

PHOTOVOLTAICS

Basics

Photovoltaics is the direct conversion of light energy, usually from sunlight, into electrical energy using solar cells.

Solar power is environmentally friendly and an important part of the future power supply of Switzerland and the whole world. Nevertheless, the share of solar energy in the total energy production of Switzerland is only about 4,5%. About 165 kilowatts of solar power can be generated annually throughout Switzerland.

How many square meters of rooftop space are needed to install solar panels in order to power an average household of four for a year?

1 solar panel (1 square meter) = min. 150 kwh, max. 230 kwh (average 190 kwh) per year

1 average household = 4000 kWh per year

Maximum:

1 Panel (square meter) = 150 kwh

x Panels (square meter) = 4000 kwh

(Calculation: $x = 1/150 \cdot 4000$)

26.6 panel (square meter) = 4000 kwh

Minimum:

1 Panel (square meter) = 230 kwh

x Panels (square meter) = 4000 kwh

(Calculation: $x = 1/230 \cdot 4000$)

17.39 panel (square meter) = 4000 kwh

To power an average household of four for a year, between 17.39m² and 26.6m² of rooftop space is needed to install the solar panels, depending on their power.

Solar energy

Inside the sun, temperatures of up to 15 million degrees Celsius prevail. This heat is generated by the fusion of atomic nuclei¹. The temperature at the surface of the sun is about 580 degrees Celsius. The earth is 150 million km away from the sun. At this distance, the radiation power² of the sun on a vertical surface is 1370 watts per square meter. This value is called solar constant³. Calculated over the entire surface of the irradiated hemisphere the power density is about 300 watts per square meter.

Energy balance of the earth

Only a part (51.6 %) of the radiant energy reaches the earth's surface, 31 % is reflected back into space and 17.4 % is absorbed by the atmosphere. A part contributes to the heating of the oceans and the continents, to the feeding of the wind systems, the water cycle, the ocean current and to the photosynthesis of the plants.

Advantages of photovoltaic

- Profitable
- No interference with the landscape when installing the solar panels: nature conservation is respected
- Every homeowner can become an energy producer
- Neither air pollutants nor CO₂ are produced

¹ Atomkerne

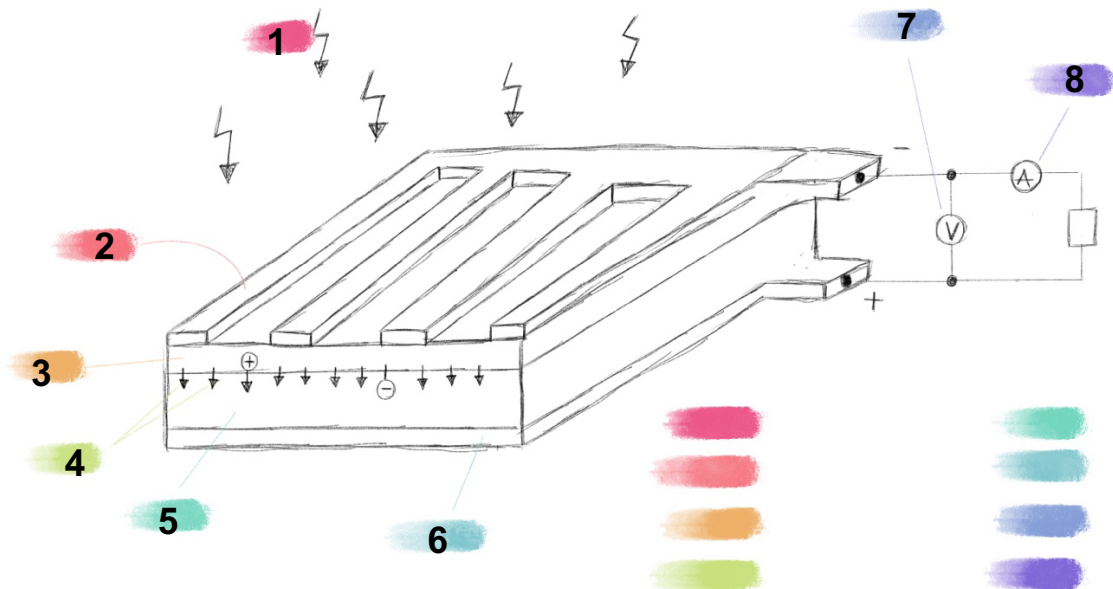
² Strahlungsleistung

³ Solarkonstante

Solar Cells

The power of solar cells is expressed as peak power⁴ in Wp, kWp or MWp. This value shows the maximum output of a solar cell when the solar radiation is 1000 watts per square meter at 25 degrees Celsius temperature.

Principle of a solar cell



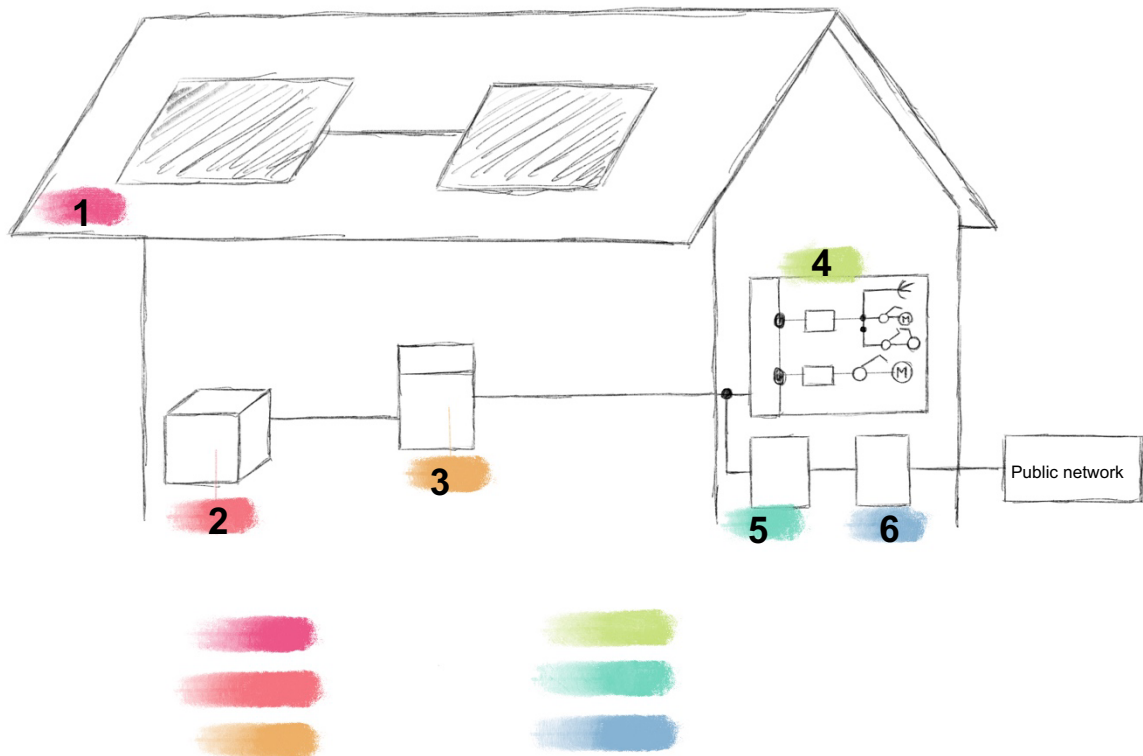
- | | |
|---|---|
| 1. Light (Licht) | 5. P-layer (P-Schicht) |
| 2. Contact finger (Kontaktfinger) | 6. Back surface contact (Rückseitenkontakt) |
| 3. N-layer (N-Schicht) | 7. Photovoltage (Photospannung) |
| 4. Electrical field (Elektrisches Feld) | 8. Photocurrent (Photostrom) |

To achieve higher outputs, solar cells can be connected in series (= higher voltage) or in parallel (= higher current) to form so-called modules. These solar modules usually consist of 30 to 40 solar cells, have operating voltages of 15 - 20 volts and outputs of 40 - 60 watts. To protect the solar cells, bypass-diodes are connected in parallel.

⁴ Spitzenleistung

System with inverter⁵

Inverters convert the direct current generated in the photovoltaic system into alternating current. This conversion is necessary because our power grids and power lines operate with alternating current. The conversion is done accordingly to make the photovoltaic current "compatible".



1. Solar generator / solar panels (Solargenerator / Solarpanels)

2. Inverter (Wechselrichter)

.. is used for the conversion of sunlight into direct current.

3. Individual meter (Privatzähler)

.. measures the energy production of the photovoltaic system.

4. House wiring (Hausinstallation)

.. (light, electrical appliances etc.)

5. Einspeisezähler

.. records the energy that is supplied to the grid.

6. Supply meter (Verbrauchszähler)

.. records the energy that is drawn from the grid.

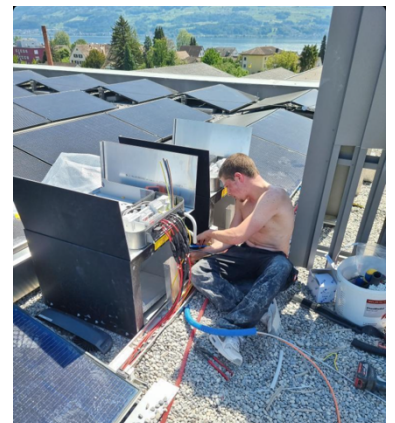


Image 1: Inverter being installed

Now, how does the photovoltaic system work? When sunlight falls on the solar cells, an electrical voltage is generated which is conducted via power lines to the solar generator. This converts the energy into direct current, which in turn is converted directly into usable alternating current via the inverter. The "end product" solar power is either consumed directly, stored via a solar power storage system for later consumption, or fed into the public power grid.

⁵ Wechselrichter

Highlights

It was quite interesting learning more about photovoltaic as an energy source. After I've finished writing about it, I paid close attention to which houses in our neighbourhood had solar panels on their roofs and there were actually quite a few. It's amazing how many households already use eco-friendly energy.



Image 2: House with solar panels in neighbourhood



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A huge THANK YOU!

I wanna thank my best friend Marc Pfister for helping me with this project. Marc works as an electrician and could explain to me exactly how photovoltaics works. Most of the information used in the text above is directly from him. However, I also got some of the information from the following websites:

[1] [Photovoltaics](https://en.wikipedia.org/wiki/Photovoltaics) (Wikipedia.com)

[2] [Photovoltaikanlage](https://www.sonnenstrom.net/) (Sonnenstrom.net)