gives an overview of the most important requirements of batteries in autonomous power supply systems.

System designs for autonomous power supply systems should track the properties and the requirements of the storage system from the very beginning. Planning of a system and later on just adding the storage will neglect the numerous interactions between the storage, its peripherals and its operation strategy and the overall system design and control. Therefore, only an integrated planning of the system allows to use all synergies and to design systems that can be operated during their lifetime at minimum costs.

18.2 GENERAL CONCEPT OF ELECTROCHEMICAL BATTERIES

18.2.1 Fundamentals of Electrochemical Cells[1]

18.2.1.1 The equilibrium potential

The basic element of each battery is the electrochemical cell. A positive and a negative electrode are immersed in an electrolyte. The reactive substances (the active materials) are stored in the electrodes.[2] Chemical and electro chemical reactions, the electrode reactions, occur at both electrodes, which release or absorb electrons according to

$$S(N)_{\mathrm{red}} \rightarrow S(N)_{\mathrm{ox}} + n \cdot \mathrm{e}^- \quad \text{or} \quad S(P)_{\mathrm{ox}} + n \cdot \mathrm{e}^- \rightarrow S(P)_{\mathrm{red}}$$

N and P indicate negative and positive electrodes, S_{red} and S_{ox} indicate the reduced and oxidised states of the chemical compounds that react and n is the number of electrons involved in the process. The possibility of splitting up the cell reaction into two separate electrode reactions is a decisive prerequisite for the realisation of any electrochemical cell. Only then can the electron exchange connected with the electrode reactions be collected as a current that flows through the consumer (or the charging device), and the energy input or output connected with the chemical reaction be converted into electrical energy. Otherwise, the reaction would occur merely as a chemical reaction. The electrical charge would be exchanged directly between the reacting substances and the released energy would be converted predominantly into heat and to some extent into volume energy.

The electrochemical storage system is based on the conversion of chemical energy into electrical energy and vice versa. The amount of energy that can be stored in a cell is determined by the different energy content of chemical substances that represent the charged and discharged states. Consequently, the characteristic parameters of the system are determined by a number of electrochemical reactions and the energetic changes connected with these reactions. In total, these reactions result in the cell reactions that characterise the battery system.

[1] This section is based on Chapters 2.1, 2.2 and 2.3 from the book of D. Berndt "Maintenance-free batteries" [3] which can be highly recommended for a deeper insight into applied battery technology.

[2] Please note: the wording used herein is characteristic for classical electrochemical secondary accumulators with solid active masses and a liquid electrolyte. In fact, batteries with solid electrolytes and liquid active masses exist as well. Examples are redox-flow batteries (see Section 18.5.1) or the NaS batteries (liquid Na and S as active masses, solid oxide ceramic as electrolyte).