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Density in the Data Center

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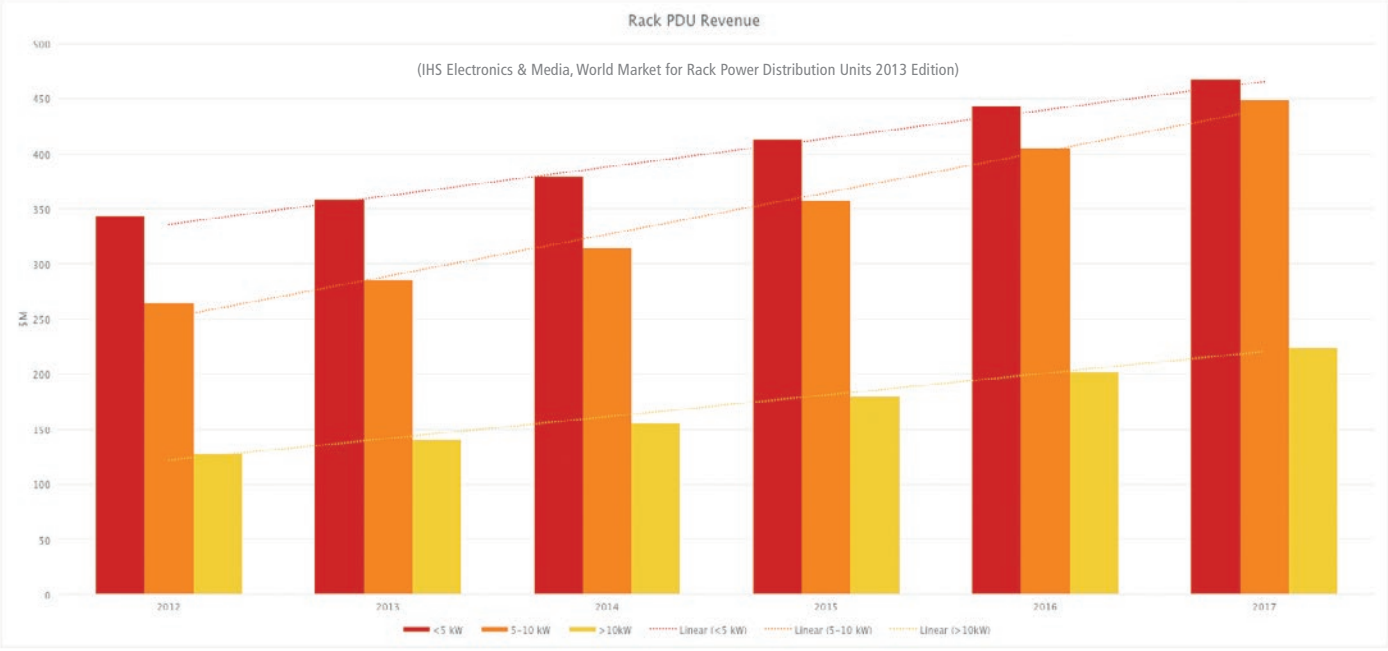
Density in the datacenter refers to the electric power consumed per square foot of floor space (or unit volume of space), number of servers, and the cooling system's load.

A number of factors in today's market are driving the datacenter operator to increase the density and the operational loading of the compute infrastructure. Among these factors are the desire to reduce both capital and operational expenditures, improve energy efficiency (lower PUE), avoidance of new build-out, reduction of latency times, and better management of network traffic flow.

Historically, the aggregate power load of the datacenter cabinet has ranged from 1-5 kW for a 42U rack. A full rack of single (or dual) corded 1U servers, in the aptly nicknamed "pizza box" form factor, were the original drivers for a high density (scale out) rack and high outlet count PDU. As the equipment manufacturers adopted a number of new form factors, such as 2U, 4U, 5U, and 10U enclosures incorporating multiple server chips and large banks of both storage and memory, the demands placed on the power supplies within those servers went up, requiring higher power delivery per cord and outlet, driving the widespread requirement of C19 outlets over the previously dominant C13 outlets.

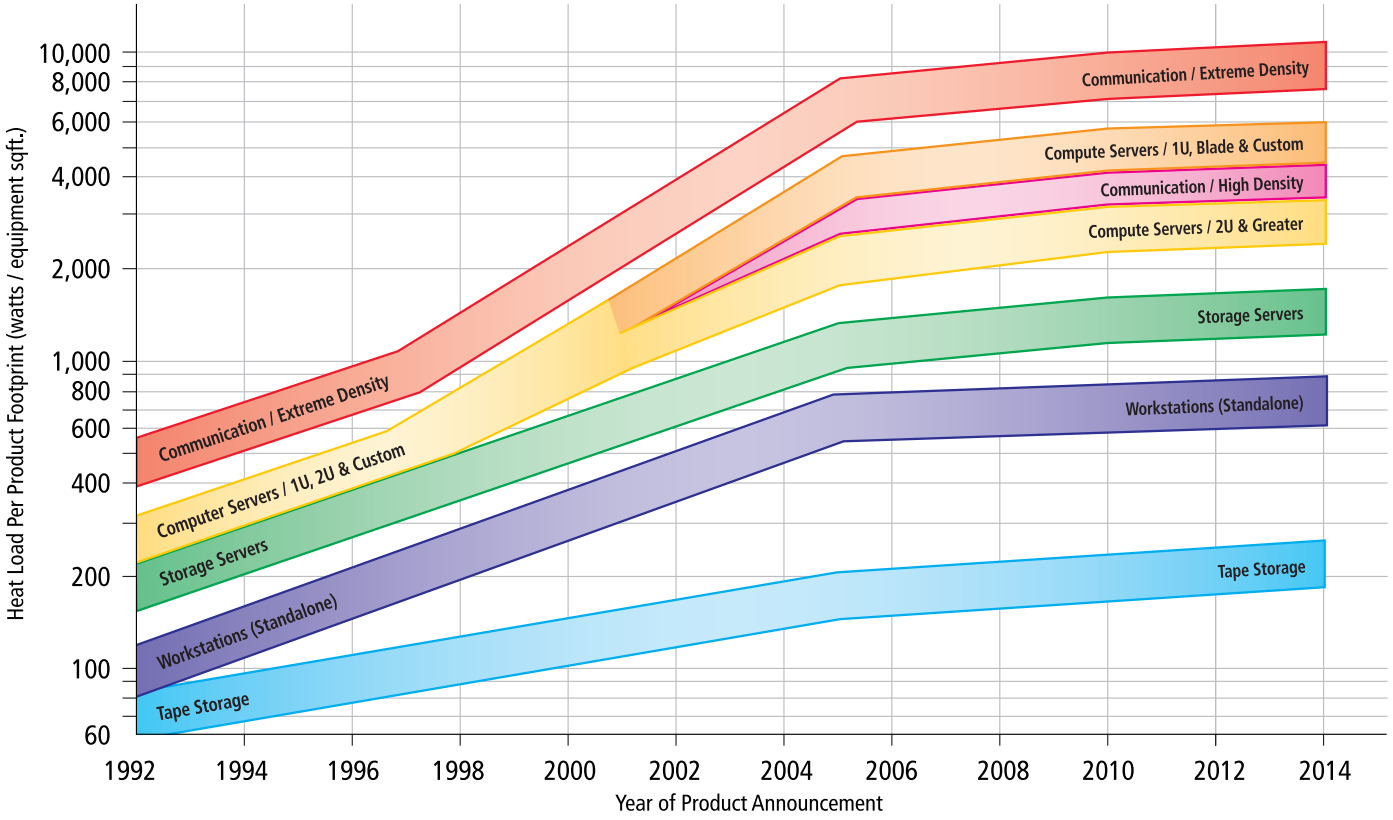


According to the 2013 IHS report **"The World Market for Rack Power Distribution Units,"** the market for 5-10kW and >10kW PDU will outgrow the low power (<5kW) segment at nearly twice the rate through 2017. The growth for the high power segment will average over 11% while the low power PDU market is estimated to be just over 6%.

Long Term Heat Load Footprint

The following graph was first generated in 2005 as a long term forecast of heat load by footprint in the IT datacenter and the telecom market. The practical upper limit of today's air-cooled compute infrastructure is in the range of 4.5kW / ft^2, right in line with the ASHRAE projections almost 10 years ago. New liquid cooling and liquid immersion systems allow for further compute density to be achieved, but require additional infrastructure to function effectively.

FIGURE 1: Heat Load Footprint



Source: ASHRAE, Datacom Equipment Power Trends and Cooling Applications, CH. 3, Fig 3.10 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Density Challenges

There are a number of challenges for both the Facilities and IT teams of a datacenter that are associated with implementing a power-dense data center. Amongst these are cost, heat, load balancing, environmental and power monitoring, increased network traffic, and configuration management of systems.

FIGURE 2: Density Challenges

CHALLENGE	IMPACT
Reducing Capital Expenditure	> Requires consolidation and integration of servers and systems along with virtualization > Reduces the amount of gear present on the datatenter floor
Phase Balancing	> Unbalanced phases lead to power inefficiency > Unbalanced phases lead to larger electrical bills. > With heavier loads in the servers, the potential swings in power demand are greater, making the task of load balancing the power phases even more difficult
Higher Operating Temperatures	> There is less time for IT and facilities to react in the event of a cooling system failure or thermal runaway of a server system > Hot aisle or cold aisle containment are frequently needed > HVAC systems need automation
Power Consumption	> Higher voltages & currents are often demanded to support the desired IT load densities. > Today's dense IT loads often require 208V 3-phase 60A (21 kW) circuits, or even 415V 3-phase 60A (40+ kW)
Criticality of Power Availability	> Less room for error, as more computations/work are being done by a given asset. > Also less tolerance for a CRAC or CRAH to go down, as the speed with which thermal runaway can occur is faster.
Increasing Network Traffic	> IOT, video, and sensors are all contributing to higher network loads. > Through consolidation and virtualization, the datacenter is able to reduce the number of switches and cables necessary to peform interconnect all of the working pieces of the datacenter
Configuration Management	> Today's servers have more CPUS with more cores running more VMs than ever before. Making sure the configuration of the servers is correct becomes a difficult task requiring significant upfront efforts to develop automation, particularly at large scale installations
Complexity	In addition to the servers, all of the other supporting systems are more complex: > Virtualized storage on SAN or NAS > Software defined networking > the links to physical infrastructure such as UPS systems, CRACs and CRAHs over BACnet all require vigilent attention on the part of the IT team to ensure proper oeprations
Idle/unused Vms and Idle Machines	> Unused or underutilized systems need to be identified and then either be put into a deep sleep state or taken offline altogether in order to reduce power consumption

Managing the Challenges of Density

Data Center Configuration

There are a number of companies and industry organizations devoted to improving the state of the art of datacenter design and power utilization effectiveness. ASHRAE, IEEE, The Green Grid, and Emerge Alliance are among those organizations continuously seeking to foster new ideas and new technologies leading to more energy efficient datacenters. **Most studies and papers from these groups have concluded that minimizing the number of power conversions and operating power supplies at the most efficient (highest) input voltage possible will result in significant savings on operational expenses (OPEX) for the datacenter.**

Modern green field datacenters are using 480V/277VAC, 415V/240VAC, and 380VDC as typical power going to their racks, with amperages ranging from 16A all the way up to 100A. A 1200mm x 800mm cabinet fed with 415V/63A power has a usable capacity of 45.4kW in a footprint just over 10.3sqft. This configuration would be at the upper right of **Figure 1 (Page-2)**, and represents the practical upper limit of density for most datacenters today. This is a typical configuration for many modular datacenters that are readily available. Most applications that require higher density are running very specialized applications and are supported by liquid cooling technology.

Figure 2 (Page-3) shows a few of the challenges of density and their respective impacts.

By making use of the available power and configuration management tools provided by the various server manufacturers, the datacenter designer and operator can come to a consensus on the best approach to achieving the power and compute density needed for their application. These tools are readily available from manufacturers such as HP, IBM, and Dell, and they can give the best idea of what level of compute density can be achieved for a given budget.

Datacenter Infrastructure Management (DCIM) Tools

Another category of software tool that is available to support critical compute loads running in dense datacenters is Datacenter Infrastructure Management (DCIM). Typically incorporating support for SNMP, most DCIM tools provide a way of measuring power consumption, assessing available power capacity, profiling thermal conditions within the datacenter, exercising closed-loop control of HVAC systems, providing some degree of IT asset tracking, and determining the status of the various elements of UPS that may be distributed throughout the datacenter. DCIM tools help provide a "single pane of glass" for knowing what is going on in the datacenter. Depending on the DCIM tool selected, it may also provide hooks into any of a number of configuration management and virtualization management packages that enable the dense datacenter to rapidly configure new servers or move compute loads around to available underutilized resources within the datacenter.

Managing the Challenges of Density (cont.)

Thermal Considerations

Computational fluid dynamics software tools are used to determine how the cooling infrastructure is performing relative to the heat loads that are distributed within the datacenter. CFD will help ensure that hot aisle / cold aisle containment systems are performing optimally while identifying opportunities to redeploy assets to make the best use of available cooling capacity.

Operating the datacenter at the upper limits of the allowable inlet air temperature range helps achieve lower cooling costs and lower PUE, while requiring the temperature monitoring and control systems to operate reliably and respond quickly to changing conditions. The potential for thermal runaway is exacerbated in this case. The ability for modern PDUs to monitor both power consumption and temperature within the cabinet provides a "last line of defense" in the high temperature environment of the exhaust (hot aisle) side of the datacenter rack. The alerting, alarming, and reporting functions of modern PDUs provide critical information to HVAC systems, DCIM tools, and the IT and Facilities personnel responsible for overseeing the successful operation of the datacenter. The more individual loads within the racks, the more critical it becomes for the PDU to have granular measurement and reporting capabilities along with supporting the targeted hot aisle temperature.

Minimizing Wasted Power with 3-Phase

Placing many servers in a single cabinet plugged into a 3-phase power source necessitates careful planning and monitoring as well. The datacenter can minimize wasted power and maximize power delivery to the IT gear when the loads on all three phases are as close to equal as possible. This requires the servers and the PDUs to report power consumption and provide an aggregate figure of consumption by phase in order to give the datacenter operator a chance at having a maximally efficient datacenter. Utilizing the alternating phase HDOT modules minimizes the potential for accidentally unbalanced loads across the phases.

The Solution to Your Challenge HDOT

High Density Outlet Technology (HDOT™) — Only from Server Technology

Providing power to a dense heterogeneous computing environment requires highly integrated and extremely reliable power distribution. HDOT (High Density Outlet Technology) from Server Technology provides both. HDOT is available in a **"Build Your Own"** PDU that allows the user to configure a PDU meeting their exact specification. By selecting the appropriate input power (voltage, amperage, and phases), input cord, PDU orientation, outlet mix, and connectivity, the datacenter designer and IT specifier can get a PDU that is custom-tailored to their high compute density application.

HDOT modules are available for individual phases per module, and in our new, alternating phase configuration. *(Alt Phase PDU shown at right)*

The Benefits of HDOT

HDOT delivers on the promise of modern PDU design capabilities. With its modular construction and its completely re-thought outlet layout, HDOT provides as many combinations as possible of locking C13 and C19 power outlets, all in a standard form factor that fits most datacenter cabinets. At just 1.75" wide, 2.2" deep, and 70" tall, the HDOT PDU is suitable for all server racks 42U and taller. HDOT is also capable of operating at full power load in a 65˚C environment, allowing the datacenter to run with a warmer ambient temperature. The Smart version of HDOT also allows for remote monitoring of both power and temperature, alerting, and reporting, thus enabling the datacenter manager to make the most use of the available datacenter compute infrastructure and available power.

The benefits of the alternating phase modules are numerous — they simplify load balancing while minimizing cord lengths, and they make it easier to identify which asset is plugged into each outlet of the CDU.

Key HDOT Benefits:

> Industry standard C13 & C19 with minimized footprint

> Maximum possible outlet density in an Intelligent PDU

> Operation to 65˚C (149˚F) ambient

> Robust high temperature materials employed

> Thousands of variations available using our online "Build-Your-Own" Smart PDU Tool

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Why Server Technology for High Density Data Centers?

Server Technology's power strategy experts have provided power solutions for labs, data centers, and telecommunications operations for 30 years. Over 60,000 customers around the world rely on our cabinet power distribution units and award winning power management solutions to reduce downtime, facilitate capacity planning, improve energy utilization, and drive efficiency. With the best quality, best technical support and most patents, Server Technology products provide uncompromising reliability, innovation, and value for the datacenter.

Only with Server Technology will customers **Stay Powered, Be Supported & Get Ahead — www.servertech.com**

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HEADQUARTERS NORTH AMERICA
Server Technology
1040 Sandhill Drive
Reno, NV 89521
United States
Tel: +1.775.284.2000
Fax: +1.775.284.2065
sales@servertech.com
www.servertech.com
www.servertechblog.com

WESTERN EUROPE, MIDDLE EAST & AFRICA
Server Technology
Fountain Court
2 Victoria Square
Victoria Street
St. Albans, AL1 3TF
United Kingdom
Tel: +44 (0) 1727 884676
Fax: +44 (0) 1727 220815
salesint@servertech.com

CENTRAL EUROPE, EASTERN EUROPE & RUSSIA NIEDERLASSUNG DEUTSCHLAND
Server Technology
42119 Wuppertal
Germany
Tel: +49 202 693917 x0
Fax: +49 202 693917-10
salesint@servertech.com

APAC
Server Technology
Room 2301, 23/F, Future Plaza
111-113 How Ming Street,
Kwun Tong, Hong Kong
Tel: +852 3916 2048
Fax: +852 3916 2002
salesint@servertech.com