

## Appendix D: Solar Charts and References

**Table D.1: State of CA PV Projects by December 2004<sup>1</sup>**

	kW Installed	Percent of Total
California Energy Commission*	44,759	48.07%
California Public Utilities Commission*	26,091	28.02%
Los Angeles Department of Water and Power	9,572	10.28%
Sacramento Municipal Utility District	9,252	9.94%
Pre-1998	1,918	2.06%
City of Riverside Public Utilities	389	0.42%
City of Anaheim Public Utilities	335	0.36%
City of Palo Alto Utilities	290	0.31%
City of Roseville Electric	133	0.14%
City of Pasadena Water and Power	84	0.09%
Modesto Irrigation District	60	0.06%
City of Santa Clara Electric Utility	54	0.06%
Imperial Irrigation District	30	0.03%
City of Ukiah Public Utilities	20	0.02%
Azusa Light and Water Department	20	0.02%
City of Glendale Water and Electric	19	0.02%
Pacific Power	19	0.02%
Truckee-Donner Public Utilities District	12	0.01%
City of Redding Electric Utility	10	0.01%
City of Burbank Water and Power	10	0.01%
Healdsburg Municipal Electric Department	10	0.01%
City of Lompoc Electric Department	9	0.01%
City of Alameda Power and Telecom	5	0.01%
City of Lodi Electric Utility	4	0.00%
<b>TOTAL</b>	<b>93,104 kW</b>	
	<b>93.10 MW</b>	

<sup>1</sup> [http://www.energy.ca.gov/renewables/emerging\\_renewables/2005-01-18\\_GRID\\_PV.XLS](http://www.energy.ca.gov/renewables/emerging_renewables/2005-01-18_GRID_PV.XLS).

**Table D.2: Grid Connected Renewable Energy Sources in the SDG&E Region  
(03/04/05)**

<b>Grid Connected Renewables in SDG&amp;E Region</b>										
<b>Updated on: 04/01/05</b>										
(KW)	Prior to 3Q03	3Q03	4Q03	1Q04	2Q04	3Q04	4Q04	1Q05	Total Installed	Pending thru 3/31/05
Bio-gas										6,620
Bio-mass										40,000
Hydro/Storage Pump *										44,000
PV										
PV NEM - Residential	2802	630	550	693	705	627	649	673	7,329	1,012
PV NEM - C/I & Govt	2339	122	349	271	272	591	471	656	5,071	4,002
<b>Totals</b>	<b>5,141</b>	<b>752</b>	<b>899</b>	<b>964</b>	<b>977</b>	<b>1,218</b>	<b>1,120</b>	<b>1,329</b>	<b>12,400</b>	<b>95,634</b>
# of Metered Accts	Prior to 3Q03	3Q03	4Q03	1Q04	2Q04	3Q04	4Q04	1Q05	Total Installed	Pending thru 3/31/05
Bio-gas										3
Bio-mass										1
Hydro/Storage Pump *										2
PV										
PV NEM - Residential	839	173	136	223	213	187	214	181	2,166	442
PV NEM - C/I & Govt	42	5	7	4	5	12	15	9	99	46
<b>Totals</b>	<b>881</b>	<b>178</b>	<b>143</b>	<b>227</b>	<b>218</b>	<b>199</b>	<b>229</b>	<b>190</b>	<b>2,265</b>	<b>494</b>
* This category includes hydro, hybrid hydro and bio-mass, and hydro storage pump projects.										

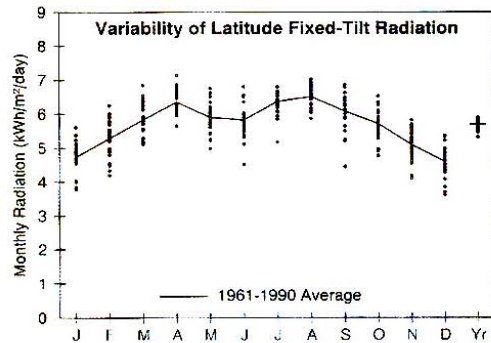
**Table D.3: San Diego Climatic Factors for Setting Panel Tilt**

**San Diego, CA**

WBAN NO. 23188

LATITUDE: 32.73° N  
LONGITUDE: 117.17° W  
ELEVATION: 9 meters  
MEAN PRESSURE: 1014 millibars

STATION TYPE: Primary



**Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%**

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	3.1	3.9	4.9	6.1	6.3	6.5	6.9	6.5	5.4	4.4	3.4	2.9	5.0
	Min/Max	2.6/3.5	3.3/4.4	4.4/5.7	5.5/6.8	5.3/7.2	5.0/7.6	5.6/7.4	5.9/7.0	4.2/6.0	3.8/4.9	3.0/3.7	2.4/3.2	4.7/5.2
Latitude -15	Average	4.1	4.8	5.6	6.4	6.3	6.3	6.8	6.7	6.0	5.3	4.5	3.9	5.6
	Min/Max	3.3/4.8	3.9/5.6	4.9/6.5	5.8/7.2	5.3/7.2	4.9/7.4	5.5/7.3	6.1/7.3	4.5/6.7	4.5/6.0	3.7/5.0	3.2/4.5	5.2/5.7
Latitude	Average	4.7	5.3	5.8	6.3	5.9	5.8	6.4	6.5	6.1	5.7	5.1	4.6	5.7
	Min/Max	3.8/5.6	4.2/6.3	5.1/6.8	5.7/7.1	5.0/6.8	4.5/6.8	5.2/6.8	5.9/7.0	4.4/6.9	4.8/6.5	4.1/5.8	3.6/5.4	5.3/5.9
Latitude +15	Average	5.1	5.5	5.7	5.9	5.2	5.1	5.6	5.9	5.8	5.4	5.0	5.5	5.5
	Min/Max	4.0/6.1	4.3/6.5	5.0/6.8	5.3/6.7	4.5/6.0	4.0/5.8	4.6/5.9	5.4/6.4	4.2/6.6	4.8/6.7	4.3/6.2	3.8/5.9	5.1/5.7
90	Average	4.5	4.3	3.9	3.2	2.4	2.1	2.2	2.9	3.6	4.4	4.6	4.5	3.5
	Min/Max	3.4/5.4	3.3/5.3	3.3/4.5	2.9/5.5	2.2/2.5	1.9/2.1	2.0/2.3	2.7/3.0	2.7/4.0	3.5/5.0	3.6/5.4	3.4/5.4	3.3/3.7

**Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m²/day), Uncertainty ±9%**

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	4.4	5.4	6.7	8.0	7.7	7.8	8.8	8.4	7.2	6.1	4.9	4.2	6.6
	Min/Max	3.5/5.3	4.1/6.6	5.7/8.1	6.8/9.2	6.1/9.4	5.5/9.9	6.6/9.7	7.3/9.4	4.9/8.3	5.0/7.0	3.9/5.8	3.3/4.9	6.1/6.9
Latitude -15	Average	5.2	6.1	7.2	8.3	7.7	7.8	8.7	8.6	7.6	6.7	5.7	5.0	7.1
	Min/Max	4.1/6.3	4.6/7.4	6.1/8.7	7.1/9.6	6.1/9.4	5.4/9.8	6.6/9.7	7.4/9.6	5.2/8.8	5.5/7.8	4.4/6.7	3.8/5.9	6.4/7.3
Latitude	Average	5.7	6.5	7.4	8.2	7.5	7.4	8.4	8.4	7.7	7.1	6.2	5.5	7.2
	Min/Max	4.4/6.9	4.8/7.9	6.2/9.0	7.0/9.6	5.9/9.1	5.2/9.3	6.3/9.3	7.3/9.4	5.2/8.9	5.7/8.3	4.8/7.3	4.2/6.5	6.5/7.4
Latitude +15	Average	6.0	6.6	7.3	7.9	7.0	6.9	7.8	8.0	7.5	7.1	6.5	5.8	7.0
	Min/Max	4.6/7.3	4.9/8.1	6.1/8.9	6.7/9.2	5.5/8.6	4.8/8.6	5.9/8.7	6.9/8.9	5.0/8.7	5.7/8.4	4.9/7.6	4.4/6.9	6.4/7.3

**Solar Radiation for 2-Axis Tracking Flat-Plate Collectors (kWh/m²/day), Uncertainty ±9%**

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	6.0	6.6	7.4	8.3	7.8	7.9	8.9	8.6	7.7	7.2	6.5	5.9	7.4
	Min/Max	4.6/7.3	4.9/8.1	6.2/9.0	7.1/9.6	6.2/9.5	5.5/10.0	6.7/9.8	7.4/9.6	5.2/8.9	5.8/8.4	5.0/7.7	4.4/7.1	6.8/7.7

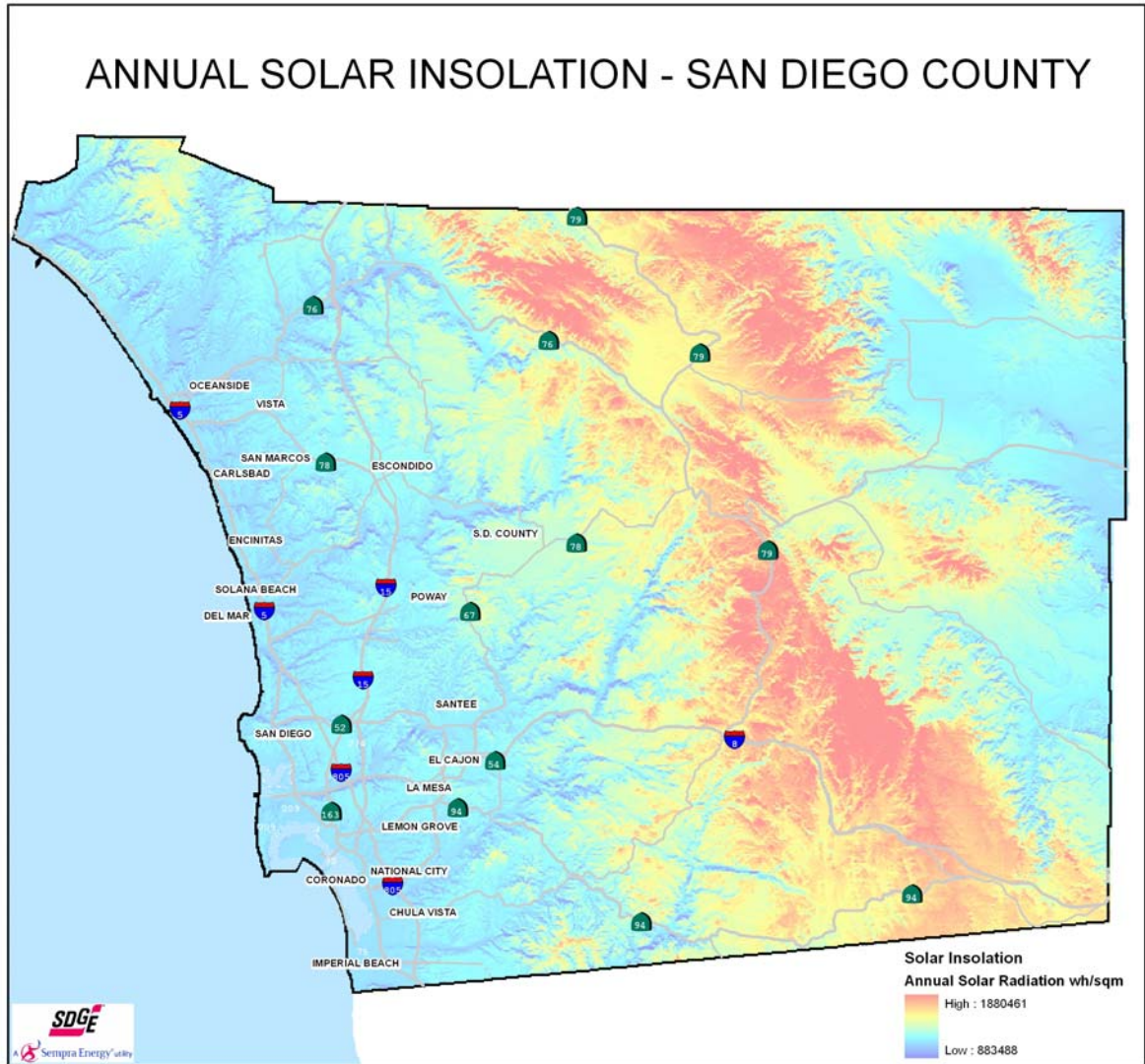
**Direct Beam Solar Radiation for Concentrating Collectors (kWh/m²/day), Uncertainty ±8%**

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W Horiz Axis	Average	3.8	3.8	3.9	4.3	3.9	4.0	4.9	4.8	4.2	4.1	4.0	3.8	4.1
	Min/Max	2.4/4.9	2.5/5.1	2.9/5.3	3.4/5.5	2.5/5.2	1.8/5.7	2.9/5.8	3.8/5.6	1.9/5.2	3.0/5.2	2.7/5.2	2.5/4.8	3.6/4.5
1-Axis, N-S Horiz Axis	Average	3.1	3.8	4.6	5.6	4.9	5.0	6.2	6.1	5.1	4.4	3.6	3.0	4.6
	Min/Max	2.0/4.1	2.3/5.1	3.4/6.3	4.3/7.1	3.1/6.8	2.3/7.3	3.6/7.4	4.7/7.2	2.3/6.3	3.2/5.5	2.4/4.6	2.0/3.8	3.9/5.0
1-Axis, N-S Tilt=Latitude	Average	4.2	4.7	5.1	5.7	4.7	4.7	5.8	6.1	5.5	5.2	4.6	4.1	5.0
	Min/Max	2.7/5.4	2.9/6.2	3.8/7.0	4.4/7.3	3.0/6.5	2.1/6.8	3.4/7.0	4.7/7.2	2.5/6.8	3.8/6.5	3.1/6.0	2.7/5.2	4.3/5.4
2-Axis	Average	4.5	4.8	5.1	5.8	5.0	5.1	6.2	6.3	5.5	5.3	4.9	4.5	5.3
	Min/Max	2.9/5.8	3.0/6.4	3.8/7.1	4.5/7.4	3.2/6.9	2.3/7.3	3.7/7.5	4.9/7.4	2.5/6.9	3.8/6.6	3.3/6.3	3.0/5.7	4.5/5.7

**Average Climatic Conditions**

Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	14.1	14.8	15.3	16.7	17.8	19.3	21.7	22.6	21.9	19.8	16.7	14.1	17.9
Daily Minimum Temp	9.4	10.4	11.6	13.1	15.1	16.6	18.7	19.6	18.7	16.1	12.2	9.3	14.2
Daily Maximum Temp	18.8	19.2	19.1	20.2	20.6	22.0	24.6	25.4	25.1	23.7	21.1	18.9	21.6
Record Minimum Temp	-1.7	2.2	3.9	5.0	8.9	10.6	12.8	13.9	10.6	6.1	3.3	1.1	-1.7
Record Maximum Temp	31.1	31.1	33.9	36.7	35.6	38.3	35.0	36.7	43.9	41.7	36.1	31.1	43.9
HDD, Base 18.3°C	136	105	98	63	41	28	7	0	11	13	61	135	698
CDD, Base 18.3°C	5	6	5	13	25	58	111	133	117	59	11	4	547
Relative Humidity (%)	63	66	67	67	71	74	75	74	73	69	66	64	69
Wind Speed (m/s)	2.7	3.0	3.5	3.7	3.7	3.6	3.5	3.5	3.4	3.1	2.8	2.6	3.3

Figure D.1: Annual Solar Insolation Map of San Diego County



## PV Technology References

Technology excerpts taken from:

Herig, C. October 2000. Assessing Rooftop Solar-Electric Distributed Energy Resources for the California Local Government Commission. Unpublished data.

Judkoff, R.; Thornton, J.; Strawn, N.; Gay, C.; Torcellini, P. May 1997 (revised). *Disaster! Reduce the Risk of Insurance Loss with Renewable Energy Technologies*. NREL Report No. BR-330-22820. Golden, CO: NREL.

National Center for Photovoltaics. Undated. *PV FAQs*. NREL Report No. FS-520-24588. Golden, CO: NREL

NREL. Undated. *Electricity Where You Need It-From the Sun*. NREL Report No. MK-411-20527. Golden, CO: NREL.

NREL. Undated. *Building-Integrated Solar Electricity*. NREL Report No. FS-520-29842. Golden, CO: NREL.

NREL. 1995 (revised). *Tapping Into the Sun: Today's Applications of Photovoltaic Technology*. DOE/CH10093-203-Rev.1. Golden, CO: NREL.

NREL. September 1998. *Photovoltaics and Commercial Buildings—A Natural Match*. DOE/GO-10098-657. Golden, CO: NREL.

NREL. 2001. *Solar Electricity: The Power of Choice*. NREL Report No. BR-520-30280. Golden, CO: NREL.

NREL. 2002. *Renewed Hope for a Brighter Future: Make Solar a Part of Your Rebuilding Plans*. Golden, CO: NREL.

NREL. 2002. *Strengthening Our Energy Security—A Sampling of Renewable Energy Technologies*. NREL Report No. FS-31656. Golden, CO: NREL.

Thornton, J. 2000. "Renewables on Main Street." *Public Works Management & Policy* 4(3):224-236.

Thornton, J. 2002. *Assuring America's Energy Infrastructure*. Presented at Solar 2002, Sunrise on the Reliable Energy Economy, Reno, NV, June 15-20.