Technology: Lead-Acid Battery

GENERAL DESCRIPTION

Mode of energy intake and output

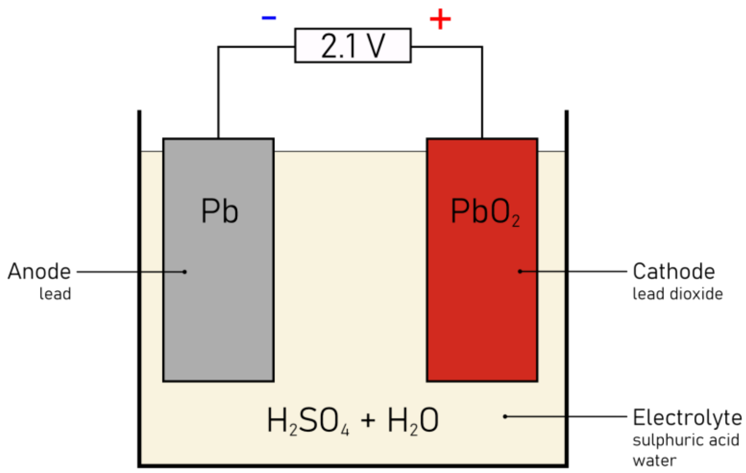
Power-to-power

Summary of the storage process

When discharging and charging lead-acid batteries, certain substances present in the battery (PbO_2, Pb, SO_4) are degraded while new ones are formed and vice versa. Mass is therefore converted in both directions. In this process, electrical energy is either stored in (charging) or withdrawn from the battery (discharging).

System Design

There are two general types of lead-acid batteries: closed and sealed designs. In closed lead-acid batteries, the electrolyte consists of water-diluted sulphuric acid. These batteries have no gas-tight seal. Due to the electrochemical potentials, water splits into hydrogen and oxygen in a closed lead-acid battery. These gases must be able to leave the battery vessel. Moreover, demineralised water needs to be refilled occasionally. In sealed lead batteries, the electrolyte (also diluted sulphuric acid) is contained in a glass-fibre fleece or gel. Hence, there is no need for water refilling and the cells must not be opened. Occasionally occurring hydrogen and oxygen gases are released into the environment via valves in the battery lid.



$$Pb + PbO_2 + 2\,H_2SO_4 \underset{\text{charging}}{\overset{\text{discharging}}{\rightleftharpoons}} 2\,PbSO_4 + 2\,H_2O$$

Figure 1: Schematic view of a lead-acid battery with chemical reactions for charging and discharging

Suitable fields of application

Emergency power supply, provision of control energy for power generation and distribution, shaving of load or generation peaks, intermediate storage of electric energy e.g. combined with renewable energies, provision of traction energy, and application as a starter battery.

State of development/commercial availability

Lead-acid batteries have been commercially available for over a hundred years and undergone optimisation for specific applications in a variety of designs. Due to their long history, lead-acid batteries are technically very mature (TRL 9).

Figure 2: Closed lead-acid batteries with armour plate electrode (l.) and grid plate electrode (r.) (© Maurer Elektro-maschinen)

Moreover, lead-acid batteries can be further subdivided by their different types of positive electrode into armoured plate, grid plate, and large surface types (Fig. 3).

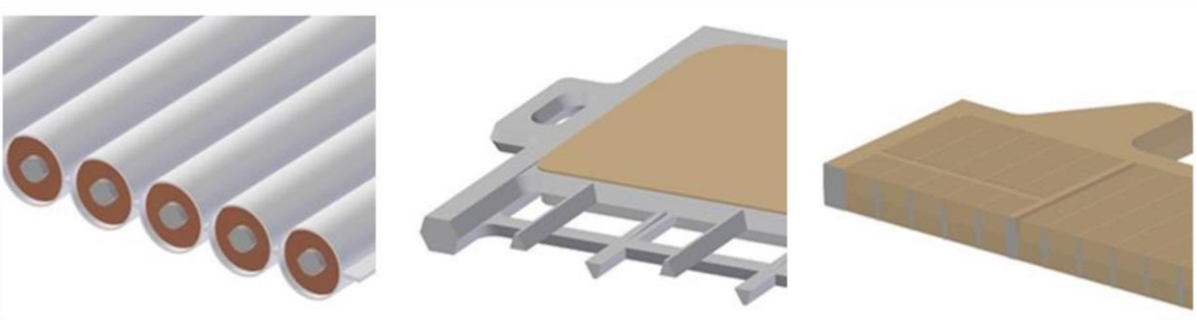


Figure 3: Armoured plate battery, grid plate battery, large surface battery (f.l.t.r.)

TECHNICAL SPECIFICATIONS

Specific energy storage density	kWh/m^3	kWh/t
	60-90	35
Specific power density	kW/m^3	kW/t
	63-154.5	26-125
Typical/feasible storage size	MWh_{out}	MW_{out}
	Irrelevant	Irrelevant
System efficiency	Depends on system configuration	
Storage efficiency	87-92 %	
Storage duration	Hours-days	

Response time	< 1 s	
Service life (maximum)	Cycles 3.000 (at 50 % DoD)	Years Up to 25 (GroE battery)
Loss per time in %	2-3 % per month	

ECONOMIC SPECIFICATIONS

Investment cost per kW: battery only ca. 55-165 €/kW

Investment cost per kWh: battery only ca. 145-450 €/kWh

Operating and maintenance cost (based on investment)

≤ 1 %/year (highly depending on battery type)

Cost of energy provided in concrete applications

Example 1:
Application: Intelligent renewable energy storage for 250 households
Location: Kisselbach, Germany
Capacity: 288 kWh
Battery cost: 175€/kWh
(battery only, not including system)

Example 2:
Application: buffer storage for PV energy, approx. 320 cycles/year
Location: Tahiti
Capacity: 927 kWh
Battery cost: 145€/kWh
(battery only, not including system)