Solar Aquaponics

Designing a 100% Solar Aquaponics Greenhouse

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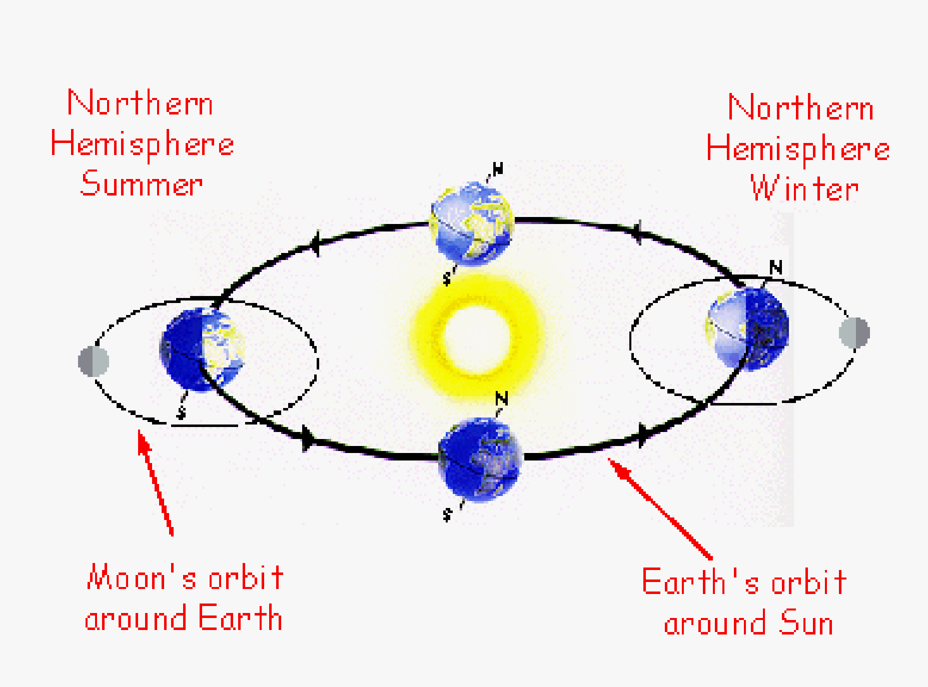
Topics

* Creating a 100% solar operation
* Efficiency First!
* Solar electricity – lighting, water pumps, and aeration
* Not resistive heating!
* Solar thermal – heating water
* Passive solar heating and cooling

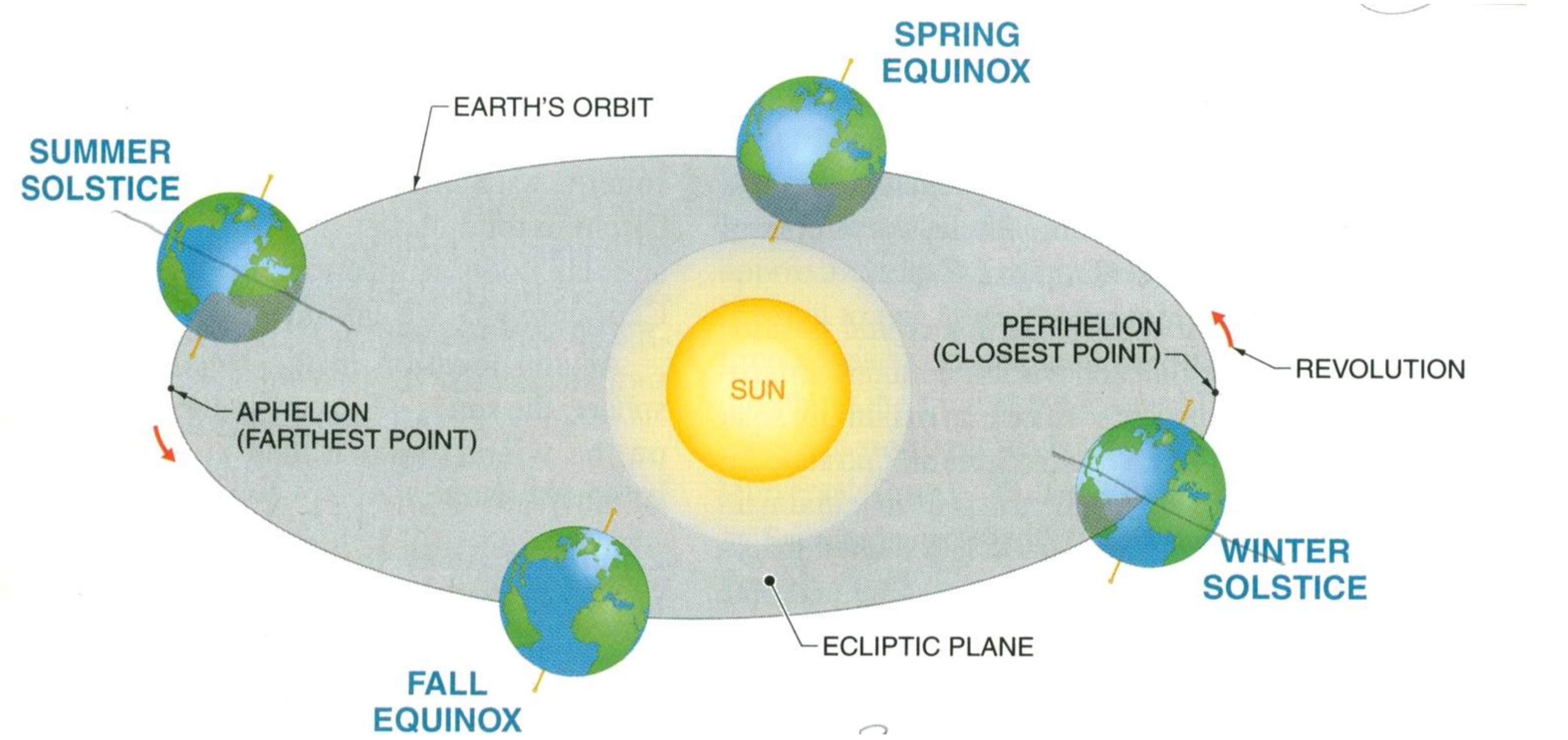
Understanding Solar Energy

The Sun

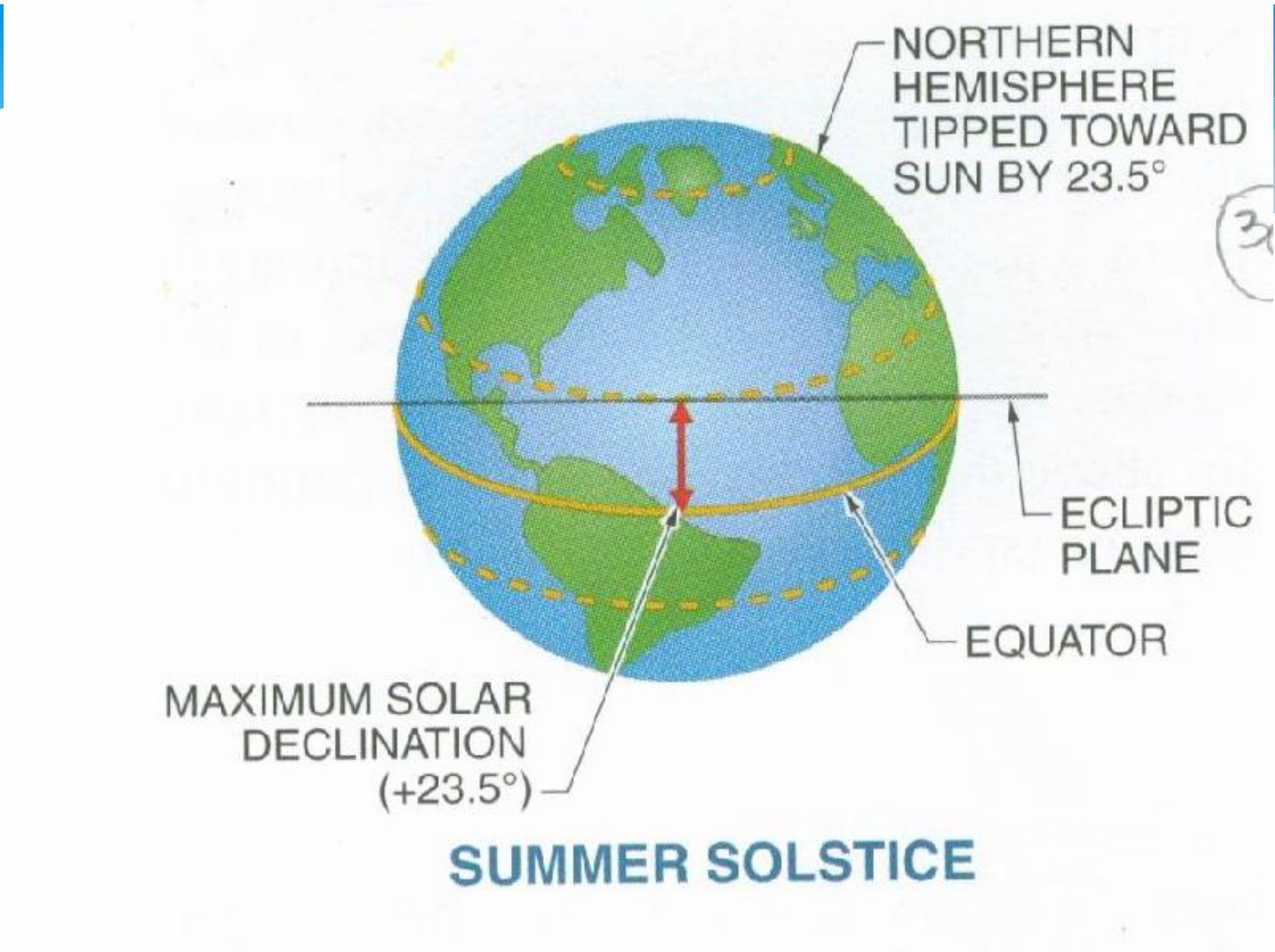
- Earth orbits around the sun
- Completing its path every 365 days
- Earth's orbit is elliptical
- Distance from the Sun varies
- Earth is closest to the Sun during the winter
- Farthest from the Sun in the summer



Understanding Solar Energy



From Jim Dunlop, Photovoltaic Systems, ATP



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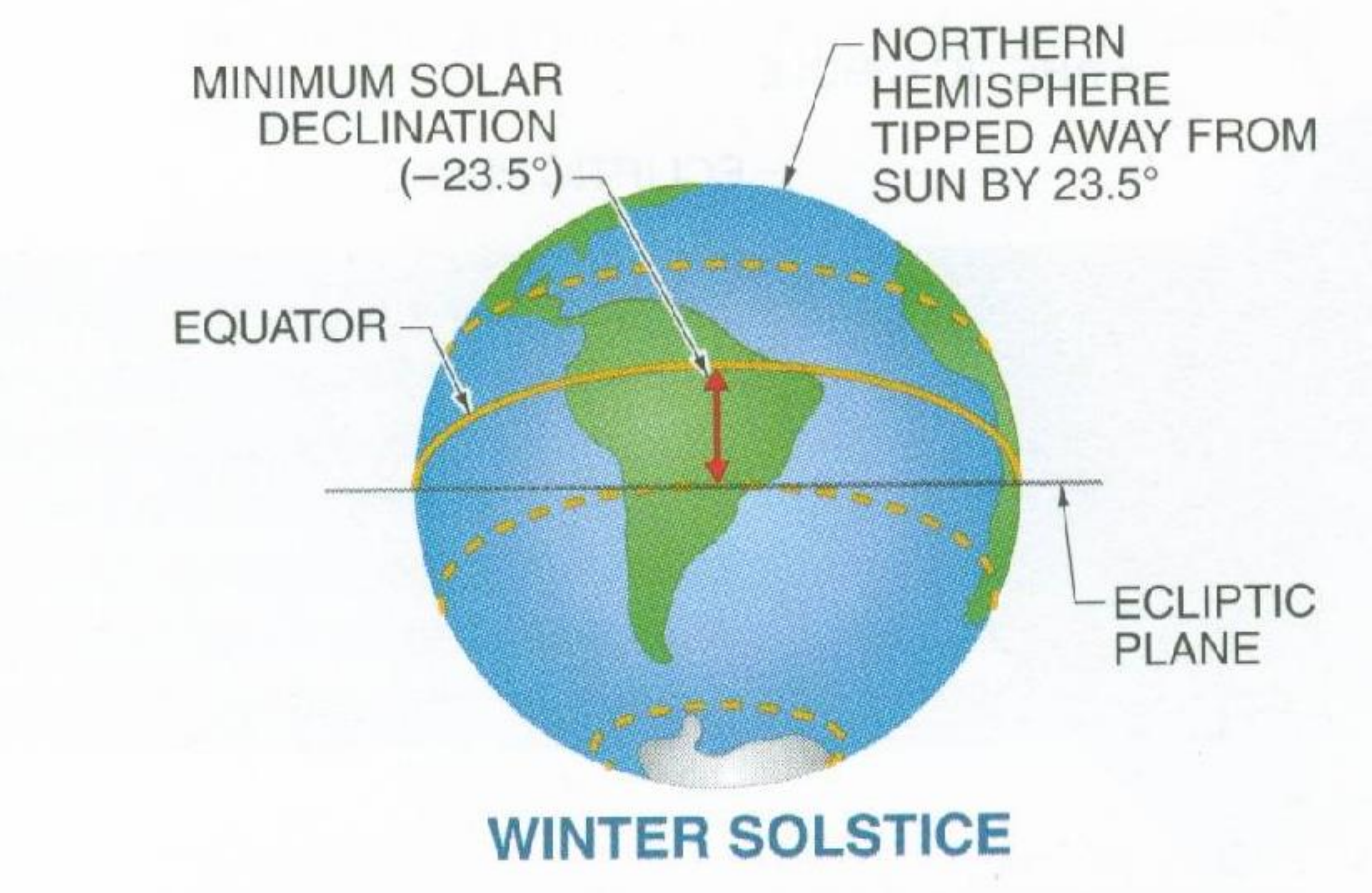
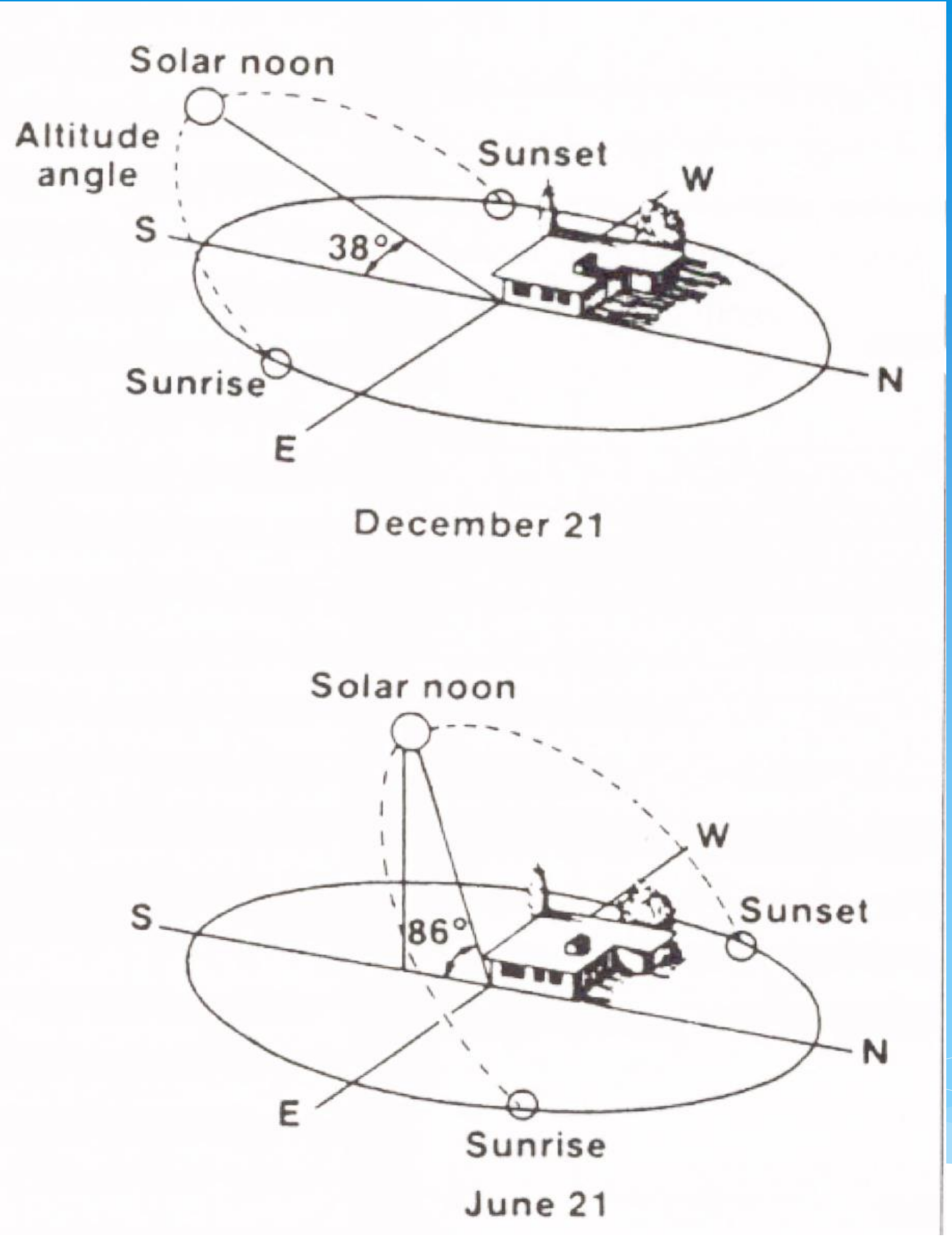


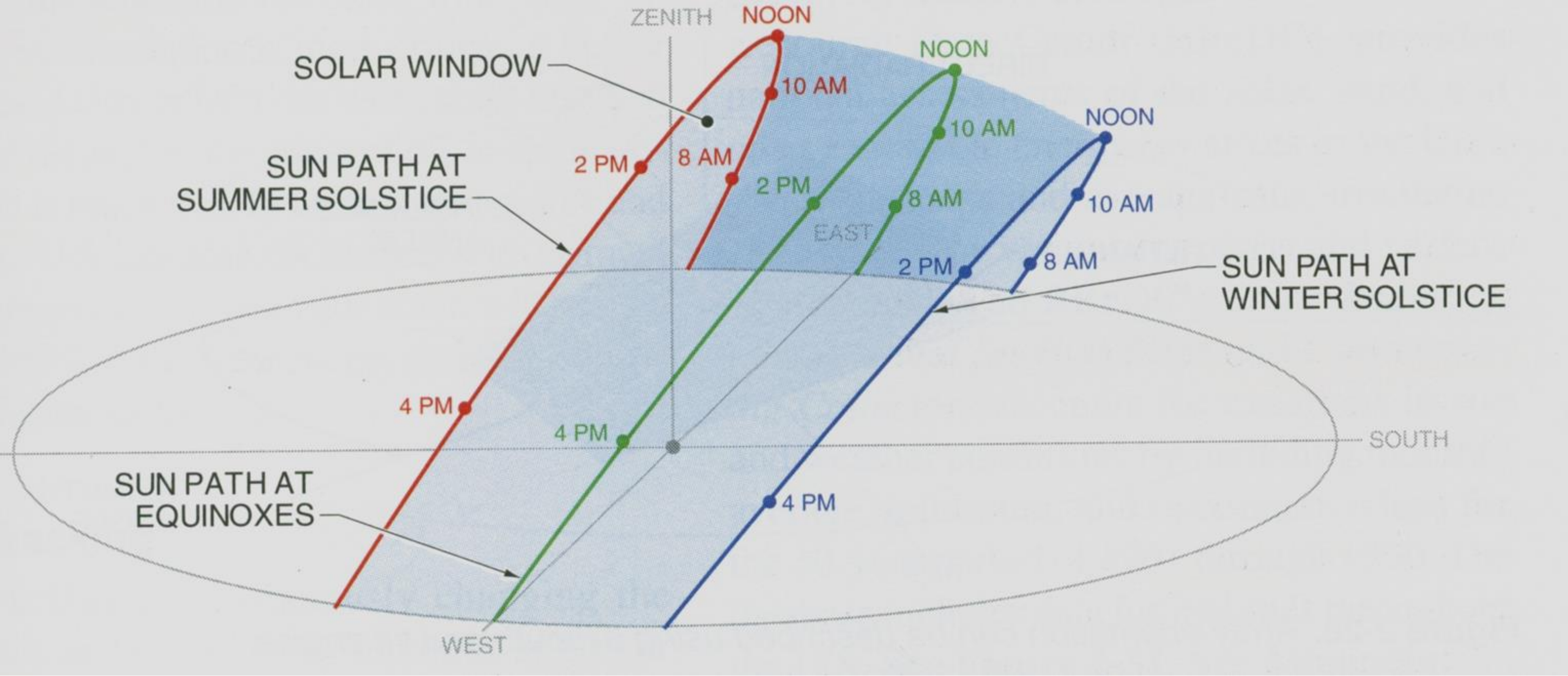
From Jim Dunlop, Photovoltaic Systems, ATP

The Sun's Path

- Position of the Sun changes during the year
- As a result of the changing relationship between the Earth and the Sun
- Sun "carves" a high path across the summer sky
- Reaches its highest point on June 21
- June 21 = longest day of the year
- Aka the Summer Solstice
- Sun carves a low path across the sky on December 21
- Shortest day of the year
- Winter Solstice


Solar noon
Altitude angle
Sunset
W
S
38°
Sunrise
N
E
December 21
Solar noon
W
Sunset
S
86°
N
E
Sunrise
June 21

Solar Window



Solar Electricity

Solar Electricity -- Photovoltaics

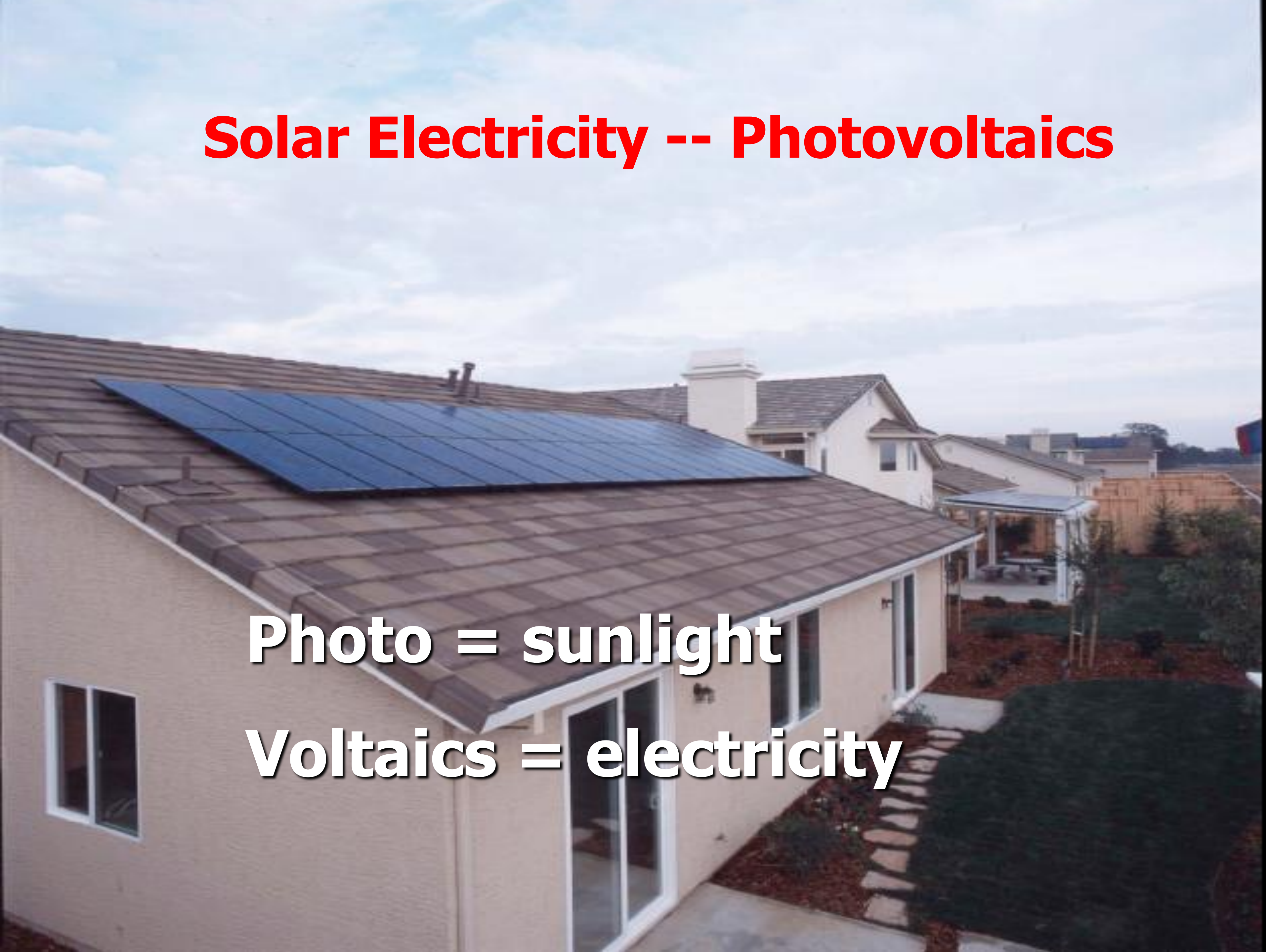
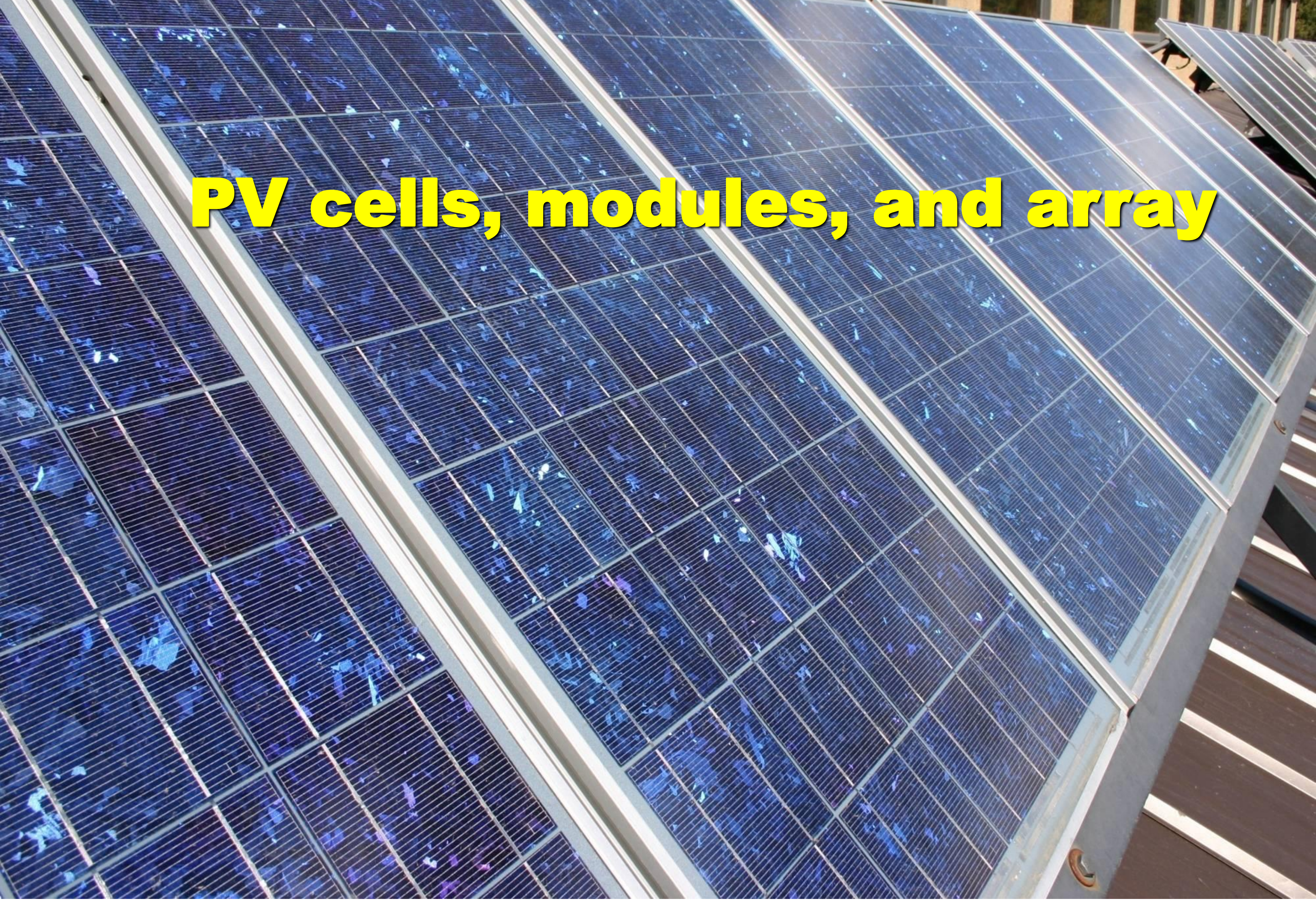


Photo = sunlight

Voltaics = electricity


PV cells, modules, and array

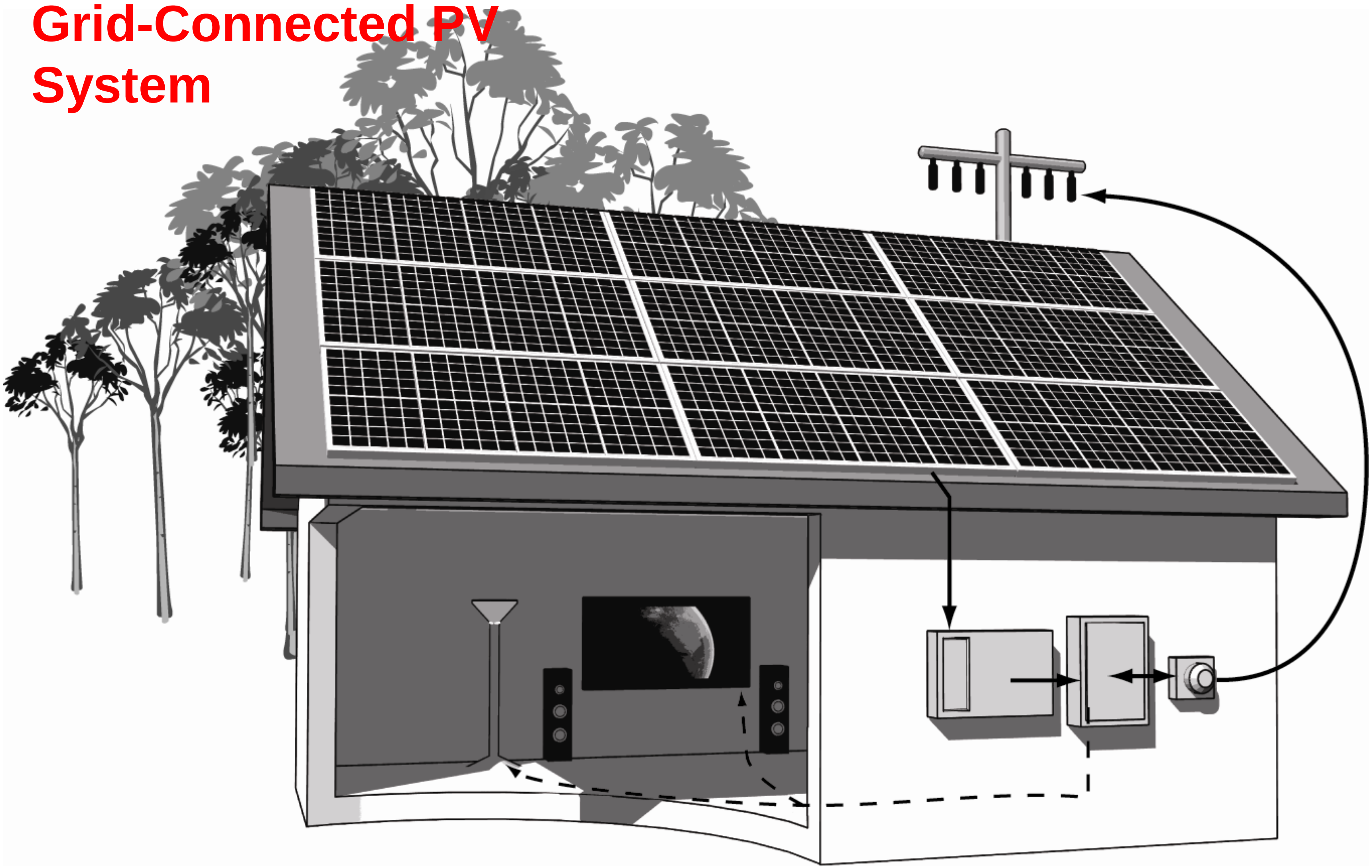
How to go solar

* Lots of options
* Easiest of all
* Install a PV system on your home
* Simply plug in
* If aquaponics system is on its own meter
* Can install a PV system to supply it
* Wire it into the panel
* Add batteries for backup

Types of Systems

- Grid Connected
- Grid-Connected with Battery Backup
- Off-grid or Stand Alone

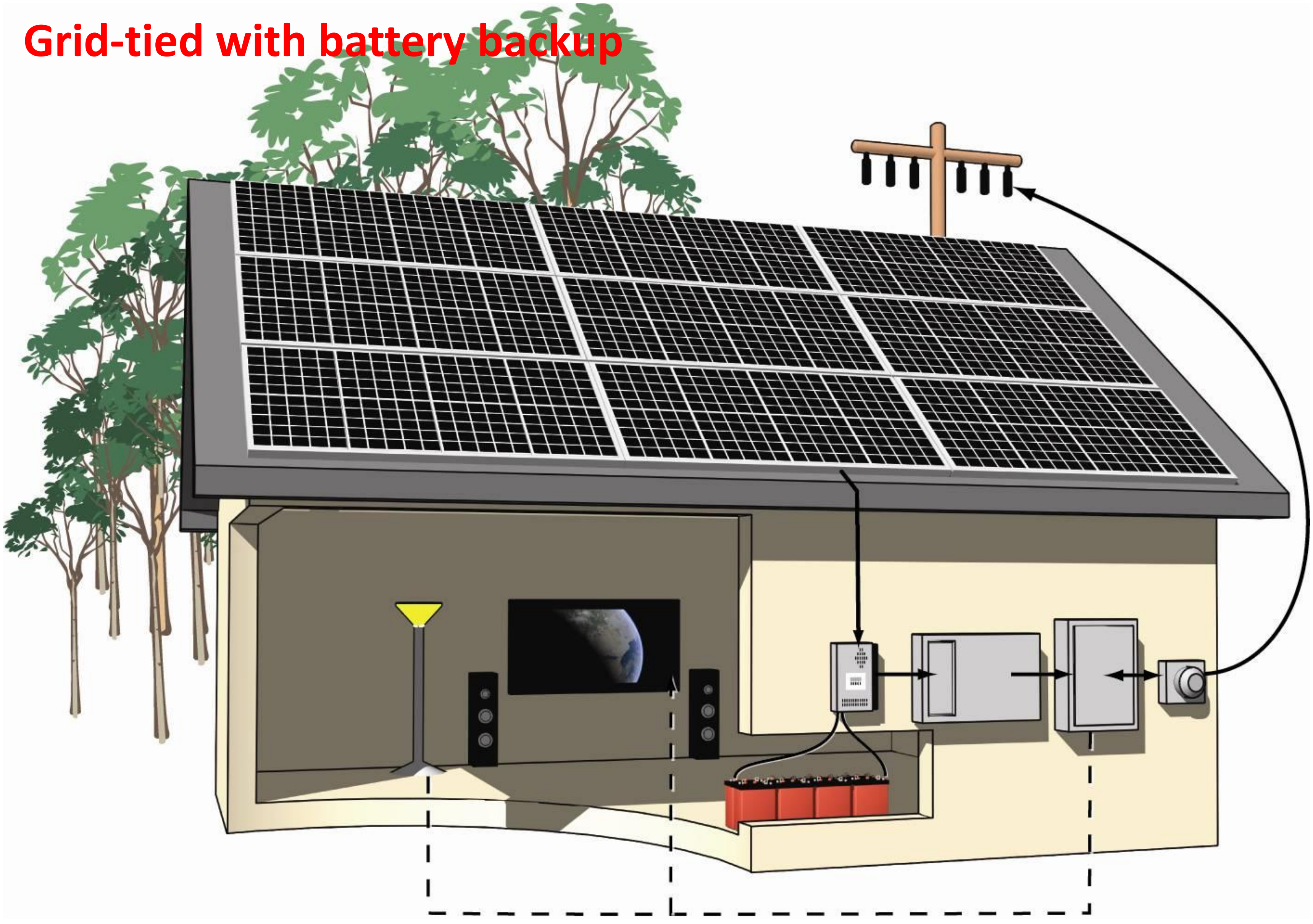
Grid-Connected PV System



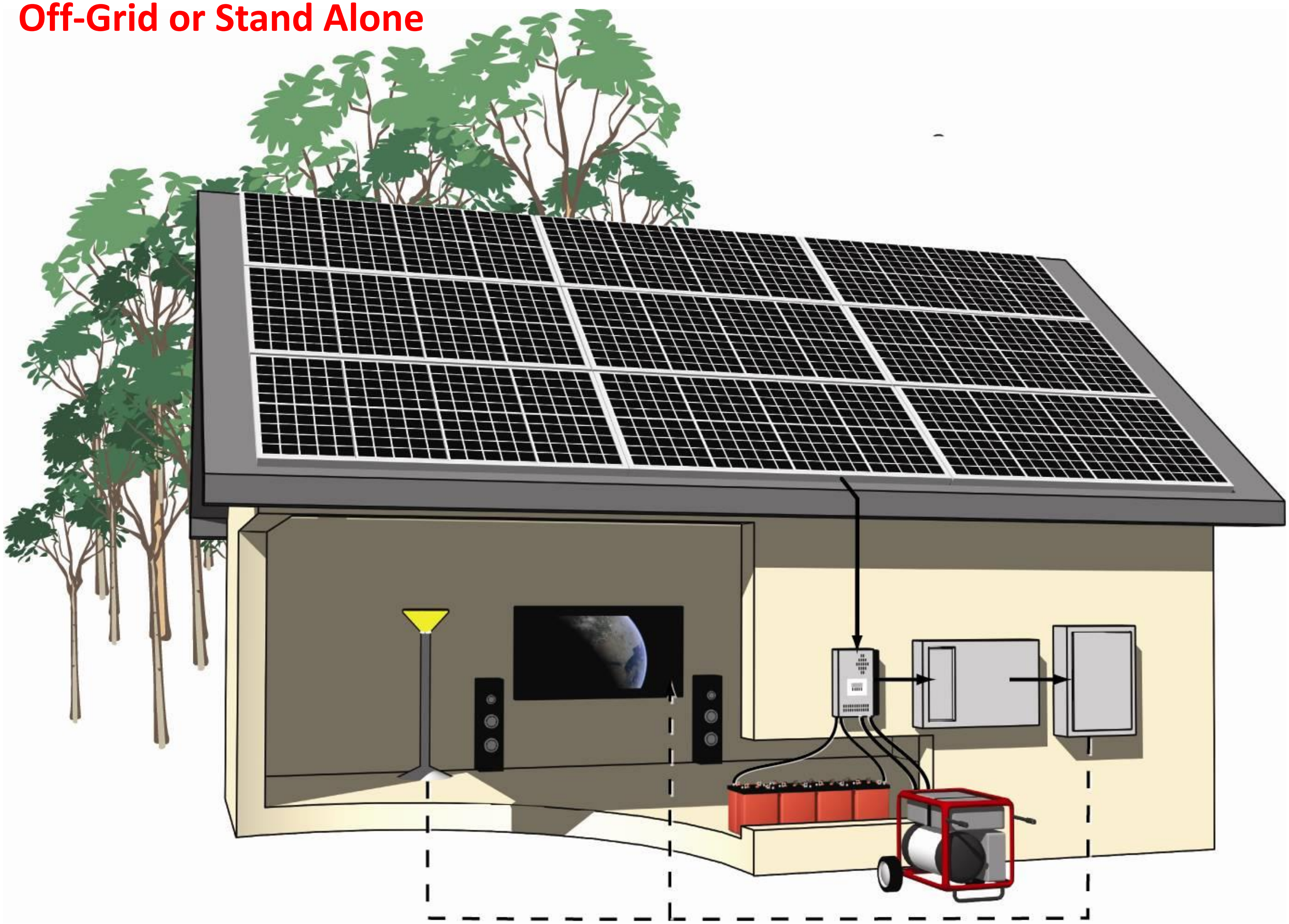
When the grid goes down

so does your system!

Grid-tied with battery backup



Off-Grid or Stand Alone



Mounting options

- Ground
- Building—typically roof

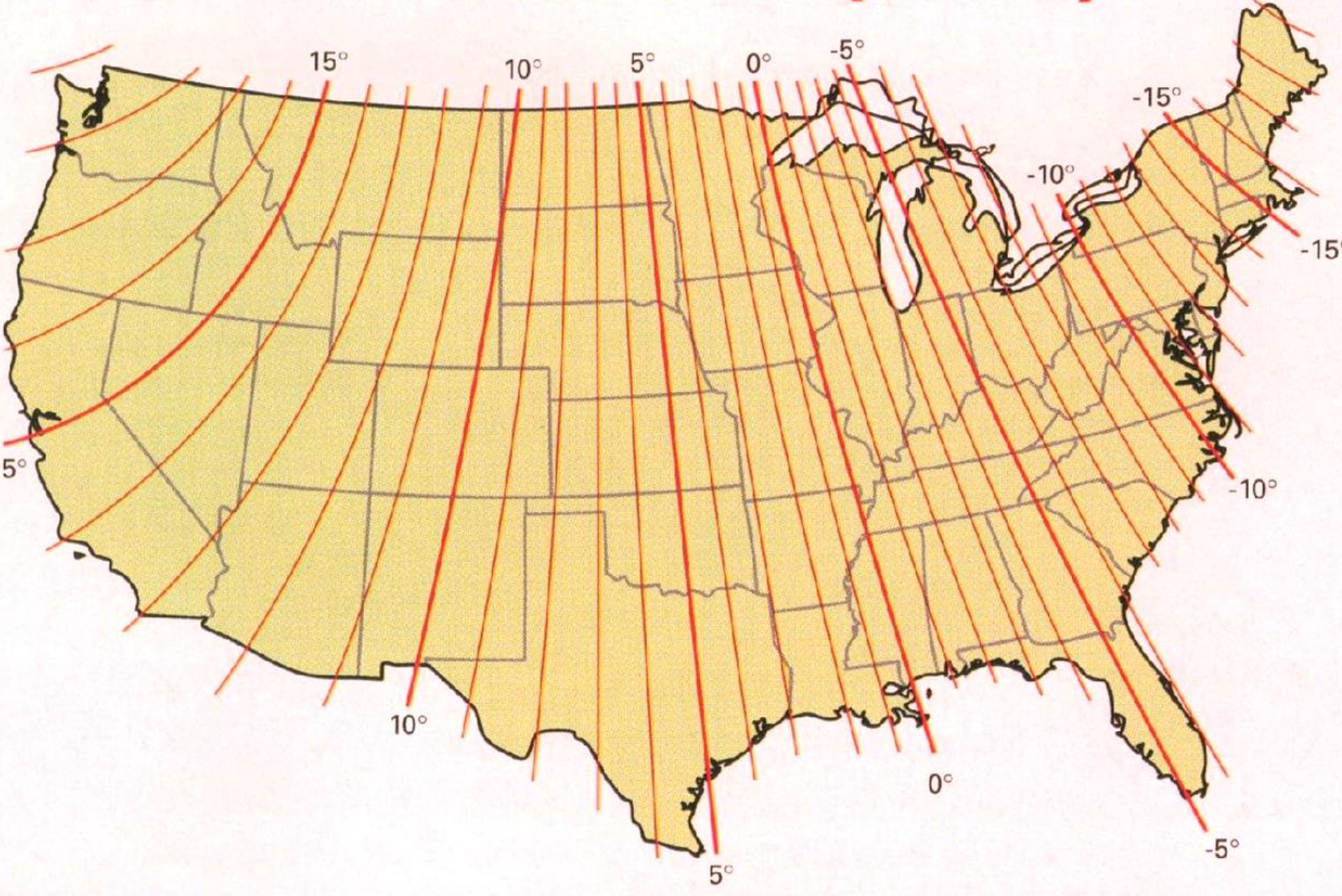
Courtesy Rochester Solar Technologies

Orientation of Solar Modules

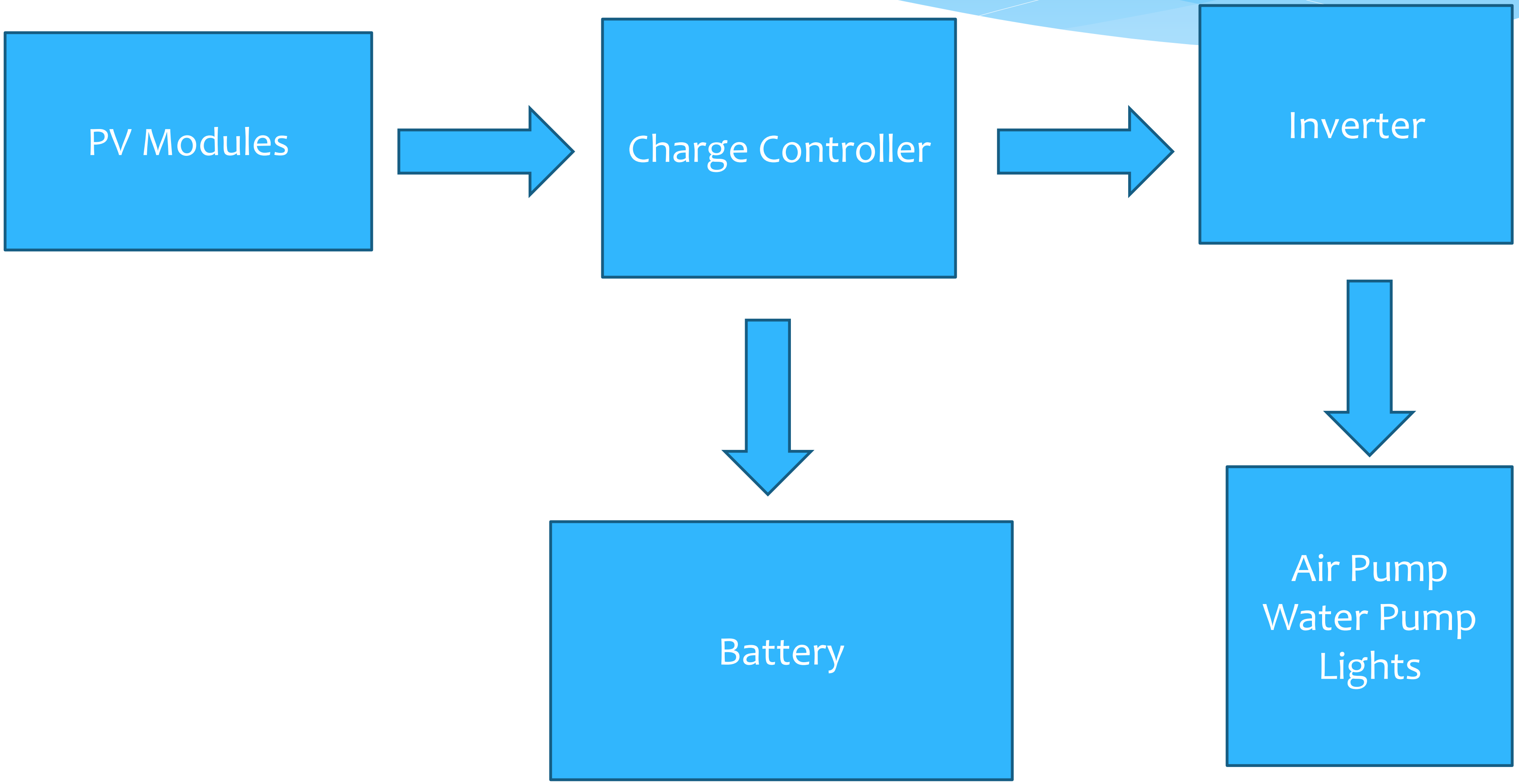
- For maximum output
- Solar modules should be perpendicular to the sun from sunrise to sunset
- This is possible with a tracker
- For fixed array, array should be pointed true south
- Not magnetic south

True south and magnetic south rarely coincide

Magnetic Declination (2005)



Dedicated PV System for Aquaponics




Will this work?
45-watt system
Need to purchas
battery and 300-
inverter

How to Size a System

- Determine the size of the PV system
- Add up wattages of pumps
- Multiply each one by hours in use per day
- To determine watt-hours
- Convert to kWh per day
- Air pump -- 20 watts
- Water pump -- 40 watts
- Both run 24 hours per day

How to Size a System

* Total = 60 watts
* 60 watts x 24 hours per day
* 1,440 watt-hours per day
* 1000 watt-hours = 1 kWh
* 1.44 kWh per day
* Multiply by 365 for annual use
* 1.44 x 365 = 526 kWh per year

How to Size a System

* 1 kW system in Colorado
* 5.7 peak sun hours per day
* X 365 days
* X 0.78 efficiency factor
* 5.7 x 365 = 2080
* 2080 x 0.78 = 1,622 kWh per year
* Unshaded array
* Orientation -- true south

How to Size a System

* 526 divided by 1,622 = about a 0.32 kW system
* A 320-watt system for air and water pumps
* Most modules these days around 250 to 260 watts
* So may need 2 modules
* Cost about $1/watt or $250 each
* Harbor freight 45-watt array is not going to suffice
* Then you need to size the battery to hold electricity
* Why?
* Night time function
* Power outages

How to Size a System

- Size battery bank for three days of battery-only operation
- 60 watts x 24 hours = 1.44 kWh per day
- 3 x 1.44 = 4.32 kWh
- Can’t discharge batteries more than 50%
- Need to double battery size
- Need 8.64 kWh of storage
- Four large solar batteries
- Cost of $400 each

Heating Water in Aquaponics

- Heating water can be a huge challenge
- Resistive heaters consume lots of electricity
- Water heater element – 4,500 watts to 5,500 watts
- Run 4,500 watt heater
- 8 hours a day in cold weather
- 36 kWh per day – roughly $3.60 per day per heating element
- Won't need that year round
- But maybe for three to six months
- Advice
- Move South!

Heating Water in Aquaponics

* Smaller system
* Tank heater – 400 watts
* 8 hours a day
* 3.2 kWh per day per heater
* May not need that much electricity year round
* If you did, you'd need 1,168 kWh per year
* You'd require a 0.7 kW system
* Small solar system (approximately 1 kW) on your house would power your heater and your pumps

Heating Water in Aquaponics

* Suggestions
* For existing systems
* Improve efficiency – reduce the loss of heat from tanks and grow beds
* New systems – build them right!
* Insulate tanks and grow beds
* Insulate pipes, especially if they run through a concrete slab
* Starting new: *Build a superefficient greenhouse that is thermally stable and hence provides most of the heat for the water!*
* Provide heat via a solar hot water or solar thermal system

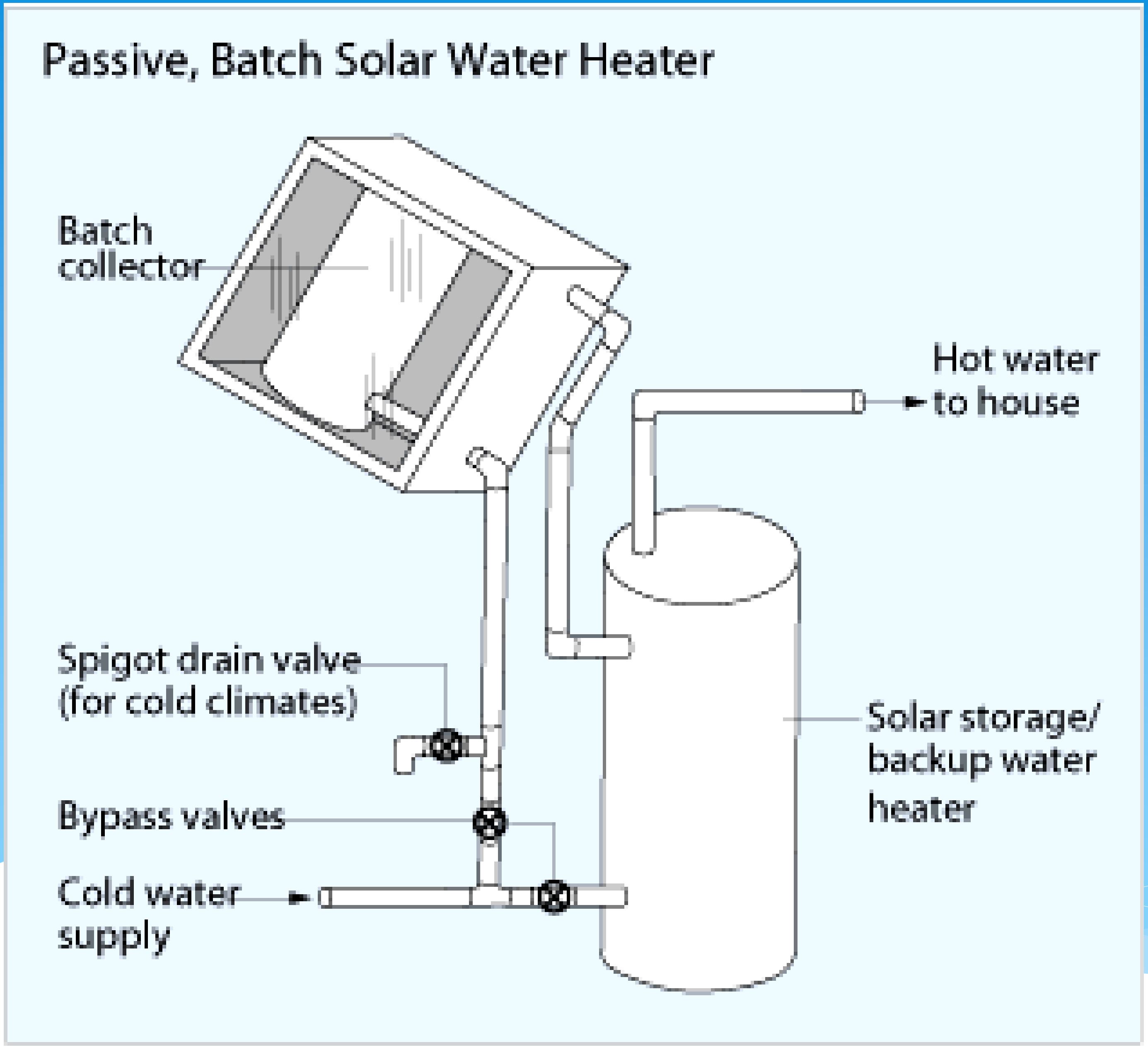
Types of DSHW Systems

- Two types of systems -- active and passive
- Components – solar collector and storage tank
- Often linked to conventional storage water heater or on-demand (tankless) water heater

Solar Batch Water Heater

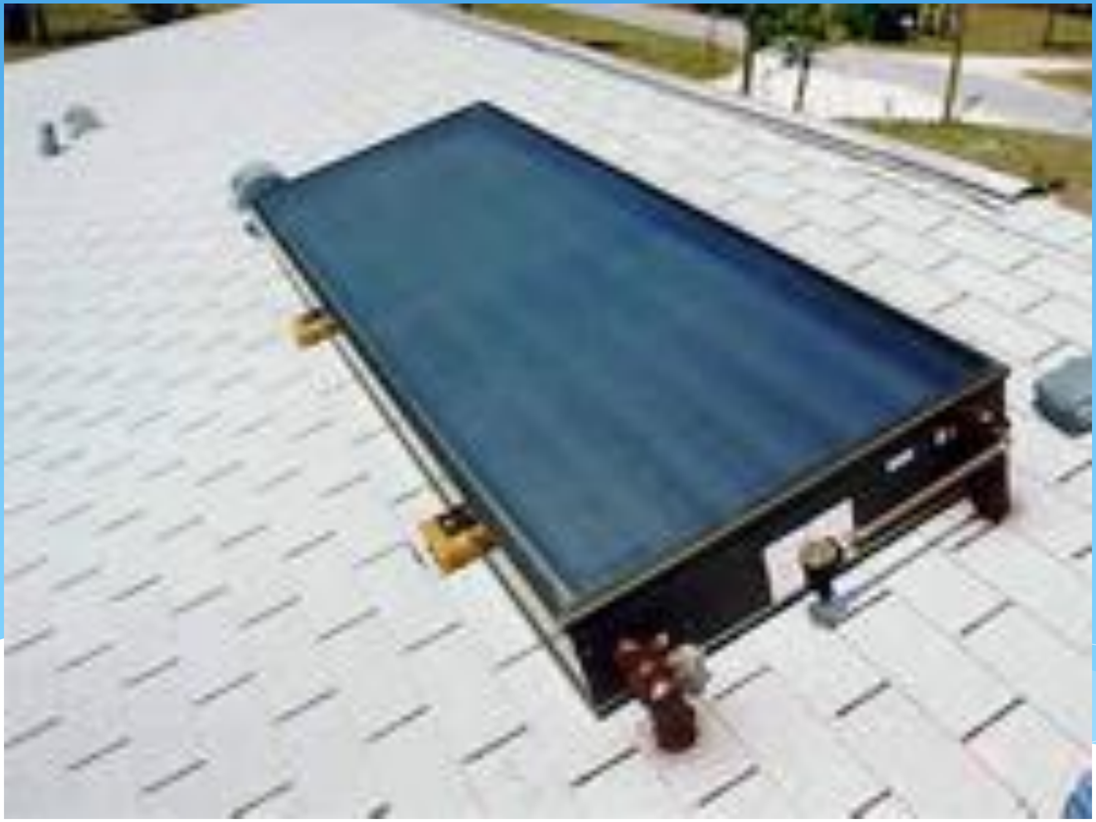
Integrated collector-storage system

Open system



Passive, Batch Solar Water Heater
Batch collector
Hot water to house
Spigot drain valve (for cold climates)
Solar storage/ backup water heater
Bypass valves
Cold water supply

Progressive Tube Solar Water Heater



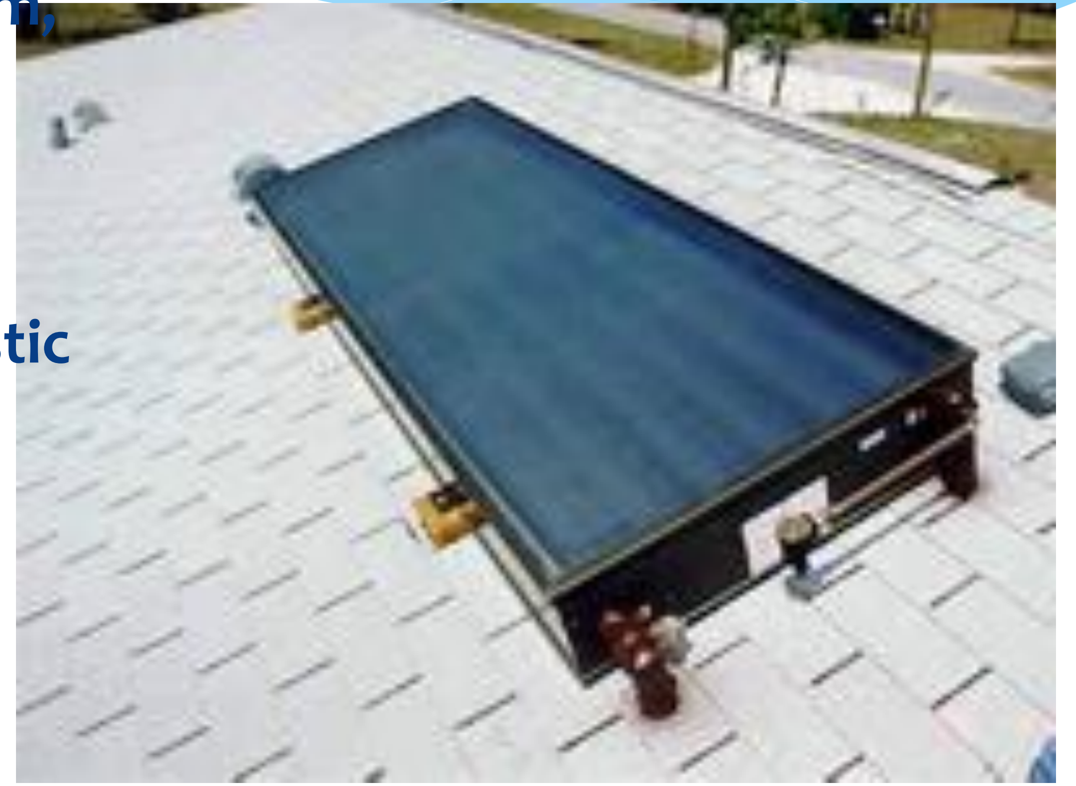
30, 40, and 60 gallon capacity

Progressive Tube Solar Water Heater

* **Provide 100% of hot water on sunny days**
* **Preheat water on cloudy days**
* **Reduce fuel use and utility bill**
* **Fairly inexpensive**
* **Fairly easy to install**
* **No pumps**
* **No electricity**
* **No sensors or costly controls**
* **Little or no maintenance**
* **Heavy – be sure roof can support load**

Progressive Tube Solar Water Heater

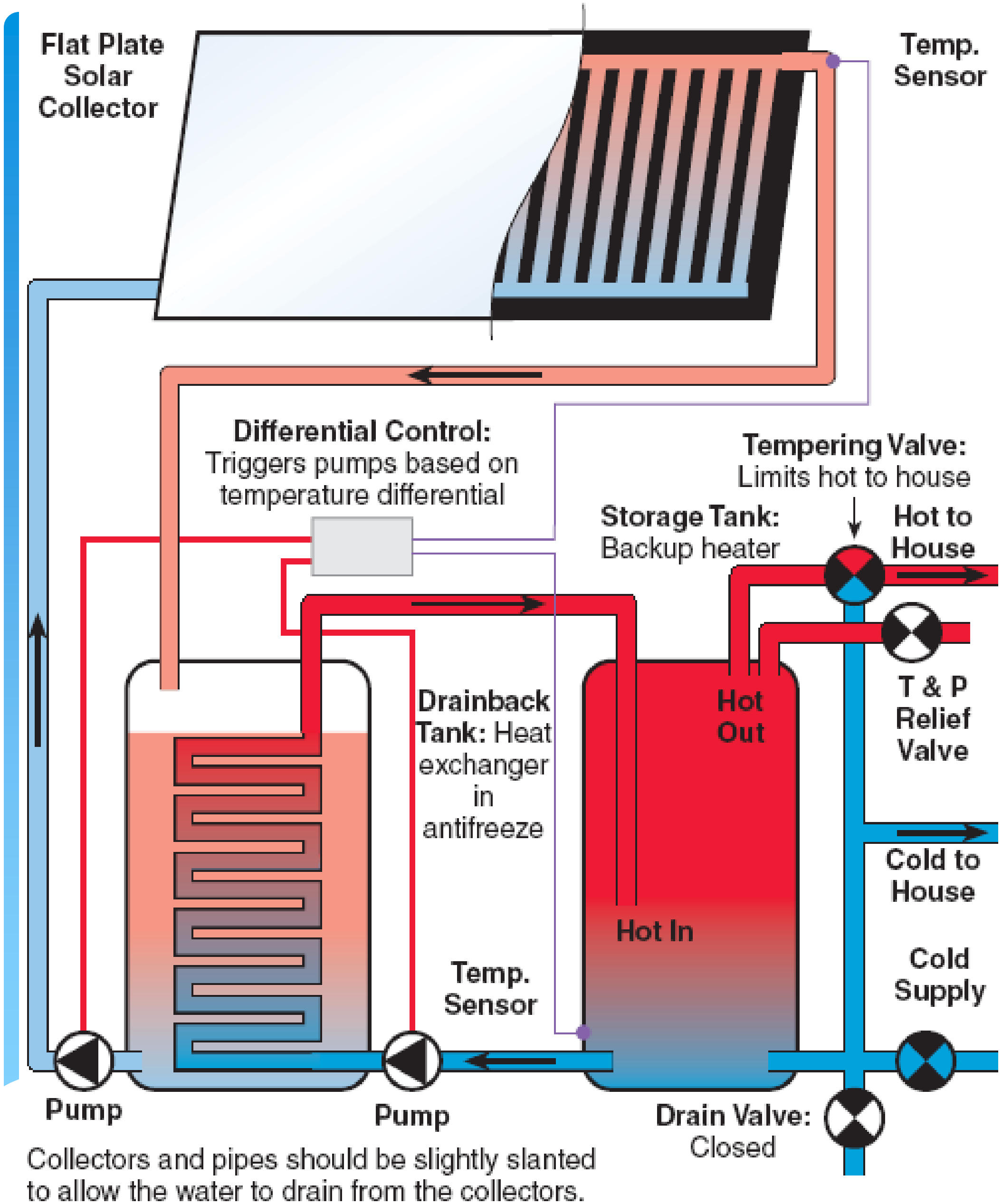
* **Suitable for use in warm, sunny climates**
* **Not suitable for cold climates**
* **Can also use for domestic hot water**



Active Systems -- Pump-Circulation systems

Pump-Circulation systems

* **Separate storage and collection**
* **Collector on the roof**
* **Storage tank located inside the house**
* **Advantage: reduces heat loss from storage tank at night**
* **Two common options**
* **drainback (water = heat exchange fluid)**
* **glycol (propylene glycol = heat exchange fluid)**

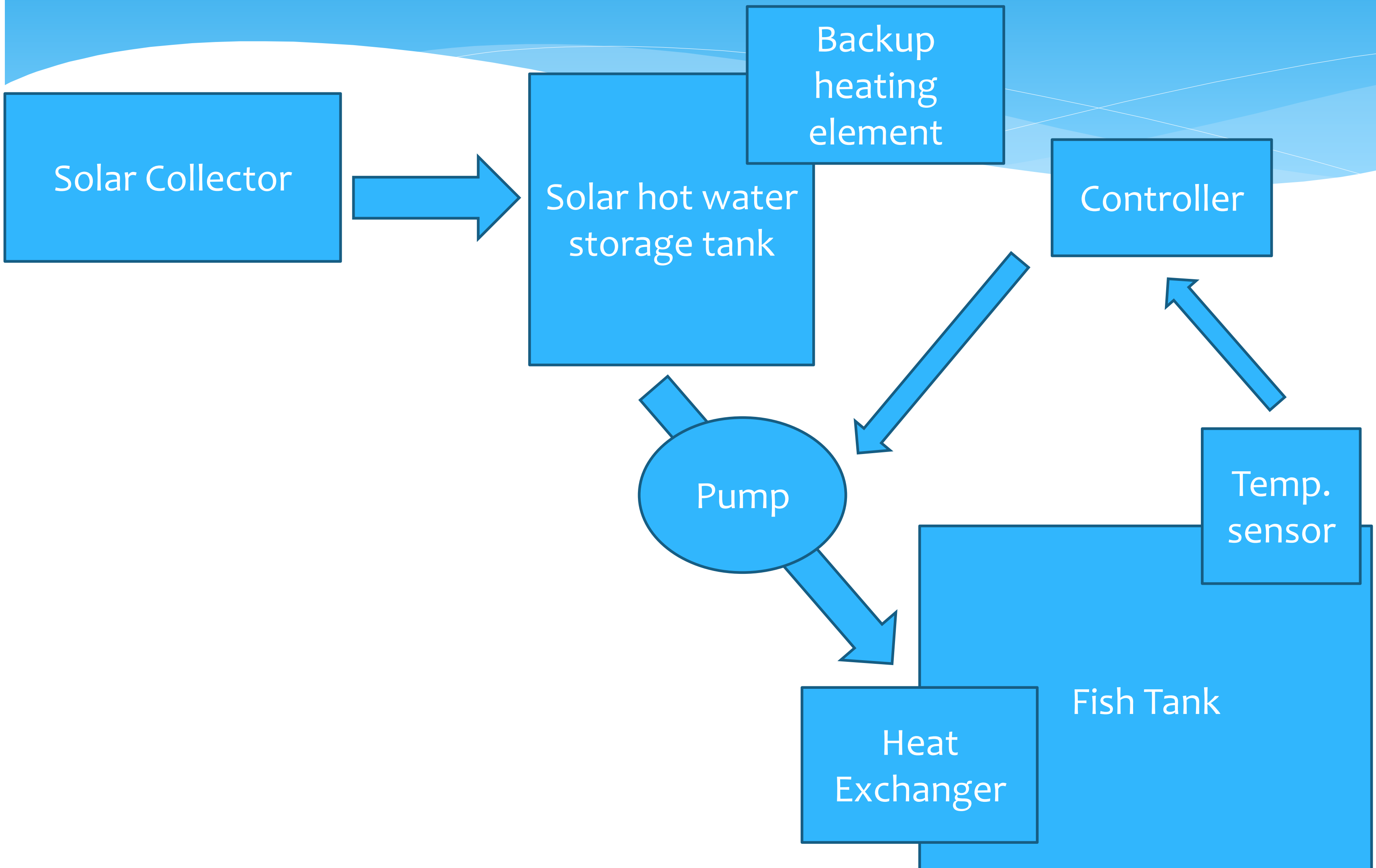


Solar Hot Water

- Drainback System
- Active system -- pump driven
- Heat exchange fluid = water
- Closed system
- Designed for areas where freezing occurs

Courtesy of Home Power Magazine

Solar Hot Water Design Ideas



Solar Greenhouse

Passive Solar Heating and Cooling

* Proper orientation and design of greenhouse
* Cooler in the summer
* Warmer in the winter
  Design all wrong
* Most greenhouses are spacious, uninsulated
* Too much volume
* No thermal mass
* Wide temperature swings year round
* Vent heat even in the winter
* Lots of energy to heat and cool them

Passive Solar Heating and Cooling

* We tend to use technology developed in Holland
* Large greenhouses
* Massive volume
* Single-pane glass
* Burn lots of wood, natural gas, coal, or oil to heat
* Then vent and cool in the summer
* Amount of fuel needed
* Exceeds amount needed to transport equivalent amount of produce from regions where it's in season

Design Like a Solar Home

- Design to capture winter sun
- Plenty of sun in summer
- Orient greenhouse on an east-west axis
- No glass on north side
- Minimize or eliminate glazing on east and west sides
- Insulate north side
- Better yet, earth shelter and insulate on north side
- Provide thermal mass
- Double-pane glass or double plastic

How do we solve these issues?

* In winter, store excess heat during day rather than vent
* Use stored heat at night in winter
* Produce heat
* Passively
* May also supplement with solar thermal system
* Store summer heat for use in winter
* Tricky but can be done

How do we solve these issues?

* Even larger challenge
* Store summer heat
* For use in winter
* Tricky but can be done
* Underground storage
* Sand beds
* Water storage tanks
* Ground beneath or around the greenhouse
* Draw that heat off during the winter

How do we solve these issues?

- Sound impossible?
- Consider the Chinese Greenhouse
- Passive solar greenhouses in China
- No supplemental lighting
- Little or no supplemental heating
- Produce vegetables through Fall, Winter, and Spring

How do we solve these issues?

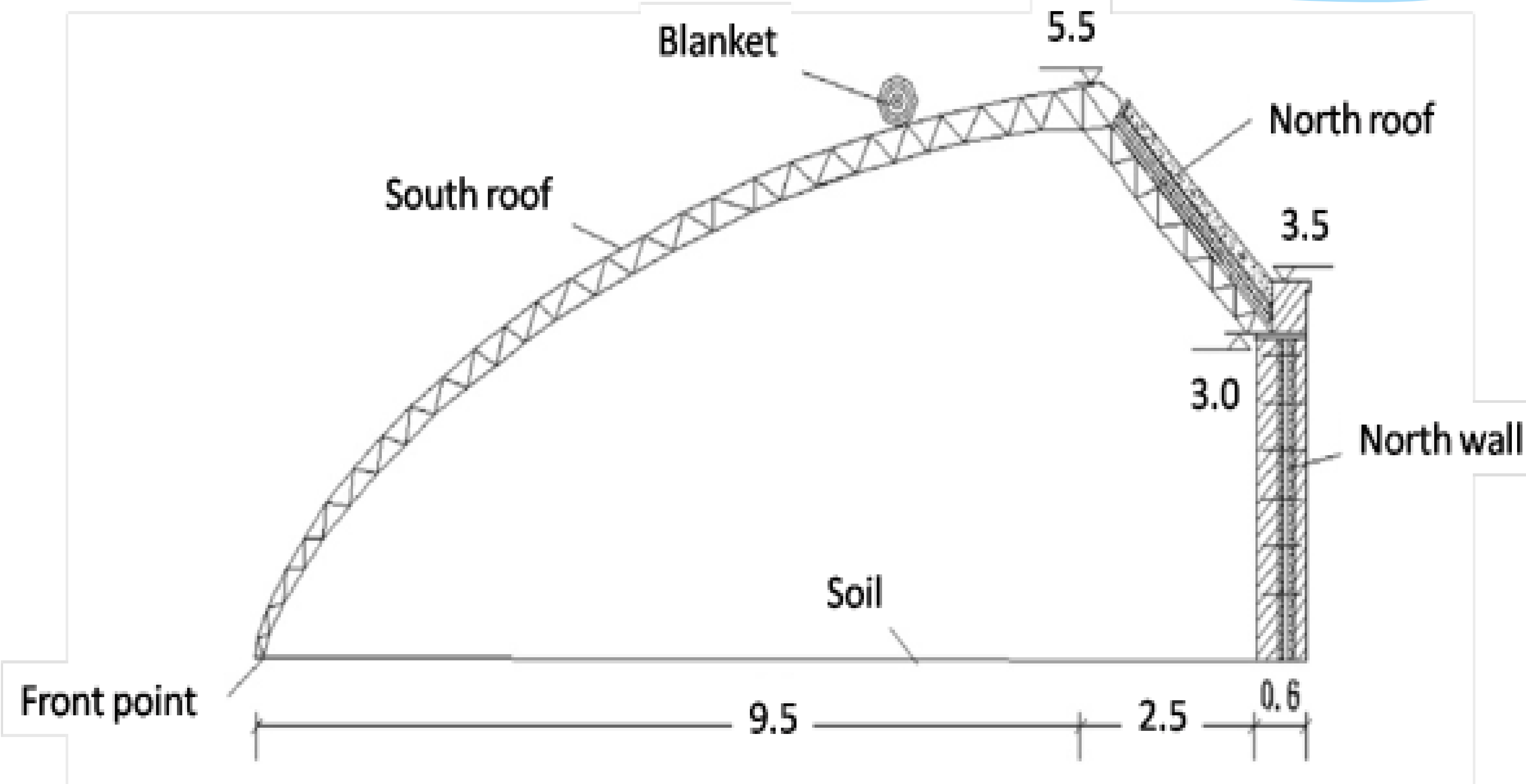
* Chinese greenhouse
* Developed in mid-1980s
* Highly evolved technology
* In 2000, covered 650,000 acres
* No current estimate
* Virtually unknown in North America

Secrets of Success of Chinese Solar Greenhouses

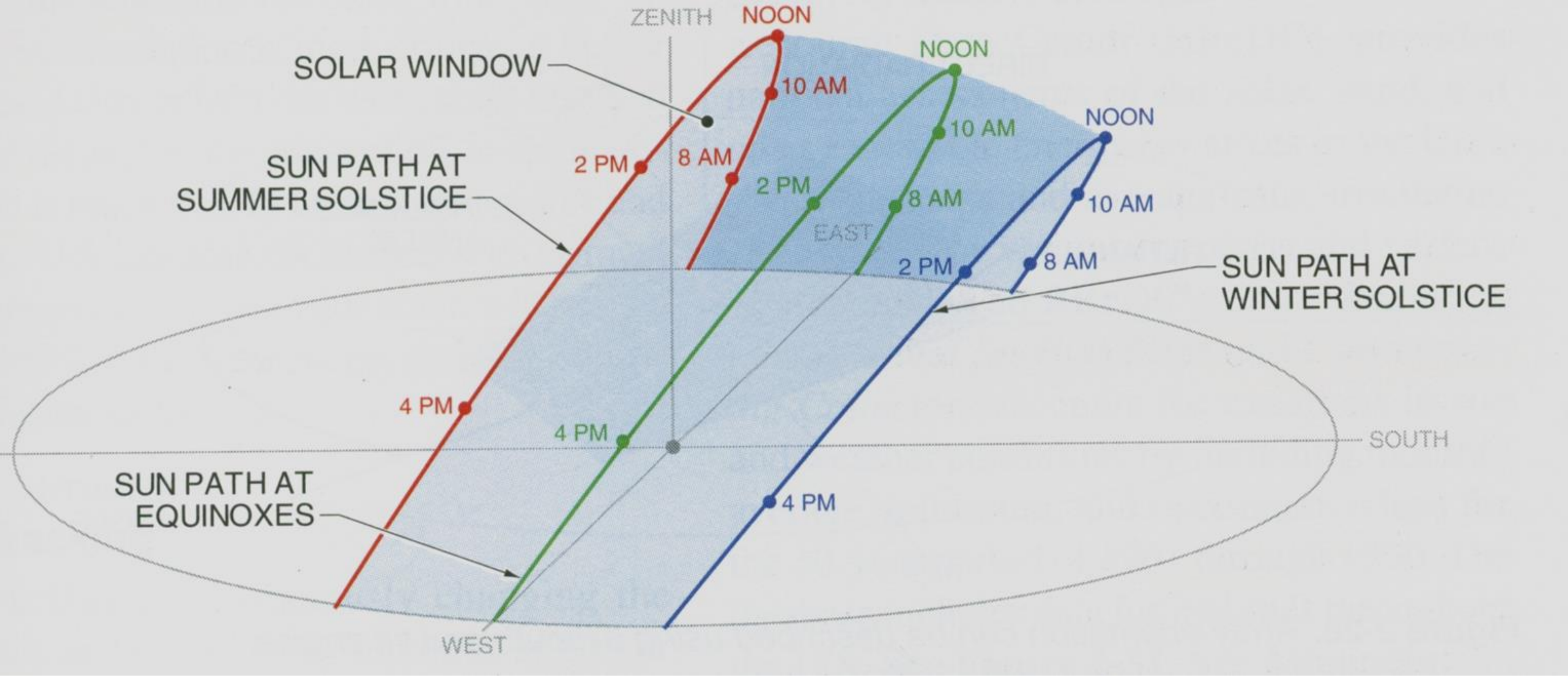
* Long axis oriented East-West
* Not North-South
* Low-profile greenhouse
* Minimize surface area for winter heat loss
* 30 to 46 feet wide
* Not all glass design
* Thick insulated back wall
* and partial roof
* Back wall contains thermal mass

Secrets of Success

- Large interior thermal mass
- Conventional greenhouse = soil, floors, and back walls
- In aquaponics systems – floors, back wall, and water


Blanket
5.5
North roof
South roof
3.5
3.0
North wall
Soil
Front point
9.5
2.5
0.6

Solar Window



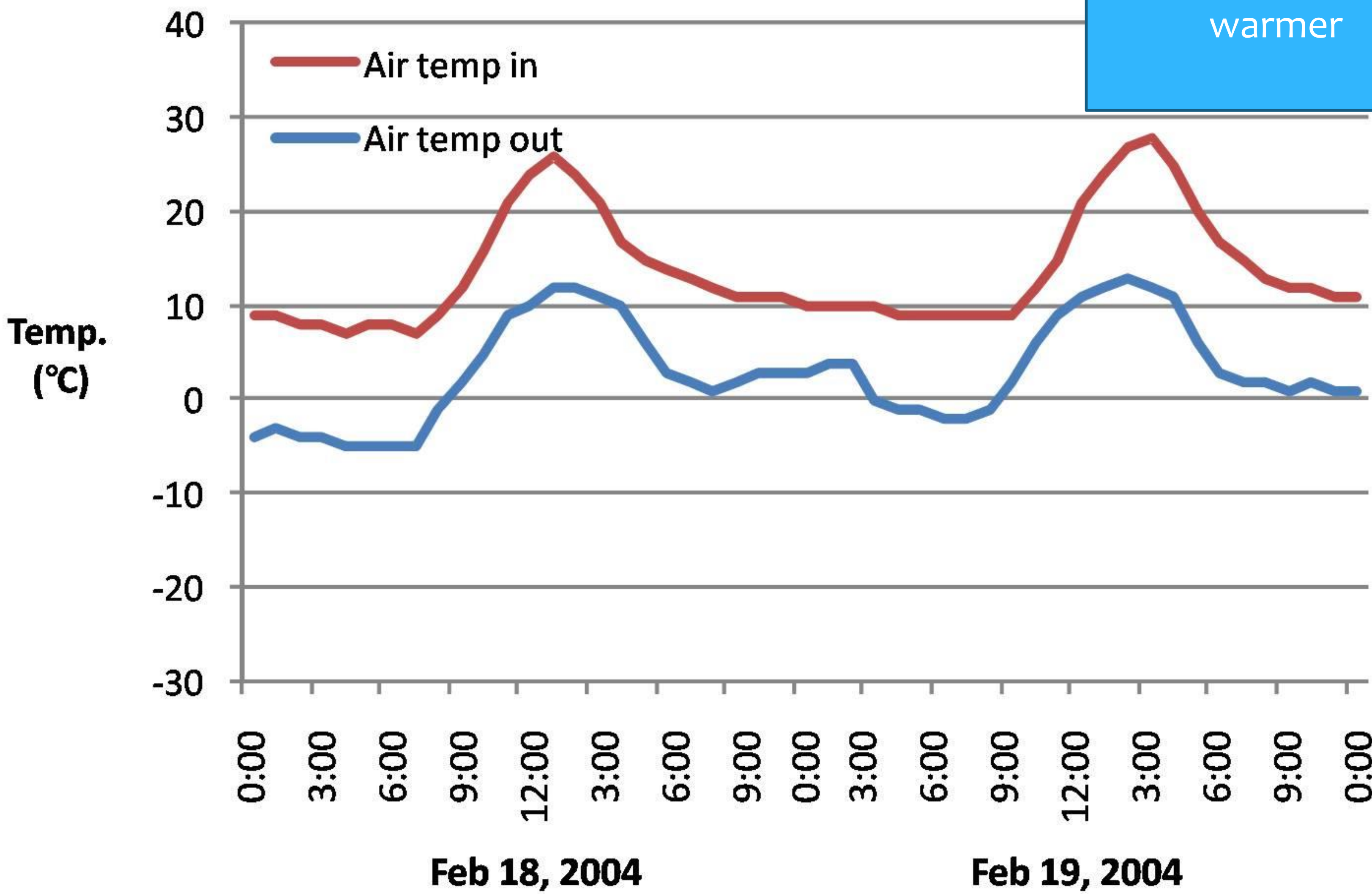

zhiboruihua.ecvv.com

Design Features

* Arched struts (beams)
* Up to 12 meters (39.6 feet)
* Single layer of plastic
* Could be improved by applying a double layer
* Thermal blanket to insulate at night

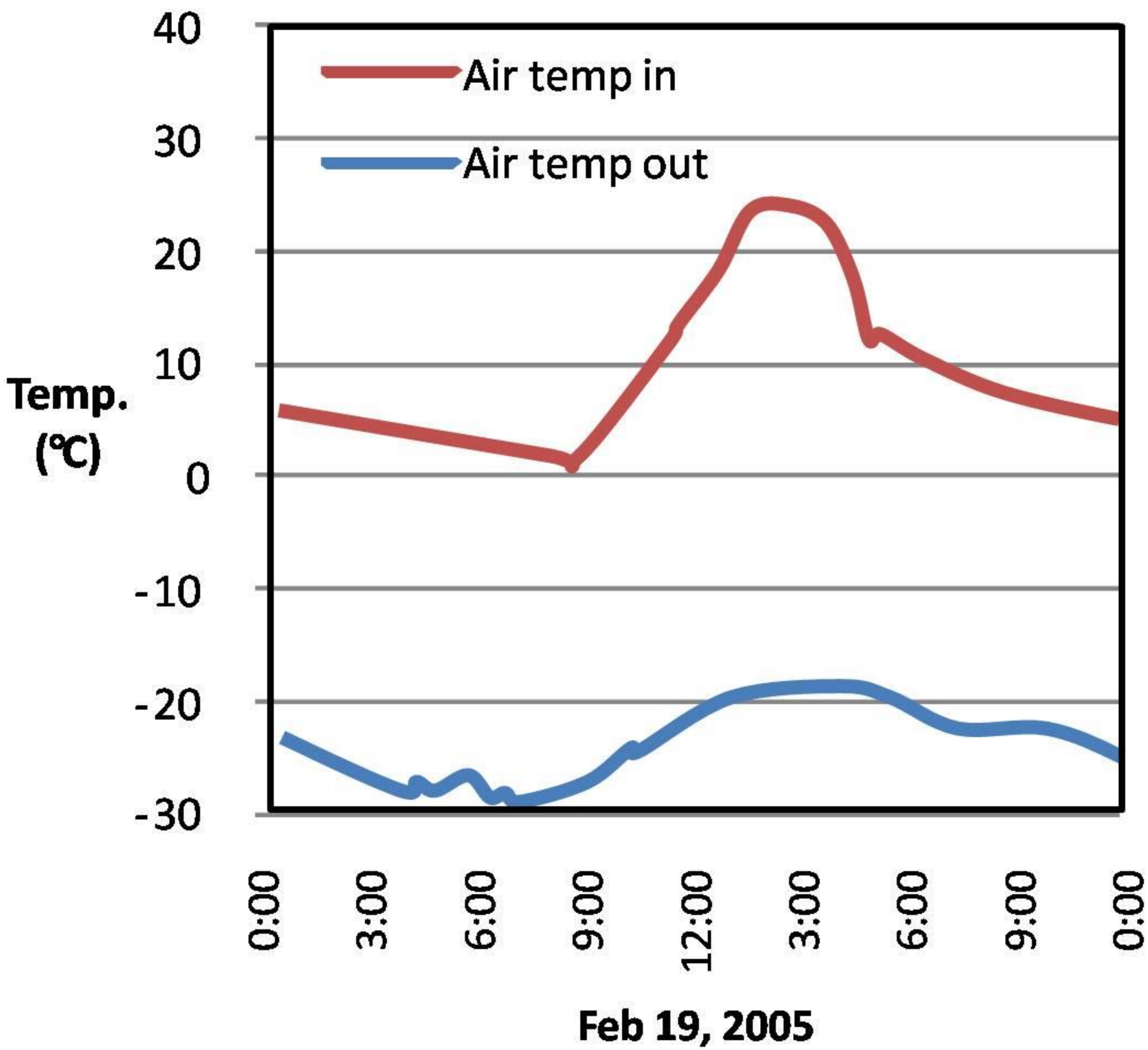
Temperature Inside and Outside Chinese Greenhouse in Shenyang, China

Temperatures were 10 to 15°C (18-27°F) warmer



Temperature inside and outside a Chinese Style Greenhouse in Manitoba, Canada

Temperatures were 10 to 30°C (54°F) warmer



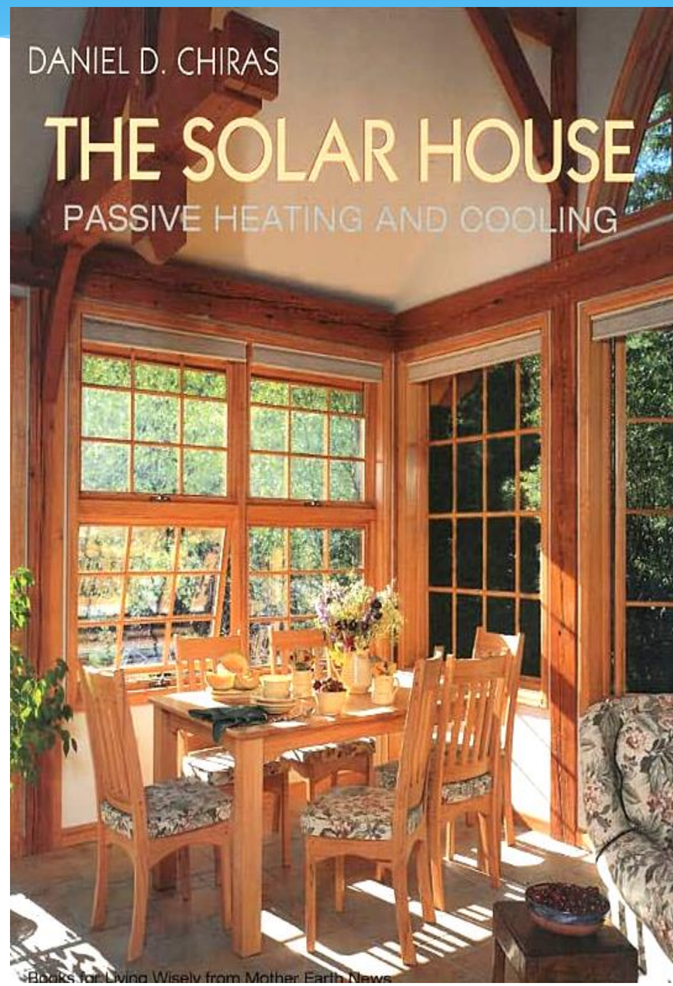
Design for heat retention

* You wouldn’t live in a greenhouse
* Because of wide temperature swings
* So how can our plants and fish?
* Redesign – Chinese Style
* Create heat storage for winter day-night cycling
* Underground heat storage for summer to winter heat storage
* Surplus summer heat pumped underground
* Released in winter

Design for heat retention

* Also earth shelter greenhouse
* Keep it cooler in the summer and
* Warmer in the winter
* Or consider
* Hoop houses over grow beds
* Underground heat storage
* Solar thermal heat storage

For Additional Information



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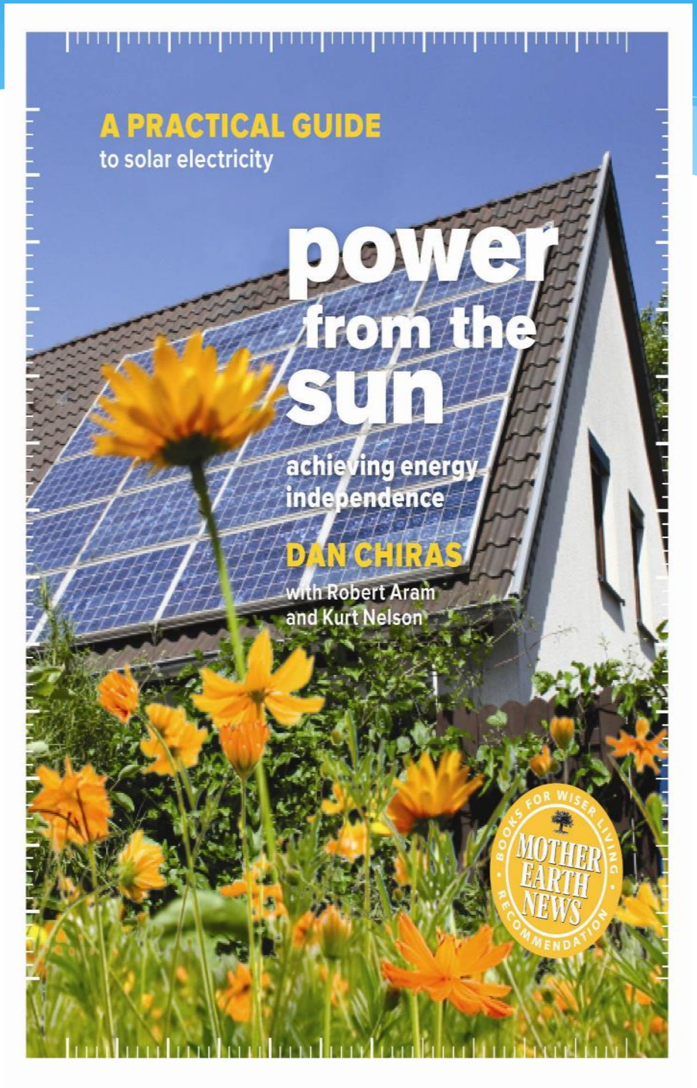

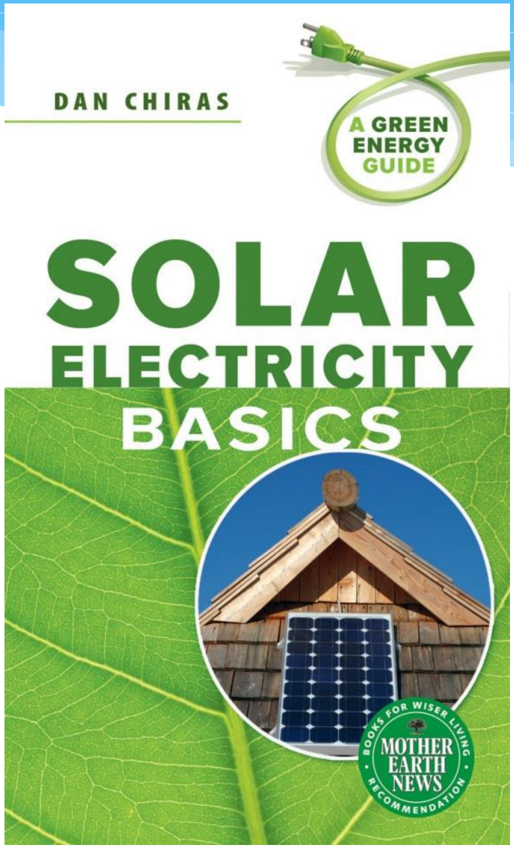

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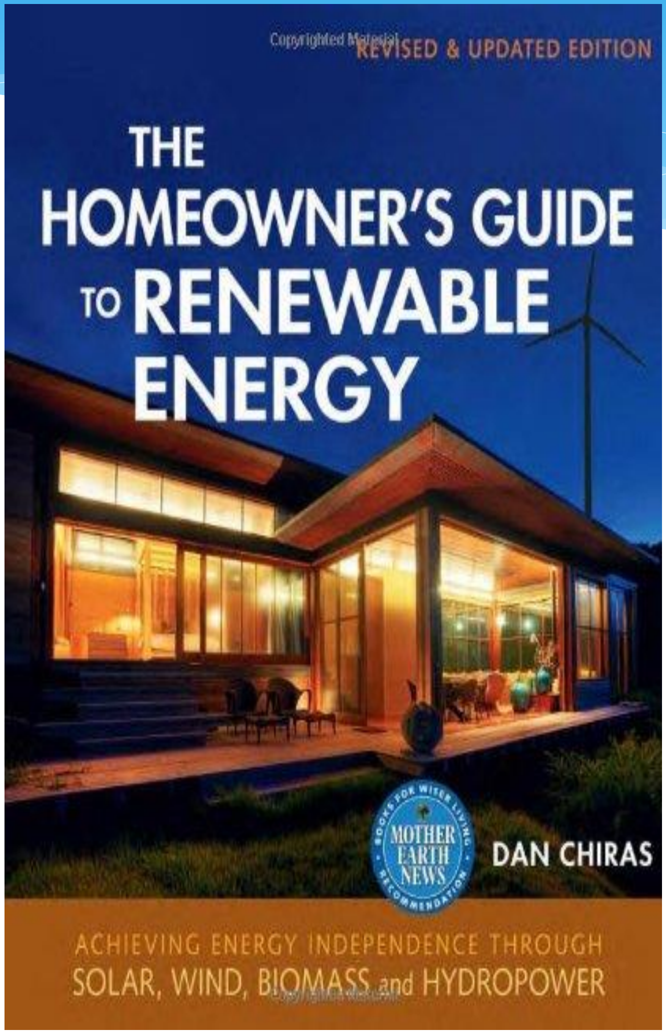

Let the Sun Shine in!

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