# Everything You Need to Know About Photovoltaics without Being an Engineer

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The sun produces light at a fairly constant rate. The energy contained within that light is represented as the solar constant. The solar constant is 1353 watts per square meter in space and about 1000 watts per square meter (95 watts per square foot) at sea level at the equator at solar noon.

Photovoltaics (PV) is a solid-state technology that converts solar radiation directly into electrical power, with no moving parts, requiring no fuel, and creating virtually no pollutants over its life cycle. As long as the sun is shining, energy can be developed directly by use of a PV module.

The PV effect is the physical phenomenon of converting light directly into electricity. Edmund Becquerel, a French physicist, first observed this phenomenon in 1839. He discovered that illuminating one of two electrodes in a weak solution produced a voltage. During the 1880s, the first PV cells were made from selenium. These preliminary cells operated with a conversion efficiency of 1-2%.

New photovoltaic technology was developed to power satellites, as part of the space program in the 1960's. In addition, advancement in the transistor industry provided for better materials. PVs and transistors are made from similar materials and many of their working principles are determined by the same physical mechanisms.

Today’s PVs are made from silicon, similar to semiconductors. Through a process called doping, the silicon is separated into two distinct layers, called negative (n-type) and positive (p-type.) The n-type has an excess of electrons, and the p-type has vacancies or missing electrons. The two layers are separated by a n-p junction.

Light passes through the thin n-silicon layer and hits the p-silicon layer. The light is absorbed by the p-silicon layer. The photons in light displace the electrons in the p layer. Some of these displaced electrons have sufficient energy to pass through the n-p junction to the n layer. A potential is developed between the n and p layers. For silicon, this potential is approximately one-half volt. By connecting the n and p layers through wires and a load, current (electrons) can flow from the negative layer back to the positive layer. The electrons which have returned to the positive layer, are once again available for displacement, resulting in a completely renewable resource.

## Photovoltaic Cell Crystalline Solar Cell

Single crystal silicon cells have a theoretical efficiency of 29%. The maximum efficiency achieved in a laboratory was approximately 24%. Single crystal silicon cells are not commercially viable to mass produce.

Poly-crystal silicon cells are the most popular of the PV cells on the market today. The cells are widely used in calculators, watches, landscape lighting, etc. The cells are relatively easy and cheap to manufacture with little loss in efficiency over the single crystal cells. Typically, the poly-crystal cells on the market today reach a maximum of 15% efficiency. The general rule of thumb is to figure a net of 10 watts per square foot of solar array surface area.

The major disadvantage of the poly-crystal cells is the wasted materials in the manufacturing process. The poly-crystal silicon is cast and sliced into thin silicon wafers. During the slicing process, almost half of the raw silicon is lost.

## Thin-film Cell

In order to lower the manufacturing costs, a thin-film solar cell was developed. The thin-film method uses less material and makes available a more automated manufacturing process. In addition, the thin-film can be incorporated into many building materials and applications.

The big disadvantage to the thin-film cells is their relatively low efficiency. However, as more applications are available, more surface areas are utilized for PV production, offsetting the lowered efficiency. Typically, the efficiency of the thin-film PV cell would be approximately 8% or about seven watts per square foot. The film can be applied to roofing materials, siding, etc. The film can also be applied to skylights and perforated with a laser to achieve the desired light transmission.

The various PV panels would be interconnected through series/parallel connections to develop the desired voltages and currents. No maintenance is required for the PV panels. Having been designed for the rigorous demands in space, PV modules can withstand high temperatures, and direct impact from rocks or other projectiles.

## OTHER COMPONENTS

### Inverters

The inverter converts the direct current produced by the PV modules into a 120/208 volt three phase current. This three-phase current can be directly injected into the building electrical system. When the building is in operation, the generated power is used within the building, reducing utility demand. When the building is not in use, the power is transformed and delivered back to the utility.

The technology for the inverter is very common with uses in uninterruptable power systems (UPS), variable speed drives (VSD), control systems, and other standard installations. Routine maintenance is required for the inverter and would take no more than eight hours per year.

### Wiring

The wiring for the system is the same as for all other building systems, therefore no special wiring or wiring requirements are needed.