



Designing Fault-Defiant Electrical Power Systems For Data Centers

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The American engineering community was jolted into the Modern Age on October 4, 1957: the day the former Soviet Union launched Sputnik-1, the first man-made object to orbit the Earth. Fearing that America was threatened by a shortage of engineering firepower needed to win “The Space Race,” the U.S. Congress passed the “National Defense Education Act,” launching millions of engineering careers.

Nearly 50 years later, a similar wake-up call came: on August 14, 2003 in a mere eight minutes, the infamous Northeast Blackout moved like a tsunami, knocking out 250 power plants across a million square miles. Ten million people in the Canadian province of Ontario (about one-third of Canada’s population) and 40 million people in eight U.S. states (about one-seventh of its population) were left without electrical power.

Data Centers: Corporations’ Multimillion-Dollar Nest Egg

Geographically, these states are home to some of the world’s most computing-intensive industries: financial services (New York), manufacturing (Ohio and Michigan), and telecommunications and healthcare (New Jersey). Of the entire FORTUNE 500, 319 companies are headquartered in states where the blackout took its heaviest toll. For many, their data centers – even those equipped with massive investments in on-site power generation, UPS, and fault-tolerant systems– were hit by surprise, and were hit hard:.

By the time power was restored, almost one third of the nation's enterprise data centers had been affected financially by the Blackout. According to the data center research firm AFCOM, a survey of more than 500 data center executives found that after The Blackout, nearly half suffered significant financial losses:

- 10 reported that they lost more than \$10 million as a result of the outage
- 2 reported losses of between \$5 million-\$10 million
- 15 reported losses between \$1 million and \$5 million
- 25 reported losses between \$500,000-\$1 million
- 50 report losses of \$100,000-\$500,000
- 125 reported losses of between \$10,000 and \$100,000

The lesson learned was a simple but painful one: interruptions in electrical power service can have costly, even catastrophic, consequences for data center operators, especially in facilities where they felt they were sufficiently prepared... and their false sense of security exacerbated their troubles.

Why do “failsafe” backup systems fail? A common problem is that that most backup systems are generally installed and are then left alone, perhaps for years... until a failure during a power outage reveals that they were not properly maintained.

Failure to properly maintain backup systems, or to diagnose their preparedness for changing loads, can have serious ramifications: 40% of all business down is caused by electrical power problems... and 80% of those problems are rooted in internal causes (overloading, inadequate system maintenance, failing to upgrade backup systems in response to equipment changes, etc.)

For example, in typical installations, an acceptable startup time for an on-premise generator will take up to three minutes from the time of failure. During those three minutes, a series of UPSs and batteries – designed to carry the load for only 15 to 60 minutes –will provide emergency power until the generator starts. This is to allow for any gradual shutdown and disaster recovery of computer equipment in the event the generator does not come on after three minutes.

But in order to provide the desired protection, UPS units must be properly maintained. One of the most commonly-neglected components is the UPS's battery: sealed lead/acid batteries have a useful lifetime of 3–5 years, and they lose their ability to hold a charge gradually over that time. So if a UPS started with one hour of runtime for the connected load, after a year, it may only provide 45 minutes, and so on.

The Price of Prevention

Businesses dependent on their data center operations face skyrocketing costs to build and maintain the IT systems they need to meet demand. There are five primary factors driving the spike in the cost of operating a data center:

1. Demand, real estate prices are up
2. Construction prices are up
3. Consolidated, higher-capacity infrastructure
4. Utility consumption, prices are up
5. Obsolete electrical power infrastructure

1. Demand, Real Estate Prices are up: According to the San Jose Mercury-News, data center vacancies in the area “in the single digits.” Prime office space in downtown San Jose costs about \$2 a square foot per month... but data center rents are as high as \$30 a square foot per month.

2. Construction prices are up: In 2006, the typical 50,000 square foot data center would cost approximately \$20 million to construct, based upon a current rate of \$400 per square foot. This cost is projected to at least triple – and some say, increase to \$5,000 per square – foot by 2010, meaning that today’s \$20 million data center construction will cost at least \$60 million three years from now.

3. Consolidated, higher-capacity infrastructure: Organizations are putting “all of their eggs” into fewer and smaller baskets. According to Gartner Inc., 94% of IT departments are in the process of either consolidating their servers, or planning to do so. Randy Mott, CIO for Hewlett-Packard, has said publicly that he plans to reduce the number of HP data centers from 85 to six... a more than 90% reduction.

Sales of servers are estimated to increase 40% to 50% annually over the next four years, meaning that higher-density servers are being installed at a very rapid rate. Because server performance and density are more doubling every year, more and more IT resources are being squeezed into a smaller footprint... and dramatically increasing the risk to reduced-site operations.

4. Utility consumption, prices are up: In the United States alone, data centers consume some where between 30 and 40 billion kilowatts of electricity annually. A typical data center consumes 15 times more energy per square foot than typical office space, and is estimated to be 100% more energy intensive, in terms of density. The more dense the server components, the more heat they generate, thus, the more air conditioning they require.

5. Obsolete infrastructure: It's not just older data centers that are being taxed by computing clusters. According to AMD, facilities built as little as two years ago are ill-equipped to hold today's high-density server racks, due to inherent limitations in their power utilization and cooling output.

When data centers are constructed, they are subject to a physical limit as to how much power can be delivered to the site and stored. In 2006, the typical data center was designed to handle 40 watts of heat per square foot; because of increasing server density, this is projected to handle up 500 watts of heat per square foot by 2010.

Similarly, data centers' air conditioning systems are limited in how many BTUs of cooling power can be delivered in a given space and, in public data centers, a predetermined level of wattage per cabinet that can be dissipated. The problem is so pervasive that through year-end 2008, heat and cooling requirements for servers will prevent 90 percent of enterprise data centers from achieving the maximum theoretical server density.

The Below-the-Floor Solution

As noted earlier, the most common cause of data center failures lies in the electrical power infrastructure supporting it. Most of these failures could be prevented in either of two ways:

- 1) Better up-front design, prior to construction
- 2) Better post-construction diligence, diagnostics, and insight



One company, Power Analytics Corp., has developed an innovative solution to both problems, that it calls “power analytics.” Its Paladin software platform uses allows data center designers to not only ensure that their power systems designs are “perfect on paper,” but allows those design specifications to be repurposed as part of a live, operational system that diagnoses system integrity. Specifically:

- Using the Paladin DesignBase design and simulation platform, potential electrical infrastructure problems can be “designed out” of a facility before it is constructed or modernized. The use of DesignBase results in more than a typical CAD blueprint of a data center: it creates a dynamic, “virtual model” of all internal systems and components. This model is used to simulate and validate the operational parameters of the overall electrical distribution system, to ensure system-wide integrity even before it is physically constructed... even potential “what if” problems that are beyond the scope of operational probability.
- Once the facility is constructed, the DesignBase model can be taken from “design mode” to “operations mode” using Power Analytics’s Paladin Live on-line power analytics platform. Once in this mode, Paladin Live compares predictions from a fully synchronized “virtual model” – armed with all expert knowledge about the facility’s target operating specifications – to actual, online data from the facility’s physical equipment to check for deviations. In comparing the “actual” and “virtual” performances of the electrical infrastructure, the software is able to detect variations. This actual-to-virtual methodology helps identify conditions that, if left undetected, could result in power problems if left undetected.

The combined use of Paladin DesignBase and Paladin Live brings tremendous operational benefits to data center users: the maintain unprecedented insight into the systems-wide integrity of their data center infrastructure; potential power problems are identified at their earliest stages, isolated, and resolved before they pose a threat to operations; and operators gain a clear, real-time understanding of capacity, load behavior, and other symptoms of power systems health.

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