GE Energy

Solar Electric Power System

Owner's Manual

v4.2nmtr

imagination at work

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General Safety Instructions

⚠ **WARNING**

- Read this entire manual and associated product manuals before using your system.
- **SAVE THESE INSTRUCTIONS**. This manual contains important guidelines that should be followed when maintaining your system.
- There are no user serviceable parts in your system. Only qualified personnel should service your GE Energy solar electric power system.
- Use GE Energy solar modules for their intended use only. Follow all manufacturer instructions. Do not disassemble the module, or remove any part installed by the manufacturer, as this will void any manufacturer warranties and UL listings.
- Do not drop, allow objects to fall on, stand or step on solar modules.
- Do not concentrate sunlight on modules with mirrors, reflectors or lenses, or in any other manner. Doing so voids any warranty and the UL listing for the module.
- Do not touch the solar modules or the mounting structure once installed. When these surfaces are exposed to sunlight they can become extremely hot.
- Do not walk, lean, sit or rest heavy objects on solar panels.
- Solar modules have a protective glass front. Broken solar module glass is an electrical safety hazard (electric shock and fire). These modules cannot be repaired and must be replaced immediately. If you have a broken module turn your system off.
- Do not store anything in front of the inverter or system disconnects.
- Do not store anything above or below the inverter. A minimum of 12" of clearance must be maintained to allow heat to naturally flow from the inverter.
- Call for service immediately if the inverter indicates a Ground Fault Error. Refer to the troubleshooting section found in this manual to determine if the inverter has a ground fault.

Documents

It is recommended that you keep the following documents with this manual for easy reference. Please note that these documents may not apply to your system as installation requirements vary:

- Electrical permit and documentation
- Utility interconnection agreement and net metering agreement
- Electrical schematic
- Product manuals, warranties and specification sheets

Congratulations

Your solar electric power system from GE Energy enables your home to generate a portion of its own electrical power from sunlight. Your GE Energy solar electric system has been engineered to provide many years of automatic operation without producing noise or air emissions and without requiring fuel or extensive mechanical maintenance.

The benefits of solar electric power are now yours

- ### Reduced Pollution and Environmental Protection

  Solar energy uses the sun to generate clean renewable power. Power produced by a solar electric system displaces the need for conventional power generation. It is estimated that every kilowatt of installed solar generation prevents 14,000 pounds of CO_2 (associated with global warming) and 30 pounds of NO_X (one source of smog) during its operating life.

- ### Reduced Utility Bills

  Every kilowatt-hour (kWh) generated by the system means less energy needed from the electric utility, and that means lower electric bills from your utility.

Principles of Operation

Solar Modules

Solar modules are typically either roof mounted or ground mounted. During daylight hours, the solar modules instantly convert sunlight energy into direct current (DC) electrical energy. Modules are connected in series (positive to negative), making "panels" with enough DC voltage to operate the inverter (discussed below). The DC current (amps) output of a solar module is directly proportional to sunlight intensity. Output varies with sun angle, shadows and shading - all of which can greatly impact electricity output.

Power Flow

Wiring carries the DC power from the solar panels (1) to a DC-AC "inverter" (2) that automatically converts the solar- generated DC power into common household alternating current (AC). The AC output from the inverter may pass through an optional external lockable visible disconnect switch (your local utility may require this) and then connect to a new breaker installed in the house utility power panel (3). If the system includes more solar power than one inverter can handle, several inverters will be wired in parallel into the utility power panel. If your local utility accepts excess generated power back onto their grid, your electric utility meter will spin backward when they are accepting power (4), thereby generating a credit toward electricity purchased from the utility.

Power Usage

During the day, the AC power produced by the inverter can be consumed immediately for power needs within the residence. The solar power is displacing power that would have been provided by the utility. If more power is needed than the solar modules can produce, the extra power needed is drawn from the utility.

At night or during periods of low sunlight, the solar modules do not produce power, and the residence operates completely on utility power.

During each day, if the residence is not consuming all of the electricity produced by the solar power system, and the homeowner and utility company have entered into a "net metering" agreement, then the excess power is sent out through the utility meter to the utility company. This generates a credit against what will be consumed by the residence at night. The residential monthly electric utility bill will be reduced by the power generated by the solar electric system during that month, either through displacing power that would have been consumed or through sending excess power to the utility. Many states have implemented net metering laws that require electric utilities to purchase your solar system's excess power at the same rate the utility sells its power. Utilities will normally require some form of Interconnection Agreement and Metering Agreement for residential solar power systems before interconnection is allowed.

Automatic Shut-off During Outages ("Anti-Islanding")

To prevent injury to utility personnel working on power lines, power from the inverter to the home's electric panel is shut off immediately when there is a utility outage. No power is allowed to flow out of the inverter into the utility grid from the system. This means that the house will have no electric power, either from the solar panels or from the utility, during a utility outage.

The inverter will automatically re-start when utility power is restored. There is a five-minute delay before the inverter returns to normal operation, during which it synchronizes with the utility power.

Measuring Your Power and Energy

Power
is a **rate**

To prevent injury to utility personnel working on power lines, power from the inverter to the home's electric panel is shut off immediately when there is a utility outage. No power is allowed to flow out of the inverter into the utility grid from the system. This means that the house will have no electric power, either from the solar panels or from the utility, during a utility outage.

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Energy
is an **amount**

Power x Time = Energy
(watts) x (hours) = (watt-hours or kilowatt-hours, kWh)

Energy is the actual work that is done by electricity. It is the heat, motion, or sound that results from electrical activity. Energy is measured in watt-hours or kilowatt-hours (kWh). This is what a customer pays for on their utility bill. Utilities charge for how much power is consumed over a certain period of time not the amount of energy being consumed at any one particular moment. The amount of energy consumed, or generated, is the product of the rate of power times the amount of time it flows.

For example

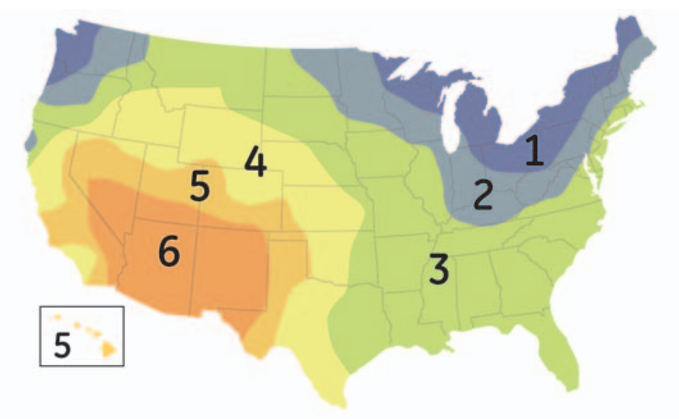
A solar electric power system producing 1,000 watts and operating at this rate for five hours would generate a total amount of energy of: **1,000 watts X 5 hours = 5,000 watt-hours or 5 kWh.**

An incandescent lamp consuming 150 watts and operating for three hours would consume a total amount of energy of: **150 watts X 3 hours = 450 watt-hours or 0.45 kWh.**

Estimating System Energy Production

To assist you in estimating the energy output of your system and your monthly savings, GE Energy provides the following map showing the average annual energy output of a solar power system in kWh/month. Find your climate zone on the map and then read across to find the estimated average monthly output of 1kW of array. Multiply this by the size of your array (in kW) to estimate your system average output. (If your location is near the border of two zones, use the average of the values in those two zones.) The output of the system will be lower in winter and higher in summer, with the table value representing the average. GE Energy has tried to take into account normal effects such as heat and inverter efficiency, but the values listed may be different from your particular system's performance. Actual performance depends on array orientation, shading, climate and other factors

Average Monthly Energy Production*



Average Monthly Output (kW AC) of 1kW DC Solar Array

Zone	
1	80-90
2	90-100
3	105-115
4	115-125
5	125-135
6	135-145

Example Calculation

Home is located in Zone 5 with (24) 110-watt modules.
Array Size = 24 X 110 = 2640 watts or 2.64 kW

135 kWh AC/kW DC x 2.64 kW DC = 356 kWh AC

Maximum average monthly output. — Estimated maximum average monthly output

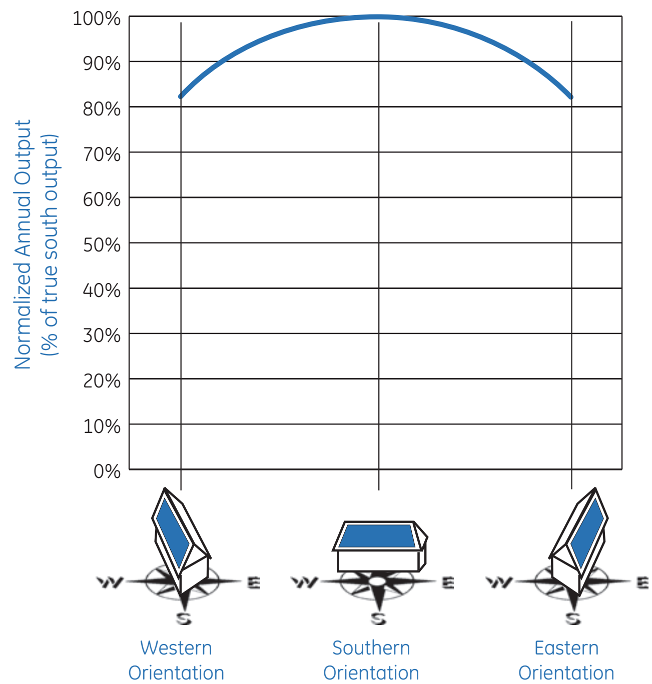
* PVGrid™ computer simulation calculations. Estimated AC kWh from inverter. Assumes clean solar panels, no shading, true south orientation, solar panels tilted to latitude angle; includes typical estimated inverter DC/AC conversion efficiency and other system losses such as wiring and connections that are typical of all solar electric power systems. Actual values may vary +/- 50% monthly and +/- 25% annually due to weather fluctuations, array orientation, shading, soiling and other site and installation factors. Calculations subject to change without notice due to improved engineering analysis, product changes, and other factors.

Effect Of Array Orientation on Annual Energy Output

A solar array generally produces maximum annual energy if it is facing directly south. True south orientation is assumed in generating the energy output values above.

Most houses are not built with roof surfaces facing directly south. As a result, the solar array usually faces slightly east or west of true south. The effect of orientation on total energy production is actually quite small for most installations. Installations with a true eastern or western orientation generally produce more than 80% of the potential capacity of a true southern facing installation. In most cases, a slight orientation to the east or west will have a very small reducing effect on average annual output

Local weather patterns will influence the effect of orientation. For example, if there is morning fog, a slightly western orientation would actually be an advantage, as the array would be positioned to capture more of the clear afternoon sun.



Data is a simplification based on typical Southern California climate with solar array on a 4:12 roof pitch. Other locations and roof pitches will result in slightly different values.

Estimating System "Peak" Power

The difference between a solar arrays "DC rating" and the actual power output indicated by the inverter is caused by variations in real world conditions as opposed to standard test conditions. The "DC rating" refers to the DC power (direct current) measured by manufacturers when classifying modules during manufacturing. The standard measurement uses ideal noon-day sunlight and solar modules operating at room temperature (25°C or 77°F). Standard measurements do not include the real-world effects of heat, dirt and dust, DC-to-AC inverter conversion efficiency, wiring, off-south orientation, non-optimal roof pitch angle, and weather conditions. This DC rating value is used by manufacturers to measure and ensure quality control prior to shipping.

The actual typical peak AC (alternating current) power generated by your system under real outdoor operating conditions will be less than this rating due to several factors:

- the solar modules are operating hot on your roof (typically above 50°C or 120°F); the solar energy shining on the modules may be less than ideal due to the angle of the sun and sky conditions (haze, fog, smog)
- power is lost when the inverter changes the solar DC power to common household AC power.

These real operating conditions typically result in peak AC output power that is about 60-70% of the artificial room temperature "DC rating" of the solar array alone. The kilowatt-hour energy estimates presented earlier are all based on the expected field AC output of the GE Energy solar electric power system.

For example, a system with 48, 100-watt solar modules could be expected to have a peak output of approximately 2,900 to 3,400 watts of power under typical operating conditions with the sun directly over the modules.

System "DC Rating"	Estimated Peak AC Output From Inverter[1]	
	Hot Hazy Summer[2]	Mild Clear Spring/Fall[3]
1200 DC watts	700 AC watts	800 AC watts
2400 DC watts	1400 AC watts	1700 AC watts
3600 DC watts	2200 AC watts	2500 AC watts
4800 DC watts	2900 AC watts	3400 AC watts
7200 DC watts	4300 AC watts	5100 AC watts
9600 DC watts	5700 AC watts	6800 AC watts

(1) Estimated output, delivered as utility grid compatible AC power. Generally applicable to peak clear sky conditions in spring, summer, fall only. Assumes clean array, no shading, direct perpendicular sun angle; includes estimated typical inverter DC/AC conversion and other system losses such as wiring and connections that are typical of all solar electric systems. Actual values may vary +/-25% because of prevailing climactic conditions, array orientation, measurement uncertainty, shading, soiling and other site-specific factors. (2) Hot hazy summer: 900 watts/m2 solar irradiance, 32°C (90°F) air temperature, 1 m/s wind speed. (3) Mild clear spring/fall: 1000 watts/m2 solar irradiance, 20°C (68°F) air temperature, 1 m/s wind speed.

Understanding Variations In Power Output

The power output [measured in watts or kilowatts (kW)] from your system at any moment will vary throughout each day, and the patterns and peak values will vary with the seasons. It is important to understand these normal variations in system performance.

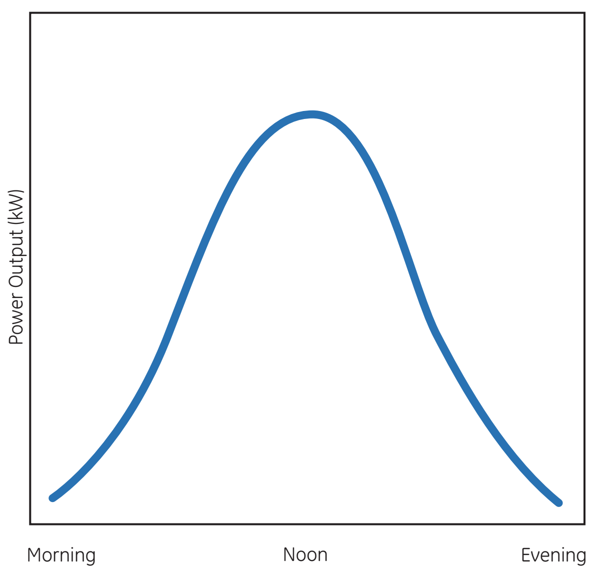
Daily Output Power Profiles

The momentary output of your system depends on the angle of the sun and the clearness of the sky as well as the temperature and the cleanliness of the solar module glass. An idealized "typical" profile of system output during a day is shown.

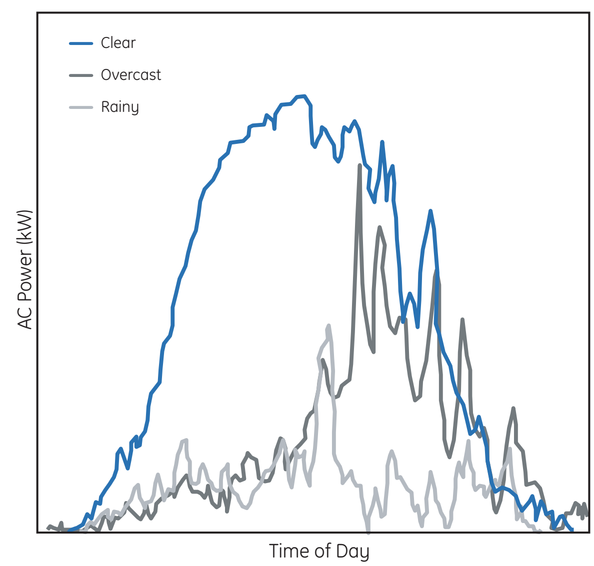
In the early morning, even though the day is "bright" to the eye, the angle of the sun to the solar modules is very low resulting in a reduced power output. As the sun rises in the sky, it moves more directly in front of the modules and the output rises to a peak value near noon. As the sun begins its decent, the angle of the sun to the panels gets lower and reduces the power output of the system.

Some actual daily profiles are shown here to illustrate the effects of sky conditions on output. Notice how the real profiles vary moment to moment compared to the smooth idealized profile shown above. This is a more true representation of how your system output will vary during a day.

Idealized Daily Profile

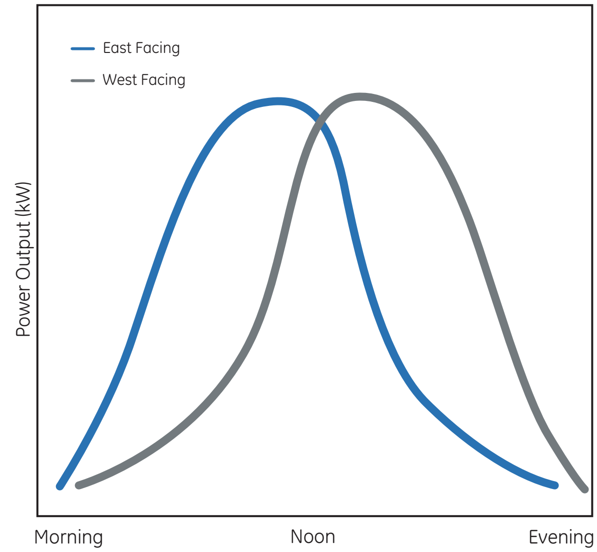


Actual Daily Output Variations



East-West Orientation

The momentary output of your system depends on the angle of the sun and the clearness of the sky as well as the temperature and the cleanliness of the solar module glass. An idealized "typical" profile of system output during a day is shown.



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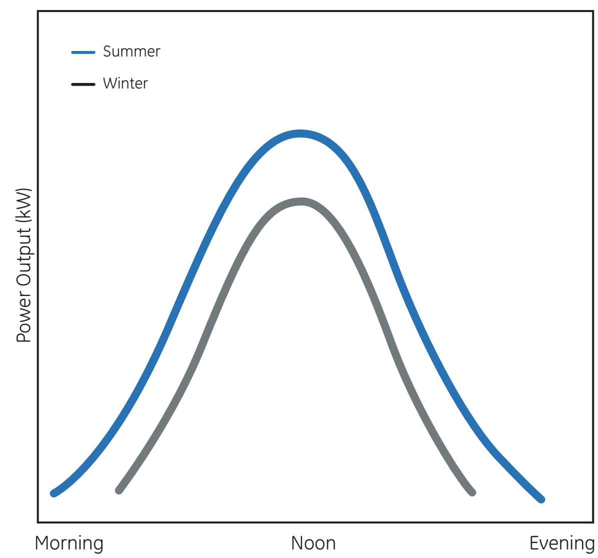
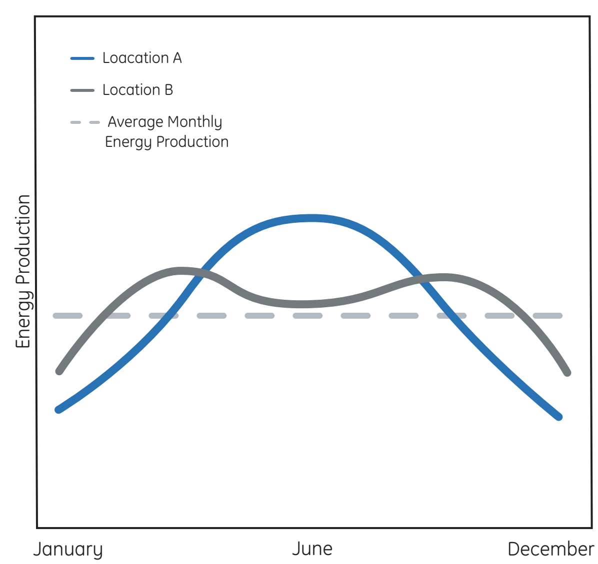
Some actual daily profiles are shown here to illustrate the effects of sky conditions on output. Notice how the real profiles vary moment to moment compared to the smooth idealized profile shown above. This is a more true representation of how your system output will vary during a day.

Seasonal Variation

During winter months the sun shines for fewer hours of the day and has a lower angle in the sky. This results in a generally lower daily output profile than in summer, when there are more hours of sunshine and the angle of the sun is higher during the day. A simplified comparison of how output will differ from summer to winter is shown.



Seasonal variations and local conditions can have a large effect on the output of your solar electric system. Some areas will have a simple profile where the winter output is low and the summer output is high (Location A). Others may have a more complex profile, with spring and fall being high and summer being lower due to high temperatures or hazy summer sun (Location B).



Maintenance

Monthly

⚠ WARNING **Monthly inspections should be performed from the ground.**

Solar Array

- Check that the solar array is not being shaded between 9am and 3pm by vegetation or building structures. Trim vegetation if necessary.
- Visually inspect the solar array from the ground for damage. Solar modules have a protective glass front that can break from excessive loading (greater then 50 pounds per square foot), from hail (greater then 1" traveling at 50 MPH), or from other causes such as vandalism. When the glass breaks the module will typically look different than the other solar modules. If broken glass is discovered, call for service immediately and turn your system off.
- Optional: Check solar array glass surface for debris, dirt, or severe soiling from bird droppings. It is not necessary to clean the module glass, as seasonal rains should wash away most normal soiling, but you may choose to do so. To clean module surfaces. First verify there are no broken solar modules in your array. Then remain on the ground and spray the glass with water from a hose.

⚠ WARNING

DO NOT clean during the middle of the day when the glass is hot. The thermal shock of cold water on hot, tempered glass could shatter the glass. Clean only at dawn or dusk when the module glass is cool.

⚠ WARNING

Solar modules have a protective glass front. Broken solar module glass is an electrical safety hazard (electric shock and fire). These modules cannot be repaired and must be replaced immediately. If you have a broken module turn your system off.

⚠ WARNING

DO NOT clean the solar modules if your inverter reads a "Ground Fault Error". Call for service immediately if the inverter indicates a Ground Fault Error. Refer to the inverter manual for additional details.

Maintenance

Annual

⚠ WARNING **Annual Service should be performed by qualified service personnel only!**

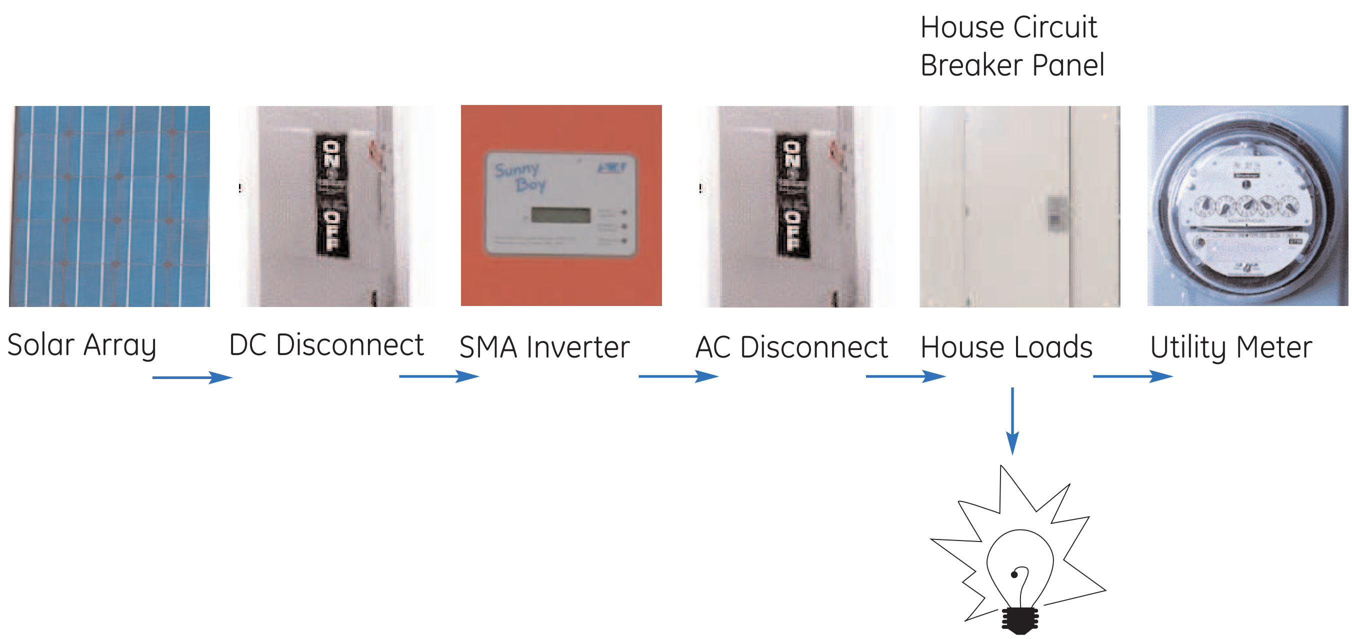
Solar Array

- Check all solar array wiring to confirm no loose connections or insulation wear.
- Check all module mounting to confirm all bolting is secure.

Power Electronics

- Check all wiring to confirm no loose connections or insulation wear

Identify Typical System Parts*



Shutdown Procedure

If for any reason you feel that your solar system is not operating safely, the system should be shut down. To shut your system down, follow the steps detailed below.

1. Disconnect DC power
   SMA Sunny Boy* inverters: switch DC disconnect switch(es) to Off position. The DC disconnect switch is typically located next to the inverter and should be labeled "DC Disconnect".

2. Disconnect AC power
   Set the utility AC disconnect switch to Off position

   The AC disconnect switch is typically located next to the utility meter and should be labeled "Solar AC Disconnect" or "Solar Disconnect".

Startup Procedure

Only qualified personnel should perform the startup procedures. Please contact your installer for assistance in turning your system on

1. Disconnect AC power
   Set the utility AC disconnect switch to On position .

   The AC disconnect switch is typically located next to the utility meter and should be labeled "Solar AC Disconnect" or "Solar Disconnect".

2. Disconnect DC power
   SMA Sunny Boy* inverters: switch DC disconnect switch(es) to On position.

   The DC disconnect switch is typically located next to the inverter and should be labeled "DC Disconnect".

** "Sunny Boy" is a trademark of the SMA Regelsysteme GmbH company*

Troubleshooting

LED (Light Emitting Diodes) are located on the face of the SMA inverter.

Problem		What to do
Utility Failed, Power Outage, Blackout	No problem	Do nothing; the inverter will automatically restart 5 minutes after the utility returns.
SMA Inverter, Steady on Green LED	No problem	The inverter is working correctly.
SMA Inverter Flashing Green LED once per second	The inverter detected a utility fault or the inverter is waking up.	This occurs whenever the inverter detects a power interruption from the utility and every morning, it means the inverter is processing its starting conditions and will start in 5 minutes
SMA Inverter No indicator lights	It is night	At night the inverter enters a sleep mode to conserve power.
	It is a bright sunny day	The DC disconnect and possibly the AC disconnects are turned off. Turning these on will allow the inverter to restart. Refer to start up procedure for power up instructions. (Page 15).
SMA Inverter Yellow LED is steady on	Read the LCD inverter display, It will cycle through several displays. One display will read an error message.	
SMA Inverter Steady on Yellow LED Error = EEPROM_d error	~	Call your installer. A 15-minute field reset of the internal computer chips is required.
SMA Inverter Steady on Yellow LED Error = Vac Bfr or Vac Srr	Utility failed	The error will clear when utility power is restored. No action is required.
	Utility has problems and is out of tolerance	The error will clear when the utility returns to providing quality power. No action is required.
	Utility is ok	Check the AC disconnect and AC circuit breaker in your main load panel. If these are off the inverter thinks the utility has failed. If these are on, wait a couple of hours to verify the utility is not having problems then contact your installer.
SMA Inverter Steady on Red LED Error = GFDI Fuse Open Or Error = EarthCurMax	A ground fault was detected	Contact your installer immediately.

For errors that are not listed above or when the red LED is on, your installer should be contacted immediately.

Before Calling for Service

1. Write down the error message that is displayed.
2. Have this manual with you so the information on the cover can be supplied.

Codes and Standards

Product Safety and Underwriter's Laboratories Certifications

The inverters used in solar electric power systems are UL-Listed. Underwriters Laboratories (UL) Standard 1741 covers inverters that convert DC electric power from photovoltaic arrays to AC electric power intended for use in parallel with an electric utility to supply common loads (utility interactive).

The GE Energy solar modules used in our systems are UL listed to applicable Underwriters Laboratories Inc. standards and requirements. The photovoltaic modules are intended for installation on buildings, or to be ground mounted (that is, not attached to buildings), in accordance with the National Electrical Code, NFPA 70, and Building Codes. The photovoltaic modules have a Class "C" Fire Rating, and must be installed over a roof of appropriate fire resistance. Do not install the solar module integral with a roof or wall of a habitable structure. Modules are not rated as roofing material.

National Electrical Code (NEC)

The National Electrical Code covers the installation of solar power systems and should be adhered to when systems are designed and installed. Article 690, Solar Photovoltaic Systems, applies "to solar photovoltaic electrical energy systems including the array circuit(s), power conditioning unit(s), and controller(s) for such systems."

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