THE TOLLY GROUP

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Rackable Systems, Inc.

C1001 Eco-Logical™ Server

Competitive Power Consumption and Power Efficiency Study

TOLLY Up to Spec CERTIFIED Test Summary

Premise: *In today's data centers, energy conservation and efficiency is becoming a vitally important factor. With rising energy prices and conservation awareness, it is highly desirable to minimize the energy used to power and cool data center servers, while also maximizing the server density for a given data center footprint.*

Rackable Systems, Inc. commissioned The Tolly Group to evaluate the power consumption and power efficiency of its C1001 Eco-Logical™ Server against similarly configured, low power-draw Intel Xeon processor-based 1U rackmount servers from Dell, Hewlett-Packard Co., IBM Corp. and Sun Microsystems, Inc.

The Tolly Group used a high-precision Chroma Model 66202 Power Meter to examine the power consumption of the servers on a 208V, 60Hz feed, at idle and while running the High Performance LinPack benchmark.

Tests also measured the power efficiency of the AC power supply unit from the Rackable Systems C1001 server at the component level.

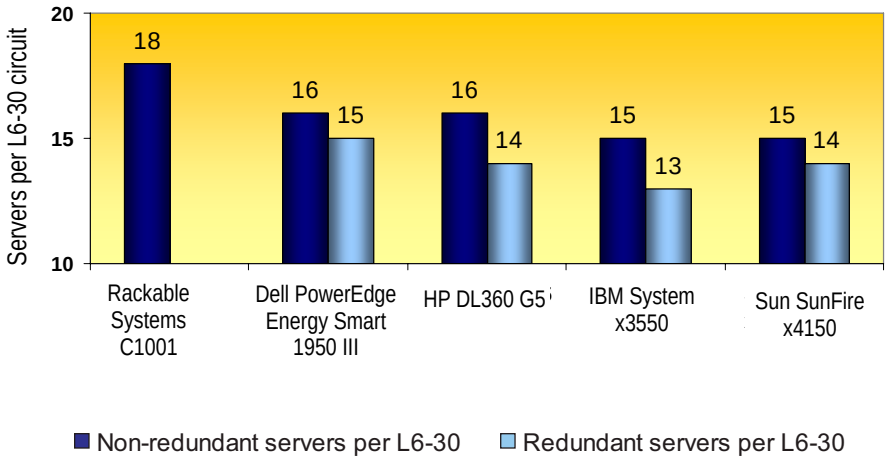
Tests were conducted in March 2008.

Test Highlights

- Consumes up to 21% less power under high compute load, and up to 31% less power at idle state versus other servers tested
- Supports up to five more servers per L6-30 data center circuit compared to the competing servers tested
- Saves between US$103,000 to US$435,600 on power and cooling costs for 1,000 servers over a three-year deployment, compared to competing servers tested
- Demonstrates greater than 90% power efficiency for its 250W AC power supply unit, thus further minimizing power consumption

Number of Servers Supported on an L6-30 Circuit

(Determined by the Maximum Power Draw, Measured using Chroma Model 66202 Power Meter and Intel High Performance LinPack 10.0.2)



* Notes: All servers were tested with dual Intel Xeon L5320 CPUs, 8GB (4x 2G) of RAM,, 2x 73GB 10K RPM SAS HDD in RAID 1 (mirroring) and running Red Hat Enterprise Linux 5. Rackable Systems C1001 server was tested with single AC or redundant feed DC PSU.

Source: The Tolly Group, March 2008

Figure 1

Executive Summary

Rackable Systems C1001 Eco-Logical Server demonstrates up to 21% less power consumption compared to competing servers tested, which translates into greater energy savings and server density per L6-30 data center power circuit.

With energy costs spiraling up, the prospect of powering and cooling servers in large data centers is becoming quite expensive. Servers equipped with low power-consumption components allow data center managers to realize appreciable savings in operating expenses, as well as increase the number of servers that can be supported on an L6-30 power circuit.

(Note: L6-30 circuits are 208 volt. 30 amp circuits as specified by the National Electrical Manufacturer's Association and are used typically in data centers.)

The Tolly Group tested Rackable Systems C1001 Eco-Logical Server against a similarly configured Dell PowerEdge Energy Smart 1950 III Server, an HP ProLiant DL360 G5 Storage Server, IBM System x3550, and Sun SunFire X4150 servers, using 208V, 60Hz power circuits.

(Note that the above-named servers may be referred to by their manufacturer's name for the remainder of this document, for the sake of brevity.)

Rackable Systems' C1001 Eco-Logical Server consumed up to 21% less power under high compute load compared to simi-

Three-year Savings in Power Cost per Server Compared to Competing Servers (Based on Maximum Power Draw Measured using Chroma Model 66202 Power Meter, While Running Intel High Performance LinPack 10.0.2)

Server Config (Dual Intel Xeon® L5320 CPU, 8GB (4x 2GB RAM), 2x 73GB 10K RPM SAS HDD in RAID 1, and one non-redundant AC PSU)	Power Draw: Non-Redundant PSU (P_{NR})	Additional Power Draw over Rackable C1001 (P_{add})	Power Draw: (kWh) - 3 yr Deployment (P_{3yr})	Power Draw & Cooling (kWh): 3-year Deployment ($P_{total} = P_{3yr}$ + 80% of P_{3yr})	3-year Cost of Power & Cooling in US $ ($Cost_{3yr} = P_{total}$ x US $0.13*)	Additional Cost over Rackable C1001 AC (Competitive Single PSU)
Rackable Systems C1001 Eco-Logical™ Server	266	0	7,000	12,600	1,608	0
Dell PowerEdge Energy Smart 1950 III Server	284	17	7,452	13,413	1,712	104
HP ProLiant DL360 G5 Storage Server	297	31	7,814	14,066	1,795	187
IBM System x3550	314	47	8,240	14,832	1,893	285
Sun SunFire x4150	318	52	8,368	15,062	1,922	314

Server Config (Dual Intel Xeon® L5320 CPU, 8GB (4x 2GB RAM), 2x 73GB 10K RPM SAS HDD in RAID 1, and redundant AC PSUs)	Power Draw: Redundant PSU (P_R)	Additional Power Draw over Rackable C1001 (P_{add})	Power Draw (kWh) - 3 yr Deployment (P_{3yr})	Power Draw & Cooling (kWh) - 3 yr Deployment ($P_{total} = P_{3yr}$ + 80% of P_{3yr})	3 Yr Cost of Power & Cooling in US $ ($Cost_{3yr} = P_{total}$ x US $0.13*)	Additional Cost over Rackable C1001 DC (Competitive Redundant PSUs)
Rackable Systems C1001 Eco-Logical™ Server	265	0	6,969	12,544	1,601	0
Dell PowerEdge Energy Smart 1950 III Server	300	34	7,883	14,190	1,811	210
HP ProLiant DL360 G5 Storage Server	327	60	8,582	15,448	1,971	370
IBM System x3550	337	71	8,858	15,945	2,035	434
Sun SunFire x4150	337	71	8,866	15,958	2,036	436

* Note: Power cost calculated at US$0.13/kWh as per Dept. Of Energy Average California commercial power cost, report from Dec. 2007 (http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.htm)

Source: The Tolly Group, March 2008

Figure 2

larly configured servers from competing vendors. At idle state after boot-up, power savings were as high as 31% compared to energy consumed by competing servers tested.

In addition, the 250W AC Power Supply Unit (PSU) in the Rackable server demonstrated a power efficiency of greater than 90% under the "Energy Star Power Supply Unit Test" which shows that the Rackable server design further minimizes power loss in the 250W AC PSU.

This means Rackable Systems C1001 server delivers considerable cost savings for power consumption over a three-year span compared to competing servers tested, and also allows greater number of servers to be deployed on an L6-30 data center circuit.

Rackable Systems also claims its DC power supplies provide greater than 1 million hours of Mean Time Between Failure (MTBF) -- an extremely high level of reliability and continued uptime through power circuit failures, comparable to that of industry-standard redundant AC power supply designs. Rackable Systems' differentiated approach to Reliability, Availability, and Serviceability (RAS) with its DC technology enables the Rackable Systems C1001 DC server to deliver high reliability without compromising power efficiency.

Results

Power Draw Measurement Test

Tolly Group tests focused on measuring the power draw of the servers at idle state and also while handling a high compute load as they resided on a 208V, 60Hz AC power circuit and were measured by a high-precision Chroma Model 66202 Power Meter.

Tests show that, using identical hardware specs (CPU, RAM, hard disk drive and non-redundant power supply), at idle load after boot-up, the Rackable server used 152 watts, or up to 22% fewer watts than other devices:

- Dell (167 watts)
- HP (186 watts)
- IBM (194 watts)
- Sun (179 watts).

When configured with a redundant feed DC power supply, the Rackable server consumed 151 watts, while the power draw of competing servers with redundant AC power supplies increased up to 21.3%:

- Dell (185 watts)
- HP (210 watts)
- IBM (218 watts)
- Sun (203 watts).

The Rackable server consumed from 8.8% to 21.3% less power than the other devices tested with a single PSU, and demonstrated power savings ranging from 18.3% to 30.9% with a redundant feed DC power supply, versus other products with a redundant, two PSU supply.

While handling a high compute load from the Intel High Performance LinPack benchmark, the Rackable server with a single PSU consumed 266 watts, on average, while the competitors with single, non-redundant power supplies consumed up to 16.3% more power:

- Dell (283 watts)
- HP (297 watts)
- IBM (313 watts)
- Sun (318 watts).

With a redundant feed DC PSU installed, the Rackable served used 265W, while its competitors with a second, redundant AC power supply installed, consumed up to 21.4% more power:

- Dell (300 watts)
- HP (326 watts)

Rackable Systems, Inc.

C1001 Eco-Logical Server

Power Consumption and Power Efficiency Study

TOLLY Up to Spec CERTIFIED

Product Specifications

Vendor-supplied information not necessarily verified by The Tolly Group

Rackable Systems, Inc. C1001 Eco-Logical™ Server

Benefits:

- Open architecture, flexible component choices supports specific business needs and budget
- Outstanding combination of price, capacity, & performance

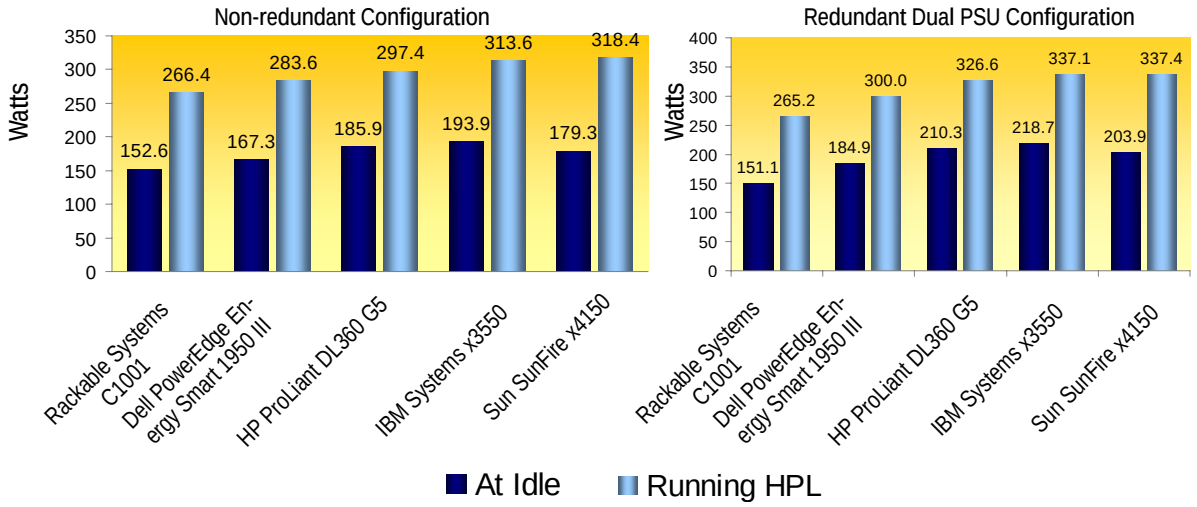
Features:

- Chipset: Intel 5000p
- CPU: Up to two Intel Xeon 5100/5200 series dual-core or 5300/5400 series quad-core
- Max cores: Eight
- Memory: Up to 64 GB DDR2 fully buffered in eight DIMM slots
- Hard drives: One 3.5" or up to two 2.5" hot-swap hard drives
- RAID levels: JBOD, 0, 1
- Expansion slot: PCI-E x8 on riser
- Networking: Dual GigE (one Intel 82541PI and one Marvell 88E050) with Intel I/OAT
- Remote management: Roamer™ Serial, Roamer IP + KVM, or IPMI 2.0
- Power supply: 250W or 450W with AC or -48V DC input
- Dimensions (HxWxD): 1.75" x 17.6" x 15.5"

For more information contact:

Rackable Systems
46600 Landing Parkway
Fremont, CA 94538
Phone: +1 510.933.8300
E-mail: sales@rackable.com
UK Sales Office
Phone: +44 (0)20 8354 1379

Comparison of Power Draw at Idle and Under High Compute Load
(Measured over a One-Minute Period Using a Chroma Model 66202 Power Meter)



- Note: Intel High Performance LinPack 10.0.2 running on Red Hat Enterprise Linux 5 on each server was used to generate the high compute load to measure power draw at high load.

Source: The Tolly Group, March 2008 *Figure 3*

- IBM (337 watts)
- Sun (337 watts).

Energy Star Compliant Power Efficiency Test

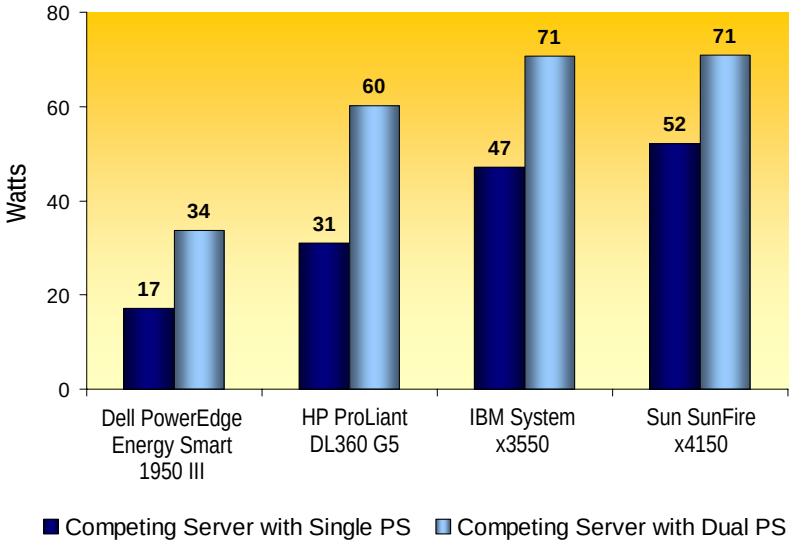
The 250-watt AC power supply in the Rackable C1001 server was tested for power efficiency using the Chroma Model 66202 Power Meter. For this test, the power efficiency was calculated at various load points chosen to mimic closely the power draw characteristics during the Intel High Performance LinPack (HPL) benchmark. Tests showed that the AC power supply unit of the Rackable C1001 Server achieved more than 90% power efficiency.

Test Setup & Methodology

The Tolly Group tested 1U rack mountable servers from Rackable Systems, Dell, HP, IBM and Sun Microsystems.

The main selection criteria was

Rackable Systems C1001 Eco-Logical Server Power Savings over Competing Servers
(Based on Maximum Power Draw Measured Using Chroma Model 66202 Power Meter, While Running Intel High Performance LinPack 10.0.2)



Notes: All servers were tested with dual Intel Xeon L5320 CPU and 8GB (4x 2GB) RAM, 2x 73GB 10K RPM SAS HDD in RAID 1 (mirroring) and running on Red Hat Enterprise Linux 5. Rackable C1001 server was tested with a single 250W AC power supply.

Source: The Tolly Group, March 2008 *Figure 4*

that the servers be 1U height, rack mountable, based on low voltage Intel Xeon CPUs.

Apart from these core selection criteria, care was taken to select server configurations as closely matched in terms of key hardware components — CPU, RAM, hard disk size and configuration. *(See Figure 5 for details on the server hardware configurations.)*

The SunFire X4150 server came standard with dual Intel Xeon E5320 (80W) processors, and 8GB RAM in the form of 8x 1GB. Similarly, the Dell PowerEdge Energy Smart 1950 III could not be ordered with dual Intel Xeon L5320 (50W) CPUs standard at procurement time.

In order to make the competitor servers as closely configured to the Rackable Systems C1001 server, engineers swapped the same physical pair of Intel Xeon L5320 (50W) processors into each server under test. This was done to achieve parity among the servers under test in terms of CPU configuration by minimizing any skew in power draw between two specimens of the same processor model.

Also, the SunFire X4150 server was tested with 8GB RAM (4x 2GB sticks), in order to ensure parity in terms of RAM configuration.

For all tests, the test bed was set up with a 208V 60Hz power connection feeding a Chroma ATE 61503 AC Source. The Chroma ATE 61503 AC Source provided power to the servers under test. A Chroma ATE 66202 Power Meter was connected inline between the Chroma ATE AC power source, and the server under test, in order to monitor and measure the power draw of the server.

For the Power Draw measurement test, the engineers measured the power draw of the server for a period of one minute, under two conditions --using

Comparison of Configuration of Servers Under Test

Vendor	Rackable Systems	Dell	Hewlett-Packard	IBM	Sun Microsystems
Model	C1001 Eco-Logical™ Server	PowerEdge EnergySmart 1950 III Server	ProLiant DL360 G5 Storage Server	System x3550	SunFire X4150
Form factor	19" rackmount 1U	19" rackmount 1U	19" rackmount 1U	19" rackmount 1U	19" rackmount 1U
CPUs	Standard: 2x Intel Xeon L5320 (50W)	Standard: 2x Intel Xeon L5335 (50W)	Standard: 2x Intel Xeon L5320 (50W)	Standard: 2x Intel Xeon L5320 (50W)	Standard: 2x Intel Xeon E5320 (80W)
	As Tested: 2x Intel Xeon L5320 (50W) processors. The same physical pair of Xeon L5320 processors were swapped into each server under test to minimize minor skew in power draw between two physical samples of the same processor model.				
Memory	Standard: 4x 2GB FB DDR2 Reg ECC	Standard: 4x 2GB FB DDR2 Reg ECC	Standard: 4x 2GB FB DDR2 Reg ECC	Standard: 4x 2GB FB DDR2 Reg ECC	Standard: 8x 1GB FB DDR2 Reg ECC
	As Tested: 4x 2GB FB DDR2 Reg ECC in all servers, in order to ensure consistency in comparison. Sun SunFire X4150 could not be ordered with 8GB total RAM in 4x 2GB configuration.				
Hard Drives	2 x 73 GB 10K SAS SFF	2 x 73 GB 10K SAS SFF	2 x 73 GB 10K SAS SFF	2 x 73 GB 10K SAS SFF	2 x 73 GB 10K SAS SFF
Hard Drive Redundancy	Mirrored (RAID 1), Hot-swap	Mirrored (RAID 1), Hot-swap	Mirrored (RAID 1), Hot-swap	Mirrored (RAID 1), Hot-swap	Mirrored (RAID 1), Hot-swap
RAID 1 Implementation (Onboard preferred)	Onboard (Intel Integrated RAID)	Onboard (SAS 6i/R integrated)	HP SmartArray E200i/64 controller (onboard mirroring not available)	IBM ServeRAID 8k-1 SAS Controller	Sun StorageTek PCIe SAS RAID Host Bus Adapter, 8 Port Internal
GigE Networking	Onboard	Onboard	Onboard	Onboard	Onboard
Management Card	Roamer KVM (advanced networking card)	Dell Remote Access Card (5th generation)	HP Integrated Lights Out 2 (iLO 2) Standard Management	IBM Remote Supervisor Adapter II SlimLine remote management adapter	Integrated remote management
Power Supplies tested	Non-redundant (single AC), redundant (dual feed capable, single DC)	Non-redundant (single module AC), redundant (dual module AC)	Non-redundant (single module AC), redundant (dual module AC)	Non-redundant (single module AC), redundant (dual module AC)	Non-redundant (single module AC), redundant (dual module AC)
Cooling fan configuration	5 single rotor Delta FFB0412VHN (12VDC, 0.24A each)	8 dual rotor San Ace 9CRA0412G5058 (12VDC, 1.0A each)	9 dual rotor Inventec IFD04048B12-A01 6033B0005001 (12VDC, 1.9A each)	6 dual rotor AVC DB04048B12S (12VDC, 1.9A each)	14 single rotor Delta TBF0412EHN (12VDC, 0.87A each)
Cooling redundancy	Yes	Yes	Yes	Yes	Yes

Source: The Tolly Group, March 2008

Figure 5

a single, non-redundant AC PSU, and then using redundant PSUs.

In the redundant PSU test scenario, the Rackable C1001 server used a dual-channel capable DC PSU, while the competing products used dual AC PSUs in a redundant configuration.

Under each test scenario, engineers measured the power draw every second for a one-minute duration at idle after boot, and again at steady state while running the HPL benchmark. When running the benchmark, power draw was measured every second for one minute after the benchmark reached steady state with all the eight HPL threads reached 100% load. All power measurement tests were run three times and all data points were averaged.

For the Power Efficiency measurement test, engineers used the Energy Star test suite ver 0.55 of the Chroma ATE 66202 Power Meter. The 250W AC power supply unit of the Rackable Systems C1001 server was connected directly to a test harness, which connected to the Chroma ATE 66202 Power Meter.

The test parameters were calibrated to mimic the power draw under idle-state and HPL benchmark runs, and the Energy Star test suite measured the Power Efficiency of the PSU at various loads.

Fair Testing Charter™
Interaction with Competitors

The Tolly Group invited the competing vendors — Dell, HP, IBM, and Sun Microsystems to participate in the test, as per The Tolly Group's Fair Testing Charter (http://www.tolly.com/FTC.aspx) Competing vendors either declined the invitation to participate or did not respond.

All the test equipment was procured by Rackable Systems, Inc., and the servers were tested with their default BIOS settings and identical hardware and software configurations to the extent possible, as outlined in this document.

Terms of Usage

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