Power-efficient IT
with BMC Performance Management

White Paper

October 2009
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Understand Energy Consumption in the Server Room

Since reducing energy consumption has become one of the biggest challenges these days, companies around the world are looking for ways to save energy and reduce costs. The first action of any strategy should be to understand the current energy usage and to know where and by what specific equipment the energy is used.

As Moore’s law predicted computer-processing speed doubles every 18 to 24 months, and the energy consumed by the data centers keeps increasing too. It doubled between 2001 and 2006 and unless energy efficiency becomes a priority it will do so again by 2011, according to a study conducted in 2007 by the Environmental Protection Agency (E.P.A.).

The study indicates that with aggressive improvements, consumption in 2011 could fall back to the levels of 2001. But even an enlightened data center manager would have problems identifying which servers are most efficient. Unlike cars, refrigerators and washing machines, servers are not required to meet federal energy standards. The Energy Star program, which identifies especially efficient products, evaluates many pieces of computer equipment, but not servers, disk arrays, tape libraries, switches, etc.

Managers who buy data center equipment, including servers and related hardware, “need objective, credible energy performance information”, said E.P.A.

Besides the savings from lower utility bills and the benefits from reducing power plant emissions, many data centers have a pressing reason to improve efficiency. An increasing number of data centers in both the private and public sectors are hitting their limits in terms of space, power and cooling capacity. In other words, many centers cannot increase capacity without increasing energy efficiency (or spending a fortune to build more farms).

One problem has to do with the priorities of data center managers, who choose servers based on speed, performance and reliability but generally not on energy use.

Energy consumption in the data center represents a rising operational cost, but enterprises need to better understand their power usage to be more efficient, better allocate power to ensure availability, accurately budget for power costs and charge power usage to individual departments.

Facilities in IT Budget

When looking at the global budget of a typical IT department, one cannot avoid noticing that facilities constitute a more and more important share of the overall budget. In fact, recent studies show that it represents 8% of the whole IT budget and this share is growing 20% annually.

Most IT departments have an idea of the total energy consumption of their data centers simply because they receive a bill from the utility department each month.

But the ever-rising costs and lack of tools to help manage those costs constitute the source of growing frustration. How can you even start thinking about reducing data center energy costs without knowing how much energy devices are consuming?
A solution that monitors the power consumption of all IT equipment in the server room is key to handling the energy cost problem:

- Diagnosing: Identify the more power-hungry devices (servers, switches, disk arrays, etc.)
- Capacity planning: Align IT capacity with demand and budget for future energy expenses
- Reporting: Re-bill the energy costs to the application or server owners

Source: McKinsey and UpTimes: breakdown shown is typical of IT intensive businesses, forensic accounting is required to capture all facility costs

**Implications of Improved Density**

Looking at the technology evolution over the past decade hardly explains how electricity consumption has become such an issue. Faster processors and higher-capacity disks that enable running the same application on ten times less machines should logically consume ten times less energy. Nevertheless, the main reason for which this logical assumption does not apply is that application development and deployment outpaced hardware improvements by large. This implies that, in total, data centers run more servers and other devices than they used to 10 years ago.

In the meantime the power drawn by each server and the heat that it generates has increased substantially. Today, the heat generated by a rack fully loaded with blade servers draws 21 kilowatts of electricity and generates 30 kilowatts of heat. This can explain why many data centers are reaching their capacity limit in terms of power and cooling.
Given the price of electricity in the United States, the growth of energy consumption has become a serious issue.

World Data Center Electricity Use

The graph below represents the energy consumption of data centers worldwide in billions of kilowatt hours. It makes it obvious to observe that the total number double between 2000 and 2005; which confirms another study by the Environment Protection Agency that states that energy costs to operate data centers have doubled between 2001 and 2006, and will double again before 2011.

According to the E.P.A., it costs $4.5 billion a year for the electricity to run the United States’ server farms, a sum ultimately picked up by consumers. A recent IDC study also found that the expense to power and cool the worldwide installed base of servers will grow to $44.5 billion, equivalent to 70 percent of new server spending, by 2010. With increasing energy prices, the electric consumption in some server rooms has become the #1 expense ahead of human resources!

Now, the graph tells us something else: more than half of these kilowatts hours are not used for the IT equipments, that is: servers, switches, disk arrays, etc. More than 50% of this energy goes to cooling equipment and power distribution, in other words, it is dedicated to the facility operation. And this share is constant: It used to represent above 50%, and it is still does, but now represents 50% of a much bigger amount!

Power Usage Effectiveness (P.U.E.)

In what the part of electricity dedicated to non-IT operations consists of? The graph below clearly shows the three main elements:

- Cooling (air conditioning, chillers, etc.), for the biggest part
- UPS (uninterruptible power supplies)
- Losses due to voltage transformation
An efficient metric to measure the extra-energy required to power a data center consists in the “P.U.E.” (Power Usage Effectiveness); which corresponds to the total facility power divided by the IT equipment power.

\[
P.U.E. = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}
\]

The graph highlights how the P.U.E. is distributed among the different elements that consume electricity in a data center:

- IT equipment is logically 1
- Cooling is typically half of that. Which means that for every 2 watts consumed by a server, you will need 1 watt to cool this server
- UPS represent a good quarter
- The power loss in the power supplies of the server themselves must not be let aside since it still represents a significant cost.

On average, the P.U.E. of a typical data center ranges from 2 to 2.5, and if you add the server power supplies, you can easily reach a 2.3 to 2.8 range.
Evaluate Efficiently Energy Consumption Solutions

“If you can’t measure it, you can’t manage it” (Lord Kelvin).

Most IT departments have an idea of the total energy consumption of their data centers simply because they receive a bill from the utility department each month. But the ever-rising costs and lack of tools to help manage those costs constitute the source of growing frustration. How can you even start thinking about reducing data center energy costs without knowing how much energy devices are consuming?

Avoid Power-hungry Devices

Even if it is common sense, let’s not forget that not all servers are equals in term of energy consumption. Different internal architectures, different component types, different layouts draw different amount of electricity. Here are a few explicit numbers from our test lab:

<table>
<thead>
<tr>
<th>Device</th>
<th>Wattage</th>
<th>Yearly cost</th>
<th>Yearly cost (incl. cooling)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELL PowerEdge R900, 2 Xeon, 32GB RAM, 2TB disk</td>
<td>350 W</td>
<td>$146</td>
<td>$851</td>
</tr>
<tr>
<td>DELL PowerEdge 2950, 1 Xeon, 4GB RAM, 1TB disk</td>
<td>160 W</td>
<td>$158</td>
<td>$289</td>
</tr>
<tr>
<td>DELL Modular Rack Blade Chassis, 12 Blade servers</td>
<td>3,500 W</td>
<td>$3,372</td>
<td>$8,295</td>
</tr>
<tr>
<td>Cisco MDS 9506, 96FC ports</td>
<td>1,030 W</td>
<td>$1,018</td>
<td>$2,504</td>
</tr>
<tr>
<td>HPEVA 4400, 14TB</td>
<td>1,324 W</td>
<td>$1,328</td>
<td>$3,218</td>
</tr>
<tr>
<td>Sun Enterprise M8000</td>
<td>7,520 W</td>
<td>$7,246</td>
<td>$17,825</td>
</tr>
</tbody>
</table>

Source: SPEC

Should you collect the same measures in your data center, with a solution that will be fully describe further on in this document, you may discover that the most power-hungry equipment are not always the usual suspects.

Let’s take a look at the two DELL servers. It’s interesting to notice that the first one, which is twice bigger than the second one, consumes twice as much energy. The DELL blade chassis, fully loaded with 12 blade servers, consumes 3,500 watts; which corresponds to an average of 290 watts per blade server. The savings are clearly not significant.

With the SAN devices, we can see that a typical fiber switch consumes a surprisingly high amount of energy: in this case, more than 1 kilowatt. Yes, emitting lights on a fiber link consumes a lot. Also, the big Sun Enterprise M8000, the equivalent of the Sun Fire E20K, consumes 7,500 watts! You’d better have a significant number of domains running on that device to make it profitable.

The energy cost of each server, including cooling, is quite significant. A good strategy would be to know which systems or devices in your environment consumes more than others and stop purchasing such systems.

Since 2008, SPEC has been testing various servers regarding their power consumption under a certain type of workload. However, even though they are quite interesting, the tests at SPEC must be taken with caution.
because depending on the different options you choose for a given model of server from one manufacturer, the power usage will differ greatly. Having 4GB or 16GB or memory changes things significantly, as well as adding a second processor, or according to the disks type or the HBA card.

In the end, real life metrics are still the best way to identify power-hungry devices.

**Quality to Improve Efficiency**

To continue with the idea of server efficiency in terms of power, here is another graph that shows how much electricity internal components consume — these are the components of a 450 watt server.

![Average Power Usage (in Watts)](image)

It clearly illustrates that the heaviest energy consumer in a typical server is the power supply itself. Power conversion, AC-to-DC, and DC-to-DC, consumes a total of 163 watts. Then come the processors, and further on the disks.

It is common knowledge that power supplies in servers are more or less efficient. A power supply is considered efficient when performing at a minimum of 90% of its capacity while an underachiever would only score a maximum of 60%. Thus, purchasing a server with a high-performance power supply over a server, maybe less expensive but with a poor-quality power supply may save a lot of money.

The savings may count from $100 to $200 a year per server, and it could even double if you take the cooling costs into account. Let’s not forget that the cost of a server is not only determined by its price tag. Actually, the overall energy costs to operate a server will top its purchase price in less than 4 years, or even less with inefficient or badly designed systems.

*The Environment Protection Agency is currently putting together an Energy Star program for servers; even though not totally completed, a 1.0 draft version of the program has already been released to selected manufacturers last month.*
Hardware Refresh

Another efficient way to slow the growth of energy consumption would be to purchase servers that optimize processing power per watt space.

According to Intel, 184 servers with single core processors, purchased in 2005, are equivalent to only 21 Xeon 55 hundreds-based servers purchased in 2009 --a 9 time server reduction. The estimated return on investment is 8 months only.

Well, obviously, you wouldn’t expect Intel to tell you to stick with your older processors. Therefore, you can either trust Intel blindly, or do proper power consumption measurements before and after hardware refresh. However, to do so, you need some solution able to accurately monitor and report the electricity consumption of your servers.

Since the server reduction as advised by Intel implies heavy server consolidation, a proactive way to use the spare space would be to consolidate and implement an efficient virtualization project. When a virtualization project is driven by the goal of reducing the electricity bill, it is important to consider virtualizing systems which the underlying hardware was over-sized for.

This way, several virtual systems will be able to run on the same hardware without having to increase its size, and thus consuming the same amount of energy as a single system would.

Consolidate with Virtual Systems

Running several virtual systems on a single physical machine has the obvious advantage of avoiding installing new hardware, which consumes electricity. As such, the consolidation of systems on a single physical machine through virtualization is part of many "Green IT" initiatives, and is a good way to start reducing the overall power consumption of a data center.

However, if handling two virtual systems requires doubling the capacity of the server, it terms of processors, memory, and disk space, the energy savings will be less than anticipated.

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Implement the "Polluter Pays" Principle

Like outsourcers, most IT departments act as a hosting service, for the applications of other departments within a company or organization. However, IT departments are often only seen as a cost center for the company, especially when it comes to the monthly electricity bill.

By using a product like BMC Performance Management, with Sentry Software’s Hardware Monitoring solution, IT departments can now break down the overall power consumption by server and storage device. This provides the ability to re-bill a department for the electricity costs associated to their given application.

An IT department running 1000 servers could easily re-bill around $200,000 of electricity costs to other departments. This has the clear benefit of better sharing the various costs across the different departments (instead of just IT), and also enables the IT department to communicate the fact that they are not just a cost
Warm the Data Center

The equipment density in the data center is increasing due to blades, smaller and faster processors, etc, making the cooling issue more critical. Recently, The American Society of Heating, Refrigerating and Air-Conditioning Engineers recommended that data center temperature was kept between 65°F and 81°F. Most data centers are kept in the low range, around 68°F.

How to determine the data center proper temperature?

- Degree by degree, raise the thermostat of the A/C system
- Permanently check the temperature sensors and compare with the manufacturer thresholds
- Permanently check the fans speed
- Loop until temperature too close to warning thresholds or fans speed increase

Some of the most renowned organizations around the world came up with efficient ideas to keep their data center to the ideal temperature:

- Switch from large UPS to internal batteries and Optimize airflow by using containers (Google)
- Use passive/evaporative cooling techniques and move data center to colder location (Yahoo!)
- Cool data center with outside air, stop the A/C (The Green Grid)
Solution Requirements

Data center experts tend to agree that when it comes to reduce energy bills for the data center, turning up the heat is an efficient solution. In most data centers, temperature is maintained colder than necessary to keep the equipment sufficiently cooled. There's a clear financial benefit to boosting the temperature in your data center: Increasing the set point temperature by just one measly degree can reduce energy consumption by 4 to 5 percent, which translates to lower energy bills. For the environmentally conscious company, that also means a reduction in carbon emissions.

Reducing energy consumption, or at least stopping its growth, requires to implement a high-level project plan that includes an essential step, that is the capacity to measure, report and analyze the actual electricity consumption.

Data centers are complex environments, and adjusting the temperature can have some unexpected or unintended results. To establish the proper cooling level of the data center, administrators need to rely on three critical information:

- Temperature (ambient, internal sensors)
- Fans speed
- Power consumption of each device

Data centers administrators need a technology that accurately and constantly monitor the equipment to report the electricity consumption of each server in kWh, even for servers that are not equipped with a power meter. Thus, selecting the proper software technology can be at least as important as choosing optimal hardware.

While measuring temperature and fans speed is critical to evaluate the proper temperature required to ensure an optimum performance in the data center, measuring the actual consumption of each device is essential to identify the most power-hungry devices and collect sufficient data to bill the actual consumers. Implementing chargeback models based on accurate consumption data may help IT managers substantially reduce energy expenses by having the actual electricity consumers pay for what they use.
With BMC Performance Manager

BMC Performance Management is a monitoring framework that features several modules specialized in the monitoring of specific IT components, like operating systems, databases, email servers, etc.

At the core level of BMC Performance Management, there is a module that specializes in the monitoring of server hardware, storage devices, and switches. This solution, developed by Sentry Software and licensed by BMC Software, is available in two forms:

- Hardware Sentry KM for PATROL (agent-based module for BMC PATROL)
- BMC Performance Manager Express for Hardware (agent-less module for BMC Portal)

The main purpose of this module is to discover and monitor all of the hardware components of servers, disk arrays, tape libraries, fiber switches, etc.

In addition, the product also reports the power consumption of each monitored system as a simple graph in Watts in the PATROL Console or BMC Portal. This graph shows the current instantaneous power drawn by a server.

The product also enables you to create an Energy Usage report based on data that has been collected every 2 minutes for several days. The report exposes the amount of energy used by the server on a daily basis. The graph is in kWh and by knowing the price of the kWh in your region; you can easily calculate the energy cost of the system.
By using other BMC reporting products, you can build reports for the entire server room, server by server, department by department and tell whose servers are the most expensive.

How BMC Performance Manager for Hardware Innovates

Few systems are equipped with an embedded power meter. When monitoring such a server, BMC Performance Management will report the actual power consumption of the system based on the data collected through the instrumentation layer provided by the manufacturer.

Sentry Software uses an alternate method for systems that are not instrumented and do not have power meter sensors. Since the hardware monitoring module already discovers all the physical parts of the system (fans, memory modules, processors, NICs, etc.) by knowing the typical power consumption of all these internal components, BMC Performance Management is able to evaluate the power consumption of the system, based on its internal components and its activity. While it’s not an actual measure of the power consumption, it’s still a good estimation based on real data: what the server, disk array or switch is made of.
Improving data center energy efficiency is becoming a fundamental requirement for most organizations. Electricity costs are rising fast. Most businesses already spend about half as much for the electricity to power and cool their infrastructure as they do for the hardware itself, and this percentage can be expected to increase. Actually, according to data center specialist, the IT energy cost will overrun equipment expenses in 2015. It is time to take action!
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