IT@Intel White Paper

Intel Information Technology
Sustainability
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Reducing Energy Use in Offices to Increase IT Sustainability

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Executive Overview

As part of our commitment to IT sustainability, Intel IT is reducing office power consumption by evaluating and implementing enabling technologies, changing business practices, and educating employees to change usage behaviors. Reducing PC energy use is a major component of our efforts to reduce office energy consumption.

We have learned that raising employee awareness can be highly effective in reducing office energy use.

We conducted several studies to guide our sustainability efforts. One study provided data about how different generations of laptops impact power consumption and allowed us to develop an office energy use baseline.

We also implemented energy-efficient power schemes, and we evaluated energy-efficient hardware including solid-state drives (SSDs) and power-management software and technologies. In addition, we conducted a study on user awareness and behavior as it relates to saving energy in the office environment.

Our findings from these studies guided our decisions to:

- Proactively replace older, less efficient equipment with higher-efficiency models.
- Deploy new power schemes to existing and new PCs.
- Enable power setting reporting.
- Deploy SSDs as part of our enterprise-wide PC refresh process.
- Evaluate third-party power management software and Intel® vPro™ technology secure remote wake.

According to our estimates, technology and process solutions offer an opportunity to significantly reduce power consumption in the office. However, we have also learned that raising employee awareness can be highly effective in reducing office energy use. In a small proof of concept, employees who were provided energy use and cost information reduced their energy usage by more than twice as much as employees who installed power management software but were not provided with energy usage information.

We have found that by using the most power-efficient equipment available, implementing power management, and giving all employees a way to make an impact on IT sustainability, we can achieve our IT sustainability goals for reducing energy consumption in the office.

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BACKGROUND

Addressing environmental concerns with sustainable solutions plays an ever-increasing role in remaining competitive in today's marketplace. Intel is proactively addressing sustainability by establishing a corporate goal of reducing Intel's total carbon (CO_2) footprint by 20 percent by 2012 from 2007 levels.[1] Intel IT is contributing to this overall goal by developing and executing a strategy to increase our sustainable practices and decrease our CO_2 footprint.

As part of our overall sustainability strategy, we established baseline measurements and developed a sustainability roadmap, targeting high-impact business areas.[2] As shown in Figure 1, we found that our IT CO_2 footprint is comprised of:

- **70 percent from data centers.** Intel's data centers play a key role in supporting Intel's new technology development.
- **24 percent from computing and information and communications technology (ICT) equipment located outside data centers and labs.** Intel is a global company with many sites across the world, and ICT equipment plays a critical role in connecting Intel's workforce.
- **6 percent from PC computing.** Intel's PC footprint is quite low relative to Intel's larger-than-typical data center computing needs. Plus, widespread adoption of laptops across the enterprise has further reduced our PC computing energy use: More than 83 percent of Intel's workforce uses low-energy laptops and monitors.

1 See "Intel 2008 Corporate Responsibility Report." Intel Corporation, May 2009.

2 See "Establishing Baseline Measurements and a Roadmap for IT Sustainability." Intel Corporation, September 2009.

These three areas provide the highest impact in terms of sustainability benefits and cost considerations, and for each focus area, teams have identified energy savings projects. In our highest impact area, data centers, we've achieved significant results by, for example, improving data center power and cooling efficiency, refreshing servers, consolidating applications to common platforms, and decommissioning unused systems.

Although office energy use is responsible for a relatively low CO_2 emission percentage, that percentage is quite tangible, because almost every Intel employee uses a PC on a daily basis. Historically, we have evolved from a scenario where desktop PCs were always on and power consumption wasn't even considered; today, the office environment consumes less power due to widespread use of laptops and energy-efficient equipment. As we continue to reduce office energy consumption through enabling technologies, we are also using the office environment to foster awareness, encourage change, and stimulate employee involvement.

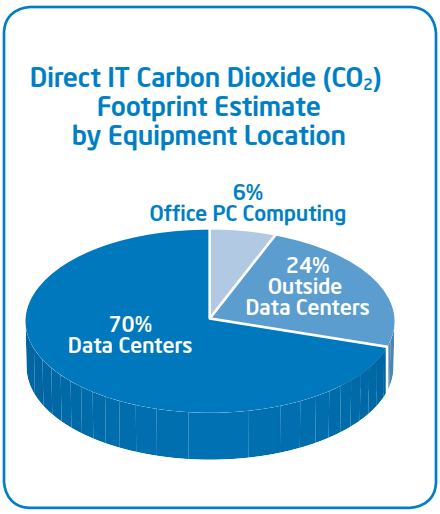

Figure 1. Our carbon emissions vary by equipment location.

SOLUTION

To meet our goal of reducing office energy use, we are using a two-pronged approach. First, we are proactively evaluating enabling technologies and changing some of our business practices. Second, we are educating employees about office energy consumption, raising their interest level, and motivating them to change their usage behaviors.

Taking Advantage of Enabling Technologies

Several technological advances, such as more energy-efficient and powerful laptop PCs, solid-state drives (SSDs), and intelligent power management software tools, are allowing us to continue to reduce energy consumption in the office environment. Additionally, we have changed our default power scheme settings to include the use of standby mode on both AC and DC power.

REPLACING DESKTOP PCs AND CATHODE-RAY TUBE MONITORS

A decade ago, we paid little attention to office energy use. Power-hungry desktop PCs with cathode-ray tube (CRT) monitors and mechanical hard drives were common, and PC power management was non-existent. Equipment was always on.

Over the last decade, however, Intel has shifted to laptop PCs for about 83 percent of the workforce, primarily in an effort to increase employee productivity. A secondary benefit has been to significantly improve energy efficiency.

To determine the factors that affect office power consumption and further improve our energy efficiency, we conducted a power consumption study, which provided data about how different generations of laptops impact power consumption and helped us develop a repeatable power consumption toolset and energy use baseline.

During this study, we learned the following:

- While newer laptop PCs consume less power than older laptop PCs, the most significant benefit is improved performance per watt.
- All laptop PCs tested consumed significantly less power than the reference desktop PC that was tested. Figure 2 shows the potential energy savings from laptop PCs.
- A high-performance laptop PC can provide similar CPU performance to the reference desktop PC at one-third the power.
- Screen brightness has a significant impact on power savings.
- BIOS and OS settings can vary idle power consumption by as much as 33 percent.

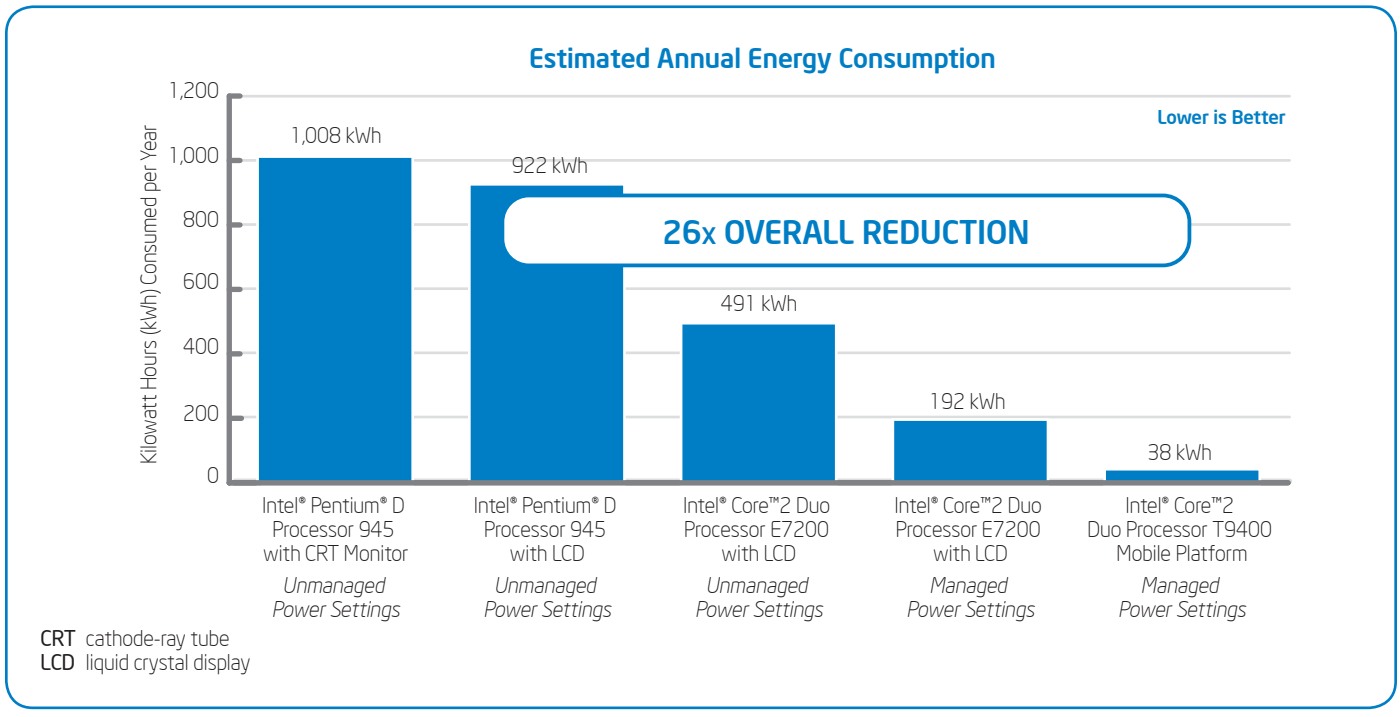

Figure 2. Laptops offer considerable power savings.

For desktop PCs, we found that another opportunity for energy savings in the office environment was to replace CRT monitors with more energy-efficient liquid crystal displays (LCDs). On a typical three-year-old desktop PC, an LCD consumes significantly less energy per year than a CRT.[3]

Using our findings from this study to change procurement practices and implement selected, proactive replacement projects, we are continuing to reduce energy use in the office.

IMPLEMENTING ENERGY-EFFICIENT POWER SCHEMES

We also investigated the impact of power schemes to reduce PC energy consumption and have since changed our default settings. We conducted a small study in 2007 that analyzed the power states of about 20 desktop and 100 laptop systems in our enterprise environment. We are currently refreshing the results from this study with a larger sample set.

The data this study provided was invaluable in answering such questions as:

- How many hours a day is the system on?
- How often does the system go in to standby?
- How hard is the CPU working?
- How does the power architecture of different generations of systems work with enterprise workloads?
- Are users running their laptops on battery or AC power?

In the past, collecting the data to answer these types of questions had been difficult because PCs do not generally feature measurement instrumentation. By using third-party power management software tools and internally developed agents to analyze the Advanced Configuration and Power Interface (ACPI) system and processor states, we are obtaining more precise usage data. This has helped us prioritize activities related to PC power and to calculate office power consumption estimates.

For example, we learned that both laptops and desktops could make better use of standby mode, especially when connected to AC power. We are using this data to encourage the use of more energy-efficient power schemes on PCs, especially AC standby mode. Our 2009 goals include the following:

- Reduce by 50 percent the use of maximum performance power schemes, which disable the CPU throttle, resulting in a higher idle power draw. CPU throttle is a feature that reduces processor frequency during idle times to conserve power.
- Increase adoption of standby mode (both battery and AC) by laptop and desktop PCs.

To achieve these goals, we are:

- Deploying new power schemes to existing PCs and changing default settings on new PCs during scheduled refreshes.
- Introducing energy-efficient power schemes, which include AC standby and adaptive CPU throttle, as build defaults instead of less energy-efficient power schemes. Internal IT testing has shown that a laptop with an adaptive CPU throttle setting will use about 25 percent less power at idle than one with the setting of "none."
- We are using electronic newsletters and social media to educate and encourage employees to select the most energy-efficient power scheme that is appropriate for their business need.

REPLACING HARD DISK DRIVES WITH SOLID-STATE DRIVES

SSDs offer an opportunity to further reduce our mobile users' energy consumption in the office. SSDs consume less energy than traditional hard disk drives (HDDs) and can therefore significantly improve battery life.[4] Increased battery life translates into extended mobile use, fewer recharge cycles, and reduced battery replacement. Because laptops with SSDs use less energy, they also run at a lower temperature and more quietly. Our evaluation quantified the substantial benefits that laptops with SSDs can provide to Intel in addition to the energy savings, and we are moving ahead with enterprise-wide deployment of SSDs as part of our PC refresh process.[5]

IMPLEMENTING THIRD-PARTY POWER MANAGEMENT TOOLS

Although third-party power management tools often require installation of an additional agent on the PC, which increases IT overhead, they do provide another way to help measure and reduce the energy consumed in the office environment. To evaluate the potential energy savings offered by third-party power management tools, we conducted two studies: one with enforced energy management and soft metering, and one using Wake on LAN (WoL) technology. We are also developing tools to report on PC power settings and will continue to improve those tools as we learn more.

3 See "PC Practices to Save Energy and Increase Productivity." Intel Corporation, 2009.

4 See "Improving the Mobile Experience with Solid-State Drives." Intel Corporation, January 2009.

5 See "Enterprise-wide Deployment of Notebook PCs with Solid-State Drives." Intel Corporation, August 2009.

Enforced power management

We installed a third-party power management tool on eight systems in an office environment as part of a larger office energy-use proof of concept (PoC). We deployed and enforced power management profiles that placed the monitors into standby mode after 10 minutes of idle time and the PCs into standby mode after 30 minutes of idle time.

This group of users reduced their power consumption by an average of 10 percent.

During the PoC we discovered several oversights: Some users did not install the third-party agent as requested, and one system was rebuilt during the PoC period and the third-party software was not reinstalled until later in the PoC. We believe the potential savings would have been even higher if all users had the third-party software properly installed throughout the duration of the PoC.

Remote power-down and power-up

We conducted a PoC on several systems in a lab using a third-party power management tool to automatically power off the systems at night and then wake them back up in the morning. The power management tool reduced the actual on-time from 24 hours per day to only nine hours per day and required no behavior change for users. We estimate the total average savings could be as high as 59 percent compared to not using a power management tool.

We are also evaluating Intel® vPro™ technology in our office sustainability strategy in light of a number of its capabilities. Intel vPro technology supports secure remote wake, which provides remote power management that is more reliable and secure than WoL. It also supports remote diagnosis and repair of PCs, which reduces Intel IT's CO_2 footprint through travel avoidance. In addition, the latest generation Intel® Core™2 processor with vPro™ technology improves energy efficiency by 46 percent.[6]

Empowering Employees to Reduce Energy Consumption

The second part of our approach to reducing PC energy consumption in offices involves empowering our employees and changing behaviors. Our studies showed that raising employees' awareness of how much power their equipment is consuming, and getting them involved in reducing that amount, is critical to success in reducing energy use in the office environment.

We conducted a small PoC that explored how we could encourage behavior modification by showing employees that small things, such as using standby mode on their laptops or turning off a printer when it's not being used, can add up to big savings. During this PoC, we first established a baseline of energy consumption through real-time metering of energy use in 12 cubicles. Once this baseline was established, we compared the effectiveness of various power saving techniques.

In one group, we focused solely on awareness and education. Every two to three days, we provided this group with information on how much energy they were using and how much it cost. We didn't provide any other information or requests to change behavior to the members of this group.

We asked a second group to install a third-party software agent that deployed and enforced power management profiles. The profiles were set up to put the monitor into standby after ten minutes of idle time and to put the PC into standby after 30 minutes of idle time.

After two additional weeks of real-time metering, we examined the energy use of the two groups. We discovered that significant energy savings can be realized with little to no cost of soft controls. Those employees who were provided energy and cost information reduced their energy usage by more than twice the reduction of employees who installed power management software but were not provided with energy usage information. Results are shown in Figure 3.

Building on these results, we have begun a second phase of this PoC on a much larger scale: We are involving about 1,000

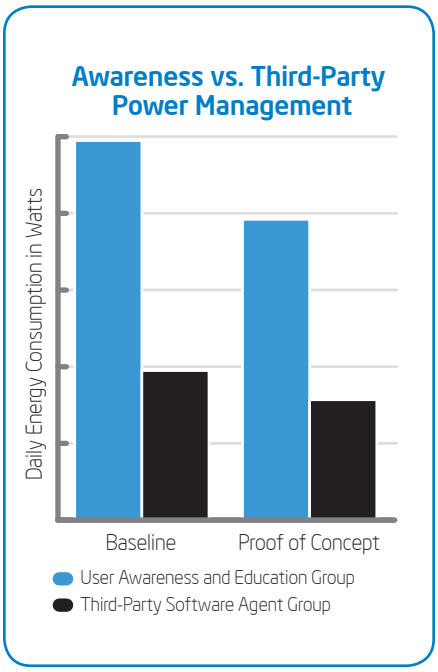

Figure 3. Raising user awareness of energy use and cost can be more effective at reducing energy consumption than third-party power management software.

6 See www3.intel.com/cd/channel/reseller/asmo-na/eng/403012.htm.

users, and the second phase will not be subject to the limiting time constraints that characterized the first phase. During this second phase, we will focus on user awareness and enforced energy profile settings. We are also building a real-time energy-awareness user interface that PoC participants will be able to access with Web browsers, as well as view on large screens in the building's lobby and cafeteria.

We hope to continue to raise employee awareness of office energy consumption through internal communications, including e-mails, white papers, corporate newsletter articles, and social media such as blogs. We also hope that by increasing awareness of energy saving opportunities in the office, this awareness may extend to other areas such as at home.

NEXT STEPS

We face several challenges as we develop our plans for continuing to reduce energy use in the office. Some of these challenges are process-related; others are more technical in nature. We will continue prioritizing ideas, planning PoCs and pilot projects, and measuring the effects of different approaches.

Determining Focus Areas

Determining where to focus our attention and getting accurate data to support our decisions can be challenging. Enterprise-wide office-environment power consumption data is not typically available; therefore, potential reductions are all estimates based on internal and external power usage studies and best-known methods (BKMs).

As part of our effort to engage employees and increase awareness, we use social media to solicit energy saving ideas. We weigh each idea for its merits to determine whether it might be a potential area of focus. Some suggestions may have a measurable impact, but the impact is too small to be a primary focus area. For example, the power consumption difference between standby mode and hibernate mode is too small to warrant attention. The same is true for devices consuming power when not in use, also known as "vampire loads." The cost of deploying an automated control to power down these devices when they are not in use would far outweigh any realized energy savings. Employee awareness and individual actions may be more effective.

Other suggestions are currently a matter of debate and would require significant further investigation to determine the right course of action. For example, is it more sustainable to run a laptop on battery power—and thus not use AC power—until the battery needs charging? Or is it better to keep the battery charged throughout the day by keeping the laptop plugged in?

Even when we know what we want to focus on, such as energy efficient power schemes, we haven't simply forced users to change. We have taken a voluntary adoption approach for changing the power management settings on existing PCs, because we have no way of knowing if specific settings have been chosen for business need and we don't want to risk interfering with those requirements on existing systems.

We are tracking and analyzing our progress in meeting our CO_2 reduction goals for the office environment, and we are also looking for and acting on ways to improve. Ideas we are considering include:

- **Enforced power management.** Our previous study efforts, discussed earlier in this paper, indicate enforced power management has significant potential for reducing energy use in the office; we will continue to look at this capability and consider it for use in the future, at least for certain segments of users.
- **Automatically scheduled standby and wake-up.** Widespread use of laptop PCs at Intel is already contributing to our sustainability efforts by enabling employees to work remotely. We are evaluating using the secure out-of-band capability in Intel vPro technology, along with other third-party power management tools, to automatically—and securely—power targeted groups of PCs on and off.

Addressing User Acceptance Issues

Sometimes we run into user resistance in our efforts to reduce PC power consumption. For example, the use of standby mode, also known as sleep, on laptops and desktops can provide a dramatic power reduction. However, Intel employees sometimes resist using it because they are reluctant to wait for their laptops to power up again, and some have experienced technical issues with standby mode in the past.

Mixed with this specific reluctance is a resistance to change in general. Based on the results from our PoCs, we believe that a major contributor to these user acceptance issues is the lack of user awareness about power usage and costs, and that more education and communication between Intel IT and office employees can help overcome these resistance points.

CONCLUSION

To be a leader in sustainable IT practices, we must continue to focus on all power efficiency opportunities. Office energy use is an important part of our IT sustainability strategy for reducing our overall IT CO_2 footprint. Although energy use in the office offers smaller savings per machine than is seen in data centers, it is spread over a wider base, and small things really do add up.

By using the most power-efficient equipment available and implementing power management, Intel IT can realize significant power savings in the office environment, relative to current energy consumption. However, the potential power savings and CO_2 reduction is dependent on the adoption rate of these new technologies. Raising employee awareness of how much energy is consumed in the office environment is a significant part of our overall reduction effort. By giving all employees a way to make an impact on IT sustainability, we can achieve our goals.

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ACRONYMS

ACPI	Advanced Configuration and Power Interface
BKM	best-known method
CO_2	carbon
CRT	cathode-ray tube
HDD	hard disk drive
ICT	information and communications technology
LCD	liquid crystal display
PoC	proof of concept
SSD	solid-state drive
WoL	Wake on LAN

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