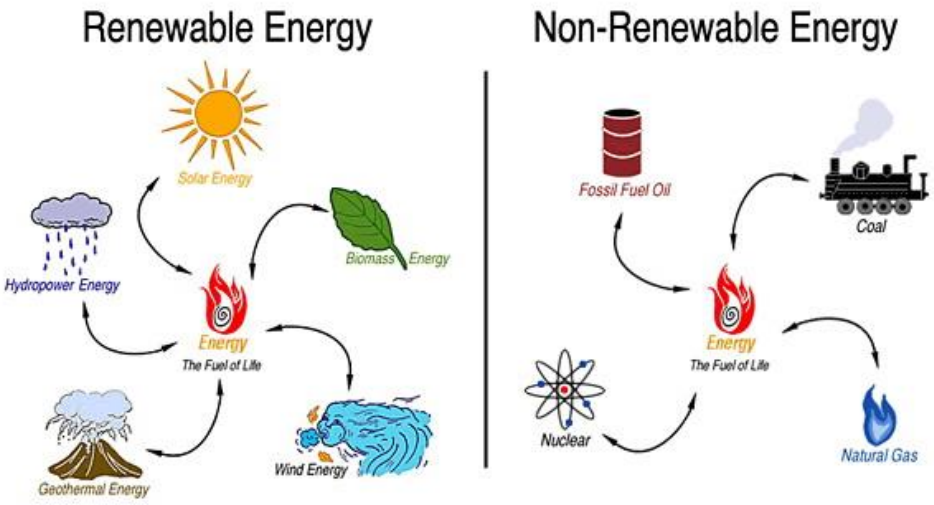
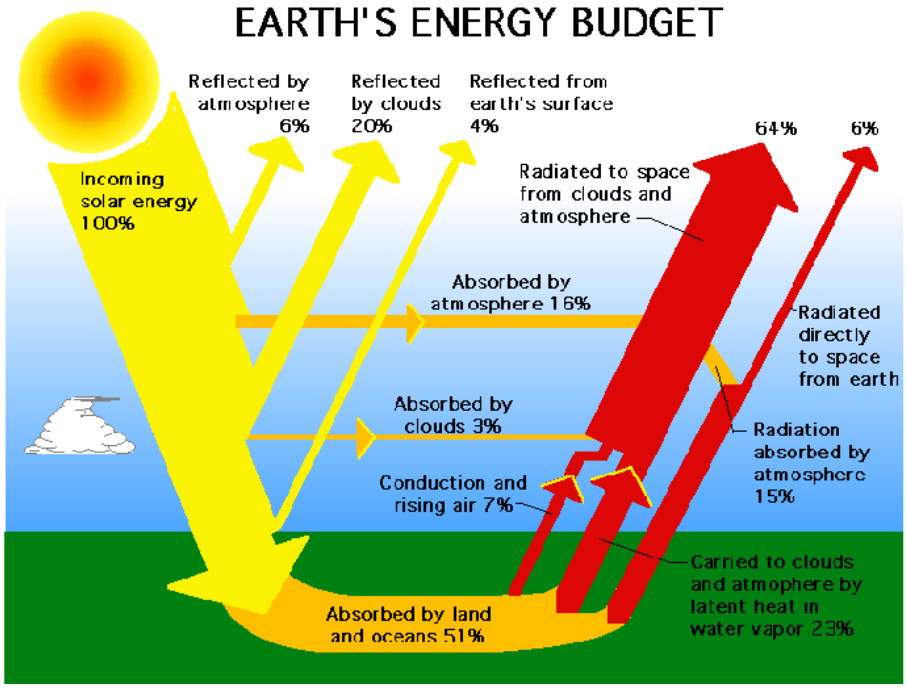
Renewable Energy - Solar

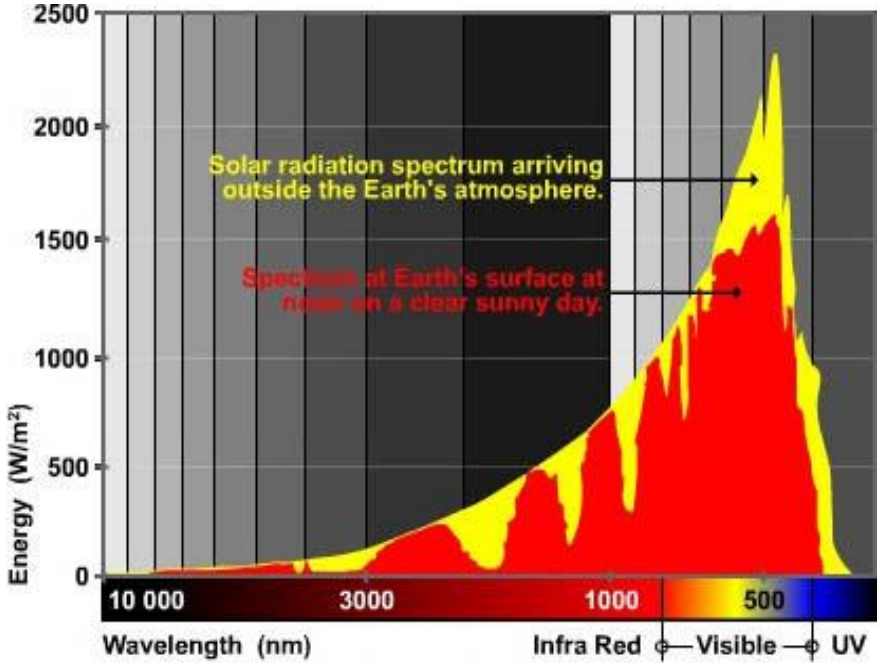


Solar Energy

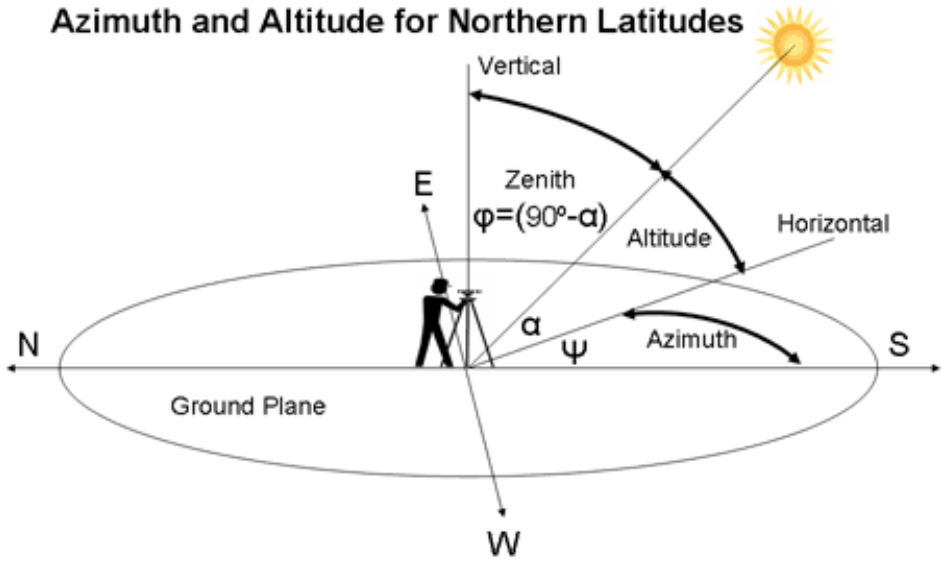
- The sun send to the universe a 3,81014 TW (1 TW = 10 to the power 12
- Sun Internal temperature 8-40 million degree
- Surface temperature 5777 K
- Annual Solar irradiation outside the atmosphere is 1367 W/m² and on the earth surface is 1000 W/m²



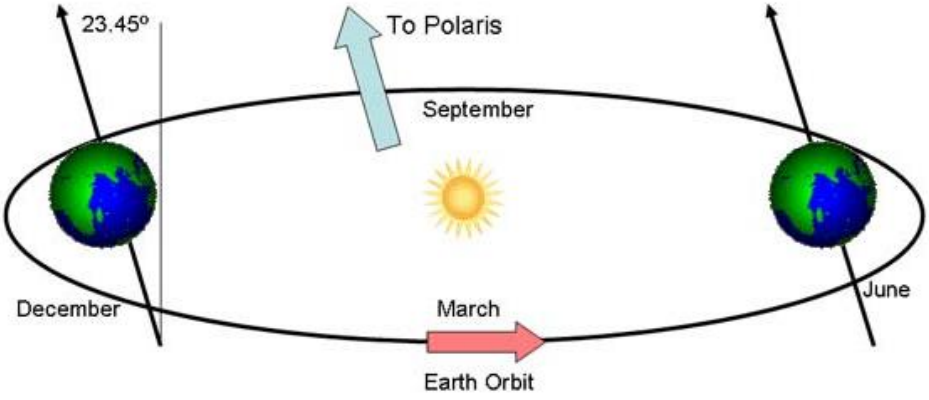
- At an average distance of 150 million km from the Sun, the outer atmosphere of the Earth receives approximately 1353 W/m² of incident solar radiation (NASA, 1971). This varies by around +/-2% due to fluctuations in emissions from the Sun itself as well as around +/-3.5% due to seasonal variations in distance and solar altitude.
- The amount of incident solar radiation that actually reaches on the Earth's surface can be as high as 1000 W/m² on a clear sunny day in summer.
- The majority of solar radiation occurs between the short-wave infra-red and ultra-violet portions of the electromagnetic spectrum. Ultra-violet (UV) radiation makes up a very small part of the total energy, roughly 8%-9%. The visible range, with a wavelength of 0.35mm to 0.78mm, represents only 46%-47% of the total energy received from the sun. The final 45% of the sun's total energy is in the short-wave infrared range of 0.78mm to 5mm.



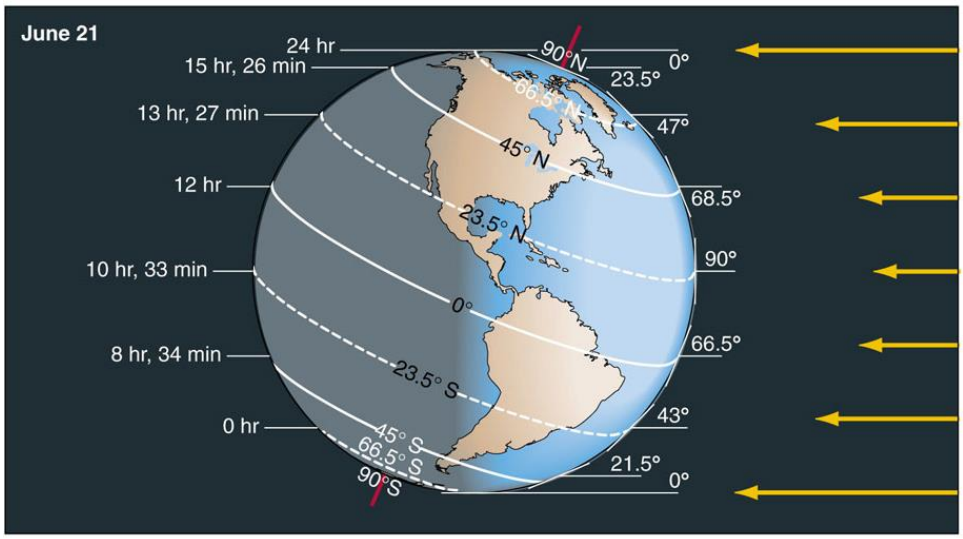
Solar position



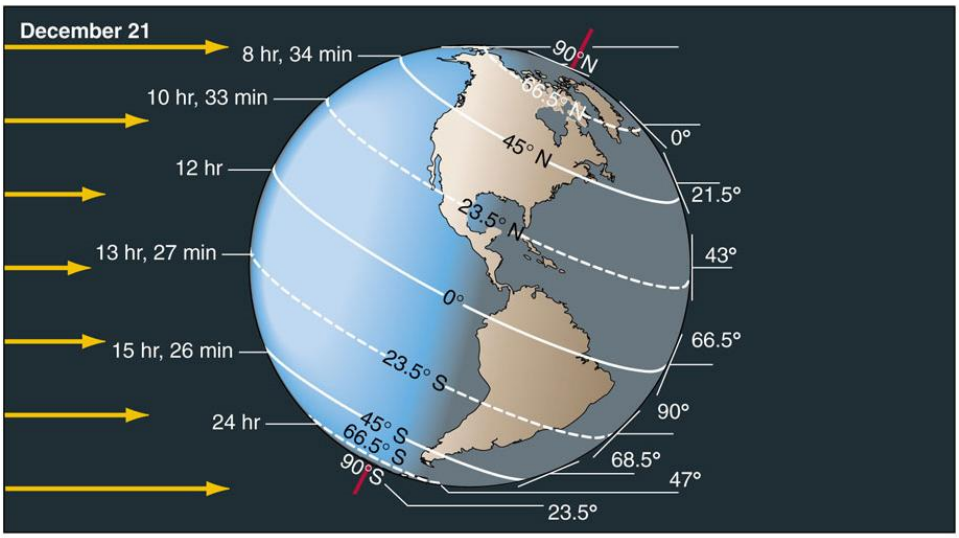
Summer and winter



Northern hemisphere facing sun



Southern hemisphere facing sun



- http://re.jrc.ec.europa.eu/pvgis/
- Ecotect – Solar Tool
- http://www.sunearthtools.com/dp/tools/pos_sun.php

Solar gain

Solar gain: refers to the increase in temperature in a space, object or structure that results from solar radiation

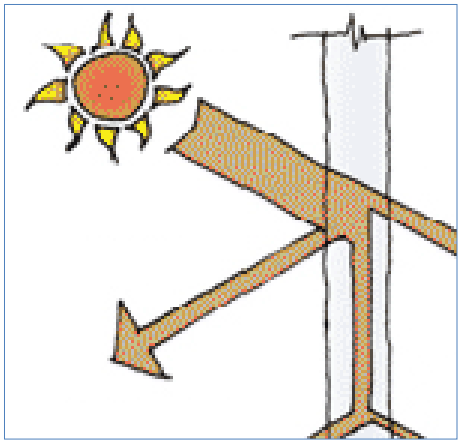
The orientation of windows within a model will determine when in the day solar gains occur within a zone. Obviously east-facing windows will let in early morning radiation whilst west-facing windows will let in mid-late afternoon sun.

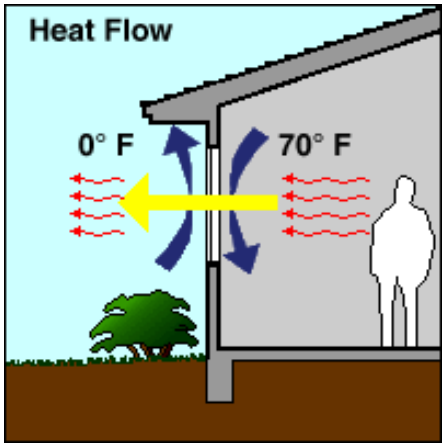
Direct solar radiation
Indirect (Diffuse) solar radiation
Incident solar radiation
Absorbed radiation
And transmitted radiation (windows)

Heat transmittance

Heat transmittance can be through

- Conduction
- Radiation
- ventilation





Heat transmittance- conduction

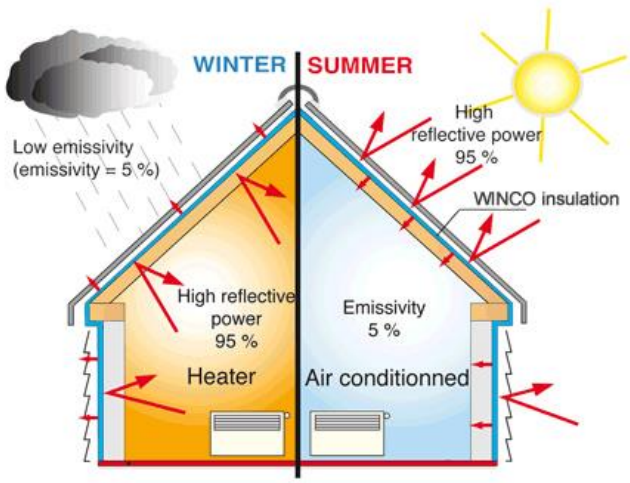
- Thermal transmittance, also known as U-value, is the rate of transfer of heat (in watts) through one square meter of a structure divided by the difference in temperature across the structure

$\Phi = A \times U \times (T_1 - T_2)$
where Φ is the heat transfer in watts,
U is the thermal transmittance,
T_1 is the temperature on one side of the structure,
T_2 is the temperature on the other side of the structure
and A is the area in square metres.

- single glazing: 5.7 W/m²K;
- single glazed windows, allowing for frames: 4.5 W/m²K;
- double glazed windows: 3.3 W/m²K;
- double glazed windows with coatings: 2.2 W/m²K;
- triple glazed windows: 1.8 W/m²K;
- well-insulated roofs: 0.15 W/m²K;
- poorly-insulated roofs: 1.0 W/m²K;
- well-insulated walls: 0.25 W/m²K;
- poorly-insulated walls: 1.5 W/m²K;
- well-insulated floors: 0.2 W/m²K;
- poorly-insulated floors: 1.0 W/m²K;

Thermal insulation

- materials used to reduce the rate of heat transfer, or the methods and processes used to reduce heat transfer



Absorbed energy (energy storage)

$H = \rho . V . C . \Delta t$

- H : Energy stored in J
- ρ : density Kg/m^3
- V: volume m^3
- C: energy capacity J/kg. K
- Δt: temperature difference