

Solve basic problems in Photo-Voltaic energy apparatus and systems.

Session 1 of 2

A QUALITY VOCATIONAL ELECTRICAL TRAINING COURSE
PROVIDED BY: GLOBAL ENERGY TRAINING SOLUTIONS

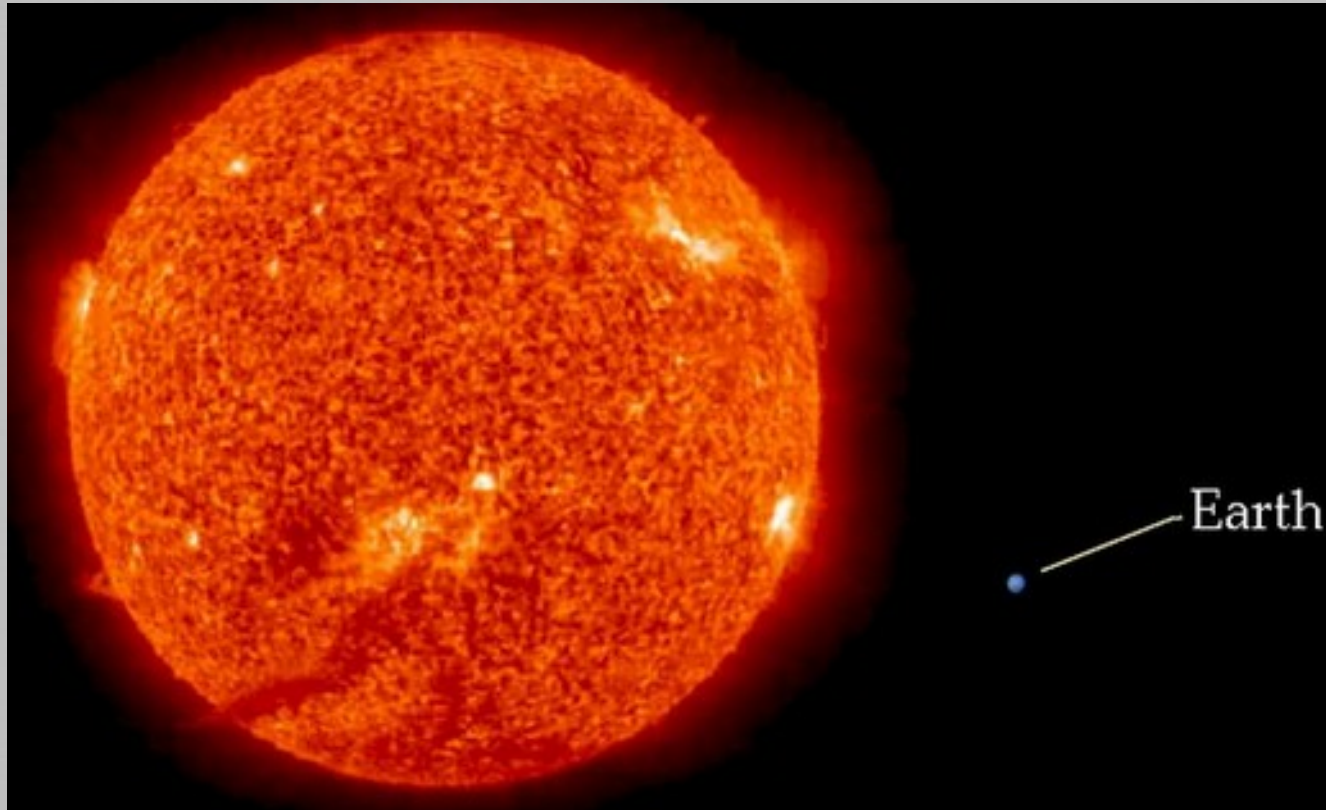
All writing in BLUE is examinable.

**Writing in RED is to help
explain terms and ideas.**

Our Sun “floods” the Earth with radiant energy, which can be used to drive PV cells (PV = Photo-Voltaic) and wind generators.

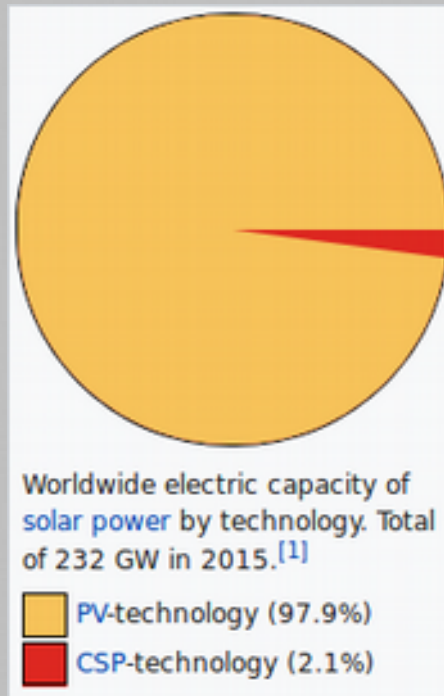
This energy is inexhaustible and free, making it the ideal energy source.





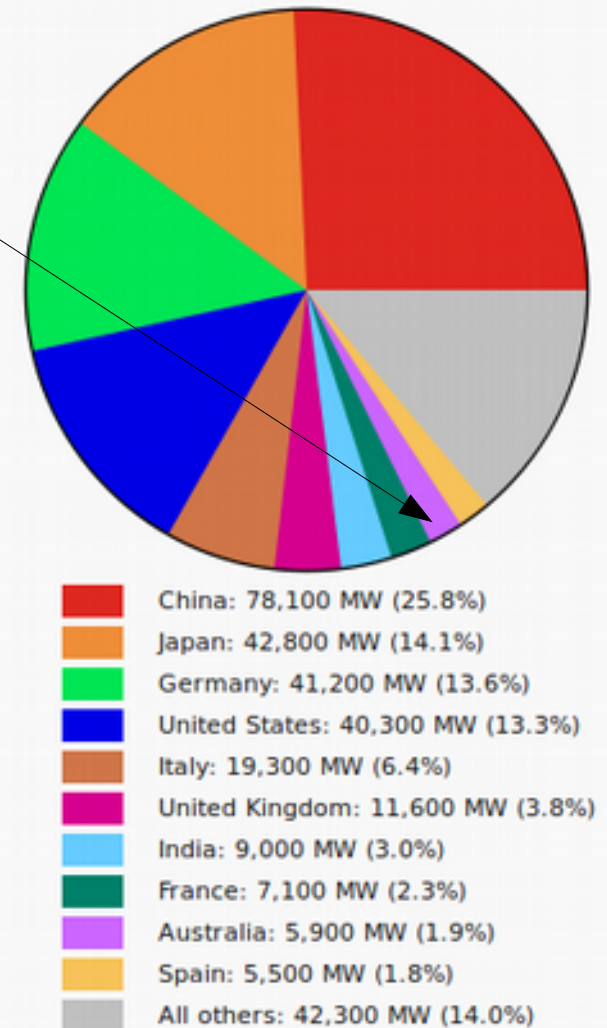
The Sun emits more energy per second than the Earth uses per day. The sun emits 2 billion times more energy than is received by the earth.

Australia is NOT a world leader in the production of Solar Energy, even though we have massive resources.



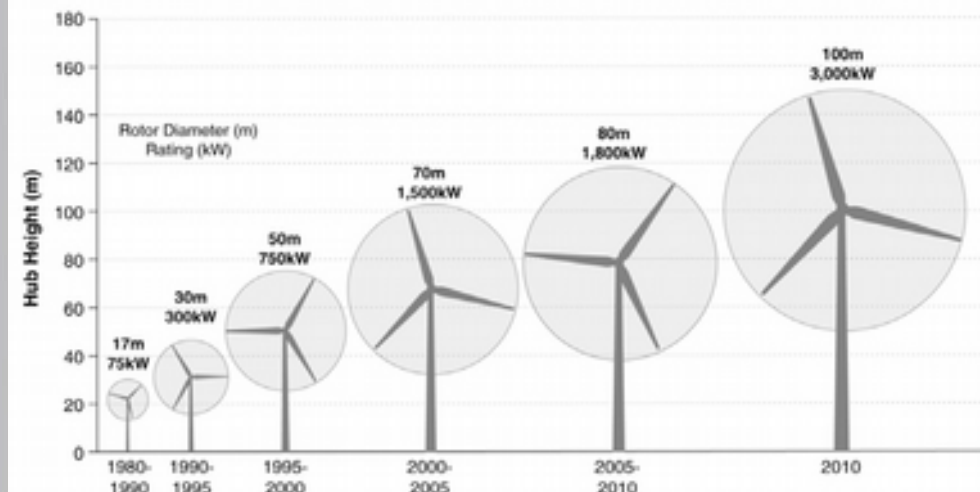
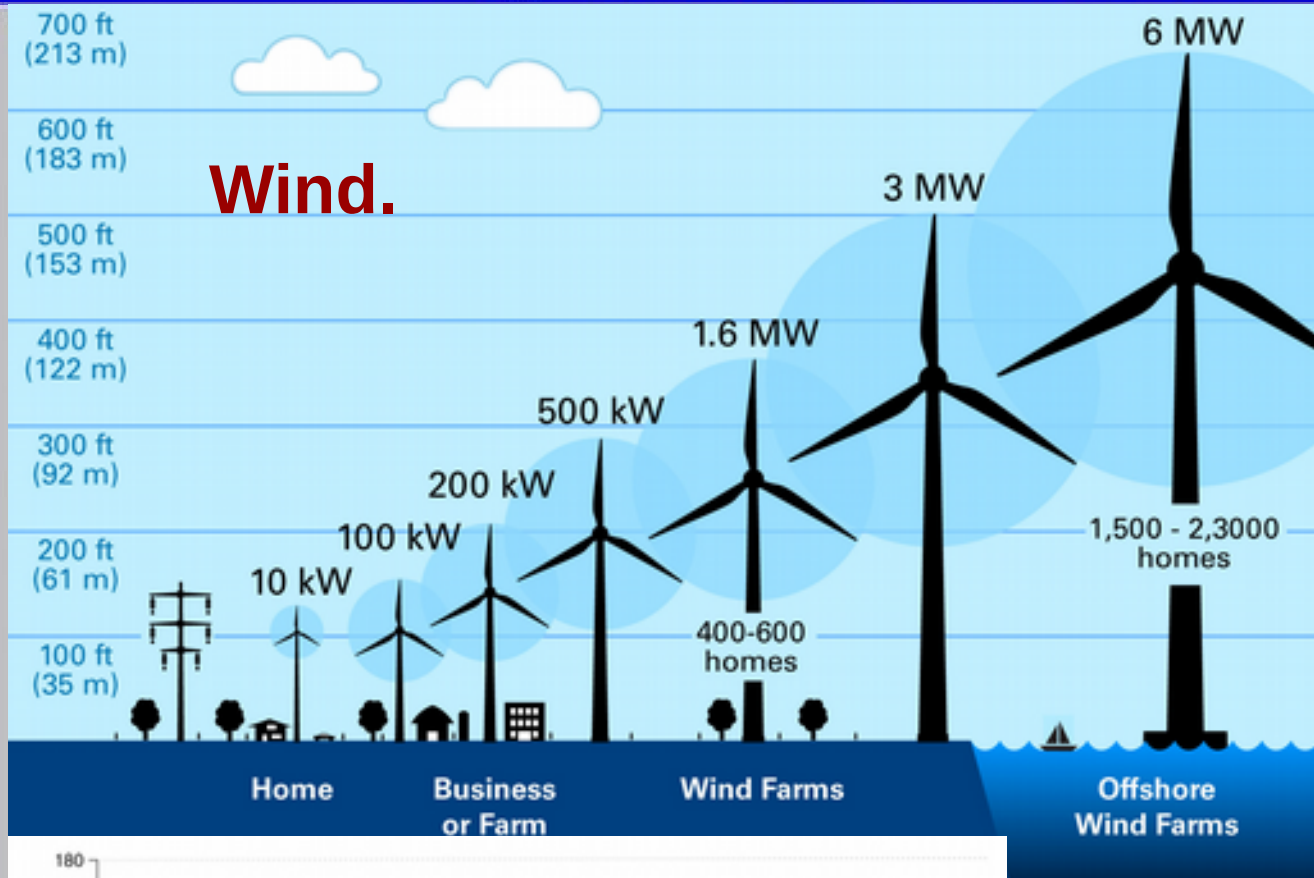
Link: https://en.wikipedia.org/wiki/Solar_power_by_country

Top 10 countries in 2016 based on total PV installed capacity (MW)^[3]



Subject # S01: Solar Basics UEENEEK125A

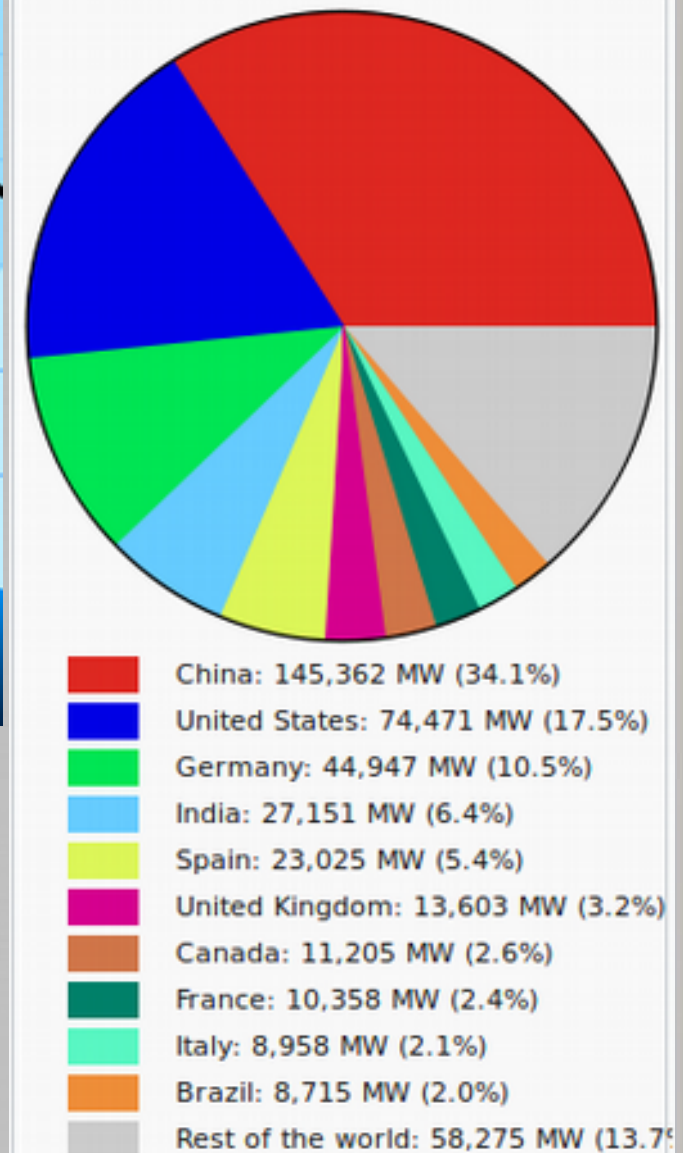
Wind.



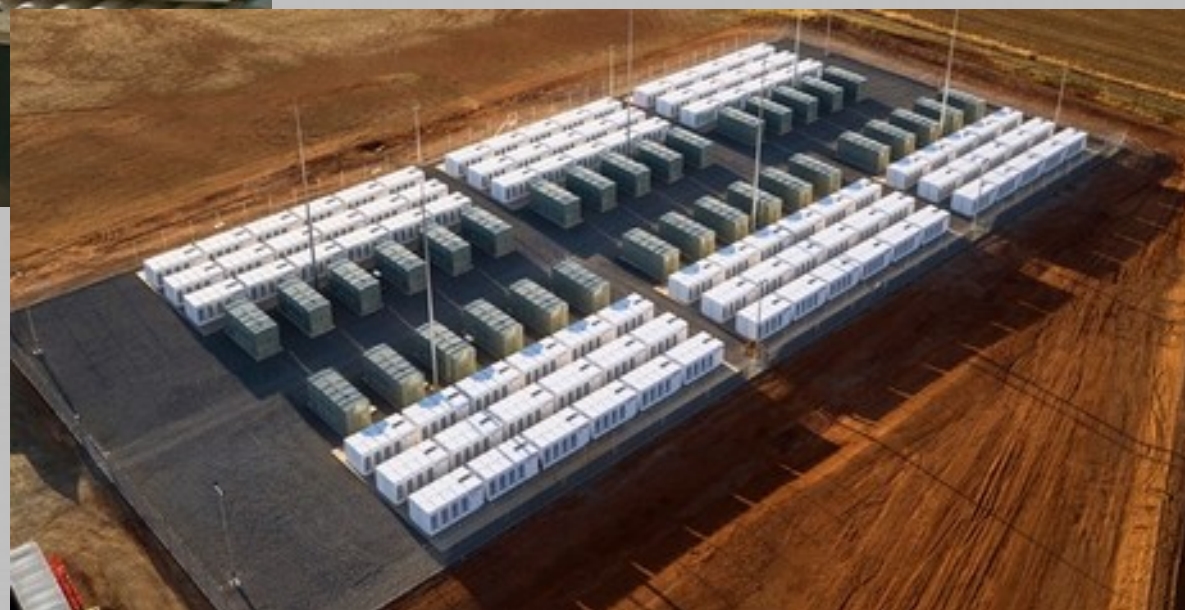
Link:

https://en.wikipedia.org/wiki/Wind_power_by_country

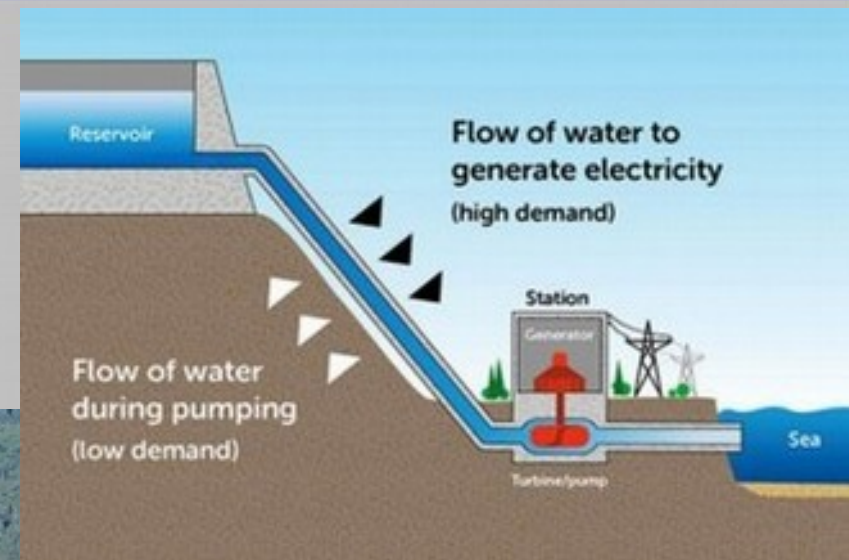
Installed capacity by country in 2015 (MW)^[3]



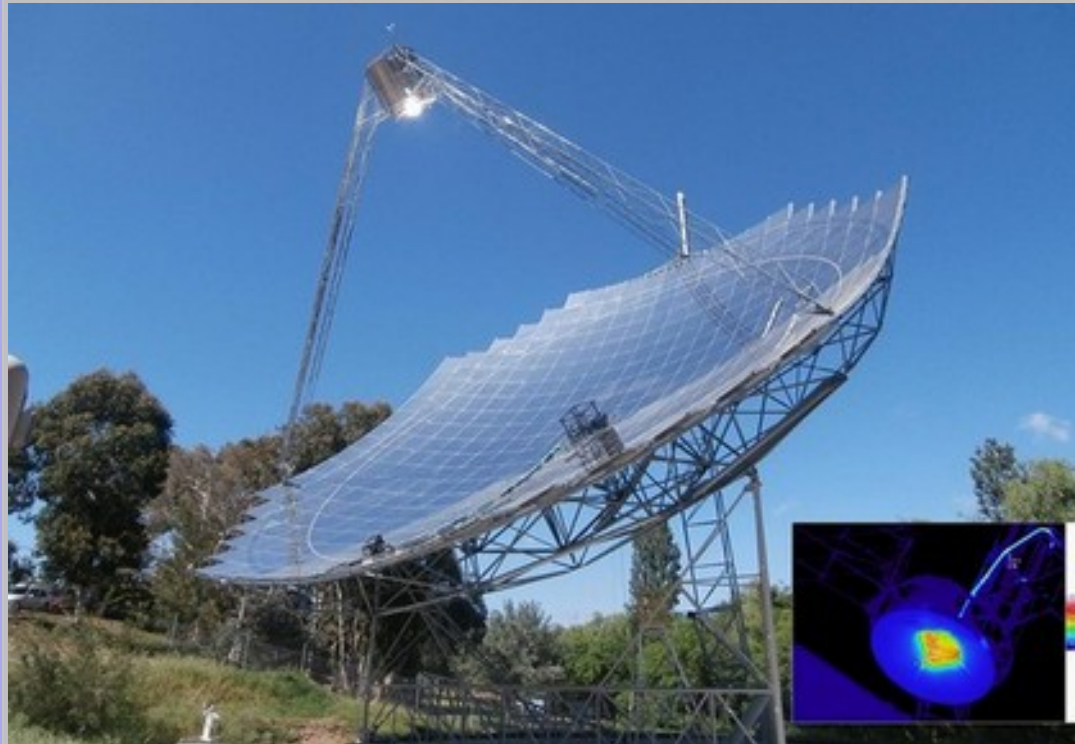
Batteries.



Pumped hydro.



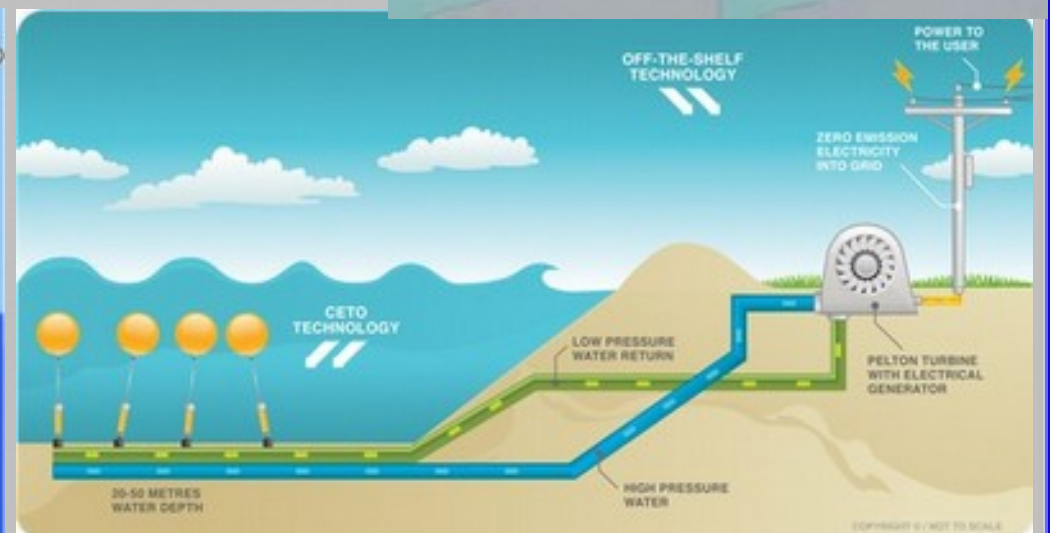
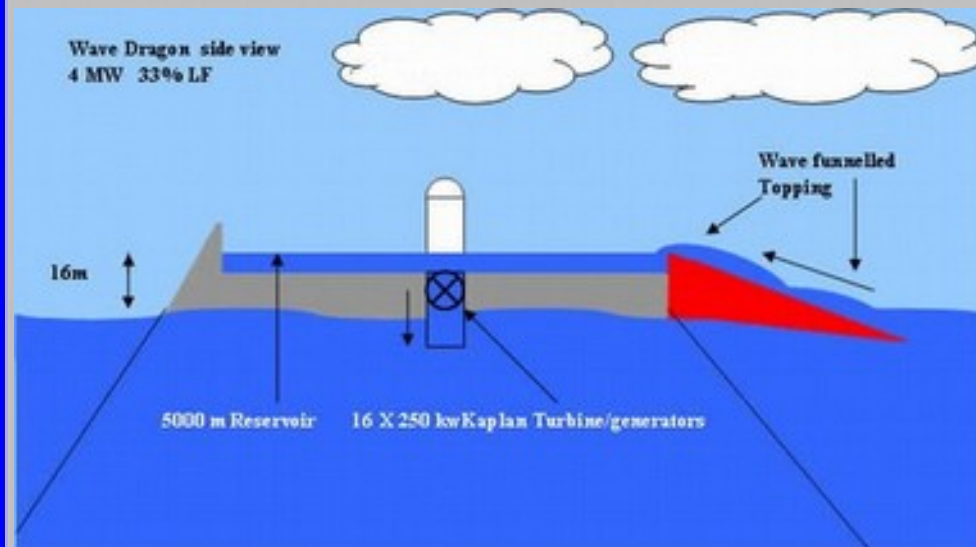
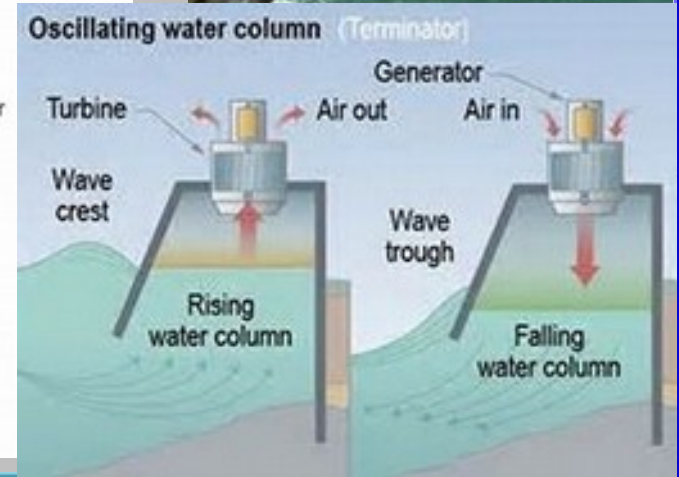
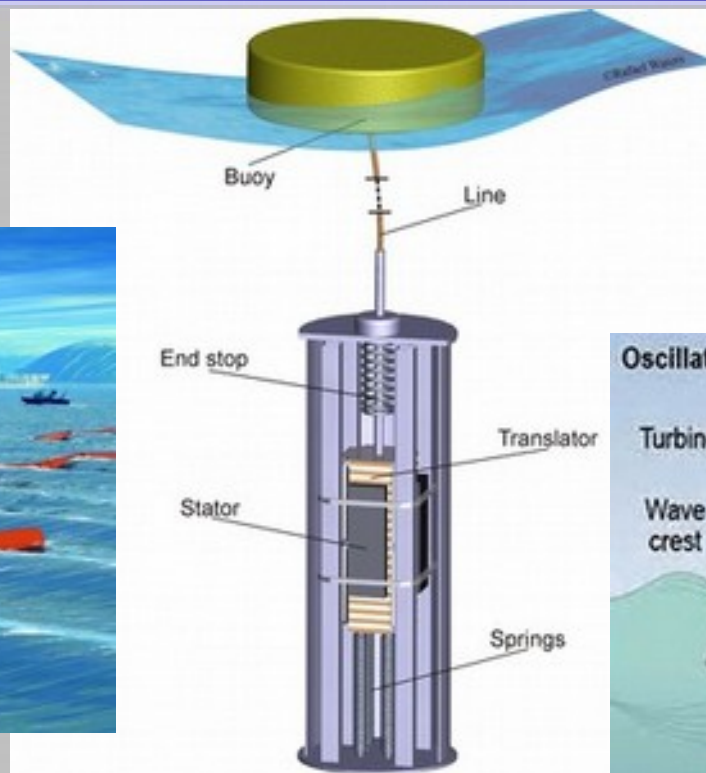
Solar Thermal.



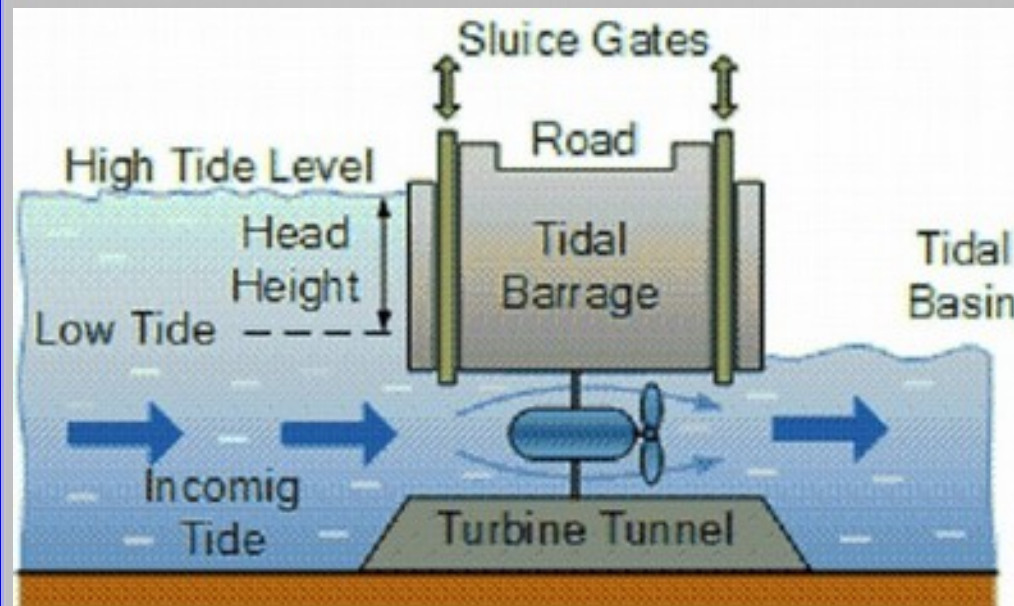
2016 World record - the team designed and built a new receiver for the solar concentrator dish at ANU, halving losses and achieving a 97 per cent conversion of sunlight into steam.



Wave.



Tidal.

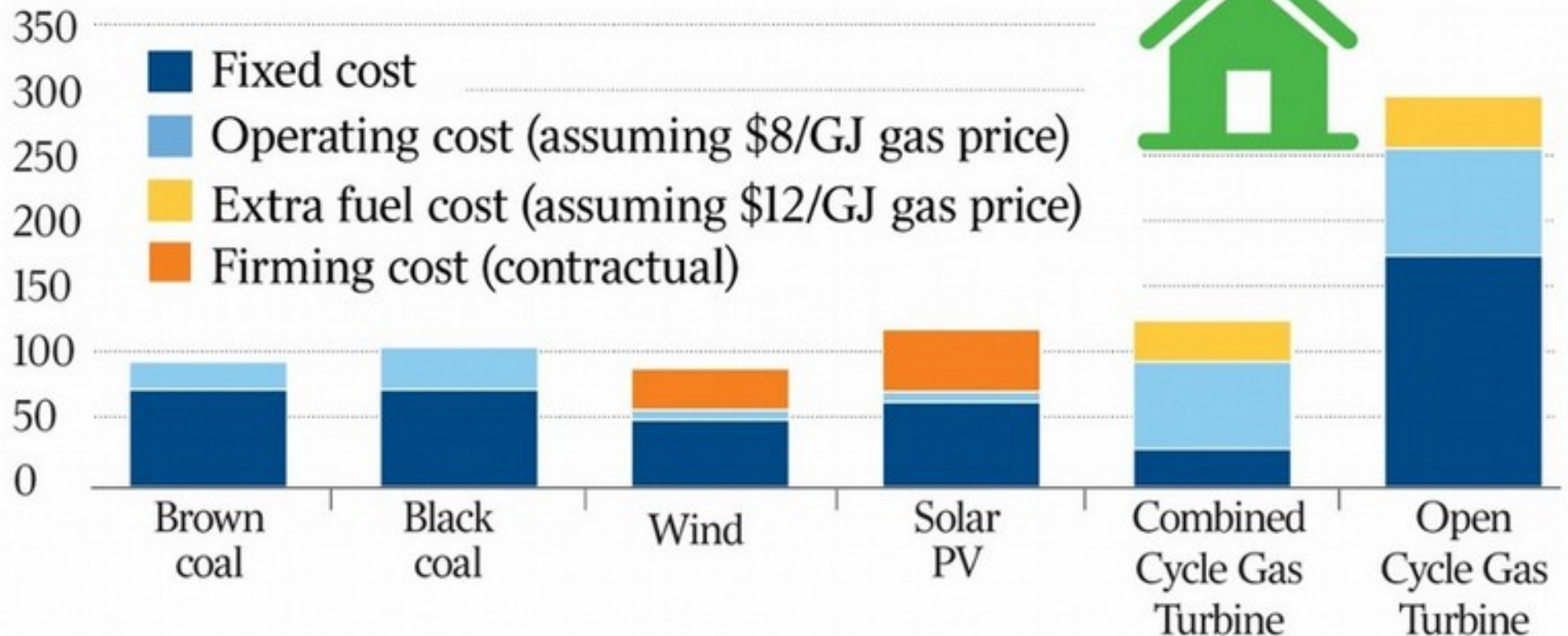


When in doubt, follow the \$.

PRICE COMPARISON

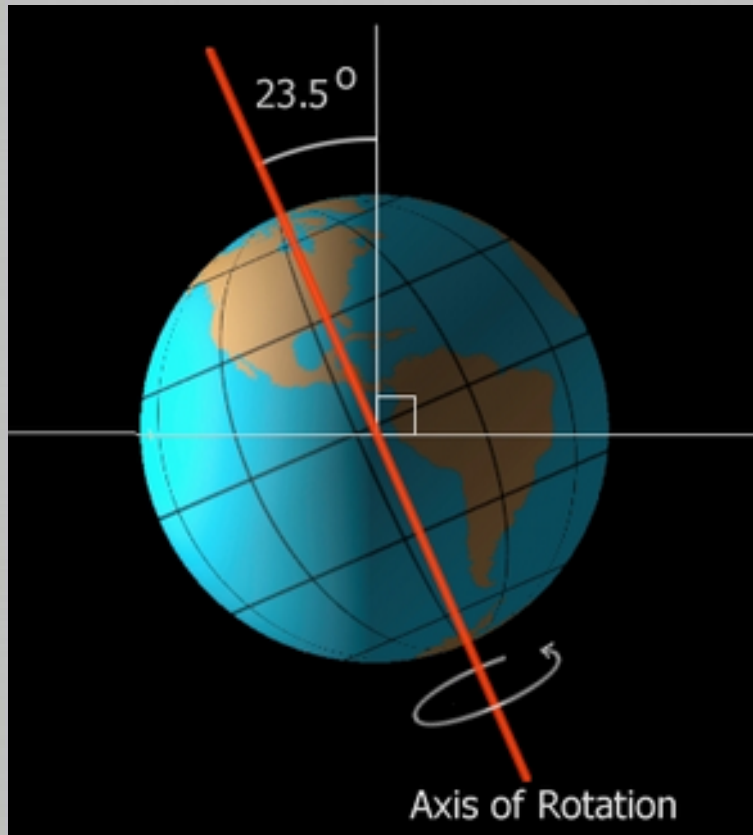
Combined costs of new electricity generation

\$/MWh



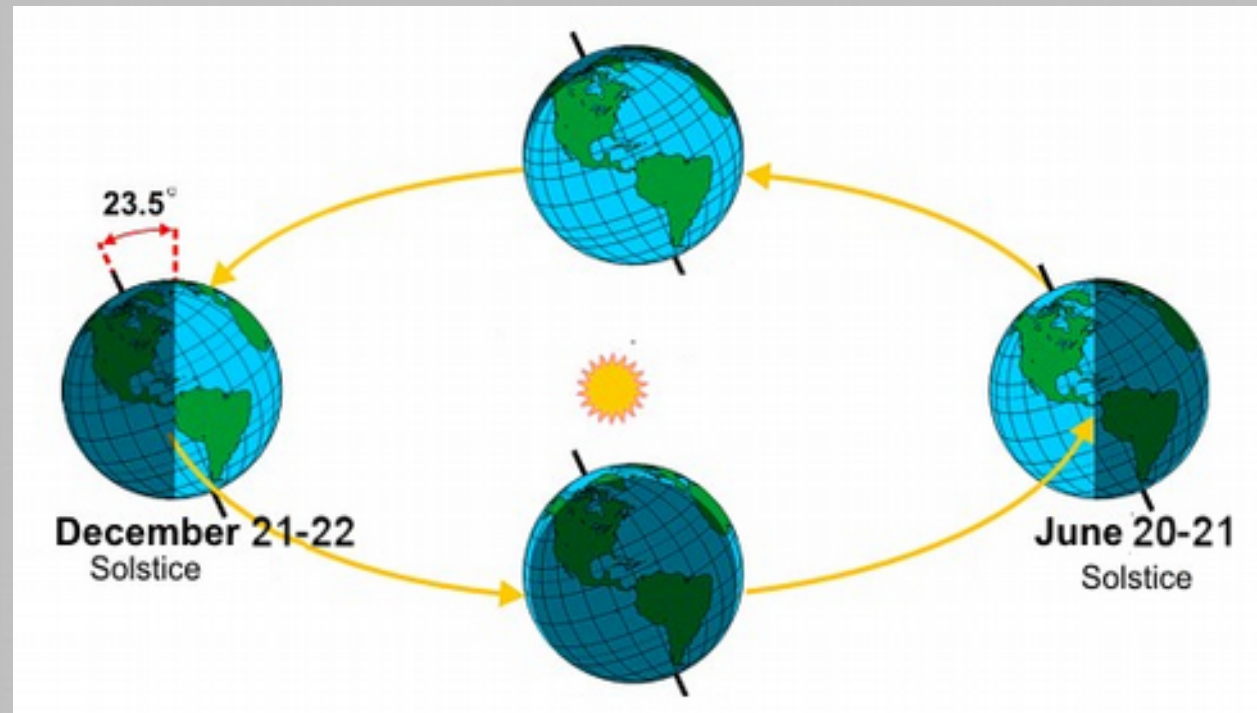
Source: Finkel report

The Earth rotates on an axis tilted (about 24°) from the vertical. This causes the seasons.



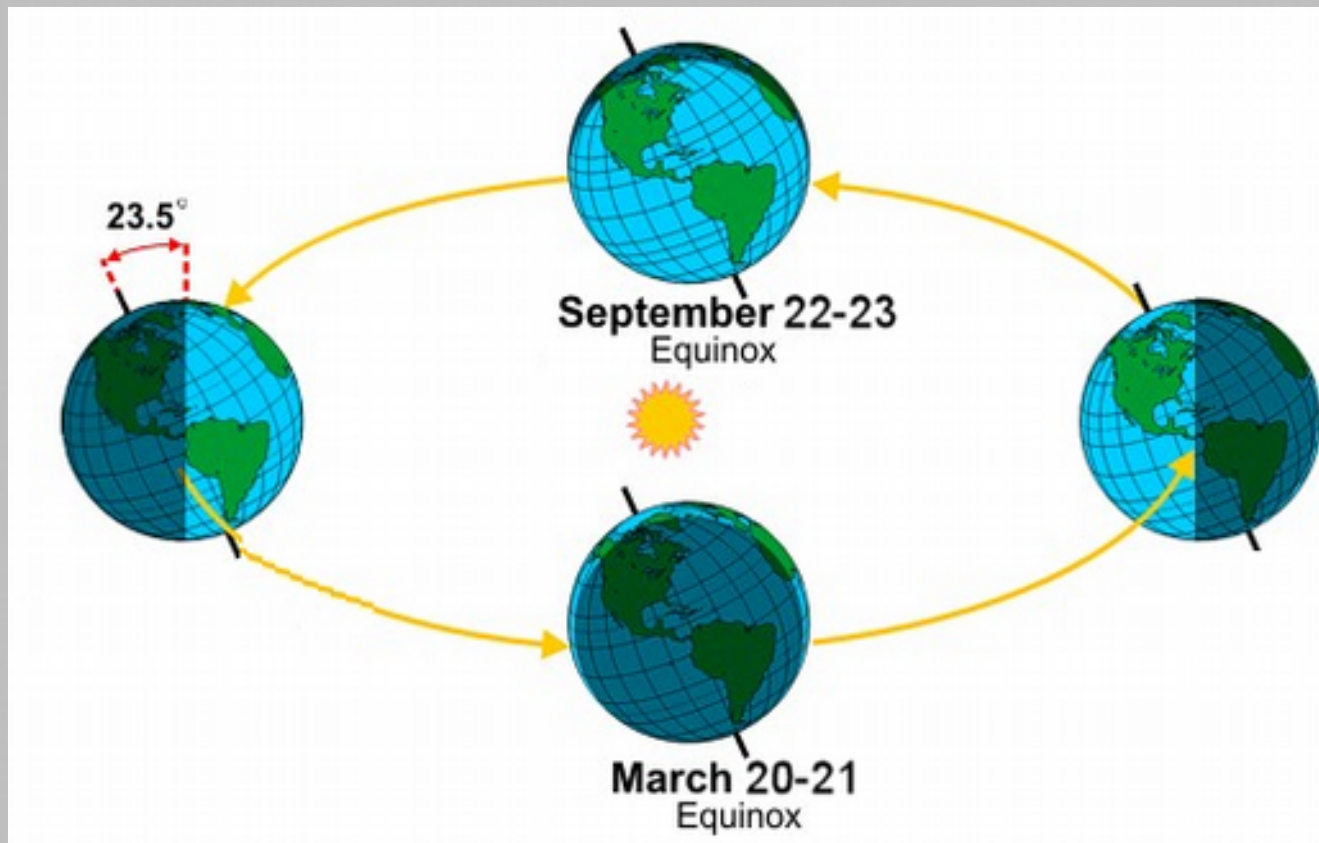
This is also called the Earth's axial tilt angle.

The summer solstice is the date, when the hours of sunlight are the greatest. Winter solstice is the shortest day of the year, ie least sunlight.



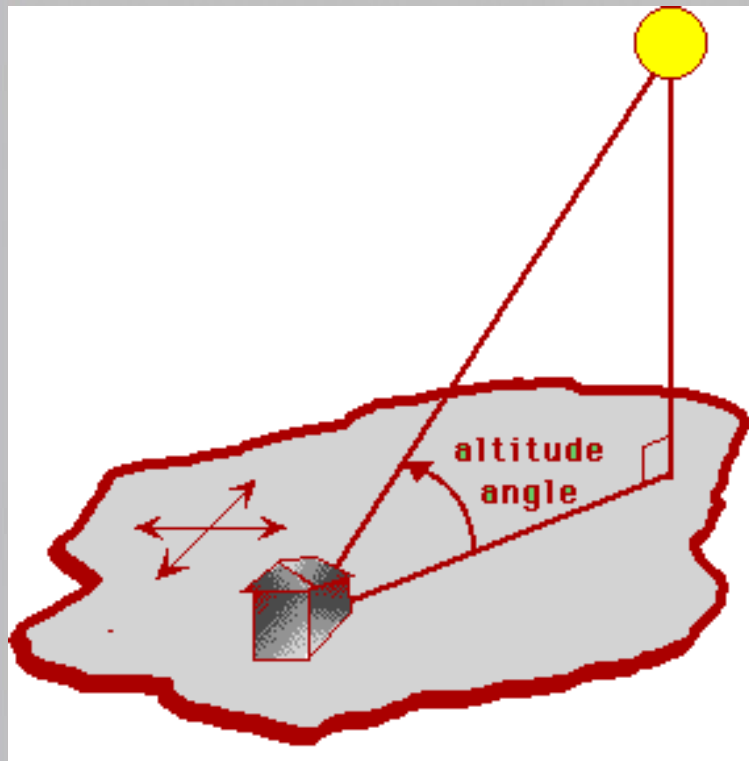
In Canberra Dec 21 or 22 is the longest day and June 20 or 21 the shortest.

The equinox is the date, (twice per year, ie six months apart) when the hours of sunlight equals the hours of darkness.

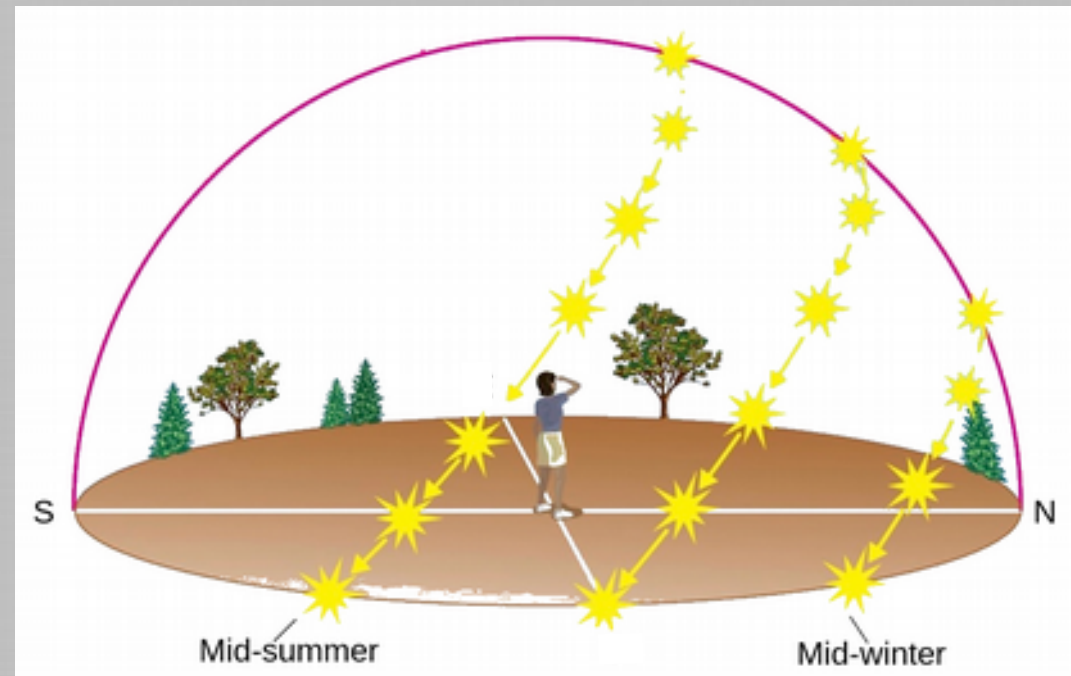


In Canberra, March 20-21 and September 22-23.

The Sun's altitude is the angle between the ground and the Sun's position in the sky.

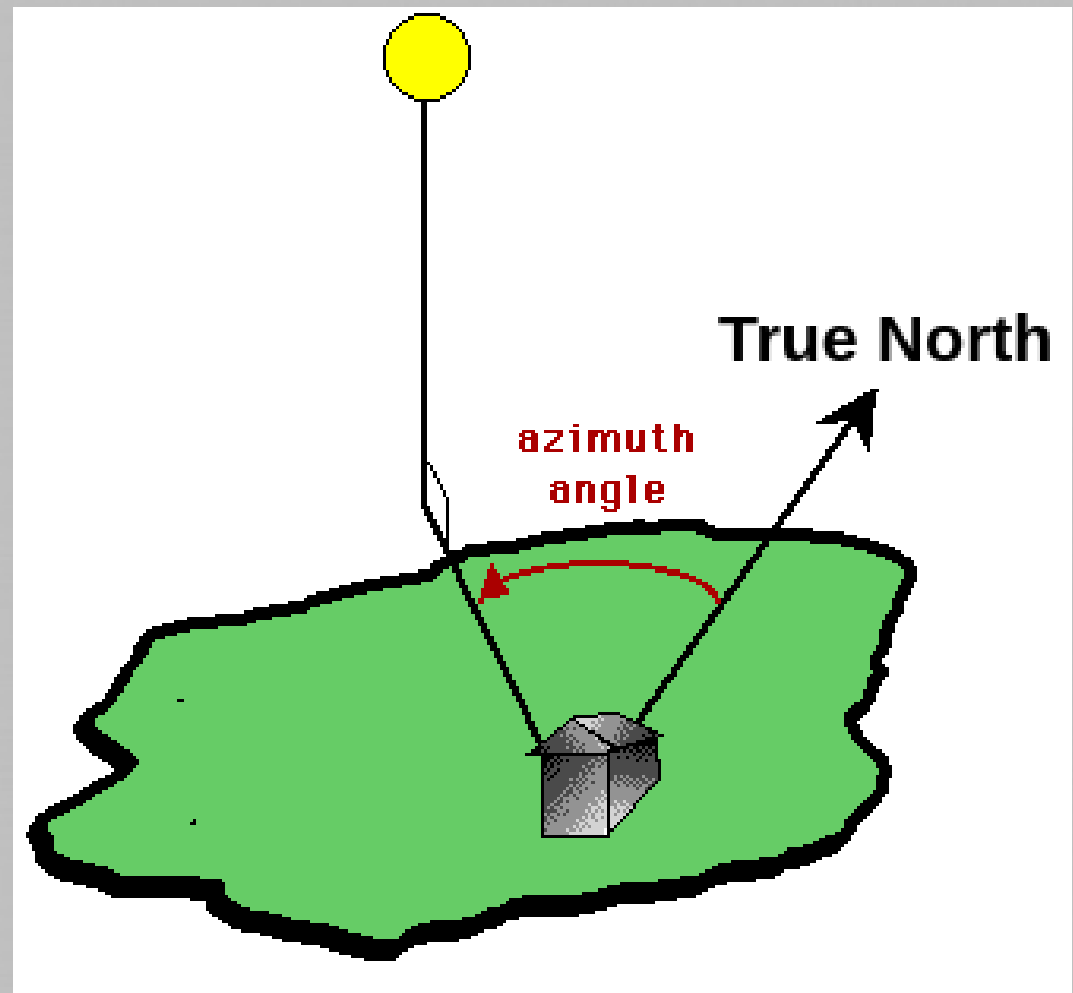


The seasons cause these angles to vary and thus the amount of sunlight falling on a fixed PV cell.



Azimuth is an angular difference between the Sun's direction and True North.

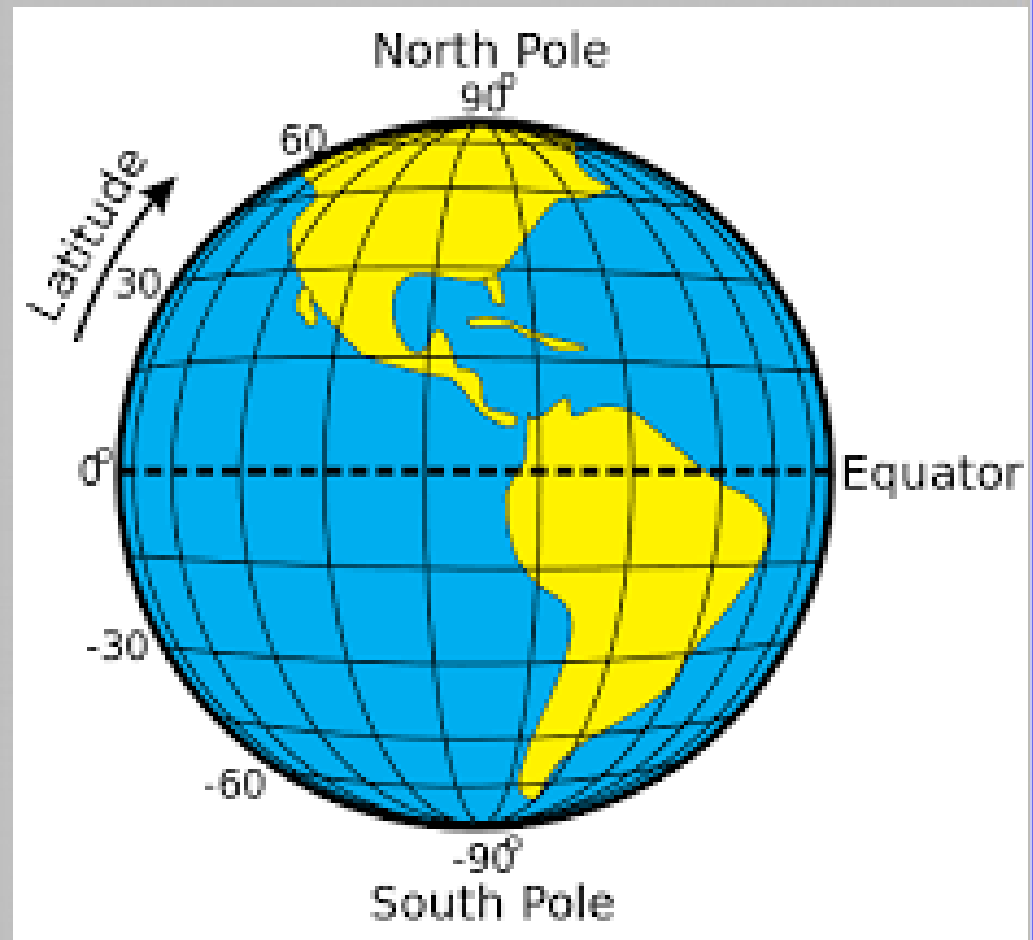
This angle is 0° at noon and about 90° at sunrise or sunset.



Latitude is the angular measure of our location above or below the equator (equator = 0° and poles = 90°).

Canberra has a latitude of 35° South (sometimes shown as -35°)

Latitude and panel tilt are DIRECTLY linked.



The angle of the solar panels (compared to the horizontal (= 0°) is the Tilt angle.



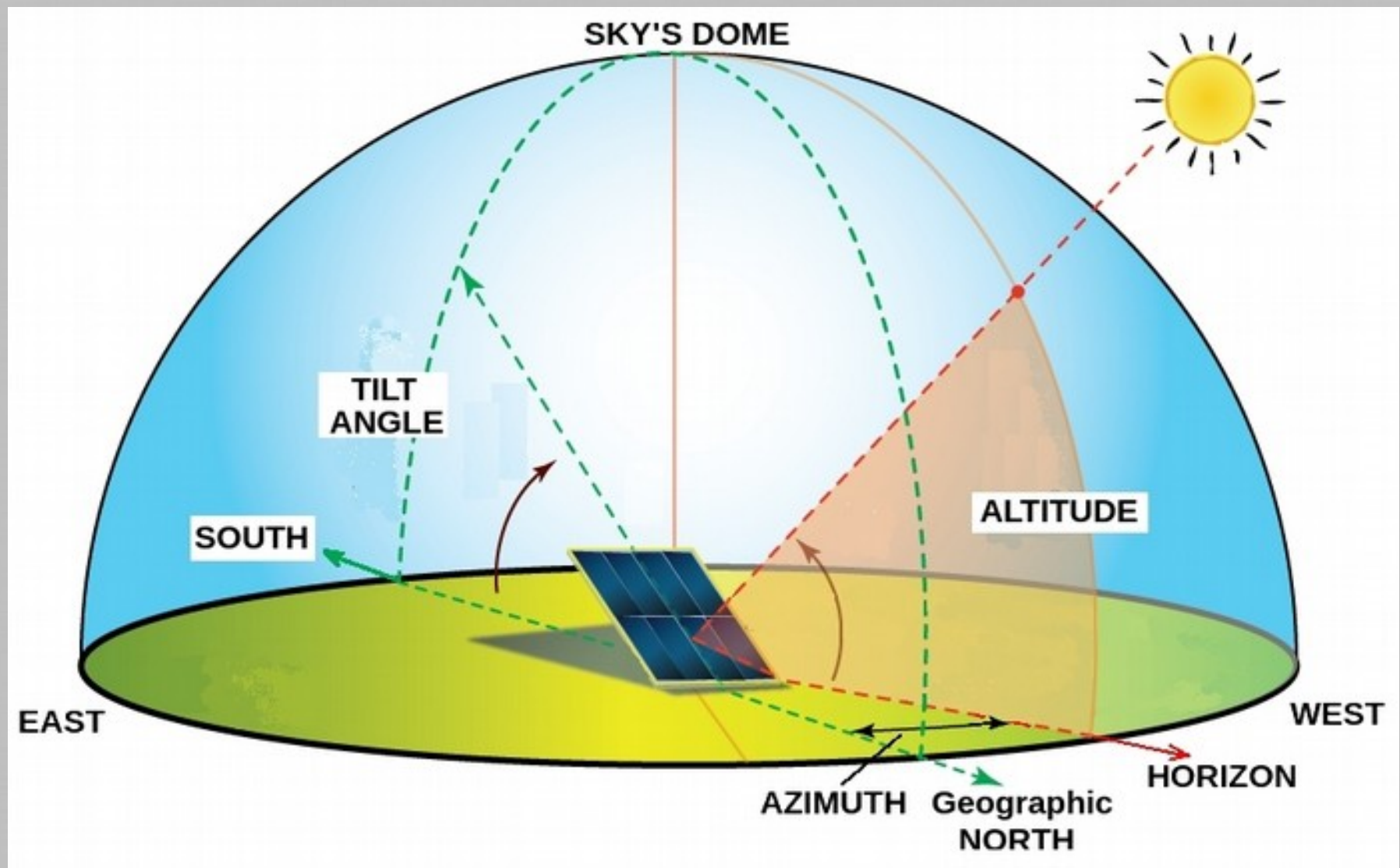
Tilt angle



Tilt angle

(Not a good tilt frame set up)

Tilt angle = latitude



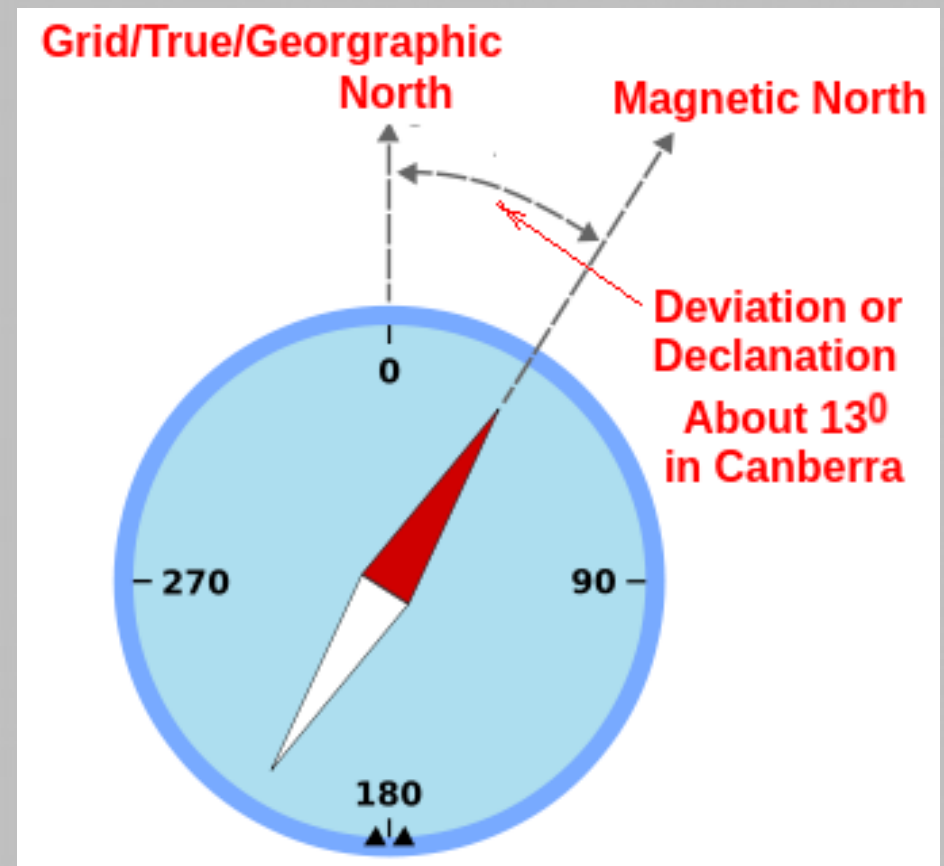
Subject # S01: Solar Basics UEENEEK125A



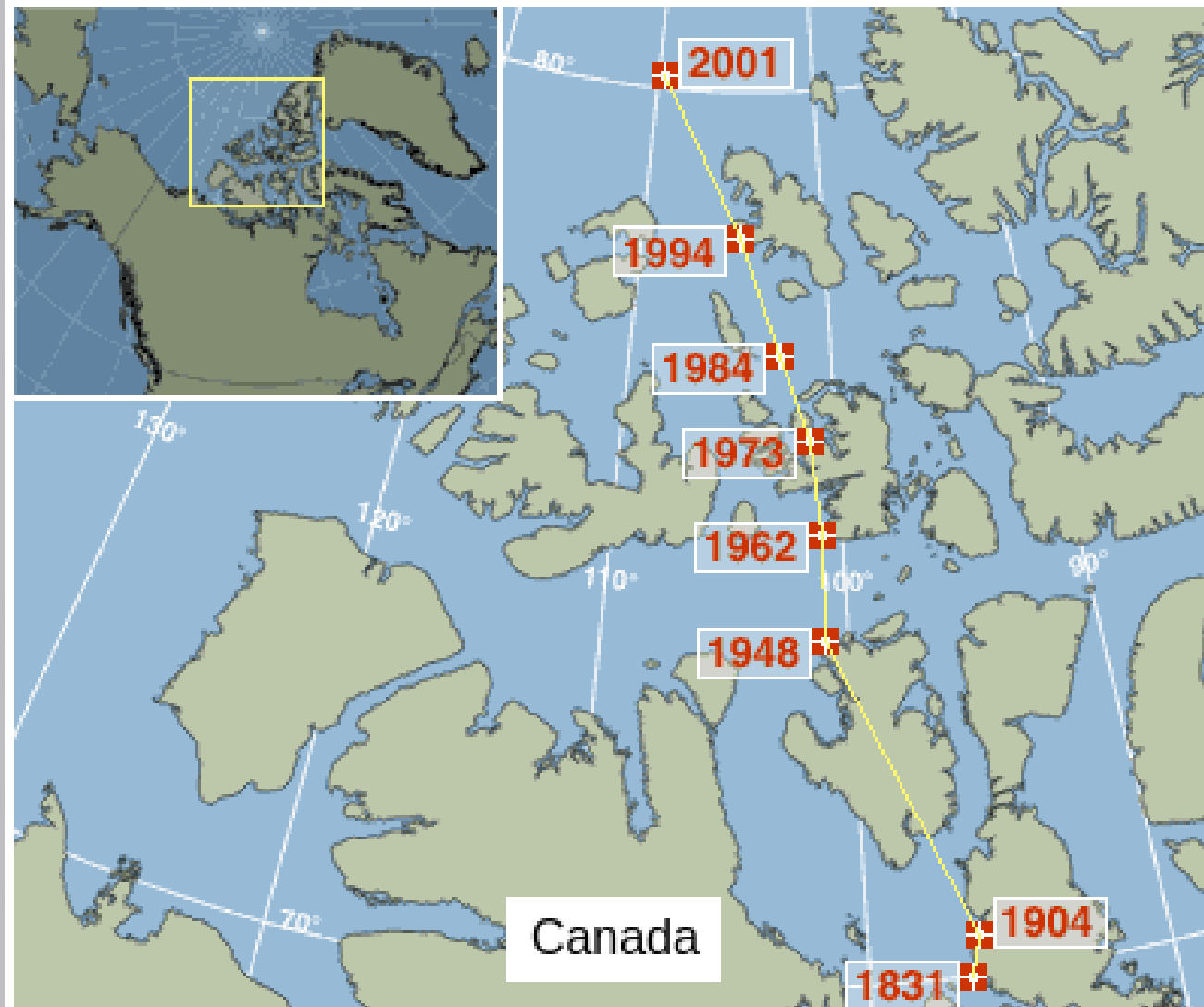
Declination has two general meanings;

- 1. the difference between the direction of true (geographic) North and magnetic North.**

Also called the magnetic deviation.



The direction of the Magnetic North pole changes each year.



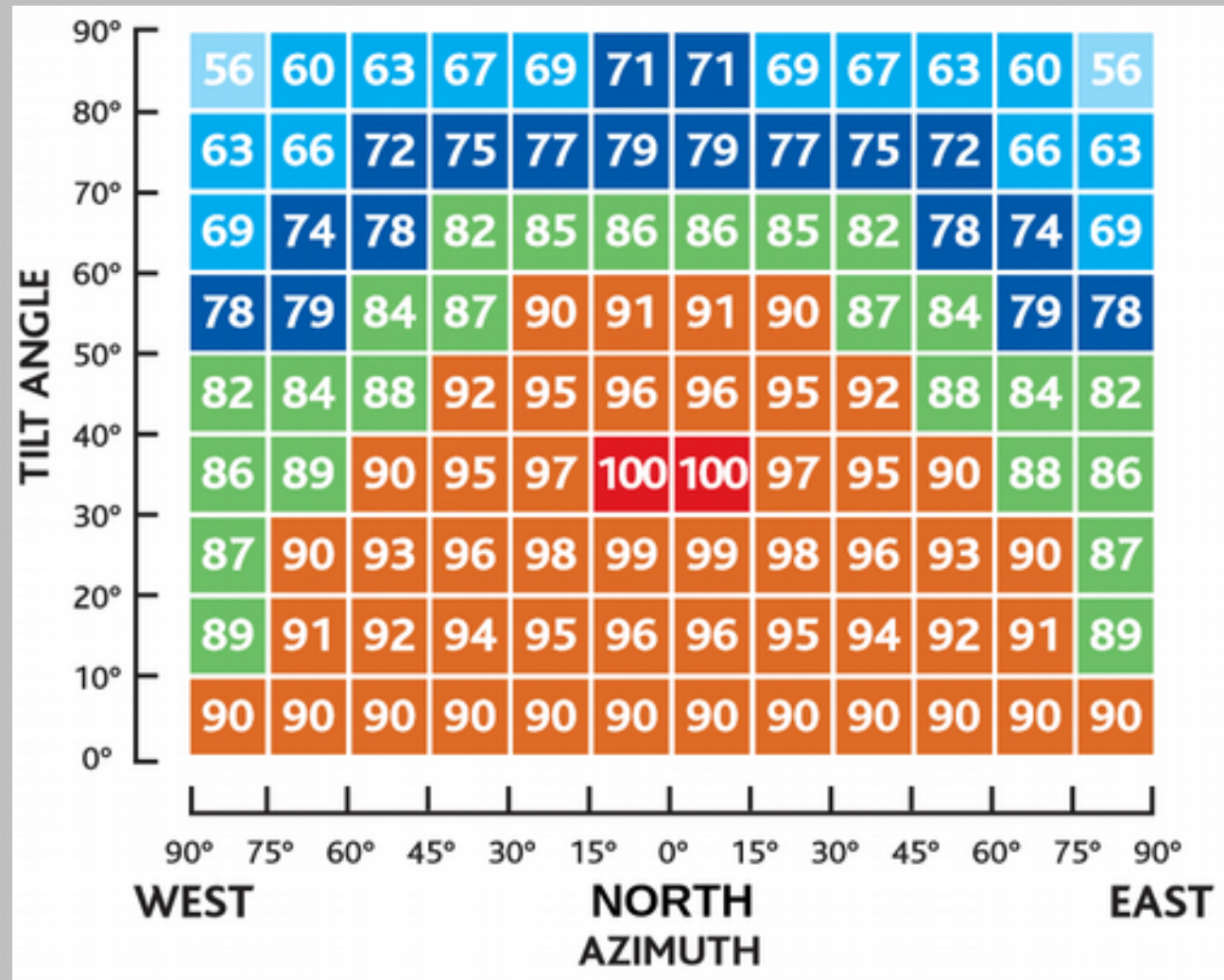
Wandering Pole

■ Position of North Magnetic Pole by year

While the North Magnetic Pole often skips around many miles each day in an oval loop, on average it migrates from 6 to 25 miles (10 to 40 km) each year to the north/northwest. The points on the map of the Canadian Arctic depict where explorers have plotted the migrating pole for almost two centuries, including Norwegian Roald Amundsen in 1904.

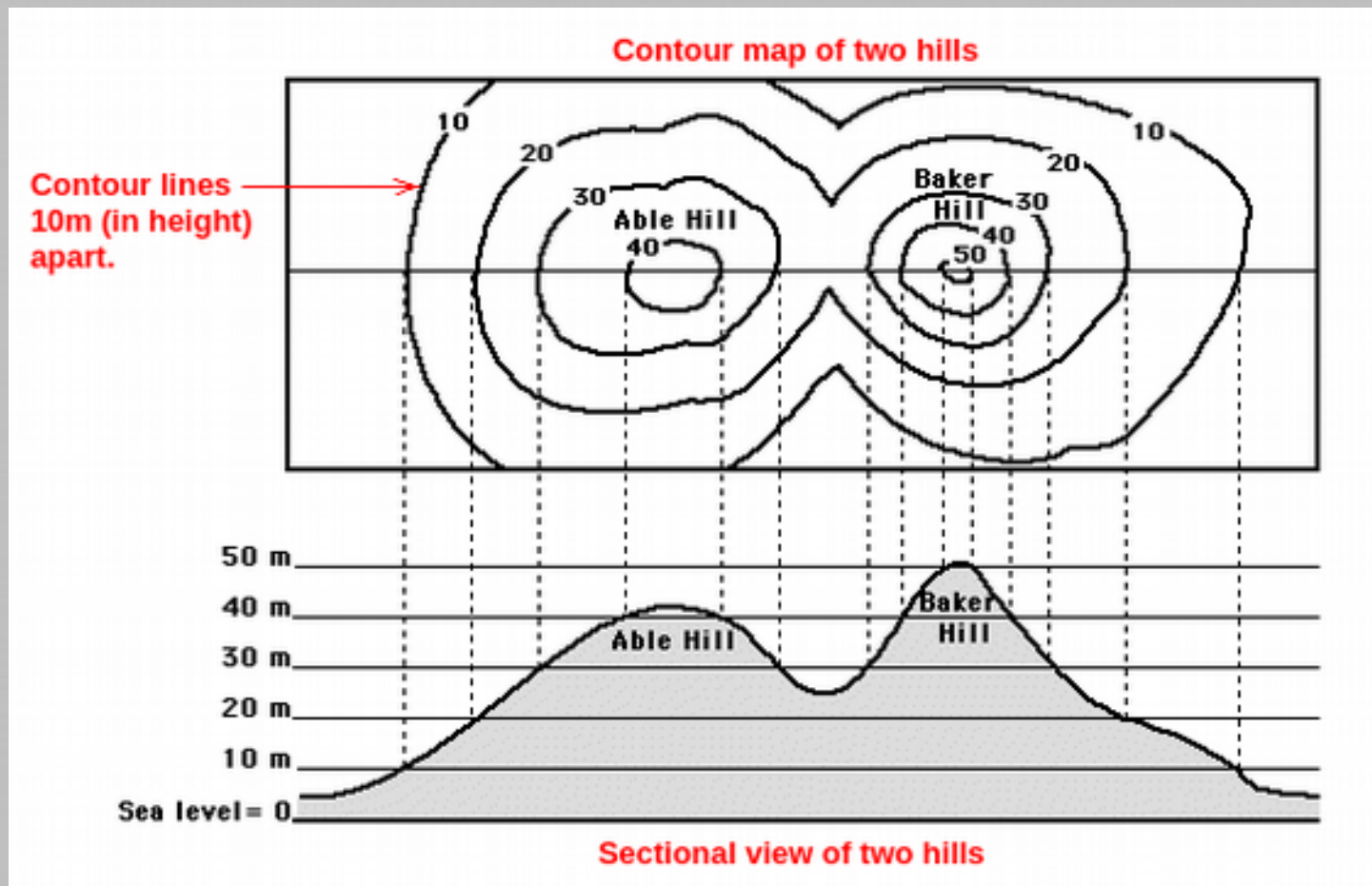
Roofs in Canberra are (usually) at 22.5° slope, fine for direct panel mounting.

Optimised Gain table for 35° latitude and up to approx. 50km North or South latitude.

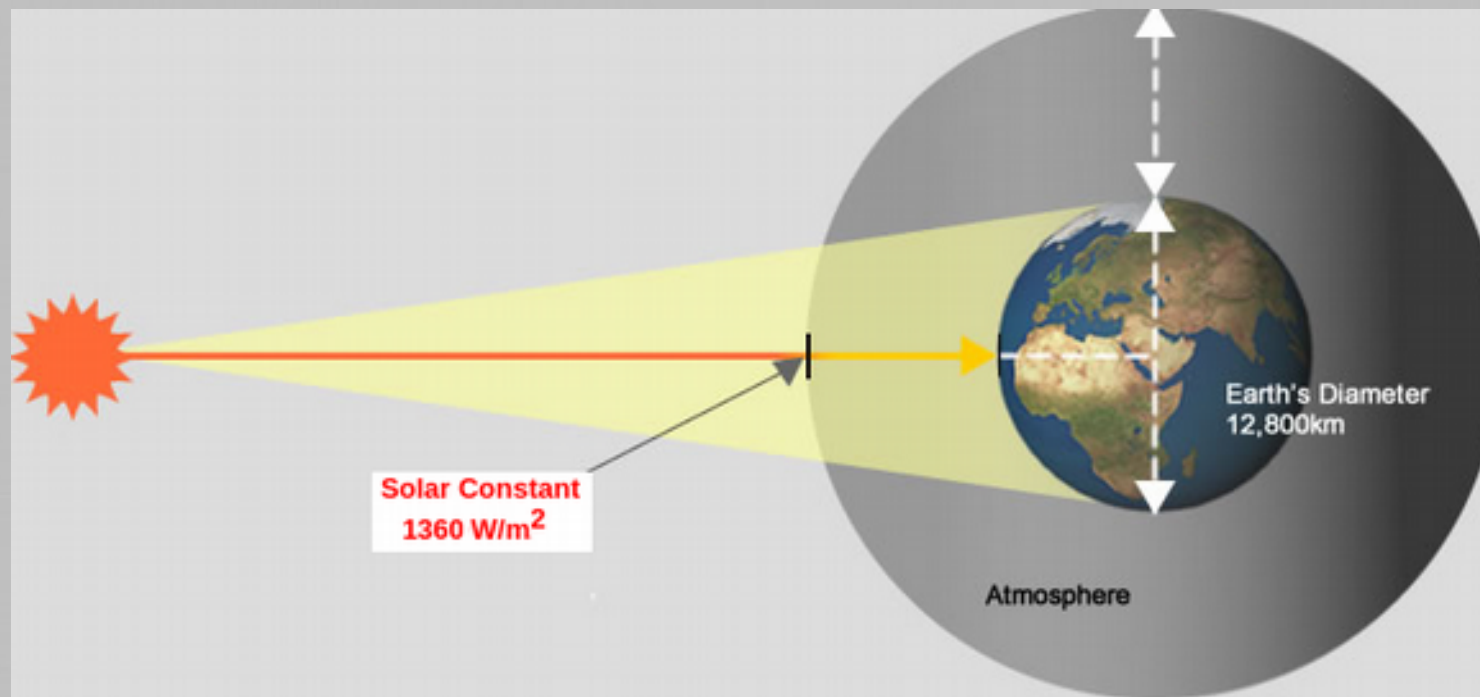




The Earth's surface is NOT flat. A map showing the changes in the land's height is called a (geographic) contour map.



Extraterrestrial irradiance is the intensity of the Sun's power at the outer edge of the Earth's atmosphere.

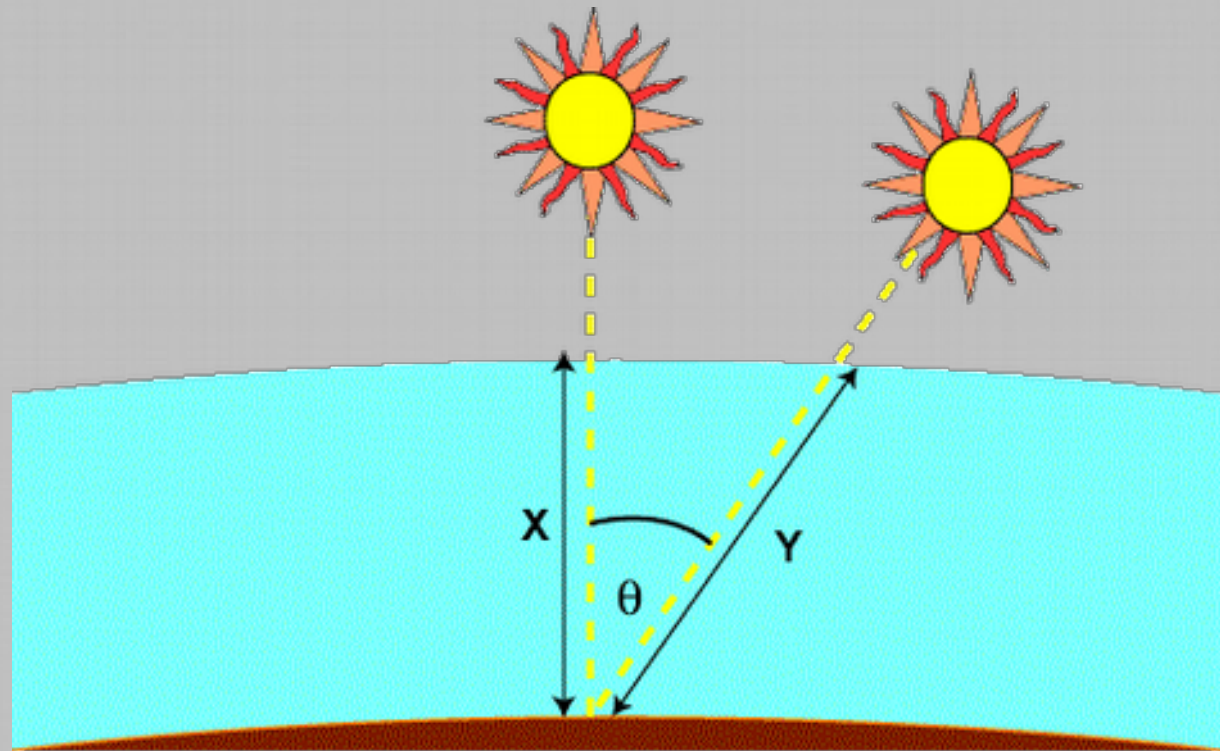


Called the Solar Constant = 1360 W/m²

(The Earth's surface gets less - about 1000 W/m² or less)

The Air Mass is the path length which light takes through the atmosphere normalised to the shortest possible path length. The Air Mass quantifies the reduction in the power of light as it passes through the atmosphere and is absorbed by air and dust.

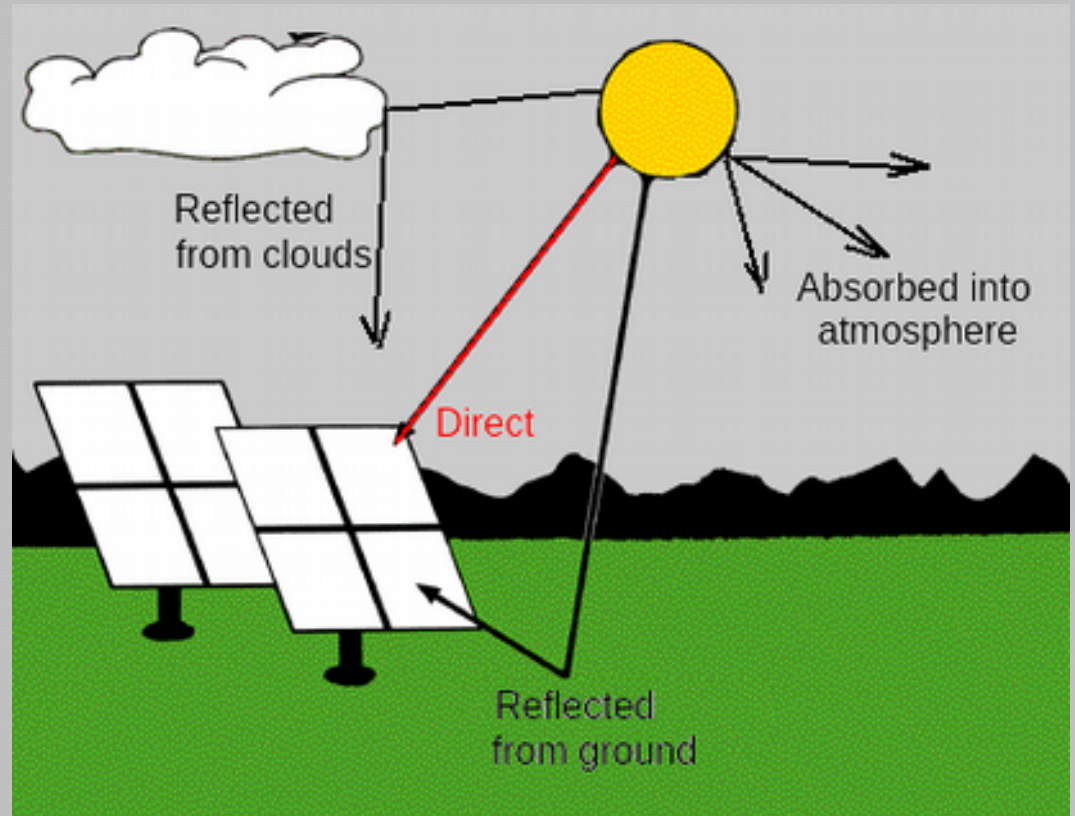
$$AM = \frac{1}{\cos(\theta)}$$



Direct radiation shines directly from the Sun.

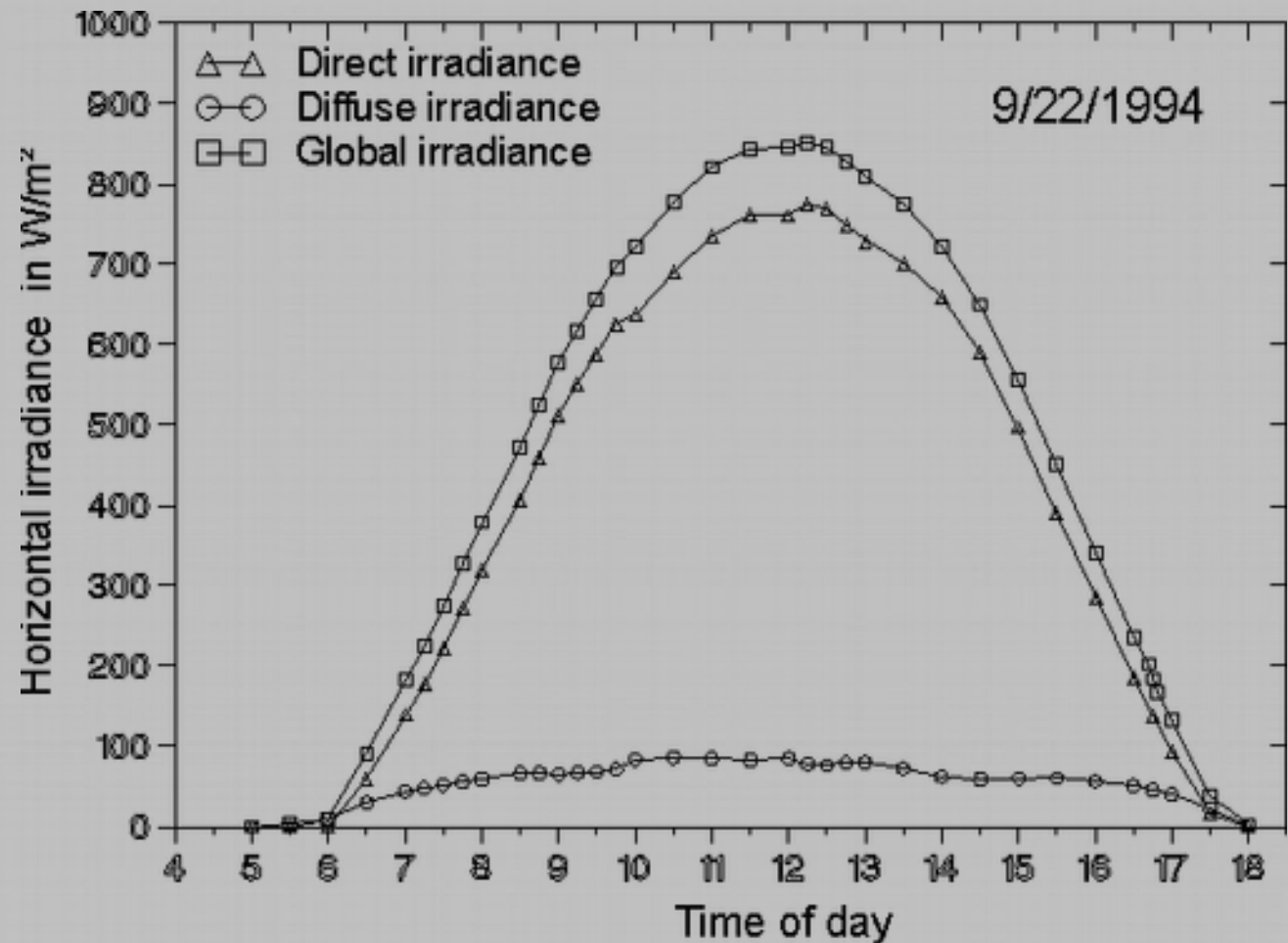
Diffuse radiation is atmosphere scattered sunlight.

Reflected radiation comes from the reflections due to buildings, ground, water, etc.



Irradiance is a measure of the intensity of the sunlight. [unit: W/m^2]

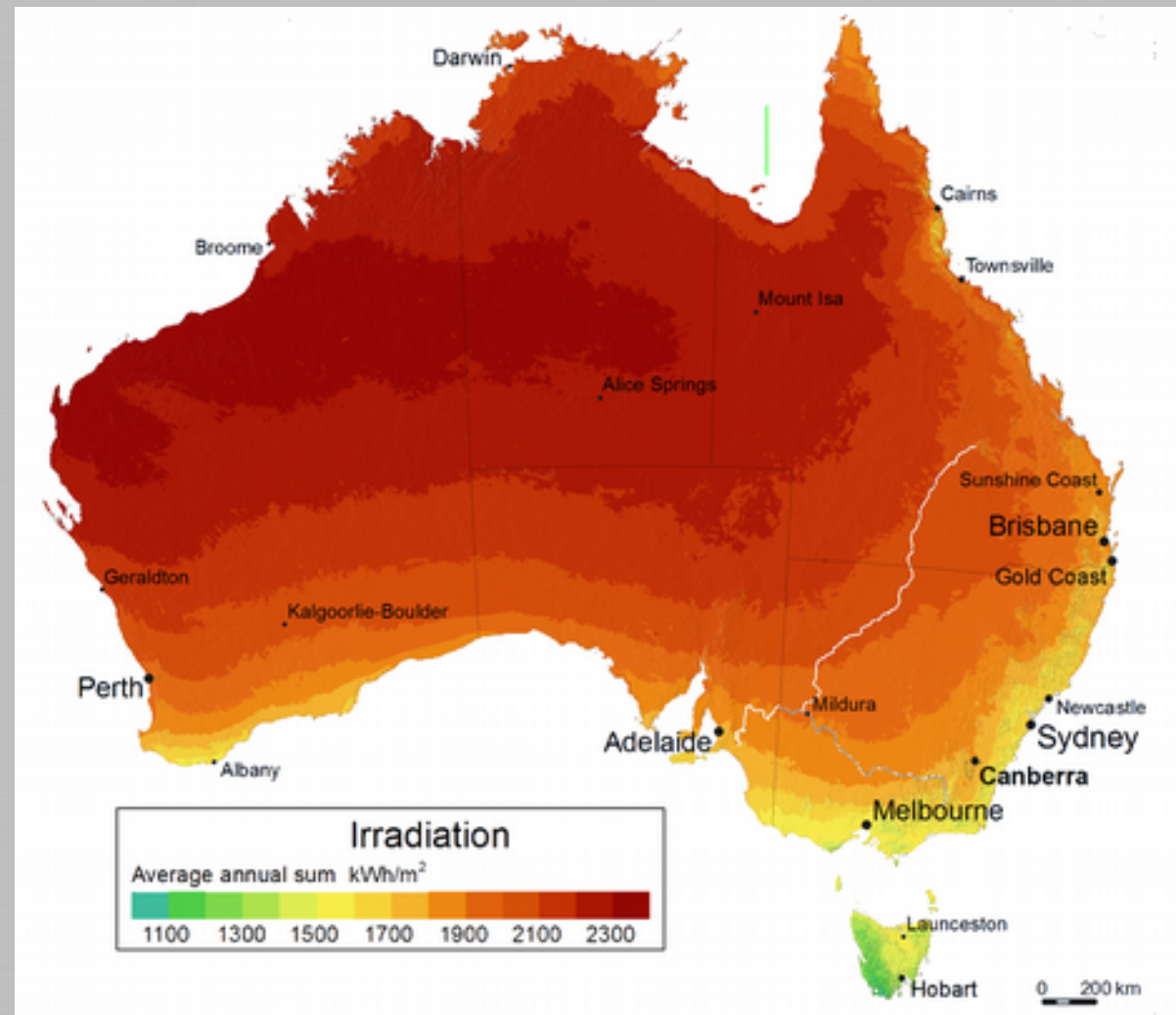
If you want to make sure that people know you are describing the strength of the sunlight on your head, right at this moment, say "irradiance".



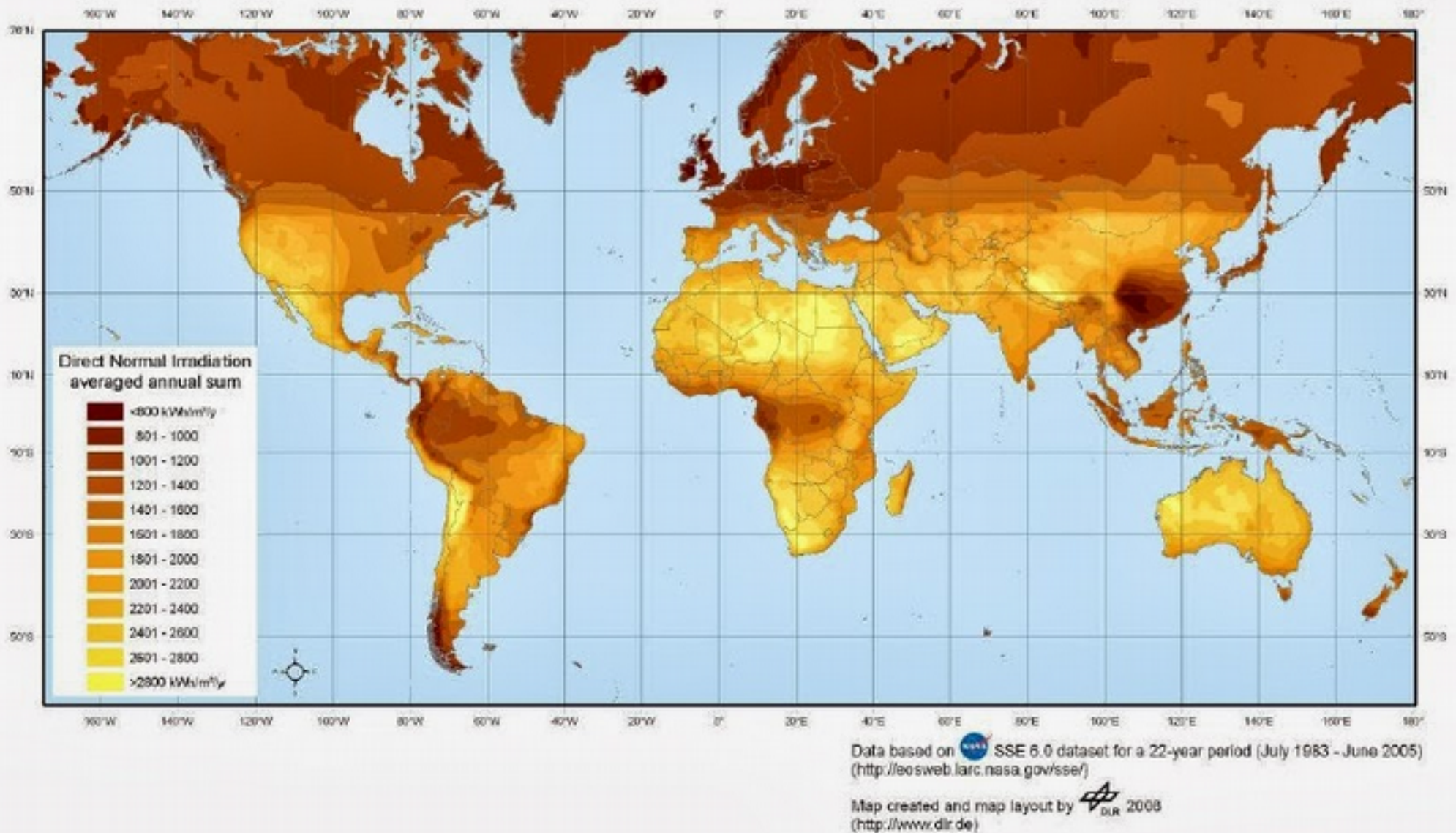
Irradiance is measured with a pyronometer in W/m^2



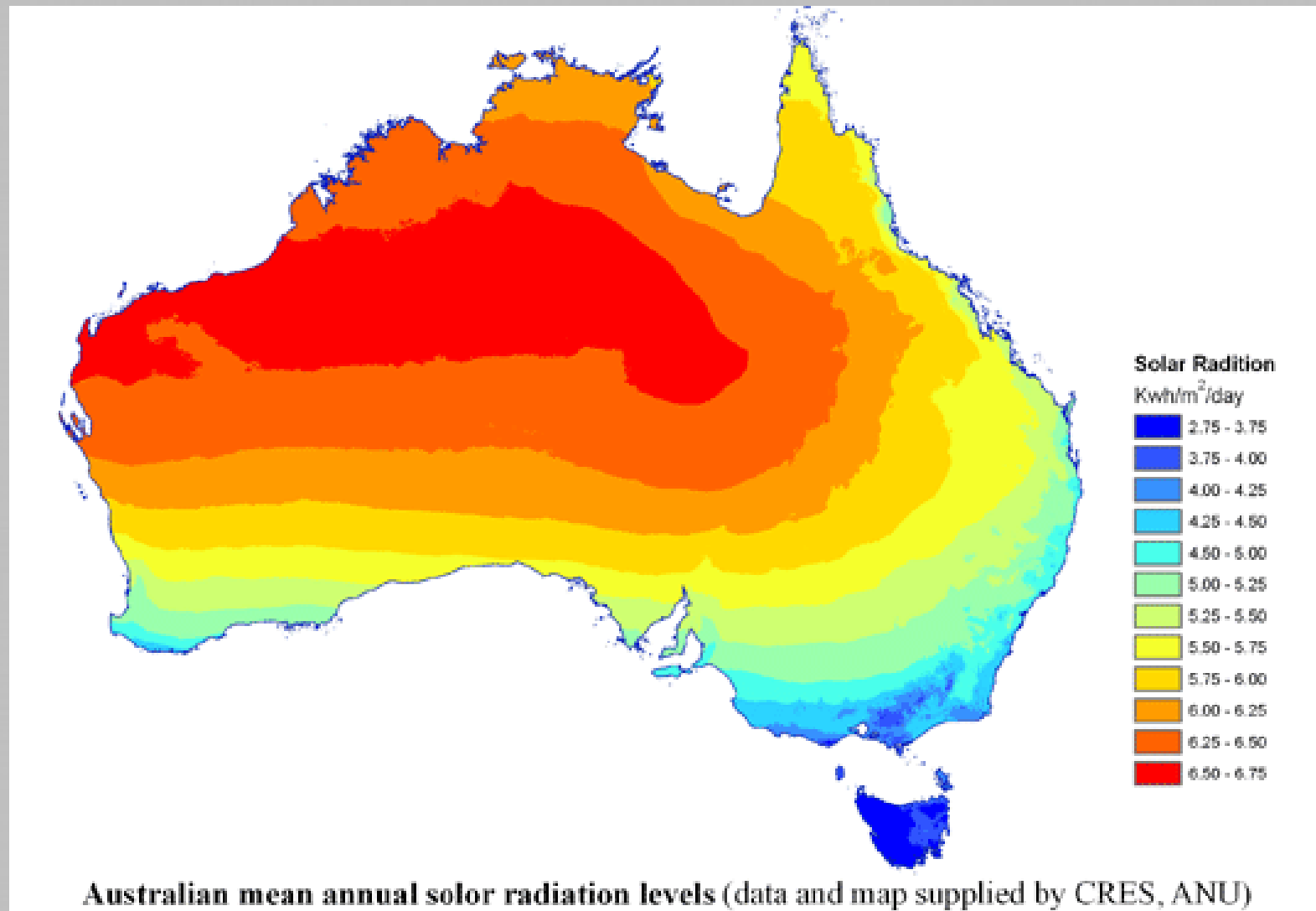
**Irradiation is a measure of the total amount of sunlight absorbed in a time period.
[unit: kWh/m²]**



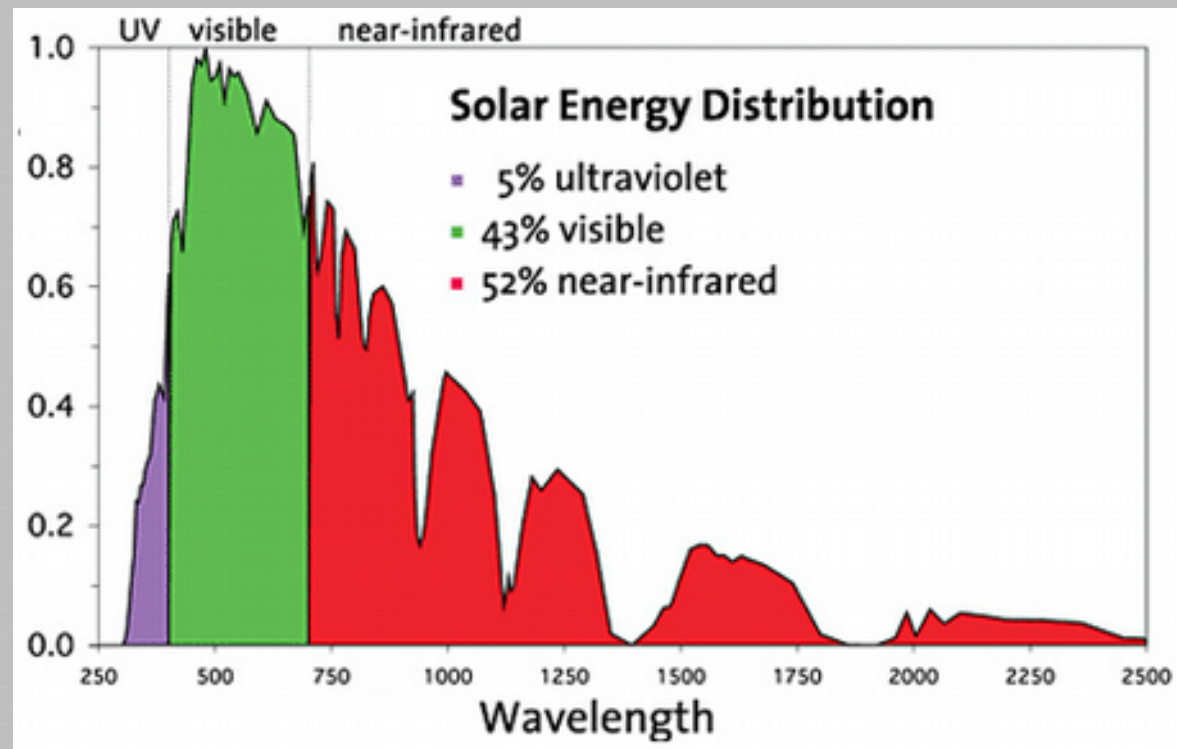
If you want to be certain everyone knows what you are talking about, ie how much total solar energy your head absorbed yesterday, say "irradiation".



When calculating energy yield we use Peak Sun Hours for the region (kW.h/m²/day)



Any hot body, gives off E.M. radiation of different types (or wavelengths). This is known as radiation.



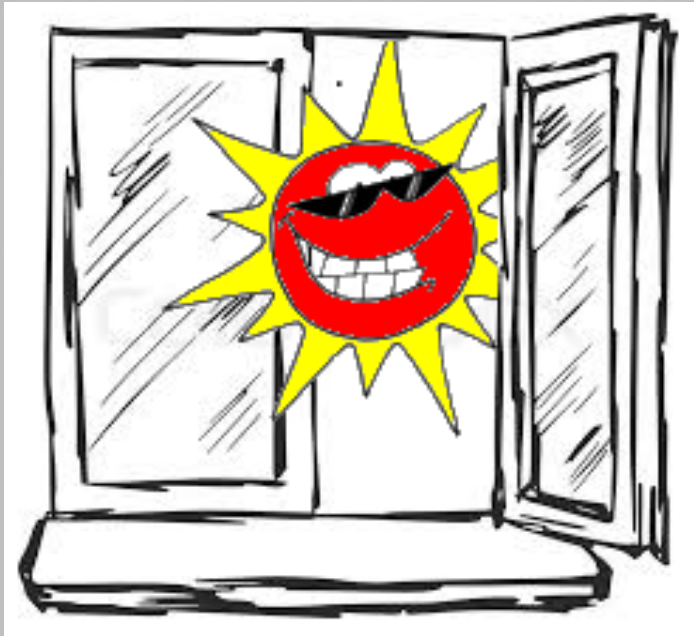
Reflectance is a property of all materials that reflect light from their surfaces.

Generally PV panels reflect less light than standard glass.

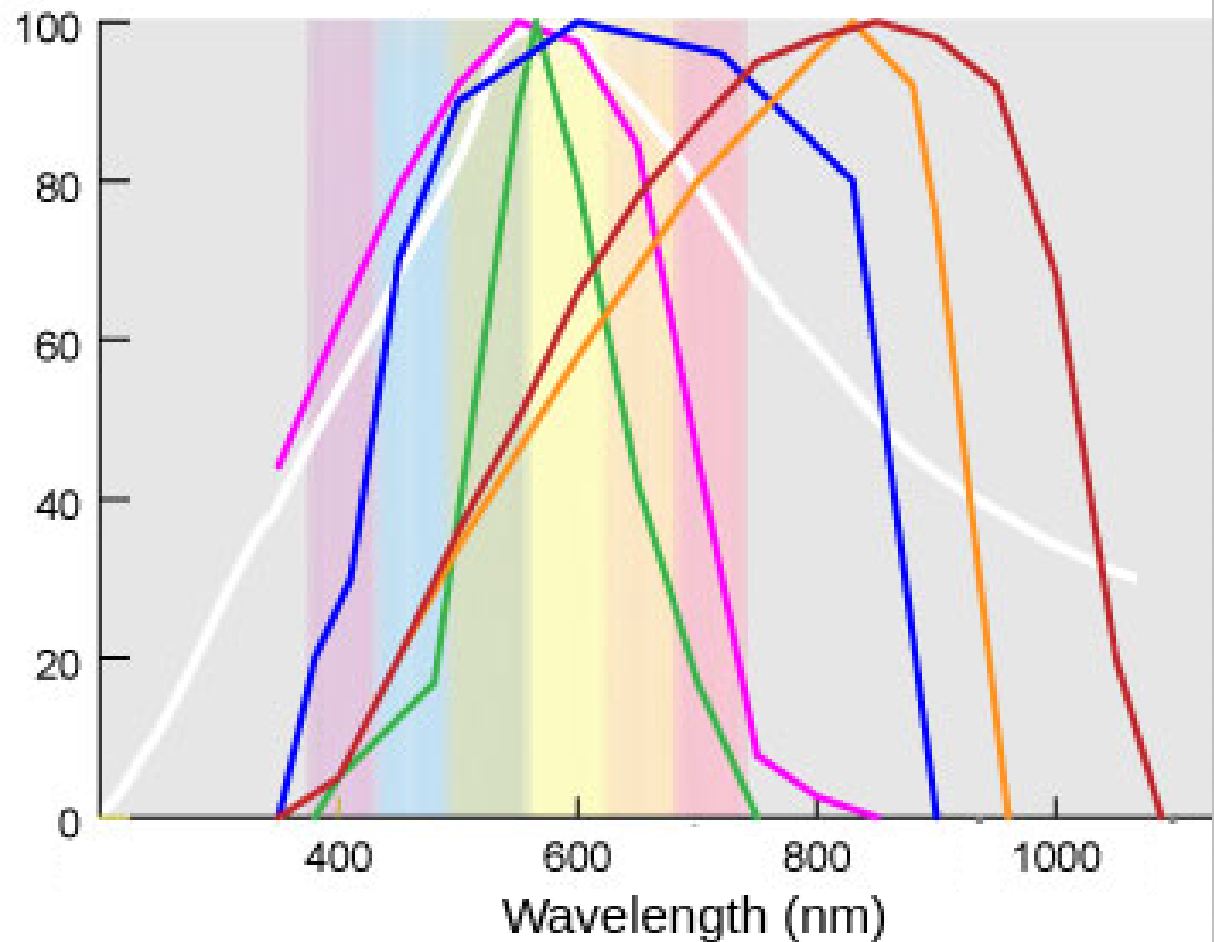


Black is the least while white is the most reflective.

The solar window is the narrow range of wavelengths, that a PV cell can use.

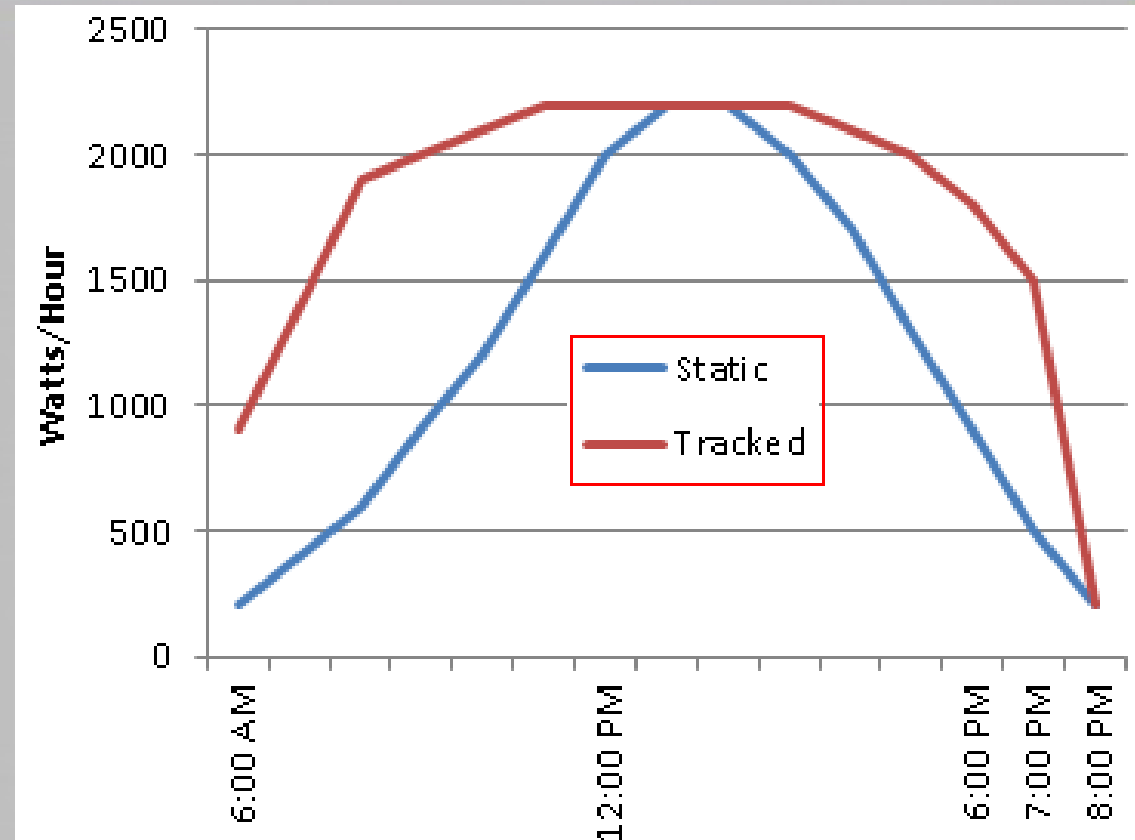


How well each type on PV cell responds to different wavelengths of solar radiation.



Types of systems include:

- **Fixed**
- **Bifacial**
- **Horizontal single axis tracking**
- **Tilted single axis tracking**
- **Dual axis tracking**



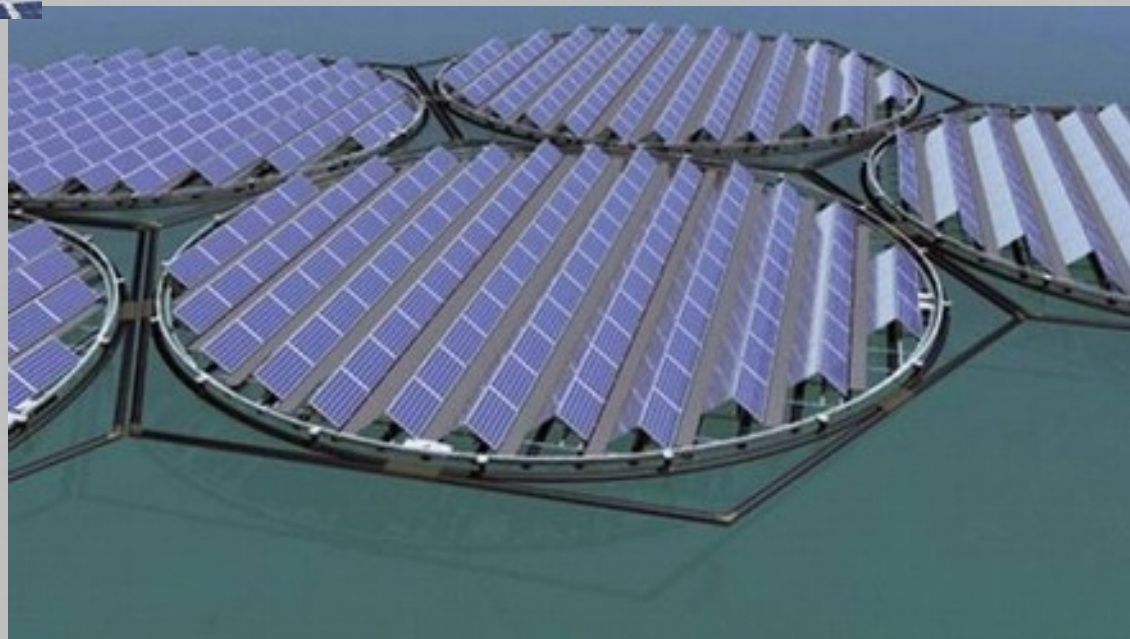
Tracking systems will increase the overall yield and extend the hours of generation. Bifacial systems also extend the hours of generation.

A fixed system tilted to face the mid winter sun will help keep batteries charged all year round.

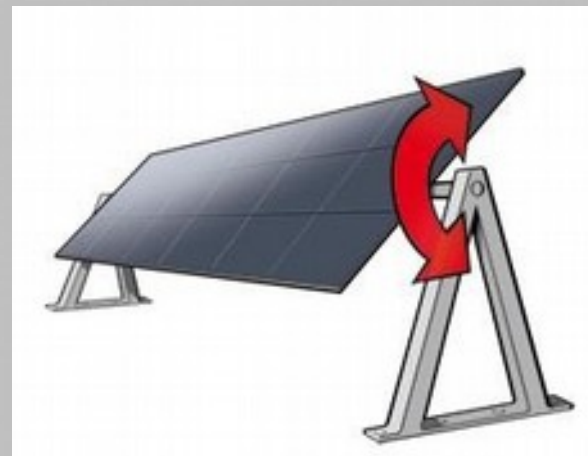
Fixed systems. (Can be made adjustable)



Bifacial systems



Horizontal single axis tracking systems



Tilted single axis tracking systems



Dual axis tracking system



To achieve an extra 20-40% yield. Designers can install a tracking system or add an extra 20-40% fixed panels



112,780 fixed solar Panels in France

The worlds largest solar power station is Tengger Solar Park in China at 1,547MW

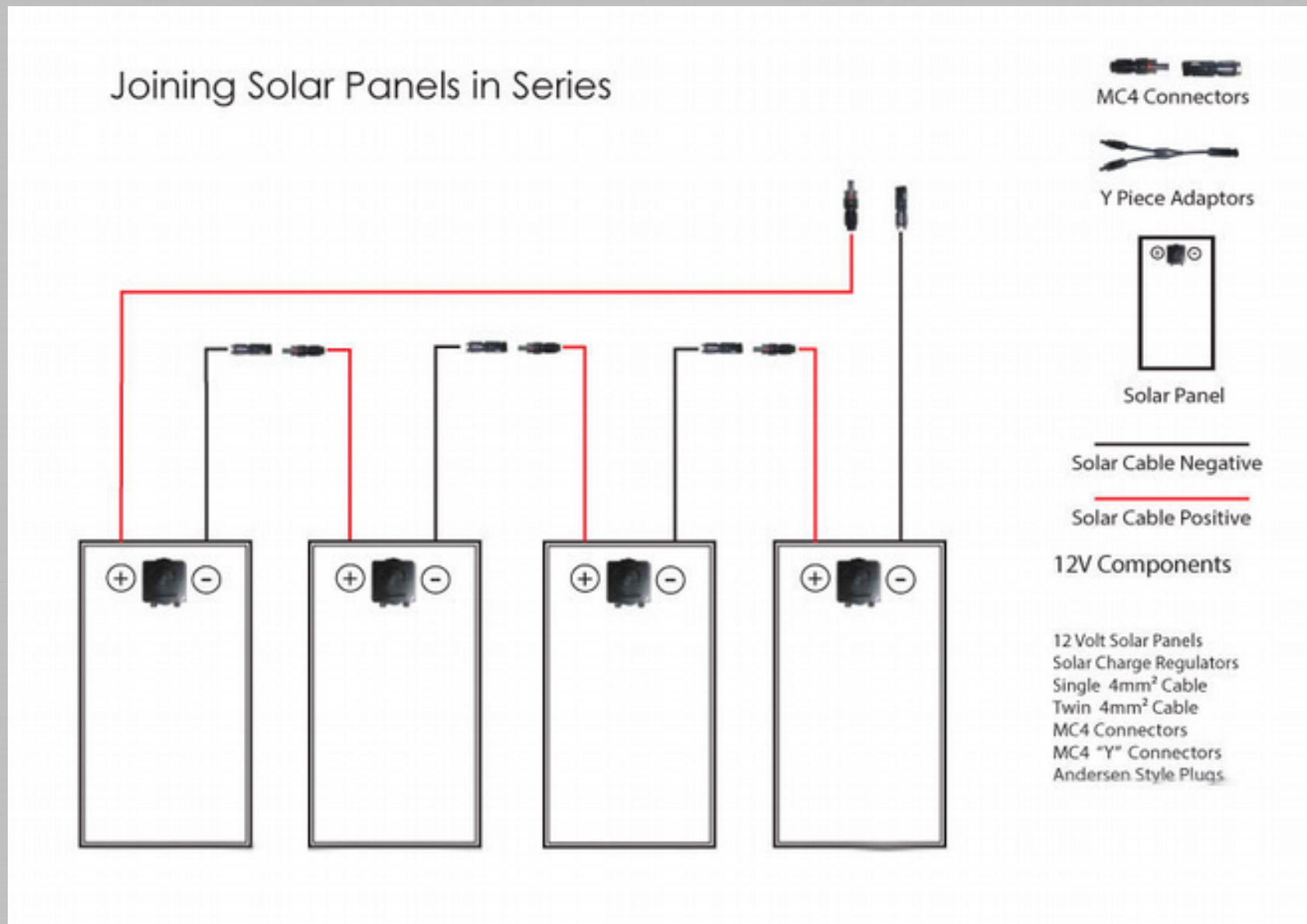


There are 6 concepts that AC electricians find unfamiliar about DC systems:

1) Positive and negative (not active and neutral)



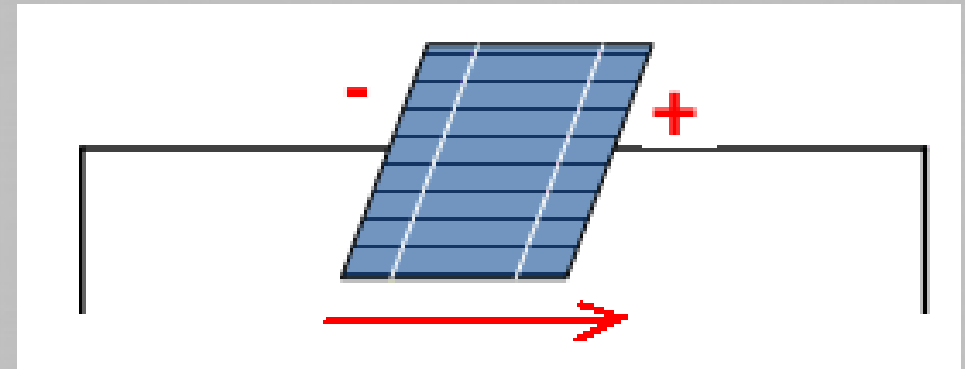
2) Series not parallel (plug red to black to red etc.)



3) Power producing device not a power consuming device

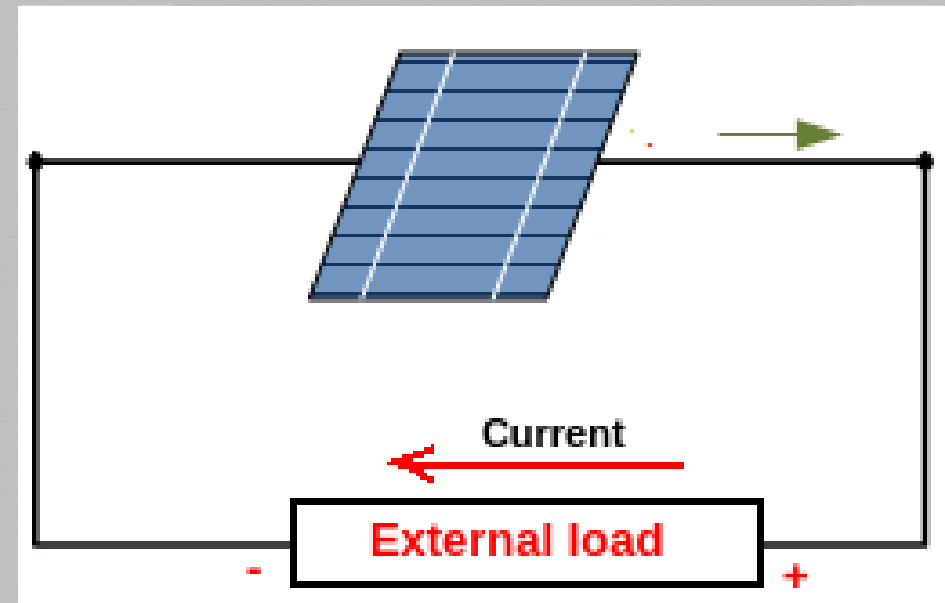
Solar panel:

Conventional current flows out of the positive terminal and into the negative terminal



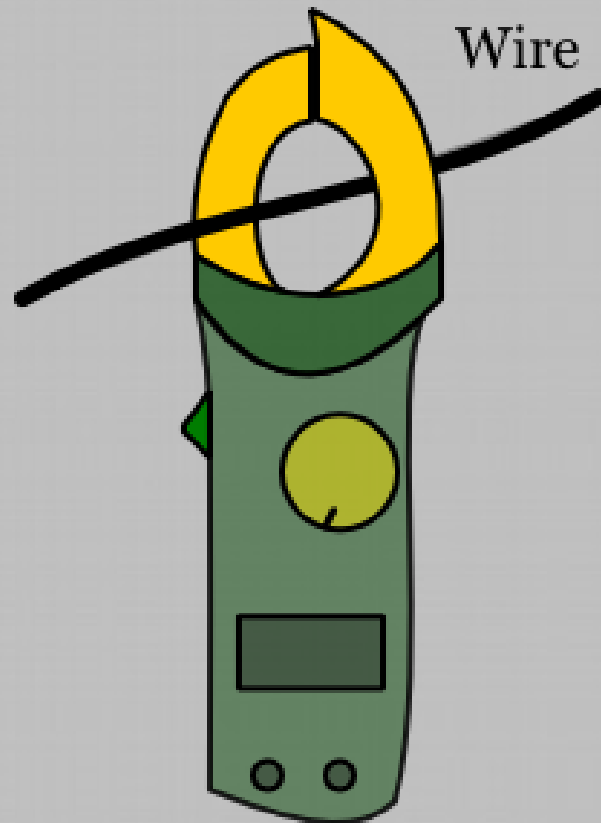
Load:

Conventional current flows into of the positive terminal and out the negative terminals

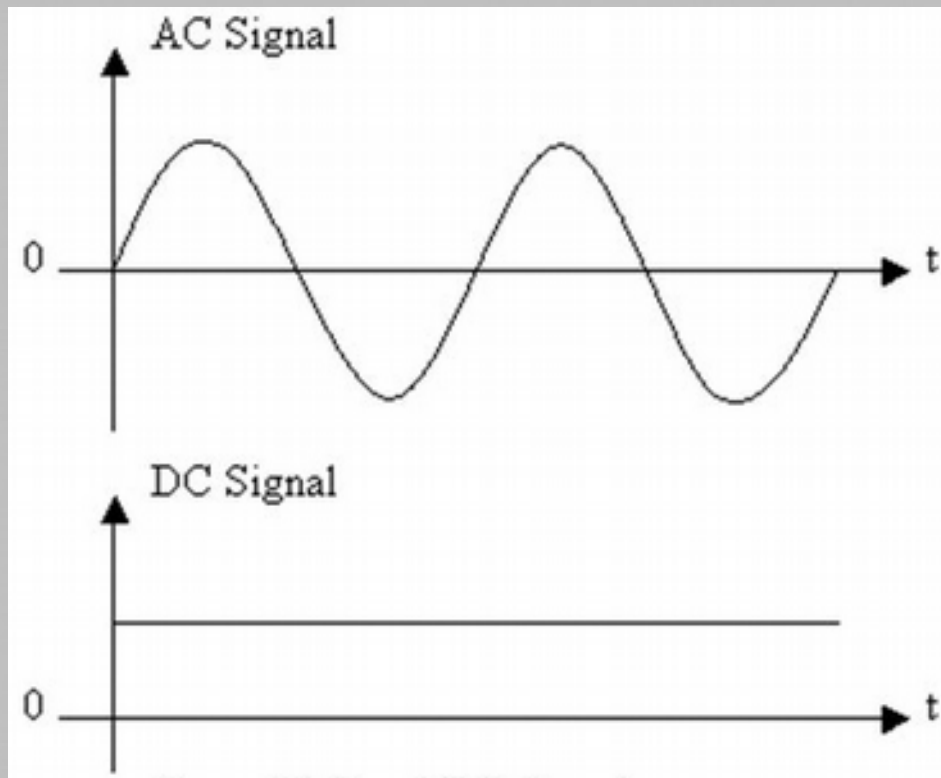


4) There is no Prospective Fault Current in a Solar cell (unlike transformers and batteries)

Turning a string on that has been shorted is not harmful to the panels and is one of our tests (Isc).



5) DC is much harder to switch



AC Switch - 20A



DC Isolator - 20A



6) Voltage and Current cannot be considered constant unlike AC mains power. Energy calculations are much more complex.



Irradiance and temperature are constantly changing