SANDIA REPORT
SAND2023-01949
Unlimited Release
Printed April 2023

Sandia National Laboratories

PV module operating conditions and temperature measurements: an open dataset for PV research

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ABSTRACT

This report describes the structure and content of an open dataset created for the purpose of testing and validating PV module temperature prediction models and their parameters. The dataset contains the main environmental parameters that affect temperature: irradiance, ambient temperature, wind speed and down-welling infrared radiation, as well as measured back-of-module temperature.

ACKNOWLEDGEMENTS

This material is based upon work supported by the U. S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technologies Office Award Number 38267.

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ACRONYMS AND DEFINITIONS

Abbreviation	Definition
IR	Infrared
NetCDF	Network Common Data Form
POA	Plane-Of-Array
PSEL	Photovoltaic Systems Evaluation Laboratory
SLTE	Systems Long-Term Evaluation
SNL	Sandia National Laboratories

1. INTRODUCTION

The Photovoltaic Systems Evaluation Laboratory (PSEL) at Sandia National Laboratories (SNL) in Albuquerque, NM has an extensive test site where PV modules and other system components are deployed and monitored for testing and evaluation. For this dataset PV Performance Labs has assembled one year of measurements from the Systems Long-Term Evaluation (SLTE) project (formerly known as PV Lifetime) providing the main variables needed to investigate and validate PV module operating temperature models: irradiance, ambient temperature, wind speed and back-of-module temperature. For use with more advanced thermal modeling, an estimate of down-welling long-wave radiation is also included.

2. INSTRUMENTS AND MEASUREMENTS

The SLTE facility has a comprehensive set of instruments to record module electrical parameters and operating conditions for a large number of modules of different types. They form the basis for a variety of studies and analyses, for example [1]. For the temperature modeling dataset we have chosen the temperatures measured on the 325 watt Panasonic HIT modules because they are centrally located in the test field. (See Figure 1) and therefore less influenced by edge effects. These modules were installed June 2018.

Details about the site and instrumentation are given in Table 1 and Table 2 respectively.

Figure 1 Site photo showing the location of PV the arrays. The dataset module temperatures are measured near the middle of the two middle rows in the middle section.

Table 1. Site and array information for SLTE systems

Parameter	Value
Latitude	35.0545° N
Longitude	106.539° W
Elevation	1660 m
Array Tilt Angle	35°
Array Azimuth Angle	180° (South facing)
Row Spacing	4.88m (16 ft)

Table 2: Summary of instruments and parameters

Parameter	Orientation/Position	Manufacturer	Model	Additional details
Broadband irradiance	Plane-of-array (POA)	Kipp & Zonen	CMP11	Cleaned twice per week
Module temperature 1	Back of module	Omega	SA1-RTD-4W	Upper module
Module temperature 2	Back of module	Omega	SA1-RTD-4W	Lower module
Module temperature 3	Back of module	Omega	SA1-RTD-4W	Lower module
Module temperature 4	Back of module	Omega	SA1-RTD-4W	Upper module
Ambient temperature	Inside aspirated shield	Climatronics	100093	Accuracy: +/- 0.1°C
Wind speed	10 m height	Climatronics	102083	Accuracy: +/- 0.11 m/s

3. DATA PROCESSING

Measurements from sensors are taken at either 1 s or 5 s intervals and one-minute average values are calculated and stored in a SNL database. These one-minute average values are published in this dataset.

The dataset covers the entire calendar year 2020 including Feb. 29. However, there is a period without data beginning on Jan. 20 and ending on Jan. 30. During this period the system was down to allow modules to be dismounted and tested indoors. The inverters were shut down several days earlier on Jan. 15, which produced several days of higher temperatures. These periods are included dataset for interest but can be excluded easily by dropping the month of January, for example.

The down-welling long-wave radiation data are obtained from the ECMWF web site [2]. These hourly values are interpolated using monotonic cubic interpolation, which produces smooth transitions without overshooting the original values.

4. PRACTICAL DETAILS

4.1. File structure

The complete data set is made available in NetCDF format. This file format is space efficient and can accommodate multidimensional data as well as associated metadata. Libraries are available for many high-level programming languages to facilitate access to the data and metadata.

4.2. Download locations (to be updated)

There are two primary download locations. The first is on the website of the PV Performance Modelling Collaborative at https://pvpmc.sandia.gov/ [3]. The second is on the Duramat Datahub at https://datahub.duramat.org/dataset/module-temperature [4].

5. AUTHOR CONTRIBUTIONS

Anton Driesse: Conceptualization, methodology, data curation, software, visualization, writing – original draft. Marios Theristis: Conceptualization, project administration, supervision, writing – review and editing. Joshua Stein: Conceptualization, funding acquisition, resources, project administration, supervision, writing – review and editing.

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[4] "DuraMAT Data Hub." https://datahub.duramat.org/

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