Prospects of a shift towards passive ventilation solutions to decarbonise commercial buildings in Australia

1 Introduction

- Buildings contribute **23-25%** or ~**133 MtCO2-e** of Australia's total carbon emissions annually with Heating, Ventilation & Air Conditioning (HVAC) responsible for ~**40%** [1]
- This research examines the potential of an underutilised sustainable alternative, **Passive** / **Natural Ventilation** (**NV**) in lieu of HVAC only systems, to decarbonise Australian non-domestic buildings.
- **Building Energy Simulation** (BES) techniques quantify HVAC energy consumption for fully air conditioned and mixed mode buildings located in Sydney, Melbourne and Brisbane (SMB), using Typical Meteorological Year (TMY) and **future weather** files.
- A review of relevant literature suggests future weather files have not been used to model mixed mode Australian commercial building performance and the impacts of air quality are not fully understood.

2 Objectives & Methodology

- Model **energy & CO_2** of air conditioned and mixed mode (NV) buildings in SMB for TMY, 2030 & 2050 climates.
- Estimate impact to NV operation from environmental factors including; **bush fires** & rising **ambient temperatures**.

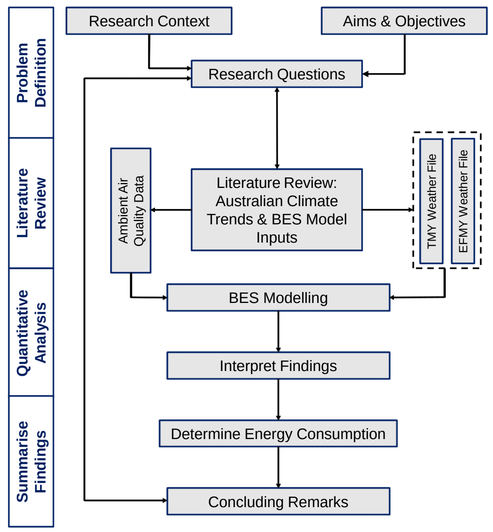


Fig 1. Research Methodology

3 BES Model Approach

2 BES Scenarios & **18** model simulations undertaken:

Scenario	Description
S1 (HVAC)	• **Mechanical only** (Typical solution) • TMY, 2030 & 2050 Weather Files • ASHRAE *Fanger* PMV/PDD
S2 (MM)	• **Mixed Mode** – NV & Mechanical • *Operable Windows* • TMY, 2030 & 2050 Weather Files • ASHRAE 55 Adaptive Comfort

Table 1. BES Model Scenario 1&2 – Overview

Theoretical NV% per climate zone;

$$NV\% = \frac{\sum_{i=1}^{n} h_{NV,i}}{h_{tot}};\ h_{NV,i} = \text{NVhrs},\ h_{tot} = 8{,}760\text{hrs/yr}$$

$$NV\%_{Acceptible}: RH\%_{>20-<80}, T_{out,max=<80\%\ limit}, T_{out,\min=>14°C}$$

BES Model heat balance principle [2] ;

$$\rho C_p V \frac{dT}{dt} = \sum_{i=1}^{n} h_i A_i (T_i - T_{int}) + \dot{Q}_{HVAC} + \dot{Q}_{int} + \dot{Q}_{nv}$$

Heat transfer equation which underpins BES model

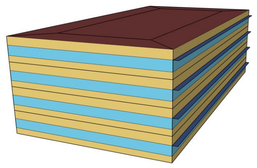


Fig 2. 4-story commercial building render

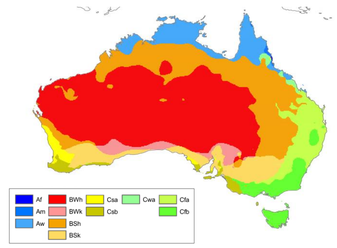
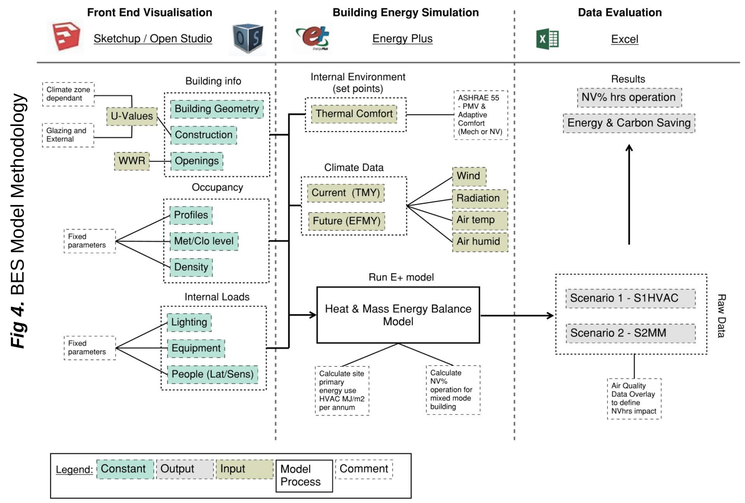


Fig 3. Köppen-Geiger climate map of Australia [3]



4 Results

Fig 5. S1(HVAC) annual HVAC energy consumption (GJ/a)

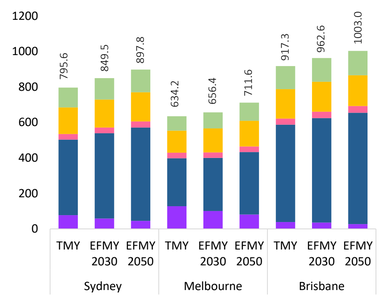


Fig 6. S2 (MM) Annual HVAC energy consumption (GJ/a)

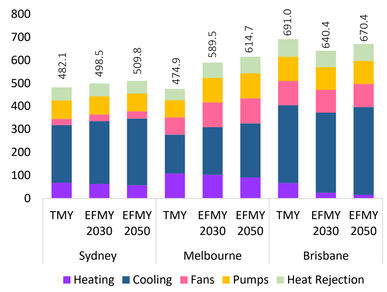


Fig 7. S1(HVAC) & S2(MM) cooling energy consumption (MJ/m²/a)
Cooling energy reductions in the order 35-45% for SMB from S1 to S2

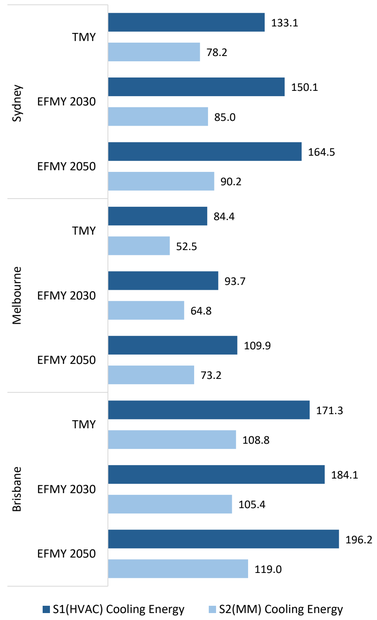
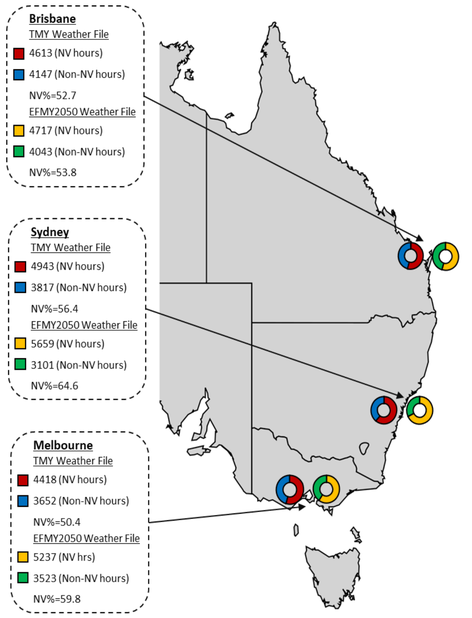


Fig 8. Theoretical *NVhrs* for Sydney, Melbourne & Brisbane -TMY & 2050 weather files
Nv hours increase from TMY to 2050 climate scenarios, improving outlook of NV



5 Conclusion

- SMB climates suitable for NV/MM, whilst maintaining healthy and comfortable internal environments.
- Results show significant reductions in cooling energy consumption for Scenario 2, mixed mode operation.
- 2030/2050 weather files indicate ambient temperatures increasing resulting in an increase to total cooling loads and corresponding energy consumption. Mixed mode ventilation may mitigate the anticipated rise.

6 Next Steps

- Calculate carbon emission savings from Scenario1 & 2 BES model results.
- Estimate impact to NV operating frequency due to deteriorating ambient air quality.

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References

[1] Bond, S. (2010). Lessons from the Leaders of Green Designed Commercial Buildings in Australia. Pacific Rim Property Research Journal, 16(3), pp.314–338.

[2] Tong et al. (2016). Energy saving potential of natural ventilation in China: The impact of ambient air pollution p.10

[3] Peel, M.C., Finlayson, B.L. and Mcmahon, T.A. (2007). Updated world map of the Köppen-Geiger climate classification. , p.36

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