DETERMINATION OF PHOTOVOLTAIC EFFECTIVE CAPACITY FOR NEVADA POWER

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EXECUTIVE SUMMARY

The effective capacity of PV power plants operating on the Nevada Power grid was estimated by analyzing three years of hourly system load data and time/site specific solar irradiance data.

Effective capacity was quantified using three complementary metrics: Effective Load Carrying Capability (ELCC), Minimum buffer Energy Storage (MBES) and Solar Load Control (SLC) requirements. ELCC is a statistical measure of capacity; in first approximation, this may be interpreted as percent ideal power plant equivalent[1]. The MBES and SLC quantify respectively the minimum amount of backup, or load shedding (via system-wide cooling temperature setpoint increase) that would be necessary to guaranty 100% ELCC.

The Effective Load Carrying Capability (ELCC) observed for Nevada Power was found to be significant. This high value reflects the natural coincidence of demand for power on the NP grid and solar resource availability. At low grid penetration, the ELCC of high efficiency PV installations reaches 80% for 1-axis tracking geometry, 60% for fixed low-tilt Southwest facing arrays, and 55% for horizontal systems. ELCC decreases with grid-penetration –see discussion below-- but remains substantial. At 10%-penetration, it is still 65%, 50% and 45%, respectively, for the three considered array geometries.

The MBES and SLC metrics also reflect the strong effective capacity of PV for the NP grid. At low penetration, it would take respectively 0.2, 04, and 0.5 installed capacity-hours of storage for the three arrays to help PV reach 100% effective capacity. At 10% penetration, requirements reach respectively 0.8, 1.2 and 1.4 installed capacity-hours, but are still well below the amount that would be needed to achieve the same capacity without PV -- 4 hours at 10% penetration.

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[1] e.g., a 1 MW PV plant with a 70% ELCC can be considered equivalent to a 700 KW ideally dispatchable power plant.

I METHODS

The effective capacity of PV was determined experimentally from hourly system load and time/site specific simulated PV output.

Hourly system load data were provided by Nevada Power for the years 2000, 2001 and 2002.

Time/site-specific irradiances were simulated from hourly geostationary satellite-derived irradiances covering the Las Vegas metropolitan area [1, 2]. Operational ambient temperatures and wind-speeds were obtained from local climatological summaries. Results are presented for the highest yield pixel location (~ 12 km northwest of the city center) and the lowest yield pixel location (4 km southeast of the city center.

PV simulations: we used PVFORM 4.0 for the simulations [note that PV-FORM is the engine at the basis of PV-Watts]. PV systems are specified in terms of PTC rating – i.e., delivered ac output at 25^{o}C ambient. – i.e., 1 kW of PV signifies 1-kW ac output at 25^{o}C ambient and 1000 Wm^{-2} plane of array irradiance.

The following modules and array geometries were analyzed:

- Modules: Two types of modules were considered (1) standard crystalline modules with a temperature degradation of ~ 0.043% per ^{o}C; and (2) high efficiency crystalline/thin film module such as the Sanyo 190 module with a manufacturer-claimed temperature degradation of only 0.025% per ^{o}C.

- Geometries: We considered three geometries – (1) standard horizontal Powerguard® configuration; (2) ~ 10^{o}-tilt Powerguard® configuration, with a 60^{o} West azimuth and (3) 1-axis tracking with horizontal axis.

Effective capacity metrics: Three types of metrics were produced:

- Effective Load Carrying Capability (ELCC): This is a statistical measure of effective capacity. The ELCC represents the increase in capacity available to a localized grid attributable to the deployed PV capacity on that grid, at constant loss-of-load probability [3, 4].

  ELCC is quantified in % of installed PV capacity *(e.g., 45% = 45 MW for 100 MW installed PV capacity)*

  The ELCC may be interpreted in terms of ideal resource equivalence; e.g., a 100 MW plant with a 45% ELCC may be considered as equivalent to a 45 MW fully dispatchable unit with no down time.

- Minimum Buffer Energy Storage (MBES): This is a deterministic measure of capacity. The MBES represents the minimum amount of back-up or storage energy sufficient to guaranty that all loads above a threshold equal to peak-load minus installed PV capacity are met by PV + storage [5]. This metric is interesting because, as a measure of the worse case situation, it removes the statistical uncertainty associated with the ELCC. In addition, it provides insight on the economic impact of guaranteeing 100% firm capacity, because it can be easily extrapolated in additional PV installed cost[2].

MBES is quantified in installed PV capacity-hours *(e.g., 0.5 hours = 50 MWh for 100 MW installed PV capacity).* The MBES is contrasted to the amount of storage or backup energy that would be necessary to accomplish the same objective without PV.

- Solar Load Control Degree-Hours (SLC): Because peak loads are driven by A/C demand, it has been shown that utility-wide cooling temperature mitigation in response to critical load-PV situations [6] could, via temporary load shedding, guaranty that PV + SLC could meet all loads in excess the threshold specified above, with minimal end-use temperature discomfort.

  SLC is quantified in terms of (1) maximum daily ^{o}C-hours of end-user discomfort, and (2) total yearly ^{o}C-hours of user discomfort. As for MBES, these metrics are contrasted to the amount of temperature increase that would b necessary to accomplish the same objective without PV.

Impact of PV grid-penetration: Because of utility load shape, peak load drivers, and because of the day-time availability of PV power, the effective capacity of PV decreases with PV penetration. This decrease is a direct consequence of the facts that peaks are indirectly driven by the sun (creating enhanced cooling load requirements during the hottest days). As PV penetration increases, PV capacity is no longer confined to meet the highest peal loads, but must also address shoulder loads, and – ultimately – base loads that are not correlated with PV.

PV grid-penetrations ranging from 1% of utility peak to 15% of utility peak have been considered.

II RESULTS

In this section we provide effective capacity results spanning the entire 2000-2002 data sets averaged over the greater Las Vegas area. Year-specific and location specific results are provide in appendix

Along with tabulated results, a qualitative visualization of PV-load relationship is provided by comparing PV output and load during each year's peak day (Figs. 1-3)

[2] For instance, 0.5 system hours at 1MW = 500 kWh; with a battery-storage cost of, e.g., $400/kWh, guaranteeing firm PV capacity would add $200 per installed PV kW.

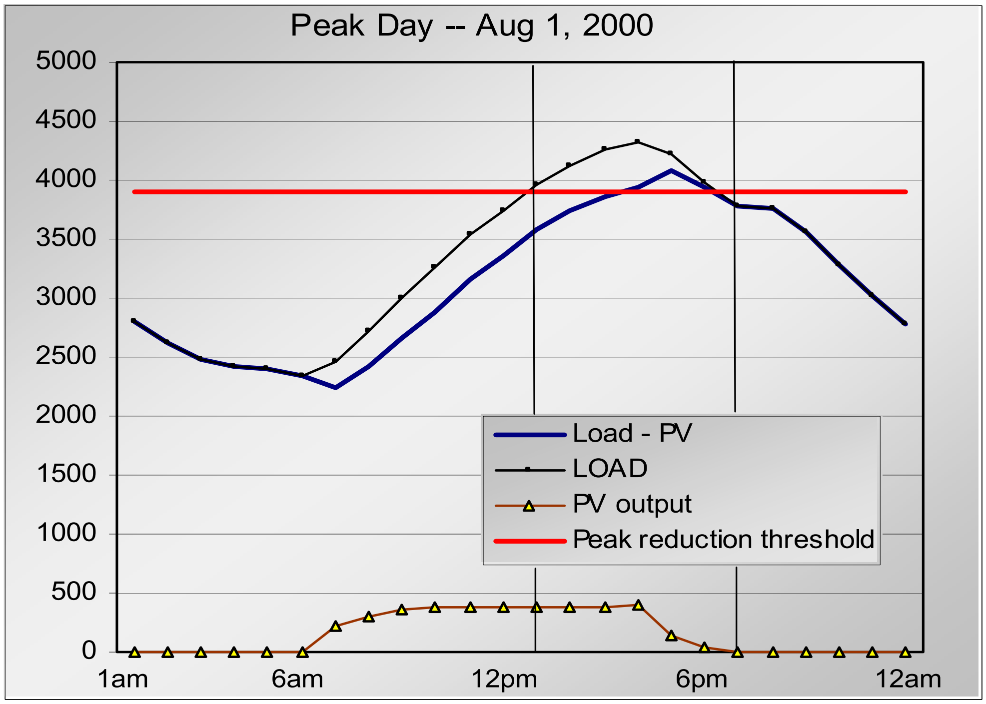

Fig. 1 – PV output and load on the year 2000 peak day.

PV output is shown for a total installed capacity = 10% of utility peak, using 1-axis tracking geometry The horizontal is set at peak minus 10%. The vertical lines at 1PM and 7PM mark the edges of the billing peak load period (note that the area between the red line and the bold line illustrates MBES requirements).

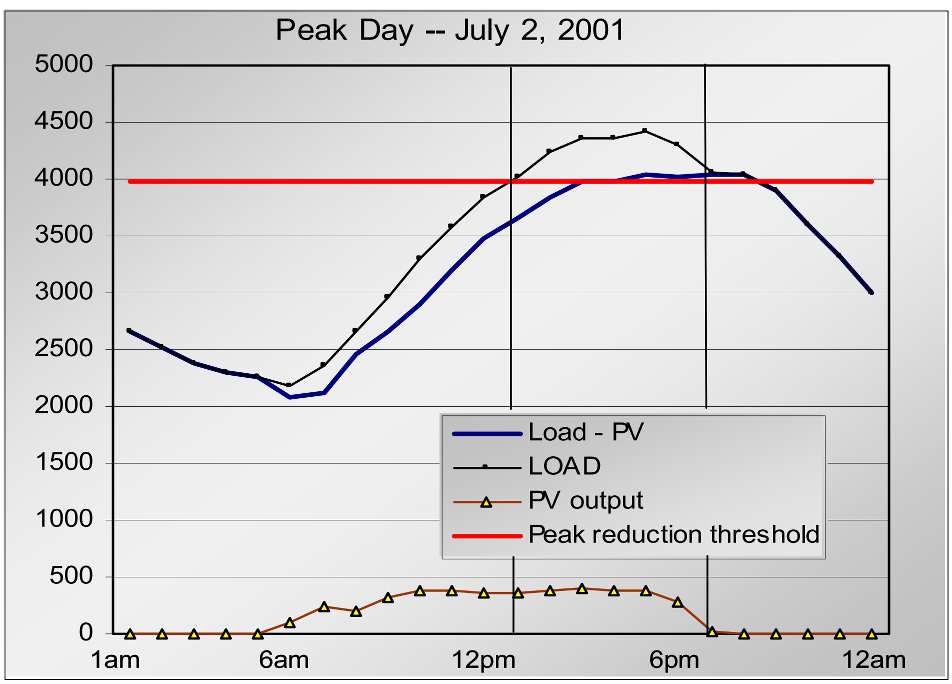

Fig. 2 – PV output and load on the year 2001 peak day.

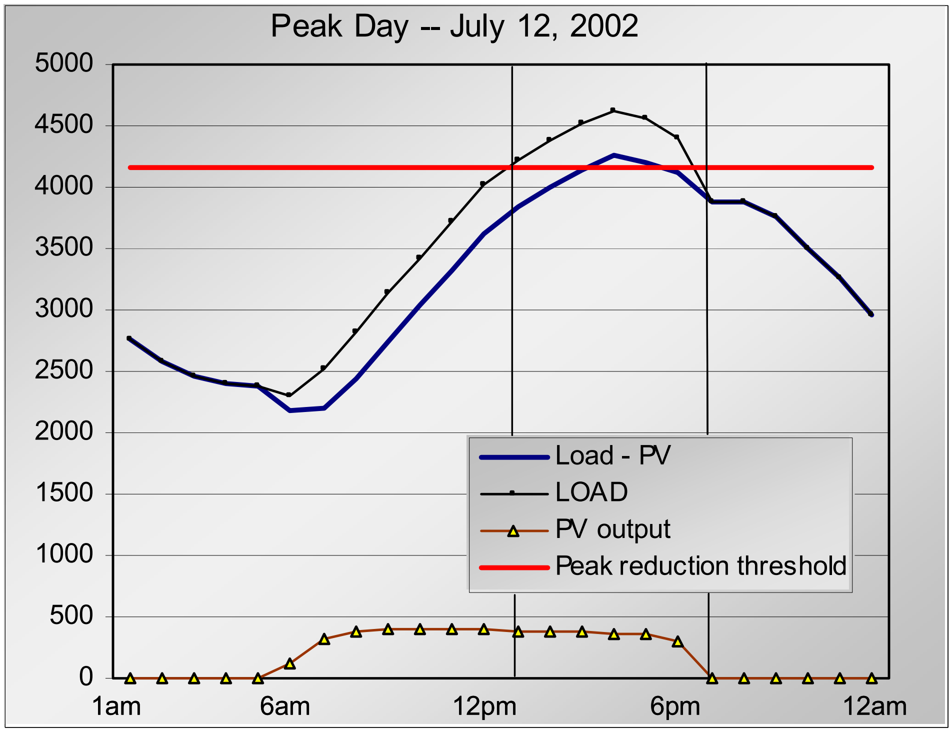

Fig. 3 – PV output and load on the year 2002 peak day.

ELCC: Results for crystalline and high efficiency PV are presented in Table 1 and 2, respectively. The results in Table 2 are graphically illustrated in Figure 4.

Table 1 -- Region-wide ELCC for crystalline PV

3-YR AVERAGE Crystalline PV	**PV PENETRATION (%)**				
	1%	**2%**	**5%**	**10%**	**15%**
1-axis tracking PV					
ELCC (%)	76%	75%	72%	64%	54%
Horizontal PV					
ELCC (%)	53%	52%	49%	44%	39%
10o-tilt 60o-West PV					
ELCC (%)	57%	56%	54%	48%	42%

Table 2 -- Region-wide ELCC for high-efficiency PV

3-YR AVERAGE high efficiency PV	PV PENETRATION (%)				
	1%	**2%**	**5%**	**10%**	**15%**
1-axis tracking PV					
ELCC (%)	80%	79%	75%	66%	55%
Horizontal PV					
ELCC (%)	55%	54%	51%	46%	41%
10o-tilt 60o-West PV					
ELCC (%)	60%	59%	56%	50%	44%

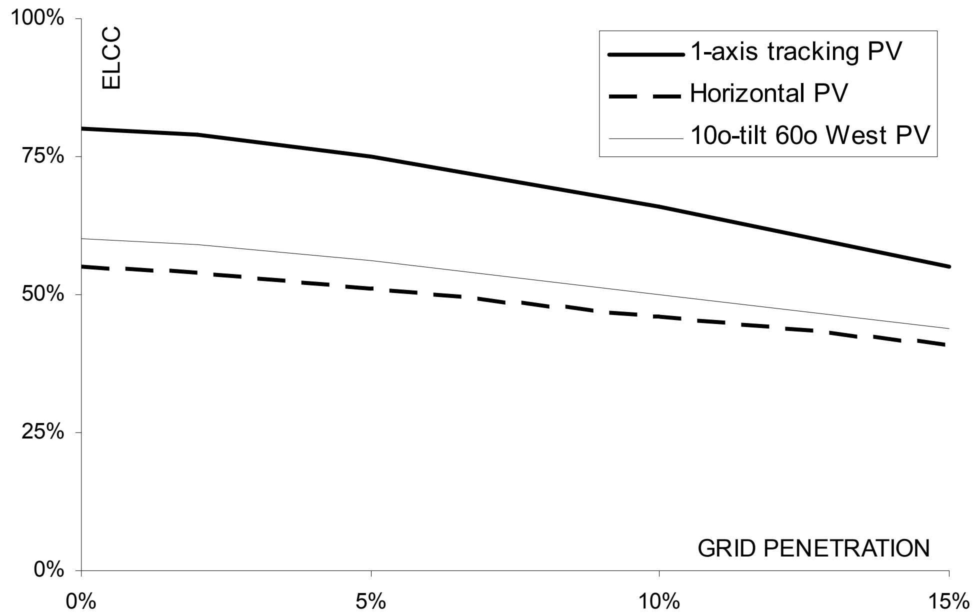

Fig. 4 -- 3-year average ELCC for high efficiency PV

MBES: Results for crystalline and high efficiency PV are presented in Table 3 and 4, respectively.

Table 3 -- Region-wide MBES for crystalline PV

3-YR AVERAGE Crystalline PV	PV PENETRATION (%) 1%	2%	5%	10%	15%
1-axis tracking PV					
MBES (Installed PV-hours)	0.25	0.28	0.45	0.82	1.49
Horizontal PV					
MBES (Installed PV-hours)	0.48	0.50	0.85	1.42	2.20
10o-tilt 60o-West PV					
MBES (Installed PV-hours)	0.43	0.45	0.74	1.25	2.02
NO PV					
MBES (Installed PV-hours)	1.00	1.48	2.65	3.97	5.33

Table 4 -- Region-wide MBES for high-efficiency PV

3-YR AVERAGE high efficiency PV	PV PENETRATION (%) 1%	2%	5%	10%	15%
1-axis tracking PV					
MBES (Installed PV-hours)	0.21	0.24	0.43	0.77	1.44
Horizontal PV					
MBES (Installed PV-hours)	0.45	0.47	0.83	1.35	2.13
10o-tilt 60o-West PV					
MBES (Installed PV-hours)	0.40	0.41	0.71	1.18	1.95
NO PV					
MBES (Installed PV-hours)	1.00	1.48	2.65	3.97	5.33

SLC: Results for the solar load control metrics are presented in Table 5-8. Tables 5 and 6 include daily maximum degree-hour discomfort. Tables 7 and 8 include total seasonal degree-hour discomfort.

Table 5 – Region-wide maximum daily temperature increase to guaranty 100% capacity credit (crystalline PV)

3-YR AVERAGE	PV PENETRATION (%)				
Crystalline PV	1%	2%	5%	10%	15%
1-axis tracking PV					
SLC1 (max daily degree-hours)	0.1	0.2	0.8	3.0	8.2
Horizontal PV					
SLC1 (max daily degree-hours)	0.2	0.4	1.6	5.2	12.0
10o-tilt 60o-West PV					
SLC1 (max daily degree-hours)	0.2	0.3	1.3	4.6	11.1
NO PV					
SLC1 (max daily degree-hours)	0.4	1.1	4.8	14.5	29.2

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Table 6 – Region-wide maximum daily temperature increase to guaranty 100% capacity credit (high-efficiency PV)

3-YR AVERAGE	PV PENETRATION (%)				
high efficiency PV	1%	2%	5%	10%	15%
1-axis tracking PV					
SLC1 (max daily degree-hours)	0.1	0.2	0.8	3.0	8.2
Horizontal PV					
SLC1 (max daily degree-hours)	0.2	0.4	1.6	5.2	12.0
10o-tilt 60o-West PV					
SLC1 (max daily degree-hours)	0.2	0.3	1.3	4.6	11.1
NO PV					
SLC1 (max daily degree-hours)	0.4	1.1	4.8	14.5	29.2

Table 7 – Region-wide total seasonal temperature increase to guaranty 100% capacity credit (crystalline PV)

3-YR AVERAGE	PV PENETRATION (%)				
Crystalline PV	1%	2%	5%	10%	15%
1-axis tracking PV					
SLC2 (year total degree-hours)	0.1	0.2	0.9	4.1	27.4
Horizontal PV					
SLC2 (year total degree-hours)	0.2	0.4	2.0	15.5	76.7
10o-tilt 60o-West PV					
SLC2 (year total degree-hours)	0.2	0.4	1.6	11.9	64.2
NO PV					
SLC2 (year total degree-hours)	0.5	1.4	12.4	102.0	356.2

Table 8 – Region-wide total seasonal temperature increase to guaranty 100% capacity credit (high-efficiency PV)

3-YR AVERAGE high efficiency PV	PV PENETRATION (%) 1%	2%	5%	10%	15%
1-axis tracking PV					
SLC2 (year total degree-hours)	0.1	0.2	0.9	3.9	26.6
Horizontal PV					
SLC2 (year total degree-hours)	0.2	0.4	1.9	13.8	70.1
10o-tilt 60o-West PV					
SLC2 (year total degree-hours)	0.2	0.4	1.6	10.3	58.7
NO PV					
SLC2 (year total degree-hours)	0.5	1.4	12.4	102.0	356.2

III DISCUSSION

Results show that the ELCC of PV is substantial at low penetration reaches 80% for 1-axis tracking installations and 60% for low-tilt South-West facing fixed array. It would take little in terms of energy storage to increase ELCC levels to 100%, respectively 0.1 and 0.3 system-hours for the tracking and the optimized SW fixed array.

ELCC decreases with increased PV grid penetration. This is understandable since, as penetration increases, PV must meet shoulder loads which are not as well correlated with the solar resource as peak loads. At 15% penetration ELCCs for tracking and fixed optimized systems are respectively down to 58% and 45% under the conditions illustrated in Table 15.

Still, considering the MBES and SLC metrics, it would only take a backup/storage amount of 1.2 and 1.9 system hours respectively, to increase PV ELCC to 100% even at this high penetration. By contrast, it would take 5.3 system-hours worth of stored or backup energy to accomplish the same without PV. When quantified in terms of SLC via cooling temperature mitigation a total yearly end-user discomfort of 28 degree-hours for the tracking PV option and 60 degree-hours for the fixed option would be needed to guaranty firm PV capacity at 15% grid penetration. Accomplishing the same task without PV would require and end-use discomfort in excess of 350 degree-hours.

The capacity performance of the high efficiency modules is 2-3% better than conventional modules[3].

[3] Note that, had the arrays been defined in terms of stc-rating (20^{o}C module temperature) instead of ptc, the apparent capacity gain of the high efficiency over conventional arrays would have been ~ 10%.

Results show that year-to-year variability is minimal and that effective capacity numbers stay consistent over time, reflecting a robust relationship between peak loads and solar gain.

Likewise, geographic variability throughout the greater Las Vegas is minimal. Slightly better results are observed in the city Northwest but differences are not significant.

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APPENDIX
YEAR & SITE-SPECIFIC RESULTS

Table A-1 ELCC for Crystalline PV

	PV PENETRATION (%)				
Crystalline PV	**1%**	**2%**	**5%**	**10%**	**15%**
1-axis tracking PV					
2000					
northwest location	78%	77%	74%	65%	55%
southeast location	75%	74%	70%	60%	50%
2001					
northwest location	77%	76%	73%	65%	55%
southeast location	78%	77%	73%	65%	55%
2002					
northwest location	78%	78%	76%	70%	60%
southeast location	72%	71%	67%	59%	50%
3-yr area-wide average	**76%**	**75%**	**72%**	**64%**	**54%**
Horizontal PV					
2000					
northwest location	54%	53%	50%	45%	40%
southeast location	52%	51%	48%	43%	38%
2001					
northwest location	54%	54%	51%	46%	41%
southeast location	55%	54%	51%	46%	41%
2002					
northwest location	52%	51%	49%	45%	40%
southeast location	49%	48%	46%	41%	37%
3-yr area-wide average	**53%**	**52%**	**49%**	**44%**	**39%**
10^o-tilt 60^o-West PV					
2000					
northwest location	59%	58%	55%	49%	43%
southeast location	57%	56%	53%	47%	40%
2001					
northwest location	59%	58%	55%	50%	44%
southeast location	59%	58%	56%	50%	44%
2002					
northwest location	57%	56%	54%	49%	44%
southeast location	53%	53%	50%	45%	40%
3-yr area-wide average	**57%**	**56%**	**54%**	**48%**	**42%**

Table A-2 ELCC for High Efficiency PV

High Efficiency PV	PV PENETRATION (%) 1%	2%	5%	10%	15%
1-axis tracking PV					
2000					
northwest location	82%	81%	77%	67%	56%
southeast location	79%	77%	73%	62%	50%
2001					
northwest location	81%	80%	76%	67%	56%
southeast location	81%	80%	77%	67%	56%
2002					
northwest location	82%	81%	79%	72%	62%
southeast location	75%	74%	70%	61%	51%
3-yr area-wide average	**80%**	**79%**	**75%**	**66%**	**55%**
Horizontal PV					
2000					
northwest location	56%	56%	52%	47%	41%
southeast location	55%	54%	50%	45%	39%
2001					
northwest location	57%	56%	53%	48%	42%
southeast location	57%	56%	53%	48%	42%
2002					
northwest location	54%	53%	51%	47%	42%
southeast location	51%	50%	47%	43%	38%
3-yr area-wide average	**55%**	**54%**	**51%**	**46%**	**41%**
10^o-tilt 60^o-West PV					
2000					
northwest location	62%	61%	57%	51%	44%
southeast location	59%	58%	55%	48%	41%
2001					
northwest location	61%	61%	58%	52%	45%
southeast location	62%	61%	58%	52%	45%
2002					
northwest location	59%	59%	56%	51%	45%
southeast location	56%	55%	52%	47%	41%
3-yr area-wide average	**60%**	**59%**	**56%**	**50%**	**44%**

Table A-3 MBES for Crystalline PV

	PV PENETRATION (%)				
Crystalline PV	**1%**	**2%**	**5%**	**10%**	**15%**
1-axis tracking PV					
2000					
northwest location	0.10	0.10	0.27	0.63	1.29
southeast location	0.22	0.22	0.70	1.10	1.81
2001					
northwest location	0.17	0.17	0.19	0.59	1.58
southeast location	0.14	0.14	0.14	0.58	1.50
2002					
northwest location	0.22	0.22	0.22	0.33	0.88
southeast location	0.67	0.84	1.20	1.69	1.88
3-yr area-wide average	**0.25**	**0.28**	**0.45**	**0.82**	**1.49**
Horizontal PV					
2000					
northwest location	0.34	0.34	0.56	0.96	1.79
southeast location	0.41	0.41	0.87	1.34	2.05
2001					
northwest location	0.52	0.52	0.90	1.59	2.52
southeast location	0.49	0.49	0.87	1.68	2.60
2002					
northwest location	0.41	0.41	0.71	1.18	2.07
southeast location	0.69	0.84	1.20	1.74	2.16
3-yr area-wide average	**0.48**	**0.50**	**0.85**	**1.42**	**2.20**
10^o-tilt 60^o-West PV					
2000					
northwest location	0.28	0.28	0.46	0.78	1.61
southeast location	0.36	0.36	0.81	1.22	1.93
2001					
northwest location	0.46	0.46	0.71	1.42	2.35
southeast location	0.43	0.43	0.68	1.46	2.39
2002					
northwest location	0.36	0.36	0.60	0.97	1.89
southeast location	0.67	0.79	1.15	1.62	1.97
3-yr area-wide average	**0.43**	**0.45**	**0.74**	**1.25**	**2.02**
NO PV					
2000	1.00	1.17	2.24	3.47	4.74
2001	1.00	1.86	3.26	4.61	6.11
2002	1.00	1.41	2.44	3.84	5.14
3-yr average	**1.00**	**1.48**	**2.65**	**3.97**	**5.33**

Table A-4 MBES for High Efficiency PV

High Efficiency PV	PV PENETRATION (%) 1%	2%	5%	10%	15%
1-axis tracking PV					
2000					
northwest location	0.08	0.08	0.26	0.59	1.24
southeast location	0.18	0.18	0.67	1.03	1.74
2001					
northwest location	0.15	0.15	0.18	0.56	1.53
southeast location	0.12	0.12	0.13	0.54	1.45
2002					
northwest location	0.19	0.19	0.21	0.31	0.85
southeast location	0.57	0.71	1.14	1.59	1.81
3-yr area-wide average	**0.21**	**0.24**	**0.43**	**0.77**	**1.44**
Horizontal PV					
2000					
northwest location	0.32	0.32	0.54	0.91	1.73
southeast location	0.39	0.39	0.84	1.28	1.99
2001					
northwest location	0.49	0.49	0.87	1.52	2.44
southeast location	0.47	0.47	0.85	1.60	2.53
2002					
northwest location	0.39	0.39	0.69	1.13	2.01
southeast location	0.65	0.79	1.17	1.67	2.09
3-yr area-wide average	**0.45**	**0.47**	**0.83**	**1.35**	**2.13**
10^{o}-tilt 60^{o}-West PV					
2000					
northwest location	0.26	0.26	0.45	0.74	1.56
southeast location	0.33	0.33	0.78	1.15	1.86
2001					
northwest location	0.42	0.42	0.68	1.35	2.27
southeast location	0.40	0.40	0.65	1.38	2.31
2002					
northwest location	0.34	0.34	0.58	0.92	1.82
southeast location	0.62	0.73	1.11	1.53	1.90
3-yr area-wide average	**0.40**	**0.41**	**0.71**	**1.18**	**1.95**
NO PV					
2000	1.00	1.17	2.24	3.47	4.74
2001	1.00	1.86	3.26	4.61	6.11
2002	1.00	1.41	2.44	3.84	5.14
3-yr average	**1.00**	**1.48**	**2.65**	**3.97**	**5.33**

Table A-5 Maximum 1-day SLC degree-hours for Crystalline PV

Crystalline PV	PV PENETRATION (%)				
	0.0	**0.0**	**0.1**	**0.1**	**0.2**
1-axis tracking PV					
2000					
northwest location	0.0	0.1	0.5	2.2	6.8
southeast location	0.1	0.2	1.2	3.9	9.6
2001					
northwest location	0.1	0.1	0.3	2.1	8.6
southeast location	0.0	0.1	0.2	2.1	8.1
2002					
northwest location	0.1	0.2	0.4	1.3	5.0
southeast location	0.3	0.6	2.3	6.4	10.7
3-yr area-wide average	**0.1**	**0.2**	**0.8**	**3.0**	**8.2**
Horizontal PV					
2000					
northwest location	0.1	0.2	1.0	3.4	9.5
southeast location	0.1	0.3	1.5	4.8	10.9
2001					
northwest location	0.2	0.4	1.6	5.8	13.6
southeast location	0.2	0.4	1.6	6.1	14.1
2002					
northwest location	0.2	0.3	1.3	4.5	11.7
southeast location	0.3	0.6	2.3	6.6	12.2
3-yr area-wide average	**0.2**	**0.4**	**1.6**	**5.2**	**12.0**
10o-tilt 60o-West PV					
2000					
northwest location	0.1	0.2	0.8	2.8	8.6
southeast location	0.1	0.3	1.4	4.3	10.3
2001					
northwest location	0.2	0.3	1.3	5.2	12.7
southeast location	0.2	0.3	1.2	5.3	13.0
2002					
northwest location	0.1	0.3	1.1	3.7	10.7
southeast location	0.3	0.6	2.2	6.1	11.2
3-yr area-wide average	**0.2**	**0.3**	**1.3**	**4.6**	**11.1**
NO PV					
2000	0.4	0.8	4.0	12.3	25.2
2001	0.4	1.3	5.9	16.7	33.1
2002	0.4	1.1	4.6	14.6	29.2
3-yr average	**0.4**	**1.1**	**4.8**	**14.5**	**29.2**

Table A-6 Maximum 1-day SLC degree-hours for High Efficiency PV

	PV PENETRATION (%)				
High Efficiency PV	**0.0**	**0.0**	**0.1**	**0.1**	**0.2**
1-axis tracking PV					
2000					
northwest location	0.0	0.1	0.5	2.1	6.6
southeast location	0.1	0.1	1.2	3.6	9.3
2001					
northwest location	0.1	0.1	0.3	2.0	8.3
southeast location	0.0	0.1	0.2	2.0	7.8
2002					
northwest location	0.1	0.1	0.4	1.2	4.8
southeast location	0.2	0.5	2.2	6.0	10.3
3-yr area-wide average	**0.1**	**0.2**	**0.8**	**2.8**	**7.8**
Horizontal PV					
2000					
northwest location	0.1	0.2	1.0	3.2	9.2
southeast location	0.1	0.3	1.5	4.5	10.6
2001					
northwest location	0.2	0.4	1.6	5.5	13.2
southeast location	0.2	0.3	1.5	5.8	13.7
2002					
northwest location	0.1	0.3	1.3	4.3	11.4
southeast location	0.2	0.6	2.2	6.3	11.9
3-yr area-wide average	**0.2**	**0.3**	**1.5**	**4.9**	**11.7**
10o-tilt 60o-West PV					
2000					
northwest location	0.1	0.2	0.8	2.6	8.3
southeast location	0.1	0.2	1.4	4.1	9.9
2001					
northwest location	0.2	0.3	1.2	4.9	12.3
southeast location	0.1	0.3	1.2	5.0	12.5
2002					
northwest location	0.1	0.3	1.1	3.5	10.3
southeast location	0.2	0.6	2.1	5.8	10.8
3-yr area-wide average	**0.1**	**0.3**	**1.3**	**4.3**	**10.7**
NO PV					
2000	0.4	0.8	4.0	12.3	25.2
2001	0.4	1.3	5.9	16.7	33.1
2002	0.4	1.1	4.6	14.6	29.2
3-yr average	**0.4**	**1.1**	**4.8**	**14.5**	**29.2**

Table A-7 Total Seasonal SLC Degree-Hours for Crystalline PV

	PV PENETRATION (%)				
Crystalline PV	**0.0**	**0.0**	**0.1**	**0.1**	**0.2**
1-axis tracking PV					
2000					
northwest location	0.0	0.1	0.5	3.0	27.7
southeast location	0.1	0.2	1.2	4.6	30.4
2001					
northwest location	0.1	0.1	0.7	3.7	27.0
southeast location	0.0	0.1	0.4	3.6	26.3
2002					
northwest location	0.1	0.2	0.4	1.7	21.2
southeast location	0.3	0.6	2.3	8.0	31.4
3-yr area-wide average	**0.1**	**0.2**	**0.9**	**4.1**	**27.4**
Horizontal PV					
2000					
northwest location	0.1	0.2	1.0	11.7	81.9
southeast location	0.1	0.3	1.5	13.5	84.4
2001					
northwest location	0.3	0.6	2.8	10.9	54.8
southeast location	0.3	0.6	2.7	11.1	55.9
2002					
northwest location	0.2	0.3	1.4	21.4	89.1
southeast location	0.3	0.6	2.4	24.4	93.9
3-yr area-wide average	**0.2**	**0.4**	**2.0**	**15.5**	**76.7**
10o-tilt 60o-West PV					
2000					
northwest location	0.1	0.3	0.8	8.6	67.3
southeast location	0.1	0.3	1.4	10.3	69.3
2001					
northwest location	0.2	0.5	2.2	9.6	45.6
southeast location	0.2	0.5	2.0	9.5	46.5
2002					
northwest location	0.1	0.3	1.1	15.2	75.9
southeast location	0.3	0.6	2.2	18.2	80.7
3-yr area-wide average	**0.2**	**0.4**	**1.6**	**11.9**	**64.2**
NO PV					
2000	0.4	0.8	9.5	115.5	432.6
2001	0.7	2.4	11.2	72.8	269.6
2002	0.4	1.1	16.5	117.7	366.4
3-yr average	**0.5**	**1.4**	**12.4**	**102.0**	**356.2**

Table A-8 Total Seasonal SLC Degree-Hours for High-Efficiency PV

	PV PENETRATION (%)				
High Efficiency PV	**0.0**	**0.0**	**0.1**	**0.1**	**0.2**
1-axis tracking PV					
2000					
northwest location	0.0	0.1	0.5	2.8	26.9
southeast location	0.1	0.1	1.2	4.3	29.5
2001					
northwest location	0.1	0.1	0.6	3.4	26.2
southeast location	0.0	0.1	0.4	3.4	25.6
2002					
northwest location	0.1	0.1	0.4	1.6	20.6
southeast location	0.2	0.5	2.2	7.5	30.5
3-yr area-wide average	**0.1**	**0.2**	**0.9**	**3.9**	**26.6**
Horizontal PV					
2000					
northwest location	0.1	0.2	1.0	10.4	74.9
southeast location	0.1	0.3	1.5	12.0	77.2
2001					
northwest location	0.2	0.5	2.7	9.7	50.1
southeast location	0.2	0.5	2.6	9.9	51.1
2002					
northwest location	0.1	0.3	1.4	19.1	81.5
southeast location	0.2	0.6	2.3	21.7	85.8
3-yr area-wide average	**0.2**	**0.4**	**1.9**	**13.8**	**70.1**
10o-tilt 60o-West PV					
2000					
northwest location	0.1	0.2	0.8	7.4	61.5
southeast location	0.1	0.2	1.4	8.9	63.3
2001					
northwest location	0.2	0.4	2.2	8.3	41.7
southeast location	0.2	0.4	1.9	8.3	42.4
2002					
northwest location	0.1	0.3	1.1	13.1	69.3
southeast location	0.2	0.6	2.1	15.8	73.7
3-yr area-wide average	**0.2**	**0.4**	**1.6**	**10.3**	**58.7**
NO PV					
2000	0.4	0.8	9.5	115.5	432.6
2001	0.7	2.4	11.2	72.8	269.6
2002	0.4	1.1	16.5	117.7	366.4
3-yr average	**0.5**	**1.4**	**12.4**	**102.0**	**356.2**