

A heart/lung transplant for your GMC

by Jerry Work
GMCWS 2019

Modern LiFePO4 lithium batteries with on-board electronic controls and new means of recharging both lead acid starting batteries and lithium house batteries at the same time now allow you to live a carefree life on the road cost effectively without regard (within reason) for which appliances you use, when or for how long

Disclaimers - Jerry Work presentation to GMCWS, October 2019

The opinions expressed herein are my own

I have no affiliation with any of the companies or products shown

I am not compensated in any way by anyone for making this presentation

This seminar and any recommendations made are for educational purposes - do your own research and make your own decisions as to proper installation and use

10 years ago at GMCWS in Pueblo, CO, I gave a presentation on how to add enough battery capacity to make life on the road a real joy.

At that time the only viable choice was to use over 300 pounds of lead acid batteries that were hard to fit in many GMC configurations

Now, just 10 years later, everything has changed. Reliable, cost effective, safe, lithium based batteries coupled with modern electronic controls provide even more capacity & can fit into most GMC configurations

Living large in your GMC...

How to add enough battery power to make life in your coach a real joy no matter where you go

by Jerry Work
GMC Western States/International
Pueblo, CO 2009

You can download a copy of this presentation from my website
<http://jerrywork.com>

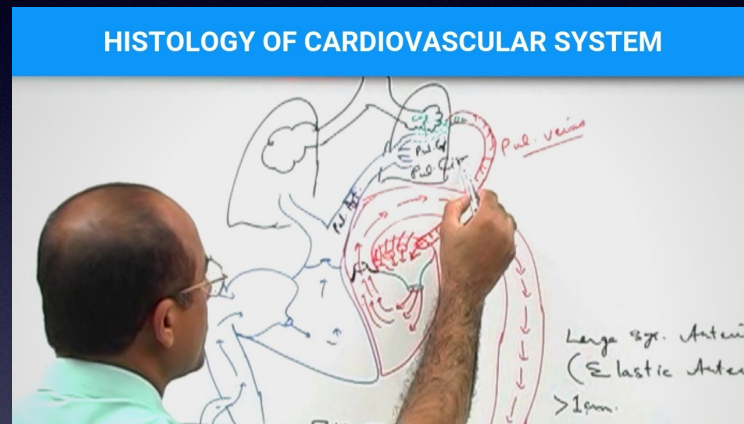
In the next hour we are going to talk about what all has changed, how that might benefit you, and what you will need to do if you want to add this new technology to your GMC

It will require an up front investment and will not be the right thing for everyone. So, we will go over a set of questions to answer for yourself whether making such a change now is the right thing for you to consider

We will cover costs in detail and I will give you my recommendations on specific products to buy and why - for a good, a better, and a best configuration for a GMC

Along the way I hope to also dispel some of the many myths surrounding this technology for use in motorhomes so that by the end of our time together you will be well equipped to decide whether lithium house battery systems are right for you

In your body, oxygen rich blood is pumped by the heart through arteries to provide power to every part of the body. Oxygen depleted blood is then carried back to the lungs by veins where it is recharged with fresh oxygen and the cycle repeats.



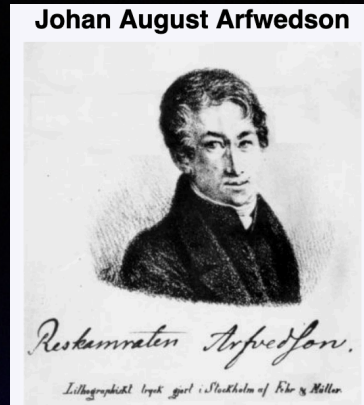
In your GMC the voltage in the battery or shore plug pushes electrons through wires to provide power to do useful work for you. When the battery becomes depleted and you are not plugged into shore power the flow of electrons stops until you can recharge the batteries and the cycle repeats.

Giving your GMC the equivalent of a heart/lung transplant cost effectively is now possible thanks to significantly improved battery technology and even more significant improvements to the means of controlling the recharge cycle and the devices that do the useful work for you.

Things like inverter/battery chargers, lights, motors, audio and video equipment, cooking appliances, heating and air conditioning are all way better now than they were in the mid-70s when our GMCs were designed.

To get started understanding all these things and how this improved technology can greatly enhance your pleasure living in and using your GMC, we first need to meet four notable people.....

Johan Arfwedson
discovered a strange new
unstable lightweight metal
called lithium

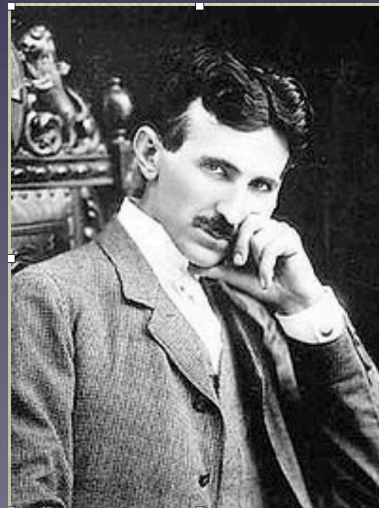
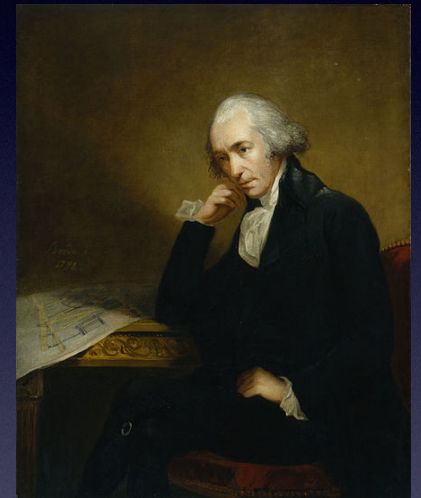


James Watt developed
the modern
classification of
weights and measures.
He also described the
amount of work
electricity could do as
 $\text{Watts} = \text{Amps} \times \text{Volts}$



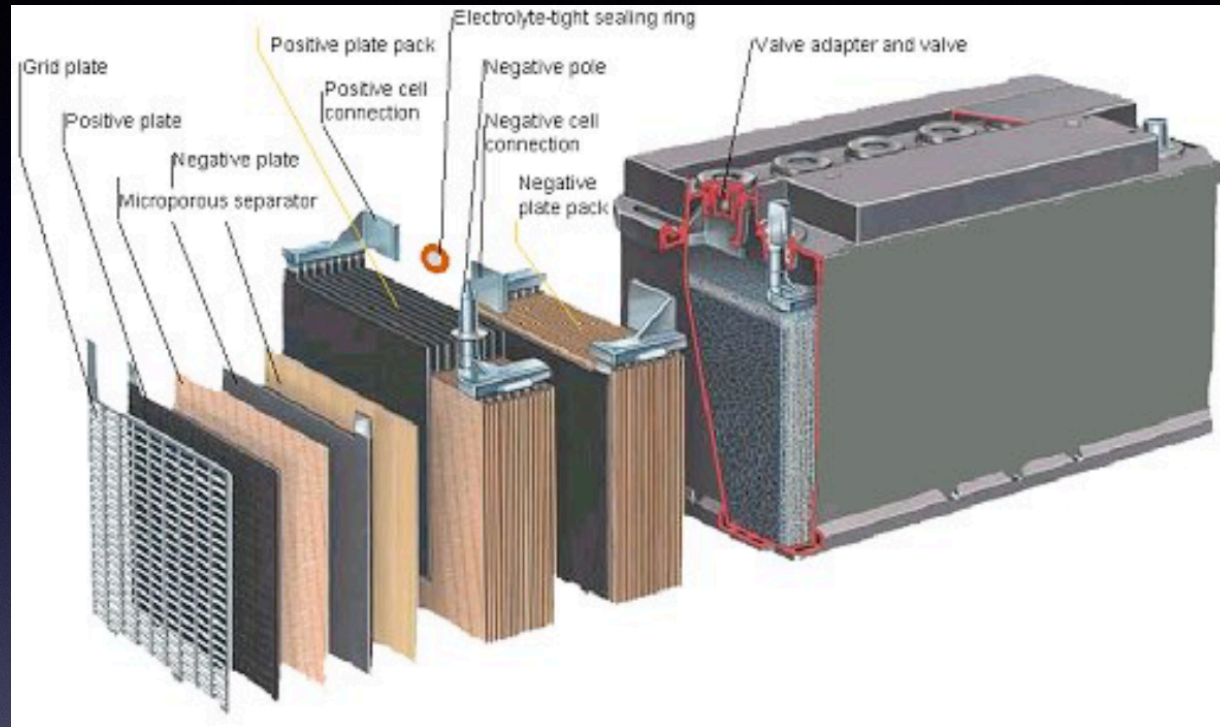
Alessandro Volta
invented the battery
in 1800, a chemical
way of generating
electricity

To get started we
need to meet four
notable people



Nikola Tesla invented
or greatly improved
upon everything we
know about
mechanically
generating and using
electricity

Now we have all the ingredients leading to today's battery revolution, but it didn't happen over night



Lead alloyed with other chemicals for the anode and cathode, and the use of a liquid acid as the electrolyte was the most common type of battery from the early 1800s until well into the 1900s - like the common auto battery shown here

Throughout this period battery development was focused on trying to overcome the many challenges associated with a lead/acid battery

The many challenges of a lead/acid battery

It is very heavy so only useful for stationary applications

Voltage drops as soon as you start to use it which means Watts also drop so the battery can do less and less useful work the more it is used

The heavier the load you put on the battery, the faster the volts drop so the amount of work the battery can do drops even more quickly

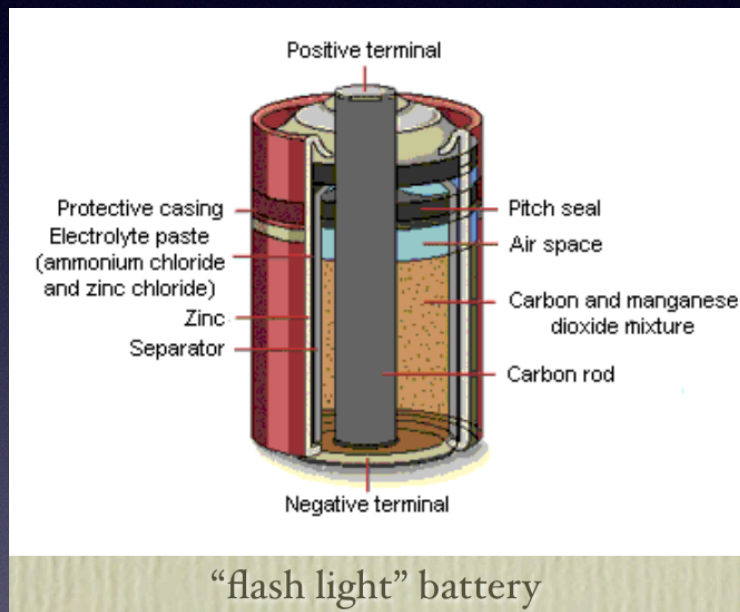
The chemistry is such that you can only use about half or less of the battery's capacity or you will shorten the life of the battery significantly

In high draw applications, like powering the appliances and lights in our GMCs, this means you can only really get to 30% to 40% of the watts the battery can supply to do useful work for us

A lead/acid battery has a limited useful life and can only be recharged 200 to 600 times in high draw applications such as house batteries for our GMCs - not the 1000 times the books say they should

A lead/acid battery gives off highly corrosive fumes when being charged or discharged so has to be mounted away from people and vented to the outside to be safe. And, the liquid acid can make a real mess if it gets spilled.

During this period of the 1800s to late 1900s work was also done using other metals like zinc and nickel, and safer electrolytes than acids, to try to make a lighter, safer battery with more capacity and longer life.



Toyota used NI-MH batteries in its hybrid from inception through 2014. They still use them in some Prius models.



High-power Ni-MH battery of
Toyota NHW20 Prius, Japan

In the late 1990s the focus changed to various kinds of lithium based batteries that offered far greater energy density and much longer life

Six different types emerged, each with a different set of characteristics in terms of:

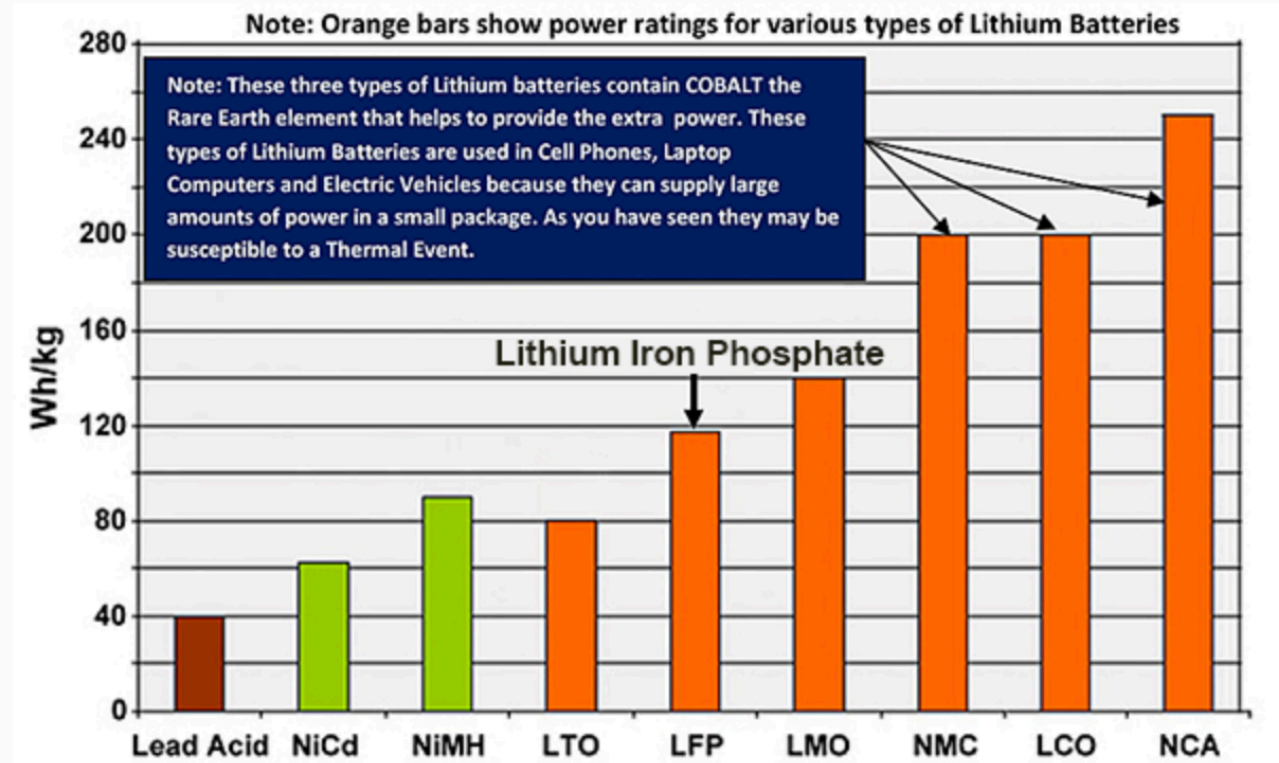
Energy content

Life span

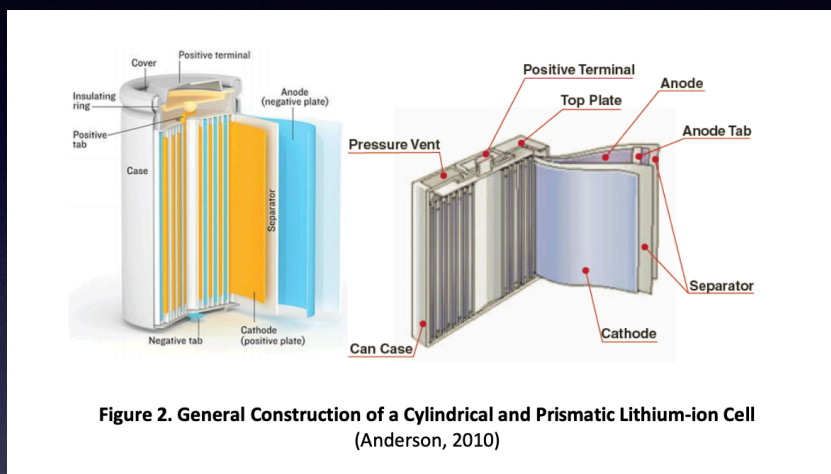
Safety

Cost

Performance



These six different Lithium battery chemistries are used everywhere from cheap Chinese flash lights, to expensive cell phones, household appliances, every kind of power tool you can think of and certainly in electric cars and trucks.



There are two types, flat and round cells that can be wired together to form just about any shape, voltage or amperage the designers need for their application

A Tesla Model S for example uses over 7000 round cells wired series/parallel to propel their cars over 300 miles on a single charge, but those batteries require liquid cooling, continuous monitoring and near real time micro processor management to be reliable and safe in this application

The cell phone in your pocket uses flat cells shaped to fit every nook and cranny inside the phone and a lot of the smarts in your phone are devoted to keeping those batteries reliable and safe in this unique application

The kinds of lithium batteries we need to power the living requirements in our GMCs use Lithium Iron Phosphate (LiFePO₄) chemistry and very intelligent built-in, micro-processor controlled active battery management



The first lithium batteries offered, like the one shown left, required a lot of owner involvement in the management, charging, temperature control and cell balancing of the batteries. They often were neither reliable nor overly safe for this application

***The battery world
has changed rapidly***

In just the last few years highly automated battery manufacturing processes have brought prices down and allowed the addition of real time, active battery management and automatic battery cell balancing, perfect for our application. At the same time reliability and safety have been greatly enhanced as well.



As but one example of how fast everything is changing when it comes to lithium batteries, most of you have a smart phone in your pocket, right? How long ago was it that Steve Jobs introduced the first really smart phone?



As but one example of how fast everything is changing when it comes to lithium batteries, most of you have a smart phone in your pocket, right? How long ago was it that Steve Jobs introduced the first really smart phone?



2007
and it was
made
possible by
reliable
lithium
batteries with
electronic
battery
management

Getting back to our GMCs.

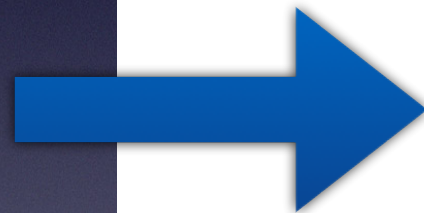
**Lithium Iron Phosphate (LiFePO₄) 12v
batteries are way better than lead acid
for house batteries in our GMCs.**

Here is why

Here is the biggy - Lithium batteries work at higher voltages than lead acid batteries so produce more watts of useable power.

Note that 85% of the capacity of a lithium battery takes place at voltages higher than where a fully charged lead acid battery even starts!

This is where a fully charged lead acid battery STARTS!

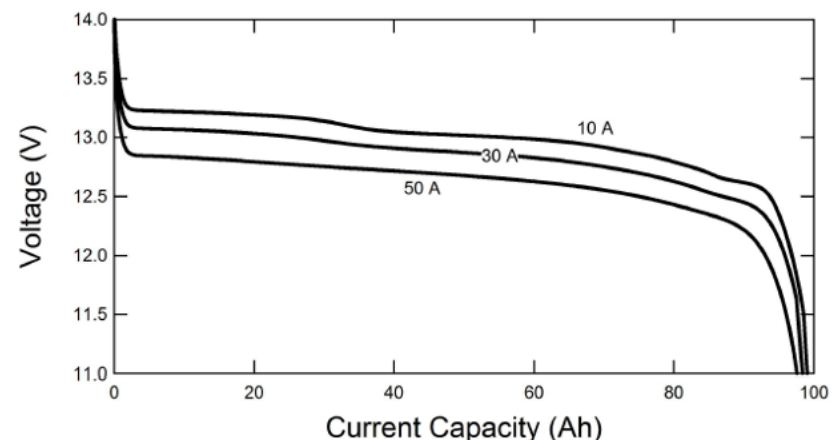


VOLTAGE VS CAPACITY

14.4V	100%
13.6V	100%
13.4V	99%
13.3V	90%
13.2V	70%
13.1V	40%
13.0V	30%
12.9V	20%
12.8V	17%
12.5V	14%
12.0V	9%
10.0V	0%

Voltage Level

Remaining capacity



In addition, Lithium Iron Phosphate (LiFePO₄) 12v batteries are way better than lead acid for house batteries in our GMCs for several other reasons, too

Two to three times the useable power

Less than half the weight

Charge 5 times faster

Very low self discharge rate

Last four to six times longer

100% safe and reliable

Deliver full voltage, even in high draw situations, through 90% or more discharge

So, what do we gain by having more battery power available to do useful work for us?

Use your microwave and toaster to your hearts content

Use as many computer devices as you wish

Overhead fans all night long without concern

Lights to match your mood

Even a little AC for a short time on a hot day

Recharge everything from tools to phones

CPAP machine all night long without concern

Your Instapot becomes your friend for easy meals on the road dry camping

Use your hair dryer when you come out of the shower

All the tunes or video you want

Electric coffee maker or tea pot anytime, anywhere

No more worry about waking up at 3:00 AM to find the furnace turned off on a cold night when the batteries got too low

Bake in a toaster oven or convection microwave

Induction cooktop whenever and wherever you are

Put in a residential refrigerator or freezer if you wish

In short, you live in your coach just like you do at home

Now let's talk about cost

Here is a partial list of 2019 prices in roughly descending order. All have active, on-board battery management built in. Most have automatic cell balancing as well:

Expion360 - \$1345, 120ah, Redmond, OR, cells and battery manufacturing location ?

Briter - \$1200, 100ah, South Bend, IN, prismatic cells and battery manuf. location ?

Trojan - \$1075, 110ah, California based, cell and battery manufacturing location ?

Battle Born, \$949, 100ah, Reno, NV, cell?, battery manufacturing in-house

Dakota, \$900, 100ah, Seattle, WA, cell and battery manufacturing location ?

Relion, \$879, 80ah, Rock Hill, SC, cell and battery manufacturing location ?

AIMS, \$852, 100ah, Reno, NV, cell and battery manufacturing location ?

Renogy, \$765, 100ah, Ontario, CA, cell and battery manufacturing location ?

For context, to equal the output of one of these lithium batteries, you will need two to three 100ah 12v Trojan deep cycle AGM lead/acid batteries which will initially cost \$600 to \$900 and last not nearly as long.

The battery is not your only cost - you have to change or add components to properly charge both your lead/acid starting battery and your lithium house battery bank from all four of the common charging sources in your GMC:

Charging from the alternator while driving

Charging from shore power

Charging from the generator

Solar charging

Lithium batteries bulk charge at 14.2 to 14.6 volts at 50 amps and float at 13.6 volts. Lead acid batteries charge at 13.6 or so volts and float at 13.2 or less volts. At less than the voltages shown lithium batteries may take longer to reach a full charge or may never reach a full charge. Some converter/chargers can be set to these voltages while others cannot. Most GMC alternators put out about 14.x volts but cannot provide 50 or more amps for very long without damaging the alternator from over heating.

Charging from your GMC alternator can be done but will require a battery isolation monitor which limits duty cycle to keep the alternator from over heating. A battery isolation manager only allows the output of the alternator to be on for 15 minutes out of every 35 minutes to keep the alternator from over heating while recharging the lithium house batteries.

Lead acid batteries will only take a fraction of the alternator's potential output before dropping down to a slow absorption charge rate.

Lithium batteries will happily take all the amperage the alternator is willing to provide up to the amp hour capacity of the battery. Trouble is, the alternator was never designed to output 50 to 100 amps for more than a short time before it over heats. Cost is \$175

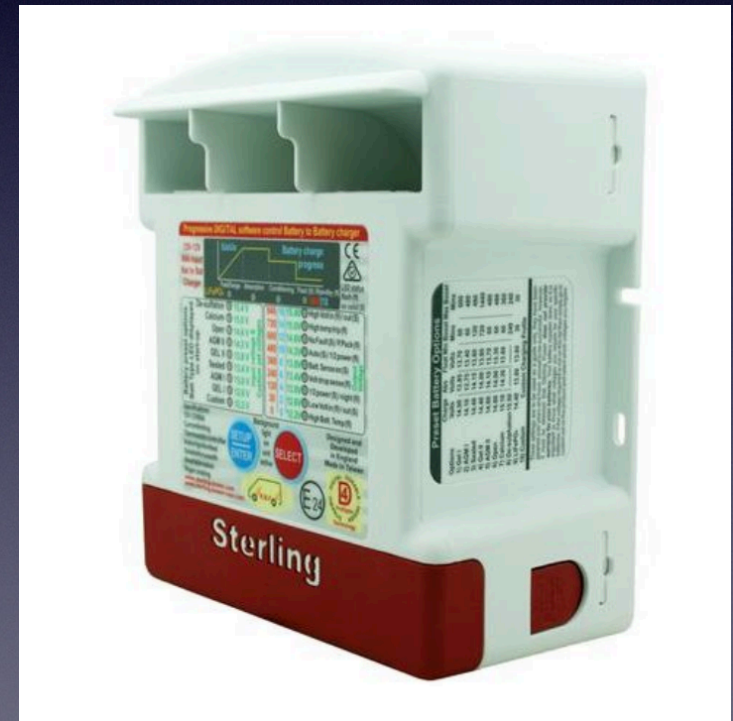


If you have changed to a higher output alternator, a smart combiner like the Sterling Power 4 stage Battery to Battery 60 amp unit shown here can also be helpful.

This unit takes the output from your engine alternator and boosts it to the proper voltage and amperage charge profile for the lithium battery bank. It still allows your alternator to charge your lead/acid starting battery without over charging it.

It keeps the starting battery and the lithium house batteries isolated so one will not run down the other. It charges lithium batteries much faster than a stand alone alternator trying to also recharge the lead acid starting battery - 5 to 10X faster.

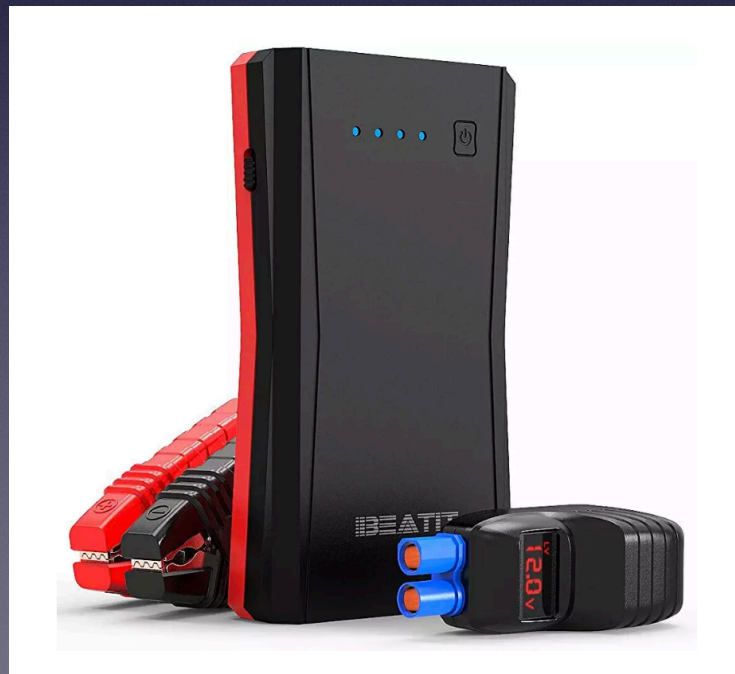
Cost is \$400 for the 60 amp unit or \$330 for the 30 amp unit. You don't need this unit if you still have a stock 80-100 amp alternator, a BIM is enough.



You do NOT want your lithium house and lead/acid starting batteries to be connected together for any extended period

The lithium house batteries function at a higher voltage than the lead/acid starting battery. If they are connected for any extended period the lithium battery will try to bring the lead/acid battery to the same voltage, discharging the lithium battery without doing any useful work for you and it could damage the starting battery by causing it to over heat.

You CAN leave the battery boost circuit and switch in place to start your coach in an emergency, just be sure to turn that switch OFF as soon as it starts.



Best bet is to buy a \$50-\$60 Portable Car Jump Starter like this BEATIT one from Amazon, remove the boost solenoid and never connect the two together

Charging from shore power or generator power will require a converter/battery charger with lithium battery charging parameters

Your existing unit might be able to be used, but the lithium batteries will not charge as fast or may not get fully charged

Iota says they have a \$28 plug in module to provide correct charging for lithium batteries.

Progressive Dynamics with Charge Wizard allows you to press the button to go into Boost mode and get the correct settings for your lithium battery bank, but it will not do that automatically. They also offer a \$7 module.

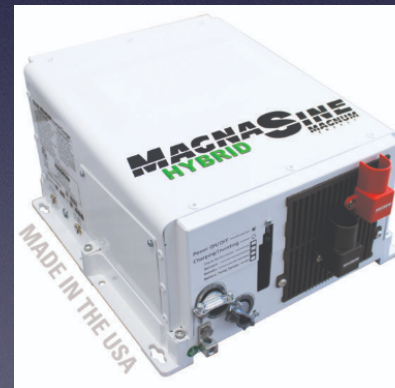
The very best solution is to install a modern inverter/charger that has the lithium parameters built in. You will get a much better inverter, an automatic transfer switch, rapid charging of your house battery bank and perhaps even load sharing.



New PD 9160ALV \$270



Spartan 4000w \$1100



Magnum 3000w \$1800



Victron 3000w \$1275

Now, we have all the pieces to put together my “good”, “better”, “best” recommendations for a GMC

Good - one 100ah lithium battery, BMI, a stand alone lithium profile charger and new cables
\$1000 to \$1300



Battle Born is my pick for a 100 amp LiFePO4 battery offering high quality, long life & a 10 year warrantee at an attractive price.

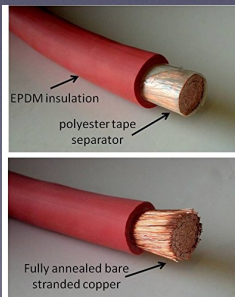
100 useable amps is enough for many GMC coaches. While your existing converter/battery charger may charge this lithium battery, you may need to periodically bring the lithium battery to full charge with a stand alone charger.



The \$175 Battery Isolation Manager will allow you to use your existing alternator without damaging it.



A \$150 stand-alone smart battery charger will properly recharge the one lithium battery from shore or generator power without you having to change your converter/charger.



Replace your old corroded battery cables with new, larger multi-strand marine cables

Better- 200ah and battery monitor \$2200 to \$2500

This is more than I could get ten year ago with 300 pounds of lead acid batteries!



AND



Victron battery monitor acts like a fuel gauge for your lithium batteries
\$150 - \$200

Charging from alternator



Battery isolation manager \$175 will keep the alternator from overheating by turning it on for 15 min, then off for 20

Charging from converter/charger



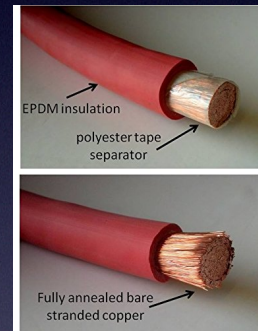
New PD 9160ALV \$270

OR



New module for your existing PD or Iota \$7-\$13

OR



Replace your old corroded battery cables with new, larger marine cables

Manually press the boost button on your existing PD 91xx Charge Wizard \$0





AND



AND



Victron battery monitor
acts like a fuel gauge
for your lithium batteries
\$150 - \$200

Charging from alternator



The \$175 Battery Isolation
Manager will allow you to use
your existing alternator without
damaging it.

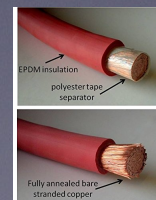
**Best- 300ah of lithium
batteries plus everything
shown will give your GMC a
much needed full heart/lung
transplant for a bit over \$4000!**

Charging from inverter/charger



Modern
inverter/charger
such as

Victron 3000w \$1275
plus control panel



Replace your
old corroded battery
cables with new, larger
marine cables

Now for good news

BattleBorn batteries has agreed to bundle everything we need into packages priced at a 10% discount for the GMC community.

If you buy from BattleBorn directly, the package prices will be as shown, they will ship to you free anywhere in the country and will not charge any sales tax.

In all cases you will procure new battery cables plus any required fuses and switches yourself to fit your specific configuration. You can work with Battle Born to supply these as well if you wish.

GMC-1 (Good):

12v 100AH Battle Born battery
Lithium Battery Isolation Manager
Victron Blue Smart IP65 15 amp battery charger

Retail price of \$1,294.11
GMC owners special \$1,165

GMC-2 (Better):

QTY 2 12v 100AH Battle Born Batteries
Lithium Battery Isolation Manager
Victron Battery Monitor
Progressive Dynamics PD9160 charger

Retail price of 2,544.65
GMC owners special 2,290

GMC-3 (Best):

QTY 3 12v 100AH Battle Born Batteries
3000w Victron Multiplus inverter/charger
Lithium Battery Isolation Manager
Victron Battery Monitor
Digital Multi Control (control panel for the inverter)

Retail price of 4,672.65
GMC owners special of 4,205

Call Battle Born Batteries, 855-292-2831

Can you run your roof AC with the “better” or “best” set up?

Likely, but only for an hour or so.



Depending on the age, design and state of maintenance of your roof AC, you can run it with either the “better” or the “best” set up, but you may or may not be able to start it with the “better”. The starting amp draw can be two to five times the approximately 100 to 150 running amp draw.

Even if you can get it started, you only have 200 to 300 amp hours available from your two or three lithium batteries so can only run a small roof AC for at most 2 hours, more likely an hour or so. Enough time to run in and eat lunch but not enough to go through a hot day or night.

Now it is decision time!

Do NOT do this if:

You plan to sell within two years

If you have AGM house batteries that are less than two years old

If your budget can't stand a \$1000 or more hit

If you are plugged into shore power or running your generator 80+% of the time

If your GMC is a yard queen up on blocks!



Now it is decision time!

In all other circumstances consider carefully doing this now, as you likely will find it one of the best things you ever did. And, if you are thinking about adding solar panels at some point in the future, be sure to do this now.

At the end of the first year you will say, wow, I didn't know being in the GMC could be so much fun.

At the end of the second year you will say, this really is the best thing ever!

At the end of the third year you will say do you even remember what it was like to live with those old lead/acid house batteries? Yuk!



There simply is nothing like being able to live a carefree life on the road in your GMC without regard (within reason) for which appliances you use, when or for how long.

Dry your hair with your hair dryer, make coffee in an electric coffee maker, use your toaster and microwave to your hearts content, bake in your convection microwave oven, cook on your induction cook top, run your furnace all night long on a cold evening, use a household refrigerator if you wish (“better” and “best” only), play tunes as loud as you like, enjoy your flat screen TV and computers for as long as you want to, recharge tools and other appliances -

*In short, just live as **large** as you want to in your GMC once you have given it a heart/lung transplant!*

Now I will open it up for your questions

To really compare battery technologies, like lead acid and lithium, we need to talk WATT HOURS not AMP HOURS.

Watt hours (amp hours times average voltage) reflect the amount of useful work the battery can do for us, while amp hours only tell us how many amps the battery can deliver under whatever the assumed amp draw was that the battery manufacturer used when rating the battery.

For a typical 100 amp hour lead acid battery we know we can only access at most 50 amp hours without damaging the battery. Also voltage drops from 12.6 volts quickly down to 11 or so volts in heavy use. So, that battery provides us at best 600 watt hours (12 volts average times 50 amp hours), and more realistically only around 500 watt hours.

A 100 amp hour lithium battery will provide more than 1250 watt hours, so will do more than twice as much useful work for us.