energy from regenerative breaking and to support acceleration. However, storage times are in the range of seconds. Compressed air storage in the MWh range, which after decades of development has not reached the market, and pumped water storage are the other technologies that store the energy mechanically. Pumped water storage shows a pronounced economy of scale, which means that larger systems have lower specific investment costs and better storage efficiencies. This is the reason pumped storage has its application in small grids that supply power in megawatt hours per day rather than in the domain of energy systems based on photovoltaics, which are and will be designed to deliver some 10 kilowatt hours per day.

The most promising storage technologies today for the application of which we are discussing here, are electrochemical systems [1]. Therefore, this chapter is dedicated to electrochemical storage systems only.

Although a variety of storage technologies are under development, for the systems focused in this chapter the lead acid battery still is, and will be for some years to come, the working horse for autonomous power supply systems. The ageing effects that limit battery lifetimes are treated in detail. Optimised control strategies allow increasing the battery lifetime and a considerable reduction of the overall system costs.

For storing large energy quantities with low power requirements, electrochemical storage systems with separate storage and power conversion units are under development. These are namely hydrogen storage systems with an electrolyser and a fuel cell as converters and redox-battery systems. The latter use charged ions from metal salts dissolved in liquids as the storage medium and a converter unit quite similar to a fuel cell. These systems are getting more and more interesting as seasonal storage systems and for balancing power generation and power demand in grids with a high penetration of renewable power sources (mainly wind and sun).

There are numerous requirements for storage systems in autonomous power supply systems. Their importance in different applications is different; some of them are in contradiction to each other and therefore they cannot be fulfilled at the same time. Table 18.1

Table 18.1 Requirements to electrical storage systems in autonomous power supply systems (the order of appearance does not imply any weighting of their importance)

• High energy efficiency	• Low exposure
• Long lifetime (years)	• Easy recycling
• Long lifetime in terms of capacity throughput	• Low toxicity of materials
• Low costs	• Fail-safe behaviour at overcharging or deep discharge
• Good charge efficiency even at very low currents	• Easy extendibility in voltage and capacity through series and parallel connection
• Low self-discharge rate	• Low voltage gap between charging and discharging (allows direct connection of loads to the battery)
• Low maintenance requirements	• Fast charging ability
• High availability worldwide	• No memory effect
• High power availability	• Low explosive potential
• Easy estimation of state of charge and state of health	• High reliability in operation: high MTBF

Note: MTBF: mean time between failure