voltage threshold (worst operating condition). If the PV generator has been dimensioned to be too small for the envisaged loads, the battery will reach deep discharge conditions more frequently during the year and its lifetime will be short. If, instead, the PV generator is over-dimensioned, the battery will reach 100% full charge conditions nearly every day of the year, and its lifetime will be longer.

As battery lifetime is one of the key factors that determine lifetime costs of the whole stand-alone Photovoltaic system, one must obey a complex set of rules when aiming for maximum battery lifetime, that is, choose the best suited technology for your application, define properly suited end-of-charge and end-of-discharge thresholds, avoid deep discharge, avoid acid stratification in the electrolyte, avoid high battery temperatures, assure frequent full charging, avoid individualisation of single cells in a series of connected batteries and so on [28, 29]; for more details see Chapter 18.

In Table 17.1 the most important rules to achieve long battery lifetime are summarised.

It must be pointed out that some of the rules are generally in contradiction to each other (e.g. full charging needs high voltages but high voltages accelerate corrosion). In photovoltaic stand-alone systems, it may be difficult to follow these rules at all times. A compromise must be found between the demands of the battery for regular recharging and the investment into expensive photovoltaic generators, so energy may not be available during low insulation periods for recharging of the battery. As the application of the rules is the responsibility of the charge controller, it becomes evident how complex the technical design for this important electronic system component can be.

17.3.2 Charge Controller

Although photovoltaic systems can be used without charge controllers and this practice can be found very often in small PV systems, it has to be stated that while planning the long-term operation of a stand-alone photovoltaic system, it is a must to avoid overcharge and deep discharge. As has been seen in the previous chapter, battery costs over the lifetime of a PV system take the major share of the cost of the system. Battery lifetime again depends to a large degree on its operation strategy.

Table 17.1 Rules for battery management and their positive effects when they are applied

Rule for battery management	Effect when applied
Avoid high voltages during charging on the battery	Less corrosion and loss of water
Avoid low voltages during discharge of the battery	Less corrosion
Avoid extended periods without full charging of the battery	Less sulphatation
Avoid deep discharge	Less sulphatation and growth of dendrites
Avoid reverse charging of the cells	Less degradation of negative electrodes
Avoid stratification of the electrolyte	Less sulphatation
Avoid high battery temperatures	Slower ageing processes
Overcharge the battery slightly once a month	Frequent full charging is assured