

## Worldwide there is an increased demand for Greener Longer Lasting, Sustainable Batteries.

### 1. Why

- VRLA Gel Batteries are fast becoming unacceptable to the growing number of environmentally aware and technologically advanced communities the world over.
- The process of manufacturing and producing Gel Batteries has major environmental impacts like, waste, pollutant emissions and effluents during and after manufacture. Also after the battery life there is a problem to dispose of Gel batteries.

### Answer

- To meet the new market requirements, extensive R & D expenditure has gone into the development of the Lead Crystal and the Ferrous Lithium Ion Phosphate Battery.
- Greener Longer Lasting, Sustainable Battery.
- The batteries are manufactured in accordance with environmental protection standards.

### Criteria Considered

- Battery Life - Batteries will in general have between 1000 to 8000 charge/discharge cycles (10 ± years battery life). Under similar conditions conventional VRLA Gel batteries will have between 300 to 350 charge/discharge cycles.
- Shelf Life - Batteries to be able to be stored for 2 years with no additional charge. Simplifies Logistics.
- High-Rate Discharge - Discharge rate of up to 10C.
- Excellent Charge Performance - The charge time, 3 to 5 times faster than conventional batteries used in the Telecommunications market.
- Depth of Discharge - The battery can be discharged to 0 Volt (100% DOD) and then restored to full rated capacity.
- Temperature Resistance – To operate comfortably in the temperature ranges from - 40°C to +65°C without significant degradation. Internal temperature to be very low when being charged and discharged.
- Green – The batteries not to emit fumes or harmful gaseous emissions, the basic electrolyte to be neutral, non-corrosive.

### 2. Comparison Chart

ITEM	VRLA GEL	LEAD CRYSTAL	FERROUS LITHIUM PHOSPHATE
Range of Working Temperature	-15°C to + 40°C	-20°C to + 41°C	-20°C to + 55°C
Battery Life	3-4 Years	5-10 Years	5-10 Years
Environment	Not Friendly	Friendly	Friendly
Safety Transportation	Normal	Good	Good
Discharge Cycles to 50% @ 25°C	460	2050	8000
Discharge Cycles to 80% @ 25°C	260	1000	4600
Discharge Ability at High Current	Not Good	Good	Very Good
Weight	Normal	Normal	Light - typically 50% lighter
Size (mm) LxHxW	530x318x125	560x320x125	540x365x220
Cost	Low	Slightly Higher than Gel	Much Higher than Gel

3. The Ferrous Lithium-Ion Phosphate and the Lead Crystal battery has its advantages and disadvantages as shown in the table below:


Battery Type	Advantage	Disadvantage
Fe Li-Ion Phosphate	<ol style="list-style-type: none"> <li>1. Handles the highest operating temps</li> <li>2. Light weight typically 50%</li> <li>3. Smaller physical size per AH</li> <li>4. Can be charged &amp; discharged very quickly 3 – 5 times</li> <li>5. Can be discharged to very high depths of discharge</li> <li>6. Longer Operational Life</li> <li>7. Long Shelf life</li> <li>8. No harmful materials in manufacture, electrolytes etc.</li> <li>9. Built in Battery Management can interface to Remote Site Management System</li> </ol>	<ol style="list-style-type: none"> <li>1. Highest cost in the region of 4 to 5 times that of Lead Acid.</li> <li>2. If electronics fail can cause battery damage.</li> </ol>
Lead Crystal	<ol style="list-style-type: none"> <li>1. Handles higher temp than Lead Acid</li> <li>2. Can be charged and recharged quicker than Lead Acid</li> <li>3. Can be discharged to very high depths of discharge</li> <li>4. Long Shelf life</li> <li>5. No harmful materials in manufacture, electrolytes etc.</li> <li>6. Can be transported by Air</li> <li>7. Form fit replacement for Lead Acid</li> </ol>	<ol style="list-style-type: none"> <li>1. Higher cost than Lead Acid in the region of 30% more.</li> </ol>

4. Shown below are calculations for various battery types and the savings in certain areas however bringing costs back in other areas. The calculations are based on hybrid solutions for 1000 sites.

#### a) Battery Sizing Gel Battery

Assumptions:


1. Working temperature above 30°C – Typically encountered in outdoor cabinets.
2. Cycled once a day.
3. Life cycle 18 months

Rectifier Sizing				
DC Load=	Product BTS	Watts 1000	Voltage 48	Currents 20.83
<div> <div> Total Load = 20.83  DC System Voltage = 48  Load Current = 20.833333  Hrs Autonomy = 8.00  Hours to Recharge = 5 </div> <div> <b>Rectifier Size = 20.833333 Amps</b> </div> </div>				
<div> <div> Load Current = 20.833333  Hours Autonomy = 8.00  Depth Discharge = 50% </div> <div> <b>Battery Size = 334 AH</b> </div> </div>				
<div> <div> <b>With Actual Battery Size</b>  Battery Size 450  Charge Current % 7% </div> <div> <b>Closest Battery String Size</b>    450  33.4 </div> </div>				
<div> <div> Rectifier Size <b>54.233333 Amps</b>   Rectifier P/N 60 Amps  No of Rectifiers 2 </div> </div>				
Battery Sizing				
<div> <div> Load Current = 20.833333  Hours Autonomy = 8.00  Depth Discharge = 50% </div> <div> <b>Battery Size = 334 AH</b> </div> </div>				
<div> <div> <b>Gel VRLA Battery</b>  Volts 12  AH 150 </div> </div>				

## b) Battery Sizing Lead Crystal Battery

Assumptions:

1. Working temperature above 30°C – Typically encountered in outdoor cabinets.
2. Cycled twice a day.
3. Life cycle 24 months

Rectifier Sizing						
DC Load=	Product BTS	Watts 1000	Voltage 48	Currents 20.83	Closest Battery String Size	
						
Total Load =	20.83				<u>With Actual Battery Size</u>	
DC System Voltage =	48				Battery Size	
Load Current =	20.8333333				Charge Current %    16%	
Hrs Autonomy =	8.00				55.683333	
Hours to Recharge =	3				Rectifier Size	
Rectifier Size = 20.8333333 Amps					76.516667 Amps	
					Rectifier P/N	
					No of Rectifiers	
					60 Amps	
					3	
Battery Sizing						
Load Current =	20.8333333					
Hours Autonomy =	8.00					
Depth Discharge =	65%					
Battery Size = 257 AH						
Lead Crystal Battery	V 12	AH 170				

## c) Battery Sizing Ferrous Lithium-Ion Phosphate Battery

Assumptions:

1. Working temperature above 30°C – Typically encountered in outdoor cabinets.
2. Cycled twice a day.
3. Life cycle 60 months

Rectifier Sizing

DC Load=

Product

BTS

Watts

1000

Voltage

48

Currents

20.83

Total Load =

20.83

DC System Voltage =

48

Load Current =

20.8333333

Hrs Autonomy =

8.00

Hours to Recharge =

3

Rectifier Size =

20.8333333

Amps

Closest Battery String Size

300

55.7333333

76.5666667

Amps

With Actual Battery Size

Battery Size

300

Charge Current %

19%

Rectifier Size

60

Amps

No of Rectifiers

3

Battery Sizing

Load Current =

20.8333333

Hours Autonomy =

8.00

Depth Discharge =

80%

Battery Size =

209

AH

Fe Li-Ion Phosphate

Volts

3.3

AH

300

Battery Prices

P/N	Unit Price	QTY	Sub Total	Total	Operation a Life in Years	Number of Replacements in 5 Years	Total Spent	Unit Spent
Fe Li-Ion Phosphate	\$ 950.00	15	\$ 14 250.00	\$ 14 250 000.00	5		\$ 14 250 000.00	\$ 14 250.00
150AH Gel	\$ 360.00	12	\$ 4 320.00	\$ 4 320 000.00	1.5	3.33333333	\$ 14 400 000.00	\$ 14 400.00
170AH Lead Crystal	\$ 400.00	8	\$ 3 200.00	\$ 3 200 000.00	2	2.5	\$ 8 000 000.00	\$ 8 000.00

Rectifiers

P/N	Unit Price	QTY	Sub Total	Total
30A Rectifier	\$ 634.00	1	\$ 634.00	\$ 634 000.00
30A Rectifier	\$ 634.00	0	\$ -	-
30A Rectifier	\$ 634.00	1	\$ 634.00	\$ 634 000.00

#### d) Generator run time results with various batteries in a Hybrid Solution

Generator as normal	Fe Li-Ion Phosphate	Gel	Lead Crystal
Size in KVA	15	15	15
Run Time in hrs	24	24	24
Run Time per month in hrs	720	720	720
Fuel Consumption in L/Hr	2.5	2.5	2.5
Fuel Consumption in litres per month	1800	1800	1800
Fuel Cost in USD per Litre	\$1.50	\$1.50	\$1.50
Fuel Cost per month	\$2 700.00	\$2 700.00	\$2 700.00
Required Service Interval	250	250	250
Services per month	2.88	2.88	2.88
Costs per Service in USD	\$350.00	\$350.00	\$350.00
Service Costs per month	\$1 008.00	\$1 008.00	\$1 008.00
<b>Total Costs per month on Generator</b>	<b>\$3 708.00</b>	<b>\$3 708.00</b>	<b>\$3 708.00</b>
<b>Generator on Hybrid Solution with various batteries</b>			
Size in KVA	15	15	15
Run Time in hrs	6	9	6
Run Time per month in hrs	180	270	180
Fuel Consumption in L/Hr	2.5	2.5	2.5
Fuel Consumption in litres per month	450	675	450
Fuel Cost per month	\$675.00	\$1 012.50	\$675.00
Services per month	0.72	1.08	0.72
Service Costs per month	\$252.00	\$378.00	\$252.00
<b>Total Costs per month on Generator</b>	<b>\$927.00</b>	<b>\$1 390.50</b>	<b>\$927.00</b>
Savings in Dlr	\$2 781.00	\$2 317.50	\$2 781.00
Percentage savings	75.00%	62.50%	75.00%
Generator Savings / annum / site	\$33 372.00	\$27 810.00	\$33 372.00
<b>Total Generator savings per annum</b>	<b>\$33 372 000.00</b>	<b>\$27 810 000.00</b>	<b>\$33 372 000.00</b>

#### Payback Results

SOLUTION COST					
Fe Li-Ion Phosphate		Gel		Lead Crystal	
<b>Number of sites</b>		<b>Number of sites</b>		<b>Number of sites</b>	
Number of Sites	1 000	Number of Sites	1 000	Number of Sites	1 000
Equipment Cost per site	\$3 372	Equipment Cost per site	\$3 372	Equipment Cost per site	\$3 372
Cost of installation per site	\$1 200	Cost of installation per site	\$1 200	Cost of installation per site	\$1 200
Additional Rectifiers	\$634	Additional Rectifiers	\$0	Additional Rectifiers	\$634
Batteries	\$14 250	Batteries	\$4 320	Batteries	\$3 200
Extrapolated Equipment cost	\$19 456 000	Extrapolated Equipment cost	\$8 892 000	Extrapolated Equipment cost	\$8 406 000
Extrapolated EF&I cost	\$1 200 000	Extrapolated EF&I cost	\$1 200 000	Extrapolated EF&I cost	\$1 200 000
NMC Costs	\$51 751	NMC Costs	\$51 751	NMC Costs	\$51 751
<b>Extrapolated Total cost</b>	<b>\$20 707 751</b>	<b>Extrapolated Total cost</b>	<b>\$10 143 751</b>	<b>Extrapolated Total cost</b>	<b>\$9 657 751</b>
Total Ratio against Gel Initially	204.14%	Total Ratio against Gel Initially	100.00%	Total Ratio against Gel Initially	95.21%
Battery percentage cost against Gel	329.86%	Battery percentage cost against Gel	100.00%	Battery percentage cost against Gel	74.07%
<b>Data</b>		<b>Data</b>		<b>Data</b>	
Cost of Solution	\$20 707 751	Cost of Solution	\$10 143 751	Cost of Solution	\$9 657 751
Generator Savings on sites	\$33 372 000	Generator Savings on sites	\$27 810 000	Generator Savings on sites	\$33 372 000
<b>Total Saving from Investment</b>	<b>\$33 372 000</b>	<b>Total Saving from Investment</b>	<b>\$27 810 000</b>	<b>Total Saving from Investment</b>	<b>\$33 372 000</b>
Payback period due to savings (Years)	0.62	Payback period due to savings (Year)	0.36	Payback period due to savings (Years)	0.29
Payback period due to savings (Months)	7.45	Payback period due to savings (Months)	4.38	Payback period due to savings (Months)	3.47
First Year Payback Percentage	161%	First Year Payback Percentage	274%	First Year Payback Percentage	346%
Second Year Payback Percentage	322%	Second Year Payback Percentage	385%	Second Year Payback Percentage	691%
Third Year Payback Percentage	483%	Third Year Payback Percentage	577%	Third Year Payback Percentage	779%
Fourth Year Payback Percentage	645%	Fourth Year Payback Percentage	592%	Fourth Year Payback Percentage	1038%
Fifth Year Payback Percentage	806%	Fifth Year Payback Percentage	602%	Fifth Year Payback Percentage	1039%
Cost per site over 5 yrs	\$20 707.75	Cost per site over 5 years	\$20 223.75	Cost per site over 5 years	\$14 457.75
Total Cost over 5 years	\$20 707 751.00	Total Cost over 5 years	\$20 223 751.00	Total Cost over 5 years	\$14 457 751.00
Total Saving against Gel over 5 Years	-\$484 000.00			Total Saving against Gel over 5 Years	\$7 666 000.00
Total Savings against Crystal over 5 Years	-\$6 250 000.00			Total Savings against Fe Li-Ion Phosphate over 5 Years	<b>\$6 250 000.00</b>

NB: Payback percentages include replacement batteries over the 5 year period

#### 5. Conclusion:

Although conservative numbers were used the Fe Li-Ion Phosphate battery has the ability to operate at the higher temperatures without loss of performance, downsizing of the battery because of the charging cycles being the best of all batteries. The cost of the battery still does not make economic sense when compared to the Lead Crystal battery as shown in the calculations above. If the objective is to keep maintenance to minimum and be aware when there are any problems with a cell then the Fe Li-Ion Phosphate battery has the advantage as this has a built in Battery Management System (BMS) unit with the following functions:

- Alarms, protection for over-charging, over-discharging, over-current and over-temperature thus ensuring good combination and communication between the battery block and the rectifier system.
- Protection of the charging-discharging cycles and the management of the float voltage.



- a) Automatic power disconnect when the voltage of single cell or battery block is lower or higher than the pre-set alarm value.
- b) The function of remote communication with the NOC can be used for unattended sites.
- c) High stability giving a good combination of power control technology with the NOC, to ensure the monitoring, management of the parameters and state of the battery system at any time.

With respect to cost and the ability to quickly obtain a payback, then the Lead Crystal presents both a technical and economic solution to the user.