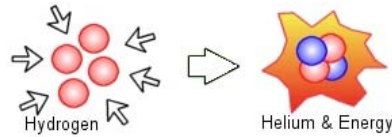


Introduction to Solar Power

The Sun

The sun is a blazing globe of hot gases fuelled by nuclear fusion - where small atoms are squeezed together at great pressure to make heavier atoms with the release of massive amounts of energy.



The Ultimate Source of Energy...

Hydro-electric: heat from the sun evaporates water, which falls as rain in high places, then flows down to the dam and drives the turbines.

Wind: winds are created by temperature differences caused by heating from the sun

Wave: driven by the wind.

Solar: light is turned directly into useful energy.

Biomass: (plant material e.g. wood). Plants turn carbon dioxide and water into carbohydrates (a chemical store of energy) using light energy to drive the process.

Fossil fuels: petrol, gas and oil are simply biomass that has been subject to great pressures underground for thousands of years.

Exceptions to the rule: **nuclear power** (a bit scary), **tidal power** (driven by the moon), **geothermal** (hot rocks underground) and **nuclear fusion** (like in the sun but a bit tricky to arrange on earth)

The energy from the sun is radiated out in all directions as light. Much of the energy striking the earth is reflected back into space by the atmosphere, but a staggering 90,000 TW of power arrives at the earth's surface, 6,000 times more power than the entire human race uses.

Using sunlight

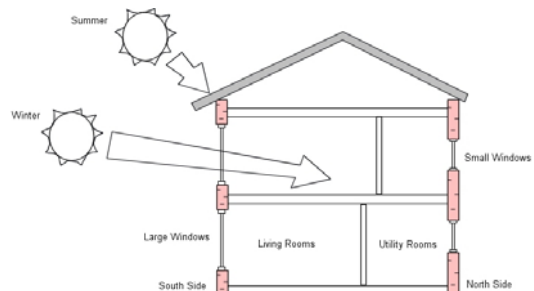
Although most forms of energy have the sun as their ultimate source (see box), the term solar energy is generally used to refer to methods of collecting light and turning it directly into a useful form of energy. Available technologies are:

1. Passive Solar Gain

This form of energy is often taken for granted; sunlight enters through windows, and warms the house. In an average house in the UK, passive solar gain contributes 14% of the heating demand.

Thoughtful design can improve this figure further with very little, if any, increase in the cost of building the property:

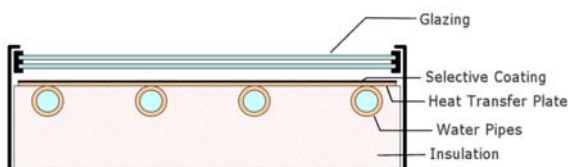
- Orienting the house so that the more often used rooms face south;
- larger windows on the south side, smaller on the north;
- using building materials that store heat by adding "thermal mass" to the house and
- laying out housing so that buildings do not over shadow each other.



2. Solar Thermal Collectors

This technology uses a solar panel that is specifically designed to collect light and heat up. Some, more carefully insulated panels, do not require direct sunshine, and will work even on a cloudy day. Typical working temperatures are below 100C, and the energy is normally used to provide either space heating or hot water for washing. There are many different designs, but two types have found favour in cooler climates – the flat panel and the evacuated tube.

X-Section Flat Panel Solar Collector

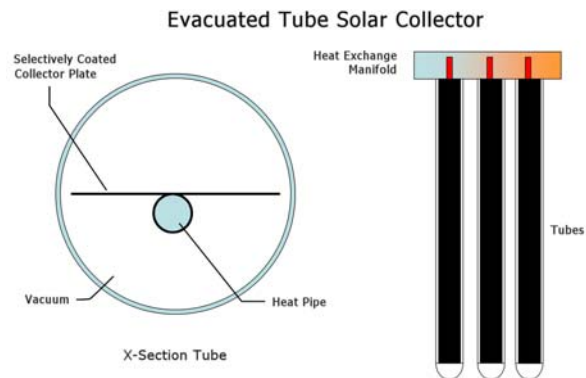


The flat panel solar collectors are generally cheaper systems per unit area. Their common feature is a flat plate with a black surface which absorbs sunlight. This surface may be of a selective coating which absorbs almost all light, but doesn't radiate heat so well.

The heat is transferred to water which is pumped through pipes that are connected to the flat plate. A glazing material insulates the hot plate while letting the sunlight through. Layers of insulation behind the hot plate reduce heat loss to the rear.

Evacuated tube collectors benefit from the extremely high insulation of a vacuum (like in a vacuum flask), which totally eliminates losses by conduction and convection.

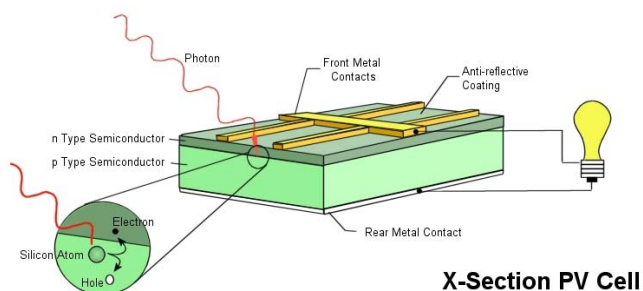
The vacuum is maintained inside a sealed glass tube. Sunlight is absorbed by a selective coating on a collector plate inside the tube (right). Heat may be removed by direct circulation of the water or by a "heat pipe" that contains a refrigerant. The refrigerant evaporates in the tube, and condenses at the cold end, transferring heat into water circulating there.



Evacuated tube collectors are said to be more efficient due to lower losses, and consequently to perform better on cold or cloudy days. Solar thermal systems typically achieve efficiencies over 80%.

3. Photovoltaic Cells

Photovoltaic (PV) cells, which convert light directly into electricity, have become commonplace on devices such as calculators and watches. There are a number of technologies in development with the aim of making PV more economic for electrical power generation. All use semiconductor materials like those used in silicon chips.



The heart of a PV cell is the interface between two different types of semiconductor. When a light photon hits a silicon atom in this region, it throws out an electron. The electron travels through the n-type semiconductor to metal contacts on the surface. The hole left by the absence of the electron travels in the opposite direction, through the p-type semiconductor. Once at the metal contact, the electron flows through an electrical circuit back to meet up with a hole at the other contact.

As it flows through the external circuit, the electron does useful work, like charging a battery, or operating an electrical appliance. Photovoltaic systems have been reducing in cost, and increasing in efficiency in recent years. The most efficient commercially available systems can convert up to 16% of the light energy that strikes them into electrical energy.

4. Solar Concentrators

If the sun's rays are concentrated using mirrors, much higher temperatures can be created – enough to make steam to drive a turbine and generate electricity. The light is focused onto a central collector with oil flowing through it. The oil heats up to 400C, and then moves on to heat water and make high pressure steam.

Solar concentrators only work in direct sunshine, and when aimed right at the sun. The mirror is held on a support that can turn to follow the sun as it moves throughout the day, adding to complexity and cost. Because of this, they are only used in areas benefiting from a sunny climate, with more clear days.