Understanding the Challenges of Delivering Cost-Effective, High-Efficiency Power Supplies

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It's no small matter. Power supplies can account for as much as one-fifth of the wasted power in data center servers. By emphasizing energy-efficient power supply design, Dell is addressing a key factor that can help reduce overall power and cooling requirements and contribute to lower total cost of ownership.

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Rising power and cooling costs have made energy efficiency a strategic concern for data center managers. To help organizations lower total cost of ownership (TCO) and create a strategy for continuing growth, Dell is addressing energy efficiency at every level—from component and server design to the overall data center infrastructure. This article explains how and why Dell is setting its sights on the redesign of the power supply as a key contributing factor to energy efficiency in the data center.

Although data center managers have the flexibility to choose many different system components to strike the most advantageous balance of performance and energy efficiency, power supply options have been limited. Common industry practice is to provide a single power supply design to cover the full range of system configurations and loads for a given server model. For years, cost-effectiveness has driven power supply design considerations, and energy efficiency has been a secondary concern.

In an ongoing effort to optimize energy usage in the data center, Dell has identified power supplies along with fans, processors, and memory as the components that typically consume the most energy within a server. A Dell power usage study in summer 2006 revealed that 20 percent of power loss in a typical data center server can be attributed to inefficient power supplies.[1] Clearly, improving power supply efficiency offers a significant opportunity to help lower energy costs for data center servers.

Dell has made it a priority to reduce power loss and improve energy efficiency in power supplies. Dell is working with key power supply manufacturers such as Artesyn Technologies, Delta Electronics, and Astec Power to help improve power supply designs and move power supply technology forward.

Understanding power supply specifications

When systems engineers specify the power supply requirements for an enterprise-class server, their approach is similar to that of a civil engineer designing a tunnel. Even though most traffic passing through the tunnel may be cars, the tunnel must be able to accommodate the largest trucks on the road. Likewise, common industry practice has been to specify a single power supply for each server based on maximum system configuration and load requirements.

Theoretically, systems engineers could utilize a different power supply for each server configuration, but designing to multiple power supply specifications could be cost-prohibitive. Instead, manufacturers typically purchase high volumes of a single power supply design to reduce cost and pass that component savings on to the customer.

When it comes to power supply design, balancing cost, performance, and efficiency is an ongoing challenge. Dell

[1] For more information, see "Data Center Efficiency in the Scalable Enterprise," by John Pflueger, Ph.D., and Sharon Hanson, in *Dell Power Solutions*, February 2007, www.dell.com/downloads/global/power/ps1q07-20070210-CoverStory.pdf.

continually weighs the need for improved energy efficiency against increasing cost. In addition to cost and energy efficiency considerations, Dell is committed to offering the most flexible server configurations possible.

Given current power supply design guidelines, the goal for systems engineers is to specify a single maximum power supply output rating that can handle a wide variety of configuration options and load requirements. For example, a Dell™ PowerEdge™ 2950 server can be configured in such a way that processor, memory, and hard disk power needs vary by as much as 480 W (see Figure 1). (Other configuration options—such as I/O adapters, internal storage controllers, and tape backup—can further widen the load requirements.) Although the minimum server component configuration in this example may draw as little as 60 W and the maximum server configuration may draw as much as 540 W, today's industry practice is to specify one power supply for both configurations.

	Minimum configuration		Maximum configuration	
	PowerEdge 2950 server component	Power draw	PowerEdge 2950 server component	Power draw
Processor	One dual-core Intel® Xeon® 5148 processor at 2.33 GHz	40 W	Two dual-core Intel Xeon 5080 processors at 3.73 GHz	260 W
Memory	Two 256 MB dual in-line memory modules (DIMMs) at 533 MHz	20 W	Eight 8 GB DIMMs at 667 MHz	120 W
Hard disk drives	None	0	Eight Serial Attached SCSI (SAS) drives at 15,000 rpm	160 W
Total		**60 W**		**540 W**

Figure 1. *Illustrative budgetary power requirements for Dell PowerEdge 2950 server component minimum and maximum configurations*

Comparing power supply output ratings

Even taking into account different component suppliers, system configurations, and design principles, published output data specifications indicate that maximum power supply ratings are fairly uniform across the industry. Figure 2 lists the published power supply output ratings of comparable enterprise-class servers—noting processor, memory type, chassis size, and whether they support redundant power supplies.

Each server manufacturer must support a wide range of configuration options, making the improvement of power supply efficiency an industry-wide challenge. However, careful choice of configuration flexibility and overall power supply output can drive significant distinctions in energy efficiency even though different manufacturers may incorporate similar power supply components.

Aligning design specifications with energy efficiency

Meeting the power requirements of a flexible, configurable enterprise-class server while improving energy efficiency requires a fundamental shift in power supply design specifications. Tackling this challenge—a challenge shared by all vendors in the industry—necessitates examining the causes of inefficiency in today's power supply designs.

When it comes to efficiency, a power supply may be likened to an internal combustion engine. Like an idling car burning fuel at a stoplight, a power supply uses some energy just to operate. And similar to automobiles cruising at highway speeds, power supplies typically exhibit top efficiency as they do more work. Still, this does not indicate that a power supply becomes more efficient at higher loads. Rather, the energy

Server model	Processor	Memory type	Chassis size	Support for redundant power supplies	Power supply output rating
Dell PowerEdge 1950	Intel Xeon	667 MHz fully buffered DIMM (FBD)	1U	Yes	670 W
HP ProLiant DL360 G5[a]	Intel Xeon	667 MHz FBD	1U	Yes	700 W
Intel Server Chassis SR1550[b]	Intel Xeon	667 MHz FBD	1U	Yes	650 W
IBM System x3455[c]	AMD Opteron 2000 series	667 MHz double data rate 2 (DDR2)	1U	No	650 W
IBM System x3550[d]	Intel Xeon	667 MHz FBD	1U	Yes	670 W
Dell PowerEdge 2950	Intel Xeon	667 MHz FBD	2U	Yes	750 W
HP ProLiant DL380 G5[e]	Intel Xeon	667 MHz FBD	2U	Yes	800 W
IBM System x3650[f]	Intel Xeon	667 MHz FBD	2U	Yes	835 W
IBM System x3655[g]	AMD Opteron 2000 series	667 MHz DDR2	2U	Yes	835 W

[a] h10010.www1.hp.com/wwpc/pscmisc/vac/us/en/ss/proliant/dl360g5-models.html
[b] www.intel.com/design/servers/chassis/sr1550/index.htm
[c] www-03.ibm.com/systems/x/rack/x3455/specs.html
[d] www-03.ibm.com/systems/x/rack/x3550/specs.html
[e] h10010.www1.hp.com/wwpc/pscmisc/vac/us/en/ss/proliant/dl380g5-models.html
[f] www-03.ibm.com/systems/x/rack/x3650/specs.html
[g] www-03.ibm.com/systems/x/rack/x3655/specs.html

Figure 2. *Maximum power supply output ratings for enterprise-class servers comparable to Dell PowerEdge 1950 and PowerEdge 2950 servers (as of January 1, 2007)*

losses become a smaller percentage of the total power being consumed, and it is this change in the energy consumption–to–energy loss ratio that results in higher efficiency. In other words, when a power supply is operating below peak loads—a state that might describe a minimally configured server or a server at idle—energy losses account for a greater percentage of the total energy being consumed, which results in a corresponding drop in efficiency. The "Redundancy Penalty: Availability Versus Energy Usage" sidebar in this article illustrates a common power supply efficiency curve, and explains how energy losses can be compounded by the use of redundant power supplies.

Hybrid vehicle technology may have solved the idling inefficiency dilemma in automobiles, but a different approach is needed to improve power supply efficiency. Because peak loads are not typical for every server deployed, design engineers are working toward improvements in energy efficiency throughout the power supply output range. To that end, Dell is working with power supply manufacturers to take the necessary steps to improve power supply efficiency. For example, changes in component materials and circuit design can help control power losses, as can low-resistance transistors or transistors operating in parallel. Alternatively, power supply designers can adopt new technologies that inherently offer higher efficiency than current practices.

Dell is working toward a goal of achieving over 80 percent efficiency throughout the power supply output range to help minimize energy loss regardless of server configuration or workload. Technology is available to accomplish this goal, but it is rare that advances in efficiency come without additional cost. More expensive circuit materials increase up-front power supply expenses. But with energy costs climbing, a growing number of organizations may view the investment in energy efficiency to be a worthwhile one. In many cases, long-term energy cost savings may offset the incremental up-front cost of energy-efficient components.

Benefiting from power efficiency in the data center and beyond

Optimizing power supply efficiencies throughout load ranges with effective designs and materials can help minimize power loss in data center servers and contribute to reduced power and cooling requirements in the data center as a whole, particularly in server farms and other dense computing environments. By minimizing power loss, energy-efficient power

REDUNDANCY PENALTY: AVAILABILITY VERSUS ENERGY USAGE

Configuring servers with redundant power supplies is common practice throughout data centers. Utilizing both power supplies helps ensure that a server can continue running if one power supply fails, or if the AC power to one of the supplies is lost (many large data centers provide dual redundant AC power delivery grids). Redundant power supplies are a characteristic element of highly available data center systems in particular.

However, this enhanced availability comes at the expense of an energy usage penalty associated with redundant power supplies. Because power supplies are inherently less efficient at lower loads, sharing loads across two power supplies reduces overall energy efficiency. For example, in a 200 W configuration, a single power supply rated at 800 W might carry the entire 200 W load, or 25 percent of its capacity. If a second power supply is added, the original 200 W load is distributed to two 800 W power supplies providing 100 W each. That means the power supplies in the redundant configuration are running at 12.5 percent of capacity. As shown in Figure A, that drops the efficiency from 83 percent for a 25 percent load to less than 65 percent for a 12.5 percent load.

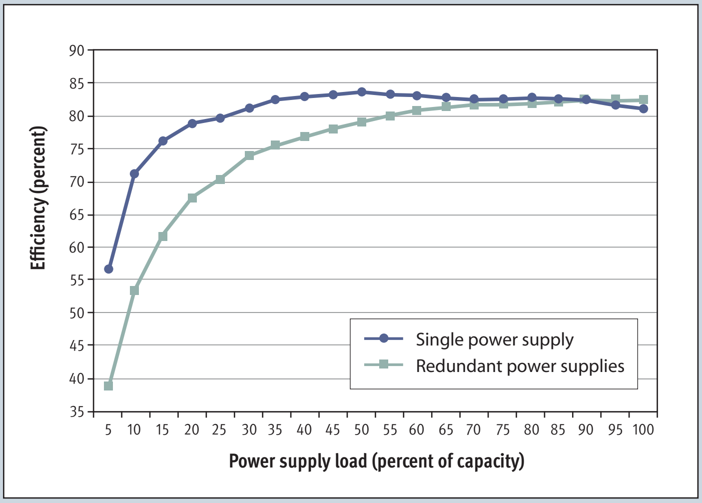

Figure A. *Energy efficiency of power supplies in single and redundant configurations*

The efficiency curve in Figure A is based on power supply evaluation testing performed by Dell engineers in May 2006, and is representative of current-generation redundant power supply design characteristics. Actual power supply efficiencies will vary, but the penalty for redundancy is relatively consistent across current designs.

Although high availability may trump efficiency for many data center managers, organizations that are interested in reducing energy costs should carefully consider availability requirements, or employ alternative high-availability methods, before uniformly configuring servers with redundant power supplies.

supplies can help reduce energy costs and contribute to lower TCO in the data center.

Today, many Dell products and services are available to help organizations improve efficiency throughout the data center life cycle. For example, the Dell Datacenter Capacity Planner is available online at www.dell.com/calc. This tool can help data center managers configure servers, storage, and peripherals in a drag-and-drop manner to produce reports that estimate power and cooling needs for various data center configurations.

While the Capacity Planner helps data center managers get a view of the big power and cooling picture, Dell is concerning itself with optimizing energy efficiency at every level of the data center. Energy efficiency in power supply design is one of the many facets of building an energy-conscious data center that is reliable, scalable, and highly available.

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