



# A study on the impact of time resolution in solar data on the performance modelling of CSP plants



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## ABSTRACT

Availability of long term solar data and the quality of available data is usually an obstacle to the development of proposals for new concentrating solar power plants. Typical or representative meteorological years using hourly solar and weather data that has been selected to match long-term averages are often used to perform the preliminary design and performance assessment of solar power plants. Although the use of this data is convenient due to the reduced computational requirements in plant optimization, it may result in a simplistic prediction of plant operations that does not reflect the real plant performance by neglecting the impact of short-term variability in solar irradiance and the variations in weather and available solar energy for different years. This study conducts a systematic analysis of the influence of multi-year data sets with a range of different time step sizes (5, 15, 30 and 60 min) and thermal storage capacities (4, 8 and 12 h) using the physical parabolic trough with molten salt storage model in NREL's System Advisor Model. Results indicate that the appropriateness of different step sizes is likely to vary depending on the purpose of the modelling; however, sensitivity to step size is reduced for larger storage capacities.

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## 1. Introduction

Collecting a number of years of detailed solar and weather data for the target site is an important step in accurately designing and predicting the financial performance of a concentrating solar power (CSP) plant over the expected lifetime. However, detailed and long term solar data is not available for many sites. It is therefore common to use some form of typical year data with time resolutions of 1 h which has sometimes been developed from less accurate data, e.g. predicted using satellite measurements, for the preliminary design, optimization, and performance predictions. Typical solar data is widely used in the literature for analysing CSP systems [1–5]. For example, Hinkley et al. [6] selected Longreach in central Queensland (Australia) as their hypothetical plant site to provide an assessment of potential of CSP systems (i.e. parabolic trough and central receiver systems) using NREL's System Advisor Model (SAM) with hourly data. Enjavi-Arsanjani et al. [7] assessed a total of six Iranian sites, firstly converting global horizontal irradiance (GHI) data to estimated direct normal irradiance (DNI) data before

using the generated hourly data in SAM.

Although using typical years simplifies plant optimization and performance prediction, it may lead to a biased and simplistic view of plant operations that does not match well with real operations over the expected 25–30 year plant lifetime. Several different approaches have been proposed to account for variation in annual solar irradiance. Röttinger et al. [8] assumed that there would be a normal distribution of annual solar irradiance around the typical year value based on historical data for a site in Brazil. This was then used to produce a distribution of performance predictions from SAM. Chhatbar and Meyer [9] performed a more detailed assessment of the distribution of solar data using multiple sets of data from different sources for three main sites, generating typical year data from each and comparing the predictions from SAM. This was used to establish the significance of data quality, with variations in predicted performance of up to 9% identified due to inaccuracy in the typical years. Ho and Dobos [10] used a stochastic approach to sampling solar data from a 30 year data set for use in establishing inputs to SAM. In comparison with the uncertainty in multiple other inputs, it was determined that uncertainty in the solar irradiance had the most significant impact on predicted plant performance. Meybodi and Beath [11] provided an insight into the impact

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of solar data variations on the economics of central receiver systems of different sizes and varying thermal storage capacities at three Australian cities; namely Alice Springs, Kalgoorlie and Mildura, utilising SAM. In addition to typical years, which were used to optimise the design of the systems, multiple real years of solar data for each site were used to investigate the influence of variations in solar data on the performance predictions and consequently the economic feasibility of systems.

Literature assessments of the optimum time step size for solar data which is used in plant performance prediction are surprisingly rare. In recent years the transient analysis of parabolic trough plants is becoming more common [e.g. Wagner and Wittmann [12], Almasabi et al. [13]] which by necessity requires detailed solar data as a continuous input. However, the optimization of plant design and prediction of annual performance using transient models requires significant computational resources; therefore, studies tend to concentrate on predictions of the response of specific plant items over shorter time periods. One transient study by Schenk et al. [14] concentrated on the power block performance and determined that the time taken for significant response varied from 6 to 25 min depending on load, which indicated that data input at shorter time scales might not be required. Similarly, Gertig et al. [15] described a novel modelling approach using variable time steps for different components of a CSP plant and indicated that step times of 15 min were appropriate as a balance between computational intensity and prediction accuracy.

In recent years the Australian Bureau of Meteorology has released sets of 1 min solar data for a range of sites around Australia that use calibrated ground stations, as shown in Fig. 1 with the number of years of data available given after the place names [16].

The approximate annual direct normal irradiance (DNI) at the sites is also indicated. As evident from the figure, the highest solar irradiance for Australia is in a zone from the western coast into central Australia.

In addition to the solar data, weather data at 30-min intervals for the same sites is available from the Bureau of Meteorology, typically for a much greater range of years [17]. In combination, this data can be used with CSP modelling tools, such as SAM, to produce optimized plant designs that offer the best balance of cost and performance over the plant's lifetime. However, the literature lacks the information on the required time resolution of data and the number of years which are required to ensure the robustness of the output of these modelling tools. Therefore, in this study an extended range of years of data with different time steps are used to clarify the impact of these variables on the quality of the predicted performance for a potential CSP plant.

## 2. Site selection and solar data

Key issues in determining the long term viability of concentrating solar power projects include the availability and quality of significant periods of solar data for a subject site. One particular challenge when conducting studies is the limited number of sites where long term experimentally measured direct normal irradiance (DNI) data is available. Much of the publicly available solar data is derived from satellite data and the quality can be variable, depending on the location of the satellites used for the measurements and the estimation techniques used. Alice Springs, in central Australia just north of the Tropic of Capricorn, was used as a reference site in a previous paper [11], where 13 years of ground-

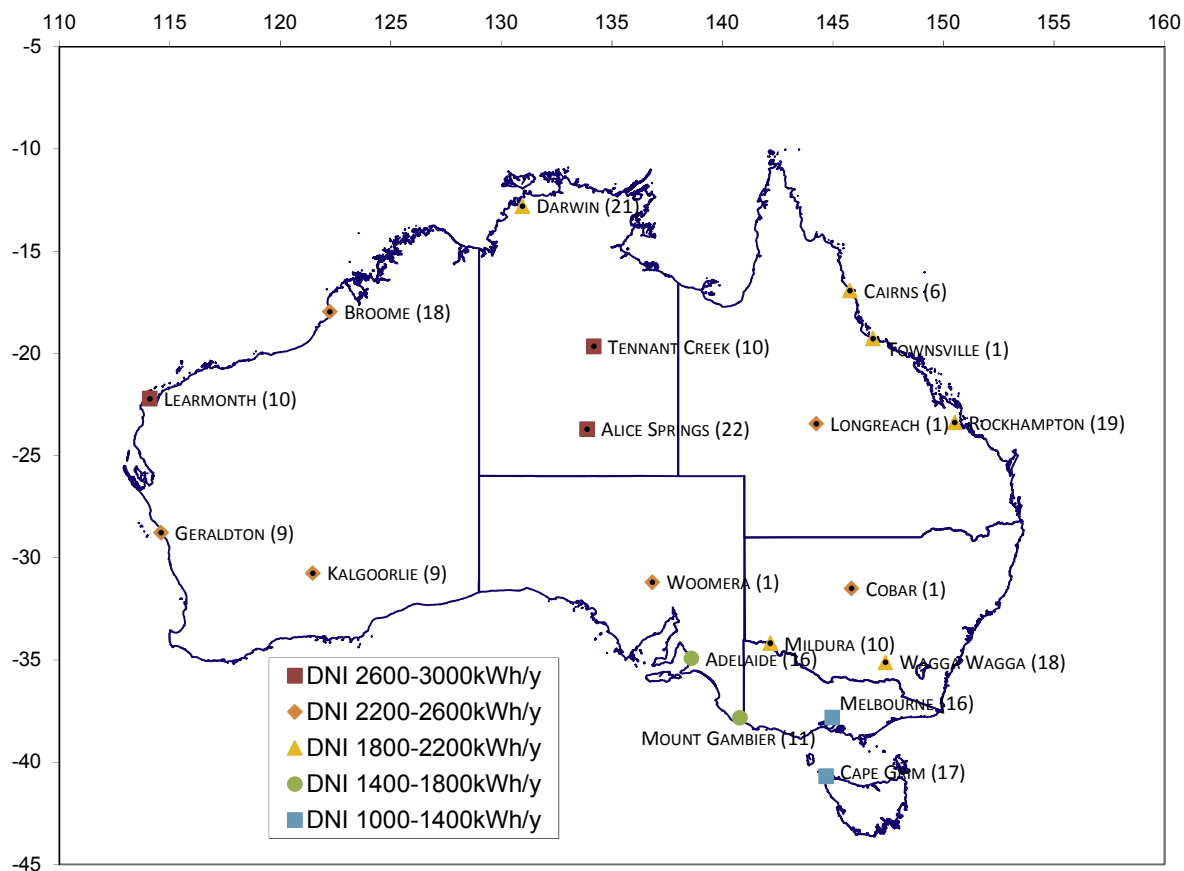


Fig. 1. Location of Australian sites with high quality solar data and number of years available.

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