CENTER OF EXPERTISE FOR ENERGY EFFICIENCY IN DATA CENTERS

Computer Server Selection Guidelines for Energy Efficiency and Decarbonization in Data Centers

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Executive Summary

A data center houses computer servers, storage, and networking equipment as well as critical support infrastructure such as cooling and electrical systems. This report focuses on servers since they generally use more energy than all other IT equipment combined. More specifically, it addresses air-cooled computer server selection guidelines in order to facilitate energy efficiency and decarbonization in data centers. The objective of this report is to help data center operators to operate more energy efficiently by purchasing computer servers that meet strict performance criteria.

For that purpose, four key industry documents are reviewed and condensed in this report with the intent of providing a clear understanding what each document covers and how the individual documents complement one another. These key documents are as follows:

- ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Thermal Guidelines
- ENERGY STAR for Computer Servers
- Electronic Product Environmental Assessment Tool (EPEAT)
- Environmental Leadership and Corporate Social Responsibility Assessment of Servers, Standard NSF/ANSI 426-2019.

The ENERGY STAR document builds partially on the ASHRAE Thermal Guidelines, which defines standard operating thermal environments for data centers. EPEAT/NSF 426-2019 provides stricter performance requirements and criteria than ENERGY STAR.

Adopting aggressive standard operating thermal environments provides opportunities to significantly reduce cooling energy use in data centers, since the efficiency of cooling equipment improves with increasing operating temperatures. And, specifying and selecting thermally robust computer servers allows operating at higher temperatures. The ASHRAE document provides several standard operating environments, but does not require a specific environment.

The ENERGY STAR document requires a server to report intake air temperature so the operator can show conformance with the selected ASHRAE standard environment. Like ASHRAE, ENERGY STAR does not require a specific operating environment. It also requires reporting on input power and CPU utilization since they are important for managing the data center. In addition, it provides criteria for server efficiency, power supply efficiency, power factor, and power management. When less power is required to operate the servers and the cooling system, there will also be less loss in the electrical system. ENERGY STAR qualified servers are a requirement for Federal agencies.

EPEAT helps identify greener electronic devices. One of several product categories is computer servers. EPEAT server category criteria are based on standard NSF/ANSI 426-2019 Environmental Leadership and Corporate Social Responsibility Assessment of Servers. It requires the computer server to be ENERGY STAR certified as well as support operation in higher temperature environments than the lowest ASHRAE class, that is, the equipment must be more robust. Federal agencies should consider EPEAT-registered servers to further maximize energy savings.

Specifying servers that are more energy efficient and thermally robust is imperative for making the data center more energy efficient and thereby help meet important decarbonization goals. In addition, there are potential first-cost savings. If energy efficient and thermally robust servers are selected for a new data center, the support systems can be sized with reduced capacity.

Introduction

A data center is a facility that houses Information Technology (IT) equipment, typically computer servers, storage gear, and networking equipment. The infrastructure also includes support systems such as cooling and electrical systems. Data centers are critical to the mission of many types of organizations. Data center operators are challenged to address key mandates: deliver reliable services, operate efficiently, and ensure resiliency and flexibility.

This report focuses on improving operational efficiencies of air-cooled computer servers in data centers, specifically energy efficiency and decarbonization. Servers generally use more energy than all other IT equipment combined, and energy savings at the server level will cascade through the support infrastructure.

The selection of computer servers can have a profound impact on overall energy efficiency and decarbonization in data centers. Four key industry documents help data center operators to operate more energy efficiently by purchasing computer servers that meet certain performance criteria. In this report, these documents are discussed individually as well as how they interact.

- **ASHRAE Thermal Guidelines** for Data Processing Environments (ASHRAE, 2021) provide standardized operating thermal environments (temperature) for electronic equipment to create a better alignment between equipment manufacturers and facility operations to ensure energy-efficient and fault-tolerant operation within data centers.

- **ENERGY STAR®** Product Specification for Computer Servers (ENERGY STAR, 2018), issued by the Environmental Protection Agency (EPA), include a number of certification criteria and standard performance data measurement and output requirements promoting server and cooling energy efficiency in data centers.

- **EPEAT** for Computer Servers. The Electronic Product Environmental Assessment Tool is a global rating system for greener electronics (EPEAT, 2021). It ranks products on specific criteria to help identify greener electronic devices. In other words, EPEAT is an eco-label for the IT sector. The server category criteria are based on standard NSF/ANSI 426-2019.

- **Standard NSF/ANSI 426-2019** Environmental Leadership and Corporate Social Responsibility Assessment of Servers (NSF, 2019) establishes both product environmental performance criteria and corporate performance metrics that demonstrate environmental leadership and corporate social responsibility. This standard includes references to the ASHRAE Thermal Guidelines and ENERGY STAR.

Specifications and requirements quoted in this report from the documents above are condensed for clarity. Please consult the original documents for unabridged information. See the Reference section for links.

1. ASHRAE Thermal Guidelines

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Thermal Guidelines for Data Processing Environments (Figure 1) and Telcordia Network Equipment-Building System (NEBS) GR-63/3028 (Figure 2) provide guidance on intake air temperature and humidity for IT equipment.

One of the purposes of the ASHRAE Thermal Guidelines (ASHRAE, 2021) is to provide standardized operating environments for IT equipment. The fifth edition of the Guidelines was primarily authored by IBM, Dell, AMD, and Intel. It is primarily intended for data-center equipment and facilities. On the other hand, the NEBS de-facto standard is usually preferred in environments for telecommunications equipment (Telcordia 2001, 2012). The NEBS standard has a two-part documentation. The first part provides guidelines for facility operation whereas the second provides guidelines for IT equipment robustness and testing.

Environmental conditions and environmental tests for telecommunications equipment are also discussed in detail in the European Telecommunications Standards Institute (ETSI) standard ETSI EN 300 019-1-3 (2014).

Adopting the ASHRAE or NEBS environmental criteria provides opportunities for reducing cooling energy use in data centers. All IT electric power is released as waste heat into the data center. Less heat from the equipment means less demand on the cooling system. Furthermore, when less power is required for running the servers and the cooling system, there will also be less loss in the electrical system. Understanding this cascading effect makes server upgrades all the more attractive.

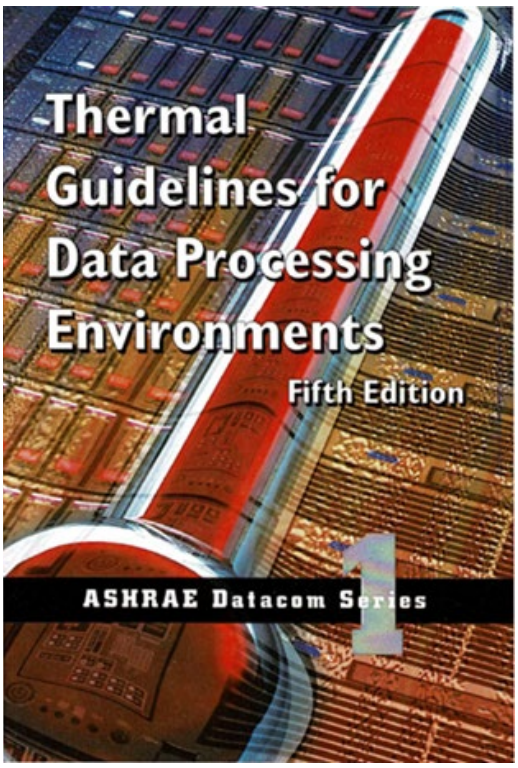

Figure 1. ASHRAE Thermal Guidelines (ASHRAE, 2021)

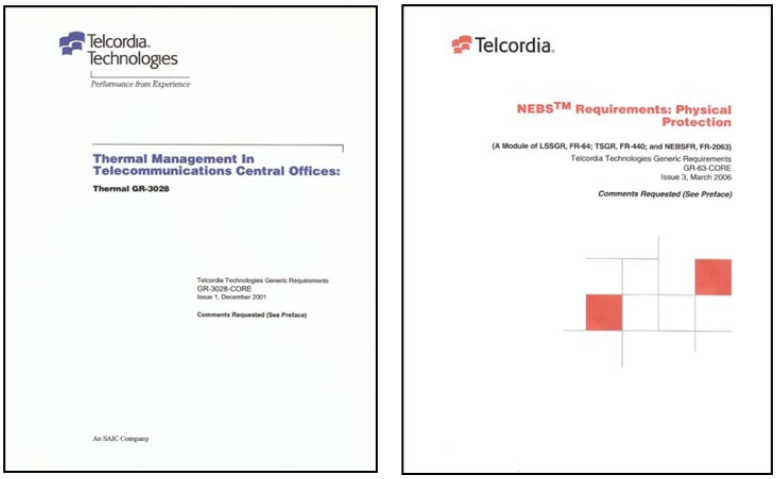

Figure 2. NEBS Thermal Guidelines (Telcordia, 2001 and 2012)

The thermal equipment environment is defined by the temperature of the air drawn into the air-cooled equipment, the temperature the electronics depend on for reliable cooling and operation. Those are the temperatures to monitor for managing the thermal environment. The return temperature or the temperature in the middle of the aisle, for example, has little to do with equipment cooling.

Key nomenclature for understanding these industry guidelines includes “recommended” and “allowable” IT equipment intake air temperatures. Figure 3 shows the concept of minimum and maximum values for recommended and allowable temperature ranges. The purpose of the recommended and allowable ranges is to give guidance to data center operators on maintaining high reliability but yet operate their data centers in an energy-efficient manner.

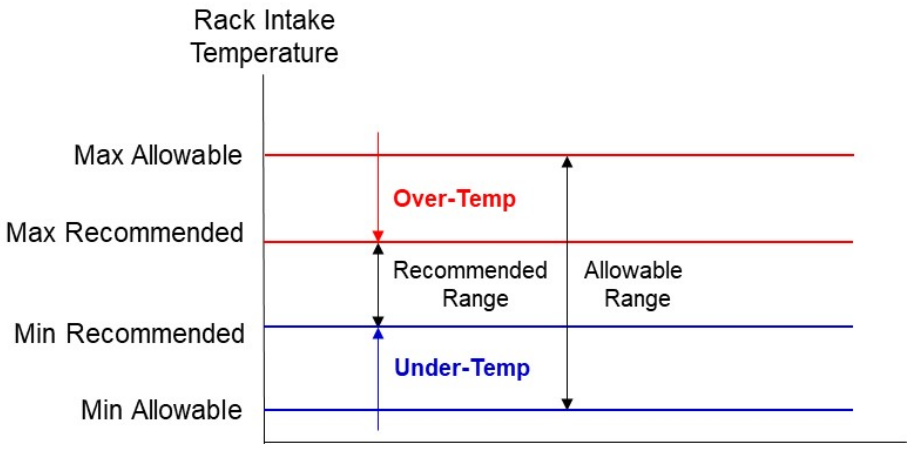

Figure 3. Recommended and Allowable definitions (DCEP, 2021)

The Recommended range, which is a statement of reliability, is the preferred facility operation; most intake air temperatures should be within this range. Facilities should be designed to achieve, under normal circumstances, intake air conditions that fall within the recommended range.

The Allowable range, which is a statement of functionality, is a measure of the robustness of the server equipment; no values should be outside this range. These are the boundaries where server manufacturers test their equipment to verify that the equipment will function.

Server manufacturers consider their equipment warrantied for operation within the allowable range without any time limit imposed on operation at any temperature and humidity value within that range. However, for long-term reliability, server manufacturers recommend that the equipment be maintained within the recommended range for most of the time. Prolonged exposure of operating equipment to conditions outside its recommended range, especially approaching the extremes of the allowable operating environment, can result in decreased equipment reliability and longevity. Operating equipment outside its allowable operating environment risks catastrophic equipment failure.

The ASHRAE Thermal Guidelines defines four (A1-A4) allowable environmental Classes and also a new H1 high-density Class. The Guidelines specify the temperature conditions that the IT equipment intake air must meet for each Class. The "default" Class A1 is typically a data center with tightly controlled environmental parameters and mission critical operations. Furthermore, the Guideline provides a single recommended operating environment (roughly 65°-80°F) for all four allowable Classes and the opportunity for facility operators to plan excursions into the allowable range or modify the recommended range based on the effect of data center environments on server operation and reliability.

Selecting thermally robust servers allows operating at higher data center temperatures. The ASHRAE Thermal Guidelines do not require a certain thermal environment but rather provide a number of standardized options. The other industry documents discussed in this report either specify that servers must report intake air temperature based on onboard sensors or specify a certain standardized intake air temperature for increased cooling equipment efficiency.

Table 1. Comparison between ASHRAE (2021) and NEBS (2001 and 2012).

(@ Equipment Intake)	Recommended (Facility)	Allowable (Equipment)
Temperature		
Data Centers Class A1	65° – 80°F	59° – 90°F
Telecom NEBS	65° – 80°F	41° – 104°F

With proper air management, the intake air temperature can be raised without negatively affecting the thermal equipment environment. Indeed, designers and operators should target a temperature near 80°F (maximum recommended temperature) for maximum energy savings through improved cooling efficiency/capacity and increased economizer utilization ("free" cooling).

The efficiency of cooling equipment improves with increased data center air temperature. Most cooling equipment increases its efficiency by 1-3% for each degree F increase in the data center temperature (LBNL, 2021a). Consequently, the savings can be substantial.

Figure 4 shows all ASHRAE environmental "envelopes" in the standard psychrometric chart, where both temperature (x-axis) and absolute humidity (y-axis) are included. This representation provides a concise way of presenting the environmental conditions. This figure shows recommended and allowable (A1-A4) operating conditions for low level of pollutants in the data center. However, the temperature limits are the same for high level of pollutants.

As can be seen from Figure 4, Class A4 has a much larger envelope and a higher maximum temperature compared to Class A1. Class A1 is increasingly being phased out and replaced with larger envelopes (A2-A4). Server manufacturers can self-certify their electronic equipment will operate as intended in

environmental Class A1, A2, A3, A4, or H1. There is data center equipment certified for ASHRAE Class A3 and even for Class A4.

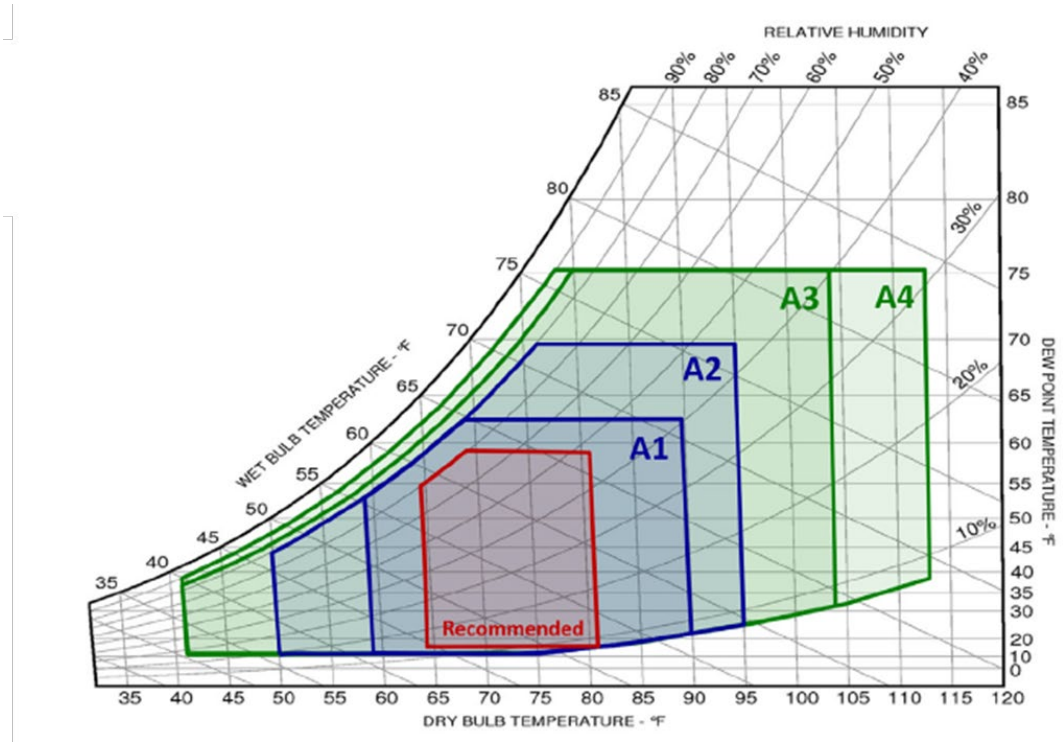

Figure 4. ASHRAE environmental envelopes (low level of pollutants in the data center).

Adopting the ASHRAE or NEBS temperature criteria provides opportunities for reduced cooling energy use. Whatever temperature Class you decide to operate to, make sure to conform with that Class during operation. Thermal guidelines become truly useful when there is an objective way of showing compliance (Herrlin, 2008) and using a standardized way of measuring the temperatures (LBNL, 2020).

The next document we will look at is “ENERGY STAR for Computer Servers”. It requires a compliant computer server to report intake air temperature along with other parameters, including power supply efficiency and power factor criteria. The ASHRAE Guidelines provided the importance of those temperatures on data center cooling energy consumption.

2. ENERGY STAR® for Computer Servers

ENERGY STAR is a program administrated by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) that promotes energy efficiency. The program provides information on the energy consumption of products and devices using standardized methods. ENERGY STAR products are third-party certified to be energy efficient. The ENERGY STAR label is found on more than 75 different product categories, including computer servers and other data center equipment.

Federal laws and requirements mandate that Federal agencies purchase ENERGY STAR qualified products. FEMP states that Federal purchases can generally assume products that meet ENERGY STAR efficiency requirements are life-cycle cost effective (FEMP, 2021). An efficient product is cost effective when the lifetime energy savings from avoided energy costs over the life of the product, discounted to present value, exceed the additional up-front cost (if any) compared to a less efficient option.

The ENERGY STAR label makes it easy to find an energy efficient server to meet specific needs. Using the ENERGY STAR (2021) Product Finder, you can select from hundreds of certified energy efficient servers from different companies. In addition, ENERGY STAR Active Certifications (2021) provides a listing of all currently certified servers. There are also ENERGY STAR rated UPSs, storage products, and networking equipment.

ENERGY STAR (2018) Product Specification for Computer Servers (Figure 5) includes Power Supply Requirements (efficiency and power factor), Power Management Requirements, Active State Efficiency Criteria, and Idle State Efficiency Criteria. The Standard Performance Data Measurements and Output Requirements include Measurement and Output. We will now look closer at these requirements and criteria.

- Power Supply Requirements

Power Supply Efficiency Criteria: A rack-mounted computer server must be configured with only Power Supply Units **(**PSUs) that meet or exceed the applicable efficiency criteria specified in Table 2 prior to shipment.

A single-output power supply delivers the majority of its rated output power to one primary Direct Current (DC) output for powering a computer server. And, a multi-output power supply delivers the majority of its rated output power to more than one primary DC output for powering a computer server.

Table 2: Power Supply Efficiency Criteria.

Power Supply Type	Rated Output Power	10% Load	20% Load	50% Load	100% Load
Multi-output (Ac-Dc)	All Output Levels	N/A	90%	92%	89%
Single-output (Ac-Dc)	All Output Levels	83%	90%	94%	91%

ENERGY STAR® Program Requirements
Product Specification for
Computer Servers

Eligibility Criteria
Version 3.0

Following is the Version 3.0 ENERGY STAR Product Specification for Computer Servers. A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

1 DEFINITIONS

A) Product Types:

1) Computer Server: A computer that provides services and manages networked resources for client devices (e.g., desktop computers, notebook computers, thin clients, wireless devices, PDAs, IP telephones, other computer servers, or other network devices). A computer server is sold through enterprise channels for use in data centers and office/corporate environments. A computer server is primarily accessed via network connections, versus directly-connected user input devices such as a keyboard or mouse. For purposes of this specification, a computer server must meet **all** of the following criteria:

   A. is marketed and sold as a Computer Server;

   B. is designed for and listed as supporting one or more computer server operating systems (OS) and/or hypervisors;

   C. is targeted to run user-installed applications typically, but not exclusively, enterprise in nature;

   D. provides support for error-correcting code (ECC) and/or buffered memory (including both buffered dual in-line memory modules (DIMMs) and buffered on board (BOB) configurations).

   E. is packaged and sold with one or more ac-dc or dc-dc power supplies; and

   F. is designed such that all processors have access to shared system memory and are visible to a single OS or hypervisor.

2) Blade System: A system comprised of a blade chassis and one or more removable blade servers and/or other units (e.g., blade storage, blade network equipment). Blade systems provide a scalable means for combining multiple blade server or storage units in a single enclosure, and are designed to allow service technicians to easily add or replace (hot-swap) blades in the field.

   A. Blade Server: A computer server that is designed for use in a blade chassis. A blade server is a high-density device that functions as an independent computer server and includes at least one processor and system memory, but is dependent upon shared blade chassis resources (e.g., power supplies, cooling) for operation. A processor or memory module that is intended to scale up a standalone server is not considered a Blade Server.

      (1) *Multi-bay Blade Server*: A blade server requiring more than one bay for installation in a blade chassis.

      (2) *Single-wide Blade Server*: A blade server requiring the width of a standard blade server bay.

Figure 5: ENERGY STAR (2018) Product Specification for Computer Servers (Page 1).

Power Supply Power Factor Criteria: A rack-mounted computer server must be configured with only PSUs that meet or exceed the applicable power factor criteria specified in Table 3 prior to shipment, under all loading conditions for which output power is greater than or equal to 75 watts.

Table 3: Power Supply Power Factor Criteria.

Power Supply Type	Rated Output Power	10% Load	20% Load	50% Load	100% Load
Ac-Dc Multi-output	All Output Ratings	N/A	0.80	0.90	0.95
Ac-Dc Single-output	Output Rating ≤ 500 W	N/A	0.80	0.95	0.95
	Output Rating > 500 W and Output Rating ≤ 1,000 W	0.65	0.80	0.95	0.95
	Output Rating > 1,000 watts	0.80	0.90	0.95	0.95

- Power Management Requirements

Server Processor Power Management: A computer server must offer processor power management that is enabled by default. All processors must be able to reduce power consumption in times of low utilization.

- Active State Efficiency Criteria

Active State Efficiency Reporting: A computer server must be submitted for certification with the SERT rating tool results disclosed in full and in the context of the complete active state efficiency rating test report.

The Server Efficiency Rating Tool (SERT) suite is a next-generation tool set for measuring and evaluating the energy efficiency of computer servers (SERT, 2021). The SERT® standard was created by the Standard Performance Evaluation Corporation (SPEC®).

Active State Efficiency Requirements: Active state efficiency score shall be greater than or equal to the minimum active state efficiency thresholds (Eff_{ACTIVE}) listed in Table 4 for all configurations submitted for certification.

Eff_{ACTIVE} is comprised of Eff_{CPU}, Eff_{MEMORY} and $Eff_{STORAGE}$ which are defined in equations 3 through 6 in ENERGY STAR (2018) Product Specification for Computer Servers.

Table 4: Active State Efficiency Thresholds for Computer Servers.

Product Type	Minimum Eff_{ACTIVE}
One Installed Processor	
Rack	11.0
Two Installed Processors	
Rack	13.0
Greater Than Two Installed Processors	
Rack	16.0

- Idle State Efficiency Criteria

Idle State Data Reporting: Idle state power shall be measured and reported.

- Measurement and Output

A computer server must report input power consumption, intake air temperature, and average utilization of all CPUs. The data must be made available in a published or user-accessible format that is readable by third-party, non-proprietary management software over a standard network. In other words, IT vendors must offer the ability to view these server performance data in real time using onboard sensors and automation software.

- Measurement Accuracy

Input power: Measurements must be reported with an accuracy of no worse than ±5% but with an accuracy no worse than ±10W for each installed PSU through the operating range from idle to full power. Input power measurements must be sampled internally to the computer server.

Intake air temperature: Measurements must be reported with an accuracy of no worse than ±2°C. Intake air temperature measurements must be sampled internally to the computer server.

CPU utilization: Average utilization must be estimated for each CPU that is visible to the Operating System (OS). Processor utilization measurements must be sampled internally to the computer server.

The fact that these three parameters are part of the ENERGY STAR requirements is a testament to the importance of the data to server and data center energy efficiency. These parameters are summarized below.

- Input Power: Accurate and complete input power readings are important for data center power capacity planning or tracking energy-efficiency improvements at the server level. Traditionally, costly external intelligent rack Power Distribution Units (PDUs) were used to monitor input power to servers. With onboard server data, real-time data can be collected without deploying such infrastructure.

- Intake Air Temperatures: Accurate and complete intake air temperatures are imperative for energy management and for maintaining server health. The DCEP program (DCEP, 2021) has training modules looking at different ways of improving the energy efficiency and equipment reliability with proper thermal management. Up until recently, costly external sensors were used to monitor the server intake air temperatures. Thanks to advances in server monitoring, onboard sensors can now be used.

- CPU Utilization: Accurate and complete utilization monitoring is critical to identify idling or underutilized servers. Data center operators often lack guidance on how to identify and decommission/consolidate such energy-wasting servers. Accessing the onboard CPU utilization data can greatly help in this endeavor. The DOE Data Center Energy Practitioner (DCEP) training program (DCEP, 2021) has a module looking at ways of improving the energy efficiency of IT equipment, including maximizing the CPU utilization.

Servers that include a pre-installed Operating System (OS) must include all necessary drivers and software for end users to access these parameters. Products that do not include a pre-installed OS must be packaged with printed documentation of how to access registers that contain relevant sensor information. This requirement may be met via either printed materials, electronic documentation provided with the computer server, or information publicly available on the Partner's website where information about the computer server is found.

The ENERGY STAR document was not designed to provide implementation guidance to meet the requirements. Consequently, smaller data centers in particular may need a bit of hand holding to access the data. An LBNL 2021 report tries to help in this regard: Accessing Onboard Server Sensors for Energy Efficiency in Data Centers (LBNL, 2021b). The report reviews opportunities to leverage existing internal (onboard) server sensors for monitoring rather than external sensors for physical parameters. Such an approach has many benefits for data center management, including higher data resolution and lower overall costs.

The next document we will look at is the "Electronic Product Environmental Assessment Tool" (EPEAT). EPEAT is a rating system for greener electronics. It has a number of product categories and among them is Computer Servers.

3. Electronic Product Environmental Assessment Tool (EPEAT)

EPEAT stands for the Electronic Product Environmental Assessment Tool, which is a global rating system for greener electronics (EPEAT, 2021). It ranks products and services on a number of specific criteria, to help identify greener electronic devices. In other words, EPEAT is an eco-label for the IT sector. The Global Electronics Council (GEC) manages the EPEAT eco-label.

Products currently meeting EPEAT criteria, known as active EPEAT-registered products, are listed on the EPEAT Registry (EPEAT, 2021). Purchasers can search for products based on product name, product type, manufacturer, location of use, EPEAT tier (Bronze/Silver/Gold), or status (active).

EPEAT interactive environmental Benefits Calculators (EPEAT, 2021) allow purchasers to measure and report the environmental benefits gained from purchasing electronic products covered by the EPEAT ecolabel. The benefits calculators also enable purchasers to estimate how they can achieve further reductions in environmental impact by using products longer and responsibly recycling them when taken out of service.

EPEAT has several Product Categories: Computers and Displays, Imaging Equipment, Mobile Phones, Network Equipment, Photovoltaic Modules and Inverters, Servers, and Televisions. We will limit this discussion to the Server Product Category since servers dominate electronic equipment in data centers. The EPEAT Server Category criteria are based on standard NSF/ANSI 426-2019 Environmental Leadership and Corporate Social Responsibility Assessment of Servers (NSF, 2019). Federal agencies should consider EPEAT-registered servers when upgrading or replacing hardware to maximize energy efficiency since this standard provides stricter performance requirements and criteria than ENERGY STAR.

The last document we will review is Standard NSF/ANSI 426-2019 “Environmental Leadership and Corporate Social Responsibility Assessment of Servers” published by the National Center for Sustainability Standards. Again, EPEAT server category criteria are based on this standard. In the Energy Efficiency Performance Category, it requires a server to be able to operate in ASHRAE Class A2 conditions.

4. Standard NSF/ANSI 426-2019

EPEAT Server Category criteria are based on standard NSF/ANSI 426-2019 Environmental Leadership and Corporate Social Responsibility Assessment of Servers (NSF, 2019). The purpose of this Standard, shown in Figure 6, is to establish product environmental performance criteria and corporate performance metrics that demonstrate environmental leadership and corporate social responsibility.

This Standard can be used by purchasers for identifying environmentally preferable products as well as to provide market recognition for conforming products and manufacturers. It spares purchasers from the difficult task of defining environmental and corporate social responsibility performance for servers and server manufacturers.

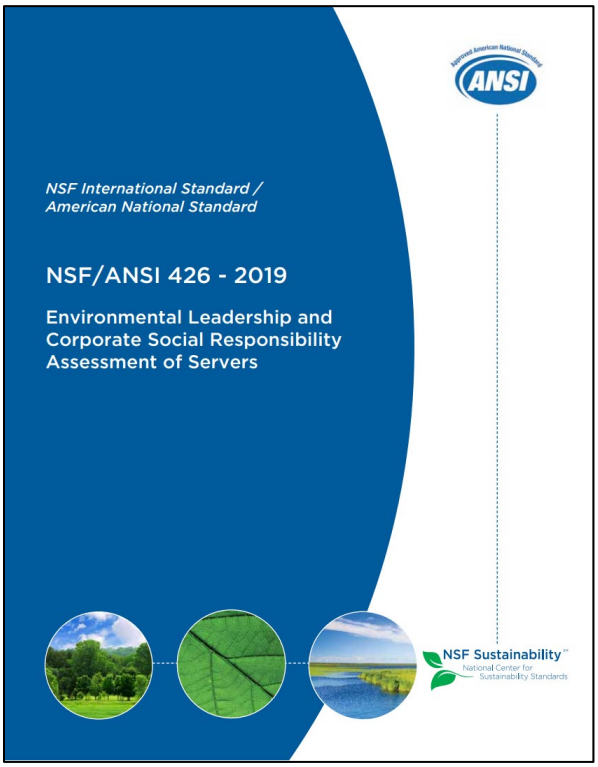

Figure 6. NSF International Standard/American National Standard NSF/ANSI 426 – 2019 Environmental Leadership and Corporate Social Responsibility Assessment of Servers (NSF, 2019)

This Standard has eight Performance Categories with required criteria and optional criteria: energy efficiency; management of substances; preferable materials use; product packaging; design for repair, reuse, and recycling; product longevity; responsible end-of-life management; and corporate responsibility. Each category has required criteria that must be met in order to conform to the Standard. In this report, we will limit ourselves to the Energy Efficiency Performance Category.

As we already have seen, making the servers more energy efficient not only reduces the power requirements for the servers but also for the data center cooling and electrical systems. In addition, a thermally robust server allows operation at higher intake air temperatures (ASHRAE Class A2 or higher). Higher temperatures, in turn, make the data center cooling system more energy efficient.

If servers are upgraded in an expanding data center, there may not be a need to add capacity to the infrastructure support systems. If energy efficient and thermally robust servers are selected for a new data

center, the support systems can be down-sized compared to a more conventional design. Significant capital cost savings can result.

For the Energy Efficiency Performance Category, there are two Required Criteria: Product needs to be ENERGY STAR certified and support ASHRAE Class A2 allowable environmental operating range. Once the required criteria are met, products may achieve higher levels of conformance by meeting a specified percentage of Optional Criteria (points), which incentivizes efficiency levels beyond ENERGY STAR for power supplies and active/inactive power states. The optional points can come from any of the eight Performance Categories. We will review the required and optional criteria in the standard. Please consult the Standard for full details.

There are three levels of environmental conformance defined in the Standard:

- Bronze: meets all Required Criteria for each of the eight Performance Categories;
- Silver: meets all Required Criteria plus at least 50% of the optional points; and
- Gold: meets all Required Criteria plus at least 75% of the optional points.

- Required – ENERGY STAR

The product shall conform with the ENERGY STAR (2018) Product Requirements for Computer Servers. These requirements include the following (see Section 2: ENERGY STAR for Computer Servers for details):

- Power Supply Requirements
- Power Management Requirements
- Active State Efficiency Criteria
- Idle State Efficiency Criteria
- Data Measurement and Output Requirements.

- Required – Allowable Temperature and Humidity Specifications

Product shall support Class A2 allowable environmental operating range published in the ASHRAE Thermal Guidelines (ASHRAE, 2021). Selecting servers thermally robust enough to be operated at this higher temperature class reduces the need for data center cooling energy. The documentation shall include the estimated number of hours per a specified time period that the server can operate in the allowable range without materially affecting the server reliability.

- Optional – Servers Operable at ASHRAE Class A3/A4 Temperature Ranges

Server shall have allowable equipment environmental ranges as specified in ASHRAE Thermal Guidelines of Class A3 or A4. Selecting servers thermally robust enough to be operated at these higher intake air temperatures (compared with Class A2) can further reduce the need for cooling energy. Optional points to be awarded are as follows:

Table 5: Points values for operating at higher temperatures.

Server type	Criterion	Point Value
Other (non-resilient) server	Server operable in ASHRAE class A3	1
Resilient server	Server operable in ASHRAE class A3	2
Other (non-resilient) server	Server operable in ASHRAE class A4	2
Resilient server	Server operable in ASHRAE class A4	3

Criteria for determination of "Resilient" Server to be taken from the ENERGY STAR Product Specification for Computer Servers. In short, a Resilient Server is designed with extensive reliability, availability, serviceability, and scalability features integrated in the micro architecture of the system, CPU, and chipset.

The documentation shall include the estimated number of hours per a specified time period that the server can operate in the allowable range without materially affecting the server reliability. Although the standard does not mention that intake temperatures at the A2 and A3 levels often cause the server fans to speed up to limit the CPU temperature, this should be kept in mind. Higher fan speeds will increase server energy use. Indeed, this increase in server energy may overtake the energy savings at the cooling system level. It may be prudent to inquire about the correlation between intake temperature and fan speed.

- Optional Power Supply Efficiency – 80 Plus® Program Titanium Level

Power supply shipped with the product shall have been tested by an independent, third-party laboratory as in conformance with the requirements of the 80 Plus program Titanium level (CLEAResult, 2021). These power supply efficiencies are slightly higher than those required by ENERGY STAR. Points shall be awarded as detailed below at the 80 Plus Titanium Level (Table 6). This high level of performance will reduce the server energy usage.

Table 6: Point values for using Titanium level power supply.

Power supply unit	Point Value
Single output	1
Multi-output	2

Again, a single-output power supply delivers the majority of its rated output power to one primary DC output for powering a computer server. And, a multi-output power supply delivers the majority of its rated output power to more than one primary DC output for powering a computer server.

- Optional Power States – Active State Power Management Enablement

Product shall be shipped with all of the following active state power management states enabled: processor dynamic voltage and frequency scaling, processor low power idle state, and dynamic memory low power state. The documentation shall include product specification or screen snapshots of BIOS, firmware, or OS which show the power management states defined in above criterion are enabled on the product. Point value: 1

- Optional – Server inactive Power State #1 (<10 seconds recovery)

The product shall be capable of achieving an inactive power state that seeks to reduce the energy use across the system to the extent practical while maintaining a rapid recovery time. The inactive Power State #1 will have a power level which is less than the idle power measurement reported for certification to ENERGY STAR, and recovery to a full active state can be achieved in 10 seconds or less. Manufacturer shall provide information in the product specification on Inactive Power State #1 power usage and the time required to achieve full active state when reactivated from Inactive Power State #1. Point value: 1

- Optional – Server inactive Power State #2 (<20 minutes recovery)

The server is capable of achieving an inactive power state in which all components are unpowered with the exception of a subset of components, such as the power supply, a service processor, and other I/O electronics, necessary to allow for restart upon a call (signal) from the data center management software. The inactive Power State #2 will have a power level which is 30% or less of the idle power as measured for the product conformance with ENERGY STAR Computer Servers Eligibility Criteria, and recovery to a full active state can be achieved in 20 minutes or less. Manufacturer shall provide information in product specifications on inactive Power State #2 power usage and the time required to achieve full active state when reactivated from inactive Power State #2. Point value: 1

- Optional – Energy Efficient Supply Chains

Manufacturer shall demonstrate that supplier facilities providing the design and manufacture of one or more electronics components or services meet certain criteria, including energy. This is not further discussed in this report since it is not directly tied to the operation of the product. Complete information can be found in NSF (2019). Point value: 1 or 2

- Optional – Reduce Energy Lost from Power Conversion

The product shall operate at high voltage AC power, 400/230 V or 480/277 V to reduce energy loss from power conversion during distribution and provide an overall higher system efficiency. This is not further discussed in this report since it is not directly tied to the operation of the product. Complete information can be found in NSF (2019). Point value: 1

- Optional – Logged Server Activity Metrics

Product shall have the capability to log the metrics specified in the Standard Performance Data Measurements and Output Requirements section (Section 5) of the ENERGY STAR (2018) Product Requirements for Computer Servers. These metrics are input power consumption, intake air temperature, and average utilization of all logical CPUs. Point value: 1

Conclusions

There are great opportunities in selecting computer servers to promote energy efficiency and decarbonization in data centers. The four industry documents reviewed and summarized in this report provide a roadmap for such computer server selection.

By condensing the key information in each document, the intent of this report was to provide a clear understanding what each document covers and how the documents fit together. If the full details are desired, the original documents should be reviewed.

Key considerations for making computer servers more energy efficient include improved active and inactive server state efficiency, power supply efficiency, power supply power factor, and server power management capabilities. The direct effect of these measures is more energy efficient servers. However, there are also cascading benefits in other energy consuming systems in the data center.

Making servers more energy efficient not only reduces the power requirements for the servers but also for the data center cooling system. All electric power to a server is released as waste heat into the data center space. Less heat means less demand on the cooling system, which is responsible for providing a "comfortable" operating thermal environment for the servers. Furthermore, when less power is required for running the servers and cooling system, there will also be less loss in the electrical system. Understanding this cascading effect makes the server upgrade (refresh) even more attractive.

Selecting energy efficient servers also offers yet another opportunity by selecting thermally robust equipment. A thermally robust server allows operation at higher intake air temperatures (ASHRAE Class A2 or higher). Higher temperatures, in turn, makes the cooling system more energy efficient. This means we now not only have less demand of power to the cooling system but also more energy efficient operation of the system.

If energy efficient and thermally robust servers are selected for a new data center, the capacity of the support systems can be reduced compared to a more conventional server design. If servers are upgraded in an expanding data center, there may not be a need to add capacity to the infrastructure support systems. Significant cost savings may result.

Clearly, making the servers more energy efficient and thermally robust as outlined in the four reviewed industry documents is imperative for making the data center overall more energy efficient and thereby help meet important decarbonization goals. Federal agencies are required to purchase ENERGY STAR qualified servers and they should also consider EPEAT-registered servers to maximize the energy savings.

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