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

- Comparison between the average of 1990-2015 (CSIRO Typical Meteorological Year) weather and the average of the most recent 15 years weather (2009-2023 TMY) with National Construction Code (NCC) climate zone classification
- Heating and Cooling Energy Consumption simulation conducted for 34 years (1990-2023) to check trend with weather elements
  - Added precipitation to analysis of meteorological data
  - Involved analysis of meteorological data, EnergyPlus building energy simulations

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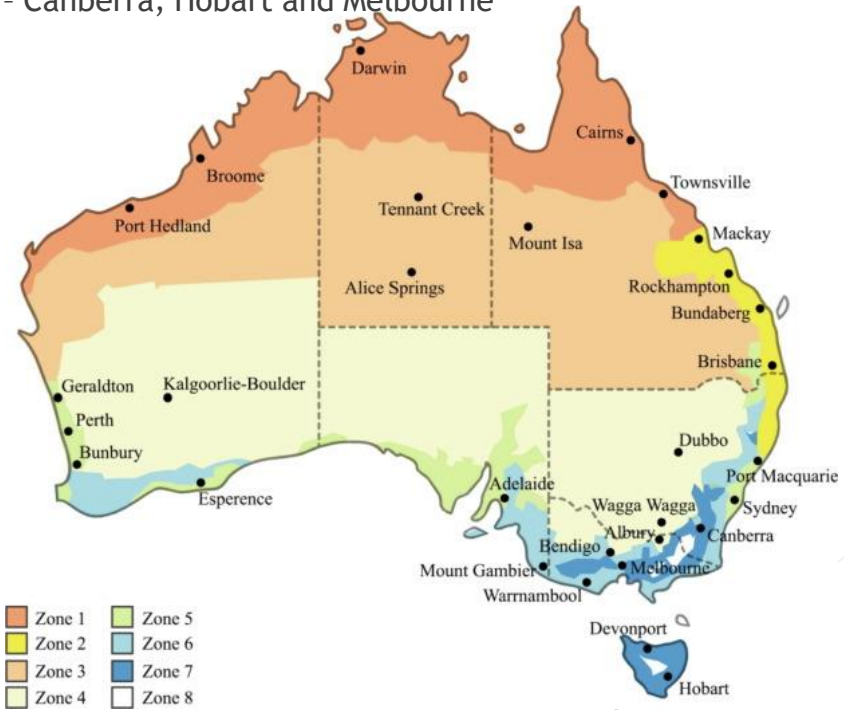
NCC Climate Zones

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



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

- Sydney
  - DBT: 0.3 ℃ increase (0.6 ℃ increase in January and October average)
  - Moisture Content: 3.2g/kg increase, (7.6 and 6.2 g/kg increase in January and March)
  - Precipitation: 7.5mm increase, (90mm increase on March average)

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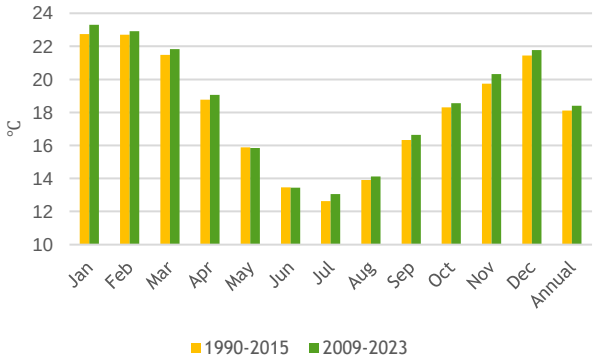
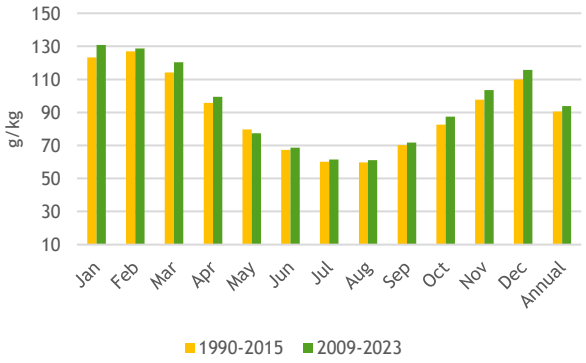
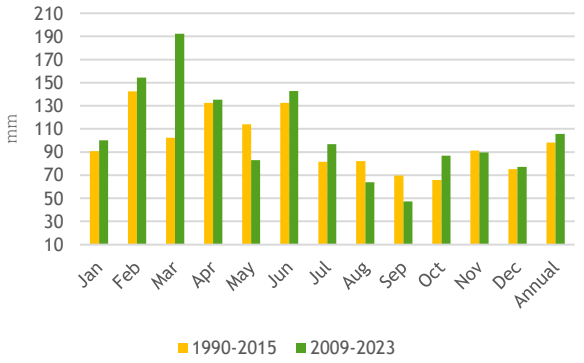
Sydney DBT comparison



Sydney Moisture Content Comparison



Sydney Precipitation comparison



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

- Adelaide
  - DBT: 0.3 ℃ increase (0.7 ℃ increase in January average)
  - Moisture Content: 0.3g/kg increase (3.2g/kg increase in March average)
  - Precipitation: 0.3mm decrease (7.9mm decrease in September average)

- Perth
  - DBT: 0.4 ℃ increase (1.0 ℃ increase in November average)
  - Moisture content: 0.2g/kg decrease (4.3g/kg decrease in May average)
  - Precipitation: 4.3mm decrease (18.6mm decrease in June average)

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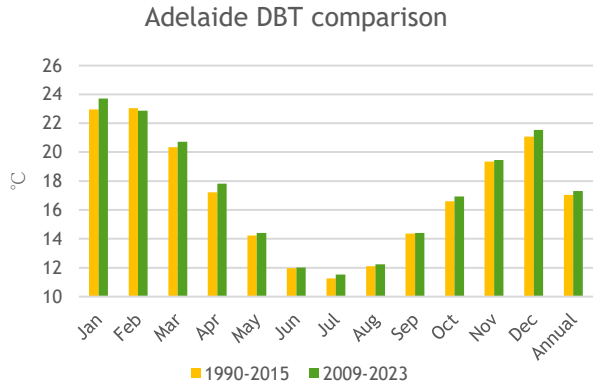
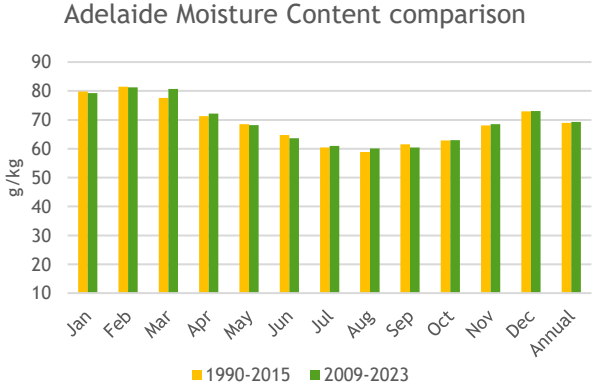
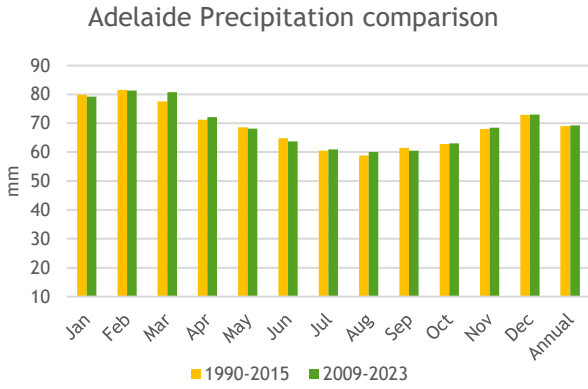
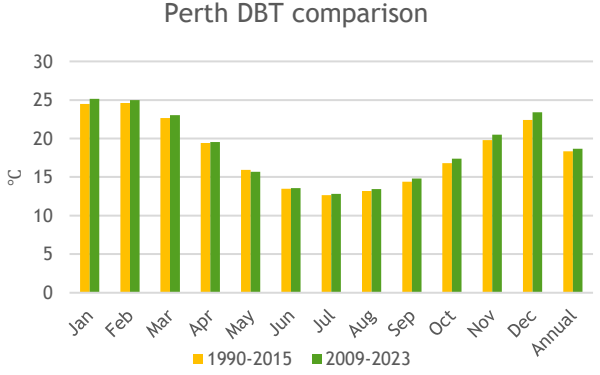
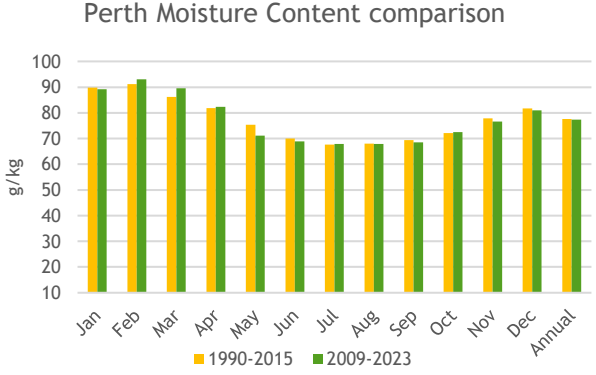
Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ5)

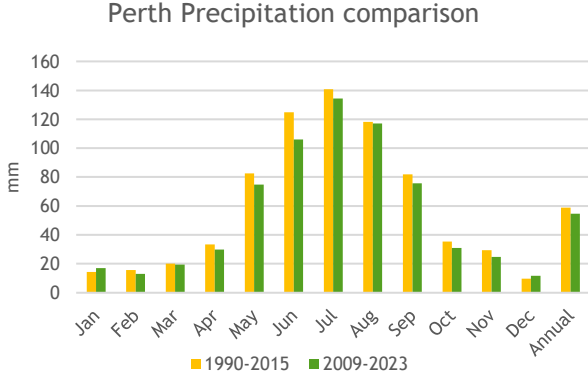












Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ1 & 2)

- Brisbane
  - DBT: 0.3 ℃ increase (0.6 ℃ increase in March, July and August)
  - Moisture Content: 9.5g/kg increase (11.8g/kg increase in August)
  - Precipitation: 5.7mm increase (43.7mm increase in March)

- Darwin
  - DBT: 0.3 ℃ increase (0.5 ℃ increase in March)
  - Moisture content:2.4g/kg increase (6.5/kg increase in April)
  - Precipitation: 4.7mm decrease (78.5mm decrease in March)

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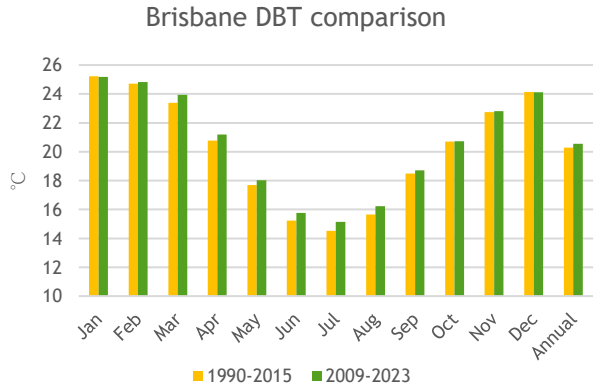
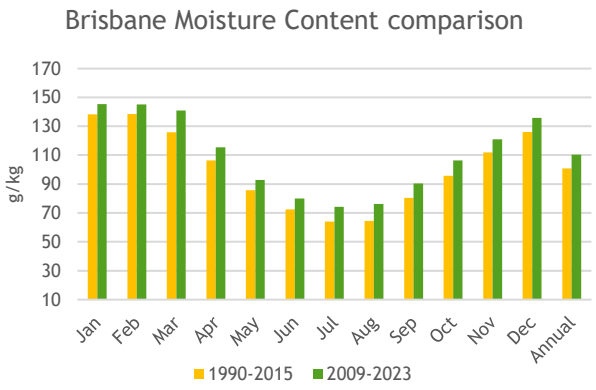
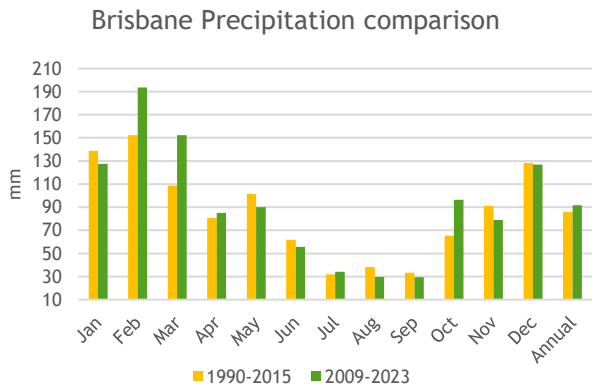
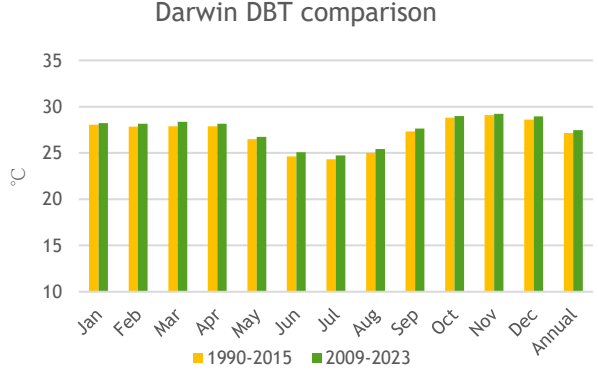
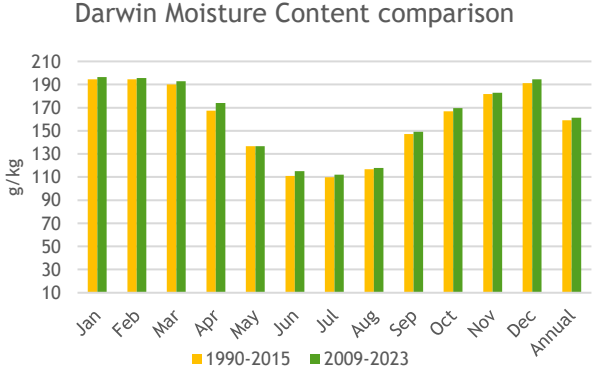
Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ1&2)

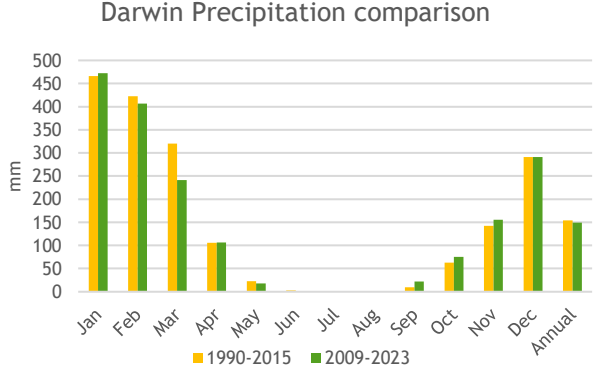












Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ6 & 7)

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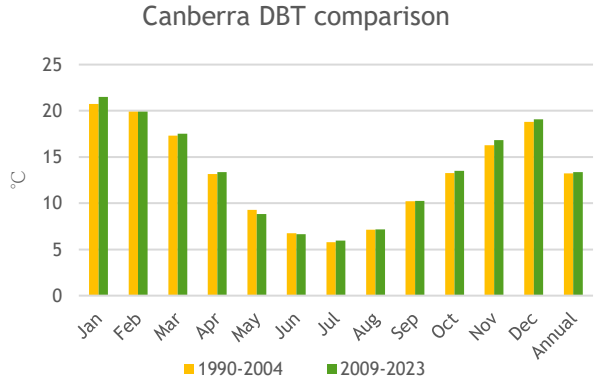
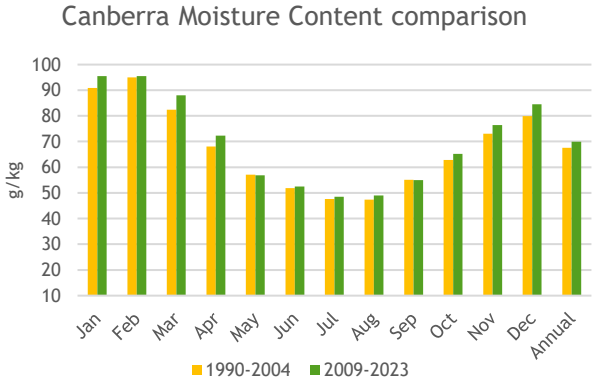
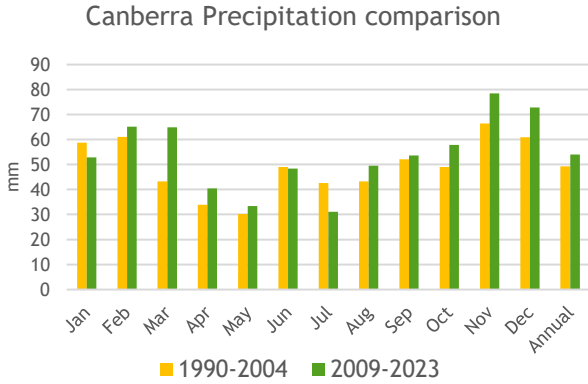
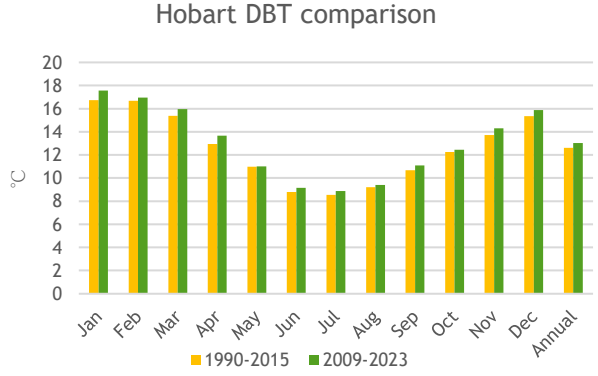
- Canberra
  - DBT: 0.2 ℃ increase (0.8 ℃ increase in January average)
  - Moisture Content: 2.3g/kg increase (5.7g/kg increase in March average)
  - Precipitation: 4.8mm increase (21.6mm increase in March average)
- Hobart
  - DBT: 0.3 ℃ increase (0.8 ℃ increase in January average)
  - Moisture content:1.3g/kg increase (3.0/kg increase in November and December average)
  - Precipitation: 1.9mm increase (22.4mm increase in April average)
- Melbourne
  - DBT: 0.1 ℃ increase (0.4 ℃ increase in January average)
  - Moisture content:3.2g/kg increase (5.7/kg increase in January average)
  - Precipitation: 0.8mm increase (12.6mm decrease in February average)

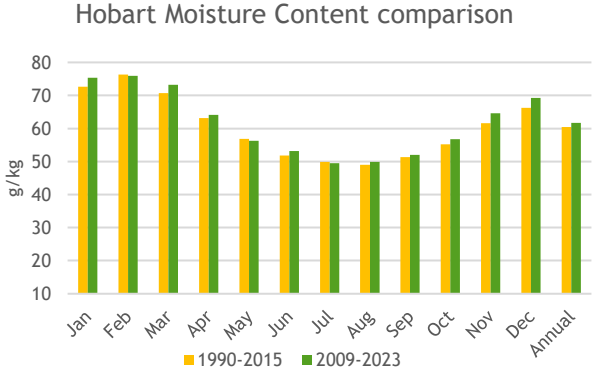
Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ6&7)

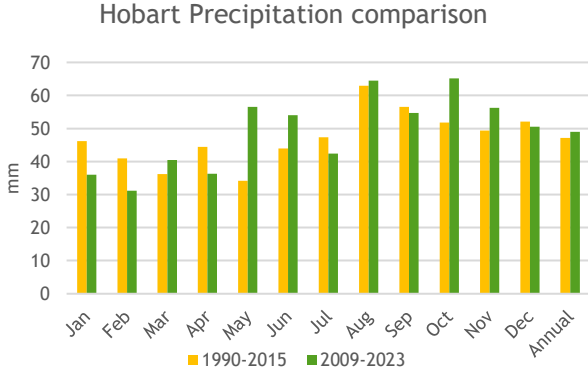




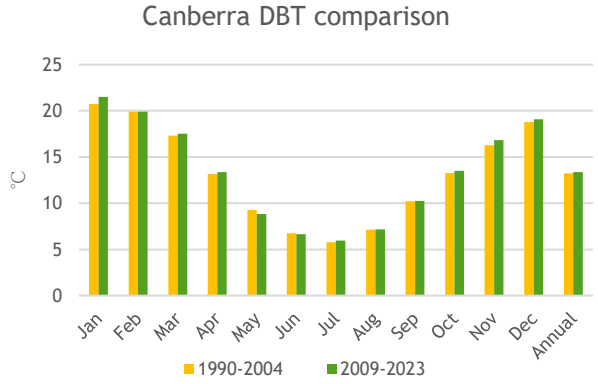


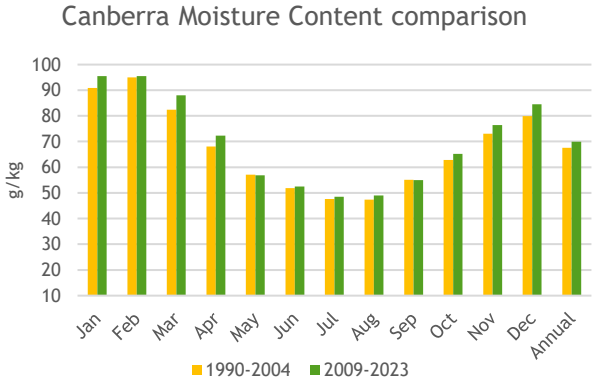


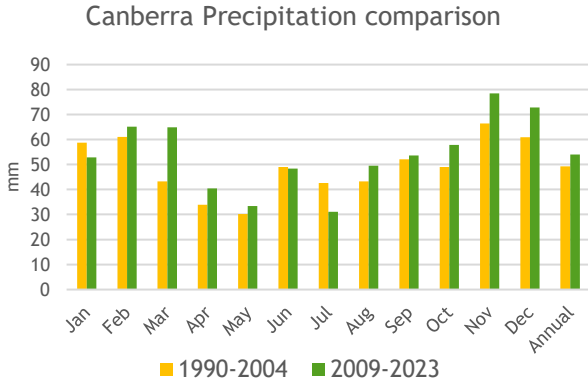


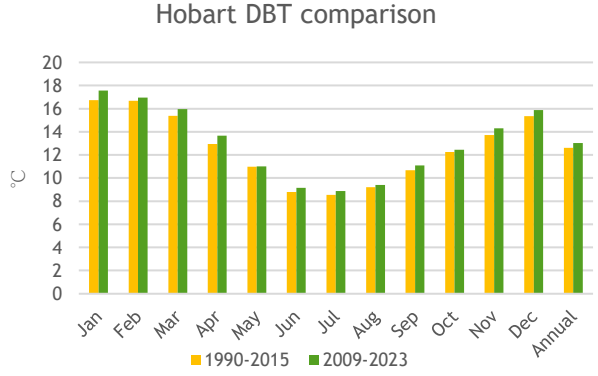


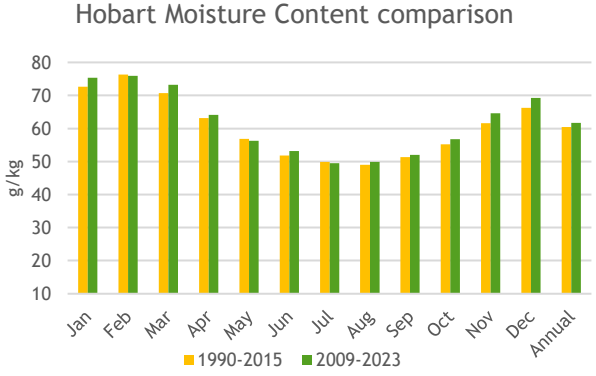
Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ6&7)

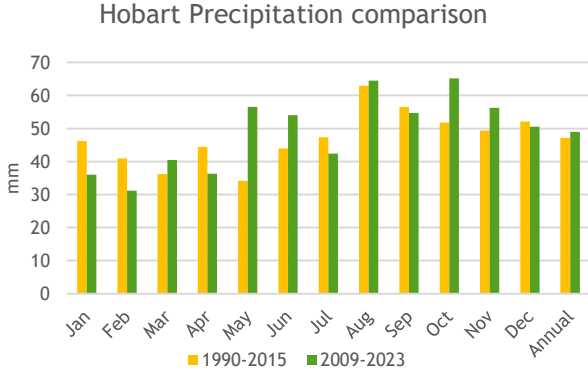




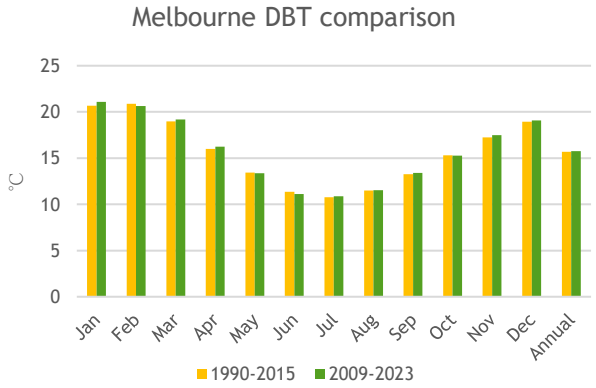


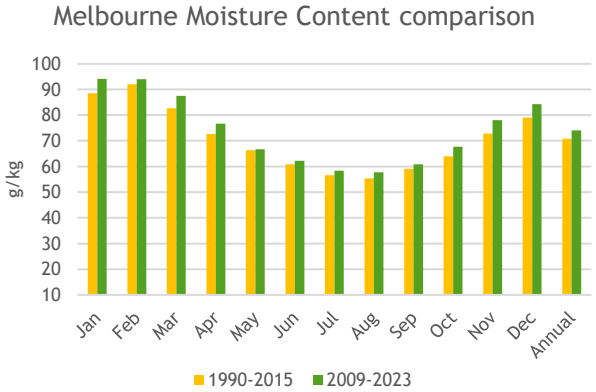


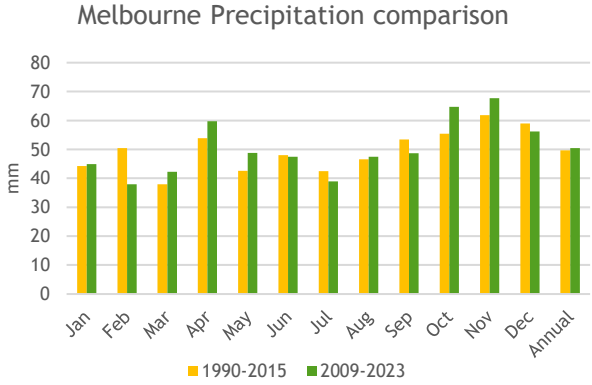




Temporal Analysis of Meteorological Data: Yearly Averages – (NCC CZ6&7)







Summary

- Notable differences in critical meteorological elements within the recent 2009-2023 period compared to the 1990-2015 period.
  - Overall, the 2009-2023 period tended to have higher DBT (0.3℃), Moisture content (2.7g/kg) and Precipitation compared to the 1990-2015 period.
  - Notable increase in precipitation in recent years for most capitals
  - All cities have extremely high weather changes notified on specific months.
  - Cooler areas tend to have fewer weather changes than warmer areas.
  - January and March had bigger weather elements differences than the other months.

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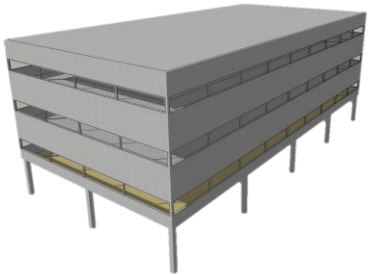
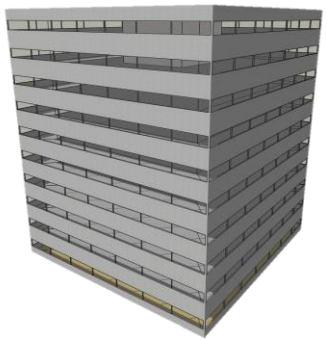
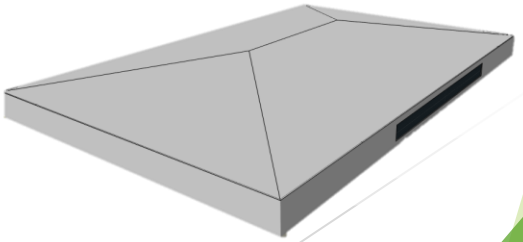
Examining HVAC Energy Consumption Trends

- Considered 3 archetypical buildings compliant with the current NCC: a 3-storey office building, a 10-storey office building, and a ground-level supermarket
- Analysed HVAC heating, cooling, and total energy consumption by simulating with 34-year weather data for each of the capitals for 1990-2023 with building models in EnergyPlus







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EnergyPlus Building Simulation Results

- Analysed monthly Heating and Cooling energy consumption from 1990-2023 to check the trend of each climate zone.
  - CZ1 & 2 (Humid and Warm area) – Brisbane and Darwin
  - CZ5 (Warm area) – Adelaide, Perth and Sydney
  - CZ6 & 7 (mild and cool area) – Canberra, Hobart and Melbourne

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EnergyPlus Building Simulation Results

- For all buildings: Sydney
  - Increasing cooling demand (15% increase from 1990 to 2023)
  - Decreasing heating demand (12% decrease from 1990 to 2023)

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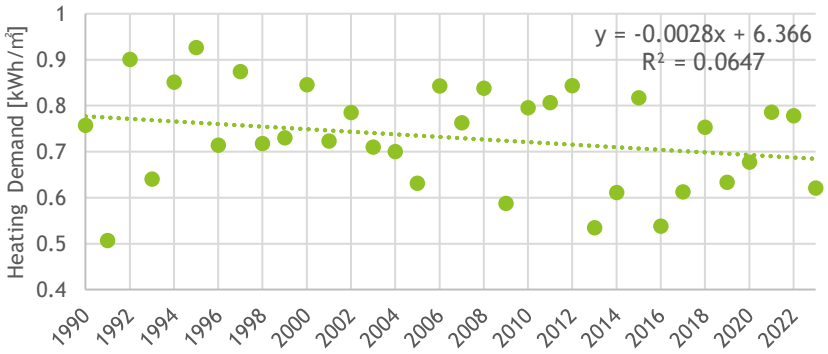
Annual Cooling Energy Consumption for Sydney

Annual Heating Energy Consumption for Sydney



EnergyPlus Building Simulation Results

- For all buildings: Adelaide and Perth (NCC CZ5)
  - Increasing cooling demand (13.9%,14.4% increase from 1990 to 2023)
  - Decreasing heating demand (18.1%,11.9% decrease from 1990 to 2023)

- For all buildings: Brisbane and Darwin (NCC CZ 1&2)
  - Increasing cooling demand (10.4% and 2.4% increase from 1990 to 2023)
  - Decreasing heating demand (16.3% - Brisbane only - decrease from 1990 to 2023)

- For all buildings: Canberra, Hobart and Melbourne (NCC CZ 6 & 7)
  - Increasing cooling demand (13.8%, 27.5% and 11% increase from 1990 to 2023)
  - Decreasing heating demand (2.2%, 24.4% and 4.6%decrease from 1990 to 2023)

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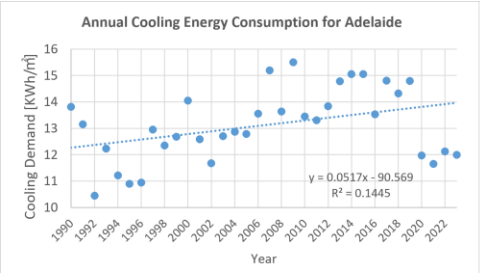
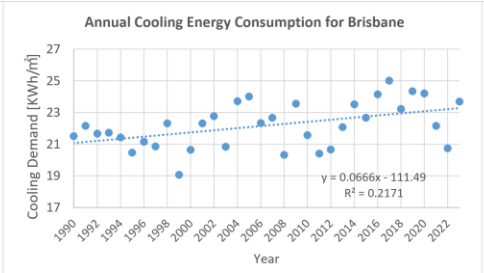
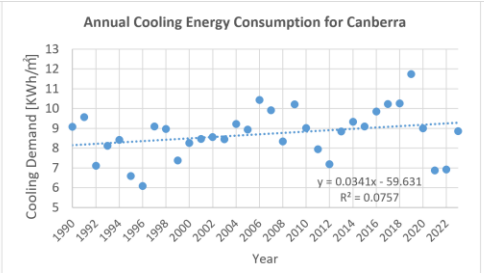
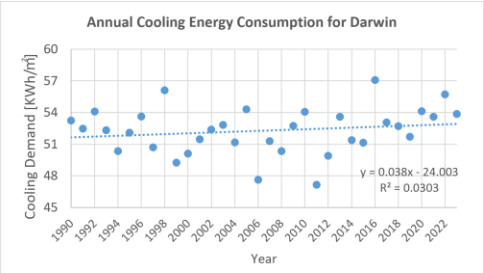
EnergyPlus Building Simulation Results – Cooling

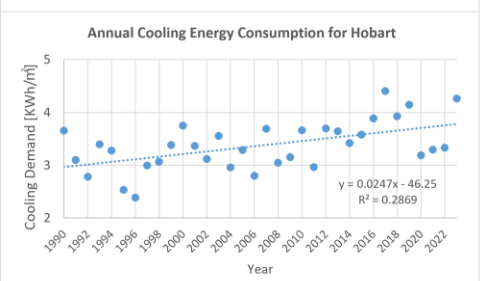
all 8 capitals in alphabetical order – y-axis selected to suit

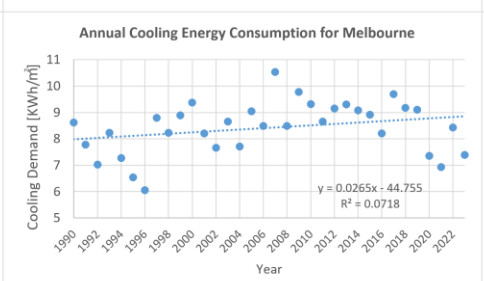


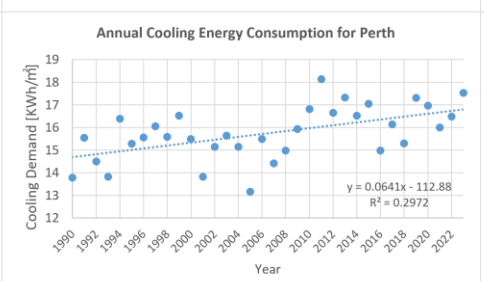


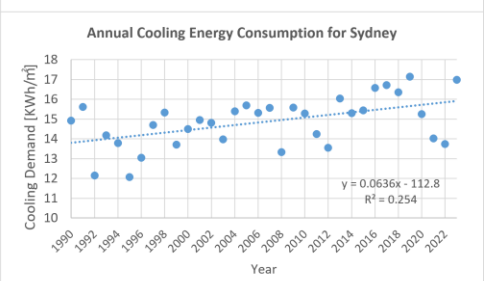






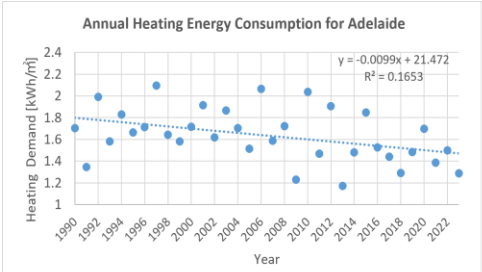


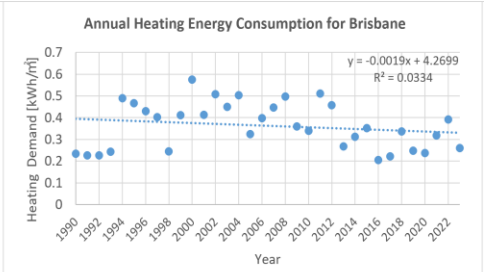


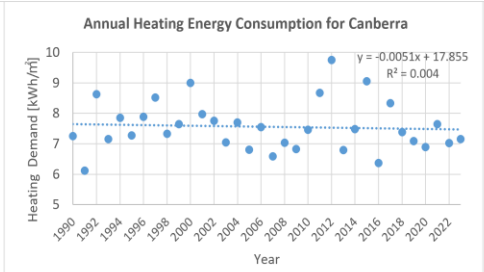


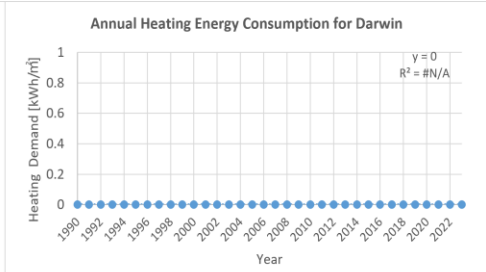
EnergyPlus Building Simulation Results – Heating

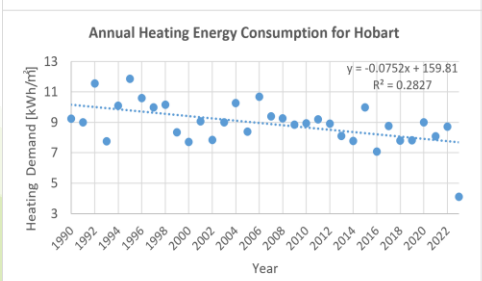
all 8 capitals in alphabetical order – y-axis selected to suit

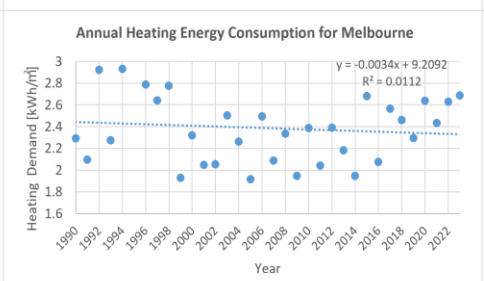


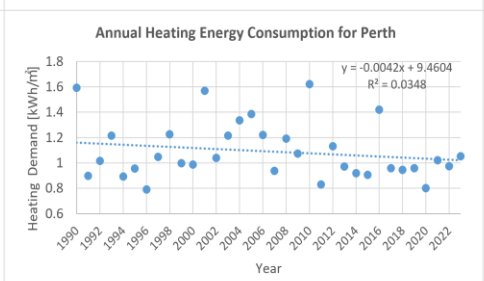


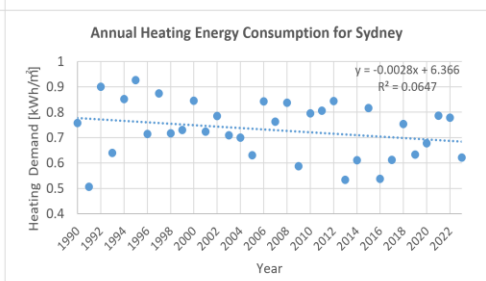












Building Simulation – Water Penetration and Condensation

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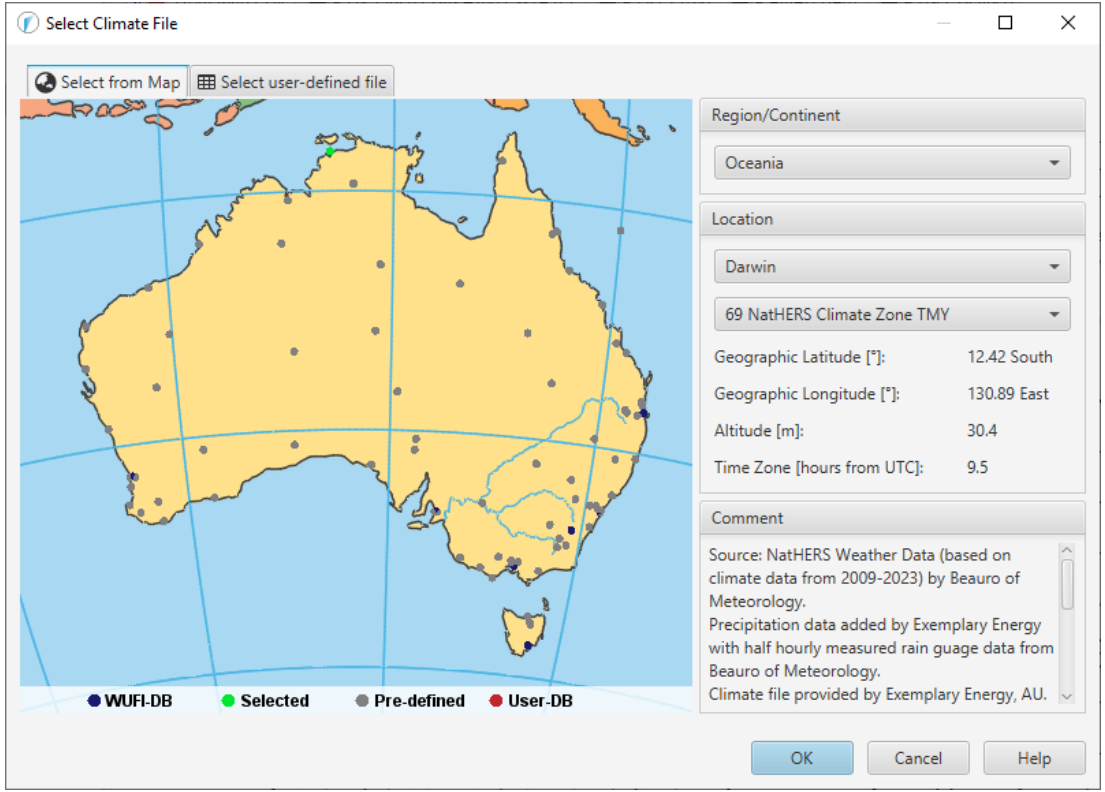

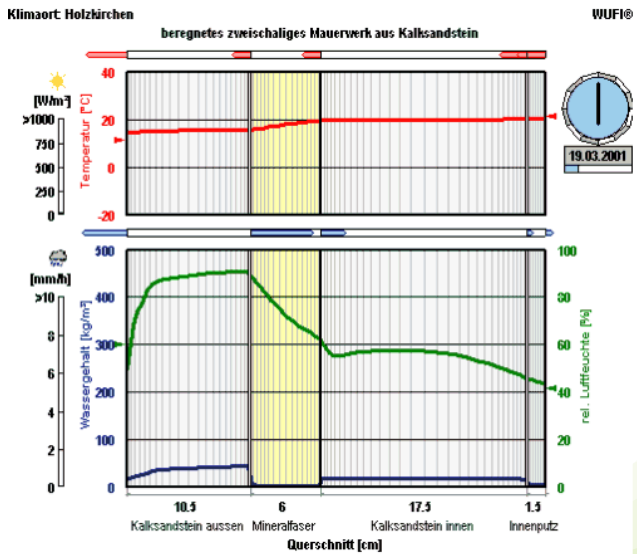

Summary

- Trends in weather elements and their impacts on HVAC energy consumptions corroborate our preference for using the latest 15 year period (2009 to 2023) as the basis for our derived Typical Meteorological Years
- This recent data set allows all the usual weather data to be matched with coincident precipitation data measured on a half-hourly frequency to allow reliable simulation of weather-proofing and condensation for the construction industry
- Precipitation data also allows more precise simulation of rain washing effects on solar energy systems and their efficiency in actual service conditions
- Trends observed in building heating and cooling demand are consistent with the trends in critical meteorological elements used in building simulations over the past decades across all capital cities
  - All cities have increasing cooling demand with decreasing heating demand
  - Darwin has the smallest changes on cooling and no heating demand
  - Overall, cooling demands are over 10% increase across all capital cities without Darwin
  - Cooler areas have a smaller decreased heating demand than the other cities

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Questions?

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