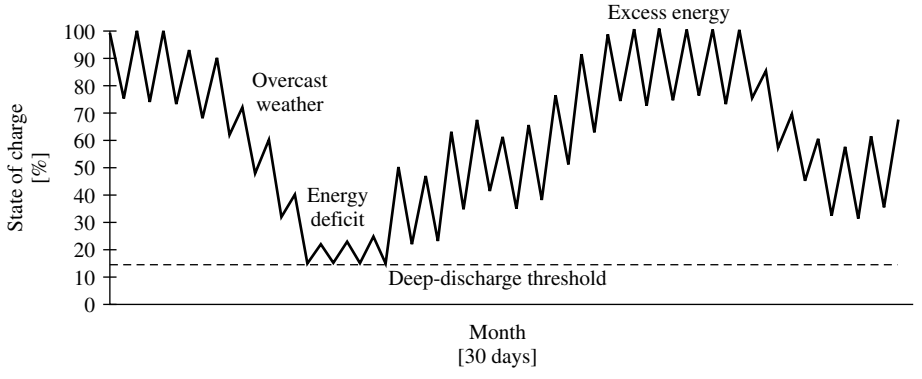

Figure 17.34 Operating conditions of batteries in PV systems

demand of the envisaged loads under average irradiation conditions. These two basic assumptions allow the following points regarding the typical operating conditions of a battery in a stand-alone PV system to be deduced (see also Figure 17.34):

- *Excess energy operation*: In summer, any PV system operates under excess energy operating conditions, since it is designed for lower (average) solar irradiation conditions. As a result, the battery reaches the maximum charge voltage threshold nearly every day at midday or during the early afternoon, and, until evening, it is fully (100%) charged. During the night, the battery discharges and in the morning, at sunrise, it reaches its minimum state of charge, approximately 70% of its rated capacity. During the next day, it repeats the same charge cycle as during the previous day and is again fully charged in the evening. These are optimum operating conditions for a PV battery.
- *Energy deficit operation*: In winter, if not significantly over-dimensioned, the same PV system will encounter energy deficit operating conditions more or less frequently. Each time cloudy weather (without direct sun) persists for some days, the state of charge of the battery will gradually diminish and sooner or later the battery voltage will drop below the minimum discharge voltage threshold. Unless the user reduces consumption voluntarily, the result will be that the DDP cuts off the load. Load cut-off will be maintained by the DDP until the battery is recharged during the next sunny day and reaches a reasonable voltage level, allowing the DDP to switch the load on again. During winter, depending on how carefully the user manages his/her PV system, the battery may very frequently suffer long periods of harmful deep discharge.
- *Float cycling operation*: During those days when the battery reaches neither the 100% full charge condition nor the minimum discharge voltage threshold, it cycles in a semi-charged float condition that is difficult to characterise. However, in comparison to the other two previously described operating conditions, this intermediate operating condition is of little overall significance for the life of the battery since it does not occur nearly as frequently as the other two.

Accordingly, the operating conditions and lifetime of a PV battery are primarily determined by the number of days when the battery reaches 100% full charge condition (which is the optimum) and the number of days when it reaches the minimum discharge