SOLAR ELECTRIC MODULES

The balance of this catalog lists and describes all of the equipment that you might need for a renewable energy system. We start with solar modules since they are your power producers and we progress through your system concluding with the loads your system will operate.

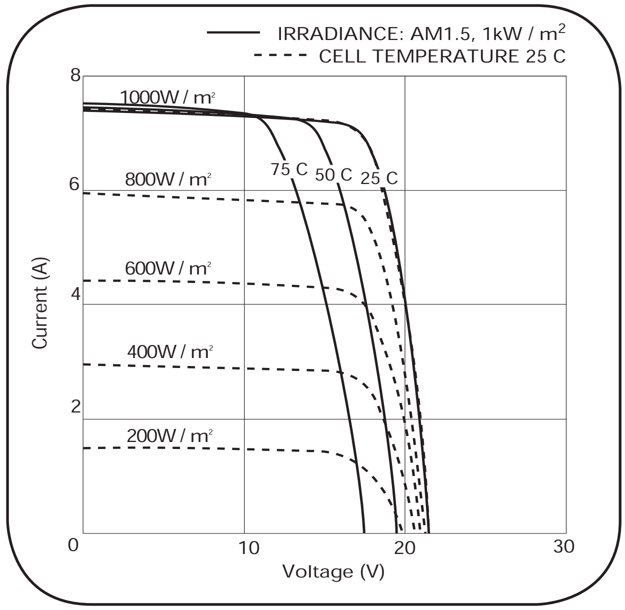
Solar Module Power Characteristics

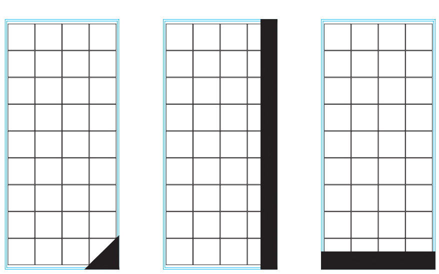
The current and power output of photovoltaic modules are approximately proportional to sunlight intensity. At a given intensity, a module's output current and operating voltage are determined by the characteristics of the load. If that load is a battery, the battery's internal resistance will dictate the module's operating voltage.

A module which is rated at 17 volts will put out less than its rated power when used in a battery system. This is because the working voltage will be between 12 and 15 volts. As wattage (power) is the product of volts times amps, the module output will be reduced. For example: a 50 watt module working at 13.0 volts will produce 39.0 watts (13.0 volts x 3.0 amps = 39.0 watts).This is important to remember when sizing a PV system.

An I-V curve as illustrated to the right is simply all of a module's possible operating points, (voltage/current combinations) at a given cell temperature and light intensity. Increases in cell temperature increase current slightly, but drastically decrease voltage.

Maximum power is derived at the knee of the curve. Check the amperage generated by the solar array at your battery's present operating voltage to better calculate the actual power developed at your voltages and temperatures.





Examples of partial-cell shading that reduce PV module power by ½

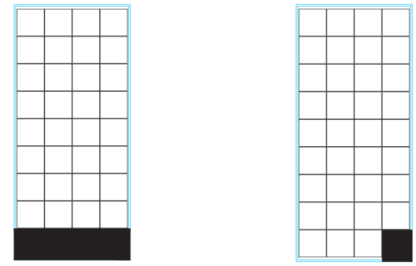
Shading

PV modules are very sensitive to shading. Unlike a solar thermal panel which can tolerate some shading, many brands of PV modules cannot even be shaded by the branch of a leafless tree.

Shading obstructions can be defined as soft or hard sources. If a tree branch, roof vent, chimney or other item is shading from a distance, the shadow is diffuse or dispersed. These soft sources significantly reduce the amount of light reaching the cell(s) of a module. Hard sources are defined as those that stop light from reaching the cell(s), such as a blanket, tree branch, bird dropping, or the like, sitting directly on top of the glass. If even one full cell is hard shaded the voltage of that module will drop to half of its unshaded value in order to protect itself. If enough cells are hard shaded, the module will not convert any energy and will, in fact, become a tiny drain of energy on the entire system.

Partial-shading even one cell of a 36-cell module, such as the KD135SX, will reduce its power output. Because all cells are connected in a series string, the weakest cell will bring the others down to its reduced power level. Therefore, whether ½ of one cell is shaded, or ½ a row of cells is shaded as shown above, the power decrease will be the same and proportional to the percentage of area shaded, in this case 50%.

When a full cell is shaded, it can act as a consumer of energy produced by the remainder of the cells, and trigger the module to protect itself. The module will route the power around that series string. If even one full cell in a series string is shaded, as seen on the right, it will likely cause the module to reduce its power level to ½ of its full available value. If a row of cells at the bottom of a module is fully shaded, as seen in Figure 7, the power output may drop to zero. The best way to avoid a drop in output power is to avoid shading whenever possible.



Example of full-cell shading that can reduce PV module power to zero

Example of full-cell shading that can reduce PV module power by ½

Tilt Angle

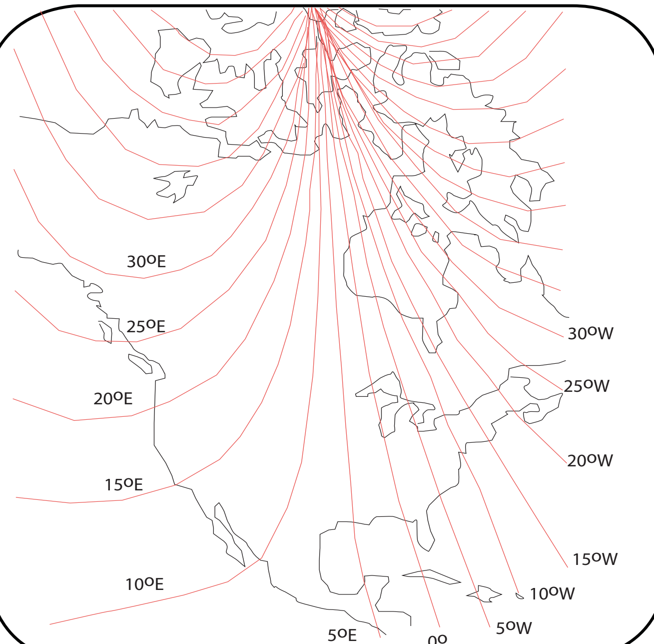
To capture the maximum amount of solar radiation over a year, the solar array should be tilted at an angle approximately equal to a site's latitude, and facing within 15° of due south. To optimize winter performance, the solar array can be tilted 15° more than the latitude angle, and to optimize summer performance, 15° less than the latitude angle. At any given instant, the array will output maximum available power when pointed directly at the sun.

To compare the energy output of your array to the optimum value, you will need to know the site's latitude, and the actual tilt angle of your array-which may be the slope of your roof if your array is flush-mounted. If your solar array tilt is within 15° of the latitude angle, you can expect a reduction of 5% or less in your system's annual energy production. If your solar array tilt is greater than 15° off the latitude angle, the reduction in your system's annual energy production may fall by as much as 15% from its peak available value. During winter months at higher latitudes, the reduction will be greater.

Azimuth Angle and Magnetic Declination

If a south-facing roof is unavailable, or the total solar array is larger than the area of a south-facing roof section, an east or west-facing surface is the next best option. Be aware that solar power output decreases proportionally with a horizontal angle, or "azimuth," greater than 15° from due south. The decrease in annual power output from a latitude-tilted east or west-facing array may be as much as 15% or more in the lower latitudes or as much as 25% or more in the higher latitudes of the United States. Avoid directing your tilted solar panels northwest, north or northeast, as you'll get little power output.

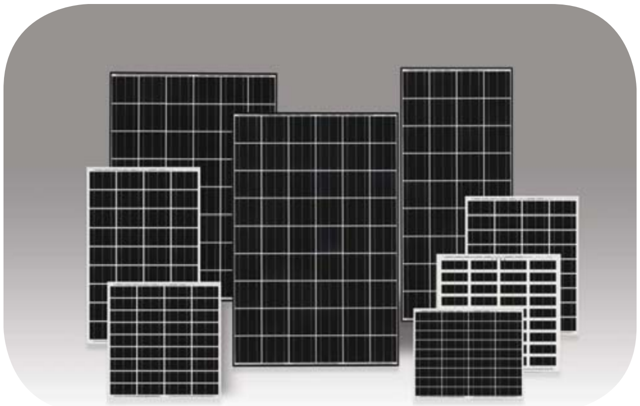
Magnetic declination, the angle difference between magnetic south and true solar south, must also be taken into account when determining proper solar array orientation. If a magnetic compass alone is used to determine where to point the array, you may not capture the maximum amount of solar radiation. For a general view of the magnetic declination field lines in North America, see the map on the right. If you wish to gain in-depth information about magnetic declination, visit the following web site:
http://www.ngdc.noaa.gov/seg/geomag/declination.shtml.



Magnetic declination map of North America for the year 1995

Kyocera Solar Modules [KC/KD]

Kyocera's advanced cell processing technology and automated production facilities have produced multi-crystalline solar cells with efficiencies of over 18.5%. All modules are constructed using a tempered glass front, EVA pottant and a PVF backing to provide maximum protection from the most severe environmental conditions.



KD Module Family

The entire laminate is framed in a heavy duty anodized aluminum frame to provide structural strength and ease of installation. Because Kyocera modules are so efficient less space is required than other solar modules of equal output. This translates to both more wattage per square foot and lower mounting structure cost.

KD 210GX-LP

Features

- KC65T - KC130TM modules have a +10/-5% power tolerance, KC40T-50T: +15/-5%
- KD135GX-LP - KD210GX-LP modules have a +5%/-5% tolerance
- UL listed
- Low iron, tempered glass, EVA encapsulant and anodized aluminum frame construction
- 20 year output warranty on Kyocera modules
- Weather resistant junction box (KC40T-KC130TM) or multi-contact connectors (KD130GX-LP, 180GX-LP, 205GX-LP & 210GX)

Quality Assurance

Kyocera multi-crystal photovoltaic modules exceed government specifications for the following tests:

- Thermal cycling test
- Thermal shock test
- Thermal/Freezing and high humidity cycling test
- Electrical insolation test
- Hail impact test
- Mechanical, wind and twist loading test
- Salt mist test
- Light and water exposure test
- Field exposure test

Product Name and Descriptions	KD 210GX-LP	KD 205GX-LP	KD 180GX-LP	KD 135GX-LP	KC 130TM	KC85T	KC65T	KC50T	KC40T
Part Number	**503091**	**501015**	**501014**	**501013**	**501004**	**703004**	**703005**	**703007**	**703008**
Rate of Power(Watts)	210	205	180	135	130	87	65	54	43
Series Fusing(Amps)	15.0	15.0	15.0	15.0	15.0	7.0	6.0	6.0	6.0
Current at Max. Power(Amps)	7.90	7.71	7.63	7.63	7.39	5.02	3.75	3.11	2.48
Voltage at Max Power(Volts)	26.6	26.6	23.6	17.7	17.6	17.4	17.4	17.4	17.4
Short Circuit Current(Amps)	8.58	8.36	8.35	8.37	8.02	5.34	3.99	3.31	2.65
Open Circuit Voltage(Volts)	33.2	33.2	29.5	22.1	21.9	21.7	21.7	21.7	21.7
Length (Inches)	59.1	59.1	52.8	59.1	56.0	39.6	29.6	25.2	20.7
Width (Inches)	39.0	39.0	39.0	26.3	25.7	25.7	25.7	25.7	25.7
Depth of Frame (Inches)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Depth including j-box	1.4	1.4	1.4	1.4	2.2	2.2	2.1	2.1	2.1
Shipping Weight (lbs.)	45.8	45.8	41.4	33.0	33.0	24.0	18.0	16.0	13.0

All specification at 25°C. cell temperature, 1.5 AM and 1000W/m2. KC "T" and "TM" modules have a conduit ready junction box. "GX" modules have locking multi-contact connectors. See Appendix A for module dimensions and shipping information

Replacement bypass diodes for Kyocera J-Box equipped modules are sold in packs of 25; part number 705070