BATTERY STORAGE TECHNOLOGIES
Exploring Li-Ion Batteries

COMPARITIVE CHEMISTRY OVERVIEW AND DIVERSE STORAGE APPLICATIONS

December 2019 | Sequoya Cross
EVALUATING LITHIUM ION BATTERIES
# LITHIUM ION BATTERY CHEMISTRY

<table>
<thead>
<tr>
<th>Lithium Ion Chemistry Comparison</th>
<th>LFP</th>
<th>NMC</th>
<th>LMO</th>
<th>NCA</th>
<th>LCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danger of Thermal Runaway &amp; Fire</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Toxic Elements</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Landfill Safe</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Involves Abusive Mining Practices</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Ventilation Required</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Cooling Equipment Required</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Safety Monitoring Equipment</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Able To Withstand High</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Temperature Environments up to 140°</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- **LFP**: Lithium Iron Phosphate
- **NMC**: Lithium Nickel Manganese Cobalt Oxide
- **LMO**: Lithium Manganese Oxide (May Contain Cobalt)
- **NCA**: Lithium Nickel Cobalt Aluminum Oxide
- **LCO**: Lithium Cobalt Oxide
LEVELIZED COST OF ENERGY- HOW TO EVALUATE TRUE COSTS OF STORAGE

What’s the cost of every kWh I can get out of this system?

\[
\frac{Price}{Capacity \times Cycles \times \eta \times DoD} + \text{Ancillary Costs}
\]

AKA Hidden Costs

- Square Footage → Installation Location
- Weight → Shipping Costs
- Forklift/Install Equipment → Rental to Site
- Maintenance → Truck Rolls
- Cooling → Additional Cost + Materials
- Ventilation/Setback Requirements → Area
- Construction Support → Weight Related
- Replacement Costs → Performance Related
LCOE COMPARISON: 10 YEAR- DOES NOT INCLUDE REPLACEMENT COSTS

<table>
<thead>
<tr>
<th>PHI 3.8</th>
<th>FLA</th>
<th>VRLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>QTY 2</td>
<td>QTY 4</td>
<td>QTY 12</td>
</tr>
<tr>
<td>6 usable kWh (@ 80% DOD): C/2</td>
<td>~4.6 usable kWh (@50% DOD): C/20</td>
<td>~7.3 usable kWh (@20% DOD): C/8</td>
</tr>
<tr>
<td>77.5 lbs. per battery</td>
<td>114 lbs. per battery</td>
<td>211 lbs. per battery cell</td>
</tr>
<tr>
<td>155 lbs. total</td>
<td>456 lbs. total</td>
<td>2,532 lbs. total</td>
</tr>
<tr>
<td>13.9” x 13.5” x 8.1” per battery</td>
<td>11.66” x 6.94” x 16.74” per battery</td>
<td>13.3” x 8.04” x 27.12” per battery</td>
</tr>
<tr>
<td>3,039.93 total in³</td>
<td>5,418.43 total in³</td>
<td>34,799.95 total in³</td>
</tr>
</tbody>
</table>

- .09/kWh
- .27/kWh
- .80/kWh
DROP-IN REPLACEMENT FOR LEAD ACID
DoD COMPARED TO CYCLE LIFE- WARRANTY

- **100% SOC**: 10 Years, 10,000 Cycles
- **80% SOC**: 10 Years, 5,000 Cycles
- **90% SOC**: 10 Years, 3,500 Cycles
- **0% SOC**: 10 Years, 3,500 Cycles

End of life (EOL) capacity: 80%
COST & PERFORMANCE COMPARISON LEAD ACID TO LITHIUM

- Higher upfront investment for LFP
- Lower DOA rates
- More usable capacity (100% v 30-50%)
- Very low self-discharge
- No maintenance
- Longer duration between replacement - FLA replaced 3X
- Overall lower cost over time (LCOE)
- Non-Toxic Chemistry

LFP (302Ah) v Flooded Lead Acid (420Ah):
10 years

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<thead>
<tr>
<th></th>
<th>LFP</th>
<th>Flooded Lead Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upfront Investment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacement Costs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• Reduce Fuel Costs: $2,759.40/year
• Extend Life-Span of Generators: Run less
• Reduce Maintenance
• 70% of diesel generators non-operational in field
• Fuel can be hard to source
• No Noise or Pollution

Costs LFP v Generator: 10 years

- Initial Costs
- Maintenance & Replacement
- Fuel Costs
DIVERSE APPLICATIONS IN AFRICA
TANZANIA: RELIABLE 24/7 MICROGRID POWERS AN ORPHANAGE
TANZANIA: RELIABLE 24/7 MICROGRID POWER FOR SCHOOLS
BOTSWANA: RELIABLE OFF GRID POWER FOR CHEETAH PRESERVE
NIGERIA: RELIABLE POWER FOR 34 HOSPITALS & CLINICS IN CONFLICT ZONES
NIGERIA: 24/7 ENERGY ACCESS FOR DISPLACED CHILDREN AT 7 SCHOOLS
NIGERIA: COMMERCIAL – DIESEL OFFSET & 60% UTILITY BILL REDUCTION
SIMPLIPHI ENERGY STORAGE SOLUTIONS
A FULL RANGE OF STATIONARY AND MOBILE ENERGY STORAGE SOLUTIONS

• Commercial – Residential – Disaster Relief – Personal Power

• SimpliPhi Delivers:
  • Industry-leading cycle life even when fully discharged
  • Industry-leading efficiency eliminates the need for ventilation or cooling
  • Safest, non-toxic LFP cell chemistry reduces installation cost and risk
  • Widest operating temperature reduces integration costs
  • Balance of energy and power density is ideal for renewable energy systems
MILITARY-ENDORSED SOLUTIONS

• U.S. Marine Corps and Army were among first SimpliPhi customers
  • Demand for constant innovation, testing and rapid deployment now integral part of company DNA

• Testing at Camp Lejeune and Aberdeen Proving Ground more rigorous than any industry standard

• Proven performance in extreme temps, environments and use cases

• Official report: ZERO battery failure rate
  • 100+ systems deployed to power a wide range of military operations and equipment
SUCCESSFULLY DEPLOYED IN 40+ COUNTRIES

60+ MWh since 2010
PHI BATTERIES

Compatible: 24 V OR 48 V

• Simple parallel connection
• Scalability
• Drop in Lead Acid replacement
• 24V and 48V
• Integrated Battery Management System
• Integrated circuit breaker for protection

2.9 kWh
115 Ah @ 24 V
57 Ah @ 48 V

3.8 kWh
151 Ah @ 24 V
75 Ah @ 48 V
EASY-TO-BUILD BATTERY BANKS

- Simple parallel wiring configuration
- No communications lines to run
- Both energy and power scales up

Note: All conductors from battery terminals to DC busbars should be the same length.
MODULAR AND SCALABLE

~300 kWh

sideways orientation
PORTABLE POWER- ENERGY DENSITY FOR SMALL APPLICATIONS

- Portable emergency power for LED lighting, mobile charging and powering smaller loads
- Small footprint
- Easily charged from solar
- Provides reliable power where it is needed
- Can be deployed to multiple households
THANK YOU!