BEST PRACTICES FOR INCREASING DATA CENTER ENERGY EFFICIENCY

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Increasing data center energy efficiency is not only an environmentally friendly strategy, but also a key way to cut costs. By consolidating systems using virtualization and Dell™ PowerEdge™ Energy Smart servers, organizations can retire legacy hardware to help significantly reduce power and cooling requirements and create a green data center.

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Data centers are one of the most financially concentrated assets of any organization, and holistically assessing their true total cost of ownership can be difficult. In the past, facilities staff and IT staff have treated their operational costs separately, spreading overall costs across these organizations and making it difficult to assess their full impact. Meanwhile, each department faces its own separate challenges—with facilities staff struggling with limits on rack and floor space, power availability, and equipment, while IT staff try to ensure they have sufficient processing power, network bandwidth, and storage capacity to support upcoming IT initiatives and sufficient redundancy to handle system disruptions.

However, the rising costs of power and cooling combined with high-performance, high-density systems are changing the economics of IT, driving enterprises to optimize their data centers with green technology. The cost savings and environmental benefits of this approach are closely aligned, and maximizing them requires a partnership between managers in the business, facilities, and IT departments (see Figure 1).

Optimizing data center energy efficiency requires careful planning and the deployment of components such as power, cooling, and networking systems that can meet both current needs and scale for future requirements while minimizing total cost of ownership. When data centers reach 85–95 percent of their power, cooling, space, and network capacity, organizations must seriously consider either expanding their existing data center or building a new one—a difficult decision that can have a major impact on the bottom line.

Green strategies show how best practices for capacity expansion can increase the energy efficiency of a data center to help increase density, reduce costs, and extend the life expectancy of existing data centers. This article outlines specific steps organizations can take to develop an integrated, comprehensive green strategy for existing data centers, helping optimize investments and ensure reliable performance now as well as the flexibility to scale to meet future business and IT needs.

MONITORING CURRENT ENERGY USAGE

In a green data center, the mechanical, electrical, and spatial elements (facilities) as well as servers, storage, and networks (IT) are designed for optimal energy efficiency and minimal environmental impact. The first step in energy-efficiency planning is measuring current energy usage. The power system is a critical element in the facilities infrastructure, and knowing where that energy is used and by which specific equipment is essential when creating, expanding, or optimizing a data center (see Figure 2).

DELL VIRTUALIZATION SERVICES

Dell Services has created a consistent framework and best practices to assist organizations in implementing a virtualized infrastructure (see Figure A):

- Dell Services provides a flexible, tested process for data center efficiency and virtualization, matched to current user needs and future demands.
- An experienced services team helps organizations make informed decisions throughout the process by working to understand their needs. This team has best practices and tools to support the organization from strategy formulation and benchmarking to the road map for implementation.

For more information on Dell Virtualization Services, visit DELL.COM/VirtualizationServices.

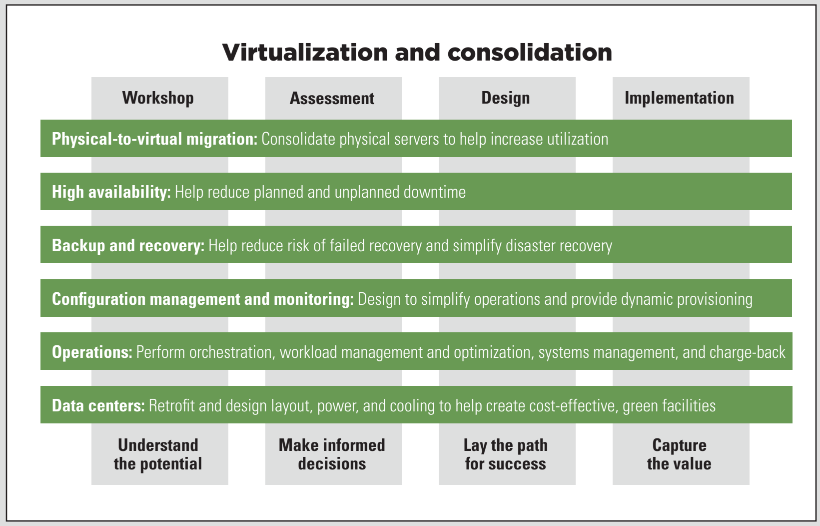

Figure A. *Virtualization and consolidation framework used by Dell Services*

A key part of this step is calculating the data center's Power Usage Effectiveness (PUE), defined by the following equation:

$$\text{PUE} = \frac{\text{Total facility power}}{\text{IT equipment power}}$$

In this equation, the total facility power is the energy used by the data center as whole, while IT equipment power consists of energy used specifically by servers, storage, networking switches, and other IT components (not including external power delivery systems, cooling systems, lighting, and so on). A PUE of 1 would represent theoretically perfect efficiency, in which all energy was used directly by IT equipment. Knowing the PUE value is useful in several ways. For example, it allows enterprises to determine how much power the data center actually uses for a given piece of equipment: in a data center with a PUE of 3.0, supporting a 600 W server actually requires the delivery of 1,800 W to the data center as a whole.

Unfortunately, many organizations lack power-consumption metering that can break down usage at a level that allows them to gauge the results of their optimization efforts. For example, because typically only facilities departments see a monthly power bill that includes energy use in data centers and offices, IT departments never see the impact of their decisions, and so have little incentive to increase efficiency.

To help alleviate this problem, efforts to monitor energy use should start with the creation of a "power profile" for each rack in the existing data center. This profile should meter usage from the data center level all the way down to individual components—such as generators, uninterruptible power supplies (UPSs), power distribution units (PDUs), generators, servers, storage, and networking switches—to help ensure that they are within acceptable limits, identify which business units are charged for the power used by those components, and establish

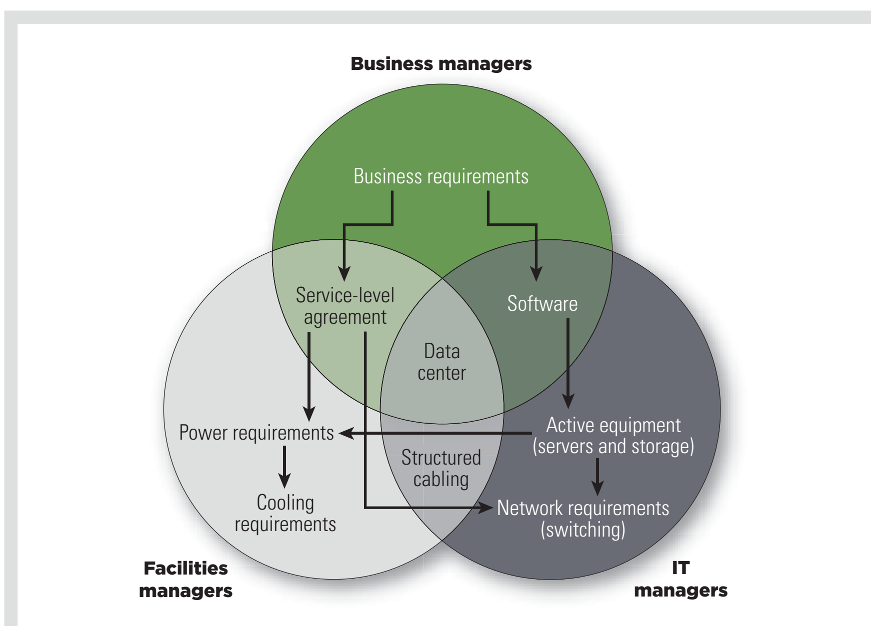

Figure 1. *Typical relationships between managers in business, facilities, and IT departments*

UNLOCKING HIDDEN DATA CENTER CAPACITY THROUGH VIRTUALIZATION AND FACILITY UPGRADES

Many data centers built 10–15 years ago are underpowered and lack the cooling capacity to fully support today's high-performance, high-density servers. But despite their insufficient energy and cooling infrastructure, they are still usable, and already represent a significant investment. By evaluating the existing infrastructure and using tools such as virtualization, organizations can often find additional capacity to bridge the gap between IT load and facility constraints such as power, cooling, and space. This section describes a virtualization and facility upgrade project performed by Dell Services in summer 2007 and identifies how virtualization and energy-efficient servers helped reduce power consumption and operational costs. The results described serve as an example; the results of similar refreshes and upgrades in other data centers will vary for different environments and configurations.

Figure A shows this example data center layout, which encompassed 17,500 square feet of space and 1,862 servers on 386 racks. This data center had not followed best practices for hardware deployment, electrical and cooling distribution, and layout planning and management, and was struggling with space, electrical, and cooling challenges.

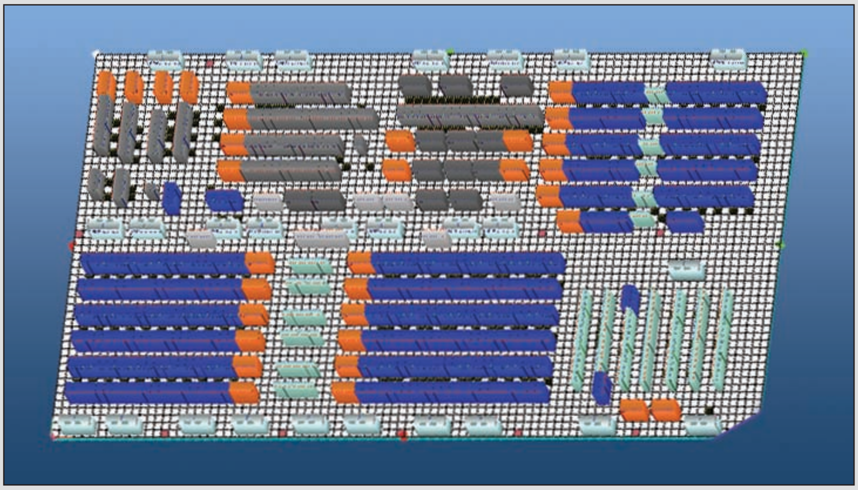

Figure A. *Original data center layout*

ASSESSING THE INFRASTRUCTURE

The first step was to perform asset discovery and determine the data center's resource utilization to help identify whether consolidation and/or virtualization could help increase the efficiency of existing resources. When performing this type of assessment, organizations should first gather up-to-date information about the current server environment, including hardware and software inventory and up to a business cycle's worth of performance data. They can then use that information to help analyze the data, assess the environment, and outline the consolidation, decommissioning, and virtualization opportunities available in the existing infrastructure.

The second step was to create a power and cooling profile (including the level of supply and the amount used by the facility as a whole and IT resources in particular) for each rack in the existing data center, which allowed Dell Services to estimate the potential future growth and IT expansion requirements. This information also provides a baseline that can help determine whether to retrofit an existing data center or build a new one.

Of the servers in this example data center, 22 percent were more than five years old, 56 percent were three or four years old, and 22 percent were two years old or less. Each rack utilized 17U of space on average. The IT equipment required a total of 1,061 kVA of electrical capacity and a total of 242 tons of cooling. As a whole, the Power Usage Effectiveness (PUE) of this data center was 3.5. Its operation required US$1.2 million in annual energy costs.

In terms of cooling, cold air was supplied by 24 Liebert 22-ton air-cooled down-flow units, which produced a total of 528 tons of air-conditioning, leaving 286 tons of cooling capacity available above the 242 tons required by the IT equipment. In terms of electrical capacity, the electrical capacity requirements were supported by four Liebert 750 kVA uninterruptible power supplies (UPSs) in an $n + 1$ high-availability configuration, which provided a total of 2,250 kVA of electrical capacity, leaving 1,189 kVA of UPS capacity available above the 1,061 kVA required by the IT equipment. These UPSs used the $n + 1$ load-sharing configuration so that if one UPS failed, the others could carry its load until it could be replaced.

This electrical capacity was also supported by 32 Liebert power distribution units (PDUs) in a $2n$ high-availability configuration, which provided a total rating of 1,620 kVA. These PDUs used the $2n$ load-sharing configuration so that if one PDU failed, the others could carry its load until it could be replaced. This redundancy allowed the data center to operate even with only 40 percent of the PDUs functioning, for a capacity of 1,620 kVA.

IMPLEMENTING VIRTUALIZATION, ENERGY-EFFICIENT SERVERS, AND RETROFIT

As a result of performing a Virtualization Readiness Assessment of the servers, the Dell Services team identified 70 percent of those more than three years old as candidates for virtualization or replacement. After virtualizing these systems and replacing others with Dell PowerEdge Energy Smart servers, the data center cut its total number of servers by more than 50 percent, going from 1,862 servers to

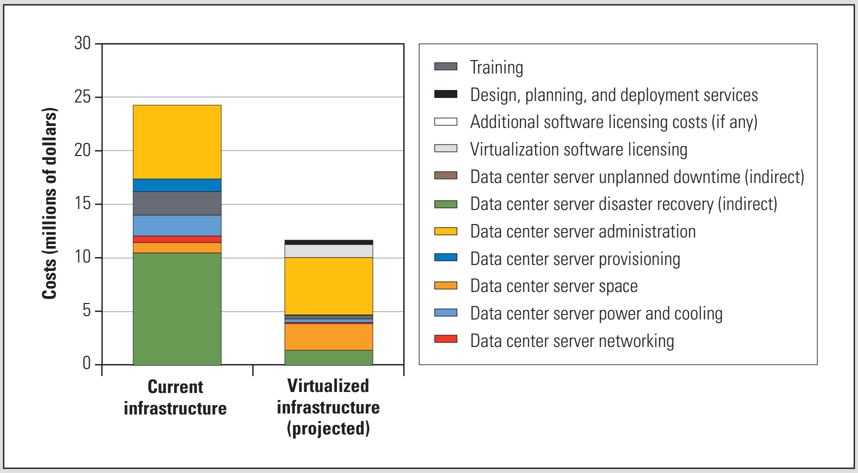

Figure B. *Three-year total cost of ownership projection for current and virtualized infrastructure*

926: 104 virtualized servers supporting 10 virtual machines each, 403 PowerEdge Energy Smart servers, and 419 servers that could be retained because they were two years old or less.

Reducing the number of servers helped reduce total power consumption by 250 kW. Other infrastructure modifications—including adding PDUs, upgrading circuits from 110 V circuits to three-phase 208 V circuits, and optimizing cooling systems—helped support a density of 4.0 kW per rack, a significant increase over the previous 2.2 kW per rack, potentially doubling the capacity of the original data center and helping avoid the cost of building another data center to support future IT growth.

EVALUATING TOTAL COST OF OWNERSHIP

Based on the IT refresh and upgrade described in the preceding section, Dell Services calculated an estimated three-year total cost-of-ownership comparison between the previous environment and the upgraded environment (see Figure B). The projected benefits included the following:

- Reducing 1,040 servers to 104 through virtualization, with a target consolidation ratio of 10 to 1
- With the reduction in overall number of servers, reducing total operating power by 7,665,000 kW (2,190,000 kW multiplied by the PUE of 3.5) per year; combined, these enhancements could help reduce total energy costs to US$750,000 annually, saving US$450,000 each year and reducing carbon emissions by 11,497,500 pounds, equivalent to taking 730 cars off the road per year
- Achieving a return on investment of 200 percent from an investment of US$11,767,987 in a virtual infrastructure and retrofit facility upgrade, with projected direct savings of US$11,534,602
- Avoiding the approximate US$22,000,000 cost of building a new 17,000-square-foot data center (at approximately US$1,300 per square foot)

a baseline for calculating return on investment from future changes (see Figure 3).

RETIRING IDLE SERVERS

In many data centers, between 5 and 15 percent of servers are no longer required and could be turned off. The cost savings from retiring these idle servers can add up quickly. For example, given an energy price of US$0.10/kWh and an average idle-server power consumption of 0.25 kWh, each idle server uses US$219 worth of energy each year. When factoring in an example PUE of 3.0 to take into account total data center energy usage in support of those servers, however, each idle server actually costs US$657 annually.

Maintaining an asset management database can help enterprises ensure that they are using resources efficiently. This database should contain accurate, up-to-date information on server configuration and location, enabling IT staff to easily identify variables of power, cooling, and available rack space when planning future server and storage deployments and identifying potential systems to retire.

DEPLOYING ENERGY-EFFICIENT VIRTUALIZED SERVERS

Once they have removed idle servers, data center managers should consider moving as many server-based applications as they can onto virtual machines (VMs) and/or

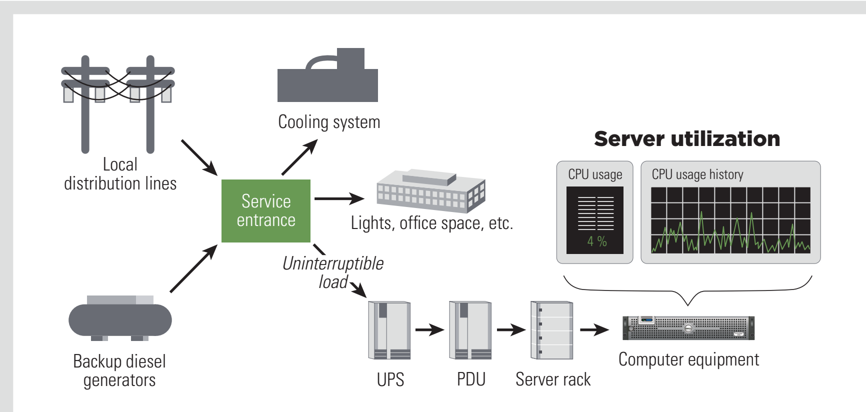

Figure 2. *Facilities and IT components that contribute to energy usage*

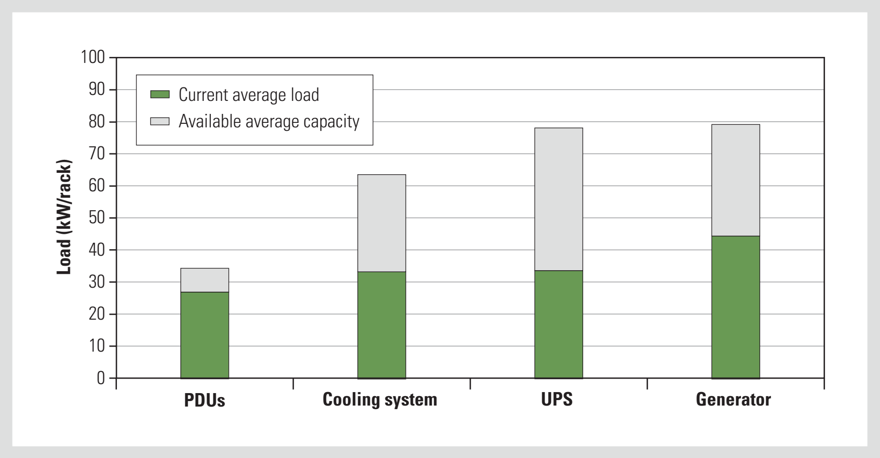

Figure 3. *Example comparison of average load density with available capacity*

energy-efficient servers. This strategy allows them to not only substantially reduce the overall number of physical servers, but also increase the efficiency and utilization of those that remain.

In the past, IT organizations have tended to host a single application per server. Given the cost-effectiveness of many industry-standard servers, this strategy helped simplify deployment and reduce potential software conflicts without requiring undue investments in hardware and support infrastructure. But server numbers have increased worldwide in the past decade, and so have the costs associated with maintaining these systems.

For example, a 2007 U.S. Environmental Protection Agency report assessed opportunities for energy-efficiency improvements for government and commercial servers and data centers in the United States. The report estimated that U.S. data centers accounted for approximately 1.5 percent of the country's electricity consumption in 2006, and that energy consumption of servers and data centers has doubled in the past five years—and predicts that it will almost double again in the next five years, to more than 100 billion kWh, costing about US$7.4 billion annually.[1] An increase in the number of servers accounts for 90 percent of the additional power consumption, according to a study by Jonathan Koomey of Lawrence Berkeley National Laboratory and Stanford University.[2]

However, average server performance has also increased: today's servers are more powerful than those of a decade ago, and virtualization enables enterprises to take advantage of that performance to consolidate multiple physical servers onto a single virtualized server—helping increase utilization and reduce power consumption. Most non-virtualized servers today, for example, typically run at a utilization level of less than 15 percent. By efficiently utilizing computing capacity through virtualization, Dell PowerEdge Energy Smart servers, and the retirement of legacy systems, enterprises can maintain performance with 40–50 percent of their existing server population, which can translate into major savings in energy use and related costs. Dell Services offers virtualization workshop, assessment, design, and implementation services to help enterprises carry out a migration to a virtualized infrastructure.[3]

For more information on how Dell Virtualization Services can help organizations implement a virtualized infrastructure, see the "Dell Virtualization Services" sidebar in this article; for a specific example of how IT and facility upgrades can help reduce power consumption and total cost of ownership, see the "Unlocking hidden data center capacity through virtualization and facility upgrades" sidebar in this article.

DESIGNING A GREEN DATA CENTER WITH DELL

As energy costs continue to rise, aligning the goals and requirements of business, facilities, and IT departments is critical to optimizing energy use and reducing power costs in enterprise data centers. Following the strategies outlined in this article—including monitoring current energy usage, retiring idle servers, and deploying energy-efficient virtualized servers—and taking advantage of Dell Services assessment, design, and implementation services can help enterprises take a major step toward the realization of the green data center.

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Tim Webb is the director of Dell Global Virtualization and Data Center Optimization Consulting Practice. He has a degree in Engineering from Princeton University.

[1] "Report to Congress on Server and Data Center Energy Efficiency: Public Law 109-431," by the U.S. Environmental Protection Agency, August 2, 2007, www.energystar.gov/ia/partners/prod_development/downloads/EPA_Datacenter_Report_Congress_Final1.pdf.

[2] "Estimating Total Power Consumption by Servers in the U.S. and the World," by Jonathan G. Koomey, Ph.D., Lawrence Berkeley National Laboratory and Stanford University, February 15, 2007, enterprise.amd.com/downloads/svrpwrusecompletefinal.pdf.

[3] For more information, see "Achieving Balance-Sheet Business Value with Virtualized Server Solutions," in *Dell Power Solutions*, August 2007, DELL.COM/Downloads/Global/Power/ps3q07-50070497-DellSvcs.pdf.