Alcatel·Lucent

STRATEGIC WHITE PAPER

Reducing power consumption

Improving the heat and power efficiency of switching and telephony equipment

Enterprises around the world are seeking out IT suppliers whose products and solutions take the environment and human health into account. Reducing power consumption ranks high on the list of companies' environmental priorities — especially given its attendant benefits of bringing down operating and capital expenses. This paper looks at technologies available today that achieve these important environmental and business goals by minimizing heat and power dissipation in Ethernet-based switching and telephony equipment.

Table of contents

1. Introduction

Rising awareness of the need for sustainability is prompting enterprises to seek out IT suppliers whose offerings are safe, energy and material efficient, designed for recyclability and supported by end-of-life recycling programs.

The growing insistence on efficiency in this context dovetails with a larger-scale culture shift underway within many organizations: the move toward becoming *dynamic enterprises* in which the network, people, processes and knowledge all function as part of a seamless whole focused on production, innovation, performance and transformation. The benefits of such a model are many — ranging from greater responsiveness to lower operating costs — but for them to be realized efficiency must become a reflexive value of the enterprise.

What does this mean? Fundamentally, it means that environmental and health-related objectives are no longer extraneous, add-on considerations for organizations. Instead, they are part of an overall movement toward lean, agile, flexible and sustainable operation.

1.1 The environment and business

According to a recent study, more than 50 percent of enterprises consider "greenness" when selecting a vendor. A third of enterprises already consider it important or very important that their IT suppliers have so-called green offerings, and nearly 80 percent of executives say Green IT is becoming more important to their organizations. Gartner Group findings reinforce these assertions, indicating that environmentally friendly IT ranks among the top 10 trends and technologies for 2008 and beyond.[1]

One of the major drivers of Green IT (and, more broadly, eco-sustainability) is *sustaining economics*, a key consideration of which is the need to reduce energy consumption. Cutting back power consumption has a direct impact on operating expenditures (OPEX) by reducing energy costs — and also on capital expenditures (CAPEX) by minimizing the amount of equipment needed for cooling and backup power.

Although environmental issues have been strongly highlighted in recent years and many organizations have publicly declared eco-friendly commitments, a large number of businesses have yet to turn their intentions into action. Today, however, with technology increasingly available to support environmental aims, this has potential to change.

Alcatel-Lucent develops and builds equipment that meets environmental requirements and has already achieved compliance with a number of environmental directives including RoHS (Restriction of Hazardous Substances), WEEE (Waste Electrical and Electronic Equipment) and Electrical Emissions.

Alcatel-Lucent enterprise switching and telephony equipment dissipates significantly less power than that of the company's main competitors. Dissipating less power reduces energy costs — not only those associated with the equipment itself, but also supplementary equipment such as battery backups, power generator backups and air conditioners. In addition to having lower energy costs, the initial cost of power backup and cooling will also be lower when deploying low-power equipment.

1 *Gartner Data Centre Conference: Day 2 Highlights Top-10 Disruptive Technology Areas*. Carl Claunch, David J. Cappuccio, Mike Chuba. Gartner: November 28, 2007.

2. Power and heat dissipation

In enterprise data networks, IP infrastructure and IP phones are operational 24 hours a day, seven days a week — consuming power and dissipating heat. This chapter will give a generic technical background of power dissipation and heat dissipation of Ethernet switches, Power over Ethernet switches, Power over Ethernet terminals, and servers.

2.1 Ethernet switches

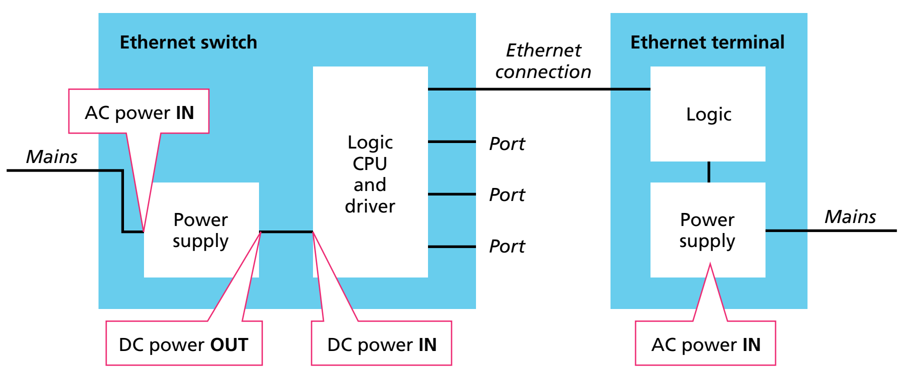
2.1.1 Hardware

Enterprises commonly deploy Ethernet switches to build infrastructures that interconnect peripherals such as PCs, IP phones, printers, application servers, database servers, Internet gateways and the like.

Figure 1. Alcatel-Lucent OmniSwitch 6850 Gigabit Ethernet Switch

The following is a logical representation of an Ethernet switch connecting an Ethernet terminal:

Figure 2. Ethernet switch to Ethernet terminal



The Ethernet switch contains the following components:

- Mains AC power input
- Power Supply Unit (PSU) converting AC to DC
- Connection between PSU and Logic Unit
- Logic unit, containing CPU (CPU, packet processor, etc.) and physical Ethernet drivers
- Ethernet connection ports

2.1.2 Power dissipation

Power is needed to drive Ethernet connections and process Ethernet packets. The mains provide power to the PSU. In turn, the PSU transforms the main AC power into DC power for use by the processor and physical Ethernet drivers.

The amount of DC power the Logic Unit dissipates depends on the type of components used, the clocking speed of the components and, to a lesser extent, actual processing. The PSU should deliver the amount of power the Logic Unit requires.

The operational AC power dissipation of the PSU is the amount of DC power needed by the Logic Unit (i.e., PCU DC output power) divided by the PSU's efficiency factor. The efficiency of a PSU defines the loss of power (dissipation of heat) when converting AC to DC.

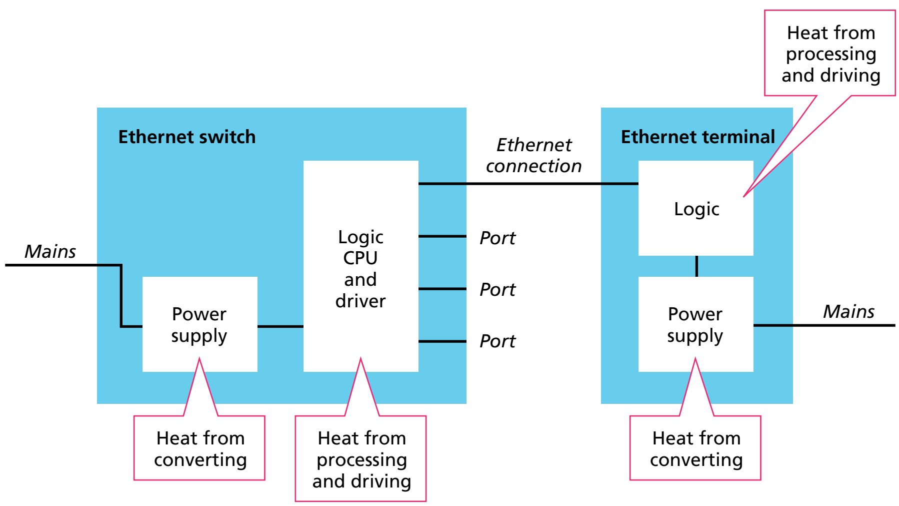
To calculate yearly energy costs:
Operational AC power dissipation (Watts) x 24 hours x 365 days x cost/Wh (Watt hours)

2.1.3 Heat dissipation

The heat dissipation of the Ethernet switch is equal to the AC power dissipation by the PSU per unit of time. This is especially important when additional cooling is required. If it is not specified, the heat dissipation can be calculated in BTU/hr, by multiplying the AC-power dissipation by 3.41214.

The picture shows the various components in the system where heat is dissipated:

Figure 3. Ethernet switch — points of heat dissipation



2.2 Power over Ethernet switches

2.2.1 Hardware

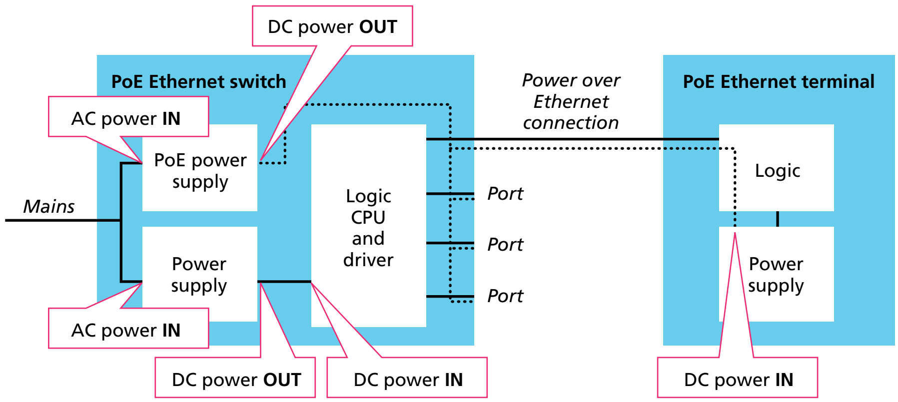
Enterprises deploy Power over Ethernet (PoE) switches to build access layers in the Ethernet infrastructure. As with Ethernet switches, these access layers are used to interconnect PCs, Ethernet-powered IP phones, Ethernet-powered wireless access points, printers and other peripherals. Many of the technical points below are similar (and in many instances identical) to those given above for Ethernet switches, but bear repeating here for clarity's sake.

Figure 4. Alcatel-Lucent OmniSwitch 6850 Stackable Gigabit LAN Switch with Power over Ethernet capability

2.2.2 Power dissipation

- The PoE switch contains the following components:
- Mains AC power input
- PSU converting AC to DC for Ethernet processing and driving
- Connection between PSU and Logic Unit
- PoE power supply converting AC to DC for Power over Ethernet
- Connection between PoE PSU and PoE ports
- Logic Unit containing CPU (CPU, packet processor, etc.) and physical Ethernet drivers
- PoE connection ports

Figure 5. PoE switch to PoE terminal



Power is needed to drive Ethernet connections, process Ethernet packets and provide PoE. The mains provide power to both PSUs. The PSU transforms the main AC power into DC-power used by the processor and physical Ethernet drivers, while the PoE PSU transforms the main AC power into DC power used by the PoE ports to power PoE terminals.

The amount of DC power the Logic Unit dissipates depends on the type of components used, the clocking speed of the components and, to a lesser extent, the actual processing. The DC power dissipation of the PoE ports depends on the amount of DC power lost in the Ethernet connection and the DC power dissipated by the PoE terminal(s). The PSU should deliver the amount of power the Logic Unit and PoE ports require.

The operational AC power dissipation of the PSU is the sum of DC power needed by the Logic Unit AND the power requested by terminals from the PoE ports, divided by the PSU's efficiency factor. The efficiency of a PSU defines the loss of power (dissipation of heat) when converting AC to DC.

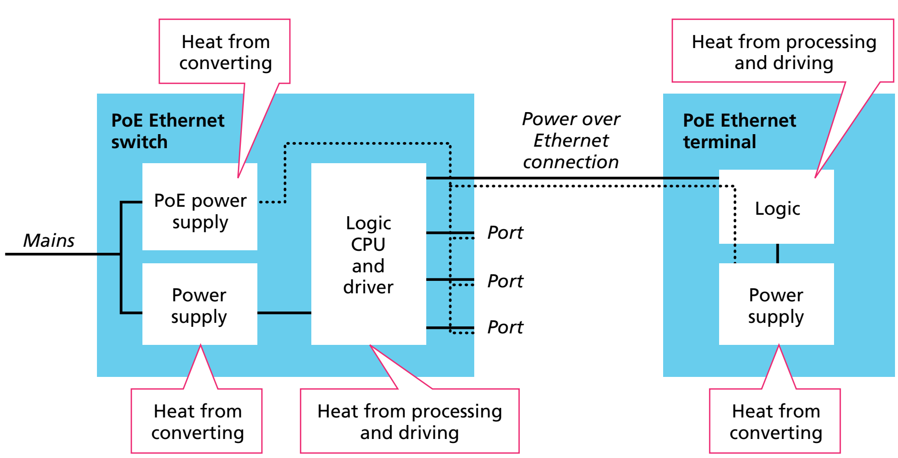
To calculate yearly energy costs:
Operational AC power dissipation (Watts) x 24 hours x 365 days x cost/Wh

It should be noted that operational power varies with the amount and type of connected PoE terminals.

2.2.3 Heat dissipation

The heat dissipation of a PoE switch is different from a non-PoE switch. Heat dissipated as a result of the power consumed by a PoE terminal is not dissipated in the switch itself, except for the AC to DC conversion needed to drive the PoE terminal itself.

Figure 6. PoE switch — points of heat dissipation



2.3 Power over Ethernet terminals

2.3.1 Hardware

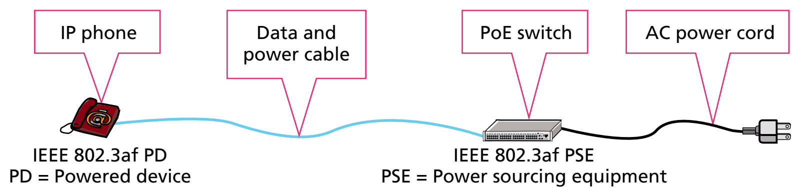
It is a good idea to power small terminals such as phones and wireless access points via Ethernet to consolidate power backup and minimize the need for additional power bricks in offices or hard-to-reach access points (e.g., ceilings).

Figure 7. Alcatel-Lucent IP Touch Phone and Wireless Access Point

2.3.2 Power dissipation

The following depicts a PoE switch connecting an IP phone:

Figure 8. PoE switch to IP phone



Idle/operational + Cable loss + Power supply efficiency = Power

The IP phone is PoE-powered by the PoE switch via the cable. This meets the IEEE 802.3af standard. IEEE 802.3af defines classification of the amount of power delivered by the power source equipment (PSE) to the powered device (PD). The following table shows the various classes and maximum power output at the PSE and maximum power input at PD:

Table 1. Device classes according to power usage/output

CLASS	USAGE	RANGE OF MAXIMUM POWER USED BY THE PD	MAXIMUM POWER LEVELS AT OUTPUT OF PSE
0	Default	0.44 to 12.95 Watts	15.4 Watts
1	Optional	0.44 to 3.84 Watts	4.0 Watts
2	Optional	3.84 to 6.49 Watts	7.0 Watts
3	Optional	6.49 to 12.95 Watts	15.4 Watts
4	Reserved for future use		Treat as Class 0

The total power PoE devices need equals the amount of power consumed by the device when idle (active but waiting to be operated) or operated plus the power lost in the data cable as well as the efficiency (loss of power when converting AC to DC) of the PoE power supply of the PoE switch.

2.3.3 Heat dissipation

The heat dissipation of a PoE device is equal to the power of the device. If this is not specified, it can be calculated in BTU/hr, by multiplying the DC power dissipation by 3.41214. Additional heat is generated in the cabling and the power supply of the PoE switch.

A note on power classification

By classifying PD devices it is possible for a PSE device to assign a power to the port a PD device is connected to. This budget is in turn subtracted from the total PoE power budget available for the PSE device. This is helpful in not oversubscribing the total PoE power budget of a PSE device.

There are multiple ways to classify power at the PSE level:

a) *IEEE 802.3af class 0*. Regardless of PD class, the PSE will reserve maximum power (15.4 W) for the port the PD connects. In the event the total PoE power budget of the PSE is smaller than the amount of Ethernet ports multiplied by 15.4 Watts (Class 0), a number of PDs will remain unpowered.

b) *IEEE 802.3af*. When the PD is capable of sending its class, the PSE reserves classified power for the port the PD connects. In the event that the total PoE power budget of the PSE is smaller than the total amount of power to be assigned, a number of PDs may remain unpowered. However, due to the granular classification, the chance of unpowered devices is lower than in the above case.

c) *IEEE 802.1AB*. To allow for more granular power classification, the IEEE defined a specific TLV (type-length-value) in its standardized Link Layer Discovery (LLD) Protocol. At the time of writing, the existing power classes are supported by IEEE 802.1AB. One is defining a TLV to allow for more granular power classification. Indeed, the target resolution is 0.1Watt steps.

2.4 Servers

2.4.1 Hardware

Virtualizing servers helps reduce total energy consumption.

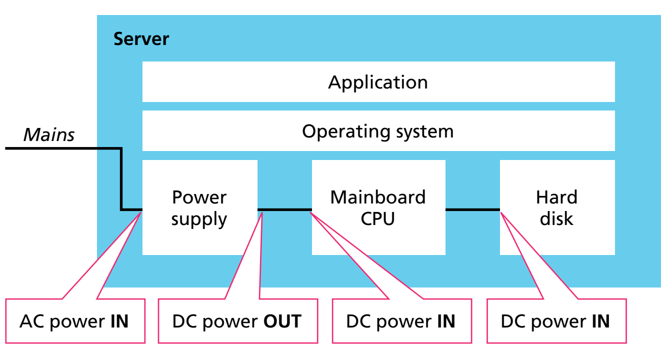
Figure 9. Alcatel-Lucent Business Information and Communication Server (BiCS)

2.4.2 Power dissipation

The server contains the following components:

- Mains AC power input
- PSU converting AC to DC for the main board and hard disk
- Connection between PSU and main board and hard disk
- An operating system running to support applications
- An operating system optimized application

Figure 10. Server with power inputs/outputs

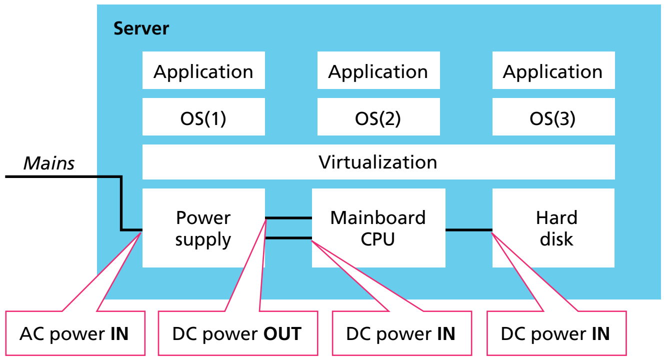


The main board and disks require power for the server to run. Despite the fact that applications do not tend to use CPUs to their fullest extent, they still consume a great deal of power — as does a hard disk that has to continue spinning even when there is no read or write access. Of course, more applications might be run on the server, but this is only valid if the applications are optimized for the same operating system and do not interfere with each other.

2.4.3 Optimized power dissipation

Virtualization is the ideal means of optimizing power dissipation (here the optimized state refers to the minimal dissipation possible).

Figure 11. Virtualized server with power inputs/outputs

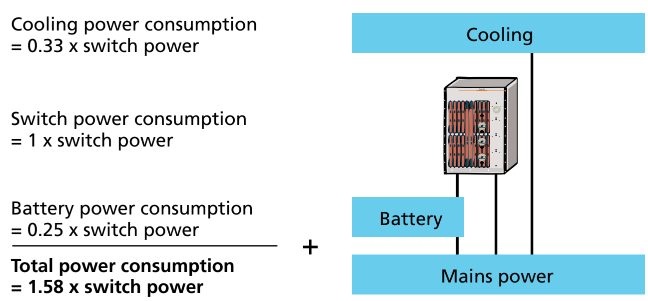


By sizing the server hardware appropriately and adding a virtualization layer, a single hardware platform can run multiple types of operating systems — and therefore operating system-optimized applications — using far less power than separated platforms. (The additional advantages of server virtualization such as redundancy, teaming, etc., are beyond the scope of this paper).

2.5 Cooling and power backup costs

Network equipment in data centers and main equipment rooms needs to be kept below a certain temperature and requires backup power to ensure it is always available for business-critical applications. Power dissipation associated with cooling and backup is a factor fixed to the power dissipation of the network equipment. The lower the power dissipation, the less power is needed to cool and backup — reducing both energy and equipment costs.

Figure 12. Cooling and power backup cost calculation



3. Ethernet in the future

The preceding equipment-specific examples of power and heat dissipation — and the associated opportunities to conserve power in switches, terminals and servers — are among the the considerations of the IEEE (Institute of Electrical and Electronics Engineers) working group on energy efficiency, known formally as the IEEE 802.3az Energy Efficient Ethernet Task Force. The main focus of this group is to reduce energy consumption in Ethernet devices by defining a mechanism to reduce power consumption during periods of low link utilization for the following PHYs:

- 100BASE-TX (full duplex)
- 1000BASE-T (full duplex)
- 10GBASE-T
- 10GBASE-KR
- 10GBASE-KX4

IEEE 802.3az also defines a protocol to coordinate transitions to or from a lower level of power consumption and sets out the specifications for a 10-megabit PHY with a reduced transmit amplitude requirement that renders it fully interoperable with legacy 10BASE-T PHYs over 100 meters of class D (category 5) or better cabling to support reduced power implementations. Per IEEE recommendations, any new twisted-pair or backplane PHY for energy-efficient Ethernet shall include legacy compatible auto negotiation.

Alcatel-Lucent shares the IEEE's commitment to shaping the energy-efficient future of Ethernet. Through the products indicated in the sections above, Alcatel-Lucent offers demonstrable advantages over conventional offerings as detailed in the following section of this paper.

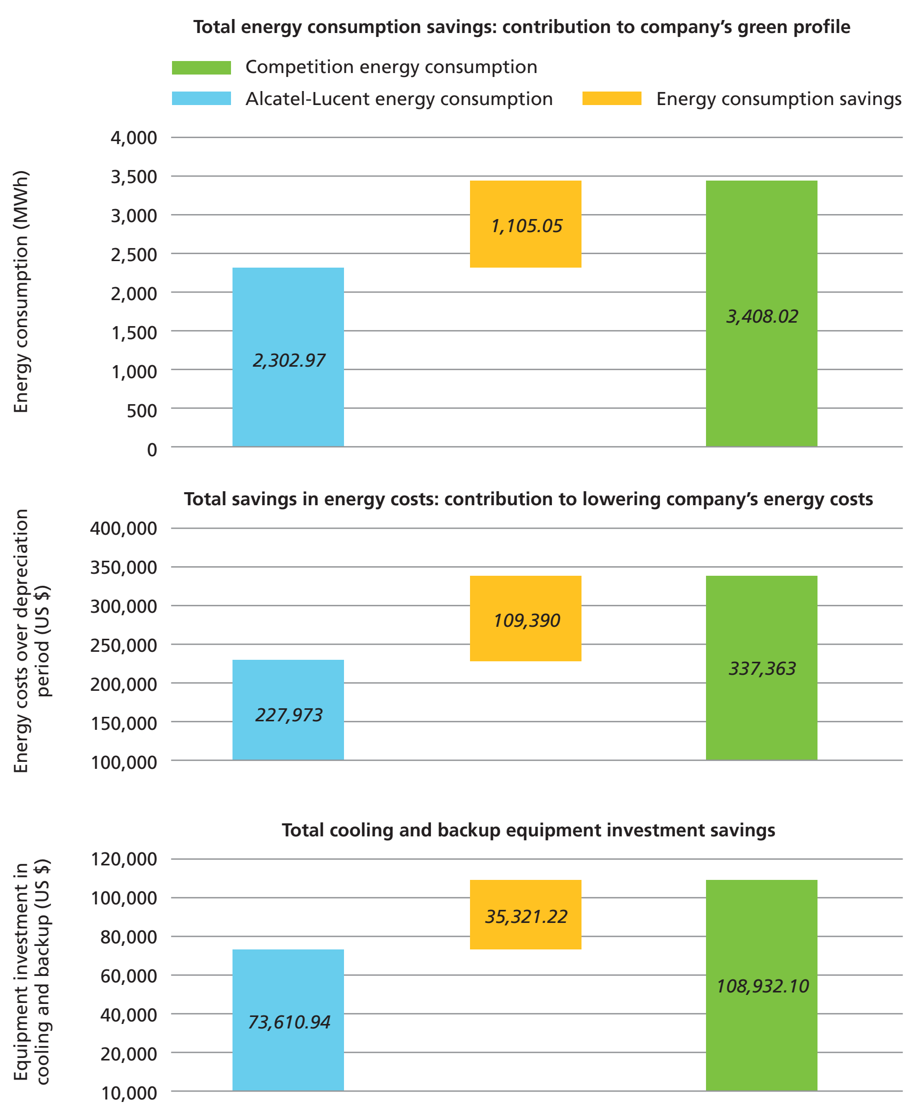
4. The Alcatel-Lucent difference

For the sake of comparison, consider a network with 6,000 one-gigabit access ports and 3,000 high-end IP phones in a 10-gigabit backbone configuration. In conjunction with business consultants Frost & Sullivan, Alcatel-Lucent has developed an energy efficiency calculator to assist in calculating environmental and energy cost savings. Available from Alcatel-Lucent representatives, this calculator illustrates the environmental and financial benefits of lower energy-consuming devices.

By entering two core (OmniSwitch 9800) and 12 access (OmniSwitch 6850) switches including 3000 IP Touches over five years, enterprises can save:

- More than 1000 megawatt hours
- More than US$150,000

Figure 13. Calculated energy savings per scenario described above



5. Conclusion

The telecommunications industry has tremendous potential to contribute to overall greenhouse gas reductions and global energy conservation: by substituting travel with 'virtual' meetings, by enabling the 'dematerialization' of products and services through the use of electronic documentation and media, and of course in a direct way by improving the efficiency of telecommunications networks and equipment.

Corporations seeking to operate more efficiently and flexibly, streamline their costs and reduce their environmental impacts — integrating their networks, people, processes and knowledge within the cohesive whole of the *dynamic enterprise* — are, as part of that movement, looking for equipment vendors who can promise not only high-performance but also sustainable and energy-efficient products and solutions.

Alcatel-Lucent is determined to be a driver of the industry's move toward greater energy efficiency, and has already introduced numerous products that offer environmental and related OPEX/CAPEX benefits. Specific to this paper, the company has identified and capitalized on opportunities to conserve by limiting power and heat dissipation in switches, terminals and servers.

6. Glossary

BTU/hr	British Thermal Units per hour
CAPEX	capital expenditure
CPU	central processing unit
IEEE	Institute of Electrical and Electronics Engineers
LLD	link layer discovery
OPEX	operating expenditure
OS	operating system
PD	powered device
PoE	Power over Ethernet
PSE	power source equipment
PSU	power supply unit
RoHS	Restriction of Hazardous Substances
TLV	type-length-value
WEEE	Waste Electrical and Electronic Equipment
Wh	Watt hours

7. References

Gartner Green IT survey: Gartner Data Center Conference: Day 2 Highlights Top-10 Disruptive Technology Areas, November 28, 2007
IEEE 802.3az Energy Efficient Ethernet Task Force: http://www.ieee802.org/3/az

For more information, contact your Alcatel-Lucent representative.
www.alcatel-lucent.com/enterprise