

Recent and Planned Enhancements for PVWATTS

B. Marion, M. Anderberg, and P. Gray-Hann

*Presented at the 2004 DOE Solar Energy Technologies
Program Review Meeting
October 25-28, 2004
Denver, Colorado*

Conference Paper
NREL/CP-520-37016
January 2005

NREL is operated by Midwest Research Institute • Battelle Contract No. DE-AC36-99-GO10337



NOTICE

The submitted manuscript has been offered by an employee of the Midwest Research Institute (MRI), a contractor of the US Government under Contract No. DE-AC36-99GO10337. Accordingly, the US Government and MRI retain a nonexclusive royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for US Government purposes.

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

Available electronically at <http://www.osti.gov/bridge>

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: <mailto:reports@adonis.osti.gov>

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: <http://www.ntis.gov/ordering.htm>



Recent and Planned Enhancements for PVWATTS

B. Marion, M. Anderberg, and P. Gray-Hann
National Renewable Energy Laboratory
Golden, CO 80401
bill_marion@nrel.gov

ABSTRACT

PVWATTS is an Internet-accessible software program that allows the user to easily calculate the energy production and cost savings for grid-connected photovoltaic (PV) systems located throughout the United States. Recent enhancements have been made to allow the user to define the system location by the use of zip code or latitude and longitude coordinates, and to receive more detailed performance information by providing a.c. energy production for each hour of the year. Future enhancements under consideration are also discussed. They include more flexibility for the user in defining system losses from soiling and in the conversion from d.c. to a.c. power, an option for international locations, and accounting for PV module shading.

1. Objectives

The purpose of this work was to add features to PVWATTS that would improve the ease of use and provide more complete information on the performance of grid-connected photovoltaic (PV) systems. An easy to use PV performance predictive model available to anyone via the internet facilitates the deployment and acceptance of grid-connected PV systems by providing a common predictor of expected performance for both buyers and sellers of PV systems.

2. Technical Approach

The original PVWATTS [1], Version 1 released in 1999, is an Internet-accessible simulation tool for providing quick estimates of the electrical energy produced by a grid-connected crystalline silicon PV system for any of 239 locations. These locations correspond to the 239-station Typical Meteorological Year (TMY2) database [2] for the United States and its territories. Users select a location from a station map and set PV system parameters, or select default values, and PVWATTS performs an hour-by-hour simulation that provides monthly and annual alternating current (a.c.) energy production in kilowatts and energy value in dollars. System parameters that may be specified include size (a.c. rating for Standard Reporting Conditions), local electric costs, PV array type (fixed or tracking), PV array tilt angle, and PV array azimuth angle. The performance model used by PVWATTS is based on Sandia National Laboratories' PVFORM [3], but with fewer allowed specified inputs.

Before the release of Version 2 in 2001, if the desired location was between TMY2 stations, the PVWATTS user needed to choose between two or more stations based on which station they judged to be climatically similar, or in

some cases, the nearest. In these instances, PVWATTS Version 2 provides better performance estimates by the use of 40-km resolution data grid values of monthly global horizontal, direct normal, and diffuse horizontal solar radiation; and maximum daily temperature to translate performance from a nearby TMY2 station to the desired grid cell. To run PVWATTS Version 2, users select the 40-km resolution grid cell containing the desired location from an interactive map, and then in the same manner as for Version 1, specify the system parameters, or accept the default values, and click the calculate button to initiate the performance simulation.

The selection of the grid cell is accomplished with a map server that permits layering of information such as cities, roads, lakes and rivers, and state and county boundaries to help identify a desired location. Compared to displaying a simple station map as for Version 1, the map server generated maps with layered data require processing a significant amount of data, and if the user volume is high this results in slower rendering of the maps. Consequently, to keep rendering times within a reasonable limit, Version 2 was moved to an updated software and new hardware platform.

3. Results and Accomplishments

In September 2004, PVWATTS Version 2 was moved to a higher speed server and modified to run on ESRI ArcIMS Version 9.0 software. On the map server, PVWATTS is a tool that may be invoked from the top level "United States Solar Atlas" screen that shows a map of the United States with elevation shading (see Fig. 1).

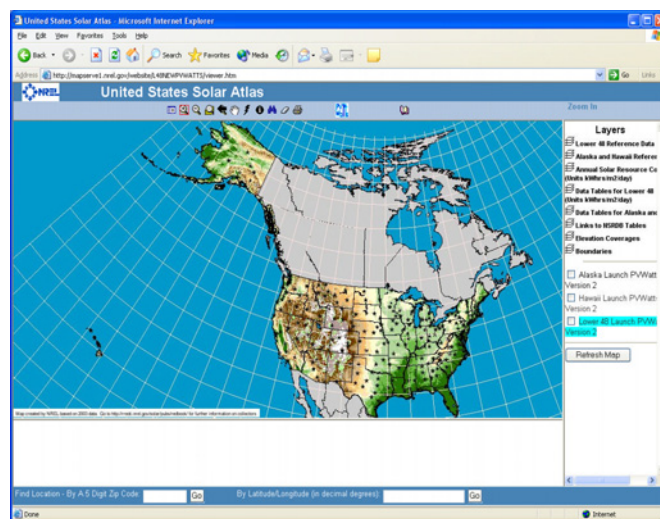


Fig. 1. Top level "United States Solar Atlas" screen from which PVWATTS Version 2 is invoked.

In addition to elevation shading, a new feature was added permitting the user to display a map showing values of solar radiation for any of 14 different collector orientations or types. More options have also been added for selecting the location. Besides zooming on a region of the map to select a grid cell, the user may now select a location by entering either a zip code or the latitude and longitude coordinates.

PVWATTS Version 1 has also been updated with an option to provide hourly values of a.c. energy for each hour of the TMY. From the “AC Energy and Cost Savings” screen showing the results of the simulation, the “Output Hourly Performance Data” button may be clicked to display hourly performance. If desired, hourly performance results may be saved as a text file. This feature is not available for Version 2 because Version 2 results are determined with interpolations using monthly solar radiation values.

4. Conclusions and Future Direction

Enhancements were made to PVWATTS to improve its performance, ease of use, and output. Version 2 was moved to an updated software and a new hardware platform to provide better performance for an expanding user group, and options were added for defining site locations using zip codes and latitude and longitude coordinates. For Version 1, an option for providing hourly values of a.c. energy was added. Both versions of PVWATTS reside on the National Renewable Energy Laboratory’s website and may be accessed by pointing your browser to <http://rredc.nrel.gov/solar/calculators/PVWATTS/>.

With increasing interest in grid-connected PV systems, PVWATTS is seeing increased use. PVWATTS provided approximately 40,000 performance simulations in FY2004, an increase of about 20% from FY2003. Because it’s easier to use, about 80% of the simulations were performed with PVWATTS Version 1. PVWATTS had 21,000 unique visitors in FY2004, with 3700 of them returning one or more times. A typical visit to the site might include three or four simulations as the user explores the sensitivity of performance to changes in input parameters.

The user domain name suffixes indicate that about 60% of PVWATTS users are from business (.com), 33% from

individuals or very small business (.net), and the remaining 7% from education, government, and the military.

For FY2005, the following changes are being considered to improve the usefulness of PVWATTS:

- Instead of an input for the a.c. power rating, use an input for a d.c. nameplate rating in conjunction with an input for a d.c. to a.c. derate factor.
- Add a user input for specifying soiling losses instead of using a hard-coded value of 3%.
- Add a user input for system availability.
- Add user input(s) for specifying the geometry of obstacles that may shade the PV array to account for shading losses.
- Add international weather data for PVWATTS simulations for regions outside the U.S.

For users willing to provide feedback on the above changes, or recommend other changes, a survey form at <http://rredc.nrel.gov/solar/calculators/PVWATTS/survey2004.cgi> may be completed. Results of the survey will be used to identify and prioritize future changes to PVWATTS.

REFERENCES

- [1] B. Marion and M. Anderberg. “PVWATTS An Online Performance Calculator for Grid-Connected PV Systems,” *Proceedings of the ASES Solar 2000 Conference*, June 16-21, 2000, Madison, WI.
- [2] B. Marion and K. Urban. *Users Manual for TMY2s-Typical Meteorological Years Derived from the 1961-1990 National Solar Radiation Data Base*, NREL/TP-463-7668, Golden, CO: National Renewable Energy Laboratory, 1995.
- [3] D. Menicucci and J. Fernandez. *User’s Manual for PVFORM: A Photovoltaic System Simulation Program for Stand-Alone and Grid-Interactive Applications*, SAND85-0376, Albuquerque, NM: Sandia National Laboratories, 1988.
- [4] B. Marion, M. Anderberg, R. George, P. Gray-Hann, and D. Heimiller, “PVWATTS Version 2 – Enhanced Spatial Resolution for Calculating Grid-Connected PV Performance,” *Proceedings of the 2001 NCPV Program Review Meeting, Lakewood, CO*, pp. 143-144.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Executive Services and Communications Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.

1. REPORT DATE (DD-MM-YYYY) January 2005		2. REPORT TYPE Conference Paper		3. DATES COVERED (From - To)		
4. TITLE AND SUBTITLE Recent and Planned Enhancements for PVWATTS			5a. CONTRACT NUMBER DE-AC36-99-GO10337			
			5b. GRANT NUMBER			
			5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S) B. Marion, M. Anderberg, and P. Gray-Hann			5d. PROJECT NUMBER NREL/CP-520-37016			
			5e. TASK NUMBER PVC57101			
			5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) National Renewable Energy Laboratory 1617 Cole Blvd. Golden, CO 80401-3393			8. PERFORMING ORGANIZATION REPORT NUMBER NREL/CP-520-37016			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S) NREL			
			11. SPONSORING/MONITORING AGENCY REPORT NUMBER			
12. DISTRIBUTION AVAILABILITY STATEMENT National Technical Information Service U.S. Department of Commerce 5285 Port Royal Road Springfield, VA 22161						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT (Maximum 200 Words) PVWATTS is an Internet-accessible software program that allows the user to easily calculate the energy production and cost savings for grid-connected photovoltaic (PV) systems located throughout the United States. Recent enhancements have been made to allow the user to define the system location by the use of zip code or latitude and longitude coordinates, and to receive more detailed performance information by providing a.c. energy production for each hour of the year. Future enhancements under consideration are also discussed. They include more flexibility for the user in defining system losses from soiling and in the conversion from d.c. to a.c. power, an option for international locations, and accounting for PV module shading.						
15. SUBJECT TERMS PV; Internet-accessible software program; energy production; grid-connected system; a.c. power; d.c. power; module-shading;						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UL	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON	
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (Include area code)	

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18