Lithium Ferro Phosphate (LFP) Batteries – A brief history

- Lithium Ferro Phosphate (also known as LFP) batteries first came to light in 1996 when researchers at the University of Texas discovered that Phosphate was a suitable cathode material for rechargeable Lithium batteries.

- However, Lithium rechargeable batteries have been in popular use for about 25 years.

    - Initially this new breed of rechargeable batteries was used in portable electronic devices: mobile telephones, digital cameras and portable music players (now converged into a single Smartphone device). Their large scale adoption by the then 'Yuppies generation' created a large demand for Lithium batteries.

    - They replaced the technically and environmentally challenging Nickel Cadmium (NiCd) and Nickel Metal Hydride (NiMH) batteries that had dominated the electronics world for 2 previous decades.

    - On the positive side, Lithium ion batteries (as they have become known) had a much higher energy density profile than other rechargeable batteries; as a result, they were lighter and smaller in packaging – paving the way for smaller portable electronic devices.

    - Unfortunately, the early Lithium ion batteries were notoriously difficult to charge, and incorrect usage led to extreme heat release, resulting in fire and explosions inside electronic devices.

    - Due to the amount of 'heavy metals' in the earlier generations of Lithium batteries, disposal was a problem.

- Since the introduction of these early Lithium technologies, scientists and engineers have been searching for a more reliable, safer, easier to use and environmentally more responsible Lithium chemistry.

    - Although LFP was discovered in 1996, their large scale adoption by the electronics industry did not happen until about 10 years ago.

- It is clear that LFP batteries are not as energy dense as earlier generations of Lithium technology; however there are some significant advantages that are propelling them to become the energy storage technology of choice for large scale systems.

Lithium Ferro Phosphate (LFP) batteries – Features and benefits

- **Working Voltage**: LFP batteries exhibit a working voltage range that is well suited to replacement of Lead Acid batteries (ie the predominant large scale energy storage medium for the past half century or more).
    - A single LFP cell (the lowest common denominator in the design of a LFP battery pack) has a nominal operating voltage of 3.2V.
        - Therefore four of these in series will give us a 12.8V nominal operating voltage. (This is comparable to 12V for a typical Lead Acid battery or 2V per cell.)
    - The lowest recommended discharge voltage per cell is 2.5V.
        - Four of these in series will give us 10.0V 'drop out voltage'. (Compare this with 9V for a typical Lead Acid battery or 1.5V per cell.)
    - The maximum recommended charge voltage per cell is 3.65V.
        - Four of these in series will yield a 14.6V 'maximum charge voltage setting'. (Compare this with 15V for a Lead Acid battery.)
- **Weight**: LFP batteries have an energy density of about 90Wh/kg. (Compare this to 33 to 42Wh/kg for Lead Acid batteries.)
    - In practical terms, this means an LFP battery can be 3 times lighter than an equivalent Lead Acid battery with the same capacity.
    - Since LFP batteries are used in many EV (Electrical Vehicles), this power-to-weight ratio gives a significant edge for energy storage.
    - Similarly, for static deployments, the infrastructure required to house LFP batteries are much less mechanically stringent than for Lead Acid batteries because of this weight advantage.
- **Longevity**: LFP batteries can be charged and discharged excess of 2000 cycles at 100% depth of discharge.
    - Compare this with a Lead Acid solution which can typically give only 500 to 800 cycles of charging and discharging – with a maximum depth of discharge (even for specially designed 'deep-cycle' batteries) at 80%.
    - In practical terms, this means an LFP battery pack will outlive a Lead Acid battery solution at a ratio of around 3:1.

- If batteries need to be cycled daily, a Lead Acid battery will work for say around 2 years best case scenario; meanwhile, an LFP will work for over 5 years.

- Furthermore, if a Lead Acid battery is discharged beyond 80% depth of discharge, it will expire prematurely. By contrast, an LFP battery pack will happily work to a 100% depth of discharge time and time again.

- In cases where the LFP battery pack only has to work down to say 75% depth of discharge, the battery will continue working for up to 6000 cycles (or over 15 years continuous operating life).

- **No special storage required**: While Lead Acid batteries will expel explosive gases during charging and discharging, and require special ventilation systems to cope, LFP batteries do not have this characteristic.

  - Furthermore, LFP can be designed and manufactured to fit into 'oddly shaped spaces' due to their cell geometry.

- **Designed for long term usage**: As Lead Acid batteries age, they often 'bulge' and distort (and even crack) the plastic cases which contain the highly toxic and corrosive Phosphoric Acid electrolyte contained inside.

  - On the other hand, LFP batteries are usually encased in steel cell structures (similar to the traditional 'C' or 'D' dry cells available today). This means the risks of damage from ageing or accidental damage by collision or crushing are significantly reduced, if not eliminated.

- **High temperature characteristics**: Another challenge facing Lead Acid users for long term energy storage is that they do not tolerate high temperatures well. Battery characteristics for a Lead Acid battery show that at elevated temperatures (above 30 deg C) their energy storage capacities are reduced, and their overall longevity is significantly shortened.

  - On the other hand, LFP will work perfectly well up to 60 deg C. In fact, at elevated temperatures, the LFP capacity increases marginally (ie the complete opposite to Lead Acid batteries).

- **Safety concerns**: In recent years, there have been many reported incidents involving Lithium batteries (eg Boeing 787 fire, factory fires, reports of 'exploding' smartphones, etc). However, none of these have involved LFP batteries.

- While older Lithium Cobalt batteries could potentially ignite at approximately 150 deg C, LFP will not enter this dangerous state until over 400 deg C. If a device is operating at that temperature, something is seriously wrong!

- Furthermore, even in the event of ignition, LFP batteries will release only 1/4 of the amount of heat energy as that of the older Lithium batteries of the early 2000’s. They will generate smoke, but not fire – unless seriously mechanically compromised (ie crushed or smashed).

Where will Radlink add value to LFP technology?

- For the past 8 years, Radlink Communications has been consistently delivering highly reliable, remotely located, large-scale, digital 2-way critical communications infrastructure for many 'blue chip' companies such as BHP, Rio Tinto, FMG, Atlas Iron, Chevron, BP, CSBP, as well as law enforcement, public health and safety agencies.

- A very large number of these systems have been deployed in remote parts of Australia where there is no easily accessible grid-connected electrical power.

- Therefore, Radlink has spent much time developing suitable technologies to enable both standalone statically located and mobile trailer-based communications systems to operate without human intervention, day after day, year after year, in highly challenging environmental conditions.

- To date, Radlink has supplied and installed radio solutions with an aggregated land coverage area equivalent to the size of Greece (or over 125,000 km^2 across Australia).

- For many years, Radlink has been using 'traditional' deep-cycle Lead Acid battery solutions. However, while relatively low-cost and reliable in the initial deployments, these have been found to be high maintenance after the first two or three years.

- As a result, Radlink has been searching for suitable alternative energy harvesting and storage technologies to improve the overall performance of their energy product offerings.

- Recently, Radlink has partnered with a 'Tier One' Lithium battery supplier in China to offer turn-key energy storage design, manufacture, supply, maintenance and support in Australia.

    - This Chinese company controls the entire supply chain from Lithium materials all the way to the production of battery cells and battery packs. (Compare this with many 'Tier Two' and lower suppliers that only purchase the battery cells and manufacture 'standard Lead Acid replacement battery packs'.)

    - This Chinese company has an extensive R&D team that is working closely with Radlink's R&D team to create innovative energy storage solutions suitable for the Australian market and beyond.

    - Radlink has immediate access to over 1 million LFP cells for any large scale project.

    - Radlink has, and will continue to specify specialist energy storage solutions outside the 'standard' solutions offered by other LFP battery suppliers. These solutions may require special charging or energy delivery mechanisms specific to the needs of the client.

    - Radlink has established a stable and reliable supply chain from China to three Australian ports: Fremantle, Brisbane and Melbourne.

    - Typical turnaround time for projects is 4 to 12 weeks for design and manufacturing, followed by 1 to 3 weeks of QC/QA, then 3 to 7 weeks transit time from China to Australia.

- Radlink's electrical and mechanical engineering teams work very closely with our Chinese supplier to design fit-for-purpose and robust solutions to meet the needs of non-standard and specific client requirements.

- The state-of-the-art 'analogue' BMS (Battery Management Systems) technologies offer instantaneous protection against accidental or deliberate abuse due to the following fault conditions:
    - Over-charging;
    - Over-discharging;
    - Excessive operating temperature;
    - Excessive current draw; and
    - Short circuits

- Radlink's R&D team is now designing and collaborating with our Chinese partner to create 'networked battery solutions' to enable the ability for clients to monitor the 'live' performance characteristics (including voltage, current, temperature, state of charge, and other vital statistical information of every individual bank of cells) through a new generation of BMS.

- We are at the forefront of creating an 'Internet of batteries' technology framework. This will have significant implications for users that have long term, large scale storage requirements – well beyond the 'Lead Acid battery replacement' mindset.

- Because of the longevity of LFP battery solutions, it is important that users are able to accurately predict 'end of life' scenarios and take steps to avoid unplanned outage and system malfunction.

- The new generation of 'digital' BMS will enable users to estimate remaining operating life of battery solutions, and provide a 'big data' pool for future analysis and action to improve energy storage solutions. No longer will users make assumptions about the performance of their energy storage system, they will have the data to back up those assumptions.

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