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pvlib python: a python package for modeling solar energy systems

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Software

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Summary

pvlib python is a community-supported open source tool that provides a set of functions and classes for simulating the performance of photovoltaic energy systems. pvlib python aims to provide reference implementations of models relevant to solar energy, including for example algorithms for solar position, clear sky irradiance, irradiance transposition, DC power, and DC-to-AC power conversion. pvlib python is an important component of a growing ecosystem of open source tools for solar energy (William F. Holmgren et al. 2018).

pvlib python is developed on GitHub by contributors from academia, national laboratories, and private industry. pvlib python is released with a BSD 3-clause license allowing permissive use with attribution. pvlib python is extensively tested for functional and algorithm consistency. Continuous integration services check each pull request on multiple platforms and Python versions. The pvlib python API is thoroughly documented and detailed tutorials are provided for many features. The documentation includes help for installation and guidelines for contributions. The documentation is hosted at readthedocs.org as of this writing. A Google group and StackOverflow tag provide venues for user discussion and help.

The pvlib python API was designed to serve the various needs of the many subfields of solar power research and engineering. It is implemented in three layers: core functions, the `Location` and `PVSystem` classes, and the `ModelChain` class. The core API consists of a collection of functions that implement algorithms. These algorithms are typically implementations of models described in peer-reviewed publications. The functions provide maximum user flexibility, however many of the function arguments require an unwieldy number of parameters. The next API level contains the `Location` and `PVSystem` classes. These abstractions provide simple methods that wrap the core function API layer. The method API simplification is achieved by separating the data that represents the object (object attributes) from the data that the object methods operate on (method arguments). For example, a `Location` is represented by a latitude, longitude, elevation, timezone, and name, which are `Location` object attributes. Then a `Location` object method operates on a `datetime` to get the corresponding solar position. The methods combine these data sources when calling the function layer, then return the results to the user. The final level of API is the `ModelChain` class, designed to simplify and standardize the process of stitching together the many modeling steps necessary to convert a time series of weather data to AC solar power generation, given a PV system and a location.

pvlib python was ported from the PVLib MATLAB toolbox in 2014 (J. S. Stein 2012, Andrews et al. (2014)). Efforts to make the project more pythonic were undertaken in 2015 (W. F. Holmgren et al. 2015). Additional features continue to be added, see, for example (J. S. Stein et al. 2016, W. F. Holmgren and Groenendyk (2016)) and the documentation's "What's New" section.

pvlib python has been used in numerous studies, for example, of solar power forecasting (Gagne II et al. 2017, William F. Holmgren, Lorenzo, and Hansen (2017)), development of solar irradiance models (J. Polo 2016), and estimation of photovoltaic energy potential (Louwen et al. 2017). Mikofski et. al. used pvlib python to study the accuracy of clear sky models with different aerosol optical depth and precipitable water data sources (Mikofski et al. 2017) and to determine the effects of spectral mismatch on different PV devices (M. Mikofski et al. 2016). pvlib python is a foundational piece of an award, "An Open Source Evaluation Framework for Solar Forecasting," made under the Department of Energy Solar Forecasting 2 program (Energy 2018).

Plans for pvlib python development includes the implementation of new and existing models, addition of functionality to assist with input/output, and improvements to API consistency.

The source code for each pvlib python version is archived with Zenodo (Contributors, n.d.).

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