Climate Data for Building Optimisation and Energy Management

Trevor Lee

Solar Irradiation of Key Surfaces in Coombatta

Monthly Mean Daily Irradiation (MJ/m²/d)
Climate Data for Building Optimisation and Energy Management

The Australian Solar and Climate Resource
- Australian Solar Radiation Data Handbook background and applications

Beyond TMY: Climate Data for Specific Applications
- Australian Climate Data Bank and using Reference Meteorological Years

Creation of Ersatz Future Weather Data Files
- Measuring energy performance of buildings under predicted future weather conditions
Australian Solar Radiation Data Handbook - AuSES

- **Table 1** Climate averages (highest monthly mean, overall daily mean and lowest monthly mean) based on old ASRDH
- **Table 2** Clearness Index figures (average hourly clearness figures for each month)
- **Tables 3** Solar radiation based on Horizontal Plane (includes direct, diffuse, global and daily direct threshold percentages)
- **Tables 4** Vertical and Tracking Planes – (Average total hourly irradiance (W/sq.m.) and daily irradiation (MJ/sq.m.) on a north-south axis tracking plane by hour for each month)
- **Tables 5** Daily totals by month for inclined planes (Plane azimuth versus plane inclination)
- **Tables 6** Vertical windows – (eg. Average hourly (W/sq.m.) and daily (MJ/sq.m.) solar heat gain factor through a north facing vertical window for each month)
- **Tables 7** Sequences of days (e.g. Proportional occurrence (%) of sequences of days for which the daily global irradiation is less than 10 MJ/sq.m.)
Table 4.5:

Average total hourly irradiance (W/sq.m.) and daily irradiation (MJ/sq.m.)
on a north facing plane inclined at latitude angle for each month

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Daily 23.3 22.9 19.7 15.1 11.4 10.1 11.4 13.2 16.4 19.3 20.9 22.3 17.2
Solar Irradiation of Key Surfaces in Oodnadatta

- Global
- Beam on Horizontal
- Direct Beam Normal
- Total North Vertical
- Total North Latitude Tilt
- Total North 45° Tilt
- Total North 51° Tilt
The enhanced ACDB could be used as the data source for ASRDH 5.

- 100 sites most with ersatz solar irradiation data inferred from satellite measurements of radiation being reflected back into space.
- With simultaneous temperature, humidity, wind speed and direction and cloud cover (octas).
- Impractical as a reference book so likely to be an enhanced version of AUSOLRAD.
- Non-reference meteorological “years”
Climate Data - satellite measurement
Climate Data - satellite measurement

Exemplary Australian Solar Energy Atlas

Map showing solar radiation data for Australia, with color coding indicating radiation levels.
Solar Data Source - AUSOLRAD

- **User selects:**
  - orientation in 1° increments
  - tilt in 1° increments (including facing down)
  - Depth of overhang
  - Reflectivity of the “ground”

- **AUSOLRAD produces:**
  - Tables for all geometries of engineering and architectural interest including single and double axis tracking
  - NO frequency tables for storage design optimisation

- Distributed by AuSES
Beyond TMY: Climate Data for Specific Applications
# Background

## Weightings for RMY datasets

### Weights for RMY with recorded diffuse irradiance

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<th>Weather Element</th>
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### Weights for RMY without recorded diffuse irradiance

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<td>Diffuse Radiation</td>
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Further Enhancements

Using alternative RMY-month selection procedures

Weighted Mean calculations can be further modified to create:

• Bias towards data from recent years to represent future climate expectations
• Weighting extreme conditions (eXtreme Meteorological Year: XMY)
### Modifying Weather Element Weights

Meteorological data to meet any set of weightings

#### Examples include:

<table>
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<tr>
<th>Potential weights for large office buildings</th>
<th>Potential weights for wind farms</th>
<th>Potential weights for solar-sensitive infrastructure</th>
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eXtreme Meteorological Year (XMY) data sets still require full definition

Examples include

- Performance during a hot, dry (El Niño) year
- Performance during a windy, wet (La Niña) year
- Amalgamation of ‘hottest summer’ with ‘coldest winter’ months
- Warmest months ever (changed warmer climate)
Real-time Data

- Model Calibration
- Building or system monitoring
- Measuring actual output or consumption in the previous year relative to RMY

Real-time year-to-date data (RTY)
Results

Comparison of:

- ACDB 2005 RMY
- ACDB 2008 RMYA
- ACDB 2008 RMYB
- ACDB 2008 RMYC
- RTY
- DTD (decade-to-date)
- 40 year historical averages

Using 11 house models with varying energy usage in the CSIRO thermal simulation software, AccuRate.
Figure 1: Simulated consumption of a ‘lightweight’ dwelling at 0° orientation
Figure 2: Average difference between simulation results using representative data and historical mean.
Key Results

Figure 3: Total heating and cooling energy between RTY and 2008 RMY-A as a percentage of 2008 RMY-A

Figure 4: Total heating and cooling energy between DTD and 2008 RMY-A as a percentage of 2008 RMY-A

Heating energy demand of both the RTY and DTD relative to RMY-A is smaller while cooling energy demand has increased

Indication of past climate change
CREATION OF ERSATZ FUTURE WEATHER DATA FILES
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” (Seasonal)

National Temperature change 2070 Summer

- Low emissions
- Medium emissions
- High emissions

10th Percentile

50th Percentile

90th Percentile

°C
Climate “Forecast” (Seasonal)

National Temperature change 2070 Winter

Low emissions  |  Medium emissions  |  High emissions
--- | --- | ---
10th Percentile
50th Percentile
90th Percentile

°C

Legend:

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Climate “Forecast” (Seasonal)

- 50th percentile change in dry-bulb temperature
Climate “Forecast” (Seasonal)

- 50th percentile change in relative Humidity
Energy Impacts for Dwellings

Average Energy Per Location 2005 vs 2070 High

- Ave Total Latent Cooling (MJ/m²)
- Ave Total Sensible Cooling (MJ/m²)
- Ave Heating (MJ/m²)
Energy Impacts for Non-residential Buildings

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

- Specific projection scenarios based on climate modelling are being produced to improve accuracy

- Re-setting the baseline
  - The 2008 update to the ACDB included improvements to calculations in several areas
  - New RMYs based on data up to the end of 2007 and using these techniques are available
  - Ideally, baseline RMYs would be created for the 1980-1999 period forming the baseline of specific CSIRO projections

- Other applications of these techniques may include estimation of the effect of urban heat islands, as in the upcoming paper:

Conclusions

- Climate and weather data may be tailored to suit a wide range of renewable energy and energy conservation applications.


- RMYs may be created to meet the specific requirements of an application based on the weighting assigned to the different weather elements.

- XMYs and YTDs can be created for system design and operational optimisation.

- Ersatz Future Weather Data based on “forecast” scenarios for climate change can predict energy performance in the future.
Climate Data for Building Optimisation and Energy Management

Questions?

Trevor Lee