Arizona Department of Commerce

Residential **P**hoto**V**oltaic (Solar Electric) Stand-Alone 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.
- If you use 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.

How do I get more information ?

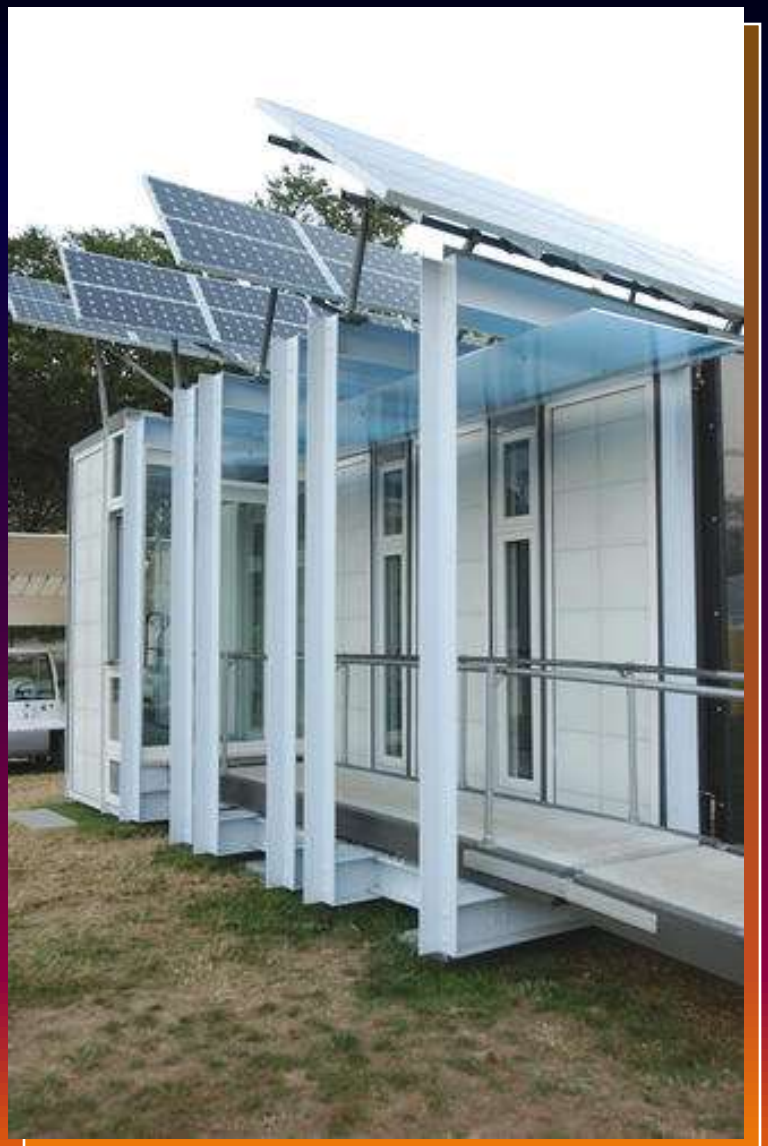
- Ask home owners who have PV, they are normally more than happy to explain their system and how to get one.
- Call your Utility company.
- Find a local PV dealer in the yellow pages

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.



STAND ALONE SYSTEMS

Stand Alone System

- Total independence from Utility power.
- Provides all electric needs.
- Large battery bank for night and cloudy days.
- Consider a backup generator / inverter incase of system failure.
- Minimize Electricity Usage.

Electric Use

- Choose appliances for energy use.
- Use only Appliances that require Electricity!
- Minimize “parasitic loads” – loads that are ALWAYS on, but do not need to be:
  - VCR / Coffee maker clocks
  - Appliances in Stand-by mode

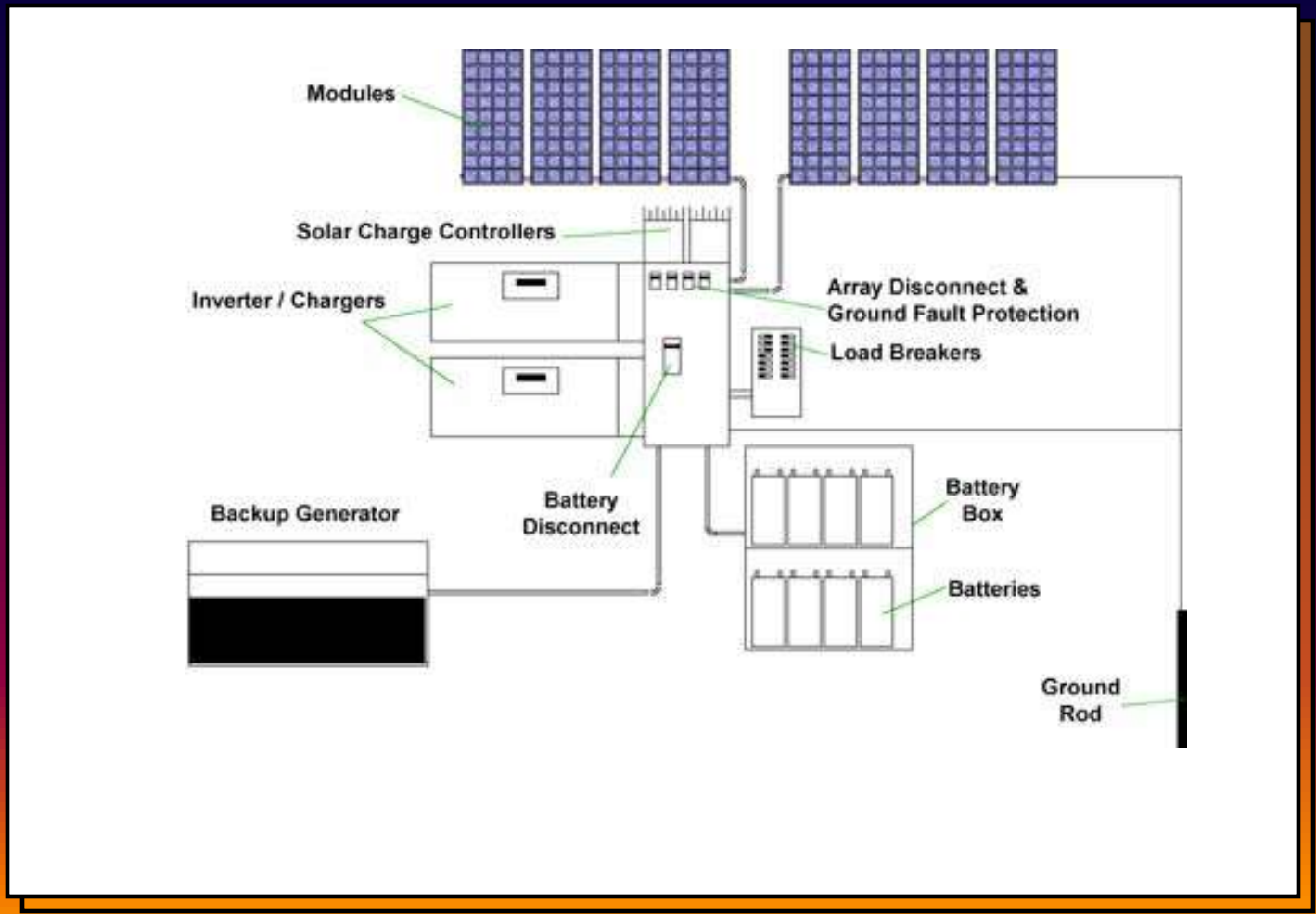
Other Thoughts

- Propane refrigerators
- Gas stove and dryers
- Gas / passive water heating

Components

- Solar Array
- Stand-Alone Inverter
- Batteries
- Battery Cutoff
- Other (depends on inverter)

Typical Stand Alone System



What it will do ?

- Provide **all electrical** power for off-grid home.
- Solar may be used to pump water well if available.
- Care must be taken to correctly size and maintain system.

Other Applications

- Solar Water pumps.
- Pool Pump.
- Irrigation control.
- Lighting.
- Evaporative (swamp) Coolers.

Solar Water-Well pumps

Solar-Powered Pool Pump

Solar Irrigation Controllers

Solar Lighting

DC-Powered Evaporative Cooler

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

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

- Prosine
- ExelTech
- Modified Square Wave inverters

SW Series Inverter

- Xantrex /Trace SW Inverter / Battery Charger. Can be used stand-alone or Grid-Tied (with interface)
- This is the workhorse inverter for many standalone systems.
- Available in 4kW and 5.5kW
- Inverters can be combined to provide 240VAC, or stacked in parallel to increase power.

ProSine Series

- Small, light inverters, often used in the RVs and boats.

Exeltech

- Innovative design that provides redundancy and upgrade capabilities by adding modules.
- No Battery charging capability.
- Very high quality sine wave.

Non Sine-wave Inverters

- Non sine-wave are cheaper than sine-wave inverters, but the electrical signal is much noisier.
- Non sine-wave inverters can be used for non-critical power requirements such as power-tools, heaters etc.
- Non sine-wave inverters can ONLY be used in standalone systems, they can NEVER be connected to feed power back to the utility.

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.

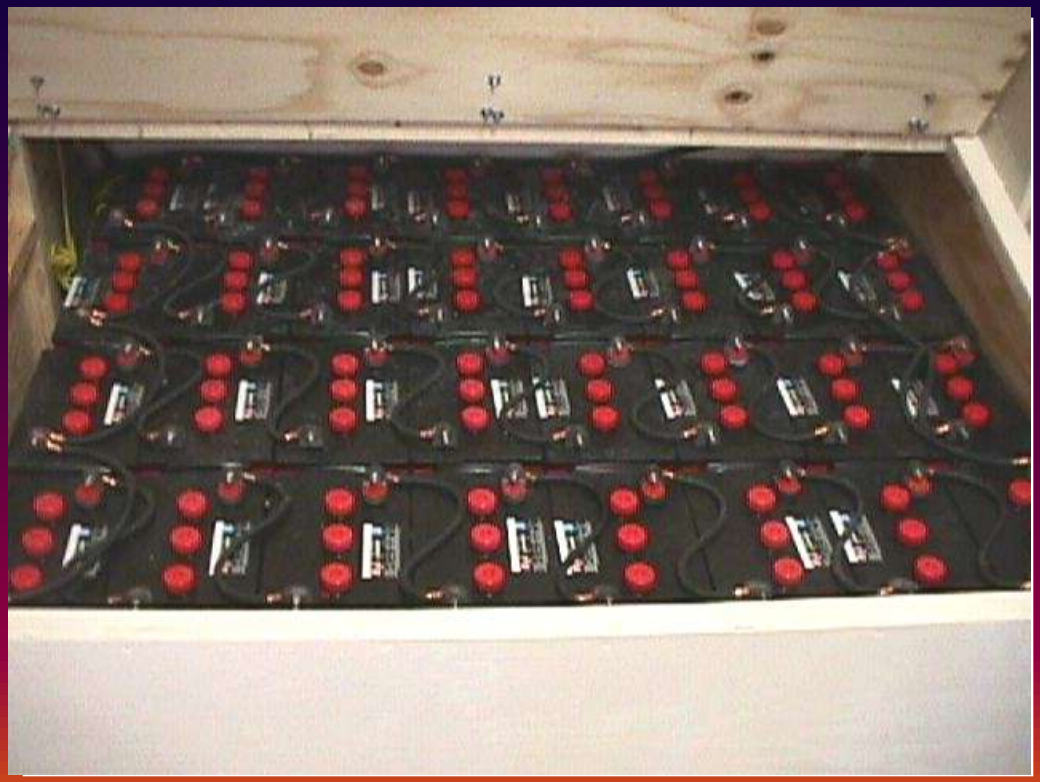
  $$Wh\ (Watt\ Hours) = Voltage \times Ah$$

  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.
- Wind Generators.
- 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.

Wind Generators

- Small wind generators can be excellent compliment to a Solar system.
- Can provide power at night.
- Require a minimum of 5-7mph wind.
- Moving parts require maintenance and replacement.

Residential sized Wind Generators

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.

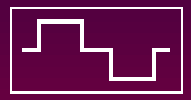
- **VRLA** Batteries: **V**alve **R**egulated **L**ead-**A**cid Battery
  - Sealed battery requiring no maintenance other than checking connections.
  - **Gell Cell Batteries:**
    - **Sealed battery with the electrolyte in the form of a gel.**
  - **AGM Battery: Advanced Glass Mat**
    - Another form 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.

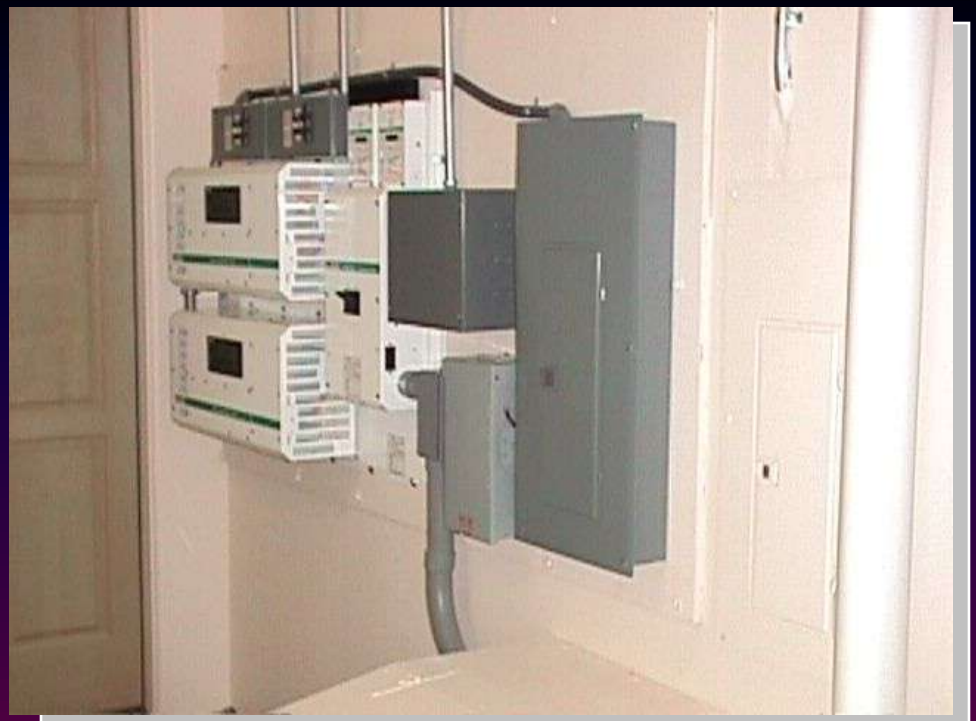
- Sine Wave:
  - The shape of the electrical wave-form varies smoothly, like the Utility power.

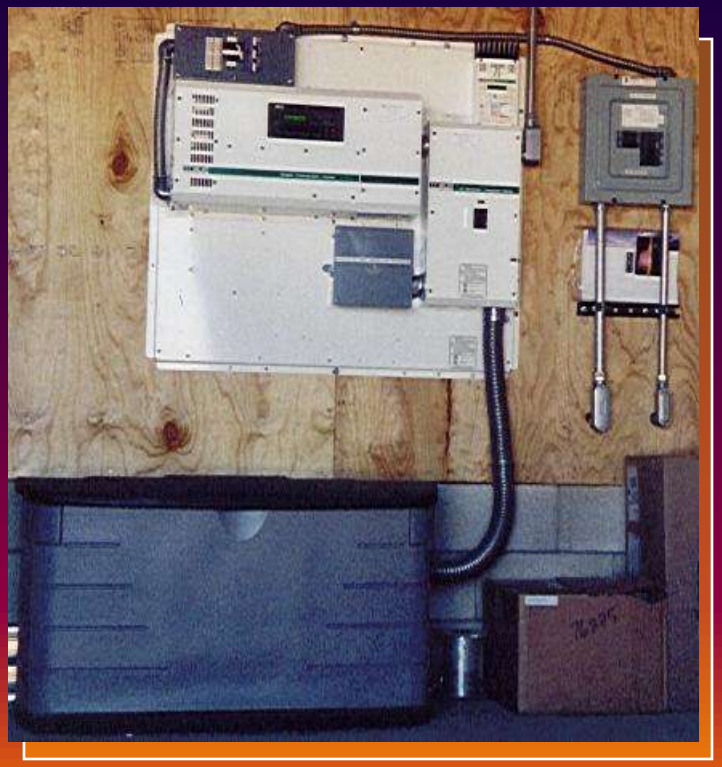
- Square Wave:
  - The shape of the electrical wave-form changes abruptly from one voltage to another. (only found in very old inverters)



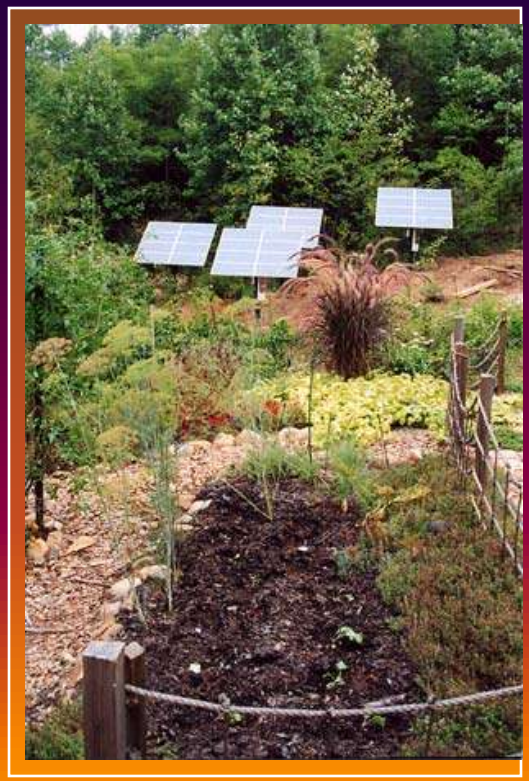
- Modified Sine / Square Wave:
  - A compromise wave-form found in cheap inverters. Should only be used for powering simple loads (e.g. motors). Appliances powered from a modified wave-form can buzz.

SYSTEMS





Stand-alone Power Centers



Remote Modules

Passive, thermal and PV

Tracking Mount

Roof Mounted

Wind & Sun

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)

Photo & Illustration Credits

- Andrew Jones
- Kyocera Solar Inc.
- Kyocera Corp.
- Wade Webb (Solar Webb)
- Sundance Solar
- Sandia National Lab and NREL
- Exeltech
- SMA America
- Xantrex
- Dan Aiello
- SouthWest Wind power