Ypsilanti Solar Project – City Hall

Dave Strenski
June 20, 2007

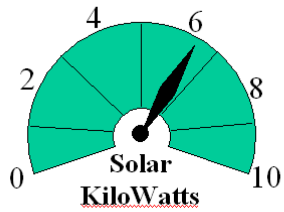
Summary

The Ypsilanti Solar Project is a proposal to place solar photovoltaic panels on the south wall of Ypsilanti's City Hall, and hopefully other buildings within the City limits in the future. This report covers the benefits, installation plan, materials, costs, and structural analysis of placing solar panels on the back of the City Hall.

Benefits to the City

The exit from I-94 leads directly to City Hall. Because of the timing of the traffic lights at Michigan Avenue, inbound traffic often stops on Huron Street just behind City Hall. This south facing brick wall is 40 feet wide and approximately 50 feet tall and, having no neighbor to the south, the wall receives full sun throughout the day and year round. The top of this south facing wall would be an excellent location for solar panels, providing both electrical power and offering visibility for the general public, sending a positive image to visitors and residents of Ypsilanti.

This potential project is already a hot topic among Ypsilanti residents. The project will be showcased on the City of Ypsilanti's website (www.CityofYpsilanti.com) which will feature a small solar power meter pictured here. The solar meter icon would show the power being generated by the solar panels in real time, and also show the total electrical power generated for the day, for the month (last 30 days), and for the year (last 365 days). Clicking on the icon would then lead the internet visitor to a solar web page which would have graphs of electrical solar production along with power purchased from the utility company and power consumed by the building. This page would also contain links to papers and presentations about this project and other solar power informational resources.

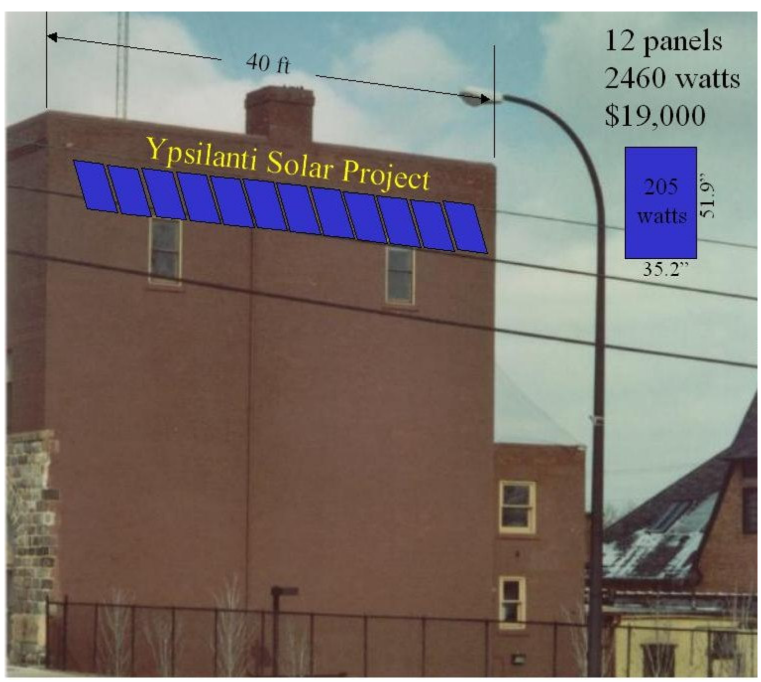


Initially this icon would only represent the power (solar and utility) for City Hall. In the future we would like to have this icon represent all the solar power being generated within the City. This icon would then lead to multiple icons with a meter for each solar installation within the City. Clicking on any of these meters would bring the visitor to graphs and information about that particular installation.

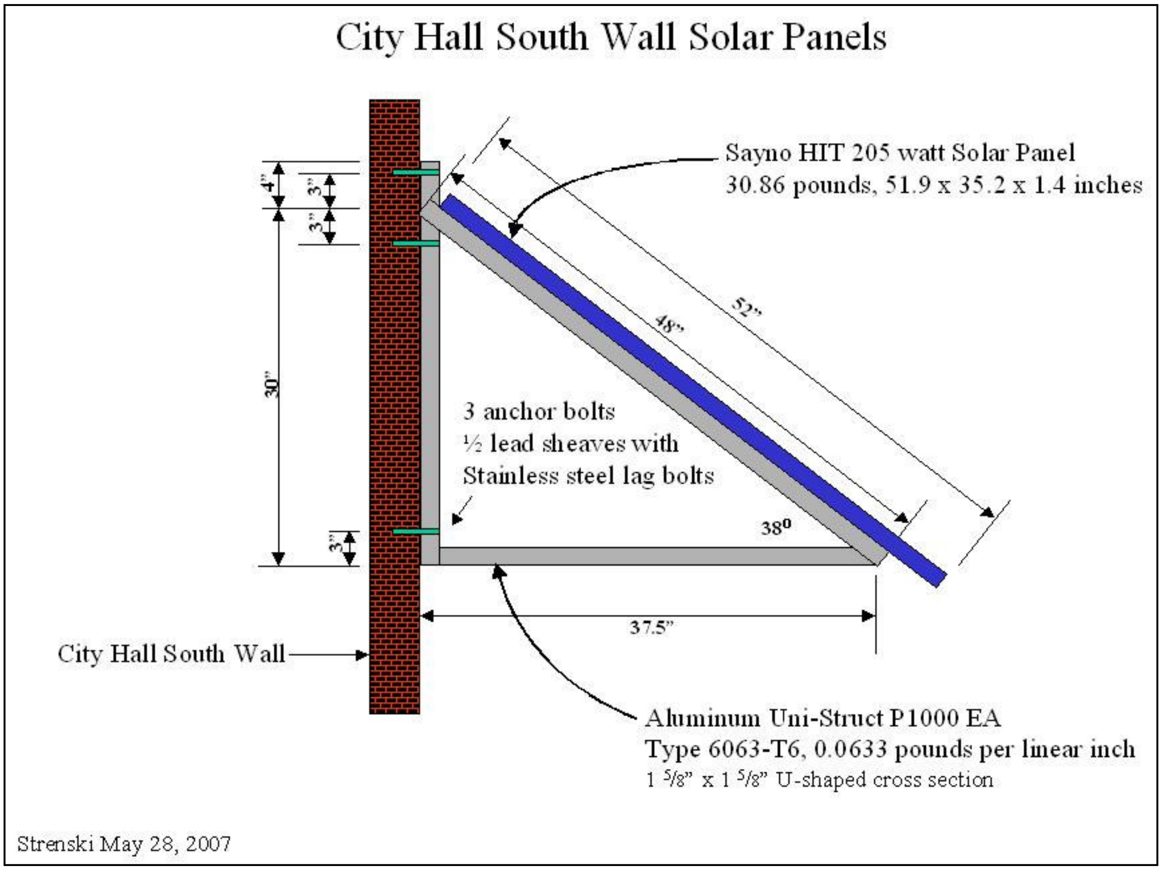
The ultimate long-term goal of this installation are: 1) To generate a solar energy revolution within the City, encouraging more residents and businesses to install solar panels on their buildings; 2) To attract and grow new businesses, centered around renewable energies, that would locate in Ypsilanti.; and 3) Generate useful power for the residents of Ypsilanti at peak demand times, reducing our need for additional power plants.

Installation

The current plan for City Hall is to put one row of Sanyo 205 watt solar photovoltaic panels on the south wall just above the two windows. A system schematic for this project can be seen in appendix A.



The panels are 35.2 inches wide with an installed width of 36 inches, making a string of 12 panels 36 feet long. The back wall of City Hall is 40 feet wide, leaving about 2 feet of brick on either side of the panels. The panels are 51.9 inches high and will be hung at an angle from the building so that they make a 38 degree angle from the horizontal.



To hold the panels at this angle, 13 triangular frames will be constructed from Aluminum Uni-Strut extruded channels (model number P1000 EA). This material comes in lengths of 10 feet and would be cut and bent into the shape shown in the figure above. The corners would be welded or bolted together. These frames may need to be shimmed to compensate for irregularities in the brick wall. With 12 panels and 13 frames, each panel would be supported on each side by a frame. The frames would be bolted to the brick wall using ½ inch long lag shield anchors, which can be seen in the picture to the right (lower anchor) and reference data given in appendix E. To install these anchors, ¾ inch diameter holes would be drilled into the brick wall to a depth of 7 inches. The installer would then have a short metal tube connected to compressed air to clean the dust out of the hole. Epoxy cement would then be squirted into the hole and a 7 inch long lag bolt would be lightly threaded into the lag shield and push to the back of the hole. This configuration would place the lag shield in the center of the three courses of brick in the wall and the epoxy, once set, would allow for additional bonding of the anchor to the brick wall.

The panels would be attached to the frames using top mount clamps from Uni-Rac specifically designed for Sanyo lipped modules. These clamps can be seen in the picture to the left and also shown in the frame cross-section diagram in appendix B. Reference material for the Sanyo HIT solar panels can be seen in appendix H.

The installation would proceed by having all the material staged on the roof of City Hall. Once there, a person in a cherry picker would move into position for the middle frame. Workers on the roof would lower the first frame using ropes and help hold it in place while the person in the cherry picker would drill holes for the anchor bolts to hold it in place. A second frame would then be lowered and anchored to the building in the same way. To ensure proper alignment, once the first two frames are in place, the first solar panel would be lowered and attached to the frames. Then the installation would proceed, adding the next frame and then the next solar panel. Work would proceed outwards from the middle until the last panel is placed for that half of the row and work would continue again from the middle.

Once the panels are mounted, wire and conduit would be attached to the building and the solar panels wired together as two strings of 6 panels, wired in parallel, and connected to the wires in the conduit. Near the bottom of the south wall, an SMA Combi-Switch would be attached to the outside of the building and the wires from the solar panels terminated within this box. A picture of the Combi-Switch box can be seen to the right and reference material found in appendix F.

From the Combi-Switch, the power goes to the SMA Sunny Boy 2500u inverter installed inside the building near the main power service box. A picture of the inverter can been seen here and referenced in appendix G. The inverter converts the DC (Direct Current) power from the solar panels into AC (Alternating Current) that is used by the building. The inverter measures the amplitude and frequency of the power coming from the utility and matches that power. It is UL listed and also checks for power loss from the grid and will shut down if the utility power grid goes down as an additional safety feature. The Sunny Boy has two terminals inside for the DC power, one for positive and one for negative, and two terminals for the two 120 volts AC wires. The Sunny Boy also has grounding terminals for both the AC and DC side. From the Sunny Boy inverter the AC power is connected to the existing service panel using a 20 amp 240 volt breaker.

Net-Metering the Power

For DTE Energy net-metering, the installation will need 3 utility meters: one for the **forward** power going into the building from DTE, one for the **backward** power coming out of the building, and one for the onsite **generated** power. These meters will be supplied by DTE, but the project will have to pay for the installation of the meter sockets. The meters will have a customer interface on them and be read directly and continuously by a computer. This information will be pooled on the computer and fed to the City of Ypsilanti's website. The information will be used to show total power consumption, along with what percentage of that consumption is coming from on-site generation (the solar panels) and what percentage is coming from the utility. It will also track any amount of over production that is sold back to the utility. See schematic in appendix A.

Cost Benefit Analysis

The cost of the installation is $18,534. Rounding this up to $19,000 and dividing by the total watts (12 x 205w) we get a dollar-per-watt cost of $7.72 ($19,000/2460w), which is reasonable. I have heard professional solar panel installers quote a rough price of about $10/watt installed.

Michigan gets about 4.1 peak hours of sun a day for a fixed panel. Rounding this down to 4.0 and multiplying by 2460 watts, we should get 9,840 watt-hours of power per day, or 295 KWH (9,840 x 30 / 1000) per month. Conservatively the panels and inverter should last over 30 years, producing a total of 106,272 KWH (295.2 x 12 x 30) of power for the $19,000 investment.

Assuming a fixed DTE cost of $0.10 per KWH for electricity, 295 KWH of power would cost $29.50 per month. 30 years of power at 295 KWH per month would cost $10,620 (29.50 x 12 x 30). It is very likely that electricity costs will go up, but even if it stayed constant for the 30 years, the project would be paying a $7,914 premium ($18,534 - $10,620) for power from this renewable source.

If we inflate the price of power by 4% each year, that same amount of power would cost $354 ($29.50 x 12) for the first year, $368 ($354 x 1.04) for the second year, $383 ($368 x 1.04) for the third year and so on for 30 years. After 30 years this total would be $19,854, so with an assumed 4% annual rise in power costs, the payback period for the project would be less then 30 years.

Another benefit to the City is a constant price for power for the lifetime of the materials. Even if power prices spike, the cost of this portion would remain constant.

Itemized Cost Estimate

Description	Quantity	Price	Total
Sanyo HIT 205 solar panel Wholesale Solar, 12 @ $1100 + $250 shipping Affordable Solar, 12 @ $1102 + $250 shipping	12	$1100.00	$13,450.00
SMA Sunny Boy 2500u inverter Alternative Energy Store $1900 + $50 shipping SC Solar $1900 + $50 shipping Solar-Electric $1975 + $50 shipping	1	$1950.00	$ 2,000.00
SMA Combi-Switch	1	$ 380.00	$ 380.00
UniStrut, aluminum channel, 10 feet per frame	130 ft	$5.2/foot	$ 676.00
Bolts/nuts/washers, 2 inches long, 3 per frame	39	$2/bolt	$ 78.00
Anchor Bolts, 3 per frame	39	$2/bolt	$ 78.00
Epoxy for anchor bolts, 1 tube per hole	39	$2/tube	$ 78.00
Grounding lugs, 1 per panel	12	$1.00	$ 12.00
UniRac, Top mount 12 panel kit, Sanyo	1 kit	$46.50	$ 47.00
Grounding rod and clamp	1	$20.00	$ 20.00
Grounding wire	100 ft	$0.25/ft	$ 25.00
Electrical conduit	100 ft	$3/10 ft	$ 30.00
Stranded wire, 4 wires @ 100 feet	400 ft	$0.15/ft	$ 60.00
Watt meter with customer interface and enclosure	1	$300.00	$ 300.00
DTE Co-Generation permit	1	$100.00	$ 100.00
Building permit	1	$100.00	$ 100.00
Electrical permit	1	$60.00	$ 60.00
Historic District permit	1	$30.00	$ 30.00
Misc. Hardware, fasteners, 240/20A breaker, etc	1	$50.00	$ 50.00
Labor cost – 4 person days	32 hr	$30/hr	$ 960.00
Cherry picker with operator	1 day	city	$ 0.00
Total			$18,534.00

Structural Analysis of Installation

The design still needs to be evaluated by a licensed structural engineer. The biggest concern for this installation is the pull-out forces on the anchors in the brick. Looking at the dead load forces in appendix C, we see a shear load on the anchor bolts of 12.8 pounds and a pull-out (tension) force on the top two anchors bolts of 12.8 pounds. These are very small forces so for most of the time the ½ inch anchors are more then enough.

Next we have to consider live loads on the structure. For the live loads calculations a snow load of 10 pounds per square foot is used. Snow on the panels will quickly melt off or slide off, because the panels are very smooth and dark. Once the sun comes out the snow will slide off. This snow load will add 43.3 pounds of shear force and 46.6 pounds of pull-out force on the top two anchors.

Wind is the biggest concern. The panels are mounted on the south side of the building so there is no wind loading from the north. Wind from the south will push the panel onto the building so it is not a concern. The east and west winds can also be ignored because they blow along the structure with equal wind on both sides of the panels. The two wind loadings to consider are an up draft and down draft. The worst case is a downdraft because it will add to the snow load and the dead loads.

The worst case loading for the top two anchors is the dead load plus the snow load and down draft load. In shear this will be (12.8 + 43.3 + 1516.3) 1572.4 pounds and (12.8 + 46.6 + 1630.0) 1689.4 pounds of pull-out force. See appendix D. The ½ inch long anchor are rated as having a pull-out force of 2800 pounds in 6000 psi concrete. If the anchors are not strong enough, we can add an additional anchor near the top of the frame and/or use a larger anchor.

Funding the Project

The City currently does not have any available funds for this project. Furthermore, if the City did have extra funds, insulating City building, replacing lighting for more efficient models, and other energy conservation activities, should be a higher priority. The most cost effective use of your dollar is to conserve energy. This is a demonstration project and meant to bring attention to energy conservation and renewable energies and promote Ypsilanti as a city of the future.

An initiative has been started to ask the general public to fund this project. Currently we have 56 people and businesses pledging $50 in support of this project. The website to make a pledge is (www.PledgeBank.com/YpsiSolar). With a project cost of $19,000 we will need ($19,000 / $50) 380 pledges to fully fund this project. Hopefully enough people will support this project, or alterative funding sources found.

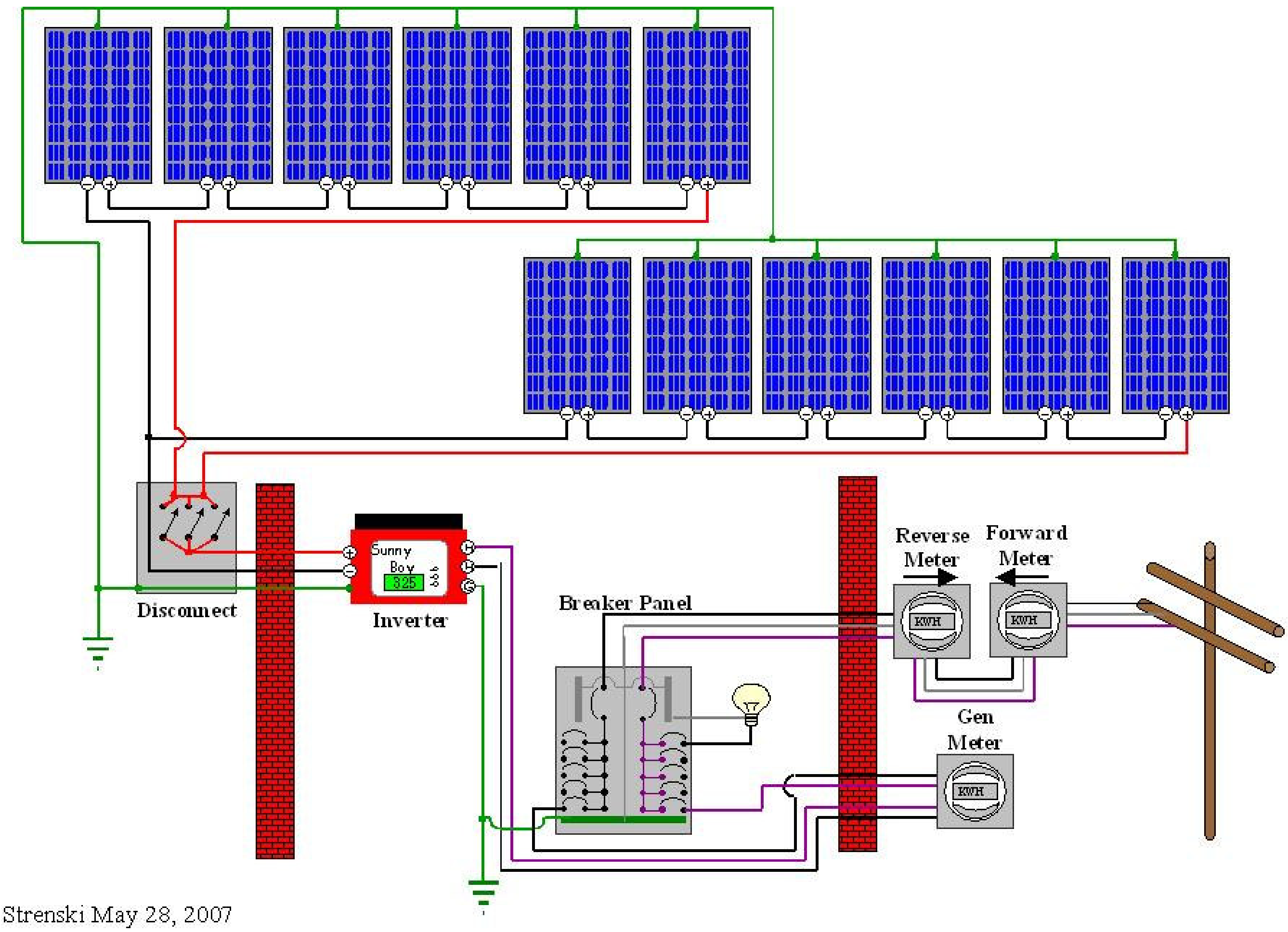
Issues and Concerns

One concern is the availability of panels. Sanyo 205 watt panels are not plentiful. If Sanyo 205 watt panels are not available when we decide to purchase them, we might consider 200, 195 and/or 190 watt panels. All have the same form factor, but would cost less and produce less power. Another option would be to pick a different manufacturer, but this might cause a redesign of the mounting frame.

Acknowledgements

Already many people have helped on this project. When the installation is complete we should invite all that have helped to a grand unveiling of the panels and acknowledge these individuals.

Appendix A – System Schematic



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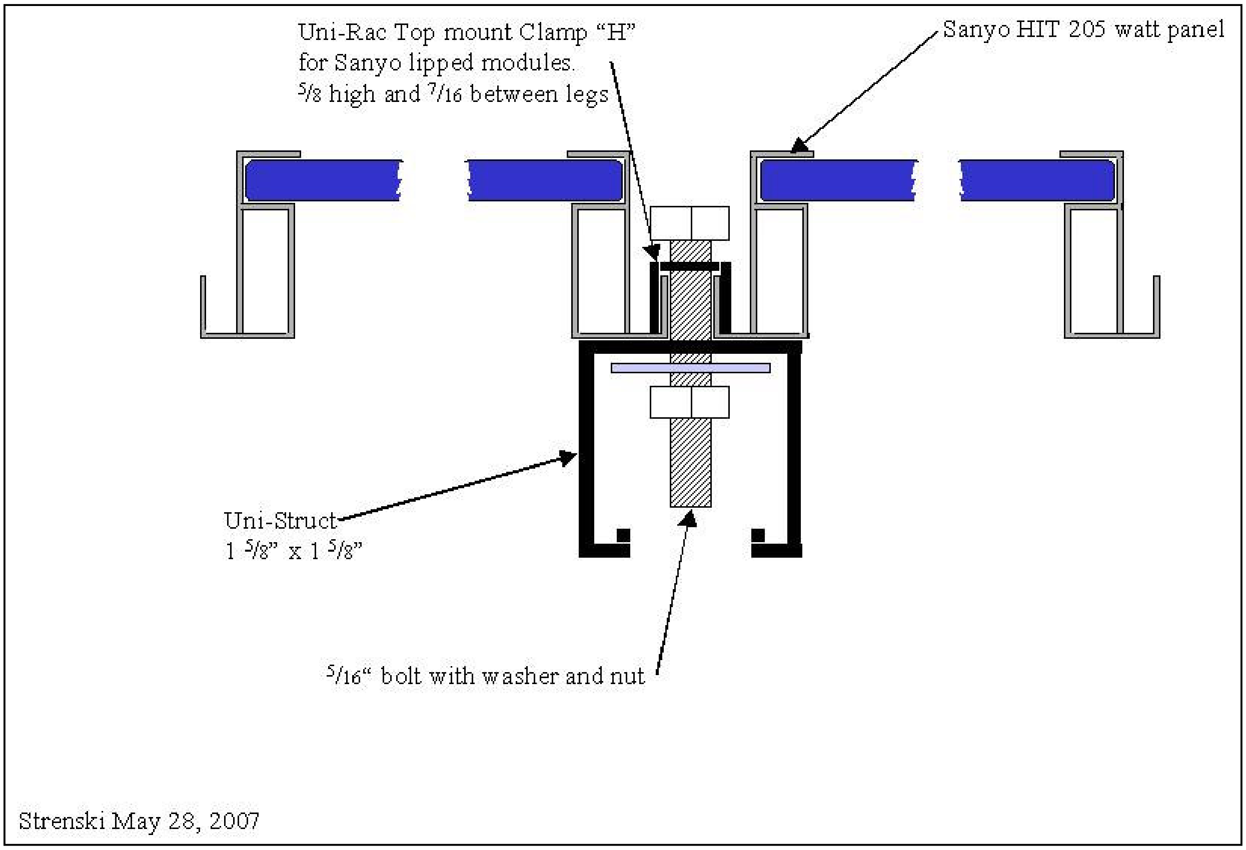
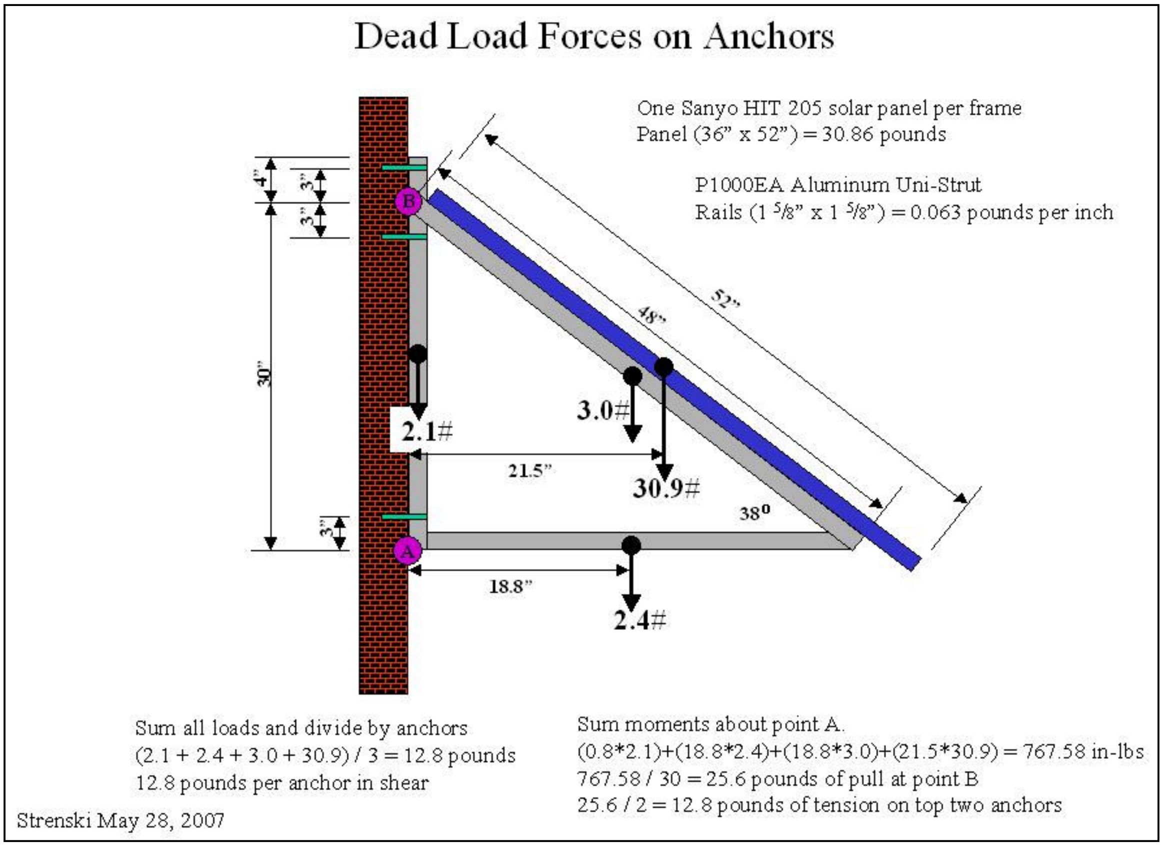
Appendix B – Mounting Frame/Solar Panel Cross-Section

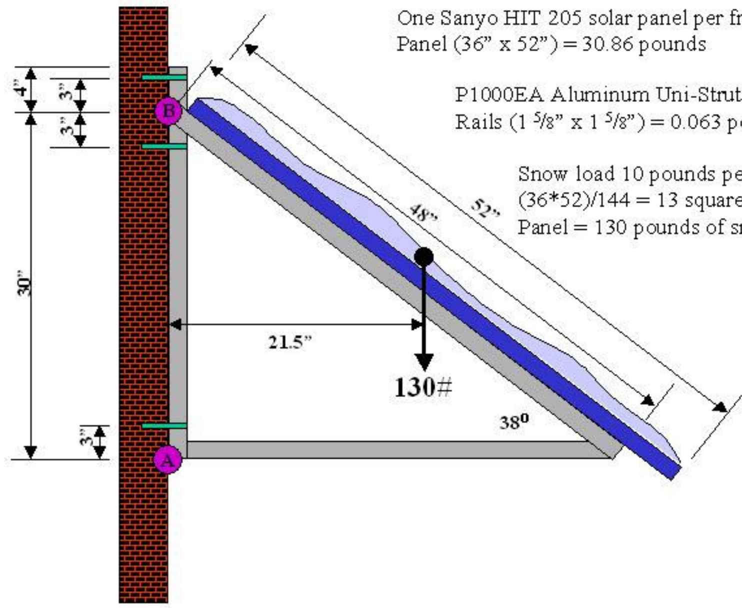


Appendix C – Structural Analysis – Dead Loads



Appendix D – Structural Analysis – Live Loads

Snow Load on Anchors



One Sanyo HIT 205 solar panel per frame
Panel (36" x 52") = 30.86 pounds

P1000EA Aluminum Uni-Strut
Rails (1 5/8" x 1 5/8") = 0.063 pounds per inch

Snow load 10 pounds per square foot
(36*52)/144 = 13 square feet
Panel = 130 pounds of snow load

Sum all loads and divide by anchors
130 / 3 = 43.3 pounds
43.3 pounds per anchor in shear

Sum moments about point A.
21.5*130 = 2795 in-lbs
2795 / 30 = 93.2 pounds of pull at point B
93.2 / 2 = 46.6 pounds of tension on top two anchors

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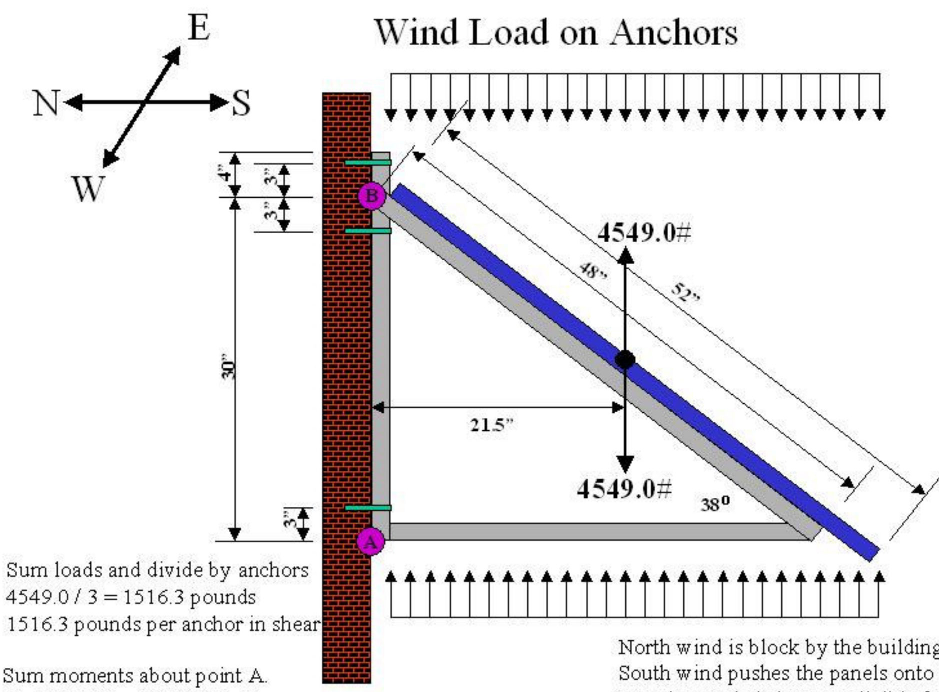
Wind Load on Anchors



Sum loads and divide by anchors
4549.0 / 3 = 1516.3 pounds
1516.3 pounds per anchor in shear

Sum moments about point A.
21.5*4549.0 = 97803.5 in-lbs
97803.5 / 30 = 3260.1 pounds of pull at point B
3260.1 / 2 = 1630 pounds of tension on top two anchors

North wind is block by the building.
South wind pushes the panels onto the building.
West/East winds have negligible forces on panels.
Up/Down winds will effect the forces on the anchors.
Wind speed of 30 mph = 30*30*0.0027 = 2.43 psi
Wind load on panel = 2.43 * 36 * 52 = 4549.0 pounds

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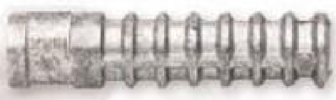
Appendix E – Concrete Fastener Reference Sheet

CONCRETE FASTENING SYSTEMS

p 888.498.5747
f 216.391.5352
www.confast.com



LAG SHIELD ANCHOR

This two-part expansion shield is pre-assembled into a self-contained single unit. The shell-like unit has tapered internal threads for a portion of its length. The outside of the anchor has a series of circumferential ribs starting at the bottom and running for a major portion of its length. The back end of the anchor has two equally spaced ribs that protrude beyond its diameter and run for a portion of its length. Precision internal threads permit easy turning of the lag screw without lubrication. Once fastened, an object may be easily unbolted and removed. All parts of the completed unit are made of zinc alloy commonly known as Zamak 5, a rust-proof material. The anchor comes in two lengths, short or long. The short lag shield is for anchoring in high grade concrete or where thickness of base material prohibits the use of a longer length shield. The long Lag shield is for use in lower grade base material or where extra anchoring strength is required.

TECHNICAL INFO

Approvals: Meets G.S.A. Specification FF-S-325, Group II, Type 1, Class 1 & 2. Zamak #5 Zinc Alloy meets the A.S.T.M. specification XXV (AC41A) and S.A.E. 925.

Applications: Light to medium duty into concrete, block and brick.

Installation: (1) Drill hole of recommended diameter, into the base material equal to the length of the expansion anchor plus one half inch (1/2") or more. (2) Clean the hole of all dust and cuttings. (3) Place the expansion anchor, ribbed end first, into hole. Tap with a hammer until flush with the surface of base material. (4) Position the material to be fastened over the shield in the base material and screw in the lag screw. (5) If the lag screw begins to torque-up or tighten before the head of the lag screw mates up against the object being fastened, the shield should be driven deeper into the hole by hand hammering the head of the lag screw until flush to the object being fastened. Re-tighten the lag screw to complete the expansion of the shield and to secure the material being fastened.

Screw Length: Thickness of material to be fastened plus Lag Shield length plus 1/2" equals Lag Screw length.

Anchor Spacing: The forces on a Lag Shield anchor are transferred to the material that it is installed in. If the anchors are installed too close together, it can cause an interaction of the forces, thus reducing the holding power of the anchor. As a rule of thumb, the expansion industry has established a minimum standard of ten (10) anchor diameters for spacing between anchors and five (5) anchor diameters from an unsupported edge. When vibration or sudden impact are part of the load condition anchor spacing should be increased.

TECHNICAL DATA

ANCHOR SIZE	HOLE SIZE	ANCHOR LENGTH	PULL-OUT 6000 PSI CONCRETE
1/4" Short	1/2"	1"	400 lb.
5/16" Short	1/2"	1-1/4"	800 lb.
3/8" Short	5/8"	1-3/4"	1300 lb.
1/2" Short	3/4"	2"	2100 lb.
5/8" Short	7/8"	2"	3400 lb.
3/4" Short	1"	2"	5000 lb.
1/4" Long	1/2"	1-1/2"	500 lb.
5/16" Long	1/2"	1-3/4"	1000 lb.
3/8" Long	5/8"	2-7/16"	1600 lb.
1/2" Long	3/4"	3-1/2"	2800 lb.
5/8" Long	7/8"	3-1/2"	4400 lb.
3/4" Long	1"	3-1/2"	6500 lb.

Values shown are average ultimate values and are offered only as a guide and are not guaranteed. A safety factor of 4:1 or 25% is generally accepted as a safe working load. Reference should be made to applicable codes for the specific working ratio. Minimum embedment for satisfactory anchor performance is 4-1/2 bolt diameters. Deeper embedments will yield higher tension and sheer capacity.

Appendix F – SMA Combi-Switch Reference Sheet

Combi-Switch

SMA

Combination DC Disconnect and PV Array Combiner Box

- Greatly simplifies PV input wiring
- 4 circuit fused input protection
- Compact, rugged low-cost design
- Heavy-duty, lockable, visible blade disconnect switch
- PV positive wires all land directly on Touch Safe™ fuse holders
- Sturdy NEMA 3R wall mountable steel enclosure
- ETL Listed to UL 1741

Introducing SMA America's new Combi-Switch specifically designed for use with the Sunny Boy 6000U inverter. The Combi-Switch conveniently combines both an external DC disconnect switch and PV string fusing all in one compact enclosure. Simply mount the Combi-Switch next to the inverter, connect the field wiring and you're done. The rugged NEMA 3R enclosure allows for outdoor installation. Designed with installers in mind, we know you'll find the new Combi-Switch a welcome addition to our great line of Sunny products.

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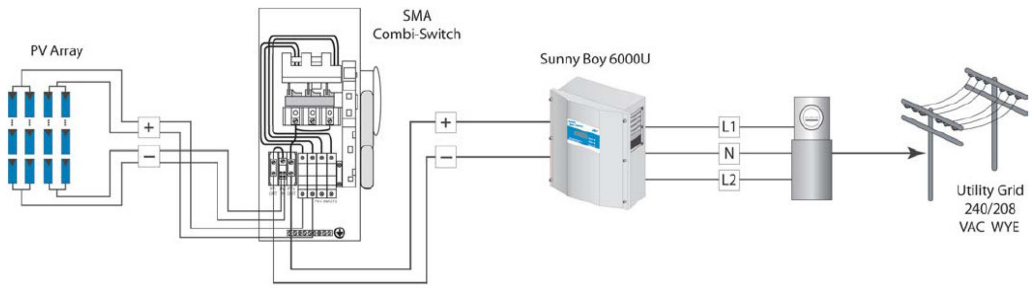

The new Combi-Switch was specially designed with installers in mind. It provides the code-required external DC disconnect and protection for the SB6000U inverter all in one small enclosure. The Combi-Switch allows for up to four PV strings to be landed on individual Touch Safe™ fuse holders. 10 Amp fuses are provided for PV string over-current protection. The fuse outputs are then combined and routed through the disconnect switch. One pair of wires conveniently connects the entire PV array to the SB6000U's DC inputs. The familiar enclosure is NEMA 3R rated for outdoor installation. Numerous knockout rings are provied for simplified conduit installation. The Combi-Switch is also ETL listed to UL 1741. Please contact your distributor for additional information and availability.

Specifications

Number of Inputs	4
Wiring Configuration	Positive or Negative Ground
Pos. Input Wire Size	14 to 8 AWG
Pos. Input Terminal Torque	14 in-lb.
Neg. Input Wire Size	14 to 8 AWG
Neg. Input Terminal Torque	35 in-lb.
Output Wire Size	6 to 2 AWG
Output Terminal Torque	40 in-lb.
Max. Input Fuse Rating	10 A, 600 VDC, Midget
Max. Output Current	40 ADC
Max. Voltage	600 VDC
Max. Cont. Output Current	32 ADC
Max. Number of Outputs	1 Positive, 1 Negative
Enclosure Type	NEMA 3R, Steel
Weight	10 lbs. (approx.)
Dimensions (with handle) HxWxD (inches)	15.0 x 7.75 x 5.75

Combi-Switch Interior

Available From:

SMA America, Inc.
Grass Valley, CA. USA
info@sma-america.com
www.sma-america.com

Solar Today...
Energy Tomorrow

Appendix G – SMA Sunny Boy 2500u Inverter Reference Sheet

Sunny Boy 2500U

SMA

The leading grid-tied photovoltaic inverters in Europe and America

- UL 1741 Listed for grid interactive inverters
- 5-year comprehensive warranty standard
- Rugged NEMA 4X stainless steel enclosure standard
- Exceptional reliability and energy capture ratio
- Easy to install three-point mounting system
- Comprehensive communications and data collection options
- SMA's modular string inverter design is expandable to virtually any size system

The SMA Sunny Boy inverter, the most popular grid-tied photovoltaic inverter in Europe, is now UL 1741 Listed and available in North America. Sunny Boy's extensive track record in some of the world's most demanding markets has made it a favorite among PV professionals everywhere. Over 250,000 Sunny Boy inverters have been installed worldwide. Superior design, rock-solid German engineering and exceptional real-world efficiency have made Sunny Boy the top choice for American solar designers.

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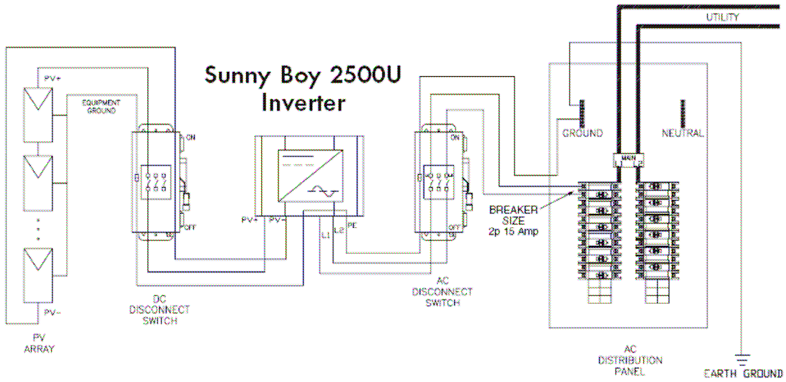


Sunny Boy's unsurpassed reliability and efficiency are the result of SMA's manufacturing philosophy that combines simple design with robust execution. SMA's state-of-the-art maximum power point tracking performance results in greater real-world energy capture than any other grid-tied inverter. Sunny Boy's safety and reliability record is also exceptional due, in part, to the inverter's redundant grid monitoring and built-in ground fault detection and interruption protection. The inverter's IGBT power stage generates a nearly perfect sine wave with the lowest harmonic distortion in the industry and meets ultra-strict FCC EMC standards. SMA's unique String Inverter technology makes future system expansion simple. SMA advanced communication options are available to satisfy almost any application.

Specifications

Inverter Technology	Real sine-wave, current source, high frequency PWM
AC Input Voltage	213-262 (240V AC) or 183-229 (208V AC)
AC Input Frequency	59.3 - 60.5 (60Hz) (50Hz also available)
DC Input Voltage	250 - 600V DC
Peak Power Tracking Voltage	234 - 550V DC (at 240V AC)
PV Start Voltage	300V DC
Minimum DC Input Voltage	207 - 256V DC dependent on available line voltage
Maximum Array Input Power	3000W (240V AC)(DC@STC) 2600W (208V AC)(DC@STC)
Maximum AC Power Output	2500W (240V AC) 2100W (208V AC)
Current THD	< 4%
Power Factor	Unity
Peak Inverter Efficiency	94.1%
Cooling	*Convection cooling (no fan)
Maximum AC Output Current	12A
Maximum DC Input Current	12A

Distributed by:

DC Voltage Ripple	< 5%
Power Consumption	0.25W nighttime < 7W standby
Ambient Temperature Rating	45°C
Enclosure	NEMA 4X (iP65) Stainless Steel
Dimensions	17.10W x 11.60H x 8.40D in 434W x 295H x 214D mm
Weight	71 lbs (32 kg)
Compliance	United States UL 1741, E210376, UL 1998, IEEE 519, IEEE 929, ANSI C62.41 C1 & C3, FCC part 15 A & B International DIN EN50082 Part 1, 61000-32, 50081, 50014, 600055 Part 2 55011 Group 1 Class B, 50178, 60146 Part 1-1

* Optional external fan (Sunny Breeze) available

SMA America, Inc., 12438-C Loma Rica Dr.
Grass Valley, CA. 95945
Tel: 530.273.4895 Fax: 530.274.7271
www.sma-america.com

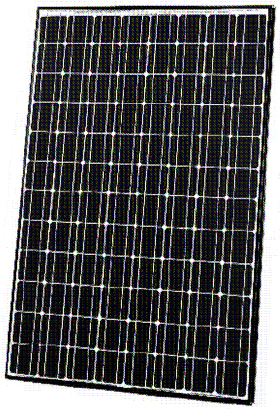
Solar Today...
Energy Tomorrow

Appendix H – Sanyo 205 Watt Photovoltaic Solar Panel Reference Sheet

HIT PHOTOVOLTAIC MODULES

Models: HIP-180BA3, HIP-186BA3, HIP-190BA3, HIP-195BA3, HIP-200BA3, HIP-205BA3

SANYO



Power Output: 180 - 205 Watts

Cell Efficiency: 17.8% - 20.2%

Module Efficiency: 15.3% - 17.4%

Proprietary Technology

SANYO HIT (**H**eterojunction with **I**ntrinsic **T**hin layer) solar cells are hybrids of single crystalline silicon surrounded by ultra-thin amorphous silicon layers.

High Efficiency

SANYO HIT solar panels are a leader in cell and module efficiency. With models up to 16.2 Watts per sq. foot (17.4% module efficiency) you obtain maximum power within a fixed amount of space. You save costs for using fewer support materials, wiring, and spend less time installing. The powerful modules are ideal for grid-connected solar systems, areas with performance-based incentives, and renewable energy credits.

Temperature Attributes

As temperatures rise, SANYO HIT solar panels produce more electricity (kWh) than conventional crystalline silicon solar panels at the same temperature.

Unique Structure

SANYO HIT solar panels have a black anodized double-wall aluminum frame. The panels come pre-equipped with a touch-safe junction box, lead wires, MC™ plug-n-play connectors, and a unique mounting lip, all of which help to minimize support structure materials, installation time and costs.

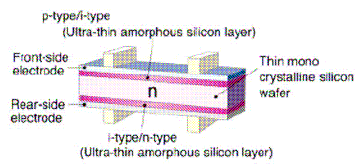
Valuable Features

SANYO HIT solar panels have no moving parts and weigh less than 31 pounds (14kg). The panels are 100% emission and noise free. The panels come with a 20-year Limited Power Output Warranty and a 2-year Limited Product Workmanship Warranty. Panels are UL 1703 safety rated for wind, fire and hail. You can transport the panels to a site using less space and our eco-package minimizes cardboard waste deposited in a customer's trash.

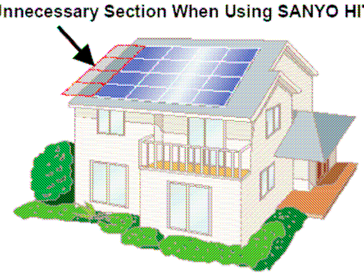
Quality, Ratings, Reliability

SANYO silicon wafers are manufactured in the USA, and the panels are assembled in Mexico. All SANYO solar factories in North America are ISO 9001 and 14001 certified. The panels undergo strict inspections to ensure electrical, mechanical, environmental, and visual compliance. SANYO's conservative model ratings give customers more kWh per rated kW, and assist to more accurately predict performance and financial economics.

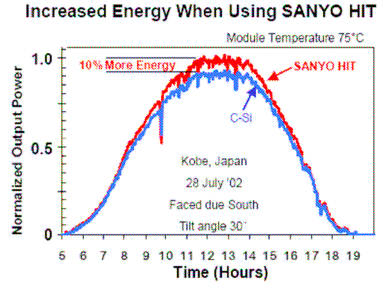
SANYO HIT Solar Cell Structure



Unnecessary Section When Using SANYO HIT



Increased Energy When Using SANYO HIT



Models HIP-xxxBA3

Electrical Specifications		180	186	190	195	200	205
Rated Power (Pmax)[1]	W	180	186	190	195	200	205
Maximum Power Voltage (Vpm)	V	54.0	54.4	54.8	55.3	55.8	56.7
Maximum Power Current (Ipm)	A	3.33	3.42	3.47	3.53	3.59	3.62
Open Circuit Voltage (Voc)	V	66.4	67.0	67.5	68.1	68.7	68.8
Short Circuit Current (Isc)	A	3.65	3.71	3.75	3.79	3.83	3.84
Minimum Power (Pmin)	W	162.0	167.4	171.0	175.5	180.0	184.5
Max System Voltage (Vsys)	V	600	600	600	600	600	600
Series Fuse Rating	A	15	15	15	15	15	15
Temperature Coefficient (Pmax)	%/°C	-0.33	-0.30	-0.30	-0.30	-0.29	-0.29
Temperature Coefficient (Voc)	V/°C	-0.173	-0.168	-0.169	-0.170	-0.172	-0.172
Temperature Coefficient (Isc)	mA/°C	1.10	0.85	0.86	0.87	0.88	0.88
Electrical Tolerance	%	+/- 10	+/- 10	+/- 10	+/- 10	+/- 10	+/- 10
PTC Rating[2]	W	168.0	174.9	178.7	183.5	188.7	193.4
Cell Efficiency	%	17.8	18.4	18.8	19.3	19.7	20.2
Module Efficiency	%	15.3	15.8	16.1	16.5	17.0	17.4
Power per Square Foot	W	14.2	14.7	15.0	15.4	15.8	16.2

Mechanical Specifications

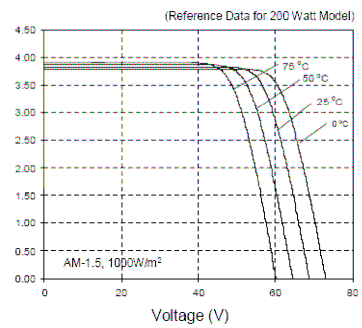
Internal Bypass Diodes	4 Bypass Diodes
Module Area (m^2)	12.69 Ft^2 (1.18m^2)
Weight (kg)	30.86 Lbs. (14kg)
NOCT (°C)	112°F (44.2°C)
Dimensions LxWxH (mm)	51.9x35.2x1.4in (1319x894x35mm)
Cable Length -Male/+Female (mm)	30.7/24.8in (780/630mm)
Cable Size / Connector Type	No.12 AWG / MC^{TM} Connectors
Static Load Wind / Snow (Pa)	50PSF (2400Pa) / 39PSF (1876Pa)
Pallet Dimensions LxWxH (mm)	53x36x63in (1346x912x1600mm)
Pieces per Full Pallet / Weight (kg)	36pcs / 1102 Lbs (500kg)
Quantity per 20'/40'/53' Container	360pcs / 756pcs / 972pcs

Standard Operating Conditions (SOC) and Safety Ratings

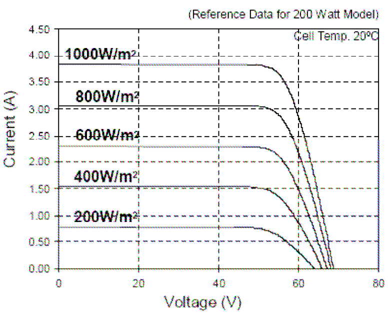
SOC Temperature[3]	-4°F to 104°F[3] (-20°C to 40°C)
SOC Relative Humidity	45% to 95%
Hail Safety Impact Velocity	1" hailstone (25mm) at 52mph (23m/s)
Fire Safety Classification	Class C
Safety & Rating Certifications	UL 1703, cUL, CEC
Limited Warranties	2 Years Workmanship / 20 Years Power Output

[1]STC: Cell Temp. 25°C, AM1.5, 1000W/m² [2]PTC: Ambient Temp. 20°C, AM1.5, 1000W/m², 1m/s Wind [3]Range defined as the monthly average low and high of the installation location

Dependence on Temperature



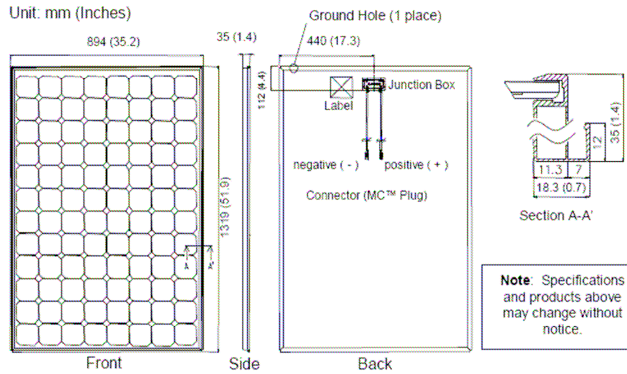
Dependence on Irradiance



CAUTION! Read the operating instructions carefully before use of these products.

Dimensions

Unit: mm (Inches)



Note: Specifications and products above may change without notice.

Visit www.sanyo.com or contact our Authorized Representatives for more information: