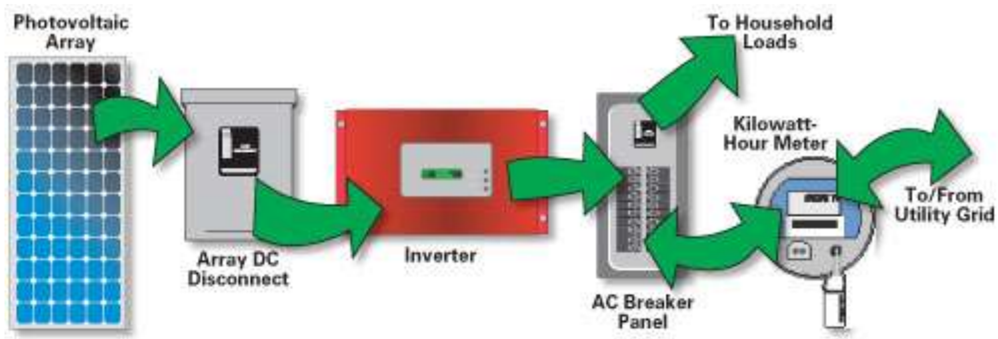
Solar Electricity Basics

The three most common types of solar-electric systems are grid-intertied, grid-intertied with battery backup, and off-grid (stand-alone). Each has distinct applications and component needs.

Grid Intertied Solar-Electric Systems

Also known as on-grid, grid-tied, or utilityinteractive (UI), grid-intertied solar-electric systems generate solar electricity and route it to the electric utility grid, offsetting a home's or business' electrical consumption and, in some instances, even turning the electric meter backwards. Living with a grid-connected solar-electric system is no different than living with grid power, except that some or all of the electricity you use comes from the sun. In many states, the utility credits a homeowner's account for excess solar electricity produced. This amount can then be applied to other months when the system produces less or in months when electrical consumption is greater. This arrangement is called net metering or net billing. The specific terms of net metering laws and regulations vary from state to state and utility to utility. Consult your local electricity provider or state regulatory agency for their guidelines.

The following illustration includes the primary components of any grid interie solar electric system. See our Solar Electric System Components section for an introduction to the function(s) of each component.



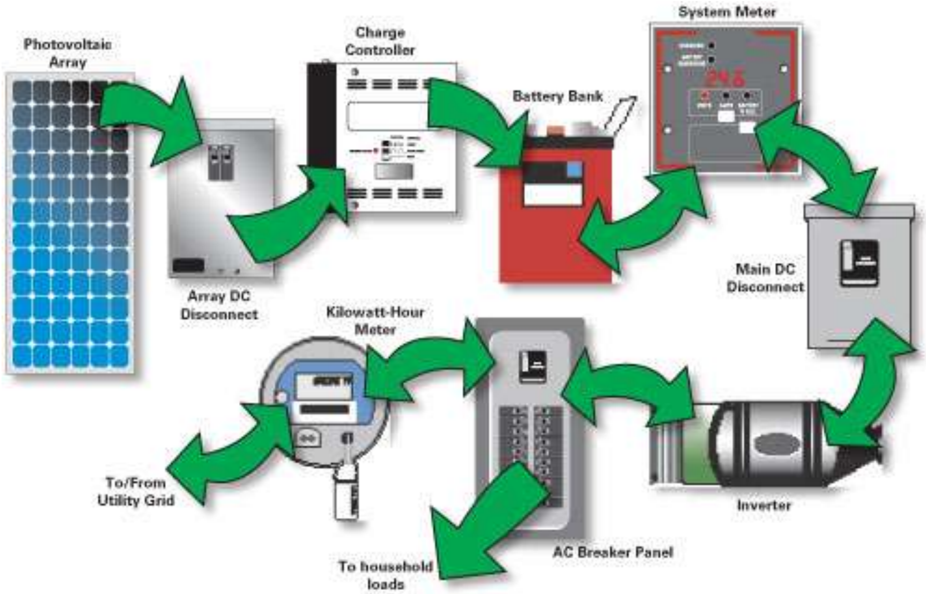
See also the following Home Power feature articles:

Energy Smarts-Efficiency Gains + Solar Electricity
Creating A Brighter Future
Getting Off the Lifetime Utility Payment Plan: Grid-Connected PV

Grid-Intertied Solar-Electric Systems with Battery Backup

Without a battery bank or generator backup for your gridintertied system, when a blackout occurs, your household will be in the dark, too. To keep some or all of your electric needs (or "loads") like lights, a refrigerator, a well pump, or computer running even when utility power outages occur, many homeowners choose to install a grid-intertied system with battery backup. Incorporating batteries into the system requires more components, is more expensive, and lowers the system's overall efficiency. But for many homeowners who regularly experience utility outages or have critical electrical loads, having a backup energy source is priceless.

The following illustration includes the primary components of any grid intertied solar electric system with battery backup. See our Solar Electric System Components section for an introduction to the function(s) of each component.



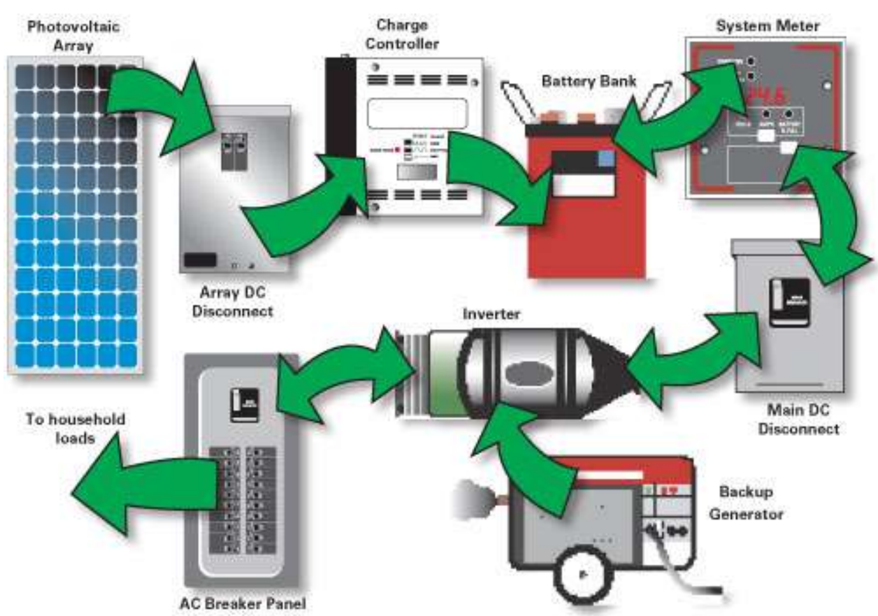
See also the following Home Power feature articles:

Eight Years of Solar Electricity: and Counting...
Walking the Talk: Energy Group Gets Solarized

Off-Grid Solar-Electric Systems

Although they are most common in remote locations without utility grid service, off-grid solar-electric systems can work anywhere. These systems operate independently from the grid to provide all of a household's electricity. That means no electric bills and no blackouts—at least none caused by grid failures. People choose to live off-grid for a variety of reasons, including the prohibitive cost of bringing utility lines to remote homesites, the appeal of an independent lifestyle, or the general reliability a solar-electric system provides. Those who choose to live off-grid often need to make adjustments to when and how they use electricity, so they can live within the limitations of the system's design. This doesn't necessarily imply doing without, but rather is a shift to a more conscientious use of electricity.

The following illustration includes the primary components of any off grid solar electric system. See our Solar Electric System Components section for an introduction to the function(s) of each component.



See also the following Home Power feature articles:

Postmodern PV Pioneers
Solar Comfort in the Idaho Wilderness: Off-Grid PV
All Creatures Under the Sun—My Solar Powered Barn
Green Half-Acre: Off-Grid Country Living – In the City

System Components

Understanding the basic components of an RE system and how they function is not an overwhelming task. Here are some brief descriptions of the common equipment used in grid-intertied and off-grid solar-electric systems. Systems vary—not all equipment is necessary for every system type.

Solar Electric Panels
Array Mounting Rack
Array DC Disconnect
Charge Controller
Battery Bank
System Meter
Main DC Disconnect
Inverter
AC Breaker Panel
Kilowatt-Hour Meter
Backup Generator

Solar-Electric Panels

AKA: solar-electric modules, photovoltaic (PV) panels

PV panels are a solar-electric system's defining component, where sunlight is used to make direct current (DC) electricity. Behind a PV panel's shimmering facade, wafers of semiconductor material work their magic, using light (photons) to generate electricity—what's known as the photovoltaic effect. Other components in your system enable the electricity from your solar-electric panels to safely power your electric loads likelights, computers, and refrigerators.

PV panels are assigned a rating in watts based on the maximum power they can produce under ideal sun and temperature conditions. You can use the rated output to help determine how many panels you'll need to meet your electrical needs. Multiple modules combined together are called an array.

Although rigid panels are the most common form of solar electricity collector, PV technology also has been integrated into roofing shingles and tiles, and even peeland-stick laminates (for metal standing-seam roofs).

PV modules are very durable and long lasting—most carry 25-year warranties. They can withstand severe weather, including extreme heat, cold, and hail stones.

See also the following Home Power feature articles:

Home Power's 2007 Solar-Electric Module Guide
A Peek Inside a PV Cell
Solar Electric Modules — Clean Energy from Cradle to Cradle

Array Mounting Rack

AKA: mounts, racks

Mounting racks provide a secure platform on which to anchor your PV panels, keeping them fixed in place and oriented correctly. Panels can be mounted using one of three approaches: 1) on a rooftop; 2) atop a steel pole set in concrete; or 3) at ground level. The specific pieces, parts, and materials of your mounting device will vary considerably depending on which mounting method you choose.

Usually, arrays in urban or suburban areas are mounted on a home’s south-facing roof, parallel to the roof’s slope. This approach is sometimes considered most aesthetically pleasing, and may be required by local regulators or homeowner’s associations. In areas with a lot of space, pole- or ground-mounted arrays are another choice.

Mounting racks may incorporate other features, such as seasonal adjustability. The sun is higher in the sky during the summer and lower in the winter. Adjustable mounting racks enable you to set the angle of your PV panels seasonally, keeping them aimed more directly at the sun. Adjusting the tilt angle increases the system’s annual energy production by a few percent. The tilt of roofmounted arrays is rarely changed. Adjusting the angle is inconvenient and sometimes dangerous, due to the array’s location.

Changing the tilt angle of pole- or ground-mounted arrays can be done quickly and safely. Pole-mounted PV arrays also can incorporate tracking devices that allow the array to automatically follow the sun across the sky from east to west each day. Tracked PV arrays can increase the system’s daily energy output by 25 to 40 percent.

See also the following Home Power feature articles:

To Track or Not to Track
How to Install... A Pole-Mounted Solar-Electric Array: Part 1
How to Install... A Pole-Mounted Solar-Electric Array: Part 2
REview: General Specialties: Universal Pole Mount

Array DC Disconnect

AKA: PV disconnect

The DC disconnect is used to safely interrupt the flow of electricity from the PV array. It´s an essential component when system maintenance or troubleshooting is required. The disconnect enclosure houses an electrical switch rated for use in DC circuits. It also may integrate either circuit breakers or fuses, if needed.

See also the following Home Power feature articles:

What The Heck? Disconnect

Charge Controller

AKA: controller, regulator

A charge controller’s primary function is to protect your battery bank from overcharging. It does this by monitoring the battery bank. When the bank is fully charged, the controller interrupts the flow of electricity from the PV panels. Batteries are expensive and pretty particular about how they like to be treated. To maximize their life span, you’ll definitely want to avoid overcharging or undercharging them.

Most modern charge controllers incorporate maximum power point tracking (MPPT), which optimizes the PV array’s output, increasing the energy it produces. Some batterybased charge controllers also include a low-voltage disconnect that prevents over discharging, which can perma nently damage the battery bank.

See also the following Home Power feature articles:

Under Control: Charge Controllers for Whole-House Systems
What is a Charge Controller?
Get Maximum Power From Your Solar Panels with MPPT
What The Heck? Charge Controller

Battery Bank

AKA: storage battery

Your PV panels will produce electricity whenever the sun shines on them. If your system is off-grid, you'll need a battery bank—a group of batteries wired together—to store energy so you can have electricity at night or on cloudy days. For off-grid systems, battery banks are typically sized to keep household electricity running for one to three cloudy days. Gridintertied systems also can include battery banks to provide emergency backup power during blackouts—perfect for keeping critical electric loads operating until grid power is restored.

Although similar to ordinary car batteries, the batteries used in solar-electric systems are specialized for the type of charging and discharging they'll need to endure. Lead-acid batteries are the most common battery used in solar-electric systems. Flooded leadacid batteries are usually the least expensive, but require adding distilled water occasionally to replenish water lost during the normal charging process. Sealed absorbent glass mat (AGM) batteries are maintenance free and designed for grid-tied systems where the batteries are typically kept at a full state of charge. Gel-cell batteries can be a good choice to use in unheated spaces due to their freeze-resistant qualities.

See also the following Home Power feature articles:

Top 10 Battery Blunders and How to Avoid Them
Flooded Lead Acid Battery Maintenance
Battery Box Basics

System Meter

AKA: battery monitor, amp-hour meter

System meters measure and display several different aspects of your solar-electric system's performance and status, tracking how full your battery bank is; how much electricity your solar panels are producing or have produced; and how much electricity is in use. Operating your solar-electric system without metering is like running your car without any gauges, although possible to do, it's always better to know how much fuel is in the tank.

See also the following Home Power feature articles:

The Whole Picture: Computer-Based Solutions for PV System Monitoring
Mutichannel Metering: Beta-Testing a New System Monitor
Control Your Energy Use & Costs: with Solar Monitoring

Main DC Disconnect

AKA: battery/inverter disconnect

In battery-based systems, a disconnect between the batteries and inverter is required. This disconnect is typically a large, DC-rated breaker mounted in a sheetmetal enclosure. This breaker allows the inverter to be quickly disconnected from the batteries for service, and protects the inverter-to-battery wiring against electrical fires.

See also the following Home Power feature articles:

What The Heck? Disconnect

Inverter

Inverters transform the DC electricity produced by your PV modules into the alternating current (AC) electricity commonly used in most homes for powering lights, appliances, and other gadgets. Grid-tied inverters synchronize the electricity they produce with the grid's utility grade AC electricity, allowing the system to feed solar-made electricity to the utility grid.

Most grid-tie inverters are designed to operate without batteries, but battery-based models also are available. Battery-based inverters for off-grid or grid-tie use often include a battery charger, which is capable of charging a battery bank from either the grid or a backup generator during cloudy weather.

Most grid-Intertied inverters can be installed outdoors (ideally, in the shade). Most off-grid inverters are not weatherproof and should be mounted indoors, close to the battery bank.

See also the following Home Power feature articles:

What's Going On—The Grid? A New Generation of Grid-Tied PV Inverters
Off-Grid Inverter Efficiency

AC Breaker Panel & Inverter AC Disconnect

AKA: mains panel, breaker box, fuse box

The AC breaker panel is the point at which all of a home's electrical wiring meets with the provider of the electricity, whether that's the grid or a solar-electric system. This wall-mounted panel or box is usually installed in a utility room, basement, garage, or on the exterior of the building. It contains a number of labeled circuit breakers that route electricity to the various rooms throughout a house. These breakers allow electricity to be disconnected for servicing, and also protect the building's wiring against electrical fires.

Just like the electrical circuits in your home or office, an inverter's electrical output needs to be routed through an AC circuit breaker. This breaker is usually mounted inside the building's mains panel, which enables the inverter to be disconnected from either the grid or from electrical loads if servicing is necessary, and also safeguards the circuit's electrical wiring.

Additionally, utilities usually require an AC disconnect between the inverter and the grid that is for their use. These are usually located near the utility KWH meter.

Kilowatt-Hour Meter

AKA: KWH meter, utility meter

Most homes with a grid-tied solar-electric system will have AC electricity both coming from and going to the electric utility grid. A bidirectional KWH meter can simultaneously keep track of how much electricity flows in each of the two directions—just the information you need to monitor how much electricity you're using and how much your solar-electric system is producing. The utility company often provides Intertied-capable meters at no cost.

Backup Generator

AKA: gas guzzler

Off-grid solar-electric systems can be sized to provide electricity during cloudy periods when the sun doesn't shine. But sizing a system to cover a worst-case scenario, like several cloudy weeks during the winter, can result in a very large, expensive system that will rarely get used to its capacity. To spare your pocketbook, size the system moderately, but include a backup generator to get through those occasional sunless stretches.

Engine generators can be fueled with biodiesel, petroleum diesel, gasoline, or propane, depending on the design. These generators produce AC electricity that a battery charger (either standalone or incorporated into an inverter) converts to DC energy, which is stored in batteries. Like most internal combustion engines, generators tend to be loud and stinky, but a welldesigned solar-electric system will require running them only 50 to 200 hours a year.

Whole Home Cost (approximate)

i. Rocky Mountain Power: http://portal.ecosconsulting.com/rmp_solar/guide_to_solar.html

ii. Cost:

Small scaled photovoltaic systems with built in inverters that produce about 1 kW of power may cost about $10 to $12 per watt ($10,000-$12,000) installed. These small systems will offset only a small fraction of your electricity bill. At the high end, a 5 kW system that will completely offset the energy needs of many conventional homes may cost $7 to $10 per watt ($35,000-$50,000).

a. Small scale: ~ $10 - $12 for 1 kW ($10,000 - $12,000)
b. Large scale: ~$7 - $10 for 5 kW ($35,000 - $50,000)

iii. What is the pay back?:

A 1 kW system that is properly installed and positioned can typically generate approximately 2,000 kW hours (kWh) per year. Using a $.10 per kWh rate, that equates to $200 worth of electricity per year.

Average cost	$11,000 (based on a range of $10,000 - $12,000)
Estimated electricity generated per year	2,000 kilowatts (kW) (~8,765 hrs in one year)
Estimated total yearly value of photovoltaic generated electricity	$200 @ $.10/kWh
Payback without incentive	55 years ($11,000/$200)
Incentive for 1 kilowatt system	$ 1,550.00
Payback with incentive	47 years ($11,000 -$1,550 = $9,450/$200)

Sources:

Solar:

Utah Clean Energy (Solar): http://utahcleanenergy.org/our_work/solar_salt_lake_project

Rocky Mountain Power Solar Program: http://portal.ecosconsulting.com/rmp_solar/program_info.html, http://portal.ecosconsulting.com/rmp_solar/guide_to_solar.html

Utah Solar Energy Association: http://www.utsolar.org/

Wind:

Utah Clean Energy (Wind): http://utahcleanenergy.org/our_work/utah_wind_power_campaign

Retail Stores:

Harbor Freight: http://www.harborfreight.com/

Northern Tool: http://www.northerntool.com/