ANA ENERGY

WHY LTO AND HOW DOES IT COMPARE

ANACORP.COM

WHY LTO AND HOW DOES IT COMPARE

Lithium-ion batteries power a vast range of industrial and consumer products we rely on every day, from smartphones and laptops to electric vehicles (EVs). As global efforts intensify to reach net-zero emissions by 2050, lithium-ion technology is at the forefront of energy storage solutions.

While all lithium-ion batteries share core characteristics, they vary significantly in their chemical composition, molecular structure, and cathode materials, each influencing energy density, power output, performance, safety, lifespan, and cost. Here, we explore these variations, detailing each technology's maturity and ideal applications to guide you in selecting the right battery for your needs. The tables below offer a concise comparison of lithium-ion battery types.

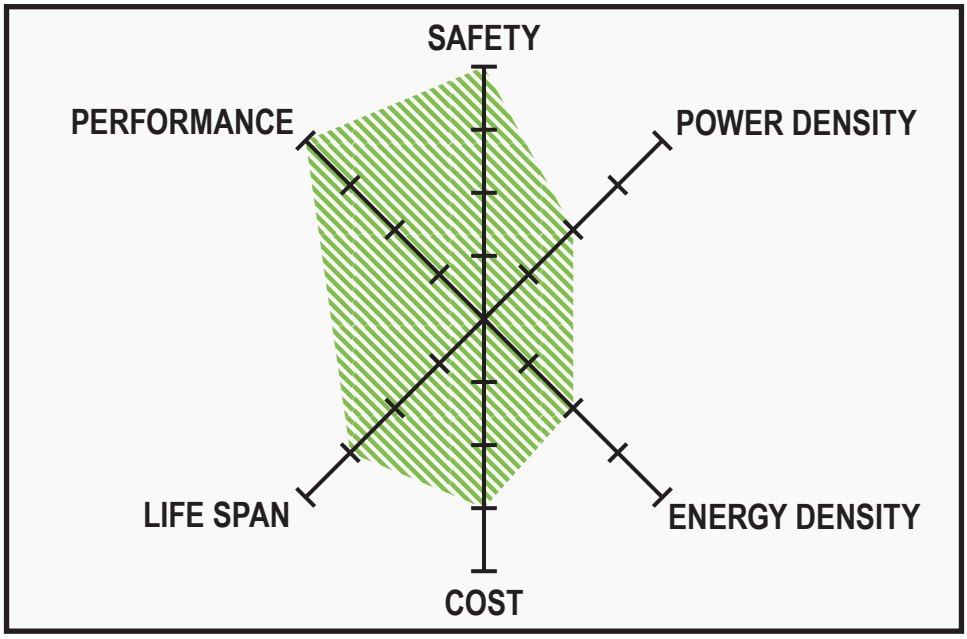
TOP 5 LITHIUM BATTERIES

1. Lithium Iron Phosphate
2. Lithium Nickel Manganese Cobalt Oxide
3. Lithium Manganese Oxide
4. Lithium Nickel Cobalt Aluminum
5. Lithium Titanate

KEY ACTIVE MATERIAL	LITHIUM-IRON PHOSPHATE	LITHIUM NICKEL MAGNANESE COBALT OXIDE	LITHIUM MANGANESE OXIDE	LITHIUM NICKEL COBALT ALUMINUM	LITHIUM TITANATE
Technology Short Name	LFP	NMC	LMO	NCA	LTO
Cathode	$LiFePO_4$	$LiNi_xMn_yCo_{1-x-y}O_2$	$LiMn_2O_{4(spinel)}$	$LiNiuCoAlO_2$	variable
Anode	C (graphite)	C (graphite)	C (graphite)	C (graphite)	$Li_4Ti_5O_{12}$
Safety					
Power Density					
Energy Density					
Cell Costs Advantage					
Lifetime					
BESS Performance					

1

LITHIUM IRON PHOSPHATE (LFP)



SAFETY: 4/4 • POWER DENSITY: 2/4 • ENERGY DENSITY: 2/4
COST: 3/4 • LIFECYCLE: 3/4 • PERFORMANCE: 4/4

PROS:
+ HIGH SAFETY RATING
+ MEDIUM TO LONG LIFECYCLE
+ FAIRLY STRONG POWER CAPABILITY

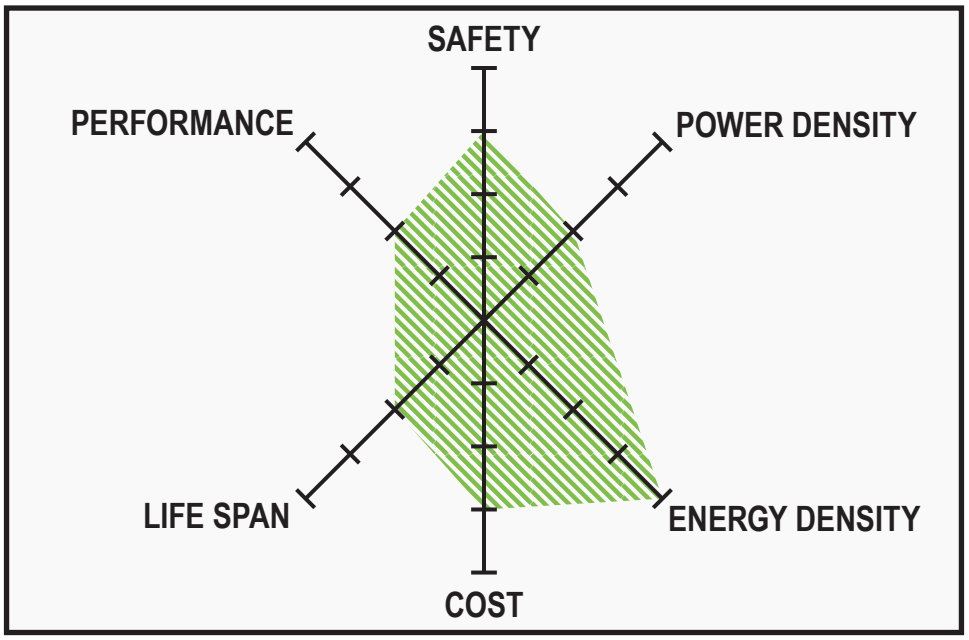
CONS:
− LOWER ENERGY DENSITY

Lithium Iron Phosphate (LFP) batteries offer moderate to high ratings across most characteristics, with the exception of energy density. Known for their high power density, strong safety profile, long lifespan, and affordability, LFP batteries perform reliably compared to other battery types.

LFP has become the traditional choice among lithium batteries for commercial energy storage systems, electric vehicles, and a variety of industrial applications, thanks to its extended lifespan and excellent safety record. With decades of proven reliability, LFP technology continues to advance in the battery market. Its robust safety and longevity make it ideal for replacing outdated Lead Acid batteries, providing backup power, and supporting frequency regulation.

2

LITHIUM NICKEL MANGANESE COBALT OXIDE (NMC)



SAFETY: 3/4 • POWER DENSITY: 2/4 • ENERGY DENSITY: 4/4
COST: 3/4 • LIFECYCLE: 2/4 • PERFORMANCE: 2/4

PROS:
+ HIGHEST SAFETY RATING
+ LOW COST

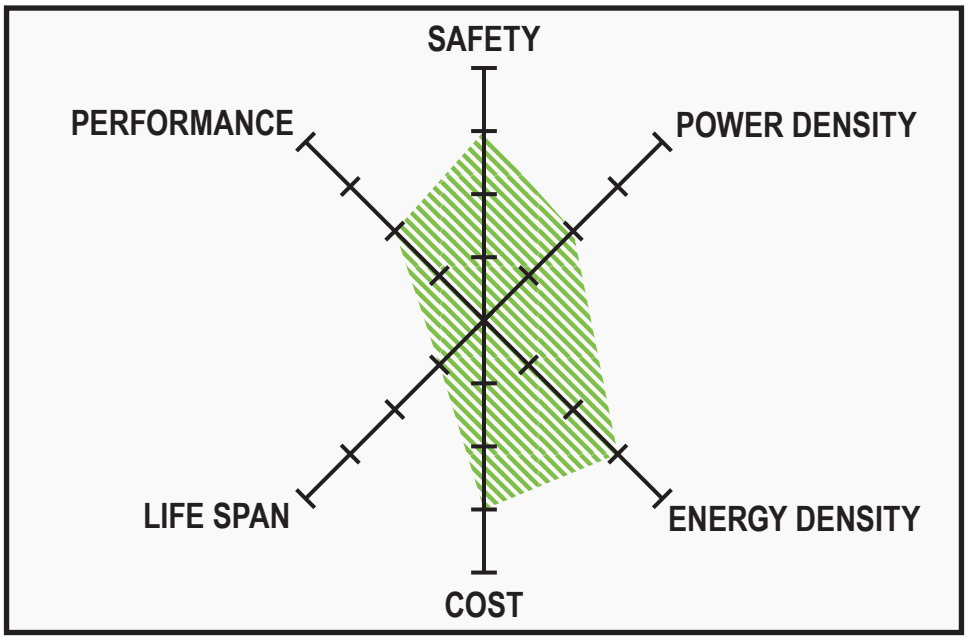
CONS:
− LOWER ENERGY DENSITY
− LOWER PERFORMANCE

Lithium Nickel Manganese Cobalt Oxide (NMC) batteries stand out for two primary reasons: their high energy density and relatively low cost. NMC's high energy density enables it to store a substantial amount of energy in a compact size, which has made it popular in electric powertrains, EVs, and e-bikes. However, this high energy density has raised safety concerns, as there's a risk of fire in the event of a collision, which can worry some vehicle owners.

While NMC batteries perform well in energy storage, their ratings in power output, safety, lifespan, and overall performance are generally low to moderate when compared with other lithium battery types. The chemical makeup of NMC can be adjusted by altering the ratio of nickel to manganese to prioritize either specific power or specific energy. Due to the finite supply and environmental impact of mining nickel and cobalt, many companies, including Tesla, are shifting toward LFP batteries, which offer a more sustainable and often superior option for EV applications.

3

LITHIUM MANGANESE OXIDE (LMO)



SAFETY: 3/4 • POWER DENSITY: 2/4 • ENERGY DENSITY: 3/4

COST: 3/4 • LIFECYCLE: 1/4 • PERFORMANCE: 2/4

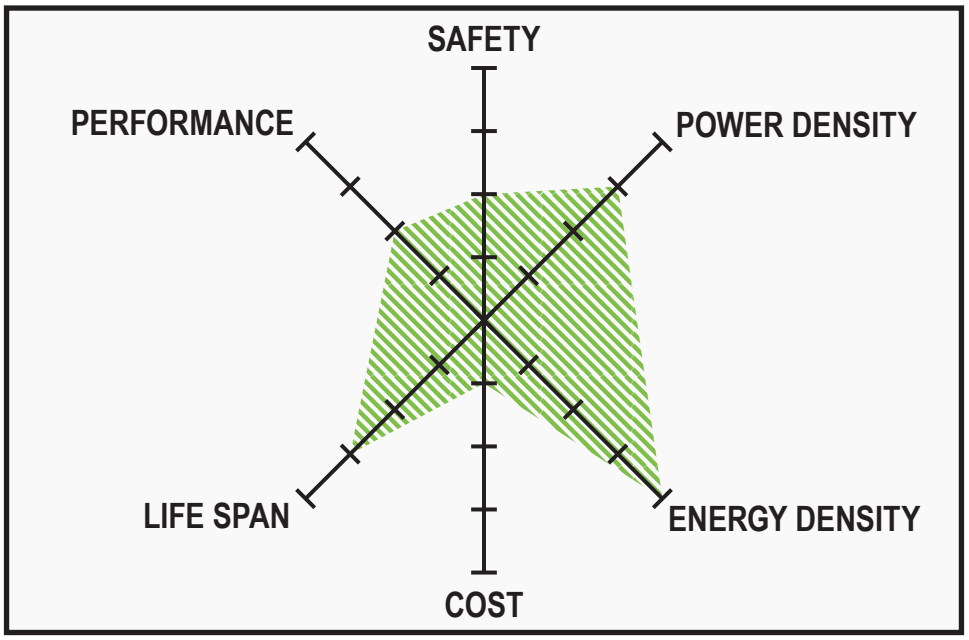
PROS:	CONS:
+ ENHANCED SAFETY	− LIMITED PERFORMANCE
+ LOW COST	− LOWER LIFE SPAN

Lithium Manganese Oxide (LMO) batteries are known for their balanced performance, often described as "jack of all trades, master of none." With moderate power and energy density, LMO batteries offer two key benefits: affordability in production and high thermal stability, which enhances safety.

However, LMO batteries have some limitations, including below-average performance and shorter lifespan, leading to more frequent replacements or the need for supplementary power. First introduced in 1996, LMO technology has since proven reliable and continues to evolve. These batteries are commonly used in medical devices and power tools, where their cost-effectiveness and safety features are particularly advantageous.

4

LITHIUM NICKEL COBALT ALUMINUM (NCA)



SAFETY: 2/4 • POWER DENSITY: 3/4 • ENERGY DENSITY: 4/4

COST: 1/4 • LIFECYCLE: 3/4 • PERFORMANCE: 2/4

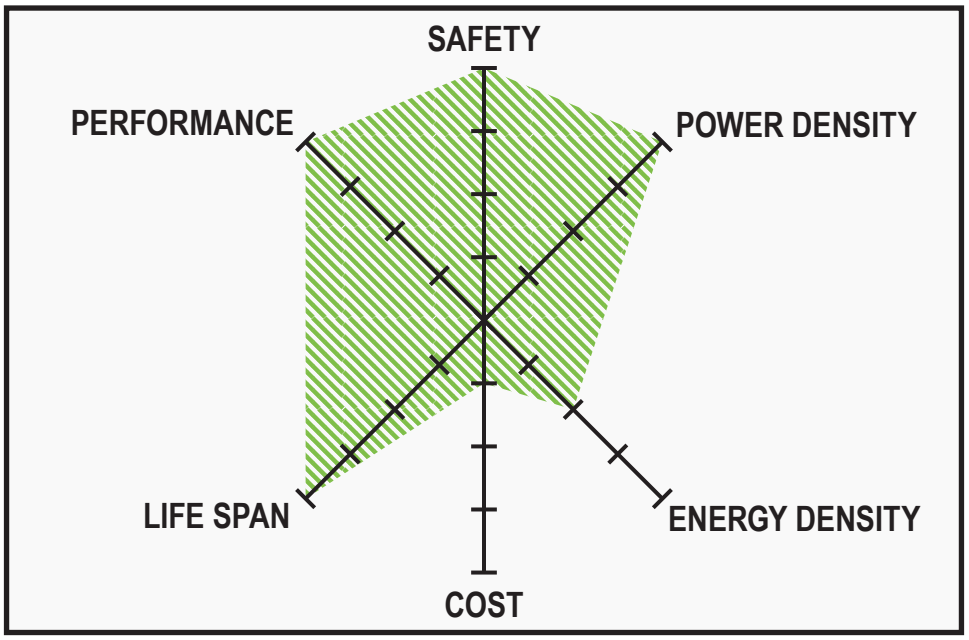
PROS:	CONS:
+ HIGH POWER	− EXPENSIVE
+ HIGH ENERGY DENSITY	− WEAK PERFORMANCE
+ LONG LIFECYCLE	− LOW SAFETY RATING

Lithium Nickel Cobalt Aluminum (NCA) batteries are composed of a balanced blend of nickel, cobalt, and aluminum, providing them with high power and energy capabilities and an extended lifecycle. These features make NCA batteries popular in stationary applications and electromobility.

While NCA batteries are powerful, this strength also poses challenges. Their high cobalt content makes them one of the more expensive lithium-ion options, and cobalt's limited availability and environmental impact further complicate their use. Additionally, NCA batteries have shown variable safety and performance, making them a less favored choice for some energy storage applications.

5

LITHIUM TITANATE (LTO)



SAFETY: 4/4 • POWER DENSITY: 4/4 • ENERGY DENSITY: 2/4
COST: 1/4 • LIFECYCLE: 4/4 • PERFORMANCE: 4/4

Lithium Titanate (LTO) batteries, with a history dating back to the 1980s, offer decades of proven stability, performance, and fast recharge capabilities, which have made them a strong choice for mobile generator optimization systems. In these setups, the generator's continuous availability allows for a smaller LTO battery, which cycles frequently to meet power needs without requiring large storage capacity. This design supports a compact, portable package—an advantage in mobile applications.

While LTO batteries do come at a higher production cost, their extended cycle life and resilience with frequent cycling help justify the investment. This balance of compact size, reliability, and longevity positions LTO as a noteworthy option for applications needing dependable and mobile power solutions.

PROS:
+ HIGHEST POWER DENSITY
+ HIGHEST SAFETY RATING
+ LONG LIFECYCLE

CONS:
– EXPENSIVE
– LOW ENERGY DENSITY

WHICH LITHIUM BATTERY IS THE BEST?

Energy storage is vital for enabling diverse applications such as utility grid supplementation and bridging support, demand charge reduction, resilience building, and EV charging infrastructure. Choosing the optimal lithium battery chemistry for these applications requires careful evaluation of financial and environmental considerations, as each chemistry is tailored to specific use cases.

For commercial and utility-scale energy storage systems where grid is available, LFP is a versatile and reliable option. It offers reasonable power density, strong performance, inherently safe and non-toxic materials, and a medium life cycle, making it a good choice when space claim and environmental conditions are not a major concern.

For hybrid systems designed to optimize standard diesel generators, Lithium Titanate (LTO) emerges as the superior choice. It has exceptional cycle life, unmatched power density, and the ability to perform in harsh environmental conditions. LTO ensures consistent, long-term performance in even the most challenging environments.

Lithium Titanate (LTO) batteries stored in tray under unit.

ANA ENERGY

JOURNEY TO ZERO

(562) 450-3570 // ANACORP.COM // sales@anacorp.com