PV Generation Estimate Model:
Sample Output for distribution
rev 09/13/11, bdc

Call key: entry | recall | fixed
used value | return recall

Location

Name	Wasco\NSTP, I-North Valley - California	
Elevation	76	across
Latitude	35.6	degrees
Avg Annual Insolation:	5.1	hours/day

	Solar alt. deg.	Avg Max Temp	Sunrise (24hr)	Sunset (24hr)	Hours Daylight	Hours Insolation	Est. hours
January	29.2	13.4	7.25	17.21	9.93	5.1	4.1
February	40.0	16.0	6.57	17.57	10.95	5.6	4.6
March	51.0	21.1	6.07	18.07	12.00	6.1	5.1
April	61.6	22.4	5.37	18.38	13.00	6.6	5.6
May	70.0	25.1	4.50	18.25	13.75	6.9	5.9
June	73.5	29.3	4.07	18.42	14.33	6.7	5.7
July	69.5	33.3	3.58	18.38	14.83	6.7	5.7
August	62.0	32.8	4.17	18.17	14.00	6.4	5.4
September	50.0	30.6	5.00	18.00	13.00	6.1	5.1
October	39.5	26.3	6.25	17.38	11.05	5.6	4.6
November	29.2	18.6	7.05	16.95	9.90	5.1	4.1
December	26.0	15.1	7.33	16.83	9.50	4.9	3.9
				Avg dayl. hrs:	12.10		

Locale temp. used to calc. PV cell temp (30 deg C added, ref. Temp Coeff.)
Est. hours derived from avg. insol. daylight hours

PPA Info

Bid Price:	$230.00	$/MWhr
Annual Escalation:	1.5%	% (PPI3 must allow for)
Contract period:	25	years (30 max)
Available/Built capacity:	8.0	MW - DC (see PV Panels: Installed DC wattest)

TOD Periods & Factors: (sec. 4, & 3)

1. Off Peak	13.00	20.00	M-F, except NERC Holidays				
2. Shoulder	7.00	13.00	20.00	22.00	7.00	22.00	M-F | NERC Holidays
3. Night	22.00	6.00	All days				
A. (month #)	5	9			1A	2,294	2A 1,5231 3A 0.6866
B. (month #)	10	4			1B	1,6578	2B 0.9367 3B 0.7934
C. (month #)	11	3			1C	1,4589	2C 0.8835 3C 0.7509

Note: representation of sale month-nearly month (-1 for non)

NERC Holidays (#, by month)	January	1	February	2	March	3	April	4	May	5	June 6
	July	7	August	8	September	9	October	10	November	11	December 12

Prod. Penalty thresholds (annual basis): (sec. 4.4) Over: 120 % Rate (ref contracted price): 25 %
(sec. 3.1a/b/d/f) Under: 90 % 25 %

(contract negates obligation of Buyer to purchase anything over 110%)
Wosten's GEP penalties of up to 75% contract price, MW

Forecasting Penalty thresholds (daily): (sec. 4.5(c)(i)) +/- 15% Penalty (ref. contracted price): 50%

(sec. 4.5(c)(ii)) 1 Under: 30 % 1 Over: 30 %

Contract Deposits (Performance Assurance), estimated

Bid Assurance	$24,000	= C (SolPro)
Project Development Security	$25	/KW/dc
Delivery Term Security	$ 200,000	= Min Chrg. Qty

$/kW/dc 8.4(a)(i)(C) 8.4(a)(i)(D)(1) 8.4(a)(i)(D)(2)

Misc

Annual Cost Index (ACI): 2.0 %
(impacts on equip. repl. & wages)

Installation

PV Panels

Panel Type:	CanadianSolar CS6X-310P			
Installed Wattage:	7.81	MW - DC		
Instal. Cost/kWdc:	$3,195.00	+	Instal. Cost:	$24,950,000
MWhr/kw (DC):	1.6	**	Resid. Accrual:	$0
O&M/kWh:	$0.00	+	Annual O&M:	$342,000
Panel Life:	30	years	(sales, w/o ACI)	
Panel Power (TP) Watt (T = nat'l)	310	Watts		
Panel Imp:	9.4	Volts		
Panel Vmp:	33.0	Volts		
Efficiency:	15.9	%		
Power/ft2:	15	Watts		
Temp Coeff:	-0.50	% C deg of Power		
Warranty:	25	years	% power	
Degradation:	0.5	% annually		
	Industry average		**=Wattage * Panel W (=J4)/1000 / ((J11 x Panel Ht (=J14) / Panel wd (=J14)))	

Inverters

Inverter:	Undefined	
Efficiency:	94	%

Overall Power Handling

DC = AC Conv. factor: 79 %

Site

Down (month#s):	1	% annual	
Rainy season:	1	(month #)	
Panel wash:	1	(month #)	
Dust/soiling attenuation factor:	1	% loss/month	
Dry season:	1	%	
		(presumes distinct seasons)	

Tracking

Tracking: 1 (1/0)
Mfr/Model: Sunflower

Fixed: Az rot: 180 deg West of TSouth (assume 12 dec/hour, middle time of Suser-1 factor)
(positioning) Alt tilt: 15 deg From horizontal, Super-A factor optimization

Output for June 21st:

Fixed Panel Placement

TOD	Panel	
5:00	1	Night
6:00	1	Night
7:00	21	Shoulder
8:00	42	Shoulder
9:00	63	Shoulder
10:00	84	Shoulder
11:00	98	Shoulder
12:00	98	Shoulder
13:00	98	Shoulder
14:00	84	Super
15:00	63	Super
16:00	42	Super
17:00	21	Super
18:00	1	Super
19:00	1	Super
20:00	1	Night
	800	total Pc wat

Single Axis Tracking (i.e. east->west)

TOD	Panel	
5:00	10	Night
6:00	30	Night
7:00	91	Shoulder
8:00	94	Shoulder
9:00	97	Shoulder
10:00	98	Shoulder
11:00	100	Shoulder
12:00	100	Shoulder
13:00	100	Shoulder
14:00	98	Super
15:00	97	Super
16:00	94	Super
17:00	91	Super
18:00	30	Super
19:00	10	Super
20:00	1	Night
	1132	total Pc wat
	28.3%	output improvement (over fixed)

Estimated Tracker Benefit, by month

December	11.0%
January	11.0%
February	15.7%
March	19.0%
April	24.2%
May	26.3%
June	26.0%
July	27.7%
August	24.3%
September	20.5%
October	15.5%
November	11.0%
December	10.4%
	19.0% average (tracking factor)

Est. benefit derived from solar angle, ref. June

%product Night: 1.4% Night: 4.4%
Shoulder: 35.2% Shoulder: 50.5%
Super: 63.5% 100.0% Super: 43.9% 100.0%

Tracker/Fixed Note:
- Tracking assumes North/South Sunflower tracker graphs (Fixed, TD single-axis) for Las Vegas (~36 deg lat; ~6.4 insol.), June 21st. [Technology & Economics of High-Efficiency c-Si PV]
- I use this data for estimating year round %production by category (an extrapolation contingent upon proper array siting)
Fixed: Azimuth = True South, Altitude = solar alt for summer solstice and/or peak rate period
Tracking: Azimuth = True South, Altitude = rotar perpendicular; typically improves power out by 15-20% (averaged over the year, summer can be 40%+)

Emissions & Resource Avoidance (Offset \| MW annually)

CO2:	1,600	tons
HFO:	1,600	tons (Like Fire Parts: + wst, NOx, SOx, etc.)
Water:	1	Mgal (as used in conv. nat. gas elect. grid.)

Estimated Annual Production & Value

Year	Total Prod. (MWhr)	Total (TOD) Prod.	Degrade Production	Net Utility Value	Ave. $/MWhr	Return after PM/M/INS costs	Prod. Breakdown (MWh, AC by TOD category, with PV degrad. factor & downtime) 1-Jan	2-Feb	3-Mar	4-Apr	5-May	6-Jun	7-Jul	8-Aug	9-Sep	10-Oct	11-Nov	12-Dec	Crude Eol (Kwhr)	Total (UC)	PPA Esc. Factor
1	17,163	$3,556,479.76		$3,033,479.76	$176.76	$2,867,479.76	341.45	819.59	0.00	380.91	794.93	0.00	489.77	998.05	31.35	593.19	1,007.26	136.71	350.62	1,284.15	213.53	571.77	1,033.18	223.87	558.85	1,041.07	185.76	597.54	986.80	120.52	381.96	921.99	59.07	348.57	886.76	0.00	282.32	817.90	0.00	298.08	792.23	0.00	18,479.2	8.66	1.0000
2	17,163	$3,660,581.21		$3,126,581.21	$182.32	$2,958,581.21	338.12	812.01	0.00	377.88	787.48	0.00	485.28	988.95	31.05	588.00	998.02	135.51	348.02	1,272.51	211.67	566.77	1,023.75	222.17	554.00	1,032.74	184.26	592.46	977.72	119.51	378.46	912.94	58.57	345.57	878.57	0.00	279.89	810.11	0.00	295.57	785.11	0.00	18,454.2	8.77	1.0127
3	17,163	$3,381,240.45		$3,181,240.45	$185.45	$2,713,240.45	335.68	806.28	0.00	374.91	782.01	0.00	482.21	979.09	30.81	584.19	991.19	134.52	345.51	1,263.64	211.78	562.52	1,016.75	220.56	550.21	1,024.41	182.73	588.40	969.65	121.05	375.46	907.24	58.12	343.00	875.55	0.00	277.87	804.82	0.00	293.31	779.55	0.00	18,394.7	8.91	1.0253
4	17,163	$3,487,240.45		$3,187,240.45	$185.70	$2,719,240.45	333.24	800.37	0.00	372.21	776.27	0.00	478.71	971.76	30.57	579.81	984.36	133.54	342.99	1,254.77	210.21	558.27	1,009.76	218.95	546.42	1,016.88	181.40	583.94	962.58	120.17	372.71	900.51	57.68	340.43	869.00	0.00	275.84	798.88	0.00	291.05	773.98	0.00	18,262.4	9.05	1.0414
5	17,163	$3,592,783.21		$3,192,783.21	$186.00	$2,724,783.21	330.80	793.17	0.00	369.51	770.53	0.00	475.21	964.43	30.33	575.42	977.52	132.57	340.47	1,245.89	208.64	554.00	1,002.77	217.34	542.63	1,009.35	180.07	579.48	955.51	119.29	370.00	893.78	57.24	337.83	862.45	0.00	273.80	793.15	0.00	288.79	768.68	0.00	18,129.2	9.19	1.0574
6	16,58	$3,143,458.57		$3,143,458.57	$189.51	$2,785,934.84	327.79	786.41	0.00	365.67	763.12	0.00	470.58	955.21	30.08	570.04	968.67	131.34	336.85	1,240.82	206.42	549.56	991.98	215.01	517.27	999.43	178.31	487.22	946.16	118.38	366.30	885.11	56.75	334.53	854.17	0.00	271.05	785.15	0.00	286.18	760.54	0.00	18,492.4	9.35	1.0773
7	16,58	$3,183,689.69		$3,183,689.69	$191.74	$2,825,933.81	324.56	780.08	0.00	362.64	756.76	0.00	467.45	947.25	29.81	565.71	959.85	130.15	333.24	1,232.15	204.60	544.14	983.72	213.20	512.56	991.10	176.63	483.15	938.28	117.28	362.25	877.74	56.43	331.84	847.09	0.00	268.72	778.48	0.00	283.72	754.24	0.00	18,456.7	9.51	1.0952
8	16,58	$3,224,442.44		$3,224,442.44	$194.02	$2,867,033.32	322.32	773.58	0.00	359.58	750.40	0.00	463.95	938.29	29.55	561.33	951.03	129.08	330.78	1,223.47	203.17	539.73	975.45	211.42	508.00	982.77	175.34	479.10	929.41	116.21	358.75	870.36	56.15	329.05	839.93	0.00	265.51	772.12	0.00	281.20	747.81	0.00	18,096.4	9.68	1.1088
9	16,58	$3,265,197.44		$3,265,197.44	$196.34	$2,908,633.32	320.09	767.21	0.00	356.52	744.04	0.00	460.69	929.33	29.29	556.95	942.21	127.99	328.32	1,214.79	201.74	535.32	967.18	209.64	503.44	974.44	173.99	475.06	920.54	115.14	355.24	862.97	55.87	326.26	832.78	0.00	263.31	765.10	0.00	278.69	741.38	0.00	17,736.4	9.86	1.1209
10	16,58	$3,305,544.55		$3,305,544.55	$198.67	$2,950,033.21	317.87	760.39	0.00	353.46	737.68	0.00	457.43	920.37	29.03	552.57	934.38	126.89	325.86	1,206.11	200.31	531.00	959.00	207.86	499.00	966.11	172.72	470.98	912.68	114.08	351.73	855.61	54.61	323.46	826.10	0.00	261.08	758.05	0.00	276.22	734.19	0.00	17,376.2	9.99	1.1353
11	15,95	$3,345,544.55		$3,345,544.55	$201.01	$2,990,533.21	314.14	751.64	0.00	350.44	731.33	0.00	453.19	915.40	28.83	549.33	926.58	125.77	322.57	997.45	198.01	525.03	950.65	206.05	495.72	957.78	170.98	466.92	904.76	113.04	351.04	848.23	54.34	320.69	818.59	0.00	258.74	752.47	0.00	274.24	728.65	0.00	17,506.7	7.83	1.1503
12	15,95	$3,385,215.11		$3,385,215.11	$203.37	$3,031,033.21	310.42	742.91	0.00	347.04	724.04	0.00	448.94	906.74	28.55	545.51	918.64	124.65	319.37	988.79	196.29	521.45	942.30	204.26	491.37	949.45	169.46	462.85	896.87	112.07	347.88	840.85	53.87	317.89	811.49	0.00	256.42	746.89	0.00	271.80	722.12	0.00	17,359.9	7.77	1.1654
13	15,95	$3,424,885.55		$3,424,885.55	$205.74	$3,072,033.21	308.00	736.17	0.00	343.68	717.20	0.00	445.07	898.55	28.27	540.69	910.70	123.53	316.18	980.13	194.57	516.87	933.95	202.47	487.01	941.12	167.94	458.78	888.99	111.09	344.72	832.47	53.40	315.10	803.39	0.00	254.09	740.30	0.00	269.37	715.56	0.00	17,212.7	7.70	1.1806
14	15,95	$3,464,576.19		$3,464,576.19	$208.12	$3,113,033.21	305.57	729.43	0.00	340.32	710.36	0.00	441.19	890.37	27.99	536.00	902.76	122.42	313.00	971.47	192.84	512.30	925.53	200.69	482.66	932.79	166.42	454.66	881.10	110.11	341.56	824.09	52.93	312.32	795.28	0.00	251.76	733.38	0.00	266.93	708.95	0.00	17,117.2	7.49	1.2019
15	15,95	$3,504,267.44		$3,504,267.44	$210.50	$3,154,533.21	303.21	727.61	0.00	337.56	704.81	0.00	437.75	883.67	27.80	531.87	895.81	121.46	310.51	963.81	191.31	508.17	917.89	199.11	478.87	925.47	165.09	451.09	873.22	109.20	338.71	816.71	52.49	309.57	788.17	0.00	249.62	726.85	0.00	264.78	703.39	0.00	17,022.8	7.28	1.2235
16	15,95	$3,544,247.55		$3,544,247.55	$212.84	$3,211,222.53	300.48	721.06	0.00	335.20	699.53	0.00	434.39	875.80	27.53	442.61	886.56	120.31	494.55	954.09	189.49	503.18	909.32	197.09	474.17	915.14	163.45	446.62	867.31	108.19	335.77	811.35	51.98	306.74	782.89	0.00	246.44	719.75	0.00	262.51	697.18	0.00	16,930.4	7.37	1.2392
17	15,95	$3,584,247.55		$3,584,247.55	$215.19	$3,248,222.53	297.75	714.49	0.00	332.84	694.25	0.00	431.03	868.02	27.26	439.42	877.31	119.17	490.97	944.37	187.67	498.20	900.75	195.07	469.49	905.82	161.82	442.24	858.43	107.18	332.49	803.00	51.47	303.91	776.60	0.00	243.26	712.64	0.00	259.94	690.97	0.00	16,844.2	7.46	1.2549
18	15,95	$3,624,247.55		$3,624,247.55	$217.56	$3,285,222.53	295.02	707.92	0.00	329.48	687.00	0.00	427.67	860.24	27.000	436.75	868.07	118.03	487.39	934.66	185.85	493.23	892.18	193.05	464.81	896.50	160.19	437.86	849.56	106.16	329.22	794.66	50.95	299.19	770.34	0.00	240.81	705.53	0.00	257.37	684.54	0.00	16,757.8	7.58	1.2707
19	15,95	$3,664,247.55		$3,664,247.55	$219.94	$3,322,222.53	292.29	701.39	0.00	326.09	680.43	0.00	423.12	851.72	26.60	432.10	859.07	116.89	483.84	924.95	183.99	488.27	883.61	191.11	460.34	887.19	158.56	433.47	840.68	105.14	325.92	786.33	50.50	296.19	762.64	0.00	238.41	698.42	0.00	254.81	677.91	0.00	16,592.8	7.71	1.3070
20	15,95	$3,704,247.55		$3,704,247.55	$222.32	$3,359,222.53	289.55	694.84	0.00	323.01	674.00	0.00	418.58	843.19	26.33	428.70	854.11	115.85	480.31	915.24	182.13	484.58	875.05	189.20	455.93	887.03	157.21	429.37	832.79	104.17	322.78	778.79	50.06	293.30	754.94	0.00	236.01	691.58	0.00	252.27	671.31	0.00	16,428.9	7.84	1.3237
Totals:	320,13	$64,464,390.21		$64,664,390.21	$201.71	$58,464,390.21	Net																										

*** Tracker Question

Emissions & Resource Offset:
CO2, tons: 298,320 UFPs, tons: 79 H2O, Mgal: 272

Formulas
Monthly/TOD AC Production: MW (installed wt) for temp, soiling, AC conv [h55] * (1 - PV annual degrad)^(19/100) * (#hours cal)[h57] * down[100-a20]/100]

Financials

Bond Costs	$24,950,000 (from PV section)
30% ITC	$7,485,000
Land	$1,000,000
Financing	$1,000,000
Net Costs	$16,465,000
Tax Rate	35% (from Est. Prod. Return)
Revenue	$12,929,773 28.12%

Notes:
1. This model is meant only as a ROUGH estimation of expected production. Influences of wind speed, area fires (haze), climate change, leap years, DQ or other mandated curtailment periods, etc. have not been accounted for…
2. Tracking systems are assumed to be single-axis, north-south orientation (sunflower).
This model does not accommodate regions of interest where sunset occurs after Super period (or in 2nd cut. Shoulder)…
Every effort has been made to include critical factors and to ensure the accuracy of the data.
3. Contract Deposits are estimated based on Contract Section 8.4(a)(i)(C) Bid Assurance, Available Cascade (1.5) and Contract Cascade (3.1b/f) since the facility's grid tie point is unknown at this time. Costs of such connection are not included for the same reason.
3. Contract stated each year will have its own quantity specified (ref. PV degradation, see Total Prod. column) [3.1(a)(i) and Appx V]
4. The Production and Forecasting Penalty segments of this model are presently inactive. In general all projections will be based on similar data as this model (including averaged downtime).
5. All references included (where applicable) are for the sample PG&E PV PPA, except where SolProt noted (PG&E 2010 Solicitation Protocol document).

(Green cancelled are Ken Bode's Cost 2/10/11)

Queries / Concerns for PG&E:
1. Need to clarify Guaranteed Monthly Production (100%), sec. 3.1a/d/f/h - does this mean we guarantee a minimum of 100% of annual contract etc over 2 years (i.e. 80% annual)? -- Yes
2. Need to clarify Forecasting Penalties (50% (twice) or 150% (Penalty)) and Under & Over (30%) (see Section 3.1 for proper figure)
2. Need to clarify Forecasting Penalties (150%), sec. 4.5(c) - This is a pretty narrow band when considering overcast conditions, fire or other haze, etc.
3. There is a provision of Energy Deficiency (sec. 3.1(b)) that may be useful (i.e. selling overflow to others), but I suspect this would be complex (CalISO regist., school, etc.).
4. Contract Deposits (Section 8.4) seem high (see Section 8.4 above).
5. Does Contract Cascade refer to total production capacity, annual cap (ref. PV degradation), or an average? -- see Section 3.1(f) -- it comes from the annual production of what will be produced.
6. Wasco and equipment cost rise over time; the PPA contract needs to have these provisions negotiated, at least in 5 year increments (note impact, ref. ACI). -- No negotiations for service rates or escalone

and

Formulas
Crude Production = MW inst. capacity * (power conv-effic. - (PV annual degrad)) * tracking factor * #hours insolation * (#days year - down)
Crude Value = contract price * above (NO escalation factor incl.)

Checks

Prod. avg. (DC)	18,129.2	
Paid for sold/wasted: Prime * (sol degradation factor * #months since wash)	0	
Prod. AC, Prod DC * DC to AC conversion factor	0	
Wattage/TOD cat. * Cat1 + (#days in month/7)*2 - #NERC holidays for month [wasest, counting weekdays - NERC holidays]; Cat2 = #days in month - Cat1 days [wasest, Counting Sat, Sun NERC holidays];	0	
Prd hours/cat: Super: #days cat. * ((sunset - 0.5hrs) - Super start)); [sunset presumed before end of super]; Shoulder: (#days mo. * (Tracker, 1 = no tracker, 1)) - (Super hrs + 0.5hrs) * #days cat.; Night: if sunrise < 0.5hrs = Night end, (Night end - sunrise + 0.5hrs) * #days cat.; Check total against: (Avg. hrs. - 1hr) * #days in year	0	
Prod. Hours/cat: Super: pot. hrs * ((insol hrs * (Tracker, 1 = no tracker, 1)) + ((pot hrs - ((days/4hrs - 1)) * (((insol hrs * (Tracker, 1 = no tracker, 1)) - ((pot hrs - ((days/4hrs - 1))); Shoulder: (#days * insol hrs * (Tracker, 1 = no tracker, 1)) - ((pot hrs - ((days/4hrs - 1))); Night: pot. hrs * ((insol hrs * (Tracker, 1 = no tracker, 1)) - ((pot hrs - 1))	0	
Insol. Hours: 365 days * average insolation for site	1,860.5	hours
Value/MWhr: Bid price * (if(month == low month & sol month == high month A), use cash, else if(month == low month || sol month == high month B), use cash), else use calc);	$150.00	Avg value

Interim Formulas
Temp comp: soiling = ((((avg temp for month+30 deg)-25 deg)*temp coef)/100)*inst. Wattage) + inst. Wattage

Crude Eol (Kwhr)

Total (UC)	7,863

Total Crude Eol. Prod. (GWHr): 98.1
Crude Prd. Value of above: $14,955,874

Prod. MWhr Avg -- lifetime

Formulas
Crude Value = contract price * (1 - PPA annual degrad) * tracking factor * #hours insolation * (#days year - down)