

Part 1

ASHRAE IT Power Trends

BY DONALD L. BEATY, P.E., FELLOW ASHRAE; DAVID QUIRK, P.E., MEMBER ASHRAE; JEFF JAWORSKI

ASHRAE's Datacom Series' *IT Equipment Power Trends*, third edition, published earlier this year brought about three significant tools to help data center owners and design engineers better estimate the current and future power demands in data center designs as follows:

1. Power trends as a function of workload (software applications);
2. Compound annual growth rate (CAGR) metric to estimate future growth needs; and
3. Boundary conditions (typical vs maximum configurations).

Next to the *Thermal Guidelines*, the *IT Power Trends* is one of the most significant and impactful publications for the data center industry. The updates to this third edition help to solve one of the most misunderstood publications by HVAC engineers by attempting to quantify power consumption as a function of workload and how it can deviate significantly from maximum configurations (i.e., below them).

The original publications sought to raise awareness about the increasing power demands of the IT equipment as a function of the product class and year released. The trends aimed to provide a consensus of the IT manufacturers' peak power demands, assuming maximum configuration, and fully utilized. This was an attempt to define the worst possible condition or extreme for power requirements for a given data center.

Each subsequent edition of *Power Trends* has attempted to further expand and clarify the diversity in the product classes, configurations, and utilizations as a function of software applications. Updates to *IT Power Trends* have been adapted to consider how the industry is evolving including taking into account the increasingly common practice to use purpose-built servers tailored to specific software applications.

This trend has led to the next evolution server power trends reflected in the third edition of *Power Trends*. The trends now reflect the power of these purpose-built servers when being used to perform specific workloads.

This column serves as an introduction to the updates in *Power Trends*.

Power Trend Evolution

As with previous editions, the intended use for the book is as a reference for making current and future server power usage projections. These projections

Donald L. Beaty, P.E., is president, David Quirk, P.E., is vice president, and Jeff Jaworski is an engineer at DLB Associates Consulting Engineers, in Eatontown, N.J.

FIGURE 1 Uptime Institute, 2000.

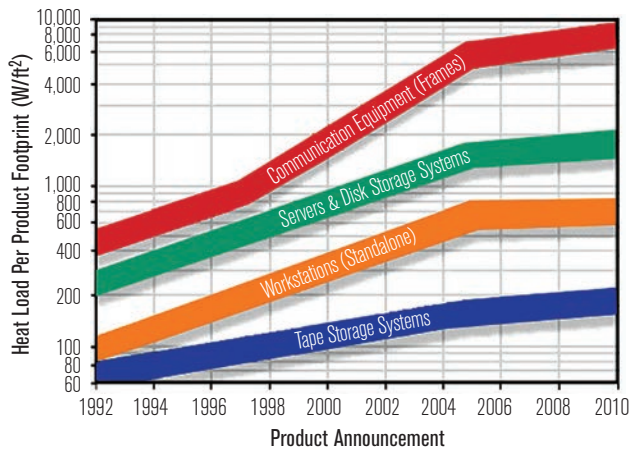


FIGURE 2 First edition, 2005.

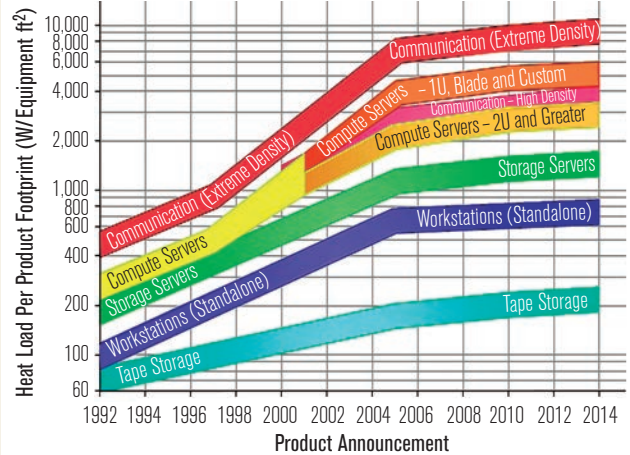


FIGURE 3 Second edition, 2012.

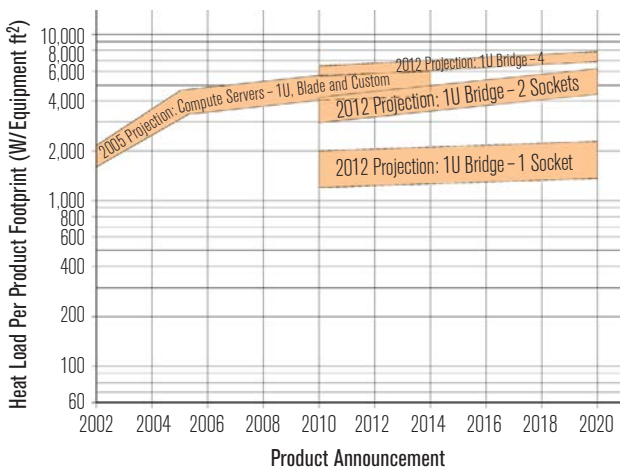
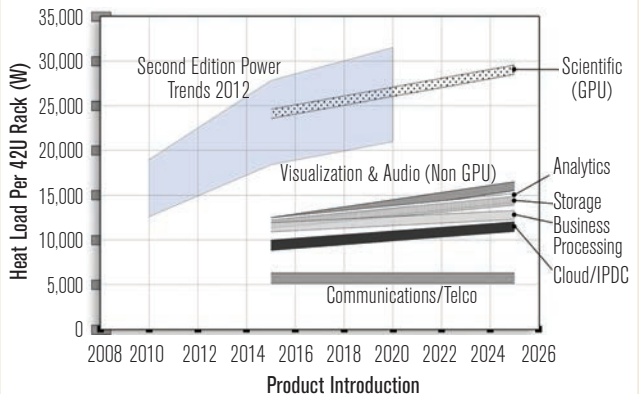


FIGURE 4 Third edition, 2018.



are particularly useful when planning the design and construction of new, expanded, or renovated data centers.

Keep in mind that the trend data represents a consensus opinion of representatives from participating IT manufacturers. The data is not intended to be utilized as a baseline for making product comparisons. They are also not intended as the only reference for the design of a new data center. A new design should begin with an understanding of the company's goals, both now and in the future.

Power Trends has evolved with a focus on becoming easier to understand and apply. The following is a recap of the timeline of changes:

Uptime Institute, 2000:¹ Four trend bands presented graphically and categorized by equipment type (Figure 1).

First edition, 2005: Seven trend bands presented graphically and categorizing by equipment type (Figure 2).

Second edition, 2012: Nine compute server trend bands presented graphically over multiple charts and categorized by equipment type and the number of CPU sockets deployed within its servers. Figure 3 shows one of the six compute server charts with four of the nine compute server trend bands.

Third edition, 2018 (Figure 4):

- Seven workload types defined
- Workload types correlated with their typical server configurations
- CAGR introduced with values assigned to each server configuration associated with a workload type.

- Trends presented for each workload type and bounded by “Maximum Expected” and “Typical Expected.”

The above is best represented with graphs to depict the evolution of changes to the main power trends. The following figures and descriptions help to paint the historic picture.

As shown in *Figure 1*, the original trends chart published by the Uptime Institute had the equipment types divided into four broad categories. At this point in time, the communications equipment was noted as the highest density based on the commonly smaller footprint frames used at the time.

This began to lead to confusion for the industry as many argued that communications equipment was not the most dense, particularly when configured in larger cabinets. This is an important item to note later in the third edition and part of the reason why the product footprint was ultimately abandoned.

First Edition

These equipment types were further divided into seven categories when published in the first edition of *Power Trends* as noted and shown below in *Figure 2*. This was in response to the industry developing a broader range of hardware configurations (e.g., blade servers) that expanded the range of potential density for a given type.

Equipment Types

- Communication equipment
 - High density
 - Extreme density
- Compute Servers
 - 1U, Blade, custom
 - 2U and higher
- Storage Servers (disk storage systems)
- Workstations (stand-alone)
- Tape storage systems

Second Edition

The second edition stayed with the same seven equipment type classifications for the hardware, but further expanded the sub-types by more granularity with the applications as noted below:

TABLE 1 Workload types.

Table 4.1 Workload Types

Workload Type		Definition/Examples
Workload Types could be in Cloud Hosting	Scientific	Scientific-based application including biological sciences, geosciences, weather forecasting, engineering, simulation, design, defense, security, and training of deep machine learning applications (versus run-time)
	Analytics	Discrete data warehousing, data analysis, big data analytics, and run-time deep machine learning applications
	Business Processing	Enterprise wide line of business applications that manage transactional, operational, and customer databases
	Cloud/IPDC (Internet Portal Data Center)	Wikis, portals, social media, video-sharing websites, search engines, and online auction websites
	Visualization & Audio	Data center visualization applications including video processing, remote visualization, and audio processing
	Communications/Telco	Wired and wireless networking applications: application, control, packet, and signal processing.
	Storage	Dedicated storage infrastructure and services including backup, tiering, and deduplication

Note: Web Hosting (cloud)/IPDC is a defined workload; examples include wikis, portals, social media, video-sharing websites, search engines, and online auctions. This should not be confused with cloud service providers.

Equipment Types

- Communication equipment (frames)
 - Extreme Density
 - High Density
- Compute Servers (cabinets)
 - 1U, Blade & Custom
 - 2U & Greater
- Storage Servers (disk storage systems)
- Workstations (stand-alone)
- Tape storage systems.

Perhaps the more significant addition was the introduction of equipment differentiation using CPU “sockets” as a metric.

Third Edition

In the current edition, the evolution and development of methods for projecting future power consumption took another fundamental leap. Workload types have been introduced as a means of reflecting server configurations and utilization.

Trends were modified to be based on a 42U cabinet instead of using cabinet footprint. This was done to make the information easier to use and apply in application since cabinet footprints were largely variable and customer dependent.

Trends for custom servers, blade servers and workstations were eliminated as there was too much variation

and inability to gain consensus on the data.

Server configurations and their utilization for each workload were also identified.

Workload Types

The transition to using workload type was brought about by the recognition that “software is the real load in data centers.”² These workloads and their software drive server energy usage composed of a mix of both transient and steady-state components.

At the high end of the energy usage trends is the scientific workload. This is composed primarily of steady-state server utilization at a high level since they are continuously “crunching numbers.”

Toward the lower end is the Business Processing Workload, where processor utilization is composed of longer idle periods during data entry followed by spikes after the data has been entered.

Future Growth Trends Using CAGR

Compound annual growth rate (CAGRs) has also been introduced in the current edition with actual values for each workload type and their common server configurations. These values represent a consensus of the participating IT equipment manufacturers and strive to take into account:

- Historic growth rates;
- Economic factors;
- Market demands;
- Projections of computational performance improvement via: hardware advances and optimization and software refinements and tuning; and
- Projections of new application

development.

These CAGRs are intended to serve as a technical reference for estimating future power usage. The equation for using the CAGRs is:

$$\text{Future load} = \text{Current Load} \times (1 + \text{CAGR})^{(t-t_0)}$$

Upon review of this equation, the following observations became apparent:

Highest CAGRs

CAGR: 4.7%

- Workload: Analytics
- Form Factor: 1U ½-width



OUR BUSINESS IS COOLING YOURS™

When commercial grade isn't enough.

Innovative products, reliable solutions and an unwavering commitment to excellence has earned us the reputation as an industry leader. Understanding a customer's project needs and offering product design flexibility has made us a trusted partner.

Chillers For Data Centers

- Capacities from 5 – 500 Tons
- Mission Critical Design
- Exclusive Integrated Free-Cooling System
- Scaleable Solution
- Optional Adiabatic System
- Market Leading Annualized P.U.E.
- Start-up Operation to -40° F
- Scroll and Screw Compressors

motivaire
COOLING SOLUTIONS

ChilledDoor
Rack Cooling System

info@motivairecorp.com • www.motivairecorp.com

- Sockets: 2 CPUs

CAGR: 4.1%,

- Workload: Scientific
- Form Factor: 1U
- Sockets: 2 CPUs

CAGR: 2.9%,

- Workload: Visualization & Audio
- Form Factor: 1U ½-width
- Sockets: 2 CPUs (Non GPU)

One of the conclusions that can be drawn from this is that significant focus is being placed on these three workload types and the 1U & 1U ½-width servers.

It is reasonable to expect that the CAGR values reflect market demand for a server configuration and thus the IT industry's focus on continued development of that configuration. In other words, high CAGR values are for Workloads where demand for cutting edge servers is highest.

Boundary Conditions

Trends by workload type are provided with boundaries for maximum expected and typical expected rack power levels based on the year of project introduction (Figure 5).

Historically, the biggest misconception of *Power Trends* was that the forecasted maximums were the typical. Arguably, this led to many over-provisioned data centers as many engineers designed to these forecasted maximums. The delta between the typical expected and maximum expected is significant as shown in Figure 5.

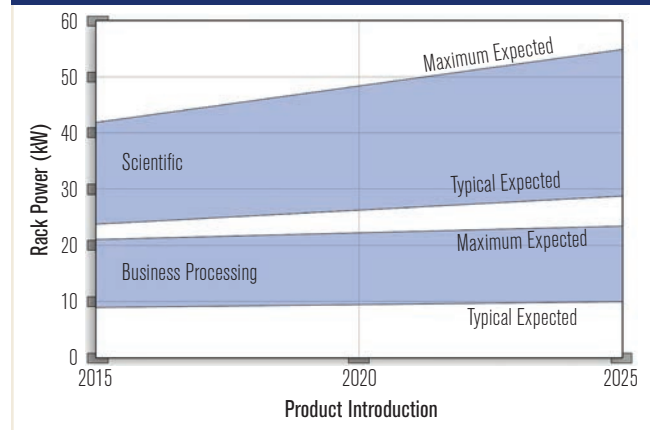
The range between typical expected and maximum expected requires some iteration and understanding of how a client configures their equipment in a rack, how much utilization is expected, and the workloads of the software on that configured hardware.

Conclusions

This third edition of *Power Trends* provides much more detailed information that can be utilized by data center owners and design engineers to develop realistic power growth projections for use in planning their data centers. The challenge now becomes acquiring the detailed insight into the IT plans and strategies to utilize this new trend information to its full potential.

The software *applications* running on the equipment will dictate power densities and they will *never* be the

FIGURE 5 Third edition, 2018.



same as these published *hardware* trends. The published values are based on actual power measurements of servers performing each workload. These measurements were then adjusted to correspond with 42U cabinets fully provisioned with servers.

Each data center has a unique combination of the following that ultimately dictates the real power trends in a given data center:

- Equipment types;
- Equipment configurations;
- Equipment utilizations (how much of the cabinet is populated, how much of the row is populated, etc.);
- Software applications;
- Software utilizations; and
- Technology refresh rates (how often is equipment changed out).

The evolution of ASHRAE *Power Trends* helps demonstrate some of the factors that have gone into further clarifying the combination of hardware and software trends that have driven the power increases in data centers over the years.

Armed with the third edition of *Power Trends*, and a deeper understanding of the intended applications, data center owners and design engineers are better equipped to plan their next data center growth project.

References

1. Beaty, D.L. 2015. "Data center loads – unknown, unseen, unheard. why you must know what your software is doing." *ASHRAE Journal* (10).
2. The Uptime Institute. 2000. "Heat Density Trends in Data Processing, Computer Systems, and Telecommunications Equipment." White Paper. ■

NEW MIAMI-DADE APPROVAL for our EFJ-937 Dual-Module Severe Duty Louver.
Features multiple installation options requiring minimal hardware and assembly time.

When the Unthinkable Happens ...

WHAT'S INSIDE MATTERS

Pottorff's NEW
Dual-Module
EFJ-937-MD
Miami-Dade
Approved Louver



The EFJ-937-MD 9" dual-module louver features exterior horizontal J-blades for a pleasing appearance and internal vertical blade section for performance. It has been engineered to withstand the extreme loads, debris impact and cyclic fatigue associated with hurricanes.

Free Area: 53.9%

- ▶ **NEW Miami-Dade Listing**
- ▶ **AMCA Certified for Water Penetration, Air Performance and Wind-Driven Rain**
- ▶ **AMCA 540 (Impact Resistant) and 550 (High Velocity Rain Resistant) Listed**

5 year
warranty

POTTORFF®

www.pottorff.com