Why is LiFePO4 Better Than Lead Acid?
Is LiFePO4 Really Expensive Than Lead Acid?
WHAT IS A PERFECT BATTERY?

- Long Cycle Life
- High Rate Discharge Ability
- Temperature Performance
- Cost Effective
- High Energy Density
- Low Self Discharge
- Fast Recharge
- Safety Performance

WHAT IS A PERFECT BATTERY?

LITHIUM ION PHOSPHATE VS LEAD ACID
## Lead Acid vs. LiFePO₄

<table>
<thead>
<tr>
<th>Feature</th>
<th>Lead Acid</th>
<th>LiFePO₄</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long Cycle Life</strong></td>
<td>&gt;200 cycles</td>
<td>&gt;2000 cycles</td>
</tr>
<tr>
<td><strong>High Energy Density</strong></td>
<td>35-40 Wh/kg</td>
<td>80-120 Wh/kg</td>
</tr>
<tr>
<td><strong>Low Self Discharge</strong></td>
<td>15 months/25°C: &gt;50% SOC</td>
<td>15 months/25°C: &gt;80% SOC</td>
</tr>
<tr>
<td><strong>Fast Recharge</strong></td>
<td>5-10 hours</td>
<td>0.5-5 hours</td>
</tr>
<tr>
<td><strong>High Rate Discharge Ability</strong></td>
<td>3-5C, Capacity Reduce</td>
<td>5-40C, Capacity Stable</td>
</tr>
<tr>
<td><strong>Temperature Performance</strong></td>
<td>0.5C</td>
<td>10°C-50% Capacity; 0°C-45% Capacity</td>
</tr>
<tr>
<td><strong>Cost Effective</strong></td>
<td>Cheap Price, Low Performance, Short Life</td>
<td>5 times Price, High Performance, 10 times Life</td>
</tr>
<tr>
<td><strong>Safety Performance</strong></td>
<td>Lead is harmful for human, H₂SO₄ is corrosive</td>
<td>The safest lithium battery technology so far, need BMS protection</td>
</tr>
</tbody>
</table>
# GENERAL COMPARISON

<table>
<thead>
<tr>
<th>ITEM</th>
<th>LEAD ACID (2.0V)</th>
<th>LiFePO₄ (3.2V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Nominal Voltage</td>
<td>2.0V</td>
<td>3.2V</td>
</tr>
<tr>
<td>Cathode Material</td>
<td>PbO₂</td>
<td>LiFePO₄</td>
</tr>
<tr>
<td>Anode</td>
<td>Pb</td>
<td>Graphite</td>
</tr>
<tr>
<td>Electrolyte</td>
<td>H₂SO₄</td>
<td>Organic Electrolyte</td>
</tr>
<tr>
<td>Manufacturing Access Level</td>
<td>Easy</td>
<td>Difficulty</td>
</tr>
<tr>
<td>Market Share</td>
<td>Large (Traditional)</td>
<td>Growing fast (New Energy)</td>
</tr>
<tr>
<td>Weight Energy Density</td>
<td>30~50Wh/Kg</td>
<td>100~150Wh/Kg</td>
</tr>
<tr>
<td>Volume Energy Density</td>
<td>60~90Wh/L</td>
<td>200~250Wh/L</td>
</tr>
<tr>
<td>Discharge DOD by C₁</td>
<td>63~67%</td>
<td>99~100%</td>
</tr>
<tr>
<td>Recharge Method</td>
<td>Boost Charge, Float Charge, CC/CV, (Float Charge is OK)</td>
<td>Good</td>
</tr>
<tr>
<td>Fast Charge Ability</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Recharge Voltage</td>
<td>2.35V/Boost: 2.23~2.37/Float</td>
<td>3.65V/cell</td>
</tr>
<tr>
<td>Cycle Life (C₅, 25°C, 100%DOD, 80% remain)</td>
<td>200~300</td>
<td>2000~3000</td>
</tr>
<tr>
<td>Cycle Life (C₅, 25°C, 50%DOD, 60% remain)</td>
<td>550~650</td>
<td>4000~4500</td>
</tr>
<tr>
<td>Working Temperature Range</td>
<td>-10~55°C</td>
<td>-20~65°C</td>
</tr>
<tr>
<td>Discharge Capacity by -20°C C₂</td>
<td>Approx. 15%</td>
<td>Approx. 55%</td>
</tr>
<tr>
<td>Self-Discharge/Month (100%, 25°C)</td>
<td>15~30%</td>
<td>&lt;3%</td>
</tr>
<tr>
<td>50% SOC Remain Storage Period</td>
<td>16 Months</td>
<td>&gt;30Months</td>
</tr>
<tr>
<td>Assembly Flexibility</td>
<td>Standard Blocks</td>
<td>Any kinds of Shape</td>
</tr>
<tr>
<td>Environmental Protection</td>
<td>Polluted</td>
<td>Meets RoHS</td>
</tr>
<tr>
<td>Protection Circuitry</td>
<td>Not needed</td>
<td>Need it to keep Battery Healthy</td>
</tr>
<tr>
<td>Assembly Base</td>
<td>2V, 6V, 12V Units</td>
<td>3.2V Units</td>
</tr>
<tr>
<td>Installation Direction</td>
<td>Top need to be upside</td>
<td>Any Directions</td>
</tr>
<tr>
<td>Safety</td>
<td>Electrolyte is corrosive</td>
<td>Safe</td>
</tr>
<tr>
<td>IATA Safety Level</td>
<td>Class 8</td>
<td>Class 9</td>
</tr>
</tbody>
</table>
PERFORMANCE COMPARISON

**LIFEPO4 26650 3.2V 3.2AH CYCLE LIFE (1C)**

- **TESTING CONDITION:**
  1. Temperature: 20~30°C
  2. DOD (Dept of Discharge): 100%
  3. Charging Current: 1C (3.2A CC/CV)
  4. Discharge Current: 1C (3.2A CC)

- **TESTING RESULTS:** Cycle Life > 2500 cycles

**LEAD ACID 12V 7AH CYCLE LIFE (0.1C)**

- **TESTING CONDITION:**
  1. Temperature: 20~30°C
  2. DOD: 100%/50%/30%
  3. Charging Current: 0.1C (2.45V/cell)
  4. Discharge Current: 0.1C (700mACC)

- **TESTING RESULTS:**
  - 100%DOD: 200~300 cycles
  - 50%DOD: 400~500 cycles
  - 30%DOD: 1000~1200 cycles

**PERFORMANCE COMPARISON**

- **LITHIUM ION PHOSPHATE VS LEAD ACID**
**PERFORMANCE COMPARISON**

**LEAD ACID 12V7.5AH**

This is a discharge performance curve of a 12V 7Ah lead acid battery from a leading manufacturer at room temperature. By constant current, the battery fails to meet its rated capacity, even at 350mA (0.05C) discharge rate. When the battery is subjected to higher loads of 1400mA (0.2C) and 5000mA (0.7C) the voltage drops more severe and the delivered capacity is less than half.

**ANTBATT LiFePO4 12V7.5AH**

By comparison, AntBatt LiFePO4 12V7.5AH is the same size as its lead acid equivalent but less than half the weight. This battery exhibits a consistently flat voltage profile throughout its discharge until energy is depleted. This superior performance is maintained even at higher discharge currents, and the discharge capacity keeps stable even the discharge rate changes.

**DISCHARGE EFFICIENCY**

This is a discharge curve of a high rate 26650 cell, it shows that the discharge capacity difference is very limited.

**26650 2300 3.2V Discharge At Different Rates**

Charge: 1C CC/CV | 25°C    Discharge: CC | 25°C
This testing graph shows us the different discharge capacity under temperature influence.

Testing Condition:
Charging Current: 0.2C CC/CV | Discharge Current: 0.5C CC

Testing Result:
60°C Capacity Rate: 102%
40°C Capacity Rate: 102%
30°C Capacity Rate: 100%
20°C Capacity Rate: 100%
15°C Capacity Rate: 100%
10°C Capacity Rate: 98%
5°C Capacity Rate: 92%
0°C Capacity Rate: 84%
-10°C Capacity Rate: 65%
-20°C Capacity Rate: 48%

To Comparison with LiFePO4, we only chose the 0.5C Rate show the result:

Testing Result:
50°C Capacity Rate: 85%
40°C Capacity Rate: 80%
30°C Capacity Rate: 72%
20°C Capacity Rate: 66%
15°C Capacity Rate: 62%
10°C Capacity Rate: 57%
5°C Capacity Rate: 50%
0°C Capacity Rate: 45%
-10°C Capacity Rate: 40%
-20°C Capacity Rate: <30%
**PERFORMANCE COMPARISON**

**HIGH ENERGY DENSITY**

*How to get the Weight Energy Density:*

Battery Energy (Wh) / Battery Weight (Kg) = Energy Density (Wh/kg)

*How to get the Volume Energy Density:*

Battery Energy (Wh) / Battery Size (L or Dm³) = Weight Density (Wh/L)

LIFEPO4 battery averagely has 1/3 the weight, 1/2 the volume of LEAD ACID battery.

12V7.5AH/90Wh/151x65x94mm (0.923L)

**Volume Energy Density:** 97.5Wh/L

- **LEAD ACID:** 2.45KG --> 36.7Wh/kg
- **LIFEPO4:** 1.1KG --> 81Wh/kg

26650-3.2V-3200MAH (10.24Wh)

**WEIGHT ENERGY DENSITY:** 119.07Wh/kg

**VOLUME ENERGY DENSITY:** 296.81Wh/L

12V100AH/1200Wh/342x173x232mm (13.72L)

**VOLUME ENERGY DENSITY:** 87.5Wh/L

**WEIGHT ENERGY DENSITY**

- **LEAD ACID:** 30.4KG | 39.5Wh/kg
- **LIFEPO4:** 13.6KG | 94.1Wh/kg

LIFEPO4 12V7.5AH/0.9kg/94x82x75mm

**WEIGHT ENERGY DENSITY:** 106.7 Wh/kg

**VOLUME ENERGY DENSITY:** 166Wh/L

LIFEPO4 12V100AH/11.6kg/115x224x310mm

**WEIGHT ENERGY DENSITY:** 110.3 Wh/kg

**VOLUME ENERGY DENSITY:** 160Wh/L

---

**By Weight (Wh/Kg)**

- **LIFEPO4:**
  - 12V7.5AH: 81Wh/kg
  - 26650: 119.07Wh/kg
  - 12V100AH: 110.3 Wh/kg

- **LEAD ACID:**
  - 12V7.5AH: 36.7Wh/kg
  - 26650: 36.7Wh/kg
  - 12V100AH: 39.5Wh/kg

**By Volume (Wh/L)**

- **LIFEPO4:**
  - 12V7.5AH: 94.1 Wh/L
  - 26650: 296.81Wh/L
  - 12V100AH: 166Wh/L

- **LEAD ACID:**
  - 12V7.5AH: 87.5 Wh/L
  - 26650: 296.81Wh/L
  - 12V100AH: 160Wh/L
LiFePO4 Battery’s Self Discharge Rate is much lower than LEAD ACID Battery.
LITHIUM ION PHOSPHATE VS LEAD ACID

PERFORMANCE COMPARISON

LEAD ACID vs LIFEPo4

Battery Life
Work time / Charge
Maintenance Cost
Single Buy Price

FROM THE COMPARISON, WE CAN SEE LIFEPo4 BATTERY SOLUTION IS MUCH MORE COST-EFFECTIVE IN LONG TERM CONSIDERATION.
# LIFEPO4 BATTERY LIST

## FOR LEAD ACID REPLACEMENT

<table>
<thead>
<tr>
<th>LITHIUM IRON PHSOPHATE (LIFEPO4) BATTERIES</th>
<th>6.4V9.6Ah</th>
<th>12.8V7.5Ah</th>
<th>12.8V12Ah</th>
<th>12.8V20Ah</th>
<th>12.8V32Ah</th>
<th>12.8V40Ah</th>
<th>12.8V55Ah</th>
<th>12.8V60Ah</th>
<th>12.8V100Ah</th>
<th>12.8V200Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Voltage</strong></td>
<td>6.4V</td>
<td>6.4V</td>
<td>6.4V</td>
<td>6.4V</td>
<td>12.8V</td>
<td>12.8V</td>
<td>12.8V</td>
<td>12.8V</td>
<td>12.8V</td>
<td>12.8V</td>
</tr>
<tr>
<td><strong>Typical Capacity</strong></td>
<td>9.6Ah</td>
<td>7.5Ah</td>
<td>12Ah</td>
<td>20Ah</td>
<td>32Ah</td>
<td>40Ah</td>
<td>55Ah</td>
<td>60Ah</td>
<td>100Ah</td>
<td>120Ah</td>
</tr>
<tr>
<td><strong>Typical Energy</strong></td>
<td>61.4Wh</td>
<td>96Wh</td>
<td>153.6Wh</td>
<td>256Wh</td>
<td>410Wh</td>
<td>512Wh</td>
<td>714Wh</td>
<td>768Wh</td>
<td>1280Wh</td>
<td>2560Wh</td>
</tr>
<tr>
<td><strong>Max. Continuous Discharge Current</strong></td>
<td>7A</td>
<td>15A</td>
<td>25A</td>
<td>40A</td>
<td>50A</td>
<td>60A</td>
<td>70A</td>
<td>80A</td>
<td>100A</td>
<td>120A</td>
</tr>
<tr>
<td><strong>Typical Discharge Cut-off Voltage</strong></td>
<td>5V</td>
<td>10V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Charge Voltage</strong></td>
<td>7.2V/7.3V</td>
<td>14.4V/14.6V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Charge Method</strong></td>
<td>CC/CV</td>
<td>CC/CV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operating Temperature</strong></td>
<td>0°C to +45°C</td>
<td>-20°C to +60°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Max. Charge Current</strong></td>
<td>9.6A</td>
<td>7.5A</td>
<td>12A</td>
<td>20A</td>
<td>32A</td>
<td>40A</td>
<td>55A</td>
<td>60A</td>
<td>80A</td>
<td>100A</td>
</tr>
<tr>
<td><strong>Internal Resistance</strong></td>
<td>≤50mΩ</td>
<td>≤70mΩ</td>
<td>≤60mΩ</td>
<td>≤50mΩ</td>
<td>≤45mΩ</td>
<td>≤35mΩ</td>
<td>≤30mΩ</td>
<td>≤20mΩ</td>
<td>≤15mΩ</td>
<td></td>
</tr>
<tr>
<td><strong>Termination</strong></td>
<td>T1</td>
<td>T2</td>
<td>T2</td>
<td>T3</td>
<td>T5</td>
<td>M6</td>
<td>M6</td>
<td>M8</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nominal Dimensions</strong></td>
<td>Length</td>
<td>Width</td>
<td>Height</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Typical Weight</strong></td>
<td>0.68kg</td>
<td>1.1kg</td>
<td>1.7kg</td>
<td>2.7kg</td>
<td>4.8kg</td>
<td>5.75kg</td>
<td>8.1kg</td>
<td>8.82kg</td>
<td>13.6kg</td>
<td>29.6kg</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>90mm</td>
<td>151mm</td>
<td>151mm</td>
<td>181mm</td>
<td>195mm</td>
<td>197mm</td>
<td>257mm</td>
<td>259mm</td>
<td>342mm</td>
<td>522mm</td>
</tr>
<tr>
<td><strong>Width</strong></td>
<td>70mm</td>
<td>65mm</td>
<td>98mm</td>
<td>77m</td>
<td>130mm</td>
<td>165mm</td>
<td>132mm</td>
<td>168mm</td>
<td>173mm</td>
<td>240mm</td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td>101mm</td>
<td>94mm</td>
<td>95mm</td>
<td>167mm</td>
<td>178mm</td>
<td>170mm</td>
<td>200mm</td>
<td>208mm</td>
<td>212mm</td>
<td>224mm</td>
</tr>
<tr>
<td><strong>Protection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Protection against over-charge, over-discharge, over-current, over-temperature. Cell balancing function included
WHY BUILD CUSTOMIZED BATTERY PACKS?

> FLEXIBLE & BETTER PRODUCT DESIGN

There is no liquid electrolyte exist in the lithium battery cells, so we can lay down the battery pack in any directions as we want. And there are many different size cells available, so we can assemble the battery pack in thousands of assembly structures to get the optimal battery shape.

> BETTER PERFORMANCE

Assemble bigger battery packs by the existing 12V LiFePO4 Batteries seems more easier, but it's not a good way to assemble a good battery pack:

A, if you do the series connection by 12V blocks, you may face the capacity shortage when the battery pack get older, because the balance can’t work between 12V packs; also, you need to check with us to make sure the BMS can stand the final battery pack voltage.

B, if you do the parallel connection, the balancing is always proceeding between the 12V packs, so we need to check the 12V pack voltages to make sure the balancing current is not too big to make the BMS go to over current protection.
HOW TO GET A CUSTOMIZED BATTERY PACK?

We need some basic info to build a battery pack:
1. Battery Pack Voltage & Capacity
2. Battery Pack Max. Continuous Output Power
3. Battery Weight & Dimension
4. Battery Pack Housing
5. Charge & Discharge Terminal
and other detail and special requirement.

Then, we will be able to design the battery pack according to customers’ requirement.