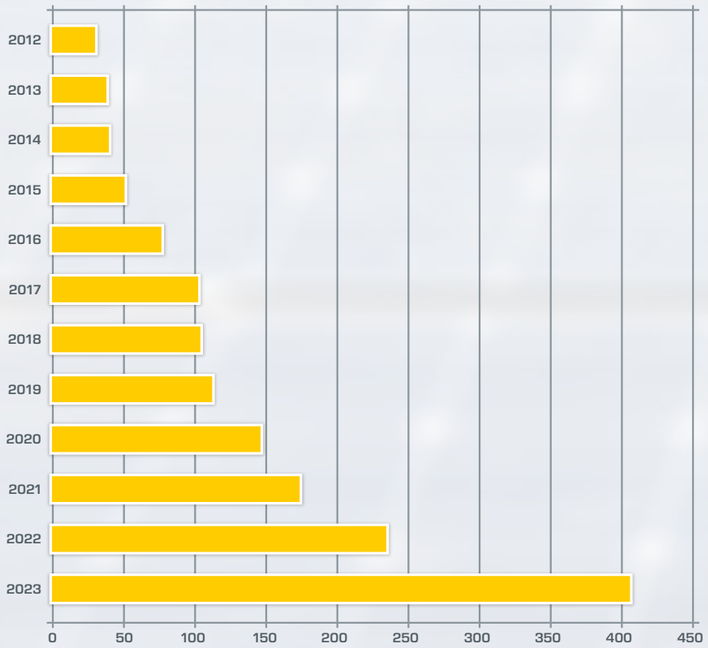
Basic knowledge
Photovoltaics

The energy payback period is the time it takes for a photovoltaic system to generate as much energy as was consumed for its production, installation and maintenance. According to the IEA (International Energy Agency), this period was around 1 to 1,3 years in Europe in 2023.

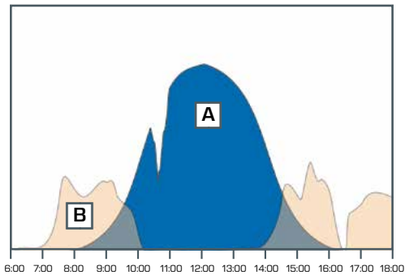
By the end of 2023, systems with a total electrical output of more than 1580 GW had been installed worldwide. As can be seen in the diagram below, the capacity of newly installed systems increased from 236 GWp to more than 400 GWp in 2022 and 2023.



Annual photovoltaic capacity installed worldwide in GWp (source: IEA-PVPS)

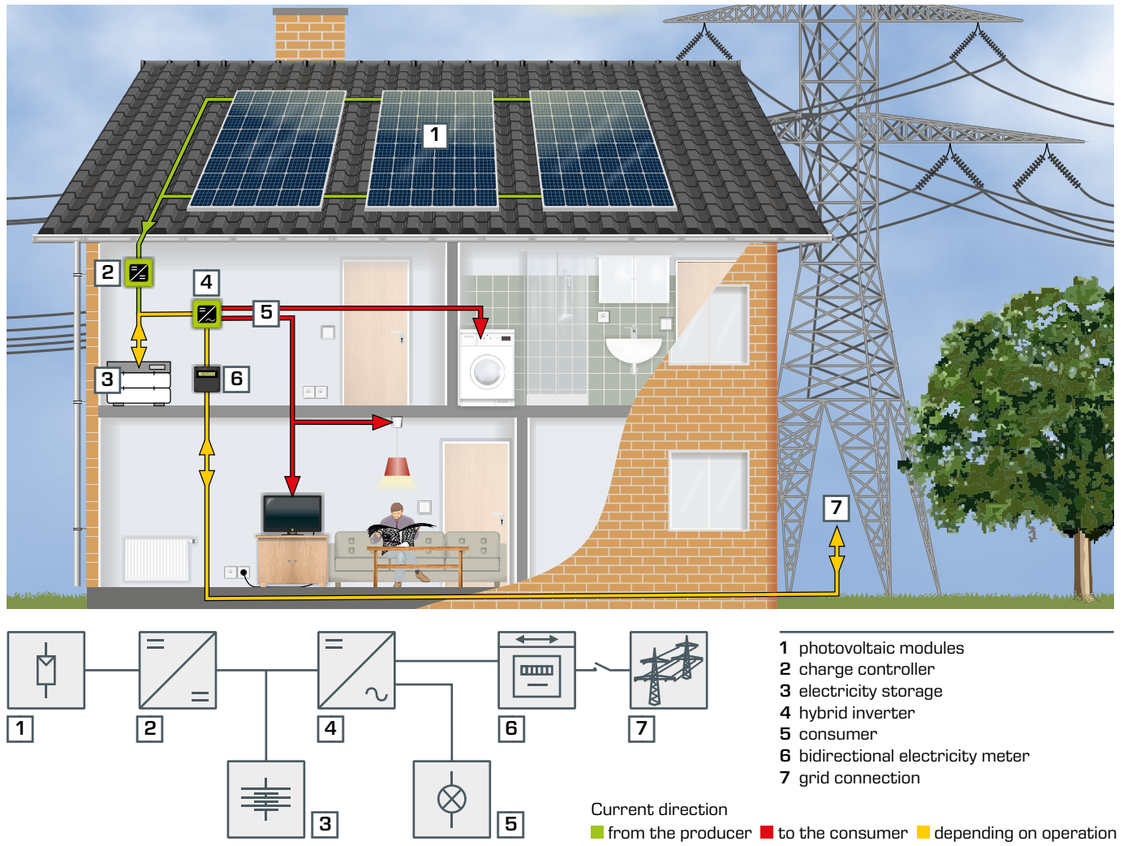
Solar electricity and electricity demand in a residential building

Typical measurement data for the generated solar electricity and the electricity demand of a residential building throughout a day show the need for stored electricity. Only the storage of electricity make it possible to cover the demand in the morning and evening hours.



A electricity generation by photovoltaic modules
B coverage of electricity demand by storages

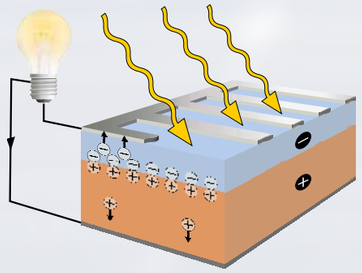
System components for solar electricity utilisation



1 photovoltaic modules
2 charge controller
3 electricity storage
4 hybrid inverter
5 consumer
6 bidirectional electricity meter
7 grid connection

Current direction
from the producer
to the consumer
depending on operation

How semiconductor solar cells work



A semiconductor solar cell converts the radiation energy of light into electrical energy. This requires that the absorbed photons have sufficient energy and/or wavelength. An electron can only be released from the bond of the atomic crystal lattice if the absorbed energy in the semiconductor is sufficient. The mobile electron leaves a free space behind in the crystal lattice. This space, known as a hole, has a positive electrical charge and can also move freely in the semiconductor.

In order to be able to use this mobile electrical charge carrier, an electric field is established in the semiconductor by doping it with suitable impurity atoms.

Under the influence of this internal electric field, generated positive and negative charge carriers can be separated in the solar cell. This means it is possible to use the solar cell as a source in an electrical circuit.

Using solar electricity efficiently

In order to collect the photovoltaic solar electricity, 36 (for example) individual solar cells are combined into one single module. The subsequent use of the solar electricity can be divided into different concepts:

- stand-alone operation
- grid-connected operation
- grid-connected operation with storage

Stand-alone operation is suitable for applications in remote locations with no connection to a public power grid. In this case, some kind of storage is crucial for an uninterrupted electricity supply, in order to also be able to use the electrical energy at night, for example.

Grid-connected photovoltaic installations feed the solar electricity directly into the public grid. This type of setup requires an inverter to convert the direct current of the photovoltaic modules into an alternating current with the appropriate frequency and voltage.

An excess supply of feed-in electricity can cause the public power grid to become unstable. To avoid this effect, there are financial incentives to encourage the private consumption of solar electricity in Germany. Storage systems are added to the necessary grid-connected photovoltaic installations. By skilfully managing consumption and storage load, the proportion of solar electricity that is consumed at the point of generation can be increased considerably.