

# Photovoltaics – Solar Electricity

## 1. Solar Energy

Solar energy is one of the preconditions for life on earth. The sun continually emits energy in form of electromagnetic waves and typically about 1000 Watts per square meter of this power reaches the earth. The earth itself is a huge solar energy collector and uses this energy direct in form of heat or indirect through photosynthesis.

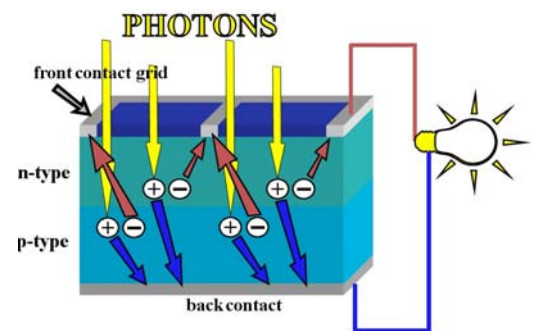
## 2. What is Photovoltaics

Researchers are trying to use the sun's energy to generate electricity. And the answer for this is photovoltaic. The term photovoltaic literally means light-electricity, whereas photo refers to light and voltaic to voltage. Photovoltaic devices and materials do nothing else as to convert light energy into electrical energy.

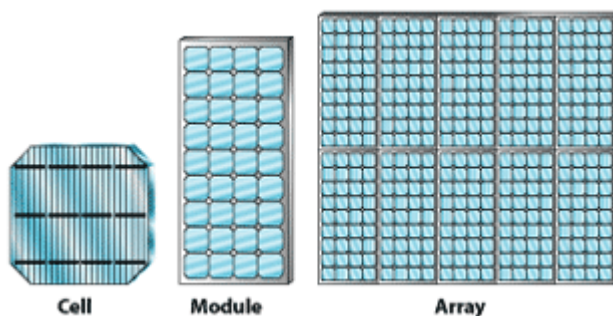
## 3. Photoelectric Effect

How do we get electricity out of light? This is done by the so called photoelectric effect. In 1839, Edmond Becquerel discovered the process of using sunlight to produce electric energy, but it took another century to truly understand it. And how does it work? The photoelectric effect only occurs in so called semiconductors. These are Materials which are conductors and non-conductors at the same time.

Putting an n-type (overabundance of electrons, negative electrical charge) and a p-type (shortage of electrons, positive electrical charge) semiconductor together creates a p/n junction. Now the overabundance of electrons from the n-layer try to move to the holes of the p-layer, the result is difference in potential, an electrical field. The entering photons of the light set more electrons free and so the current is accelerated, because the freed electrons can not return to the positively charged side (holes) without flowing through an external circuit. The result is electrical energy, which could be used directly to load an accumulator or to power a device.



## 4. Terminology



### 4.1. Solar Cell

The photovoltaic or solar cell is the component responsible for converting light to electricity. More details a little bit later.

#### 4.2. **Photovoltaic Module**

A photovoltaic module encapsulates interconnected solar cells in a weatherproof cover with glass front, mostly framed into aluminium frames suitable for mounting.

#### 4.3. **Photovoltaic Array**

Photovoltaic arrays are in series or parallel connected photovoltaic modules, to increase the total output of power.

### 5. **Solar Cell**

Nowadays there are many types of solar cells but of all types silicon is the raw material. Thin Film cells use amorphous silicon which is used as 2 micrometers thin films. The efficiency of these cells is about 10% to 15%, the costs are relatively low and they are mostly produced by steaming the material on a basic-layer. Crystalline Silicon cells are produced with a size from about 1cm to 10cm across. Monocrystalline cells are made out of wafers, like them used in microchip production. These are very expensive, have efficiency about 25% and are commonly used in astronautics. Multicrystalline cells are much cheaper, have efficiency less than 16% and are the wide spreadest form of solar cells.



#### 5.1. **Peak Watt**

Photovoltaic Modules are rated by their power output, the so called peak watts. This is the amount of power a module produces at Standard Test Conditions (STC). These are 25°C and full noontime sunshine. Note that most solar modules never operate at the ideal conditions and so the output is often less than given.

### 6. **Range of Application**

Examples for the usage of solar systems are water pumping systems in the third-world, gate openers, electric fences or even little chargers for mobile devices. There are different kinds of systems, for each possible condition:

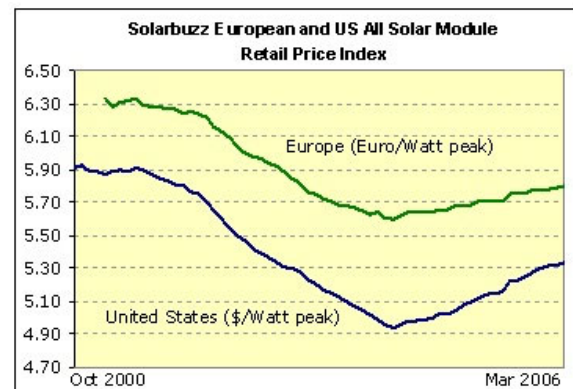
- **Stand-Alone Systems**  
Stand-Alone Systems are used in regions where no other power source is available or for uses that do not require a lot of power.
- **Systems with Battery Storage**  
Most Systems have a Battery Storage Systems. This system grants constant and uninterrupted power supply, also on cloudy days.
- **Systems with generator**  
Must power supply always be available also by darkness or current peaks, it is recommend to pair solar panels with diesel generators.
- **Net Metering**  
Net Metering names a system where owners of a photovoltaic array installed at their house could sell the overproduced energy to the utility power supplier.
- **Utility Power Production**  
More and more utility power suppliers are installing photovoltaic power plants to produce energy for public use. Most of these energy parks are located near the equator.

## 7. Costs / Market

Nowadays solar systems are serious alternatives to conventional power supplies.

Manufacturers guarantee a lifetime from about 10 to 20 years and many of the cells would live much longer. The costs for a solar system including the panel, batteries, inverters and other components needed belong to 10\$-15\$ per Watt.

In 2005 the world production of electric energy by photovoltaic reached a record high of 1460 Megawatts. That would represent an annual growth of 34%. Alone Germany has doubled his production from 2004 to 2005 to 837 Megawatts. These are 57% of the world market.



## 8. Future

By increasing oil prices, global warming and the rising interest in alternative energy, solar energy and photovoltaic will play a great role in future. It won't be the cure-all but it has to be taken seriously. The production processes will get easier and the costs per watt will decrease rapidly if silicon won't get much more expensive. And new technologies aim on methods without the need of expensive silicon. All in all a great technology and a growing market which should be kept in view.

## 9. References

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