DOCKETED

Docket Number:	16-BSTD-03
Project Title:	Updates to the 2016 Residential Alternative Calculation Method Reference Manual and Software
TN #:	211216
Document Title:	California Utilities Statewide Codes and Standards Team Comments: On Solar PV Modeling Procedure
Description:	Comments on Draft Title 24 Residential Alternative Calculation Method (ACM) Solar PV Modeling Procedure
Filer:	System
Organization:	Statewide Utility Codes and Standards Team
Submitter Role:	Public
Submission Date:	4/22/2016 5:02:03 PM
Docketed Date:	4/25/2016

Comment Received From: Statewide Utility Codes and Standards Team
Submitted On: 4/22/2016
Docket Number: 16-BSTD-03

Statewide Utility C&S Team - Comments on Solar PV Modeling Procedure

Additional submitted attachment is included below.

CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Comments on Draft Title 24 Residential Alternative Calculation Method (ACM) Solar PV Modeling Procedure

2016 CALIFORNIA BUILDING ENERGY EFFICIENCY STANDARDS

California Utilities Statewide Codes and Standards Team

April 22, 2016

Prepared by: Bill Dakin and Marc Hoeschele (Davis Energy Group)

This document was prepared by the California Statewide Codes and Standards Enhancement (CASE) Program that is funded, in part, by California utility customers under the auspices of the California Public Utilities Commission.

TABLE OF CONTENTS

1. INTRODUCTION

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (CEC) efforts to update California's Building Energy Efficiency Standards (Title 24) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE) and Southern California Gas Company (SoCalGas) – and Los Angeles Department of Water and Power (LADWP) sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings.

This document presents the Statewide CASE Team's comments on the Draft Residential Alternative Calculation Method (ACM) PV modeling procedure included in CBECC-Res. CBECC-Res 2016.1.1 Beta (815). This version was made available prior to the March 29, 2016 Residential ACM Workshop. The review was completed by Davis Energy Group to verify that the PV integration was implemented properly and also address any potential CBECC user interface issues.

2. REVIEW OF ACM PV IMPLEMENTATION

Davis Energy Group (DEG) evaluated the newly added PV modeling capabilities in CBECC-Res. CBECC-Res 2016.1.1 Beta (815) was run to evaluate the PV modeling with the Energy Design Rating (EDR) module. We completed runs using all the permutations and options currently provided with this version, including simplified and detailed modeling, CFI, and use of multiple arrays.

A summary of questions and recommendations are included below. We understand that additional revisions have been made to the ACM that may reflect some of these items listed.

- Revise the CFI range to be used to between 2:12 and 7:12. This will reduce the percent variance closer to 5% within the azimuth range of 150 to 270 degrees. Flat installations result in the highest reduction in TDV production and do not vary by azimuth. It is recommended that they be run outside CFI.
- Modeling of on or off-roof shading should be incorporated into the CBECC-Res PV model for applications not using the CFI assumption. As buildings use this tool to meet the ZNE tier in 2016 CALGreen, PV systems may need to be sized at 6 kW or larger, requiring systems to be installed on multiple roofs and in locations that do not meet the CFI minimal shading criteria.
- There needs to be a method to allow for inspectors and HERS raters to easily identify *Premium* module types from *Standard*.
- Why is thin-film only available under the detailed input screen? And why is output from production output from thin-film higher than both *Standard* and *Premium*?
- Until CBECC-Res has more detailed modeling capabilities (to account for shading, optimized designs, higher efficiency equipment or tracking), recommend that the

software have the capability to take PV generation outputs from outside software as inputs. Need to control what is acceptable so the system is not "gamed", but TDV outputs from CEC-PV tool which can model shading could be used in these situations while it is still supported and until CBECC-Res PV modeling capabilities are further developed.

- Recommendations to outputs from PV Energy Design Rating (EDR) runs:

Energy Use Details Tab

- Proposed Design Total kTDV/ft2-yr value at bottom includes the PV compliance credit. This is confusing because it is not used in the EDR calculation. Consider moving Total values to Design Rating tab where it is used for the EDR.
- Should PV kTDV/ft2-yr representing the total value of PV used in the EDR be reported? This would be useful.

Design Rating Tab

- Provide more information on the Design Rating tab. The limited values don't provide a lot of context.
- Should non regulated load breakdown be in a separate results table under Design Rating? Having these values reported is very useful but is confusing when reported with compliance credit values.
- Add PV TDV production value on this tab. When multiple PV arrays are entered, reporting the TDV production value for each unique array along with total would also be beneficial.
- The Statewide CASE Team has started reviewing the ruleset for the solar PV compliance option. Our initial feedback is provided below. As mentioned, the comment period for this draft of the ACM Reference Manual was not sufficiently long to develop robust comments. The Statewide CASE Team plans on continuing its review of the solar PV ruleset and providing CEC with additional comments at a future date.

2.1 California Flexible Installation Performance Variance

When the California Flexible Installation (CFI) option is taken, the PV system is modeled as having an azimuth of 170 degrees and a tilt of 22.6 degrees (5:12 roof pitch). To qualify for the CFI option, the PV system must be installed at an azimuth between 150 and 270 degrees and a tilt between 0 (flat) and 30.2 degrees (7:12 pitch). The installation must also meet the minimal shading criteria[1].

DEG verified that the CFI runs were identical with modeling of a PV system at 170 azimuth and 5:12 roof pitch. Table 1 presents specific production results from the model assuming the California Flexible Installation (CFI) for standard modules.

[1] Refer to reference to Minimal Shading Criterion as defined under Appendix B Section F.1 in the NSHP Guidebook at the end of this document.

Table 1: Results for California Flexible Installation (CFI) Runs in 2016 CBECC-Res (815)

Climate Zone	kWh/kW	kTDV/kW
Climate Zone 1	1,338	35,742
Climate Zone 2	1,565	39,648
Climate Zone 3	1,578	40,946
Climate Zone 4	1,610	40,446
Climate Zone 5	1,682	43,769
Climate Zone 6	1,579	39,141
Climate Zone 7	1,638	40,323
Climate Zone 8	1,582	38,220
Climate Zone 9	1,633	38,877
Climate Zone 10	1,630	39,105
Climate Zone 11	1,592	39,006
Climate Zone 12	1,569	37,782
Climate Zone 13	1,545	37,503
Climate Zone 14	1,797	40,965
Climate Zone 15	1,673	37,572
Climate Zone 16	1,699	40,677

When the CFI option is selected in CBECC-Res, actual production will differ from results using actual azimuth and tilt of the installed PV systems. Table 2, Figure 1 and Figure 2 summarize the variance in performance within the CFI range for Climate Zone 12. The specific annual kWh value for the CFI assumption is close to the maximum specific site kWh production within the CFI range, but closer to the mid-range of specific TDV values.

With the exception of Climate Zones 1, 11, and 16, the percent difference between the CFI values and actual is within 10%. The largest difference in PV production is with flat arrays that are typically at least 9% lower than the CFI values for that climate. In Climate Zone 12, production from a flat array (0:12 tilt) is 9.1% less than the calculated value and production from an array at 7:12 pitch and 225 degree azimuth is 5.2% higher annual TDV (see

Table 2).

If a 5 kW PV system is installed at a 0:12 tilt and the system is run using the CFI calculation, that system would underestimate TDV production by an equivalent of 500W of installed PV.

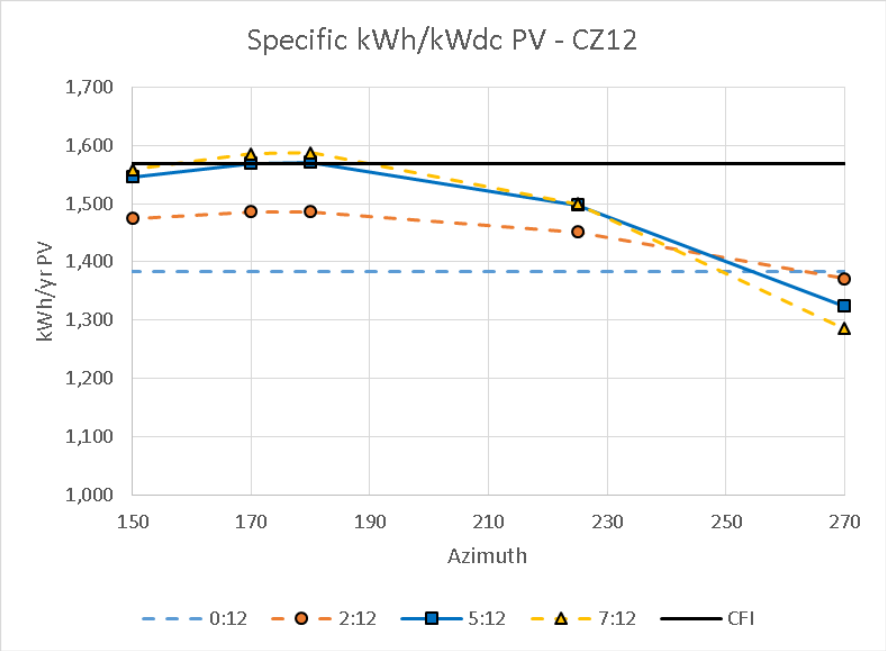


Figure 1: Specific Annual PV Production for Varying Azimuths and Tilts – Climate Zone 12

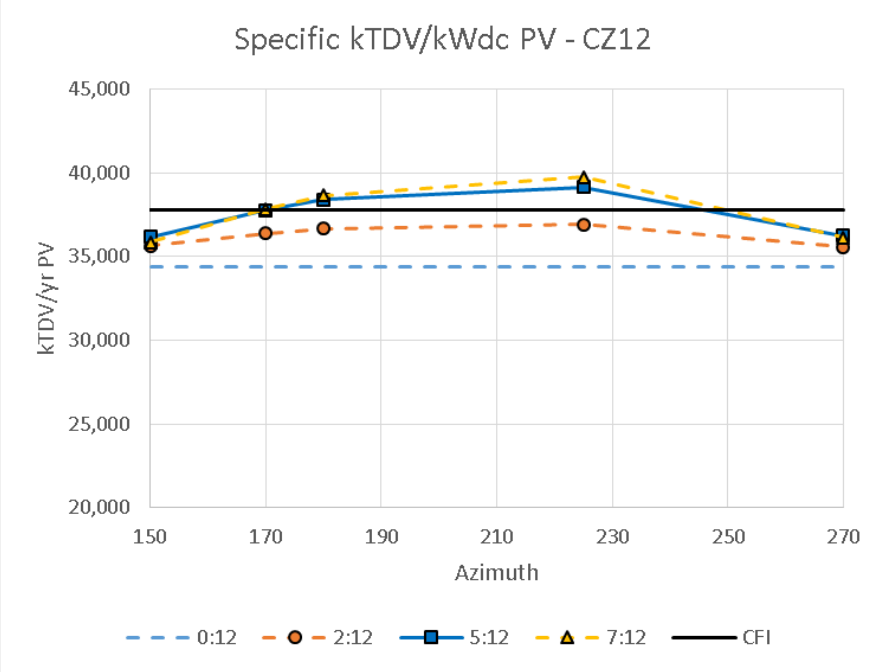


Figure 2: Specific Annual TDV PV Production for Varying Azimuths and Tilts – Climate Zone 12

Table 2: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 12

	Azimuth				
Tilt	**150º**	**170 º**	**180 º**	**225 º**	**270º**
0:12	-9.1%	-9.1%	-9.1%	-9.1%	-9.1%
2:12	-5.6%	-3.7%	-3.0%	-2.2%	-5.8%
5:12	-4.3%	0.0%	1.7%	3.7%	-4.1%
7:12	-5.1%	0.1%	2.3%	5.2%	-4.3%

Specific TDV PV production for various tilts and azimuths for all 16 climate zones can be found at the end of the memo.

2.2 CBECC-Res Comparison w/ PV Watts

NREL's System Advisor Model (SAM) was run using the PVWatts performance module and applying the 2013 California climate zone weather file for Climate Zone 12. The following system design parameters were fixed in both the SAM and CBECC-Res 2016 EDR models and various azimuths were evaluated.

- Standard module type
- 5:12 roof pitch
- Fixed open rack array type
- 96% inverter efficiency

Additional design parameters, not included as CBECC-Res inputs, are requested in the SAM model. Following are the values that were used, all of which are default assumptions in PVWatts. It's uncertain what values are assumed in the CBECC model.

- 1.1 DC to AC ratio
- 14.08% total system losses

Figure 3 compares the CBECC-Res with PVWatts results. The two models predict similar specific production values at various azimuths. The variance in specific production is highest at 90 degree azimuth (1.3% lower in CBECC), but mostly less than a 1% variance. This isn't a significant value, and at the high end would result in a difference of ~65 Watts for a 5 kW system. Without knowing what assumptions CBECC-Res uses for the DC-to-AC ratio and System Losses, it is impossible to know the source of the differences.

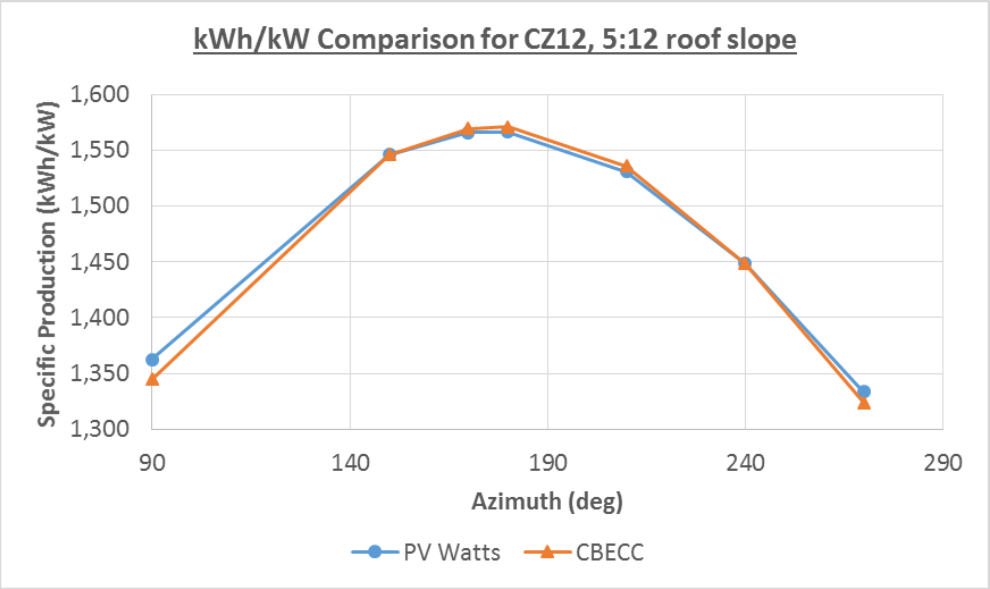


Figure 3: Comparison of PVWatts and CBECC-Res 2016

2.3 Modeling of Multiple PV Arrays within a Project

Under the Detailed option, CBECC-Res input allows the user to input up to five (5) unique PV systems of varying size and orientation. In the detailed output files, CBECC-Res only provides a single PV output value that is based on the total of all systems input. DEG ran multiple arrays at different azimuths and compared the results to summing of individual arrays of the same design. The total value reported in CBECC-Res is correctly totaling the PV values from the individual arrays, but we feel that there is value in reporting the PV production of each system modeled, in addition to the total, in order for the user to easily evaluate the relative contribution of arrays in different orientations.

2.4 Other Parametric Checks

Other parametric checks were done on the CBECC-Res PV model. They include effects of:

- Inverter efficiency
- Module type (Premium and Thin Film vs. Standard)
- Roof-mount vs. Open Rack array type

Inverter efficiency affects total kWh and TDV production by 1.05% per % change in inverter efficiency. For example, reducing inverter efficiency from the default value of 96% to 92% reduces annual PV output by 4.2%. This affect is uniform across all climate zones.

Module type specified affects module performance relative to both module efficiency and the temperature coefficient of power, so the effects differ based upon climate, time of day and operating temperatures. Premium modules result in between 0.7 and 3.5 percent increase in annual TDV production, depending on climate zone. Thin-film PV modules result in a 0.9 to 6.9 percent increase in annual TDV production. It is unclear why the annual production for thin-film is higher than both standard and premium crystalline modules, but running PV Watts predicts similar results.

The default value for array type in CBECC is *Fixed (open rack)*. The other option under array type is *Fixed (roof mount)* which results in a 1.4% decrease in TDV PV production.

2.5 EDR Input Screen

Observations and suggestions for EDR Input Screen:

- Revise the CFI range to be used to between 2:12 and 7:12. This will reduce the percent variance closer to 5% within the range of 150 to 270 degrees. Flat installations result in the highest reduction in TDV production and do not vary by azimuth.
- Modeling of on or off-roof shading should be incorporated into the CBECC-Res PV model for applications not using the CFI assumption. As buildings use this tool to meet the ZNE tier in 2016 CALGreen, PV systems may need to be sized at 6 kW or larger, requiring systems to be installed on multiple roofs and in locations that do not meet the CFI minimal shading criteria.
- How do you identify and verify *Premium* module type from *Standard*? Per CEC document, *Premium* assumes 18-20% efficiency and temperature coefficient of power of 0.35%/°C, but these numbers are not reported on the CEC database and not always available or easy to find on manufacturers' websites. There needs to be an easy method for HERS verification of performance.
- Report additional values on online CEC database to be used in verification?
- Can it be calculated based on ratio of PTC rating and DC Rating?
- *Thin-film* is only listed under detailed input option. Why here only and not in simplified as well?
- Does it make sense that *Thin-film* PV production would be higher than both *Standard* and *Premium* module type options? This difference is also found in PV Watts. According to PV Watts manual the thin film option "assumes a low efficiency (~11 %), and a significantly lower temperature coefficient which is representative of most installed thin film products in 2013". The lower temperature coefficient of power (0.20%/°C) may result in better production during some conditions but it still seems the difference is more than can be explained by the assumptions. Consider removing thin-film as an option or investigate the source of the difference and it is confirmed by field performance.

2.6 EDR Outputs

Energy Use Details Tab

- Proposed Design Total kTDV/ft2-yr value at bottom includes the PV compliance credit. This is confusing because it is not used in the EDR. Consider moving Total values to Design Rating tab where it is used for the EDR.
- Should PV kTDV/ft2-yr representing the total value of PV used in the EDR be reported? This would be useful.

Design Rating Tab

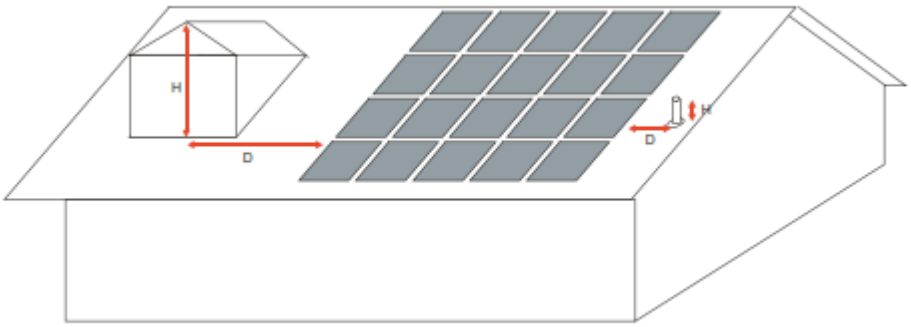
- Provide more information on the Design Rating tab. The limited values don't provide a lot of context.
- Should non regulated load breakdown be in a separate results table under Design Rating? Having these values reported is very useful but is confusing when reported with compliance credit values.
- Add PV TDV production value on this tab. When multiple PV arrays are entered, reporting the TDV production value for each unique array along with total would be beneficial.

APPENDIX A: MINIMAL SHADING CRITERION

The minimal shading criterion is that no obstruction is closer than a distance ("D") of twice the height ("H") it extends above the PV array. (See Figure 4 for an artistic depiction of "H" and "D.") As the figure illustrates, the distance "D" must be at least two times greater than the distance "H." All obstructions that project above the point on the array that is closest to the obstruction must meet this criterion for the array to be considered minimally shaded.

Obstructions that are subject to this criterion include:

- Any vent, chimney, architectural feature, mechanical equipment, or other obstruction that is on the roof or any other part of the building.
- Any part of the neighboring terrain.
- Any tree that is mature at the time of installation of the PV system.
- Any tree that is planted on the building lot or neighboring lots or planned to be planted as part of the landscaping for the building (the expected shading must be based on the mature height of the tree).
- Any existing neighboring building or structure.
- Any planned neighboring building or structure that is known to the applicant or building owner.
- Any telephone or other utility pole that is closer than 30 feet from the nearest point of the array.



Source: California Energy Commission

Figure 4: The Minimal Shading Criterion Artistic Depiction of "H" and "D"

APPENDIX B: CBECC-RES PV OUTPUTS FOR ALL CALIFORNIA CLIMATE ZONES

Specific Annual TDV PV Production for all 16 Climate Zones for varying azimuths and tilts within CFI Criteria.

Climate Zone 1

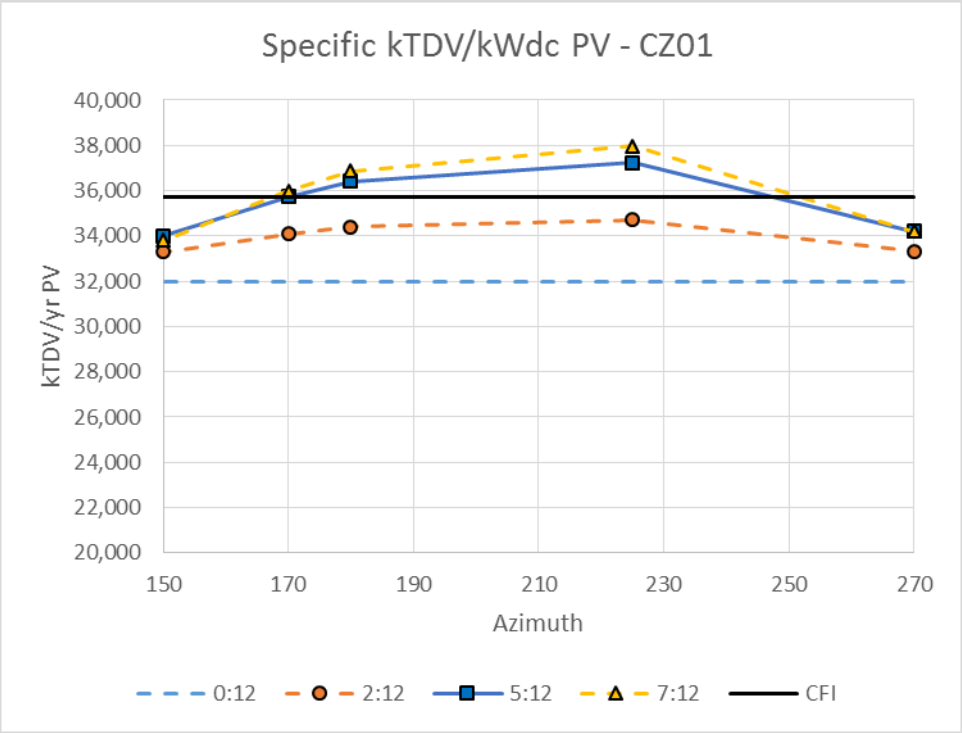


Figure 5: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 01

Table 3: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 01

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-10.6%	-10.6%	-10.6%	-10.6%	-10.6%
2:12	-6.8%	-4.6%	-3.8%	-2.9%	-6.7%
5:12	-4.9%	0.0%	1.9%	4.2%	-4.3%
7:12	-5.4%	0.7%	3.1%	6.2%	-4.3%

Climate Zone 2

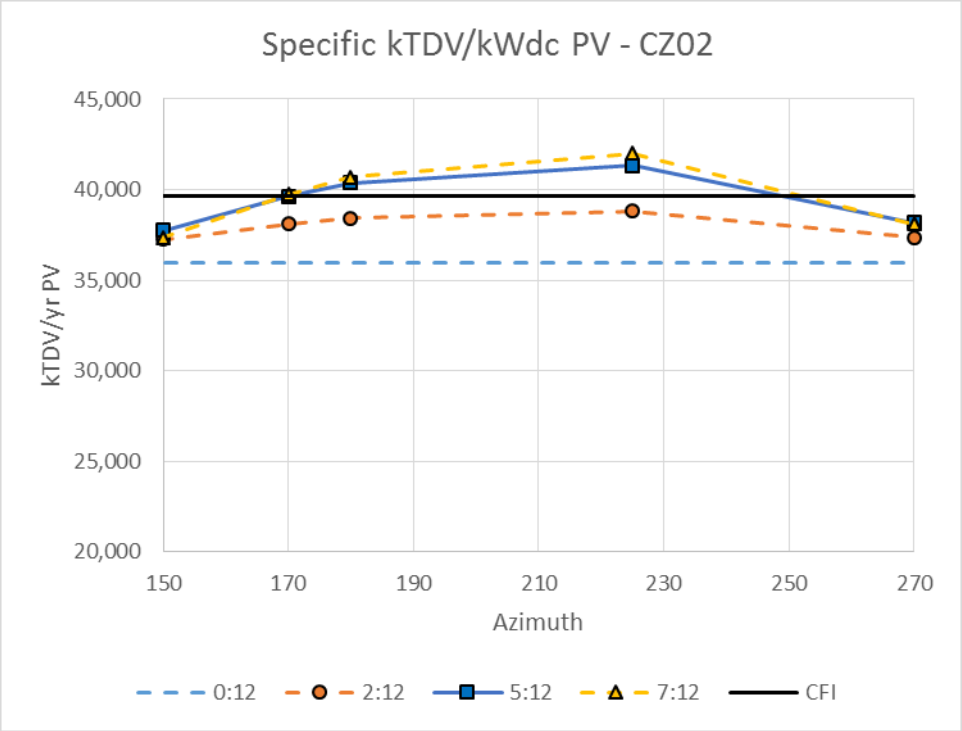


Figure 6: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 02

Table 4: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 02

	Azimuth				
Tilt	**150°**	**170°**	**180°**	**225 °**	**270°**
0:12	-9.4%	-9.4%	-9.4%	-9.4%	-9.4%
2:12	-6.0%	-3.9%	-3.0%	-2.1%	-5.8%
5:12	-4.8%	0.0%	1.9%	4.2%	-3.7%
7:12	-5.7%	0.2%	2.6%	5.9%	-3.9%

Climate Zone 3

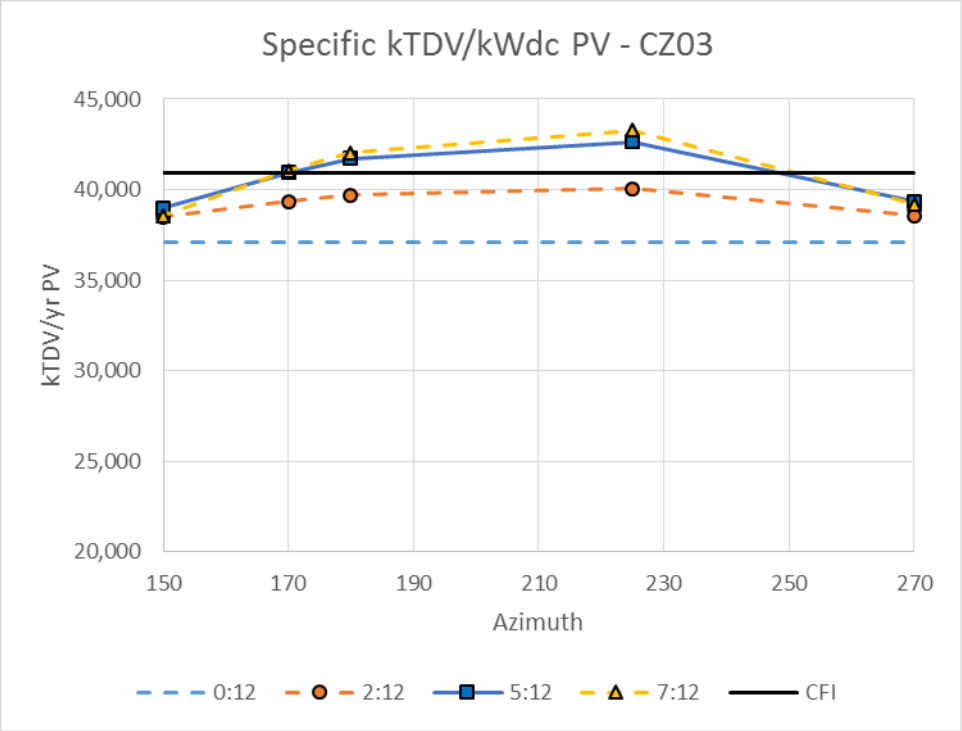


Figure 7: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 03

Table 5: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 03

	Azimuth				
Tilt	**150°**	**170 °**	**180°**	**225°**	**270°**
0:12	-9.4%	-9.4%	-9.4%	-9.4%	-9.4%
2:12	-6.0%	-3.9%	-3.1%	-2.2%	-5.8%
5:12	-4.8%	0.0%	1.9%	4.1%	-3.9%
7:12	-5.8%	0.2%	2.6%	5.7%	-4.3%

Climate Zone 4

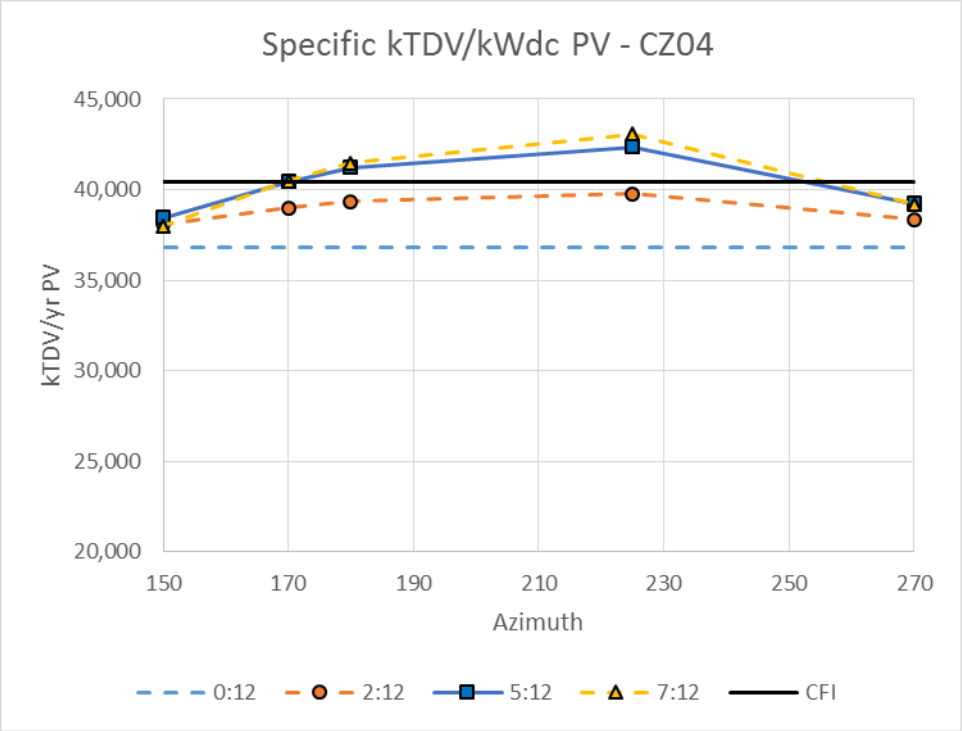


Figure 8: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 04

Table 6: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 04

Tilt	Azimuth				
	150°	**170°**	**180°**	**225°**	**270°**
0:12	-9.0%	-9.0%	-9.0%	-9.0%	-9.0%
2:12	-5.8%	-3.6%	-2.8%	-1.6%	-5.2%
5:12	-4.9%	0.0%	2.0%	4.7%	-2.9%
7:12	-6.0%	0.0%	2.6%	6.4%	-3.1%

Climate Zone 5

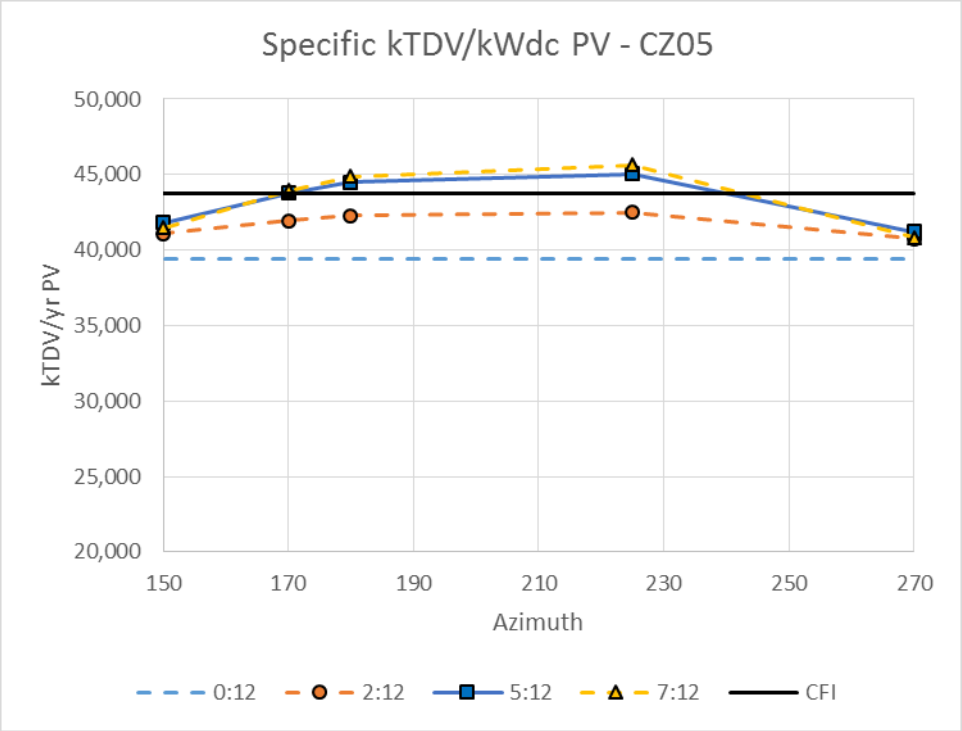


Figure 9: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 05

Table 7: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 05

Tilt	Azimuth				
	150°	**170°**	**180°**	**225°**	**270°**
0:12	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%
2:12	-6.1%	-4.2%	-3.4%	-3.0%	-6.9%
5:12	-4.4%	0.0%	1.7%	2.9%	-5.8%
7:12	-5.2%	0.3%	2.5%	4.3%	-6.7%

Climate Zone 6

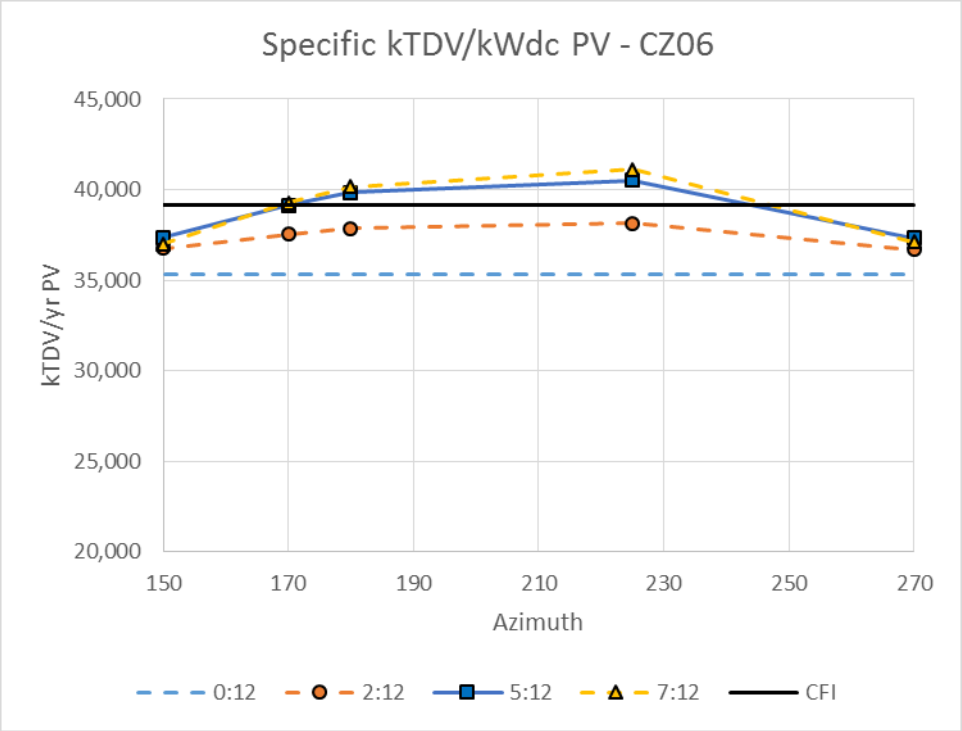


Figure 10: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 06

Table 8: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 06

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-9.7%	-9.7%	-9.7%	-9.7%	-9.7%
2:12	-6.1%	-4.0%	-3.3%	-2.6%	-6.3%
5:12	-4.6%	0.0%	1.8%	3.5%	-4.6%
7:12	-5.4%	0.4%	2.6%	5.1%	-5.2%

Climate Zone 7

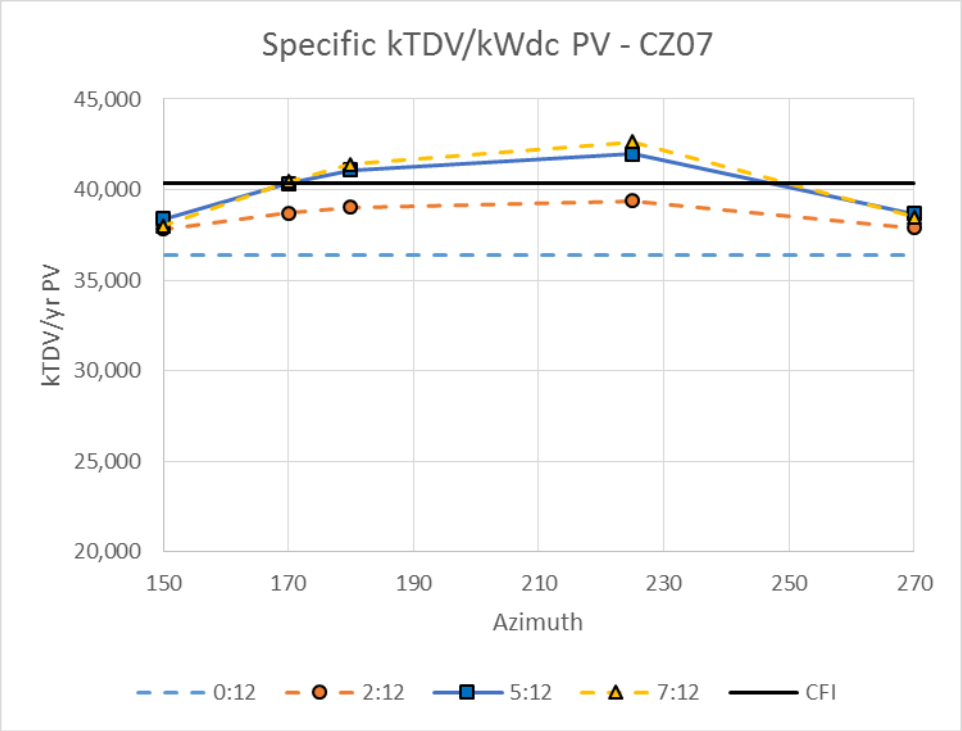


Figure 11: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 07

Table 9: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 07

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-9.7%	-9.7%	-9.7%	-9.7%	-9.7%
2:12	-6.2%	-4.0%	-3.2%	-2.3%	-6.0%
5:12	-4.8%	0.0%	1.9%	4.1%	-4.0%
7:12	-5.8%	0.3%	2.7%	5.7%	-4.5%

Climate Zone 8

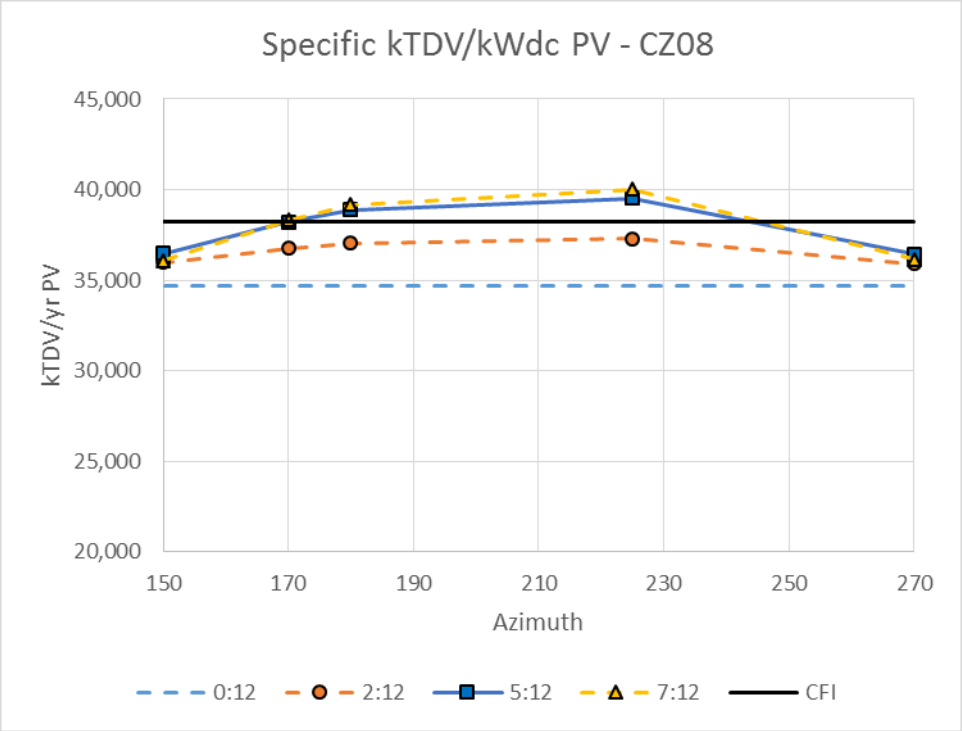


Figure 12: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 08

Table 10: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 08

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-9.3%	-9.3%	-9.3%	-9.3%	-9.3%
2:12	-5.8%	-3.8%	-3.1%	-2.4%	-6.1%
5:12	-4.5%	0.0%	1.7%	3.4%	-4.7%
7:12	-5.6%	0.2%	2.4%	4.7%	-5.4%

Climate Zone 9

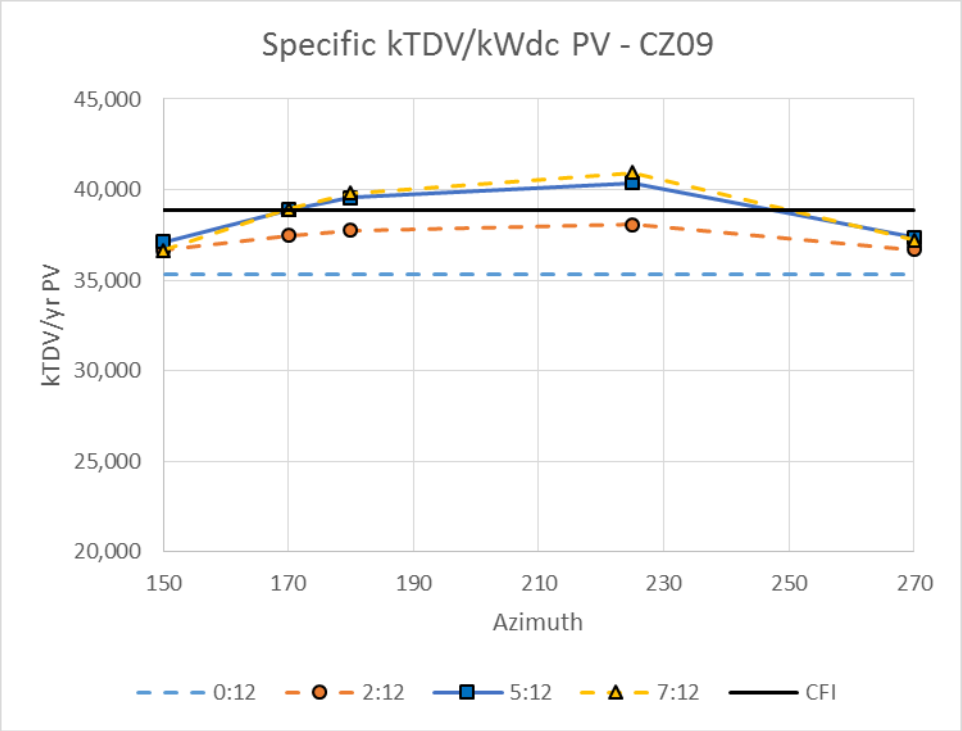


Figure 13: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 09

Table 11: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 09

	Azimuth				
Tilt	**150º**	**170º**	**180º**	**225º**	**270º**
0:12	-9.1%	-9.1%	-9.1%	-9.1%	-9.1%
2:12	-5.7%	-3.7%	-2.9%	-2.1%	-5.6%
5:12	-4.6%	0.0%	1.8%	3.9%	-3.9%
7:12	-5.7%	0.1%	2.4%	5.3%	-4.3%

Climate Zone 10

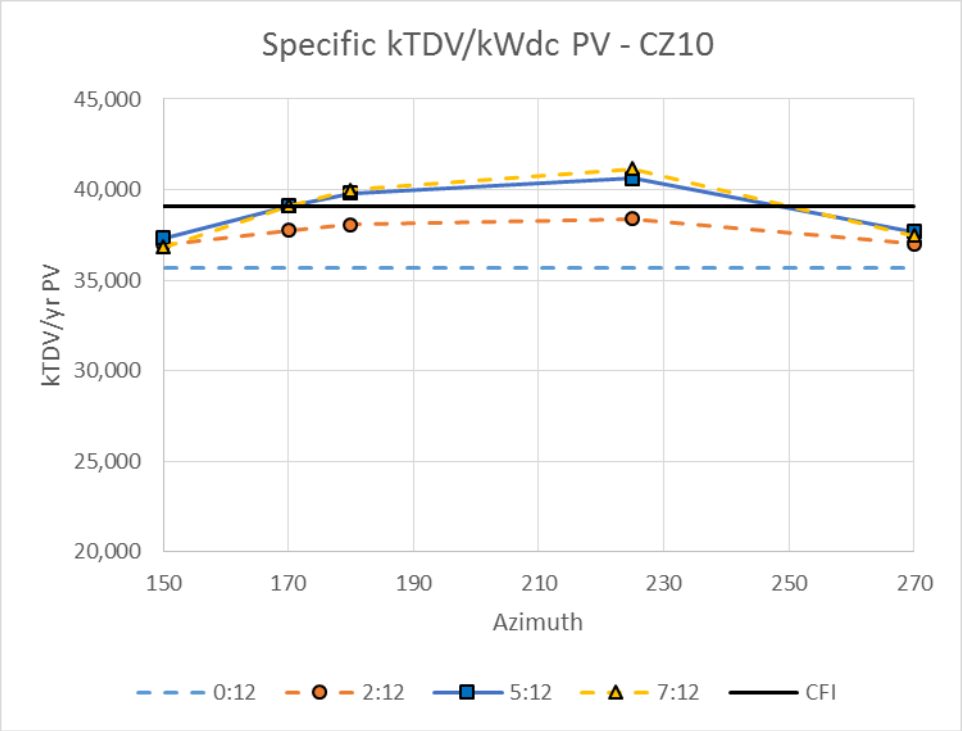


Figure 14: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 10

Table 12: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 10

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-8.7%	-8.7%	-8.7%	-8.7%	-8.7%
2:12	-5.5%	-3.5%	-2.7%	-1.9%	-5.3%
5:12	-4.5%	0.0%	1.8%	3.9%	-3.7%
7:12	-5.8%	0.0%	2.2%	5.2%	-4.2%

Climate Zone 11

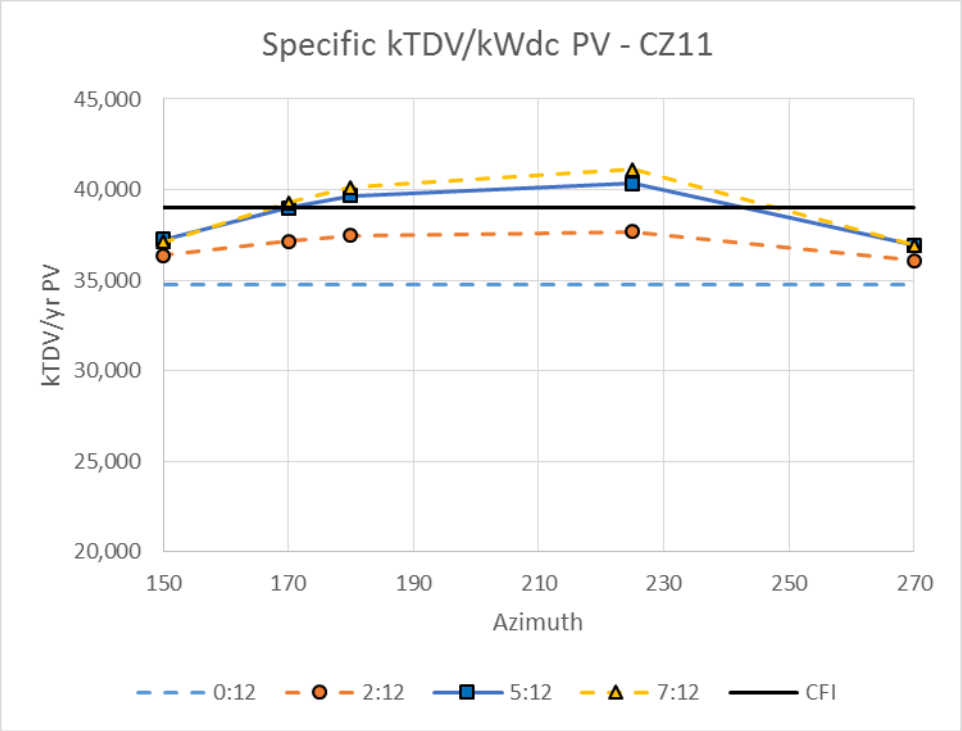


Figure 15: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 11

Table 13: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 11

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-10.9%	-10.9%	-10.9%	-10.9%	-10.9%
2:12	-6.8%	-4.7%	-4.0%	-3.4%	-7.5%
5:12	-4.5%	0.0%	1.7%	3.4%	-5.3%
7:12	-4.9%	0.7%	2.9%	5.4%	-5.3%

Climate Zone 12

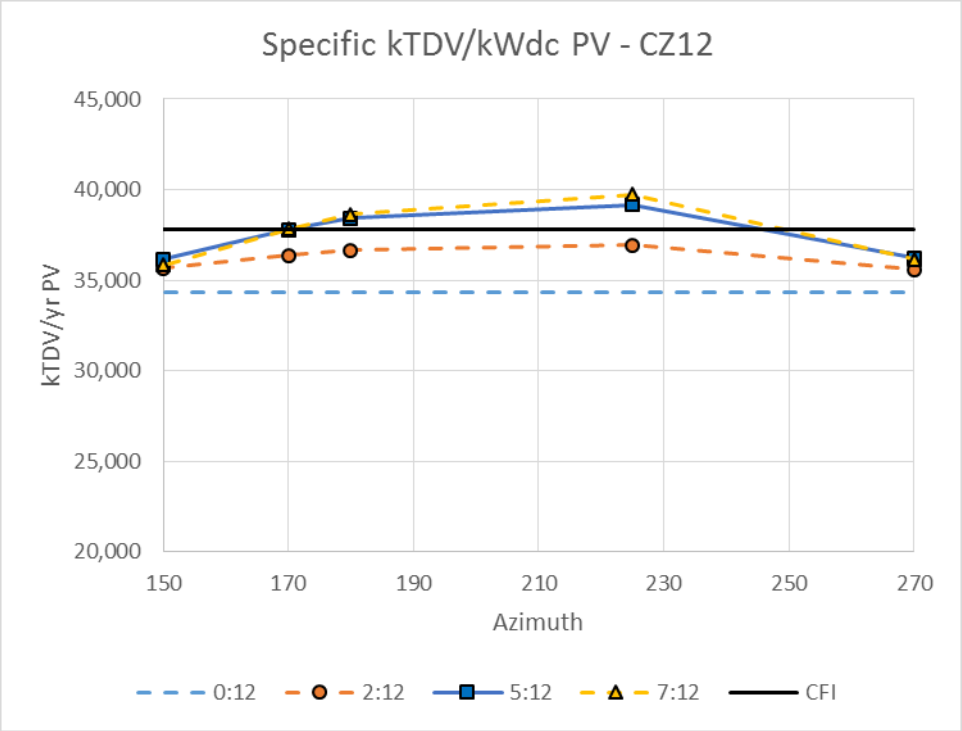


Figure 16: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 12

Table 14: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 12

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-9.1%	-9.1%	-9.1%	-9.1%	-9.1%
2:12	-5.6%	-3.7%	-3.0%	-2.2%	-5.8%
5:12	-4.3%	0.0%	1.7%	3.7%	-4.1%
7:12	-5.1%	0.1%	2.3%	5.2%	-4.3%

Climate Zone 13

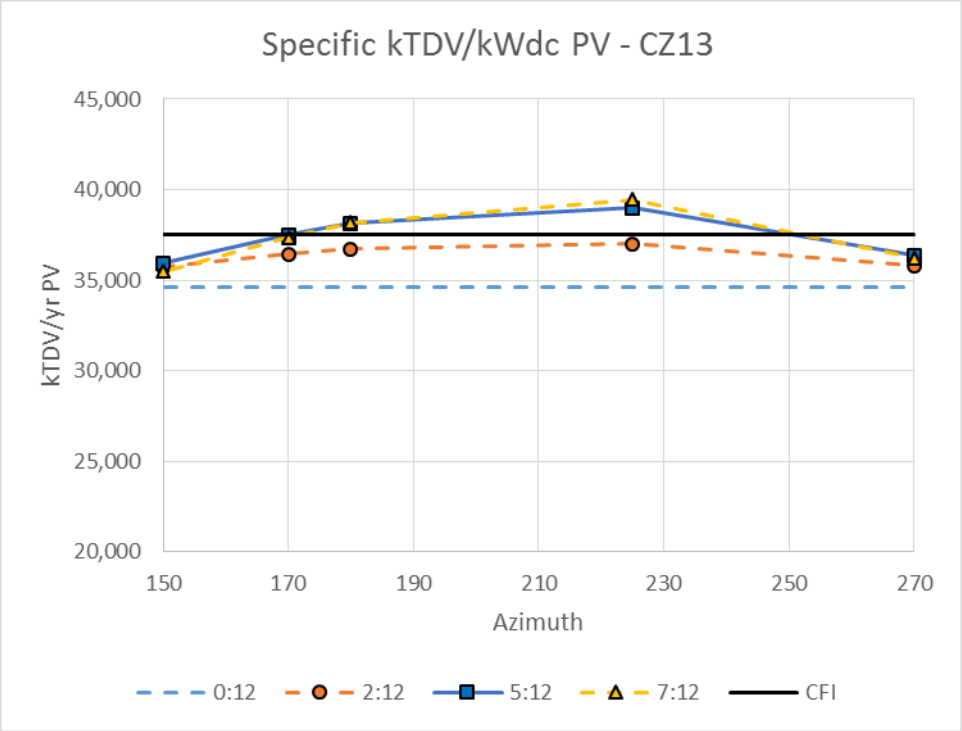


Figure 17: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 13

Table 15: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 13

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-7.6%	-7.6%	-7.6%	-7.6%	-7.6%
2:12	-4.7%	-2.8%	-2.1%	-1.3%	-4.5%
5:12	-4.1%	0.0%	1.7%	4.0%	-3.0%
7:12	-5.4%	-0.3%	1.8%	5.2%	-3.4%

Climate Zone 14

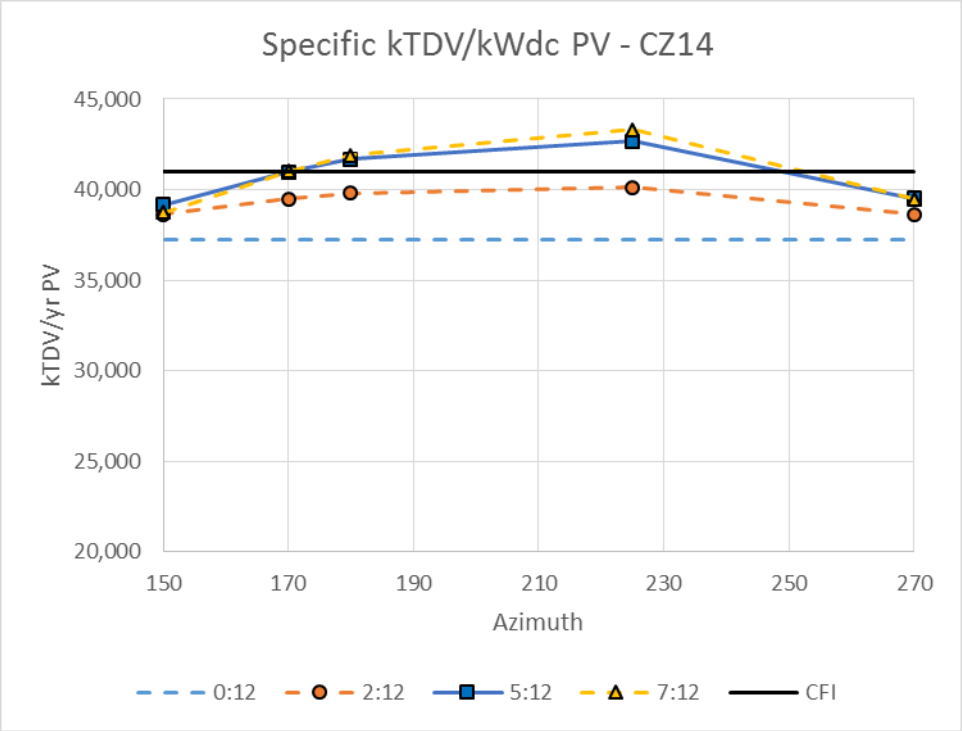


Figure 18: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 14

Table 16: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 14

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-9.1%	-9.1%	-9.1%	-9.1%	-9.1%
2:12	-5.7%	-3.6%	-2.9%	-2.0%	-5.6%
5:12	-4.4%	0.0%	1.8%	4.2%	-3.5%
7:12	-5.4%	0.1%	2.3%	5.8%	-3.6%

Climate Zone 15

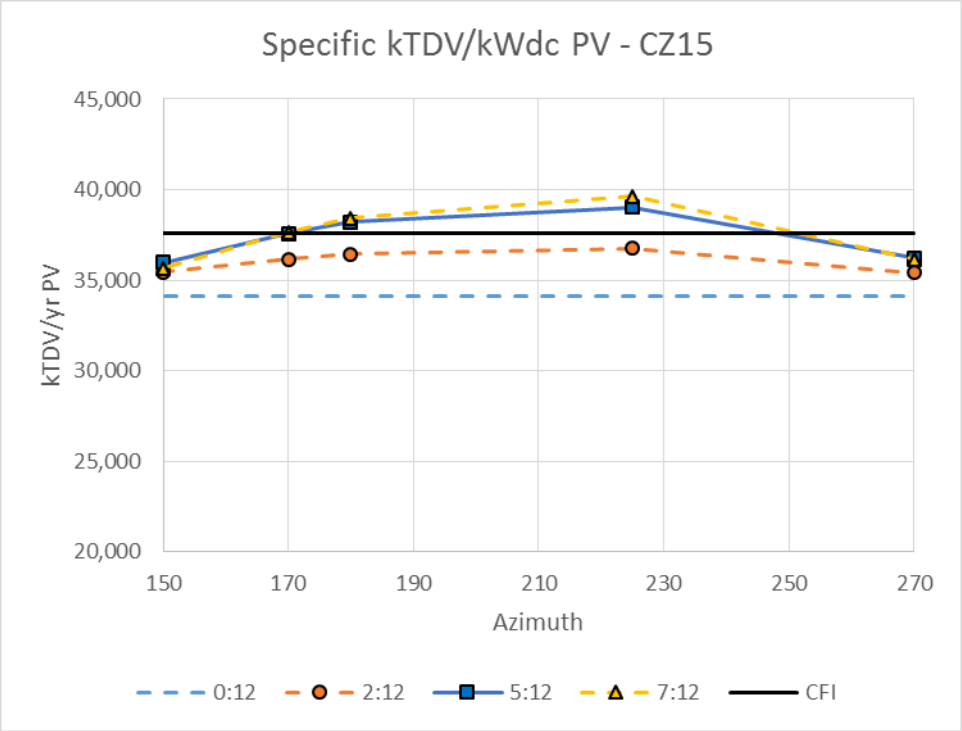


Figure 19: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 15

Table 17: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 15

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-9.2%	-9.2%	-9.2%	-9.2%	-9.2%
2:12	-5.7%	-3.7%	-3.0%	-2.2%	-5.7%
5:12	-4.2%	0.0%	1.7%	3.9%	-3.6%
7:12	-5.1%	0.2%	2.3%	5.5%	-3.7%

Climate Zone 16

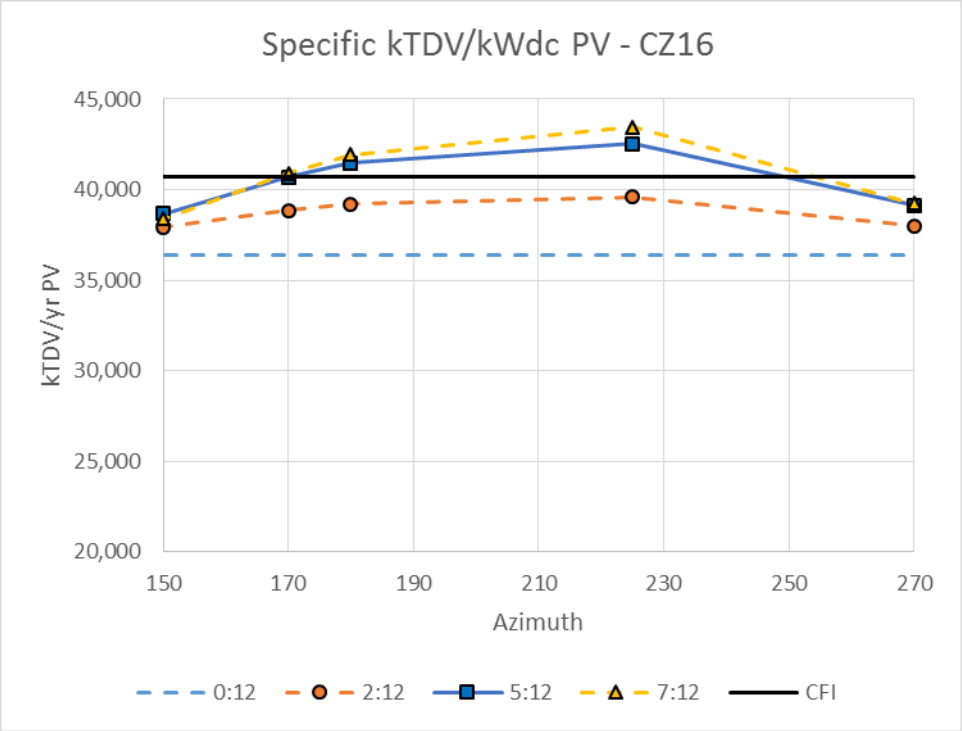


Figure 20: Specific Annual TDV PV Production for Varying Azimuths and Tilt – Climate Zone 16

Table 18: Percent Variance in Annual TDV Production Compared to CFI Value – Climate Zone 16

Tilt	Azimuth				
	150º	**170º**	**180º**	**225º**	**270º**
0:12	-10.5%	-10.5%	-10.5%	-10.5%	-10.5%
2:12	-6.8%	-4.5%	-3.6%	-2.6%	-6.6%
5:12	-4.9%	0.0%	2.0%	4.6%	-3.8%
7:12	-5.6%	0.5%	3.1%	6.8%	-3.6%