Lithium Battery Guidebook

by Gavin Shoebridge

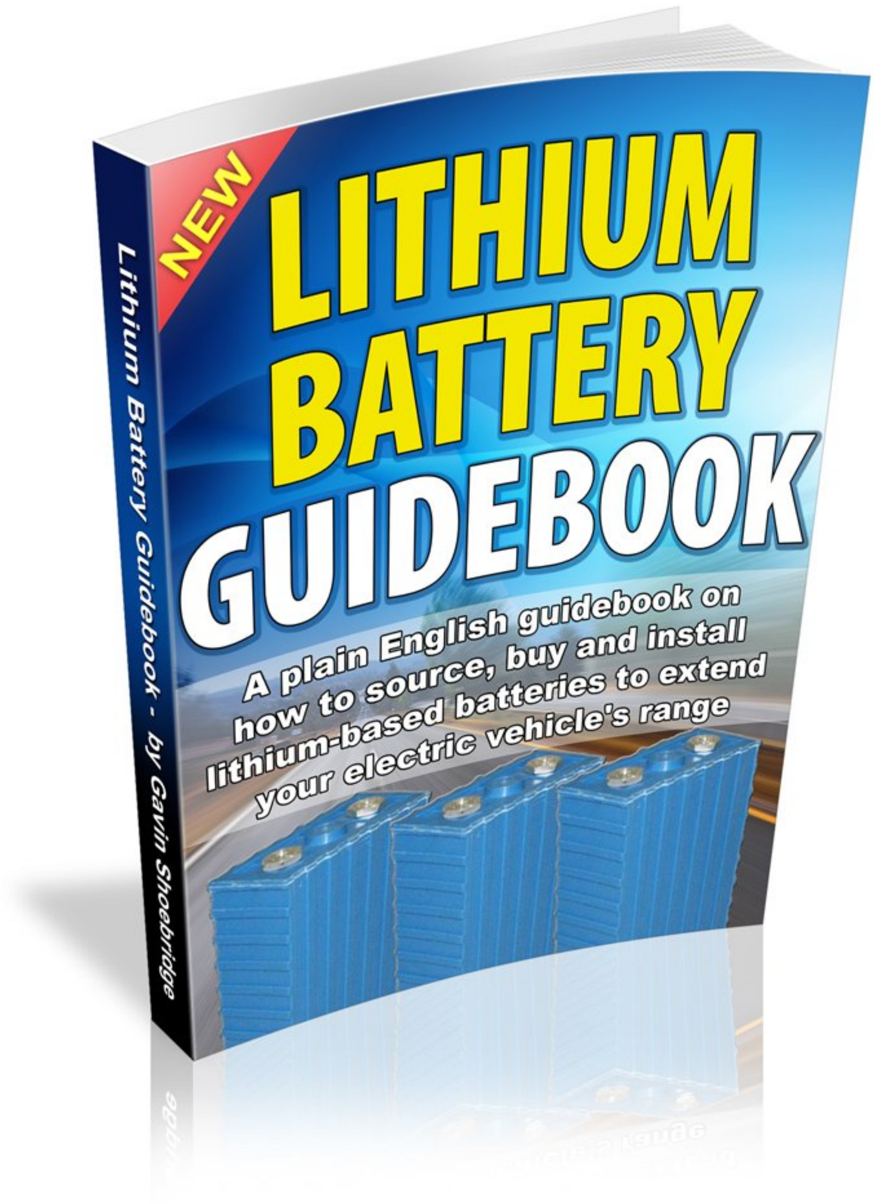

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Table Of Contents

A prismatic LiFePO4 battery. Image courtesy of EV Works Australia www.evworks.com.au

Chapter #1 – About Lithium Batteries

While there are several different compounds of lithium battery available, the most suitable for converters is the Lithium Iron Phosphate battery. This is because they're safe, proven and affordable.

This is different from the similarly named *Lithium Ion* battery, which are more expensive and not as manageable for the typical home hobbyist.

Perhaps the largest reason more people aren't yet using Lithium Iron Phosphate batteries is due the confusion around them.

I often see questions such as:

- ✓ *Are they really expensive?*
- ✓ *How many do I need?*
- ✓ *How long do they last?*
- ✓ *Are they easy to install?*
- ✓ *Are they more complicated?*

The chances are that you have fairly similar questions in your mind.

The truth is, they're just as simple to install as lead acid batteries, the main difference being a Battery Management System needing to be installed to keep them healthy.

A battery management system is made up of a couple of very easy to install devices available from most lithium battery suppliers. We'll cover that in the next chapter. First of all, let's start off with a little basic education.

Lithium Iron Phosphate Batteries (LiFePO4 in "tech speak") are lightweight for their size compared to lead based batteries. For example, a one kilowatt-hour lead acid battery might weigh around 40 lbs (18 kilograms), whereas the same capacity in LiFePO4 batteries would be closer to 20 lbs (9 kg) – though this isn't an exact example as some lead batteries are heavier than others.

They're also more tolerant to cold climates than lead based batteries, with a wide operating temperature range of -20º C (-4º F) to 70º C (158º F), with only minimal performance loss expected if the pack's core temperature goes below 0º C (32º F) compared to lead based batteries.

LiFePO4 batteries also have the advantage of being maintenance-free, with no need to top up the electrolyte, as is required with flooded lead acid batteries, and no forced venting required as they emit no toxic or flammable gases.

Another advantage that LiFePO4 batteries have is the ability to withstand greater discharging than lead-based batteries. For example, a battery pack with flooded lead-acid batteries should never be taken below 50% Depth of Discharge (50% of capacity remaining) to stop irreparable damage.

LiFePO4 batteries on the other hand can be comfortably taken down to 80% Depth of Discharge (20% of capacity remaining) without damage.

This hardiness combined with the reduced weight means your EV will go further per kilowatt hour (kW/h) using LiFePO4 batteries, instead of lead acid batteries.

Admittedly being a relatively new technology they are more expensive per kW/h than lead acid batteries, but have the advantage of a predicted useful lifespan of 7 to 10 years. This means one battery pack could outlast the vehicle's body, rather than the other way around, so while an expensive purchase, it could very well be a good motoring investment.

#1.1 - Comparisons to Lithium Ion Batteries

Lithium Iron Phosphate batteries have advantages and disadvantages when compared to the more well known Lithium Ion battery compound.

Some advantages to *LiFePO4* are an increased resistance to “thermal runaway” where Lithium Ion batteries can overheat and destroy themselves, a higher peak current rating (which means more *oomph* per battery) than it's lithium ion counterpart, and a longer calendar life.

One more often overlooked benefit is that *LiFePO4* batteries are kinder to the environment if disposed of in a landfill. Though I don't know why anyone would simply *dump* used lithium batteries in a landfill when your local metal recyclers would pay you handsomely for them!

Some of the disadvantages are that Lithium Iron Phosphate batteries have a lower capacity per kilogram or pound than Lithium Ion batteries. This means you'd need more batteries (more weight) to achieve the same range as an identical Lithium Ion powered car.

Additionally, I've seen it recommended to “break in” *LiFePO4* batteries by not driving them hard or far during the first few months, keeping them well above 33% DOD (*Depth of Discharge*) until they've seen about 20 charge cycles. This is to avoid damaging the batteries long term.

#1.2 - What Range Can You Expect

So how far can you go with LiFePO4 batteries?

Almost as far as you like, with the only restrictions being the higher cost per kW/h than lead, and the weight and storage limitations of your vehicle.

If long range is your goal, then feast your eyes on these typical home-converted *LiFePO4* powered EVs with their impressive range results.

Jack Rickard's Porsche Speedster Conversion. 100+ miles per charge.
More details available at www.evtv.me

Brian Blocher's Honda S2000 Conversion. 100+ miles per charge.
More details available at http://s2kev.blogspot.com/

There are many more out there with similar long range results, proving that you *can* have an attractive, reliable, long-range electric vehicle in your garage today.

#1.3A - Cost

When they first arrived for sale the early 2000's the technology was still being improved & developed and was understandably very expensive, but over the last 3 years it's gradually fallen into the reach of consumers as a very real option for use in electric vehicles.

At the time of writing (January 2010), the average cost per kW/h is around $400 US. This is approximately 25% less than what was typically quoted in late 2007, and prices are still falling due to increasing production in China – all of which is great news for you as a consumer.

#1.3B – How Many Do I Need?

Let's try some real world figures to assess how many batteries you would need to give a typical EV a good, healthy range of 100 miles per charge. Let's also work out how much would it cost with some simplified maths.

If the average EV uses around 0.3 kW/h of electricity per mile, then we can easily calculate that 100 miles would require 30 kW/h of electricity.

Now without taking a bulk discount into consideration, and without shopping around, that might cost about $12,000 US.

Understandably that may seem a little steep for batteries, so let's look at ways we can bring it down.

#1.4 – Cost Reduction

Cost Reduction Tip1: First of all, ask yourself honestly just how much range you need. This is important as each extra mile adds a few more dollars to the battery cost.

Cost Reduction Tip 2: Use the smallest, lightest car you can find for your conversion. This will reduce the amount of energy required to move it about.

Cost Reduction Tip 3: Streamline! As mentioned in the bonus ebook "*Getting the Most out of your Electric Vehicle*" that's supplied with this package, you can really boost your mileage just by reduce your car's overall weight and wind resistance.

If you're lucky, you might find you don't *really* need 100 miles per charge for your typical daily driving, and that a small, lighter vehicle will suit your needs instead of a big truck. If so, this is good because it means instant savings on your overall battery purchase.

Now because every car is different, I suggest comparing your model of donor car with other already-converted cars at www.evalbum.com and checking out their weight & kWh per mile ratings.

For example, the all-electric Mitsubishi MiEV only uses 0.16 kWh per mile due to it being small and lightweight.

This means if you could achieve an economy of 0.2 kWh per mile, and if you only really need to drive, say, 60 miles per charge then suddenly your battery pack would only need to be *12* kWh in capacity, at around $4800 US. Just like that you've saved $7200 in battery costs!

Bear in mind that this is only an example and your needs may be different, but once you've worked out what sized battery pack you'll need, something to keep in mind is the *DOD* (depth of discharge) limitations of these batteries:

In Chapter 1 I mentioned that you can only take lead batteries to 50% *DOD* (half full) of their actual rated capacity without damaging them. This has been one of the largest inconveniences of lead acid batteries, but fortunately *Lithium Iron Phosphate batteries* don't suffer quite so badly.

You can drain Lithium Iron Phosphate batteries to 80% *DOD* (nearly completely empty) without damaging them.

Now while that's good news it means you'll need to make sure there's enough extra capacity in your battery pack to drive your required distances without taking the pack below 80% DOD. This means you should have a little more capacity than you actually need. It's something important to keep in mind if you're range calculations are done to the inch!

While we're talking about depth of discharge levels, another thing to keep in mind regarding lithium iron phosphate batteries is their predicted life: most LiFePO4 batteries are rated at having 2000 cycles (full charges and discharges) before they start suffering from capacity loss and this would be if you took your batteries down to 80% DOD (near flat).

However if you only take your pack down to 70% DOD (not as low) then the expected lifespan jumps up to an estimated 3000 cycles!

Bottom line?
If you're looking at very long term ownership of the pack, don't drain your batteries down to their limits and they might last well beyond 10 years!

#1.5 - Voltages and Current Ratings

Because an individual LiFePO4 battery's nominal rated voltage is 3.2 volts (actually 3.65 volts when fully charged), you'll need several batteries connected in series (battery 1's negative goes to battery 2's positive etc) to make up your battery pack.

Therefore a battery pack of 120 volts will need 38 batteries – which would actually equate 121.6 volts - because you can't get add up a perfect 120v out of units of 3.2v.

Now that you've decided your ideal voltage and subsequently added up how many batteries are needed to make that voltage, you'll need to work which battery amp-hour (Ah) rating will give your battery pack the right capacity to meet your desired range.

As we know, total battery capacity is measured in kW/h. This is made up of A/h multiplied by Volts.

For example, imagine your small, aerodynamic 120 volt car needs 60 miles of range. If it uses 0.25 kW/h per mile, then it will need 15 kW/h (15,000 W/h) of batteries at your chosen voltage (120 volts in this example).

Therefore the A/h rating on your batteries can be worked out like this:
15,000 W/h ÷ 120 v = 125 A/h

And there you go. For a small, efficient car car to reach 120 volts, it will need 38 batteries. And for the batteries to be big enough to do 60 miles, they'll need to be rated at 125 A/h each.

One thing to keep in mind however is that you may not find 125 A/h cells and may have to go with 120 A/h or 140 A/h instead. This is because the sizing range of these batteries is still growing and 125 A/h is an unusual size.

If you can afford it, I recommend going with the slightly larger battery if you have to substitute.

Have you noticed that if you use *144* volts with the same theoretical car the necessary battery capacity goes *down*? This means the higher the voltage, the less A/h you'll need to reach that kW/h goal! Try experimenting if you like.

Remember, if you've worked out your range to the exact inch, you'll need to add in a little extra capacity as not to take your batteries below 80% *DOD*.

#1.6 - 3CA or 20CA – What does that mean?

You may have noticed people talking about LiFePO4 output ratings, using terms like 3CA or 20CA.

Don't worry, this is much simpler than it sounds. Each battery will have it's own maximum recommended *continuous* (all day long) output, and it's maximum recommended *impulse* (just a short burst) output.

The next image is taken from a *Thundersky* battery information sheet (available for download in Chapter 2 of this ebook).

Notice in the Max Discharge Current section, the Constant Current rating of 3CA? In English that simply means its maximum continuous amperage can be 3 times the A/h rating.

型号(MODEL): TS–LFP100AHA

標稱容量 Nominal Capacity	100Ah	
工作電壓 Operation Voltage	充電 (Charge)	4.25V
	放電 (Discharge)	2.5V
最大充電電流 Max Charge Current	≤3CA	
最大放電電流 Max Discharge Current	恒電流 (Constant Current)	≤3CA
	脉衝式 (Impulse Current)	≤20CA

A battery with an A/h rating of 100 means it's Constant Current output is 300 amps (3CA = 3 x the A/h rating). A constant output of 300 amps is impressive amperage and shows just how versatile this technology is.

Next is the 20CA Impulse Current rating which is once again the A/h rating (100) multiplied 20 times, which equals 2000 amps for short bursts! Amperages of that level can melt motors!

#1.7 - Discharging Over Time

Lead acid batteries have a strong tendency to discharge when not in use. Over the course of a couple of months, a fully charged lead acid battery can fall well below 50% *DOD* – right into its permanent damage zone.

While large *LiFePO4* batteries also self-discharge, they do so at the leisurely rate of around 5% per month. This means it would take more than a year to bring the voltage of a fully charged pack of LiFePO4 batteries down to a dangerous level.

#1.8A - Battery Management System (BMS)

LiFePO4 batteries are very susceptible to damage from overcharging. This is one area where lead acid batteries are superior in their tolerance.

The way to solve this problem is to buy a battery management system (BMS) for your battery pack. It's not so much a luxury as a must-have.

Without a BMS you'll most likely find yourself replacing batteries within 3 to 5 years – a very expensive learning curve!

The Battery Management System(BMS) consists of 3 main elements:

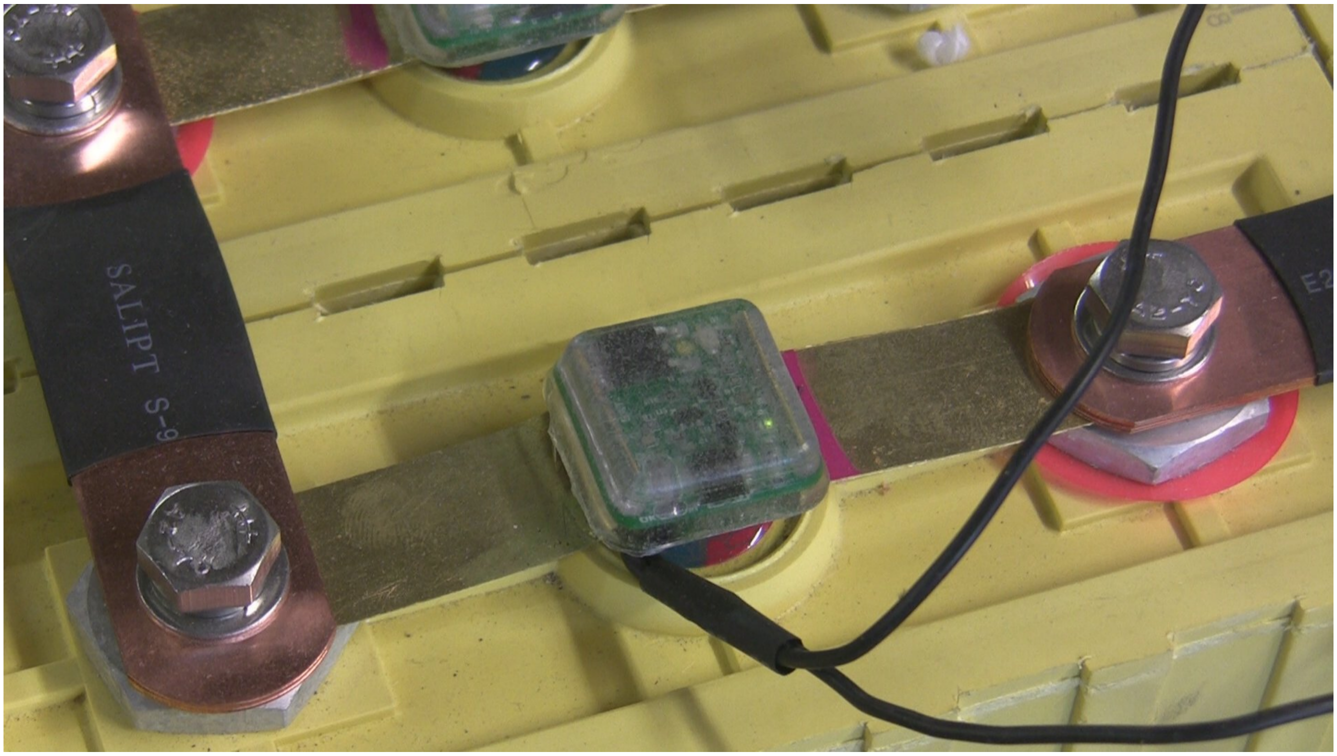
1. A charger
2. Balancing Modules
3. A Master Control Unit

Me holding a popular Zivan NG3 battery charger,
tuned for my specific battery pack.

1. A charger that has been tuned to your particular battery pack. If you buy your charger from the same company that supplies your batteries, they should take care of the required tuning adjustments.

Having a “tuned” battery charger means that it will be fully automatic & will shut itself down well before overcharging and/or damaging your batteries.

However, the charger can only charge the pack properly if all the individual batteries inside the pack are 'equalized”. To ensure this happens, you'll need equalizers (also known as balancing modules) on each battery.



A balancing module, monitoring the charge of the battery beneath it.

2.The only way to effectively equalize a series of LiFePO4 batteries that would normally change their battery voltages is with individual Balancing Modules (one on each battery).

These devices monitor each battery individually, constantly checking everything from its state of charge to its temperature. Every battery should have one, and the collective data is sent to a master control unit which monitors the pack collectively.

A Master Control Unit. Image courtesy of EV Works Australia
www.evworks.com.au

3. A Master Control Unit which oversees the battery pack during charging. Each cell's balancing module is wired into it, and it can control the charging and discharging to prevent overcharge and over-discharge.

Those 3 items: a programmed charger, balancing modules, plus a master controller are what make up a battery management system.

Battery management systems are an extra cost, but an essential cost. Expect to pay around $200 to $300 US for a master control unit, and around $10 to $20 US per individual equalizer.

Fortunately there are many people building their own *BMS systems* to sell to the public, so if you don't mind the slight risk then by all means buy your BMS from separate suppliers.

Preferably I recommend you buy your BMS from the same supplier of your batteries. This way you'll know you're getting a BMS that's *designed* for the batteries in your pack.

Another thing you could consider once your pack is installed is a monitoring system that you can read while driving.

This will provide a way for you to monitor each battery in your pack with the push of a button. This will also highlight any battery that is lagging behind before it brings down the whole pack and/or dies, leaving you stranded. One popular device for this purpose is called the *PakTrakr*.

A battery "Fuel gauge". Image courtesy of EV Works Australia
www.evworks.com.au

If you're not keen on a *PakTrakr* or similar device, then at the very least speak to your battery supplier to find an appropriate battery "Fuel gauge" to monitor the total state of charge on your pack. This will be more accurate than simply reading the voltmeter and should be an essential purchase to extend the life of your pack.

#1.8B - Making your Own BMS

While not for the faint-hearted, many converters have made their own battery management systems using everything from simple light-bulbs to programmed microchips.

I don't recommend absolute beginners risk damaging their precious new batteries by attempting their own *BMS*, but if you have a fair understanding of electronics then check out this “open source” page on building your own system here: http://batteryvehiclesociety.org.uk/forums/viewtopic.php?t=1245

Be warned, it's 60+ pages of thorough instructions and questions from other converters!

Another, more rudimentary system is available here:
http://www.eaa-hev.org/wiki/Battery_Management_System

The above link is based on a couple of *Zener diodes* with a light bulb across each battery which has the potential to regulate your batteries (at least the overcharge risk only) for around $5 per cell. A bargain perhaps, but it's not without risk.

If you have an understanding of electronics and think you have the ability to build your own regulators from scratch, you should be made aware of the characteristics of LiFePO4 batteries and what a BMS needs to do.

In which case, grab a cup of coffee and have a good read through here:
http://www.mpoweruk.com/bms.htm

#1.9 - Regenerative Braking

LiFePO4 batteries are typically fine for regenerative braking, though the best batteries for this purpose are the ones with the highest CA rating for being charged.

Look for a battery that has a 3CA (or higher) maximum charge rating if you plan on using regenerative braking as there's often a high current inrush in many regenerative braking situations.

#Chapter #2 – Sourcing & Buying

Below is a recently updated list of well-known LiFePO4 suppliers that sell Prismatic Cells (the manageable, brick-like shape) to everyday converters:

EV Works (Australia)
http://www.evworks.com.au/

LiFeBATT (USA)
http://www.lifebatt.com/new2/retail_sheet.html

EVComponents (USA)
http://www.evcomponents.com/

Elite Power Solutions (USA)
http://elitepowersolutions.com/products/index.php

China Free Power (China)
http://www.chinafreepower.com/product_show.asp?id=32

Lionik (China)
http://www.lionikbattery.com/liliz/lilipe.htm

BatterySpace (USA)
http://tinyurl.com/ykkyud9

TradeKey (Global)
http://www.tradekey.com/ks-prismatic-lifepo4-battery/

Valence (USA)
http://tinyurl.com/yzm9en7

Yesa (China)
http://www.yesa.com.hk/

Power Force (USA)
http://www.powerforceusa.com/Products/Products.htm

OSN Power (China)
http://www.osnpower.com/productID/plistone-2256367-1.html

Lion EV (USA)
http://www.lionev.com

Note: Feedback appears to be mixed regarding lionev.com so do your research before buying to be safe.

The supplier locations listed are where they are believed to have offices located, not where the batteries are produced as in most cases these batteries are produced in China.

I recommend using prismatic (brick shaped) cells because they're the most popular for conversions, very easy to work with, fit well physically into packs, and are generally proven performers.

If you prefer the specifications of cylindrical LiFePO4 cells then by all means, investigate them as an option for your conversion.

#2.1 - Risks

Regardless of whether your chosen supplier is or isn't on the above list, I recommend contacting other people who have used their batteries with success before purchasing. This is due to the amount of scam artists out there trying to take your money then giving you a perpetual run-around.

The first place to ask would be www.diyelectriccar.com, as well as www.visforvoltage.com.

Searching through the "*threads*" on the supplier of the battery you're looking into and/or placing a public announcement should get you some honest, unbiased answers on their service levels, honesty and quality.

#2.2 - Warranties

These batteries have now been around long enough for their manufacturers to offer one year warranties at the very least. Check with your supplier to ensure they have a warranty and a returns policy on factory defects.

#2.3 - Taxes

If you're buying from overseas you'll most likely pay import taxes. This varies from country to country and can be quite crippling. Unfortunately many countries will have a higher import tax on vehicle related items than they would on household items. I've heard of other converters using their cunning to classify their imports as house batteries for a solar-powered battery bank, rather than for automotive use, getting a lower tax rate – but do so at your own risk! Check with your local Customs office to see what taxes you'll be in for if buying direct from China or if you're outside the USA.

#2.4 - Bulk Purchasing

In order to bring prices down, quite often electric car groups will get involved in a bulk buying. This happens more often than you might think so check out the usual conversion websites:www.diyelectriccar.com, and www.visforvoltage.com to see if there are any bulk purchases planned in your area.

Be warned; make sure you're dealing with people you trust. If they're trustworthy then chances are they're worried too and therefore would have no problem entering a written agreement to protect all parties from someone "*doing a runner*"!

#2.5 - Buying Extra Cells

When it comes time to purchase your batteries I recommend buying 2 additional batteries (also known as *cells*) if your budget will allow it. While normally highly reliable, faults can happen with LiFePO4 individual cells. This could be caused by overcharging, undercharging, improper physical installation or even factory defects.

By having an extra cell or two lying around you'll be able to replace the offending cell in minutes, without having to wait weeks for a replacement under warranty (assuming the fault is covered under warranty).

Another reason to buy 2 cells is that the battery's chemical compound (what it's made of) can change from year to year. This means a replacement battery from 2011 may be chemically different to the batteries you bought in 2010. Installing an unused spare battery from your initial purchase order will ensure this doesn't affect your pack's operation.

If installed correctly, problems with *LiFePO4* cells are fairly uncommon, but if your budget allows it a couple of extra cells could be a future lifesaver. I also recommend buying an extra battery balancing module or two (the part of the *Battery Management System* that sits on top of each battery) for the very same reason.

#2.6 - Plan First, Buy Last

As with lead acid batteries, you should plan the location and installation of your batteries well before you buy them. This way you'll be able to adjust the layout in your car as you go, well before your pack arrives. You'll also have the advantage of a fresh batch of batteries going straight into your car, instead of a pack that's been sitting around for 5 months - with only 7 months of warranty left!

#2.7 - Specifications

While there are many other makes available, *Thundersky* are perhaps the most well known brand of *LiFePO4* batteries available. This makes finding data for them easy, so we'll use them as an example.

To give you an idea of sizes and specifications, here’s a selection of data sheets to download with all the *Thundersky* cell versions currently available:

40 A/h Cell
http://www.thunder-sky.com/pdf/TS-LFP40.pdf

60 A/h Cell
http://www.thunder-sky.com/pdf/TS-LFP60.pdf

90 A/h Cell
http://www.thunder-sky.com/pdf/200931791117.pdf

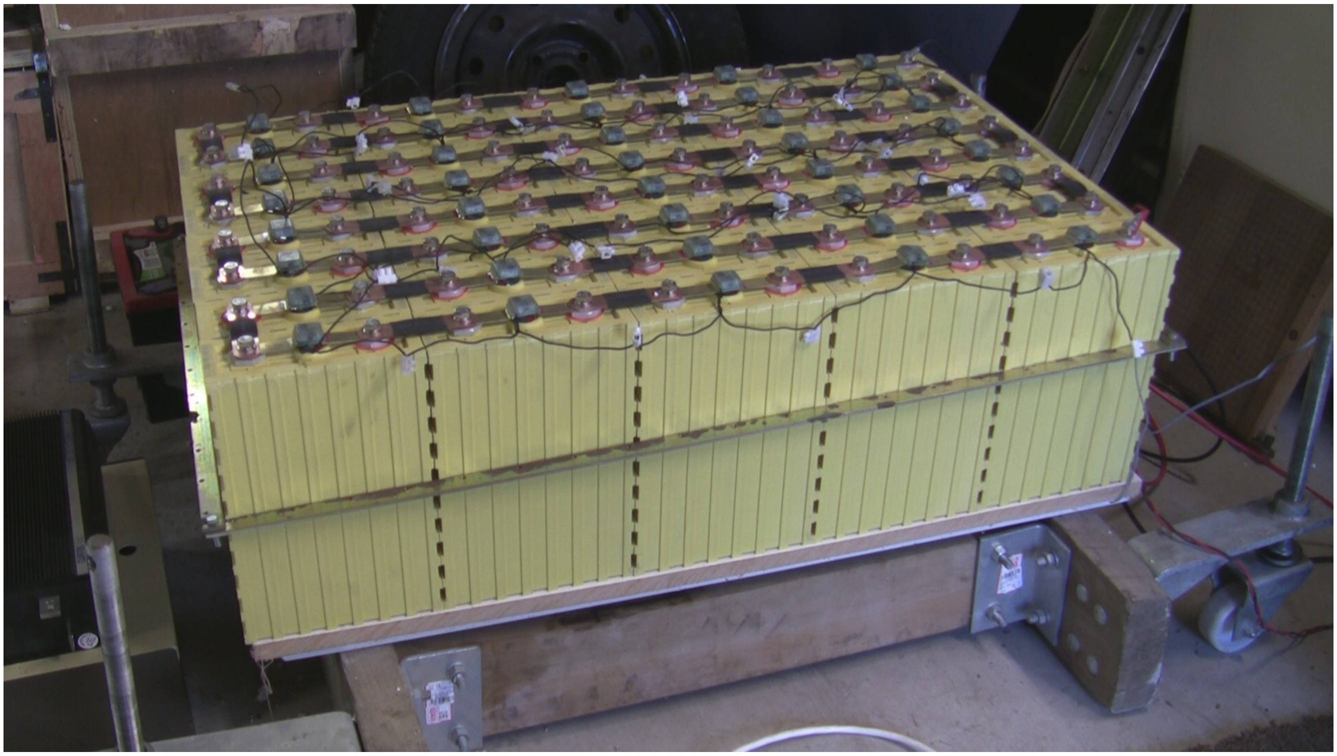
100 A/h Cell
http://www.thunder-sky.com/pdf/200964145219.pdf

160 A/h Cell
http://www.thunder-sky.com/pdf/200871782241.pdf

200 A/h Cell
http://www.thunder-sky.com/pdf/2008926101921.pdf

With the information you've learned, you'll be able to pick out which batteries will be best suited to make up your pack's size and voltage.

Chapter #3 - Installation



A pack of brand new LiFePO4 batteries awaiting installation.

As with any battery installation, the use of cardboard mock ups is very handy to get a real view of their actual size and how they'll fit into your car. You'll probably be surprised how big they are when you're trying to jam them under your rear seats or in the trunk etc.

Try to keep your cardboard mock ups as realistic as possible, perhaps even making an inflexible wooden frame to mimic the dimensions of the complete pack.

#3.1 - Keep The Cells Together If Possible

I've seen it recommended to keep your cells altogether in one large pack, rather than splitting it up throughout the car to keep them all at the same temperature under operation and to allow accurate monitoring.

That being said, I've seen conversions with larger battery packs split up into two sections successfully as well, so if you plan on splitting up your pack into sections, contact your particular battery supplier and ask if their chemistry has particular installation needs.

From the conversions I've seen, as long as they're protected from extreme climate conditions, physical abuse and their BMS is installed they'll be just fine whether they're split up or kept in one large pack.

It's also recommended to place restraining plates on the end faces of each line of batteries, and to bind the whole assembly with strapping to keep the flat surface of the cells from ever having the chance to bulge out during charging.

If they do ever bulge out, and it has been known to happen, the internal plates can start to spread apart, allowing dry spots to develop with the cell's capacity slowly lowering with each charge, to the point where the battery will finally fail.

By having the batteries forced into conformity, there's no chance of having the cell change it's shape to the point of dry spots developing inside.

Fortunately most battery suppliers I've seen have the option to purchase these "*Jig strips*" which hold strings of batteries together snugly, and some even include jig strips in the battery price.

#3.2 - Use Flexible Inter-connectors

When joining the batteries together be sure to use flexible inter-connectors with a section of thick metal braiding, or a semi-buckled (warped) design, rather than a flat metal copper joiner.

As with any other battery type, the *LiFePO4* battery is not designed to be thrown about by its terminals. Having rock-solid inter-connectors will put a fair amount of strain on the terminals of your pack as it's jostled about on a bumpy road, increasing the chance of failure – while voiding your warranty.

Combating this problem is easy though as many battery suppliers will have the option of buckled or braided inter-connectors to go with the batteries. This way your batteries can jiggle about on a bumpy section of road with the strain going onto the battery pack's frame, and not the individual terminals.

Also, inter-connectors should be sized large enough that there is very, very little noticeable change in the inter-connector's temperature after a typical EV drive.

#3.3 - Battery Terminal Clearance

As mentioned in the main ebook *Electric Conversion Made Easy*, make sure you keep a safe clearance above your batteries when installed. LiFePO4 batteries have the potential to deliver extremely high amperages if shorted out. Make sure you allow enough space above your batteries for the terminal bolts and BMS balancing modules and use a polymer or wooden cover over the top of the terminals, instead of metal.

#3.4 - Follow Your Battery Manufacturer's Instructions

You'll receive instructions from your battery supplier regarding the psychical installation of your batteries. Follow these instructions above all else.

Chances are you'll be dealing with some dangerous voltages as you start to join your battery pack together. By following the standard safety precautions set out in the primary *Electric Conversion Made Easy* ebook you'll be fine.

Things such as taping up your tools with electrical tape, being careful where you place metal objects and wearing high voltage gloves will ensure you get through your conversion completely shock-free.

#3.5 - BMS Individual Installation Requirements

As with batteries, each supplier will have their own specific instructions for their BMS systems. It sounds obvious, but follow their instructions and don't rush things.

As you've seen in Chapter #2, each battery will have a balancing module between it's terminals to regulate its charge. This means that when a particular battery is charged ahead of the rest of the pack, it will simply allow the current to bypass it, charging the remaining batteries without overcharging the already finished cell. Make sure your balancing modules are installed the correct way around or they'll be inactive - if they survive being installed back-to-front of course!

#3.6 - Charging Requirements

Many chargers are programmed to a specific sized battery pack. If you're buying your battery charger from an EV parts supplier they should be made aware of your chosen battery type and pack size.

Ideally it helps to purchase your batteries, your BMS, and your charger from the same supplier. This way you'll get a system that's designed and programmed to work with all the selected components, while saving on shipping individual items from different locations.

Final Note

As all conversions are different with different batteries, suppliers and parts, you'll find that each car has its own set of specific installation requirements. Therefore my advice is to follow the instructions given to you by your battery supplier above all else, and contact them exclusively if you encounter any battery issues.

In most cases I've heard only positive customer service stories and trouble shooting from LiFePO4 suppliers. Part of this may be because bad news spreads very quickly in the EV conversion community.

As with any of these guidebooks, I must remind you that they are just that – *guide*books and information tools. Ultimately any technical decisions must be made by you, the converter and I'm unable to accept responsibility for mistakes made.

That being said, from my experience there's little to go wrong in a typical EV conversion with LiFePO4 batteries as long as normal safety precautions are taken.

I trust you now have an understanding of how simple LiFePO4 batteries work and if they're suitable for your conversion. I always enjoy seeing photos your converted vehicles, and if you choose to use LiFePO4 batteries I would certainly love to hear your success stories!

In any case I wish you good luck, and happy - long distance – motoring!

Best regards,
Gavin Shoebridge

PS: All photos used with permission. Special thanks go to EV Works at www.evworks.com.au Jack Rickard at www.evtv.me and Brian Blocher at http://s2kev.blogspot.com

I'd also like to recognize and thank the friendly, helpful, and growing electric car community at www.diyelectriccar.com and www.visforvoltage.com