Best Practices in Data Center Power Management

An ENTERPRISE MANAGEMENT ASSOCIATES® (EMA™) White Paper
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EMA™ IT & DATA MANAGEMENT RESEARCH, INDUSTRY ANALYSIS & CONSULTING

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Executive Summary

Power management techniques for reducing IT energy consumption can provide significant opportunities for operational cost savings and other business value. To maximize effectiveness in the data center, however, a holistic approach must be employed that identifies, monitors, and addresses all applicable energy-consuming components. Utilizing the appropriate tools, enterprises can overcome the most challenging inhibitors to implementing "green IT" initiatives. In this white paper, Enterprise Management Associates (EMA) explores the best approaches to developing, deploying, and managing an effective data center power management solution.

Introduction: The Value of Power Management

As organizations have increased their reliance on IT to achieve business goals and drive profitability, infrastructure requirements necessary for maintaining larger and more powerful IT operations have proportionally expanded. Nowhere is this more evident than in the increased power requirements necessary to support IT resources. Because of the environmental impacts associated with excessive power consumption, IT solutions for energy reduction are a primary component of "green IT" implementations. Green IT solutions are products, services, and practices designed to improve the efficiency of computing resources in such a way as to reduce the environmental impact of their utilization. Founded on the "triple bottom line principle," green IT solutions address economic, environmental, and social impacts of IT deployment.

Today's economic realities underscore the need to reduce expenses associated with increased IT power requirements. In fact, EMA primary research indicates "reducing energy costs" as the primary motivator cited by 94% of IT managers for implementing energy reduction initiatives. This should be no surprise as significant savings can be achieved with energy reduction solutions, often justifying the implementation cost of the solution in less than a year. This value has changed the focus of green IT solutions to be more about the green in a wallet than the green of the grass.

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In many areas, energy reduction initiatives can actually be used to generate revenue. Commodities associated with power and carbon emission reductions (commonly identified as White, Green, and CO_2 e-Reduction certificates) can be traded in locations that have implemented a trading system. Although such programs are more common in Europe, 24 states in the U.S. have instituted them and legislation for a national program is currently pending. Additionally, utilities are increasingly offering incentive and rebate programs that either reduce or reimburse a percentage of power costs as a reward for utilizing energy efficient resources.

Although economics is the primary driver for implementing energy efficient IT solutions, the value is by no means limited to the financial advantages. For instance, a major challenge exists for organizations that have reached the limit of available power for their facilities. Typically, these impact data centers that were initially designed for capacities below current business IT demand. By limiting growth in the data center, these enterprises must either reduce existing power consumption or risk limiting the growth of their business.

Certainly, a sense of social responsibility has also encouraged many organizations to reduce power consumption in order to decrease carbon emissions and geopolitical confrontations associated with a dependency on oil. Lacking collective business altruism, many government institutions worldwide have instituted regulatory compliance initiatives to limit or reduce power consumption to achieve these social requirements at local, state, and national levels. For many enterprises, energy reduction solutions are critical for achieving these regulatory goals without incurring a business impact. Ironically, however, broad reductions in energy utilization are essential for the ongoing sustainability of individual businesses. Just as the logging industry long ago learned they needed to plant a tree for each they cut down, today's IT-based industries need to reduce power consumption to ensure future cost-effective energy resources.

Finally, the marketing value of implementing power reduction solutions should not be underestimated. Not only do businesses often receive free publicity in mainstream markets, but publically traded enterprises that are energy efficient become more attractive to fund managers looking for fiscally and/or socially responsible investments.

Regardless of which value proposition provides the greatest driver for introducing power management initiatives, it is clear that introducing energy efficiency solutions specifically for information technology implementations can achieve quantifiable return on investment for the business. For organizations dependent on IT in particular, power requirements for supporting the technology infrastructure can dwarf any other energy expenditures in the enterprise. Achieving maximum value in IT power management initiatives, however, requires a holistic approach to reducing energy consumption in the data center that begins with an in-depth understanding of business requirements and IT utilizations that will enable informed decisions to be made on the most effective solutions to implement.

Energy Reduction Opportunities in the Data Center

According to a 2007 US Environmental Protection Agency (EPA) study, the total amount of national data center energy utilization had accelerated to a total of 61 billion kilowatt-hours of power – or about 1.5% of all U.S. electricity consumption combined. To put this in perspective, that's almost twice as much power as consumed by all the nation's color televisions and more than half as much consumed by all U.S. household lighting. Worse, there's every indication that power utilization will double this amount by 2011 resulting in a whopping $7.4 billion dollars in annual electricity costs.

Aside from increasing business reliance on IT, the primary reason for excessive data center energy consumption is the requirement for continuously operational systems. EMA research indicates that, on average, data center servers are kept fully operational 88% of the time and the reason most often cited for this is simply that the business production environment is utilized 24/7. This means that excess power consumption cannot be reclaimed significantly through automated power down and power management practices the way they can on desktops. Although limited power reductions can be achieved by managing power during the 12% of time systems are not in use, critical backup and maintenance periods will need to be worked around, so this solution is not recommended as the sole energy reduction process in the data center.

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Appreciable savings in the data center, however, can be achieved through consolidation initiatives. Most servers in a data center are not utilized to their full capacity. In fact, often there are servers that are operational and drawing power, but rarely – if ever – actually utilized. Even when idle, systems consume roughly half their maximum power draw, resulting in significant energy waste. By employing tools for identifying how resources are being utilized, informed decisions can be made on which servers are underutilized and can be consolidated into a fewer number of supported systems. Unused systems can then be retired or redeployed to prevent the purchase of new equipment. Clearly, fewer servers translate into lower power consumption and infrastructure costs. Virtualization is a particularly powerful method for achieving consolidation. By utilizing a large, energy efficient central server – such as a blade server or mainframes – multiple virtual servers can be created to replace energy wasteful physical systems. Grid computing can also be utilized to consolidate systems by ensuring unused processing time from existing systems is reallocated. The emergence of cloud-based infrastructures, both public and private, has provided further opportunities by leveraging these technologies for consolidating resources across multiple enterprises and business units.

Investing in energy efficient hardware solutions can also provide appreciable savings. As mentioned, blade servers and mainframes are particularly designed for energy efficiency with load balancing and hardware-level energy controls. Servers can similarly benefit from intelligent chip sets that allow CPU power throttling to reduce power consumption during periods of low activity. Energy Star-approved equipment should be invested in for all required IT components – including servers, network devices, and storage systems – to ensure power supplies are at least 80% efficient in converting wall current. Also, real-time monitoring of power consumption can provide crucial information for determining which IT components are most wasteful and can help justify investment in more efficient equipment.

Thermal management should also be performed to ensure environmental units are most effective and power efficient. This involves identifying and eliminating "hot spots" and ensuring proper airflow in the data center to ensure cooling units are not over-compensating for heat generated by only a small number of systems. Additionally, power and cooling infrastructure components can often be oversized to meet maximum data center usage requirements rather than actual need, resulting in excessive and unnecessary energy loss.

Data centers typically require a variety of approaches to achieve significant energy consumption reduction. Determining which will provide the greatest value (i.e., power reduction versus implementation costs) requires a holistic approach to environment data collection to identify system power consumption, server utilization, and thermal conditions.

Mitigating Barriers to Success with Green Governance

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Despite the clear financial gains and other value that can be attained from implementing an energy efficient initiative, many organizations are challenged getting the program off the ground. Lack of time to diagnose the infrastructure and implement changes can often lead to insufficient executive commitment out of fear of business performance impacts.

This is where automated tools best practices become critical in simplifying the process and enabling the development of effective solutions.

For larger enterprises, traditional organizational structures create additional problems. Departments and business teams are typically siloed into separate autonomous units (for example, accounting departments, development teams, testing groups, etc.) and each with its assigned set of IT resources. Similarly, data centers are usually managed by two separate organization types – IT management maintains the technology while facilities operations are responsible for the infrastructure. Neither of these organizations has the ability to institute a power management policy. Typically, IT management has no control or responsibility over power consumption and facilities operations have no access to the technology. To achieve power goals, energy efficiency initiatives must have executive authority above these siloed groups to ensure they all work together. Organizations that have achieved the greatest success have done so through the creation of green or energy governance bodies that can drive results in these two organizations. Similar to a change advisory board, these governance bodies provide an approval process of all departments affected by the implementation of power management changes and then evaluate any new IT deployments to ensure they meet business energy consumption policies. With this type of policy implemented, an organization could go to the next level and implement charge-back programs which hold each department responsible for the power they consume.

Understanding Power Requirements

Even with the executive clout and commitment to implementing a power management initiative, many organizations are confused as to where to begin. The first critical step is to establish a deep understanding of the environment so that informed decisions can be made on which energy reduction solutions to implement. Utilizing quality monitoring tools will provide a holistic view of the entire infrastructure by collecting granular environmental information from a variety of sources, including: intelligent chip sets, power distribution units, and general product specifications. To be effective, this information should be comprehensive in scope and detailed at the individual IT component level. The data collection should also be performed continuously and in real time to identify on-going power utilization (i.e., to identify energy spikes and other environmental changes) rather than just a one-time snapshot. By analyzing this collected data, actual energy consumption and total carbon footprint statistics can be compiled to help determine where the greatest opportunities for energy reductions can be found and to track improvements after solutions have been implemented. For instance, real-time measurements and historical reporting on data center environmental conditions can identify optimal sizing configurations for electrical and cooling components. Another critical piece is the understanding of how assets are being utilized. A particular server may consume a great deal of power, but if it is a high-profile system supporting critical business requirements, that expense may be justified. Real-time monitoring of both power and system utilization will also identify system workloads that can be shifted to non-peak hours when energy costs may be reduced.

Utilizing quality monitoring tools will provide a holistic view of the entire infrastructure by collecting granular environmental information from a variety of sources, including: intelligent chip sets, power distribution units, and general product specifications.

Visual modeling solutions can be used to enhance and simplify the data collection and analysis process. With visual modeling, a graphical representation of IT assets, such as racks in a data center, provides an interface for quickly identifying environment status information such as energy consumption and thermal conditions. The view can either be a real-time representation of the existing implementation or it can model a future configuration to identify any unanticipated problems, such as excessive heat or power draw, before physically deploying new IT assets. Armed with this level of detailed information, the most effective infrastructure changes can be determined to achieve power management goals.

Pragmatic Power Management

Emerson Network Power has developed a prescriptive model called Energy Logic (available for review at http://www.efficientdatacenter.com) that leverages established best practices for identifying prime opportunities for power consumption improvement in data center infrastructures. Designed from data representing expected energy consumption for a typical 5,000 square foot data center, Energy Logic has determined 10 key areas of improvement that can generate dramatic improvements – achieving an estimated 52% reduction in power costs if fully implemented. The 10 principle areas outlined by Energy Logic for focus in power reduction are:

- **Lower Power Processors** – Low voltage versions of popular processor brands have been determined to provide equivalent performance while achieving an estimated 10% reduction in total data center power consumption.
- **High-Efficiency Power Supplies** – The greater the efficiency of a power supply, the less energy is lost in conversion from the wall socket to the IT resource. Replacing common 75% efficiency power supplies with best-of-breed 90% efficiency units all operating at 30% load yielded an 11% total infrastructure power reduction in the model data center. Also, since power supplies are, by default, typically sized by manufacturers to accommodate maximized server configurations (a one-size-fits-all philosophy), it is important to understand actual load requirements prior to purchase so that optimally configured systems are deployed.
- **CPU Throttling** – Data center utilization is not constant. At moments (such as late nights) it can barely be utilized, while at others, resources can spike to maximum capacity. Traditional environments size data center components and power requirements based on expected peak loads, wasting power during the majority of time when the systems are less active. Some of the newer intelligent processors include the built-in ability to "throttle back" processor power during periods of low use, which in the Energy Logic model results in an overall 8% data center power reduction. Independent EMA research supports this conclusion with businesses that have implemented power throttling reporting an average of 21% reduction in power consumption on the systems on which it was utilized.
- **Blade Servers** – Consolidation efforts are most commonly implemented on blade servers, not only because they provide the computing densities necessary to support a number of combined services, but also because they achieve greater efficiencies in power consumption than mainframes or supercomputers. Reduction results will vary greatly with this implementation as it is dependent on density of consolidation and the types of systems being replaced.

- **Server Virtualization** – A key enabler of consolidation and often employed with blade server deployments, virtualization offers additional opportunities to combine common resources, reducing the collective amount of processing, memory, and storage space necessary to support enterprise IT requirements.
- **Higher Voltage AC Power Distribution** – In order to ensure high availability of critical data center resources, most organizations pipe incoming power through a double-conversion UPS, so that in the event of a power loss, no fail-over process is required. These systems, however, can be inefficient in how they deliver if they are designed to convert power to maintain a consistent current. UPS systems that do not convert power can reduce energy loss but need to be carefully considered as they do not fully condition incoming power.
- **Cooling Best Practices** – A key element in minimizing the amount of power necessary to keep data centers appropriately chilled is to ensure uniform temperature is maintained by enabling proper airflow and optimal distribution of equipment. The idea is to prevent the emergence of "hot spots" which often require chillers to operate overtime to reduce the uniform temperature of the data center just to cool one or a few densely packed or poorly vented racks. Computational fluid dynamic (CFD) evaluations should be performed to identify opportunities for efficiency improvement.
- **Variable-Capacity Cooling** – Computer room air conditioners (CRACs) are commonly designed to meet peak load data center cooling requirements, which is often wasteful during periods of low use. Recent advancements in CRAC technology allow for fans to be run at variable speeds to more closely match environment utilization.
- **High-density Supplemental Cooling** – Although blade servers and mainframes are able to operate more efficiently than multiple independent servers with equivalent compute capabilities, the sheer density of components generates a great deal of heat. CRAC units alone cannot efficiently handle these hot spots, so supplemental cooling units should be introduced that are dedicated to reducing heat on those particular systems so that ambient data center temperatures are not thrown out of balance.
- **Cooling Monitoring and Optimization** – Cooling control systems can monitor conditions across a data center to ensure all units are working together effectively to prevent environment conflicts.

It should be noted that none of these initiatives need to be an independent implementation. Many improvements can be combined to meet an overall green operations strategy or as part of an unrelated project implementation. For instance, consider an environment that consolidates a large number of critical servers onto a virtualized blade server solution. Each blade can be outfitted with low power processors with throttling enabled and the chassis can be deployed with high-efficiency power supplies. By reducing the number of systems in the data center, cooling costs are reduced and there is less of a requirement for AC power distribution. This same example illustrates how power consumption issues in the data center are interconnected and how reducing one factor at a server level – such as with a consolidation effort – can have a cascading effect that improves other data center components – like reducing cooling requirements. In fact, the Energy Logic model has determined that 1 watt saved at the server component translates into a savings of over 2.84 watts in power and cooling.

Automated Tools for Success

As we've seen, achieving power reduction goals requires a variety of management techniques including data collection, monitoring, automation, and modeling. All of these rely on software-based solutions for accuracy and prompt utilization. Although many point products are available that target specific pieces of these requirements, EMA recommends an integrated solution suite for consistency and breadth of functionality. Critical elements to look for in a power management solution suite include:

- **Intuitiveness** – Interface should be easy to use and understand with a common look and feel across the toolsets. This facilitates quick status identification and simplifies training.
- **Accuracy** – Detailed, real-time data collection, metrics, and reporting. This is critical to performing regulatory compliance, charge-back programs, and white certificate commodity trading.
- **Centralization** – A single holistic view should be provided for the entire IT infrastructure eliminating "swivel-chair-management" challenges of utilizing multiple interfaces.
- **Integration** – Internal functionality should be fully integrated and allow data gathering from a variety of external third-party data collection points.

As an example, Avocent (a subsidiary of Emerson) offers the DSView® 3 management software designed to identify and monitor power utilization across an entire data center. With pre-built integration into a wide array of data center components, DSView 3 Power Manager identifies the actual power consumption of a server, rack, row of racks or an entire data center so that informed decisions can be made on how much power savings is required to meet availability. With live data collected from devices such as power distribution units, real-time and historical reports can be generated to reveal actual power consumption of individual components or the data center as a whole. With this data, governance bodies and decision makers can make informed decisions on which power reduction techniques to implement – for example, by identifying server prospects for consolidation. Detailed power consumption data can also be used to facilitate a charge-back program by identifying how much electricity was consumed by each independent department. Regulatory compliance and green certificate generation goals are similarly achieved.

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DSView 3 management software is also directly integrated with Avocent's visual modeling solution, MergePoint® Infrastructure Explorer software. Through the provided visual representation of a physical infrastructure, enterprises can holistically view power consumption data at the component, rack or data center level. Thermal indicators are also provided so that hot spots can easily be identified and corrected, and the theoretical modeling capabilities allow for effective power capacity planning to occur before hardware is physically installed. When utilized collectively, Avocent's two key power management software solutions – DSView 3 management software and MergePoint Infrastructure Explorer software – provide the energy-monitoring, automation, and detailed reporting functionality necessary to achieve the holistic and pragmatic best practice implementation steps identified in Emerson's Energy Logic program.

EMA Perspective

EMA primary research has indicated that, on average, enterprises which have implemented energy efficiency initiatives have seen a 19% reduction in total IT power consumption. Although for many businesses with large IT infrastructures and costly monthly electric bills a 19% reduction may seem to provide sufficient justification for the introduction of a green initiative, this figure does not represent the greater value that could be achieved if a holistic set of power management techniques was implemented. EMA survey results have identified several businesses that have achieved greater than 60% power reduction, and a few organizations have publicly announced gaining as much as 80% greater efficiency. Of course, not all businesses can be expected to achieve this level of success, but it is clear that higher returns are attainable if holistic methods of energy monitoring and management are applied.

Both efficient hardware and energy-focused systems management software solutions need be introduced to maximize data center power reductions. EMA recommends all organizations seeking to introduce power management solutions review the holistic best practices identified in Emerson's Energy Logic and invest in solutions, such as those provided by Avocent, in order to implement energy reduction initiatives across the data center.

About Emerson Network Power and Avocent

Emerson Network Power, a business of Emerson (NYSE:EMR), is the global leader in enabling Business-Critical Continuity™ from grid to chip for telecommunication networks, data centers, health care, and industrial facilities. Emerson Network Power provides innovative solutions and expertise in areas including AC and DC power and precision cooling systems, embedded computing and power, integrated racks and enclosures, power switching and controls, monitoring, and connectivity. All solutions are supported globally by local Emerson Network Power service technicians. Learn more about Emerson Network Power products and services at www.emersonnetworkpower.com.

Avocent (a wholly owned subsidiary of Emerson) delivers IT infrastructure management solutions that reduce operating costs for IT environments via integrated, centralized in-band and out-of-band hardware and software. Additional information is available at www.avocent.com.

About Enterprise Management Associates, Inc.

Founded in 1996, Enterprise Management Associates (EMA) is a leading industry analyst firm that specializes in going "beyond the surface" to provide deep insight across the full spectrum of IT management technologies. EMA analysts leverage a unique combination of practical experience, insight into industry best practices, and in-depth knowledge of current and planned vendor solutions to help its clients achieve their goals. Learn more about EMA research, analysis, and consulting services for enterprise IT professionals and IT vendors at www.enterprisemanagement.com or follow EMA on Twitter.

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