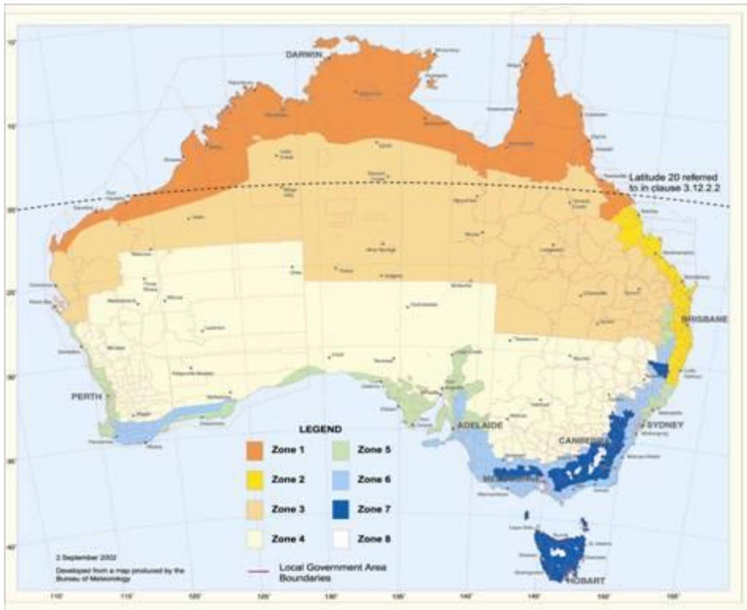
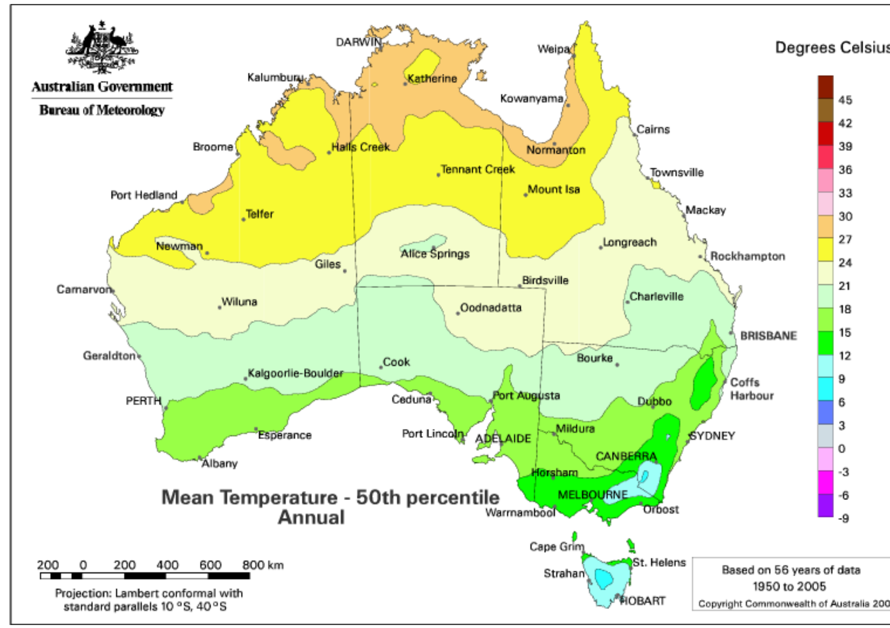
CREATION OF ERSATZ FUTURE WEATHER DATA FILES



Climate zones of the Australian Building



50^{th} Percentile Temperatures (Annual)

Trevor Lee
Director, Buildings

A Little History (2005)

- **"An Assessment of the Need to Adapt Buildings for the Unavoidable Consequences of Climate Change"** (BRANZ for AGO)
  - Trevor Lee et al (Exemplary Energy)
  - Lynda Amitrano (BRANZ Ltd)
  - Rachel Hargreaves (BRANZ Ltd)
  - Ian Page (BRANZ Ltd)
  - Kevin Hennessy (CSIRO)
  - Les Winton (Artcraft Research)
  - Rosalie Woodruff (ANU-NCEPH)
  - Tord Kjellstrom (ANU-NCEPH)

Unavoidable Climate Change

- Commercial and residential buildings
- 13 sites selected to represent Australia
- Climate change information
  - Temperature
  - Rainfall
  - Wind (including cyclones)
  - Flooding
  - Fire
  - Hail
  - Humidity
  - Radiation

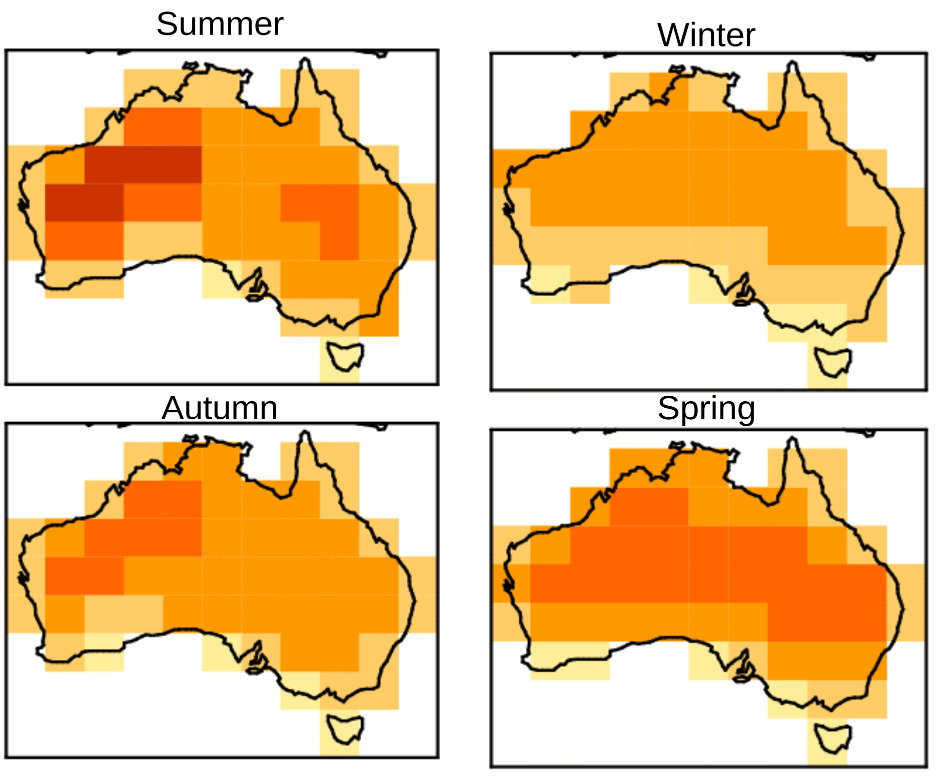
Setting the Climate Baseline (2005)

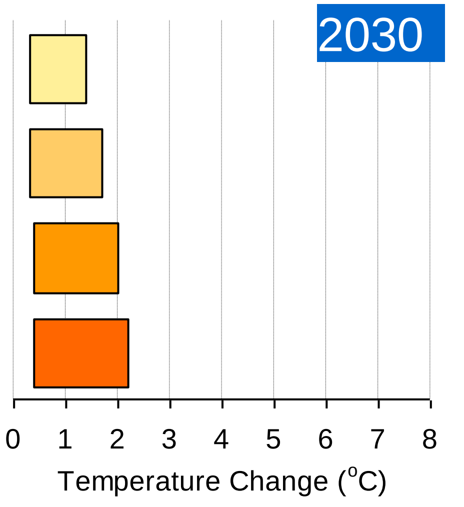
- That work predated ACDB 2006 which processed and archived BOM data from 1967 to 2004 inclusive
- CSIRO used the 4 decades centred on 1984 (ie, 1964 to 2004) as the baseline
- No adjustment for apparent warming over the baseline period

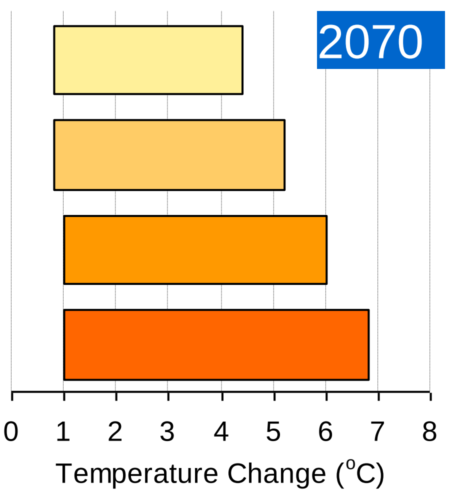
“Forecasting” the Climate (2005)

- Weather “forecast” for the 4 decades centred on 2030 and 2070
- Each weather element “forecast” as a wide range of possible values
- No indication of a “most likely” value
- Each element “forecast” independently (eg, higher temperature, lower <u>relative</u> humidity, higher-or-lower insolation, higher-or-lower wind speed)

Previous Climate "Forecast" (Seasonal)



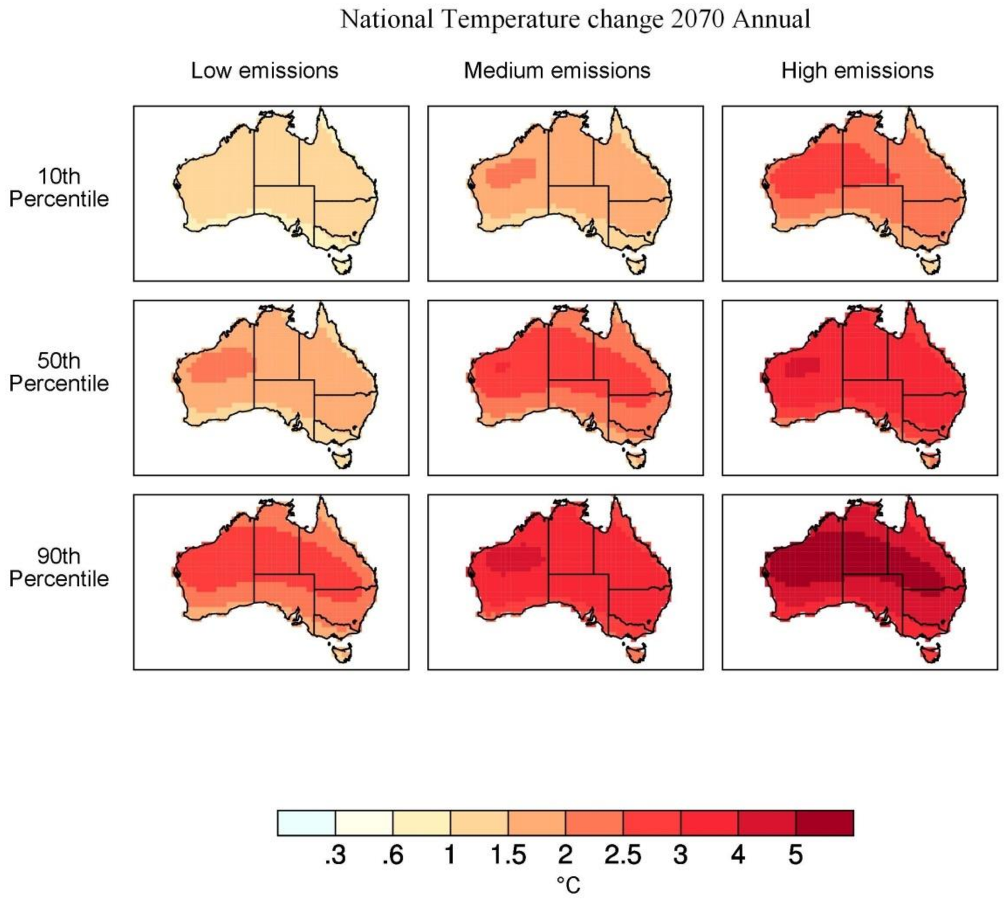




- **Baseline of 4 decades centred on 1984**
- **Most warming spring and summer.**
- **10-50% more hot days by 2030.**
- **Increase in number of hot spells**

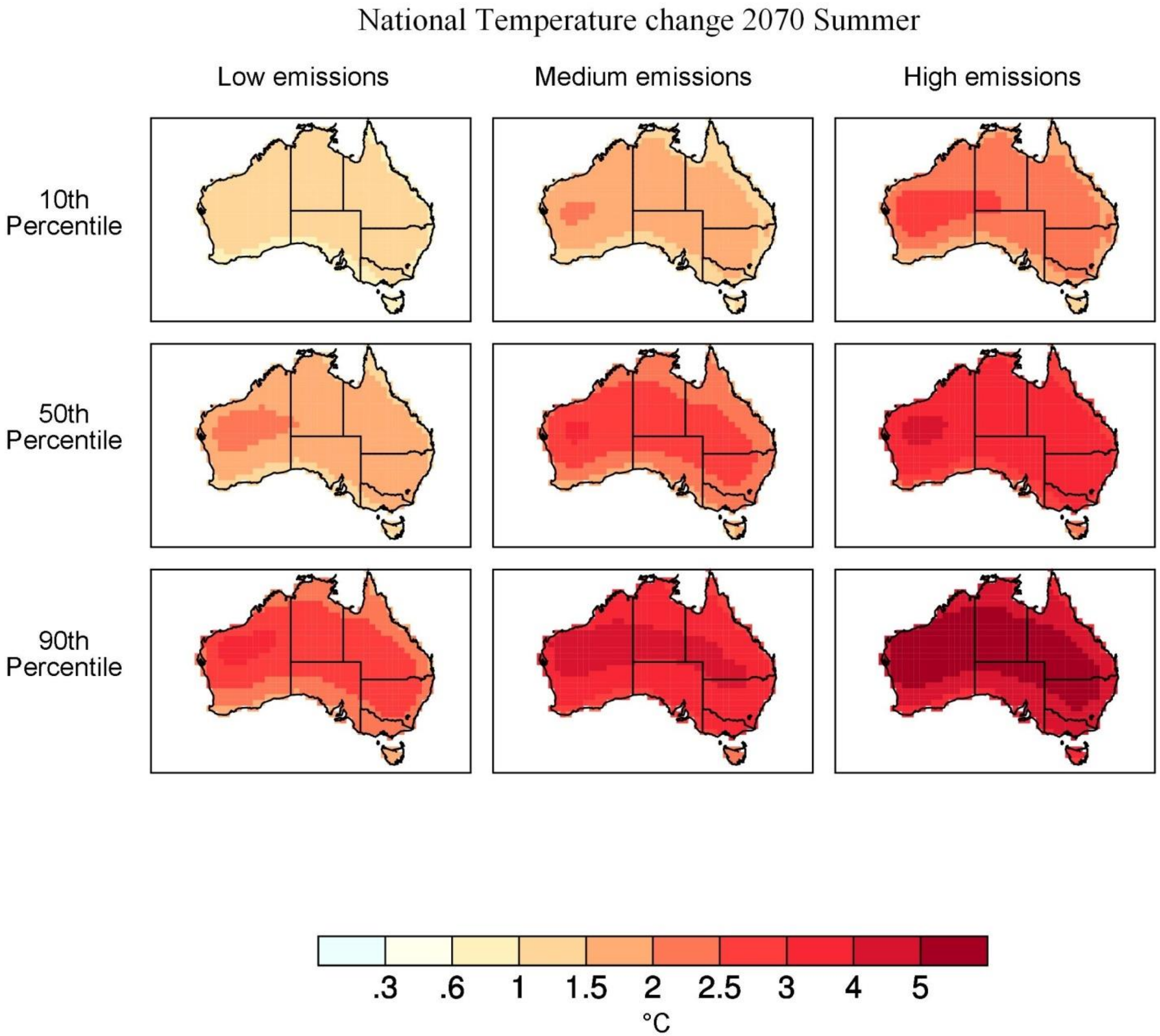
Updated Climate "Forecast" (Annual)

Available at: http://www.climatechangeinaustralia.gov.au

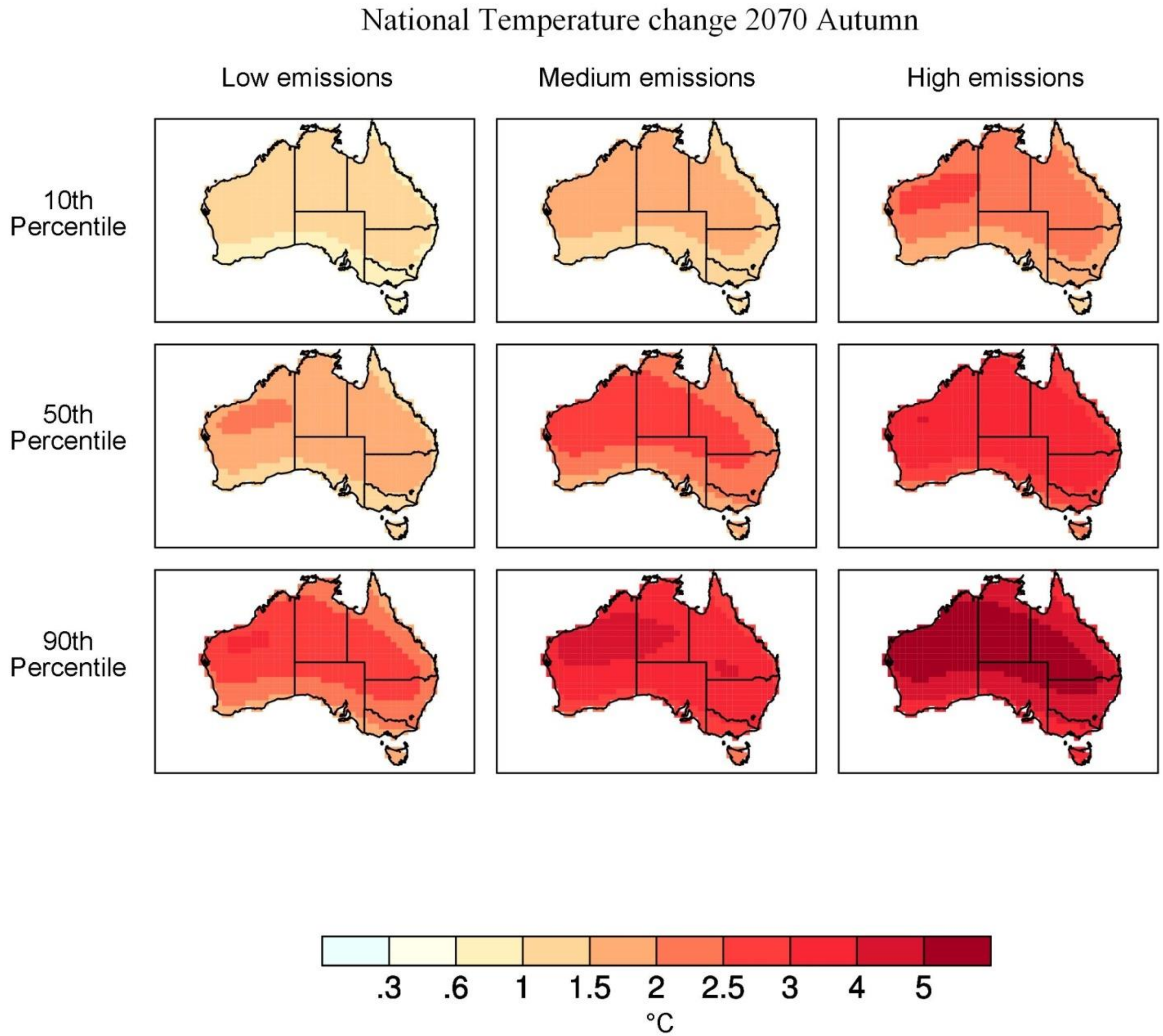


- **More accurate updated projections, at finer resolution**
- **Projections are presented relative to the period 1980-1999 (referred to as the "1990 baseline" for convenience).**
- **The 50th percentile (the mid-point of the spread of model results) provides a best estimate result.**
- **The 10th and 90th percentiles provide a range of uncertainty.**

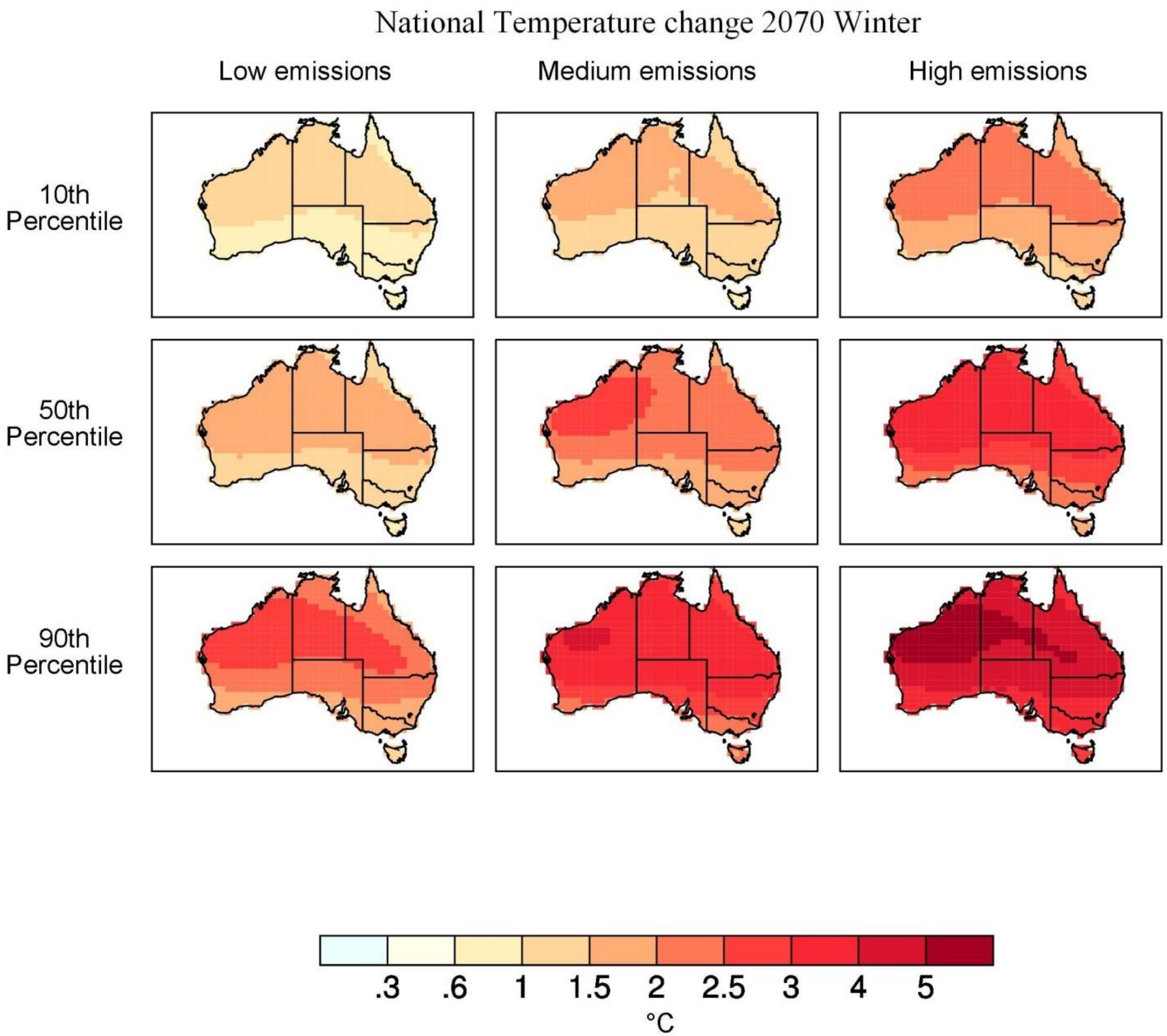
Climate “Forecast” (Summer)



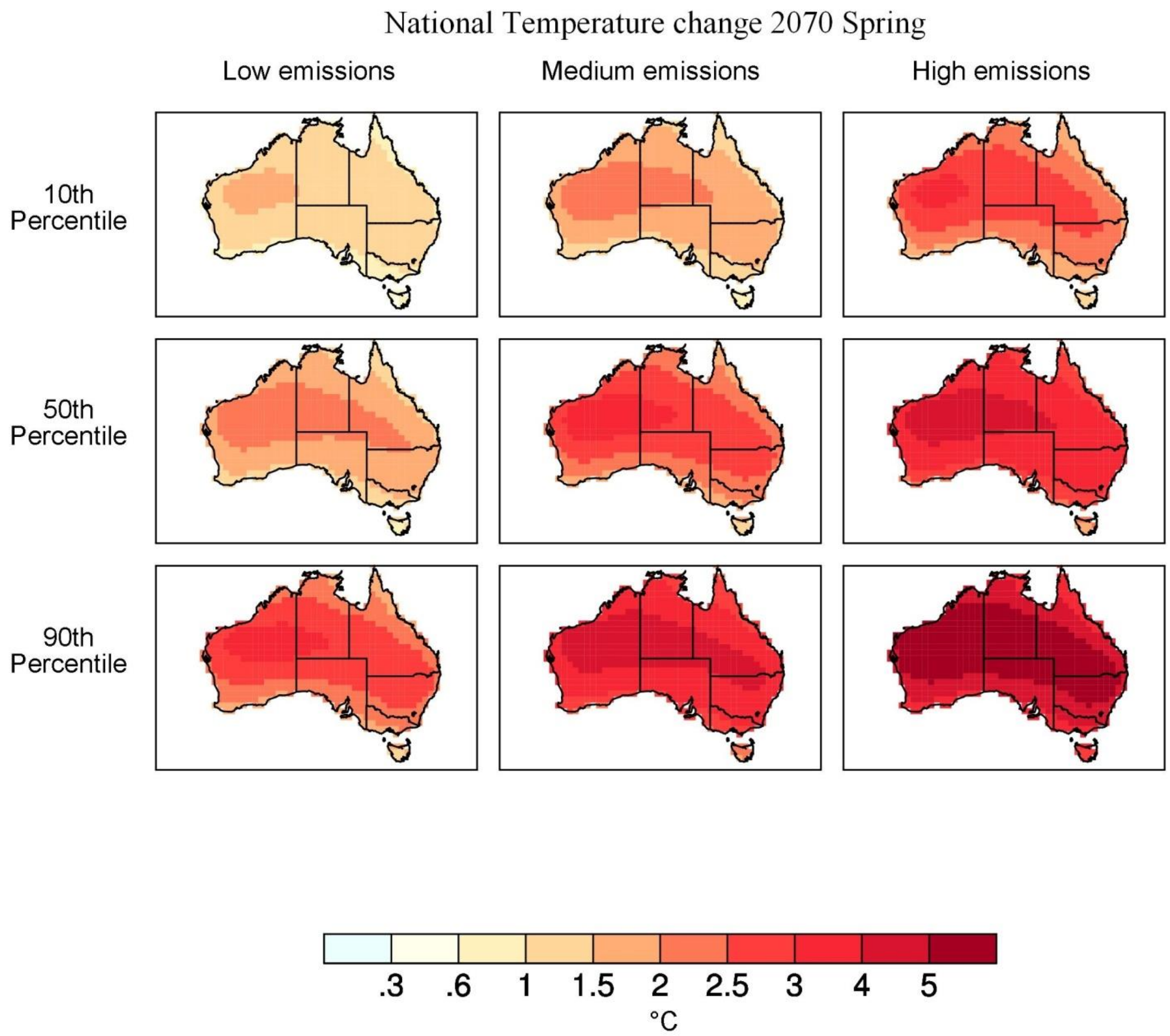
Climate "Forecast" (Autumn)



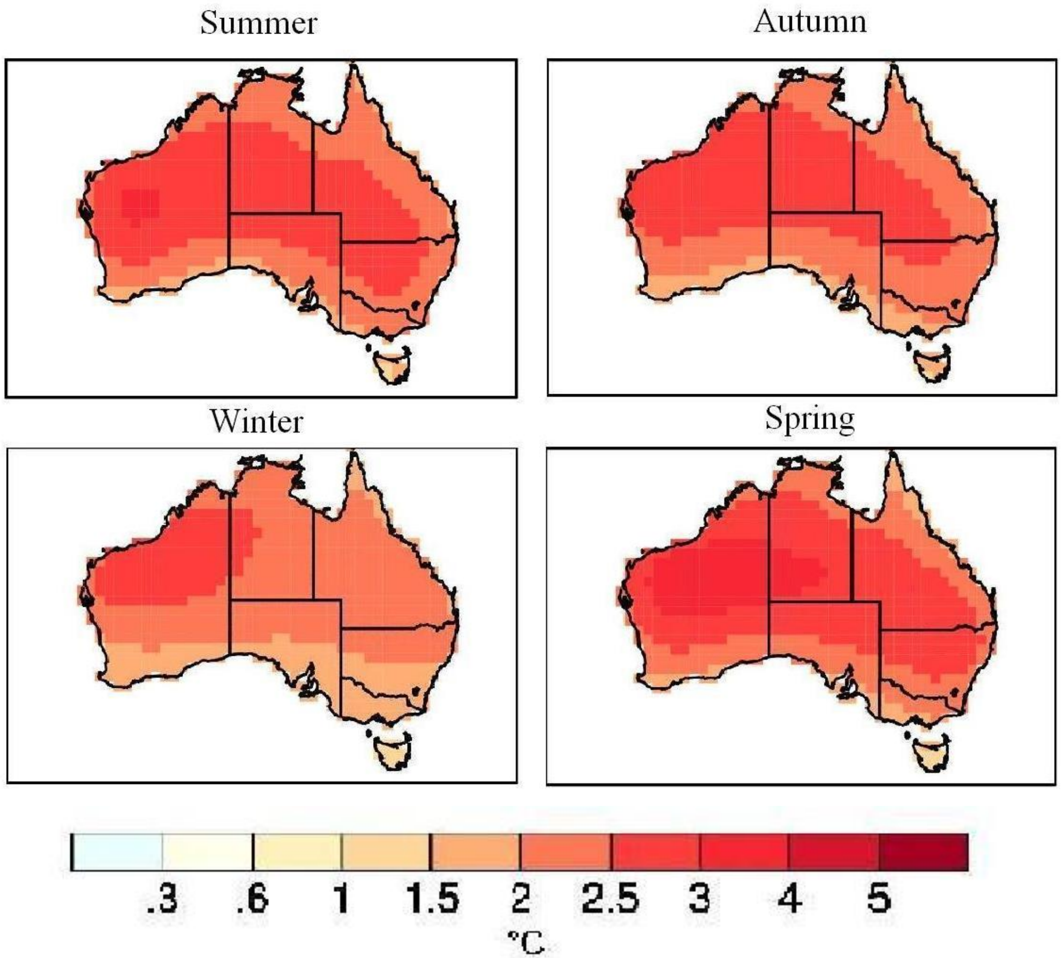
Climate "Forecast" (Winter)



Climate "Forecast" (Spring)

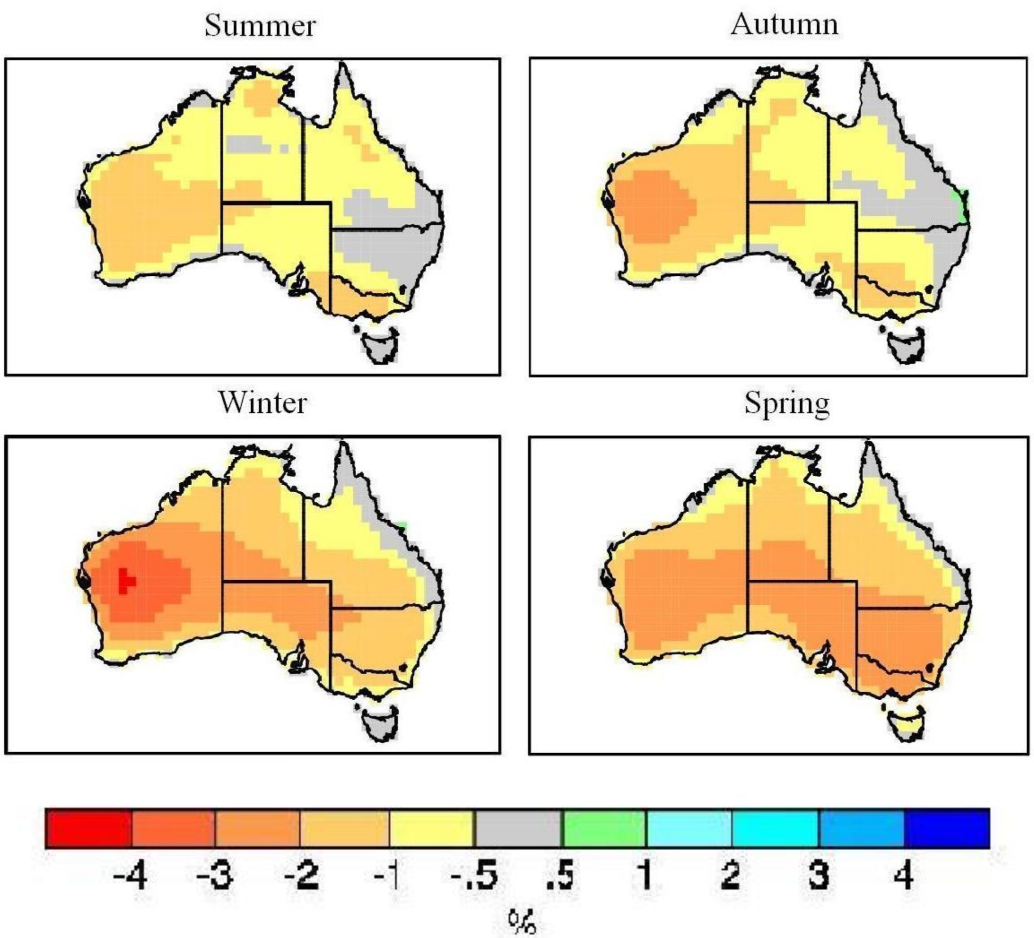


Climate “Forecast” (Seasonal)



- 50th percentile change in dry-bulb temperature

Climate "Forecast" (Seasonal)



- 50th percentile change in Relative Humidity

Setting the Weather Data Baseline

- 2005 Based on TRYs created by BOM and CSIRO in 1980s
- Test Reference Year (actual) selected by excluding years of extraordinary dry bulb temperature
- Subsequent work for DCCEE based on targeted PCVs for 11 locations (8 capitals plus other 3 BCA climate zones) and RMYs prepared in 2008 but unpublished

Setting the Weather Data Baseline

Recent Work

- Subsequent “Baseline Meteorological Year” (BMY) data (12 actual months concatenated) is selected on the basis of statistical averages for the current baseline of 1990.
- 1990 BMYs for 100 locations generated based on 1975 to 2004 inclusive
- Incorporating BOM’s satellite-derived hourly solar data from 1990 initially released 2010 (with subsequent ~quarterly updates)
- New PCVs provided by CSIRO in late 2014
- New code for synthesizing EFMYs from BMYs
- Now available for building and energy system simulation.

Creating the Ersatz Weather Data

- Weather files for two scenarios for 2030 and four scenarios for 2050 (high to low emissions) were created in ACDB and TMY2 formats
- Monthly Projected (not “Forecast”) Change Values (PCVs) provided by CSIRO on a <u>coarser</u> geographic grid
- Interpolation used on PCVs near the boundary between two (or three or four) grid cells
  - Temperature
  - Humidity
  - Insolation and cloud cover
  - Wind

Creating the Ersatz Weather Data

- Monthly Projected Change Values (PCVs) provided by CSIRO on a coarse geographic grid

CHANGE IN 2030 (A1B) WITH RESPECT TO 1990									
STORY	MODEL	MEAN RELATIVE HUMIDITY (CHANGE % OF ORIGINAL %)				MEAN SURFACE TEMPERATURE (CHANGE °C)			
		DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Most likely (20 models)	INM-CM3.0	-1.08	-0.45	-0.64	-3.1	0.96	0.78	0.69	0.7
Warmest case (2 models)	CSIRO-Mk3.5	-1.68	-2.02	-2.99	-5.26	1.21	1.27	1	1.22
CHANGE IN 2050 (B1) WITH RESPECT TO 1990									
Most likely (18 models)	INM-CM3.0	-0.85	-0.35	-0.51	-2.43	0.76	0.61	0.55	0.55
Warmest case (1 model)	CSIRO-Mk3.5	-1.32	-1.59	-2.35	-4.13	0.95	1	0.79	0.96
CHANGE IN 2050 (A1FI) WITH RESPECT TO 1990									
Most likely (9 models)	INM-CM3.0	-3.1	-1.28	-1.84	-8.84	2.75	2.23	1.98	2.01
Warmest case (1 model)	CSIRO-Mk3.5	-4.81	-5.76	-8.55	-15.02	3.46	3.62	2.86	3.49

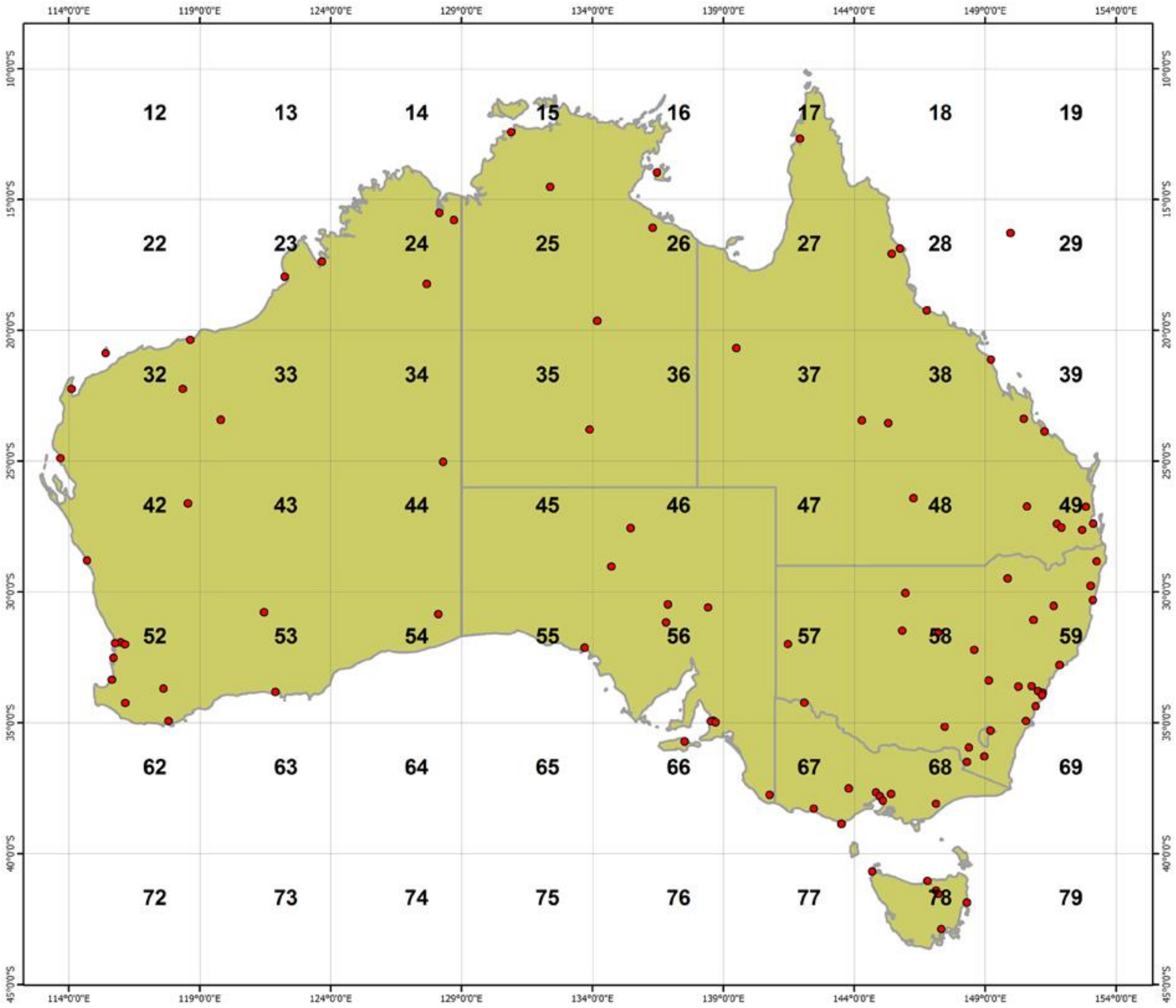
Creating the Ersatz Weather Data

- Monthly Projected Change Values (PCVs) provided by CSIRO on a coarse geographic grid
- CSIRO Report "Future climate data for 100 prospective Australian solar energy sites"

Monthly-predicted changes in mean maximum temperature (change °C) relative to 1990 for 2030 (emissions scenario A1B)

MODEL	SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INM-CM3.0	Brisbane	0.54	0.71	0.88	0.68	0.69	0.69	0.66	0.87	0.70	1.05	0.75	0.67
	Melbourne	0.82	0.94	0.72	0.77	0.71	0.68	0.69	0.70	0.77	0.81	0.89	0.70
	Sydney	0.85	0.96	0.89	0.85	0.81	0.77	0.75	0.90	0.90	1.16	1.17	0.90
CSIRO-Mk3.5	Brisbane	1.20	1.33	1.34	1.38	1.41	1.22	1.23	1.34	1.19	1.31	1.38	1.36
	Melbourne	1.20	1.46	1.41	1.51	1.37	1.13	1.18	1.29	1.47	1.55	1.49	1.43
	Sydney	1.44	1.20	1.48	1.55	1.56	1.31	1.34	1.52	1.61	1.53	1.48	1.45

Creating the Ersatz Weather Data



Creating the Ersatz Weather Data

- Temperature – separate PCVs for Min, Mean and Max linearly interpolated for each day (treating the lowest hourly value as the Min and the highest hourly value as the Max)
- Humidity
- Insolation and cloud cover
- Wind

Creating the Ersatz Weather Data

- Humidity – more or less water in the troposphere?

  Relative humidity value (hypothetical) for location on 15 July from RMY: 50%

  Projected winter change for location in 2050 under the A1FI emissions scenario: -10%

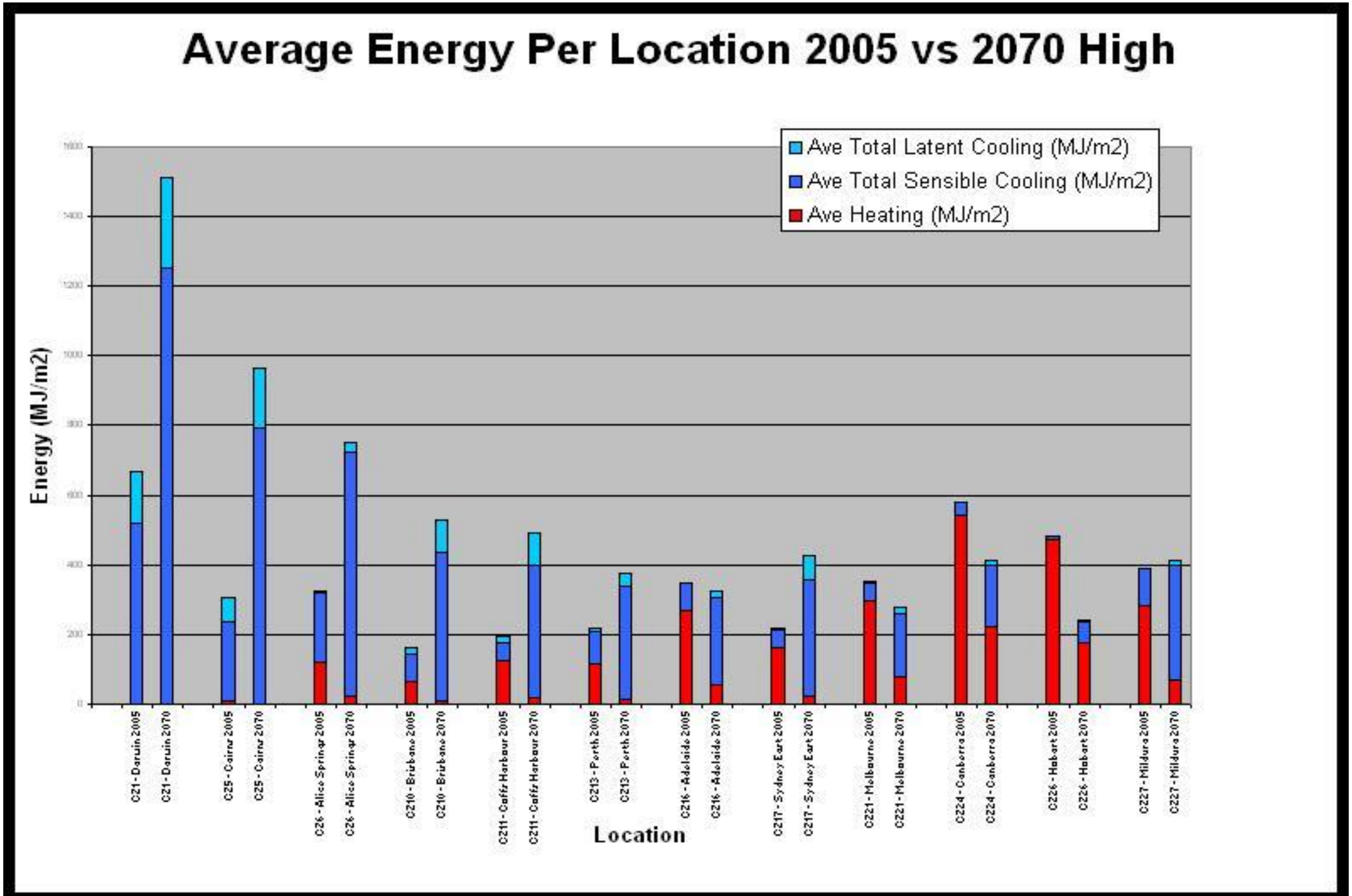
  Projected relative humidity value for 15 July in the 2050 RMY = 50 + (50 × -0.10) = 45%

  We applied the interpolated monthly CSIRO increment to the monthly mean RH and monthly mean dry bulb temperature (and atmospheric pressure) to derive the absolute humidity increment for ACDB format data and convert to RH at the projected future temperatures

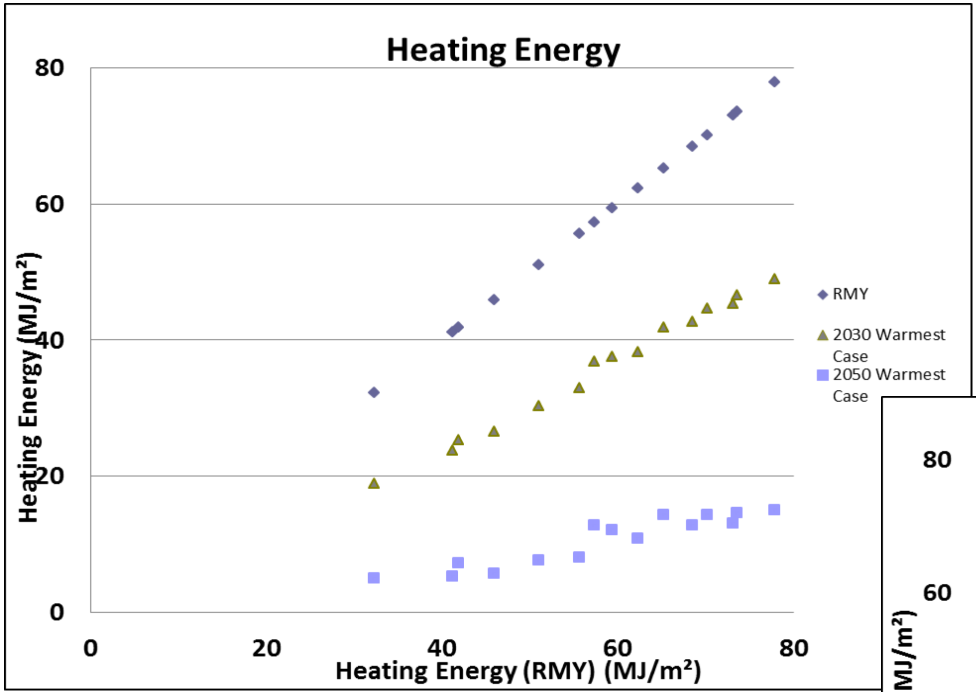
Creating the Ersatz Weather Data

- Insolation and cloud cover
  - irradiance values were retained wherever zero octas (clear sky)
  - monthly total (sum) of global irradiation to be the original level multiplied by the CSIRO increment factor (PCV)
  - optimisation performed for estimation of "forecast" direct:diffuse ratio
  - for any one hour, direct irradiance was not permitted to increase over Clear Sky levels (ASHRAE, 2009), while diffuse irradiance was permitted to increase, but restricted to less than double RMY levels
  - cloud cover not incremented due to absence of a technique, very coarse integer units and it being a second order effect on building energy performance
- Wind
  - keep all wind directions unchanged
  - increase all non-zero wind speeds by the same factor that CSIRO "forecast" for mean wind speeds

Energy Impacts for Dwellings

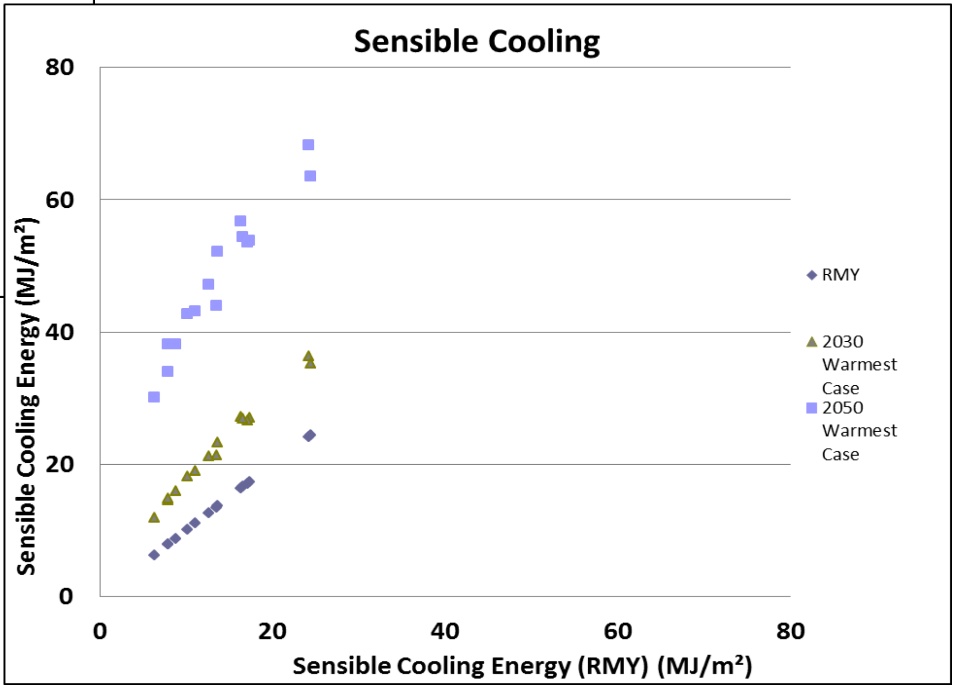


Energy Impacts for Dwellings

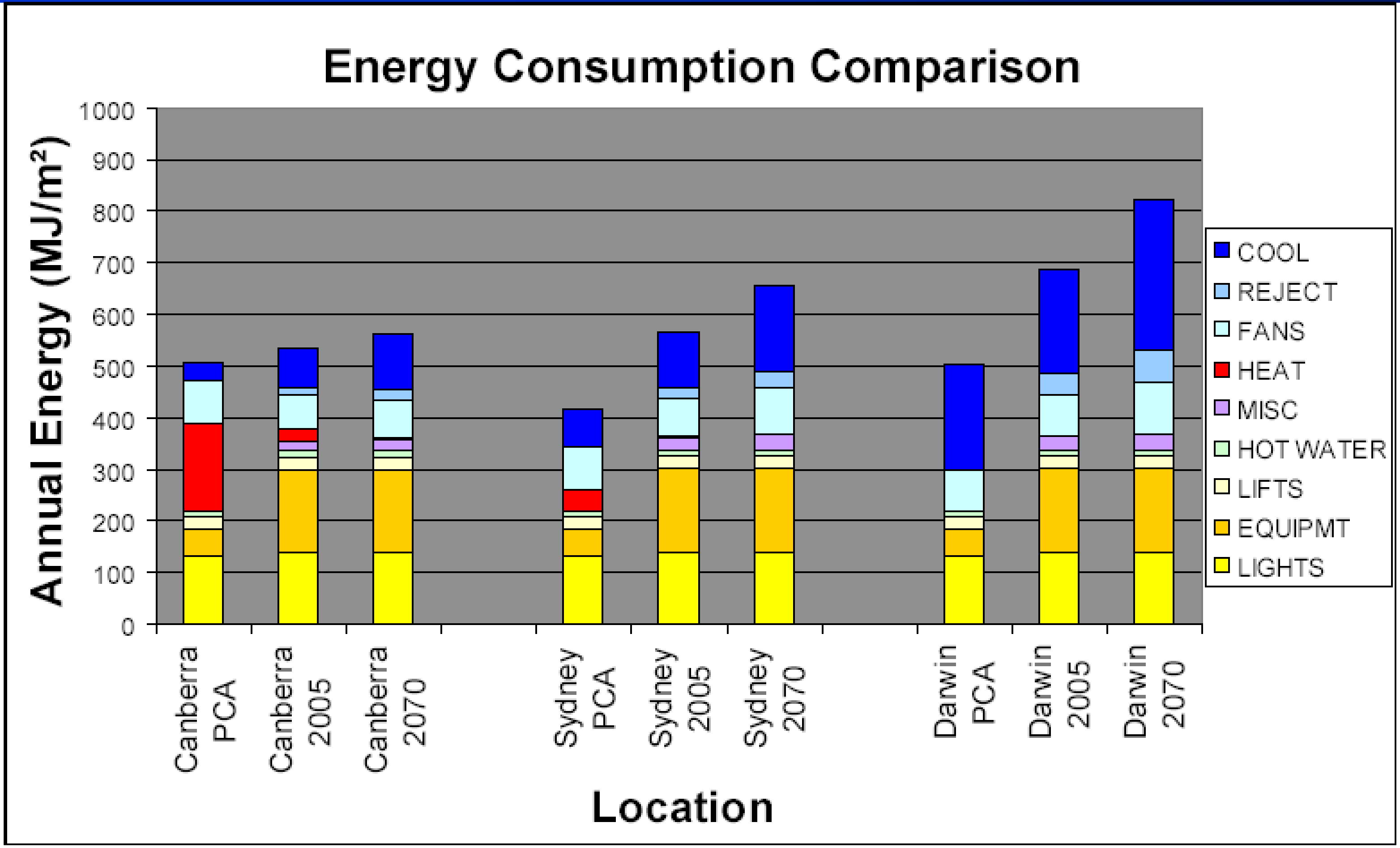


Adelaide

AccuRate simulation of cumulative loads

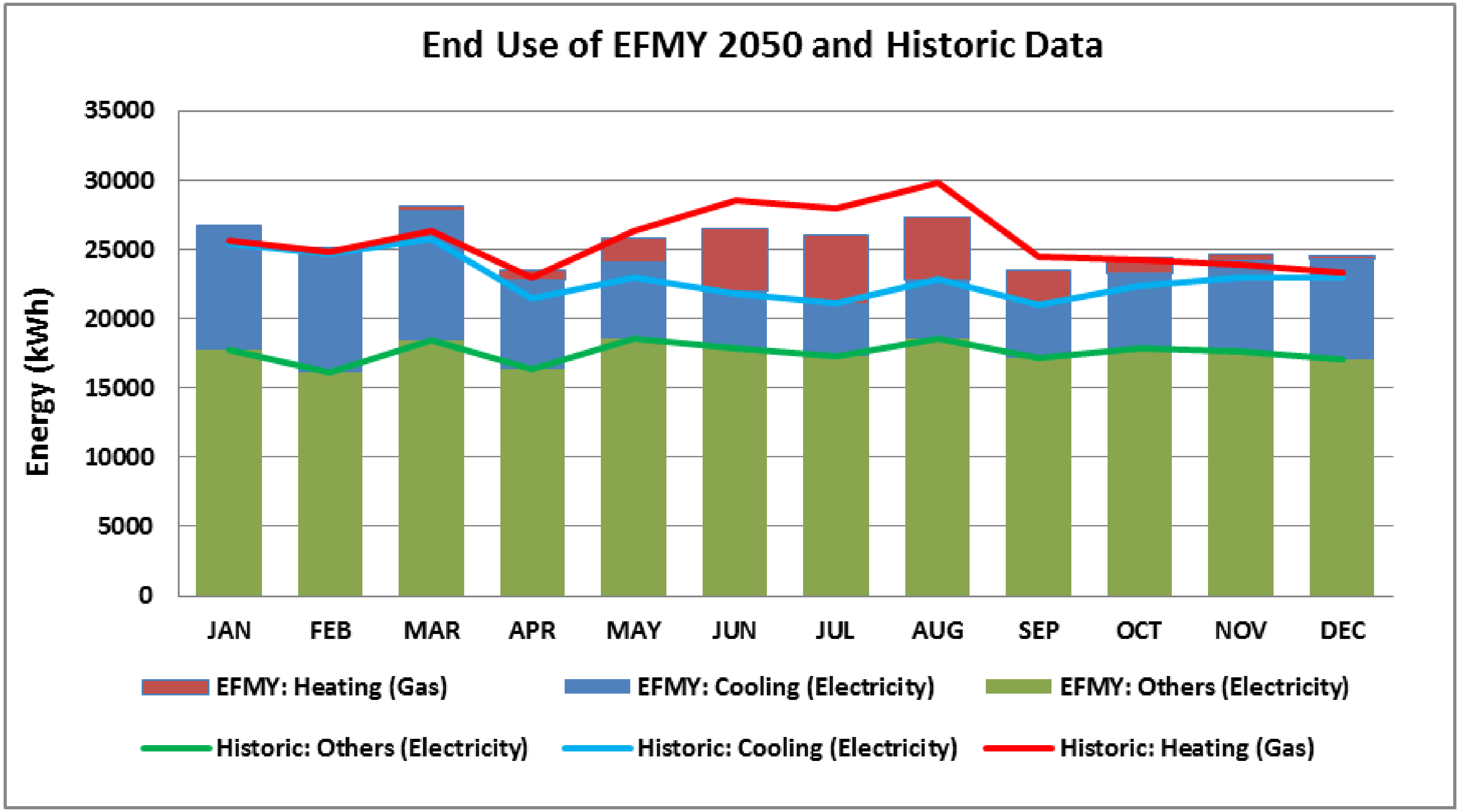


Energy Impacts for Non-residential Buildings (2005)



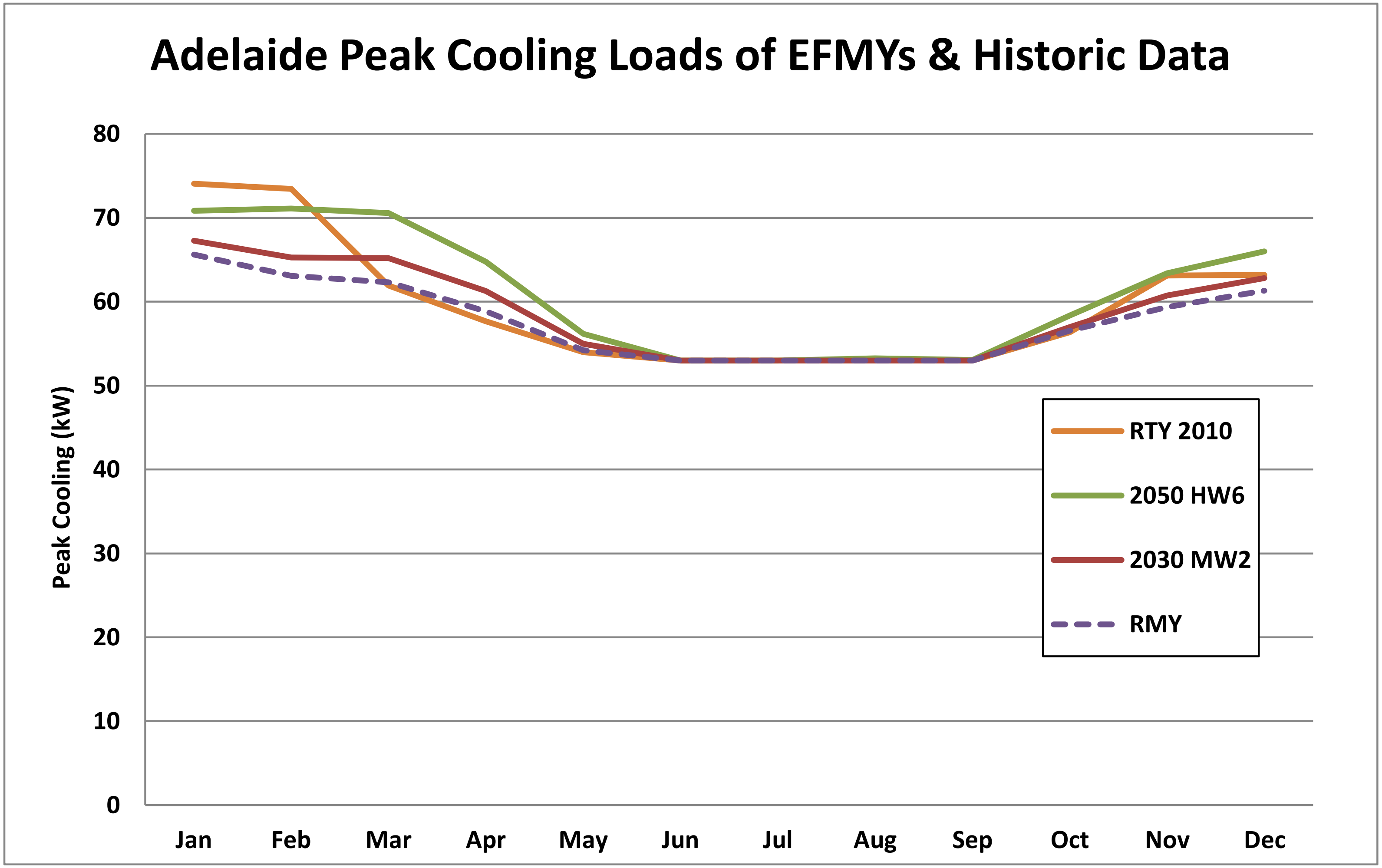
Simulated end-use energy consumption of 10-storey office building

Energy Impacts for Non-residential Buildings



Simulated end-use energy consumption of 3-storey office building (no economy cycle)

Impacts on plant size



Building Integrated Photovoltaics

- Overall improved performance under future climatic conditions (as predicted in 2005)
  - Greater improvement in amorphous silicon PV systems compared to mono crystalline silicon PV systems

	Performance Increase (2070)	
	M-si	A-Si
Darwin	4.4%	6.6%
Sydney	3.2%	5.5%
Melbourne	6.9%	8.8%

Conclusions in 2005, 2011 and now

- **a general increase in the energy consumption of air conditioned buildings and a decrease in the heating:cooling ratio for cooler climates as a result of "forecast" climate change**
- **also a reduction in the size of heating plant (and its obviation in some warmer climates) and an increase in the size of cooling and dehumidifying plant**
- **review of relevant HVAC sizing guides recommended is now under active consideration**

Current and Future Work

- **"Forecast" XMYs (eXtreme Meteorological Years) are needed for design and evaluation purposes.**
- **Other applications of these techniques may include estimation of the effect of urban heat islands, as in:**

  Crawley, D. *"Estimating the impacts of climate change and urbanisation on building performance".* Journal of Building Performance Simulation.

  Erell, Pearlmutter and Williamson, *"Urban Microclimate – Designing the Spaces Between Buildings"*, Earthscan, Nov 2010.

- **There is an evident need for review of sizing and energy consumption guides for HVAC to ensure comfort/control/efficiency over the full life of new buildings.**
- **www.exemplary.com.au**

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