# Comparison Battery Technologies for Telecom

## Secondary battery technologies

**Rechargeable batteries play an important role in our life and many daily chores would be unthinkable without the ability to recharge an empty battery. Points of interest are specific energy, years of service life, load characteristics, safety, price, self-discharge, environmental issues, maintenance requirements, and disposal.**

### Lead Acid

One of the oldest rechargeable battery systems; is rugged, forgiving if abused and economical in price; has a low specific energy and limited cycle life. Lead acid is used for wheelchairs, golf cars, personnel carriers, emergency lighting and uninterruptible power supply (UPS).

### Nickel-cadmium (NiCd)

Mature and well understood; is used where long service life, high discharge current, extreme temperatures and economical price are of importance. Due to environmental concerns, NiCd is being replaced with other chemistries. Main applications are power tools, two-way radios, aircraft and UPS.

### Nickel-metal-hydride (NiMH)

A practical replacement for NiCd; has higher specific energy with fewer toxic metals. NiMH is used for medical instruments, hybrid cars and industrial applications. NiMH is available in AA and AAA cells for consumer use.

### Lithium-ion (Li-ion)

Most promising battery systems; is used for portable consumer products as well as electric powertrains for vehicles; is more expensive than nickel- and lead acid systems and needs protection circuit for safety.

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The lithium-ion family is divided into three major battery types, so named by their cathode oxides, which are cobalt, manganese and phosphate. The characteristics of these Li-ion systems are as follows.

- **Lithium-ion-cobalt** or *lithium-cobalt* ($LiCoO_2$): Has high specific energy with moderate load capabilities and modest service life. Applications include cell phones, laptops, digital cameras and wearable products.

- **Lithium-ion-manganese** or *lithium-manganese* ($LiMn_2O_4$): Is capable of high charge and discharge currents but has low specific energy and modest service life; used for power tools, medical instruments and electric powertrains.

- **Lithium-ion-phosphate** or *lithium-phosphate* ($LiFePO_4$): Is similar to lithium-manganese; nominal voltage is 3.3V/cell; offers long cycle life, has a good safe record but exhibits higher self-discharge than other Li-ion systems.

There are many other lithium-ion based batteries. Missing in the list is also the popular lithium-ion-polymer, or *Li-polyme*r. While Li-ion systems get their name from their unique cathode materials, Li-polymer differs by having a distinct architecture. Nor is the rechargeable lithium-metal mentioned. This battery requires further development to control dendrite growth, which can compromise safety. Once solved, Li-metal will become an alternative battery choice with extraordinary high specific energy and good specific power.

## TABLE 1

| Specifications | LEAD ACID | NiCD | NiHN | LI-ION | | |
|---|---|---|---|---|---|---|
| | | | | Cobalt | Manganese | Phosphate |
| **Specific energy density (Wh/kg)** | 30–50 | 45–80 | 60–120 | 150–190 | 100–135 | 90–120 |
| **Internal resistance[1] (mΩ)** | <100<br>12 V pack | 100–200<br>6 V pack | 200–300<br>6 V pack | 150–300<br>7.2 V | 25–752<br>per cell | 25–502<br>per cell |
| **Cycle life[1] (80% discharge)** | 200–300 | 1000[3] | 300-500[3] | 500–1 000 | 500–1 000 | 1 000–<br>2 000 |
| **Fast-charge time** | 8–16h | 1h typical | 2–4h | 2–4h | 1h or less | 1h or less |
| **Overcharge tolerance** | High | Moderate | Low | Low. Cannot tolerate trickle charge | | |
| **Self-discharge/mo (room temp)** | 5% | 20%[5] | 30%[5] | <10%[5] | | |
| **Cell voltage (nominal)** | 2V | 1.2V[7] | 1.2V[7] | 3.6V[8] | 3.8V[8] | 3.3V |
| **Charge cutof voltage (V/cell)** | 2.40<br>Float 2.25 | Full charge detection by voltage signature | | 4.20 | | 3.60 |
| **Discharge cutoff voltage (V/cell, 1C)** | 1.75 | 1.00 | | 2.50–3.00 | | 2.80 |
| **Peak load current Best result** | 5C[9]<br>0.2C | 20C<br>1C | 5C<br>0.5C | >3C<br><1C | >30C<br><10C | >30C<br><10C |
| **Charge temperature** | -20 to 50°C | 0 to 45°C | | 0 to 45°C [10] | | |
| **Discharge temperature** | -20 to 50°C | -20 to 65°C | | -20 to 60°C | | |
| **Maintenance requirement** | 3–6 months[11] (topping chg) | 30–60 days (discharge) | 60–90 days (discharge | Not required | | |
| **Safety requirements** | Thermally stable | Thermally stable, fuse protection common | | Protection circuit mandatory[12] | | |
| **In use since** | Late 1800s | 1950 | 1990 | 1991 | 1996 | 1999 |

***Compares the characteristics of four commonly used rechargeable battery systems showing average performance ratings at time of publication.***

**Table 1:** Characteristics of commonly used rechargeable batteries The figures are based on average ratings of commercial batteries at time of publication; experimental batteries with ratings are excluded.

1. Internal resistance of a battery pack varies with milliampere-hour (mAh) rating, wiring and number of cells. Protection circuit of lithium-ion adds about 100mΩ.
2. Based on 18650 cell size. Cell size and design determines internal resistance.
3. Cycle life is based on battery receiving regular maintenance.
4. Cycle life is based on the depth of discharge (DoD). Shallow DoD improves cycle life.
5. Self-discharge is highest immediately after charge. NiCd loses 10% in the first 24 hours, then declines to 10% every 30 days. High temperature increases self-discharge.
6. Internal protection circuits typically consume 3% of the stored energy per month.
7. The traditional voltage is 1.25V; 1.2V is more commonly used.
8. Low internal resistance reduces the voltage drop under load and Li-ion is often rated higher than 3.6V/cell. Cells marked 3.7V and 3.8V are fully compatible with 3.6V.
9. Capable of high current pulses; needs time to recuperate.
10. Do not charge regular Li-ion below freezing.
11. Maintenance may be in the form of equalizing or topping charge to prevent sulfation.
12. Cut-off if less than 2.20V or more than 4.30V for most Li-ion; different voltage settings apply for lithium-iron-phosphate.

## Stationary battery alternatives

Stationary batteries are almost always lead acid. Size and weight is of lesser concern. The limited cycle count does not pose a major problem because the batteries are seldom deep discharged. Large stationary systems are mostly mature flooded systems that provide a reliable and economical service, but they need regular maintenance in form of checking the electrolyte level and adding water. Automatic watering reduces some of this routine maintenance work.

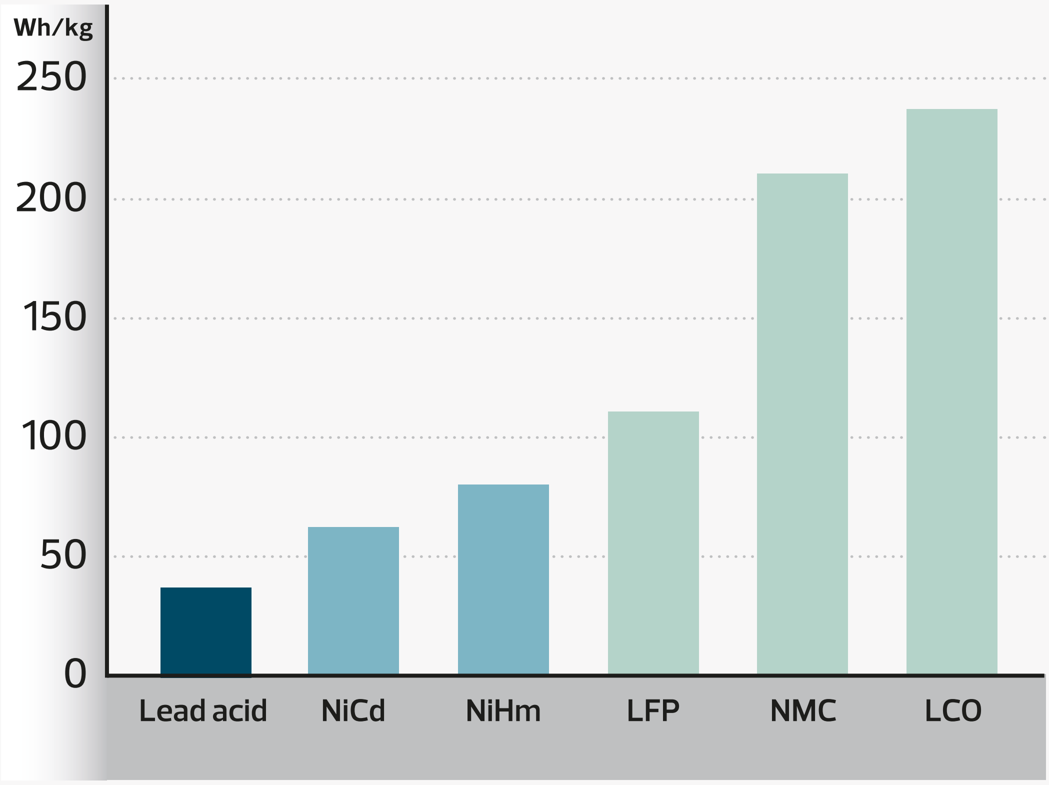
*Valve-regulated lead acid (VRLA)* offers a lower-cost alternative to flooded lead acid. Being maintenance-free, the battery can be installed and forgotten. This benefit is often taken to the extreme in that the batteries are neglected. In the absence of adding water, maintenance comes in the form of checking the voltage, internal resistance and verifying capacity.

*Flooded nickel-cadmium batteries* are used in applications that need regular deep cycling or are exposed to hot and cold temperatures. NiCd for stationary applications is about four times the price of lead acid; however, the vendors say that improved longevity will make up for the higher cost. Flooded nickel-cadmium batteries are nonsintered and don't have memory.

Battery manufacturers are introducing *NiMH* and *Li-ion* batteries for stationary uses. **The advantages are wide temperature range and the ability to deep cycle and fast charge. These batteries have a small footprint, need minimal ventilation and have a long life.**

**When storing energy from renewable sources, such as from solar cells, NiMH and Li-ion do not suffer from sulfation as lead acid does when not fully charged. Li-ion has the added benefit of being light. It can be made semi-portable for temporary systems and remote installations.**

NiMH and Li-ion have been more expensive than lead acid and the industry has continued to rely on lead acid batteries for common UPS systems. Experts earlier predictions that alternate chemistries will find market acceptance for general use once the total cost of ownership is similar or better of a lead acid system.




*Data and info: www.batteryuniversity.com*