DCD INTELLIGENCE

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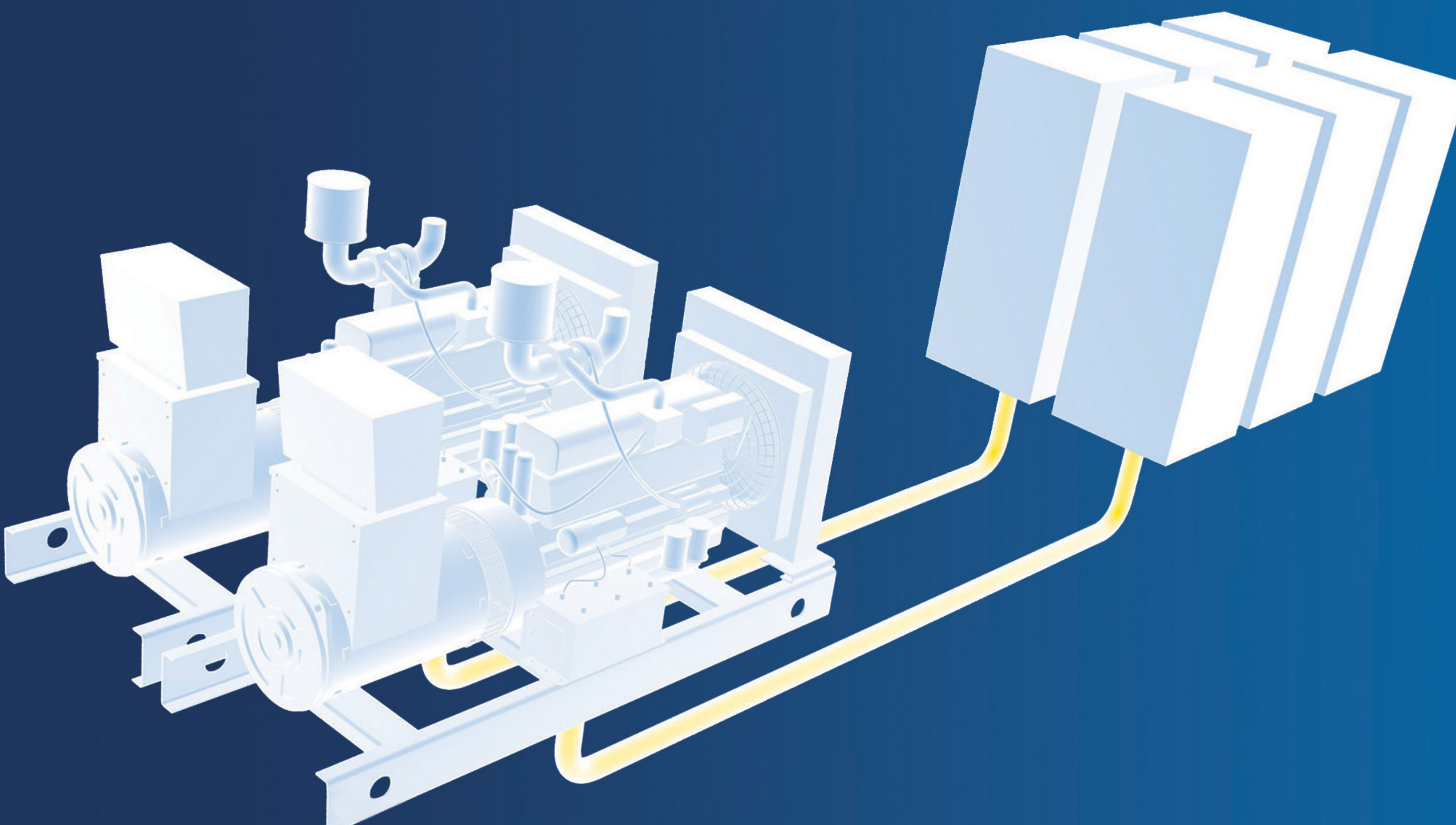
GLOBAL TECHNOLOGY BRIEFING

POWER OPTIMIZATION BEST PRACTICES



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EXECUTIVE SUMMARY

The progression of the data center mirrors how power is provided, measured, and used for maximum efficiency. The importance of data center power delivery is paramount. In the past, the data center's power chain was designed to support where the business was predicted to be in 10 to 15 years.

Now, pressures to operate efficiently to reduce costs, increase IT capacity, and move to a cloud model have forced a shift in thinking on how power is being generated, designed, and managed in the data center. The data center itself is becoming a source of revenue rather than just a cost. This means that operating a facility that can scale real-time based on business demands requires smarter capital investment and higher operating margins. This evolution gives more weight to efforts to decrease operating expenses (OPEX) and increase capacity through more efficient power distribution and avoidance of costly outages.

Yet, there exists a gap between efficiency monitoring and consumption with many data center managers. According to DCD Intelligence, 46 per cent of data center managers continuously monitor efficiency, yet 68 per cent watch consumption closely as a key energy parameter. The takeaway is simple — if you can't measure it, you can't manage it as management guru Peter Drucker once said.

This report details current data center approaches, challenges, and standards. It also covers Anixter's concept of the intelligent power chain, which includes the entrance feed, UPS systems, room and cabinet distribution, and the IT equipment. The report concludes by exploring the future of the data center including power, industrytrends, and energy technologies and what they mean for owners, managers, and operators.

The same basic principles apply to all different approaches to a data center, including on-premise enterprise facilities, co-location, or cloud. What is different is ownership and responsibility of the equipment. For example, a multi-tenant data center will likely own the UPS and generator functions, whereas the enterprise customer co-located there is responsible for what is inside the server cabinet.

The majority of this paper will focus on the data hall and rack-level distribution, because it is easier to modify in a retrofit environment, representing the majority of today's data center activity. In addition, roughly 60 per cent of the total power generated for the facility is consumed by IT equipment, according to DCD Intelligence. Bottom line, you can make a big impact — even with a limited budget — when you focus on optimizing power within the data hall and cabinet. So, while all components of a data center is important, this paper is weighted towards those areas that will provide the maximum benefits from applying an intelligent power chain approach.

According to DCD Intelligence, 46% of data center managers are continuously monitoring **efficiency**, yet 68% continuously monitor **consumption**.

INTRODUCTION

THE EVOLUTION OF DATA CENTER REQUIREMENTS

Increasing requirements for continuous accessibility to the Internet — more processing and more storage, for example — have driven the need to increase IT capacity. Other drivers include:

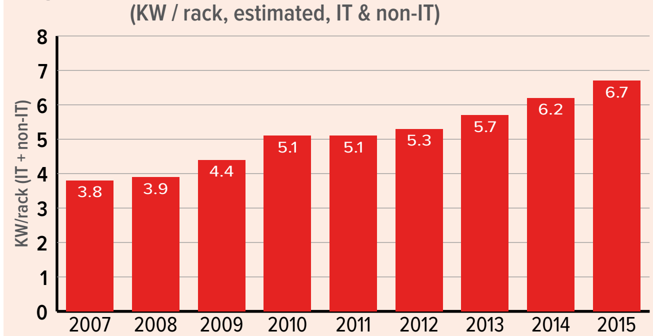
- High-performance computing requirements
- Increased use of Internet communication and streaming entertainment
- Retail, banking, and financial institutions increased online availability and transactions
- Digitization of healthcare and government records
- Migration toward online business models
- Heightened information and national security requirements
- Video surveillance now moving to IP-based video storage.

To keep up with increasing computing demands, IT is constantly adding servers. However, because space comes at a premium, facility operators face severe constraints in housing additional IT equipment. As a result, servers have been designed to incorporate higher processing power in less space. This type of server consumes three to five times more power than previous generations in the same footprint, so power densities per rack are on the rise.

Higher power demands have necessitated investment in the IT support infrastructure, namely physical cabling, network hardware, and server and storage systems. However, in today's economy the business is pressuring facilities and IT managers to reduce operating expenses, improve space utilization, enable virtualization and cloud technologies, and improve sustainability. How can a data center make strides in improving operating efficiency through new capital investment? The answer lies in the power chain.

According to DCD Intelligence, 27 per cent of data center operating costs are spent on facility power. By increasing the efficiency of the hardware throughout the power chain, operating expenses will theoretically be reduced. This optimization can be done by using scalable, modular systems that will help limit data center capital investment and will allow for growth as IT needs dictate. Measuring at different points along the power's path will provide the data needed to tune the system so it is running as efficiently as possible, and it will also help make sure space is being used effectively.

Figure 1: Data Center Global Density Per Rack (KW / rack, estimated, IT & non-IT)



Source: DCD Intelligence

LEGACY POWER DESIGN

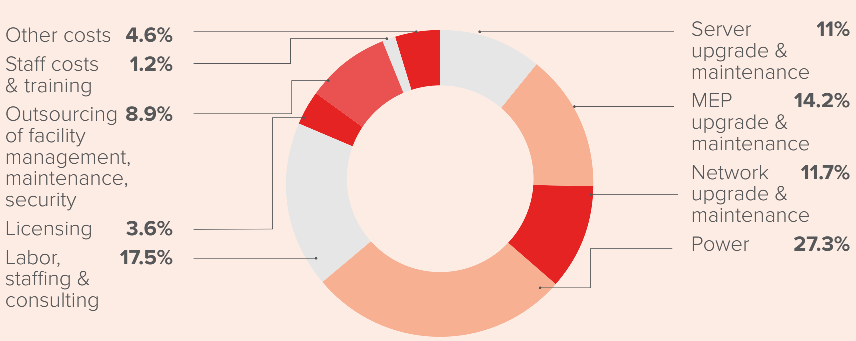
The modern data center consumes more power per square foot than ever, yet many of the same methods and technologies for power distribution to IT equipment has remained the same for decades.

Legacy power designs that are over the 10-year mark are rigid and have limited ability to scale. These systems required high upfront capital investment and were designed to support more than 10 years of IT growth with limited software integration capabilities.

Social and economic drivers have led to the construction of data centers that are designed with a fixed amount of power despite rapidly changing IT needs—namely unpredictable IT requirements that lead to capacity fluctuations. Having a view into the total power chain is critical to ensure capacity is being managed effectively and efficiency goals are met. Having this complete view also prevents unnecessary outages that can lead to downtime, ultimately resulting in a potential cost in the hundreds of thousands of dollars. In addition, today's applications require more processing power from servers though smaller footprints are increasingly the norm. Couple that with the virtualization trend, and one can see why power densities per cabinet are rising. So how does your data center address these issues and support your business's application-focused needs? Whether your data center is a co-location facility or enterprise, you need to budget and have a contingency plan that addresses all of these challenges.

Designing an intelligent power chain requires careful planning, weighing performance versus costs, and scalable hardware and useful analytics to capture insightful data that will help companies quickly adapt to changing IT requirements.

Figure 2: Annual Data Center Operating Costs (%)



Source: DCD Intelligence

COST OF OUTAGES AND DOWNTIME

Every IT team understands that downtime has the potential to significantly impact the profitability of its business. In extreme cases, an outage can seriously threaten the viability of an enterprise.

Take for example the Singapore Stock Exchange (SGX) outage that closed one of the world's biggest exchanges for almost three hours on November 5, 2014, after its systems failed to cope with a voltage fluctuation caused by a lightning strike. Ultimately, it was discovered that a flaw in the design of the electrical infrastructure failed to prevent the outage, which was attributed to human error on the part of third-party contractors. This was followed by another three-hour outage due to a software error one month later.

The financial fallout and damage to the exchange's reputation was nothing short of devastating. Besides the millions of dollars in revenues lost during the outage, SGX spent 15 million USD to address the flaw and another one million USD on an education fund to help restore investor confidence. The country's regulatory authority also imposed a moratorium on exchange fee increases due to the outage, until an overseeing committee could guarantee the issues were addressed.

In a survey conducted by the Ponemon Institute, the results clearly illustrate the substantial economic impact of data center downtime to the bottom line. The analysis was based on 67 independent data centers located in the United States, querying five key categories of functional leaders.

Some of the key takeaways from the study were related to the financial impacts around outages and how they are increasing. The cost now ranges from 45 to 95 USD a square foot or a minimum of 74,000 to 1.7 million USD per organization in the study.

Also, 83 per cent of survey respondents knew the cause of the outages. The most frequently cited root causes were:

› UPS battery failure – 55 per cent

› UPS capacity exceeded – 46 per cent

› UPS equipment failure – 27 per cent

› PDU/circuit breaker failure – 26 per cent

Clearly, just this small sampling of outage examples demonstrates what downtime can do to a business, with the damage multiplying exponentially according to the size of the business. Outages are inevitable. They are going to happen. However, there are steps that can be taken to reduce the likelihood and duration of outages in the future.

Source: Cost of Data Center Outage: Ponemon Institute, December 2013

SURVEY OF 67 INDEPENDENT DATA CENTERS		
Facility manager	CIO	DC manager
CTO	IT compliance	Security officer
The cost per square foot of data center outages now ranges from 45 to 95 USD	Minimum cost of 74,223 USD to a maximum of 1,734,433 USD	

MAJOR CAUSES OF OUTAGE		
UPS system failure	Accidental error	Weather
CRAC failure	Generator failure	IT equipment failure
• UPS battery failure • UPS capacity exceeded • PDU/circuit breaker failure • UPS equipment failure		

TOP CHALLENGES AND CONCERNS

Many data center power decisions and product choices aim to address and solve the following challenges and concerns.

Preventing accidental outages

Recent research shows that 73 per cent of data center downtime is caused by human error, according to Rick Schuknecht, Uptime Institute vice president. These types of outages can be caused by poor performance in the areas of training, maintenance, and operational governance. The majority of outages are accidental. You can have the most robust system money can buy, but if someone accidently unplugs something he isn't supposed to, it will still cause an outage.

Understanding capacity needs

Measurement of capacity throughout the entire power chain is vital to ensure facilities can effectively support future IT needs. Poor capacity planning can lead to outages and delays in deploying new business applications. On the other hand, proactive capacity planning helps to make sure the power chain is optimized and power is there when it is needed.
In some data centers, an opportunity may exist for better collaboration in gauging capacity needs.

Power chain visibility

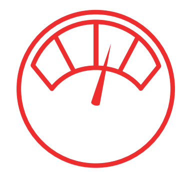
Having visibility into the entire power chain is important in order to "tune" the system to make sure it is being run as efficiently as possible. According to the Green Grid Association, to have full insight into an infrastructure's energy efficiency, multiple components from the utility entrance through the IT equipment should be monitored. In addition, having this information gives facilities and IT the full picture to better make deployment decisions on new equipment.

Budgeting of the unpredictable

IT hardware requirements are constantly in motion. They are being driven based off the business applications that they need to support. Facilities managers are being pressured to reduce operational expenses by running as lean and efficiently as possible. It becomes a challenge to do that when the infrastructure that needs to be supported is a moving target.

Performance versus investment costs

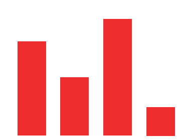
Weighing design decisions with available budget is always an issue. What is the right balance? How can you design a system that is resilient at a reasonable cost? The reality is more complicated than it used to be. According to DCD Intelligence, the major investment drivers growing year on year have to do with the data center becoming a strategic rather than just an operational resource. Does it make more sense for the business to move the data center to the cloud? Have needs shifted due to a recent acquisition or significant market change? Can the current data center still support the business?



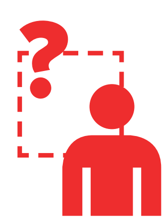
Cannot gauge CAPACITY needs

Lack of TOTAL POWER CHAIN visibility

PERFORMANCE vs COST



Budgeting of unpredictable IT REQUIREMENTS



PREVENTING accidental outages

DATA CENTER POWER STANDARDS

Standards have enabled our industry to effectively get on the same page, empowering faster advances in technology. In the early days of data centers, many facilities were designed in the absence of established standards, especially as it related to power distribution. Even today, many network administrators face the challenge of making power distribution choices and deciphering how to properly implement them without the benefit of well-researched, documented, and methodical standards.

The following is a selective offering of power distribution standards.

ANSI/TIA-942-A: Telecommunications Infrastructure Standard for Data Centers
The purpose of the ANSI/TIA-942 standard is to provide requirements and guidelines for the design and installation of a data center or computer room. It is intended for use by designers early in the building development process and covers site space and layout, cabling infrastructure, tiered reliability, and environmental considerations.

As it relates to power, the ANSI/TIA-942-A standard offers an overview on the following categories:

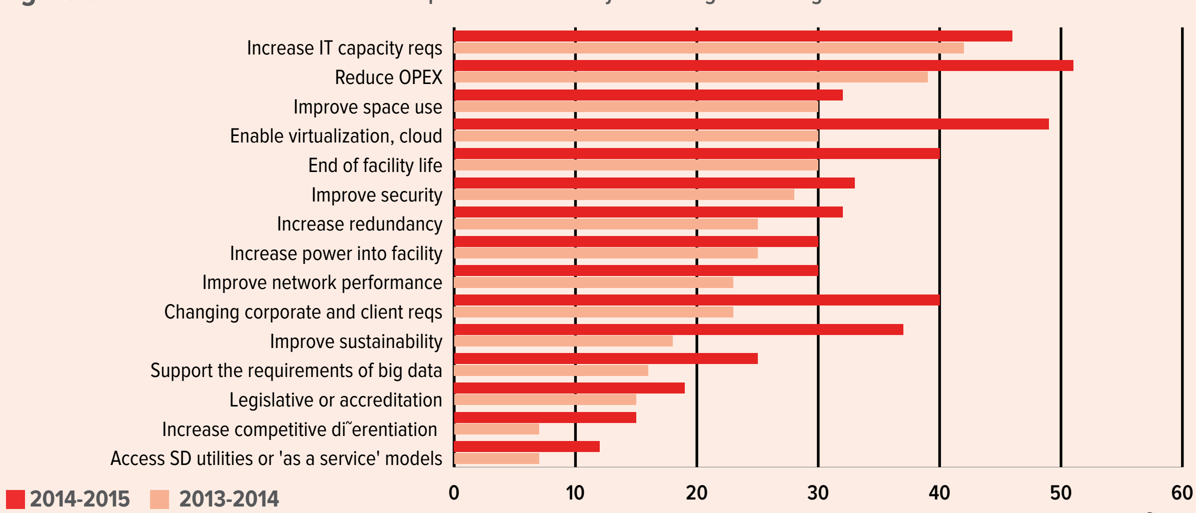
› Utility service entrance and primary distribution
› Standby generation
› Uninterruptible power supply (UPS)
› Computer power distribution
› Data center grounding infrastructure
› Building management system

ANSI/BICSI 002-2014: Data Center Design and Implementation Best Practices
The BICSI standard is primarily a data center design standard with installation requirements and guidelines related to implementing a design.

BICSI offers insight into everything from data center site selection, electrical systems, mechanical systems, fire protection, data center management, and building systems and telecommunications cabling. As it relates to power, the BICSI standard offers a comprehensive guide into the following areas:

› Utility service
› Distribution
› Mechanical equipment support
› Uninterruptible power supply (UPS) systems
› Standby and emergency power systems
› Automation and control
› Lighting
› Bonding, grounding, lightning

Figure 3: Data Center Investment Drivers: Operational Efficiency and Outage Risk Mitigation



Source: DCD Intelligence

DATA CENTER POWER STANDARDS

- protection, and surge suppression
- Labeling and signage
- Testing and quality assurance
- Ongoing operations
- Electrical systems matrix

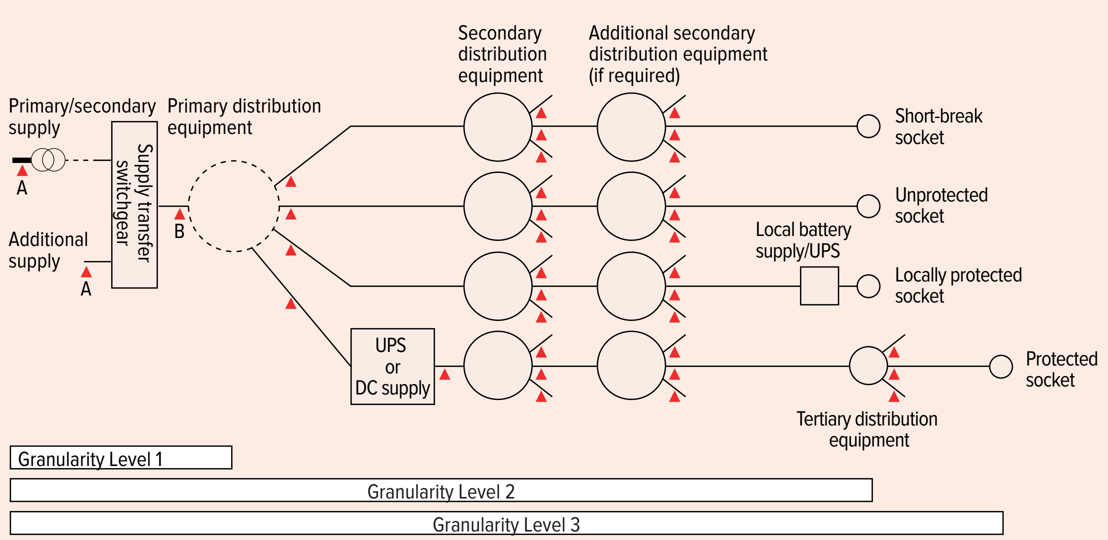
European Committee for Electrotechnical Standardization (CENELEC)
EN 50600: Information technology: Data center facilities and infrastructures
CENELEC has developed a series of European standards for data centers. This document specifies recommendations and requirements to support the various parties involved in the design, planning, procurement, integration, installation, operation, and maintenance of facilities and infrastructures within data centers.

The EN 50600-2-2 standard focuses specifically on power distribution and specifies requirements and recommendations for the following:

- Power supply and distribution within data centers
- Dimensioning of power distribution systems
- Availability
- Power supply
- Power distribution
- Incorporation of LVDC distribution
- Emergency power off (EPO)
- Energy efficiency enablement and power distribution

The EN 50600-2-2 standard also addresses using intelligence to improve

Figure 4: Possible Power Chain Measurement Points



Source: CENELEC EN 50600-2-2 Section 8 Energy Efficiency Enablement and Power Distribution

DATA CENTER POWER STANDARDS

data center power efficiencies, outlining three levels of granularity:

LEVEL 1
Provides simple global information for the data center as a whole

LEVEL 2
Provides detailed information for specific facilities and infrastructures within the data center

LEVEL 3
Provides granular data for elements within the spaces of the data center

Uptime Institute data center site infrastructure tier classification system
Even though it's not necessarily a standard, the Uptime Institute is recognized for the creation and administration of tier classifications and certifications that enable data centers to achieve their mission while mitigating risk. The classification system establishes four distinctive definitions of data center site infrastructure tier classifications and the performance confirmation tests for determining compliance to the definitions. The tiers can be defined as follows:

- Tier I: basic site infrastructure
- Tier II: redundant site infrastructure capacity components
- Tier III: concurrently maintainable site infrastructure
- Tier IV: fault tolerant site infrastructure

Table 1: Uptime Institute Tier Requirements Summary

	Tier I	Tier II	Tier III	Tier IV
Activity capacity components to support the IT load	N	N+1	N+1	N after any failure
Distribution paths	1	1	1 active and 1 alternate	2 simultaneously active
Concurrently maintainable	No	No	Yes	Yes
Fault tolerance	No	No	No	Yes
Compartmentalization	No	No	No	Yes
Continuous cooling	Load density dependent	Load density dependent	Load density dependent	Class A

DEFINING THE FIVE BEST PRACTICES OF AN INTELLIGENT POWER CHAIN

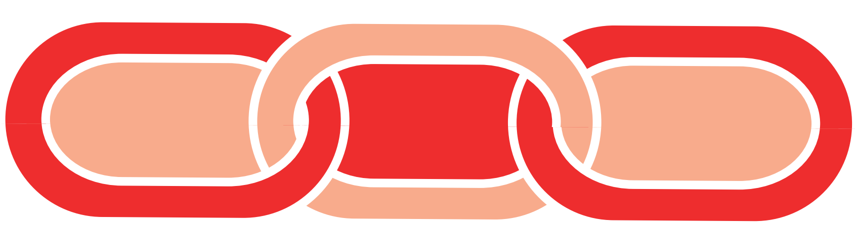
Anixter defines the intelligent power chain for data centers as a combination of the right hardware (intelligent hardware design) and the right analytics (software for data collection). Data centers that execute on the concept of the intelligent power chain can gain substantial benefits.

- Improved overall power system efficiencies – for more efficient power distribution to IT load
- Better capacity planning and management – design closer to capacity with option to scale as needs grow, better understand your capacity ahead of time, and free up stranded capacity to extend the life of the facility
- Reduce risk of outages – proactive monitoring (data/analytics) that helps you identify trends and understand potential problems before they create an outage; create a clear business process to mitigate and resolve outages quickly

The following sections will examine five key areas where the application of the intelligent power chain concept will make the most difference in the dependability and efficiency of data center power distribution.

Anixter defines the intelligent power chain for data centers as the right hardware (intelligent hardware design) with the right analytics (software/data collection).

THE INTELLIGENT POWER CHAIN



IMPROVED OVERALL efficiency

BETTER CAPACITY management

REDUCED RISK of outages

BEST PRACTICE 1 OF 5

ENTRANCE FEED

1

The data center entrance feed is the gateway that connects a facility with power utilities. Proper selection and sizing of the medium-voltage feeder cable from the utility to the service entrance can save a business a significant amount of investment capital. Paired with monitoring and measurement of the critical power applications, it will help to prevent downtime and improve efficiency.

Sizing

The ampacity of the cable should equal or exceed the maximum current the cable will be expected to carry during its service life. Conductors that are undersized can overheat, cause damage to the insulation or jacket of the cable, and potentially cause harm to equipment or people. It's better to install a cable with a higher ampacity rating versus one that is too small, allowing for future growth.

Jacket type

Data centers aren't industrial settings, so PVC tends to be a popular and suitable choice for the jacket. Most facilities in the U.S. use EPR insulation because of its excellent mechanical properties, high resistance, and durability.

Termination

As far as termination, medium-voltage cables require a special on-site termination. An experienced installer will ensure this is done correctly. Testing should be conducted to measure current and any discharge coming off the cabling after termination. This will help ensure that the cabling, once installed, is terminated correctly and performing properly.

Testing

Besides cabling installation, testing is another vital area for the entrance feed cabling system. Field tests can be broadly grouped into three categories:

- Acceptance
- Maintenance
- Fault location testing

Conducted on wire or cable after an installation but before placing it into service, an acceptance test detects installation or shipping damage that might affect cable performance. After the cable has been placed in service, maintenance tests detect in-service deterioration. Fault location tests pinpoint the exact failure site in a cable. Identifying the failure point of a cable permits the cable to be repaired or replaced as necessary.

Deployment

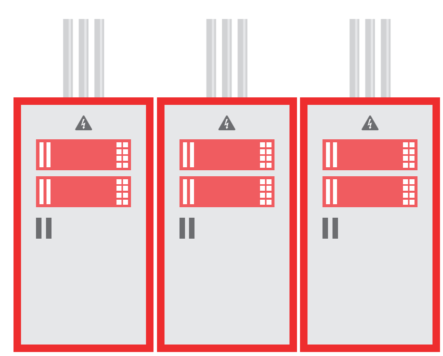
Medium-voltage cables for data centers are a heavier type of cabling installation. They contain larger conductors that may be difficult to work with and move. Installation can put a significant amount of stress on cabling, so it is important to:

- Allow for adequate clearance between conduit and cable
- Use suitable lubrication — there are a number of commercially available wire pulling compounds (many of which are UL Listed)
- Avoid sharp bending of the cable at the first pulley in overhead installations
- Use sufficient rollers to stop cable from dragging on the tray.

Monitoring the entrance feed

Consider monitoring at the point of utility service entry into the building. A power meter can be installed directly on the low- or medium-voltage switchgear that brings the incoming utility power into the building. The meter can be mounted on the wall or inside the switchgear cabinet, but it is typically mounted into a cutout in the front panel of the switchgear cabinet for easy viewing without opening the equipment. The meter has a wiring harness that connects current transformers (CTs) to the incoming three-phase power to deliver measurements of voltage, current, and frequency. Based on that data, the meter can calculate watts or kVA. Consider meters that use Modbus or Ethernet so the data can easily be pulled into a data center infrastructure management (DCIM) or building management system (BMS) software without the use of protocol converters.

ENTRANCE FEED



BEST PRACTICE 2 OF 5

UPS SYSTEMS

2

An uninterruptible power supply is one of the cornerstones of the data center; it offers essential protection against disruptions that would otherwise result in downtime, lowered productivity, and even server hardware issues. Power costs are high and all power required by the critical IT load comes from the UPS, which means subtle gains in efficiency could mean savings of hundreds of thousands of dollars per year. According to a DCD Intelligence survey, the two highest drivers for investing in a new UPS were to reduce operating expenses and the need to increase capacity.

Legacy UPS systems, or systems 10 to 15 years old, are on average 5 to 15 per cent less efficient than their modern-day counterparts. In addition, modern UPS systems are much more efficient at smaller loads, which is typical with data center designs (less than 40 per cent utilization). Selecting the best UPS for your enterprise takes a thoughtful and methodical process that marries the ideal hardware configuration with analytics. Your UPS system should meet the unique needs of your computing equipment, as well as be aligned with your energy management and power distribution strategy.

The types of data center UPS systems can be broken down into three categories:

- Offline
- Line interactive
- Online double conversion

Offline and line interactive UPS systems are rarely used by data center operators, largely because of long switch-over times and load problems. Online double-conversion UPS systems constitute the vast majority of data center UPS systems. That's because this technology creates new and clean wave versus an offline or line-interactive UPS that just filters the power, thus an online double-conversion UPS is better suited for mission-critical applications.

UPS design considerations

When it comes to the various technologies and design factors that make up a data center UPS system, there are several innovative and highly useful variables that you should consider. The following is an overview of these design considerations with some guidance on how they may factor into your UPS purchasing decision.

Legacy UPS systems are on average 5 to 15 per cent less efficient than their modern-day counterparts.

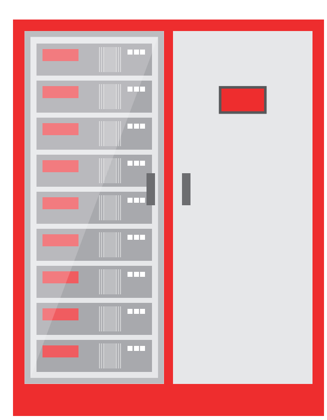
Modular UPS systems

One UPS design consideration that can help data center operators decrease energy waste by scaling as the IT needs dictate is the introduction of modularity. The closer a UPS operates to its full load capacity, the more efficient it will be, so modularity can allow operators to adjust the size of the UPS system based on the needs of the IT equipment. Modular UPS designs can either scale through hardware modules or use software-based activation keys.

Modular UPS systems have several key benefits:

- Avoid term overspending in capital and defer capital expenditures (CAPEX) until needed
- Buy only the power components needed, reducing installation and maintenance costs

UPS SYSTEMS



› Provide internal N+1 capability, reducing redundancy costs and floor real estate

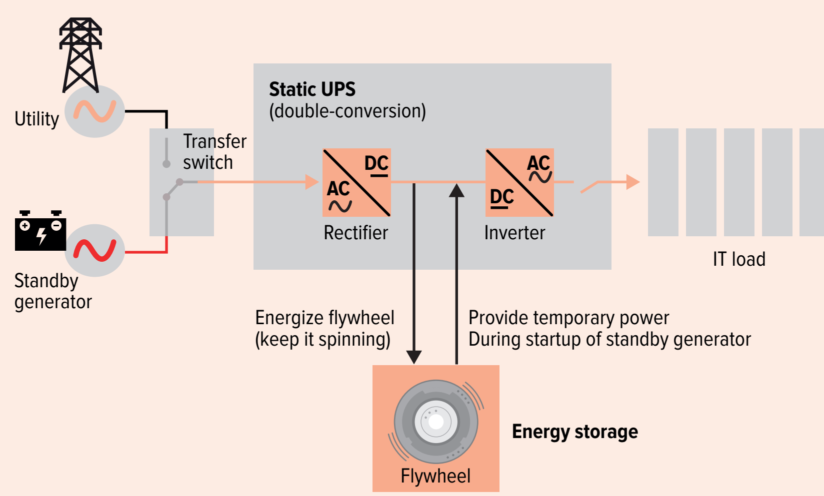
The last point is an important one. If you choose a modular UPS system, make sure the architecture allows for the scaling of UPS capacity to closely match your actual load. Doing so will have the most substantial impact on efficiency.

Transformerless UPS systems
In the past, many legacy UPS solutions had a permanent transformer installed onboard that increased its physical size and weight and reduced its efficiency. There are reasons why a transformer might be required. For example, there might be a need to include stepping down voltage from 480 V to 208 V because the mains voltage is not the same as the voltage used by the IT equipment, which is common in North America.

Nowadays, many UPS solutions are omitting the transformer, thereby increasing UPS efficiency and allowing for greater flexibility for placement. Today's transformerless UPS systems are not only significantly smaller and lighter than transformer-based systems, but also more efficient, more reliable, and better equipped to limit fault current. In addition, they enable companies to capitalize on sophisticated features such as the energy saver system and variable module management system, which add reliability via reduction of mechanical complexity while lowering power costs.

It's because of these advantages that transformerless UPS designs are becoming more wildly adopted. In fact, today's transformerless UPS designs outnumber older technologies by a factor of two to one for new installations in North American data centers. According to IHS Technology, high single-digit growth rates are expected over the next five years in transformerless UPS systems, outpacing the growth of traditional transformer designs.

Figure 5: Flywheel UPS System



Source: Green Data Center Design

Flywheel UPS systems
Flywheel systems store energy kinetically, using the inertia of a spinning mass to store and regenerate power. They are mainly used to provide load leveling for large battery systems, such as an uninterruptible power supply for data centers, because they save a considerable amount of space compared to battery systems.

Flywheel systems in production as of 2001 have storage capacities comparable to batteries and faster discharge rates. Newer flywheel systems completely levitate the spinning mass using maintenance-free magnetic bearings. There are several key advantages to flywheel UPS system use in a data center:

› Less mass that creates a lighter, more compact footprint, saving premium data center space and making weight less of a consideration in floor design
› Excellent energy efficiency with minimal heat generation
› Reduced noise, with the flywheel, coolant pump and fan typically only operating when needed

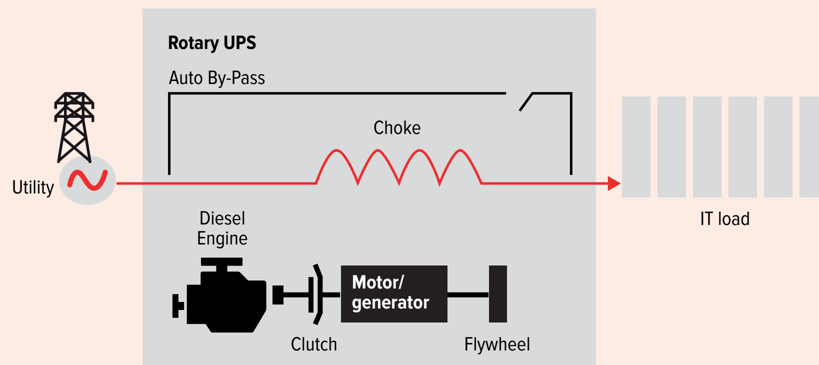
- Relatively simple installation
- Low maintenance, with routine replacement of bearings every five to 10 years, with some newer models eliminating mechanical bearing maintenance and failures

Diesel rotary UPS systems
Data centers rely on an uninterruptible and continuous power supply, and generally a diesel-generator back-up system is a requirement. Diesel rotary uninterruptible power supply devices (DRUPS) combine the functionality of a battery-powered or flywheel-powered UPS and a diesel generator.

When mains electricity supply fails, stored energy in the flywheel is released to drive the electrical generator, which continues to supply power without interruption. At the same time (or with some delay, for example two to 11 seconds, to prevent the diesel engine from starting at every incident), the diesel engine takes over from the flywheel to drive the electrical generator. The electromagnetic flywheel can continue to support the diesel generator in order to keep a stable output frequency. Typically a DRUPS will have enough fuel to power the load for days or even weeks in the event of failure of the mains electricity supply. Some advantages of a DRUPS compared to a battery-powered UPS system include:
- Higher overall system energy efficiency
- Smaller footprint
- Use of fewer components
- Longer technical lifetime (no use of power electronics)
- No chemical waste (from batteries).

ENERGY STAR certified UPS
- The ENERGY STAR program specification for UPS systems establishes minimum average efficiencies based on different input dependency characteristics – voltage and frequency dependent (VFD), voltage independent (VI), and voltage and frequency independent (VFI)
- Rated output power goes from less than 1,500 kVA to greater than 10,000 kVA.
- Load profiles range from 25, 50, 75, and 100 per cent load

Figure 6: Diesel Rotary UPS System



Source: Green Data Center Design and Management

New, efficient UPS products generally range from 92 per cent to 95 per cent efficient. An ENERGY STAR qualified UPS can cut energy losses by 30 to 55 per cent. A 1,000 kVA UPS used in a large data center could save 18,000 USD annually.

Eco-mode operation
The “eco-mode” with today’s data center UPS system – also known as “high-efficiency mode,” “bypass mode” or “multi-mode” is a method of operating the UPS through the bypass line at a reduced power filtration in order to obtain improved electrical efficiency and save energy. Most surveys indicate that eco-mode (or similar technology) can provide a reduction of approximately two per cent in data center energy consumption.

Eco-mode offers efficiency due to the bypass path, which is typically between 98 and 99 per cent, as compared to the base UPS efficiency of 94 to 97 per cent. The downside is that the IT load is exposed to raw utility mains power without normal conditioning from a double-conversion, online UPS. The UPS must continuously monitor the mains power and quickly switch to the UPS inverter when a problem is detected, before the problem can affect the critical load. More advanced UPS systems with eco-mode have integrated technology that mitigates these risks substantially.

Nevertheless, many data center operators do not use eco-mode, mainly due to risks associated with electrical protection and reliability as described above. These risks vary depending on the design of a data center's electrical architecture and the exact UPS eco-mode design approach and functionality. When the risks and rewards are weighed, some operators opt to forego the energy savings to avoid potential issues, while others will take steps to mitigate the risks and choose to use eco-mode. One crucial step that will help to avoid any negative impact of eco-mode is to ensure that the utility power is in an acceptable voltage tolerance of the UPS system's voltage settings.

Three benefits of running a UPS in eco-mode include:

- Less generated heat, which puts less strain on the cooling system
- PUE improvements
- Energy savings increases (exact savings dependent on data center size).

Bottom line, eco-mode does involve some risks, but advances in eco-mode technology have significantly reduced these risks and have done so at only a small cost in efficiency. When evaluating a UPS system and the use of eco-mode, pros and cons should be weighted.

UPS and battery health monitoring

There are two areas of visibility that are vital to the success of any data center: UPS monitoring and battery health monitoring.

To effectively manage and monitor UPS systems, consider these action items:

- Make sure the UPS system has Ethernet connectivity to simplify integration into existing monitoring systems.
- Integrate data into a building management system or a DCIM solution so when there is an issue both facilities and IT are notified.
- Look for UPS systems with an onboard LCD display that shows status information.

Battery health monitoring is the other important front. According to the Ponemon Study on data center outages, 55 per cent of respondents who reported an outage attributed the issue to UPS battery failure. Additionally, the same report revealed that only 46 per cent feel that the UPS batteries are regularly tested and monitored.

There are four factors that can impact battery life:

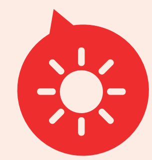
- Ambient temperature
- Battery chemistry
- Cycling
- Maintenance

It's important to ensure guidelines for proper storage, temperature, usage, and maintenance, which contribute to battery life, are followed.

How long should batteries last? The Institute of Electrical and Electronics Engineers (IEEE) defines "end of useful life" for a UPS battery as the point when it can no longer supply 80 per cent of its rated capacity in ampere-hours.

Battery monitoring software can be a feature of a modern UPS or standalone. Look for solutions that provide some form of visual health indication so you know if the battery is functional. You also want to be able to access data remotely with real-time alerting.

SOME OF THE BENEFITS OF RUNNING IN ECO-MODE INCLUDE...



More efficient UPS generates less heat, putting less strain on the cooling system

PUE improvements

Energy savings increases (exact savings dependent on data center size)

BEST PRACTICE 3 OF 5

ROOM DISTRIBUTION

3

Power distribution technology has advanced substantially in efficiency, density management, monitoring capabilities, and flexibility. The options available for data centers are greater than ever, allowing facilities to more accurately align the needs of IT. Changes in how power is deployed in data centers has been largely driven by the desire to be more efficient and better manage capacity.

Applying the concept of the intelligent power chain – an efficient hardware configuration planned for variable capacity demands and tuned for application optimization – is paramount in this area because it touches upon so many different aspects of data center functionality.

Modular PDUs

Modern data centers must meet rapidly increasing demands, so alternative power distribution approaches, such as modularity, are starting to become more prevalent. Modularity can help provide benefits such as greater reliability, flexibility, and easier manageability.

Modular options provide the following advantages:

- Integrated branch circuit monitoring
- Generally require less floor space than traditional PDUs
- Transformerless options increase efficiencies

Preterminated power whips

Overhead or underfloor cabling from the floor PDU can be run to feed the rack PDUs. The cables can be preterminated to simplify on-site deployment. A best practice in a raised-floor environment is to distribute power cabling overhead to allow for more efficient airflow delivery from perimeter cooling systems.

Busway distribution

The use of overhead busway systems in data centers is typically comprised of busway sections, or straight lengths containing busbars, as well as a slot for continuous access. Tap off boxes, or plug-in units containing circuit protection and wiring devices, are also typically integrated into a busway distribution system.

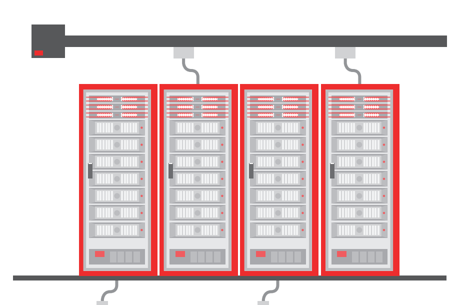
Busway systems can provide an overhead power distribution solution that integrates valuable features. These can include branch circuit monitoring via integrated or retrofittable metering units, as well as flexible design configurations that allow operators and data center architects to simplify layouts, add components, and make any other needed changes quickly and easily. This flexibility also accommodates varying voltages and rack densities through the use of customizable tap off boxes.

In addition, a data center horizontal bus distribution system:

- Provides visual control on rack loading, whips, and rack PDUs
- Speeds up and minimizes coordination and costs for upgrades and changes
- Is simple and safe to install installation

The growth of busway systems is a direct result of these practical advantages. According to IHS Technology, overhead

ROOM DISTRIBUTION



busbar systems are expected to grow in the high single digits within the next five years.

Higher voltage delivery
In North America, typical data center voltages are 120 V and 208 V, which inherently have some inefficiencies when compared to the 230 V used in Europe and Latin America (240 V in Australia). IT equipment manufacturers typically design their power supplies to accept up to 240 V, due to the differences in voltages around the world. A general rule of thumb is the higher the current (amps), the higher the electrical losses and cost of energy.

In addition, higher overall efficiencies throughout the power chain result in:

- Less current and heat for lower cooling costs
- Reduced copper costs, due to the thinner wire required for higher voltage and less current
- Less transformers because you can consolidate floor PDU transformers into a single transformer sized to the UPS capacity
- Increases in floor space because you can move the transformer outside the room, freeing up space for IT equipment.

But higher voltage isn't without its downside. Like any attempt to maximize efficiency, complications may reduce the potential gains. One such complication is the added costs associated with running a full neutral connector within the system to all the distribution points. Another risk is that equipment needs to handle higher levels of available fault current, so more expensive branch breakers with higher interrupting current ratings are needed.

It is recommended due to the nuances associated with high-voltage power designs that data center operators should:

- Apply higher voltage to new (greenfield) data center designs, or self-contained "pods" within an existing data center
- Consider rack PDUs that provide distribution breaker options capable of delivering high-interrupting capacities
- Use rack PDUs that provide current overload protection for connected loads

According to a recent report by IHS Technology, 400 Vac rack PDUs have recently grown in adoption in North America, which means higher voltage delivery from the floor PDU versus traditional 208 V power distribution. This trend has largely been driven by new, large data center build-outs.

According to IHS Technology, use of 400 Vac rack PDUs is growing in North America largely due to new data center build-outs.

Branch circuit monitoring
Power monitoring provides the data needed to:

- Prevent downtime
- Better manage capacity
- Improve efficiency

It's a tool that provides insight to use power more wisely and efficiently through greater transparency into energy usage. Today's operators understand the value of branch circuit power monitoring. However, to maximize its effectiveness, it's also important to implement best practices.

One best practice is using hardware that provides utility-grade accuracy, or within one per cent of the actual amount of power consumed. Although most data center power meters claim to offer accuracy that is within five per cent of the actual power utilization, a utility-grade level of accuracy enables co-located and other data centers to fairly rebill clients for the cost of energy.

It's also vital to incorporate both flexibility and adaptability within your data center.

With the variety of power distribution products and suppliers, your power monitoring system has to be able to work with all of them. So it's vital to have a platform that ensures compatibility with your equipment as well as various amperage sizes and circuit configurations.

Another consideration is the use of standard, not proprietary, communication protocols for the hardware used to collect the power data. Whether SNMP, Modbus TCP, or BacnetIP, you need to make sure that you can integrate the meters with a DCIM or BMS system. Metering platforms should support all power distribution products, communicate easily with the software, and interact seamlessly with the other data center components as well.

Finally, look for a power monitoring solution with robust and rich functionality. Most monitoring solutions use a complex and costly network of protocol conversions, middleware, and data interpretations to give operators and staff the most complete picture of power usage. Look for useful and practical features such as onboard Ethernet, onboard data logging, onboard alarming, and a Web interface that can reduce the failure points and cost associated with a monitoring deployment.

Metered power cables

Another monitoring option available today is the integration of metered power cables that can provide a host of valuable real-time information and analytics. These products feature the same power monitoring components found in many rack PDUs packaged in a unique power cord format. Intelligent power cables can provide a host of monitoring options, such as tracking temperature, humidity, and pressure.

Look for useful power monitoring features such as onboard Ethernet, onboard data logging, onboard alarming, and a Web interface.

These cables are typically self-powered by the line voltage with some products having the capability to wirelessly transmit detailed power information and self-configure with other nearby compatible cables. A key benefit to using this type of cable is with installations where the operator might not have the ability to install intelligent PDUs in the cabinet. For instance, some SAN solutions have everything integrated into the SAN cabinet. These cables are installed just upstream of the cabinet, allowing for data capture without voiding the SAN provider's warranty.

In addition, metered power cables are ideal for a retrofit (brownfield) environment where there are nonintelligent PDUs installed and a lack of budget dollar to replace them.

Metered power cables can be plugged into the PDU (replacing a standard power whip) to monitor, which makes for a highly cost-effective solution.

BEST PRACTICE 4 OF 5

CABINET DISTRIBUTION

4

Intelligent PDUs are growing at an exceptional rate in the data center space. In fact, global PDU revenues are forecast to grow 5.6 per cent in 2015, according to a recently published IHS report. In addition, intelligent PDUs are growing twice as fast as basic (nonintelligent) PDUs highlighting the continued shift toward adopting intelligence in the IT cabinet.

There are several reasons why intelligent PDU adoption is growing globally. Intelligent PDU technology can help a data center operator:

- Effectively monitor usage
- Report efficiency metrics
- Decrease power use in the data center
- Enable capacity planning.

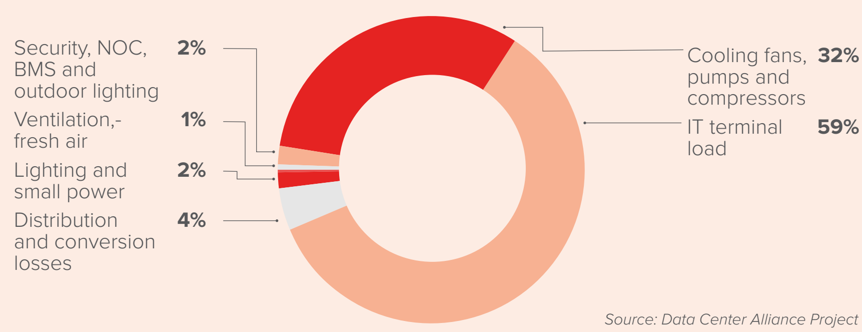
According to the Data Centre Alliance (DCA) Project, in a typical data center the IT equipment consumes roughly 59 per cent of the total power to the facility. If you can use the data gained from an intelligent PDU to free up stranded capacity and measure how you can be more efficient in your cabinets, you can potentially make a significant impact on your operational expenses and even defer additional capital expenses.

Types of PDUs

Data center operators have a choice of several types of PDUs that range significantly in price and function. The tier level and mission-critical nature of your data center will often dictate the PDU you choose.

Basic – The most economical choice; provides simple power feeds to equipment with no additional features

Figure 7: EU Data Center Power Consumption (KW)



Source: Data Center Alliance Project

Monitored – Provides a status on input current via an onboard display, a handy feature that allows the user to locally verify the load on the circuit or phase

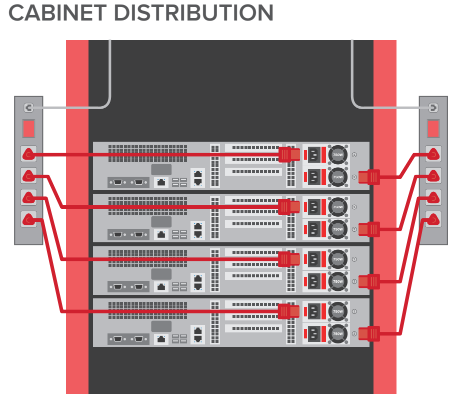
Metered – Provides the ability to broadcast information via an onboard communications port allowing data to be collected remotely; allows PDUs to be monitored at the input or outlet level

Switched – Connects to the network and offers remote control of individual outlets. Typically monitoring is also available at the input or outlet level

Upgradeable – Gives data center managers the flexibility to install the intelligence they require today with the option to upgrade technology as needs evolve

From a value-oriented perspective, basic and monitored can be considered entry-level choices, due to their low-cost, nonintelligent design. Intelligent PDUs (metered and switched) are forecasted

CABINET DISTRIBUTION



to grow twice the rate of nonintelligent PDUs, according to IHS Technology. Adoption rates currently are higher in Europe and the Americas, with steady growth in the Middle East as well.

PDU selection considerations
PDUs should be chosen based upon the product's ability to serve a facility's need for optimum power distribution. Here are some key factors to consider.

Application needs
These needs will drive the type of PDU you choose in many respects. If the supported application is mission-critical, then an intelligent PDU with more functionality is recommended. You may also be faced with a scenario whereby power is being monitored upstream at the breaker, and IT is gathering power usage data directly from the server, so the need is simply power distribution at the cabinet. In those situations, a basic or monitored PDU is all that's needed.

For mission-critical applications, you may also want to consider PDUs that have hot-swappable intelligence modules. That way, should a PDU intelligence module fail it can be replaced in the field without having to power down the entire strip, keeping the equipment online and mitigating the risk of downtime.

Business needs
Some IT departments will "charge back" the costs of their services that support the business. However, charging back the cost of power can be challenging. A metered by outlet PDU can accurately measure (within one per cent) power down to the individual outlet. That information can be pulled through a standalone power monitoring software or fed into a central DCIM solution. PDUs that claim that they have "utility" or "billing" grade accuracy should be certified to ANSI C12. 1-2008 or IEC 62052-11 or 62053-21 standards.

Something often overlooked when purchasing intelligent PDUs is the need to support the IP connectivity. Ethernet ports are very valuable on a network switch and using up a port per PDU can prove quite costly. In order to reduce those costs, consider PDUs that support one of the following technologies:

- Daisy chaining, which allows a limited number of PDUs to connect together under one IP address
- Wireless connectivity, which eliminates the need for copper cabling entirely and transmits information back via a proprietary gateway mounted in the IT cabinet
- Ethernet connection via a proprietary wired gateway mounted in the IT cabinet. The amount of PDUs that can be supported will be limited to the gateway itself. Generally, the gateway will also have additional ports designed to support temperature/ humidity sensors, cabinet door locks, and cameras

Equipment location
If there is equipment located in a remote location, with no IT staff locally, a switched PDU could help minimize potential downtime. Switched PDUs have individual outlet control functionality, so if a server isn't responding to the outlet it is connected to, it could be turned on and off remotely without IT staff intervention or requiring remote assistance. However, proper asset management practices need to be followed to ensure the accuracy of the server to outlet associations.

PDU COST

Typical cost for a 48-port Gigabit switch

$2500

or

$52

per port

Typical 100-cabinet installation contains

200

intelligent PDUs Each requiring one switch port

For a total cost of roughly

$10,000

for Intelligent PDU Connectivity

Cabinet density
The choice of PDU depends on the purpose of the individual cabinet (server, storage, and network) and the power density required. In cabinets that are relatively full of equipment, inrush current protection could be needed. In the event of power loss to a cabinet, once the power comes back online, the resulting high-current surge during start up (inrush current) can be several times greater than normal operating current. This could result in tripped fuses and circuit breakers. Switched PDUs can alleviate this concern by allowing the user to power outlets sequentially or groups of outlets that minimize the effects of inrush current.

Low-profile circuit breaker PDU designs are a good choice for higher-density cabinets. These designs minimize the space required to mount the PDU within the cabinet and allows operators more clearance when working within the cabinet. In addition, when PDUs are side-mounted within a data center cabinet, not having low-profile breakers can sometimes lead to equipment accessibility issues when performing maintenance, particularly the outlets near the bottom of the PDU. That means having to remove the PDU to access certain IT equipment, potentially causing downtime.

DCIM integration
More and more data centers are deploying DCIM solutions in their environment. In order for DCIM software to be effective, data from intelligent hardware are needed. PDUs provide cabinet-level power data that are fed to DCIM software in order for managers to report on that information and make decisions.

PDUs can provide more than just power data. Various sensors, such as airflow temperature and pressure, humidity, water leak detection, and door contact all can be plugged into various dedicated ports on the PDUs themselves, feeding valuable information back to the DCIM software. Onboard USB ports further provide functionality such as the ability to use Wi-Fi dongles, and even video cameras.

Thermal management strategy
In 2008, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) expanded the recommended temperature range at the inlet of the server from 68° F (20° C)–77° F (25° C) to 64.4° F (18° C)–80.6° F (27° C).

As a result the IT exhaust temperatures also rise. So, depending on the thermal management strategy one adopts, along with the density of the cabinet, IT exhaust temperatures can reach upward of 120° F (49° C). The PDU selected needs to be rated above those temperatures to prevent any failures. A majority of outages at the cabinet are caused by human error. There are five simple and cost-effective choices to help reduce the potential for costly cabinet outages. Many of them use visual cues, such as colors, to help your staff easily identify power feeds, which partly ensures work is done on the right equipment.

The overwhelming majority of outages can be attributed to human error.

Table 2: Cabinet PDU Functionality

Category	Basic	Monitored	Metered	Outlet metered	Outlet switched	Outlet metered and switched
Branch/phase circuit breakers	●	●	●	●	●	●
Local display		●	●	●	●	●
Branch/phase monitoring		●	●	●	●	●
Temperature/humidity monitoring			●	●	●	●
Network IP address for remote monitoring			●	●	●	●
IP daisy chaining			●	●	●	●
DCIM integration			●	●	●	●
Outlet sequencing				●	●	●
IT device chargeback				●		●
Zombie device identification				●		●

Color-coding on phase outlets, power cords, and intelligent PDUs can help to mitigate that risk.

Cabinet-level monitoring

Data center operators and owners are under constant pressure to increase efficiency and reduce energy costs, but without proper monitoring tools in place to understand where your power is consumed or where there are hot spots, these goals are difficult to achieve. It's also vital to understand the impact of any power conservation changes within your data center's eco system in order to avoid unintended performance degradation or downtime.

As stated previously, more than half of the power in the data center is used at the IT load or within the equipment cabinet or rack (typically anywhere from 40 to 60 per cent of power usage within a data center). The IT load also is the largest source of heat, making these two areas the obvious targets for increasing efficiency and lowering costs. Here we'll look at two different ways to monitor the IT load at the infeed (cabinet) and individual outlet (device).

Infeed (cabinet)

The power cable whips coming out of the remote power panel (RPP) are typically called branch circuits and are the power infeeds into the rack PDUs. This is the point in the power chain where you can measure the amount of power used within each cabinet and available power for new devices, helping you to better understand how to manage capacity. Software tools allow data to be plotted to view trends over time. Sometimes this information is already being monitored by facilities team at the RPP directly, but often this data resides with a building management system (BMS) that is not usually accessed by your IT group. Therefore, having this data at the rack level is useful so it can be accessed and compared by both facilities and IT.

Outlet (device level)

The use of power monitoring at the outlet is growing rapidly because it gives users a better understanding of information down to the individual device. Outlet-level monitoring of more than one outlet can be directly related to a particular device or server. Device power information has value because it helps you look at the power consumption of a group of similar devices to help determine those that are actually useful versus sitting idle and wasting power. Multiple devices or servers can often be tied to the power usage of a particular application or group within your organization. This information is

1 Procure PDUs with locking receptacles when possible. Locking power cords can be used as a substitute if the PDUs that are already deployed do not have outlet locking functionality.

2 Color-coded alternating phase outlets help to take the guess work out of balancing the phases at the cabinet by distributing the phases on an alternating receptacle basis vs. grouping the phases together.

3 Color-coded power cords, with proper labeling, provide a simple visual identifier for different power feeds at the cabinet.

4 Color-coded PDUs provide visual cues to identify different power feeds and different voltages in a mixed-voltage environment.

5 Rack automatic transfer switches (ATS) allow devices with a single power supply to be connected to redundant A/B power sources. In the event that one power feed fails, the ATS will switch to the other feed.

also valuable if your organization has considered billing back to different departments for their power usage.

Three benefits of monitoring at the cabinet

There are many advantages to monitoring at the cabinet, but these three top our list as the biggest benefits.

1. Identification of stranded capacity ("zombie servers")

Monitoring power usage and identifying additional capacity in the current facility over the significant costs of adding additional capacity via new infrastructure is simply a much more cost-effective approach. However, the status of data center power is often based on allocated power without real-time monitoring data. Power is often being consumed by IT devices that are no longer in use, sitting there idle, still feeding off the data center's power which costs you money.

Removing these "zombie" devices can be difficult because it is mainly a manual identification process that requires significant staff resources. However, PDUs with outlet level metering can streamline the identification process by providing the data needed to quickly locate the devices.

2. Outage prevention

The use of intelligent rack PDUs can help notify your team of issues before they occur. Warnings and critical threshold settings ensure that the rack PDUs do not experience overload conditions that could otherwise trip the breaker and the connected loads. Additionally, intelligent PDUs can provide environmental information, informing data center staff when temperatures are high enough to cause hardware failure.

3. Improved capacity planning

There are many issues that can be resolved if you know how much power your cabinets need, as well as the amount available. Knowing the IT load is also a key parameter in power efficiency metrics like the Power Usage Effectiveness (PUE) parameter created by The Green Grid.

One of the ways power usage data can assist in capacity planning is access to reports that identify cabinets with power and space availability for new devices. In addition, managers can identify cabinets that have exceeded or will exceed their capacity in the future, based on the current growth rate.

Power monitoring software

Unfortunately, many managers don't have the IT equipment and site infrastructure power monitoring data and valuable insight to help increase the efficiency of their data center and avoid possible outages. Without that data, it's difficult to have a focused strategy for maintaining and improving efficiency, as well as mitigating downtime. Power monitoring software can be a tool to help managers and operators take advantage of readily available opportunities to substantially reduce energy costs and prevent outages, which will save operational expenses too.

When evaluating power monitoring software, it is important to understand and measure the areas in the power chain that are the responsibility of your business. In the case of an enterprise-owned facility, it's critical to have intelligent hardware that can measure at multiple points discussed throughout this report: entrance feed, UPS systems, room distribution, cabinet distribution and IT equipment levels to feed into your software.

BEWARE THE ZOMBIES

According to Uptime Institute's estimates based on industry experience, around 20 per cent of servers in data centers today are obsolete, outdated, or unused. They also estimated that decommissioning one rack unit (1U) of servers can save an organization on average:

- 500 USD per year in energy costs
- An additional 500 USD in operating system licenses
- 1,500 USD in hardware maintenance.

BEST PRACTICE 5 OF 5

IT EQUIPMENT

5

The various IT equipment running in data centers represent a significant power load and expense. Naturally, the more IT equipment and upgrades invested into a data center, the more this hardware needs a reliable and efficient power infrastructure to support all these hard assets.

Applying Anixter's intelligent power chain concept of the right hardware configuration matched to analytics for greater intelligence can result in substantial benefits in this area because so much of the power usage comes from IT equipment. Focus on these key areas to increase power efficiency and maximize savings.

High-voltage power supplies
The choice of power supplies and the use of high-voltage distribution are often evaluated when trying to achieve energy efficiency and optimum power usage. The selection of the proper input voltage has a direct impact on power supply output capacity, conversion efficiency, thermal operation, and reliability. All of these variables impact the bottom line.

Some considerations for high-voltage power supplies:

- One less transformer needed to step down voltage at the 208 V level
- For each 1,000 W power supply, there's 1 to 2 percentage points of difference in efficiency
- 208 V U.S. 230 V globally

According to the U.S. ENERGY STAR program, substantial savings can be gained from a single watt saved.

Server virtualization
Virtualization can help data center operators reduce the overall IT equipment physical footprint by virtue of system consolidation. With virtualization, IT power consumption is designed to drop given the lower number of servers in operation. However, more power per square foot due to higher density or kW per rack is consumed.

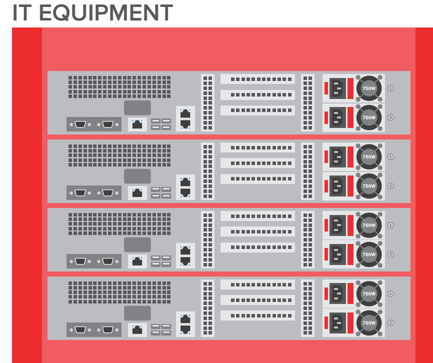
It is therefore imperative to ensure the power and cooling infrastructure are adjusted to accommodate the higher densities and loads in order to maximize savings. Also, there are more applications running on a limited number of hardware appliances, which often means that it is even more critical to maintain a high level of availability, making intelligent PDUs with monitoring capabilities even more important.

Equipment efficiencies
Improving the energy efficiency of your data center equipment can reduce server power use with no impact on your runtime. Efforts in this area also have the potential for offering increased computer capacity, power savings, and business continuity.

ENERGY STAR servers
In comparison to the rest of the equipment housed in a data center, servers comprise a substantial share of power usage. Deploying more efficient servers throughout the data center can be an effective method for reducing overall energy consumption. Additionally, as a byproduct of improved server efficiency, less heat is generated, which can reduce cooling costs.

The more IT equipment and upgrades invested into a data center, the more this hardware needs a reliable and efficient power infrastructureto support hard assets.

IT EQUIPMENT



In 2009, ENERGY STAR released its first energy specification for computer servers. To earn the ENERGY STAR certification, servers must offer the following features:

- Efficient power supplies
- Improved power quality
- Capabilities to measure real-time power use, processor utilization, and air inlet temperature
- Advanced power management features
- A power and performance data sheet that standardizes key information on energy performance, features, and other capabilities

Power capping

Server workloads can vary depending on level of use. Data center managers generally allocate enough power per rack to ensure performance in, in case all the servers are at 100 per cent utilization. Unfortunately, this approach results in stranded power capacity that could be used somewhere else in the data center. Power capping allows IT managers to set a threshold that servers cannot exceed. This ensures that the power consumption of all servers in the rack will not exceed the available capacity, which will usually trip a circuit breaker. The advantage to this approach is that it allows data center managers to effectively allocate available power closer to actual usage, without having to worry that capacity would be exceeded. This frees up power to be used where it is most needed.

Intel® Data Center Manager

One platform that may be particularly helpful with improving the efficiency of IT equipment, particularly in the area of power capping, is the Intel Data Center Manager and Intel Intelligent Power Node Manager.

Intel Data Center Manager (DCM) is a companion to intelligent PDUs. DCM provides insight into the server itself. It provides real-time, accurate power and thermal consumption data, enables management of data center hotspots, and allows for power usage planning and forecasting. Also many DCIM software platforms are beginning to integrate directly with DCM so that data center operators get the power and cooling info needed all the way down to the server itself.

Intel Intelligent Power Node Manager is an out-of-band power management policy engine. It enables regulation of individual server power consumption (power capping) through modulation of the processor's performance (P) and throttle (T) states.

A well-designed strategy for hardware refreshes for your data center equipment is one of the cornerstones of improving efficiency.

Hardware refresh cycles

A well-designed strategy for hardware refreshes for your data center equipment is one of the cornerstones of improving efficiency. Executing on it will:

- Mitigate outage risks
- Improve server performance in a smaller footprint
- Simplify your IT infrastructure through standardization
- Improve capabilities, including energy-efficiency technologies and operating modes.

The never-ending challenge with hardware refresh cycles is balancing the performance and energy efficiency benefits with the impact on your IT budget. Make sure you weigh all the pros and cons, and take the time to carefully consider what is optimal in terms of both equipment choices and cycles time span for your unique data center needs.

Grounding and bonding

Grounding should be addressed in the following areas: electrical distribution systems, IT cabinets and racks, and HVAC systems. If properly designed and built, the ground system is essentially a radial system from the electrical service entrance.

Building grounding systems should be directly bonded to all major power distribution equipment, including switchgear, generators, UPS systems, and transformers. Your facility should possess a building electrical main ground bus (MGB) where all the large-load feeder facility ground terminates.

Some additional grounding and bonding recommendations:

- Make sure to ground all dead metal objects with the data center.
- Where there are multiple power service entrances, the ground ring conductor should be sized at 107 mm (4/0 AWG) minimum bar copper.
- All below-grade grounding connection should be made by NRTL-approved methods, such as exothermic weld or high-compression connectors.
- Ground bus bars should be placed to facilitate bonding and visual inspection.

Also, supplementary bonding and grounding methods should be deployed to improve facility and equipment performance. Examples of supplementary components include metallic raceways, racks and cable trays, under the raised floor or above the cabinet and rack metallic grid work, metal plates and sheets, multiple bonding conductors from equipment to a grounding, or bonding structure.

THE FUTURE OF DATA CENTER POWER GENERATION

Data centers continue to get more efficient in the way that they consume energy. Yet, there are many significant challenges that lie ahead. With the trend in consolidating smaller data centers into larger facilities, how are operators going to get the power that they need to operate? Also, as data centers start to become larger, being inefficient starts to exacerbate and multiply power issues and expose vulnerabilities and weaknesses. And what about getting power from sustainable sources?

Sustainable energy trends

There is currently a transition to clean energy, partially due to social and governmental pressures. Additionally, because energy is the largest data center cost and every environment is unique, different methods of energy generation are being considered.

Where will the energy that powers tomorrow's data centers come from? There's no crystal ball, and innovations in this area are fast and furious, so it's impossible to predict with certainty how facilities will be powered years from now. However, sustainable energy has growing momentum.

Here are some recent examples of data centers that use sustainable energy:

- Green Mountain Norway – hydroelectric
- Datadock France – geothermal
- Facebook Texas (2016) – wind

There has also been a rise recently in renewable energy investment. Examples of that are:

- 51,000 MW of wind was added globally in 2014, a 44 per cent increase over 2013.
- Solar costs have fallen 80 per cent globally since 2008.
- Solar and wind provided 55 per cent of new electricity generation capacity in the U.S. during 2014.
- China invested 90 billion USD in renewable energy in 2014, a 32 per cent increase over 2013, according to Greenpeace.

Fuel cell technologies

The adoption of hydrogen fuel cells is another fascinating area where there appears to be some significant investment. The trends suggest that adoption will occur first in applications where generator use is impractical, such as remote locations or confined environments.

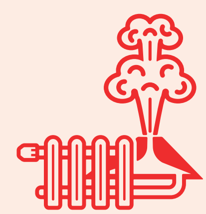
For example, Microsoft currently has some IT equipment cabinets powered entirely by fuel cells bringing the power plant inside the facility thereby minimizing power distribution losses.

Another telling statistic is that, in 2013, fuel cell industry sales generated revenues of approximately 1.3 USD billion, according to the U.S. Department of Energy. Fuel cell system revenues grew by 35 per cent over 2012, with significant growth seen both in North America, with a revenue increase of about 50 per cent over 2012, and Asia, with about 33 per cent growth over 2012. Europe showed a slight decline in fuel cell system revenues.

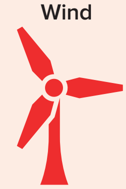
SUSTAINABLE ENERGY TRENDS

Hydroelectric

Geothermal



Wind

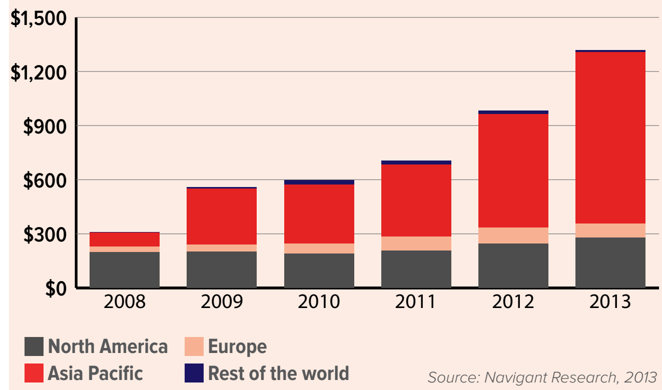


THE FUTURE OF DATA CENTER POWER GENERATION

Battery technologies
According to IHS Technology, lithium ion batteries have recently been gaining more adoption in the market. However, they are in the beginning stages of development and have noticeable disadvantages when compared to lead acid batteries, such as a weaker safety record, low-current discharge, and higher costs. Currently, lithium-ion battery technology is enjoying a boost in research and development in the electrical vehicle market, which is helping to drive down manufacturing costs.

In recent news, Elon Musk and Tesla® have made headlines in their effort to potentially bring their Powerpack™ battery technology to data centers. Data center operators will be more interested in the larger-capacity Tesla Powerpack, a 100 kWh battery storage system, which, according to Musk, is infinitely scalable. Several large-scale organizations have already started pilot programs with Tesla.

Figure 8: Fuel Cell System Revenue (US$M)



Source: Navigant Research, 2013

CONCLUSION

This report covered the complex nature of powering the data center. The drive for improved efficiencies and managing variable IT capacity requirements are top priorities for all data center operators and managers. The intelligent power chain achieved via the right hardware configuration coupled with intelligence and analytics can provide robust gains in five key areas. Additionally, intelligent data center design decisions – whether brownfield or greenfield – can boost overall efficiencies and mitigate the risk of outages.

Breaking the intelligent power chain down into five best practices helps to simplify things, however each area requires attention to multiple variables, and sometimes a subset of variables.

But the key takeaway is not the complexity of all the moving parts that go into an intelligent power chain. The most important thing to hold onto is the fact that each piece of the puzzle can result in improvements in energy efficiency, performance, and equipment longevity. And these improvements can range from incremental to substantial in terms of impact and savings. Taken as a whole, and as you check off the list of what constitutes an intelligent power chain, your data center can become an ultra-efficient and highly reliable facility that maximizes energy usage to everyone's benefit.

Contact Anixter to learn about how power optimization works with the other building blocks of Anixter's Infrastructure as a Platform solution. Infrastructure as a Platform focuses on helping you create an agile and scalable data center by addressing the five key building blocks for data center interoperability:

› Risk management
› Network migration
› Power optimization
› Thermal efficiency
› DCIM enablement

For more information on how adopting an intelligent power chain in your data center can reduce operational expenses, allow for better capacity management, and reduce the risk of outages, visit anixter.com/datacenterdcd or contact your local Anixter representative.

DCD INTELLIGENCE

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Through our unmatched global distribution network, supply chain management expertise and technical know-how, we drive efficiency and effectiveness to benefit your bottom line.

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