16.2.3 Energy-based Performance Rating Methods

Despite its widespread acceptance, the peak power rating (i.e. maximum instantaneous watts) does not capture the differences among the plethora of flat-plate and concentrator-module designs with different total irradiance, diffuse irradiance, spectral irradiance, and temperature sensitivities. Energy-based ratings (i.e. integrated power over time in kWh) capture the module performance in the "real" world. It is easy to integrate the measured PV power produced over a time interval to obtain the total energy produced compared with the incident energy. A variety of rating criteria besides the standard reference conditions listed in Table 16.1 exist, depending on the application in Table 16.4.

The AM/PM method, proposed by ARCO/Siemens Solar Industries, attempts to rate a module in terms of the PV energy produced during a standard solar day with a given reference temperature and total irradiance distribution [44]. The AM/PM method is appealing because it is an energy-rating method that is not site-specific. A variation on the AM/PM energy-rating method was developed in which a regression analysis of the measured power and irradiance data to a nonlinear response function was summed over a standard day defined by a fourth-order polynomial [45].

A rating scheme based on the PV energy delivered over a standard day has been proposed for a small set of standard days [46–49]. These five days were obtained from the typical meteorological year database (*http://rredc.nrel.gov/solar/old_data/*) corresponding to a hot-sunny, cold-sunny, hot-cloudy, cold-cloudy, and a nice day [49, 50]. The meteorological data for the standard days include latitude, longitude, date, air temperature, wind speed, relative humidity, and direct, diffuse-horizontal, and global-normal irradiances. The direct-beam and plane-of-array spectral irradiances were then computed for hourly intervals throughout the day using a spectral model [51]. The model developed by Nann requires only the meteorological parameters listed in the standard days. Figure 16.3 shows the meteorological characteristics of the hot-sunny standard day [46–49]. The hot-sunny day was taken from the meteorological data for Phoenix Arizona, US, on June 24, 1976 [49, 50].

Other schemes for energy rating based on site-specific conditions instead of standard days have also been developed. In 1990, a rating based on realistic reporting conditions (RRC) was proposed. This method measured the performance of PV modules under different irradiances and temperatures and predicted the module's output under

Table 16.4 Photovoltaic rating criterion for PV applications

Application	Relevant PV parameter
Grid-connected, hydrogen production	Annual energy delivered
Power for peak utility demand	Power near solar noon
Remote system for cooling	Temperature coefficient and NOCT
Remote system with storage	Energy during cloudy day
Pump system for agriculture	Energy during growing season
Small power consumer products	Efficiency at very low irradiance
High value (Space)	High efficiency, radiation, and thermal stability