THE SCIENCE OF SOLAR

Solar Power is one of the more high-profile alternative energy sources on the market, and probably for good reason. The sun emits massive amounts of energy every day, so why not collect some of that energy and put it to good use? This is rather easy to do, and the basic technical workings are not too hard for the scientific layperson to understand. For that reason, I have put together a very brief guide to how solar power works.

There are, in fact, two ways to make use of the sun's energy. Solar power generally brings electricity to mind, but we often forget that the sun also emits heat, which is useful in its own way. This is most commonly done by using a **flat-plate thermal collector**, which absorbs heat from the sun and passes it on to a liquid or gas running through the collector. This process can be used for providing hot water or even heating one's house.

Most flat-plate thermal collectors consist of a metal plate, with tubes running through it to carry the heat-transfer fluid. This plate is insulated on the back, to prevent excess heat leaking away, and painted black on its surface to increase the amount of sunlight it absorbs. Layers of glass are then placed over top, which take advantage of the greenhouse effect to trap as much energy as possible.

This method is so effective that the best thermal collectors can absorb and retain 95% of all the solar radiation it receives. In ideal conditions, water passing through the plate once can be heated up to 10 degrees Celsius.

Of course, one might ask why it is so important to run the fluid *through* the plate as opposed to *over* it. The answer is that heat is transferred more efficiently by using these tubes. The tubes increase the surface area of the fluid in direct contact with the sheet, heating it faster and more efficiently, while the sheet loses less energy to the fluid overall, since it has a greater surface-area that is *not* in contact with the water, and is instead free to absorb solar radiation.

There are quite a few advantages to using flat-plate thermal collectors in this way. They are cheap to manufacture, have a long life span, and are incredibly efficient because they absorb a wide light spectrum. That said, there are a few problems which can arise with these collectors. Firstly, when using a liquid as the heat-transfer fluid, special care must be taken in colder climates to avoid freezing. To avoid this, liquid thermal collectors are generally oriented vertically, and allowed to drain when not in use. Furthermore, if the heat-transfer liquid has a great deal of oxygen dissolved in it, it may oxidize the metal plate and cause corrosion. Both these difficulties are avoided if a gas is used as the heat-transfer fluid, but this comes with the drawback of being less versatile. Nevertheless, thermal collectors are a cheap and easy way to reduce one's heating costs.

The second way to use solar energy is by directly generating electricity, through **photovoltaic cells**. These cells are made from silicone, with some impurities, called **dopants** added. To explain why these impurities are necessary, some basic chemistry is required. All atoms have what are called shells of electrons. Each of these shells can hold a very specific number of electrons, and atoms usually want their outermost shell to be full. They accomplish this by giving, receiving, or even sharing electrons. Silicone has four electrons in its outer shell, and can feasibly hold four more. Consequently, silicone atoms tend to lock into square lattices, sharing electrons with four of its neighbours.

This is a very arrangement, which makes it very difficult to create the flow of electrons required to generate electricity. This is where dopants are introduced. Phosphorus has five electrons in its outer shell, so when it is added, as a dopant, to the silicone lattice, it shares electrons with the four surrounding silicone atoms, but one is left unbonded. This results in a sheet with a negative charge, so it is called **n-type**. A second sheet is then doped with boron, which has only three electrons in the outer shell. This means there is one silicone atom in need of an extra electron. This causes a positive charge, and so the new sheet is called **p-type**.

When these two sheets are brought together, the extra electrons in the n-type sheet are attracted to the empty places in the p-type sheet, resulting in an electric field.

Any electron that enters into gap between the sheets will be carried through this field to the p-type sheet. When a sufficiently powerful photon hits the n-type sheet, it dislodges one of the excess electrons from the phosphorus atoms and propels it into this gap, where the electron settles into one of the available spaces. Metal conduits are then used to carry off these electrons, allowing for a continuous flow of electricity.

The biggest problem with photovoltaic energy is that it is not very efficient. In order to dislodge the electrons in the n-type sheet, a photon must have a certain amount of energy. Any less than this limit would place the electron in the **forbidden energy zone**, which is, as evidenced by the name, forbidden. These photons simply pass right through the cell. Photons of a higher energy will dislodge the electron, but the remaining energy will simply be lost as heat. Consequently, most of the solar energy goes to waste, meaning that even the best solar panels today have only 42.8% efficiency. Despite this drawback, photovoltaic electricity is a major contender as an alternative energy source, and it is the most prevalent energy source for missions into outer space.

As you can see, solar power is not particularly complicated. Photovoltaic energy requires a little background knowledge to understand, but thermal capture essentially amounts to placing a metal sheet in the sun and running water through it. There are other methods of harnessing solar energy, such as salt-gradient solar ponds or concentrating solar collectors, but flat-plate thermal capture and photovoltaics are the most common, and simplest to understand. Hopefully, this article has provided you with a basic understanding of how these two essential methods work..

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