

# LITHIUM-ION BATTERIES



**CASES**

## FACT SHEET

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## What is a Lithium-Ion Battery?

Batteries are a technology that stores and releases energy. This occurs through an electrochemical reaction between two electrodes: a positive electrode, called the cathode, and a negative electrode, called the anode. The movement of electrons from the anode to the cathode converts chemical energy into electricity. In lithium-ion batteries, the electrons that travel from the anode to the cathode are lithium ions.

Lithium-based batteries have become a popular choice for rechargeable batteries thanks to lithium's high energy density and ability to store energy for relatively long periods.

## What Are Lithium-Ion Batteries Used For?

Lithium-ion batteries were initially developed to power portable consumer electronics. Since they offer high energy density, they can provide hours of power in a small, lightweight package. Additionally, they have a long lifespan, which means that they can be recharged thousands of times with little performance loss.

These features have made lithium-ion batteries an attractive option even beyond the consumer electronics industry. Today, they are used in vehicles, residential and industrial power support, and even grid-scale power plants.

The increased demand for lithium-ion batteries has led to greater efficiencies in the technology and manufacturing of lithium-ion batteries. These developments have reduced their cost over the last decade by 90%.[1]

[1] International Energy Agency, The Role of Critical Minerals in Clean Energy Transitions, Revised version March 2022, 11.

## Lithium-Ion Batteries and Renewable Energy

Lithium-ion batteries play an increasingly important role in the deployment of renewable energy solutions, particularly solar photovoltaics and wind turbines. These two sources of energy are considered intermittent. This means that they do not provide constant power since they rely on either daylight hours or wind patterns.

Large-scale lithium-ion battery modules can balance these inconsistencies when used as a battery energy storage system, or BESS. When the wind is blowing but there is little need for electricity—particularly at night—or when solar energy is greater than demand, the excess power can be stored in batteries. This prevents the potential energy from being lost and allows users to access this power from the battery when needed.

Lithium-ion batteries are advantageous in the event of a power outage or grid failure since they can supply electricity rapidly. The disadvantage of lithium-ion batteries is that they provide an average of four hours of power when discharging at maximum power capacity.

## Types of Lithium-Ion Battery

In most lithium-ion batteries, the anode in the battery cell is made of a lithium graphite compound and the electrolyte (the material through which the lithium ions travel between the negatively charged anode and the positively charged cathode) is an organic solvent containing lithium salt.



However, the materials that make up the electrodes come in a variety of combinations. Different compositions produce different forms of lithium-ion batteries that have varying characteristics. These include variations in the cost, performance, specific energy, specific power, lifespan and safety profile among the several types of lithium-ion batteries.

### **Six Types of Lithium-Ion Batteries**

#### **1. Lithium Nickel Manganese Cobalt Oxide (NMC)**

NMC is one of the most common types of lithium-ion batteries. The ratio between the nickel, manganese and cobalt can be adjusted to determine the cost and operational attributes of the battery.

A higher proportion of nickel produces a battery with a lower cost, longer lifecycle, high specific energy and greater energy density. A greater proportion of manganese provides higher specific power and greater durability.

The lower cost of NMC batteries along with their high charge lifecycle makes them a popular choice for applications that require frequent charging and a high safety standard, such as medical devices, electric vehicles and energy storage systems.

#### **2. Lithium Iron Phosphate (LFP)**

The material composition of LFP makes it a more cost effective, safer and more durable option. Its high heat threshold means that there is a lower risk of thermal runaway. On the other hand, LFP is susceptible to reduced performance in cold temperatures.

The LFP battery has a lower voltage and thus lower specific energy than other lithium-ion batteries. However, it provides higher specific power. It also has a higher life cycle at over 2000 charge cycles.

#### **3. Lithium Nickel Cobalt Aluminum Oxide (NCA)**

The cathode composition of NCA provides high specific energy and moderate specific power rather than a tradeoff between one or the other. The ability to provide high power and a long charge makes it a popular choice for electric vehicles.

The downside of the NCA battery is its high cost. It is also less stable than other compositions, which increases the risk of thermal runaway.

#### **4. Lithium Manganese Oxide (LMO)**

LMO has a short lifespan but is low in cost. Its ability to provide moderately high specific power has made it a popular option for electric vehicles in combination with NMC batteries. The LMO provides power on acceleration while the NMC provides a long range.

Its high specific power and relatively high safety also makes it a popular option for power tools and medical devices.

#### **5. Lithium Cobalt Oxide (LCO)**

LCO batteries are low cost and have high specific energy. As they provide a low energy load over a long period, they are commonly used in consumer electronics, such as laptops, tablets, cameras and phones.

They have a short lifespan and are more susceptible to thermal runaway. This risk increases if they are fully charged.

#### **6. Lithium Titanate (LTO)**

LTO batteries are unique in that they replace the graphite-based anode with a lithium titanate composition. This enables rapid charging, greater performance range, higher safety and long lifespan.

The cathode chemistry used in LTO batteries is either LMO or NMC. LTO batteries have low energy density and are more than double the cost of other lithium-ion batteries. They are most commonly used in aerospace and military applications.



## Key Attributes that Differ Across Lithium-Ion Battery Compositions

**Cost**—The cost differences between each type of lithium-ion battery is dependent on the market value of the metals used in the electrodes.

**Performance**—The performance of a battery refers to its ability to store and supply power under wide ranges of hot and cold temperatures.

**Specific Energy**—This refers to the duration of a battery expressed in Watt-hours per kilogram (Wh/kg).

**Specific Power**—This refers to the power capacity of a battery expressed in Watts per kilogram (W/kg). A battery will have either a high power capacity and short duration (i.e. power tools) or moderate power output and a long duration.

**Lifespan**—The lifespan of a battery describes both how long it will last in years and how many charge and discharge cycles it can go through before performance decline.

**Safety**—Although rare, the primary safety concern is thermal runaway, which is overheating that can lead to flaming gases. This could occur due to damage to the battery or using an old battery.

