PowerTech
ADVANCED ENERGY STORAGE SYSTEMS

Safety of Lithium-Ion batteries

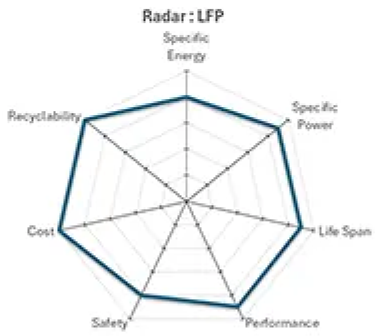
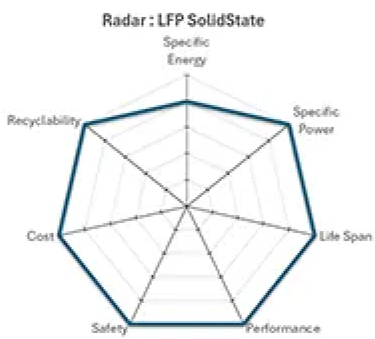
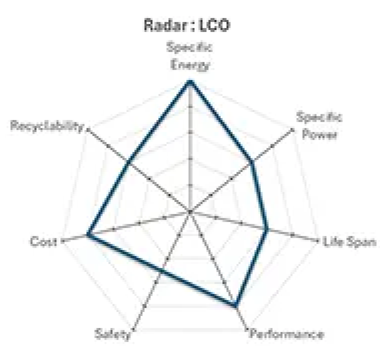
Lithium-Ion refers to a family of Lithium-based battery technology. This family includes several sub-families or technologies, such as:

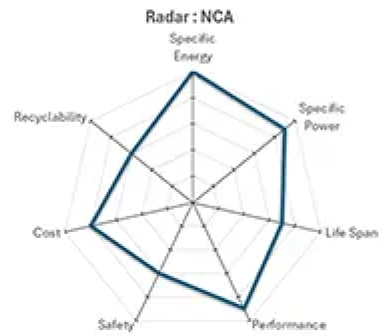
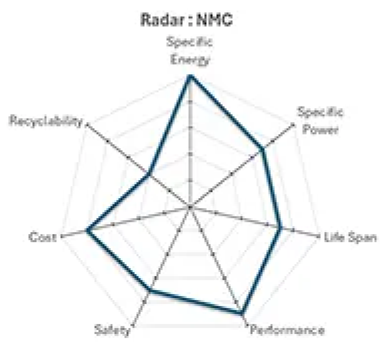
- LCO: Lithium Cobalt Oxide
- NCA: Nickel Cobalt Aluminium
- NMC: Nickel Manganese Cobalt
- LiFePO4 or LFP: Lithium Iron Phosphate
- LTO: Lithium Titanate Oxide, etc…

Often, we can hear that a product is equipped with **"Lithium-Ion" batteries**, this does not really have any meaning on the technology used. However, out of habit, the technology referred to as Lithium_Ion is usually **LCO, NCA or NMC**

Each of these technologies has **very different characteristics**, particularly in terms of **safety**, which can be found in the table below.

TECHNOLOGY	PROS / CONS	APPLICATION FIELD

Lithium Iron Phosphate (LFP-LiFePO4)  *LFP Radar*	• Excellent lifespan • High level of safety • Specific power • Abundant material : Iron + Phosphate • Good recyclability • Slightly lower specific energy than LCO, NMC and NCA	• Vehicle traction (EV) • high power applications • Renewable energy storage • Stationary batteries • UPS, back-up, etc.
Lithium Iron Phosphate Solid State  *LFP SolidState Radar*	• Excellent lifespan • Very low cell temperature rise during use • Extremely high level of safety • Full charge in 30 minutes • Very high power levels • Cost • Abundant material : Iron + Phosphate • Good recyclability • Slightly lower specific energy than LCO, NMC and NCA	• Vehicle traction (EV) et heavy duty traction • Marine propulsion • Robotics and AGV • High power applications • Renewable energy storage • UPS, back-up, etc.
Lithium-Cobalt-Oxyde (LCO)  *LCO Radar*	• Specific energy • Limited Lifespan • Dangerous chemistry if poorly controlled • Rare material : Cobalt • recyclability	• Low power application • Power tools
Lithium Nickel Cobalt Aluminium (NCA)	• Specific energy • Specific power • Cost • Dangerous chemistry if poorly controlled	• Embedded applications • EV • Power tools, etc.

 *NCA Radar*	• Rare material : Cobalt / Nickel • recyclability	
Lithium Nickel Manganese Cobalt (NMC)  *NMC Radar*	• Specific energy • Limited Lifespan • Safety • Rare material : Cobalt + Manganese + Nickel • recyclability	• Embedded applications • EV • Power tools, etc. • Powerwall (TESLA)

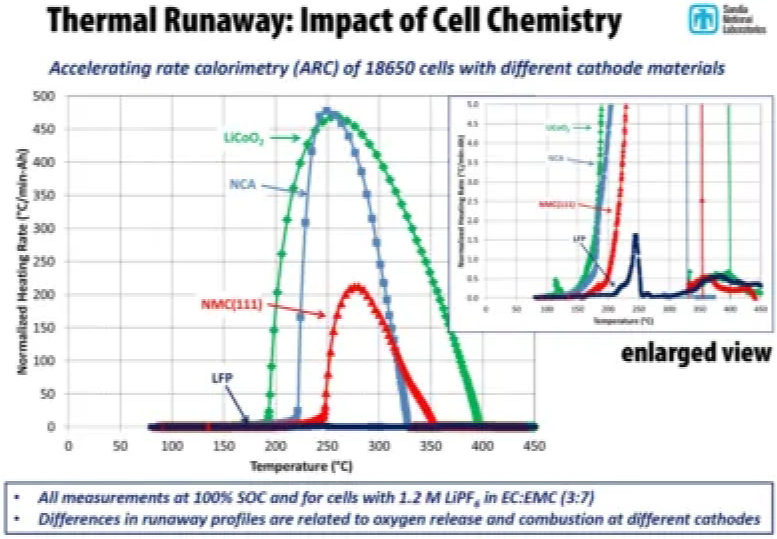
Thermal Runaway

One of the main causes of danger for lithium-ion cells is related to the phenomenon of thermal runaway. This is a heating reaction of the battery in use, caused by the nature of the materials used in the chemistry of the battery.

Thermal runaway is mainly caused by the solicitation of batteries under specific conditions, such as overload under adverse climatic conditions. The result of a thermal runaway of a cell depends on its level of charge and can lead in the worst case to an inflammation or even an explosion of the Lithium-Ion cell.

However, not all types of Lithium-Ion technology, due to their chemical composition, have the same sensitivity to this phenomenon.

The figure below shows the energy produced during an artificially induced thermal runaway



Thermal Runaway Lithium-Ion – Impact of cell chemistry

It can be seen that among the Lithium Ion technologies mentioned above, **LCO and NCA are the most dangerous chemicals** from a thermal runaway point of view with a temperature rise of about **470°C per minute**. The **NMC chemistry** emits about half the energy, with an increase of 200°C per minute, but this level of energy causes **in all cases the internal combustion of materials and the ignition of the cell**.

In addition, it can be seen that **LiFePO4 – LFP technology** is **slightly subject to thermal runaway** phenomena, with a temperature rise of barely **1.5°C per minute**.

With this very low level of energy released, the **thermal runaway** of the Lithium Iron Phosphate technology is **an inherently improbable event** in normal operation, and even very difficult to artificially trigger.

More recently, with the arrival of **LFP Solid-State technology**, the level of safety now exceeds all safety standards, with a **thermal runaway that is intrinsically impossible to trigger** in normal operation.

Combined with a BMS, Lithium Iron Phosphate (LifePO4 – LFP) is currently the most secure Lithium-Ion technology on the market.

Mecanical Safety of Lithium-Ion Cells

Like thermal runaway, Lithium-ion cells have a different level of safety depending on the shocks or mechanical treatments they may undergo during their lifetime.

The nail penetration test is the most revealing way to qualify level of safety of Lithium-Ion batteries.

The test presented below is performed by perforating a Lithium Ion NMC cell and a Lithium Ion LiFePO4 cell.

We find here the same extremely stable behavior of Lithium Iron Phosphate cells while the NMC cell ignites almost immediately.

For information, the LCO, NCA, or Lithium Polymer cells have a similar behavior to the NMC in a perforation test (immediate inflammation)

Stress Tests of Lithium Chemistries Lithium Polymer (LiPo) vs Lithium Titanate (LTO) vs Lithium Iron Phosphate (LFP) :

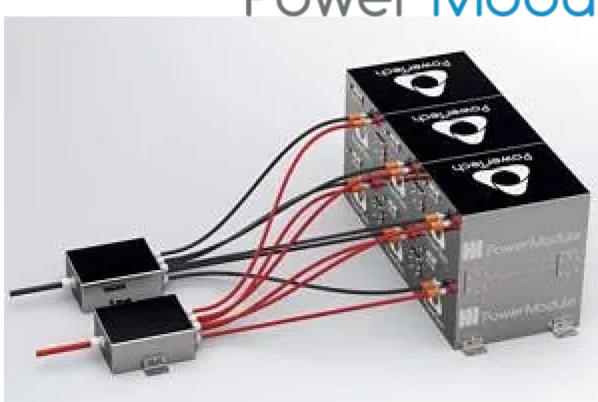
Drop-In AGM Replacement : PowerBrick®

PowerBrick

PowerBrick

Modular batteries for electric traction : PowerModule®

PowerModule



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