Why lithium iron phosphate (LiFePO4) batteries are suitable for industrial and commercial applications.

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Why lithium iron phosphate ($LiFePO_4$) batteries are suitable for industrial and commercial applications.

A few years in the energy sector is usually considered a blink of an eye. This makes the rapid transformation of the battery storage market in recent years even more remarkable. The battery storage landscape in the electricity sector is moving away from NiCd; it has shifted towards lithium-ion batteries, as well as advanced lead-acid. For many applications, lithium-ion has proved preferable to other chemistries with respect to energy and power density, cycle and calendar life, and cost. The lithium-ion deep discharge cycle life, energy and power density, and other attributes have proved preferable over other battery types. In conjunction with rapid cost decreases, this has led to increased deployment of lithium-ion. (IRENA, 2015).

Lithium-ion is a category that includes lithium-titanate, lithium-iron phosphate, nickel-manganese-cobalt, lithium-manganese-spinel, nickel-cobalt-aluminum, lithium- cobalt. Because iron is the most stable element in the periodic table, lithium iron phosphate cells are also stable and safe. Lithium-iron-phosphate (LiFePO4) cells are generally accepted as the best lithium-ion type for industrial applications.

- Lithium Iron Phosphate ($LiFePO^4$) cells are generally accepted as the best lithium-ion battery for industrial applications.
- $LiFePO_4$ contain almost no toxic or hazardous materials and are not usually considered to be hazardous waste.
- NiCd cells contain cadmium, a known carcinogen. Lead-acid batteries contain lead, which can severely affect mental and physical development. Industrial NiCd batteries are classified as hazardous.
- $LiFePO_4$ are a safe technology that will not catch fire or explode with overcharging, nor produce flammable gases under any circumstances.
- $LiFePO_4$ weigh one third to one quarter of the weight of a lead-acid battery of equivalent power.
- $LiFePO^4$ can deliver more than 5000 deep discharge cycles, compared to around 300 to 800 for ten-year design-life VRLA, or 1500 cycles to 50% depth of discharge for 20 year design-life VRLA.
- In higher discharge-rate applications, $LiFePO_4$ can produce double the usable capacity of similarly rated lead-acid batteries.
- $LiFePO_4$ have a flat voltage discharge curve, delivery little to no “voltage sag” (as with lead-acid batteries).
- $LiFePO_4$ have a higher discharge-rate capability (10C continuous, 20C pulse discharge).

- $LiFePO_4$ accept higher continuous charge rates - up to 3C , allowing for much shorter recharging times, compared to VRLA which have 0.1C to 0.25C recommended charge rates.
- Unlike lead-acid batteries, LiFePO4 can be left in a partially discharged state for extended periods without causing permanent reduction of capacity. $LiFePO_4$ can have low self-discharge rates (unlike lead-acid which will go flat quite quickly if left sitting for long periods).
- $LiFePO_4$ do not suffer from thermal runaway. VRLA charge rates and block temperatures must be limited to avoid thermal runaway.
- $LiFePO_4$ can be used in high ambient temperatures, up to 65 oC without significant performance or service-life degradation. For every 10 oC rise in operating temperature, the service-life of a VRLA battery halves.
- $LiFePO_4$ are relatively maintenance-free for the life of the battery. VRLA batteries require yearly discharge capacity testing, impedance or conductance testing.
- $LiFePO_4$ can be operated in any orientation, including inverted. Many VRLA batteries must be oriented vertically, some horizontally.
- $LiFePO_4$ do not contain any toxic heavy metals such as lead, cadmium, nor any corrosive acid or alkali electrolyte.
  $LiFePO_4$ batteries are the most environmentally friendly battery chemistry available today.
- $LiFePO_4$ have almost twice the energy density than NiCd.
- $LiFePO_4$ weigh about one third to half of the weight of a NiCd battery of equivalent power.
- $LiFePO_4$ have relatively low self-discharge; less than half that of NiCd. Left uncharged, $LiFePO_4$ cells can retain their charge for up to ten years.
- Higher cell voltage of $LiFePO_4$ (3.6V) means fewer cells and associated connections and electronics are needed for high voltage batteries. One $LiFePO_4$ cell can replace three NiCd cells, which have a cell voltage of only 1.2V. (110V NiCd = 87 to 91 links, $LiFePO_4$ will have 33 or 34 links).
- $LiFePO_4$ contain no liquid electrolyte which means they are immune from leaking. NiCd contain liquid potassium hydroxide which, if leaked, is extremely corrosive and so toxic it is fatal if ingested.
- In higher discharge rate applications $LiFePO_4$ can produce double the usable capacity of similarly rated NiCd batteries
- Flat voltage discharge curve means maximum power available until fully discharged (no “voltage sag” as with NiCd batteries)
- $LiFePO_4$ cells can deliver a very high discharge rate, 10C continuous, 20C pulse discharge.
- $LiFePO_4$ accept much higher charge rates - up to 3C = much faster recharging possibilities
- Unlike NiCd batteries, $LiFePO_4$ can be left in a deep discharged state for extended periods without causing permanent reduction of battery capacity.
- $LiFePO_4$ do not suffer from “thermal runaway”
- Can be used safely in high ambient temperatures, up to 65 oC without significant performance degradation. NiCd can only operate reliably at up to 35 to 40oC.
- $LiFePO_4$ are 100% maintenance-free for the life of the battery. NiCd must be maintained (electrolyte checked and topped up) at least once every year, some NiCd manufacturers recommend maintenance once every six months.
- $LiFePO_4$ can be operated in any orientation, including inverted.

- $LiFePO_4$ do not contain any toxic heavy metals such as lead, cadmium, nor any corrosive acids or alkalis.
- $LiFePO_4$ batteries are the most environmentally friendly battery chemistry available today.
- Phosphate based technology possesses superior thermal and chemical stability which provides better safety characteristics than those of lithium-ion technology made with other cathode materials. Lithium phosphate cells are incombustible in the event of mishandling during charge or discharge, they are more stable under overcharge or short circuit conditions and they can withstand high temperatures without decomposing. When abuse does occur, the phosphate based cathode material will not burn and is not prone to thermal runaway.
- Phosphate chemistry also offers a longer cycle life. Recent developments have produced a range of new environmentally friendly cathode active materials based on lithinated transition metal phosphates for lithium-ion applications.
- Doping with transition metals changes the nature of the active materials and enables the internal impedance of the cell to be reduced.
  The operating performance of the cell can also be “tuned” by changing the identity of the transition metal. This allows the voltage as well as the specific capacity of these active materials to be regulated. Cell voltages in the range 2.1 to 5 Volts are possible.
- Phosphates significantly reduce the drawbacks of the cobalt chemistry, particularly the cost, safety and environmental characteristics. Once more the trade off is a reduction of 14% in energy density, but higher energy variants are being explored.
- Due to the superior safety characteristics of phosphate cells, $LiFePO_4$ batteries are more suited to larger battery capacities.
- IEC 62619:2017 specifies requirements and tests for the safe operation of secondary lithium cells and batteries used in industrial applications including stationary applications.
- Look for impedance-matched, premium, $LiFePO_4$ cells, with certification to show that they have been type-tested according to IEC 62619:2017
- For many industrial and commercial applications, the lithium battery management system (BMS) is as important as the lithium cells.
- An easy way to start to evaluate the quality of a BMS is by reviewing its operating manual and reference sites.

Contact me for assistance with designing and procuring systems with lithium batteries.

Reference: *Battery Storage for Renewables*: Market Status and Technology Outlook, IRENA, 2015.