BEGINNING PHOTOVOLTAICS

ONLINE RESOURCES

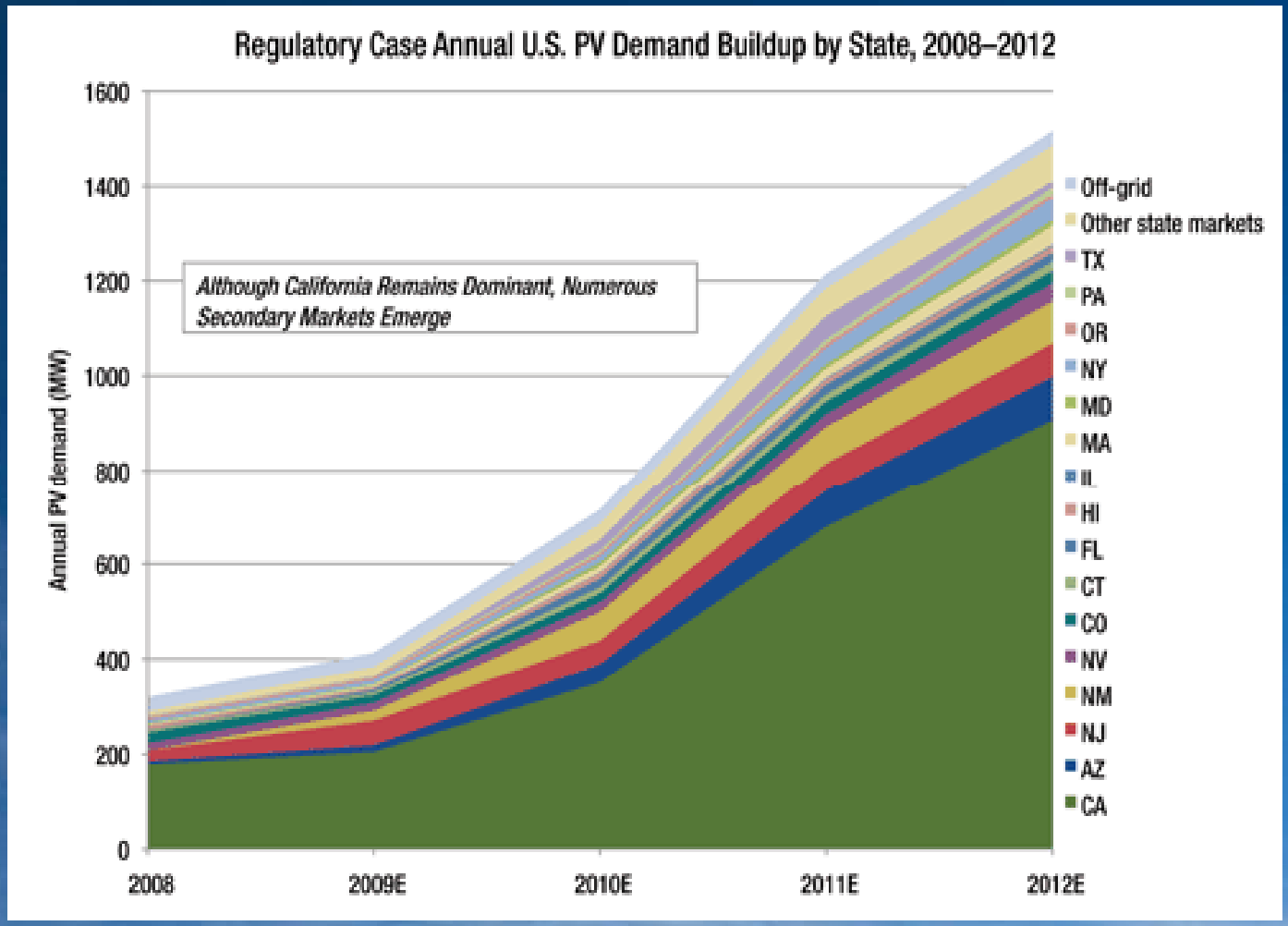
Basic Design Manual
www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF
Solar Pro Magazine
http://solarprofessional.com/home/
Orientation: Azimuth and Pitch
http://www1.solmetric.com/tools/RoofAzimTool.htm
http://www.solmetric.com/annualinsolation-us.html
Modules and Inverters
http://www.solarhub.com/
http://www.pvselect.com/index.php
Incentives and Rebates
http://dsireusa.org/
Design Programs
PV*SOL
PVSYST
PVWATTS
Solmetric SunEye
http://www.solmetric.com/
Solar Pro Magazine
http://solarprofessional.com/issue/?backissues=1
Sun Position
http://squ1.org/wiki/Solar_Position_Calculator
Backup Battery Capacity
http://www.xantrex.com/support/gtsizing/disclaimer.asp?lang=eng
Wind Speed
http://www.windspeedbyzip.com/

HISTORY AND MARKET

2010 Global PV Demand Analysis and Forecast

Between 2000 and 2009, global PV demand grew at an average annual rate of 51 percent, rising from 170 MW to 7,059 MW. Despite this impressive rate of growth, the past two years have witnessed a fundamental and difficult market shift for manufacturers. Previously, burgeoning European feed-in tariff markets enabled global demand to exceed available supply, driving up feedstock prices and attracting new entrants across the value chain. But the combination of an ensuing rapid capacity build-out and the financial crisis of 2008 and early 2009 shifted market power downstream into the hands of project developers and financiers. Today, global manufacturing capacity greatly exceeds global demand. With an estimated total of 16.1 GW of module manufacturing capacity online by the end of 2010, despite this, the global PV market is still constrained by supply.

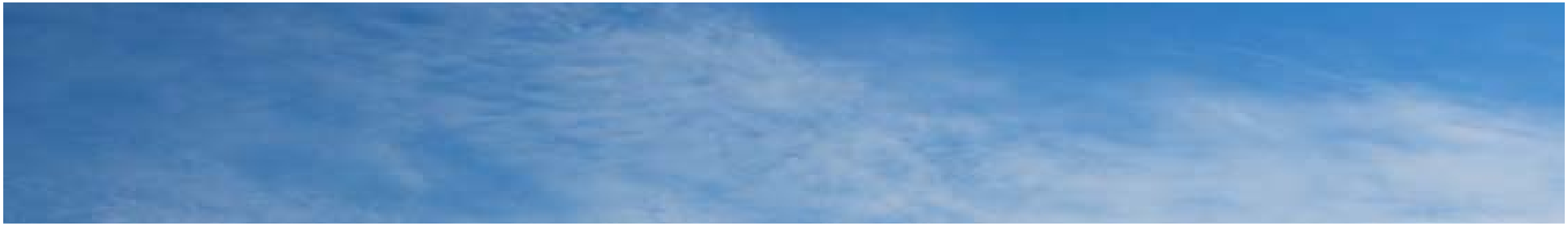
US DEMAND FOR PV



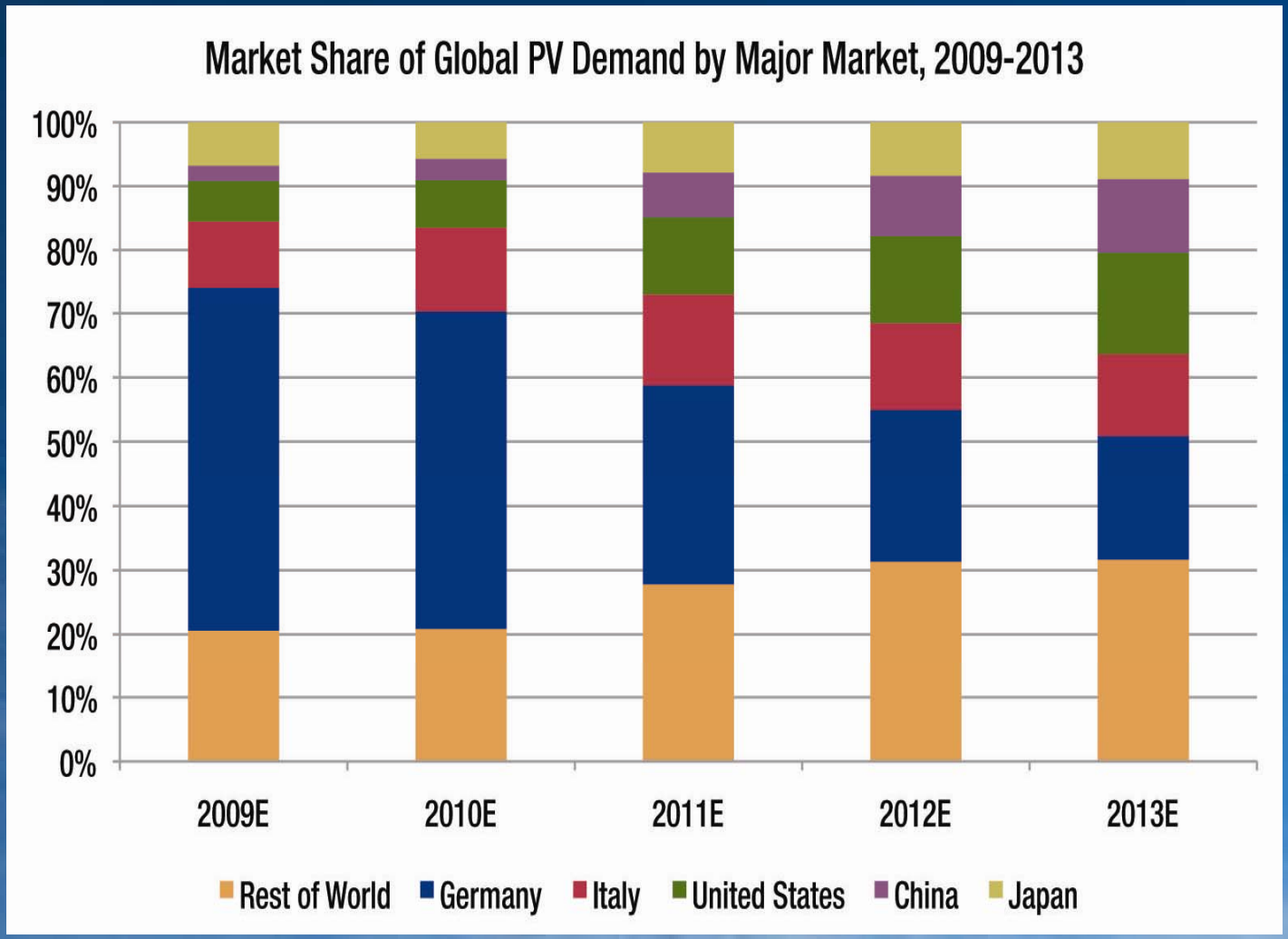
US DEMAND FOR PV

US Solar PV Forecasts (MW)

	2007	2008	2009	2010E	2011E	2012E	2013E
California	91.8	176	220	535	1,100	1,700	3,000
New Jersey	20.4	22.5	57	100	200	300	400
Florida	0	0	36	30	45	50	60
Colorado	12	22	23	25	50	75	100
Arizona	3	6	23	30	50	70	100
Hawaii	3	9	14	23	50	83	136
New York	4	7	12	19	31	52	86
Massachusets	2	5	10	10	50	80	150
Connecticut	3	5	9	14	10	17	27
North Carolina	0	4	8	8	20	50	100
Nevada	16	15	2	3	10	20	50
Oregon	1	5	3	4	10	15	25
Texas	0	0	2	8	50	50	100
Pennsylvania	0	0	2	10	30	50	70
Others	7	16	25	40	254	349	556
Non Grid	60	64	40	40	40	40	40
TOTAL	**222**	**356**	**485**	**900**	**2,000**	**3,000**	**5,000**



CURRENT DEMAND 9GW
CURRENT CAPACITY 16GW

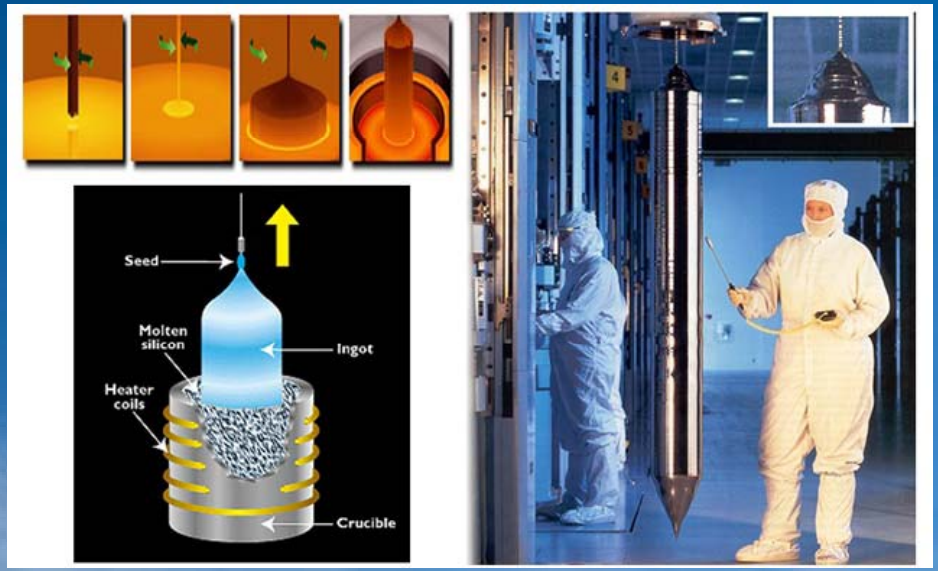


Single Crystal Silicon Solar Cell

The first generation of solar cells

- Silicon is abundant and the process is mature
- Relatively high efficiencies with broad spectrum absorption range

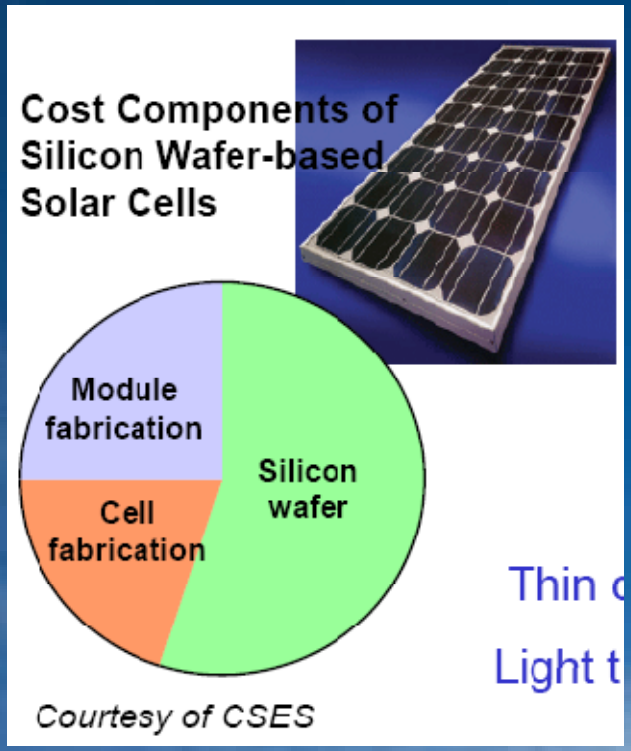
http://www.day4energy.com/EN/installations.htm

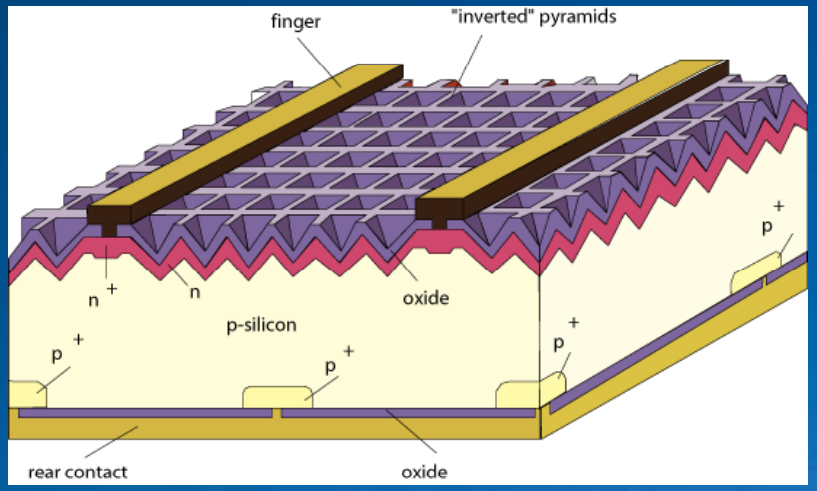


http://cnfolio.com/images/img163ingot.jpg

Single Crystal Silicon Solar Cell

- Passivated emitter with rear locally diffused cell (PERL) has a record efficiency of 24.7%[1]





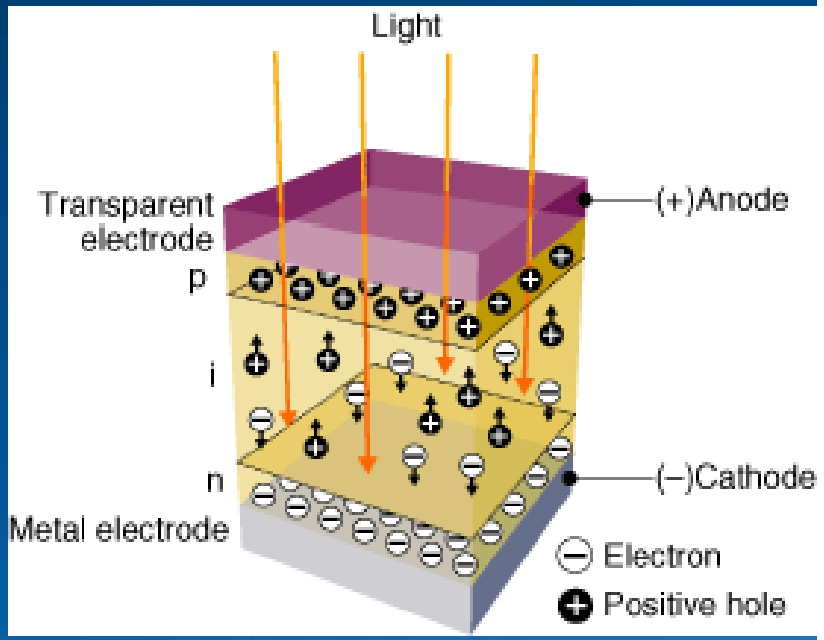
- Disadvantages
  - Expensive manufacturing costs
  - High Material Usage
  - Loss of high energy photons as heat

[1]*Prog. Photovolt: Res. Appl. 7, 471-474 (1999)*

http://www.kanoda.com/PVTechnologyandIndustry.html

Amorphous Silicon (α-Si) Solar Cell

- Advantages over c-Si:
  - Simple and inexpensive technology
  - Much less material required
  - Can be monolithically deposited on a wide range of substrates by PECVD
- Efficiency about 13%
- Large Band gap ~1.6eV
- Disadvantages
  - Low material quality
  - Not stable over time

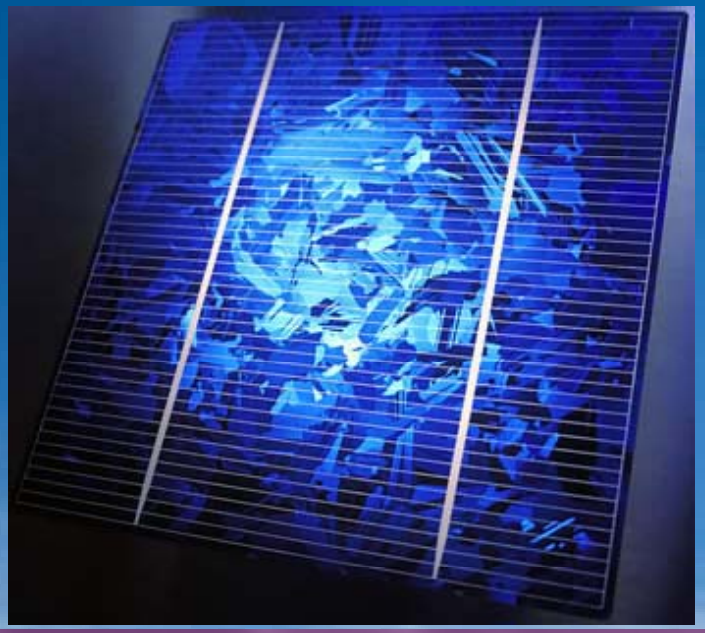


http://www.semiconductor-sanyo.com/images/amorton/sensor/st.gif
http://www.solarserver.de/wissen/photovoltaik-e.html

Amorphous silicon photovoltaic module Bangkok Solar 2.5 kW

Polycrystalline Silicon Solar Cell

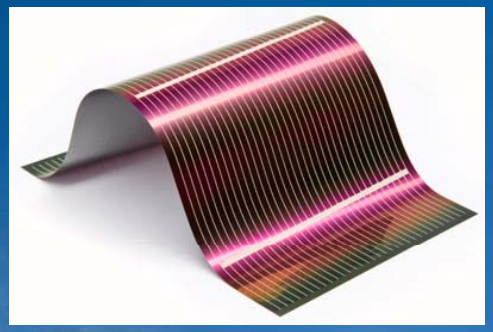
- Cheaper to produce than single crystalline silicon cells
- Simple manufacturing process
- Slightly less efficient, with average efficiencies of around 18%.
- Disadvantages
  - Lower electronic quality
  - Increased fragility



www.m0ukd.com/Solar_Panels/index.php
http://en.wikipedia.org/wiki/Crystalline_silicon

Copper Indium Gallium Diselenide (CIGS) Cell

- Deposited on either glass or stainless steel substrates by vacuum deposition or inkjet-style printing
- Band gap ~ 1.38 eV
- An efficiency of 19.9% is achieved
- Disadvantage
  - Increased toxicity
  - Scarce raw materials

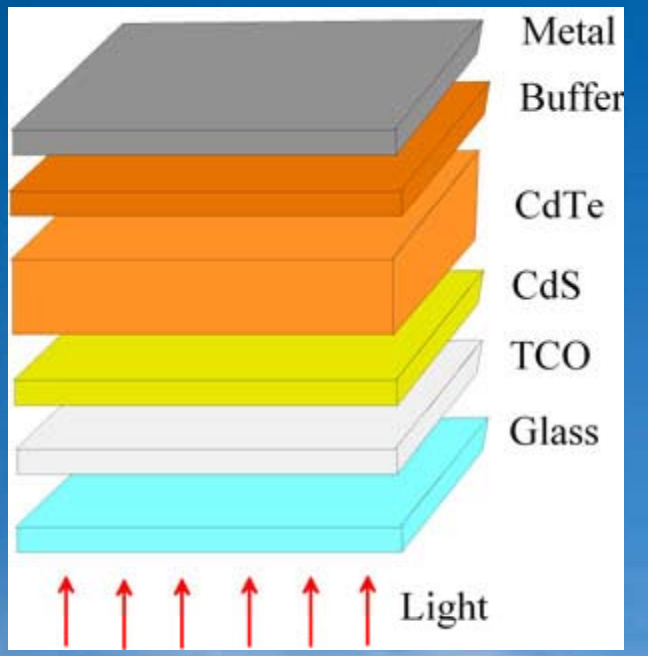


A single flexible Global Solar G2 CIGS solar cell

http://www.globalsolar.com/

Cadmium Telluride (CdTe) Cell

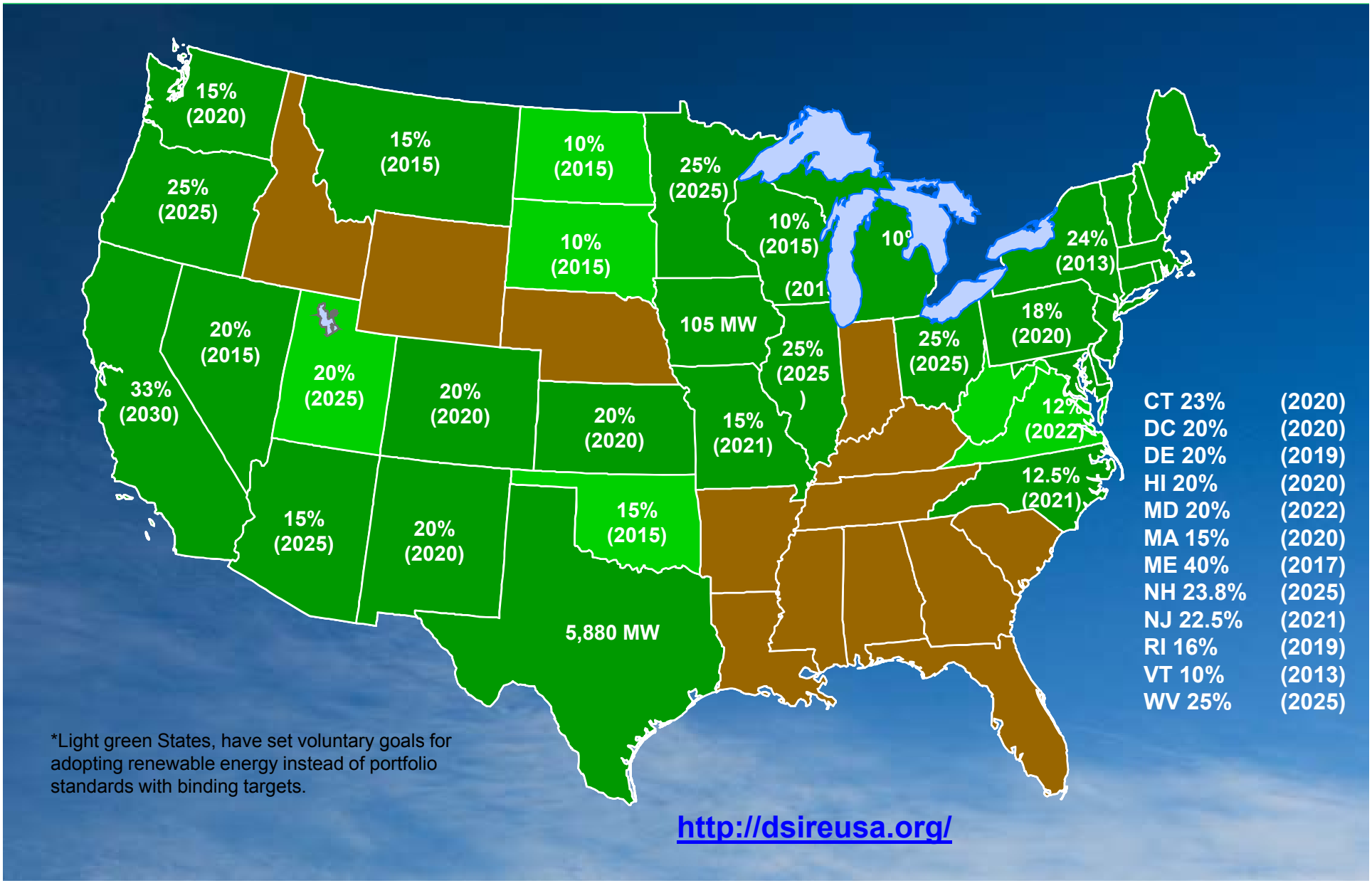
- Crystalline compound formed from cadmium and tellurium. Usually sandwiched with cadmium sulfide (CdS) to form a p-n junction cell.
- Cheaper material and inexpensive production
- Band gap ~ 1.4 eV
- Efficiency of ~16 %
- Disadvantages:
  - Susceptibility to degradation
  - Cd toxic
  - Te feedstock issues



X. Wu, Solar Energy 77 (2004) 803-814
www.solar-sse.com/cts.htm
www1.eere.energy.gov/solar/cadmium_telluride.html

FINANCING

RENEWABLE PORTFOLIO STANDARDS



*Light green States, have set voluntary goals for adopting renewable energy instead of portfolio standards with binding targets.

http://dsireusa.org/

INCENTIVE TYPES

- PBI / FIT – Performance Based Incentives / Feed in Tariff
  - Incentives based on amount of kWh produced
- REC – Renewable Energy Credits
  - In some states they can be sold, the PPA provider keeps the REC to help pay for the System. If cap and trade becomes law, then the REC's could be sold nationally.
- Rebate
  - Typically based on installed DC watt rating of the system and can be based on % or fixed $/watt
- Tax Credit

There is a 30% Federal Grant for PV until 2016

FINANCING SOLAR

- In most locations solar is not economical without incentives and subsidies.
- Systems that have a 10 year or better payback can be financed.
- Typical investors are looking for investments that are secure, long term and responsible and they accept a moderate interest rate.
- Tax equity partners receive a higher interest rate and shorter term.

EXAMPLE NEW JERSEY

500kW system with existing roof

Total Installation Cost	($2,500,000)
30% Federal Grant	$750,000
Accel. 5yr MACRS (35% Tax)	$612,500
Annual Sale of Electricity	$77,000
Annual Sale of RECS	$275,000

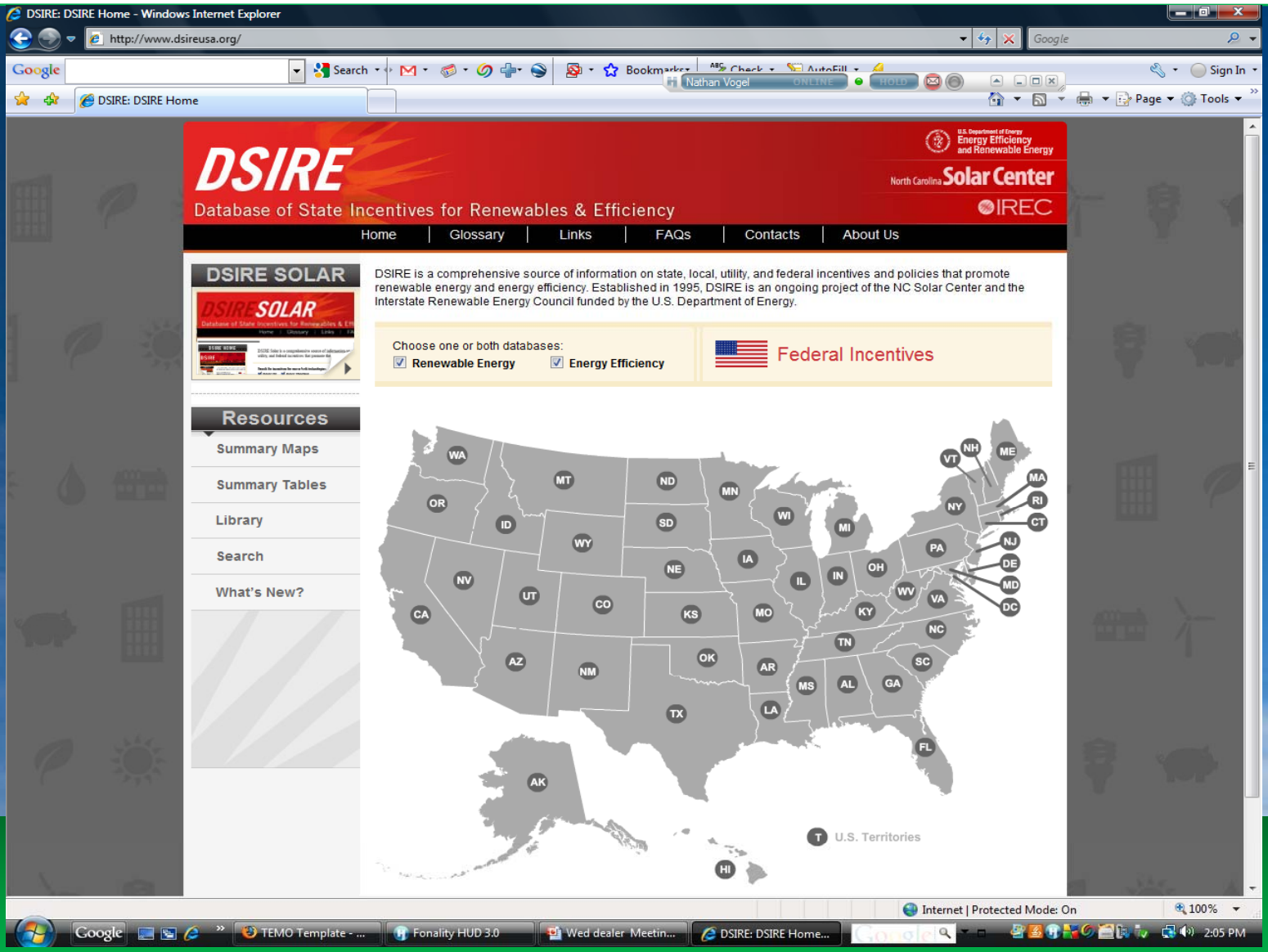
EXAMPLE OREGON

500kW system with NEW roof

Solar Installation Cost	($2,500,000)
New roof	($500,000)
Total Installation	($3,000,000)
30% Federal Grant	$900,000
50% Oregon Tax Credit (5yrs)	$1,500,000
Accel. 5yr MACRS (35% Tax)	$210,000
Annual Sale of Electricity	$33,000
Annual Sale of RECS / Tariff	$48,000

We use the roof membrane as part of the solar installation because it's fully adhered to the roof.

FINDING INCENTIVES ON DSIREUSA.ORG

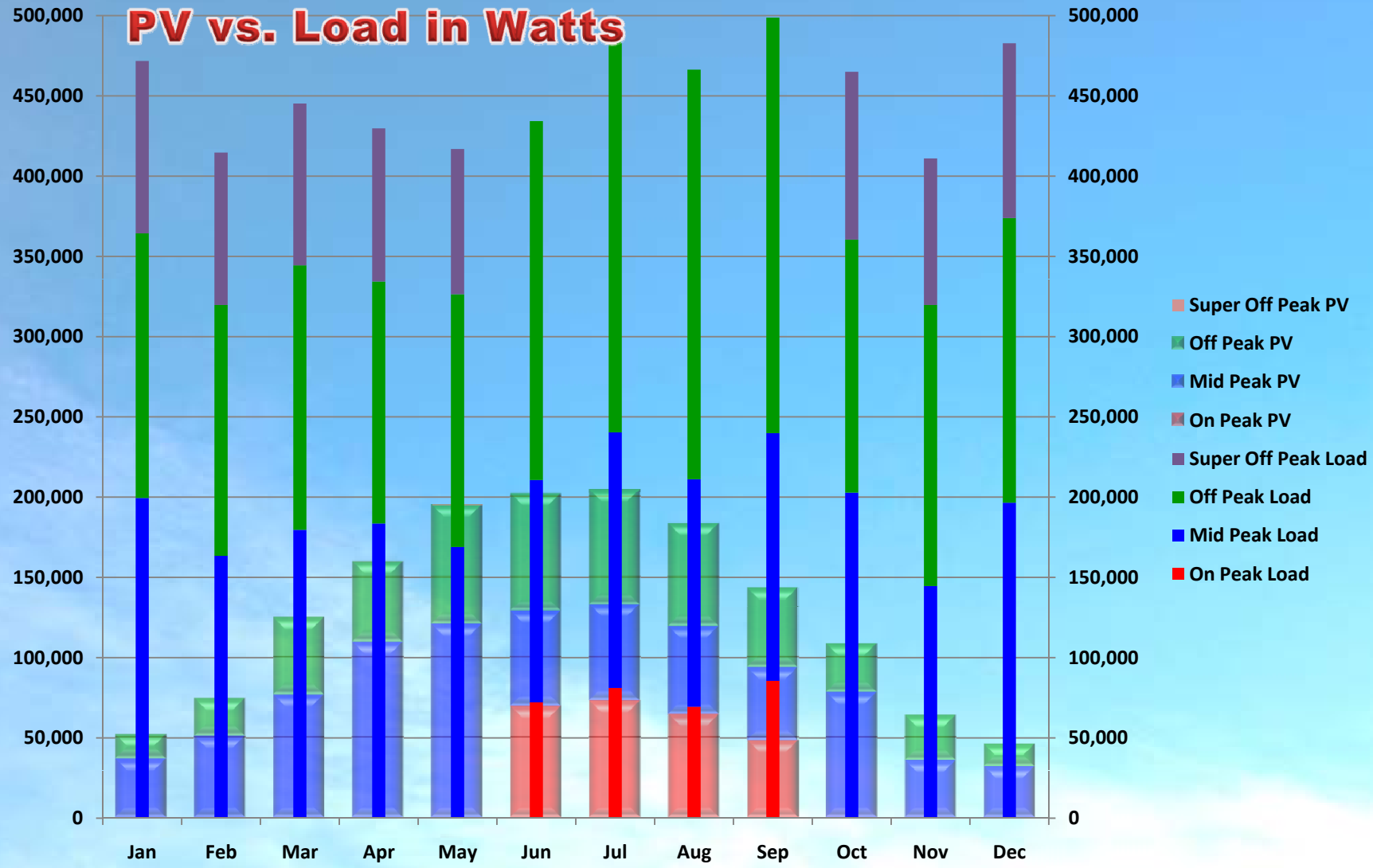


PRICES PER WATT

PV Panels	• 50% • Glass thin-film is the least expensive
Racking/Mounting	• 10% • Roof racking is the least expensive
Inverters	• 5% • Larger inverters may not be the cheapest
Balance of System	• 10% • Wiring, monitoring, etc.
Installation	• 25% • Labor to install panels and electrical
Total	• $5 to $6 • Roof mounted systems can be the cheapest

1MW $5 to $6 Million

Electrical Profile



Revenue Stream

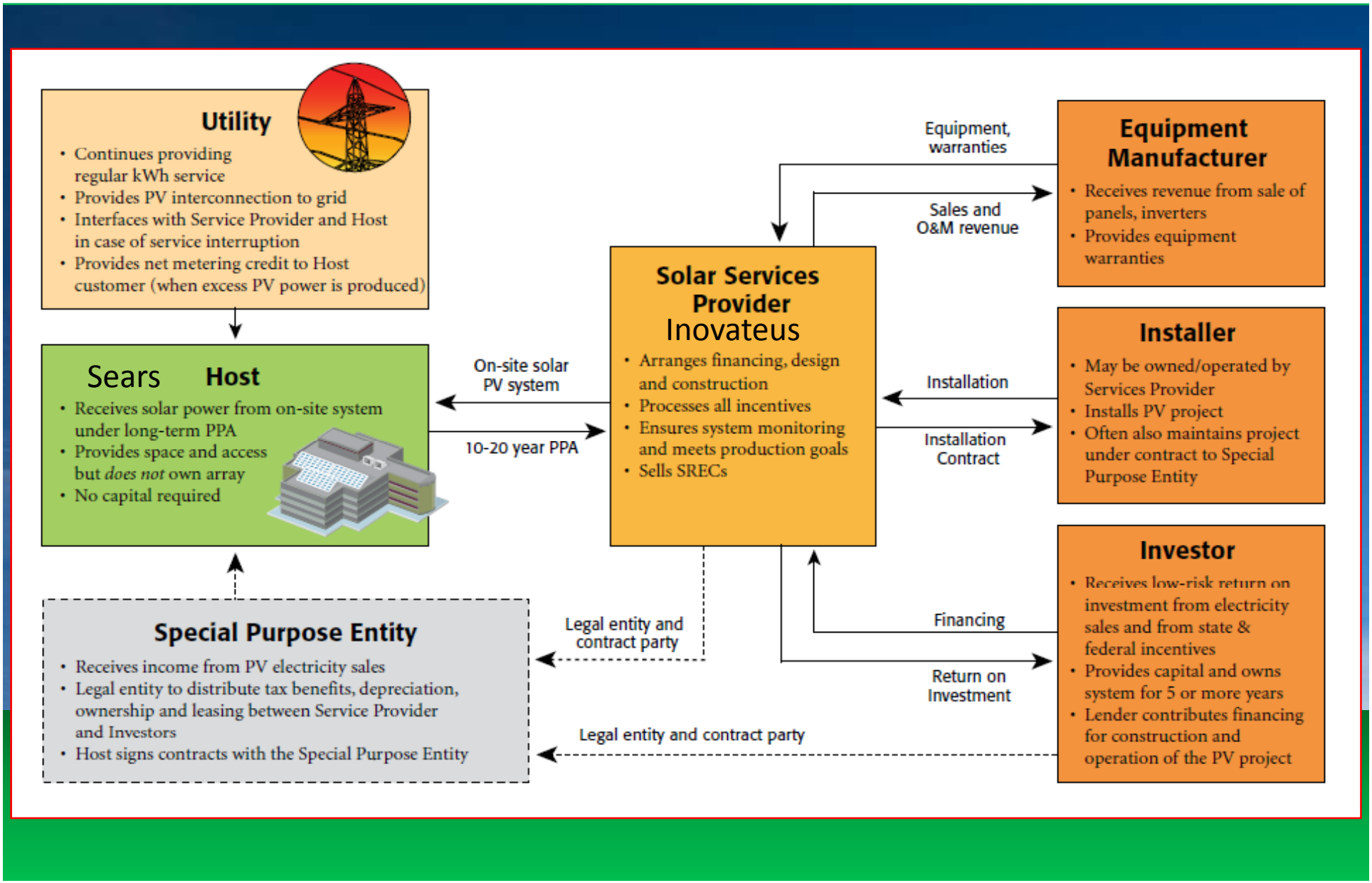
1 MW Installation

Starting Annual kWh production	1,555,504
Annual Derate of output	0.5%
Value of kWh TOU-R-Primary	$ 0.13660
Annual kWh Escalation rate	2.7%

Value of CSI kWh	$ 0.22
Maintenance Cost per kWh	$ (0.005)
Insurance cost per kWh	$ (0.005)
Inflation Rate	3%

	Year	Annual kWh	Value of kWh	Value of Elec	CSI per kWh	Value of PBI	Gross Revenue	Maint per kWh	TTL Maint Cost	Insur per kWh	TTL Insur Cost	Net Revenue
0	2010	1555504	$ 0.13660	$ 212,482	$ 0.22	$ 342,211	$ 554,693	-0.00500	$ (7,778)	-0.00500	$ (7,778)	$ 539,138
1	2011	1547726	$ 0.14029	$ 217,128	$ 0.22	$ 340,500	$ 557,628	-0.00515	$ (8,011)	-0.00515	$ (8,011)	$ 541,606
2	2012	1539988	$ 0.14408	$ 221,875	$ 0.22	$ 338,797	$ 560,673	-0.00530	$ (8,251)	-0.00515	$ (8,011)	$ 544,411
3	2013	1532288	$ 0.14797	$ 226,727	$ 0.22	$ 337,103	$ 563,830	-0.00546	$ (8,499)	-0.00515	$ (8,011)	$ 547,320
4	2014	1524626	$ 0.15196	$ 231,684	$ 0.22	$ 335,418	$ 567,102	-0.00563	$ (8,754)	-0.00515	$ (8,011)	$ 550,337
5	2015	1517003	$ 0.15606	$ 236,750			$ 236,750	-0.00580	$ (9,016)	-0.00515	$ (8,011)	$ 219,723
6	2016	1509418	$ 0.16028	$ 241,926			$ 241,926	-0.00597	$ (9,287)	-0.00515	$ (8,011)	$ 224,629
7	2017	1501871	$ 0.16461	$ 247,216			$ 247,216	-0.00615	$ (9,565)	-0.00515	$ (8,011)	$ 229,640
8	2018	1494362	$ 0.16905	$ 252,621			$ 252,621	-0.00633	$ (9,852)	-0.00515	$ (8,011)	$ 234,758
9	2019	1486890	$ 0.17361	$ 258,145			$ 258,145	-0.00652	$ (10,148)	-0.00515	$ (8,011)	$ 239,986
10	2020	1479456	$ 0.17830	$ 263,789			$ 263,789	-0.00672	$ (10,452)	-0.00515	$ (8,011)	$ 245,326
11	2021	1472058	$ 0.18312	$ 269,557			$ 269,557	-0.00692	$ (10,766)	-0.00515	$ (8,011)	$ 250,780
12	2022	1464698	$ 0.18806	$ 275,451			$ 275,451	-0.00713	$ (11,089)	-0.00515	$ (8,011)	$ 256,351
13	2023	1457375	$ 0.19314	$ 281,474			$ 281,474	-0.00734	$ (11,422)	-0.00515	$ (8,011)	$ 262,041
14	2024	1450088	$ 0.19835	$ 287,628			$ 287,628	-0.00756	$ (11,764)	-0.00515	$ (8,011)	$ 267,853
15	2025	1442837	$ 0.20371	$ 293,917			$ 293,917	-0.00779	$ (12,117)	-0.00515	$ (8,011)	$ 273,789
16	2026	1435623	$ 0.20921	$ 300,343			$ 300,343	-0.00802	$ (12,481)	-0.00515	$ (8,011)	$ 279,852
17	2027	1428445	$ 0.21486	$ 306,910			$ 306,910	-0.00826	$ (12,855)	-0.00515	$ (8,011)	$ 286,045
18	2028	1421303	$ 0.22066	$ 313,621			$ 313,621	-0.00851	$ (13,241)	-0.00515	$ (8,011)	$ 292,370
19	2029	1414196	$ 0.22662	$ 320,478			$ 320,478	-0.00877	$ (13,638)	-0.00515	$ (8,011)	$ 298,830
20	2030	1407125	$ 0.23273	$ 327,486			$ 327,486	-0.00903	$ (14,047)	-0.00515	$ (8,011)	$ 305,428

ROLES OF PPA PARTICIPANTS



SOLAR PPA REVIEW

Private Creative Financing Company (LLC established for every contract)

Capital

*Bank, Insurance

*Private Equity

*Tax Equity

Incentives

*PBI/FIT

*REC

*Rebate

*Tax Credit

MACRS

Accelerated depreciation for PV and Roofs

O&M

Roofing Manufacturer or Third Party

Insurance

PV Cleaning and Maintenance

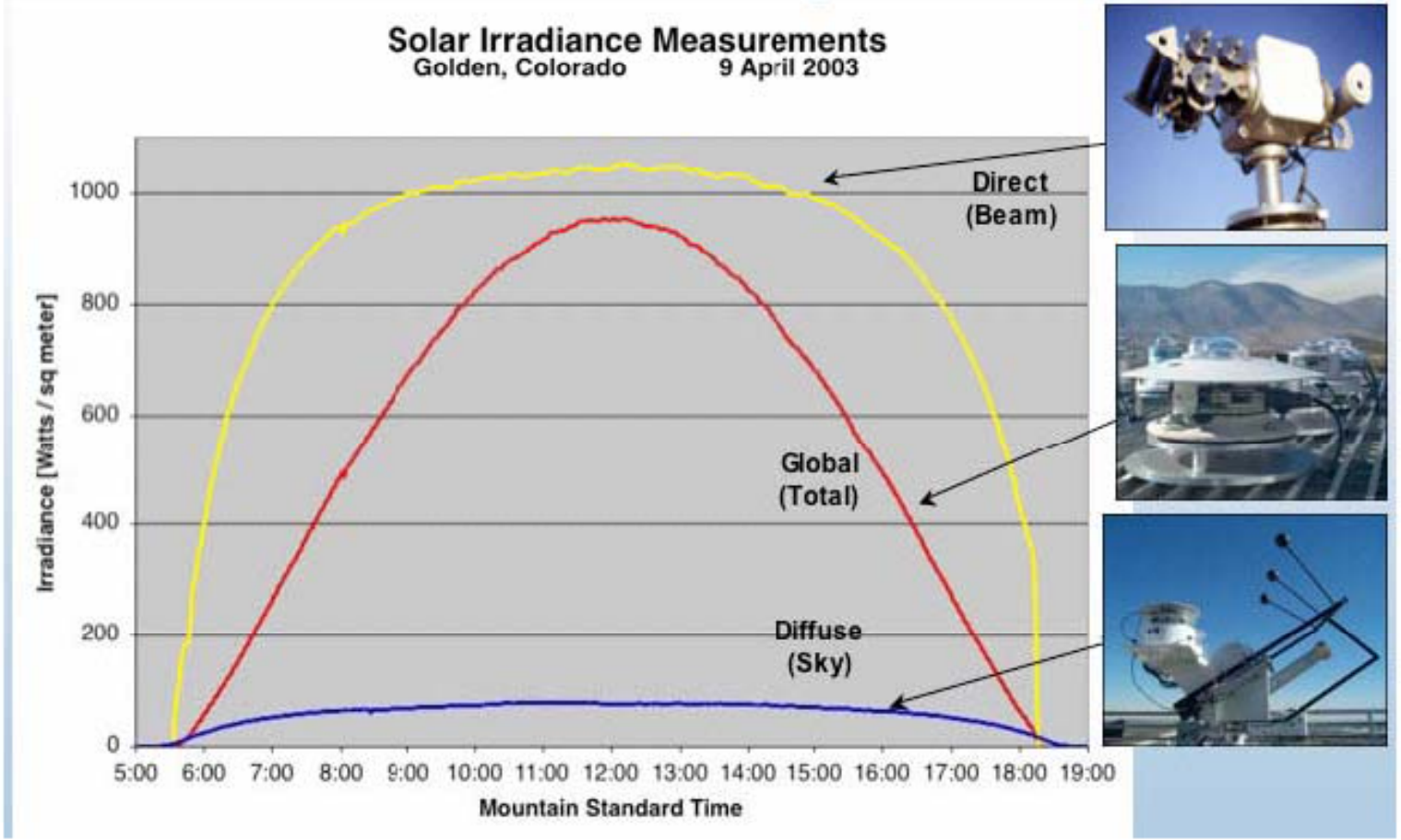
Finance Company owns and maintains the PV system for the term of the contract

Ideal Term for Sears Holding

THE SUN

How does the amount of solar radiation vary throughout the day?

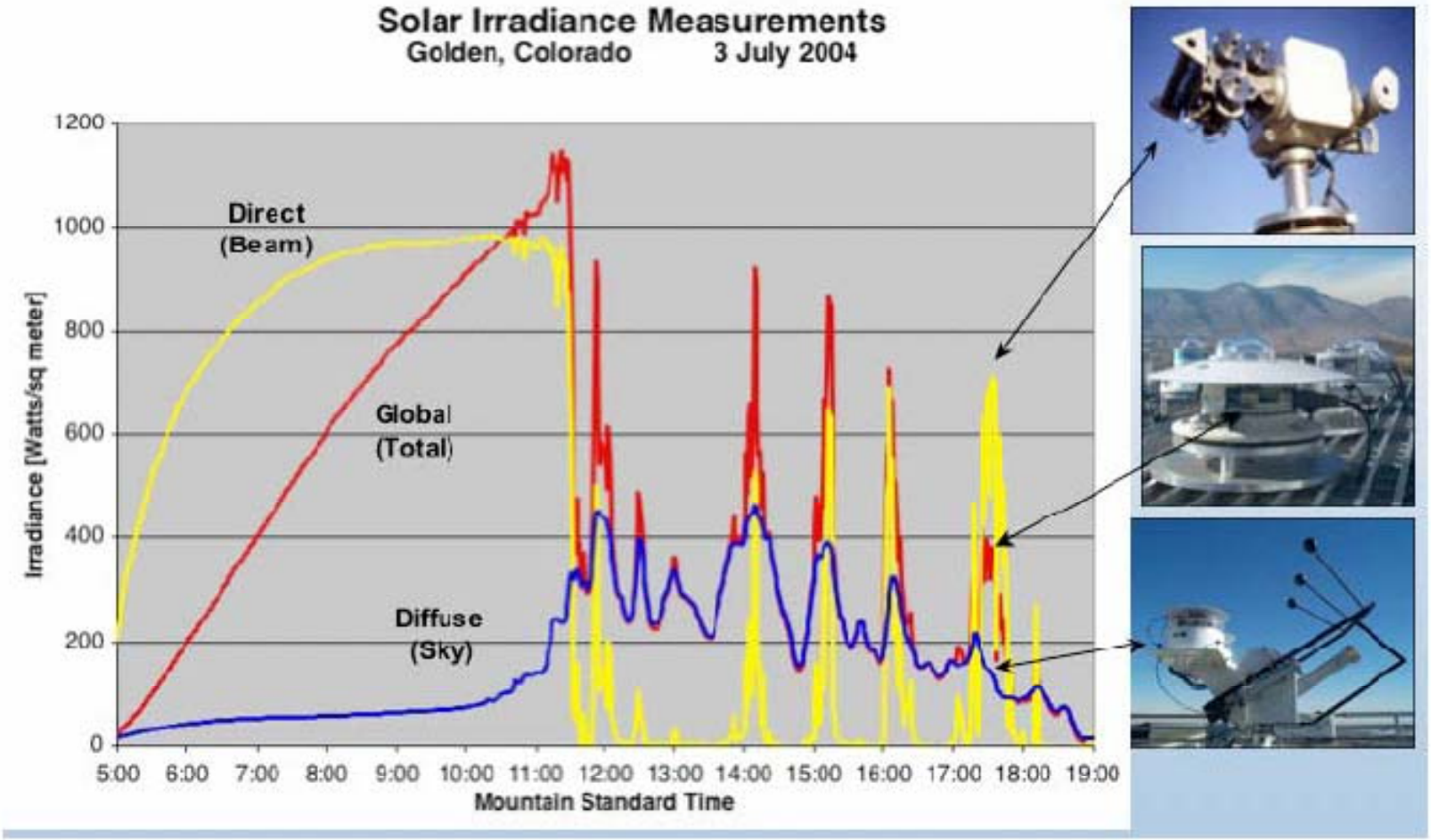
Clear Sky



http://www.nrel.gov/srrl/history.pdf

Partly Cloudy Sky

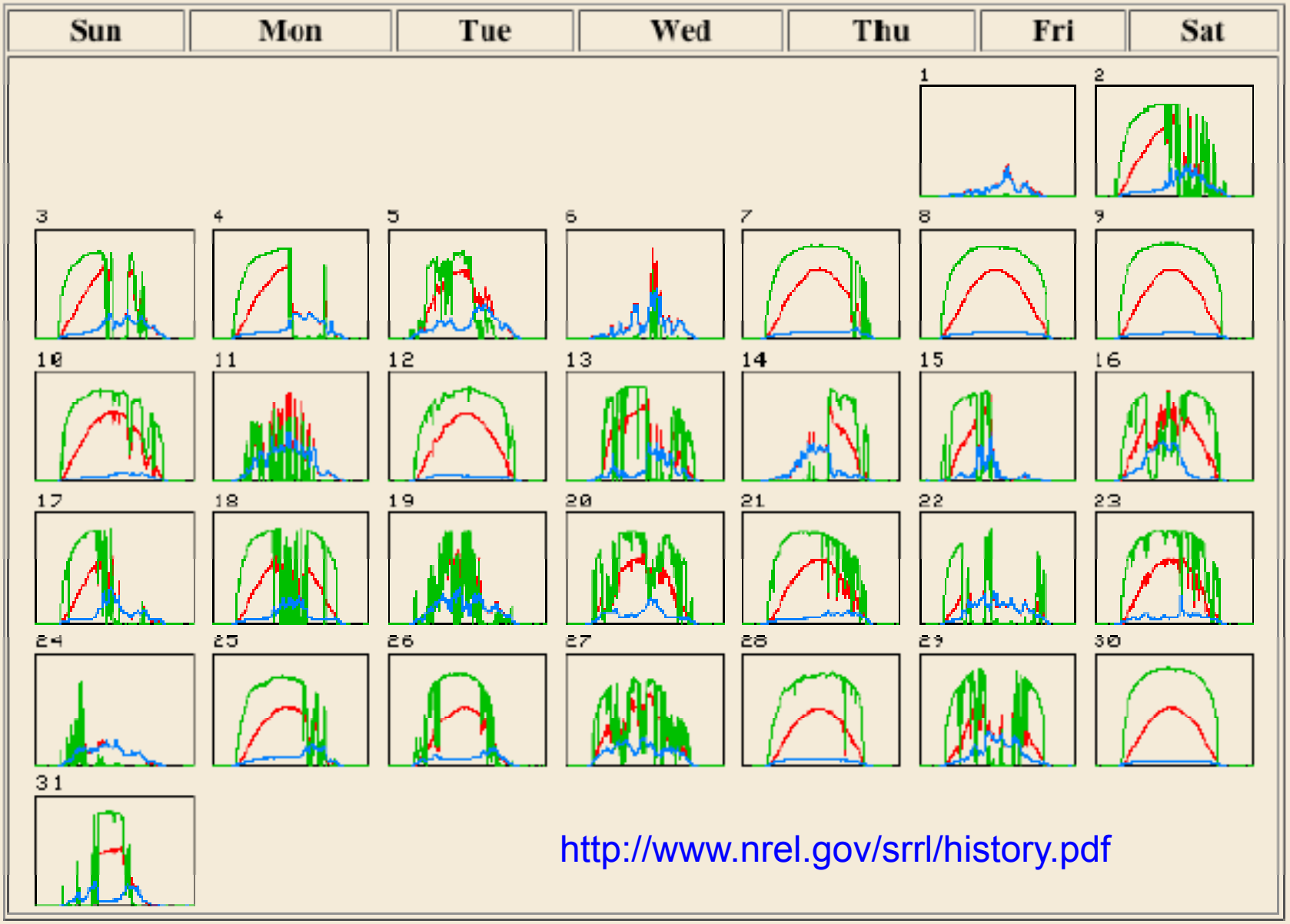
NREL Solar Radiation Research Lab



http://www.nrel.gov/srrl/history.pdf

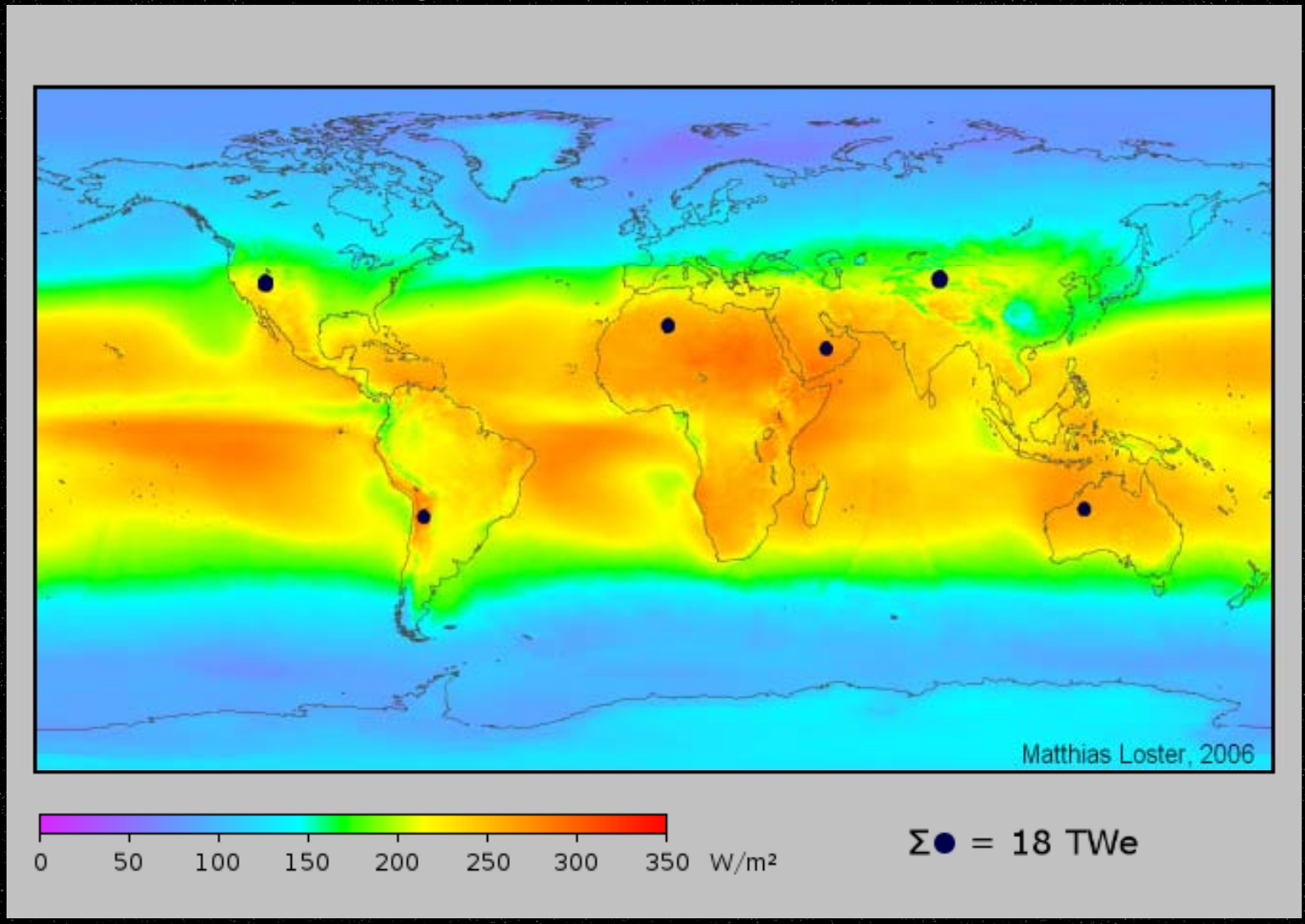
Solar Radiation Research Laboratory (BMS)

October 2004 Solar Calendar



http://www.nrel.gov/srrl/history.pdf

The average power of solar radiation is 200 W/m^2

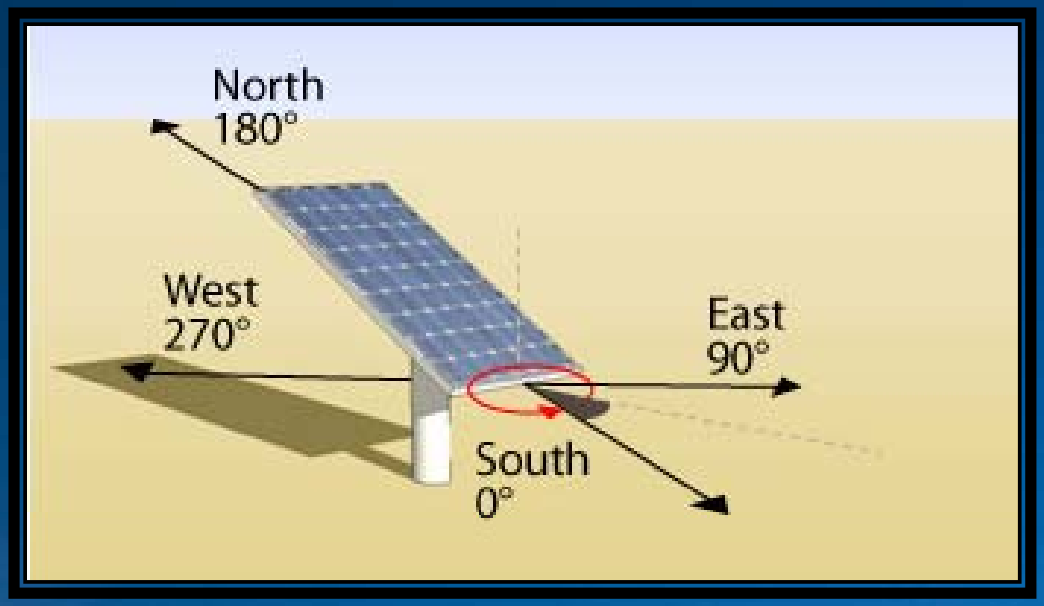


At 8% conversion, PV arrays at these locations would provide 18TW of energy.

http://www.loster.com/ml/solar_land_area/
A 'plain English' version: http://home.iprimus.com.au/nielsens/solrad.html
Wikipedia: http://en.wikipedia.org/wiki/Solar_power

DESIGN

AZIMUTH



An azimuth of 0 corresponds to a south-facing array; 90 to an east-facing array; 180 to a north-facing array; and 270 to a west-facing array. Therefore, the azimuth of an array facing 20 east of south will be 20, while the azimuth of a PV array facing 20 west of south will be 340.

http://www1.solmetric.com/tools/RoofAzimTool.htm#

1. Locate Roof

Address:

800 Fort Negley Blvd., nashville, tn Find

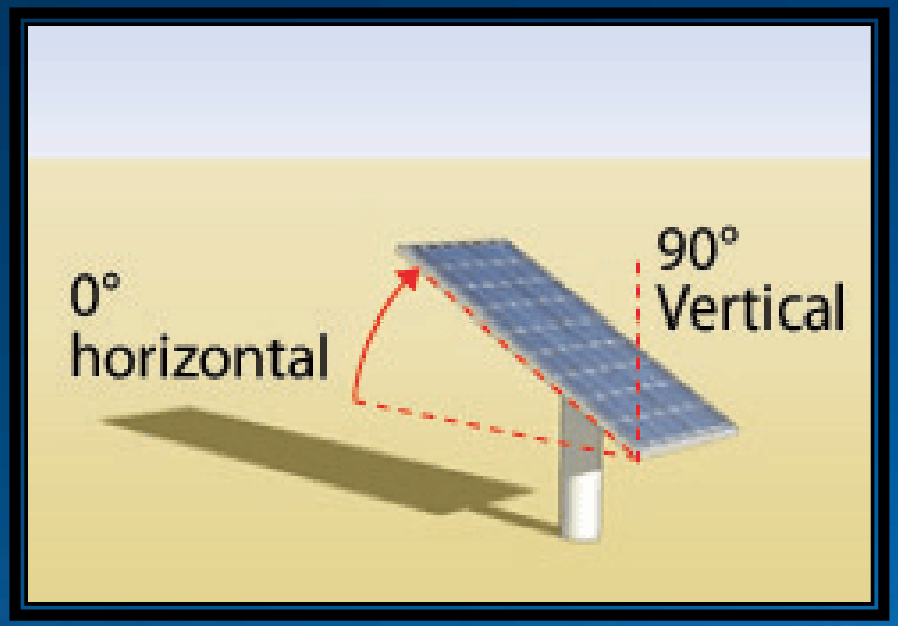
2. Measure Roof

Click this button to put your mouse pointer into "measure mode". By clicking and dragging the mouse along the roof edge, draw a line along the edge of the roof in the direction you want to measure.

3. See Results

The measured true azimuth direction is: 158.0°

PANEL TILT

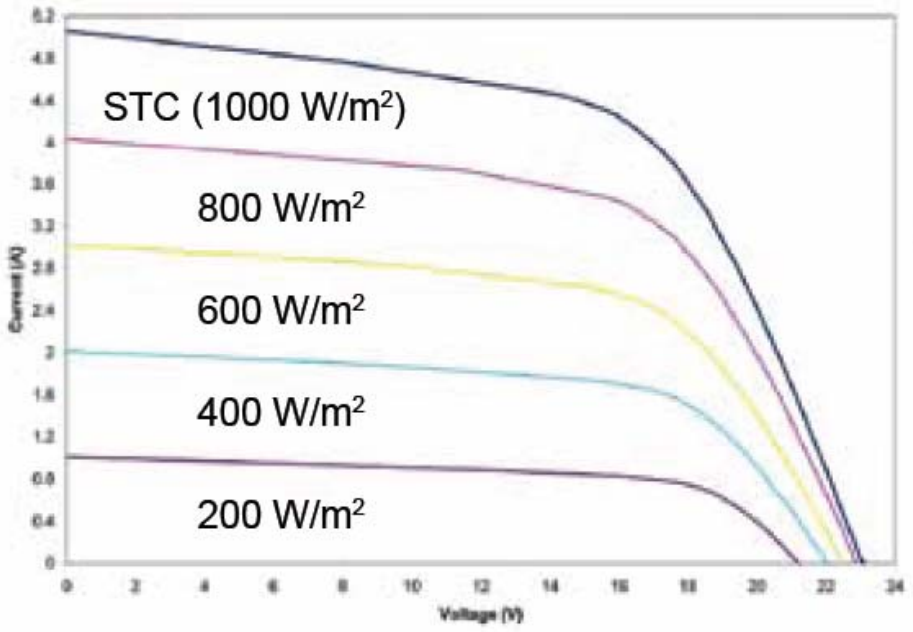


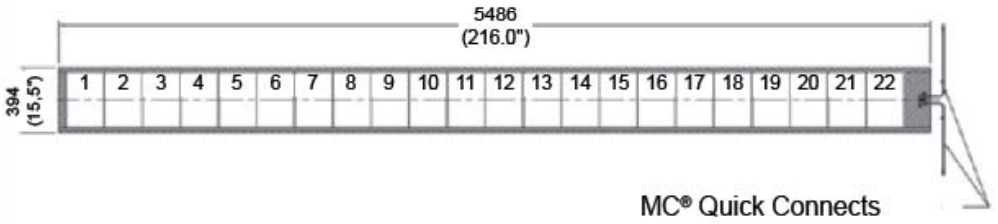
A tilt of 0 corresponds to a horizontal array, while a tilt of 90 corresponds to a vertical array.

PANEL TILT

SOLAR PANELS

Air Mass 1.5 and 25 °C Cell Temperature





PVL-136

All measurements in mm.
Inches in parentheses.
Tolerances: Length: ± 5 mm (1/4"), Width: ± 3 mm (1/8")

Electrical Specifications

STC

(Standard Test Conditions)
(1000 W/m^2, AM 1.5, 25 °C Cell Temperature)

Maximum Power (P_{max}): 136 W
Voltage at Pmax (V_{mp}): 33.0 V
Current at Pmax (I_{mp}): 4.1 A
Short-circuit Current (I_{sc}): 5.1 A
Open-circuit Voltage (V_{oc}): 46.2 V
Maximum Series Fuse Rating: 8 A

NOCT

(Nominal Operating Cell Temperature)
(800 W/m^2, AM 1.5, 1 m/sec. wind)

Maximum Power (P_{max}): 105 W
Voltage at Pmax (V_{mp}): 30.8 V
Current at Pmax (I_{mp}): 3.42 A
Short-circuit Current (I_{sc}): 4.1 A
Open-circuit Voltage (V_{oc}): 42.2 V
NOCT: 46 °C

CALCULATING MAXIMUM V & I

Temperature Coefficients

(at AM 1.5, 1000 W/m^2 irradiance)

Temperature Coefficient (TC) of I_{sc}: 0.001/°K(0.10%/°C)

Temperature Coefficient (TC) of V_{oc}: -0.0038/°K (-0.38%/°C)

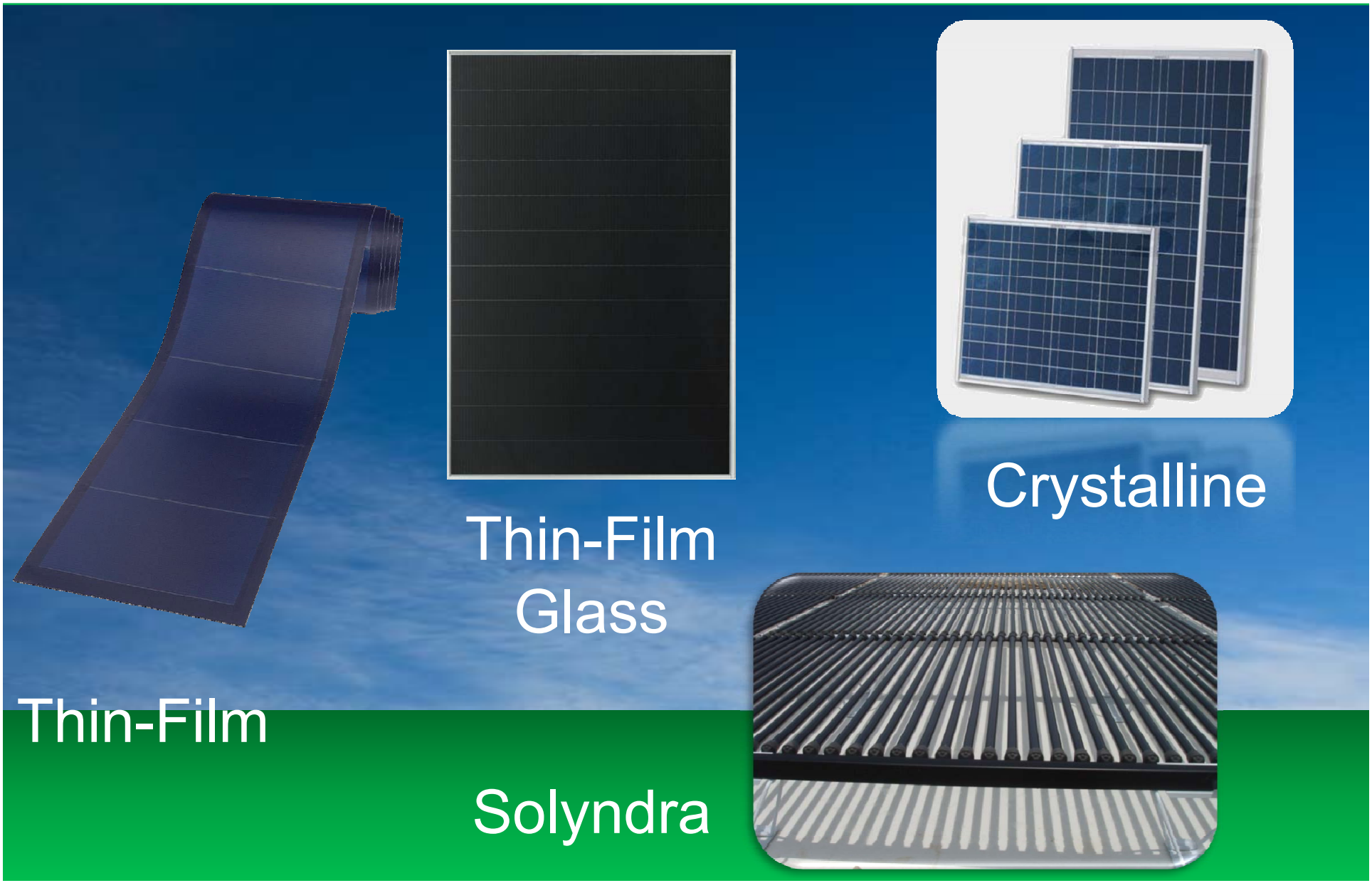
Temperature Coefficient (TC) of P_{max}: -0.0021/°K (-0.21%/°C)

Temperature Coefficient (TC) of I_{mp}: 0.001/°K (0.10%/°C)

Temperature Coefficient (TC) of V_{mp}: -0.0031/°K (-0.31%/°C)

$$y = y_{reference} \bullet [1 + TC \bullet (T - T_{reference})]$$

TYPES OF SOLAR PANELS



Crystalline

- High Density W/m²
- Ground Mount
- Framed Module

Flexible Thin Film

- Single Ply Roofs
- Metal Roofs
- Space is not Limited

Solyndra

- White Roofs
- Ballested Roofs
- Cool Roofs

Glass Thin Film

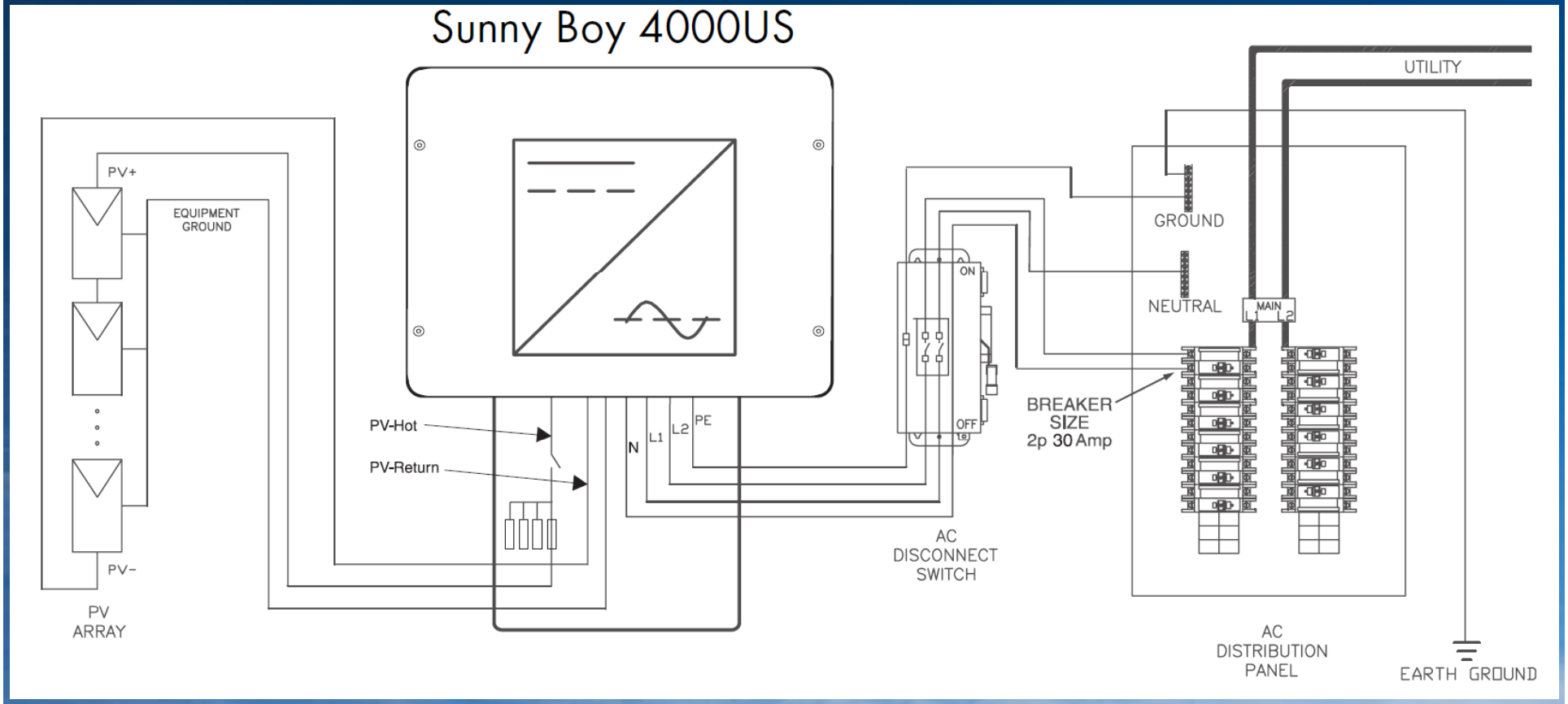
- High Density W/m^2
- Ground Mount
- Framed Module

INVERTERS & HARDWARE

INVERTER

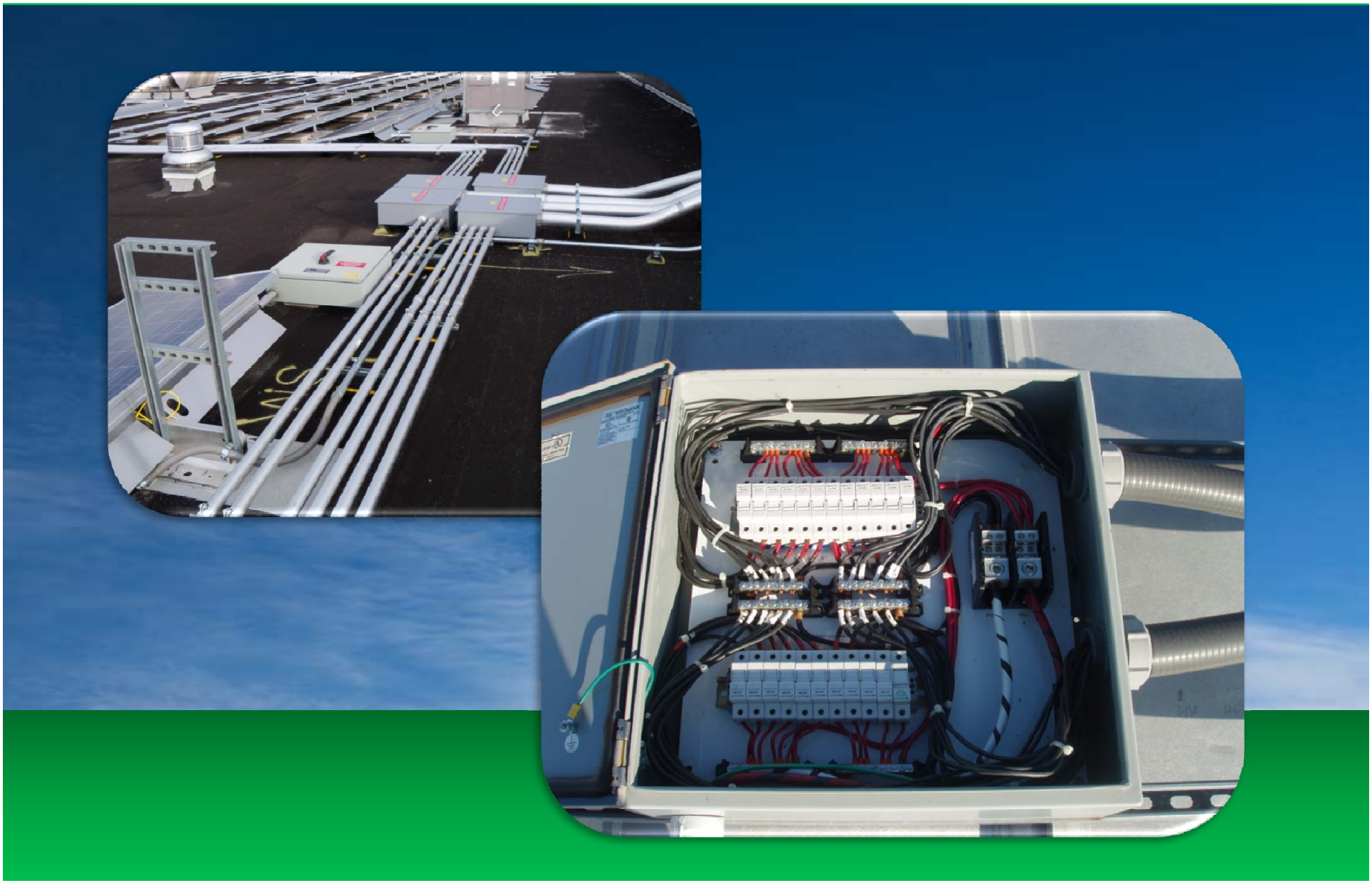
	SB 3000US	SB 4000US
Input Data (DC)		
Max. Recommended Array Input Power (DC @ STC)	3750 W	5000 W
Max. DC Voltage	500 V	600 V
Peak Power Tracking Voltage	180 – 400 V @ 208 V 200 – 400 V @ 240 V	220 – 480 V @ 208 V 250 – 480 V @ 240 V
DC Max. Input Current	17 A	18 A
DC Voltage Ripple	< 5%	< 5%
Number of Fused String Inputs	4	4
PV Start Voltage	228 V	285 V
Output Data (AC)		
AC Nominal Power	3000 W	3500 W @ 208 V / 4000 W @ 240 V
AC Maximum Output Power	3000 W	4000 W
AC Maximum Output Current	15 A @ 208 V, 12.5 A @ 240 V	17 A @ 208 V, 16.6 A @ 240 V
AC Nominal Voltage / Range	183 – 229 V @ 208 V 211 – 264 V @ 240 V	183 – 229 V @ 208 V 211 – 264 V @ 240 V
AC Frequency / Range	60 Hz / 59.3 Hz – 60.5 Hz	60 Hz / 59.3 Hz – 60.5 Hz
Power Factor	1	1
Efficiency		
Peak Inverter Efficiency	96.6 %	96.8 %
CEC weighted Efficiency	95.0 % @ 208 V 95.5 % @ 240 V	95.5 % @ 208 V 96.0 % @ 240 V
Mechanical Data		
Dimensions W x H x D in inches	17.8 x 13.8 x 9.3	17.8 x 13.8 x 9.3
Weight / Shipping Weight	88 lbs / 94 lbs	88 lbs / 94 lbs
Ambient temperature range	–13 to +113 °F	–13 to +113 °F
Power Consumption: standby / nighttime	< 7 W / 0.1 W	< 7 W / 0.1 W
Topology	PWM, true sinewave, current source	PWM, true sinewave, current source
Cooling Concept	Convection, regulated fan cooling	Convection, regulated fan cooling
Mounting Location Indoor / Outdoor (NEMA 3R)	●/●	●/●

INVERTER WIRING



LARGE INVERTERS

COMBINER BOX



MC TYPE 1, CONNECTOR

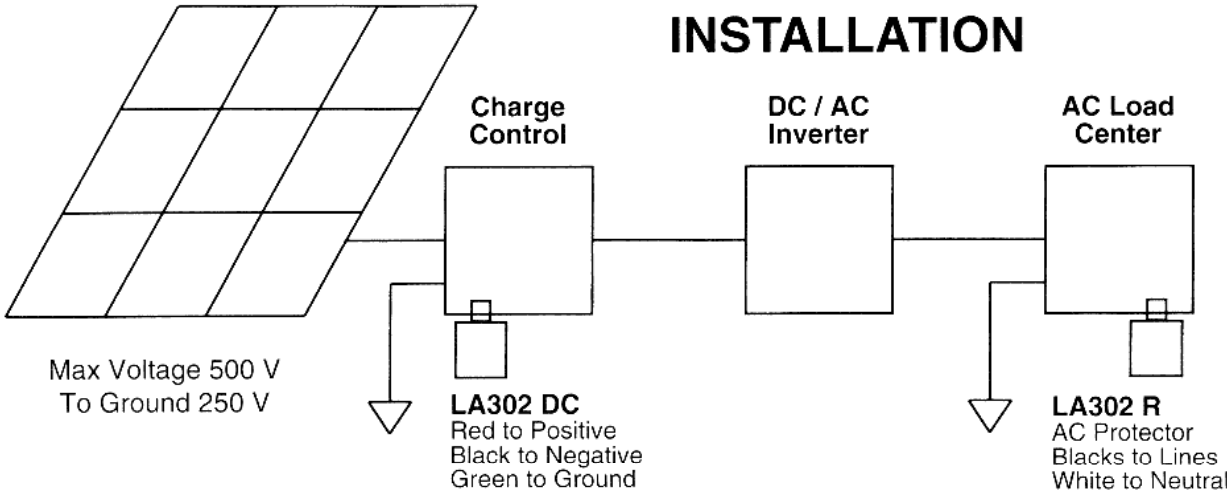
LIGHTING ARRESTORS

DIRECT CURRENT ARRESTOR

SILICON OXIDE ARRESTOR FOR PHOTOVOLTAIC AND OTHER LIMITED CURRENT DC APPLICATIONS

Collector

INSTALLATION



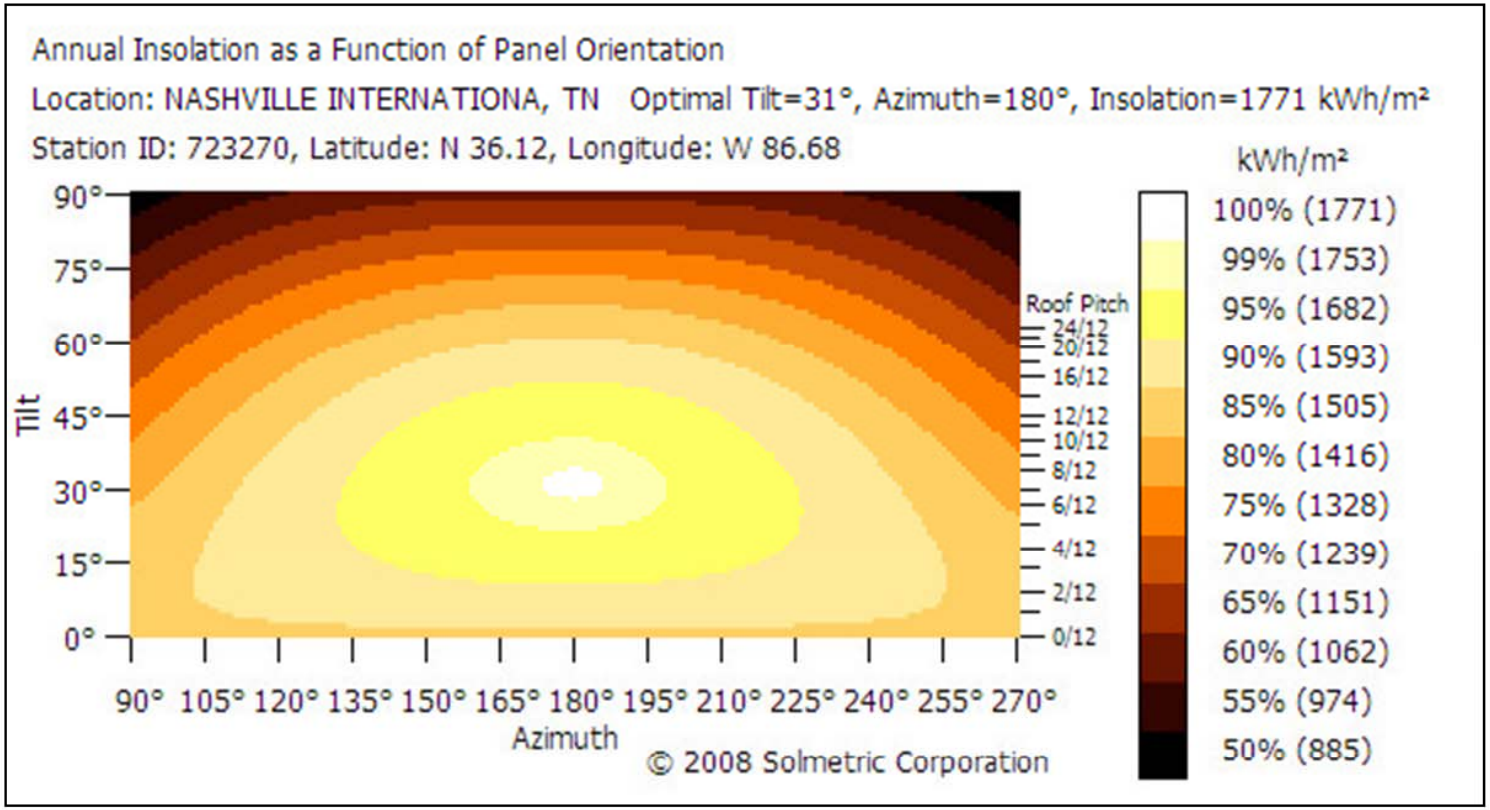
http://www.solmetric.com/annualinsolation-us.html

Insolation Lookup

TENNESSEE

Select a City:

BRISTOL TRI CITY AIRPO
CHATTANOOGA LOVELL FIE
CROSSVILLE MEMORIAL AP
DYERSBURG MUNICIPAL AP
JACKSON MCKELLAR-SIPES
KNOXVILLE MCGHEE TYSON
MEMPHIS INTERNATIONAL
NASHVILLE INTERNATIONA

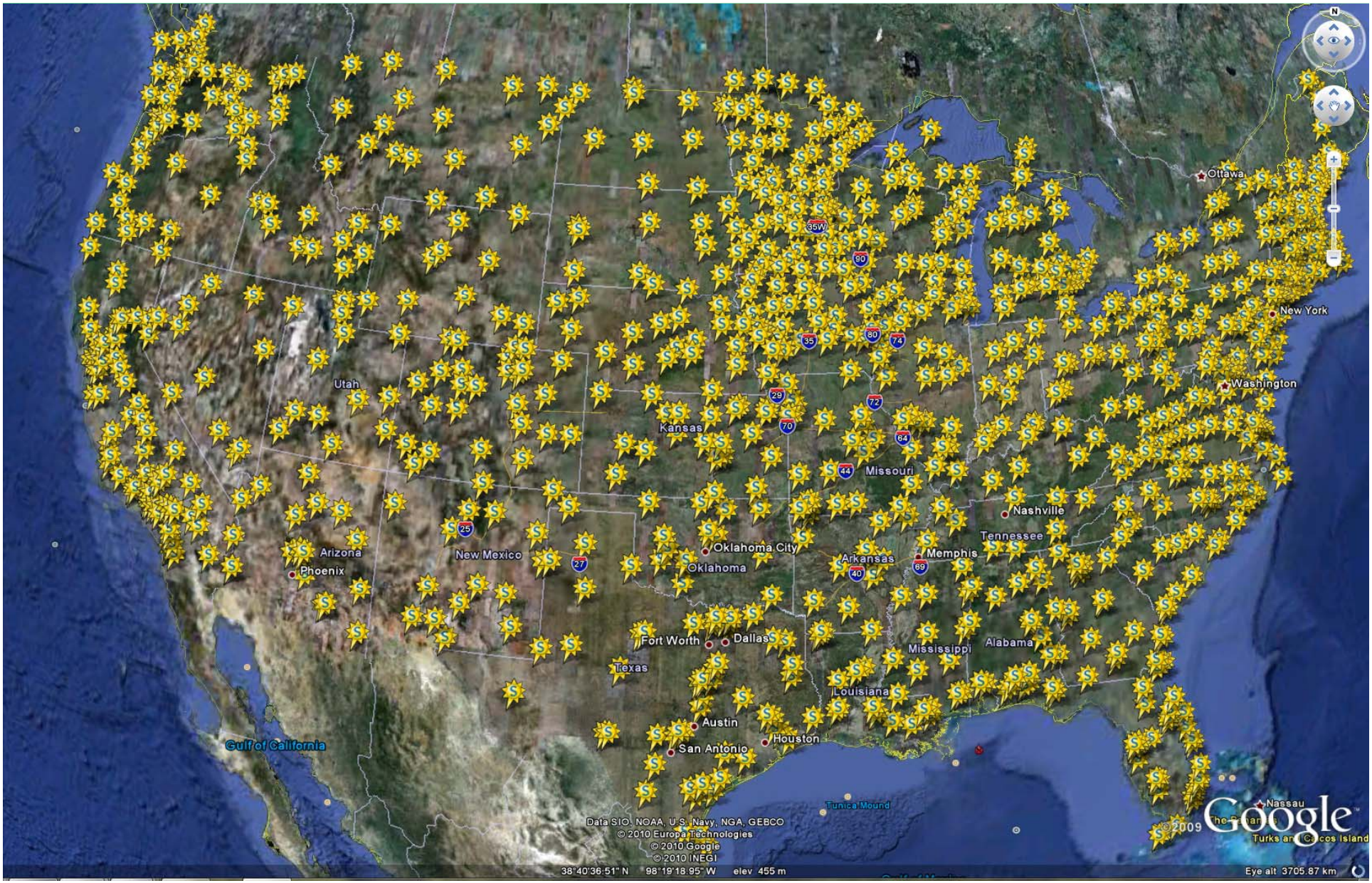


Enter panel orientation to display annual insolation and TOF

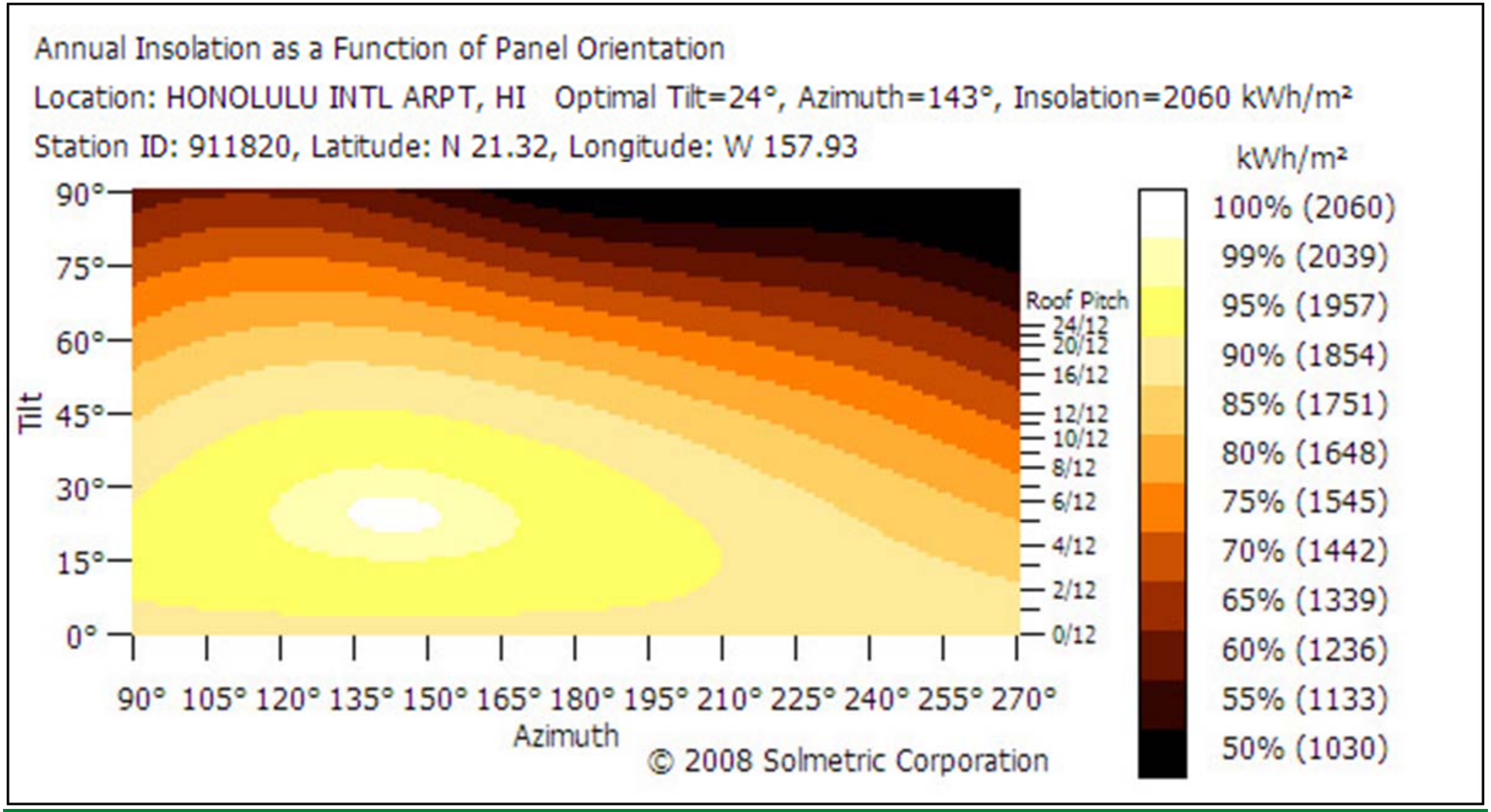
Tilt (°) 29 Azimuth (°) 179 Calculate

At Tilt: 29 ° and Azimuth: 179 °, Annual Insolation: kWh/m^2 (TOF: 100%)

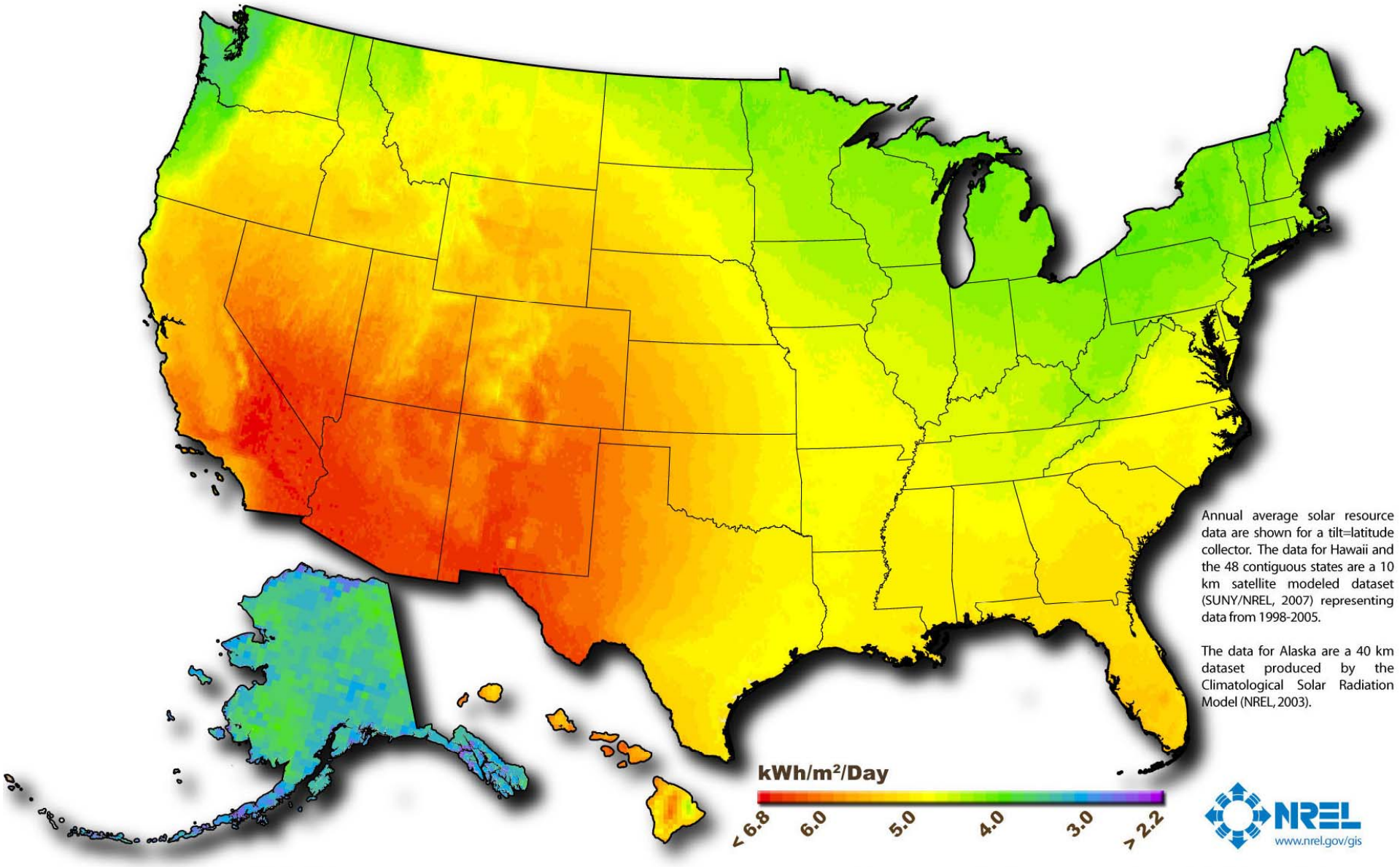
TMY3 WEATHER STATIONS



HONOLULU


Annual Insolation as a Function of Panel Orientation
Location: HONOLULU INTL ARPT, HI Optimal Tilt=24°, Azimuth=143°, Insolation=2060 kWh/m²
Station ID: 911820, Latitude: N 21.32, Longitude: W 157.93
kWh/m²
100% (2060)
99% (2039)
95% (1957)
90% (1854)
85% (1751)
80% (1648)
75% (1545)
70% (1442)
65% (1339)
60% (1236)
55% (1133)
50% (1030)
Roof Pitch
24/12
20/12
16/12
12/12
10/12
8/12
6/12
4/12
2/12
0/12
Tilt
90°
75°
60°
45°
30°
15°
0°
90° 105° 120° 135° 150° 165° 180° 195° 210° 225° 240° 255° 270°
Azimuth
© 2008 Solmetric Corporation

U.S. Photovoltaic Solar Resource



Annual average solar resource data are shown for a tilt=latitude collector. The data for Hawaii and the 48 contiguous states are a 10 km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.

The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

Author : Billy Roberts - October 20, 2008

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

RACK SPACING

ShadeCalculator - Flat Roof

solar mounting systems
SCHLETTER inc.

1. Step: Input - data

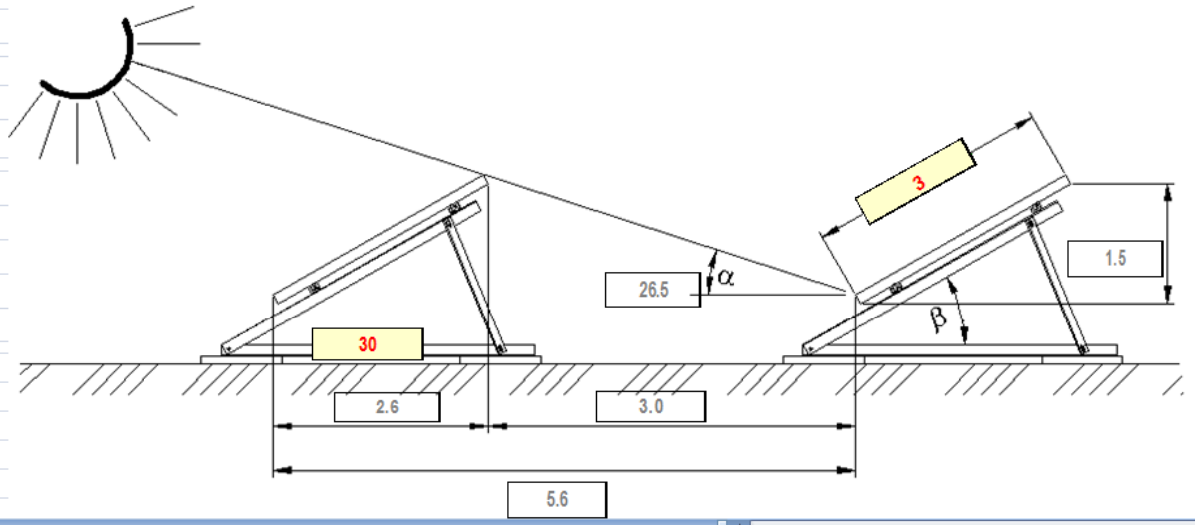
Date [Month/Day/Year]	08/02/10		
Customer	Schletter		
Project			
Latitude	40		
Module height [m]	3	[ft]	9.8
Length of row [m]	8	[ft]	26.2
Number of rows	50		
Tilt angle modules [ß] [degrees]	30		

2. Step: Shade Calculation

Shading angle alpha [degrees]	26.5		
Base line a [m]	2.6	[ft]	8.5
Vertical height [m]	1.5	[ft]	4.9
Minimum distance c [m]	3.0	[ft]	9.9
Distance row to row d [m]	5.6	[ft]	18.4

3. Step: Comparison

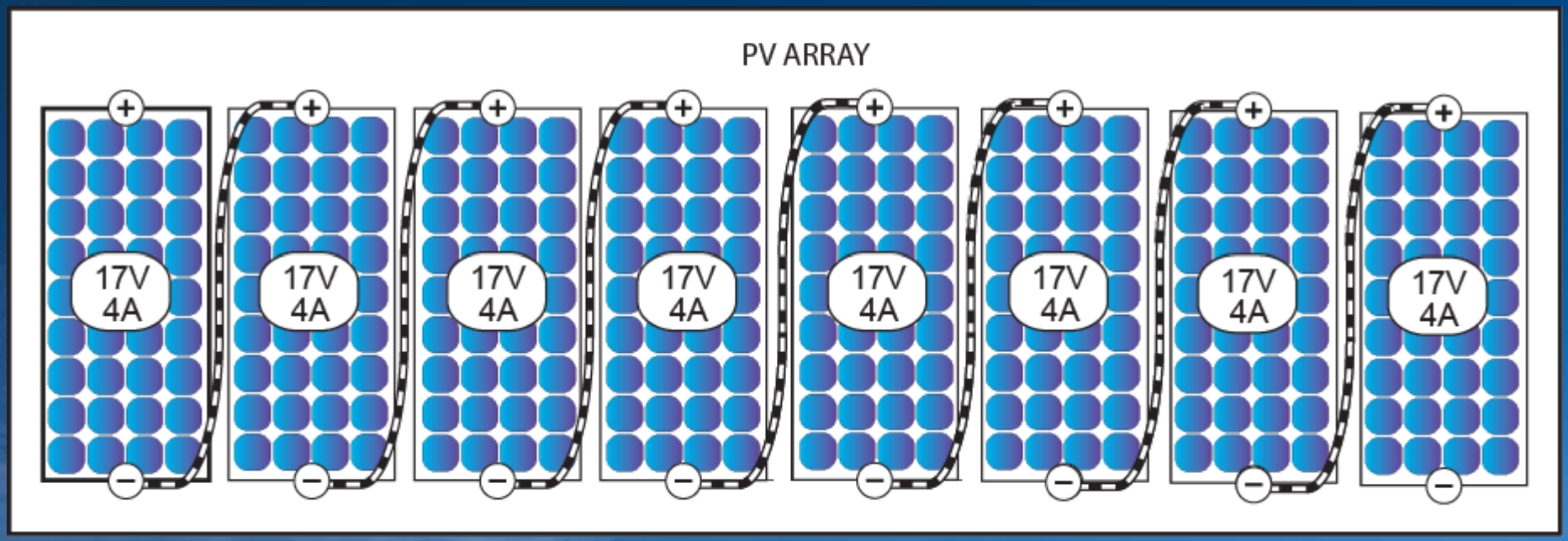
Module net space [sm]	1200.0	[sft]	12916.7
Needed roof width [m]	8.0	[ft]	26.2
Needed roof depth [m]	277.3	[ft]	909.8
Needed roof space [sm]	2218.6	[sft]	23880.5
Roof space / Module space	1.8		18.4



GROUND MOUNT RACK

ROOF MOUNT RACK

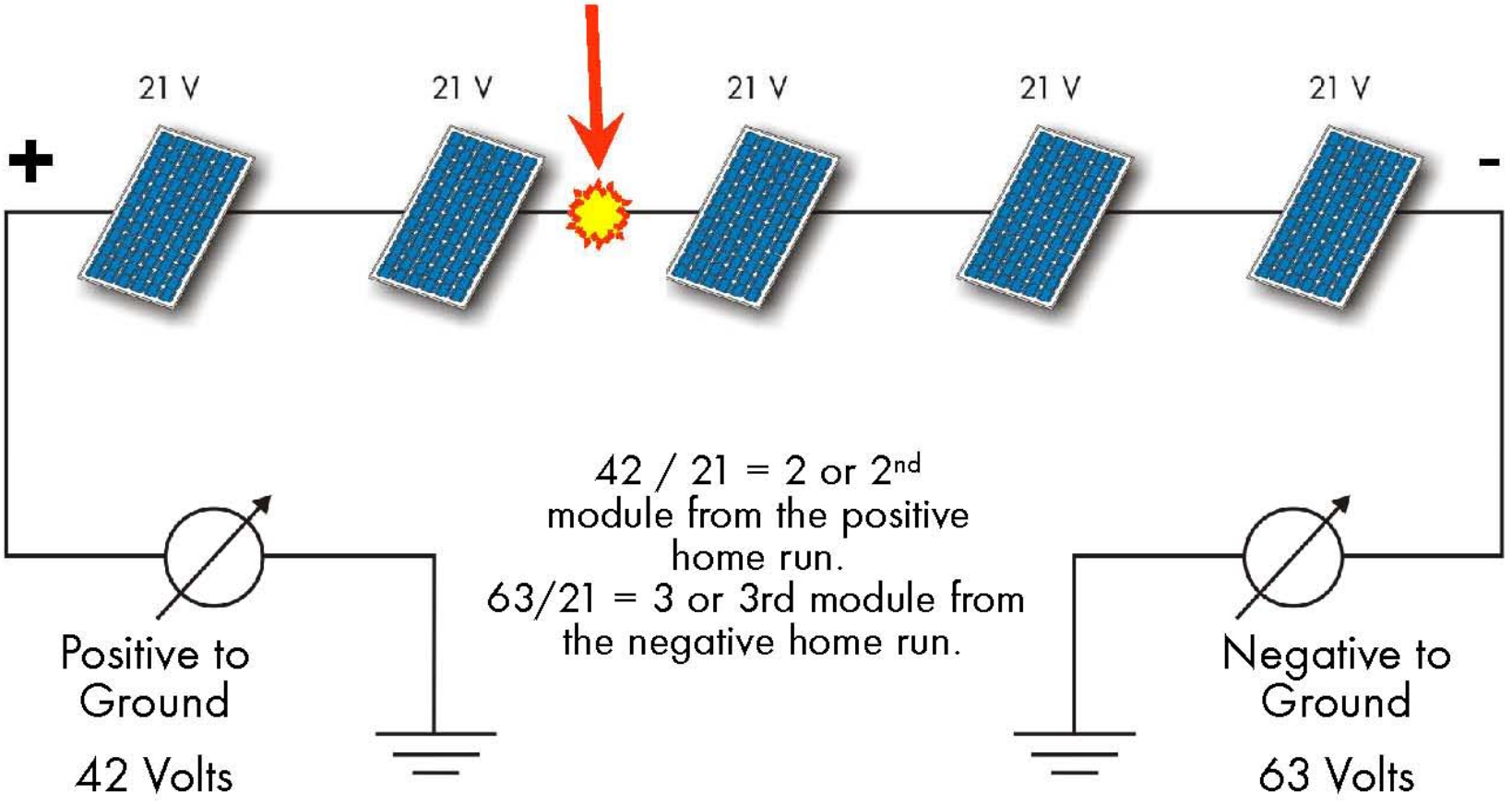
STRING SIZING



17V x 8 = 136V

4 A

Where is the Ground Fault?



http://www.xantrex.com/support/gtsizing/index.asp?lang=eng#calculator

Module

Schott Poly 230

Max Power Voltage - Vmp	30	Vdc
Open Circuit Voltage - Voc	36.9	Vdc
Voltage Temp Coeff - Vtoc	-0.121	V/°C
STC Rating - Pmp	230	Wstcdc
Max Power Current - Imp	7.66	Adc
PTC Rating	209.3	Wptc

Can't find the module you need? Let us know by email... click here

Inverter

Xantrex GT500-MV

Pnom	500000	Wac
Idc max	1717	Adc
Vmptmax	600	Vdc
Voc	600	Vdc
Vmptmin	300	Vdc
Efficiency	97	% AvgEfficiency

Temperature Specifications

Celsius or Fahrenheit	Fahrenheit
Record low ambient temperature (°F)	-13
Average high ambient temperature(°F)	98

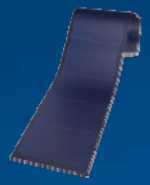
	Max Voc at Min Temp (Vdc)	Min Vmp at Max Temp (Vdc)
11 Modules	472.45	267.89
12 Modules	515.4	292.24
13 Modules	558.35	316.59

Show all strings

		11 Modules	12 Modules	13 Modules
112 Strings	STC	283360	309120	334880
	PTC	257858	281299	304741
	CEC	250122	272860	295599
113 Strings	STC	285890	311880	337870
	PTC	260160	283811	307462
	CEC	252355	275296	298238
114 Strings	STC	288420	314640	340860
	PTC	262462	286322	310183
	CEC	254588	277733	300877
115 Strings	STC	290950	317400	343850
	PTC	264764	288834	312904
	CEC	256822	280169	303516
116 Strings	STC	293480	320160	346840
	PTC	267067	291346	315624
	CEC	259055	282605	306156
117 Strings	STC	296010	322920	349830
	PTC	269369	293857	318345
	CEC	261288	285041	308795
118 Strings	STC	298540	325680	352820
	PTC	271671	296369	321066
	CEC	263521	287478	311434
119 Strings	STC	301070	328440	355810
	PTC	273974	298880	323787
	CEC	265754	289914	314073
120 Strings	STC	303600	331200	358800
	PTC	276276	301392	326508
	CEC	267988	292350	316713
121 Strings	STC	306130	333960	361790
	PTC	278578	303904	329229
	CEC	270221	294786	319352
122 Strings	STC	308660	336720	364780
	PTC	280881	306415	331950

ELECTRICAL OUTPUT

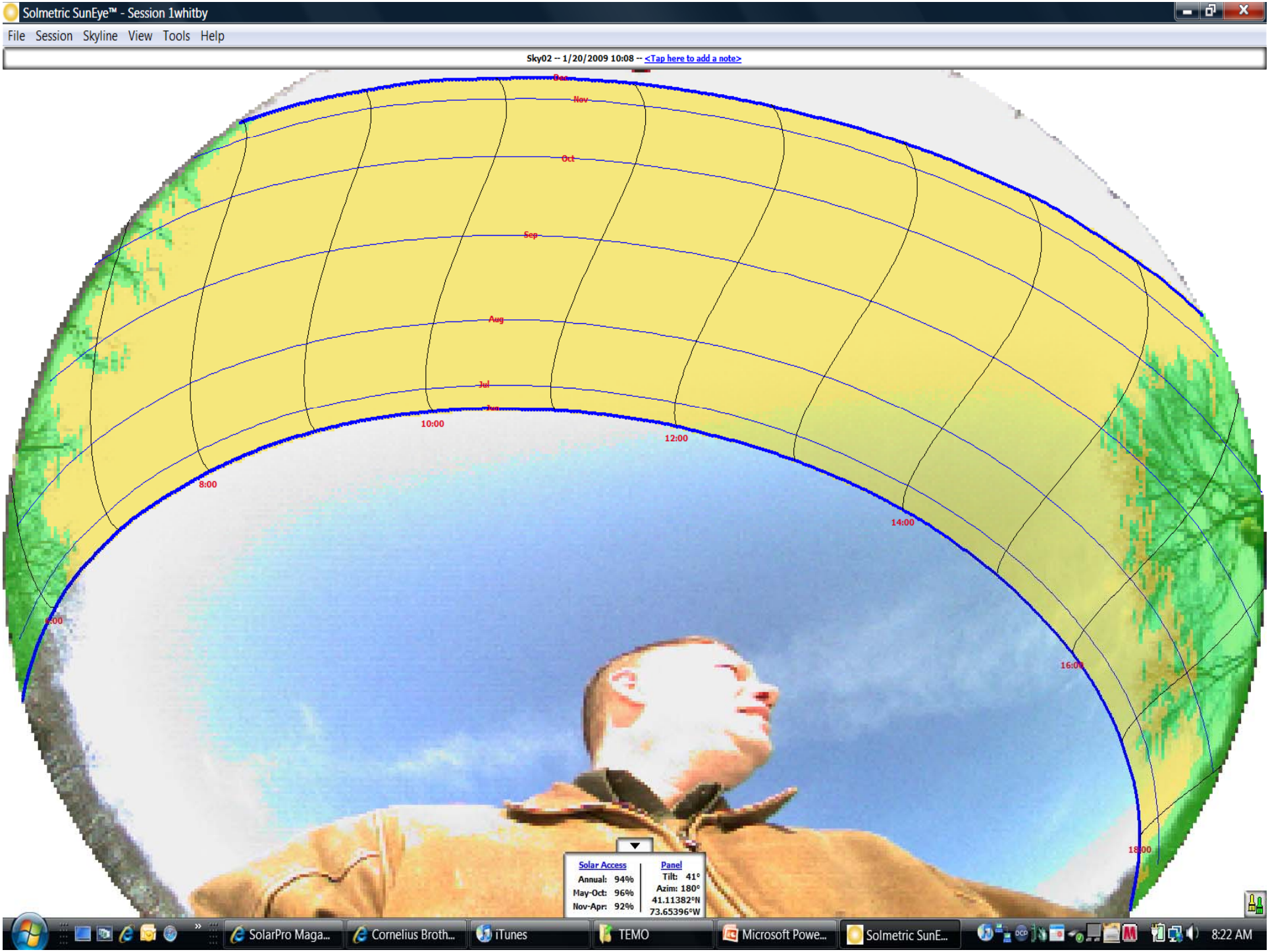
System Rated Size in DC Watts

- Seven PVL-144  7 X 144Watts = 1,008 Watts
- 1,000 Watts = 1kW

This system will produce 1,008 Watts with ideal conditions, with the sun directly overhead and no clouds.

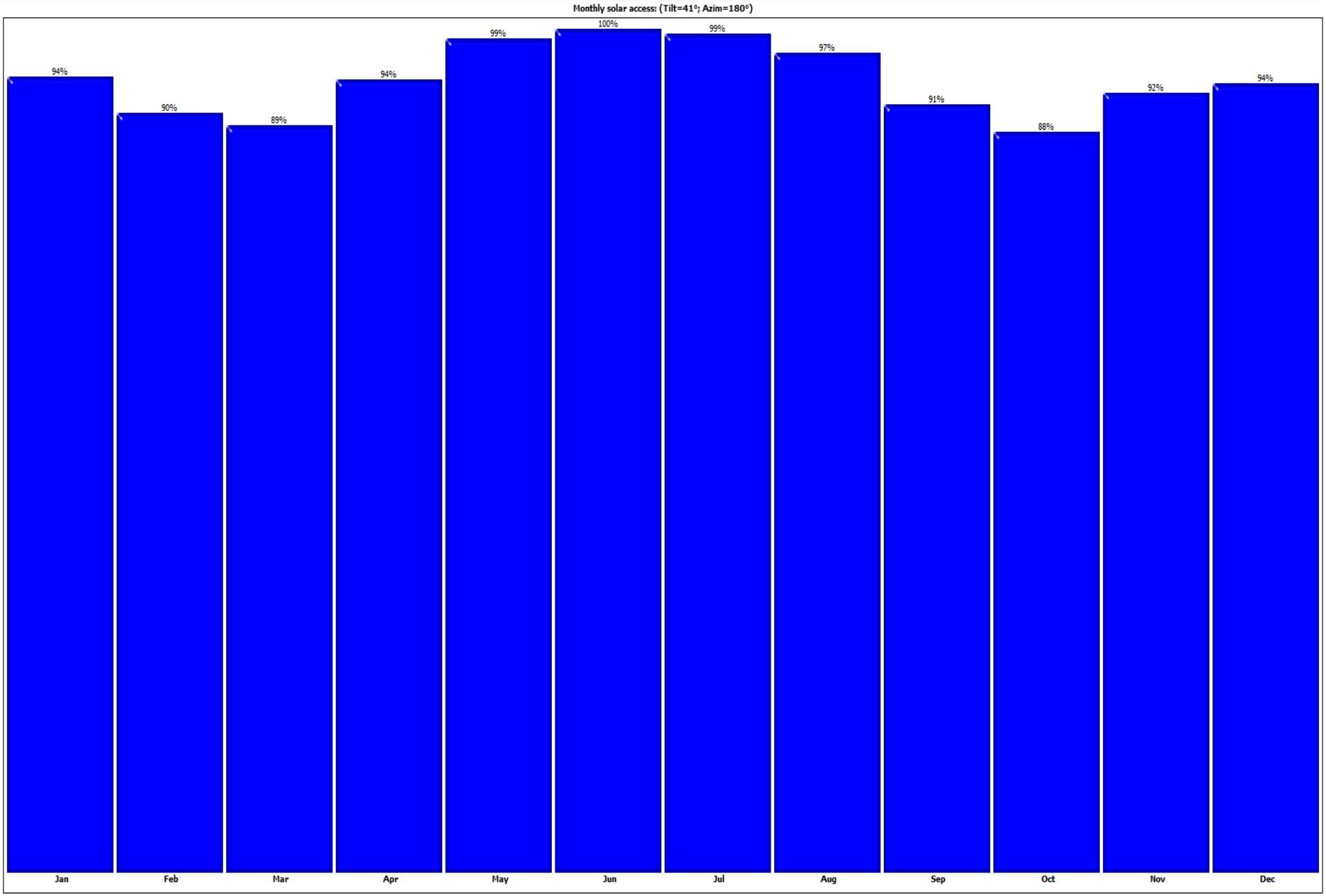
Watt Rating is Based on 1,000W/m^2 = 1 kW/m^2

SHADING

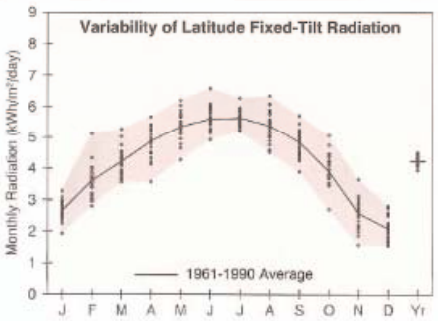

Solmetric SunEye™ - Session 1whitby
File Session Skyline View Tools Help
Sky02 -- 1/20/2009 10:08 -- <Tap here to add a note>
Dec
Nov
Oct
Sep
Aug
Jul
Jun
10:00
12:00
8:00
14:00
6:00
16:00
18:00
Solar Access
Annual: 94%
May-Oct: 96%
Nov-Apr: 92%
Panel
Tilt: 41°
Azim: 180°
41.11382°N
73.65396°W
SolarPro Maga...
Cornelius Broth...
iTunes
TEMO
Microsoft Powe...
Solmetric SunE...
8:22 AM

Solmetric SunEye™ - Session 1whitby

File Session Skyline View Tools Help



SolarPro Maga... Cornelius Broth... iTunes TEMO Microsoft Powe... Solmetric SunE... 8:24 AM



Detroit, MI

WBAN NO. 94847

LATITUDE: 42.42° N
LONGITUDE: 83.02° W
ELEVATION: 191 meters
MEAN PRESSURE: 992 millibars

STATION TYPE: Secondary

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	1.6	2.5	3.4	4.6	5.6	6.2	6.1	5.3	4.1	2.8	1.7	1.3	3.8
	Min/Max	1.3/1.9	2.1/3.2	3.1/4.0	3.6/5.2	4.6/6.5	5.5/7.3	5.7/6.8	4.6/6.1	3.5/4.7	2.2/3.4	1.3/2.1	1.1/1.5	3.6/4.0
Latitude -15	Average	2.4	3.3	4.1	5.0	5.7	6.1	6.1	5.6	4.8	3.7	2.4	1.9	4.3
	Min/Max	1.8/2.9	2.7/4.6	3.5/5.1	3.7/5.8	4.6/6.7	5.4/7.2	5.6/6.8	4.8/6.6	3.9/5.6	2.6/4.7	1.5/3.3	1.4/2.5	4.0/4.5
Latitude	Average	2.7	3.6	4.2	4.9	5.4	5.6	5.6	5.4	4.8	3.9	2.6	2.1	4.2
	Min/Max	1.9/3.3	2.8/5.1	3.6/5.3	3.6/5.7	4.3/6.2	4.9/6.6	5.2/6.3	4.5/6.3	3.9/5.7	2.7/5.1	1.6/3.7	1.5/2.8	4.0/4.5
Latitude +15	Average	2.8	3.7	4.1	4.5	4.8	4.9	4.9	4.9	4.6	3.9	2.6	2.2	4.0
	Min/Max	2.0/3.5	2.8/5.4	3.5/5.2	3.3/5.3	3.8/5.5	4.3/5.7	4.6/5.5	4.1/5.8	3.7/5.5	2.6/5.1	1.5/3.8	1.6/3.0	3.7/4.2
90	Average	2.6	3.3	3.2	3.0	2.8	2.7	2.8	3.1	3.3	3.2	2.3	2.0	2.9
	Min/Max	1.8/3.4	2.5/5.0	2.7/4.1	2.2/3.6	2.3/3.1	2.5/3.0	2.6/3.0	2.6/3.6	2.6/4.0	2.1/4.2	1.3/3.5	1.4/2.9	2.7/3.1

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	2.2	3.3	4.5	5.9	7.2	8.0	7.9	6.9	5.5	3.8	2.2	1.7	4.9
	Min/Max	1.6/2.7	2.6/4.6	3.8/5.7	4.3/7.1	5.6/9.0	6.7/9.8	7.1/9.1	5.8/8.3	4.3/6.4	2.6/5.0	1.4/3.1	1.2/2.2	4.6/5.3
Latitude -15	Average	2.8	4.0	5.0	6.3	7.4	8.0	8.0	7.3	6.0	4.5	2.7	2.1	5.3
	Min/Max	1.9/3.5	3.0/5.7	4.1/6.5	4.4/7.5	5.7/9.2	6.7/9.8	7.2/9.3	6.0/8.8	4.7/7.2	3.0/5.9	1.6/4.0	1.5/2.9	4.9/5.8
Latitude	Average	3.0	4.2	5.1	6.2	7.1	7.7	7.7	7.1	6.1	4.7	2.9	2.3	5.3
	Min/Max	2.0/3.8	3.2/6.1	4.2/6.6	4.3/7.5	5.5/8.9	6.4/9.4	6.9/9.0	5.8/8.6	4.7/7.3	3.0/6.2	1.6/4.3	1.6/3.2	4.9/5.8
Latitude +15	Average	3.1	4.3	5.0	5.9	6.7	7.1	7.2	6.8	5.9	4.7	2.9	2.4	5.2
	Min/Max	2.1/4.0	3.2/6.3	4.1/6.6	4.1/7.2	5.1/8.4	5.9/8.8	6.4/8.4	5.5/8.2	4.5/7.1	3.0/6.3	1.6/4.4	1.7/3.3	4.8/5.6

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	3.1	4.3	5.1	6.3	7.5	8.2	8.2	7.3	6.1	4.7	3.0	2.4	5.5
	Min/Max	2.1/4.0	3.2/6.3	4.2/6.7	4.5/7.6	5.8/9.3	6.8/10.1	7.3/9.4	6.0/8.8	4.7/7.3	3.0/6.3	1.6/4.4	1.7/3.4	5.1/6.0

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	1.5	2.0	2.2	2.7	3.2	3.7	3.6	3.2	2.8	2.3	1.5	1.1	2.5
	Min/Max	0.9/2.1	1.2/3.3	1.2/3.5	1.2/3.6	2.0/4.6	2.6/5.1	2.9/4.6	2.3/4.4	1.7/3.7	1.1/3.5	0.4/2.6	0.6/1.9	2.2/2.9
1-Axis, N-S Horiz Axis	Average	1.0	1.7	2.4	3.4	4.3	4.8	4.8	4.2	3.3	2.2	1.1	0.7	2.8
	Min/Max	0.6/1.4	1.0/2.7	1.4/3.8	1.7/4.6	2.7/6.2	3.4/6.7	3.9/6.2	3.1/5.7	2.0/4.3	1.0/3.4	0.3/2.0	0.4/1.2	2.5/3.3
1-Axis, N-S Tilt=Latitude	Average	1.6	2.4	2.9	3.7	4.2	4.6	4.6	4.3	3.7	2.9	1.7	1.2	3.2
	Min/Max	1.0/2.3	1.4/3.9	1.6/4.6	1.8/4.9	2.6/6.1	3.2/6.4	3.7/5.9	3.2/5.9	2.3/4.9	1.3/4.4	0.5/3.0	0.6/2.0	2.7/3.6
2-Axis	Average	1.8	2.5	2.9	3.7	4.4	5.0	5.0	4.5	3.8	3.0	1.7	1.3	3.3
	Min/Max	1.0/2.5	1.4/4.0	1.6/4.6	1.8/5.0	2.8/6.4	3.5/6.9	4.0/6.4	3.3/6.1	2.3/4.9	1.4/4.5	0.5/3.1	0.7/2.2	2.9/3.8

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	-5.1	-3.7	2.1	8.5	14.7	19.8	22.4	21.4	17.3	10.7	4.6	-2.1	9.2
Daily Minimum Temp	-9.1	-8.0	-2.8	2.7	8.4	13.5	16.3	15.3	11.4	4.9	0.1	-5.9	3.9
Daily Maximum Temp	-0.9	0.7	6.9	14.3	20.9	26.1	28.5	27.4	23.3	16.4	8.9	1.8	14.5
Record Minimum Temp	-29.4	-26.1	-20.0	-12.2	-3.9	2.2	5.0	3.3	-1.7	-8.3	-12.8	-23.3	-29.4
Record Maximum Temp	16.7	18.3	27.2	31.7	33.9	40.0	38.9	37.8	36.7	32.8	25.0	20.0	40.0
HDD, Base 18.3°C	725	616	504	295	135	21	0	9	57	242	413	632	3649
CDD, Base 18.3°C	0	0	0	0	21	64	128	103	27	4	0	0	348
Relative Humidity (%)	75	73	70	66	65	67	69	72	73	72	75	77	71
Wind Speed (m/s)	5.4	5.1	5.3	5.2	4.6	4.2	3.8	3.7	3.9	4.4	5.0	5.1	4.6

NATIONAL RENEWABLE ENERGY LABORATORY (NREL)

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	1.6	2.5	3.4	4.6	5.6	6.2	6.1	5.3	4.1	2.8	1.7	1.3	3.8
	Min/Max	1.3/1.9	2.1/3.2	3.1/4.0	3.6/5.2	4.6/6.5	5.5/7.3	5.7/6.8	4.6/6.1	3.5/4.7	2.2/3.4	1.3/2.1	1.1/1.5	3.6/4.0
Latitude -15	Average	2.4	3.3	4.1	5.0	5.7	6.1	6.1	5.6	4.8	3.7	2.4	1.9	4.3
	Min/Max	1.8/2.9	2.7/4.6	3.5/5.1	3.7/5.8	4.6/6.7	5.4/7.2	5.6/6.8	4.8/6.6	3.9/5.6	2.6/4.7	1.5/3.3	1.4/2.5	4.0/4.5
Latitude	Average	2.7	3.6	4.2	4.9	5.4	5.6	5.6	5.4	4.8	3.9	2.6	2.1	4.2
	Min/Max	1.9/3.3	2.8/5.1	3.6/5.3	3.6/5.7	4.3/6.2	4.9/6.6	5.2/6.3	4.5/6.3	3.9/5.7	2.7/5.1	1.6/3.7	1.5/2.8	4.0/4.5
Latitude +15	Average	2.8	3.7	4.1	4.5	4.8	4.9	4.9	4.9	4.6	3.9	2.6	2.2	4.0
	Min/Max	2.0/3.5	2.8/5.4	3.5/5.2	3.3/5.3	3.8/5.5	4.3/5.7	4.6/5.5	4.1/5.8	3.7/5.5	2.6/5.1	1.5/3.8	1.6/3.0	3.7/4.2
90	Average	2.6	3.3	3.2	3.0	2.8	2.7	2.8	3.1	3.3	3.2	2.3	2.0	2.9
	Min/Max	1.8/3.4	2.5/5.0	2.7/4.1	2.2/3.6	2.3/3.1	2.5/3.0	2.6/3.0	2.6/3.6	2.6/4.0	2.1/4.2	1.3/3.5	1.4/2.9	2.7/3.1

January 6.2 kWh/m²/day

This number represents the equivalent hours of full direct sun.

ELECTRICAL OUTPUT

How much Power or AC Watts

- 1,000 Watts = 1kW DC

About 80% of the DC electricity becomes AC Electricity

kWatts DC x full sun hours x system efficiency = kW AC

1 kW DC x 1.6h x .80 = 1.28 kWh AC Average Day in January

1 kW DC x 6.2h x .80 = 4.96 kWh AC Average Day in June

1kW for one hour = 1kWh = 10 X 100W Lights for one hour

INOVATEUS solar

19890 State Line Road
South Bend, Indiana 46637
7/21/09

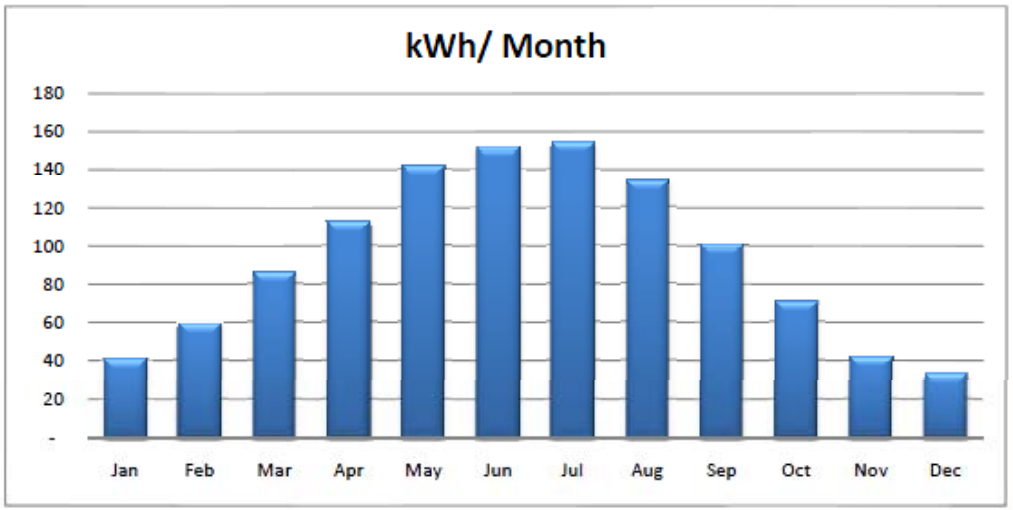
Projected Output for

Detroit, MI

Module Type:	PVL-144
Module Rating W:	144
Module Sq. Ft.:	23
Number of Modules:	7
System Rating kW:	**1.0**
System Total Sq. Ft.:	**163**
State:	IN
Module Tilt:	0

Component Derate Factors	Derate Value
Module DC Rating:	1
Inverter:	0.92
Mismatch:	0.98
Diodes @ Connections:	0.995
DC Wiring:	0.98
AC Wiring:	0.99
Soiling:	0.95
System Availability:	0.98
Shading:	1
Sun-Tracking:	1
Age:	1
Albedo:	1
Total:	0.81

Month	kWh/m²/ Day Ave	Solar Access	kWh/m²/ Month	kWh/ Month
Jan	1.6	100%	49.6	41
Feb	2.5	100%	72.5	59
Mar	3.4	100%	105.4	86
Apr	4.6	100%	138.0	113
May	5.6	100%	173.6	142
Jun	6.2	100%	186.0	152
Jul	6.1	100%	189.1	154
Aug	5.3	100%	164.3	134
Sep	4.1	100%	123.0	100
Oct	2.8	100%	86.8	71
Nov	1.7	100%	51.0	42
Dec	1.3	100%	40.3	33
Ave	3.8	100%	115.0	94
Total Estimated kWhr/Year				1,127



This is not a guaranteed output and is only a projection. The actual output may be different. Temperature can have a significant impact on the system's output, with lower temperatures increasing and higher temperatures decreasing output. The data is based on 25 Degree Celsius.

INOVATEUS solar

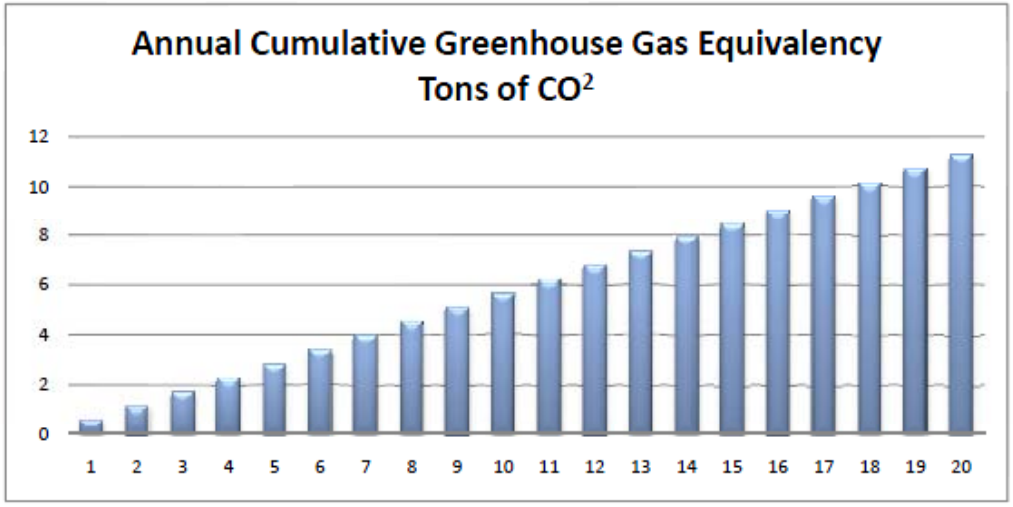
19890 State Line Road
South Bend, Indiana 46637
7/21/09

Avoided Emissions

Detroit, MI

Total Estimated kWhr/Year		1,127
	(lb/MWh)	TTL Annual #
Pounds of CO^2 Equivalency	2,088	2,353
Pounds of NOx Equivalency	2.0258	2.3
Pounds of SO^2 Equivalency	13.4570	15
Pounds of CH4 Equivalency	0.0245	0.0
Pounds of N2O Equivalency	0.0348	0.0
Pounds of Hg Equivalency	0.000045	0.000

CO^2 Equivalency	Quantity
Annual greenhouse gas emissions for passenger vehicles	0.15
Gallons of gasoline consumed	92
Barrels of oil consumed	2
Tanker trucks' worth of gasoline	0.01
Years of electricity use in one home	0.11
Years of energy use in one home	0.07
Sequestered carbon by tree seedlings for 10 years	21
Sequestered carbon annually by acres of pine or fir forest	0.18
Propane cylinders used for home barbeques	34
Burning railcars' worth of coal	0.00
Tons of recycling of waste instead of send to the landfill	0.3



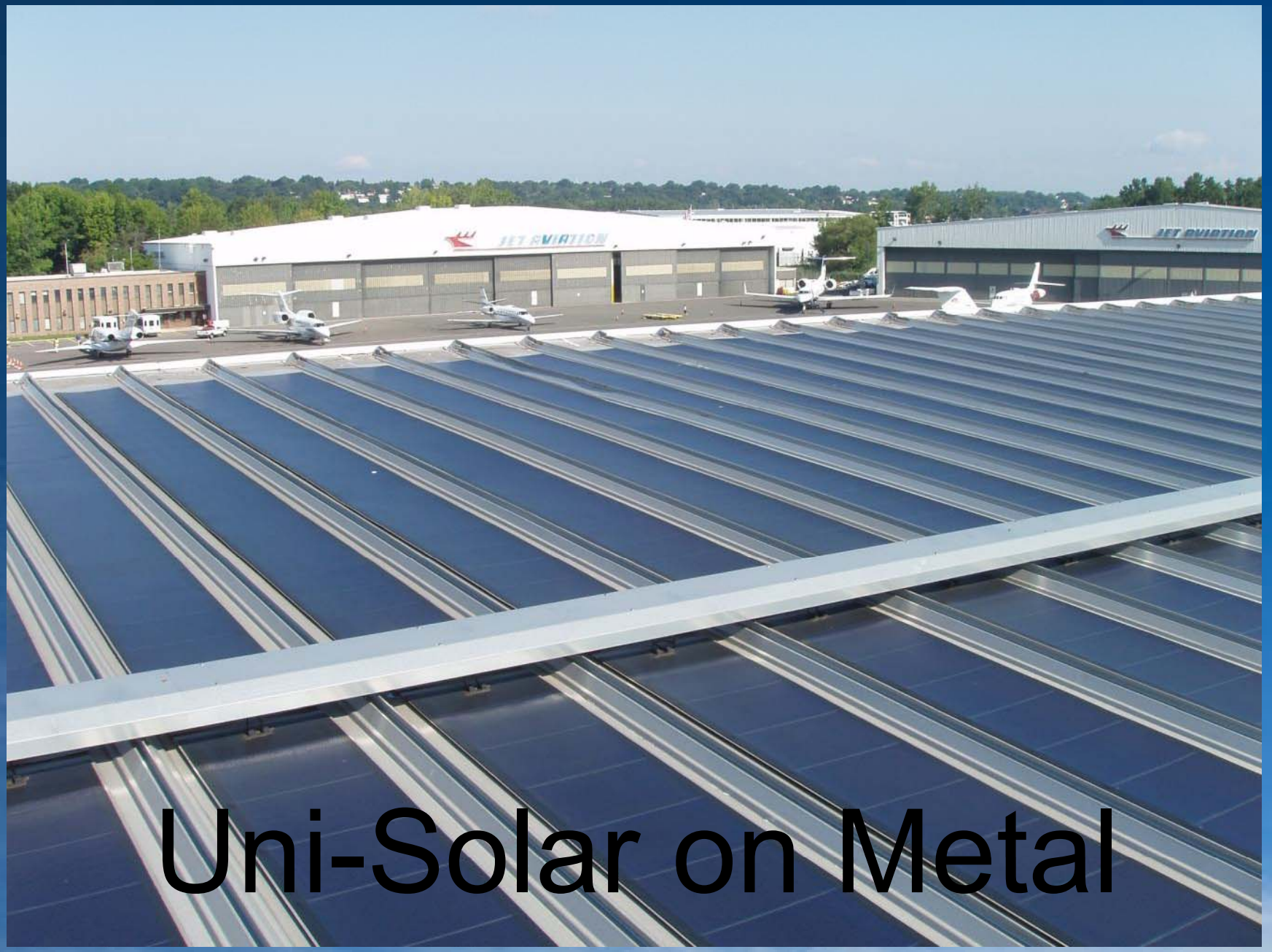
Equivalency rates are estimates only and are based on the "U.S. Environmental Protection Agency. http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

THIN-FILM BIPV

THIN-FILM GOES TO SCHOOL

CRYSTALLINE VS. THIN-FILM

SOLYNDRA



Uni-Solar on Metal


Uni-Solar on TPO


Sharp Thin Film

1MW Inverter Box

125kW SatCon Inverter

ONLINE RESOURCES

Basic Design Manual
www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF
Solar Pro Magazine
http://solarprofessional.com/home/
Orientation: Azimuth and Pitch
http://www1.solmetric.com/tools/RoofAzimTool.htm
http://www.solmetric.com/annualinsolation-us.html
Modules and Inverters
http://www.solarhub.com/
http://www.pvselect.com/index.php
Incentives and Rebates
http://dsireusa.org/
Design Programs
PV*SOL
PVSYST
PVWATTS
Solmetric SunEye
http://www.solmetric.com/
Solar Pro Magazine
http://solarprofessional.com/issue/?backissues=1
Sun Position
http://squ1.org/wiki/Solar_Position_Calculator
Backup Battery Capacity
http://www.xantrex.com/support/gtsizing/disclaimer.asp?lang=eng
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http://www.windspeedbyzip.com/


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