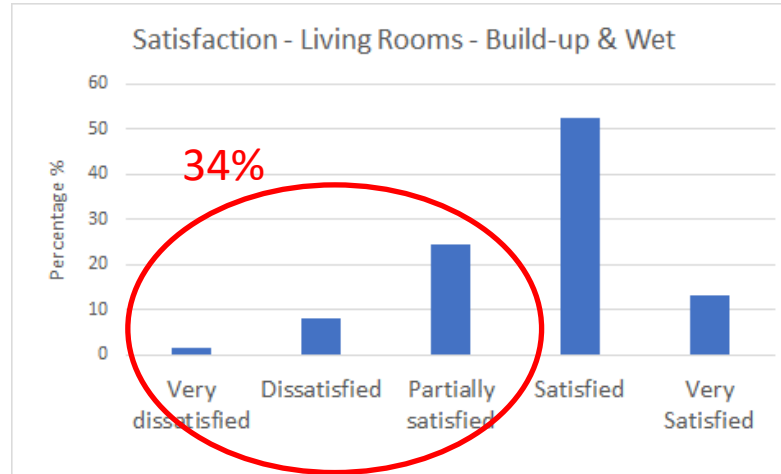
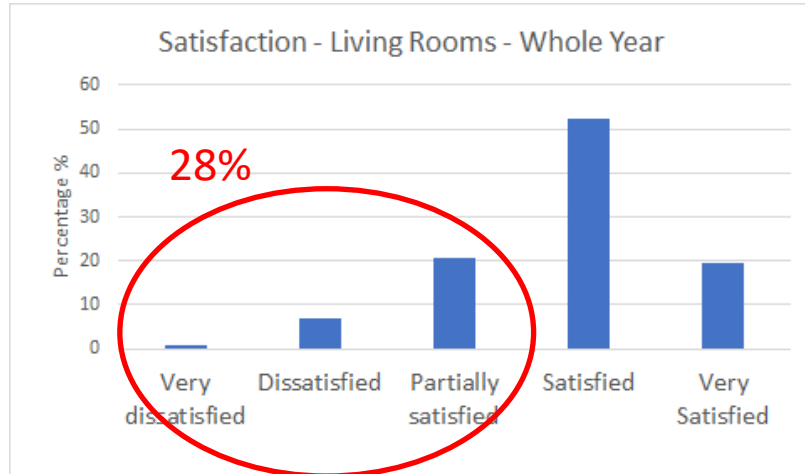
Over a range of Darwin houses the Chenath/AccuRate software provides a reliable estimate of temperatures, particularly when AC is not operating.



# Comfort Thresholds in Darwin

## *Is there an issue?*

*Occupant Survey Question: How satisfied are you with the temperature in this room?*



# Steps in Developing a Comfort Threshold

- Determine the thermal sensations and preferences expressed by occupants.

Related these to internal conditions and monthly mean external temperatures to establish adaptive thermal comfort relationship

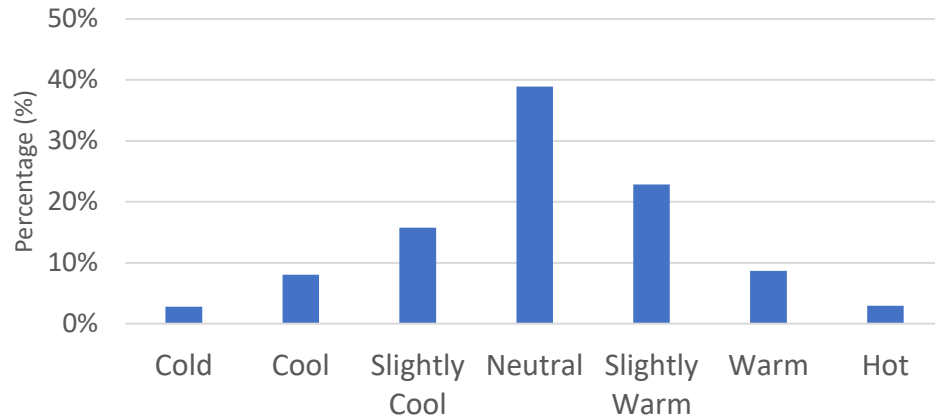
- Determine the cooling effect of air movement.
- Set the comfort threshold at an agreed level of acceptability.  
80% chosen in accordance with international standard recommendations

# Thermal Sensation & Preference

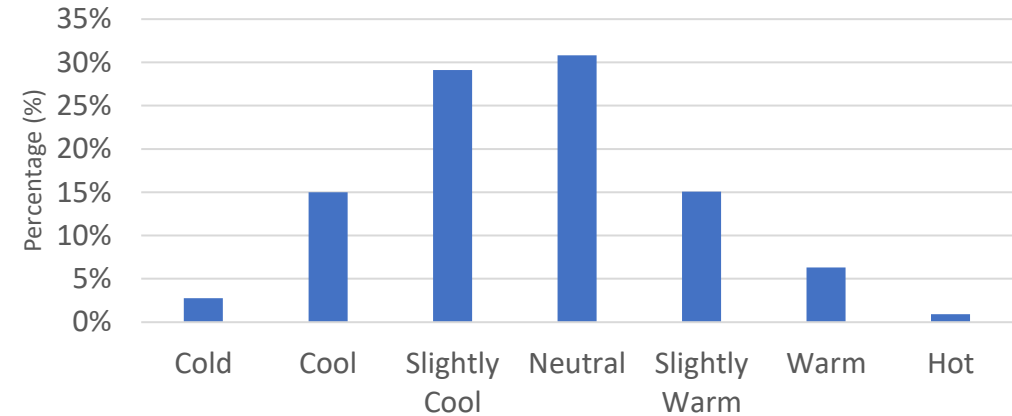
*Occupant Survey Question: How do you feel right now?*

*Occupant Survey Question: How would you like to feel? – warmer, no change, cooler*

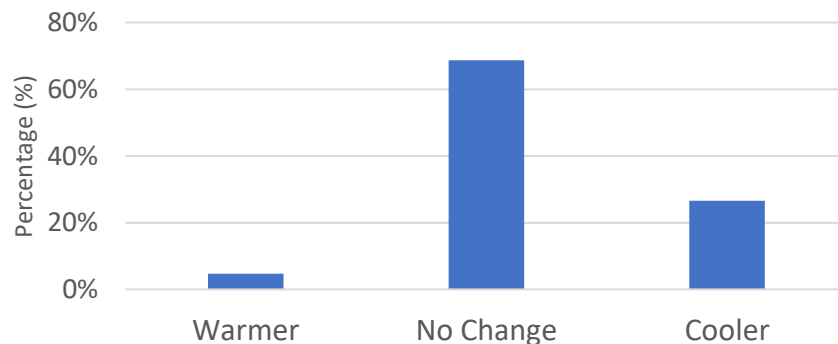
Thermal Sensation - Living Rooms



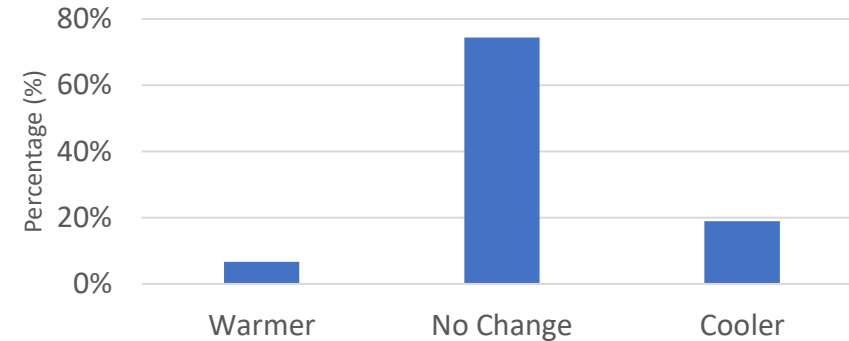
Thermal Sensation - Bedrooms



Thermal Preference - Living Rooms



Thermal Preference - Bedrooms

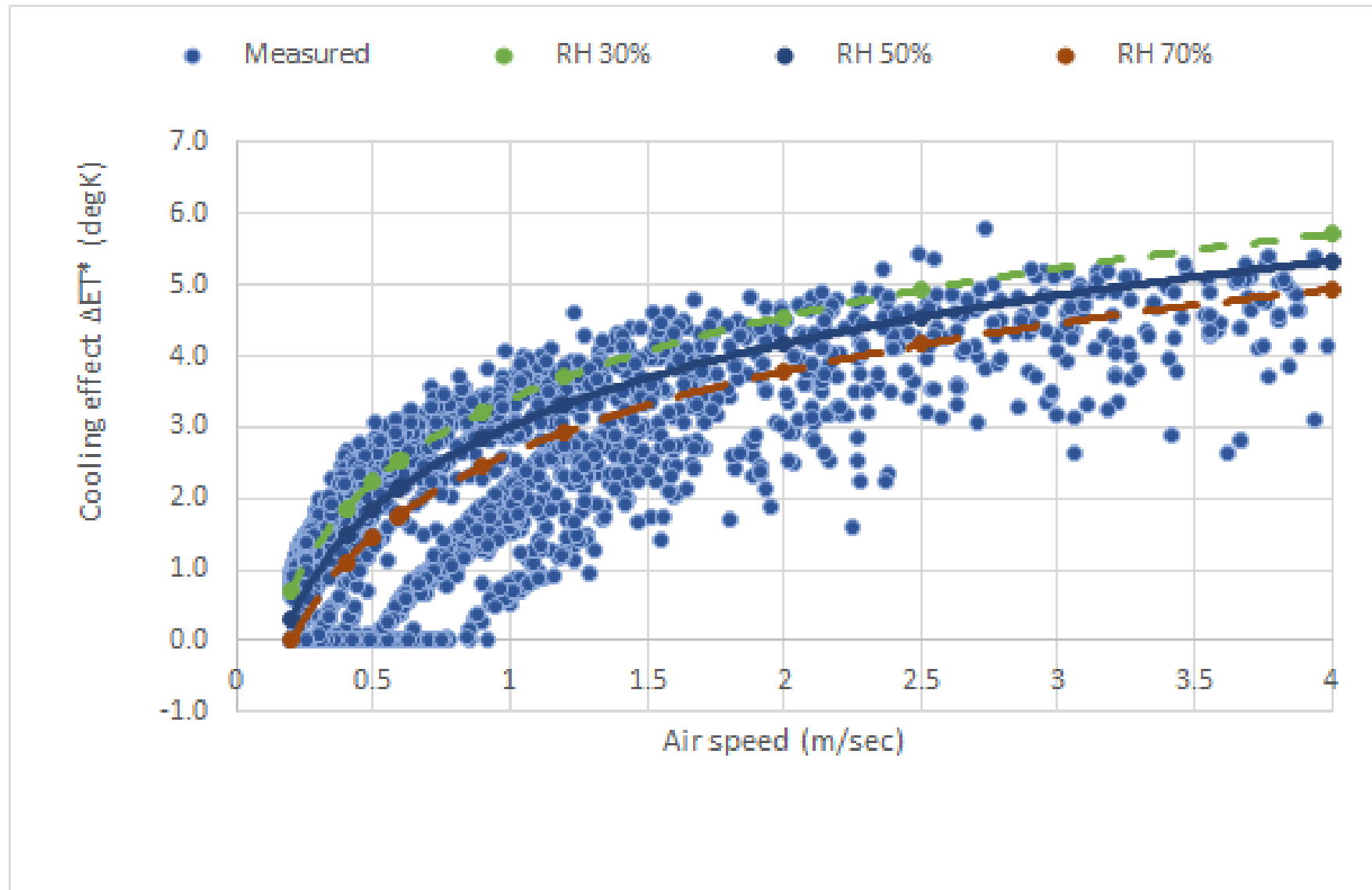


N=2668

N=1188

Note: No AC, Natural ventilation and/or fans only

# Cooling due to air movement





# Expressing the Comfort Thresholds

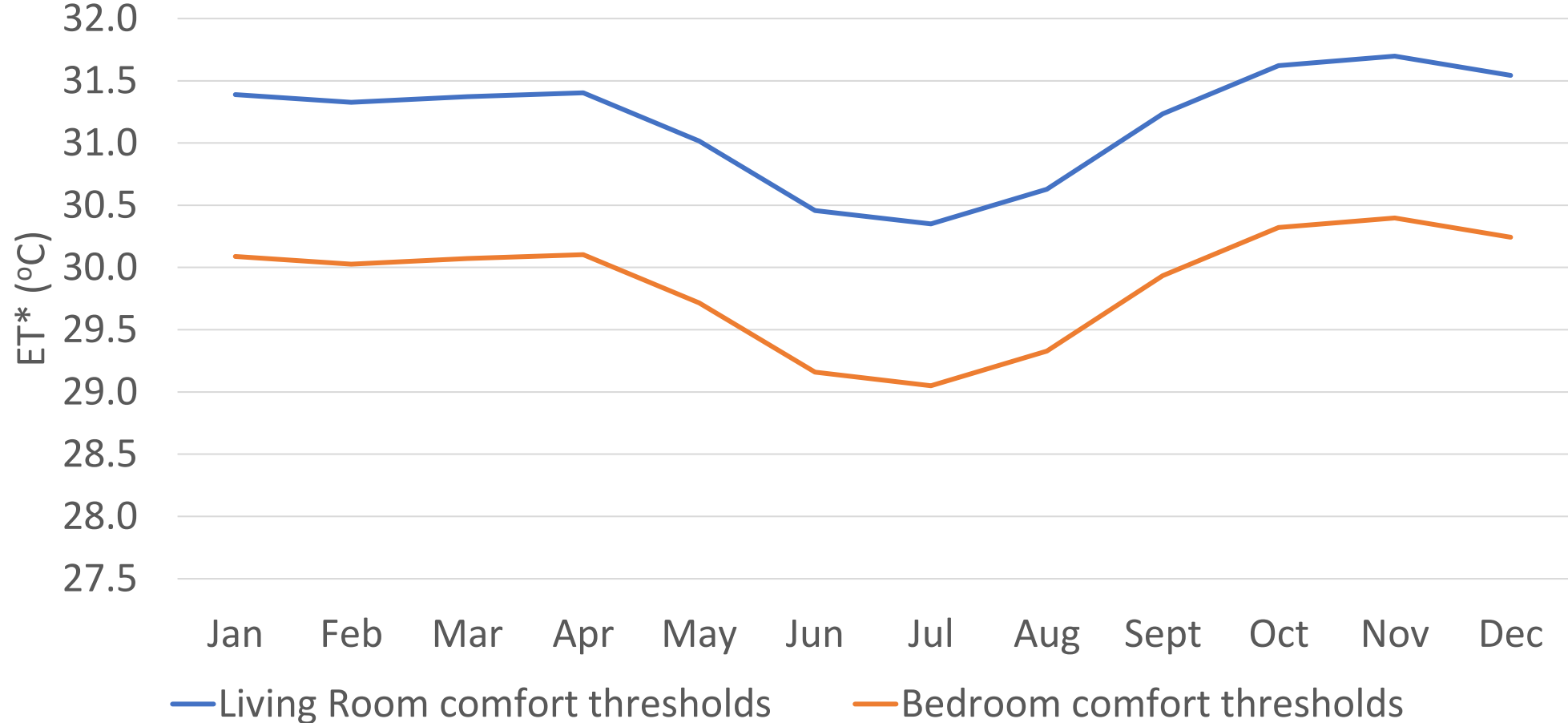
## Living rooms and Bedrooms

ASHRAE Standard 55 adaptive comfort formula used in Chenath/AccuRate software to set cooling conditions.

For consistency, the form of this formula has been applied and 'nudged' to reflect actual comfort conditions recorded in Darwin (using effective temperature  $ET^*$  - a better measure of comfort)

Differences relate to Darwinians' residential conditions such as humidity levels, clothing levels, air movement, etc compared to data used to derive ASHRAE formula

# Derived Monthly Darwin Adaptive Comfort Thresholds (80% acceptability)



Note: Applies to air speeds < 0.2 m/sec

# Thank you

Reference for detailed explanation

Williamson, T. J., Aisyah Damiati, S., & Soebarto, V. (2022). Developing a methodology to assess potential overheating of houses in Darwin. In P. Izadpanahi & F. Perugia (Eds.), *Proc. 55<sup>th</sup> International Conference of the Architectural Science Association, Curtin University, Perth, Western Australia* (pp. 219-229).

[https://www.asaconference2022.com/files/ugd/456bf3\\_b43dc55b5ad34ae2b91f35a321b9a1e0.pdf](https://www.asaconference2022.com/files/ugd/456bf3_b43dc55b5ad34ae2b91f35a321b9a1e0.pdf)

**Acknowledgements:** Thank you to the 108 Darwin residents who allowed access to their houses and provided data for these projects. Thank you to PhD students Dr Lyrian Daniel & Siti (Mia) Damiati. The funding for the PhD research projects received from CSIRO.