Proposal Information Template for:
Computer Servers

Submitted to:
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Please note: all savings estimates and information in this document are preliminary and are based on data available to the authors at the time of the report. If the CEC moves forward with this topic, we anticipate updating our estimates and recommendations based upon additional input from stakeholders.

Proposal Information Template – Computer Servers

2011 Appliance Efficiency Standards

Prepared for: Pacific Gas and Electric Company, San Diego Gas & Electric, Southern California Edison, Southern California Gas Company and NRDC

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Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, Cal. Code Regulations, §§ 1601 – 1608) This report specifically covers Computer Servers ("Servers").

Background

As our economy has shifted from paper-based to digital information management, data centers — facilities that primarily contain electronic equipment, including servers, used for data processing, data storage, communications networking — and smaller server rooms and closets have become common and essential. Data centers, server rooms and closets, and the servers they house are found in nearly every sector of the economy: financial services, media, high-tech, universities, government institutions, and many others use and operate data centers to aid business processes, information management, and communications functions.

Even with a small relative volume, servers consume a significant amount of electricity, at approximately 2% of the total U.S. electricity consumption (Koomey 2011). Annual server sales volume in the U.S. has increased at a significant rate over the past decade, though the recent rate of growth has slowed due to global economic downturn, as well as a shift towards virtualization (Koomey 2011).

The EPA Report to Congress (2007) stated that the average US server operates at 5-15% capacity while using 60-90% of maximum power. While the power proportionality (the ratio between load percentage and the percentage of maximum power) continues to improve over time, we estimate there to be a substantial percentage of servers that are wasting power in idle or very low loads. While server virtualization mitigates the problem, penetration of virtualization is still limited and even virtualized servers have typical utilization ratios of less than 30%.

There are many opportunities to reduce energy use in data centers and server rooms, including facility level efficiency, and IT measures such as virtualization and dynamic load management. There are efforts to address these through regulation including a rulemaking for 2013 Title 24 is addressing energy efficiency requirements in datacenters. While these efforts are significant, energy efficiency at an individual device level is also critical to capture savings opportunities in datacenters and server rooms, including those that do not implement server room-level energy efficiency best-practices such as virtualization. There are several potential areas of energy efficiency improvement in servers, including platform, database software (Tsirogiannis et. al 2010), hardware configuration and power supplies (EPRI & Ecos 2008a).

Of the energy savings opportunities available, we recommend both a system energy use approach using a power proportionality metric and a power supply efficiency requirement.

Overview

Description of Standards Proposal

We recommend that California adopt a two-tier, 2014 (Tier 1) and 2016 (Tier 2) standard for Servers based on a power proportionality metric for an individual device. We suggest one approach for defining such a power proportionality metric consisting of a Power Proportionality Coefficient (PPC) = Power in Idle / Max Power, but we are open to considering alternative definitions such as the Energy Proportionality metric proposed by Barroso and Hölzle In IEEE Computer, vol. 40 (2007).

Setting power proportionality limits requires the definition of appropriate workload and RAS categories (Reliability, Availability, Serviceability). Examples of server workloads include web servers, mail servers, database engines etc. RAS categories range from fault-tolerant servers which require more power at low-loads to load-balanced web servers which have less stringent availability requirements.

Recommendations for Power Proportionality levels will be developed upon further definition of the appropriate power proportionality metric and incorporation of market energy use data. We also recommend power supply efficiency requirements based on 80 PLUS levels (See Appendix B for more details on 80 PLUS):

Table U-2: Standards for Single-Output Internal Power Supplies with All Maximum Power Ratings (Based on 80 PLUS)

	Loading Condition	**Tier 1 - Effective January 1, 2014**	**Tier 2 - Effective January 1, 2016**
		Minimum Efficiency	**Minimum Efficiency**
<500W	10%	-	80%
	20%	81%	88%
	50%	85%	92%
	100%	81%	88%
≥ 500W and < 1kW	10%	75%	82%
	20%	85%	90%
	50%	89%	94%
	100%	85%	91%
≥1kW	10%	80%	82%
	20%	88%	90%
	50%	92%	94%
	100%	88%	91%

California Stock and Sales	Based on sales data from (Koomey 2011) we estimate a 2014 stock of approximately 1.5 million servers, and annual sales of 320,000 in California, (using a 12% adjusted US/California ratio and 11.5 million servers nationally).
Energy Savings and Demand Reduction	We estimate that adopting standard levels at the bottom 25th percentile for Tier 1 and the average current market levels for Tier 2 would result in 1,000 GWh of energy savings and 180 MW of peak demand after Tier 2 stock turnover. With recognized uncertainty, these estimates use currently available data for server energy use (Koomey 2011) to project energy use. These estimates do not incorporate potential market adoption of efficiency measures without a standard. It is clear that appliance standards are the only way to guarantee savings beyond business-as-usual.
Economic Analysis	The full life-cycle costs, benefits and ratios for the power proportionality standard are still to be determined. Power supply unit efficiency have shown cost-effectiveness, however. The cost of compliance would be about $4 per one percent efficiency improvement (iSuppli 2011). In practical terms, this means that a manufacturer producing a 600W PSU at 89.5% efficiency (at 50% load) would need to spend $18 to meet Tier 2. An estimated mark-up range of 1.6- 2 times the cost from manufacturer to PSU consumer results in a $47-$52 cost premium range. With an energy savings of 340 kWh over the lifetime and savings at approximately $0.175/kWh at the commercial rate (Energy Solutions 2011), the present value of the savings is approximately $59, resulting in a positive net present value life cycle benefit of $12-$7. The benefit cost ratio ranges from 1.25 -1.10 to 1. Again this does not include the additional savings (or costs) from other approaches to meet the power proportionality limits.
Non-Energy Benefits	Our proposal will reduce greenhouse gas emissions at the power generation source, helping California to meet its AB 32 goals (1990 levels by 2020). A potential external benefit to increasing power supply efficiency is the effect on the efficiencies, for example, of internal power supplies for other consumer electronics and external power supplies for notebooks.
Environmental Impacts	We are not aware of any adverse environmental impacts that will be created by the proposed standard.

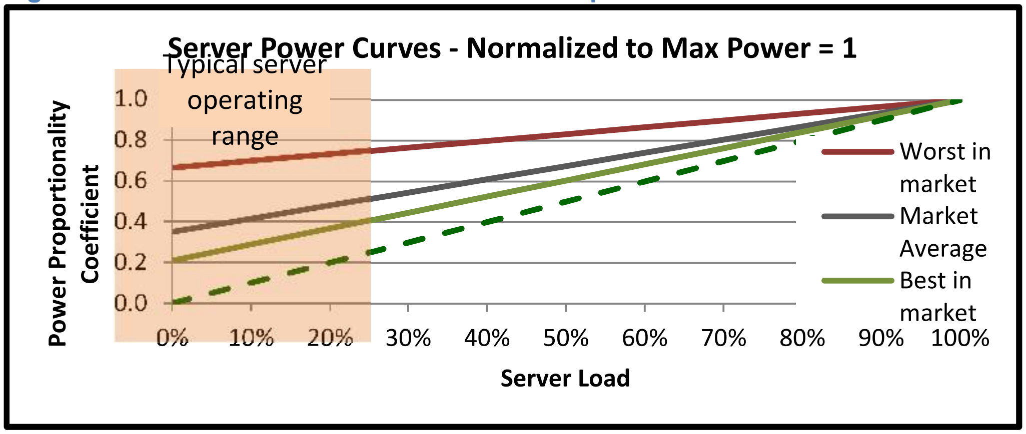
Acceptance Issues	Proceeding with a power proportionality metric would require developing a new test procedure or working with an entity such as SpecPower, who test and report power use across the entire range of load levels at 10% increments, for example, to obtain licensing rights for their test procedure. Using ENERGY STAR's definitions and test procedure (ENERGY STAR Test Method for Computer Servers, Rev. Aug-2010) should help to minimize any acceptance issues. We will monitor and update this proposal as forthcoming updates to the ENERGY STAR specifications are finalized. The Test Procedure for power supply units is consistent with the ENERGY STAR program, and the Tier I requirements correspond with those specified in ENERGY STAR for Server v.1. (effective May 2009).
Federal Preemption or other Regulatory or Legislative Considerations	There are no known interactions with other existing laws for this standard, though as mentioned above, these efforts to reduce datacenter loads are aligned with complementary efforts to develop efficiency requirements for datacenters through the 2013 Title 24 rulemaking. There is currently no federal mandatory standard, and there is significant potential California to influence the direction of national adoption. The Department of Energy is scheduled to begin a rulemaking for 'Computers, Computer Equipment and Certain Computer Components,' however, given that this rulemaking is in its very early stages, there is significant uncertainty in the schedule. At the very earliest, the effective date would be in 2018, when California's standard would have already reached full stock turnover.

Methodology and Modeling used in the Development of the Proposal

Power Proportionality Metric
We used the SPECpower_ssj2008 benchmark (http://www.spec.org/power_ssj2008/) and published data to calculate a simple Energy Proportionality metric defined as:

Power Proportionality Coefficient (PPC) = Power in Idle / Max Power

Figure 1: Normalized Server Power Curves – SpecPower 2009-2011 Test Data



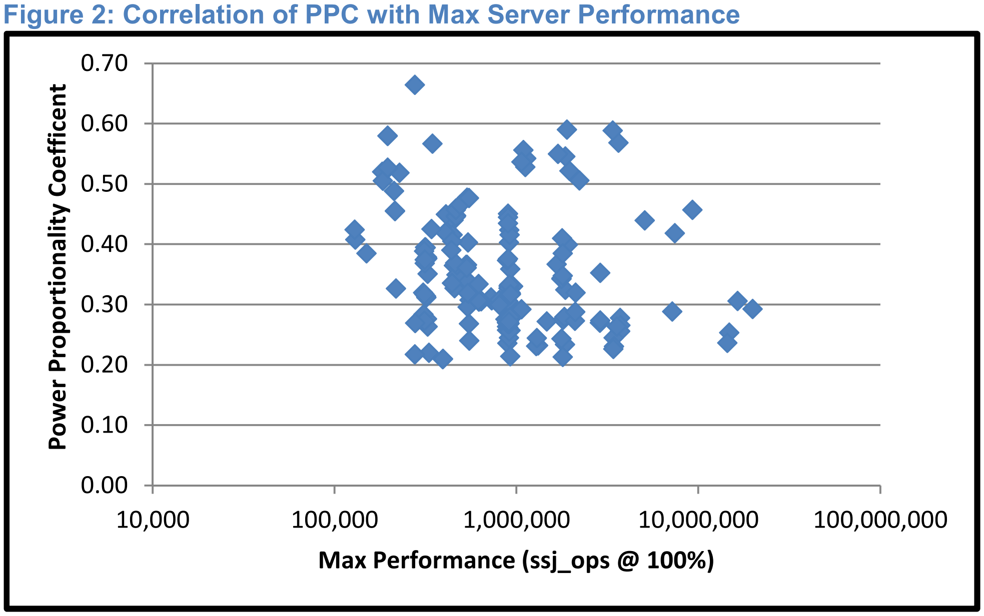
The ideal theoretical PPC would be 0, where a server would use no power when performing no work and worst PPC would 1, where a server would draw maximum power constantly, irrespective of load.

More sophisticated metrics could include other loading points instead of only active idle (0%) and full load (100%), in order to better take into account the typical 0-30% loading range, and avoid overweighting the 0% load power use.

We are also open to considering other benchmarks such as SERT currently being developed by SPEC for ENERGY STAR Servers.

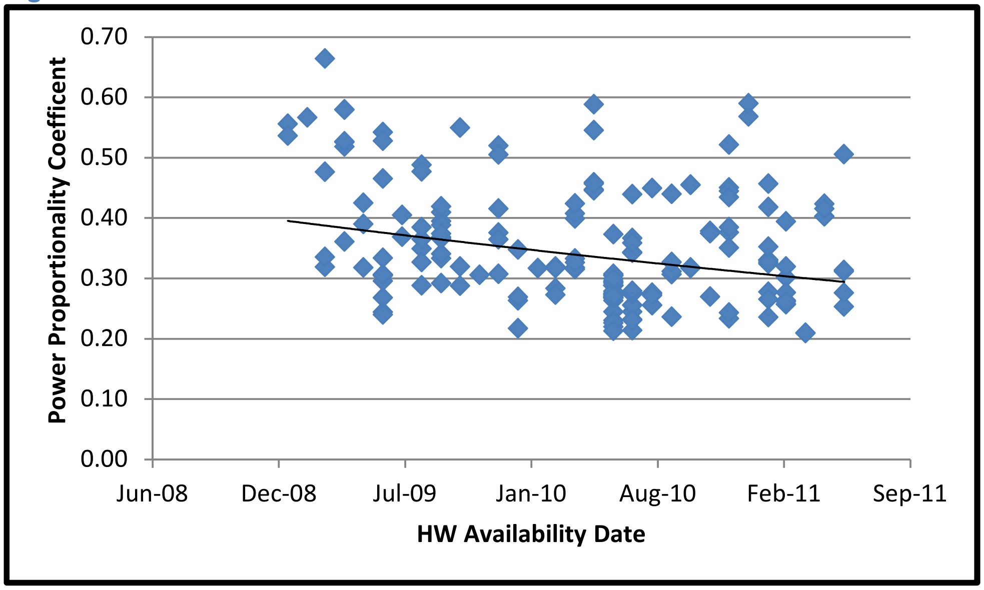
The SpecPower data shows that PPC is not correlated with performance (0.08 determination coefficient, 0 being no correlation and 1 being perfect correlation), which means that a PPC limit will not restrict performance in the market:

Figure 2: Correlation of PPC with Max Server Performance



PPC is only moderately correlated with the server release year (0.56 determination coefficient), which means that while there is some naturally occurring improvements (NOI) in PPC, server release year is not a strong predictor of PPC and a standard would have a significant benefit on the market:

Figure 3: Correlation of PPC with Server Release Date



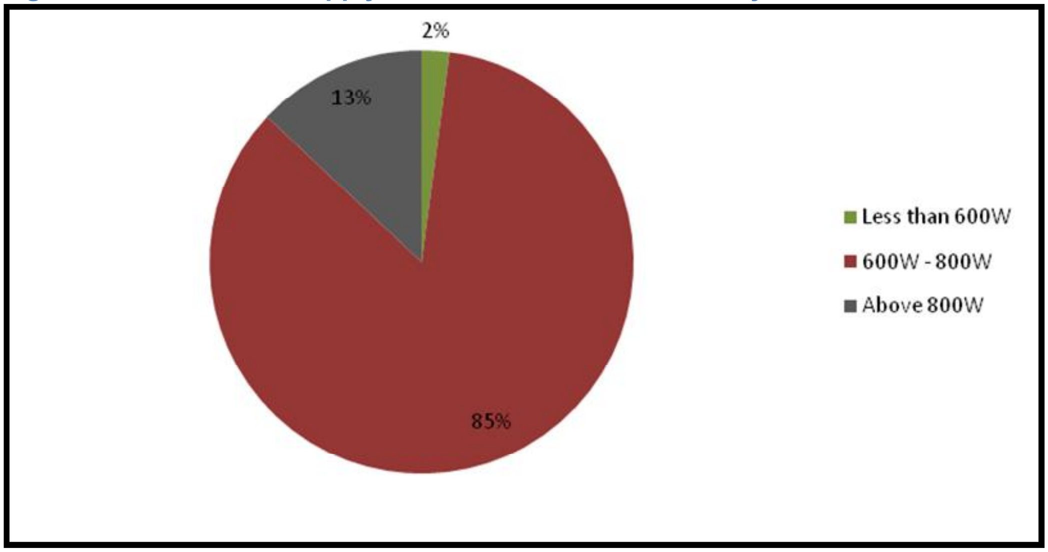
Power Supply Efficiency

Design Life
The design life for servers is estimated to be 4-6 years (Ecos 2008a).

Duty Cycle
Servers are not intended to have sleep and off mode power switching due to constant activity, and therefore are limited to two modes: active and idle. Duty cycle estimates were derived from Energy Star estimates (EPA 2005).

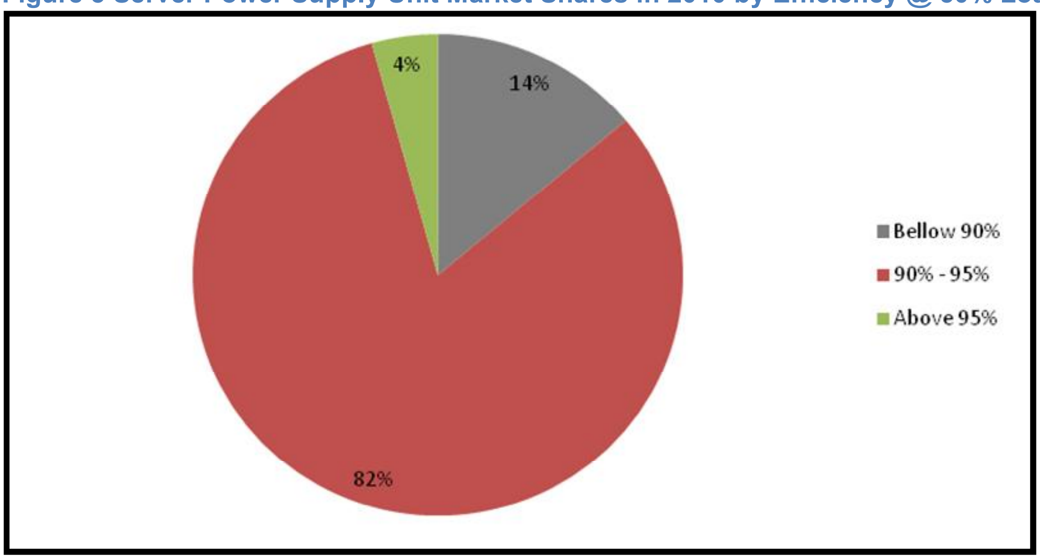
Market Saturation
Figure 4 and Figure 5 show the vast majority of server PSUs are in the name plate 600W-800W range and are already in the 90%-95% efficiency range.

Figure 4 Server Power Supply Unit Market Shares in 2010 by Maximum Power Rating



Source: iSuppli, Cost of Efficiency, prepared by iSuppli for Energy Solutions. 2011

Figure 5 Server Power Supply Unit Market Shares in 2010 by Efficiency @ 50% Load



Source: iSuppli, Cost of Efficiency, prepared by iSuppli for Energy Solutions. 2011

Data, Analysis, and Results

Stock and Sales

We estimate there will be approximately 1.8 million servers in California in 2014, with average annual sales at over half a million staying relatively flat over the next decade.

Table 1 California Server Stock and Sales in 2014

	California Stock	California Annual Sales	
Design Options	Units (millions)	Units (millions)	'09-'14 Estimated Average Annual Growth Rate
Servers	1.8	.3	-.5%

We estimate that baseline peak demand in California in 2014 will be equivalent to more than three medium sized power plants (500 MW each).

Baseline Energy Use

Table 2 California Statewide Baseline Energy Use 2014

	For First-Year Sales		For Entire Stock	
Design Options	Coincident Peak Demand (MW)	Annual Energy Consumption (GWh/yr)	Coincident Peak Demand (MW)	Annual Energy Consumption (GWh/yr)
Servers	510	3,100	1,700	8,500

We anticipate Tier 2 (2018) annual energy savings after stock turnover (4 years) to be about 1 TWh/yr.

Proposed Power Proportionality Limits and Estimated Savings
We propose the following tier limits as a straw man for further investigation, and as a basis for savings estimates:

- Tier 1: Set PPC limit at 25% worst in market (based on SpecPower 2009-2011 data)
- Tier 2: Set PPC limit at current market average (based on SpecPower 2009-2011 data)

Table 3 Estimated California Statewide Energy Savings for Proposed Standards

	For First-Year Sales		**After Entire Stock Turnover**	
Design Options	Coincident Peak Demand Reduction (MW)	Annual Energy Savings (GWh/yr)	Coincident Peak Demand Reduction (MW)	Annual Energy Savings (GWh/yr)
Tier 1	25	140	100	560
Tier 2 (relative to BAU)	45	260	180	1,100

These estimates include savings from reduced cooling requirements due to more efficient servers. Calculations use an average PUE[1] of 1.83-1.92 per Koomey 2011.

Cost of Efficiency

The cost of compliance would be about $4 per one percent efficiency improvement (iSuppli 2011). In practical terms, this means that a manufacturer producing a 600W PSU at 89.5% efficiency (at 50% load) would need to spend $18 to meet Tier 2. An estimated mark-up range of 1.6 - 2 times the cost from manufacturer to PSU consumer results in cost premium range of $47- $52. With an energy savings of 340 kWh over the lifetime and savings at approximate $.175/kWh at the commercial rate (Energy Solutions 2011), the present value of the savings is approximately $59, resulting in a positive net present value life cycle benefit of $12-$7. The benefit cost ratio range is1.25 -1.10 to 1. Again this does not include additional savings (or costs) from other approaches to meet the Power Proportionality limits.

Power Rating Market Saturation

If the distribution of maximum power rating for the server PSU market remained roughly the same over the next four years, less than 2% would be required to meet 85% efficiency at 50% load for Tier 1 and then 92% efficiency at 50% load for Tier 2. The vast majority of the market (85%) would be required to meet 89% efficiency at 50% load for Tier 1 and 94% efficiency at 50% load for Tier 2 (iSuppli 2011). Less than the remaining 13% of the market would be required to meet 92% efficiency at 50% load for Tier 1 and (94% efficiency at 50% load).

[1] Power Usage Effectiveness, a measure of the facility overhead energy use on top of IT electrical load

Proposed Standards and Recommendations

We recommend that California adopt a two-tier, 2014 and 2016 standard for Servers based on the Power Proportionality metric for an individual device, with Power Proportionality Coefficient (PPC) = Power in Idle / Max Power. Recommendations for Power Proportionality levels will be developed upon the further incorporation of updated market energy use data.

We also recommend a two-tier, 2014 and 2016, power supply efficiency requirement based on 80 PLUS levels. To the Title 20 Code language, we recommend the following changes and additions:

Section 1604. Test Method for Specific Appliances.

(u) **Power Supplies.**

The test method for Class A federally regulated and state-regulated external power supplies is US EPA "Test Method for Calculating the Energy Efficiency of Single-Voltage External AC-DC and AC-AC Power Supplies" dated August 11, 2004, except that the test voltage specified in Section 4(d) of the test method shall be only 115 volts, 60 Hz.

The test method for Class __ state-regulated internal power supplies is EPRI & ECOS "Generalized Test Protocol for Calculating the Energy Efficiency of Internal Ac-Dc and Dc-Dc Power Supplies Rev 6.5 dated" dated July 7th, 2010.

1. *Single-output State-regulated Internal Power Supplies. The efficiency of a multi-output state regulated internal power supply manufactured, shall not be less than that applicable values shown in Table U-1 at each loading condition.*

Table U-2: Standards for Single-Output Internal Power Supplies with All Maximum Power Ratings

	Loading Condition	**Tier 1 - Effective January 1, 2014**	**Tier 2 - Effective January 1, 2016**
		Minimum Efficiency	**Minimum Efficiency**
<500W	10%	-	80%
	20%	81%	88%
	50%	85%	92%
	100%	81%	88%
≥ 500W and < 1kW	10%	75%	82%
	20%	85%	90%
	50%	89%	94%
	100%	85%	91%
≥1kW	10%	80%	82%
	20%	88%	90%
	50%	92%	94%
	100%	88%	91%

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Reference and Appendices

Appendix A: Definitions

Servers:
For purposes of this specification, servers include small-scale Pedestal and Rack Mounted Servers with one to four CPU sockets, per the scope of ENERGY STAR Program Requirements for Computer Servers v1.0:
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 and other networked devices. Computer Servers are sold through enterprise channels for use in data centers and office/corporate environments. Computer Servers are designed to respond to requests and are primarily accessed via network connections, and not through direct user input devices such as a keyboard, mouse, etc. In addition, Computer Servers ***must have all*** of the following characteristics:

- Marketed and sold as a Computer Server;
- Designed for and listed as supporting Computer Server Operating Systems (OS) and/or hypervisors, and targeted to run user-installed enterprise applications;
- Support for error-correcting code (ECC) and/or buffered memory (including both buffered DIMMs and buffered on board (BOB) configurations);
- Packaged and sold with one or more AC-DC or DC-DC power supply(s); and
- All processors have access to shared system memory and are independently visible to a single OS or hypervisor.

Volume Server
A computer server packaged in either a 1U or 2U high rack-mount chassis having one processor board in the server system, rack, or enclosure.[2]

Medium/Mid-Range Server
A server with 2-4 processor socket or more systems, with ≥16 GB of system memory.[3]

High-end Server
A server with 4 processor socket or more systems, with ≥32 GB of system memory[4]

Internal Power Supply:
For purposes of this specification, per the scope of ENERGY STAR Program Requirements for Computers v.5.0:

[2] Comments from IBM to EPA regarding the Draft 1 ENERGY STAR Computer Server Specification. Dated May 12, 2008. Accessed on September 15, 2011. < http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/IBM_Comments_Revised_Definitions.pdf>
[3] Comments from Green Grid to EPA regarding the Draft 1 ENERGY STAR Computer Server Specification. Dated May 16, 2008. Accessed on September 15, 2011. < http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/Green_Grid_Comments.pdf>
[4] Ibid.

A component internal to the computer casing and designed to convert AC or DC voltage from the mains to DC voltage(s) for the purpose of powering the computer components. For the purposes of this specification, an internal power supply must be contained within the computer casing but be separate from the main computer board. The power supply must connect to the mains through a single cable with no intermediate circuitry between the power supply and the mains power. In addition, all power connections from the power supply to the computer components, with the exception of a DC connection to a computer display in an Integrated Desktop Computer, must be internal to the computer casing (i.e., no external cables running from the power supply to the computer or individual components). Internal dc-to-dc converters used to convert a single dc voltage from an external power supply into multiple voltages for use by the computer are not considered internal power supplies.

Image of Internal Power Supply

Source: Electric Power Research Institute accessed http://www.efficientpowersupplies.org/efficiency_opportunities.html

Single Output vs. Multi-Output Power Supplies

For the purposes of this specification, per the scope of Climate Savers Computing: **ttp://www.climatesaverscomputing.org/tech-specs**:

A Single-output PSU typically refers to volume servers power supplies in redundant configurations (1U/2U single, dual, four-socket and blade servers). A Multi-output PSU refers to desktop and server application power supplies in no- redundant applications.

Appendix B: Power Supply Efficiency Level Definitions

The following levels we are recommending are their corresponding 80 PLUS levels:

<u>*Single-output Power Supply Unit*</u>*:* volume servers power supplies in redundant configurations (1U/2U single, dual, four-socket):

Year – Tier	PSU Maximum Power Rating		
	< 500W rating	≥ 500W and < 1kW	≥1kW
Tier 1 – January 1, 2014	Bronze	Silver	Gold
Tier 2 – January 1, 2016	Gold	Platinum	Platinum

The following represent definitions of various "levels" of power supply efficiency performance. These are consistent with the Climate Savers Computer Initiative and 80 PLUS power supply definitions.

Single-output Power Supply Unit: volume servers power supplies in redundant configurations (1U/2U single, dual, four-socket):

Loading Condition	Bronze		Silver		Gold			Platinum		
	Eff.	p.f.	Eff.	p.f.	Eff.	p.f. <1kW	p.f. >1kW	Eff.	p.f. <1kW	p.f. >1kW
10%			75%	0.65	80%	0.65	0.8	82%	0.65	0.8
20%	81%		85%	0.8	88%	0.8	0.9	90%	0.8	0.9
50%	85%		89%	0.9	92%	0.9	0.9	94%	0.9	0.9
100%	81%	0.9	85%	0.95	88%	0.95	0.95	91%	0.95	0.95