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Benchmarking of five typical meteorological year datasets dedicated to concentrated-PV systems

Ana M. Realpe[a,*], Christophe Vernay[a], Sébastien Pitaval[a], Camille Lenoir[b], Philippe Blanc[c]

[a]*SOLAÏS, 400 avenue Roumanille, BP 309, F-06906 Sophia Antipolis Cedex, France*
[b]*NEOEN, 4 rue Euler, 75008 Paris, France*
[c] *MINES ParisTech, PSL Resear University, O.I.E. – Center of Observation, Impacts, Energy, 1 Rue Claude Daunesse, CS 10207, F-06904 Sophia Antipolis Cedex, France*

Abstract

This paper presents the benchmarking of different Typical Meteorological Year (TMY) datasets applied to a Concentrated-PV (CPV) system. Using 18-years of high quality meteorological and pyranometric ground measurements, five types of TMY datasets were generated using variable time period and following different methods: the standard Sandia method or only considering the Direct Normal Irradiation (DNI) or a more sophisticated DNI-based driver considering the characteristics of the CPV system. The results show that the Sandia method is not suitable for CPV systems. The TMY datasets obtained using dedicated drivers are more representative to derive TMY datasets from limited long-term meteorological dataset.

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* Corresponding author. Tel.: +33-04-83880295; fax: +33-04-93008814.
E-mail address: amrealpe@solais.fr

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1. Introduction

The awareness of the behavior of some meteorological parameters is essential for the conception, analysis, development and optimization of solar energy conversion systems, either photovoltaic (PV), concentrated solar power (CSP) or concentrated photovoltaic (CPV) systems. Accurate assessment of meteorological data for long-term prediction is the basis of decision making of banks and investors. Standard numerical simulations of solar energy conversion systems such as System Advisor Model or PVsyst require one year of meteorological data. Methodologies for the generation of Typical Meteorological Years (TMY) datasets representatives of the long-term solar resource of a given site have therefore been developed.

A TMY is a customized weather dataset of one-year of meteorological data that aims at representing climatic conditions deemed to be typical over a long-term period.

The most common method for solar energy conversion systems was proposed in 1978 by the Sandia National Laboratory [1], slightly modified by several researchers and well detailed in 2008 by Wilcox and Marion [2]. The resulting TMY dataset is composed of meteorological data of 12 calendar months selected from individual years from long-term record and concatenated to form a complete year, keeping the consistency across the different meteorological variables. In order to select the typical months in the long-term dataset, the method performs a specific weighted combination of the global, diffuse horizontal and direct normal irradiances (GHI, DHI and DNI), air temperature (Tamb), wind speed (WS) and relative humidity (DWT). Monthly data blocks are selected based on the smallest Filkenstein-Schafer (FS) distance measuring the difference of two cumulative distribution functions (CDF).

In 2012, a new approach was proposed in the framework of the European project FP7 ENDORSE [3]. It introduced the concept of “driver” that is defined by the user as an explicit function of the pyranometric and meteorological relevant variables to improve the representativeness of the TMY datasets with respect the specific solar energy conversion system of interest [4]. Similarly to the previous method, it calls upon the FS distance.

The overarching aim of this study is to benchmark the classical Sandia method with innovative methods based on the driver concept, in the particular case of a given CPV system in a given site.

2. Reference data used and CPV system used

The selected site is the meteorological station Desert Rock, Nevada, in the United States, which belongs to the Surface Radiation (SURFRAD) network [5]. SURFRAD has adopted the measurement standards set by the Baseline Surface Radiation Network (BSRN).

The data exploited here originates from high quality measurements with a 1-min resolution over an 18-year period from 1998 to 2015. The following meteorological variables were recovered from the SURFRAD network: GHI, DHI, DNI, DWT, Tamb, WS and atmospheric pressure.

An algorithm is used to check the quality of the meteorological data. Gap filling is performed to provide complete records, by the means of interpolation and mathematical formulas that link the various components of irradiance (GHI, DHI, DNI…). The position of the sun is calculated using the fast and accurate SG2 algorithm [6].

Regarding the system of reference, the Concentrix™ CPV technology developed by SOITEC was chosen due to its maturity in terms of product and modeling at the time the present work started. This system requires the use of a two-axis tracking system. The Concentrix technology uses optimized III-V-based multi-junction solar cells. The type of concentration is a point focusing silicone-on-glass Fresnel lenses. The model of the system selected is the CX-S540, with 2500 Wp of nominal DC power. The CPV system proposed for the simulations has an installed power of 750 kWp.

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