National Renewable Energy Laboratory

October 8, 2007

California Energy Commission
Dockets Office
Re: Docket No. 07-SB-1
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512

Dear Sir/Madam:

This letter contains my comments concerning the CEC draft "Guidelines for California's Solar Electric Incentive Programs Pursuant to Senate Bill 1".

Most of my comments are related to the requirements for the model used to calculate PV production listed on pages 12 and 13 and their likely consequence of introducing unwanted error in the estimation of energy production and that an optimized system may not operate properly.

System output is essentially proportional to the solar resource. The use of the hourly weather data for the 16 climate zones in California should not be required when higher resolution 40 km data such as used with the CSI-EPPB calculator is available and offers improved accuracy. The climate zone data were derived for building heating and cooling applications, and solar resource applications were secondary, if considered at all. This is evident by the 40-km data showing a solar resource variation of 15% for climate zone 16, which should be accounted for, but is not if the climate zone data are used instead of the 40-km data.

Requirement 7 introduces array height as an input to capture the impact of wind speed variation with height above ground. Granted, this occurs, but of greater importance is that the source of the wind data might be an airport miles away and that no wind speed adjustments are made for local topography, nearby trees and buildings, the roof structure, or the wind direction. A reasonable default height can be used instead. Wind effects are a third order effect, compared to a first order effect such as solar radiation.

Requirements 5, 8, and 9 are concerned with accounting for voltage compatibility between the PV array and the inverter, but they may introduce an unfortunate outcome as implemented because design practices that can help minimize shading losses and address losses in array voltage with age will be penalized. For example, optimal results from the NSHP Energy Commission PV calculator will result when the minimum number of modules is connected in series to meet the minimum voltage level of the inverter. This is because the CEC inverter efficiency is generally slightly more efficient at its lower voltage and the calculator doesn't address partial array shading or aging effects on the array voltage. A more fault tolerant design would include additional modules in series so that shading of 1 or 2 modules would restrict the shading loss to only those modules and there would still be sufficient voltage to operate the inverter. Similarly, with a more fault tolerant design that included additional modules in series, the PV array could lose some operating voltage with age and still provide sufficient voltage for proper operation.

At NREL, we also have preliminary results comparing modeled and measured performance of the 5-parameter model for eight PV modules representing various technologies for a one year period. The results show that the model has a tendency to overestimate the maximum power voltage as the irradiance is reduced (for some modules, 10% at 200 W/m^2 and greater at lower irradiances). This creates a further error in the NSHP Energy Commission PV calculator's optimization of PV array voltage and may result in additional fielded systems with incorrectly sized PV arrays.

For modeling maximum power, the mean-bias error of the 5-parameter model ranged from +0.3% to +7.3% depending on PV module. For comparison, the mean-bias error of the historical PVFORM model (also used in PVWATTS) ranged from -0.7% to 3.1%.

A further complication of optimizing PV array and inverter relationships is discussed in a recent publication entitled "Why Hourly Averaged Measurement Data is Insufficient to Model PV System Performance Accurately" by Steve Ransome and Peter Funtan of BP Solar. This paper looked at high resolution inverter data (15-second) and concluded that inverters should be sized larger than what an hourly simulation would indicate in order to minimize inverter power clipping at high irradiances. Hourly average data did not sufficiently reflect the energy available for irradiances above 1000 W/m^2. (For partly sunny hours, the sun can be either "on" or "off" depending on whether or not the sun is behind a cloud).

Accounting for PV array and the inverter voltage relationships by the NSHP Energy Commission PV calculator is a commendable effort in providing a more detailed evaluation of PV system performance, but based on the preceding discussion it may be prudent not to make it a requirement until it is more extensively validated and had provisions for shading and system aging. (Comment on calculator: It would be a useful feature to provide feedback to the user that identified non-optimum performance and the extent.)

Alternatively, guidelines based on a consensus of successful industry practices in California could be developed or adopted to ensure PV arrays and inverters were selected and sized appropriately, if this is an area that is considered to need oversight.

Sincerely,

Bill Marion

Bill Marion, P.E.
Principal Research Supervisor