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DATA CENTER NETWORK ADOPTION, TRENDS, AND EMERGING STANDARDS

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HOW HIGHER DENSITIES ARE IMPACTING THE RACK SPACE

By Duke Robertson

Data center cabinets are having to support advanced, heavier equipment that consumes more power and produces more heat. For successful operations, data center managers should approach the entire rack space as an integrated platform that combines intelligence and structure.

If there is one thing the past year has taught organizations, it is that business continuity is not possible without connectivity—remote connectivity. For data center managers and operators, this means the stakes have never been higher. Each new generation of data center equipment is more powerful than the previous and can replace multiple legacy technologies. With the demand for data growing quickly, the need to consolidate and expand simultaneously is compounding. How can organizations ensure reliable operations and stay up and running 24/7 while keeping costs down?

Continuous and agile operations, fast and reliable processing, robust storage, and hybrid computing architectures require a holistic approach, one that focuses on simplification, economization, and optimization.

To get there, it is important to know what hurdles to overcome.

CHALLENGE 1: RELIABLE POWER DISTRIBUTION

As more data center managers and operators deploy virtualization and consolidate equipment for more efficient computing, the average rack power density continues to rise. While an average cabinet supported 3 to 4 kW just a few years ago, today that power load is considered part of a low-density environment. It is now certainly common to have cabinets drawing 9 to 15 kW and in several cases, even higher. More density means data center operators can serve more users with more compute capacity—an invaluable benefit to business operations—but it also means that heat loads within the cabinet increase (Table 1).

More importantly, to handle increasing rack densities and more compute processing, reliable power needs to be assured. At the facility level, these assurances come from uninterruptible power supply (USP) systems that provide protection against blackouts and brownouts, while the core connection of equipment happens within the data center cabinet with rack power distribution units (PDUs). As a result, reliable rack PDUs within high-density environments should include, at a minimum, the following features:

- Appropriate input circuit to handle required capacity
- Adequate outlet type and density to plug all equipment
- Branch over-current protection to minimize nuisance tripping and downtime
- High ambient temperature rating for reliable operation within hot aisles
- Appropriate functionality level to monitor at the rack or device
- Continuous monitoring to enable proactive notification of impending issues

DATA CENTER DENSITY

Density Metric	Per Rack	Compute Space
Extreme	>= 16 kW	>= 16 kW
High	9 – 15 kW	9 – 15 kW
Medium	5 – 8 kW	5 – 8 kW
Low	0 – 4 kW	0 – 4 kW

TABLE 1: Data center density definition: AFCOM's Data Center Institute's board document. Data center density is expressed as either "design density" (Per Rack) or "measured peak load divided by number of racks" (Compute Space).

CHALLENGE 2: MINIMIZING COOLING COSTS

Reducing data center cooling costs is still a high priority among most data center operators, so addressing airflow management is key. An effective airflow management (containment) strategy allows the data center cabinet to support high-density equipment, while improving energy efficiency and lowering cooling costs.

Containment systems that effectively isolate hot and cold air enable strict control of inlet temperatures, optimal adjustment of airflow volume, and increased return air temperatures, which allow room temperatures to be reliably raised. In turn, the efficiency of cooling systems is improved and the number of days that economizers can be used for "free cooling" is increased.

Optimal airflow volume means fewer air handlers need to be operated, and chilled water temperatures can be increased. This yields additional chiller efficiencies, while power usage effectiveness (PUE) is lowered because the overall energy used for cooling equipment is reduced. In new designs in particular, initial cost can be lowered by sizing air handlers and cooling equipment for optimized airflow.

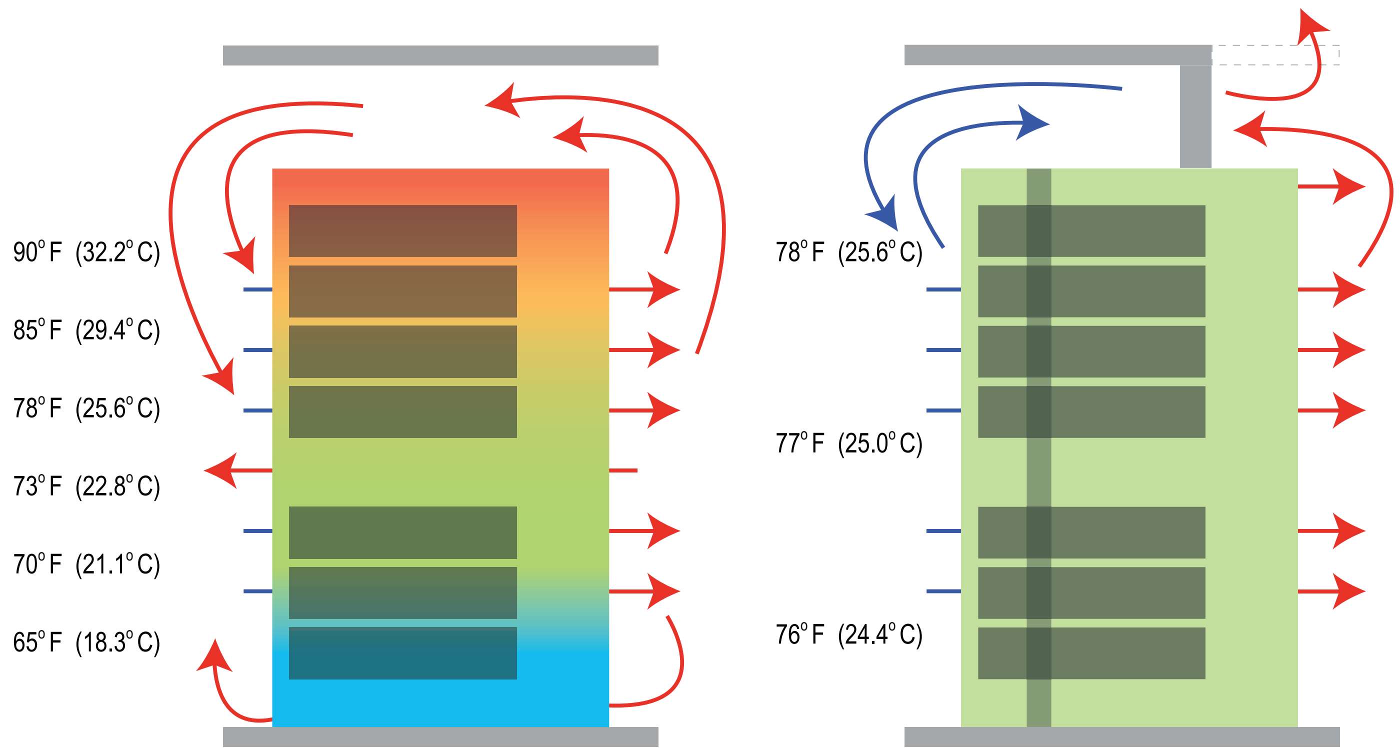

FIGURE 1: Inlet air temperature variations in a traditional hot aisle/cold aisle application (left) and a typical containment system (right). The much larger temperature variation is in the hot aisle/cold aisle application.

All of this begins with strict separation of hot and cold air within the data center, using a complete containment system for both inside the cabinet and within the room (Figure 1).

A reliable containment system inside the cabinet creates a strict front-to-rear or front-to-top pathway for airflow and includes:

- Perforated doors to allow airflow front-to-rear when used with aisle containment.
- Perforated front door and solid rear door to allow front-to-top airflow when used with a ducted exhaust.
- Panel work that seals the sides, top, and bottom of the cabinet.
- Grommets or brush seals over cable openings in top, bottom, and side panels.
- An internal front/rear seal, including a perimeter seal between the mounting rails and the side panels and blanking panels in each unused rack-mount space.
- A top-mount ducted exhaust or an overhead aisle containment to separate supply and return air within the room.

CHALLENGE 3: ENSURING UPTIME

Monitoring the power use and availability of power for each piece of equipment gives data center managers the ability to prevent issues before they result in downtime. For high-density environments, it is critical to continually monitor circuit-breaker status. Setting thresholds for all the electrical parameters being monitored (e.g., voltage, current, energy, temperature) ensures data center managers are proactively notified of alarming problems.

CHALLENGE 4: OPTIMIZING EFFICIENCY

For optimizing efficiency, the strategy is to focus on getting the highest return on power utilization for compute power at the lowest cooling cost possible. To ensure highly available power to IT equipment, all power components in the power chain need to have monitoring capabilities. This is where data center infrastructure management (DCIM) software plays a key role. The DCIM software automates centralized data collection and reporting from monitoring devices and provides power capacity trends and analysis over time, thereby helping data center managers to forecast power consumption more accurately (Figure 2).

FIGURE 2: DCIM software provides power capacity trends and analysis over time, typically in a simple and user-friendly interface.

Additionally, it is possible to obtain reports of active power by month and device, helping operators to quickly identify spikes, prevent potential power issues, and maximize uptime. Provided by the PDU, this capability can be leveraged with power monitoring at the outlet level to identify power consumption by server, which helps in the identification of under and over utilized servers for potential replacement with more efficient devices or virtual servers.

CHALLENGE 5: REDUCING DEPLOYMENT TIME

As data centers grow to support a more digitally connected way of life, data center managers need to closely monitor and optimize capital expenditures (CAPEX) and operating expenses (OPEX) to expand infrastructure or buy more equipment. Utilizing a vendor that has the capability to integrate the components of the cabinet into a single solution, perform quality checks, and deliver a cabinet ready to be deployed can simplify the supply chain and speed up operations.

NEW DATA CENTER CABINET DESIGNS

When considering the main challenges faced by data center managers and operators, the proposition then is to address them not as individual concerns, but rather holistically as equally critical components of a complete, unified cabinet ecosystem.

The Data Center Cabinet, Designed to Speed Deployment

Supporting the hyper-hybrid landscape, functioning with N+2 and sometimes 2N+2 redundancy sites, distributed real-time processing and diverse networking architectures are nothing short of demanding. The path to success: agility and flexibility.

In its 2019 report, *Infrastructure Is Everywhere: The Evolution of Data Centers,* Gartner states that "infrastructures of the future must be able to change quickly, as markets and providers change." This means data center operators must provide an environment that inherently enables rapid deployment of services, whenever and wherever needed and at the right price.

To expedite deployment, many companies across the globe are utilizing third-party integrators to populate cabinets with compute, power, and cabling. Then, they transport fully-loaded cabinets to the data center space where they are rolled into position and quickly brought online.

This "need for speed" requires an innovative, robust cabinet design with the end user in mind. This means rails and accessories that are quicker and easier to adjust, cable management solutions that accommodate a variety of applications and a strong cabinet frame architecture that can withstand high weight loads, often exceeding 4000 pounds (≈1814 kg). See Figure 3.

FIGURE 3: For faster deployment, cabinets are populated with easy cable management solutions, compute, and power.

Additionally, it is important to provide enterprise customers with the capability of configuring a cabinet that is tailored to their exact specifications with cable management, power, and thermal accessories that are factory installed.

The Data Center Cabinet, Powered by Intelligence

With cabinet densities averaging 9 to 11 kW and rising, complexities abound. As the last leg of the power chain, intelligent rack PDUs provide data center managers with the most granular information about individual equipment (e.g., voltage, current, power, energy usage, thresholds, temperature and humidity values) when integrated with environmental monitoring sensors. Simply stated, the intelligent rack PDU is the one piece of hardware that actively and remotely helps identify potential equipment problems before they result in downtime.

Modern rack PDUs have also evolved to provide intelligent power monitoring and control at the outlet (device) level, two features that became crucial in 2020 when few if any businesses had a tried and true "no person anywhere" mitigation plan (Figure 4).

Tasks that used to require hands-on labor can now be performed remotely from a secure software interface. For example, with remote outlet-level monitoring, data center managers can get detailed visibility into how much power each piece of equipment is drawing and how much power capacity they will have during peak hours. Remote outlet-level control allows equipment to be turned on and off and rebooted whenever needed, eliminating the need to send regular remote-hands maintenance.

Additionally, it is important to consider the exceptionally high temperatures within a fully-loaded data center cabinet. In these instances, a PDU with high ambient temperature ratings will provide the peace of mind that it will remain operational even in more extreme conditions (Figure 5).

FIGURE 4: An example of a cabinet integrated with intelligent rack PDU.

When it comes to intelligence and addressing the rack space, it is also important to consider the new, more advanced equipment—the types being developed for artificial intelligence (AI) and real-time, data-crunching applications—which will unequivocally produce more heat within the cabinet.

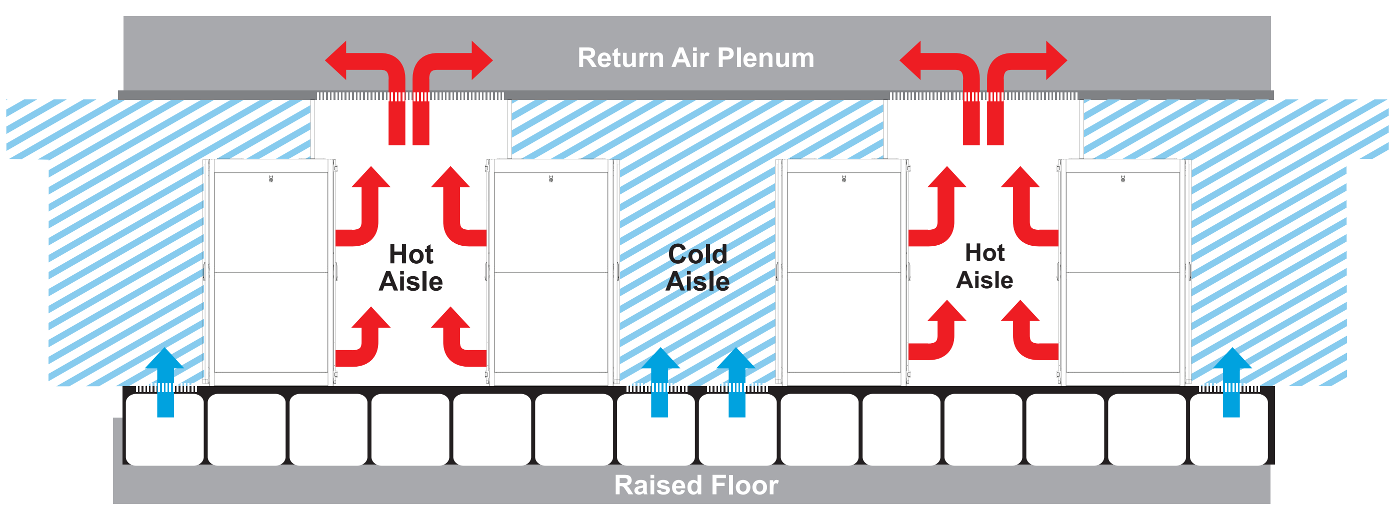

FIGURE 5: PDUs are exposed to the highest ambient air temperatures. Choose a PDU with the highest temperature rating possible.

More density means data center operators can serve more users with more compute capacity—an invaluable benefit to business operations—but it also means that heat loads within the cabinet increase.

The Data Center Cabinet, Focused on Efficiency

At higher rack densities, adding more air conditioning to the room is not the most effective option, although a large number of data centers continue to oversupply cold air in order to keep equipment operational. Instead, airflow containment, which is simply the physical separation of hot and cold air within the server room, can easily be the most important practice for maximizing cooling system efficiency. Segregating the hot and cold air not only improves chiller efficiencies, it also reduces the total plant cooling capacity and creates more free cooling hours.

This can be achieved by building an enclosure around the hot aisle, known as hot aisle containment (HAC); building an enclosure around the cold aisle, known as cold aisle containment (CAC); or by using a vertical exhaust duct accessory at the top of the cabinet to remove hot exhaust air.

Specifying cabinets that provide a complete front/rear seal around equipment and removing constraints around critical airflow design allows higher power and heat densities. The best possible isolation can be achieved with a combination of accessories (e.g., blanking filler panels, equipment-mounting area perimeter sealing air dams, and floor tile cut-out brush seal grommets) and the right system to remove the return air from the room into a suspended ceiling return air space.

It is expected that Zero Net Energy (ZNE) buildings will be a requirement in the future.[1] Presently, California is leading the pack when it comes to state regulations, and it has an aggressive goal to transition all new commercial buildings to this standard by 2030. For European Union (EU) countries, the European Commission has issued directives for nearly zero-energy buildings (NZEBs).[2]

It stands to reason that new data center facilities should begin prioritizing ZNE while mandatory codes and standards continue to evolve. To this end, it is wise to consider an integrated design approach that considers multiple systems and incorporates cabinet designs with passive cooling and ventilation.

The Data Center Cabinet, Strengthened by Design

Considering high-density racks—particularly those with more advanced, heavier equipment installed including accessories and overhead cabling—a typical load rating of 2000 to 3000 pounds (≈907 to 1361 kg) may no longer suffice for the long run. Modern cabinet design manufacturers are addressing the increasing demand for higher static and dynamic loads (Figure 6).

FIGURE 6: To meet the growing need for high-density racks, including overhead cabling and accessories, manufacturers are addressing higher load ratings beyond 3000 pounds (≈1361 kg) in next generation cabinet designs.

IMPORTANT QUESTIONS AND ANSWERS FOR SELECTING THE RIGHT CABINET DESIGN

When selecting a data center cabinet design, data center managers and ICT integrators, installers, and consultants should ask the following questions:

1. Can the cabinet be moved with the intended load, reliably?

Answer: Consider designs with load-bearing casters, ones that do not deform under a fully loaded cabinet.

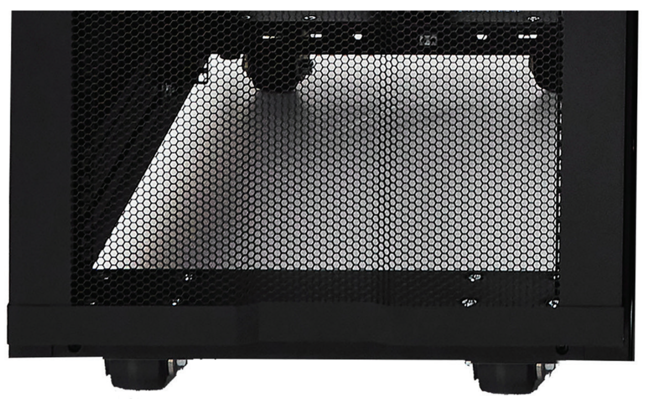

FIGURE 7: Load-bearing casters are a better option for fully loaded cabinets.

2. Is the cabinet load rating tested and verified by an independent testing laboratory?

Answer: Reputable vendors load-test their cabinets with a third-party laboratory using a common industry standard, such as UL® 2416, the UL Standard for Safety Audio/Video, ICT Equipment Cabinet, Enclosure and Rack Systems, which includes a test of up to four times their weight capacity.

3. Is the cabinet design scalable and flexible to support hybrid operations?

Answer: The design should allow for multiple configurations or be customizable to create a unique cabinet that meets a customer's exact requirements to be used as a standard solution across multiple sites.

FIGURE 8: No application is the same, so configurability and flexibility are needed when deploying equipment across multiple sites.

Segregating the hot and cold air not only improves chiller efficiencies, it also reduces the total plant cooling capacity and creates more free cooling hours.

4. Does the cabinet structure support thermal and power management accessories, as well as the cable pathway directly above it?

Answer: A strong, roll-formed, tubular and fully welded steel frame allows for reliable support of equipment and overhead cabling systems. A strong frame that can support at least 5000 pounds (≈2268 kg) better prepares data center managers for future changes regarding equipment, overhead structure and for potential transitions to liquid cooling.

5. Does the cabinet space provide enough room for a rack PDU and cable and airflow management accessories?

Answer: The cabinet design should enable separate pathways for power and cabling. Additionally, these pathways should not interfere with airflow. To speed up maintenance and equipment refreshes, consider cabinet designs that simplify attachment, alignment, and fastening of accessories with more tool-less features and intuitive adjustments.

FIGURE 9: Modern cabinet designs allow for quick, tool-less attachment of accessories like PDUs and cable and airflow management in a manner in which all systems co-exist and complement one another in a unified ecosystem.

6. Do the mechanics of the cabinet allow for easier equipment installation and maintenance?

Answer: Doors should be easy to remove during maintenance. For flexibility, doors should also open from the left or right depending on preference or application. Additionally, doors and panels should bond to the cabinet frame to provide an added level of safety for personnel and equipment. In fact, newer cabinet designs ensure proper bonding without the additional, cumbersome step of prepping the cabinet for a bonding connection. This integrated bonding capability at each attachment point ensures bonding of doors, rails, accessories, and panel work when installed after service work.

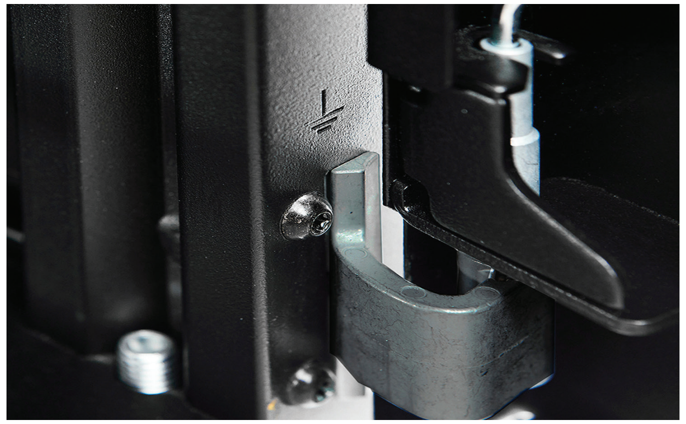

FIGURE 10: Modern cabinet designs also include integrated bonding on door hinge and side panels for a safer and more intuitive electrical installation.

7. Is the cabinet designed to facilitate unique requirements, such as seismic bracing?

Answer: Seismic areas require specific building codes and installation guidelines for buildings to ensure the safety of people and equipment. The California Building Code requires that a licensed structural engineer design the components, supports, and attachments for non-structural building components, such as equipment racks. This means an engineer defines the exact installation hardware, placement, and materials that attach the rack to the floor and, if necessary, how it will be braced overhead. Additionally, TIA-942-B, Section 6.4.4.11 specifies that the data center facilities meet all applicable seismic zone requirements.

The cabinet design must also include a calculation to determine the seismic load of the rack. Racks specifically designed for seismic applications have heavily braced frames to resist side-to-side, front-back, and up-down motion. Reputable manufacturers load-test these racks on a shaker test table that simulates a seismic event to demonstrate rack performance and verify their load claim.

The rack has to survive the test with no structural damage. Several standard shaker tests are available, but traditionally, rack manufacturers use the Telcordia Technologies GR-63-CORE, Section 4.4 test for rack and rack-mount equipment.

It is important to note that these designs are more expensive than non-seismic racks, but they generally have higher load ratings and can be filled with equipment, whereas with non-seismic racks, multiple racks are needed to hold the same amount of equipment.

For comprehensive design and installation information discussed, including seismic and other racks, cabinet airflow and cabling, multi-site data centers, DCIM, power distribution, and much more, consult ANSI/BICSI 002-2019, *Data Center Design and Implementation Best Practices*. This BICSI International Standard covers all major systems found within a data center.

READY FOR THE DATA ECONOMY

As the data economy evolves, new concerns also arise. Data centers will inevitably have to accommodate more changes. The simplest way to be prepared for these future demands is to ensure that the backbone of the infrastructure is strong, reliable, and flexible.

A sturdy, feature-rich and future-ready data center cabinet that is pre-integrated with intelligent power and airflow and cable management will go a long way toward giving customers the performance and peace of mind they value, even as site requirements change.

Energy efficiency is still king. While passive cooling is not a new concept, there is still the misconception that it is too complicated or expensive to deploy. In fact, addressing airflow containment at the cabinet or facility level should be viewed more aptly as the low-hanging fruit that it is, especially when considering its dramatic, positive impact on the bottom line.

With ZNE buildings predicted to become the new normal, data center managers, operators, BICSI Registered Communications Distribution Designers (RCDDs), and BICSI Data Center Design Consultants (DCDCs) must start considering the right infrastructure that will be fundamental in supporting goals that will not only yield present day returns, but also sustain well into the future.

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Modern cabinet design manufacturers are addressing the increasing demand for higher static and dynamic loads.

REFERENCES:

1. "Zero Energy Buildings," Office of Energy Efficiency & Renewable Energy, *U.S. Department of Energy*, https://www.energy.gov/eere/buildings/zero-energy-buildings.
2. "Nearly Zero-Energy Buildings," *European Commission*, https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en.