Battery Technology for Data Centers and Network Rooms: Lifecycle Costs

White Paper 35

Revision 4

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> Executive summary

The lifecycle cost of different UPS battery technologies is compared. The costs associated with the purchase of batteries, the infrastructure costs, and the costs associated with inflexibility to meet changing requirements are discussed and quantified.

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Introduction

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Battery Technologies for Data Centers and Network Rooms: Battery Options

Lead-acid batteries are the predominant choice for uninterruptible power supply (UPS) energy storage for data centers and network rooms. This white paper will compare the lifecycle costs the three lead-acid battery technologies, vented (flooded, also called wet cells), valve regulated (VRLA), and modular battery cartridges (MBC). Please see White Paper 30, *Battery Technologies for Data Centers and Network Rooms: Battery Options* for more information about the different types of battery technologies.

Each installation is unique and results in different costs. This paper uses estimates from several different sources. While every effort was made to ensure accuracy, the examples in this paper are only a guideline and factors relating to a particular installation must be incorporated for decision-making and budgetary purposes.

Lifecycle costs

This paper will examine two scenarios: an 80 kW UPS and a 400 kW UPS both with 10 minutes of runtime. The system design life is assumed to be 10 years. The costs shown are only for the battery solution. The UPS cost was assumed to be independent of battery technology so this cost was not examined. All three battery technologies will be compared in three steps. Step 1 is a pure battery purchase cost comparison. Step 2 will bring in outside and variable costs that can have a large impact on the overall cost. Step 3 will discuss costs associated with the lack of adaptability of typical designs.

The data indicates that purchase cost comparisons alone are insufficient predictors of lifecycle cost and that outside and variable costs must be examined.

Life expectancy

The life expectancy varies with battery type. **Table 1** shows the battery lifetime based upon experience at Schneider Electric and resulting from many years of UPS installations. These values will be used in the lifecycle costs.

Table 1
Life expectancy

	Flooded	VRLA	MBC
Design life	20 Years	7-10 Years	7-10 Years
Expected lifetime	15 Years	5 Years	5 Years

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As shown in **Table 1** flooded cells have 3 times the expected life of VRLA or MBC battery systems. This is contingent upon the flooded batteries receiving proper maintenance over its lifetime. We assume all batteries are from a quality manufacturer. Battery lifetime and failure modes are discusses further in White Paper 30, *Battery Technologies for Data Centers and Network Rooms: Battery Options*.

Step 1 – battery system costs

In this step the costs associated with the battery purchase cost, and other items or services specifically related to the battery. **Tables 2** and **3** only account for the battery solution. The tables in Step 2 account for battery infrastructure costs and adjusted lifecycle costs.

Table 2

Lifetime battery system cost for an 80 kW, 10-minute solution

	Flooded	VRLA	MBC
Initial battery cost	$20,000	$10,000	$12,000
Battery frame cost	$4,000	$3,000	$3,000
Maintenance cost	$30,000	$15,000	$0
Monitoring cost	$4,000	$4,000	$0
Installation cost	$4,000	$2,000	$1,000
Spill containment cost	$3,000	$0	$0
Battery replacement cost	0	$20,000	$24,000
End of life disposal cost	$6,000	$6,000	$4,000
Total battery system cost	**$71,000**	**$60,000**	**$44,000**

Table 2 indicates that a flooded solution is almost twice as expensive as a comparable MBC solution. The large battery replacement cost for the MBC battery system over the system lifetime is offset by the larger maintenance costs for the flooded battery. A VRLA solution (including MBC) represents a 27% savings over flooded batteries. This data helps to explain why there are so few flooded cell UPS installations in the under 100kW power range.

Table 3

Lifetime battery system cost for a 400 kW, 10-minute solution

	Flooded	VRLA	MBC
Initial battery cost	$120,000	$40,000	$50,000
Battery frame cost	$10,000	$8,000	$15,000
Maintenance cost	$100,000	$50,000	$10,000
Monitoring cost	$20,000	$15,000	$0
Installation cost	$28,000	$18,000	$10,000
Spill containment cost	$10,000	$0	$0
Battery replacement cost	0	$80,000	$100,000
End of life disposal cost	$20,000	$10,000	$8,000
Total battery system cost	**$308,000**	**$221,000**	**$193,000**

The flooded battery solution retains a cost premium over the other solutions at larger power levels as shown in **Table 3**. The selection of battery system also drives other infrastructure costs, which are not comprehended above. These costs are discussed in step 2.

Step 2 – infrastructure cost

In addition to the costs clearly associated with the purchase of components and services for the battery system, there are a number of facility infrastructure costs that are not always recognized as a cost associate with the battery system. These costs are estimated in **Tables 4** and **5**, and an adjusted lifecycle cost including the battery system costs and the facilities costs is computed.

Table 4

Battery lifecycle cost for an 80 kW, 10-minute solution

	Flooded	VRLA	MBC
Site specific engineering	10,000	$0	$0
Battery room costs	70,000	$0	$0
Ventilation	5,000	$0	$0
Site planning expenses	$10,000	$2,000	$2,000
Lost space expense	$10,000	$15,000	$15,000
Regulatory compliance expense	$3,000	$0	$0
Total infrastructure cost	**$108,000**	**$17,000**	**$17,000**
Battery system cost (Table 2)	$71,000	$60,000	$44,000
Total battery lifecycle cost	**$179,000**	**$77,000**	**$61,000**

Table 4 demonstrates why almost 100% of installations below 100 KW use VRLA batteries or MBC. The total lifecycle cost of a flooded battery solution is over two times higher than a VRLA and almost three times higher than a MBC.

Table 5

Battery lifecycle cost for a 400 kW, 10-minute solution

	Flooded	VRLA	MBC
Site specific engineering	$100,000	$10,000	$0
Battery room costs	$150,000	$100,000	$0
Ventilation	$10,000	$5,000	$0
Site planning expenses	$50,000	$10,000	$10,000
Lost space expense	$50,000	$20,000	$35,000
Regulatory compliance expense	$3,000	$3,000	$3,000
Total infrastructure cost	**$363,000**	**$148,000**	**$48,000**
Battery system cost (Table 2)	$308,000	$221,000	$193,000
Total battery lifecycle cost	**$671,000**	**$369,000**	**$241,000**

Table 5 shows that at 400 kW the total lifecycle cost of the flooded solution is almost two times as high as a VRLA battery solution and almost three times as high as a MBC solution. The costs of the batteries are actually less than the infrastructure expenses for a flooded solution. The infrastructure expense for a VRLA solution is less then 70% of the battery cost. The MBC infrastructure costs represent less than 25% of the battery cost.

Part 3 - adaptability

In this step we cover the costs that are often taken for granted or not considered when installing a battery solution. These costs vary dramatically and the value must be estimated on a case-by-case basis depending on the circumstances of the installation. A rigid design that cannot adapt to changing requirements creates an "Adaptability Penalty" that should be understood and considered when comparing the life cycle costs of alternative battery technologies for a given installation.

Speed of deployment: An engineered design, by nature takes a long time to implement. A modular adaptable battery solution is easier to design and implement, with less risk to delays. This time to implementation may have large cost in certain circumstances.

- If there is a deadline driven by unforeseen circumstances such as an earthquake, hurricane, or a terrorist attack
- If there is a possibility that the system must be moved prior to its expected lifetime

Standard pre-tested and prefabricated MBC battery systems can be wheeled into standard office space and operational in hours whereas flooded cell system design, specification, fabrication, and installation can take months. In some cases, this time difference is unimportant and no value can be assigned. In other cases, the cost of time may be millions of dollars per week. The value of time must be assessed on a case-by-case basis.
Equating Supply and Demand: A rigid design is difficult to change after installation and is normally built out to its ultimate plan configuration up-front. The plan value is often unknown as it requires determining the power requirement years in advance. Since under sizing a rigid

design is not acceptable, this means that the design configuration of the system must be larger than the mean expected value in order to assure that the system can meet the high-side estimates. Managing risk in this way is part of good decision-making given the options available, but the result is that the average data center and network room spends most of its life loaded to a small fraction of its design value.

The average data center or network room has its battery infrastructure oversized to 4X of its required battery capacity. This means that the lifecycle cost of the average battery system is 4 times what is needed. In return for this large cost the system has a very long battery run time and has the ability to accept a very large increase in load.

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White Paper 37
Avoiding Costs from Oversizing Data Center and Network Room Infrastructure

The average data center is entitled to a 75% savings in battery life cycle costs. If the battery system could simply be matched to the initial load and then expanded as needed, this cost could be avoided. See White Paper 37, *Avoiding Costs from Oversizing Data Center and Network Room Infrastructure* for more information on this subject.

Commercially available prefabricated MBC systems can be transported simply via truck and normal passenger elevators, wheeled into unimproved space, connected to a DC bus in minutes and meet all the requirements necessary to ensure adaptation to changing battery needs.

In contrast, flooded cell battery systems require long range up-front planning including specialized physical space, ventilation, safety planning, and engineering. The costs associated with incrementally expanding flooded cell systems are so large that it is normally less expensive to simply build out the entire system up-front.

The VRLA system has many of the same site planning issues as the flooded cell. Historically, these systems have not demonstrated the ability to adapt to changing requirements and they are typically built out to their design value up-front as flooded cell systems are.

The MBC system is capable of recovering much of the 75% savings in battery life cycle cost that the average data center is entitled to. When this is combined with the lifecycle cost advantage of MBC batteries of nearly a factor of three, a potential savings of over 90% is possible when compared with the flooded cell approach.

Selection factors other than life cycle costs

There are additional factors that affect battery selection. For many customers, availability is valued very highly and there is a perception that flooded Cell batteries offer availability advantages, which offset the savings associated with VRLA or MBC battery systems. These are discussed briefly here and discussed in more depth in other white papers.

The principal issues contributing to the assessment of system availability advantages for wet cells are shown in **Table 6**:

Table 6

Factors affecting battery system availability

Issue	Background	Current
Very short lifetime of VRLA batteries based on actual field experience	VRLA manufacturers had poor quality control in the 1970s through the 1980s, especially in larger batteries	Quality of VRLA has improved, especially in smaller cells used in MBC, but lifetimes are still much shorter than flooded cells.
Abrupt failures of VRLA batteries resulting in load drops	Inability to diagnose impending failure, combined with high failure rates	Use of independently monitored highly paralleled strings, and improved diagnostics, allows MBC batteries to overcome these problems.
Replacement of VRLA batteries creates an event which may cause a reduction of protection or even down time	Many flooded cell installations require no change over the system lifetime, whereas VRLA requires a number of changes	MBC batteries are in cartridges that can be swapped by unskilled personnel.

Conclusion

This analysis finds large differences in the life-cycle costs of the different UPS battery technologies. After reviewing all three steps it is clear that a MBC battery solution can offer over 50% savings over VRLA and flooded battery solutions. Often only the battery system costs are compared and then the differences might not be compelling enough to warrant a switch from a known technology. When the infrastructure costs are added the lifecycle savings between the technologies is dramatic. This is why of the UPS sold each year world wide, over 99% use VRLA batteries or MBC. The adaptability of MBC increases the speed of deployment and can allow recovery of the 75% of cost the average data center loses due to oversizing.

Factors relating to system availability have driven some installations to deploy flooded cells despite the lower life cycle cost of VRLA or MBC batteries. The technology of the MBC battery system specifically addresses many of these issues.

When compared with flooded cell battery systems, the MBC can save over 90% in life cycle costs in a real-world situation. Most of this cost advantage results from the ability to size the battery system to the current requirement and add as needed to meet changing requirements.

In cases where the ultimate load value is pre-determined and full utilization is achieved at the first commissioning of the system, much of the advantage of the MBC battery system is lost. However, the engineering, installation, and maintenance cost advantages still provide a savings of up to 60% when compared with flooded cells.

About the author

Stephen McCluer is a Senior Manager for external codes and standards at Schneider Electric. He has 30 years of experience in the power protection industry, and is a member of NFPA, ICC, IAEI, ASHRAE, The Green Grid, BICSI, and the IEEE Standards Council. He serves on a number of committees within those organizations, is a frequent speaker at industry conferences, and authors technical papers and articles on power quality topics. He served on a task group to rewrite the requirements for information technology equipment in the 2011 National Electrical Code.

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