

# CSI EPBB Design Factor Calculator User Guide

## 1. Guide Overview

This User Guide is intended to provide background on the California Solar Initiative (CSI) Expected Performance Based Buydown (EPBB) Design Factor Calculator, detailed step by step instructions on its use and instructions on how to calculate EPBB Incentives using the calculator results. The calculator is web-accessible at <http://www.csi-epbb.com>.

The CSI-EPBB calculator is available to the public and participants in the CSI program. Its sole purpose is to determine the EPBB Design Factor and calculate an appropriate incentive level based on a reasonable expectation of performance for an individual system. The results of the calculator should not be interpreted as a guarantee of system performance. Actual performance of an installed PV system is influenced by numerous factors, and may differ from the results summarized in the CSI-EPBB calculator. For this reason, contractors, participating customers, and other interested parties should utilize the calculator only to determine an appropriate incentive when applying to the CSI incentive program. Additional uses for the calculator other than its intended purpose as stated above are not endorsed or encouraged.

## 2. CSI EPBB Eligibility

EPBB eligible photovoltaic (PV) projects must be located on sites where the Host Customer is a Pacific Gas & Electric (PG&E), Southern California Edison (SCE) or San Diego Gas & Electric (SDG&E) retail electric customer, and the proposed system's CEC-AC<sup>1</sup> rating is less than 100 kW. All customer classes are eligible for CSI EPBB except for residential new construction systems which must apply to the California Energy Commission's New Solar Home Partnership (NSHP) program. NSHP details may be found at <http://www.gosolarcalifornia.ca.gov/nshp/>. The CSI EPBB incentive calculator is not applicable to systems applying to the NSHP.

Municipal electric utility customers are not eligible to receive incentives from the above designated program administrators.

Program eligibility details can be found at the Go Solar California and CSI Program Administrators' websites listed below

- Go Solar California <http://www.gosolarcalifornia.ca.gov/>
- PG&E <http://www.pge.com/csi>
- SCE <http://www.sce.com/RebatesandSavings/CaliforniaSolarInitiative/>
- SDREO <http://www.sdreo.org/ContentPage.asp?ContentID=370&SectionID=407>

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<sup>1</sup> The CEC-AC rating is the product of the number of PV panels, the PTC rating per panel and the inverter efficiency.

### 3. CSI EPBB Calculator Overview

The CSI EPBB calculator is a web-accessible tool (<http://www.csi-epbb.com>) used to determine the Design Factor and the resulting EPBB incentive for eligible CSI proposed systems.

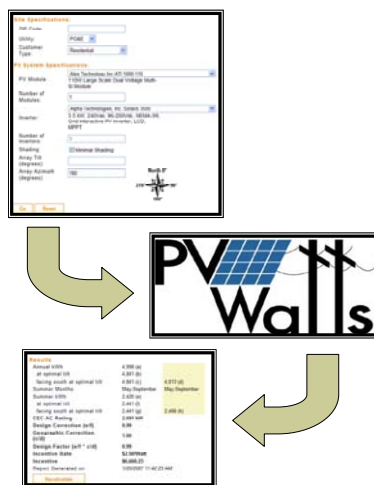
The calculator determines the EPBB incentive for a single type of PV panel and inverter combination. The incentive for multiple units of the same type of PV panel and/or inverter can be accommodated by the calculator in a single calculation. Mixed systems that use different types of inverters and/or PV panels require individual incentive calculations for each combination and the incentives summed. More details on mixed system EPBB incentive calculation can be found in Section 6 of this guide.

When first opened, the calculator has an input page, where the user inputs the zip code location of the system, the applicable utility, the type and number of PV panels, the type and number of inverters; the proposed system's tilt and azimuth.

Once all required data is entered, the user initiates the calculator by pressing the "GO" button. The calculator then calls the National Renewable Energy Laboratory's PV Watts version 2 (PV Watts) performance calculator passing to it information on the proposed system and its location. The PV Watts model returns to the calculator the monthly electric energy production of the proposed PV system.

The calculator then uses the PV Watts results to determine the Design Factor and the resulting EPBB incentive for the proposed system.

The overall process is illustrated below.



The user should press the "Recalculate" button to return to the input page and make adjustments to the inputs.

## 4. Required Calculator Inputs

The CSI EPBB Design Factor calculator is configured to calculate the incentive for a single PV panel and inverter type combination. For example if a system has two different makes or models of inverters, but the same type of PV panel, the calculator must be run twice.

The inputs for the CSI EPBB Design Factor calculator are described below.

**ZIP Code:** This is the zip code of the location of the proposed PV system. Note that this zip code must be located within the specified utility's service territory where the system is or will be located.

**Utility:** This is the utility in whose service territory the proposed PV system is or will be located. Note that the zip code inputted must be located within the specified utility's service territory.

**Customer Type:** Select the classification associated with the Host Customer. For definitions of the various customer types, refer to the California Solar Initiative Program Handbook.

**PV Module:** This is the type of module that will be used in the proposed PV system. The options in this pull-down are based on the CEC's list of eligible photovoltaic modules, which can be found at [http://www.consumerenergycenter.org/cgi-bin/eligible\\_pvm\\_modules.cgi](http://www.consumerenergycenter.org/cgi-bin/eligible_pvm_modules.cgi). If multiple module types are to be used, you must make multiple EPBB calculator runs.

**Number of Modules:** This is the total number of PV modules of the selected type that will be connected to the inverters that are selected below.

**Inverter:** This is the type of inverter that will be used with the proposed PV system. The options in this pull-down are based on the CEC's list of eligible inverters found at [http://www.consumerenergycenter.org/cgi-bin/eligible\\_inverters.cgi](http://www.consumerenergycenter.org/cgi-bin/eligible_inverters.cgi). If multiple inverter types are to be used, you must make multiple EPBB calculator runs.

**Number of Inverters:** This is the total number of inverters of the selected type that will be installed for use with the PV modules selected above.

**Minimal Shading:** This criterion, if checked, indicates that no object is closer than a distance twice the height it extends above the PV modules. If this criterion is met and Minimal Shading is checked, no derating due to shading is applied. Note that the reference optimal systems at the proposed and reference locations are always specified to meet the "Minimum Shading Criteria".

**Shading Derate Factors (%):** If the proposed system does not meet the "Minimum Shading Criteria", the user is required to input monthly non-shaded results from a shading study conducted at the proposed system site. If the Minimal Shading box is

unchecked, a table form will appear where the user is to input each month's non-shaded results from the shading study. See Section 7 for more details on obtaining and inputting the shading derate factors. The reference optimal system is specified to meet the "Minimum Shading Criteria" and thus has no derating of its monthly output due to shading.

**Array Tilt (degrees):** This is the proposed system tilt from horizontal. Flat (horizontal) systems have a 0° tilt.

**Array Azimuth (degrees):** This is the horizontal direction the proposed system is pointing; due South is 180° azimuth and due North is 0° azimuth. The optimal reference system, for proposed flat (horizontal) systems, are assumed to have a 180° azimuth.

After the inputs are set, the user can click the "GO" button and the calculations will be executed. If an input error is detected, the calculator will refresh the input page and note the error with a comment at the bottom and an asterisk next to the field containing the error. The error must be corrected before the calculator will proceed to the results output page.

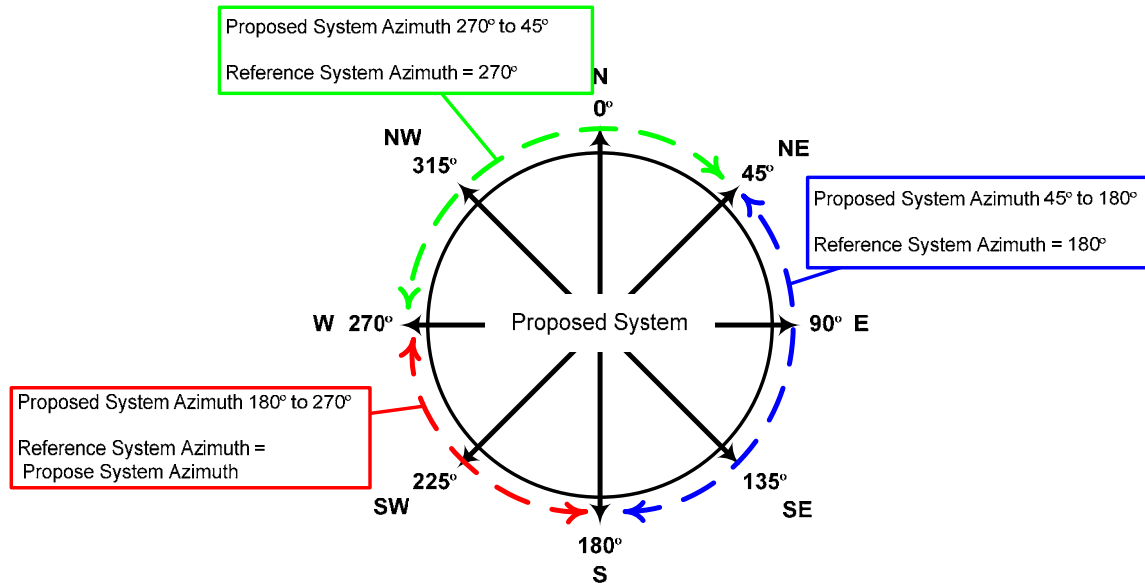
## 5. Description of the Outputs

Once the calculator has completed its computations, it will display a results page containing inputs and outputs for the proposed and reference optimal system, as well as the Design Factor. If the user wishes to use this data to apply to the CSI program, they must print out a hardcopy to be included in their application materials.

All production estimates are obtained from running NREL's PV Watts v2 photovoltaic performance model using the proposed system parameters and weather data for the proposed and reference locations.

The outputs (other than the descriptions of the proposed and reference location systems) are described below.

**Optimal Tilt (proposed azimuth):** This is the system's optimal tilt, maximizing summer output, at the proposed location. The optimal tilt also depends on the azimuth of the optimal reference system. The following illustrates how the reference system azimuth is set to equally treat south and west facing proposed systems.



**Optimal Tilt (facing south):** This is the tilt of summer optimal south facing systems at the proposed and reference locations.

**Annual kWh:** This is the estimated annual energy output of the proposed system. This value is reported for the sole purpose of transparency of the calculator and is not a guarantee of future system performance.

**at optimal tilt:** This is the estimated annual energy output of the summer optimized system at the proposed location. This value is reported for the sole purpose of transparency of the calculator.

**facing south at optimal tilt:** This is the estimated annual energy output of south facing summer optimized systems at the proposed and reference locations. These values are used to determine the Geographic Correction.

**Summer Months:** These are the months that define the summer period. The proposed and reference optimal system output for these months is used to determine the “Summer kWh”.

**Summer kWh:** This is the estimated summer energy output of the proposed system.

**at optimal tilt:** This is the estimated summer energy output of the proposed system, optimized to maximize summer output.

**facing south at optimal tilt:** This is the estimated summer energy output of the proposed and reference location systems, both optimized to maximize summer output.

**CEC-AC Rating:** This is the product of the PV module PTC rating, module count and inverter efficiency. If the CEC-AC rating exceeds the rated capacity of the inverter(s) by

no more than 25%, a warning is displayed on the results page. This warning is only informational and does not prevent the user from proposing the system in a CSI application. If the CEC-AC rating exceeds the rated capacity of the inverter(s) by 25% or more, an error is flagged which must be corrected before viewing the results.

**Design Correction:** This is the ratio of the Summer Output of the Proposed System and the Summer Output of the Optimal System at the Proposed Location.

**Geographic Correction:** This is the ratio of the annual output of the summer optimal south facing system at the proposed location and the annual output of the summer optimal south facing system at the reference location.

**Design Factor:** This is the product of the Design Correction and Geographic Correction. This Design Factor is used in the EPBB incentive calculation.

**Incentive Rate:** This is the current CSI EPBB incentive rate and depends on the selected utility and customer type.

**Incentive:** This is the total incentive for the proposed system.

**Report Generated on:** is a date and time stamp to document when the report run occurred.

After the run is complete, the user should print a hard copy of the results for use when filling out their CSI EPBB application.

## 6. Multiple Arrays, Module or Inverter Types

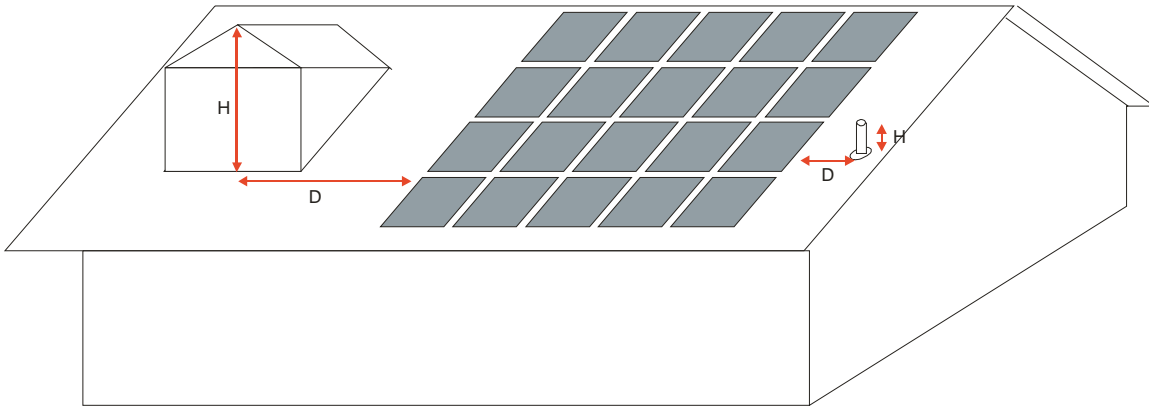
If a proposed system consists of PV arrays with different azimuths and tilts or if different PV module or inverter types will be installed as part of a PV system, a CSI EPBB calculator run must be done for each configuration and the resulting incentives totaled.

For example, a system with 30 PV panels type “A” and 2 inverters of type “Z” is proposed; only one calculator run has to be made for this type of system.

However, if a single system with 15 panels of type “A” and 15 panels of type “B”, with 1 inverter of type “Z” is proposed, the user must make one calculator run with 15 “A” panels and 1 “Z” inverter and a second calculator run with 15 “B” panels and 1 “Z” inverter. The incentives from the two runs must then be added together.

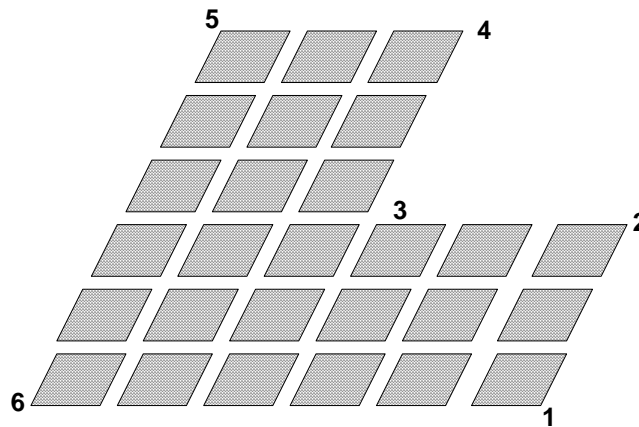
## 7. Shading Input Requirements

Proposed systems meet the “Minimum Shading Criteria” if no object is closer than a distance twice the height it extends above the PV modules (see illustration below). If this criterion is met and Minimal Shading is checked, no derating due to shading is applied.

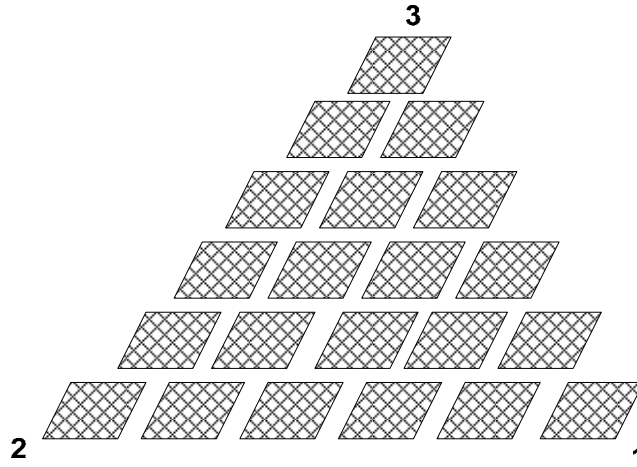


For systems that do not meet the “Minimum Shading Criteria”, the user is required to input monthly non-shaded results from a shading study conducted at the proposed system site. The study must use a shade analysis tool (and accompanying software) such as the Solar Pathfinder (<http://www.solarpathfinder.com>), the Solmetric SunEye™ (<http://www.solmetric.com>), the Wiley Electronics ASSET (<http://www.we-llc.com>) or similar instrument. These inputs are used as monthly derate factors (100% = no shading, 0% = total shading) to adjust the PV Watts output for shading. The shade analysis tool must be specific to the location, azimuth and tilt of the system being measured and must correct for magnetic declination. Do not use a shade analysis tool that is only applicable to south facing systems if your system’s azimuth is different than 180°.

The shading study must consist of shading measurements taken at of the system array’s major corners, and the average monthly derate factors input into the calculator. For rectangular areas, four shading measurements must be taken. For irregular areas, a shading measurement is taken at each corner as shown below.



It is not necessary to take measures at each panel corner, for example, in the case of staggered panels. Shade measurements should be made at the major corners of the array as shown below.



It is critical that the positions of the shade measurements are documented and communicated to the CSI field inspector so they may duplicate the measurement. The measurement locations must be accessible after the PV system has been installed for purposes of field verification by the CSI Program Administrators. It is the applicant's responsibility to document the study.

## 8. EPBB Incentive & Design Factor Computation Details

The EPBB incentive is calculated with the following formula.

$$\text{EPBB Incentive} = \text{Incentive Rate} \times \text{System Rating} \times \text{Design Factor}$$

Where,

**EPBB Incentive** – is the monetary incentive paid upfront.

**Incentive Rate** – is the maximum EPBB incentive rate (\$/Watt) available at the time of application. The table below presents the EPBB incentive rate schedule.

**Maximum EPPB Payment Amounts**

MW Step	MW per step	EPBB payments (per watt)		
		Residential	Commercial	Government/ Non-Profit
1	50	n/a	n/a	n/a
2	70	\$2.50	\$2.50	\$3.25
3	100	\$2.20	\$2.20	\$2.95
4	130	\$1.90	\$1.90	\$2.65
5	160	\$1.55	\$1.55	\$2.30
6	190	\$1.10	\$1.10	\$1.85
7	215	\$0.65	\$0.65	\$1.40
8	250	\$0.35	\$0.35	\$1.10
9	285	\$0.25	\$0.25	\$0.90
10	350	\$0.20	\$0.20	\$0.70

**System Rating** – is the product of the PV module PTC rating, module count and inverter efficiency. The PTC rating per panel can be found at [http://www.consumerenergycenter.org/cgi-bin/eligible\\_pvmodules.cgi](http://www.consumerenergycenter.org/cgi-bin/eligible_pvmodules.cgi). The inverter efficiency can be found at [http://www.consumerenergycenter.org/cgi-bin/eligible\\_inverters.cgi](http://www.consumerenergycenter.org/cgi-bin/eligible_inverters.cgi).

**Design Factor** – is a factor used to modify the maximum incentive rate based on the proposed system's estimated performance relative to an optimal system at the proposed location and an optimal system at a reference location. It is the product of a Design Correction (Dcorr) and a Geographic Correction (Gcorr). Dcorr is the ratio of the estimated summer kWh production for the proposed system at the proposed location and the estimated summer kWh production for a summer optimal system at the proposed location. Gcorr is the ratio of the estimated annual kWh production for a summer optimal system at the proposed location and the estimated annual kWh production for a summer optimal system at a reference location.

The Design Factor (DF) calculation is -

$$DF = Dcorr * Gcorr$$

$$Dcorr \text{ (Design Correction)} = S_{s,p,p} / S_{s,p,o}$$

$S_{s,p,p}$  = The system's estimated summer kWh output at the proposed location, with proposed tilt & azimuth

$S_{s,p,o}$  = The system's estimated summer kWh output at the proposed location, with summer optimized tilt & azimuth allowing for equal treatment of proposed systems oriented from South to West (i.e. the optimized system's orientation shall be the same as the proposed system for orientations due south to due west).

$$Gcorr \text{ (Geographic Correction)} = A_{s,p,o} / A_{s,r,o}$$

$A_{s,p,o}$  = The system's estimated annual kWh output at the proposed location, with summer optimized tilt & south azimuth

$A_{s,r,o}$  = The system's estimated annual kWh output at the reference location, with summer optimized tilt & south azimuth

In addition, the calculator has these characteristics and features,

- The Summer Period is defined as May 1 through October 31. This encompasses the summer periods as defined by the three California investor-owned utilities.
- All estimated kWh outputs are determined from NREL's PV Watts v2 performance model.
- Gcorr is capped at 1.0 to prevent areas with higher performance than the reference location from obtaining incentives larger than the maximum incentive rate.
- All systems oriented between 180° and 270° are treated equally.
- The “optimal reference orientation tilt” is optimized for summer production corresponding to the different acceptable compass directions from 180° to 270°.
- Location-specific criteria which account for weather variation and varying degrees of solar insolation, based on local climate and geography.
- An “optimal reference latitude tilt” that relates to local latitude.

## 9. Calculator Interaction with PV Watts v2

The CSI EBPP calculator utilizes NREL's PV Watts v2 to estimate the performance of proposed and optimal systems. PV Watts v2 calculates electrical energy produced by a grid-connected photovoltaic (PV) system. PV Watts v2 uses hourly Typical Meteorological Year (TMY) weather data and a PV performance model based on Sandia National Laboratories' PVFORM to estimate monthly and annual AC energy production (kWh). PV Watts v2 extends PV Watts v1 by incorporating NREL's 40 km resolution solar resource data to permit site-specific calculations.

PV Watts v2 calculates performance using hourly data for a nearby TMY2 site that is climatologically similar, and then the output is adjusted based on differences between the TMY2 site and the grid cell with respect to the solar resource (direct, diffuse horizontal, and global horizontal radiation) and daily maximum temperature.

PV Watts v2 has a number of default derate factors that it includes to account for various system losses. The CSI EPBB calculator assumes a fixed set of losses in the proposed and optimal systems totaling 16.3%, which is the default in PV Watts v2. These derate factors include –

<b>PV Watts Default Derate Factors for AC Power Rating at STC</b>		
<b>Component Derate Factors</b>	<b>PVWATTS Default</b>	<b>Range</b>
PV module nameplate DC rating	0.95	0.80 - 1.05
Inverter and Transformer	User Input	0.88 - 0.96

Mismatch	0.98	0.97 - 0.995
Diodes and connections	0.995	0.99 - 0.997
DC wiring	0.98	0.97 - 0.99
AC wiring	0.99	0.98 - 0.993
Soiling	0.95	0.30 - 0.995
System availability	0.98	0.00 - 0.995
Shading	1.00	0.00 - 1.00
Sun-tracking	1.00	0.95 - 1.00
Age	1.00	0.70 - 1.00

Reference: [http://rredc.nrel.gov/solar/codes\\_algs/PVWATTS/system.html](http://rredc.nrel.gov/solar/codes_algs/PVWATTS/system.html)

Note that the CSI EPBB Design Factor calculator adopts these factors as defaults except for “Inverter and Transformer”. The CSI EPBB calculator uses the proposed inverter efficiency specified by the user. A detailed discussion of appropriate derate factors can be found at <http://www.nrel.gov/docs/fy05osti/37358.pdf>.

NREL reports that PV Watts v2 results may vary due to weather patterns and other uncertainties associated with the weather data and the model used to model the PV performance. The variations may be as much as  $\pm 20\%$  when compared to individual years. Compared to long-term performance over many years, the values in the table are accurate to within 10% to 12%. NREL also cautions that the energy production values in the table are valid only for crystalline silicon PV systems. In addition to these uncertainties, PV Watts v2 utilizes NREL’s 40 km resolution solar resource data to permit site-specific calculations. However, if the locations are within the same 40 km x 40 km geographical cell area, this may result in the same system production for different locations, even though it may appear that local weather patterns would dictate that they should be different.

Detailed information on PV Watts v2 and how it works may be found at –

[http://rredc.nrel.gov/solar/codes\\_algs/PVWATTS/moreabout.html](http://rredc.nrel.gov/solar/codes_algs/PVWATTS/moreabout.html) - Overview of NREL’s PV Watts calculator.

[http://rredc.nrel.gov/solar/codes\\_algs/PVWATTS/system.html](http://rredc.nrel.gov/solar/codes_algs/PVWATTS/system.html) - Discussion of PV Watts’ parameters.

[http://rredc.nrel.gov/solar/codes\\_algs/PVWATTS/pvwatts2.pdf](http://rredc.nrel.gov/solar/codes_algs/PVWATTS/pvwatts2.pdf) - Paper discussing how PV Watts v2 incorporates NREL's 40 km resolution solar resource data to permit site-specific calculations.

[http://rredc.nrel.gov/solar/codes\\_algs/PVWATTS/interp.html](http://rredc.nrel.gov/solar/codes_algs/PVWATTS/interp.html) - Discussion of interpreting the results.

[http://rredc.nrel.gov/solar/codes\\_algs/PVWATTS/revhist.html](http://rredc.nrel.gov/solar/codes_algs/PVWATTS/revhist.html) - Lists the revision history for PV Watts

## **10. Getting Help & Providing Comments**

Questions and comments regarding the CSI EPBB Design Factor Calculator or this Users Guide should be emailed to [CSI-EPBB@aesc-inc.com](mailto:CSI-EPBB@aesc-inc.com). Questions will be addressed on a first-come first-served basis.