Extreme Climate Data Files for Design Resilience

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XMY: eXtreme Meteorological Year

- Hypothetical data set representing an extreme year of weather, i.e. representing conditions that produce extremely high or low energy consumption/generation across the entire year

Uses of XMY - design and financial applications like:

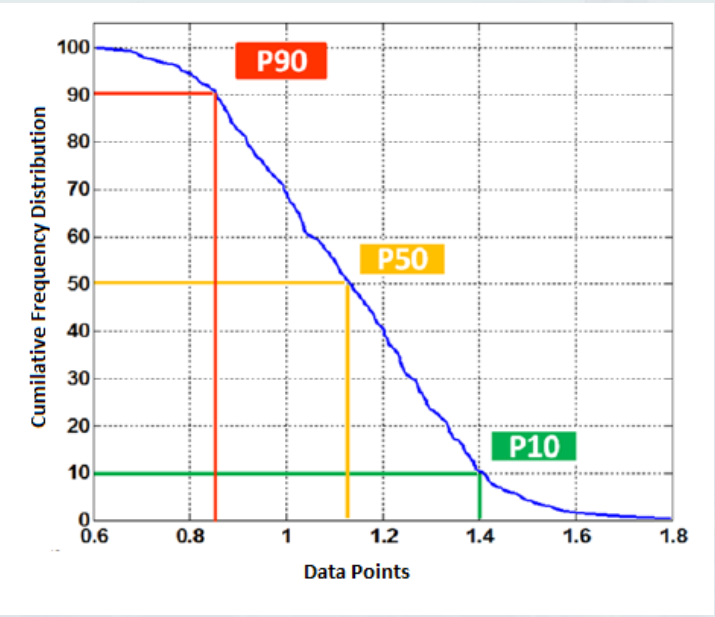
- Understanding building energy performance in extreme year
- Best Year Data – to calculate USE (unserved energy)
- Worst Year Data – to manage risk of variability of renewable sources by determining factors like DSCR (Debt Service Coverage Ratio)

Defining XMY for fixed flat-plate solar PV

- From literature survey, most XMY data were defined based on *dry bulb temperature* and *solar irradiation*.

Probabilistic Approach

- P01, P10, P90 & P99 data in statistics: a value expected to exceed 1%, 10%, 90% and 99% of the cases in a given temporal sample respectively
- Can be done using Monte Carlo simulation[1]



[1]Dobos, A. P., Gilman, P., & Kasberg, M. (2012). P50/P90 analysis for solar energy systems using the system advisor model. National Renewable Energy Lab. (NREL), Golden, CO (United States)

Previous work: XMY_{PV} Data

RESOURCES

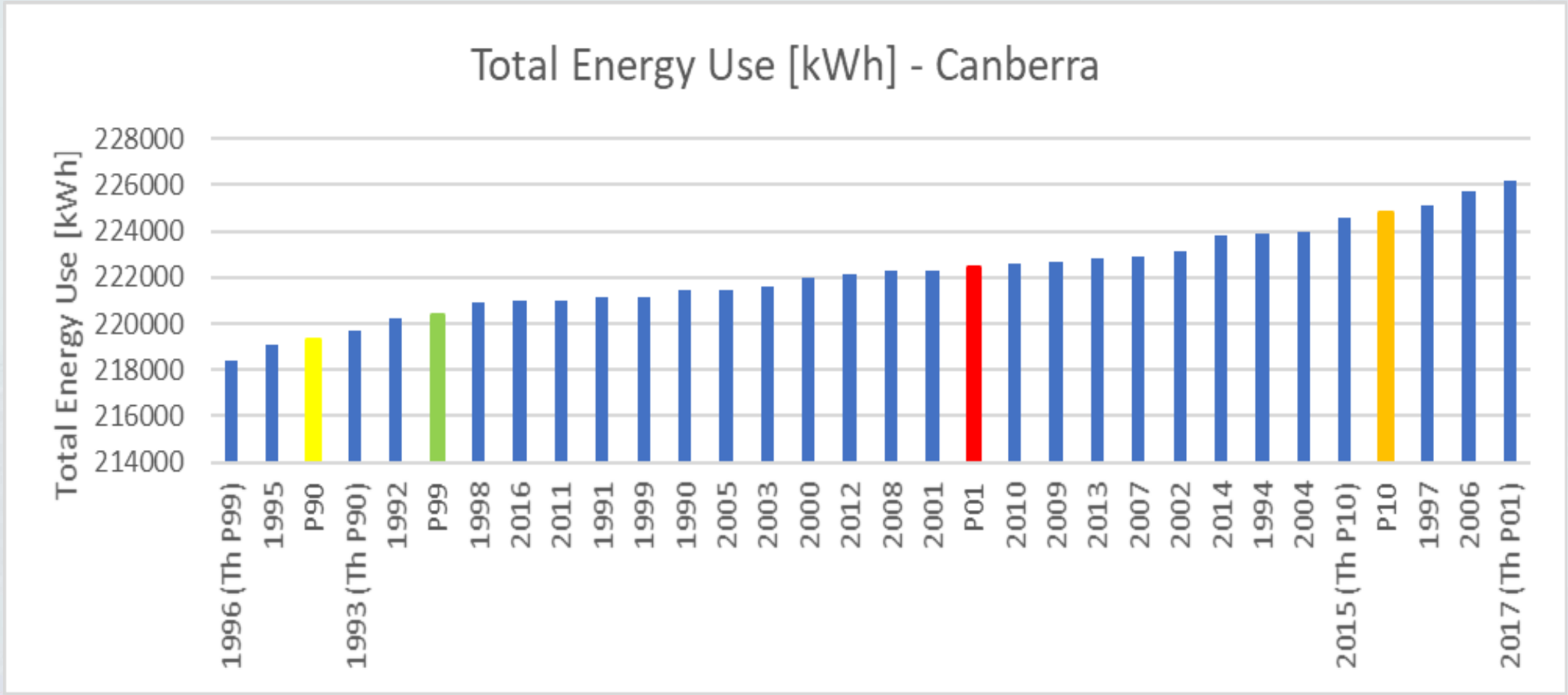
1. **System Advisor Model (SAM)** – free, readily available software developed by NREL
2. **ClimateCypher** - Exemplary Energy's in-house software package
3. **EnergyPlus** - open-source building energy performance simulation software developed by the US Department of Energy

- Generated P01, P10, P90 and P99 weather files in ClimateCypher by concatenating the most appropriate 12 historic calendar months such that synthesised year closely matches the 1st, 10th, 90th and 99th percentile criteria respectively for a PV system output.
  - Conducted for all eight Australian Climate Zones in the National Construction Code, and results were presented at the Asia Pacific Solar Research Conference 2020 and 2021.

Simulating building energy consumption

- XMY data is important for building energy simulations.
- Analysed the validity of applying the existing XMY_{PV} data to building HVAC modelling
  - The total building energy consumption was computed for Brisbane and Canberra for each year from 1990-2017 for the 3-storey building archetype
  - Total and end-use component energy consumptions corresponding to hypothetical P01, P10, P90 and P99 weather data from ClimateCypher were also computed
- As expected, results of this analysis show that the extreme weather data defined in this way proves to be incapable of correctly representing the extremities of energy consumption or demand of a building.

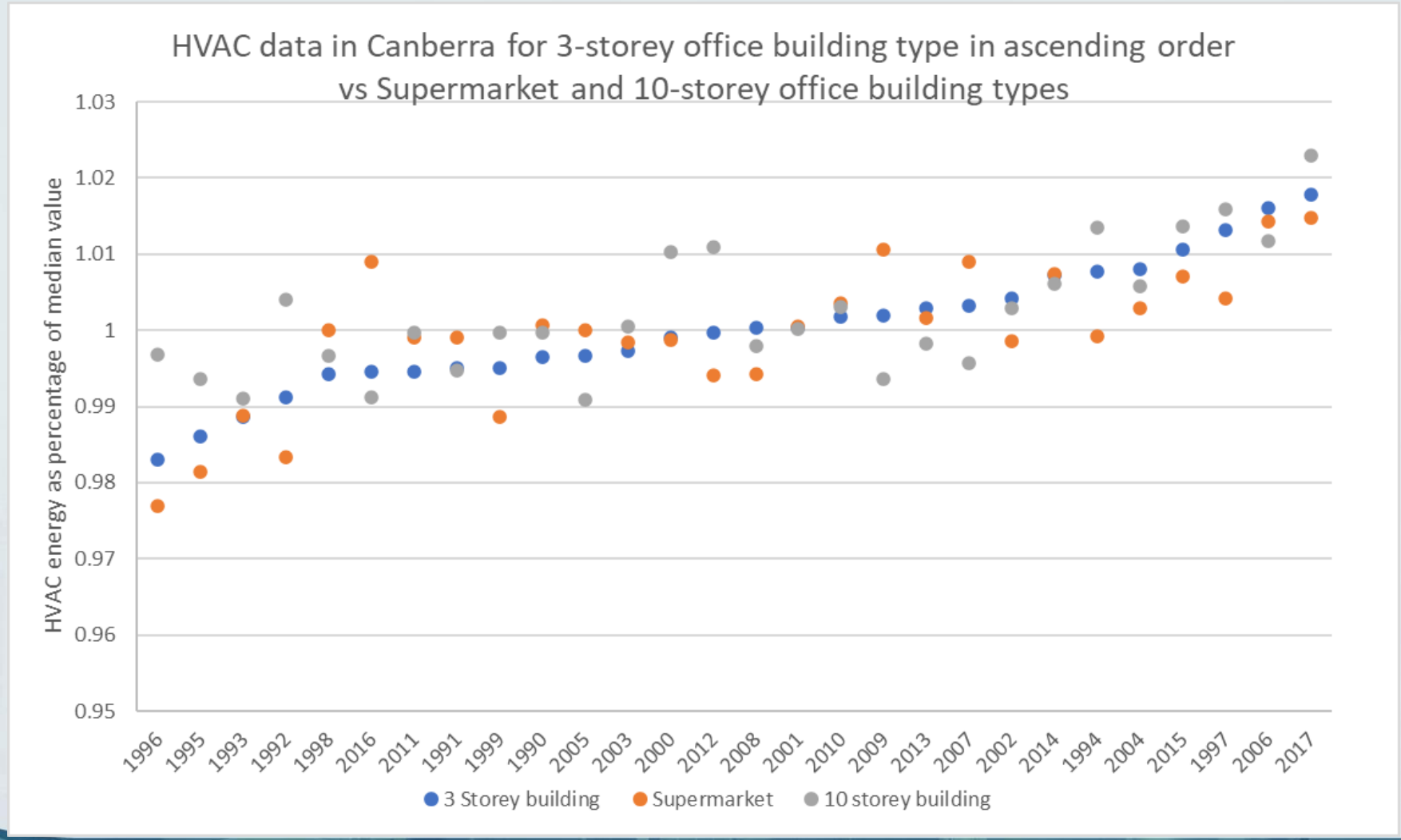
Total Building Energy Consumption for 1990-2017 and the energy corresponding to the percentile XMY_{PV} weather data for Canberra



Recent work: towards XMY (HVAC)

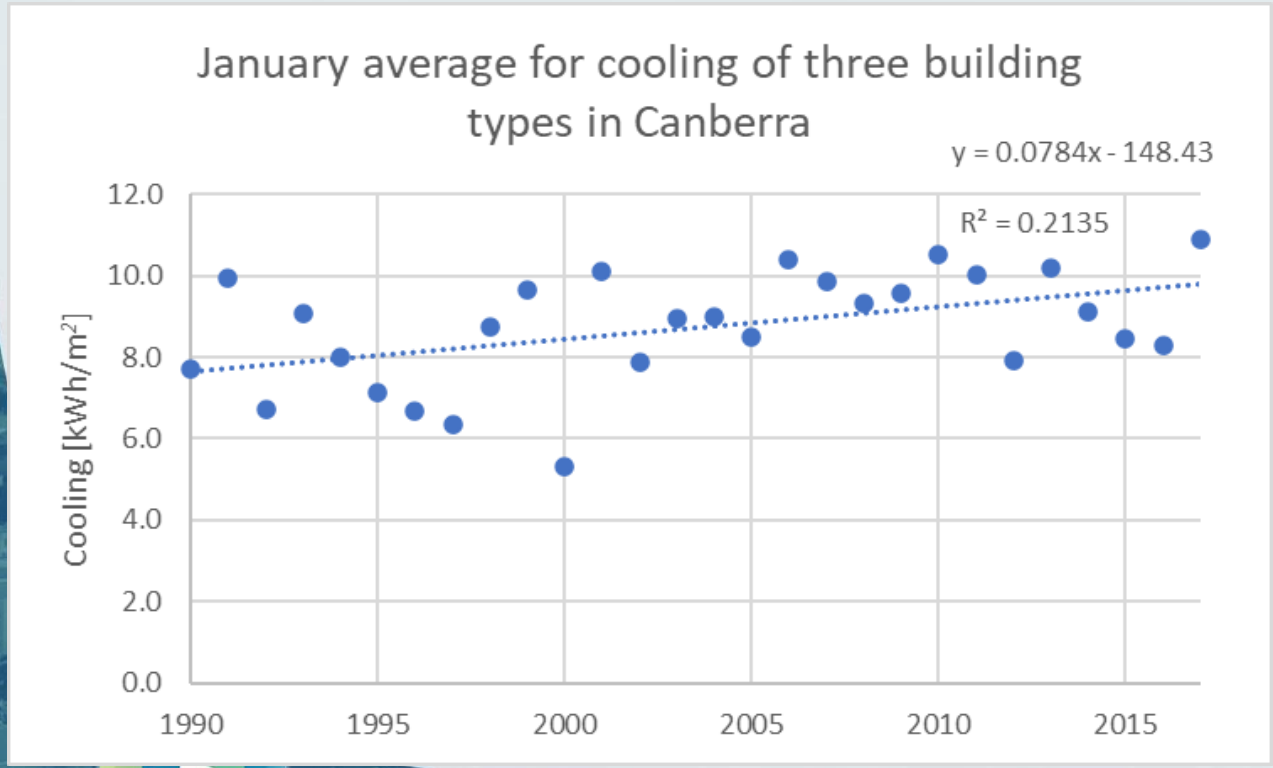
- New technique: run historical yearly weather data through EnergyPlus to generate heating and cooling energy data for our three archetype buildings - Supermarket, 3-storey and 10-storey office buildings
- We assessed whether the “extreme” year for one building type is valid for all commercial building types
  - Confirmed correlation between building types
  - Descriptive statistics (max, min, mean, standard deviation, z-scores)
  - Early work found that results fit a rough Gaussian distribution (bell curve) and therefore standard statistical techniques can be applied to the analysis

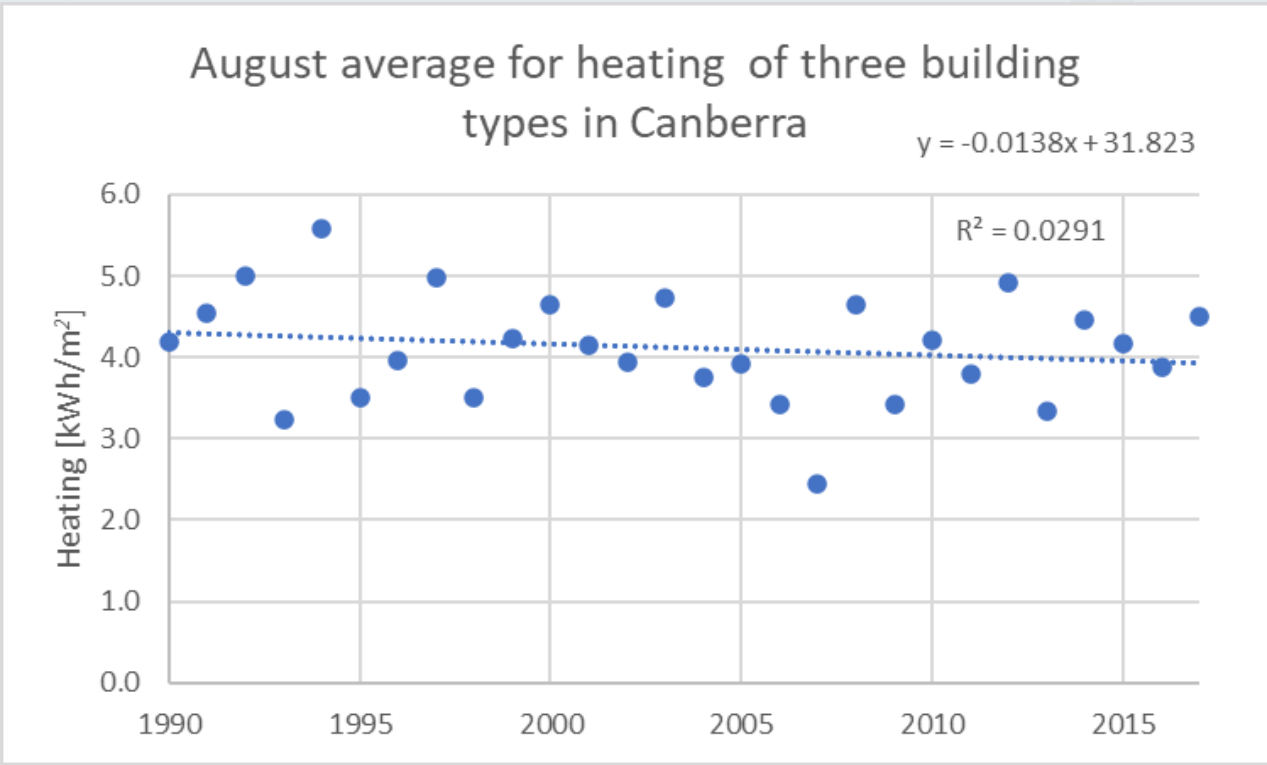
Correlation of HVAC energy use between the three building types



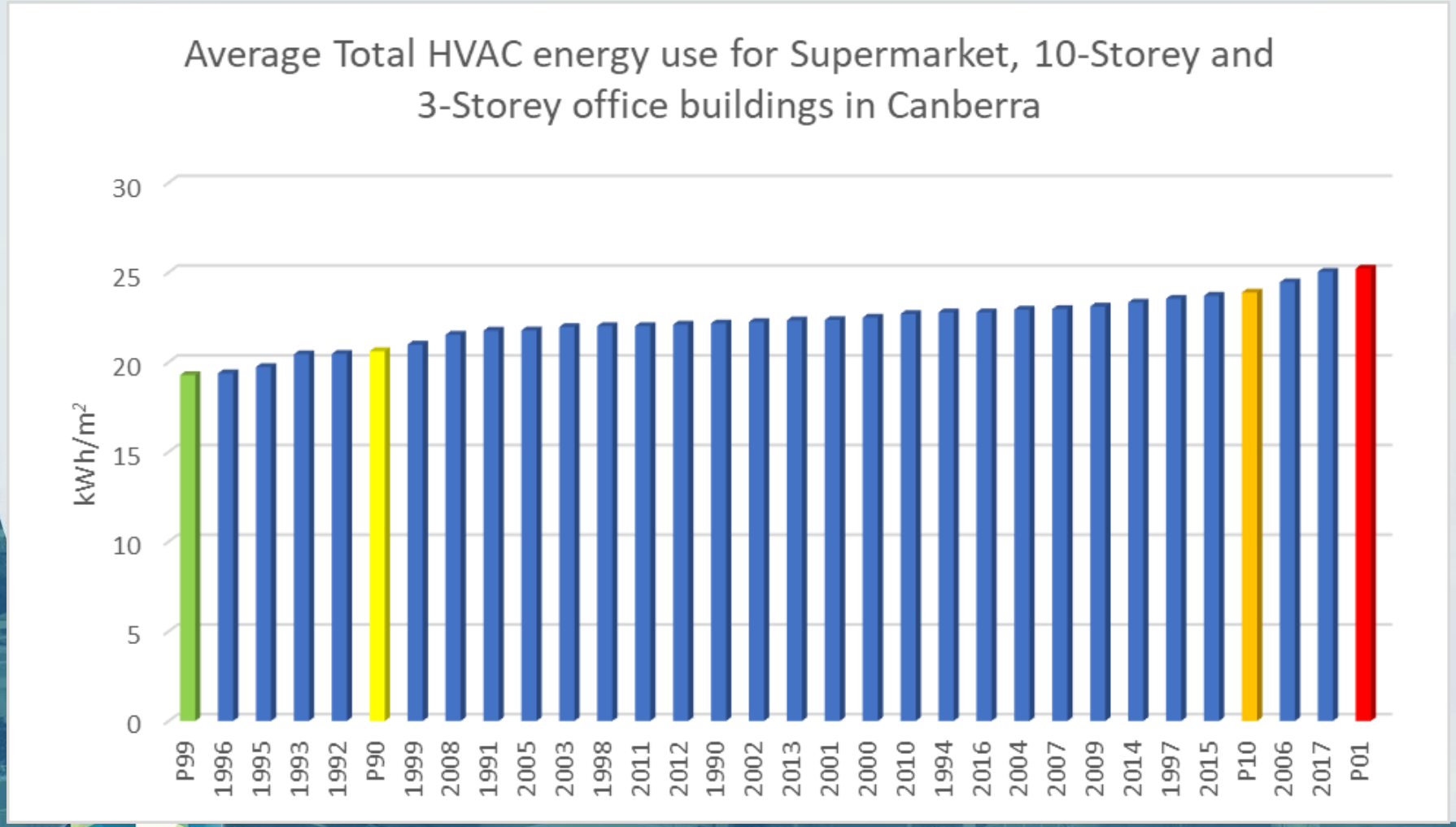
Trends over time

- Early work is showing significant correlations over time of increasing cooling load and decreasing heating, due to a warming climate





Results: P-values



Closest historical data to calculated P-values of:

- P99 is 0.988 (1996)
- P90 is 0.919 (1992)
- P10 is 0.127 (2015)
- P01 is 0.014 (2017)

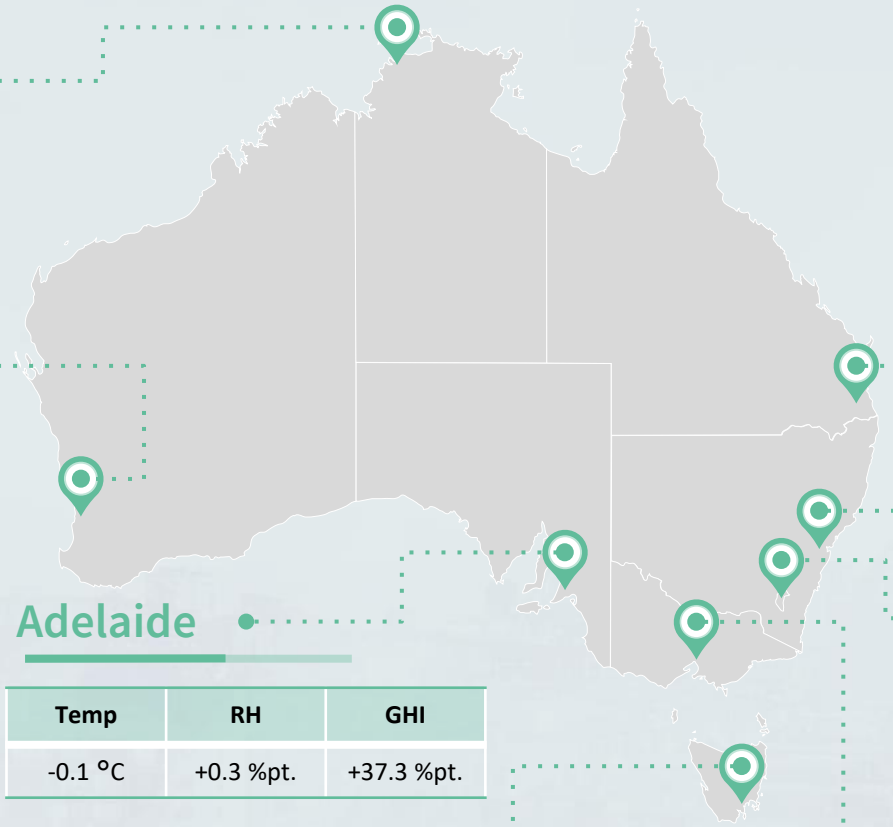
Next Steps

- To develop a technique to concatenate a series of months to create an artificial year of 12 months representative of P1, P10, P90 and P99 years for simulation testing of the robustness of building designs for energy consumption and for water penetration and condensation

Potential Applications

- Risk assessments for developers, owners and regulators
- NABERS Energy, Green Star certification and other targets for Energy Efficiency (for example NCC Section J)

Weather Index – May Monthly Means



Darwin

Temp	RH	GHI
N.A.	N.A.	N.A.

Perth

Temp	RH	GHI
+0.3 °C	+0.2 %pt.	+9.1 %pt.

Adelaide

Temp	RH	GHI
-0.1 °C	+0.3 %pt.	+37.3 %pt.

Hobart

Temp	RH	GHI
-0.3 °C	+8.3 %pt.	-6.2 %pt.

Brisbane

Temp	RH	GHI
+0.6 °C	+9 %pt.	-47.5 %pt.

Sydney

Temp	RH	GHI
+0.6 °C	+6.6 %pt.	-12.8 %pt.

Canberra

Temp	RH	GHI
+0.1 °C	+7.6 %pt.	-18.8 %pt.

Melbourne

Temp	RH	GHI
-0.6 °C	+5 %pt.	-13.5 %pt.

Context of weather and climate data services

- Weather and Energy Index (WEI) published monthly – all 8 capital cities.
- Real Time Meteorological Years (RTYs) generated monthly for sale to simulators seeking calibrated results for existing buildings and systems – all 8 capital cities.
- Full 32 year weather records for ~250 Australian locations including all 80 NatHERS climate zones adhering to time stamp conventions (1990 to 2021 inclusive).
- Reference Meteorological Years (RMYs) derived from those 32 year records based on 3 alternative weightings for solar irradiation in the Cumulative Difference Function (CFD) and including precipitation data.
- Ersatz Future Meteorological Years (EFMYs) for 2030 and 2050 scenarios.
- Extreme Meteorological Years (XMYs) for flat plate solar PV, water penetration and condensation (WPC) and building services (HVAC).
- www.exemplary.com.au blog https://exemplaryenergy.wordpress.com

Q&A

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