White Paper
XHRL Series
Extreme High Rate Batteries

Introducing the Newest CSB Breakthrough -

Max-E^2 Technology

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Abstract

Max-E^2 technology is the latest breakthrough technology by CSB Battery. This technology will increase the energy density of a standard sealed lead acid battery and improve quality, reliability and life at the same time. This paper explores why such a technology is needed. A general overview of the Max-E^2 technology is included and the resulting cost and performance benefits are also discussed.

Breakthrough Technology to Maximize Battery Performance in Energy Efficiency and Energy Density

Introduction

In the first quarter of 2008, CSB Battery will begin mass production of the next-generation high rate batteries. The XHRL series is based on its current high rate HRL series with enhancements from the new Max-E^2 technology. This revolutionary enhancement builds on the tremendous success of CSB Battery's high rate HRL series by significantly improving the energy density.

Background

CSB Battery first introduced a family of large 12-Volt HRL batteries in 2001 to meet growing requirements in the large three-Phase Uninterruptible Power Supplies (UPS) market. (see Figure 1)

BCI Group Size	Battery Part Number	15-mins Rate to 1.67V/Cell at 77°F
U1 Small	HRL12110W	110 Watts
U1	HRL12150W	150 Watts
22NF	HRL12200W	200 Watts
24	HRL12280W	280 Watts
27	HRL12330W	330 Watts
31	HRL12390W	390 Watts
31 Tall	HRL12500W	500 Watts

Figure 1

The first generation HRL series satisfied key specifications[i] that include:

- Small battery footprint
- High power density
- Maintenance free
- High reliability
- Tight battery-to-battery tolerance
- Long service life

Need

According to Frost & Sullivan 2007 World UPS Market Study Report, the world UPS market grew at a rate of 13.4% in 2006 (to US$ 6.55 billion) and expected to experience a compound annual growth rate (CAGR) of 8.6% from 2006 to 2013 (to US$ 11.67 billion). It's estimated that three-phase UPS segment commands 23% of the total UPS market (US$ 1.52 billion). [ii] As the overall UPS market continues to grow, UPS batteries demand grows in parallel. New regulations (i.e. Sarbane-Oxley[iii]) which specify redundancy requirements, increasing equipment power draw, expanding digital economy, etc are examples of further growth engines. By deploying UPS systems, they allow end users to have sufficient transit time to bridge power to a generator. They also function as temporary power for proper shutdown of a network to prevent loss of critical data or information. Furthermore, UPS systems are increasingly used as power quality management systems. They filter and condition power supply to expensive and highly sensitive equipment against voltage fluctuations, sags, outages, impulses, harmonics, electrical noise, current imbalances, interference, etc.

Despite the tremendous growth, the industry is increasingly faced with more power related challenges. According to a 2006 Data Center Users' Group Survey (DCUG)[iv], 22% listed "Heat Density (Cooling)", 19% listed "Space Constraints/Growth", 8% listed "Power Density" and 7% listed "Availability (Uptime)" as the biggest issue data centers are faced with.

Heat Density (Cooling) & Power Density

Most equipment are now drawing higher power to operate which creates more heat and increasing the equipment power density. The average power use per high end server in the US has grown from 5,534 Watts per server in 2000 to 7,651 Watts per server in 2005. Globally, it has grown from 4,874 Watts per server to 8,106 Watts per server in the same period. This equates to a 38% increase in the US and 66% globally [v]. This puts significant burden on data center cooling and power supply. Hence, increasing number of batteries and higher power density are required to keep up with required back up time.

Space Constraints/Growth

Brand new data centers are coming online worldwide. More power than ever is needed to provide the back up power for highest uptime and availability. According to a 2006 DCUG survey, 53% of the data centers will be at full capacity in 2008 and 96% of are projected to be at full capacity by 2011. Continued addition of data centers is fueling aggressive growth in the UPS market, including batteries. However, due to the high real estate cost, there's a

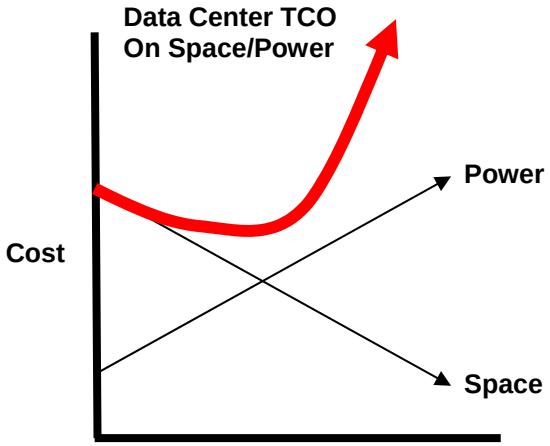


Figure 2

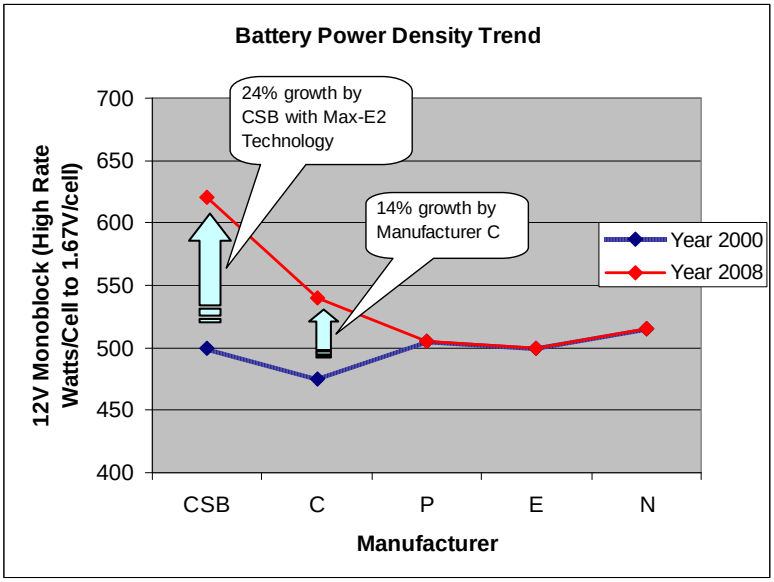
threshold on how much space UPS systems can occupy before the cost of ownership starts to reach diminishing returns (see Figure 2). In 2004, a standard Tier 3 data center would cost an average of US$ 480 per square feet [vi]. Today, the estimated cost is about US$ 600 per square feet. A general 480V battery-powered cabinet occupies 10 square feet. Therefore, batteries with the smallest dimensions and highest density are desired in data centers to reduce floor space cost.

Availability

According to a Data Center Institute (DCI) survey conducted in 2006, 82.5% of data center failures were caused by power outages. It's reported that in 1996, systems downtime cost American businesses an estimated US$ 4.0 billion due to lost productivity and revenues. It's further estimated that the cost would rise to US$ 6.6 billion in 1999. [vii] Therefore, it's crucial that data centers have adequate power quality management systems such as UPS systems. Ultimately, high quality and reliable batteries are vital to secure a sound and an always-on UPS system.

Solution

The need for more power in smaller footprint is clear. Furthermore, high quality and reliability are also key features. Lead acid battery technology by most measures, is still the most cost effective and reliable DC power solution. The high-performance, long-lasting, low-maintenance and low-cost features make valve regulated lead acid (VRLA) batteries an ideal choice for this purpose. In order to keep up with the industry growth, lead acid battery technology must evolve as well. In late 1990's and early 2000, many VRLA battery manufacturers started coming out with batteries that were specialized for UPS applications. Dubbed as 12-Volt "high rate"[viii] batteries, the first generation BCI Group 31T high rate batteries yielded power density in the range of 450 to 475 Watts per cell[ix]. Today, they are typically in the 500 to 540 Watts per cell range. The power density growth in the VRLA battery of less than 15% is dwarfed by the 38% average Watts per server growth in the US and 66% growth globally as discussed above. Clearly, a new breakthrough in VRLA battery is necessary to keep up with the pace the computing industry has set forth.



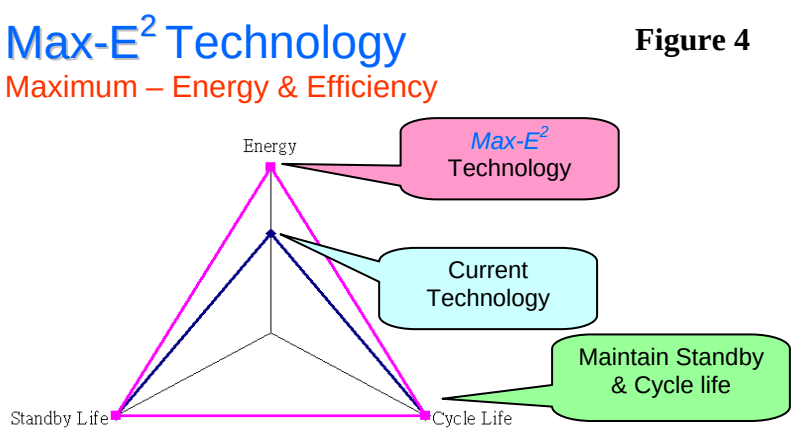
CSB Battery introduces the new XHRL batteries with a much higher power density over current high rate batteries. The technology behind the success of the XHRL batteries is the proprietary Max-E^2 Technology. By applying Max-E^2 Technology to current HRL series, CSB Battery is able to increase the power density in excess of 20%. (see Figure 3).

BCI Group Size	Battery Part Number	15-mins Rate to 1.67V/Cell at 77°F	Battery Part Number	15-mins Rate to 1.67V/Cell at 77°F	Power Density Increase
22NF	HRL12200W	200 Watts	XHRL12245W	245 Watts	22.5%
24	HRL12280W	280 Watts	XHRL12360W	360 Watts	28.6%
27	HRL12330W	330 Watts	XHRL12410W	410 Watts	24.2%
31	HRL12390W	390 Watts	XHRL12475W	475 Watts	21.8%
31T (Tall)	HRL12500W	500 Watts	XHRL12620W	620 Watts	24.0%

Figure 3

Max-E^2 Technology is a new proprietary process where the efficiency and the energy density of a battery are maximized. To increase the energy density of a battery is not difficult. By spiking the specific gravity of the acid or increasing the amount of lead would increase the energy density of a battery. However these modifications would also negatively impact the battery life. With Max-E^2 Technology, CSB Battery is able to achieve the energy density improvements without sacrificing battery life and battery footprint (see Figure 4).

Figure 4



With Max-E^2 Technology:

- Multi-step paste mixing process provides a blend of lead and addictives composition that is optimized for highly consistent plate formations
- Specially formulated paste is cured at high temperature to produce stable crystalline structure and optimized porosity
- Proprietary mix of addictives to yield increased surface areas on Positive Active Materials
- Innovative battery forming process delivers tight battery to battery tolerance
- Newly constituted electrolyte coupled with new separator design, ensure the battery's extended life feature is maintained

As a result of the above advancements, they increase overall quality of the battery, reduce battery to battery variance, extend battery life and increase power density in excess of 20%.

Benefits

The higher density XHRL batteries provide more power without the need for more space. This becomes prevalent in data centers or any environments where more power is required. Increasing power density where there's space constraint will lower total cost of ownerships. Based on the average watts per server growth from 2000 to 2005, additional battery-cabinets are needed if a standard transit time to a generator is maintained. In 2000, 2 standard battery-cabinets in parallel would provide the minimum required transit time. However, 4 standard battery-cabinets were needed instead, in 2005. In contrast, 3 battery-cabinets with the new XHRL batteries are sufficient to provide similar run time. 1 cabinet reduction will immediately reduce floor space, the extra cabinet and related electronics, installation/maintenance cost, transportations cost and the battery acquisition cost. (see Figure 5).

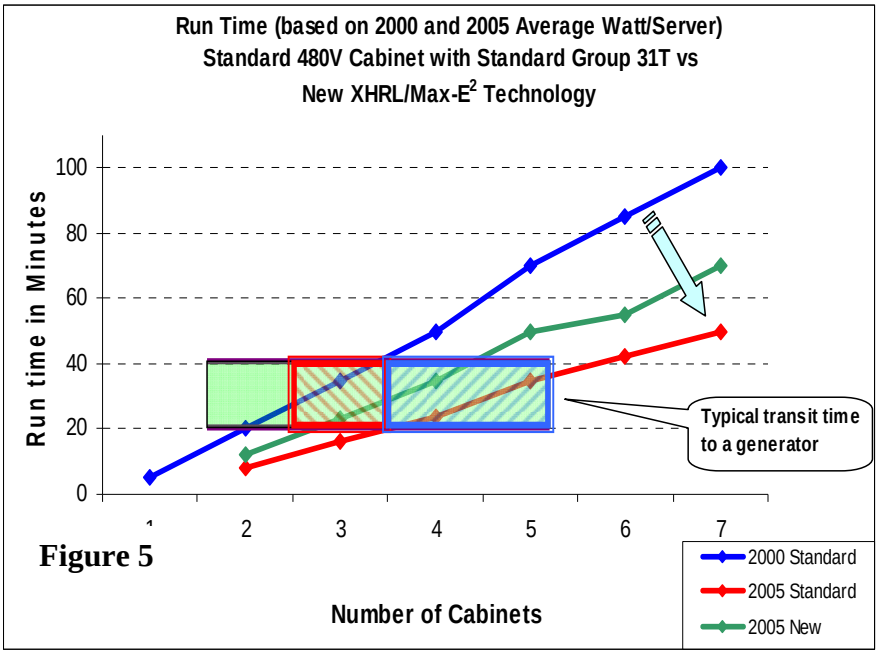


Figure 5

Moreover, the decreased number of batteries required per UPS means less handling during a new installation or when it's time to replace the batteries. This will also ultimately lead to a drop in lead demand required to meet global back up power.

It's evidenced that the new XHRL batteries will offer cost savings to end users. It can also provide performance premium with all else being equal[x]. (see Figure 6)

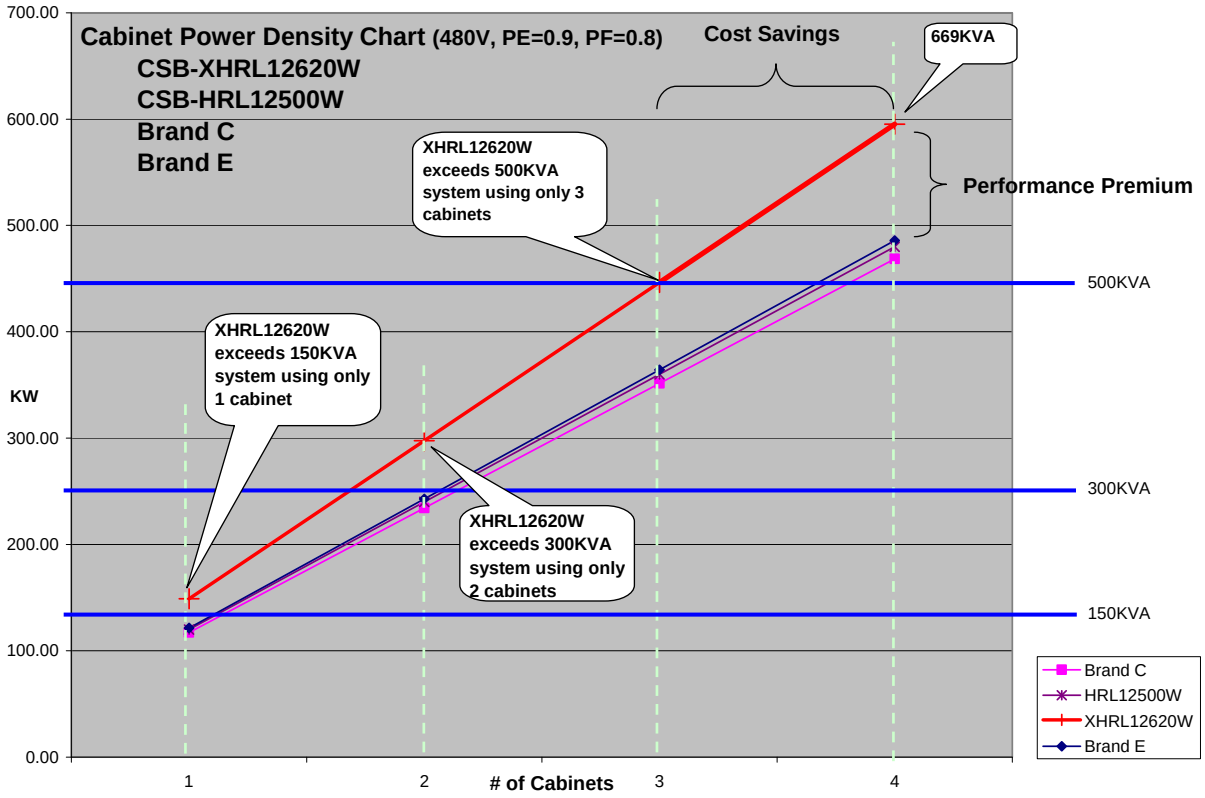


Figure 6

Cost

The new XHRL batteries offer many financial and performance benefits. The total cost of ownership (TCO) of XHRL12620W is discussed and compared against an equivalent BCI Group 31T 12-Volt battery system (Brand C) as well as 2-Volt battery systems (Brand X – Sealed 2-Volt and Brand Y – 2-Volt Wet Cells). Please see Table 1[xi] below.

Table 1.
480V Systems in a Data Center - Case Study (End User)
US$ in Thousands

Battery	XHRL12620WFR (12V)	Brand C (12V)	Brand X (2V)	Brand Y (2V)
Rated Life	10 years	10 years	20 years	20 years
Typical Life	5 years	4 years	7-10 years	12 years
Replace over 20 years UPS Life	4	5	3	2
Backup Run Time (minutes)	34	27	32	31
Number of Battery	200	200	240	240
Cabinets/Racks Cost	$ 25	$ 25	N/A	N/A
Footprint with 3 Feet Clearance (SQFT)	92	92	154	214 (3 tier)
Cost of Spaces over 20 years (US$ 600/SQFT)	$ 1,104	$ 1,104	$ 1,848	$ 2,568
Battery Replacement Cost over 20 years	$ 320	$ 340	$ 630	$ 370
Preventative Maintenance & Replacement Cost (Labor)	$ 35	$ 35	$ 42	$ 151
Total Cost of Ownerships over 20 years	$ 1,484	$ 1,504	$ 2,520	$ 3,089
Average Cost/Year	$ 74.21	$ 75.21	$ 126.01	$ 154.44
Average Cost/Backup Minute per year	$ 2.18	$ 2.79	$ 3.94	$ 4.98

The calculations above evidently show that the total cost of ownerships using the new XHRL12620WFR is the lowest among the options explored. The XHRL12620WFR option outperforms 2-Volt cell options by 70% (Brand X) and 108% (Brand Y). Even though the total cost of ownership is only about 1% lower when compared to Brand C, the run time performance is 26% higher than Brand C. By incorporating performance and cost measures, the calculations based on the Average Cost Per Backup Minutes-year, shows that XHRL12620WFR option outperforms Brand C by 28%, Brand X by 81% and Brand Y by 128%.

Conclusion

Gordon Moore, co-founder of Intel famously stated in 1965 that the number of transistors on a chip will double every 2 years. For decades this has held true. As we continue to march forward in the digital age, more and more processes are automated. New inventions constantly make the headlines while current technologies continue to improve, driving the needs for more power to satisfy power hungry equipments. If current trends continue, battery manufacturers must continue to innovate and invent new technology to quench the growing power thirst. CSB Battery introduces the first generation Max-E^2 Technology to increase power density. At the same time, CSB Battery also introduces Dura-T^0 Technology and Cyc-E^+ Technology to meet market demands. CSB Battery is committed to high quality products and innovative technologies through extensive research and development.

About CSB Battery

CSB Battery is one of the largest VRLA (Valve Regulated Lead Acid) battery manufacturers in the world. It engages in the manufacture, marketing and distribution of industrial batteries such as reserve power, renewable power and mobility power. Its reserve power products are used for backup power such as UPS (Uninterruptible Power Systems), emergency lighting system, telecommunication systems, security systems, switchgear and electrical control systems. The reserve power batteries are marketed under the XHRL, HRL, HR, HC MU, MSJ, MSV, TPL, TPX, XTV, GP and GPL series. Its renewable power products are particularly used for solar and wind based energy systems. Meanwhile, the mobility power products are used for electric vehicle systems (wheelchairs, scooters, medical equipments) and other portable equipments (cameras, remote control electronics, portable measuring equipment). The renewable power products and mobility power products are both marketed under the EVH, EVX and XTV series.

CSB Battery has manufactured VRLA batteries for 30 years. With manufacturing facilities in Taiwan, China, Vietnam and India, CSB Battery provides in excess of 3 million batteries a month to over 100 countries through an extensive network of distributors, internal sales force and independent representatives. In addition, CSB Battery owns and operates strategically located sales/support offices and warehouses to support its business partners.

CSB Battery is ISO 9001 and ISO14001 certified. CSB Battery has become a world leader in the VRLA industry through superb customer service, research and development for innovative technologies, product improvement, and a commitment to excellence in product and service.

Acknowledgments

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References

[i] Based on BattCon 2007 presentation

[ii] Frost & Sullivan 2007 World UPS Market Study Report where power range above 50KVA are categorized as three-phase UPS.

Figure 2-5 illustrates the revenue forecasts by power range for the total world UPS market from 2003 to 2013.

FIGURE 2-5

Total UPS Market: Revenue Forecasts by Power Range (World), 2003-2013

Year	Below 1kVA ($ Million)	1.1kVA to 5kVA ($ Million)	5.1kVA to 20kVA ($ Million)	20.1kVA to 50kVA ($ Million)	50.1kVA to 200kVA ($ Million)	Above 200kVA ($ Million)
2003	883.5	1,534.0	666.8	441.9	470.7	635.8
2004	950.0	1,780.0	777.6	464.3	464.4	717.6
2005	1,027.4	1,943.8	913.9	537.4	519.2	838.1
2006	1,100.0	2,235.3	1,080.0	618.5	575.9	943.4
2007	1,165.3	2,537.1	1,298.0	703.3	632.3	1,064.6
2008	1,232.7	2,782.4	1,466.8	774.3	696.2	1,171.3
2009	1,302.1	3,030.1	1,614.9	844.8	766.9	1,279.2
2010	1,373.3	3,293.7	1,765.1	921.7	835.2	1,393.5
2011	1,409.8	3,557.2	1,902.8	998.2	911.1	1,497.2
2012	1,449.4	3,820.4	2,018.8	1,076.0	995.0	1,603.9
2013	1,492.0	4,103.1	2,125.8	1,152.4	1,083.3	1,710.2
CAGR:	4.5%	9.1%	10.2%	9.3%	9.4%	8.9%

Key: CAGR = Compound Annual Growth Rate (2006-2013)

Note: All figures are rounded; the base year is 2006. Source: Frost & Sullivan

[iii] Sarbanes-Oxley Act of 2002 : Section 404

[iv] Fall 2006 Data Center Users' Group Survey Results, http://www.knuerr.ch/AF/Templates/Unternehmen/Presse/Adaptive%20pdfs/Fall_DataCenterUGSurveyResults.pdf

[v] "Estimating Regional Power Consumption by Servers: A Technical Note", Jonathan G. Kooney, December 2007

[vi] Source: Technology Management Inc.

[vii] Computer Economics & Infocorp Consulting Report

[viii] High rate batteries are batteries that are able to provide higher rate discharges typically optimized for 15 to 30 minutes constant discharge rate to 1.67V Volt per Cell

[ix] Constant power discharge rate at 77^0F to 1.67 Volt per Cell

[x] Brand C and Brand E batteries are based on same size Group 31T. Discharge data were retrieved from respective websites dated 9/12/07.

[xi] Information gathered from a few industry subject matter experts. All data are based on 1/18/07 rate. Maintenance for VRLA includes bi-annual services while 2V wet cells include monthly inspections plus quarterly measurements.