

## Fast, Slow, and Really Slow

One of the many benefits of our Lipo4 battery systems is their fast reaction time. We can discharge our Lipo4 batteries to 50% at a 3kW rate and only have a .4 volt drop. Our 1350 AH lead acid batteries are much slower. Salt water batteries this is impossible because they are limited to a 17 amp, maximum draw. To be able to draw out this power you need at least 4 sets of salt water batteries....They are really, really slow. At the 20 hr rate they are only 49.3 AH. It takes many, many cells to make a workable system. Their Battery module is 12 "stacks" of 8 cells. A Whopping 96 cells for one battery, with close to 250 battery interconnections. And weighs over 3,300 lbs. This is over 26 times the size of our Lipo4 and over 13 times the weight of our Lipo4 system. We have 16 cells and less than 20 battery interconnections. Yet at the 4 hour rate we can deliver 13 kWh and they can only deliver 14.3 kWh. And look at the cost!!! The salt water battery lists for \$15,750.00. Our list price is \$15,000 and this is an entire system, 4.4 kW inverter, Lipo4 battery charger, all necessary circuit breakers, BMS, inverter and system monitoring, totally prewired and tested in a steel enclosure.

## Lithium Battery Overview

Lithium Based batteries are quickly becoming a reasonable replacement for the 150 year old technology of Lead-Acid batteries. In applications where weight is a consideration, Lipo4 batteries are among the lightest options available. In recent years, Lithium has become available in several chemistries; Lithium-Ion, Lithium Iron Phosphate, Lithium Polymer and a few more exotic variations. Lipo4 batteries are a huge improvement over lead acid in weight, capacity, and shelf life. The Lipo4 batteries are the safest type of Lithium batteries as they will not overheat, and even if punctured they will not catch on fire. The cathode

material in Lipo4 batteries is not hazardous, and so poses no negative health hazards or environmental hazards. Due to the oxygen being bonded tightly to the molecule, there is no danger of the battery erupting into flames like there is with Lithium-Ion. The chemistry is so stable that Lipo4 batteries will accept a charge from a lead-acid configured charger. Though less energy-dense than the Lithium-Ion and Lithium Polymer, Iron and Phosphate are abundant and cheaper to extract to costs are much more reasonable. Lipo4 life expectancy is approximately 5-7 years at 80% DOD, 15-20 years at 50% DOD.

Lithium Ion batteries and Lithium Polymer batteries are the most energy dense of the Lithium batteries, but they are lacking in safety. The most common type of Lithium Ion is  $\text{LiCoO}_2$ , or Lithium Cobalt Oxide. In this chemistry, the oxygen is not strongly bonded to the cobalt, so when the battery heats up, such as in rapid charging or discharging, or just heavy use, the battery can catch fire. This could be especially disastrous in high pressure environments such as airplanes, or in large applications such as electric vehicles. To help counteract this problem, devices that use Lithium Ion and Lithium Polymer batteries are required to have extremely sensitive and often expensive electronics to monitor them. While Lithium Ion batteries have an intrinsically high energy density, after one year of use the capacity of the Lithium Ion will have fallen so much that the Lipo4 will have the same energy density, and after two years the Lipo4 will have significantly greater energy density. Another disadvantage of these types is that Cobalt can be hazardous, raising both health concerns and environmental disposal costs. The projected life of a Lithium-Ion battery is approximately 3 years from production @ 80% DOD.

Lead Acid is a proven technology and can be relatively cheap. Because of this they are still used in the majority of electric vehicle applications and starting applications. Compared to Lead-Acid batteries the only

disadvantage of the Lipo4 batteries is that they really do not perform well below about 0 degrees Celsius. However, since capacity, weight, operating temperatures and CO2 reduction are large factors in many applications, Lipo4 batteries are quickly becoming an industry standard. Although the initial purchase price of Lipo4 is higher than lead acid, the longer cycle life can make it a financially sound choice.