Conversion from AGM to Lithium Batteries in a Kimberley Karavan

My Prado-Karavan combined system has been set up and working for about six years with the manufacturer's AGM battery pack in the Karavan. In fact it was the second pack. The first lasted only two and a half years, but I suspect was abused by the first owner in the first 12 months of the van's life; it lasted only eighteen months after I bought the van. The tug's system was designed and built before the lithium batteries were ever considered. But let me say that the addition of the lithiums only recently has been a most happy enhancement!

You can read my blog on my vehicle installation at LINK

We were always careful to look after the manufacturer's AGM batteries. We diligently applied the 50% discharge rule, the sweet spot between practical daily draw-down versus the adverse effect of discharge on battery life.

We diligently re-charged as soon as possible. If that meant moving camp because there was no sun and National Parks or whoever wouldn't allow us to run a generator, then we'd move camp or go to a powered site.

The battery pack consisted of nine 12 volt, 35Ah AGM batteries in parallel. Not ideal in electrical engineering terms, but that is what the manufacturer provided to fit the available space. I ensured the pack was connected diagonally to the van – ie positive off the first battery in the string, negative off the last.

I also rotated the batteries – ie moved them along the string one at a time – at six monthly intervals to ensure they all had equal time in all positions. (The end batteries in a parallel string do the most work.) Not many people bother with that.

When not in use the van was stored either with full batteries with the negative disconnected and regularly checked and charged if necessary, or left on the mains charger on float.

Etc, etc.

In spite of the best of care, after four and a half years of pretty solid use it became apparent that these batteries had lost capacity. It hit home at a cold camp when we ran the diesel HWS/room heater for a few hours one cold night – it needs about 20 amps to light the fire and then a few amps to keep it alight and to power the fan and circulation pump. Next morning, even colder, and the heater would not start due to low voltage under the high current in the start cycle (voltage sag). The navigator/cook who arises two hours before I do was not impressed!

I had watched people in our owners club do lithium conversions with excellent results and figured, not too sadly, that now it was my turn.

Advantages of lithium batteries over AGM:

- Cycle life. Well looked-after AGM batteries might have a life of 400 to 800 cycles. Well looked-after lithium batteries have a life measured in thousands of cycles. 3000 for consumer grade batteries; over 7000 has been recorded for military grade.
- Cost of ownership. Though more expensive to buy initially, one set of lithium batteries properly cared for will



likely outlast three or more sets of lead-acid batteries. It's new consumer technology; time is yet to tell but the forecast is looking good.

- No 50% rule. Yes, depth of discharge does affect longevity, but not nearly to the same extent as it does lead-acid technology. You can safely go down to 20% state of charge on a routine basis. 320Ah of AGM gives you 160Ah useable under the 50% discharge rule. 320Ah of lithium yields 256Ah useable under the 80% discharge rule – over 1.5 times the useable capacity.
- Negligible Peukerts effect. If you have a lead acid battery with a C20 capacity of 100Ah, it means that when new it will deliver 5 amps for 20 hours (5 x 20 = 100). However it will not deliver 50 amps for 2 hours (50 x 2=100) or 100 amps for one hour or 25 amps for 4 hours. In effect, the higher the current the fewer the amp-hours the battery will deliver. It is a complex, non-linear relationship that comes into play when you start doing things like running a microwave oven off an inverter under battery power. My inverter draws 130 amps to run the microwave. 130 amps for 6 minutes would seem to be a draw-down of 130 amps x 0.1 hours = 13Ah. Under Peukerts, not so it is more, way more, and regardless of current drawn the effect gets worse as the as the battery ages. A lithium battery has no such limitation in normal recreational use.



On the other hand, lead-acid batteries drop voltage as they discharge. This may cause some appliances to pull a higher current in an effort to compensate, run slow, lack

power, etc

• Lithium batteries have a very flat discharge curve, meaning that unlike lead-acid batteries

they hold their voltage as they discharge until they get to about 10%, at which point the curve takes a dive and the voltage starts to rapidly fall. This means that for the whole of the safe 80% useage you get out of a charge cycle all your 12V appliances and systems will get full battery volts, about 13.3V.



- Lithium batteries have little voltage sag under load. If a battery is at 13.3 volts and you pull a high current out of it, the voltage will still be 13.3 while delivering that current. Lead acid batteries sag, lights dim, start cycles may get interrupted because the voltage sags below the low voltage cut-out point for the appliance. In fact that is what precipitated my move to lithium batteries.
- Lithium batteries accept a higher bulk charge rate than most deep-cycle lead-acid batteries. If you can supply the amps lithium batteries will gladly accept them and hence charge faster.
- Except at extreme temperatures not encountered in Australia, lithium batteries do not require temperature compensation when being charged.
- Most lead-acid deep cycle batteries, particularly AGM, prefer a multi-stage, tapered charge. Even if they accept a high bulk charge rate they typically need some hours at a constant voltage with tapering current to get the last 20% or so into them.

My 440 watts of solar would spend hours in the absorption phase trickling a few amps into the AGMs before they went to float. Now the system runs flat out until the batteries get to 14.6 volts, followed by about 20 minutes at that voltage for cell balancing (not capacity) and then float. Batteries are full up to four hours earlier than they used to be in similar solar conditions.

If you have to run a generator, the run time is similarly reduced.

- Lithium batteries have a higher charge efficiency than lead-acid. To get 100Ah into a leadacid battery you might have to give it 125Ah of charge. To get 100Ah into a lithium battery it might only be about 105Ah or less. That means less wastage of valuable solar energy, less generator run-time.
- No sulphation or equivalent. Lithium batteries can be left or cycled in a partially discharged state for long periods with few or no adverse effects.
- Weight. Amp-hour for amp-hour, lithium batteries are about half the weight of lead-acid batteries.

Disadvantages of lithium batteries compared to AGM.

• Primarily cost, but you can look at it two ways. If you replace good quality AGMs with the same amp-hour capacity in lithium, you'd be looking at about double the price of the AGMs.

If you look at it on the basis of useable amp-hours, then you need a much smaller lithium pack than you do AGMs. 320Ah of AGM yields 160Ah useable on the 50% discharge rule. If 160Ah is enough for you, then using the lithium 80% discharge rule you need only 200Ah of lithium, which makes the cost of the lithium batteries only about one and a quarter times the cost of the AGM. (Very rough estimates, but the principle is valid. With careful choice of lithium capacity it may be possible to break even.)

- They are intolerant of overcharge and over-discharge. One over discharge may write off a battery. Overcharge will cause swelling which is on the way to failure, or at the very least, reduced life. For this reason they need a Battery Management System which isolates the batteries from all loads and chargers if the battery voltage, or even one cell voltage, goes outside set parameters. My pack came with the BMS fitted and ready to go.
- Extreme care needs to be taken when handling them, not because they are physically fragile, but because they are so electrically strong. They can deliver huge currents in the event of a short circuit. I have read that my 360Ah pack will deliver up to 5000 amps until something blows up enough to spray molten metal about. You must work with insulated tools and ensure the battery is very firmly restrained in a carrier so it doesn't move about in an accident.
- Ummmm Can't think of anything else.

So a couple of practical and commonsense precautions and a commitment with the cheque book is all that is required!

Lithium batteries come in a variety of chemistries, just a lead-acid batteries do.



I replaced my 320Ah of AGM with 360Ah of lithium iron phosphate batteries. That's iron with an "r", not "ion". The two are often confused. The batteries we're talking about are often referred to as LiFe, LiFePO4 or LFP – all abbreviations of their chemistry. This is the type commonly used in automotive and recreational applications.

You may have heard stories about lithium batteries blowing up and that they are dangerous and unstable.

These spectacular events mostly occurred with lithium ion (without the "r") technology – a different lithium chemistry. The LFP batteries used in automotive and recreational applications with a suitable BMS are as stable and safe as a lead-acid battery.

Since we installed our 360Ah LFP batteries we have enjoyed much increased useable capacity – 288Ah instead of the 160 offered by the AGMs.

The supplier was EV-Power in WA. The website is at <u>http://www.ev-power.com.au</u>. Rod Dilkes, the proprietor, has done a number of Kimberley Karavan conversions and has come up with a bolt-out bolt-in swap-over. Well, almost. The battery box needs a bit of sheet metal work to make the new batteries fit – mostly removing an un-needed intermediate shelf and devising a strong clamping arrangement – but electrically it's very simple, just a direct replacement.

The lithium pack comes with a battery management system (BMS) that prevents over charge or over discharge in any one cell, and there are eight cells. Very clever.

The cells in healthy lead-acid batteries automatically balance. In a lithium battery they don't. By supplying an occasional charge voltage a little higher than normal the BMS shunts the charge from cells already fully charged and directs it to the cells that need to be brought up. It is an ingenious one-wire system, and part of EV-Power's standard package.

Since the change to lithium batteries our camps without sun or generator are much longer, and worrying about battery condition is a thing of the past. Used to be we were always thinking about minimising power consumption so that a daily solar re-charge to 100% could be pretty much guaranteed.

Not any more. We don't have to worry about partially charged batteries incrementally sulphating and degrading. We can run the microwave off the inverter whenever we need to and not be worried about "working the batteries too hard" and getting them into a partially charged state from which we cannot recover without mains or generator power – both of which we like to avoid.

In fact, the lithiums are so forgiving that we are seriously considering travelling without a generator, relying instead on solar and driving time. There is just a psychological hurdle to be jumped in that regard – the genny is the ultimate fallback for us and it's hard to abandon it.