Arizona Department of Commerce

Residential **P**hoto**V**oltaic (Solar Electric) Grid – Tie Systems

How To Choose a PV System

Do **NOT** think about PV First!

PV **ONLY** makes sense when
electricity is consumed efficiently!

Energy Efficiency is KEY

- Consider an Energy Audit.
- Consider energy efficiency when choosing or building a home.
- Use passive solar techniques to reduce power requirements.

Energy Efficiency

- Insulation.
- High Efficiency Appliances.
- Window Treatment.
- Roof Treatments.
- Time of use rates.
- Shade.
- Architecture.

Types of PV System

- Grid-Tie.
- Grid-Tie with Battery Backup.
- Stand Alone.

Choosing a PV System

- What Do you need it to do ?
- How much power do you need ?
- What is the daily / yearly profile of power use?
- What happens if the power (Utility or PV) system fails ?

Frequently Asked Questions

- Can I run my Air Conditioner ?
- How much does a Solar System Cost ?
- What is the payback time ?
- Can I spin my meter backwards ?
- How do I get more Information ?

Can I run my AC on Solar ?

- In principle yes, in practice it is not economically (or in the case of keeping the AC on backup power — environmentally) feasible.
- In a line-tie system then the solar power you generate will offset some of the power needed to run the AC.

How much does it cost?

- Currently the installed cost is of the order of $8 – $9 per (STC) Watt before incentives.
- State and Federal tax credits are available.
- Buy-downs, net metering (the Utility pays you for only the net power they supply you with) etc. can in some states (CA) reduce the cost to about $4 /W .

What is the payback time ?

- With a Solar PV system you are buying power at a known fixed cost .
- Payback can only be calculated by guessing figures such as energy inflation rates, etc.
- Again, using energy efficiently is the only way to win in the long-term.

Can I spin my meter backwards ?

- **Yes**. If you generate more power than you use, the power can be sold back to the utility. The rate that they pay depends on the utility company, and the local state laws and requirements.

How do I get more information ?

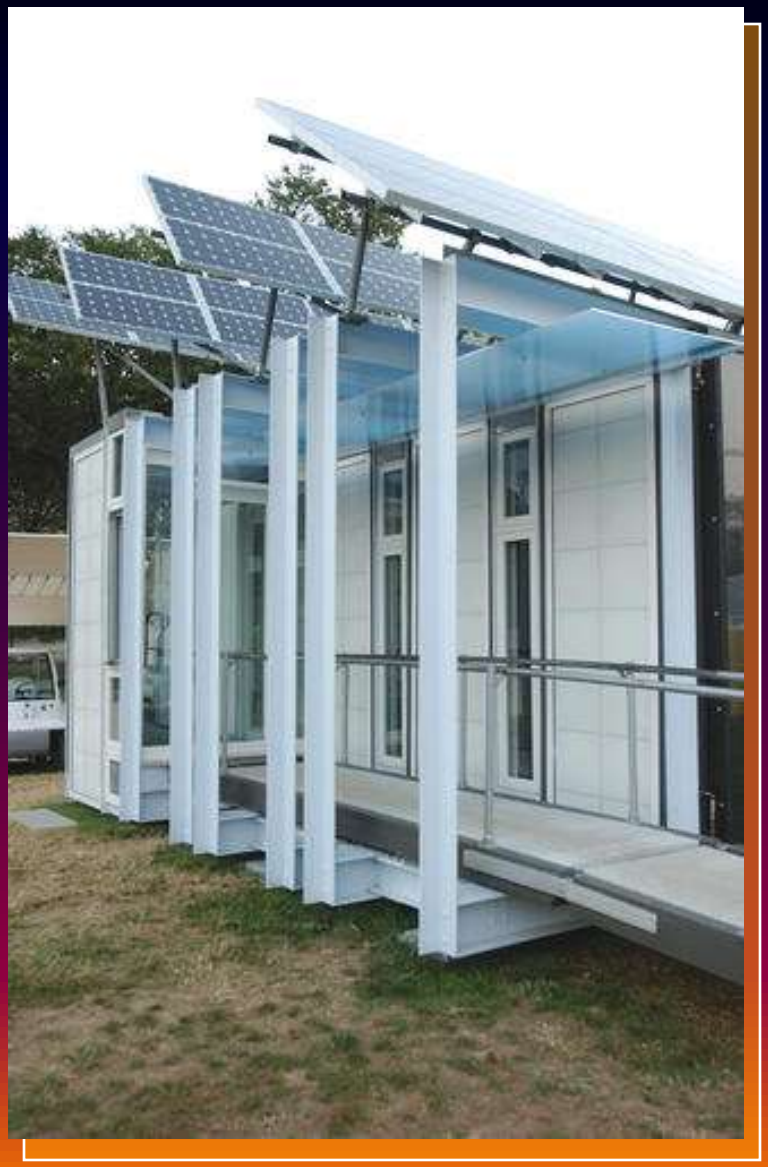
- Ask home owners who have PV, they are normally more than happy to explain their system and how to get one.
- Call your Utility company.
- Find a local PV dealer in the yellow pages

Information on the Internet

- There are many good sources of general and technical information on the Internet.
- Check PV and systems manufactures sites on the internet.
- www.AZSolarCenter.com

Magazines

- **Solar Today** and **Home Power** magazines, are the most widely available sources of printed information on PV systems. Both have a wide range on information and advertising.



GRID TIE SYSTEMS

Grid Dependent

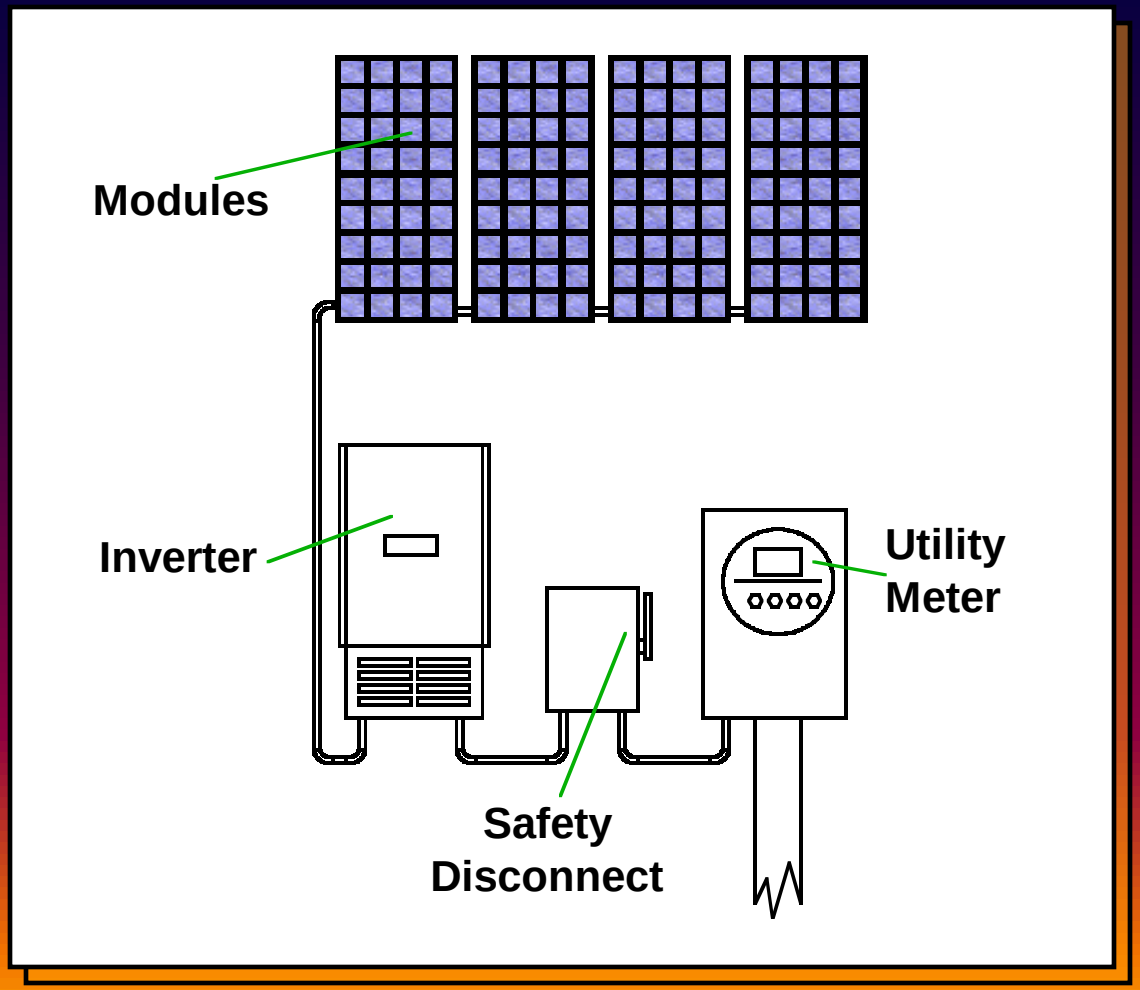
Grid-Tie Systems

- Simplest and cheapest entry.
- Displace power usage from Utility.
- Sell back (Net Metering).
- No backup if Utility power fails.

Grid-Tie Components

- PV Array
  - Convert Sunlight in to electricity.
- Inverter
  - Change DC from Solar Array to 120V AC electricity used by the utility.
- Safety Switch
  - Utility can shut system off in emergency.

Typical Grid-Tie System



What it will do ?

- Provide local power when the Sun is shining.
- Displace power that would have been used from the Utility.
- Sell power back to utility if more power is produced than used.

Grid Tie with Battery Backup

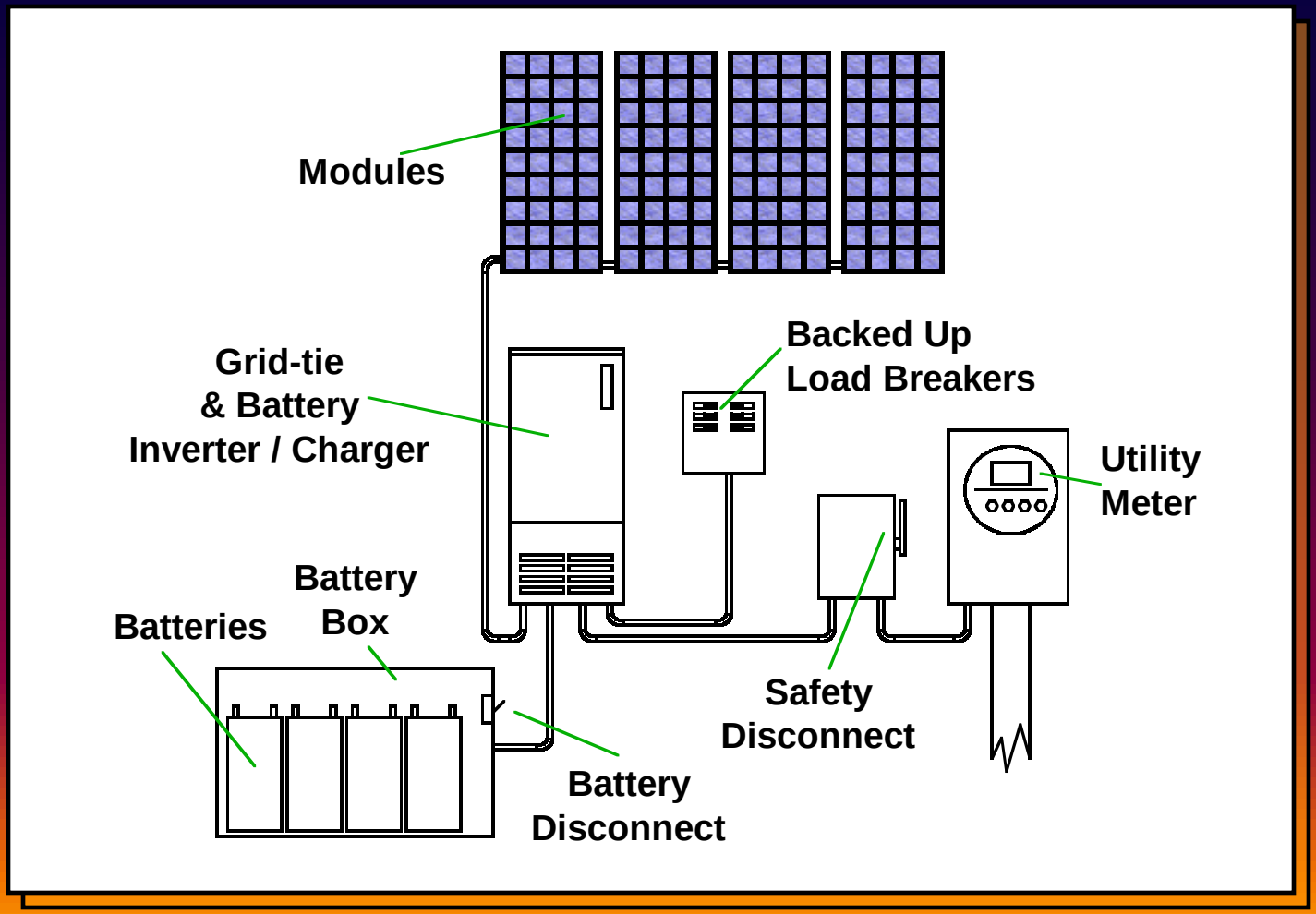
Grid Tie with Battery Backup

- More flexibility on power management.
- Provides limited power for critical loads incase of power failure.
- Requires Battery maintenance schedule.

Components

- Batteries
  - Store Energy for night time or power failure
- Battery Cutoff Switch
  - Shutoff batteries for maintenance and safety
- Other (depends on Inverter)
- Solar Array
- Inverter
- Safety Switch

Typical System



What it will do ?

- Same as Grid Tie
- Provide back-up power for critical loads incase of utility power failure.
- Back-up time and power depend on Battery and Inverter choices (Batteries can be charged from Utility if needed).
- Solar power available depends on Array and Inverter choices.

SYSTEM COMPONENTS

SOLAR MODULES

Convert Sunlight to electricity

Solar Modules

- Solar Modules will be very similar for all systems.
- Larger modules are normally cheaper in terms of $ per Watt.

Module Mounts

- Angle
  - Modules should be oriented to face the Sun.
- Module Temperature
  - The Modules produce more power when cooler.
- Aesthetics
  - The mounting and color of the modules can sometimes be chosen to blend with the architecture.
- Trackers
  - Tracking the Sun increases the amount of power from an array.

Module Mounting

Building Integrated PV (BIPV)

- Developments in modules and engineering practices that allow PV to form an integral part of a buildings structure.

INVERTERS

Convert DC (Direct Current) electricity to AC (Alternating Current) electricity

Inverters – Grid Tie Choices

- Power
  - Maximum power the inverter can handle.
- Efficiency
  - How efficiently does the inverter convert solar power to utility power?
- “Night time power”
  - How much power does the inverter consume from the grid when there is no Sunshine?

Grid Tie Inverters

- Xantrex ST-XR — low voltage (48V)
- Sunny Boy — high voltage (350V)

Xantrex SunTie XR

- 48VDC Line Tie Inverter
- Built-in system display
- Optional Remote Display
- 1kW, 1.5kW, 2kW & 2.5kW

- Early ST inverters had problems which seem to have been solved in the XR series

Sunny Boy

- High Voltage / high efficiency.
- Can be used in 3-phase circuits.
- Available as 1.8kW and 2.5kW.

Inverter - Hybrid

- Power
  - How much power do you need?
- Battery charger
  - How flexible is the battery charging?
- Generator control
  - Will the Inverter control a generator ?
- Add ons needed / supplied
  - What other equipment is needed?

Hybrid Inverters – Choices

- Trace SW Series

SW Series Inverter

- Xantrex /Trace SW Inverter / Battery Charger. Can be used Grid-Tied with GTI interface.
- Available in 4kW and 5.5kW

BATTERIES

Store DC electricity for later use

Batteries

- Use ONLY deep-cycle batteries!
- Wet batteries need to be checked at least every 6 months.
  - Check water and tightness of connectors.
- Sealed Batteries (VRLA) do not need watering, but may not last as long as wet batteries.

Battery Capacity

- Battery capacity is measured in Ah (Amp Hours – how many amps can the battery provide for an hour). The larger the capacity the more energy can be stored, and normally the more expensive the battery.
- To calculate the amount of power you can use from a battery you need both the Voltage of the battery and its capacity.

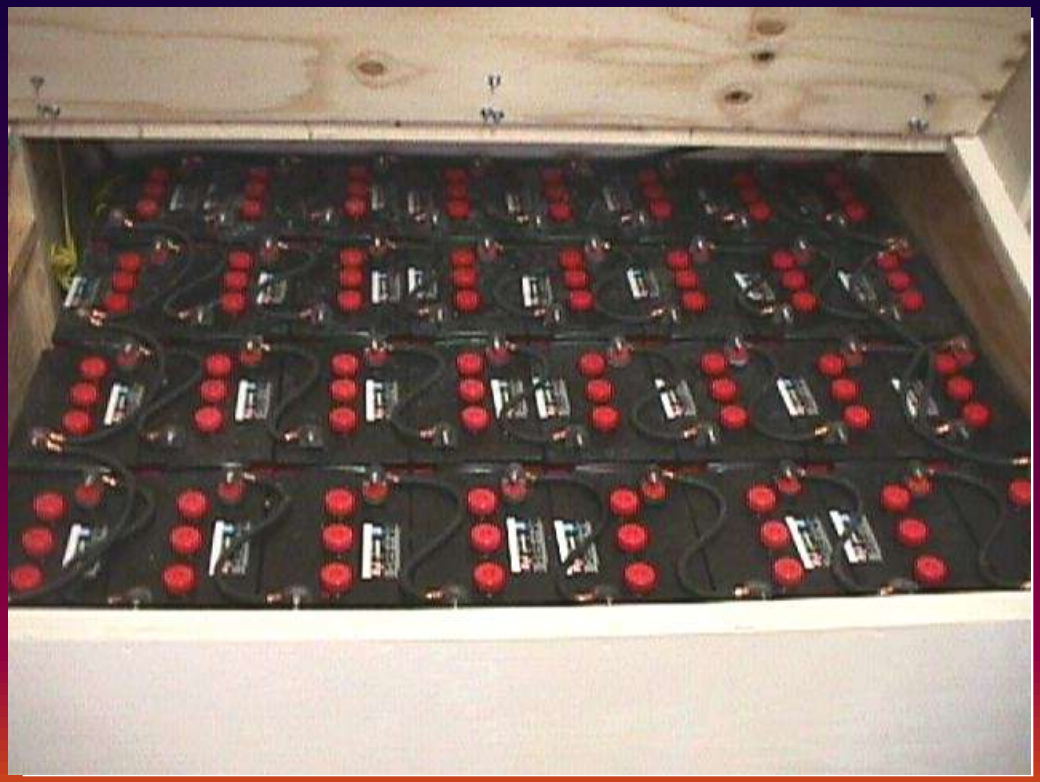
  $$Wh\ (Watt\ Hours) = Voltage \times Ah$$

  and is the amount of Power (W) that the battery can provide for one hour.
- The Voltage of the battery bank must ALWAYS be matched to the Inverter, so if you have a 24V input inverter you would need to add batteries in groups of 4 ($4 \times 6V = 24V$).
- You should **never** have more than 4 Parallel strings of batteries. The batteries will not share the load equally, and the life of the entire battery bank will suffer.

Battery Safety

- The batteries must **ALWAYS** be kept in a well ventilated area. They produce Hydrogen gas, that can explode if allowed to build up.
- Batteries contain Sulphuric acid that **BURNS SKIN on contact**.
- **ALWAYS** use insulated tools or wrap electrical tape round the handles. If you touch both + and - terminals of a battery with a metal you will start welding, at a minimum destroying the tool and possibly starting a fire.

Battery Box



Other Components

- Charge Controllers (Solar Battery Chargers).
- Disconnects and Switches.
- Remote controls.
- Meters.

Charge Controller

- Condition the power from the solar module to charge a battery.
- Modern units may be “Maximum Power Point Tracking (MPPT)” may provide up to 30% more power to the battery.
- Can be used in parallel to add more modules to a battery bank.


AMPS WATTS VOLTS
AMP-HOURS TOTAL AMP-HOURS
HOLD TO RESET AMP-HOURS
PRESS FOR LAMP
Charge / Load Controller
AMPS WATTS VOLTS
AMP-HOURS TOTAL AMP-HOURS
HOLD TO RESET AMP-HOURS
PRESS FOR LAMP
Charge / Load Controller
trace
ENGINEERING

Disconnects and Switches

- National Electrical Code and Utilities require disconnects for safety of the owner and utility workers.
- Disconnect system components for installation and maintenance.

Remote Controls

- Many systems offer remote control for convenience, and some are now starting to offer performance monitoring by computer or over the internet.

Meters and Data Acquisition

- Collects data about system performance, and sometimes local weather.
- Can be very useful for isolating system performance problems.
- Often linked into remote control packages.

What Do the Words Mean ?

- **PV**: Photo Voltaic
  - The physical principal behind the conversion of light to electricity.
- **BIPV**: Building Integrated PV:
  - The PV modules are integrated into the structure of the building.
- **Net Metering**:
  - The Utility company calculates the amount of electricity they provided – the amount of electricity you put back to the grid, and change only for the net electricity provided. Time scales for the calculation change with utility company.
- **Grid -Tie / Line-Tie**:
  - A system that can provide power back to the utility company lines.

- Modules, Panels, Arrays:
  - Assemblies of power producing photovoltaic.
- **STC: Standard Temperature Conditions:**
  - A standard test temperature for PV systems to quantify and compare components These conditions are rarely, if ever, seen in service.
- **NOCT:** Normally Operating Cell Temperature
  - A means to try and predict real-world system performance.

- **Solar Electric** vs. **Solar Thermal**:
  - Solar Electric (PV) systems convert light to electricity.
  - Solar Thermal systems convert the heat from the Sun into hot water, or heated air.
- **Time-of-day / Time-of-Use Rate**:
  - The cost of utility power can vary depending on when the power is used. Normally more expensive during the day (especially afternoon) and cheaper at night.
- **UPS**: Uninterruptible Power Supply
  - Provides power when the utility grid fails.

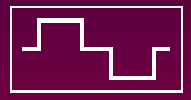
- **VRLA** Batteries: **V**alve **R**egulated **L**ead-**A**cid Battery
  - Sealed battery requiring no maintenance other than checking connections.
  - **Gell Cell Batteries:**
    - **Sealed battery with the electrolyte in the form of a gel.**
  - **AGM Battery: Advanced Glass Mat**
    - Another form of spill-proof sealed battery.
- **Wet** Batteries:
  - Lead-Acid batteries that have caps that allow the water level to be checked and filled if needed.

- L16, Group Number (e.g. Group 27), Golf Cart, etc. Batteries:
  - These refer to the physical size of the battery, which also has an effect on both the Voltage and storage capacity of the battery.

- AC (Alternating Current)
  - The current in the wire changes value 60 times a second (60Hz).
  - AC is easier to transmit over power lines without loss.
  - AC tends to be safer than DC as if you touch it it will throw you away.
- DC (Direct Current)
  - Voltage and current have steady (or very slowly changing values)
  - Batteries, and Solar modules produce DC.
  - DC can be **very dangerous**, as it will cramp muscles stopping you from moving away.
- Inverter:
  - Converts DC to AC and often changes the voltage too.

- Sine Wave:
  - The shape of the electrical wave-form varies smoothly, like the Utility power. ONLY sine wave inverters can be grid-tied.

- Square Wave:
  - The shape of the electrical wave-form changes abruptly from one voltage to another. (only found in very old inverters)



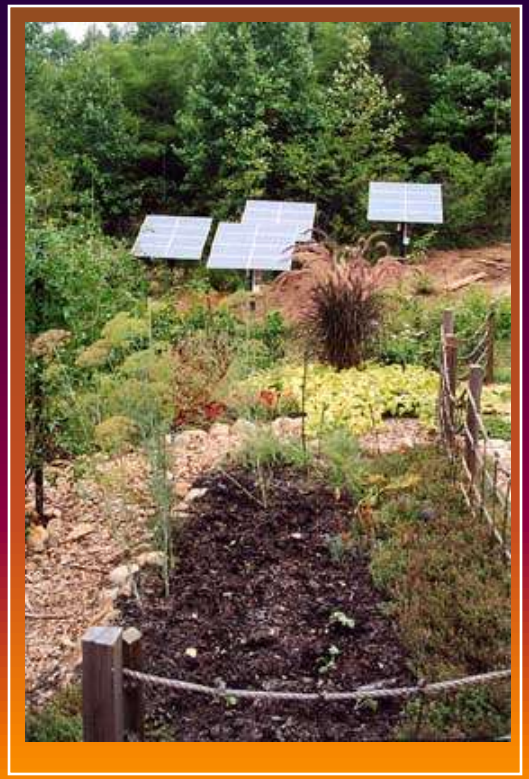
- Modified Sine / Square Wave:
  - A compromise wave-form found in cheap inverters. Should only be used for powering simple loads (e.g. motors). Appliances powered from a modified wave-form can buzz.

SYSTEMS

Inverter inside

Multiple inverters
provide more power

Outside mounting



Remote Modules

Passive, thermal and PV

Tracking Mount

Roof Mounted

Where to go for more Information

- AZ Solar Center (www.AZSolarCenter.com)
- Arizona Department of Commerce – Energy Office (www.commerce.state.az.us/energy)
- National Renewable Energy Lab (www.NREL.gov)
- California Energy Commission (www.energy.ca.gov)
- Florida Solar Energy Center (www.fsec.ucf.edu)
- DOE (www.doe.gov)

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