TABLE I
LOCATION OF CSP PLANTS IN THE SOUTHWESTERN U.S. AS OF NOVEMBER, 2011

Plant Name	Location	Technology	Capacity (MW)
Solar Electric Generating Stations	Mojave Desert, CA	Parabolic Trough	353.8
Nevada Solar One	Boulder City, NV	Parabolic Trough	72
Kimberlina	Bakersfield, CA	Linear Fresnel Reflector	5
Sierra	Lancaster, CA	Power Tower	5
Maricopa Solar	Peoria, AZ	Stirling Dish	1.5

with high LOLPs. They apply these techniques considering between the top 1% and 30% of periods, and show that the approximation can approach reliability-based estimates if a suitable number of periods are considered. Their results suggest that using the top 10% of periods is typically sufficient.

These three estimation techniques can be applied to estimate the capacity value of a CSP plant. The highest-load and highest-LOLP methods approximate the capacity value as:

$$\frac{\sum_{t \in T} C_t}{|T| \cdot \bar{C}}, \tag{6}$$

solar availability, the capacity value of a CSP plant may differ depending on whether a more limited study region is used.

WECC LOLPs are estimated by calculating the system's capacity outage table, which assumes that generator outages follow Bernoulli distributions that are serially and jointly independent [7]. Data requirements and sources used in our calculations are outlined below.

1) Conventional Generators: The rated capacities of conventional generators are obtained from Form 860 data collected by the U.S. Department of Energy's Energy Information Administration. Form 860 reports winter and summer capacities for each generator, which we use in our analysis. The WECC had between 1,016 and 1,622 generating units and 123 GW and 163 GW of generating capacity during the years that we study. This reflects load growth between the years 1998 and 2005.

We model generator outages using a simple two state (online/offline) model. We use the NERC's Generating Availability Data System (GADS) to estimate generator EFORs. The GADS specifies historical annual average EFORs for generators based on generating capacity and technology, which we combine with generating technology data given in Form 860. The EFORs used range between 2% and 17% and have a capacity-weighted average of 7%. The benchmark unit we use in the ECP calculation is a natural gas-fired combustion turbine, and we use an EFOR of 7% based on the GADS.

2) Load: Hourly historical load data for each year are obtained from Form 714 filings with the Federal Energy Regulatory Commission. Form 714 includes load reports for nearly all of the load-serving entities (LSEs) and utilities in the

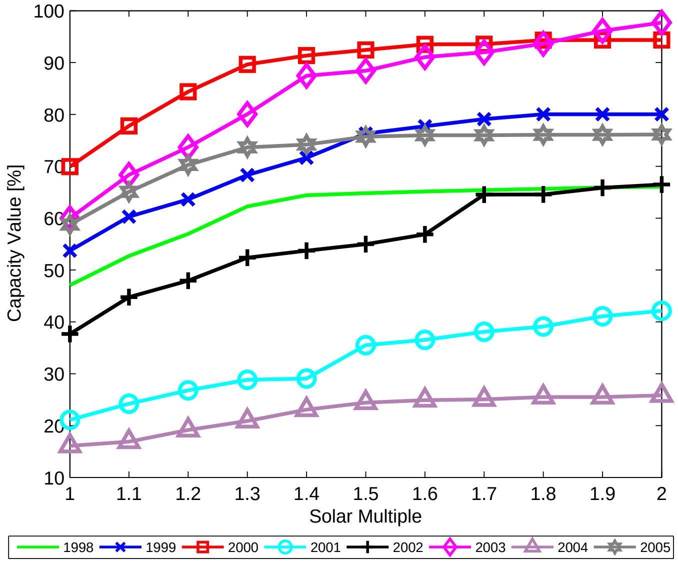


Fig. 2. Annual ECP of a CSP plant at the New Mexico location, as a percentage of 120 MW-e maximum net output of the plant.

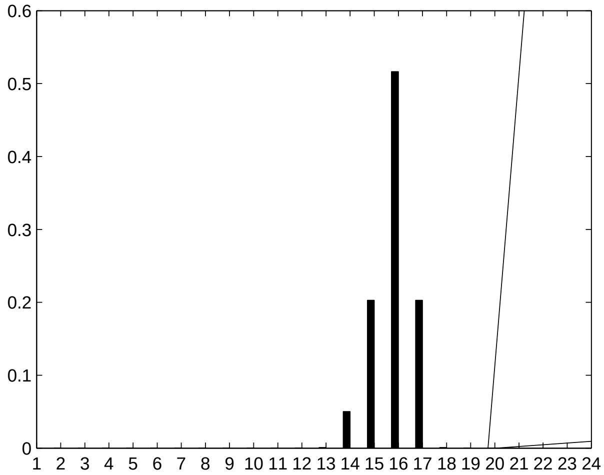


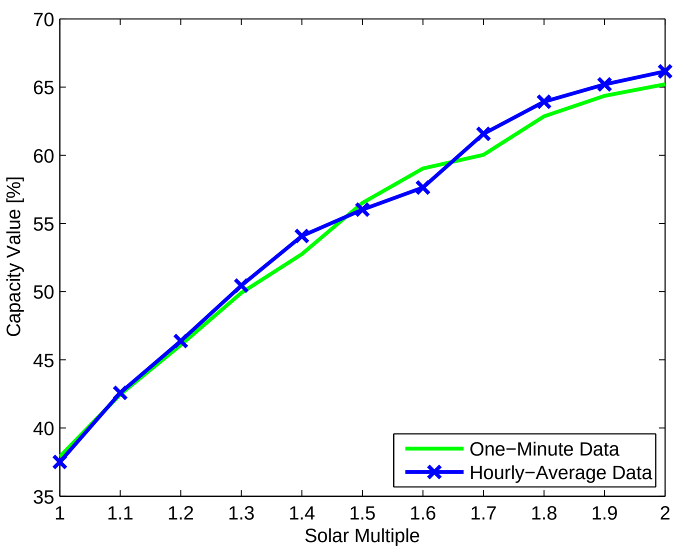
TABLE III
AVERAGE ROOT MEAN SQUARED ERROR BETWEEN ECP ESTIMATES USING ALL EIGHT YEARS AND A SUBSET OF THE DATA

Years Used	RMSE
1	13.3
2	9.4
3	6.4
4	5.5
5	4.7
6	3.1
7	0.8

To bound the effect of such misreporting, we calculate ECPs with all of the system loads shifted one hour forward and backward. Fig. 5 shows the resulting ECPs for the Imperial Valley location, which can be up to 5% less than the ECPs with unshifted loads. We observe similar results at the other locations. The fact that the ECP drops regardless of whether the load is shifted forward or backward suggests that most of the loads reported in Form 714 are correct. This is because

We use one-minute weather data, obtained from the University of Nevada, Las Vegas, from the year 2007 for a location in Boulder City, Nevada.[1] We also use the one-minute model with hourly averages of the weather data to represent a case in which hourly weather data are used to model CSP generation. We compute ECPs using the one-minute generation data and hourly WECC loads. Since the underlying modeling technique and load and conventional generator data are identical between the two cases, any differences in the ECP estimates are solely due to the use of one-minute weather data as opposed to hourly averages.

Fig. 7 shows these ECPs and demonstrates that using hourly-average data provides a close approximation of the ECP obtained with one-minute data—the maximum difference is 1.5%. Using hourly-average data overestimates the ECP for most SMs, since subhourly DNI variations can keep the powerblock from running above its minimum operating point. These effects are not fully captured when the one-minute data are averaged. Nevertheless, the small ECP differences suggest that hourly data can provide relatively good capacity value estimates if subhourly data are not available (or too computationally expensive to work with). This has also been shown for wind [20].



[15] J. Haslett and M. Diesendorf, “The capacity credit of wind power: A theoretical analysis,” *Solar Energy*