Solar Basics

PV power generation systems are made up of interconnected components, each with a specific function. One of the major strengths of PV systems is modularity. As your needs grow, individual components can be replaced or added to provide increased capacity. Although the selected components will vary depending on the applications, PV systems generally conform to the schematic shown below. What follows is a brief overview of a typical PV system.

Solar Array – The solar array consists of one or more PV modules which convert sunlight into electric energy. The modules are connected in series and/or parallel to provide the voltage and current levels to meet your needs. The array is usually mounted on a metal structure and tilted to face the sun.

Charge Controller – Although charge controllers can be purchased with many optional features, their main function is to maintain the batteries at the proper charge level, and to protect them from overcharging.

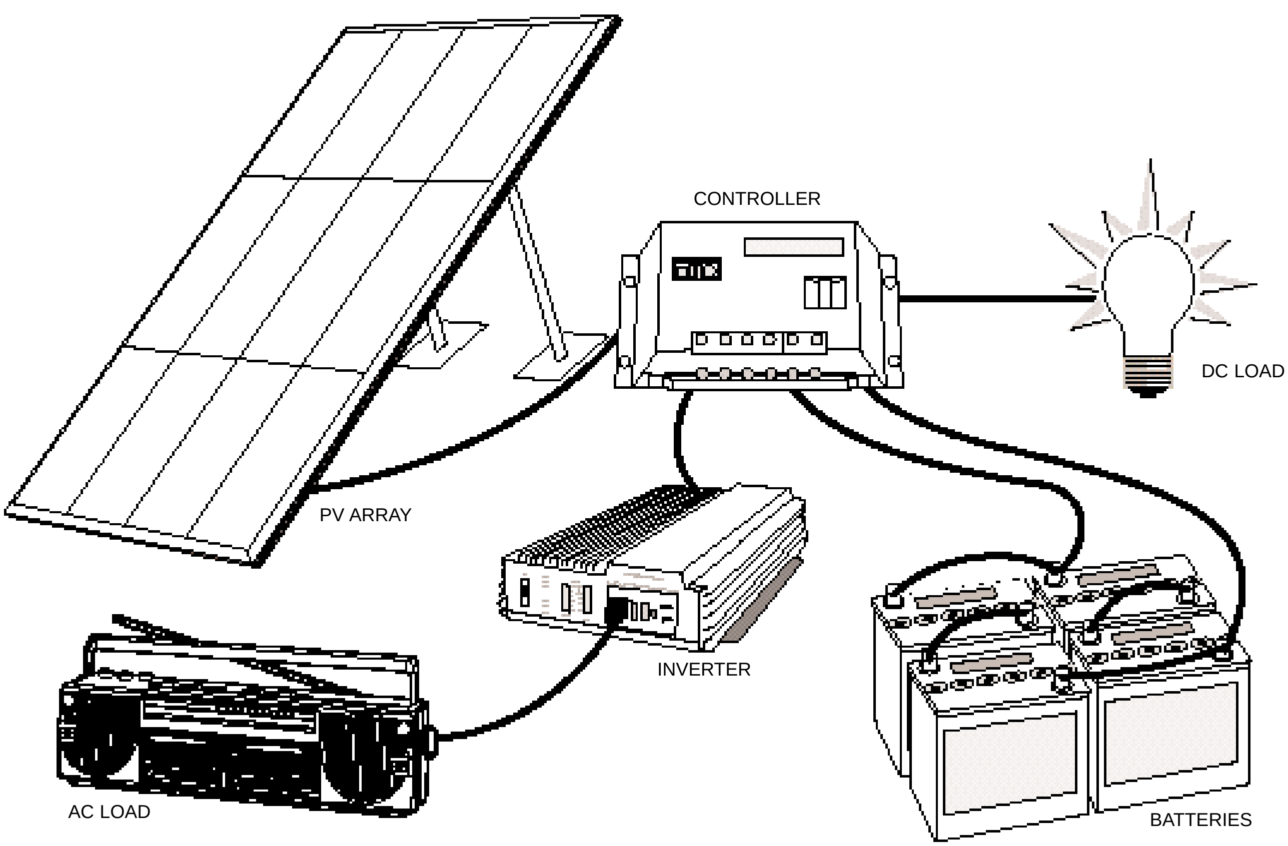
Battery Bank – The battery bank contains one or more deep-cycle batteries, connected in series and/or parallel depending on the voltage and current capacity needed. The batteries store the power produced by the solar array and discharge it when you need it.

Inverter – An inverter is required when you want to power AC devices. The inverter converts the DC power from the solar array/batteries, into AC power.

AC and DC Loads – These are the appliances (such as lights or radios), and the components (such as water pumps and microwave repeaters), which consume the power generated by your PV array.

Balance of System – These components provide the interconnections and standard safety features required for any electrical power system. These include: array combiner box, properly sized cabling, fuses, switches, circuit breakers and meters.

TYPICAL PV SYSTEM



Six Steps To Sizing A PV System

SunWize TECHNOLOGIES, INC. A Besicorp Company

We have provided you with an easy to follow, step-by-step guide for sizing your photovoltaic (PV) system. Follow these six steps to determine your requirements and specify the components you will need.

1. *Determine Your Power Consumption Demands*

Make a list of the appliances and/or loads you are going to run from your PV system. Find out how much power each item consumes while operating. Most appliances have a label on the back which lists the wattage. Specification sheets, local appliance dealers, and the product manufacturers are other sources of information. We have provided a chart that lists typical power consumption demands of common devices which you can use as a guide. Once you have the wattage ratings, fill out the load sizing worksheet.

POWER CONSUMPTION CHART

Estimated ratings for common appliances.

APPLIANCE	WATTS	APPLIANCE	WATTS	APPLIANCE	WATTS
Coffee Pot	200	Ceiling Fan	10-50	Compact Fluorescent	
Coffee Maker	800	Table Fan	10-25	Incandescent Equivalent	
Toaster	800-1500	Electric Blanket	200	40 watt equivalent	11
		Blow Dryer	1000	60 watt equivalent	16
Blender	300	Shaver	15	75 watt equivalent	20
Microwave	600-1500	Computer		100 watt equivalent	30
		Laptop	20-50	1/4” Drill	250
Hot Plate	1200	PC	80-150	1/2” Drill	750
Washing Machine		Printer	100	1” Drill	1000
Automatic	500	Typewriter	80-200	9” Disc Sander	1200
Manual	300	TV 25” Color	150	3” Belt Sander	1000
Vacuum Cleaner		19” Color	70	12” Chain Saw	1100
Upright	200-700	12” B&W	20	14” Band Saw	1100
Hand	100	VCR	40	7-1/4” Circular Saw	900
Sewing Machine	100	CD Player	35	8-1/4” Circular Saw	1400
Iron	1000	Stereo	10-30	Refrig/Freezer	
Cloths Dryer		Clock Radio	1	20cf (15 hours)	540
Electric	400	Satellite Dish	30	16cf (13 hours)	475
Gas heated	300-400	CB Radio	5	Sunfrost	
Water Pump	250-500	Electric Clock	3	16cf DC (7 hours)	112
		Lights:		12cf DC (7 hours)	70
		100W Incandescent	100	Freezer	
		25W Compact Fluor.	28	14cf (15 hours)	440
		50W DC Incandescent	50	14cf (14 hours)	350
		40W DC Halogen	40	Sunfrost Freezer	
		20W Compact Fluor.	22	19cf (10 hours)	112

AC and DC LOAD SIZING WORKSHEETS

Use this worksheet to determine the total amp hours per day used by all the AC and DC loads in your system.

Step 1: Calculate your AC loads. If there are no AC loads, skip to Step 2, “Calculate your DC Loads.”

1. List all AC loads, wattage and hours of use per week (Hrs/Wk) in the spaces below. Multiply watts by Hrs/Wk to get watt-hours per week (WH/Wk). Add all the watt hours per week to determine AC Watt Hours Per Week.

Description of AC Loads Run by an Inverter	Watts	X	Hrs/Wk	=	Wh/Wk
		X		=	
		X		=	
		X		=	
		X		=	
		X		=	
		X		=	
			Total Wh/Wk AC		

... Power Consumption *Continued*

System Loads Worksheet

Note: Wattage of appliances can usually be determined from tags on the back of the appliance or from the owner's manual. If an appliance is rated in amps, multiply amps by operating voltage (120 or 240) to determine watts.

2. DC watt hours per week. Multiply total of step 1 by 1.2 to correct for inverter loss. ______________

3. Inverter DC input voltage; usually 12 or 24 volts – enter here ______________

4. Divide line 2 by line 3. This is total amp hours per week used by AC loads. ______________

Step 2: Calculate your DC loads.

5. List all DC loads in the spaces below:

Description of DC Load	Watts	X	Hrs/Wk	=	Wh/Wk
		X		=	
		X		=	
		X		=	
		X		=	
		X		=	
		X		=	
			Total Wh/Wk DC		

6. DC system voltage. Usually 12 or 24 volts. (Same as line 3) ______________

7. To determine total amp hours per week used by DC loads, divide line 5 by line 6. ______________

8. To determine total amp hours per week used by AC loads enter line 4. ______________

9. Add lines 7 and 8. This is total amp hours per week used by all loads. ______________

10. Divide line 9 by 7 days. This is total average amp hours per day. ______________

2. *Optimize Your Power System Demands*

At this point, it is important to examine your power consumption and reduce your power needs as much as possible. (This is true for any system, but it is especially important for home and cabin systems because the cost savings can be substantial.) First identify large and/or variable loads (such as water pumps, outdoor lights, electric ranges, AC refrigerators, clothes washers, etc.) and try to eliminate them or examine alternatives such as propane or DC models. The initial cost of DC appliances tends to be higher than AC, but you avoid losing energy in the DC to AC conversion process, and typically DC appliances are more efficient and last longer. Replace incandescent fixtures with fluorescent lights wherever possible. Fluorescent lamps provide the same level of illumination at lower wattage levels. If there is a large load that you cannot eliminate, consider using it only during peak sun hours, or only during the summer. (In other words, be creative!) Revise your Load Sizing Worksheet now with your optimized results.

3. *Size Your Battery Bank (If Necessary)*

Choose the battery you want to use (See "Characteristics of Batteries"). Fill out the Battery Sizing Worksheet. Other types of storage are available depending on the type of system you are considering. (Example: water storage tanks for pumping applications.)

BATTERY SIZING WORKSHEET

The first decision you have to make is how much storage you would like your battery bank to provide. Often this is expressed as "days of autonomy" because it is based on the number of days you expect your system to provide power without receiving an input charge from the solar array. In addition to the days of autonomy, you should also consider your usage pattern and the critical nature of your application. If you are installing a system for a weekend home, you might want to consider a larger battery bank because your system will have all week to charge and store energy. Alternatively, if you are adding a PV array as a supplement to a generator based system, your battery bank can be slightly undersized since the generator can be operated if needed for recharging. Once you have determined your required storage capacity, you are ready to consider the following key parameters.

1. Enter your daily amp-hour requirement. (From the Load Sizing Worksheet, line 10) ______________

2. Enter the maximum number of consecutive cloudy weather days expected in your area, or the number of days of autonomy you would like your system to support. ______________

3. Multiply the amp-hour requirement by the number of days. This is the amount of amp-hours your system will need to store. ______________

4. Enter the depth of discharge for the battery you have chosen. This provides a safety factor so that you can avoid over-draining your battery bank (Example: If the discharge limit is 20%, use 0.2.) This number should not exceed 0.8. ______________

5. Divide the amp-hours (line 3) of storage needed by the depth of discharge (line 4) limit. ______________

6. Select the multiplier below that corresponds to the average wintertime ambient temperature your battery bank will experience. ______________

Ambient Temperature		Multiplier
80F	26.7C	1.00
70F	21.2C	1.04
60F	15.6C	1.11
50F	10.0C	1.19
40F	4.4C	1.30
30F	-1.1C	1.40
20F	-6.7C	1.59

7. Multiply the amp-hours by line 6. This calculation ensures that your battery bank will have enough capacity to overcome cold weather effects. This number represents the total battery capacity you will need. ______________

8. Enter the amp-hour rating for the battery you have chosen. ______________

9. Divide the total battery capacity by the battery amp-hour rating and round off to the next highest number. This is the number of batteries wired in parallel required. ______________

10. Divide the nominal system voltage (12 or 24V) by the battery voltage and round off to the next highest number. This is the number of batteries wired in series. ______________

11. Multiply the number of batteries in parallel by the number of batteries in series. This is the total number of batteries required. ______________

4. Determine The Sun Hours Available Per Day

Several factors influence how much sun power your modules will be exposed to:

- When will you be using your system" Summer" Winter" Year-round"
- Typical local weather conditions.
- Fixed mountings vs. trackers.
- Location and angle of PV array.

We have provided the following charts which show ratings that reflect the number of hours of full sunlight available to generate electricity. Your solar array's power generation capacity is dependent on the angle of the rays as they hit the modules. Peak power occurs when the rays are at right angles or perpendicular to the modules. As the rays deviate from perpendicular, more and more of the energy is reflected rather than absorbed by the modules. Depending on your application, sun tracking mounts can be used to enhance your power output by automatically positioning your array.

The charts reflect the difference in sunlight during spring, summer, autumn and winter. It is more difficult to produce energy during the winter because of shorter days, increased cloudiness and the sun's lower position in the sky. The charts list the sun hour ratings for several cities in North America for summer, winter and year round average. If you use your system primarily in the summer, use the summer value, if you are using your system year-round, especially for a critical application, use the winter value. If you are using the system most of the year (spring, summer and fall) or the application is not critical, use the average value. Between the chart and the map, you should be able to determine a reasonable estimate of the sun's availability in your area.

SUN HOURS PER DAY - NATIONAL

State, City	Summer Avg.	Winter Avg.	Yr Round Avg
AL, Montgomery	4.69	3.37	4.23
AK, Bethel	6.29	2.37	3.81
AK, Fairbanks	5.87	2.12	3.99
AK, Mantanuska	5.24	1.74	3.55
AZ, Page	7.30	5.65	6.36
AZ, Phoenix	7.13	5.78	6.58
AZ, Tucson	7.42	6.01	6.57
AR, Little Rock	5.29	3.88	4.69
CA, Davis	6.09	3.31	5.10
CA, Fresno	6.19	3.42	5.38
CA, Inyokem	8.70	6.87	7.66
CA, La Jolla	5.24	4.29	4.77
CA, Los Angeles	6.14	5.03	5.62
CA, Riverside	6.35	5.35	5.87
CA, Santa maria	6.52	5.42	5.94
CA, Soda Springs	6.47	4.40	5.60
CO, Boulder	5.72	4.44	4.87
CO, Granby	7.47	5.15	5.69
CO, Grand Junction	6.34	5.23	5.86
CO, Grand Lake	5.86	3.56	5.08
D.C. Washington	4.69	3.37	4.23
FL, Apalachicola	5.98	4.92	5.49
FL, Belle Island	5.31	4.58	4.99
FL, Gainsville	5.81	4.71	5.27
FL, Miami	6.26	5.05	5.62
FL, Tampa	6.16	5.26	5.67
GA, Atlanta	5.16	4.09	4.74
GA, Griffin	5.41	4.26	4.99
HI, Honolulu	6.71	5.59	6.02
IA, Ames	4.80	3.73	4.40
ID, Twin Falls	5.42	3.41	4.70
ID, Boise	5.83	3.33	4.92
IL, Chicago	4.08	1.47	3.14
IN, Indianapolis	5.02	2.55	4.21
KS, Dodge City	4.14	5.28	5.79
KS, Manhattan	5.08	3.62	4.57
KY, Lexington	5.97	3.60	4.94
LA, Lake Charles	5.73	4.29	4.93
LA, New Orleans	5.71	3.63	4.92
LA, Shreveport	4.99	3.87	4.63
MA, Blue Hill	4.38	3.33	4.05
MA, Boston	4.27	2.99	3.84
MA, E. Wareham	4.48	3.06	3.99
MA, Lynn	4.60	2.33	3.79
MA, Natick	4.62	3.09	4.10
MD, Silver Hill	4.71	3.84	4.47
ME, Caribou	5.62	2.57	4.19
ME, Portland	5.2	3.56	4.51
MI, E. Lansing	4.71	2.70	4.00
MI, Sault Ste. Marie	4.83	2.33	4.20
MN, St. Cloud	5.43	3.53	4.53
MO, Columbia	5.5	3.97	4.73
MO, St. Louis	4.87	3.24	3.78
MS, Meridian	4.86	3.64	4.44
MT, Glasgow	5.97	4.09	5.15
MT, Great Falls	5.70	3.66	4.93
MT, Summit	5.17	2.36	3.99
NC, Cape Hatteras	5.81	4.69	5.31
NC, Greensboro	5.05	4.00	4.71
ND, Bismark	5.48	3.97	5.01
NE, Lincoln	5.40	4.38	4.79
NE, North Omaha	5.28	4.26	4.90
NJ, Sea Brook	4.76	3.20	4.21
NM, Albuquerque	7.16	6.21	6.77
NV, Ely	6.48	5.49	5.98
NV, Las Vegas	7.13	5.83	6.41
NY, Bridgehampton	3.93	1.62	3.16
NY, Ithaca	4.57	2.29	3.79
NY, New York	4.97	3.03	4.08
NY, Rochester	4.22	1.58	3.31
NY, Schenectady	3.92	2.53	3.55
OH, Cleveland	4.79	2.69	3.94
OH, Columbus	5.26	2.66	4.15
OK, Oklahoma City	6.26	4.98	5.59
OK, Stillwater	5.52	4.22	4.99
OR, Astoria	4.76	1.99	3.72
OR, Corvallis	5.71	1.90	4.03
OR, Medford	5.84	2.02	4.51
PA, Pittsburgh	4.19	1.45	3.28
PA, State College	4.44	2.78	3.91
RI, Newport	4.69	3.58	4.23
SC, Charleston	5.72	4.23	5.06
SD, Rapid City	5.91	4.56	5.23
TN, Nashville	5.20	3.14	4.45
TN, Oak Ridge	5.06	3.22	4.37
TX, Brownsville	5.49	4.42	4.92
TX, El Paso	7.42	5.87	6.72
TX, Port Worth	6.00	4.80	5.83
TX, Midland	6.33	5.23	5.83
TX, San Antonio	5.88	4.65	5.30
UT, Flaming Gorge	6.63	5.48	5.83
UT, Salt Lake City	6.09	3.78	5.26

. . . Sun Hours Per Day *Continued*

SUN HOURS PER DAY - National *Continued*

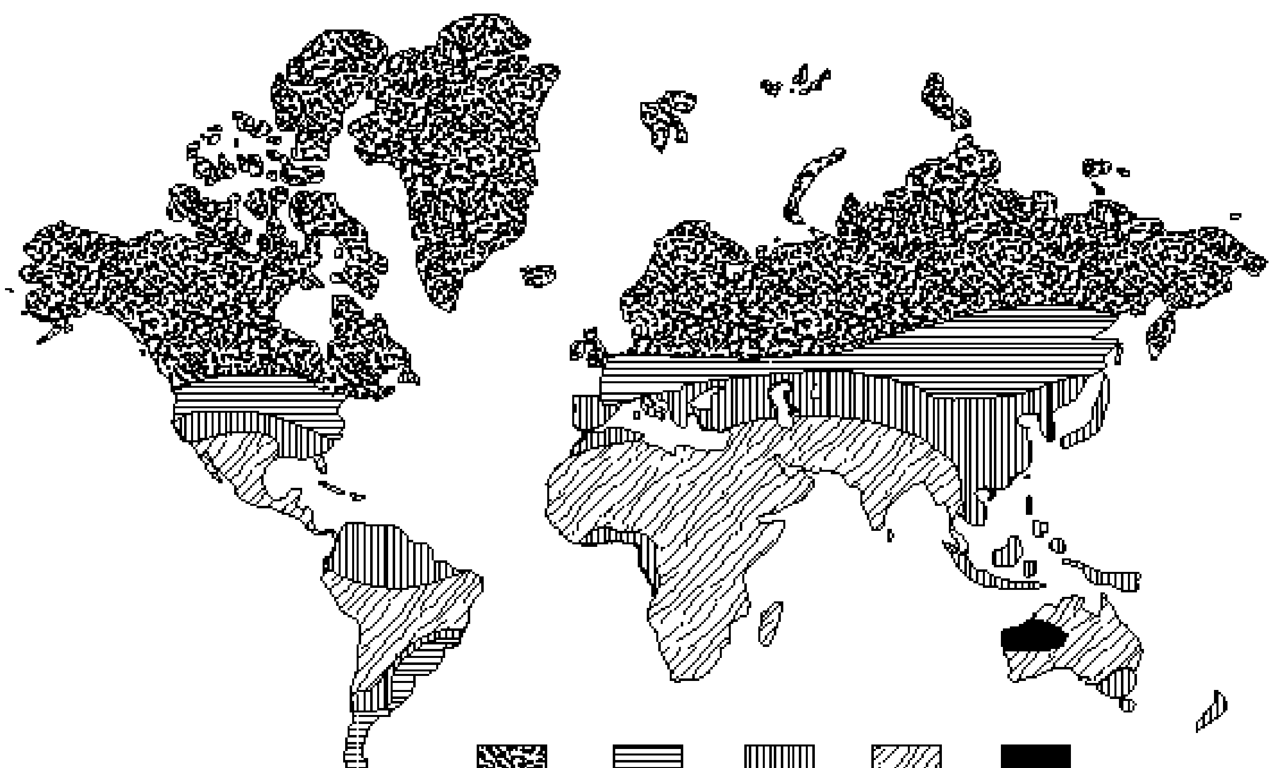
State, City	Summer Avg.	Winter Avg.	Yr Round Avg
VA, Richmond	4.50	3.37	4.13
WA, Prosser	6.21	3.06	5.03
WA, Pullman	6.07	2.90	4.73
WA, Richland	6.13	2.01	4.43
WA, Seattle	4.83	1.60	3.57
WA, Spokane	5.53	1.16	4.48
WV, Charleston	4.12	2.47	3.65
WI, Madison	4.85	3.28	4.29
WY, lander	6.81	5.50	6.06

Province, City	Summer Avg.	Winter Avg.	Yr Round Avg
Alberta, Edmonton	4.95	2.13	3.75
Alberta, Suffield	5.19	2.75	4.10
British Columbia, Kamloops	4.48	1.46	3.29
British Columbia, Prince George	4.13	1.33	3.14
British Columbia, Vancouver	4.23	1.33	3.14
Manitoba, The Pas	5.02	2.02	3.56
Manitoba, Winnipeg	5.23	2.77	4.02
New Brunswick, Fredericton	4.23	2.54	3.56
Newfoundland, Goose Bay	4.65	2.02	3.33
Newfoundland, St. Johns	3.89	1.83	3.15
Northwest Territory, Fort Smith	5.16	0.88	3.29
Northwest Territory, Norman Wells	5.04	0.06	2.89
Nova Scotia, Halifax	4.02	2.16	3.38
Ontario, Ottawa	4.63	2.35	3.70
Ontario, Toronto	3.98	2.13	3.44
Prince Edward Isl., Charlottetown	4.31	2.29	3.56
Quebec, Montreal	4.21	2.29	3.50
Quebec, Sept-îsles	4.29	2.33	3.50
Saskatchewan, Swift Current	5.25	2.77	4.23
Yukon, Whitehorse	4.81	0.69	3.10

SUN HOURS PER DAY - INTERNATIONAL

Solar Insolation

This map divides the world into five solar performance regions based on a yearly average of daily hours of sunlight for an array at latitude tilt. Specific sites within each region will differ as local weather conditions and seasonal changes can significantly affect the amount of sunlight available.



Map courtesy of Siemens Solar Industries

5. Size Your Array

Choose the appropriate module size and fill out the Array Sizing Worksheet.

ARRAY SIZING WORKSHEET

Use this worksheet to figure the total number of solar modules required for your system.

To find average sun hours per day in your area (line 3), check the local weather data, or chart on pages 7 and 8 for the city nearest to your location. If you require year-round autonomy, use the lowest of the two figures. if you require 100% autonomy in summer, use the higher figure.

The peak amperage of the module you will be using can be found in the module specifications. You can also determine peak amperage if you divide the module's wattage by the peak power point voltage, usually (17 to 17.5).

1. Total average amp hours per day from the Load Sizing Worksheet, line 10. ______________

2. Multiply line 1 by 1.2 to compensate for loss from battery charge/discharge. ______________

3. Average sun hours per day in your area. ______________

4. Divide line 2 by line 3. This is the total solar array amps required. ______________

5. Optimum or peak amps of solar module used. See module specifications. ______________

6. Multiply line 5 by 0.9 for normal loads, or by 0.8 for critical loads. ______________

7. To determine total number of solar modules in parallel required, divide line 4 by 6. ______________

8. Round off to the next highest whole number. ______________

9. Number of modules needed to provide DC Battery voltage: ______________

DC Battery Voltage	# of Modules in Each Series String
12	1
24	2
48	4

10. To determine Total number of solar modules required, multiply line 8 by line 9. ______________

6. Specify A Kit Or Custom Systems Components

We have provided several kits tailored to meet your specific needs. Choosing a kit guarantees that you will get all of the components you need, often at a lower price than if the components were purchased separately. If you require a custom system, this catalog has all of the components you require. Depending on your application, you may need to specify the following components to complete your system:

- Controller
- DC/AC Inverter
- Connecting Wires and Cables
- Fuses, Switches and Plugs
- Meters
- Mounting Hardware
- Back-up Generator

You will find all of these items in this catalog. Or, call us and we will assist you in assembling a system that meets your power needs and financial requirements.