## 17.2 PRINCIPLES OF PHOTOVOLTAIC POWER SYSTEM CONFIGURATION AND THEIR APPLICATION

Photovoltaic systems are solar energy supply systems, which either supply power directly to electrical equipment or feed energy into the public electricity grid. In the following chapters, the most important application areas will be described in detail and pictures of prominent examples will be shown.

### 17.2.1 Grid-independent Photovoltaic Systems for Small Devices and Appliances

Solar electric power supplies for appliances and small loads in the power range from several milliwatts to several hundred watts are being applied generally because of its cost-effectiveness against a grid connection, in many cases even when the consumer is situated very near to the next grid connection point. Other advantages are their reliability, portability and their environmentally benign production of energy. In very small systems such as wristwatches or scientific calculators, the solar generator consists of one or only a few solar cells. When more power is needed, the individual solar cells are connected together to form solar modules.

An energy storage unit is needed to bridge times when no light or not enough light is available to power the appliance directly. Nickel–cadmium rechargeable batteries are used in most photovoltaically powered appliances, but lead-acid batteries and capacitors (so-called supercaps) can also be used. For caravans, boats and weekend accommodation, special types of car batteries with particularly thick lead plates and special alloys for mobile application can be used. In photovoltaic systems for continuously occupied houses and daily charge/discharge cycles, heavy-duty industrial batteries, the so-called "OpzS" batteries, are most commonly used. They are characterised by very low self-discharge, extremely good tolerance to cycling and thus a long operating lifetime. For small systems, maintenance-free batteries with the electrolyte integrated in matting or in gel form are used. They cannot leak and can thus be operated in any position. As lifetime costs for a stand-alone photovoltaic system are highly dependent on the battery costs, careful selection of the best suited technology for the respective application, operation and battery management schemes are crucial for satisfactory use (see also Section 17.3.1 and Chapter 18 of this book).

A charge controller is included between the solar generator and the battery to prevent it from being overcharged or deep discharged. The charge controller usually has a blocking diode, which prevents the battery from discharging during the night via the solar generator. A good charge controller has very low internal power consumption and includes a load cut-off switch that protects the battery against discharge. Power conditioning may be needed to adapt the voltage level of the photovoltaic system to that of the load. For photovoltaically powered appliances, this is usually a DC/DC converter, which transforms one DC voltage to another. If AC voltage is needed by a consumer, an inverter must be used. This converts the DC voltage delivered by the solar generator or the battery to an AC voltage.