CHARACTERISING THE UNCERTAINTY OF A FIXED COP CALCULATION

(with applications to a residential HVAC study)

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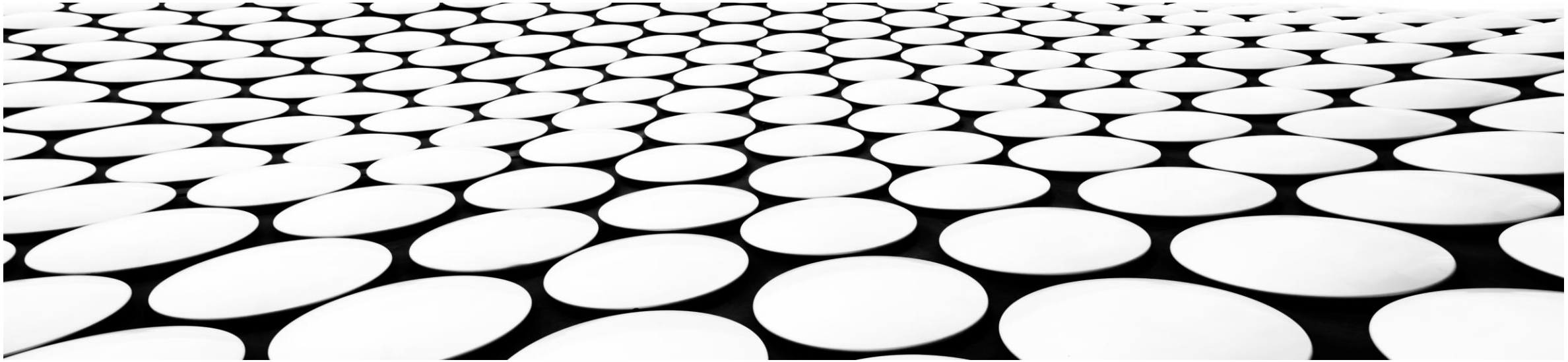
MOMENT

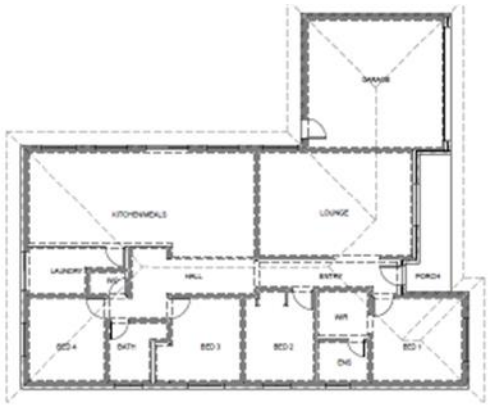
Hubble



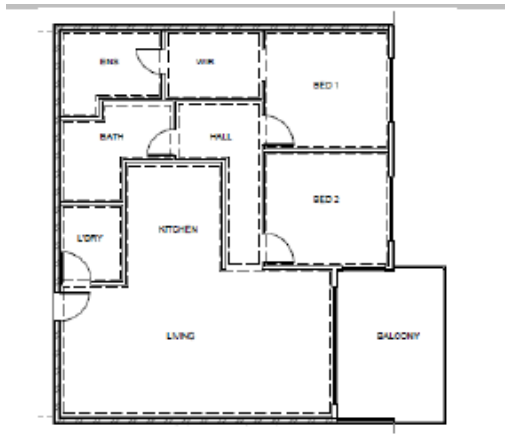
A presentation to the 2024 Australia-Pacific Solar Research Conference (APSRC2024)

MOTIVATION

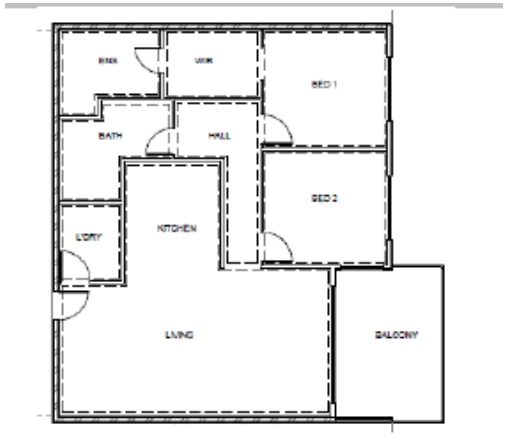
- “Electrifying everything” increases the need to understand the performance of refrigerant-based appliances
- Parametric simulation can tell a lot about the performance of building fabric, but the integration of HVAC systems in modelling adds a significant layer of complexity
- Integrated models require remodelling if the HVAC specification changes
- Simplified models of building fabric (vis NatHERS/CHENATH, among others) can provide an hourly heating/cooling load profile, which we can apply to a dynamic HVAC performance calculation (along with ambient conditions)
  - -> but again, HVAC specification changes require a complex post-processing calculation
- We can assume the COP is fixed, but is that valid??



House 100



House 620 East



House 620 West

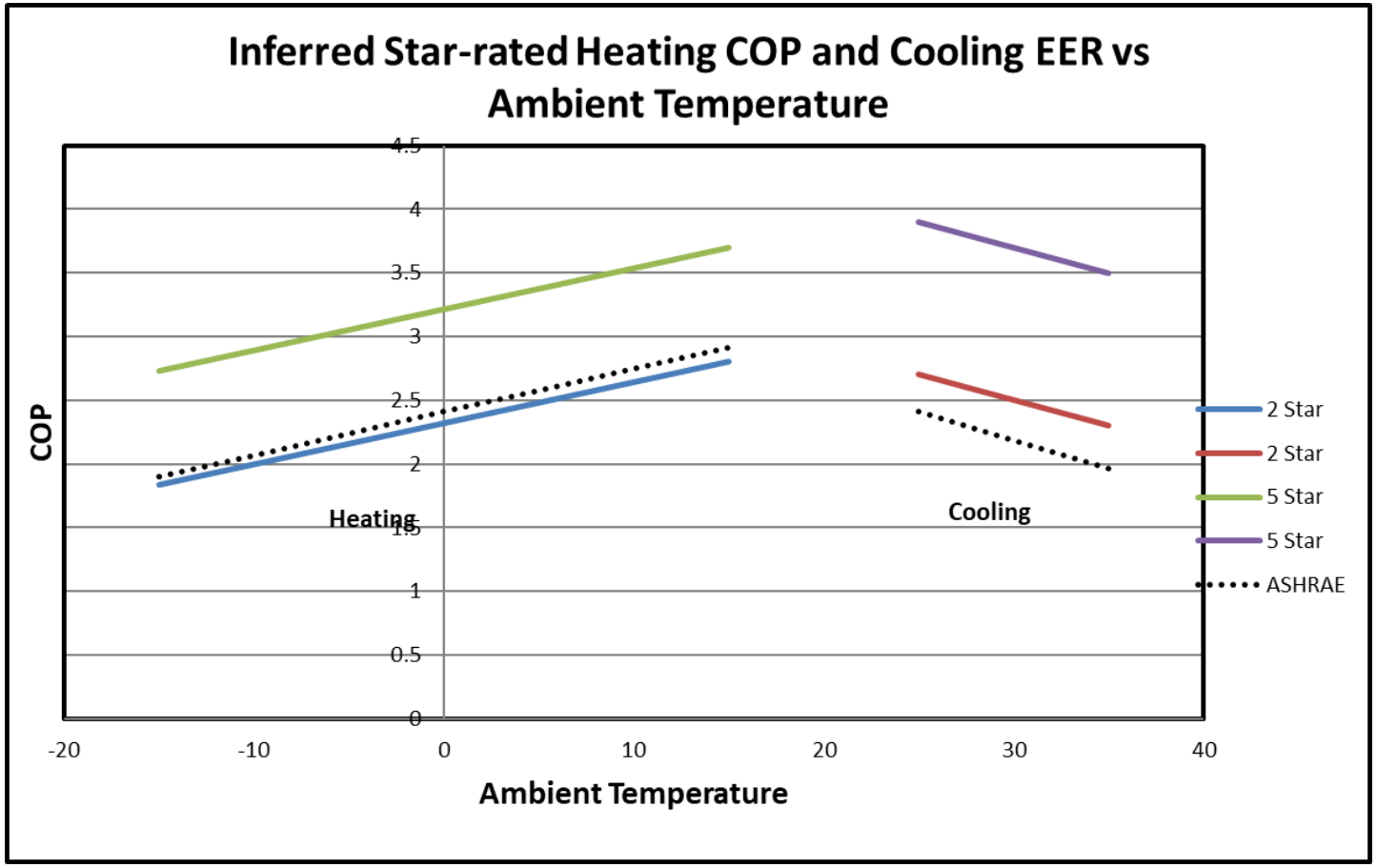
APPROACH:

3 x building models:
- typical (100)
- extreme East (620 W)
- extreme West (620 E)

+variations:
- 2 star/7 star building performance
- 2 star/5star aircon

APPROACH:

HVAC performance: the ASHRAE Model



*With thanks to Trevor Lee and Exemplary Energy

APPROACH:

Pre: Perform parametric simulation to assess building fabric performance and provide hourly heating/cooling load profile

Step 1: Compute the “ground truth” electricity consumption by applying the ASHRAE dynamic model[1] of HVAC performance to the hourly load profile + climate data

Step 2: From the building 100 results, calculate the Seasonal Energy Efficiency Ratio $SEER_{cz}$ (for cooling) and Seasonal Coefficient of Performance $SCOP_{cz}$ (for heating)

Step 3: Estimate the electricity consumption for building 620 in its various orientations by applying $SEER_{cz}$ and $SCOP_{cz}$ to the total annual cooling & heating demand

Step 4: Calculate the errors:

$$cooling\ electricity\ demand = cooling\ energy\ demand \times SEER_{cz} + \partial_C$$

$$heating\ electricity\ demand = heeating\ energy\ demand \times SCOP_{cz} + \partial_H$$

1. 2020 ASHRAE Handbook: Systems and Equipment, American Society of Heating Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia.

APPROACH:

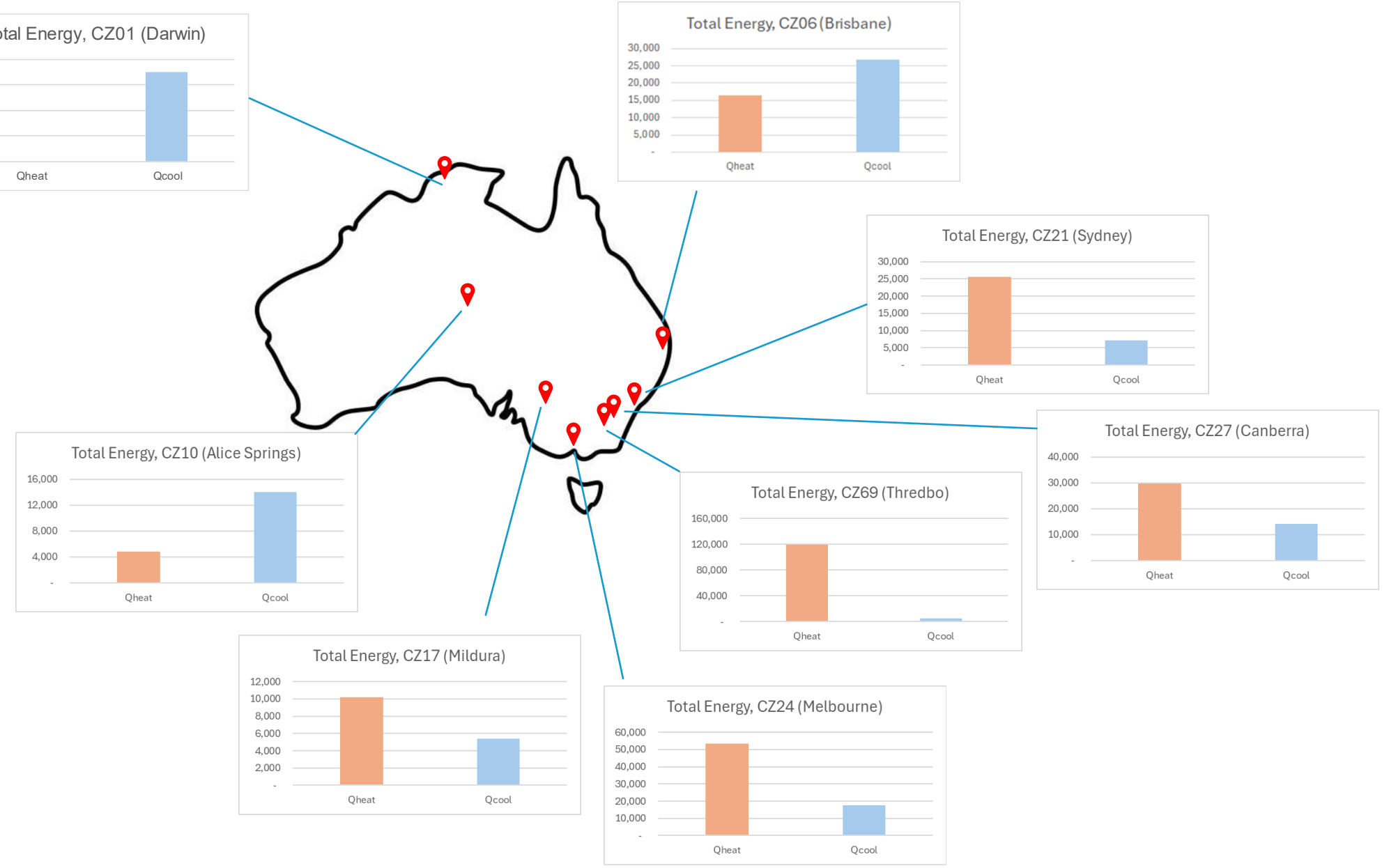
Repeat in:
Darwin
Brisbane
Alice Springs
Mildura
Sydney
Melbourne
Canberra
Thredbo

RESULTS:

- Total Energy
- Performance
- Error

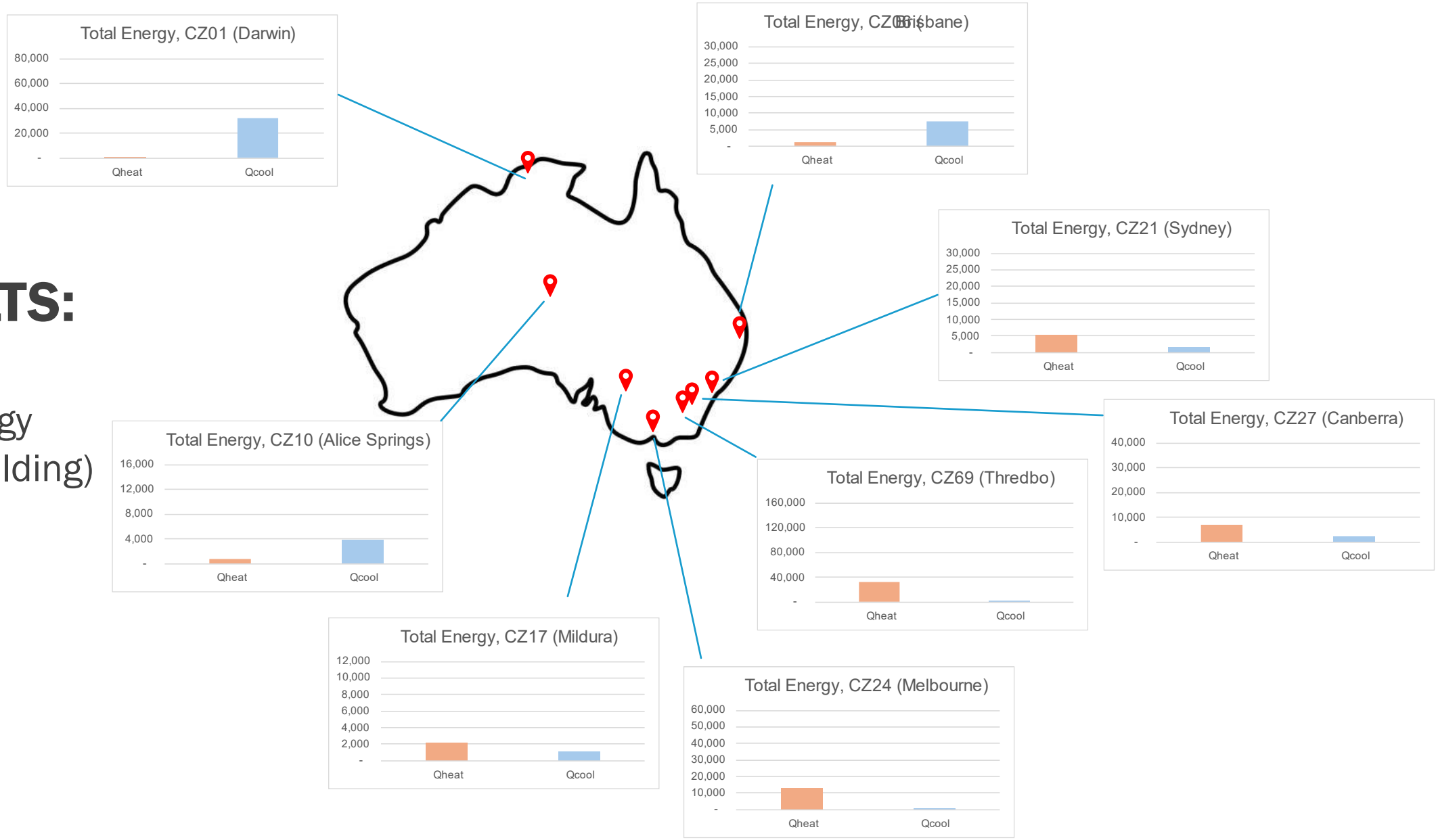
RESULTS:

Total Energy
(2 star building)



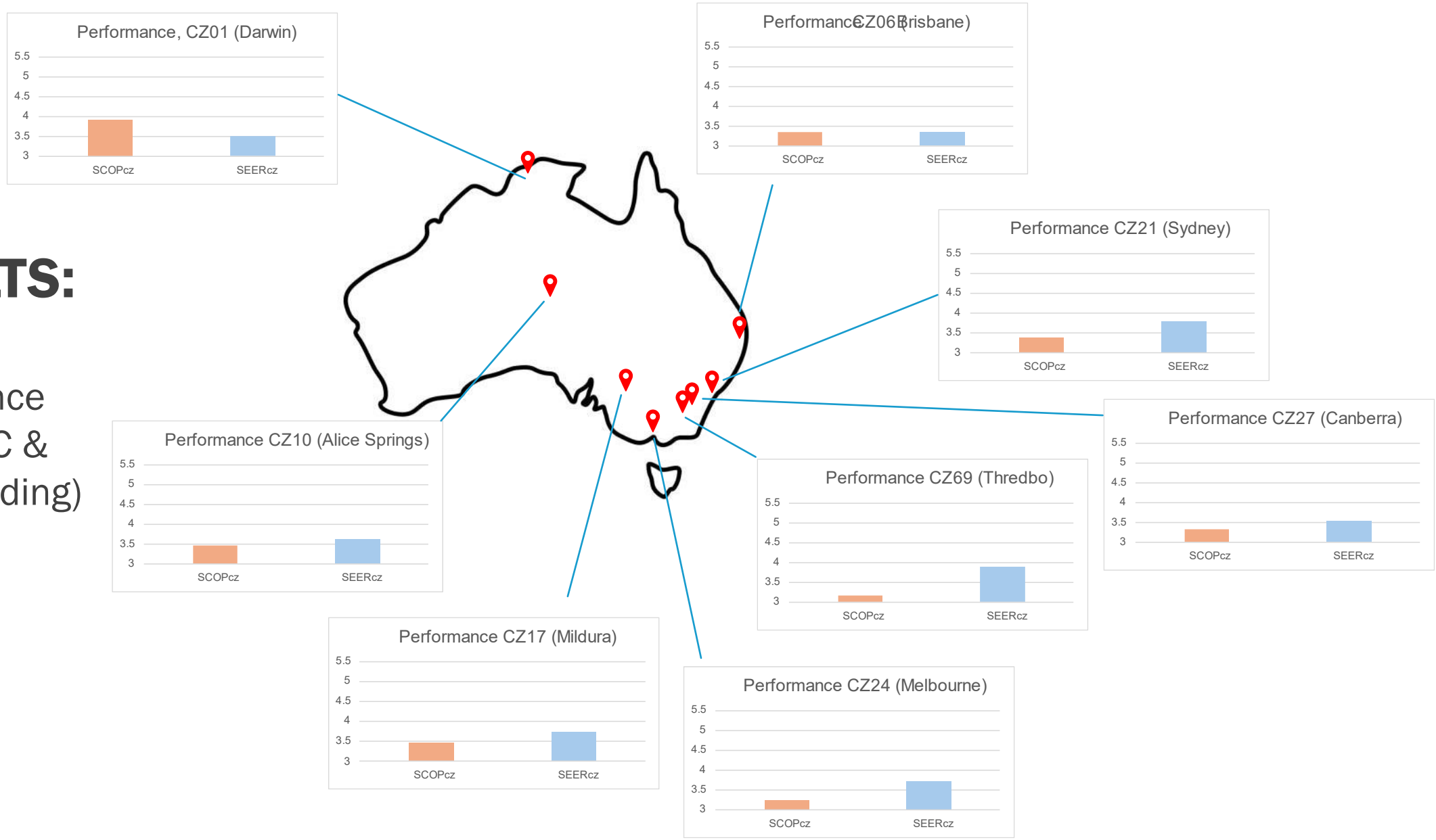
RESULTS:

Total Energy
(7 star building)



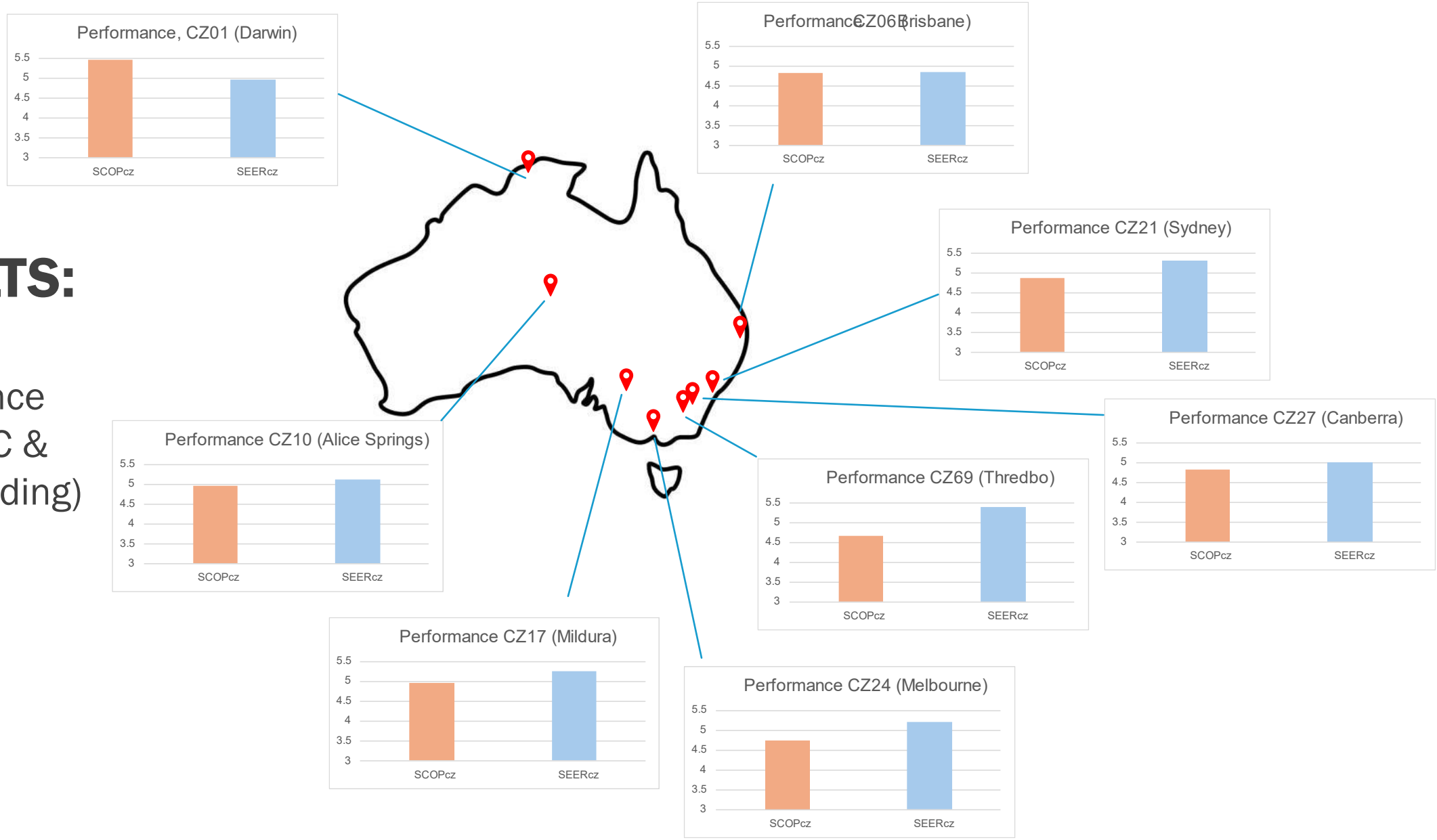
RESULTS:

Performance
(2 star A/C &
7 star building)



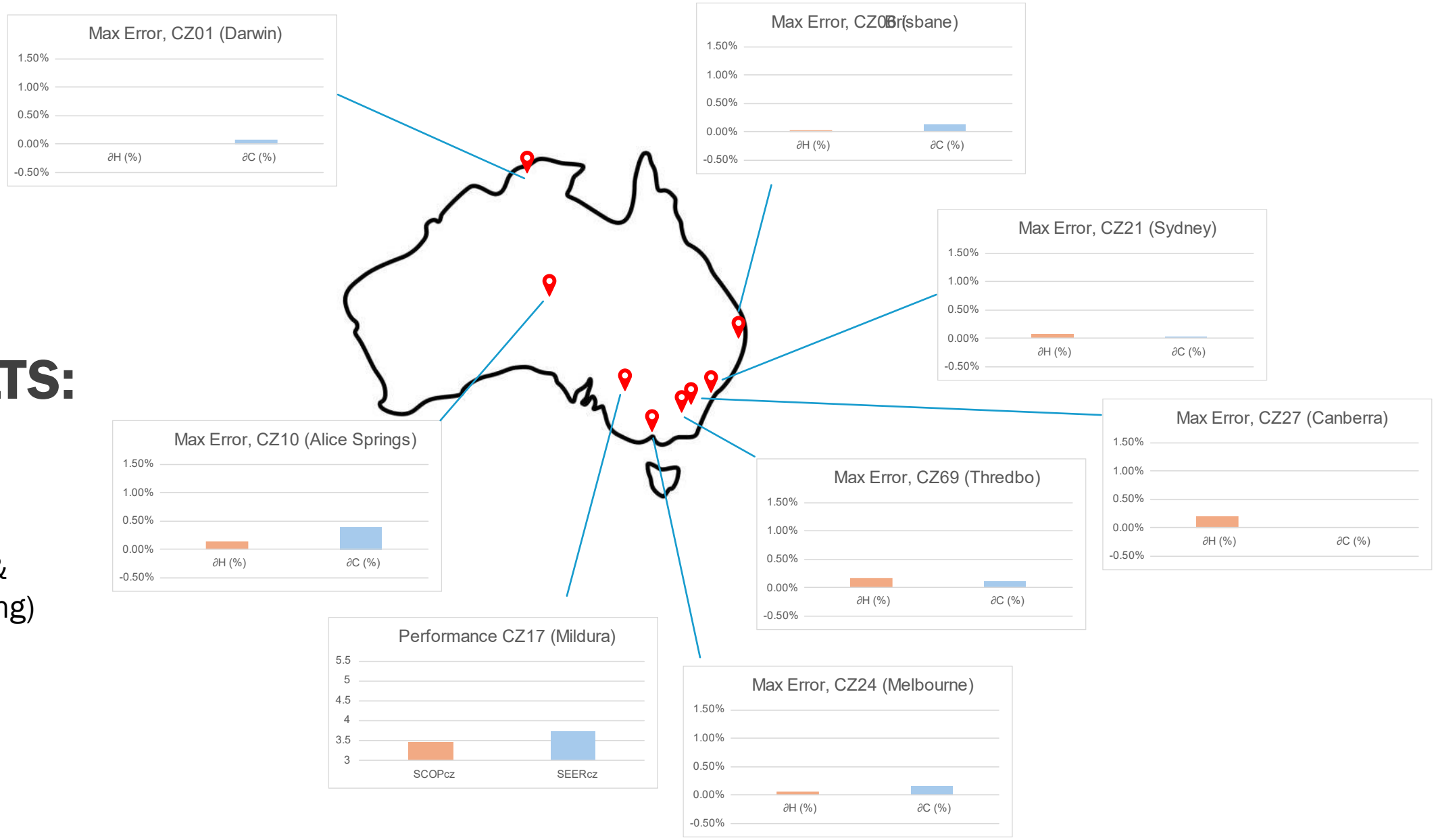
RESULTS:

Performance
(5 star A/C &
2 star building)



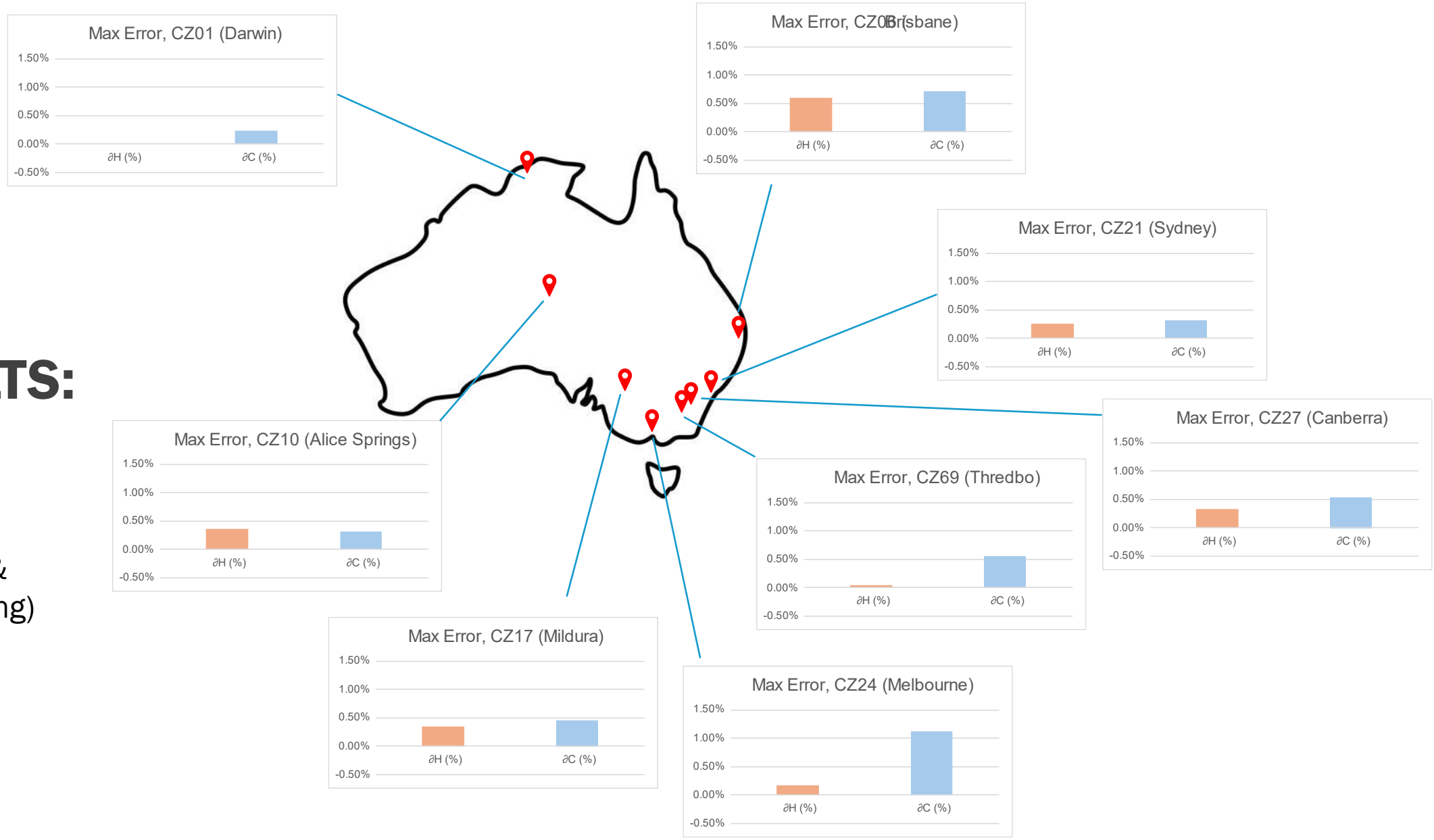
RESULTS:

Max Error
(2 star A/C &
2 star building)



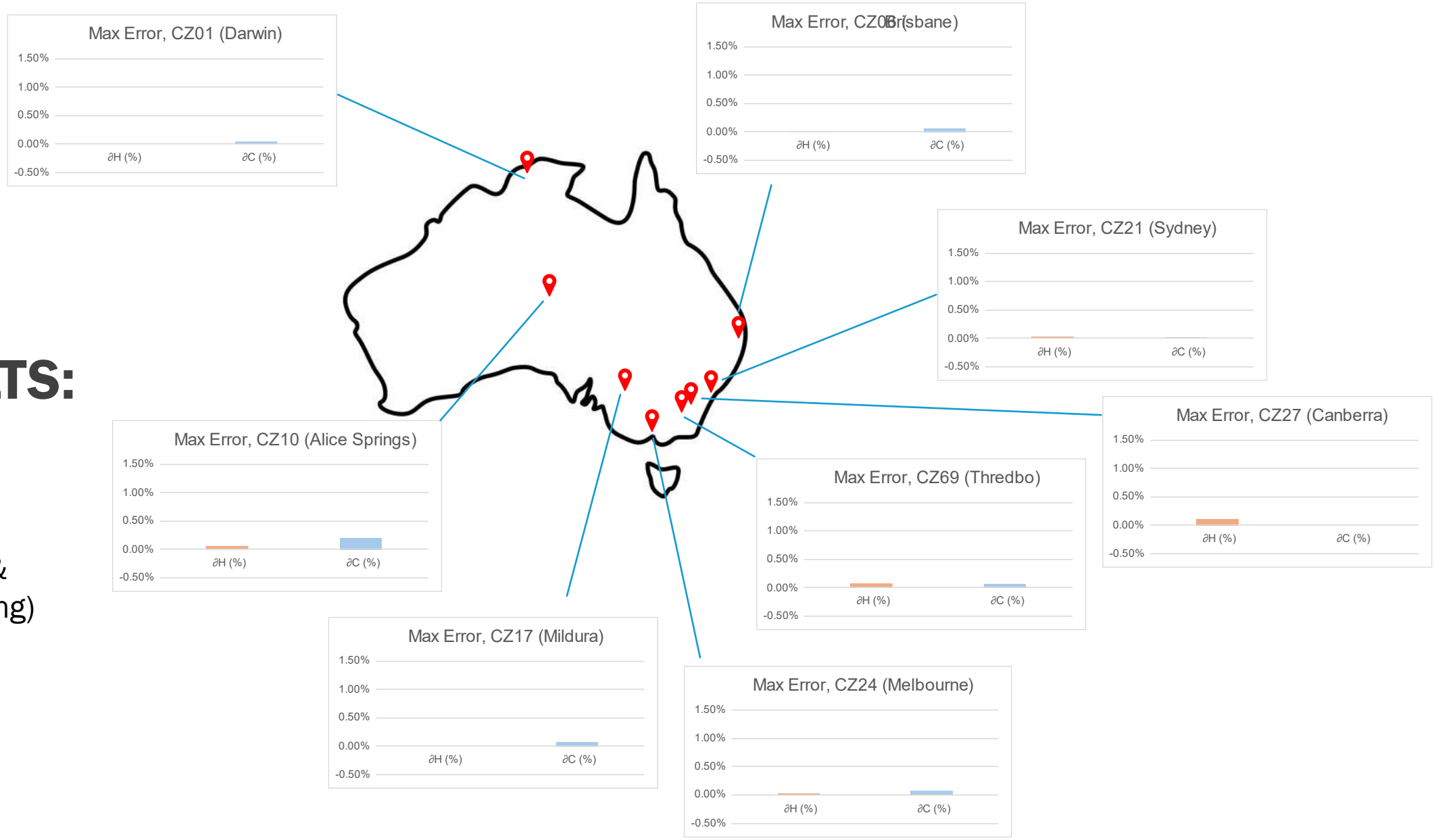
RESULTS:

Max Error
(2 star A/C &
7 star building)



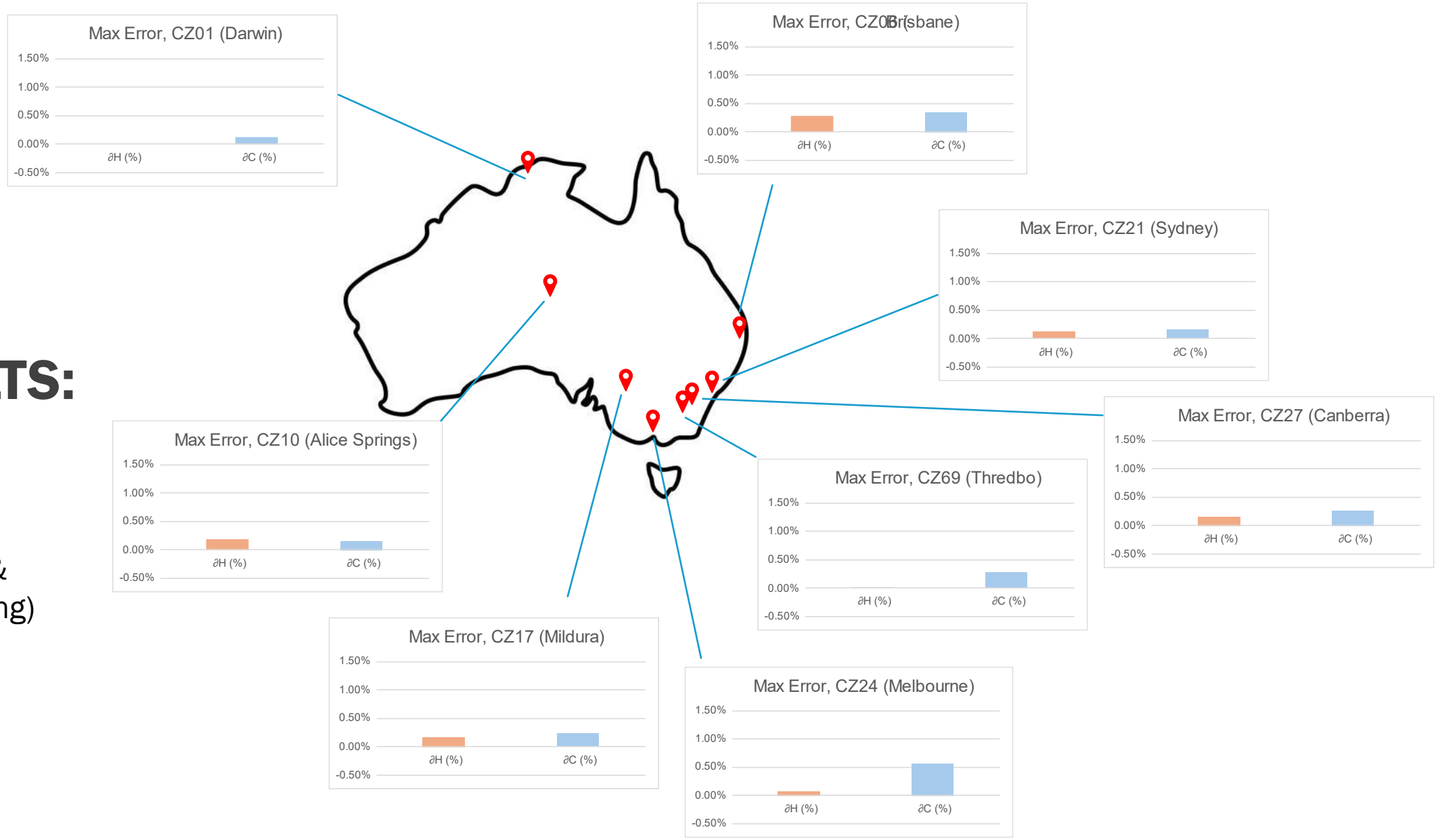
RESULTS:

Max Error
(5 star A/C &
2 star building)



RESULTS:

Max Error
(5 star A/C &
7 star building)

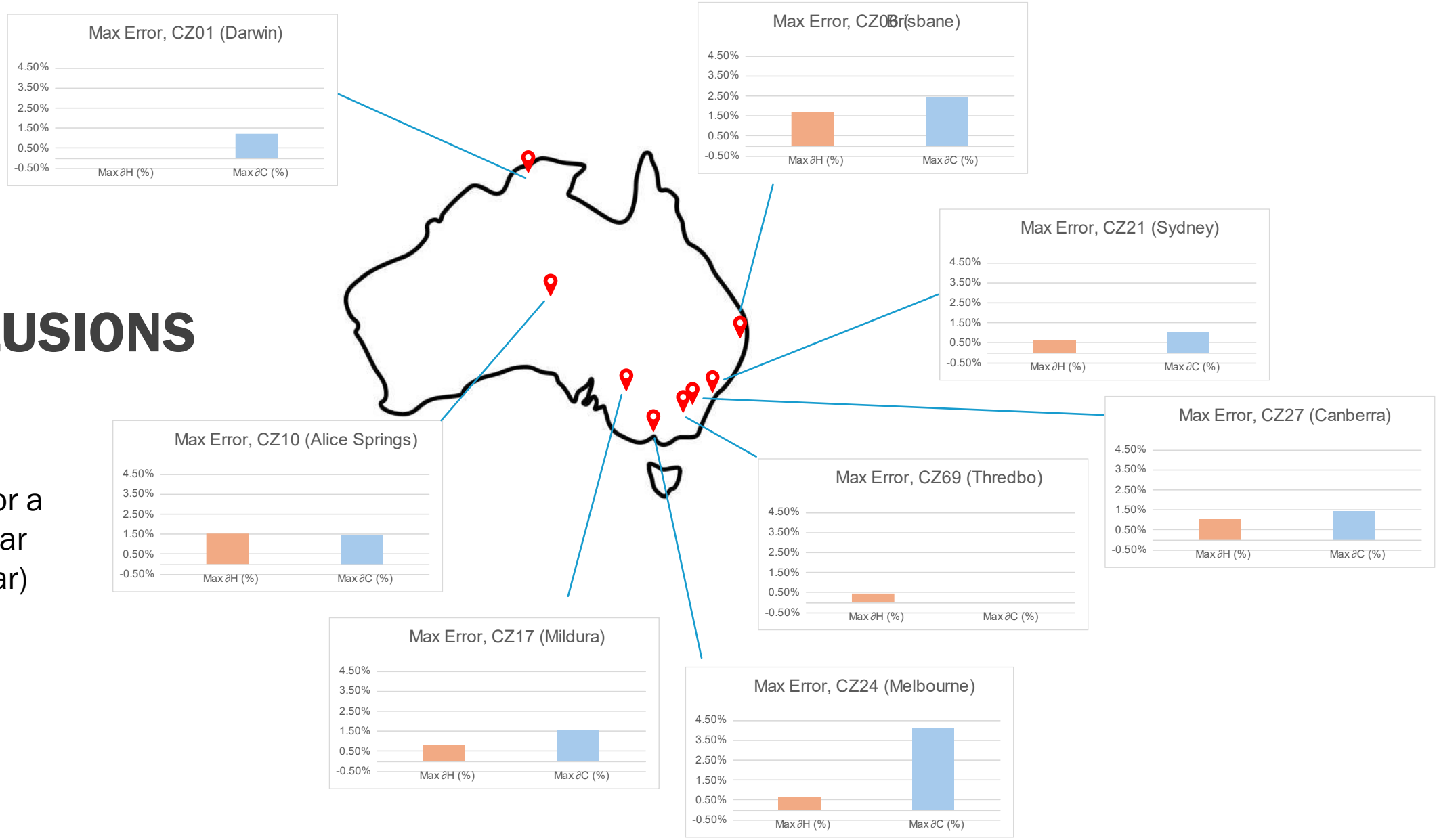


CONCLUSIONS

- Problem statement: If we know the annual heating and cooling load, is it valid to estimate electricity demand by assuming a fixed COP (EER)?
- For most applications, we know the climate zone and we can specify the A/C performance rating
- Within that (slightly broader) constraint:
  - errors are in the order of 1%
  - Maximum error < 5%

CONCLUSIONS

Max Error for a fixed A/C star rating (2 star)



CONCLUSIONS

Max Error for a fixed A/C star rating (5 star)