Sizing Residential Solar Power Systems Based on Site-Specific Energy Statistics

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Abstract : In the United States, costs of solar energy systems have declined to the point that they are viable options for most consumers. However, there are no consistent procedures for specifying sufficient systems. The factors that must be considered are energy consumption, potential solar energy production, and cost. The traditional method of specifying solar energy systems is based on assumed daily levels of available solar energy and average amounts of daily energy consumption. The mismatches between energy production and consumption are usually mitigated using battery energy storage systems, and energy use is curtailed when necessary. The main consumer decision question that drives the total system cost is how much unserved (or curtailed) energy is acceptable? Of course additional solar conversion equipment can be installed to provide greater peak energy production and extra energy storage capability can be added to mitigate longer lasting low solar energy production periods. Each option increases total cost and provides a benefit which is difficult to quantify accurately. An approach to quantify the cost-benefit of adding additional resources, either production or storage or both, based on the statistical concepts of loss-of-energy probability and expected unserved energy, is presented in this paper. Relatively simple calculations, based on site-specific energy availability and consumption data, can be used to show the value of each additional increment of production or storage. With this incremental benefit-cost information, consumers can select the best overall performance combination for their application at a cost they are comfortable paying. The approach is based on a statistical analysis of energy consumption and production characteristics over time. The characteristics are in the forms of curves with each point on the curve representing an energy consumption or production value over a period of time; a one-minute period is used for the work in this paper. These curves are measured at the consumer location under the conditions that exist at the site and the duration of the measurements is a minimum of one week. While greater accuracy could be obtained with longer recording periods, the examples in this paper are based on a single week for demonstration purposes. The weekly consumption and production curves are overlaid on each other and the mismatches are used to size the battery energy storage system. Loss-of-energy probability and expected unserved energy indices are calculated in addition to the total system cost. These indices allow the consumer to recognize and quantify the benefit (probably a reduction in energy consumption curtailment) available for a given increase in cost. Consumers can then make informed decisions that are accurate for their location and conditions and which are consistent with their available funds.

Keywords : battery energy storage systems, loss of load probability, residential renewable energy, solar energy systems
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