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Comparison of Lithium-ion batteries

For rechargeable batteries, energy density, safety, charge and discharge performance, efficiency, life cycle, cost and maintenance issues are the points of interest when comparing different technologies. There are many types of lithium-ion batteries differed by their chemistries in active materials. Here, a brief comparison is summarized for some of the variants. Battery chemistries are identified in abbreviated letters, such as:

- Lithium Iron Phosphate (LiFePO4) — LFP
- Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO2) — NMC
- Lithium Nickel Cobalt Aluminum (LiNiCoAlO2) — NCA
- Lithium Manganese Oxide (LiNiMnCoO2) — LMO
- Lithium Cobalt Oxide (LiCoO2) — LCO

LFP consists of phosphate in the cathode material. It offers higher thermal stability but moderate specific energy and a lower nominal voltage than some other types of Li-ion batteries. The key benefits are high current rating and long cycle life, as well as enhanced safety and tolerance if abused. The cost of LFP is lowest among different types of Li-ion batteries.

NMC consists of different portions of each of nickel, manganese and cobalt in the cathode material. The advantage of NMC are that its structure can be adapted to the purpose of use, for example to obtain high capacity or high specific power. In addition, it has higher energy density compared to other variants, such as LFP and LMO. However, its thermal stability is poor compared to LFP.

NCA is a development of lithium-nickel oxide, with added aluminum to increase stability. The specific energy density for NCA is similar or even higher than NMC. The battery is mostly used for high energy applications such as electric vehicles. Disadvantages are the safety and cost.

LMO consists manganese oxide in the cathode material. The structure of the cell provides low internal resistance, and thereby fast charging time, as well as thermal stability. The disadvantage of the LMO is that it has both a shorter lifespan and a shorter cycling life.

LCO consists of a cobalt oxide cathode. It offers a high specific energy. The drawback of LCO is a relatively short life span, low thermal stability and limited specific power.

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There are some other types of Li-ion batteries not mentioned here, such as Lithium Titanate (LTO) and Li-polymer batteries. The Li-ion battery technology is continuously developed for achieving higher specific energy and specific power, such as lithium-metal and solid state lithium batteries.

Some main features of different Li-ion battery technologies are compared in figure 1. The energy density for different types of batteries are also illustrated.

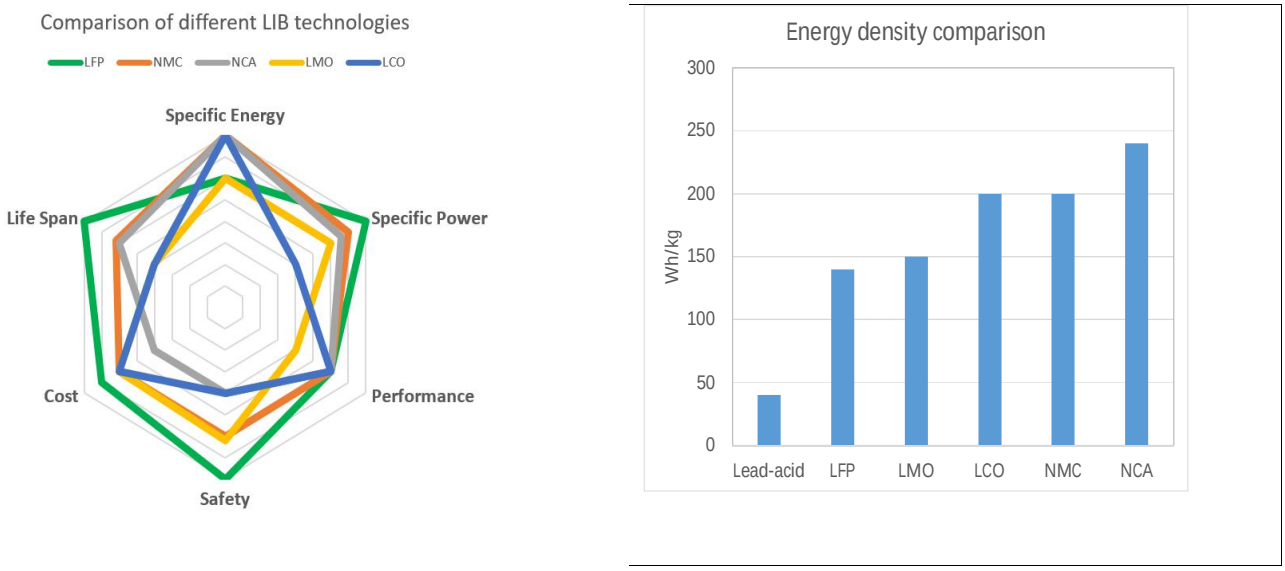

Figure 1. Snapshot and energy density for different types of batteries.

Currently, the most common Li-ion batteries in telecom applications are LFP, NMC and NCA. Some of their characteristics are summarized in the following table. Lead-acid is also compared since it's the conventional technology in telecom applications today.

Specifications	Lead-acid	LFP	NMC	NCA
Nominal voltage (V)	2	3.2	3.6 – 3.7	3.6 – 3.7
Typical operating range (V/cell)	1.6 – 2.4	2.5 – 3.6	2.5 – 4.2	2.5 – 4.2
Specific energy (Wh/kg)	30 – 50	90 – 150	150 – 220	200 – 260
Typical charge rate	0.2C	0.5C	0.5C	0.5C
Typical discharge rate	0.1-0.5C	1-2C	1-2C	1C
Charge temperature (°C)	-20 – 50	0 – 55	0 – 50	0 – 50
Discharge temperature (°C)	-20 – 50	-20 – 55	-20 – 50	-20 – 50
Cycle life (100%DOD)	200 – 300	1000 – 4000	500 – 2000	500 – 2000
Thermal runaway temperature (°C) and comment	100 – 150 Plastic container gets soften and melt	270 Very safe even if fully charged	210 High charge promotes thermal runaway	150 High charge promotes thermal runaway

Table 1. Comparison of certain battery characteristics.