Transforming light energy into electric energy: solar cells

At this station you can find out more about the materials needed for solar cells and about the advantages and disadvantages of solar cells.

Solar energy can be transformed into electricity either indirectly in solar thermal power plants or directly in **photovoltaic cells**. Photovoltaic cells (solar cells) can be installed in large plants or in smaller arrays at the places where the generated electricity is needed. So you can see them on roof tops, on parking meters, calculators, garden lanterns or even on bags!
Today solar cells usually consist of the semiconductor **silicon Si**. The processes inside the cells can be described by the following simplified explanation:
When sunlight shines on the solar cell, electrons and holes are generated inside the semiconductor silicon and move away from each other (see Station 2). Holes and electrons move into opposite directions and "produce" electricity. So solar energy is converted into electric energy.

Fig. 1 Solar cells are electronically connected as a module which is protected by a sheet of glass and framed with an aluminium frame. Modules are interconnected in arrays, giving a certain voltage and current. The array in the picture consists of 12 modules.

The silicon needed for solar cells has to be *very* clean. In so-called **solar grade silicon** (Si_{sg}) there may only be an impurity of one atom in 10 billion silicon atoms! A great amount of energy (and money) is needed to produce solar grade silicon. So the costs for arrays of solar cells are still relatively high.

Scientists have been looking for alternatives for silicon. A possible candidate is the semiconductor **titanium dioxide TiO_2**, which is usually known as white pigment in colours. Titanium dioxide is less expensive than silicon. Its disadvantage is that it does not absorb a great part of the visible spectrum of light. But if it is coated with synthetic or natural dyes, also the less energetic parts of the sunlight can be converted into electricity.

Units
1 kWh = 1000 •Watt •hour
(Watt is the unit for power
Power = quotient from work per time unit)
1 MWh = 1000 kWh
1 GWh = 1000000 kWh
1 TWh = 1000000000 kWh

Consumption
About 1 kWh is needed for:
- watching TV for 7 hrs
- 25 min use of a vacuum cleaner
- 45 min use of a blow-dryer
- 10 hours use of a 100 W light bulb
- 25 hours use of a 40 W light bulb
- boiling 240 eggs

An average family of four consumes about 4250 kWh per year.

Fig.2 Units and consumption of electric energy.

In the past years growing production numbers and more efficient production technology have lead to strongly decreasing prices. The solar photovoltaics industry is one of the world´s fastest growing industries. Solar cell arrays are long-lasting and the maintenance costs are very low. There are no fuel costs, no emissions and after about three years they have generated as much electricity as their production had required. A disadvantage is that a lot of space is needed: the newly set up solar plant "Solarpark Lieberose" in the east of Germany can provide electric energy for 150 000 households and takes the space of 210 soccer fields. Nevertheless one can find plenty of space for solar cell arrays on roofs and other public or private buildings.

☞ Questions

1) Collect advantages and disadvantages of the photovoltaic conversion of sunlight into electricity.
2) Green electricity is electricity generated from renewable energy sources. The amount of solar-based electricity is 0,48% of the total amount of green electricity. Try to find reasons why this number is so low.
3) Calculate how much energy in GWh can be generated in the "Solarpark Lieberose" (see also Fig. 2).

Words: *array:* Anlage; *silicon:* Silicium; *solar-grade silicon:* solargeeignetes Silicium; *dye:* Farbstoff; *maintenance costs:* Instandhaltungskosten.