Photovoltaic (solar electric cells) also known as Solar PV

Types: **Mono and Polycrystalline silicon**; these are the standard of the industry with efficiencies in the 12% to 16% range. Panel sizes range from 10 watt to 300 watt. Lower wattages for off grid requirements and the higher watt panels are the standard in the grid connected PV systems. About 97% of the Solar PV installed in the US is this type.

Amorphous and Thin film; these are the products you hear about "new innovations in solar". Their efficiencies range between 6% - 10 %. There are only a few companies producing market ready products. Uni-Solar is the primary consumer product manufacture for the US at this time. The benefit of these products is that they can be applied to a variety of surfaces and can be manufactured from other material besides silicon. About 3% of all US installs are of this type.

Efficiency: **Cell and Panel ratings**; the conversion of photon energy to electrical energy is difficult to do without losses in the process. The efficiency % relates to the amount of energy per square meter striking the earth at solar noon. The standard is 1000 watts per square meter. If you have a panel that is rated at 15% efficiency, it will convert 15% of that 1000 watts per meter squared to DC electricity.

System Ratings; if you have several identically rated panels mounted, you will have an array. All panels are not exactly alike so there may be 3% to 5% variance in output. This mismatch may result as a loss in the array of 1% to 3%. Panels may become dirty between rains and over time, losses can result in the 1% to 10% range. Voltage drop occurs in all wiring so expect additional losses of 2% to 3% depending on wire sizing. Inverters, batteries and charge controllers will all use energy during their operation; losses can range between 3% - 10% for each component.

- All together losses from the panels to the utility meter can range between 15 to 25 % for direct utility connected systems. For battery based systems the losses are generally between 25 to 35%.

Solar Energy received; a couple of atmospheric measuring sources, NOAA and NASA provide meteorological data bases where we can find the average daily sun/hours for any location in the world. This data is recorded for all times of the year. The sun/hour measurement is representative of the full day's sun equivalent at 1000 watts per square meter.

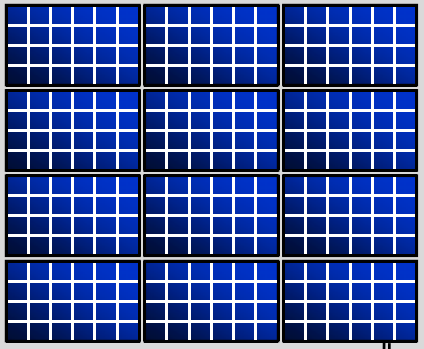
- If you have daylight for 12 hours, you may only have an equivalent 5 hours of full intensity solar irradiance equal to solar noon.

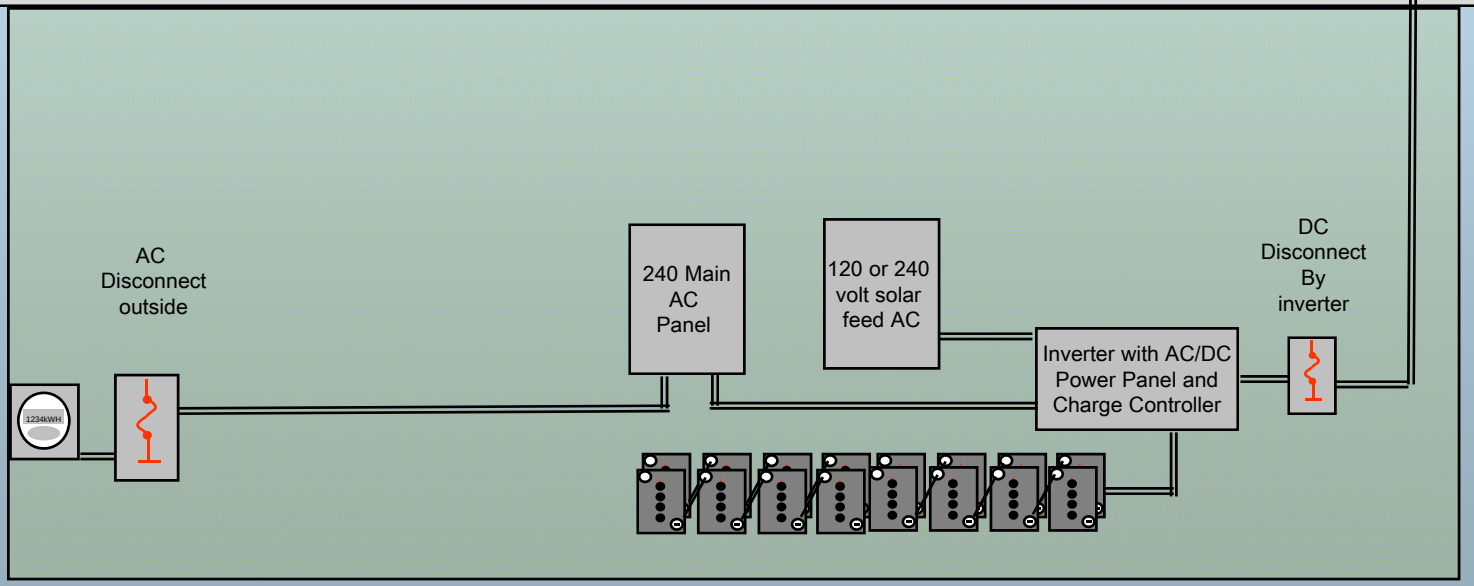
Net Output; the resulting electrical gross output is measured from the size of the array in kilowatts multiplied by the number of sun/hours the array receives. The net output is found when the efficiency losses are calculated in with the gross output.

Example: 3kW PV array in Atlanta will receive about 4.25 sun/hours (annual daily average). The 3kW array will have a gross output of 12.75kW/hrs per day. If it is a direct utility connected system it may experience 20% losses resulting in a net average daily output of 10.2kW/hrs. If it was a battery backup system, the losses would be around 30% with a net daily average output of 8.92kW/hrs.

Battery Based PV System

- 2.5kW to 10kW PV arrays for residential; up to 36kW PV for commercial
- The battery based inverter can use and sell power to the utility but also manages and uses the power stored in the batteries. These are separate outputs both of which are 120 volt.
- If 240 volt circuits are required another entire system in equal size should be added. 240 volt transformers can be used with single inverter systems but only with small loads.
- Batteries should be in conditioned location for good performance. Venting is required for flooded cell batteries.





Grid Based PV System

- 1kW to 10kW PV arrays for residential; up to 100kW PV array for commercial
- Unlike battery based 120 volt systems these inverters produce 240 volt for residential and 240/208/480 volt for commercial.
- These systems don't have stored energy so when the power is down so is the PV system.
- Grid tie inverter models are usually available for exterior locations as well as indoor. Never set an inverter in direct sunlight unless it is operating well below it's rated output.