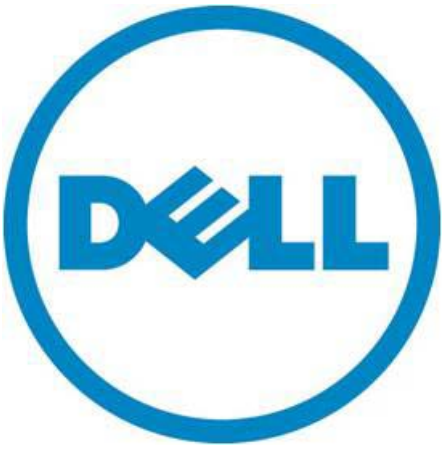
Power Protection for Virtualized IT Applications: High-Efficiency UPSs for Virtualized Environments

A Dell Technical White Paper



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Abstract

Virtualization brings the potential to deliver dramatic savings in terms of server count, footprint, power consumption and cooling requirements for datacenters. For all its advantages though, virtualization also brings some unique challenges:

- Overall power consumption is lower, but it is highly variable.
- Fewer servers are required, but each one is more critical than ever.
- Applications can be reallocated dynamically at will, but the power system cannot do the same.
- Datacenter footprint is smaller, but overall efficiency may still be suboptimal.

The power protection infrastructure—which may have been quite sufficient for pre-virtualization needs—could easily become inadequate when IT performance patterns are radically altered.

The good news is that there are practical and affordable ways to address these challenges and improve energy efficiency in the process. This paper answers some of the most pressing questions about new power demands and how the latest UPS technologies can help.

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Introduction

Virtualization enables partitioning, whereby a single physical server runs multiple virtual machines, each with its own independent and secure application and operating system. Instead of provisioning a single, physical server with enough spare (often idle) capacity to support the peak load of a single application, you can now dynamically match available processor power to meet the variable demands of applications. The same work gets done, but there's far less idle capacity.

Idle server capacity is costly and unproductive. A server still consumes 60–70 percent of its total power requirements even when idle, and a typical IT environment may have 80–90 percent of its server capacity underutilized in some instances. This inefficient use of resources can typically result in 20–50 percent higher spending on power and cooling than is necessary for the work performed.

Consider a typical business running 240 applications, one application per server, each server operating at about 10 to 15 percent CPU utilization. In a typical scenario, about 200 or more of these applications would be candidates for virtualization, at an average rate of four applications per server. Those 200 applications could then be consolidated onto 52 physical servers in a virtualized environment and 30 conventional servers, for a total of 82 hardware boxes. The savings can be dramatic.

A study commissioned based on the experiences of five representative Dell customers showed that virtualization projects can pay for themselves in a year and deliver yet another 124 percent return on the original investment within three years (*The Total Economic Impact™ of Dell's Server Virtualization Solutions*, Forrester Research, February 2009). In the case example created for the study, virtualization removed 141 servers from the equation, saving nearly $700 per server each year in power and cooling costs—$98,700 in energy savings in the third year of the phased-in project.

The power challenges of virtualization

For all its advantages in energy savings, virtualization presents some unique challenges for the power system:

Overall power consumption of IT systems is lower, but each server draws more power.

Virtualization tends to increase the amount of time a server runs at or near peak performance. On an un-virtualized platform, the average server CPU runs at only 10 to 15 percent of capacity. With virtualization, that figure jumps to about 70 to 80 percent. The higher the CPU utilization, the higher the power consumption per server. For example:

- A Dell™ PowerEdge™ 2970 server with two AMD Opteron™ 2382 four-core processors consumes an average of 141W at 10 percent utilization, 222W at 70 percent utilization, and 249W at 90 percent utilization.
- A Dell PowerEdge 2950 server requires 293W at 20 percent utilization and 358W at 80 percent utilization (Source: *Dell Server Performance Analysis Study*, November 2007)

Furthermore, servers used in virtualization schemes tend to be more power-hungry models to begin with. A virtualized server may take the place of 10 non-virtualized servers, so it is typically configured with multiple processors and requires double the power of a previous-generation counterpart in a non-virtualized environment.

Among servers designed for virtualization, Energy Smart Dell PowerEdge 1950, PowerEdge 2950 or PowerEdge 2970 servers are excellent choices, because they can deliver up to 21 percent greater performance per watt over a similarly configured server. (For more information, see the Dell Datacenter Capacity Planner online calculator tool, available at DELL.COM/Energy.)

Each enclosure draws more power than ever.

A traditional configuration spreads out power consumption across many full racks (assuming 12U of storage and networking equipment in each rack). The "after" scenario reduces power consumption overall, but increases power consumption per U and per enclosure.

Traditionally, IT managers could plan for about 60 to 100 watts of power consumption per U of rack space. A full rack of equipment averaged 3 to 4 kW of power. With today's blade servers and VoIP systems, that figure has escalated to 600 to 1000 watts per U, and it is still growing. Power consumption may soon reach up to 40 kW per rack.

There are fewer servers, but each one is more critical than ever.

In virtualized environments, each server supports multiple applications. Organizations can typically fit anywhere from 5 to 20 virtual machines (VMs) on a single physical platform, depending on the application, user demand, system configuration and the configuration of the old or replaced servers. A typical ratio is 8:1. Dell customers frequently report 10:1 or 12:1 ratios as well.

That means a power problem for one server—either due to a loss of power or equipment issues caused by dirty power—could easily bring down a dozen applications. Power redundancy is therefore more important than ever, and so is clean, quality power.

Even the cooling system becomes more critical in a virtualized environment, because virtualized servers run at higher CPU utilization, which translates into higher heat output. A malfunction in a single cooling mechanism—a door fan or enclosure exhaust fan, for instance—could cause equipment to overheat.

Higher rack densities may exceed available UPS capacity.

In traditional designs for larger datacenters, one or two high-capacity, three-phase UPSs stood alone in a separate room, providing conditioned power and battery backup for the whole datacenter, perhaps even the entire building. These UPSs fed large Power Distribution Units (PDUs) on the datacenter floor.

Virtualization projects often result in a cluster of high-density racks in a space that was designed for lower density racks. In these cases, the capacity of the existing, centralized UPS can become a bottleneck to virtualization efforts, especially as redundancy becomes more important.

Applications and their processing demands can shift at will.

Virtualization makes it possible to deploy, move, or clone an application from one platform to another at will, even while it is running. That means energy demands can shift around the datacenter at will. Yet power is a fixed asset, tied to a physical infrastructure that cannot be pressed beyond the limits specified by the National Electrical Code.

On-demand migration of applications demands new levels of visibility into how IT applications affect power, and vice versa. Is the IT equipment that runs the most important applications receiving computer-grade power? If you move processing-intensive applications, will you overload a UPS? Which UPS has enough capacity to accommodate new virtualized servers and their applications?

Overall footprint for IT systems is smaller, but energy efficiency could still be suboptimal.

Virtualization delivers dramatic energy savings, but could it be even better? In a typical one-megawatt datacenter, a 10-year-old UPS is probably wasting about 150 kW of power and dissipating high amounts of heat. With new pressures on energy conservation and cooling costs in virtualized environments, IT managers have to look more closely than ever at the efficiency and heat dissipation of the UPS.

Recommendations for power protection in virtualized environments

Dell UPSs enable you to address the power challenges of virtualized environments. With Dell's new line of small to mid-sized UPSs (500W to 5600W), IT managers can:

- Bring power protection closer to servers with serial redundancy
- Ensure power quality and availability on redundant power sources
- Extend server run time during power outages
- Provide greater visibility into power conditions at the row, enclosure and server levels
- Monitor and manage enclosure-level power from anywhere
- Remotely shut down and reboot VMware® virtualized servers
- Extend the efficiency gains of virtualization

The portfolio of UPSs includes a choice of capacity ratings, topologies and form factors to suit the specific cost and performance requirements of each virtualization scenario.

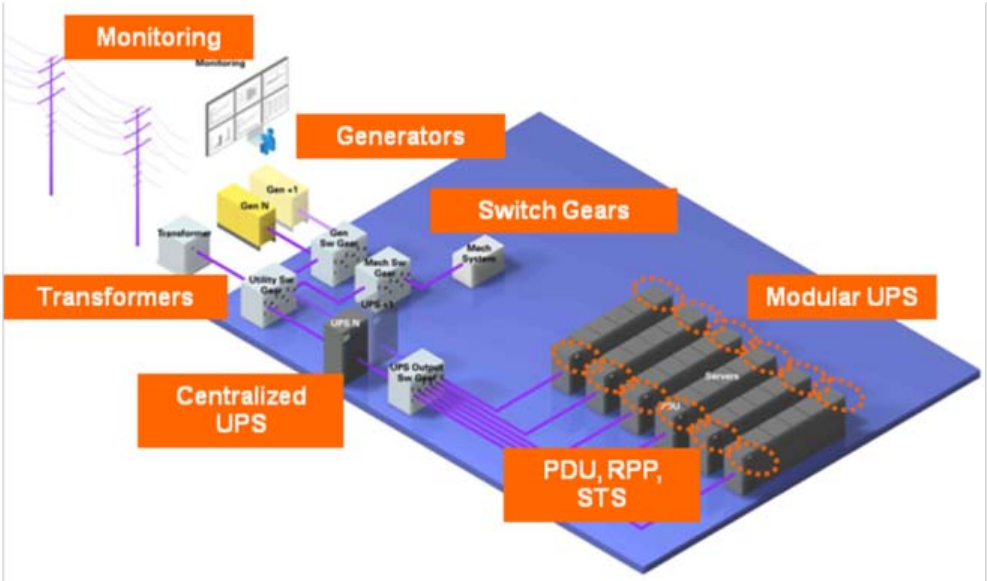
Bring power protection closer to servers with serial redundancy.

Most datacenters are protected by a centralized UPS that provides conditioned power and battery backup to the entire datacenter or, for a smaller organization, to the entire facility. But what if there's a problem with that centralized UPS? It will switch to bypass mode, and raw utility power would be passed directly to IT equipment.

Virtualized servers are too critical to be subjected to the anomalies that are common in utility power. In this case, smaller UPSs can be deployed at the enclosure or server level. Rack-mounted UPSs can be installed in the same enclosure as the virtualized servers they protect, in nearby enclosures, or at the end of the row, with power sent to enclosures via a PDU.

For smaller organizations that do not have a centralized UPS, smaller UPSs can be deployed close to the protected loads—in just the right capacity rating, efficiency rating and form factor (tower or rack-mounted) for the setting.

In the configuration shown, the large UPS is the first line of defense, receiving utility power and sending conditioned power to its protected loads. Smaller UPSs installed in the rows provide an additional layer of protection—especially key if the central UPS is offline for any reason, planned or otherwise.



Dell UPSs are ideal for providing serial redundancy downstream from a centralized UPS.

Ensure power quality and availability on redundant power sources.

Most servers used for virtualization have dual power supplies at minimum. That internal redundancy protects the applications on a specific server in case one power supply should fail. But what if a power source becomes unavailable?

For maximum protection for the applications on virtual machines, these redundant power supplies need to receive their power from separate power sources, each protected by an independent local UPS. Each UPS would protect one power path to the server hardware. UPS A and UPS B would share the load. If UPS A goes down or there is a failure on its input power source, UPS B can take over without dropping any load—and vice versa.

Extend server run time during power outages.

Dell UPSs have internal batteries that keep servers running for 5-10 minutes during a power outage when the UPS is fully loaded. If the UPS is more lightly loaded, run time is extended accordingly. For example, internal batteries provide 14 to 23 minutes of run time at 50 percent load, depending on the UPS model. That's enough time to ride through most power outages—or to gracefully shut down applications and servers in anticipation of a longer power outage.

However, in a virtualized environment, it is usually far more desirable to ride through outages of a half-hour or more, avoiding the burden of shutting down and restarting a high number of critically needed applications. Dell UPSs offer options for extending battery run time:

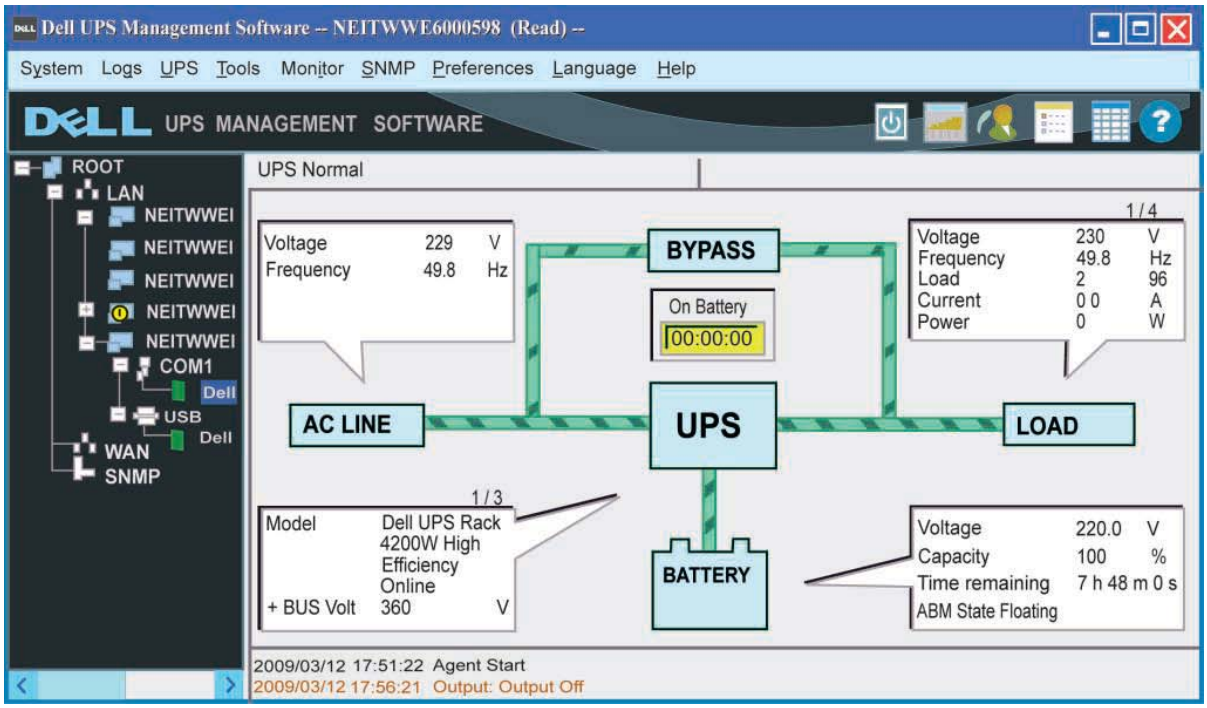
- *External battery modules (EBMs)*, deployed in the same enclosure as the UPS or in a separate enclosure, provide extra run time to run virtualized servers. Most Dell UPSs in the 1000W-5600W range support an optional EBM to extend run time from 11 to 35 minutes at 100 percent load, or 35 to 85 minutes at 50 percent load, depending on the UPS model.
- *Selective shutdown*. With the "load segments" feature, you can selectively shut down power for one or more groups of outlets on the back of the UPS. During a power outage, you could shut down power to less essential servers to extend battery backup time to more critical ones. This capability also extends overall battery life and, in turn, delays the costs of battery replacement.

Provide greater visibility into power conditions at the row, enclosure or server levels.

Not only is power quality more critical in virtualized environments, because so many applications are riding on each server, but power consumption can fluctuate with every reallocation of applications. It is no longer enough to monitor power conditions at the main switchgear level through power quality and power event data delivered by the centralized UPS.

With the power density of today's IT systems, the power distribution system is more easily stressed by even the simplest changes in your datacenter. How much current are your servers drawing right now? Are electrical circuits approaching capacity, ready to trip a breaker if transaction processing rises or a new component is added? Would you be able to see trouble coming?

Dell UPSs, working with Dell UPS Management Software, deliver a wealth of information about power consumption, power events, available battery run time, alarm conditions, and more. You get the detailed and aggregated information needed to prevent tripped circuits, understand where new systems and applications can be deployed, balance loads and diagnose power problems.



Dell UPS Management Software provides a window into UPS status and events.

Monitor or manage enclosure-level power from anywhere.

When organizations implement virtualization, the applications that formerly resided on many servers—perhaps in different locations—are consolidated into a smaller number of more densely loaded servers, more likely to be in a central location. The IT manager might not be in the same location as the servers and UPSs.

With Dell UPS Management Software, network managers can remotely monitor and manage UPSs. A Network Management Card provides a gateway for remote communications with an IT or facility monitoring/management system over your LAN/WAN and the Internet.

You can monitor and configure the UPS from any computer equipped with a Network Management Card and the appropriate authorization and connectivity. The Dell UPS Management Software itself can even be run as a virtualized application on VMware ESX 3.5 machines.

The management software delivers a panoramic view and maintains logs of relevant power information, including utility power, UPS status, UPS load and battery status—all in the same window.

Remotely shut down and reboot virtualized servers.

Dell UPS Management Software enables orderly, unattended shutdown of protected servers during power outages. Hundreds of devices in remote or unmanned sites can be protected without requiring an on-site visit from a technician. User-defined sequencing of outlets and time delays permits controlled, remote boot-up of servers. Virtual grouping of outlets permits single-click reboot of multicorded servers, entire racks or non-critical loads.

The newest enhancement to this capability is the ability to see all IT equipment powered by a given UPS—including VMware virtualized servers—and to enable connected servers and guest operating systems to shut down in their normal fashion, saving all work up until the moment of shutdown.

Extend the efficiency gains of virtualization.

Clearly, one of the greatest boons of virtualization is the substantial savings in power and cooling costs realized by reducing the number of servers. But could efficiency be even better, by expecting more out of the UPS that protects those servers? Recent advances in UPS technologies have greatly improved efficiency.

In the 1980s, most UPSs were 75 to 80 percent efficient at best. In the 1990s, UPS efficiency rose to 85 percent efficiency and higher. But still, for every dollar of utility power purchased, you got only 85 to 90 cents worth of usable power. Those energy losses are dissipated as heat, so lower efficiency meant more expensive cooling as well—thousands of dollars wasted each year.

Dell's small to mid-sized UPSs for virtualized environments offer up to 96 percent efficiency under normal operating conditions. When an online UPS has to work harder to overcome poor power conditions, efficiency is somewhat lower, but the UPS returns to its most efficient state of operations as soon as power conditions are back within acceptable parameters.

Choose the most appropriate UPS for the application.

Size rating. Dell UPSs range from 500W to 5600W to enable a close match of UPS to the requirement. Since UPSs are less efficient at lower loads, you would want to select an appropriately sized UPS and run it at higher utilization, rather than a too-large, underutilized UPS.

Many UPS models are rated by volt-amperes (VA), but that can be a confusing figure. VA represents apparent power, while watts (W) represents the real value available to servers. The relationship between VA and W is a function of the UPS's power factor.

Dell UPS models are power factor corrected, which means that watt and VA ratings are equivalent, which is not universally true of other vendors' UPSs. A UPS with a power factor of .7 might be rated for 1000VA but only able to deliver 700W of usable energy.

The rule of thumb is to add up the total IT equipment load in watts, allow for 20 percent growth, and select the UPS that comfortably handles that load. For example, if you are planning for a 900-watt load, the Dell UPS rated for 1000 watts could easily protect it.

Topology. Are energy efficiency and lowest possible total cost of ownership paramount? Or are the applications so critical that premium power protection is required? A line-interactive UPS provides efficient protection against outages, sags, surges, brownouts and over-voltage conditions. An online UPS protects against all nine common power problems, including harmonics and frequency variation, making it the best choice for mission-critical applications and servers.

Form factor. A space-saving, high-density rack-mounted UPS, such as the Dell UPS Rack 1000, can be installed in the same rack as IT equipment. Elegant tower units, such as the Dell UPS Tower 500, fit under a desk or in an office or equipment closet, and harmonize with modern office décor. UPSs with two-in-one form factors, such as the Dell Rack/Tower 2700/2300W UPS, offer deployment flexibility: rail kits for rack mounting or a stand for use as a tower.

The Dell portfolio of small to mid-sized UPSs offers choice of ratings, topologies and form factors:

Form Factor	Power Capacity	EBM	U space	Topology
Tower	500W	No		Line-interactive
Tower	1000W	Yes		Line-interactive
Tower	1920W	Yes		Line-interactive
Rack/Tower	2700W	Yes	3U	Line-interactive
Rackmount	1000W	No	2U	Line-interactive
Rackmount	1920W	Yes	2U	Line-interactive
Short-Depth Rackmount	2700W	Yes	4U	High-Efficiency Online
Rackmount	3750W	Yes	4U	High-Efficiency Online
Rackmount	4200W	Yes	4U	High-Efficiency Online
Rackmount	5600W	Yes	4U	Line-interactive
Rackmount	5600W	Yes	4U	High-Efficiency Online

Dell UPSs in context—Three case studies

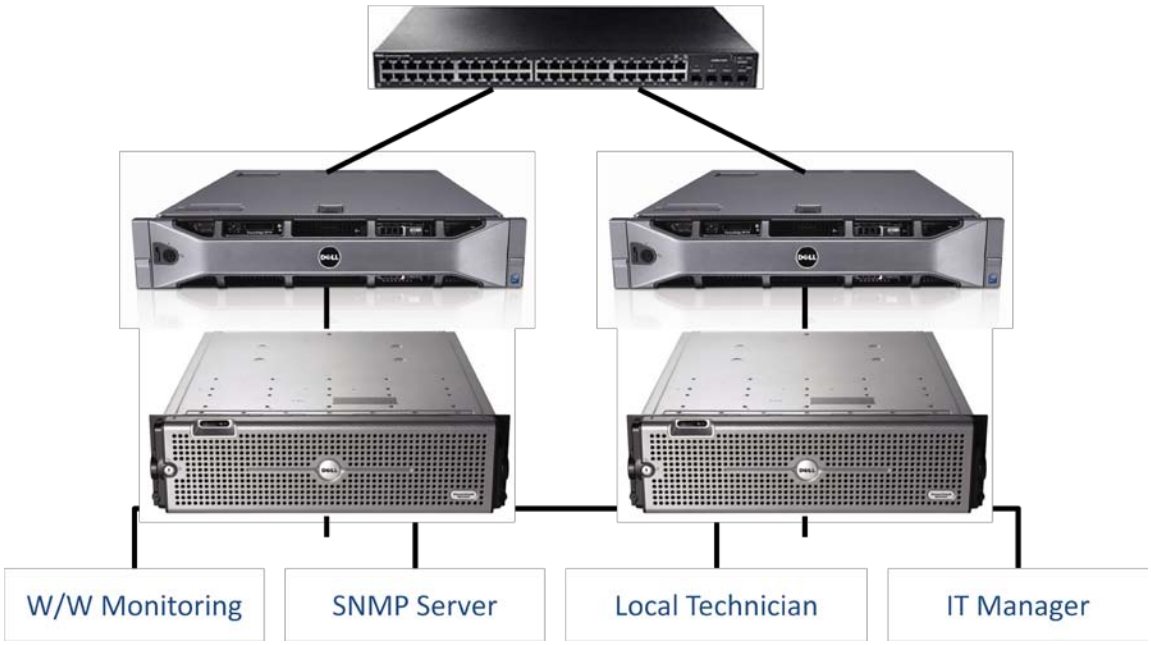
Scenario 1—Highly available, virtualized infrastructure stack solution

In this multilocation enterprise, virtualization consolidated applications from 15 servers in various branch offices are stacked onto two virtualized Dell PowerEdge R710 servers with a Dell PowerVault™ MD3000i iSCSI Storage Area Network (SAN) and two Dell PowerConnect™ 5400 Series Switches.

The combined power draw of these five pieces of equipment is 1748W, so the company deployed two 1920W, 120V line-interactive UPSs, which are installed in the same cabinet as the IT systems. UPS internal batteries can run the servers for more than five minutes during a power outage. An EBM mounted in the bottom of the cabinet extends run time to 20+ minutes.

Because the IT manager is often at another location, it was critically important to have remote monitoring and management of the UPS and servers. So the UPSs are equipped with Network Management Cards to enable remote monitoring and control. The IT manager can securely communicate with the UPSs and the virtualized servers they support through the company LAN.

A local technician can be notified of power events at the same time as the dispatch center, IT manager and anyone else designated to receive alerts. Simultaneous notification speeds response time and resolution.



Quantity	Device	Watts (Unit)	Total Watts
2	Dell PowerEdge R710 server	474	948
1	Dell PowerVault MD3000i iSCSI SAN	500	500
2	Dell PowerConnect 5400 Series Switch	150	300
	Total Power Requirement		**1748**
2	**Recommended UPS: Dell UPS Rack 1920**		

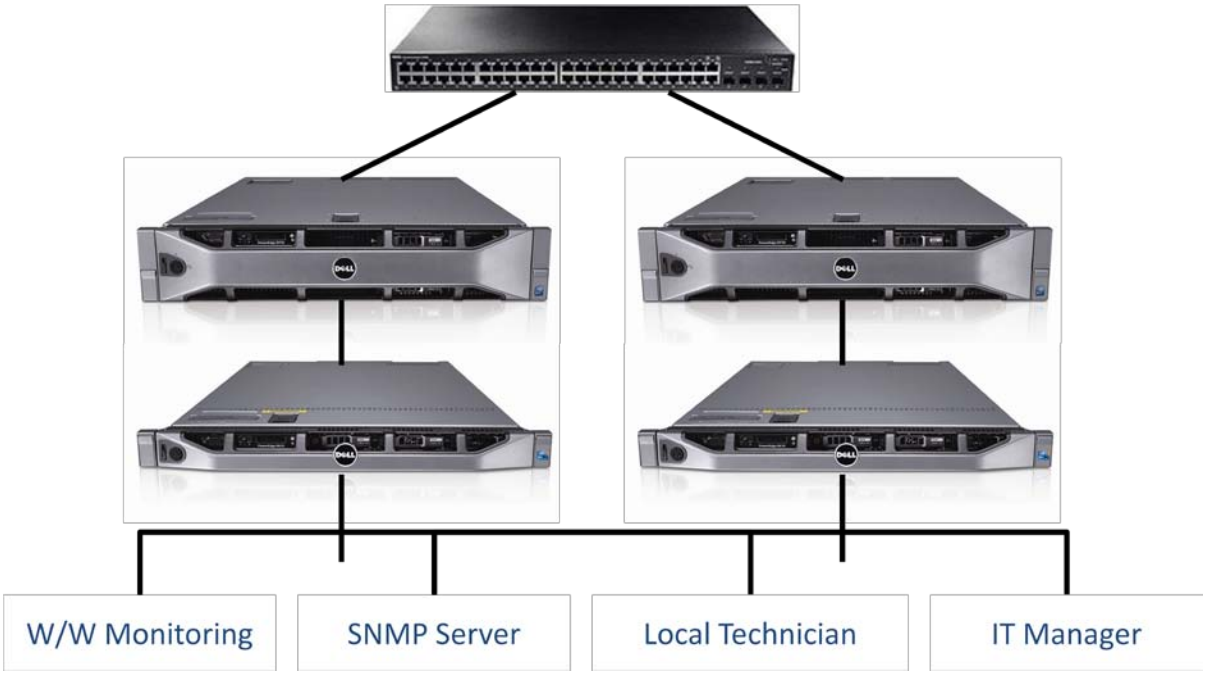
Scenario 2—Mission-critical facility with zero tolerance for unplanned downtime

The datacenter at the financial firm runs many applications that have long batch processes and large databases. Processing can take 12 hours or longer. A hiccup in one of these processes has serious repercussions for the timely posting of financial transactions—and in turn, the firm's reputation. No unplanned downtime is acceptable.

These applications and several others are consolidated onto two Dell PowerEdge R710 servers and two Dell PowerEdge R610 servers working with a Dell PowerConnect 6224 Managed Switch. The total power draw of this IT equipment is 1968W, so the firm deployed two 2700W, 120V UPSs.

A large, central UPS protects the entire datacenter, but these modular Dell UPSs provide an added layer of protection for the most critical servers that run the intensive batch processes. In case the large UPS is offline, the redundant, smaller UPSs ensure clean, continuous power. Each of the smaller UPSs has sufficient capacity to assume the workload of the other, if necessary.

Because of the critical nature of the applications being supported, each UPS is equipped with an EBM for increased run time during power outages and a Network Management Card for remote monitoring and management. Internal batteries in each UPS provide six minutes of run time; the EBM extends run time to 23 minutes. The UPS can transition seamlessly to generator power to cover for longer outages.



Quantity	Device	Watts (Unit)	Total Watts
2	Dell PowerEdge R710 server	474	948
2	Dell PowerEdge R610 server	435	870
1	Dell PowerConnect 6224 Managed Switch	150	150
	Total Power Requirement		**1968**
	Recommended UPS: Dell Rack/Tower UPS 2700		

Scenario 3—Facility subject to erratic utility power

Servers at the life sciences firm perform intensive 3D modeling for the scientific community—renderings that can run more than 24 hours at a time. Unfortunately, the facility frequently experiences erratic utility power, causing processes to abort and data to be corrupted. The firm also worries about the long-term impact of power fluctuations on sensitive IT components.

The firm identified the eight Dell PowerEdge R610 servers that ran its most sensitive and protracted processes—and designed a UPS strategy to ensure best quality power and battery run time for those critical servers.

A single Dell UPS Rack 5600 protects the eight virtualized servers, which collectively draw 3480W of power. The online topology ensures the highest possible power quality. A pre-defined load-shedding strategy ensures the longest possible run time for the most critical servers during power outages.

Quantity	Device	Watts (Unit)	Total Watts
8	Dell PowerEdge R610 server	435	3480
	Total Power Requirement		**3480**
	Recommended UPS: Dell UPS Rack 5600		

Given that the UPS is just a little more than 60 percent loaded, internal and external batteries provide at least 20 minutes of run time during an outage. (At full load, run time would be 12 minutes with the internal battery or 38 minutes with an EBM.)

The IT manager extends that run time by shedding 50 percent of the load (four less critical servers) after five minutes. Cutting the load by 50 percent usually triples available run time, thereby extending run time for the remaining four servers to 45 minutes (20-5=15, multiplied by 3=45 minutes).

If utility power hasn't resumed after 20 more minutes (a rare occasion), another 50 percent of the load is shed (two more servers), to increase the run time for the last two servers to 75 minutes. This progressive load-shedding arrangement effectively allocates 100 minutes of run time to the two most critical servers in the cluster (75+20+5=100 minutes).

Contact your Dell representative for cabling information.

Server	Run time at full load	Run time at five minutes after shedding 50 percent of load	Run time at 25 minutes after shedding another 50 percent of load	Run time at 75 minutes after shedding another 50 percent of load
1	20 minutes	shed	shed	shed
2	20 minutes	shed	shed	shed
3	20 minutes	shed	shed	shed
4	20 minutes	shed	shed	shed
5	20 minutes	45 minutes	shed	shed
6	20 minutes	45 minutes	shed	shed
7	20 minutes	45 minutes	75 minutes	shed
8	20 minutes	45 minutes	75 minutes	75 minutes

Closing thoughts

Server virtualization enables an organization to meet IT service level agreements with fewer physical servers, which in turn results in dramatic savings in energy and footprint. However, to successfully implement a virtualization project, IT teams need to account for some new realities, such as dynamic changes in power demands, higher server and rack power densities, and the critical need to protect applications with sufficient UPS capacity.

Solid solutions are available from Dell to address these power considerations—to extract the full potential of energy savings offered by virtualization and server consolidation, while ensuring that power quality and backup power requirements are met at the row, rack and server levels.