When it comes to backup power, here are some basic questions to ask yourself.

**Applications**
1. How often do you refresh and maintain your IT hardware (including servers)? What about your UPS equipment?
2. If you have a converged data-voice network, have you protected all critical switches?
3. If you have virtualized your servers, have you considered the impact on your UPS equipment?
4. What would happen if the power went out at your facility right now?
5. Have you thought about the impact of damaged or corrupted data?
6. How much energy do your UPS units consume? How efficient are they?

**UPS-specific**
1. What size UPS do you need? (kVA or amperage)
2. What voltage is currently available at your site?
3. What voltage do you need?
4. What runtime do you want?
5. Are there any clearances or size constraints?
6. Do you have bypass requirements?
7. What types of input and output connections are required?
8. Is there a generator on site?
9. Does the UPS need to be scalable?
10. Do you need redundancy?

**Accessories**
1. How is power getting from the UPS to your equipment?
2. Do you have a need for enclosures, communications, seismic mounting, floor stands or rail kits?
3. Is a maintenance bypass switch needed?

**Software**
1. Is there a need to have orderly scheduled shutdowns?
2. Do you want to remotely monitor the UPS?
3. Would you like to remotely notify others of UPS events?
4. How will your UPS software manage virtual servers during an extended power outage?

**Service**
1. Do you need immediate factory response?
2. What kind of parts and labor coverage do you need?
3. Do you want any type of preventive maintenance?
4. When’s the last time you checked the batteries in your existing UPS units?
Top UPS design considerations

The following factors outline the key design considerations to take into account when analyzing your needs.

1. Power environment: single- and three-phase
Understand your existing power infrastructure is a crucial step in the qualification and sales process. While you may focus on larger, three-phase power systems, the majority of IT managers are dealing primarily with single-phase equipment, often at the rack level.
Many existing computer rooms and small to mid-sized data centers have single-phase loads at the rack level. Ground-up designs are increasingly moving three-phase power to the point of utilization to gain efficiencies and reduce costs, creating great opportunity for three-phase solutions in new construction.

2. Installation environment
It’s imperative to understand how a prospective UPS will be deployed. Since most environments support several different solutions, you may need to evaluate these options.

3. Power load
The VA or watt rating of your power loads is one of the most important factors in identifying the right UPS. After identifying the power environment (if the UPS needs to be single- or three-phase), the size of the UPS further narrows the selection. In single-phase deployments especially, it often makes sense to select a UPS that exceeds current power requirements but offers greater runtimes and allows for future growth.

4. Availability and battery runtime
This is where you need to determine your true runtime requirements. While runtime may seem like a simple thing to quantify, understanding the facts behind the numbers help contribute to the development of end-to-end solutions.
Generally, the amount of runtime required can significantly affect the solution cost, but many Eaton solutions are actually more cost-effective in extended runtime applications.

There are four basic battery runtime configurations:
1. UPS with 10 to 15 minutes of runtime and no generator. You are covered for 90 to 95 percent of power outages. You can either use UPS shutdown clients to save your data or stay online as long as possible before the system crashes.
2. UPS with 10 to 15 minutes of runtime and a generator. You have a very reliable setup and most generators will startup within one minute (five minutes maximum). You are covered for most situations.
3. Redundant UPSs, generator and two power feeds for dual-corded servers. You have a lot of money and/or are really worried about the power failing. It’s time to get a consultative person on-site to help you figure it out.
4. UPS with two or more hours of battery runtime. In some cases, generators may not be practical and you must rely entirely upon batteries.
5. Scalability

It’s always important to consider your future expansion needs when evaluating solutions. Eaton’s scalable UPS solutions provide a competitive advantage by offering a cost-effective way to increase capacity. Virtually all Eaton UPSs with a 6 kVA or greater power rating offer some form of scalability, either through a simple firmware upgrade, the addition of modular hardware components or the paralleling of multiple UPSs.

For cost-conscious or budget-constrained customers, a UPS with inherent scalability often proves to be the best value in the long run, allowing you to increase capacity without purchasing additional hardware. A simple kVA upgrade is all that’s needed to enable a UPS with inherent scalability to operate at full capacity.

You may want to service the UPS yourself. If that’s the case, look for a unit that allows you to add capacity with power and/or battery modules.

While modular solutions—including multiple, paralleled systems—are often a more affordable option initially, they can be a more expensive solution over the long term due to added hardware and installation costs. Depending on your needs, a larger, centralized, non-modular system with inherent scalability might ultimately be the most cost-effective solution.

6. Power distribution

It is important for you to consider how power will be delivered to your critical equipment. In some cases, you may simply plug loads directly into the UPS. In others, you may need large PDUs to distribute power. You may also incorporate rack-based power strips or ePDU units into your design.

7. Manageability

While a UPS protects the attached load during a power outage, power management software is required to ensure that all work-in-progress is saved and that sensitive electronic equipment is gracefully shut down if the power outage exceeds the battery runtime of the UPS. Without software, the UPS simply runs until its batteries are depleted and then drops the load. In addition to this basic functionality of UPS software, you should consider the following monitoring and manageability capabilities:

- Power event notifications, including emails, pop-up alerts and text messages to pre-designated recipients
- Logging of power events
- Advanced capabilities in virtual environments, including integration into VMware’s ESXi and vSphere and Microsoft’s Hyper-V
- Dedicated battery monitoring and advanced service notifications
- Remote monitoring by service personnel from the UPS manufacturer.

8. Operation and maintenance

While you may value the ability to service your own equipment, the vast majority of IT and facility management professionals prefer the peace of mind that comes with full factory support through on-site service or an advanced UPS exchange agreement. To make an informed decision on service support, you must accurately assess your own technical and service capabilities. You should also look at the various UPS product designs to gauge how easy it is to swap out battery and power modules.

9. Budget

Although the latest performance features of a UPS may fit nicely with what you are looking for, budget constraints may force you to make trade-off decisions. Be prepared to prioritize your needs for redundancy, scalability, efficiency, software management, modularity and serviceability.
Other UPS design considerations

The following design guidelines should be reviewed and followed prior to ordering the appropriate UPS solution.

1. Check to see if there’s an adequate electrical supply near the UPS.
   Compare UPS fuse ratings (amps) and breaker types and whether any electrical work may be needed (i.e., cabling to the UPS terminal block input).

2. Find out the dimensions of the UPS and include any battery cabinets.
   Make sure your installation site has enough space available.

3. Ensure the UPS can be placed in its final position.
   Will the UPS components fit through doors? Please consult Eaton’s website for detailed UPS dimensions and specifications: powerquality.eaton.com.

4. Verify that the floor is strong enough to support the UPS and battery cabinets.
   The UPS and its battery cabinets can be heavy, so make sure the site has the proper floor loading capacity.

5. Confirm that the UPS will have adequate ventilation.
   Eaton UPS models use internal fans to cool them. You shouldn’t install the UPS in a sealed container or small, sealed room.

6. Always be sure which wall receptacle is required to plug in the UPS.
   Only UPSs with power ratings up to 1500 VA plug into a standard 15-amp wall outlet. All others require a larger receptacle, which must be installed by an electrician. Things go more smoothly if you aren’t waiting for this to be done after all of the equipment has arrived. Most small and rackmounted computers run on normal 120 volt, 15-amp electrical service. Some computers have power cords that require a higher voltage of 208V or 240V, in which case you’ll need a 3000 VA or larger UPS.

   Hardwired outputs are generally useful if you want the UPS output to be distributed via electrical panels. Using an electrical distribution panel allows for flexibility with receptacles types. If there’s no other UPS that fits your receptacle and power requirements, you may need to hardwire it. Hardwired UPS models typically require the use of a certified electrician to wire them to the electrical distribution panel, which could be a more costly option.

8. Installing small UPS models behind larger UPS models.
   If you’re installing a smaller UPS behind a larger UPS, you must consider the total potential power of the smaller UPS as well as other loads that will be powered by the larger UPS. For example, if you’re plugging a 1500 VA UPS into a 10,000 VA UPS, you must consider the load of the smaller UPS rather than just the load that’s plugged into it. In addition, the larger UPS must be at least five times larger than the smaller UPS. This design guideline must be followed due to charging capacity that may be required by the smaller UPS; any anomalies associated with the building power, and to avoid overheating or potential over loading of the larger UPS which may result in failure of the all UPS models in the string.

9. Using a UPS and a generator together.
   A UPS provides backup power and actively conditions and regulates voltage. Similarly, an auxiliary generator provides backup power, but typically takes 10-15 seconds to start up, depending on its type. For long-term backup servers and IT equipment, this isn’t an optimal situation, so during that downtime the UPS kicks in. Basically, the UPS bridges the power gap between loss of power and generator coming online.
   When choosing your UPS solution, it’s important to keep power ratings in mind; you cannot size a generator in a 1:1 match to the UPS and expect successful results.
   There are two reasons for this: first, UPSs aren’t 100 percent efficient and second, generators need to account for step loads. In addition, very small generators don’t often provide enough kinetic energy to provide a smooth transition. As a rule of thumb, for 20 kVA and above, auxiliary generators should be sized 1.5 times the size of the output rating of the UPS in kW, while for 20 kVA and below, they should be two times larger.
   It’s also important to note that gas-powered generators should be sized a bit larger.

   Verify that the final UPS solution meets local building codes.
How to size a UPS

You have decided that you need a UPS. What's next? Well, you have to pick the right one!

**Alternative #1:**
Visit [Eaton.com/UPSselector](http://Eaton.com/UPSselector)

**Alternative #2:**
Call Potencia Technologies knowledgeable inside sales team:
613.831.0269 or 519.914.5713

**Alternative #3:**
Do it the old fashioned way. Completing these steps is also very useful for the first two alternatives.

1. List all equipment to be protected by the UPS. (Remember to include monitors, external hard drives, routers, etc.)
2. List the amps and volts for each device. These ratings can typically be found on the label on the back of the equipment. Multiply amps by volts to determine VoltAmps (VA). Some devices may list their power requirements in watts. To convert watts to VA, divide the watts by power factor. For servers, the power factor is often 0.9.
3. Multiply the VA by the number of pieces of equipment to get the VA subtotals.
4. Add the VA subtotals together.
5. Multiply the total by 1.2 to get the grand total. This step accounts for future expansion.
6. Use the grand total to select a UPS. When choosing a UPS, be sure that the total VA requirement of supported equipment does not exceed the VA rating of the UPS.

**Alternative #4:**
Eaton's UPS Tool for iPhone®, iPad® and iPod touch® helps you find the best UPS solution without being tied to your desk: [www.powerquality.eaton.com/upstools](http://www.powerquality.eaton.com/upstools)

### UPS sizing worksheet

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Amps</th>
<th>Volts</th>
<th>VA</th>
<th>Quantity</th>
<th>VA Subtotal</th>
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<tbody>
<tr>
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</tr>
</tbody>
</table>

4 Total

5 x1.2 Grand Total

Potencia – UPS Basics
UPS cost justification worksheet

This worksheet helps you determine the estimated dollar savings that a UPS can deliver. Simply fill in the information to calculate the costs of one hour of downtime. Actual dollar amounts will vary from company to company, location to location, and industry to industry.

1. Number of critical loads: ____________________________
   Critical loads = any equipment running or supporting your applications (servers, routers, PCs, network devices, etc.)

2. Number of employees using critical loads: ________________

3. Employees’ average hourly earnings: ____________________

4. Estimated cost of lost business per hour of downtime ($1,000, $5,000, $10,000…): __________

5. Cost of service calls per hour: _________________________

6. Cost of recreating or salvaging data (if applicable): ________________

7. Cost of replacing hardware (if applicable): ________________

8. Cost of reinstalling software (if applicable): ________________

9. Lost employee time (line 2 x 3): _________________________

10. Lost business (line 4): ________________________________

11. Service (line 5): _________________________________

12. Recreating or salvaging data (line 6): ________________

13. Replaced hardware and software (line 7 + 8): ________________

14. Estimated total cost per hour of downtime: $ __________

This is only one hour. Imagine if your systems were down all day!
Input plugs and output receptacles

When you receive a UPS, you should be able to plug it in right away. If a UPS can't be plugged into the wall socket, or their equipment can't be plugged into it, you've got a problem.

Any UPS with a rating of 1500 VA or below can be plugged into a standard household receptacle/socket. UPS models with ratings higher than 1500 VA use input plugs that can't be plugged directly into a standard receptacle. Many higher rated UPSs (above 1500 VA) may also be hardwired directly into the electrical distribution panel at the installation location by a licensed electrician.

Many UPS models offer a fixed set of input and output receptacles. Other UPS models can be configured with a custom set of input and output connections.

For reference we've included the following chart to help you visually confirm input and output plug/receptacle options:

<table>
<thead>
<tr>
<th>Value</th>
<th>Max Voltage</th>
<th>Wires in connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>125V</td>
<td>L1, N, G</td>
</tr>
<tr>
<td>6</td>
<td>250V</td>
<td>L1, L2, N, G</td>
</tr>
<tr>
<td>14</td>
<td>125/250V</td>
<td>L1, L2, N, G</td>
</tr>
<tr>
<td>16</td>
<td>250V</td>
<td>L1, L2, L3, G</td>
</tr>
<tr>
<td>21</td>
<td>250V/125V</td>
<td>L1, L2, L3, N, G</td>
</tr>
</tbody>
</table>

*5-15P can plug into 5-20R
R = Receptacle, P = Plug, L = Locking
For the number before the hyphen:
5 = 125V, two-pole, three-wire (grounded)
6 = 250V, two-pole, three-wire (grounded)
14 = 125/250V, three-pole, four-wire (grounded)
The number after the hyphen indicates the amperage. For example, the LS-30R is a 30A receptacle.

Know your North American receptacles

In North American markets, most facilities utilize plugs and receptacles conforming to standards established by the National Electrical Manufacturer's Association (NEMA), which uses a smart code to define what each part number represents. If you know the part number of your connector, you can find its voltage and amperage ratings. Always check with your local electrician to verify proper wiring and installation.
A common question from IT managers is, “I have a receptacle at my facility; what is the biggest UPS can I connect to it?” If you’re looking at UPSs 6 kVA or lower, it’s a pretty straightforward question to answer as shown below:

### Local outlet

<table>
<thead>
<tr>
<th>Local outlet</th>
<th>Typical largest UPS rating per outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-15R</td>
<td>1500VA 120V</td>
</tr>
<tr>
<td>5-20R</td>
<td>2200VA 120V</td>
</tr>
<tr>
<td>L5-30R</td>
<td>3000VA 120V</td>
</tr>
<tr>
<td>L6-20R</td>
<td>3000VA 208V</td>
</tr>
<tr>
<td>L6-30R</td>
<td>6000VA 208V</td>
</tr>
<tr>
<td>IEC C13</td>
<td>2200VA 230V</td>
</tr>
<tr>
<td>IEC C19</td>
<td>3000VA 230V</td>
</tr>
</tbody>
</table>

### 1. Fixed
Smaller UPS models like the Eaton 9130 UPS provide a fixed set of output receptacles

### 2. Customized
UPS models like the Eaton 9355 can be customized with a variety of output receptacles

### 3. Hardwired
Large UPS models like the Eaton 9390 are hardwired to incoming utility power though some models leverage output receptacles

### 4. Additional receptacles
Eaton ePDU products mount easily into racks and provide additional receptacles
The difference between VA and watts

**The engineering answer:** To correctly size a UPS, it’s important to understand the relationship between watts and VA. However, we must first have a brief discussion about power terminology. Real power (measured in watts) is the portion of power flow that results in the consumption of energy. The energy consumed is related to the resistance in an electrical circuit. An example of consumed energy is the filament in a light bulb.

Reactive power (measured in VAR or volt-amperes reactive) is the portion of power flow due to stored energy. Stored energy is related to the presence of inductance and/or capacitance in an electrical circuit. An example of stored energy is a charged flash bulb in a camera.

Apparent power (measured in VA or volt-amperes) is a mathematical combination of real power and reactive power.

The geometric relationship between apparent power, reactive power and real power is illustrated in the power triangle below:

Mathematically, real power (watts) is related to apparent power (VA) using a numerical ratio referred to as the power factor (PF), which is expressed in decimal format and always carries a value between 0 and 1.0. For many newer types of IT equipment, such as computer servers, the typical PF is 0.9 or greater. For legacy personal computers (PCs), this value can be 0.60 – 0.75.

Using one of the following formulas, a calculation can be made to determine the missing quantity:

\[ \text{Watts} = \text{VA} \times \text{Power Factor} \]

\[ \text{VA} = \frac{\text{Watts}}{\text{Power Factor}} \]

Since many types of equipment are rated in watts, it's important to consider the PF when sizing a UPS. If you don't take PF into account, you may under size your UPS. As an example, a piece of equipment that’s rated at 525 watts and has a power factor of 0.7 results in a 750 VA load.

750 VA = 525 Watts / 0.7 PF

Sizing the UPS to operate at 75 percent capacity results in a UPS with a 1000 VA rating (750 VA / 0.75 = 1000 VA).

**The answer for the rest of us:**

Converting amps to VA

- Single phase: Multiply amps by voltage (120 volts in the U.S.). 10A x 120V = 1200 VA.
- Three phase: Amps x volts x 1.732 = VA.

View Eaton's Professor Wattson video on VA vs Watts:

Switchon.eaton.com/ProfWattson
Decentralized or central UPS?

Is a single, larger UPS better, or is it best to have multiple, smaller UPSs? Naturally, the answer is that it depends on a number of factors. In a decentralized (also known as distributed) UPS configuration (see Figure 2), multiple UPSs support a handful of devices or perhaps only a single piece of equipment. Decentralized UPSs typically use plug and play connections and are usually less than or equal to six kVA. In a central UPS configuration (see Figure 1), a larger UPS supports multiple devices. A centralized UPS is typically hardwired into an electrical panelboard. The following tables include a number of factors to consider when making a decision between a decentralized and central UPS. In the end it’s often best to simply go with the strategy that you are comfortable with.

### Central UPS

<table>
<thead>
<tr>
<th>Why you’d choose a central UPS solution</th>
<th>Why you wouldn’t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typically, the sales and service life of the UPS is longer.</td>
<td>A single UPS can mean single point of failure. You can overcome this concern with an N+1 or N+X UPS for redundancy.</td>
</tr>
<tr>
<td>A single UPS is easier to monitor, service and maintain than lots of smaller UPSs.</td>
<td>The single UPS may not be close physically to the equipment it will protect. A single electrical distribution panel may not feed all equipment.</td>
</tr>
<tr>
<td>Larger UPSs will be three-phase and/or 208V, 400V or 480V and often result in more efficient operation and lower operating costs.</td>
<td>There is no space for a large UPS.</td>
</tr>
<tr>
<td>A central UPS is often housed away from high traffic areas. As a result, it’s less easily disrupted, accidentally damaged or maliciously interfered with.</td>
<td>A central UPS generally requires a trained service technician or electrician to service, maintain or install.</td>
</tr>
<tr>
<td>A central UPS can be located where cooling is more tightly controlled. Remember, heat is the enemy of the batteries inside a UPS.</td>
<td>A central UPS may incur higher installation and wiring costs.</td>
</tr>
<tr>
<td>Though a technician may need to replace the batteries, you only have to worry about a single UPS. A distributed UPS configuration may result in various models that require different batteries. Do you want to take the time to replace the batteries on five to 20 UPSs?</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1

Potencia - UPS Basics
Combining the configurations

It’s important to keep in mind that decentralized and centralized power protection deployment strategies aren’t necessarily mutually exclusive. The two strategies can be used in combination to provide redundancy to mission-critical applications. For example, an entire facility may be protected by a large, centralized UPS, but a specific department such as a 24x7 call center may have decentralized UPSs as well to provide redundant protection and possibly extend runtime for call center equipment.

Decentralized UPS

<table>
<thead>
<tr>
<th>Why you’d choose a decentralized UPS configuration</th>
<th>Why you wouldn’t</th>
</tr>
</thead>
<tbody>
<tr>
<td>No rewiring is required. Use existing wall sockets. Easy plug and play installation. Can also be redeployed easily if IT systems are moved.</td>
<td>If a generator supports the building, smaller standby and line-interactive UPSs may not be able to function while it’s running.</td>
</tr>
<tr>
<td>Requires lower capital outlay and installation costs. Fits within IT manager purchase limits. Generally don’t need to approve a large capital expense. Will most likely not require additional installation costs from electrician.</td>
<td>No central panelboard exists or there’s no room for the UPS.</td>
</tr>
<tr>
<td>You have no idea how much your company will grow and don’t want to get locked into a particular UPS.</td>
<td>You don’t want to monitor or service a bunch of UPS units. A decentralized design may require more time and focus to keep up with replacing batteries and maintaining multiple UPSs.</td>
</tr>
<tr>
<td>You already have a number of smaller UPS units that are fairly new and you don’t want to discard them. (Most UPS manufacturers offer a trade-in program.)</td>
<td>You want a single UPS that can be shut down using emergency power off. Also, a decentralized design may not offer redundancy and other capabilities provided by a larger, central UPS.</td>
</tr>
<tr>
<td>Power conditioning is implemented at the point of use, which mitigates any electrical disturbances that may be coupled into the distribution wiring of a centralized system.</td>
<td>Adding redundancy, extended runtime or maintenance bypass functionality to multiple UPSs can be costly.</td>
</tr>
<tr>
<td>Diverse applications within a building may require varying levels of power protection and functionality. For example, extended runtime can be configured for specific applications, eliminating the need to add additional battery modules for less critical equipment.</td>
<td>Multiple audible alarms/alerts may be irritating.</td>
</tr>
</tbody>
</table>

Figure 2
Three-phase power, the most efficient way to distribute power over long distances, allows for large industrial equipment to operate more efficiently. It’s characterized by three single-phase waves that are offset in their phase angle by 120 degrees, or one-third of the sine wave period as illustrated in Figure 1.

Three-phase voltage can be measured from each phase to neutral or from one phase to any other. The voltage relation between phase-to-neutral and phase-to-phase is a factor of the square root of three (e.g., 120V versus 208V).

Conversely, single-phase power is distributed through common household outlets to power everyday equipment such as laptops, lighting and televisions. When looking at an oscilloscope image of the voltage coming out of a single-phase outlet as illustrated in Figure 2, there’s only a single wave. Single-phase power is obtained by simply using only one phase of a three-phase system. Its root mean square (RMS) voltage is 120V (for North America) and it oscillates between its peaks of ±170V at 60 Hz (or 60 times a second).

### Single-phase or three-phase power?

<table>
<thead>
<tr>
<th>Single-phase advantages</th>
<th>Three-phase advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>The standard for locations where three-phase power is unavailable.</td>
<td>Can help balance the loads on the utility power of the building.</td>
</tr>
<tr>
<td>Usually easier to distribute power in low kVA and low-density applications.</td>
<td>Usually easier to distribute power in higher kVA and high-density rack applications.</td>
</tr>
<tr>
<td>Allows for smaller amperage electrical devices within the solution (breakers, wiring, panels, etc.).</td>
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</tr>
</tbody>
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**Figure 1. Three-phase power**

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**Figure 2. Single-phase power**
Increase server energy efficiencies by using high-voltage power supplies and 208V UPSs

Maximizing energy efficiencies in today's data centers has become an important factor in saving costs and reducing an organization's carbon footprint. While there are new energy-saving tools and technologies being introduced every day, understanding existing methods and systems can bring immediate efficiencies and savings, often without an additional investment.

One such method is to operate equipment at high-line voltage and use 208V UPSs, which maximizes energy efficiency and uptime, and saves money. IT devices equipped with a C14 plug are capable of running on high voltage, which can dramatically increase efficiency.

Even small increases in UPS efficiency can quickly translate into tens of thousands of dollars in savings. For example, assuming a utility rate of 10 cents per kWh, a 60 kW N+1 redundant configuration would save more than $30,000 over five years. High UPS efficiency also extends battery runtimes and produces cooler operating conditions, resulting in lower utility bills.

At first glance, high-voltage input power seems counter-intuitive when thinking about energy savings. However, in the real world, power supplies operate more efficiently at high voltage. The typical server switch-mode power supply has an efficiency rating between 65 and 80 percent, with some special-purpose products able to reach 90 percent efficiency. Lower voltage causes the power supply to operate at the lower end of this range.

When operating at 208 volts, a 1 to 2 percent difference in efficiency can be experienced for a 1000W power supply, depending on the load level. When the loss in the power distribution transformer (PDU) needed to get to the 120V is added, there's an additional 1.5 to 2 percent savings. Factor in cooling efficiencies and the savings can add up to between 4 and 8 percent, which translates to about $70 per power supply. When multiplied by the number of power supplies in the server rack, the savings certainly justifies making the switch to 208 volts, especially when expanding or moving into a new location.

One of the main reasons that U.S. customers have been reluctant to switch to high voltage is that high voltage UPSs are typically fitted with IEC outlets (or even inlets) and customers don't know how to connect them to IT equipment with a traditional NEMA plug. However, all IT power supplies come with a detachable input cord with a NEMA plug on one side and an IEC plug on the other. By simply changing the standard NEMA/C13 power cord to an IEC C13/C14 power cord, these additional IT equipment efficiencies can be captured. IEC cables are fully UL-listed and are the standard method of connection in large mission-critical data centers across the U.S.

For additional info on this subject, please visit Eaton.com/pq/whitepapers.

Making the connections

Remove the standard 5-15P/C13 power cord that shipped with your IT equipment and replace it with one of the C13/C14 jumper cables that shipped with your UPS. Your IT equipment is now operating at 208V, running more efficiently and saving you money.
In an ideal world, your wall socket would provide an infinite stream of perfect power, at constant voltage and cycling exactly the same number of times per second. Don’t count on it.

<table>
<thead>
<tr>
<th>Power Problem</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Power Failure</td>
<td>When a superhero loses his ability to fly or a total loss of utility power.</td>
</tr>
<tr>
<td>2 Power Sag</td>
<td>Post-lunch sleepiness or short-term low voltage.</td>
</tr>
<tr>
<td>3 Power Surge (Spike)</td>
<td>Rush of energy following a double shot of espresso or short-term high voltage more than 110 percent of normal.</td>
</tr>
<tr>
<td>4 Under-voltage (Brownout)</td>
<td>When your amp’s too wimpy to handle the bass line or reduced line voltage for an extended period of a few minutes to a few days. Often happens during the summer months when everyone is cranking up their air conditioners.</td>
</tr>
<tr>
<td>5 Over-voltage</td>
<td>Inhuman cheefulness exuded by aerobics instructors or increased line voltage for an extended period of a few minutes to a few days.</td>
</tr>
<tr>
<td>6 Electrical Line Noise</td>
<td>Excuse you use to get off the phone quickly or a high power freq caused by radio frequency interference (RFI) or electromagnetic</td>
</tr>
<tr>
<td>7 Frequency Variation</td>
<td>Fluctuation in how often you do laundry from week to week or a lc power supply's normal frequency of 50 or 60 Hz.</td>
</tr>
<tr>
<td>8 Switching Transient</td>
<td>Breaking up with your significant other only to get back together is instantaneous under-voltage in the range of nanoseconds.</td>
</tr>
<tr>
<td>9 Harmonic Distortion</td>
<td>“Music” blaring from your nephew’s headphones or the distortion wave, generally transmitted by unequal loads.</td>
</tr>
</tbody>
</table>
UPS topologies

There are several different UPS topologies that provide varying degrees of protection. Selecting the best fit depends on several factors, including the level of reliability and availability desired, the type of equipment being protected and the application/environment. While all four of the most common UPS topologies outlined below meet the input voltage requirements for IT equipment, there are key differences in how the result is achieved, as well as the frequency and duration of demands on the battery.

**Standby UPSs** allow equipment to run off utility power until the UPS detects a problem, at which point it switches to battery power to protect against sags, surges or outages. This topology is best suited for applications requiring simple backup such as small office/home office and point-of-sale equipment.

**Line-interactive UPSs** actively regulate voltage either by boosting or decreasing utility power as necessary before allowing it to pass to the protected equipment or by resorting to battery power. Line-interactive models are ideal for applications where protection from power anomalies is required, but the utility power is relatively clean. MDF and IDF communication closets, non-centralized server and network rooms, and general IT enclosures are ideally suited for this topology.

**Online UPSs** provide the highest level of protection by isolating equipment from raw utility power—converting power from AC to DC and back to AC. Unlike other topologies, double conversion provides zero transfer time to battery for sensitive equipment. This topology is best applied to mission-critical equipment and locations where power generally is poor.

**Ferroresonant UPSs** operate similarly to line-interactive models with the exception that a ferroresonant transformer is used to condition the output and hold energy long enough to cover the time between switching from line power to battery power which effectively means a no-break transfer. Many ferroresonant UPSs are 82-88 percent efficient and offer excellent isolation. Although no longer the dominant type of UPS, these robust units are still used in industrial settings such as the oil and gas, petrochemical, chemical, utility and heavy industry markets.
Valve-regulated lead acid (VRLA) batteries, also known as sealed or maintenance free are most commonly used in UPSs. VRLA batteries are sealed, usually within polypropylene plastic, which offers the advantage of not containing any sloshing liquid that might leak or drip. Because water can’t be added to VRLA batteries, recombination of water is critical to their life and health, and any factor that increases the rate of evaporation or water loss—such as temperature or heat from the charging current—reduces battery life.

Frequently asked questions: batteries

1. What is the “end of useful life”?

The IEEE defines “end of useful life” for a UPS battery as the point when it can no longer supply 80 percent of its rated capacity in ampere-hours. When your battery reaches 80 percent of its rated capacity, the aging process accelerates and the battery should be replaced.

2. Is there any difference between the batteries used by smaller UPSs, from 250 VA to 3 kVA, and the ones used by larger UPSs?

While basic battery technology and the risks to battery life remain the same regardless of UPS size, there are some inherent differences between large and small applications. Smaller UPSs typically have only one VRLA battery that supports the load and needs maintenance. As systems get larger, increasing battery capacity to support the load gets more complicated. Larger systems may require multiple strings of batteries, introducing complexity to battery maintenance and support. Individual batteries must be monitored to prevent a single bad battery from taking down an entire string, and putting the load at risk. Also, as systems get larger, wet-cell batteries become much more common.

View Eaton’s Professor Wattson video on Batteries:
Switchon.eaton.com/ProfWattson
3. My UPS has been in storage for over a year. Are the batteries still good?
As batteries sit unused, with no charging regimen, their life will decrease. Due to the self-discharge characteristics of lead-acid batteries, it is imperative that they be charged after every six to 10 months of storage. Otherwise, permanent loss of capacity will occur between 18 and 30 months. To prolong shelf life without charging, store batteries at 10°C (50°F) or less.

4. What is the difference between hot-swappable and user-replaceable batteries?
Hot-swappable batteries can be changed out while the UPS is running. User-replaceable batteries are usually found in smaller UPSs and require no special tools or training to replace. Batteries can be both hot-swappable and user-replaceable.

6. If I add more batteries to a UPS, can I add more load?
Adding more batteries to a UPS can increase the battery runtime to support the load. However, adding more batteries to the UPS doesn’t increase the UPS capacity. Be sure your UPS is adequately sized for your load and then add batteries to fit your runtime needs.

7. If my UPS is in storage, how often should I charge the batteries?
The batteries should be charged every three or four months to prevent loss of capacity.

8. What is the average lifespan of UPS batteries?
The standard lifespan for VRLA batteries is three to five years. However, expected life can vary greatly due to environmental conditions, number of discharge cycles, and adequate maintenance. Have a regular schedule of battery maintenance and monitoring to ensure you know when your batteries are reaching their end-of-life. The typical life of an Eaton UPS with ABM technology is 50 percent longer than with standard models.

9. Why are batteries disconnected on small, single-phase UPSs when they’re shipped?
This is done to ensure they’re in compliance with Department of Transportation regulations.

10. Does the UPS need to have a load on it to charge its batteries?
The UPS should have a minimum of 10 percent load to charge its batteries. Once connected to a standard supply of electricity (via input plug or hardwiring), your UPS should charge its batteries regardless of how much load, if any, is attached to it.

11. How can you be sure UPS batteries are in good condition and ensure they have maximum holdover in the event of a power failure? What preventive maintenance procedures should be done and how often?
The batteries used in the UPS and associated battery modules and cabinets are sealed, lead-acid batteries often referred to as maintenance-free. While these types of batteries are sealed and you don’t need to check their fluid level, they do require some attention to assure proper operation. You should inspect the UPS a minimum of once per year by initiating a self-test.

12. How long does it take for the UPS batteries to recharge?
On average, it takes 10 times the discharge time for the UPS batteries to recover. (A 30-minute battery discharge requires about 300 minutes to recharge.) After each power outage, the recharge process begins immediately. It’s important to note that the load is fully protected while the batteries are recharging, but if the batteries are needed during that time, the holdover time available will be less than it would have been if the batteries were fully charged.

13. What are the risks associated with a lack of battery maintenance?
The primary risks of improperly maintained batteries are load loss, fire, property damage and personal injury.

14. What is thermal runaway?
Thermal runaway occurs when the heat generated in a lead-acid cell exceeds its ability to dissipate it, which can lead to an explosion, especially in sealed cells. The heat generated in the cell may occur without any warning signs and may be caused by overcharging, excessive charging, internal physical damage, internal short circuit or a hot environment.

15. Why do batteries fail?
Batteries can fail for a multitude of reasons, but common reasons are:
• High or uneven temperatures
• Inaccurate float charge voltage
• Loose inter-cell links or connections
• Loss of electrolyte due to drying out or damaged case
• Lack of maintenance, aging

16. How is battery performance generally measured?
Batteries are generally rated for 100+ discharges and recharges, but many show a marked decline in charging capacity after as few as 10 discharges. The lower the charge the battery can accept, the less runtime it can deliver. Look for batteries with a high-rate design that sustains stable performance for a long service term.
Factors affecting battery life

All UPS batteries have a limited service life, regardless of how or where the UPS is deployed. While determining battery life can be tricky, there are four primary factors that contribute to a battery’s overall lifespan.

1. Ambient temperature

Because the rated capacity of a battery is based on an ambient temperature of 25°C (77°F), any variation from this can affect performance and reduce battery life. For every 8.3°C (15°F) average annual temperature above 25°C (77°F), the life of the battery is reduced by 50 percent.

2. Battery chemistry

UPS batteries are electro-chemical devices whose ability to store and deliver power slowly decreases over time. Even if all guidelines for storage, maintenance and usage are followed, batteries will still require replacement after a certain period of time.

3. Cycling

After a UPS operates on battery power during a power failure, the battery is recharged for future use, which is called the discharge cycle. At installation, the battery is at 100 percent of its rated capacity, but each discharge and subsequent recharge slightly reduces its relative capacity. Once the chemistry is depleted, the cells fail and the battery must be replaced.

4. Maintenance

For larger UPS models, service and maintenance of batteries are critical to its reliability. Periodic preventive maintenance not only extends battery string life by preventing loose connections and removing corrosion, but can help identify ailing batteries before they fail. Even though sealed batteries are sometimes referred to as maintenance free, they still require scheduled service, as “maintenance free” refers only to the fact that they don’t require replacement fluid.