Enhancing Australia's Weather and Climate Data for Energy System and Weather-proofing Simulations

A Temporal Analysis of Meteorological Data and Building Energy Performance

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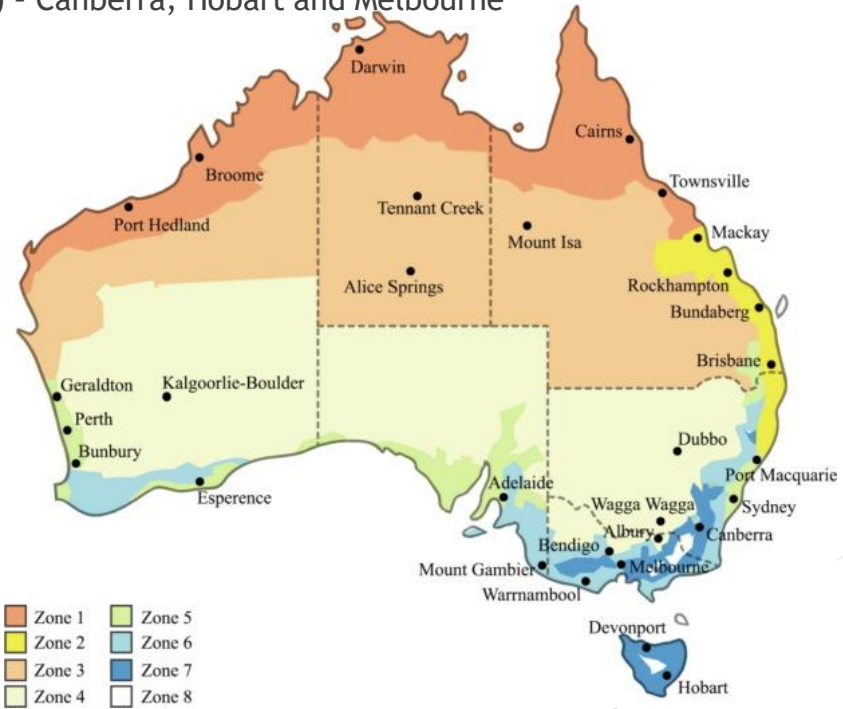
An Overview of the Temporal Analysis

- Trend
  - Australia-wide mean temperature has risen **1.46**°C in **2024** and it is the second warmest year.
  - Eight of Australia's nine warmest years have occurred **since 2013**, reflecting accelerating climate change.
- Existing climate files for simulation
  - Typical Meteorological Year (TMY) from CSIRO (1990-2015).
- Comparison
  - Average of 1990-2015 (CSIRO TMY period) and the recent 15 years (2010-2024) with NCC climate zone classification.
  - Check trend with Dry Bulb Temperature (DBT), Moisture Content (MC) and Cooling Degree Days (CDD/ Based on 18°C).

NCC Climate Zone

- CZ1 & 2 (Humid and Warm areas) – Brisbane and Darwin
- CZ5 (Warm areas) – Adelaide, Perth and Sydney
- CZ6 & 7 (Mild and Cool areas) – Canberra, Hobart and Melbourne



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Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ5)

- Sydney
  - DBT: 0.27℃ increase (0.57℃ increase in January average).
  - MC: 0.34g/kg increase (0.85 and 0.66 g/kg increase in January and March).
  - CDD: 5.95 CDD increase (18.88 and 12.03 CDD increase in January and December).
- Adelaide
  - DBT: 0.23℃ increase (0.62℃ increase in January average).
  - MC: 0.07g/kg increase (0.38g/kg increase in March average).
  - CDD: 3.23 CDD increase (16.95 and 11.62 CDD increase in January and March).
- Perth
  - DBT: 0.4℃ increase (1.07℃ increase in December average).
  - MC: 0.003g/kg decrease (0.33g/kg decrease in May average).
  - CDD: 9.28 CDD increase (19.76 and 31.82 CDD increase in January and February).

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Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ1&2)

- Brisbane
  - DBT: 0.31℃ increase (0.55, 0.67 and 0.63℃ increase in March, July and August).
  - MC: 1.06g/kg increase (1.62 and 1.31g/kg increase in March and August).
  - CDD: 3.76 CDD increase (17.14 and 12.42 CDD increase in March and April).

- Darwin
  - DBT: 0.35℃ increase (0.48 and 0.47℃ increase in March and August).
  - MC:0.29g/kg increase (0.56g/kg increase in April).
  - CDD: 10.6 CDD increase (14.89 and 14.63 CDD increase in March and August).

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Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ6&7)

- Canberra
  - DBT: 0.16℃ increase (0.67℃ increase in January average).
  - MC: 0.29g/kg increase (0.66g/kg increase in January and March).
  - CDD: 2.04 CDD increase (18.02 and 9.01 CDD increase in January and December).
- Hobart
  - DBT: 0.46℃ increase (0.89 and 0.78℃ increase in January and April).
  - MC:0.13g/kg increase (0.34 and 0.33g/kg increase in December and January).
  - CDD: 1.41 CDD increase (7.87 CDD increase in January).
- Melbourne
  - DBT: 0.03℃ increase (0.35℃ increase in January average).
  - MC:0.36g/kg increase (0.74g/kg increase in January).
  - CDD: 0.71 CDD increase (7.29 CDD increase in January).

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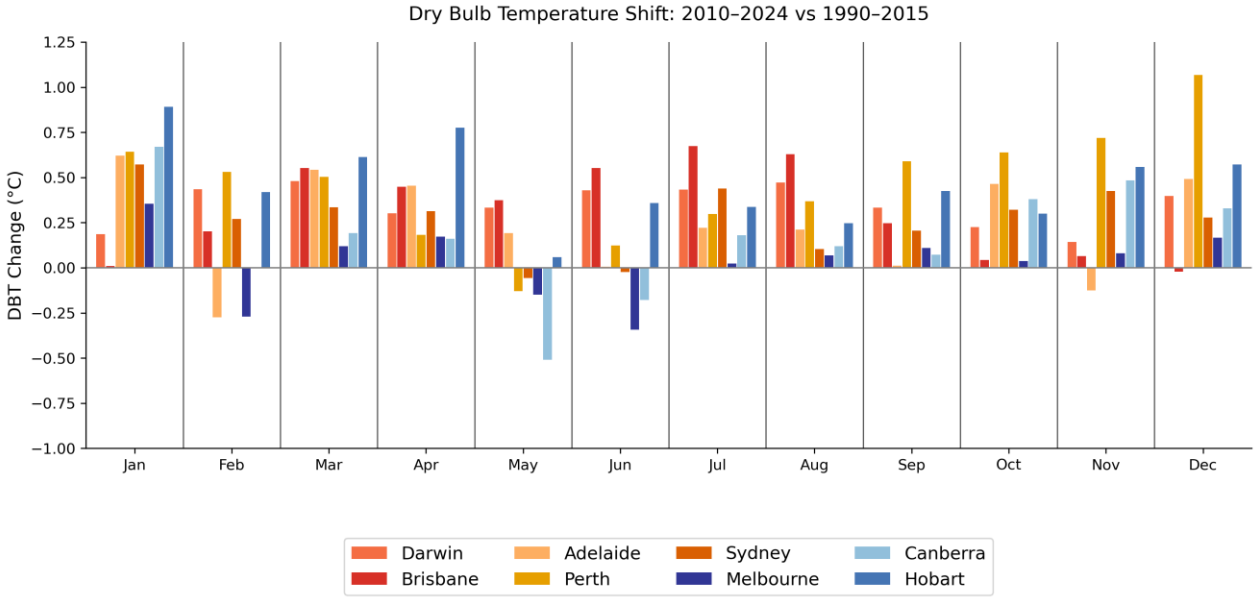
Temporal Analysis of Meteorological Data: Temperature Shift



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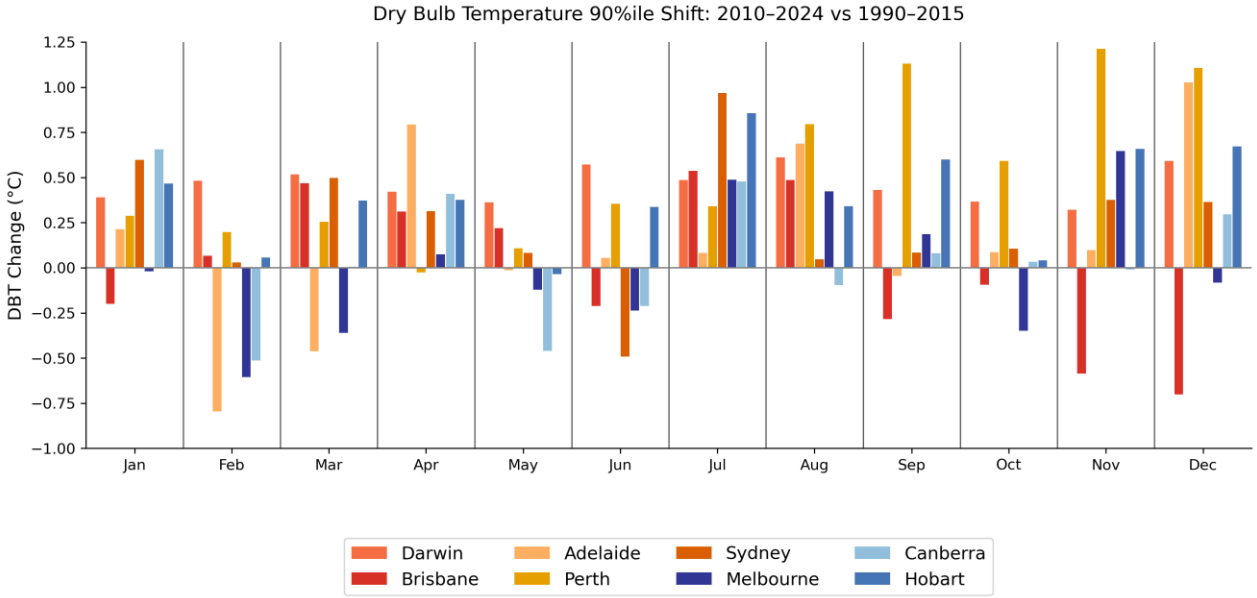
Temporal Analysis of Meteorological Data: Temperature(90%ile) Shift



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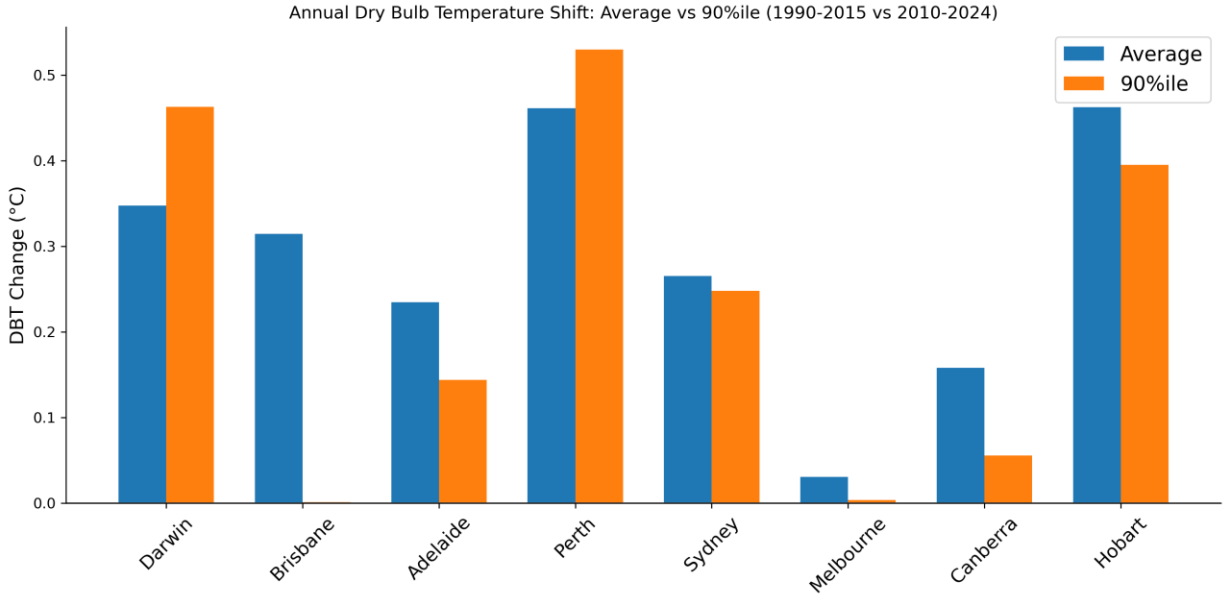
Temporal Analysis of Meteorological Data: Temperature Shift



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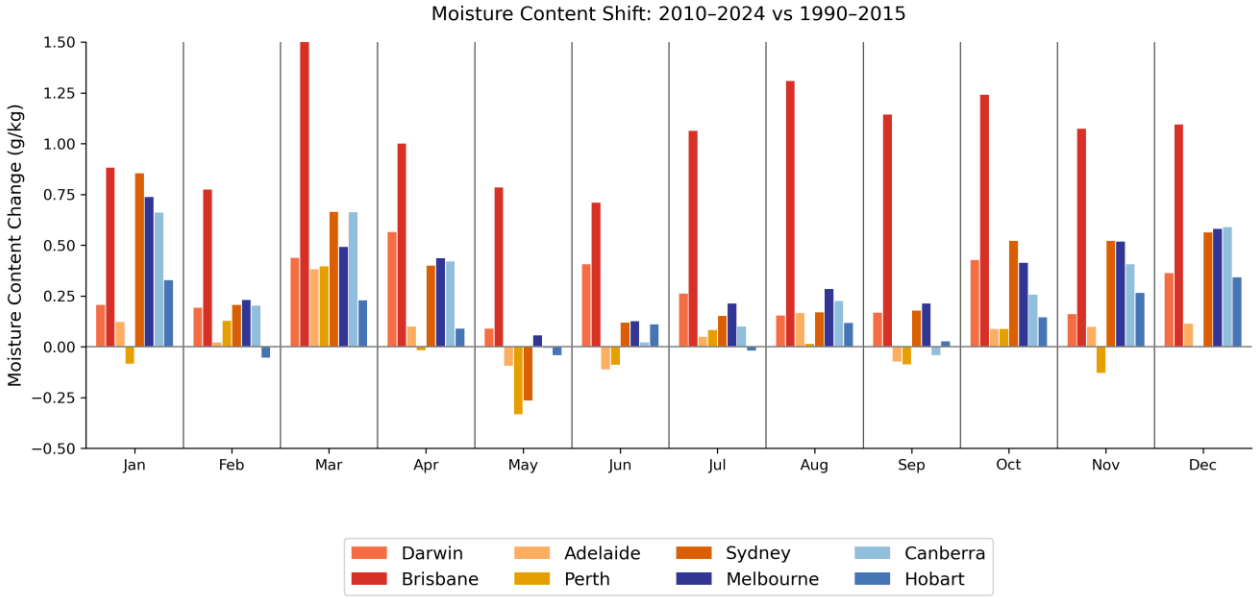
Temporal Analysis of Meteorological Data: Moisture Content Shift



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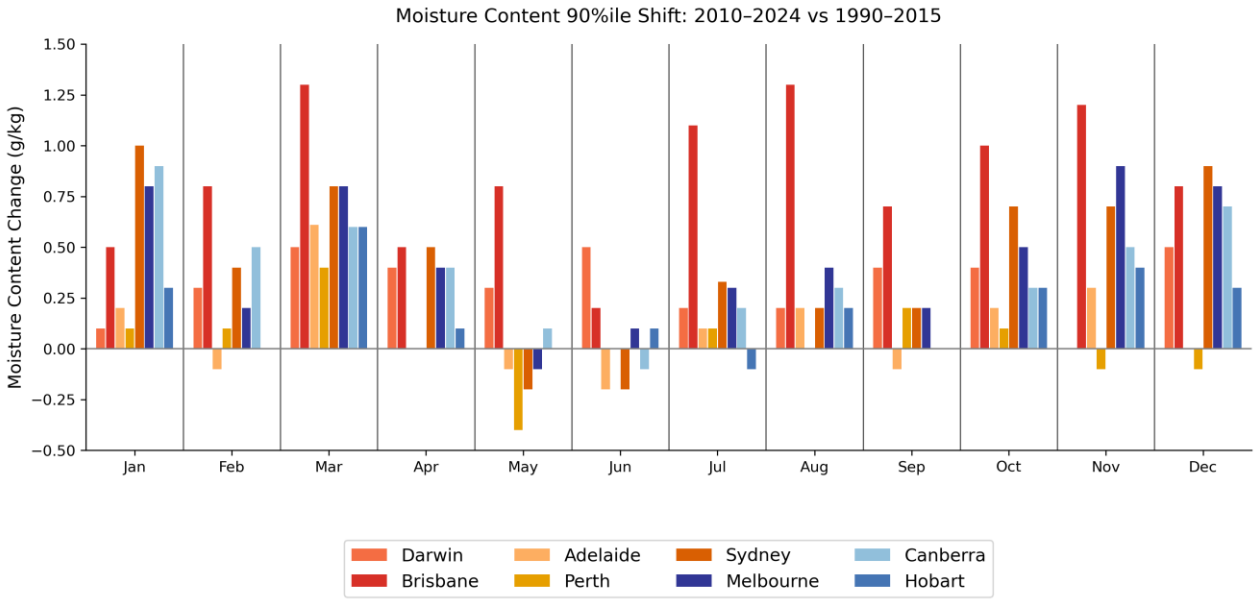
Temporal Analysis of Meteorological Data: Moisture Content(90%ile) Shift



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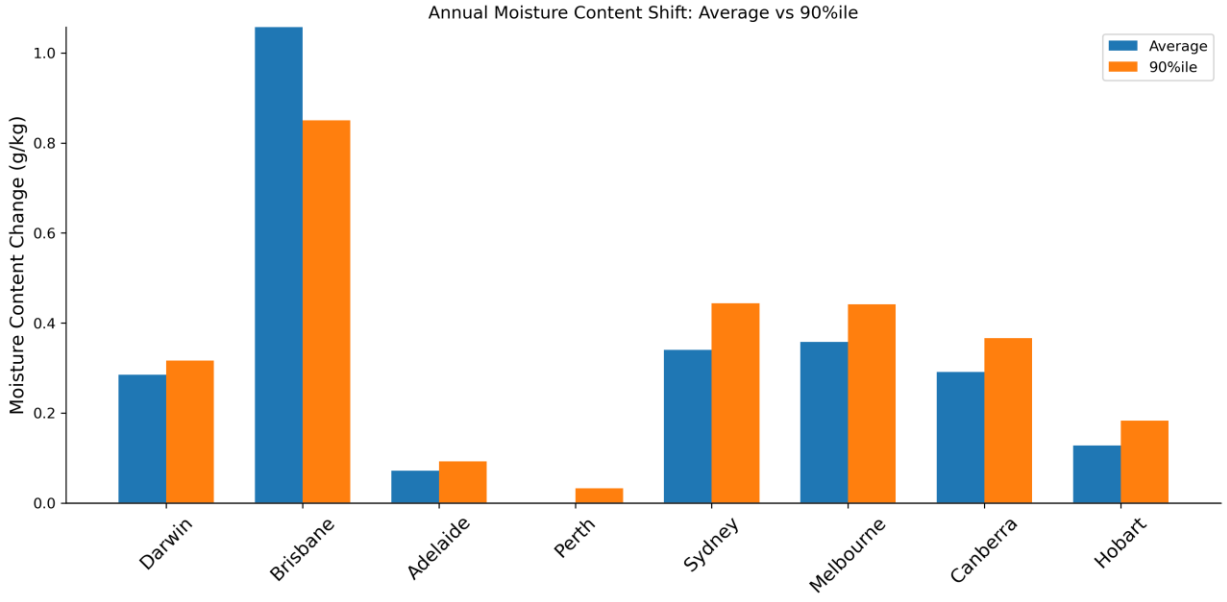
Temporal Analysis of Meteorological Data: Moisture Content Shift



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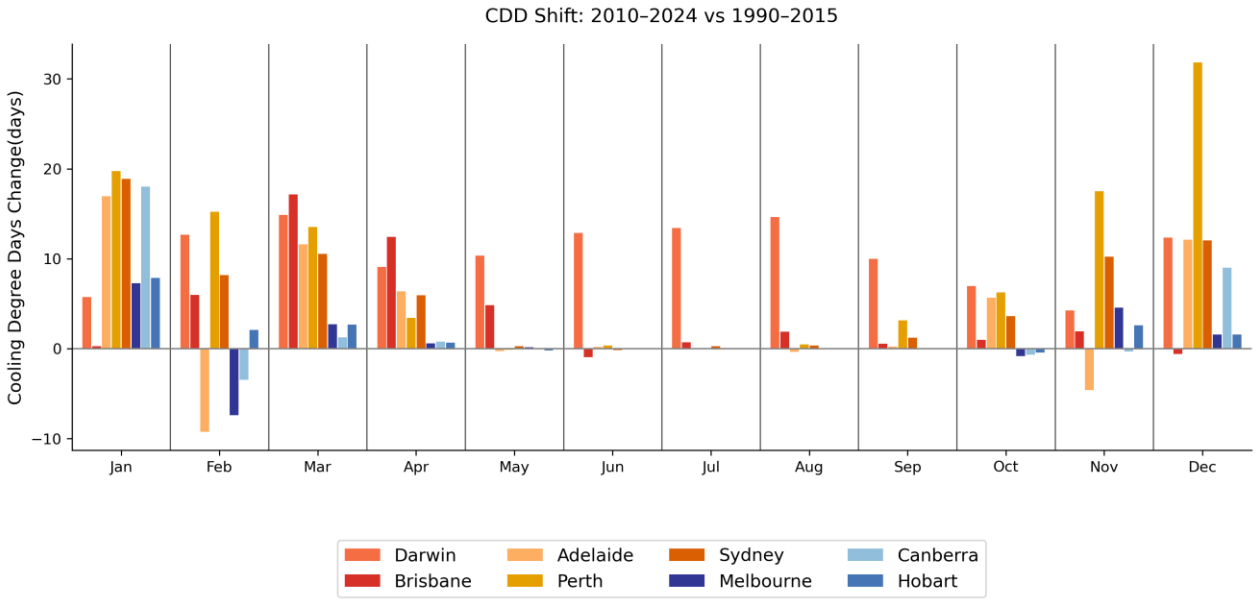
Temporal Analysis of Meteorological Data: CDD Shift



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Summary of Temporal Analysis of Meteorological Data

- Notable differences in key weather elements (2010-2024 vs 1990-2015)
  - Clear climate shift: +0.28°C, +0.31 g/kg, +4.6 CDD
  - Overall **warming** and **humidification** across all cities
  - These changes drive **higher cooling demand** in summer and **lower heating demand** in winter

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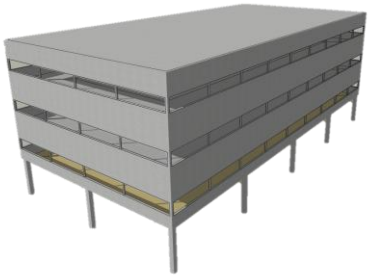
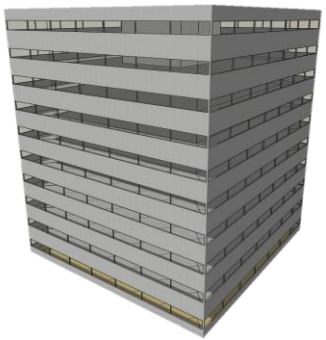
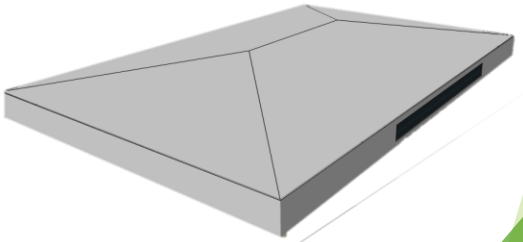
Examining HVAC Energy Consumption

- We considered 3 archetypical buildings compliant with the current NCC: a 3-storey office building, a 10-storey office building, and a ground-level supermarket
- We analysed HVAC heating and cooling energy consumption by simulating weather data for each of the capitals for 1990-2024 with building models in Energy+







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Energy+ Building Simulation Results

- We analysed monthly heating and cooling energy consumption from **1990** to **2024** examine long-term trends by **climate zone**.
  - CZ1 & 2 (Humid and Warm areas) – Brisbane and Darwin
  - CZ5 (Warm areas) – Adelaide, Perth and Sydney
  - CZ6 & 7 (mild and cool areas) – Canberra, Hobart and Melbourne
- Comparison of **average cooling and heating demand** (based on three archetypical buildings) between 1990-2015 and 2010-2024.
- Comparison of **monthly cooling and heating demand heatmaps** among 1990-2015, 1990-2024 and 2010-2024 for eight capital cities and three building types.

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Note: Some data were excluded from the reported percentage changes to prevent distortion caused by extremely low values.

Energy+ Building Simulation Results

- For all buildings: Brisbane
  - Increasing cooling demand (Increased from 21.78 kWh/㎡ to 22.96 kWh/㎡ (5.4%)).
  - Decreasing heating demand (Decreased from 0.39 kWh/㎡ to 0.31 kWh/㎡ (-19.3%)).

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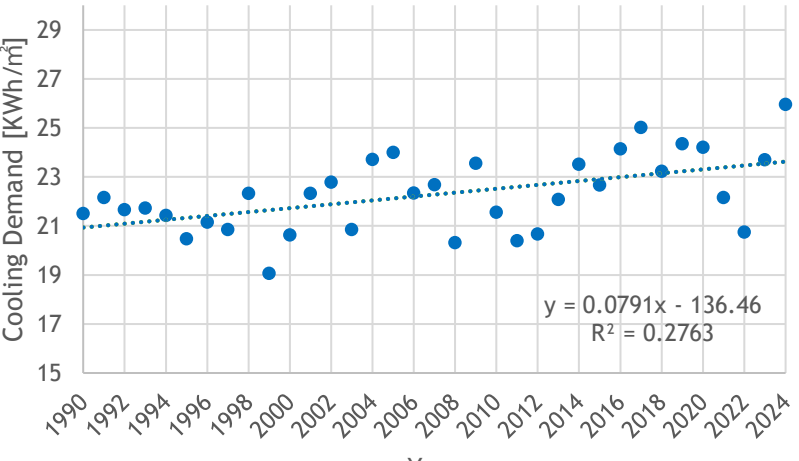
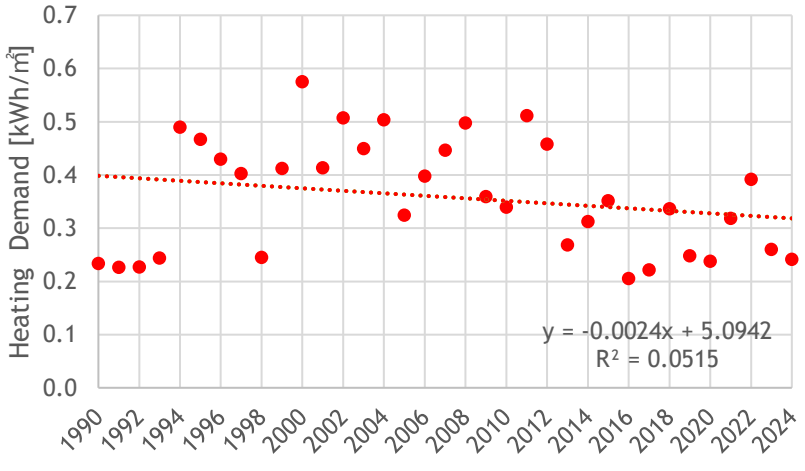
Annual Cooling Energy Consumption for Brisbane



Annual Heating Energy Consumption for Brisbane



Energy+ Building Simulation Results

- For all buildings: Adelaide, Perth and Sydney (NCC CZ5)
  - Increasing cooling demand (Increased by 4.2%, 8.1% and 6.9% respectively).
  - Decreasing heating demand (Decreased by 9.2%.9.6% and 6.2% respectively).

- For all buildings: Darwin (NCC CZ 1)
  - Increasing cooling demand (Increased by 2.3%).

- For all buildings: Canberra, Hobart and Melbourne (NCC CZ 6 & 7)
  - Increasing cooling demand (Increased by 5.1%, 14.6% and 1.5% respectively).
  - Decreasing heating demand (Decreased by 0.3% in Canberra and 14.5% in Hobart but increased by 4.2% in Melbourne).

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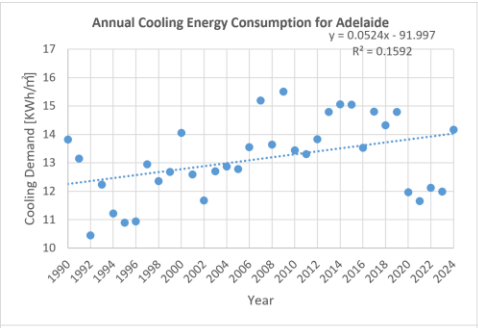
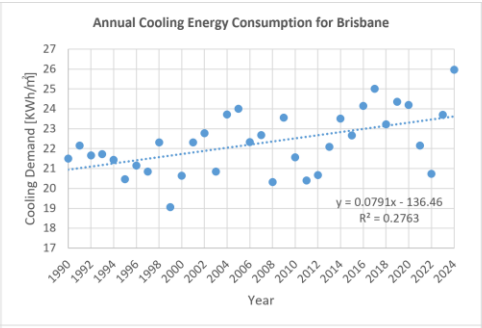
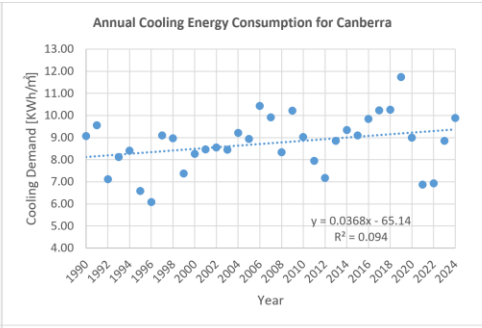
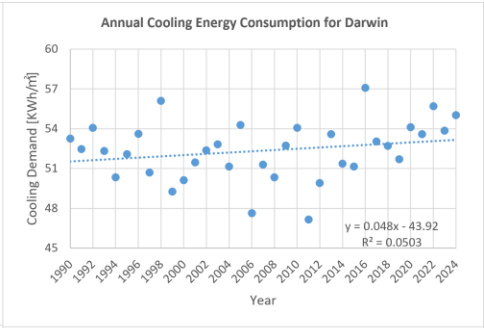
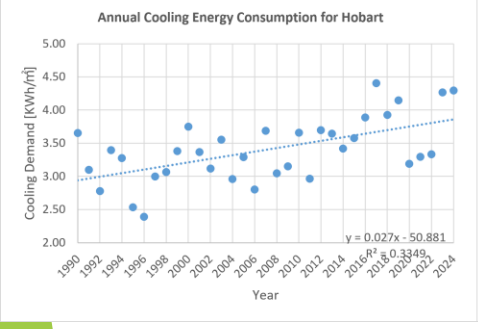
Energy+ Building Simulation Results - Cooling

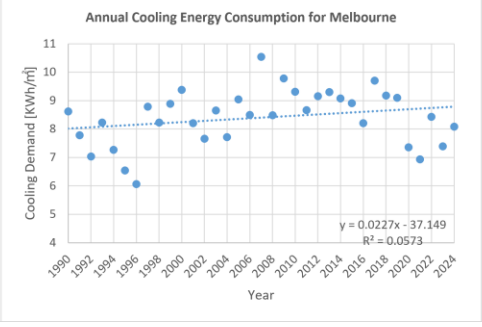


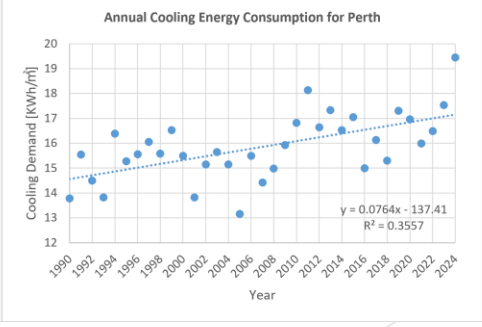


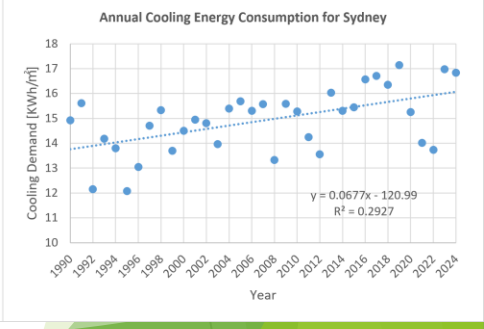




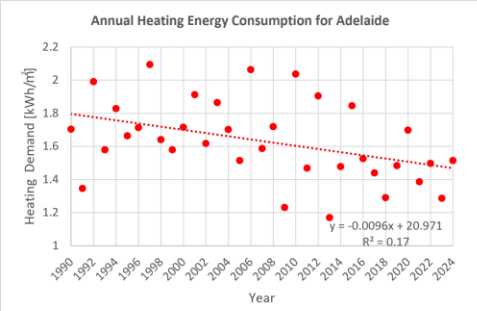


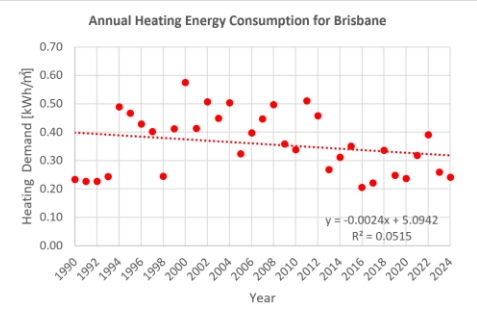


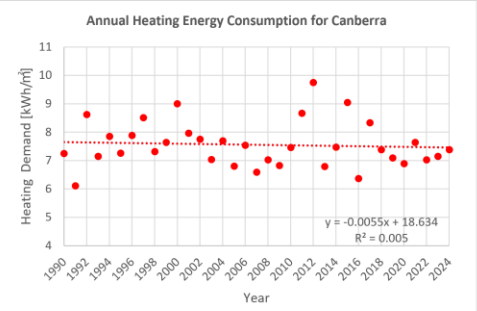


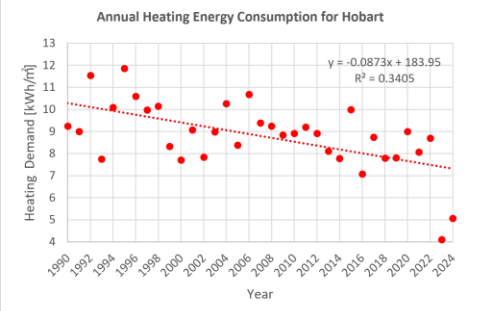


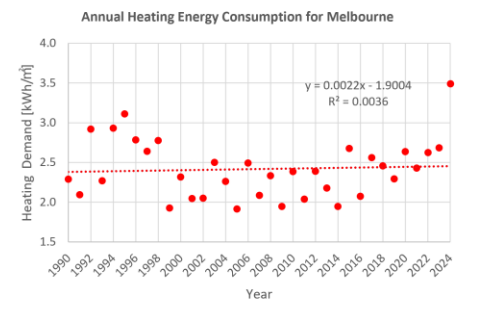
Energy+ Building Simulation Results - Heating

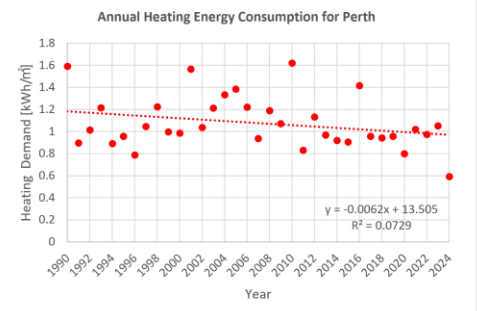


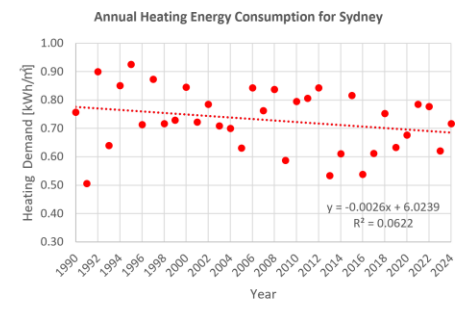












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Energy+ Building Simulation Results

- For all buildings: Brisbane (Cooling: Dec-Feb, Heating: Jun- Aug)
  - 2010-2024 has higher cooling demand than 1990-2015 and 1990-2024 period (0.7% to 6.1%).
  - 2010-2024 has lower heating demand than 1990-2015 and 1990-2024 period (-0.9% to -24.3%)

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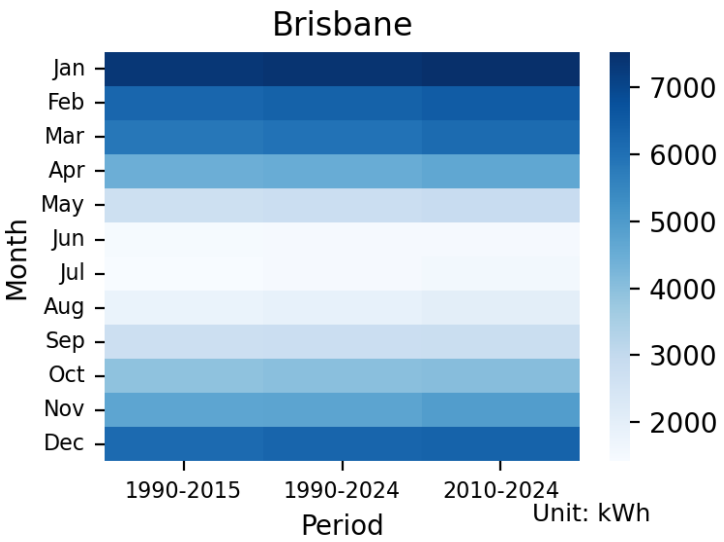
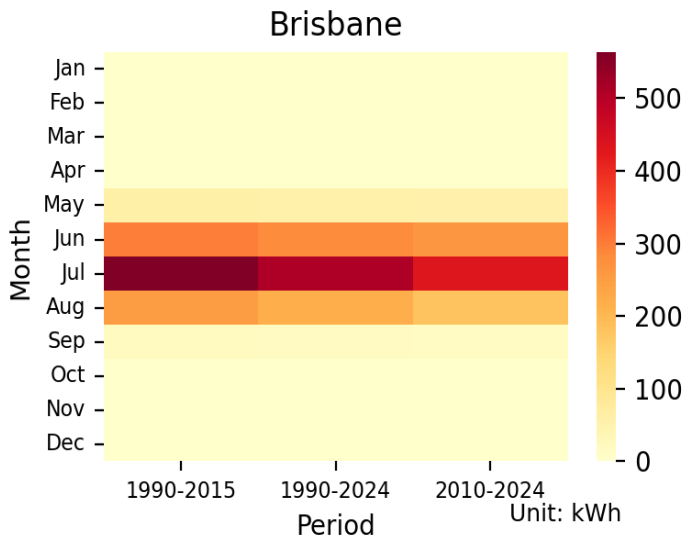
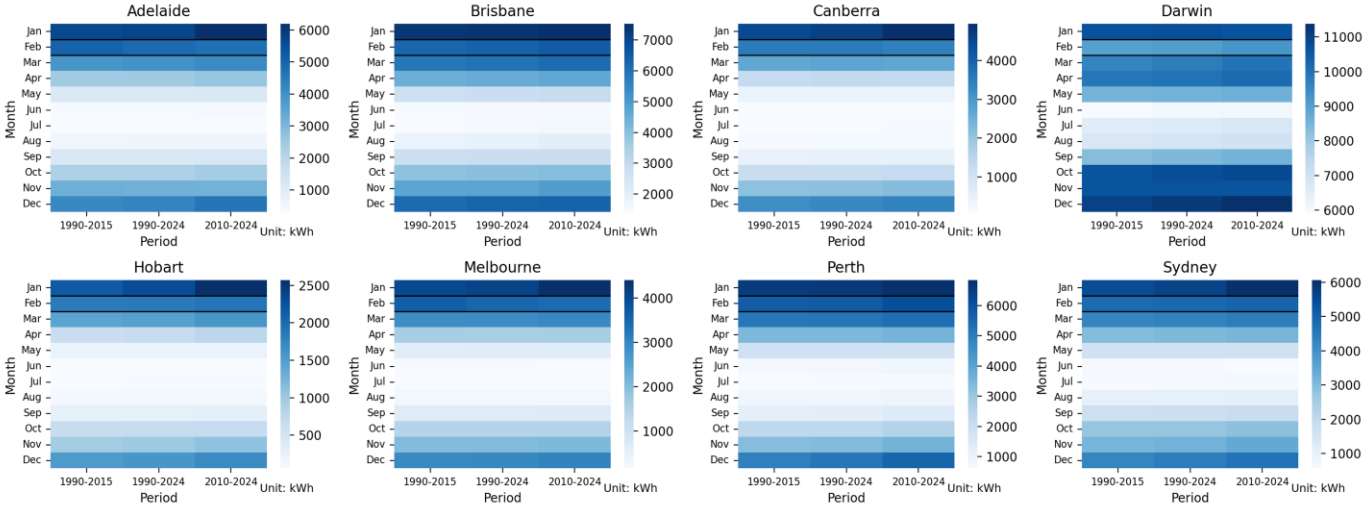




3-storey Office

Energy+ Building Simulation Results – Cooling – Monthly / 3-Storey Office



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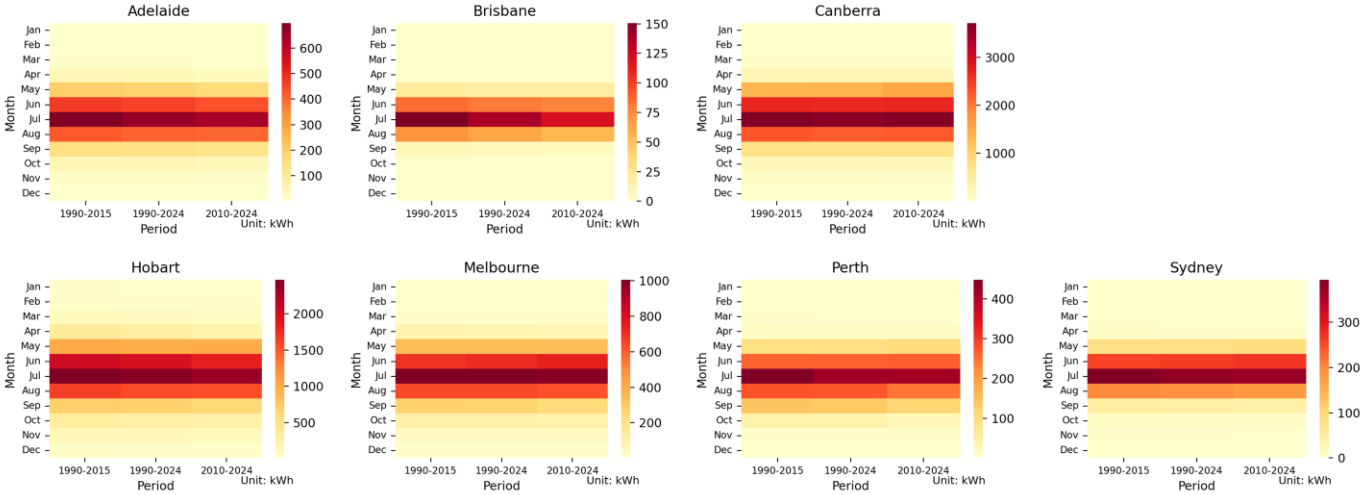
Energy+ Building Simulation Results – Heating – Monthly / 3-Storey Office



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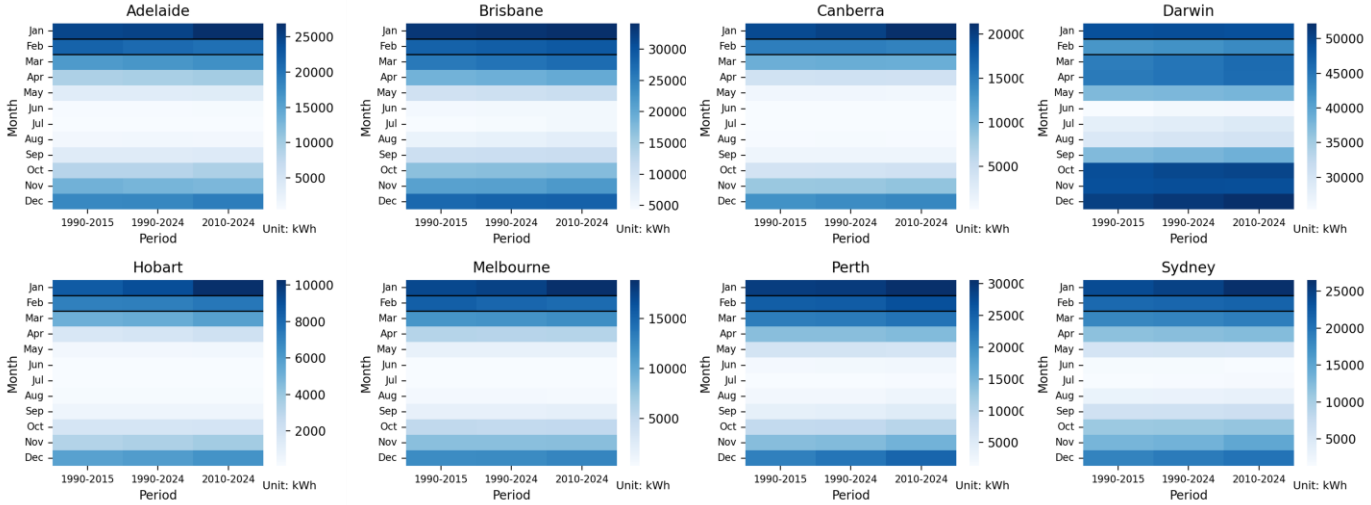
Energy+ Building Simulation Results – Cooling – Monthly / 10-Storey Office



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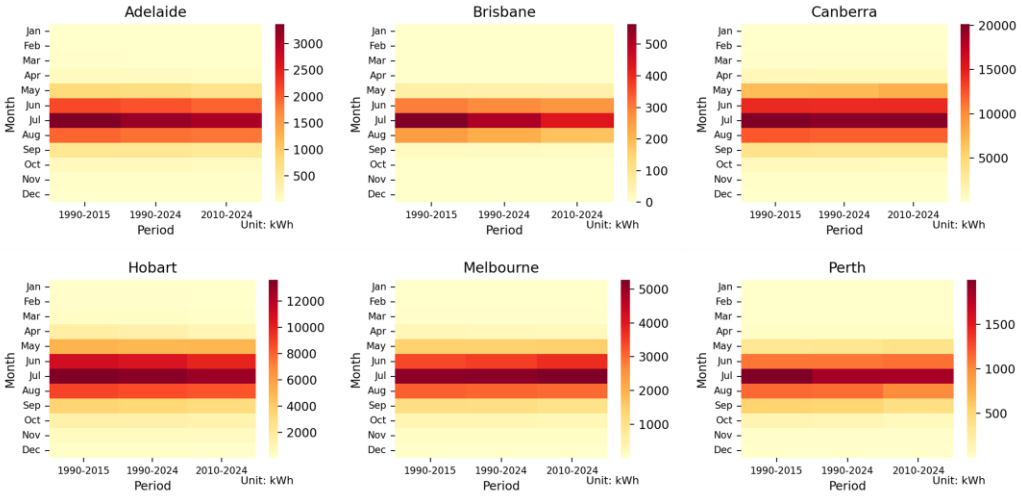
Energy+ Building Simulation Results – Heating – Monthly / 10-Storey Office



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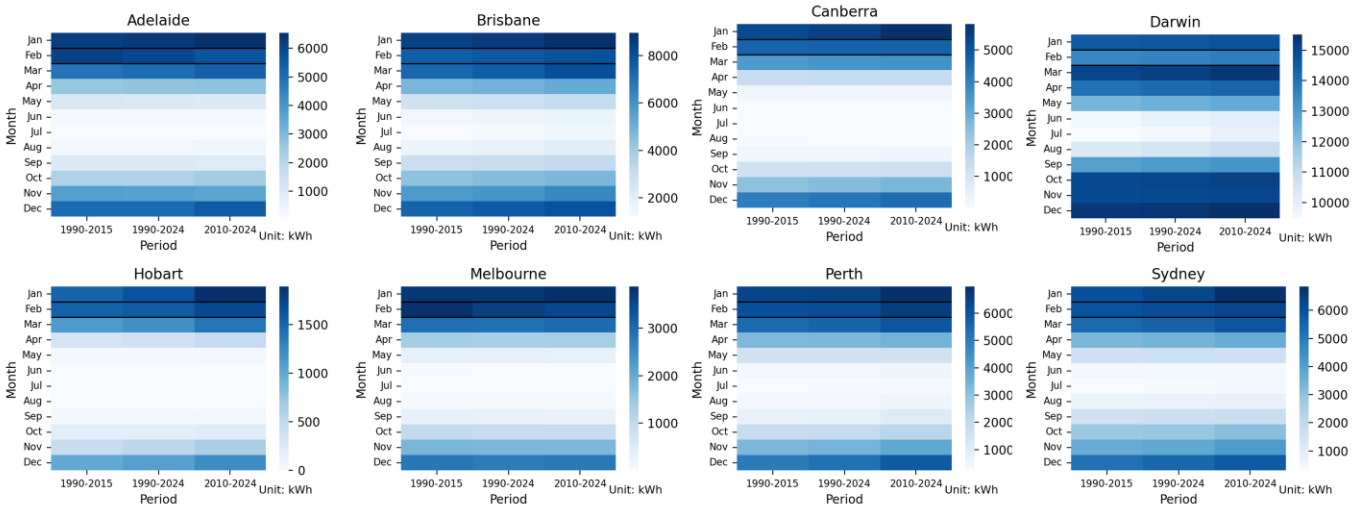
Energy+ Building Simulation Results – Cooling – Monthly / Supermarket



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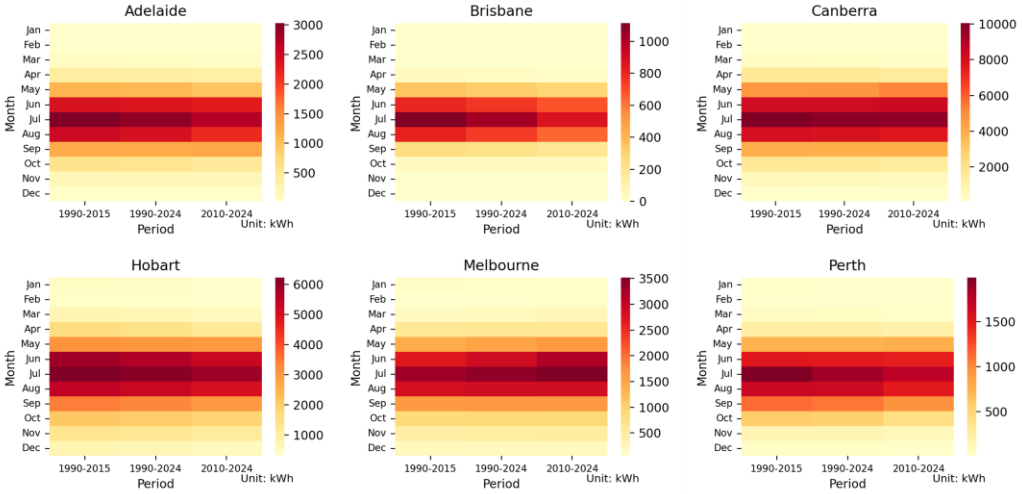
Energy+ Building Simulation Results – Heating – Monthly / Supermarket



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Summary of Energy+ Building Simulation Results

- Shifts observed in cooling and Heating demand and meteorological trends across Australian Capitals
  - Overall trend: Across all capital cities and 3 archetypical buildings, cooling demand has increased (Exceed 5% in most cities), while heating demand has generally decreased (Except for Melbourne) in the last 15 years.
  - Smallest changes: Cooling – Melbourne (1.5%), Heating – Canberra (-0.3%)
  - Biggest changes: Cooling – Hobart (14.6%), Heating – Hobart (-14.5%)
  - Heating exception: Heating – Melbourne (+4.2%)
  - Future outlook: Continued warming is expected to further increase cooling loads and reduce heating loads in future building simulations.
- To conduct more precise building simulations, CSIRO TMY files need to be updated with more recent climate data.

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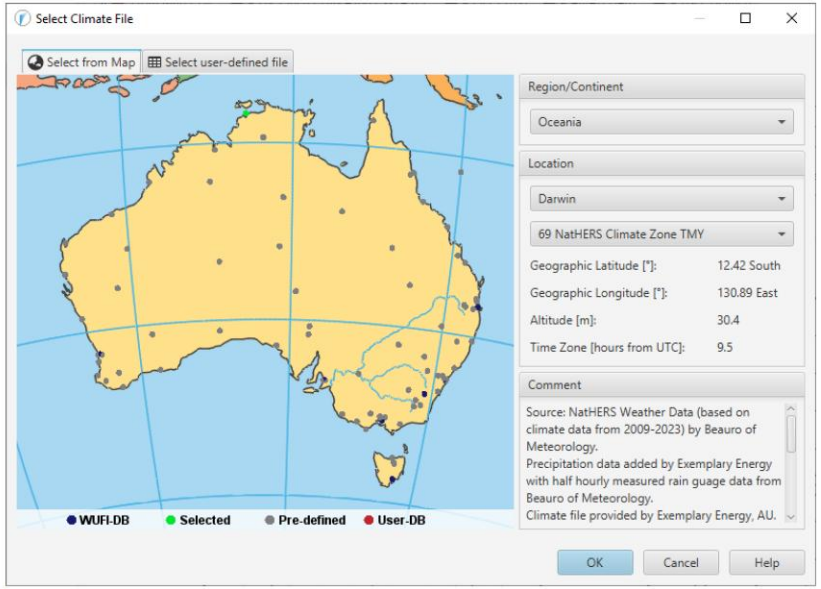
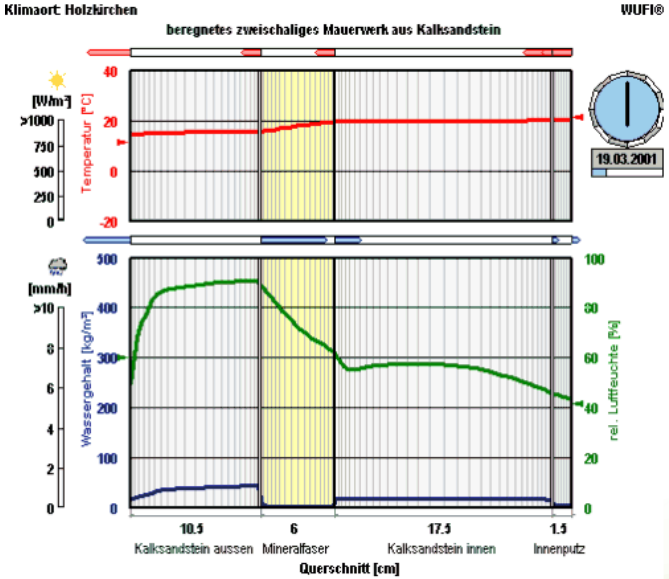
Building Simulation – Water Penetration, Condensation and Mould

all 8 capitals free in WUFI v7 – all NatHERS locations available for purchase – NCC mandated analysis

WUFI is Wärme und Feuchte instationär from Germany's Fraunhofer Institute





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Weather data with coincident precipitation data (mostly rain) has added usefulness for simulating self-cleaning of solar collectors.

Other Weather and Climate Services

Real Time Year (RTY) weather files are available monthly for the 8 capital cities as used in the freely published Exemplary Weather and Energy Index (EWEI), shown here, using three archetype buildings and a solar PV system.

The full 34-year weather record (1990-2023) for 215 Australian locations including the NatHERS/CSIRO sites through their sales portal which includes an interactive map to aid selection:

- Full Historical Weather Record - (1990-2023) in ACDB, TMY2 and EPW formats
- Reference Meteorological Year (RMY) alternatives derived from:
  - 34 Years /15 Years /15 Years with Precipitation
- 3 Typical Meteorological Years (TMY) with selected weighting of weather elements for façade-dominated, neutral and deep plan buildings
- eXtreme Meteorological Years (XMY) for solar PV - 1, 10, 90, and 99%ile
- Ersatz Future Meteorological Years (EFMY) 2050

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Thank You & Questions

Our monthly analysis (Exemplary Energy Weather and Index) can be found from here.

For more comprehensive datasets and further information, please visit our website or send us an email.

- **Website:** https://www.exemplary.com.au/
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