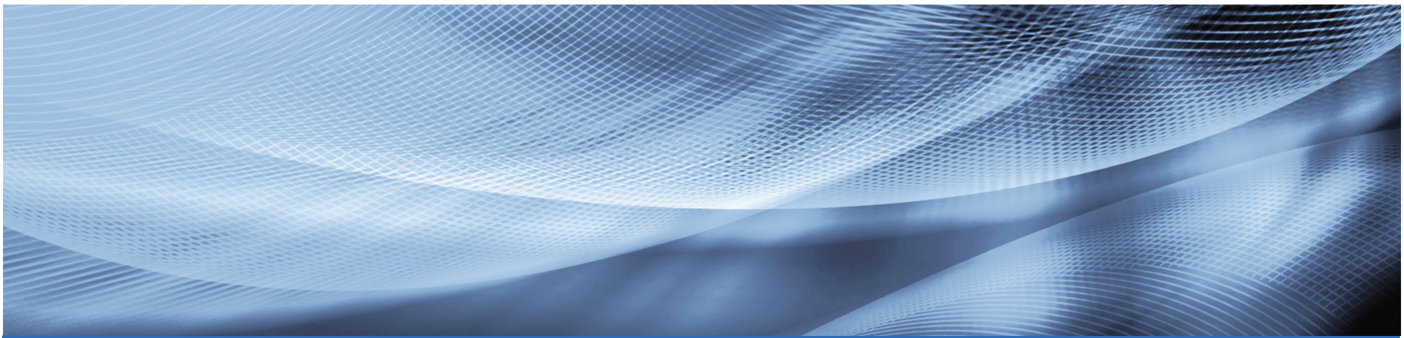
Lithium-Ion Battery



Electrochemical Energy Storage

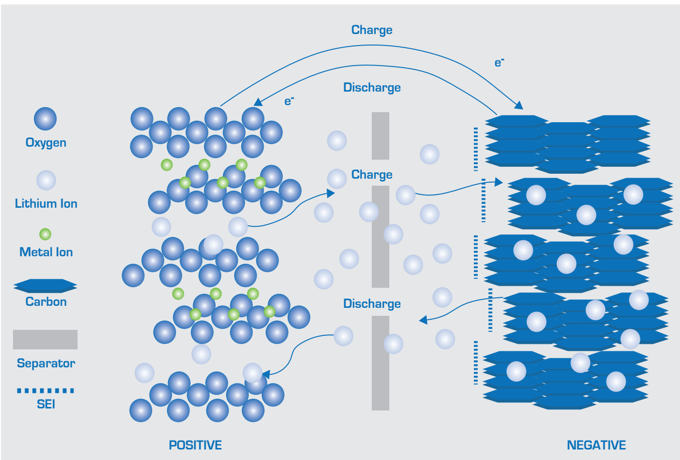
1. Technical description

A. Physical principles

A Lithium Ion (Li-Ion) Battery System is an energy storage system based on electrochemical charge/discharge reactions that occur between a positive electrode (cathode) that contains some lithiated metal oxide and a negative electrode (anode) that is made of carbon material or intercalation compounds. The electrodes are separated by porous polymeric materials which allow for electron and ionic flow between each other and are immersed in an electrolyte that is made up of lithium salts (such as $LiPF_6$) dissolved in organic liquids.

When the battery is being charged, the lithium atoms in the cathode become ions and migrate through the electrolyte toward the carbon anode where they combine with external electrons and are deposited between carbon layers as lithium atoms. This process is reversed during discharge.

Illustration: Charging principal of LI-ION



B. Important components

The main components are the following:

- Elementary cell composed of an assembling of electrodes, electrolyte and separators
- Modules composed of serial or parallel assembling of cells
- Battery systems composed of a large assembling of modules, battery management system and thermal management system
- Power Conversion System (PCS)

C. Key performance data

Power range	1kW to 50 MW
Energy range	Up to 10 MWh
Discharge time	10min to 4h
Cycle life	2,000 - 10,000 cycles
Life duration	15 – 20 years
Reaction time	Some millisec
Efficiency	90 - 98 % (*)
Energy (power) density	120 - 180 Wh/kg
CAPEX: energy	700 – 1,300 €/kWh
CAPEX: power	150 – 1,000 €/kW

(*) NOT including auxiliary loads

D. Design variants (non exhaustive)

The following design variants are available:

- Different electrochemistries: $LiCO_2$, LiNCA, LiNMC, $LiFePO_4$, $LiMn_2O_4$, LiT_0, etc.
- Liquid electrolyte or polymeric electrolyte
- Different cell shapes: cylindrical, prismatic, pouch
- Different electrode thickness according to the Energy/Power ratio
- Different battery systems according to the size: case up to container

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2. State-of-the-art

Commercialised since the beginning of the 90's, Li-Ion batteries took over 50% of the small mobile phone market in only a few years, but there are some challenges for making large-scale Li-Ion batteries. Manufacturers are working to reduce the cost of Li-Ion batteries, which is expected to drop further with the take-off of automotive and energy storage markets.

The implementation of Li-Ion batteries in the stationary field has significantly increased since 2010 and has benefited from the extensive experience gained in the development of batteries for electric and hybrid vehicles. In 2015, more than 500MW of stationary Li-Ion batteries were operating worldwide in grid-connected installations. Systems in association with distributed renewable generators from a few kW to several MW, as well as for grid support with voltages up to 1kV have been designed and successfully tested. Whereas early systems were implemented for demonstration purposes, only a commercial market is now developing for such applications in different regions of the world.

Recycling processes and installations are in place achieving a recycling efficiency of well above 50%.

3. Future developments

Technology improvements will further increase energy density, cycle and calendar life. The building up of industrial capacity for mass production of industrial size cells and batteries (driven by the automotive, energy storage and other mass markets) is poised to reduce system costs in the future. Increased market volume will drive a greater differentiation of system solutions for different application fields, along with a strong integration of segment specific system functions.

4. Relevance in Europe

Europe is one of the leading continents in utilising Li-ion batteries in multiple applications, including stationary energy storage, rail, marine, truck and automotive. For the energy storage market in particular, the leading countries for the deployment of Li-Ion batteries are: Italy for T&D grid support, Germany for PV self-consumption, and France in the island grids. Most suppliers of Li-Ion batteries are from Asia (Korea, China and Japan), but there are several European manufacturers of Li-Ion batteries and grid-connected Li-Ion storage systems. The other main European players are the so-called integrators that integrate Li-Ion battery modules from different battery suppliers together with inverters and control systems.

5. Applications

Due to their high scalability and flexibility in power and energy, Li-Ion batteries are used in a large variety of applications:

Residential and commercial buildings: time shifting and self-consumption of locally produced PV energy

Distribution grids: voltage, capacity and contingency support of smart grids

Transmission grids: Ancillary services, namely frequency regulation

Renewable generation: smoothing and shaping functions associated with voltage and frequency support to ensure better integration of large renewable plants into the electricity system

6. Sources of informations

- EASE Members
- EUROBAT
- ISEA RWTH Aachen
- Saft