AUSTRALASIAN CLIMATE DATA BANK PROJECTS

Trevor Lee[1] and Mark Snow[1]

[1]Energy Partners
PO Box 4170, Manuka ACT 2603
AUSTRALIA
Phone: +61 2 6260 6173, Fax: +61 2 6260 6555
Email: Energy.Partners@enerstrat.com.au

ABSTRACT

The key aims of the ACDB project in 2006 included updating the ACDB data set using post-1986 data in addition to the earlier weather data, and expanding the number of climate zones for second generation NatHERS tools (first generation having only 28 climates). Each of 69 locations now has a Reference Meteorological Year (RMY) being a composite of 12 typical meteorological months of best fit for a range of weather elements. This is an advancement on the previously used Test Reference Year (TRY), or actual year of best fit. In the case of non-NatHERS ACDB sites, the TRY was the year of best fit for dry bulb temperature only (ACADS, 1993).

This paper describes the further enhancements to the quality, geographic spread (including intra-metropolitan differentiation) and response to perceived climate change trends as applied in energy system design and evaluation, including low energy buildings in Australia. It also describes parallel work in New Zealand, and the potential for collaboration for ongoing improvement and compatibility, as well as the scope for replication throughout the region.

INTRODUCTION

MakeACDB (previously released as Version 8a) is the software created to process the available weather data to update and upgrade the Australian Climate Data Bank (ACDB) for use in various building and energy system simulation software. It has been used for creating continuous data sets 1967 to 2004 inclusive and Reference Meteorological Years (RMYs)1 representative of the weather measured over that period.

The purpose of this project relates to a number of concerns in the previous release of the software (MakeACDB v8a). These have come to light when the resultant data was applied to non-housing software packages.

New data for the years 2005 to 2007 inclusive was processed, and newly representative RMYs for each location were selected. Several enhancements were incorporated into

[1] Originally called Typical Meteorological Years (TMY) but changed by agreement with ACADS-BSG, ABCB and AGO to avoid confusion with the TMY acronym used internationally with the same meaning but with a different data format.

the processing methods and applied to the raw data from the original ACDB years (1967-2004). In addition, several extra locations were added to the ACDB to obviate perceived differences that were not covered in the original 69 sites. These extra sites were allocated postcodes for inclusion in the next version of 2nd Generation NatHERS software packages and the map of climate zones recast accordingly.

Updates to the ACDB algorithms

The software MakeACDB was amended, creating a new version (MakeACDB v9). This task removed all known bugs while retaining the software's amenability to ongoing use by personnel conversant with the science of weather data analysis. This new version of MakeACDB was applied to update and extend the ACDB itself as described below.

Data Interpolation

Most historic data was previously supplied by the Bureau of Meteorology (BOM) at three-hourly sample rates, whereas ACDB requirements specified that RMY representations be presented in an hourly format. In the previous version of the ACDB, hourly estimates of weather elements were made by advanced non-linear interpolation between the three-hourly values from the BOM (Ridley and Boland, 2005). MakeACDB was modified to accept both hourly (where available) and three-hourly records (which it then interpolates to hourly values) as the basis for RMY derivation.

Humidity Values at Times of High Relative Humidity

Humidity values are presented in the ACDB as absolute moisture content (AMC). These are inferred from the BOM measurements of station level pressure, wet- and dry-bulb temperatures (WB and DB, respectively), and wind speed. It is recognised that the measurement of WB is flawed for various reasons, and this in combination with the advanced non-linear interpolation techniques produces occasional erroneous AMC results.

MakeACDB uses atmospheric pressure, DB, and WB as supplied by the BOM to calculate the AMC required for the ACDB for all the known (primarily three-hourly) values. The DB and AMC values are then interpolated to hourly figures. The interpolation process employs Fourier transforms, inserting a statistically-derived estimate which attempts to model reality, allowing daily maximum temperatures to occur between noon and 3:00 pm and emulating some of the minor fluctuations which occur in reality in each case. The interpolation for DB and AMC are performed independently of each other.

Upon conversion of ACDB files to other formats it has become apparent that unreal values of humidity still occur occasionally at times of high relative humidity (RH) such that computed RH is above 100%. This is an impossible physical scenario produced by cases where the interpolation technique (three-hourly to hourly) reduces DB while increasing AMC or where the AMC value of 0.6g/kg dry air is unfeasibly high for the given low DB (instrument and reading errors will occasionally produce similar aberrations). In house energy rating, humidity is used to infer thermal comfort (affecting the operation of the ventilation routines) and to calculate latent cooling loads at elevated temperatures. As high RH generally coincides with relatively low DB, the result is generally not a significant error source in this application. In other applications the error is more important.

MakeACDB was modified to limit AMC such that WB < DB (RH < 100%) at all times.

Precipitable Water Data

Subsequent to the production of the previous ACDB sets it was noted by CSIRO that some erroneous values for Precipitable Water (PW) had been provided by BOM for the months of November and December. These resulted in unrealistically high values of atmospheric attenuation of the solar flux being calculated at times of low solar altitude (indicatively, less than 15°). Corrected PW data sets were supplied and used for this update project.

Solar Irradiation from Terrestrial Measurement

Around 1993 the data collected and held by BOM from terrestrial measurement stations changed from being based on Mean Solar Time (MST) to being based on True Solar Time (TST). In the previous ACDB and in MakeACDB (v8a), all terrestrial hourly data was processed on MST. The assumption presented a predictable but floating error of up to 15 minutes about the mean. The approximation was eliminated in the new version of the ACDB.

Solar Irradiation Inferred from Satellite Data

The ACDB format presents solar irradiance as hourly global, diffuse and direct normal weather elements. In many cases, irradiance is inferred from satellite measurements, which are only recorded by the BOM as a single total daily irradiation figure. Similarly, for the irradiance data derived from sunshine hours measurements, only daily data were previously available (this was more common for earlier years of the data record).

The previous algorithm which distributed this figure among the approximately 6 to 18 hours of the day (depending on latitude and season) over-estimated the diffuse fraction around solar noon, and hence under-estimated the direct fraction in those same hours.

A revised irradiance algorithm was applied to this daily data to compute hourly distributions of global, normal direct and diffuse components. The global and diffuse values for each hour were based on the nearest climatically analogous terrestrial site (with enough data of a reasonable quality) combined with the total daily global figure. The direct component was taken as the difference between global and diffuse (possibly with Low Altitude Correction based on Precipitable Water, as per the previous ACDB (Energy Partners, 2005)).

New Australian Climate Zones

The ACDB climate datasets were expanded from the existing 69 climate zones to include key building growth areas and incorporate more appropriate sites to recognize climate differences known to practitioners, thus improving the relevance and credibility of building simulation software. The expansion includes the new sites listed in Table 1.

Table 1: New sites in ACDB 2008

ACDB Name	State	Longitude	Latitude	Altitude (m)	ACDB Interim CZ	2LA	BCA CZ
Toowoomba	QLD	151.9	-27.6	691	70	TW	5
Atherton	QLD	145.5	-17.3	752	71	AT	1
Roxby Downs	SA	136.9	-30.5	98.5	72	RX	4
Maleny	QLD	152.9	-26.8	425	73	MN	2
Katherine	NT	132.3	-14.4	106.9	74	KN	1
Adelaide Coastal (AMO)	SA	138.5	-35.0	48	75	AC	5
Tamworth	NSW	150.8	-31.1	404	76	TA	4
Parramatta	NSW	151.0	-33.8	55	77	PA	5
Sub-Alpine (Cooma Airport)	NSW	149.0	-36.3	930	78	SU	7
Blue Mountains	NSW	149.0	-21.5	1080	79	BL	6
Coldstream	VIC	145.4	-37.7	83	80	CS	6

Inclusion of Additional Data

Recent data (2004-2007 BOM records) were included to update the ACDB to the most recently available information. This has the following advantages:

1. Extended period for calculating the long term averages from 38 to 41 years, an increase of 8%;
2. Adds weight to recent years which will bring the long term average closer to any new norms evolving due to climate change;
3. Adds to the number of years with actual hourly data, reducing the fraction of interpolated values in each data set and increasing the number of later years from which the RMY months can be chosen; and
4. Increases the number of sites with at least 14 years of Automatic Weather Station (AWS) hourly data from 86 in 2005 to 178 at present (2008).

Creation of Data for Defined Purposes

In the construction of an RMY, weights are assigned to the weather elements (variables), commensurate with their importance to the application. There is no single formulation of weights that is suitable for all applications. In the ACDB’s historic application to simulating the thermal performance of houses, solar radiation was awarded the highest weight, followed by dry and wet bulb temperature, and so on (Delsante, 1989).

For larger buildings where the centre zone dominates performance, temperature and humidity are more important than solar radiation, and wind is of only minor concern.

However, for an RMY for a wind farm proponent, the highest weight should be attributed to wind speed, and then (probably) temperature (given the correlation of electricity demand with temperature). Similarly, humidity and wind speed might take added significance for housing in northern climates.

The weightings applied in the previous version of ACDB RMYs depended on whether terrestrial diffuse radiation readings were available from BOM. These weightings are described in Table 2 and Table 3.

MakeACDB was modified to allow a third option for weather element weightings as described in Table 4. These options give lesser weight to solar irradiation, and in the case of RMY-C weight global irradiance equally with the mean values for wet- and dry-bulb temperatures.

All three RMY data sets, with varying weights on climate elements, were created for each location.

Table 2: Weightings for RMY with Diffuse (RMY-A)

Weather Element	**Weighting**
Max Temp	1/20
Min Temp	1/20
Mean Temp	2/20
Max Wet Bulb Temp	1/20
Min Wet Bulb Temp	1/20
Mean Wet Bulb Temp	2/20
Max Wind Velocity	1/20
Mean Wind Velocity	1/20
Global Radiation	5/20
Diffuse Radiation	5/20

Table 3: Weightings for RMY without Diffuse (RMY-B)

Index	**Weighting**
Max Temp	1/15
Min Temp	1/15
Mean Temp	2/15
Max Wet Bulb Temp	1/15
Min Wet Bulb Temp	1/15
Mean Wet Bulb Temp	2/15
Max Wind Velocity	1/15
Mean Wind Velocity	1/15
Global Radiation	5/15
Diffuse Radiation	0/15

Table 4: Weightings for RMY-C
(recommended for projects which are solar insensitive like deep plan buildings)

Index	Weighting
Max Temp	1/12
Min Temp	1/12
Mean Temp	2/12
Max Wet Bulb Temp	1/12
Min Wet Bulb Temp	1/12
Mean Wet Bulb Temp	2/12
Max Wind Velocity	1/12
Mean Wind Velocity	1/12
Global Radiation	2/12
Diffuse Radiation	0/12

RMY-A and RMY-B are weighted similarly to the weightings used in the development of the TMY2 data sets (Marion and Urban, 1995) (with irradiance having 50% weighting for sites with measured global and diffuse data and 33% for sites with global but without diffuse data). RMY-C is weighted in accordance with expressed industry demand.

The MakeACDB v9 software was used to produce new ACDB and RMY files for each existing ACDB climate zone as well as those new zones listed in Table 1. The full set of ACDB 2008 climate zones are described in the Appendix.

GEOGRAPHIC EXTENT OF CLIMATE ZONES

The expanded set of 80 climate zones was geographically defined both by the generation of a revised climate zone postcode schedule and by a set of maps consistent with that schedule of primary CZ allocations.

Revised Climate Zone Postcode Schedule

A revised CZ postcode schedule was created using the same methodology as in previous work (Energy Partners, 2005), including alternative CZs where required for credible rating applications. The need for these alternatives was reduced by the addition of 11 new CZs but the potential for enhanced differentiation was increased at the same time.

Revised Map Formats

A set of maps consistent with the schedule of primary CZ allocations was created in two formats:

- Fully detailed and interactive, zoomable PDF version with over 20 selectable layers (defining towns, terrain, state, postcode and ACDB areas) for academic and administrative use; and
- Graphically simplified version for publication on the Commonwealth's NatHERS website.

The same methodology as in Energy Partners (2006) was used except that superior data sets for the postcode boundaries were applied. This data was supplied by MapMakers Australia in the form of a Postcode Area GIS Data Licence purchased specifically for this project. Its advantageous characteristics include:

1. The Australia Post update applied to the data is: 29 May 2008
2. Precise spatial and attribute postcode boundaries
3. Datum for ESRI .SHP version: Australian Geocentric 1994 (GDA94)

NEW ZEALAND EQUIVALENT

In a similar but earlier project, an NZCDB was created specifically to allow the Australian 2nd Generation NatHERS software to be adapted for trans-Tasman use (Liley et al, 2007). That project incorporated extensive peer review by Energy Partners with the assistance of Adelaide Applied Algebra, Victoria University of Wellington and the US Department of Energy (Energy Partners, 2008b). It is also a work in progress with plans to add several extra climate zones to the 16 created in the inaugural project.

The NZCDB is now in limited use in the small scale voluntary House Energy Rating applications which began formally in December 2007.

CONCLUSIONS

A comparison of Australia's 2008 RMYs with 2005 RMYs indicates some significant differences. Preliminary analysis indicates that the 2008 data sets more closely reflect reality than those created in 2005.

In addition, the following further work is recommended for the reasons outlined below:

Effect on Simulation Results

The investigation should also study the variance of these data sets on simulation results by comparing the 2005 results with the 2008 sets.

Alternative Applications

Further consideration should be undertaken with regard to the varied application of the data sets. In particular, applications include simulation of solar- and wind-sensitive systems (for example, solar power systems or wind farms). Of interest would be a comparison with TRNSYS simulations for solar hot water systems modelled under the old TMY datasets after Walsh et. al. (1983) and Morrison and Litvak (1999). The ACDB methodology lends itself to modification by way of varying weather element weights in a technique similar to that described in Ferrari and Lee (2008). An RMY-S should be determined for solar applications, and RMY-W for wind applications. Additionally, the data lends itself to more detailed analysis along the lines of the ASRDH (Lee et al, 2006) as set out elsewhere at this conference (Lee, 2008).

Atypical Meteorological Years

Still further application of the data sees its use in determining system sizing as well as non-energy design testing. These applications could make use of unusual meteorological conditions, such as those seen in hot dry (El Niño) or cool wet (La Niña) years. The definition of an eXtreme Meteorological Year (XMY) data set provides for this need (Ferrari and Lee, 2008).

REFERENCES

ANUDEM software (2000) http://cres.anu.edu.au/outputs/anudem.php.

ACADS (1993) *NATHERS climate zone allocation*, ERDC Report

Australian Climatic Data Bank, on IBM format diskettes, includes data for several nearby countries, unpublished, available from ACADS, 16 High Street, Glen Iris, Victoria 3146, facsimile (03) 885 5974

Delsante, A.E. (1989). *Extension of Australian Climatic Data Bank and Outdoor Design Data* (NERDDC Project 984, Final Report), CSIRO, Division of Building, Construction and Engineering, Melbourne.

Energy Partners (2005), *Development of Climate Data for Building Related Energy Rating Software*, Report to the Australian Greenhouse Office, Canberra (unpublished)

Energy Partners (2006), *ACDB Map Output Review - Analysis of climate zones and rationales, including clear explanation of the criteria used to assign postcodes*, Report for the Australian Greenhouse Office, Department of Environment and Heritage, Canberra, November 2006 (unpublished)

Energy Partners (2008a), *Peer Review of New Zealand Climate Data For House Energy Rating*, Report to the New Zealand Energy Efficiency and Conservation Authority, Wellington (unpublished at the time of this conference)

Energy Partners (2008b), *Australian Climate Data Bank: Weather Data Enhancement For Reference Meteorological Years*, Report to the Australian Department of Environment, Water, Heritage and the Arts, Canberra (draft, unpublished at the time of this conference)

Ferrari, D. and Lee, T.R. (2008), *Beyond TMY: Climate Data for Specific Applications*, Proceedings of the ANZSES Solar '08 Conference, Sydney

Hutchinson, M.F. and Gallant, J.C. (2000). *Digital elevation models and representation of terrain shape*. In: Wilson, J.P. and Gallant, J.C. (eds), Terrain Analysis, Wiley, New York, Chapter 2, pp 29-50.

Lee, T.R., Oppenheim, D. and Williamson, T. (1995) *The Australian Solar Radiation Data Handbook (Edition 3)*, Energy Research and Development Corporation, Canberra (distributed by ANZSES)

Lee, T.R, Snow, M. and Stokes, B. (2005) *The Australian Solar Radiation Resource Updated*, in proceedings of ANZSES Solar 2005, University of Otago, Dunedin

Lee, T.R, Snow, M. and Stokes, B. (2006) *The Australian Solar Radiation Data Handbook*, Energy Partners for ANZSES, Canberra

Lee, T.R and Stokes, B. (2006) *Producing New and Specialised Climate Data Files for Australian Sites*, in proceedings of IBPSA Australasia 2006, University of Adelaide, Adelaide

Lee, T.R. (2008) *Australasian Solar Radiation Data: Proposal for Enhanced Knowledge Dissemination*, in Proceedings of the ANZSES Solar '08 Conference, Sydney

Liley, J.B., Shiona, H., Sturman, J., Wratt, D.S., 2007. *Typical Meteorological Years for the New Zealand Home Energy Rating Scheme*. National Institute of Water & Atmospheric Research Ltd, Central Otago.

Marion, W. and Urban, K. 1995. *User Manual for TMY2*. National Renewable Energy Laboratory, Colorado, USA.

Morrison, G.L. and Litvak, A., (1999) *A Condensed Solar Radiation Data Base for Australia*, Solar Thermal Energy Laboratory, UNSW, Sydney

Ridley, B and Boland, J. (2005) *Development of Climate Data for Building Related Energy Rating Software*, in proceedings of ANZSES Solar 2005, University of Otago, Dunedin

Szokolay, S.V., (1988) *Climate Data and its use in Design*, Royal Australian Institute of Architects, Canberra

Walsh, P.J., Munro, M.C. and Spencer J. W. (1983), *An Australian Climatic Data Bank for Use in the Estimation of Building Energy Use*, CSIRO, Melbourne

ACKNOWLEDGEMENTS

The authors would like to thank staff of the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) for administering the project, Energy Partners team members David Ferrari, Jessica Stewart and Yuelin Wang, staff of ACADS-BSG for helpful comments and Dru Crawley of the US Department of Energy who extensively checked the resultant data files with software he has developed for the purpose. Special acknowledgement is due to Brett Stokes of Adelaide Applied Algebra who diligently encoded the improvements into MakeACDB and applied it to create all 3 x 80 RMY files.

BRIEF BIOGRAPHY OF PRESENTER

Trevor Lee, ARAIA

An architect by initial training, Trevor is a consultant on energy conservation in the built environment through his multi-disciplinary firm Energy Partners. He is the lead author of the Australian Solar Radiation Data Handbook (ASRDH, 2006) and team leader for developing the current Australian Climate Data Bank (ACDB, 2008), the basis of all building and energy system simulation programs in current use in Australia. Subsequently, he worked on a project for the then Australian Greenhouse Office to project the impact on the built environment of “inevitable climate change”.

His interests include solar energy applications and ethical investment and, in pursuit of these, he has served as the Chairman of the Australian and New Zealand Solar Energy Society and as a director of the Sustainable Energy Industry Association (forerunner of the Clean Energy Council (CEC)) and of the Canberra-based funds manager Australian Ethical Investment Ltd.

APPENDIX – FULL LIST OF 80 AUSTRALIAN CLIMATE ZONES

ACDB name	State	ACDB name	State
Darwin	NT	Oakey	QLD
Weipa	QLD	Toowoomba	QLD
Katherine	NT	Geraldton	WA
Wyndham	WA	Forrest	WA
Willis Island	QLD	Perth	WA
Cairns	QLD	Swanbourne	WA
Atherton	QLD	Ceduna	SA
Broome	WA	Mandurah	WA
Townsville	QLD	Williamtown	NSW
Pt Hedland	WA	Esperance	WA
Learmonth	WA	Parramatta	NSW
Mackay	QLD	Sydney RO (Observatory Hill)	NSW
Rockhampton	QLD	Mascot (Sydney Airport)	NSW
Gladstone	QLD	Adelaide	SA
Maleny	QLD	Adelaide Coastal (AMO)	SA
Brisbane	QLD	Blue Mountains	NSW
Amberley	QLD	Richmond	NSW
Coffs Harbour	NSW	Manjimup	WA
Halls Creek	WA	Nowra	NSW
Tennant Creek	NT	Albany	WA
Mt Isa	QLD	Mt Lofty	SA
Longreach	QLD	Tullamarine (Melbourne Airport)	VIC
Newman	WA	Coldstream	VIC
Alice Springs	NT	Melbourne RO	VIC
Carnarvon	WA	Mt Gambier	SA
Charleville	QLD	Moorabbin	VIC
Giles	WA	East Sale	VIC
Meekatharra	WA	Warrnambool	VIC
Oodnadatta	SA	Cape Otway	VIC
Moree	NSW	Armidale (old Tamworth)	NSW
Roxby Downs	SA	Orange	NSW
Kalgoorlie	WA	Canberra	ACT
Tamworth	NSW	Sub-Alpine (Cooma Airport)	NSW
Woomera	SA	Ballarat	VIC
Cobar	NSW	Low Head	TAS
Bickley	WA	Launceston (Ti Tree Bend)	TAS
Dubbo	NSW	Launceston Airport	TAS
Katanning	WA	Hobart	TAS
Mildura	VIC	Cabramurra (old Alpine)	NSW
Wagga	NSW	Thredbo (Village)	NSW