Revisiting Energy Savings from PC Power Management Software

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ABSTRACT

In August 2008, Puget Sound Energy (PSE) implemented a personal computer power management (PCPM) incentive program to encourage managers at school district buildings, institutional facilities, and commercial buildings throughout its service territory to install software on their users' desktop computers to manage power settings and save energy. The Regional Technical Forum provisionally deemed desktop savings at 148 kWh per workstation (computer and monitor) per year, a value based on data collected in 2008. With the new ENERGY STAR® specifications that went into effect in 2009 and because technology evolves quickly, PSE asked The Cadmus Group to meter computers with and without PCPM software to determine a new deemed savings value. We metered computers from PSE program participants and from similar nonparticipants within PSE's service territory for two to three weeks. Our study found savings of 135 kWh per workstation per year.

Introduction

Personal computer power management (PCPM) software offers energy savings on computer networks. The software automatically puts computers and monitors into a low power mode when not in use, thereby reducing energy consumption while still allowing software updates. Without PCPM software, information technology (IT) personnel have limited control over computer sleep and low-power mode settings. Free software solutions are available (such as EZ GPO through ENERGY STAR®), as are turnkey commercial software products that package the activation of sleep settings with the ability to wake computers for updates. In addition, commercial solutions frequently include computer use monitoring, provide savings estimates, and define computers as "inactive" more often, generally leading to more frequent sleep mode activations. Finally, commercial solutions introduce one or more power levels between on and off. In each successive level, more hardware devices are slowed or turned off.[1]

PSE Program Status

In August 2008, Puget Sound Energy (PSE) began offering rebates for the purchase, installation, and configuration of commercial PCPM software by the customer's IT department. The rebate program targets PSE customers with a large number of personal desktop computers. Currently, laptop computers are not eligible for the rebate since they use less energy than desktops, and do not offer the same savings potential, especially if taken off-site in evenings and weekends.[2] Rebates are paid up to $8.00 per license, not to exceed 100 percent of the software cost.

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[1] An overview of commercially available software packages can be found on the ENERGY STAR Website: http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_comm_packages

[2] The average standard desktop computer uses 69 W in active mode, while a standard laptop computer uses 21 W in active mode. These values were derived from the ENERGY STAR power management calculator, downloaded June 21, 2010:

Program participants have mainly been school districts and state and local governments, along with a few commercial customers. Table 1 shows that 21 customers, most with multiple facilities, have participated in the program since 2008. These 21 customers installed PCPM on more than 24,000 desktop computers. In 2007, the Regional Technical Forum (RTF), an advisory committee in the Pacific Northwest which develops standards to verify and evaluate conservation savings, approved deemed annual savings of 170 kWh per workstation with PCPM installed (Northwest Power and Conservation Council, 2010). The program's claimed savings, based on 170 kWh per workstation, are just over four million kWh per year.[3]

Table 1. Overview of Program Participation Through August 2010

Year	Number of Unique Customers	Number of Unique Facilities	Number of Computers	Claimed Annual kWh Savings
2009*	13	163	15,900	2,703,000
2010*	8	42	8,181	1,390,770
Total	**21**	**205**	**24,081**	**4,093,770**

* These numbers reflect all the rebates PSE paid in 2009. The 2010 data include rebates they paid through August.

Overall, educational facilities (school districts and community colleges) accounted for 58 percent of energy savings, and local and state government buildings accounted for 36 percent of the savings; all other commercial buildings accounted for the remaining six percent of savings. The program has largely targeted educational and government buildings, but recognizes the substantial potential in the commercial sector and plans to target those customers in future program years.

Energy Savings Background

In 2002, Lawrence Berkeley National Laboratory (LBNL) performed a study to measure annual energy savings from PCPM software (Lawrence Berkeley National Laboratory, 2002). Based on their study results, the RTF initially deemed PCPM software savings at 200 kWh per workstation (computer plus monitor) (Northwest Power and Conservation Council, 2005). The RTF revised these deemed savings downward in 2007, based on the same data, to 170 kWh (Northwest Power and Conservation Council, 2010). In May 2010, the RTF provisionally deemed savings at 148 kWh based on research conducted by Ecos Consulting for the Northwest Power and Conservation Council (Ecos Consulting, 2008).

Deemed savings were provisionally reduced to account for the market penetration of ENERGY STAR computers and monitors, and to avoid double counting savings from ENERGY STAR equipment. Double counting would occur if a customer installed both measures deemed by the RTF to generate savings: 1) upgraded to a new ENERGY STAR computer, and 2) installed PCPM software on a new ENERGY STAR computer.

The ENERGY STAR Version 5.0 Specification for Computers went into effect on July 1, 2009. To meet these specifications, an average qualified computer must use 46 watts (W) of power or less (ENERGY STAR, 2009). To meet the Version 4.0 Specification, which went into effect in July 2007, an average qualified computer must use 67 W of power or less (ENERGY STAR, 2007). Version 4.0 took effect after the LBNL study, but before the Ecos research, showing that as computers evolve, power draw decreases.

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http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_management.

[3] As of May 2010, the RTF provisionally reduced savings to 148 kWh per computer with PCPM software. The previous 170 kWh was used to calculate savings for this program.

This affects the potential overall savings, as differences between power required for the active, idle, standby, and off modes have decreased.

Program Evaluation Goals and Methodology

The main purpose of the evaluation was to calculate energy savings based on metered data and compare the result to the deemed savings value to determine its applicability to the new generation of computers. In addition to metering the energy consumption of computers, surveys were conducted about typical usage patterns at each metered facility. Survey questions included operating hours, seasonal use variation, IT computer and software purchasing policies, computer operating systems, and computer make, model, and vintage. Nonparticipants without PCPM software were also asked if any of their computers had free PCPM installed. The survey data were used to interpret the metered data and identify causes of outliers.

Metered Sample Characteristics

Computer power was metered at one-minute intervals, for two to three weeks, to calculate energy consumption. Monitors were not metered, as they already have activated power management, so energy savings from PCPM software would be minimal.[4] Table 2 shows the number of buildings per sector where meters were installed (educational, government, and commercial), and the number of computers metered and used in the analysis. In total, 314 desktop computers were metered: 162 at participant facilities with PCPM software installed and 152 at nonparticipant facilities without PCPM software. Note that only one government participant facility was metered.

Table 2. Metered Computers by Building Sector

Sector	Number of Participant Buildings	Participant Desktops	Number of Nonparticipant Buildings	Nonparticipant Desktops
Educational	6	110	2	56
Government	1	28	4	73
Commercial	2	24	3	23
Total	**9**	**162**	**9**	**152**

The sample consisted of computers used for various purposes including administratively, in student computer labs, and as standard office computers. Table 3 shows that the majority of computers used the Windows XP operating system, though some had Windows7, Windows Server 2008, and Windows Vista. Although Windows Server 2008 would not normally be considered a desktop operating system, these computers were located in a computer lab and were therefore included in the metering analysis.[5]

[4] RTF analysis of Ecos data found 18 kWh savings per year for monitors attached to computers with PCPM software.
[5] Generally, there were no correlations between the active/idle power status and the type of operating system, except for the four computers with Windows Vista–Enterprise, which drew significantly higher power, on average, than desktops with other operating systems. Processor speeds were also compared to the active/idle power status, and there was no correlation.

Table 3. Operating Systems on Metered Participant and Nonparticipant Computers

Operating System	Number of Participant Computers	Number of Nonparticipant Computers	Total Computers
Windows7	2	24	26
Windows Server 2008	0	8	8
Windows XP	160	110	270
Windows Vista	0	10	10

Metered Data Analysis

The purpose of energy management software is to reduce the amount of time a computer is in a high power state and to maximize the amount of time it is in a low power state. The energy consumption of a computer depends on the amount of power it uses in each state, as well as the amount of time it is in each power state. Therefore, the first step in analyzing metered data was to define the power used when the computer was in the following modes: active, idle, standby, and off. Definitions for each of these modes, derived from the ENERGY STAR 5.0 specification (ENERGY STAR, 2009), are as follows:

- Active State: The computer carries out useful work in response to: a) prior or concurrent user input; or b) prior or concurrent instruction over the network.
- Idle State: The operating system and other software have completed loading, a user profile has been created, the machine is not asleep, and activity is limited to basic applications the system starts by default.
- Sleep (Standby) Mode: A low power state the computer automatically enters after inactivity or by manual selection. A computer with sleep capability will quickly "wake" in response to network connections or user interface devices and transfer to active or idle state.
- Off Mode: Power consumption is at the lowest level, which cannot be switched off (influenced) by the user and which may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with manufacturer instructions.

Field engineers recorded the power draw from computers when turned off (off mode) and again in low power mode (standby). Metered data were analyzed to determine the power used when each computer was in an active state and an idle state. Computers were found to operate within approximately a 10 W range in active and idle states, making it difficult to distinguish between the two states. For this reason, they were combined into one category: active/idle.

It was assumed and confirmed that participant computers and nonparticipant computers operated within similar power ranges in each mode, since this measurement is related to the computer itself and is not affected by PCPM software (see Table 4). The average power measurements in each mode were very similar between participant and nonparticipant computers.

Table 4. Measurements of Participant and Nonparticipant Desktop Computer Power in Active/Idle, Standby, and Off Modes

Power State	Participants (n=162)			Nonparticipants (n=152)		
	Minimum Power (W)	**Maximum Power (W)**	**Mean Power (W)**	**Minimum Power (W)**	**Maximum Power (W)**	**Mean Power (W)**
Active/Idle	19.6	89.6	**57.4**	19.7*	146.1	**63.2**
Standby	0.8	9.0	**3.9**	0.8	9.2	**2.7**
Off	0.0	8.7	**2.3**	0.0	9.1	**1.7**

* The model number was used to verify that computers operating in the 20 W range were desktop units.

Ranges overlapped for measured power in standby and off modes, indicating that some computers used less power in standby mode than other computers used when turned off. However, the mean power in standby mode was higher than in off mode, as expected. Some computers also drew power when off; often referred to as a *phantom load*, this characteristic is typical of many different types of plug loads. Examination of these data showed that many computers were nearly indistinguishable between off and standby modes. Consequently, it was not possible to distinguish between standby and off modes or between active and idle states. Computers were therefore characterized as operating at a higher power (active or idle state) or at a lower power (standby or off mode).

ENERGY STAR Requirements

To meet the ENERGY STAR Version 4.0 Specification, a computer must use 67 W power on average in an active/idle state. To meet the Version 5.0 Specification, a computer must use 46 W power on average in an active/idle state. As shown in Figure 1, most computers in this study met ENERGY STAR Version 4.0 Specifications for power consumed in the active/idle state, and many met Version 5.0 Specifications. As previously discussed, the Version 4.0 Specification took effect after the LBNL study but before the Ecos research, which the RTF referenced in determining the provisionally deemed savings.

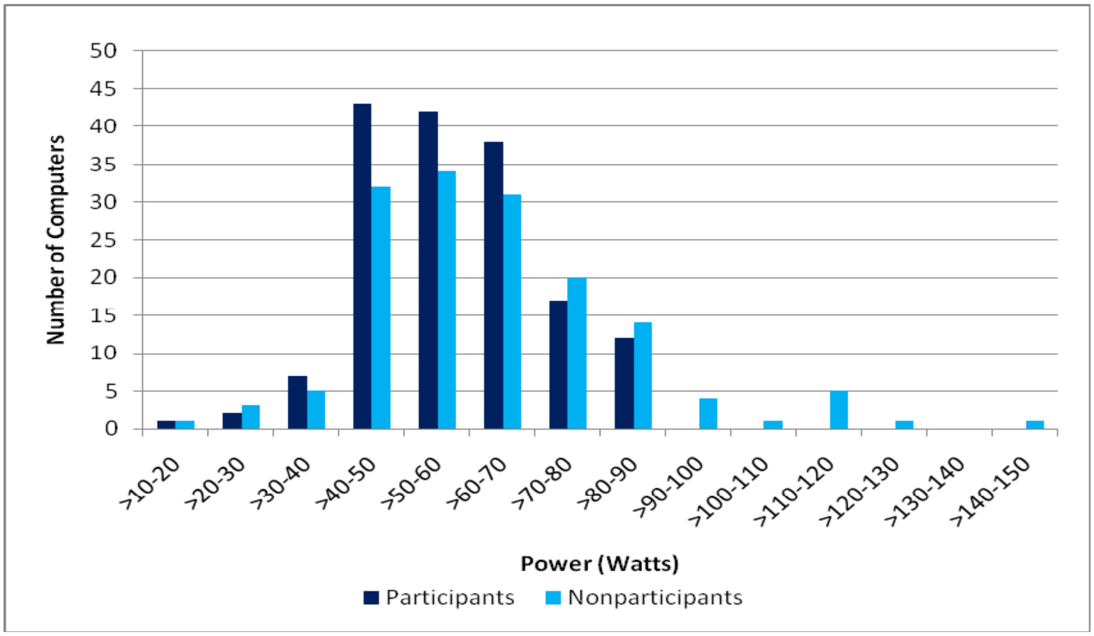

Figure 1. Distribution of Average Active/Idle Power Consumption for Participant and Nonparticipant Desktop Computers

Because the power measurements of participant and nonparticipant computers were similar, savings from power management software come directly from reducing the time spent in the active/idle state. Energy savings from PCPM were determined by comparing the energy consumption data of computers at participating facilities to the energy consumption data of computers at nonparticipating facilities.

Findings

Load shapes, the amount of time spent in an active/idle state on weekdays and weekends, and the difference in energy consumption between participant and nonparticipant computers were analyzed.

Load Shapes

Load shapes were created for desktop computers by averaging the power draw of each computer for each minute of all metered days. As weekdays and weekends often had different profiles, separate shapes were examined for each, as shown in Figure 2. The orange shaded lines represent participant desktop average usage for weekday and weekend usage. Blue lines represent nonparticipant computers, with the same shading pattern.

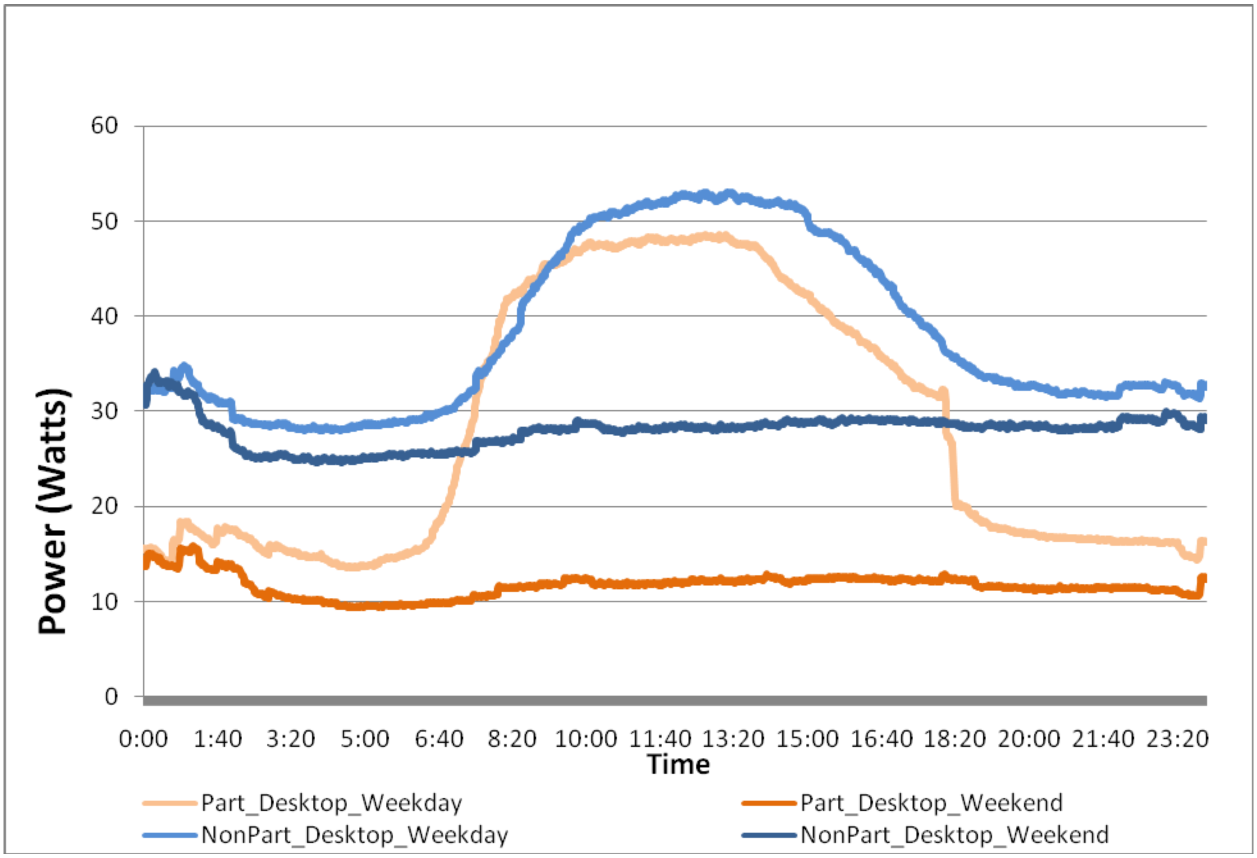

Figure 2. One-Minute Load Profiles of Desktop Computers

Participant computers clearly used significantly less power on weekends and weekday nights, suggesting that the PCPM software effectively put many computers into low power modes when not in use. Further, on average, participant computers drew slightly less power on weekdays, suggesting that the PCPM software also put computers into low power modes when not in use during operating hours.

Percent Time in Each State

Only one government participant building was metered, and, as shown in Figure 3, the PCPM software did not appear to be working; the computers were in an active/idle state for nearly the same percentage of time as nonparticipant site computers without PCPM. This site configured PCPM to only turn off monitors in some computers. Given this less aggressive PCPM approach, those computers were removed from the site. After that change, the average time the computers were in an active/idle state on weekdays lowered from 61 percent for all metered computers to 46 percent for computers with PCPM controlling more than monitors.

Commercial participant usage was also high, which may have resulted from long operating hours at two sites. The first was a hospital, where some computers with PCPM software appeared to be in use nearly 24 hours per day. The second was a commercial facility, where pre/post monitoring was conducted to examine usage changes. Metering equipment remained in place for three weeks before the PCPM software was installed, and these three weeks were used to establish baseline usage. Three weeks after the PCPM software installation, the meters were removed and the post-installation energy consumption data were analyzed, which was higher than expected. The site's operating hours were much longer than for a typical office, running from 5:00 a.m. to 11:00 p.m. during weekdays and on weekends. For comparison, the pre- and post-installation meter data were examined for a second site from the same company, which had business hours from 8:00 a.m. to 6:00 p.m., Monday through Friday (and was closed on the weekends). The PCPM software at the second site provided more than four times the savings at the first site, likely due to shorter operating hours and because computers at the first site were operating at higher active/idle powers.

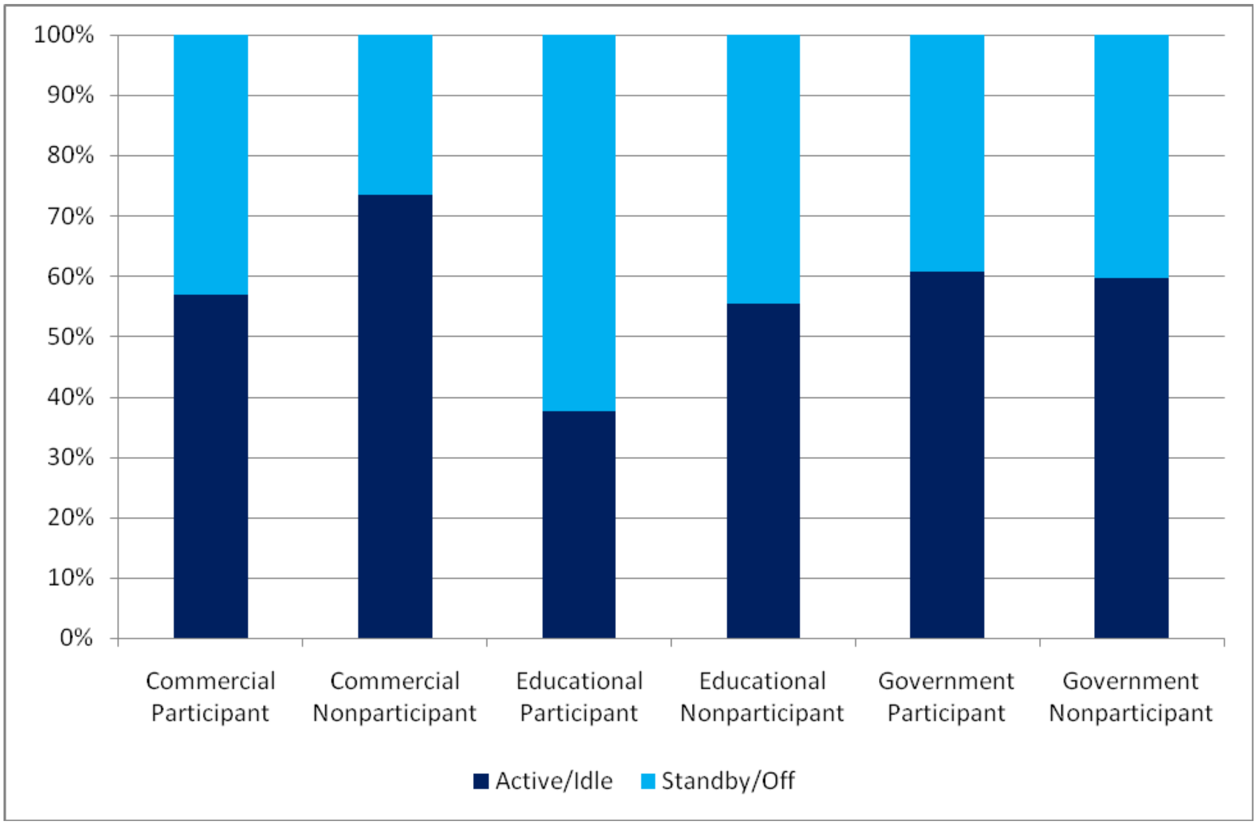

Figure 3. Percent of Time Desktop Computers are Active/Idle versus Standby/Off on Weekdays

As seen in Figure 3, commercial and educational buildings differed between participant and nonparticipant computers. This difference proved even more evident in the percent usage on weekends, shown in Figure 4. However, if PCPM software placed all participant computers into a low power mode when not in use, it is expected that they would be in a standby/off mode for the majority of those hours. They would be in active/idle state for less than 10 percent of the unoccupied hours, as Figure 4 shows for educational computers on weekends.

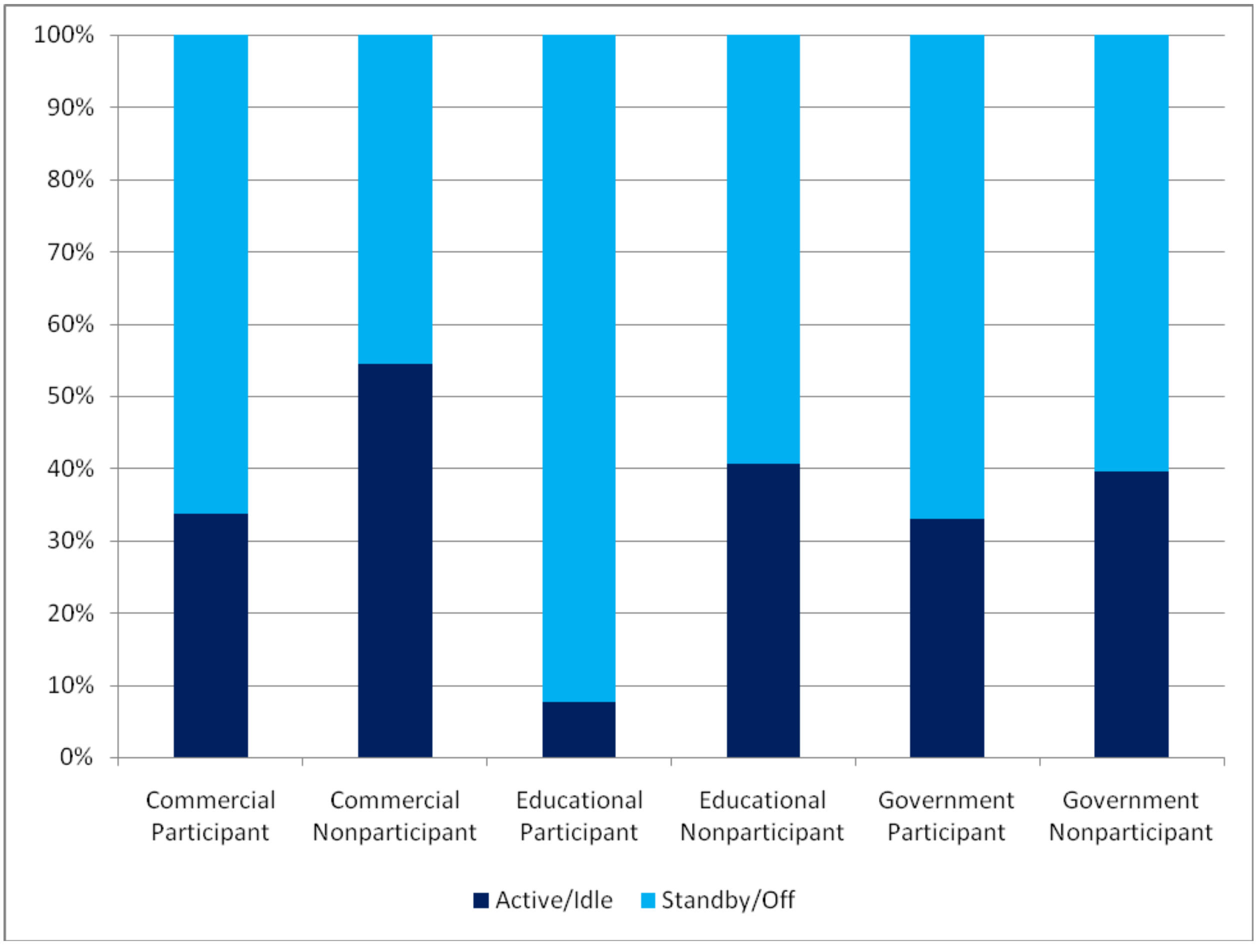

Figure 4. Percent of Time Desktop Computers are Active/Idle versus Standby/Off on Weekends

All participant and nonparticipant computer data were examined, as were the average percentages of time participant and nonparticipant computers went into standby/off mode during weekdays and weekends, as shown in Table 5. For common business hours of 8:00 a.m. to 6:00 p.m. weekdays, participant desktop computers remained in standby/off approximately 44 percent of the time, as compared to 34 percent for nonparticipant computers. On weekday nights, from 6:00 p.m. to 8:00 a.m., participant computers remained in standby/off 78 percent of the time, compared to 53 percent of the time for nonparticipant computers. On weekends, the differences were even greater—on average, almost all participant computers remained in standby/off modes, compared to slightly more than half of nonparticipant computers.

Table 5. Percent of Time Computers are in Standby/Off Mode Weekdays and Weekends

Time Period	Participant Desktops (n=162)	Nonparticipant Desktops (n=152)
8:00 a.m. to 6:00 p.m. weekdays	44%	34%
6:00 p.m. to 8:00 a.m. weekdays	78%	53%
Saturdays and Sundays	85%	55%

Energy Savings

Metered data were extrapolated to estimate annual energy savings. Peak demand savings were also estimated using the average power for participant and nonparticipant computers during PSE's peak load hours.

Annual Energy Savings. For each building type with desktop data, energy consumption was calculated for five weekdays plus two weekend days, and then summed to determine the total weekly energy consumed, as shown in Table 6. The government sector showed a relatively small difference between participants and nonparticipants, likely because only one participant building was metered (the same site discussed earlier, using less aggressive power saving settings). Savings were identical for educational and commercial buildings.

Table 6. Participant and Nonparticipant Desktop Weekly Energy Usage

	Participant Desktop Energy (kWh)			Nonparticipant Desktop Energy (kWh)			Annual Energy Savings (kWh)
Sector	**Weekday**	**Weekend**	**Weekly**	**Weekday**	**Weekend**	**Weekly**	
Educational	2.71	0.31	**3.02**	3.98	1.08	**5.06**	**113**
Government	4.69	1.04	**5.74**	4.85	1.27	**6.12**	**36**
Commercial	4.69	1.18	**5.87**	5.92	1.78	**7.70**	**113**

It was assumed that desktop computers, on average, were not in use for three weeks per year to compensate for vacation and sick days, and for an additional seven holidays, resulting in 48 weeks of annual usage. Nonparticipant computers were assumed to operate at the same power on vacations and holidays as on weekends. Applying this algorithm to the values shown in Table 6, the average annual savings were calculated as 117 kWh per computer, as shown in Table 7. When added to the RTF estimate of 18 kWh savings per monitor, resulting savings were 135 kWh per workstation (computer and monitor). These numbers may differ slightly for educational facilities, where some sites have summer breaks and many have computer labs. Savings were also examined by the general usage groups of office/administrative, computer lab, and IT, but no significant differences were found between the first two groups, and the third group did not provide a large enough sample to determine a difference.

Overall, average savings are higher than savings by sector, as average weekly usage differed for each sector. When participant and nonparticipant energy usage was calculated for each sector, savings were lower than when total average weekly energy usage was calculated across all sectors.

Table 7. Average Energy Usage by All Metered Desktop Computers

	Participant Desktop Energy (kWh)			Nonparticipant Desktop Energy (kWh)			Annual Energy Savings (kWh)
	Weekday	**Weekend**	**Weekly**	**Weekday**	**Weekend**	**Weekly**	
All Desktops	3.34	0.57	3.91	4.69	1.28	5.97	**117**

The average power and percentage of hours in standby/off and active/idle modes were also calculated for participants and nonparticipants, to allow for easy comparison between this study and the RTF's methodology. Table 8 presents the results, representative of one week (including both weekdays and weekends).

Table 8. Average Power and Percent of Hours per Week in Standby/Off versus Active/Idle Modes for Nonparticipants and Participants

	Mode	Average Power (W)	Nonparticipant Share of Hours (confidence /precision)	Participant Share of Hours (confidence /precision)
Overall	Standby/Off	2.0	45% (90/10)	64% (95/10)
	Active/Idle	60.2	55% (90/10)	36% (95/10)

Conclusions

The RTF provisionally deemed savings for desktops were 148 kWh per workstation (computer and monitor), with 130 kWh savings per computer and 18 kWh per monitor. This study found savings of 117 kWh per desktop computer. When added to the RTF estimate for monitors, slightly higher savings of 135 kWh per workstation resulted. Lower savings found in this study largely resulted from lower power consumption in the active/idle state for newer computers versus the higher power consumption of computers in use three to five years ago (but since discarded). Savings could also have been lower due to nonparticipants using Microsoft Group Settings and configuring sleep settings.

Additional Opportunities

Metered data analysis showed the average power for computers in standby/off modes fell between 2 W and 3 W. Although most participant computers operated in a low power mode at nighttime and on weekends, some computers rarely, if ever, operated in these modes. Some of these may be IT computers, required to operate all night, or may be located in computer labs with nighttime usage. Computers should not be in active/idle states when they are not in use. An opportunity exists to realize additional savings by adjusting the settings on computers rarely in low power modes. In addition, IT administrators could be encouraged to implement more aggressive settings for computers not in use on weekends and overnight.

PCPM software may be able to further reduce evening and weekend usage, as participant computers still drew an average of 10 W on weekends. If all computers were in standby/off modes, the average power would be less than 5 W. Nonparticipant computers may also realize savings during those same time frames, as they used 25 W to 30 W throughout weekends. Seven participant computers and 26 nonparticipant computers remained in active/idle modes 100 percent of the time, and 38 nonparticipant computers remained in active/idle modes more than 85 percent of the time, showing further savings opportunities.

There may be an opportunity for additional savings during the 22 percent of weeknight times and 15 percent of weekend times participant computers were not in standby/off modes. There also may be an opportunity for weeknight and weekend savings, when just over half of nonparticipant computers were not in standby/off modes.

Additional education may help participants fully realize their potential savings from PCPM software. Utilities may consider requiring each participant site to send the actual savings report from the PCPM software one month following installation. This would provide two benefits. First, it would encourage site staff to examine their systems' performance. If a report shows PCPM not working on some computers, system administrator can troubleshoot the problems. If sites begin troubleshooting PCPM software issues, they should be able to increase rates of idle/sleep modes, resulting in higher program energy savings. Second, a utility could amass data on all computers in the program and examine PCPM software success rates in future installations.

Sites with longer operating hours will have lower savings because fewer hours are available in which they could be in lower power modes. Building types with hours typical of a normal office could be targeted, with a lower emphasis placed on recruiting businesses with longer weekday operating hours or that are often occupied during weekends (such as call centers). In addition, many companies do not have a policy for turning off their computers, resulting in many computers always staying on. Those sites could be strong candidates for the PCPM software, and would likely realize above-average savings.

Another option for encouraging participation would be to offer free solutions, which often address specific power management elements and are usually not as comprehensive as purchased software.

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