Liebert®

Solution Analysis White Paper

CHOOSING THE RIGHT UPS FOR SMALL AND MIDSIZE DATA CENTERS: A COST AND RELIABILITY COMPARISON

EMERSON Network Power

Introduction

A dependable uninterruptible power supply (UPS) system is essential to protecting data centers and server rooms from unplanned downtime and equipment damage.

This paper compares two UPS systems marketed for small and midsize data centers. These products represent remarkably different design philosophies. The impact of these differing philosophies on reliability and cost of ownership is addressed. In addition, this paper addresses the following questions:

- What is the appropriate service response when a problem occurs?
- Is lower reliability a good trade-off for shorter repair time?

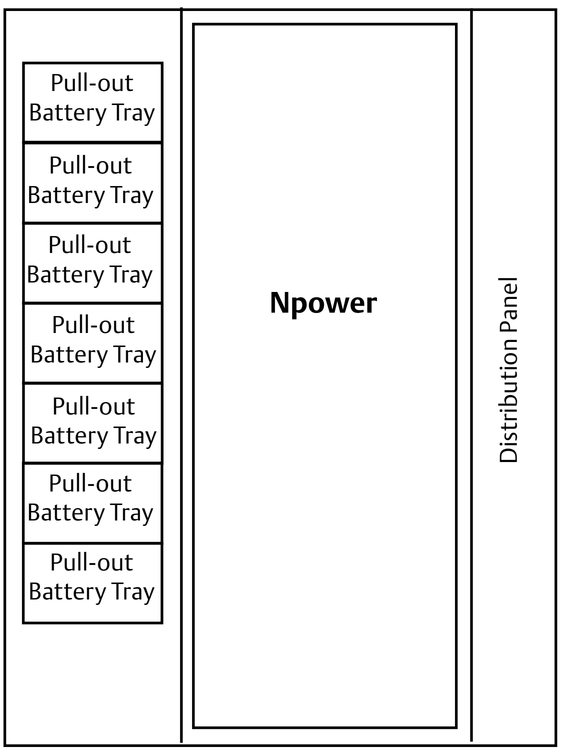

Figure 1. Liebert Npower physical layout.

- When does it make sense to time-phase capacity increases in the data center?

Product Descriptions

The Liebert Npower (Figure 1) is a cost-effective 40 kW UPS system designed for high reliability with internal construction that supports easy maintenance and repair. It is available in a broad range of fixed design points. Npower arrives on site fully tested and assembled, ready for installation by an electrical contractor or facility electrician and startup by a field engineer. Its human interface is a convenient graphic display with mimic panel that shows system power flow. Npower uses a single string of 40 batteries housed in a separate rack with a second, independent string added for redundant systems. Batteries that operate up to 38 minutes at the maximum discharge rate are available.

The second product is a highly modular UPS system designed to allow a manager to add power capacity in small increments. This system is composed of a power distribution rack that accepts up to four 10 kW power UPS modules, plus an additional module for redundant operation. Each power module functions as a full UPS when plugged into the power distribution rack and each requires a string of 32 batteries for each 6-minute increment of operation. The 32-battery increments are arranged in groups of four modules, each containing eight batteries.

The configuration shown in Figure 2 has 384 batteries for up to 18 minutes of full load operation.

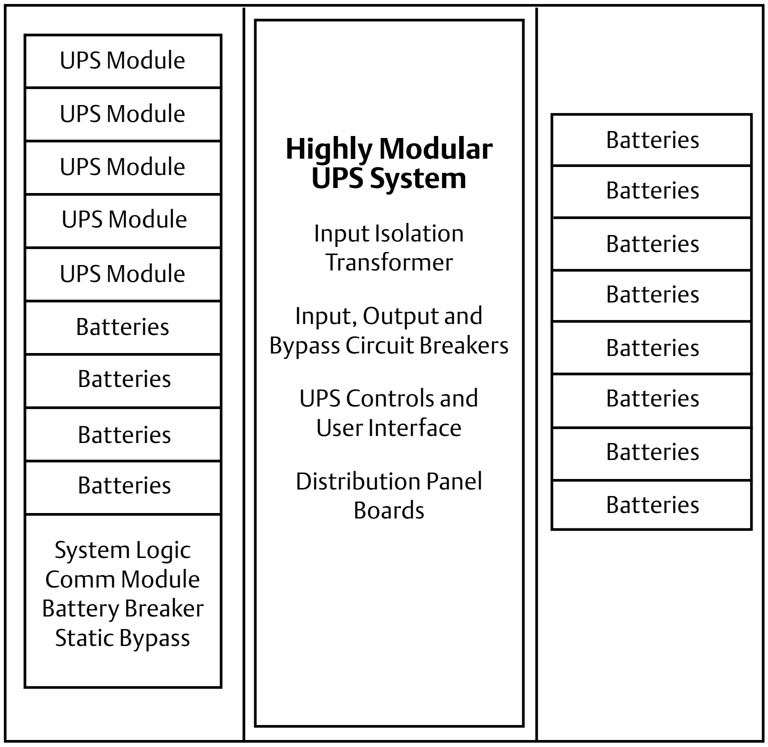

Figure 2. The highly modular UPS system physical layout.

Both systems provide conditioned power to the load and present a friendly face to the utility. In addition, they have an automatic bypass switch to provide unconditioned power to the load if the UPS fails or goes offline.

Analyzing Availability and Reliability

Availability is defined as the percentage of time power is supplied to the critical load. Two factors determine it: system reliability – number of operating hours a system runs between critical load power failures – and down time – the period from the moment of critical power failure to its restoration. For the purposes of this paper, the term availability is used only in reference to critical load power. Factors other than power can impact availability and should be considered when calculating the expected availability of business critical systems.

Experienced IT customers have become more demanding. Exposing critical applications to unreliable utility power has become unacceptable – the cost is simply too high. This is the driving force behind the popularity of redundant UPS systems that have reduced dependency on bypass power and moved critical load power availability to previously unattainable levels.

Npower has been on the market since 2001 and has demonstrated extraordinarily high reliability. Critical load power availability of Npower systems exceeds 99.999 percent, which corresponds to a system mean-time-between-failure (MTBF) of 1,000,000 hours.

Highly modular systems are a more recent entry into the market. Assessing their reliability relative to Npower requires an examination of the key differences between the two systems, particularly in the areas of component count and battery configuration.

Component Count

One of the basic truths of reliability analysis is that the more parts a device has, the more frequently that device will fail. A modular product has more parts because it has multiple modules, and it exhibits a proportionally higher predicted failure rate than a fixed-capacity UPS.

This reduction in module-level reliability can partially be compensated for by increased design margins and by using the modules in redundant configurations.

Element	Component	Component Count		
		Npower	Highly Modular UPS System	
		1x 40 kW	1 x 10 kW	4x10 kW
Rectifier	SCR	6	6	24
	Diode	0	12	48
	Transistors	0	6	24
Inverter	Transistors	6	12	48
Rect/Chg/Inv	All of above	12	38	152

Table 1. Each Npower UPS power converter has 12 power components. The highly modular UPS system has 38 per module. A 4-module version of this system has 152 (4 x 38) power components. Consequently, it is likely to experience 12 times more component failure than Npower.

Careful circuit selection is a must to prevent further decreases in module-level reliability. However, other highly modular systems are designed with circuits with a high component count, so their module-level reliability is compromised even further. When the module component count is multiplied by the number of modules, the negative impact on reliability is dramatic. Table 1 compares the power component count of both systems.

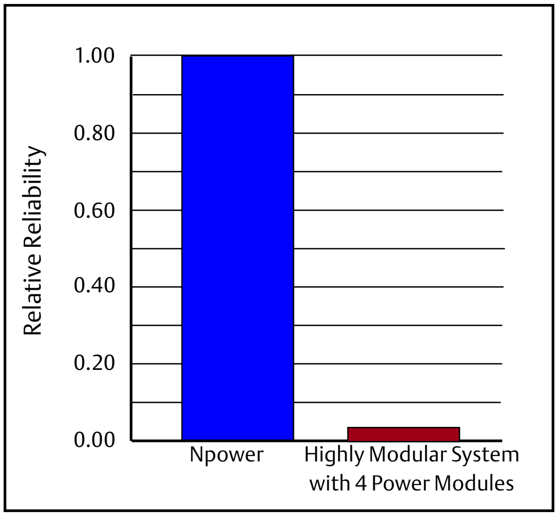

Figure 3. The reliability of Npower's power converter is assigned the value 1.0. Relative reliability calculations reflect higher power module component counts only. Similar effects of higher battery and connector counts are not considered.

Figure 3 illustrates the direct effect component count has on reliability. Note the dramatic reliability reduction as modules are added. This reduction is due in part to modularity, but stems primarily from circuit design. Ultimately, the availability of critical load power is limited by this reliability decrease.

Battery Configuration

Batteries are the data center's last stand if the power goes out. They're also the least reliable UPS element because poorly maintained batteries are a major cause of critical load power loss. Well-designed, easy to maintain UPS battery configurations are vital to long-term data center reliability.

Npower uses only 40 batteries with 80 heavy-duty bolted connectors for maximum connection integrity. A common highly modular UPS system has 32 batteries with 64 slip-on connectors per power module. In a 40 kW redundant configuration of this system, 6 minutes of operation requires 128 batteries. Extending the operating time to 18 minutes triples the number to 384 batteries and 768 slip-on connectors – and doesn't bode well for battery reliability. Because of this high battery count, a faulty battery that adds life-shortening stress to the rest of the string is more likely to go undetected.

Redundancy

The IT manager has to decide the appropriate level of protection for the data center's most critical applications. Non-redundant systems typically provide excellent power protection at a reasonable cost. If a system fails, it automatically transfers to bypass power. However, the load then depends on unreliable, unconditioned utility power. A redundant system provides an additional layer of protection and dramatically reduces the risk of power interruption at the critical load. Redundant UPS systems are the most reliable and provide the highest degree of protection and availability.

The redundant Npower 1+1 achieves the highest level of protection possible by connecting two complete, identical, fixed-capacity systems in parallel, each operating at 50 percent of rated capacity. This 100 percent redundancy combined with low system stress makes Npower extremely reliable. If one system fails, the other automatically assumes the full load until the failed system is repaired and returned to service. Figure 4 demonstrates this design, where simplicity correlates with high reliability.

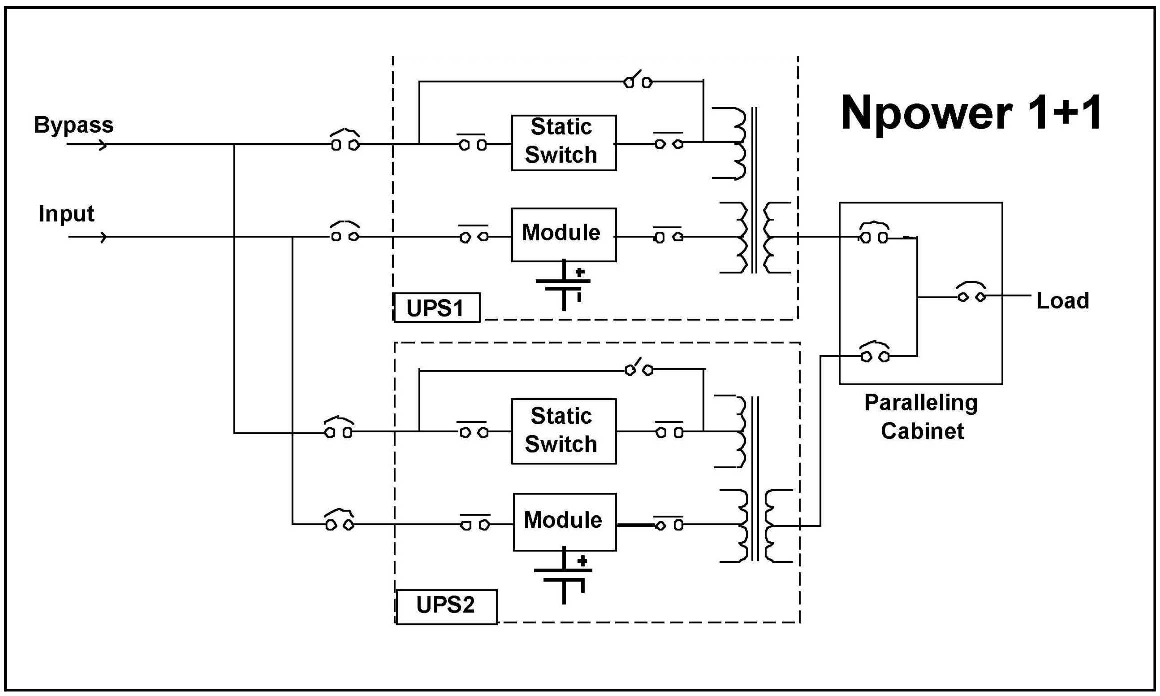

Figure 4. Complete redundancy is achieved in the Npower 1+1 configuration, where simplicity correlates with high reliability. Note the minimal common connection points between the power modules.

Since Npower 1+1 is designed with two independent battery strings, if a fault occurs on one battery bus, the other system supports the full load because its battery string is unaffected.

In the alternative UPS system, the power module is redundant but the battery bus is not. A fault on this bus might cause all UPS modules to go offline, leaving the load – and the data center – on bypass.

Figure 5 shows the block diagram for this system. The predicted availability of highly modular systems is limited by the relatively high failure rate of the power modules and by the common bus battery configuration. The service philosophy for this system is based on the rapid swap out of failed modules, or of the entire system if necessary, to restore system availability.

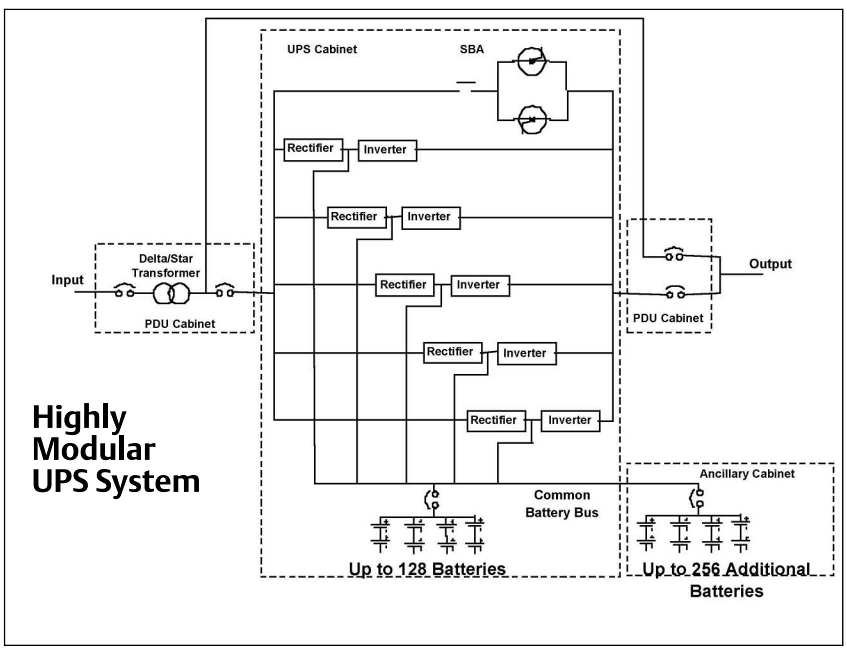

Figure 5. Highly modular system redundancy model. Note the many common connection points between the power modules.

Dealing with Downtime

No manager wants to deal with downtime, but it can happen. If a failure occurs, there is a risk that a person unfamiliar with the system may make a mistake that causes the critical load to drop.

Npower is backed by a global service organization that offers a variety of service plans, including four-hour on-site response by factory-trained customer engineers familiar with preventive and remedial procedures. It features an optional auto-dial modem to automatically dispatch a service engineer to the site and notify appropriate data center personnel as well as other advanced monitoring capabilities that support comprehensive, network-based or stand-alone monitoring.

For systems without this resource, data center personnel have to do much of their own service work and quickly replace failed modules. This means already busy IT personnel must be trained to provide 24 hours a day, seven days a week coverage. If a technician can't be present or a spare battery fails, or if the problem is not in a swappable module, the uncertainty and confusion may delay the arrival of a qualified technician. Subsequent diagnosis and repair will take longer than if a qualified technician had been called immediately. In addition, the data center manager has the added burden of ensuring technicians are both trained and practiced in the maintenance of a UPS system.

Also, consider that many non-UPS factors contribute to system failures, including system grounding and neutral issues, loose

	Predicted Availability	Predicted Average Annual Downtime
Npower 1+1 (Redundant)	0.99999998	<0.1 min
Highly Modular System (Redundant)	0.99999320	4 min
Npower (Nonredundant)	0.99996510	18 min

Table 2. Predicted Reliability for configurations in Figures 4 and 5.

or corroded cable terminations, and transformer or breaker failures. Proper installation, combined with an effective preventive maintenance program can reduce or eliminate these potential problems

System Availability
Availability is determined by reliability and downtime. It is stated as a fraction or a percentage and usually equated to average annual downtime. Npower 1+1, at an availability of 99.999998 percent, is predicted to average less than 0.1 minute per year of downtime. A highly modular system with redundancy is predicted to experience roughly 40 times that amount.

Cost of Ownership

Cost of ownership is a complex issue. Data center construction, power equipment, heat removal equipment, and equipment racks are major items to consider; primary cost drivers are floor space and power consumption. Managers need to decide if time-phased capacity increases make sense given initial data center requirements and predicted growth rate.

Floor Space
IT managers know that servers, not power supplies, generate revenue. Finished, fully-supported data center space is prime real estate and very expensive – from $200 to $450 per square foot, depending on the size of the center. Server rack power density industry-wide is predicted to grow from its current range of 1 kW – 3 kW per rack to 10 kW – 15 kW per rack within a few years. This rapid rise in power density is driving deployment of modular, rack-oriented heat management systems.

Npower gives the data center manager the power to choose where to place the UPS: on the data center floor or in a less expensive equipment room. It requires only front access for installation and maintenance so can be located against a wall and between already-installed equipment.

The comparative product can be installed only within the data center. The distribution panel is not modular, so the UPS must be installed near the server racks where floor space is most valuable. Typical configurations consume 10-20 percent of the available data center rack space. This increase in floor space directly drives construction cost. And locating UPS equipment in the data center requires 10–15 percent higher air conditioning system capacity to handle the added efficiency load.

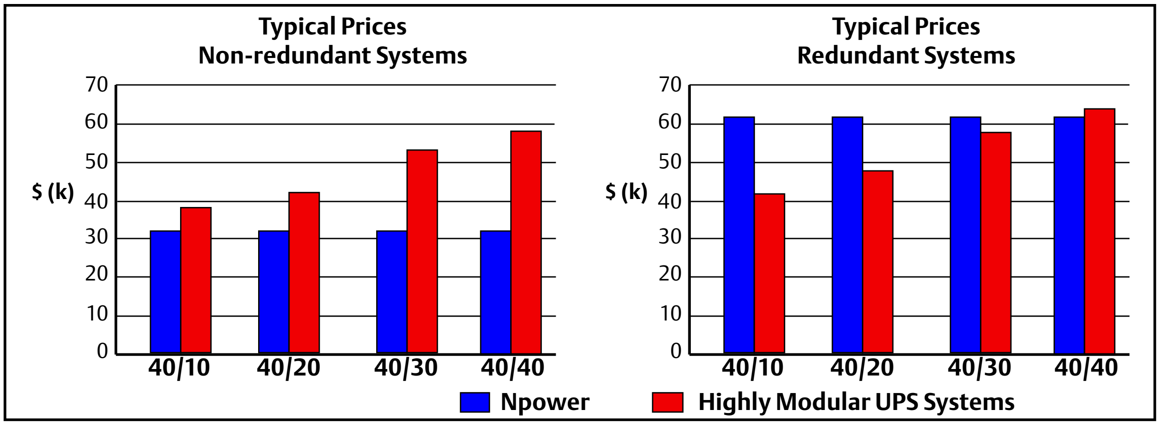

Figure 6: Comparison of Npower and highly modular UPS system prices for typical configurations.

Power Equipment Cost

The price of a non-redundant 40 kW Npower is about half that of a 40 kW highly modular system, including spare parts and startup. The higher comparative predicted reliability, combined with the increased data center construction cost brought about by locating the UPS in the data center tips the scale even more in favor of Npower. Figure 6 demonstrates typical product prices.

Spare Parts

Liebert warranties and service contracts provide spare or replacement parts as needed, with no additional cost associated with Npower spares. Without these warranties and service contracts, the customer must invest in spare parts so the person on-site that is responsible for maintenance can swap power modules, battery modules, and/or control modules when failures occur.

Installation

An often overlooked cost is the time and labor of UPS pretest and installation. Each Npower is factory-tested by trained test technicians who test all Npower subassemblies and internal modules. System-level tests include full load and overload testing. Every system is operated for 24 hours, then shipped as a complete UPS configured for each customer's specific needs. Installation is simple: a contractor puts pre-assembled sections in place and interconnects them.

If the system were to arrive in individually packaged cartons, a field engineer must assemble the product before an electrical expert installs it, and the engineer performs startup.

Cost Analysis

Figure 7 demonstrate the cost differences in two typical data center situations. In the first, total capital expense is dominated by data center construction, and purchase and installation of power equipment. Because significant additional money is needed to expand air conditioner capacity and racks, incremental additions should be considered for these items. Full-capacity installations make sense when incremental cost is low. They avoid expansion-related construction errors and save money by eliminating

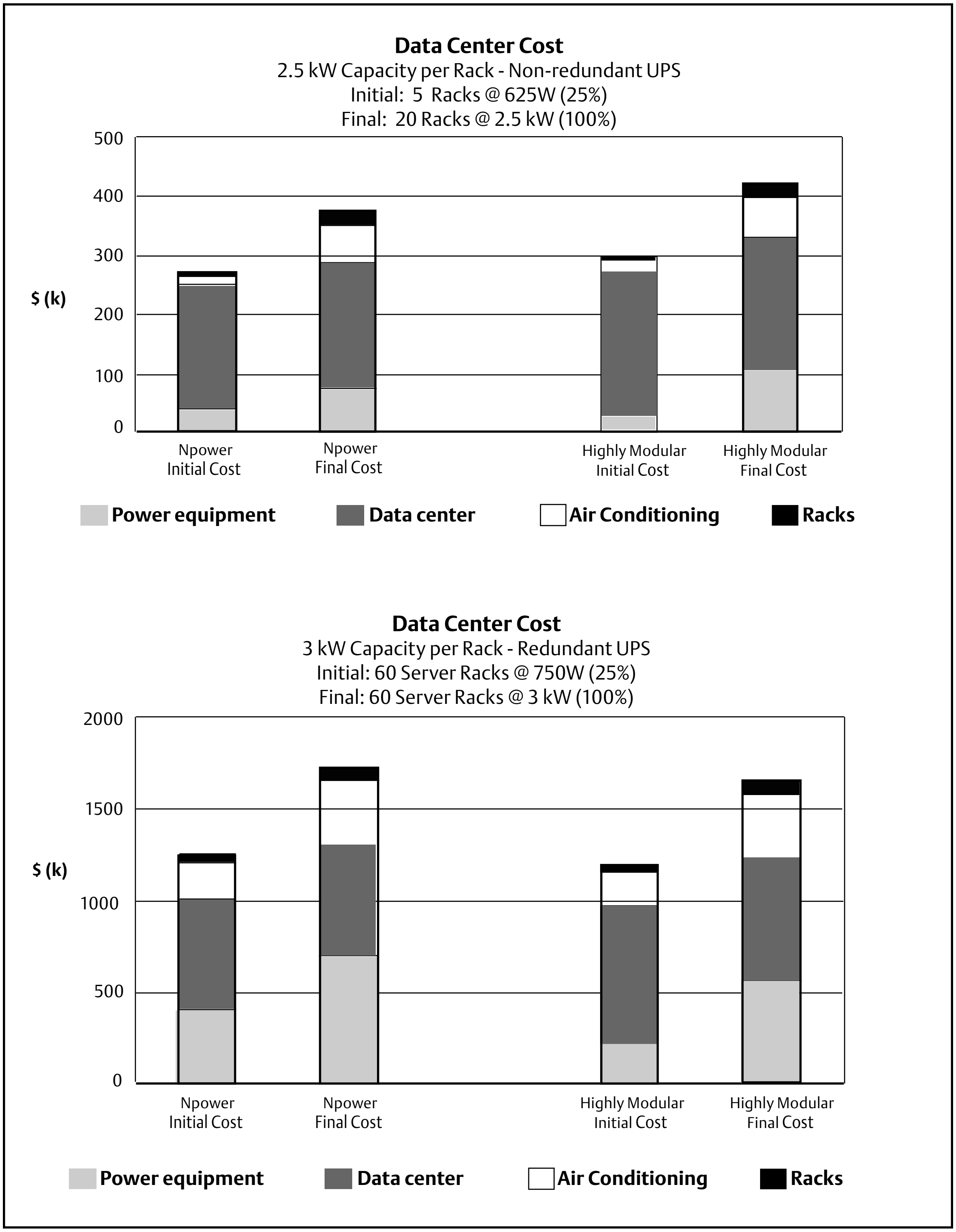

Figure 7. Initially, the power and environmental systems are matched to server rack loads (see the first bar of each pair). The systems subsequently expand as the load grows to the per-rack capacity limit.

multiple electrician visits and avoid endless capital acquisition forms, justifications, and re-approvals.

The second chart shows the difference in capital required to build a minimum capacity data center, and that needed to build out to maximum capacity, is substantial for each item. The incremental approach may be wise in such cases. It's up to the data center manager to decide whether to do the complete installation up front or wait until the load demands it.

Cost of Downtime
The true cost of data center downtime is almost immeasurable. Interruptions of critical applications cause financial losses for data center customers and financial penalties for data centers. System failures, even those that don't result in downtime, erode customer confidence.

Choosing the right UPS – one that's backed by a strong, proven service organization – is crucial to long-term data center reliability.

Conclusions

Liebert's Npower is the right UPS choice for small to midsized data centers. Designed for reliability and backed by a strong service organization, Npower meets the needs of data centers dedicated to preventing problems before they occur.

Npower Findings:

- Proven design provides superb reliability and availability
- Global service organization offers top-caliber support, maintenance, and repair
- Lower cost of ownership
- Full capacity available at installation
- Complete redundancy, including batteries

Inherently, highly modular UPS systems focus on quick repair of plug-in modules with higher failure rates. They allow high reliability to be traded away for modularity based on the premise that shorter repair time compensates for more frequent system failures.

Highly Modular UPS System Findings:

- Circuit design, not modularity, is the primary reason for its power section component count increase
- Non-redundant battery defeats system redundancy
- Repair time is fast only if spare parts and trained customer personnel are available 24/7
- Risk is high because of technicians unfamiliar with power technology
- Cost of ownership is higher because of increased component count, floor space utilization, heat management, installation and maintenance considerations, and potential cost of downtime

Liebert's design philosophy has paid off with an enviable field reliability record. Npower is the clear choice for small to midsized data centers.

Contact your Liebert service representative for more details.

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