

Nexant 1 Minute Solar Profile Statistical Analysis

A statistical analysis of the Nexant 1 minute solar profiles used in the CAISO 33% reference case has been conducted as summarized below.

The data used in the analysis includes:

1. 1 minute profiles for total Solar Thermal (referred to as All ST in the tables below), PV (All PV), DG (All DG), and Out of State (All OOS).
2. 1 minute aggregated profile of all solar (Total Solar)
3. 1 minute profiles for selected CREZs with Solar Thermal and PV (referred to as ST CREZ and PV CREZ). The Kramer CREZ was selected for ST and the Mountain Pass-Tehachapi CREZ for PV.
4. 1 minute profiles for selected ST and PV plants (referred to as ST Plant and PV Plant) from each respective CREZ.

The resulting statistics and data are presented in the following tables.

Table 1 shows annual averages (for production in hours 6-20) and standard deviations for 1 minute, 5 minute, and hourly changes. The averages and standard deviations are expressed as percentages of the total MW for each data category, which is also shown in the table. A description of the statistics is shown after the table.

Table 1: Annual Averages and Standard Deviations (for Hours 6-20) of 1 Minute, 5 Minute, and Hourly Changes, for All ST, All PV, All DG, All OSS, and Total Solar

	All ST	All PV	All DG	All OSS	Total Solar
MWs of this technology in the 33% Reference Case	5968	3150	2282	534	11934
Annual Average of 1 minute changes	0.24%	0.29%	0.19%	0.41%	0.21%
Annual Standard Deviation of 1 minute changes	0.45%	0.41%	0.34%	0.89%	0.33%
Annual Average of 5 minute changes	1.14%	1.17%	0.84%	1.73%	0.98%
Annual Standard Deviation of 5 minute changes	2.16%	1.66%	1.33%	3.54%	1.57%
Annual Average of 1 hour changes	10.97%	9.11%	9.61%	11.62%	10.00%
Annual Standard Deviation of 1 hour changes	18.63%	13.03%	13.33%	19.80%	15.12%
Annual Average of 2 hour changes	20.89%	16.60%	18.99%	21.26%	19.24%
Annual Standard Deviation of 2 hour changes	32.75%	23.14%	25.20%	33.29%	27.73%
Annual Average of 3 hour changes	28.55%	22.60%	27.35%	29.48%	26.89%

The annual average of 1 minute, 5 minute, and hourly changes is the mean of the absolute values of the changes for production hours 6-20. For the standard deviations, the raw data for hours 6-20 (both positive and negative changes from minute to minute, 5 minutes to 5 minutes, and hour to hour) are used. The data is presented in percentage of the associated MW for the category.

As can be observed in Table 1, and as should be expected, the standard deviation decreases as MW are aggregated and the diversity of the type and the location of the generation is increased.

Table 2 shows the 1 minute and 5 minute standard deviations for the single ST Plant and single PV Plant, and the corresponding ST and PV CREZ. The All ST and All PV results are included again for comparison. Again, as expected, the standard deviation decreases in all categories as the plants are aggregated into CREZs, and as the CREZs are aggregated into all ST and PV.

Table 2: Annual Averages and Standard Deviations (for Hours 6-20) of 1 minute and 5 minute changes, for ST CREZ(Kramer), PV CREZ (Mountain Pass-Tehachapi), and selected Plants from each CREZ.

	ST Plant	ST CREZ	All ST	PV Plant	PV CREZ	All PV
MWs	192	1536	5968	500	1200	3150
Annual Average of 1 minute changes	0.46%	0.31%	0.24%	0.36%	0.31%	0.29%
Annual Standard Deviation of 1 minute changes	1.25%	0.61%	0.45%	0.65%	0.50%	0.41%
Annual Average of 5 minute changes	1.96%	1.36%	1.14%	1.59%	1.27%	1.17%
Annual Standard Deviation of 5 minute changes	4.88%	2.73%	2.16%	2.79%	1.97%	1.66%

Figures 1 and 2 graphically display the average and standard deviation data in Tables 1 and 2.

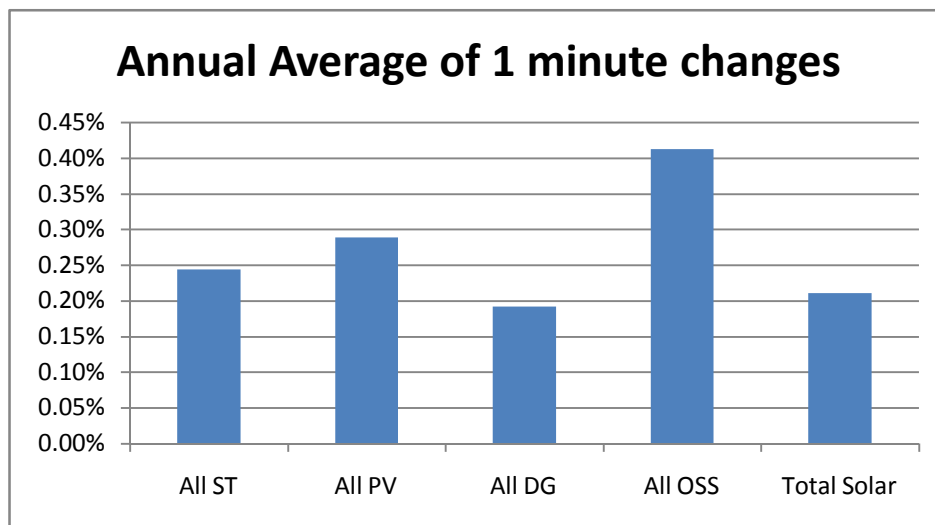


Figure 1: Annual Average of 1 minute changes (absolute values), All ST, All PV, All DG, all OOS, and Total Solar (Data from Table 1)

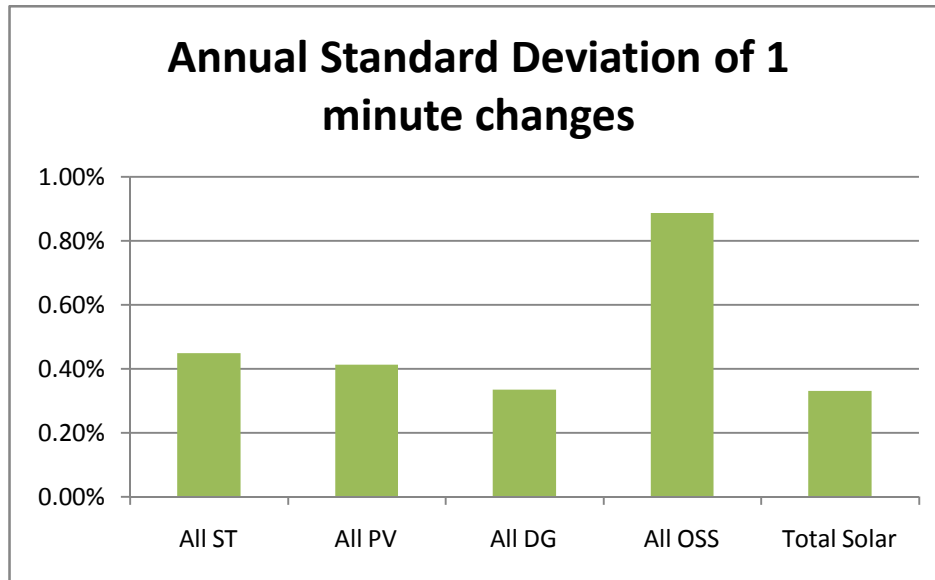


Figure 2: Annual Standard Deviation of 1 minute changes, All ST, All PV, All DG, all OOS, and Total Solar (Data from Table 1)

It may be noted from Tables 1 and 2 that the ST Plant, ST CREZ, and All ST have slightly higher annual standard deviations for the 1 minute, 5 minute, and hourly changes than the corresponding PV categories. This is a result of the faster morning and evening ramping for ST as compared to PV. During the middle of the day, the All ST standard deviation is lower than the corresponding All PV standard deviation. When aggregating these standard deviations into annual values, the annual standard deviation for ST tends to be slightly larger than that for PV.

Tables 3-10 show the corresponding seasonal results for the 1 minute and 5 minute data from Tables 1 and 2.

Table 3: Spring Averages and Standard Deviations (for Hours 6-20) of 1 Minute and 5 Minute Changes, for All ST, All PV, All DG, All OSS, and Total Solar

	All ST	All PV	All DG	All OSS	Total Solar
Spring Average of 1 minute changes	0.26%	0.37%	0.21%	0.40%	0.24%
Spring Standard Deviation of 1 minute changes	0.47%	0.50%	0.37%	0.90%	0.36%
Spring Average of 5 minute changes	1.23%	1.46%	0.92%	1.69%	1.10%
Spring Standard Deviation of 5 minute changes	2.28%	1.94%	1.46%	3.56%	1.68%

Table 4: Summer Averages and Standard Deviations (for Hours 6-20) of 1 Minute and 5 Minute Changes, for All ST, All PV, All DG, All OSS, and Total Solar

	All ST	All PV	All DG	All OSS	Total Solar
Summer Average of 1 minute changes	0.25%	0.23%	0.21%	0.32%	0.22%
Summer Standard Deviation of 1 minute changes	0.46%	0.30%	0.41%	0.67%	0.33%
Summer Average of 5 minute changes	1.20%	1.03%	0.96%	1.50%	1.05%
Summer Standard Deviation of 5 minute changes	2.26%	1.36%	1.63%	3.04%	1.63%

Table 5: Fall Averages and Standard Deviations (for Hours 6-20) of 1 Minute and 5 Minute Changes, for All ST, All PV, All DG, All OSS, and Total Solar

	All ST	All PV	All DG	All OSS	Total Solar
Fall Average of 1 minute changes	0.26%	0.26%	0.19%	0.48%	0.21%
Fall Standard Deviation of 1 minute changes	0.47%	0.38%	0.29%	0.97%	0.35%
Fall Average of 5 minute changes	1.20%	1.08%	0.85%	2.01%	0.98%
Fall Standard Deviation of 5 minute changes	2.28%	1.61%	1.19%	3.91%	1.65%

Table 6: Winter Averages and Standard Deviations (for Hours 6-20) of 1 Minute and 5 Minute Changes, for All ST, All PV, All DG, All OSS, and Total Solar

	All ST	All PV	All DG	All OSS	Total Solar
Winter Average of 1 minute changes	0.21%	0.29%	0.15%	0.45%	0.18%
Winter Standard Deviation of 1 minute changes	0.39%	0.44%	0.25%	0.98%	0.29%
Winter Average of 5 minute changes	0.95%	1.09%	0.62%	1.73%	0.77%
Winter Standard Deviation of 5 minute changes	1.79%	1.67%	0.93%	3.60%	1.29%

Table 7: Spring Averages and Standard Deviations (for Hours 6-20) of 1 minute and 5 minute changes, for ST CREZ(Kramer), PV CREZ (Mountain Pass-Tehachapi), and selected Plants from each CREZ.

	ST Plant	ST CREZ	All ST	PV Plant	PV CREZ	All PV
Spring Average of 1 minute changes	0.45%	0.32%	0.26%	0.46%	0.41%	0.37%
Spring Standard Deviation of 1 minute changes	1.26%	0.63%	0.47%	0.80%	0.62%	0.50%
Spring Average of 5 minute changes	1.93%	1.42%	1.23%	2.04%	1.65%	1.46%
Spring Standard Deviation of 5 minute changes	4.98%	2.80%	2.28%	3.36%	2.39%	1.94%

Table 8: Summer Averages and Standard Deviations (for Hours 6-20) of 1 minute and 5 minute changes, for ST CREZ(Kramer), PV CREZ (Mountain Pass-Tehachapi), and selected Plants from each CREZ.

	ST Plant	ST CREZ	All ST	PV Plant	PV CREZ	All PV
Summer Average of 1 minute changes	0.32%	0.27%	0.25%	0.27%	0.23%	0.23%
Summer Standard Deviation of 1 minute changes	0.83%	0.56%	0.46%	0.44%	0.34%	0.30%
Summer Average of 5 minute changes	1.48%	1.28%	1.20%	1.24%	1.05%	1.03%
Summer Standard Deviation of 5 minute changes	3.64%	2.69%	2.26%	1.97%	1.52%	1.36%

Table 9: Fall Averages and Standard Deviations (for Hours 6-20) of 1 minute and 5 minute changes, for ST CREZ(Kramer), PV CREZ (Mountain Pass-Tehachapi), and selected Plants from each CREZ.

	ST Plant	ST CREZ	All ST	PV Plant	PV CREZ	All PV
Fall Average of 1 minute changes	0.52%	0.34%	0.26%	0.33%	0.28%	0.26%
Fall Standard Deviation of 1 minute changes	1.31%	0.64%	0.47%	0.59%	0.45%	0.38%
Fall Average of 5 minute changes	2.24%	1.47%	1.20%	1.48%	1.16%	1.08%
Fall Standard Deviation of 5 minute changes	5.29%	2.87%	2.28%	2.54%	1.82%	1.61%

Table 10: Winter Averages and Standard Deviations (for Hours 6-20) of 1 minute and 5 minute changes, for ST CREZ(Kramer), PV CREZ (Mountain Pass-Tehachapi), and selected Plants from each CREZ.

	ST Plant	ST CREZ	All ST	PV Plant	PV CREZ	All PV
Winter Average of 1 minute changes	0.55%	0.31%	0.21%	0.36%	0.31%	0.29%
Winter Standard Deviation of 1 minute changes	1.49%	0.62%	0.39%	0.73%	0.55%	0.44%
Winter Average of 5 minute changes	2.18%	1.25%	0.95%	1.60%	1.21%	1.09%
Winter Standard Deviation of 5 minute changes	5.42%	2.53%	1.79%	3.10%	2.03%	1.67%