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

Hong Gic Oh and Trevor Lee

Exemplary Energy, Fadden ACT 2904, Australia

exemplary.energy@exemplary.com.au

Background

As of 2024, the global average temperature has warmed by 1.51 °C above the 1910 baseline, surpassing the critical 1.5 °C threshold widely referenced in global climate change assessments (Australian Government Bureau of Meteorology, 2024). Most of Australia’s warmest years have occurred since 2013. This trend has continued due to rising anthropogenic greenhouse gas emissions, significantly impacting the relevance and accuracy of climate data used in renewable energy system and building energy and weather-proofing simulations.

Climate files used typically consist of 8,760 hourly records (one year) of meteorological elements derived from historical data to represent long-term climatic conditions (Cui et al., 2017). However, with ongoing climate warming, conventional reference periods such as the Commonwealth Scientific and Industrial Research Organisation’s (CSIRO) 1990-2015 reference period no longer accurately reflect the current or projected short-term future climates at specific locations.

The climate data commonly used by modelers to demonstrate compliance with energy efficiency provisions in the National Construction Code (NCC) to size HVAC systems and to optimise building and energy system designs does not accurately represent the climate conditions that such systems will experience during their operating life.

Furthermore, CSIRO’s 1990-2015 reference period doesn’t include precipitation data, an important variable for building energy and weather-proofing simulations. The Fraunhofer Institute is developing its updated weather-proofing simulation software WUFI and, at their request in liaison with the University of Tasmania, we are contributing to it by supplying typical meteorological year data, including precipitation, based on the most recent 15 years (2009-2023) for 68 NatHERS climate zones. This data will be used to simulate weather-proofness and condensation hazard (leading to mould and its corollary health hazards) addressed by the Condensation provisions in the NCC.

Purpose

This abstract updates the previous abstract (presented at the Asia-Pacific Solar Research Conference (APSRC), 2024) and proposes using more recent reference periods to better capture evolving climate dynamics and improve building and system simulations, particularly for energy modeling.

We implement the latest 15-year reference period from 2010-2024, comparing this to a 35-year reference period from 1990-2024, as well as the CSIRO’s reference period of 1990-2015. These CSIRO files were known for two-and-a-half years to have multiple timing errors skewing the simulation results; these have belatedly been corrected (CSIRO, 2024). The authors used corrected versions generated in-house for this study and have criticised the deceptive nature of the so-called ‘update’ issued in August 2024 (Lee, 2024). The ‘update’ gives no guidance as to the severity of the skewing and hence of the necessity to repeat a wide selection of simulations done with the errant data as a sensitivity analysis.

In addition, monthly updates of the most recent data can be used for resilience testing and operational optimisation of buildings including commissioning. This function is supported by the monthly publication of a Weather and Energy Index for three archetypical buildings and one domestic solar PV system in all eight capital cities (Exemplary Energy, ongoing) as well as providing the trailing-12-months datasets for refined commissioning and analysis of finished projects in operation.

Method

Historical weather data provided by the Bureau of Meteorology (BOM) from 1990 to 2023 for 225 Australian locations including our 8 Capital cities (for which data continues to be produced) and our 61 other NatHERS Climate Zones (CZs) were processed using our in-house software “ClimateCypher” to produce 34 years of weather data in NatHERS format and EPW format suitable for simulations through EnergyPlus and most commercially available simulation packages. To analyse climate trends in our capital cities, this data was then applied to three archetype models of NCC-compliant buildings: a 1-storey supermarket building, a 3-storey office building and a 10-storey office building.

Trends in annual and monthly cooling energy demand were analysed for each building archetype individually and in aggregate to evaluate their evolution across three periods (1990–2024, 1990–2015, 2010–2024). These analyses considered Cooling Degree Days (CDD) with 18°C base temperature with 90th percentile (P90) Moisture content to highlight changes in cooling energy demand trends.
Cooling energy results below the 10th percentile were excluded for each building type to avoid distortions from extremely low values; as a result, Hobart was omitted from the reported percentage changes.

Results

The results indicate consistent upward trends in cooling energy consumption for the representative 3-storey office, 10-storey office building and supermarket across all 8 capital cities.
Comparisons across the three periods 1990-2015, 1990-2024 and 2010-2024 for all building types and cities are presented in the heatmaps (Figures 1, 2, and Table 1), where darker shades indicate higher energy consumption.

Overall, the 2010–2024 period shows higher cooling energy consumption across all cities and building types (3.4% higher than 1990–2024 and 4.9% higher than 1990–2015). Perth (CZ5) had the largest increase, with rises of 5.3% and 7% for the 3-storey office, 6% and 7.8% for the 10-storey office and 9% and 11.7% for the supermarket, compared to 1990–2024 and 1990–2015, respectively. The only exception was Melbourne, where for the supermarket the later 2010-2024 period compared to 1990-2015 period shows a *decrease* -2.3% in cooling energy consumption.

The four non-tropical climate zones here represented by Brisbane (CZ2), Perth (CZ5), Melbourne (CZ6) and Canberra (CZ7) showed consistent increases in cooling energy consumption across all building types, with the reported values representing the average of the three building types: 3.4% and 6.0% in Brisbane, 3.1% and 5.5% in Canberra, and 1.8% and 0.8% in Melbourne, compared to 1990–2024 and 1990–2015, respectively.

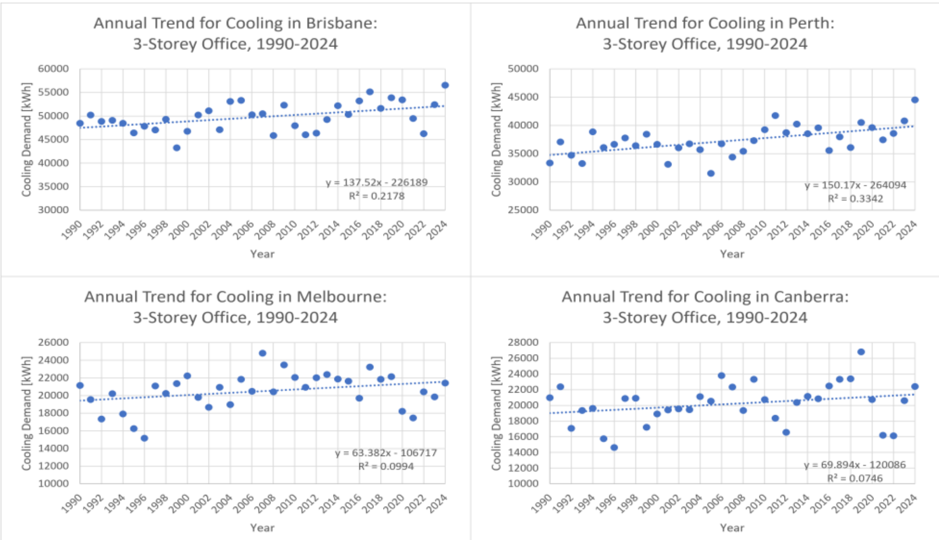

Figure 1. Annual cooling energy demand trend for a 3-storey NCC-compliant office building from 1990 to 2024.

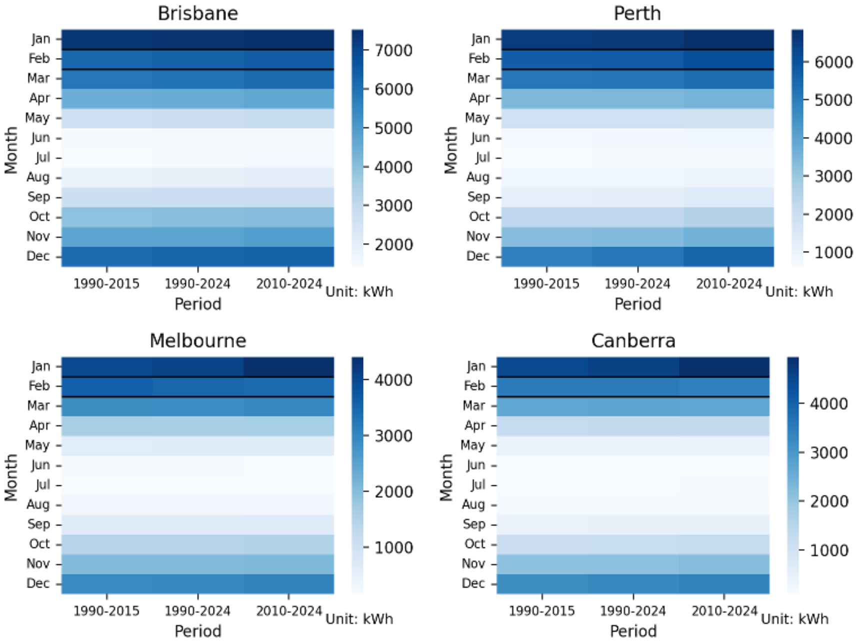

Figure 2. Comparison of cooling energy demand of 3-storey office in three periods.

All cities show downward trends in heating energy consumption, with changes much larger and more variable than those for cooling. Compared to 1990–2015, decreases range from -3.01% to -2.83%, and relative to 1990-2024, they range from -4.37% to -27.44%. Only Brisbane and Canberra (and Darwin, where there is no heating demand) present reductions less than 10%. These cooling and heating results are highly related to recent global warming trends.

Table 1. Summary of cooling energy consumption of 3-storey office in three periods.

Location (Unit: kWh)	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Brisbane	1990-2015	7345.39	6264.24	5850.23	4462.63	2718.05	1478.45	1415.02	1803.97	2754.99	3942.47	4712.66	6156.55
	1990-2024	7421.67	6359.41	5970.20	4539.10	2800.14	1505.70	1494.45	1908.18	2792.99	3997.20	4754.42	6272.74
	2010-2024	7530.69	6480.90	6131.72	4676.50	2883.59	1499.46	1581.29	2042.21	2814.59	4043.67	4939.41	6317.51
Perth	1990-2015	6541.79	5762.30	5119.89	3456.88	1886.21	765.07	612.37	834.54	1202.32	2300.24	3290.87	4935.75
	1990-2024	6581.16	5808.88	5175.10	3457.58	1890.22	784.83	645.30	850.55	1258.79	2316.34	3370.58	5162.67
	2010-2024	6845.05	6099.90	5347.77	3566.57	1849.70	835.08	666.08	951.67	1423.84	2533.47	3594.98	5565.82
Melbourne	1990-2015	4009.15	3641.78	2870.79	1620.77	635.53	174.43	155.47	297.98	658.61	1451.49	2047.05	2932.69
	1990-2024	4099.83	3518.00	2889.10	1609.21	640.38	174.02	157.05	303.83	661.74	1436.27	2049.61	2952.07
	2010-2024	4410.05	3429.91	2973.87	1640.40	642.56	161.53	158.28	298.60	701.06	1469.43	2073.11	3056.49
Canberra	1990-2015	4486.36	3551.59	2683.84	1314.29	421.71	96.37	93.48	168.28	452.11	1223.16	2107.38	3195.30
	1990-2024	4626.45	3551.39	2721.42	1349.88	426.41	99.64	105.41	176.02	461.37	1242.75	2127.64	3302.21
	2010-2024	4954.15	3467.46	2707.56	1346.00	401.48	101.48	114.35	172.98	476.52	1310.10	2205.84	3411.59

Regarding weather trend changes from Figure 3 and Table 2, a comparison of monthly average CDD between 1990-2015 and 2010-2024 reveals significant increases in cooling demand during the 2010-2024 period. Moisture content comparisons also show the recent 15 years of moisture contents are slightly higher than the other two periods in most months.

This trend underscores the significant impact of climate change, as warmer moister weather results in a reduced need for heating and a heightened demand for cooling solutions. These findings reinforce the idea that, as Australia continues to experience rising temperatures and shifting weather patterns, cooling energy consumption will continue to increase.

Across Australia’s capital cities, the comparison between 1990–2015 and 2010–2024 reveals a consistent rise in dry bulb temperature (DBT), with increases ranging from +0.03 °C in Melbourne to +0.46 °C in Hobart and Perth. CDD also increased in all cities, with Perth and Sydney showing noticeable rises of +13.3% and +10.9%, respectively, reflecting the corresponding increase in cooling demand.

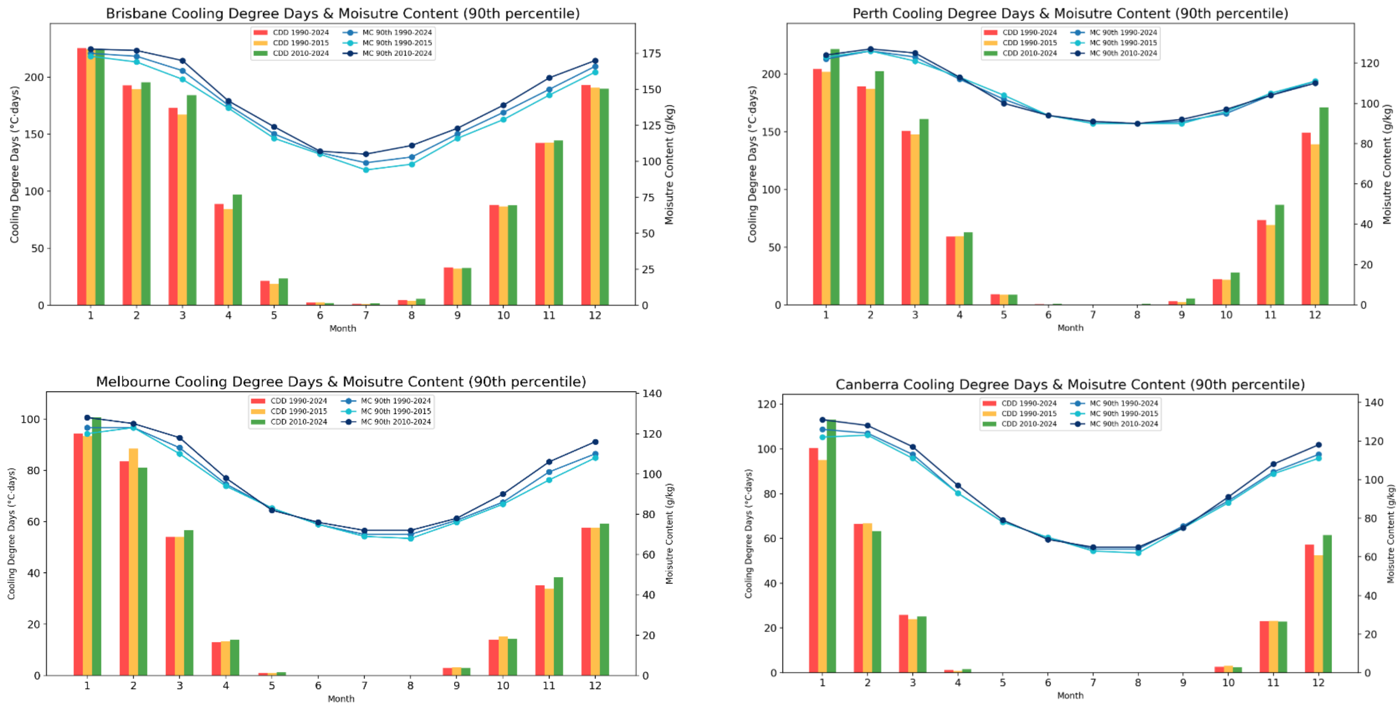

Figure 3. Cooling Degree and 90th Percentile Moisture Content in three periods

Moisture content also showed small rises in most cities, with Brisbane having the largest increase (+10.5%) while the other capital cities (except Adelaide and Perth) had modest increases. P90 also supports the increase of moisture content.

Precipitation changes notably in a few cities such as Canberra (+11.3%) and Sydney (+10.9%), but not in Adelaide (-6.3%) and Perth (-7.3%). The impact of these precipitation trends on cooling energy demand is less straightforward, suggesting that other factors such as DBT, moisture content, urban environment and internal building loads should also be considered when assessing future cooling energy requirements.

Table 2. Summary of Average Weather Variables.

Average	Dry Bulb Temperature(°C)			Moisture Content (g/kg)			Moisture Content (g/kg) / P90			Precipitation (mm)			Cooling Degree Days (°C·day)		
	1990-2015	1990-2024	2010-2024	1990-2015	1990-2024	2010-2024	1990-2015	1990-2024	2010-2024	1990-2015	1990-2024	2010-2024	1990-2015	1990-2024	2010-2024
Adelaide	17.01	17.05	17.25	68.94	69.26	69.26	92.17	92.33	93.09	44.52	43.51	41.70	653.63	654.51	692.37
Brisbane	20.25	20.38	20.57	100.62	103.72	111.22	133.50	137.17	142.00	85.94	86.63	92.86	1142.61	1165.23	1187.75
Canberra	13.17	13.25	13.33	67.44	68.37	70.37	91.58	92.83	95.25	49.19	50.78	54.77	265.28	276.90	289.88
Darwin	27.16	27.31	27.50	158.83	160.06	161.69	188.17	189.50	191.33	153.93	150.99	150.59	3343.82	3400.02	3471.07
Hobart	12.59	12.73	13.05	60.33	60.78	61.63	79.83	80.50	81.67	47.51	47.51	47.16	67.18	71.87	84.13
Melbourne	15.68	15.65	15.71	70.70	71.78	74.30	92.33	93.83	96.75	49.65	49.88	51.03	359.77	355.65	368.32
Perth	18.29	18.39	18.75	77.54	77.53	77.52	105.25	105.08	105.58	58.85	57.87	54.54	837.88	861.62	949.22
Sydney	18.09	18.18	18.39	90.43	91.97	94.38	117.64	119.58	122.08	98.32	102.29	109.00	655.29	675.72	726.70

Conclusion

These findings collectively suggest substantial shifts in local climates over the 1990-2024 reference period. Consequently, more frequent updates and shorter measurement periods may yield greater predictive accuracy for meteorological conditions, and by extension, renewable and building energy simulations (Trewin, 2007).

Comparison of the three periods (1990–2024, 1990–2015, 2009–2024) shows that conventional periods, such as CSIRO’s 1990–2015, no longer adequately reflect evolving climate conditions. Observed changes in CDD, cooling demand and key meteorological parameters highlight the importance of adopting more recent reference periods to enhance the reliability of weather data for building energy and weather-proofing simulations.

References

Bureau of Meteorology, 2025, ‘State of the Climate 2024’. Available at: http://www.bom.gov.au/state-of-the-climate/australias-changing-climate.shtml. Accessed 26 August 2025.

CSIRO, 2024, ‘CSIRO weather files for building energy modelling – update’ (sic), personal communication sent to all who had downloaded the errant files over the two and a half years that they were available, reproduced verbatim here.

Cui, Y., Yan, D., Hong, T., Xiao, C., Luo, X. and Zhang, Q, 2017, ‘Comparison of typical year and multiyear building simulations using a 55-year actual weather data set from China’, Applied Energy, 195, pages 890-904.

Exemplary Energy, monthly, ongoing, ‘Weather and Energy Index’, web published here.

Exemplary Energy, 2024, ‘Temporal Analysis and the Implications for Building Performance and PV System Simulations’, web published here.

Lee, TR, 2024, ‘Misleading HVAC data’ in Climate Control News, 13 August 2024, web published here and here.

Trewin, B, 2007, ‘The Role of Climatological Normals in a Changing Climate’, World Meteorological Organisation. Available at: https://library.wmo.int/records/item/52499-the-role-of-climatological-normals-in-a-changing-climate. Accessed 5 September 2023.

Oh, H.G. and Lee T., 2024, ‘Enhancing Australia’s Weather and Climate Data for Energy System and Weather-proofing Simulations’, *Proceedings of the Asia-Pacific Solar Research Conference (APSRC) 2024*.