

PHOTOVOLTAICS Sunlight to Electricity in One Step

The principle behind conversion of solar energy to electricity through the use of photovoltaic cells is described. The photovoltaic effect produces electrical energy from a 'free' renewable source, the sun. It holds promise for remote energy supply where conventional nonrenewable energy is not practical.

Photovoltaic Principle

The photovoltaic effect is one in which sunlight is converted directly into electricity. The conversion takes place within the solar or photovoltaic cell. A number of cells are wired together to form a panel. A group of panels is described as a photovoltaic array (see **Figure 1**). Each panel shown is approximately 0.3 m by 1.2 m.

The solar cells are actually semi-conductor devices made of two very thin layers of specially treated material, commonly silicon. When light falls on the cell, photons are absorbed and electrons set free. Excess electrons accumulate on the negative side of the cell. If a wire is connected between the two layers, one positive and one negative, a flow of electrons occurs. This becomes an electrical source able to power a motor, lights etc. The incoming sunlight keeps the process going (see **Figure 2**).



Figure 1 A Ten Panel Photovoltaic Array

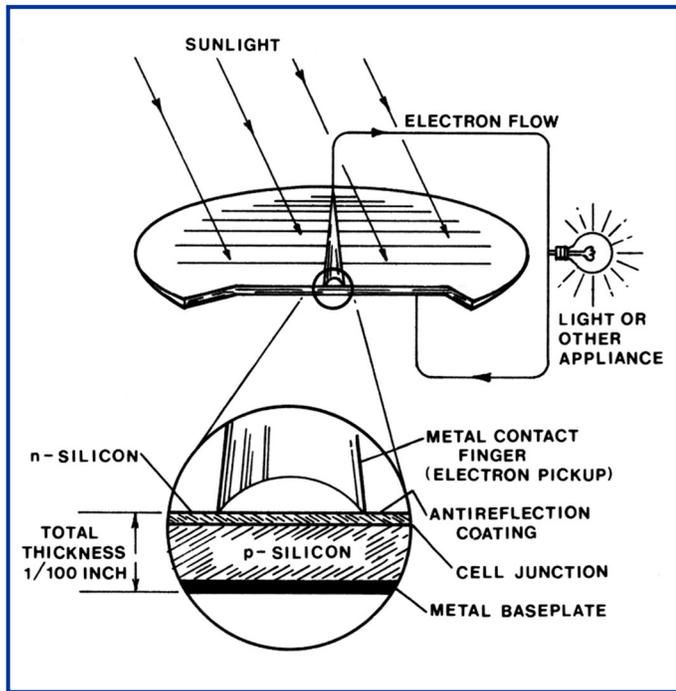


Figure 2 Photovoltaic Cell Cutaway

manufacturing method uses amorphous silicon, which is pure silicon, not crystalline. Very thin films can convert sunlight into electricity using a small amount of material. This method is very inexpensive compared to the polysilicon process. However, the conversion efficiency is much lower, typically about 1/3 less. With a better understanding of the amorphous solar cells, this process may have an impact on photovoltaic pricing. Currently amorphous cells power small devices such as watches and calculators.

Agriculture Uses of Photovoltaics

With the present cost of panels at approximately \$2 to \$5 per watt, their use is not restricted to special or low power conditions. Manufacturing and design improvements were made in recent years that reduced costs and therefore expanded the possible applications.

An early agricultural use was as a trickle charger for battery powered electric fences. This low power demand requires a small cell area and is inexpensive. It can extend the life of the battery as well as reduce fence-checking time.

Another use is photovoltaic powered pumping of livestock water on rangeland.

Other possibilities are for such things as energy for frost-free water troughs during the winter, pumping water for low demand trickle irrigation systems or other low energy requirement systems.

Silicon Solar Cell Output

The amount of current produced by the solar cell is proportional to the amount of sunlight falling on the cell. Current increases with cell area exposed, as well as light intensity. The voltage depends on the cell material and remains approximately constant with changes in light. All silicon cells produce about 1/2 volt per cell so a 33 cell photovoltaic panel can produce about 16 volts. Panels can be wired in series to raise the output voltage or in parallel to increase the current.

Manufacturing Methods Determine Cost

Silicon solar cells are formed by a silicon crystal process or the use of amorphous or non-crystalline silicon. Most commonly used is the silicon crystal process. Slow cooling of molten silicon produces an ingot or solid block of larger than normal crystals called polycrystalline silicon (polysilicon). This process is less expensive than growing single crystal silicon although it is somewhat less efficient in converting sunlight to electricity. The ingot is then sawn into thin wafers. Newer processes form the polysilicon directly into thin sheets. Another

Photovoltaics Future

Solar cells are unique energy producers because they neither consume nor give off any material. The panels are sealed units. The material does not change shape or form, as atoms are not moving, only electrons. This is reflected in the typical photovoltaic panel warranty of 10 years with no more than a 10 percent power loss. As panel costs come down, photovoltaics will be considered wherever remote power is required. As a renewable energy source, the future for photovoltaics looks bright.

References and Further Reading

1. ***“Photovoltaics”*** P. Maycock and E. Stirewalt, Brick House Pub. Co., Andover, Mass., USA.
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 3. ***“Solar Energy in America”*** W. Metz and A. Hammond, American Association for the Advancement of Science, Publication No, 78-10.
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