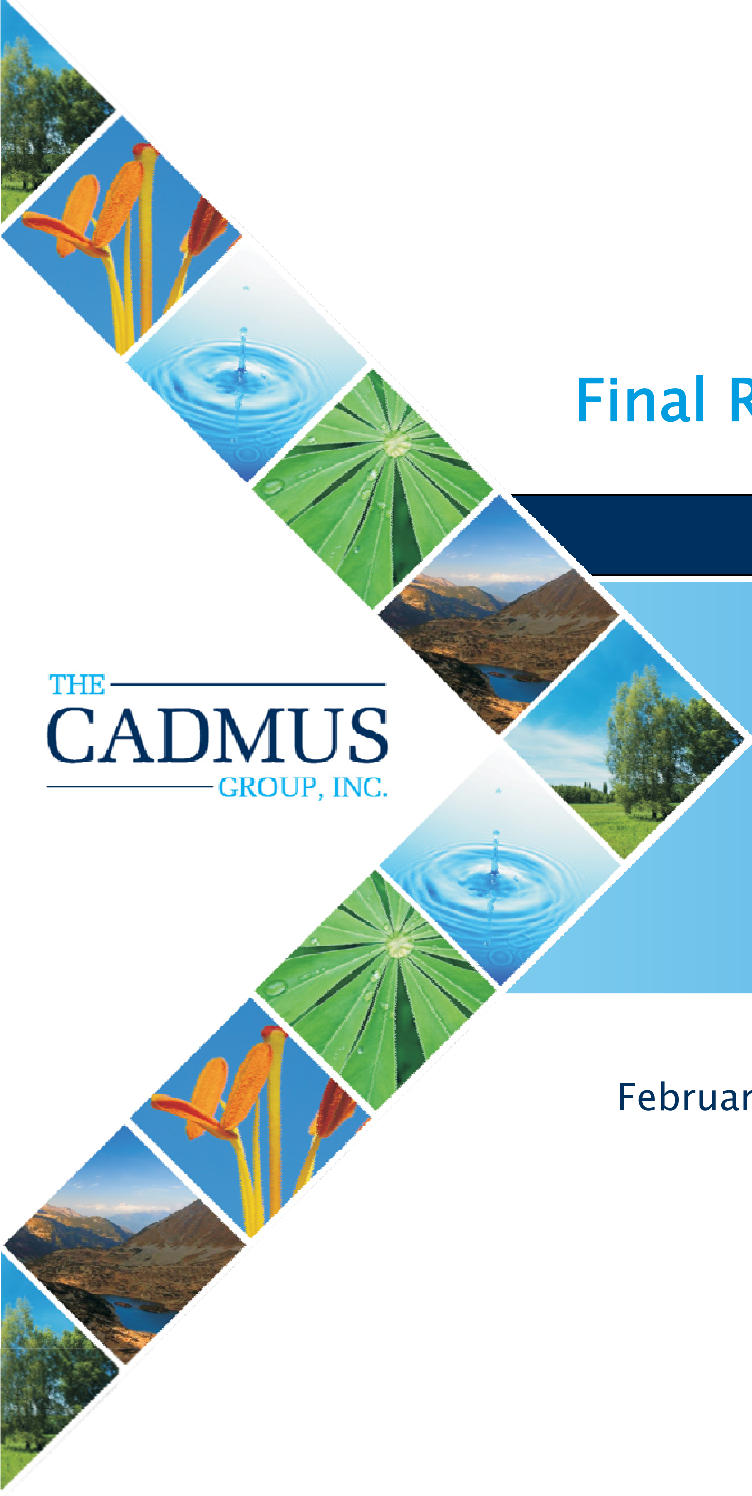
2011 PC Power Management Evaluation Documents

Contents:

- **2011 PC Power Management Evaluation**
- **Evaluation Report Response**

This document contains both the final **2011 PC Power Management Evaluation** and the Puget Sound Energy (PSE) **Evaluation Report Response** (ERR) to this evaluation. PSE program managers are required to complete an ERR upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation.



Final Report

Puget Sound Energy PC Power Management Rebate Program: Impact Evaluation Results

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Executive Summary

In August 2008, Puget Sound Energy (PSE) implemented a personal computer power management (PCPM) incentive program, encouraging school district buildings, institutional facilities, and commercial buildings throughout its service territory to install software on their desktop computers to manage power settings and save energy. PSE hired The Cadmus Group, Inc., (Cadmus) to conduct an evaluation with the following goals:

- Collect information from program participants as to their satisfaction with the program and software.
- Quantify PCPM software energy savings by monitoring a sample of desktop computers with and without PCPM software installed.
- Monitor laptop computers to determine whether PSE should offer an incentive for PCPM software installed on laptops.

Program and Software Satisfaction

In general, program participants have been satisfied with both the power management software they installed and the PSE incentive program. Sixteen of 22 participants reported being satisfied or extremely satisfied with the software, and 19 of 22 reported being satisfied or extremely satisfied with the PSE incentive program. Additionally, 18 of 22 respondents did not notice a difference in PC performance with or without power management software installed, indicating the software did not affect day-to-day work. One respondent even stated computers with power management software perform better than those without, likely due to anti-virus and pop-up blocker features. Only one respondent reported displeasure with the software, stating nearly 25 percent of the facility's computers were unusable because of the software; they were working with the vendor to solve these issues.

Program Energy and Peak Demand Savings

Since 2009, the program has provided incentives for installing PCPM software on more than 24,000 desktop computers. Cadmus' analysis found 128 kWh savings per workstation (computer and monitor), resulting in total validated program savings of over 3,000 MWh.

PSE's peak load occurs from 7:00 a.m. to 9:00 a.m. in the winter and from 6:00 p.m. to 8:00 p.m. on weekdays. For metered computers in this study, we found no morning peak demand reduction, but we did determine a 15 W per computer reduction during the evening peak, resulting in 361 kW peak demand reduction for the program. Table 1 summarizes the program's total validated energy and peak demand reduction.

Table 1. Validated Annual Energy Savings and Peak Demand Savings

Year	Number of Computers	Validated Annual kWh Savings	Validated Peak Demand Reduction (kW)
2009*	15,900	2,035,200	238
2010*	8,181	1,047,168	123
Total	24,081	3,082,368	361

*PSE paid the first rebates in 2009. The 2010 data include rebates paid through August.

Freeridership and Spillover

Participants were asked a series of questions about how influential PSE's rebate was in their decision to purchase power management software. The questions were designed to: quantify freeriders—participants who would have installed the measure without the rebate. Questions were also designed to assess spillover, where participants installed additional measures without receiving rebates. Scoring participants based on their response to three questions, Cadmus found program freeridership at 40 percent.

Program participants were also asked whether they had installed PCPM software on additional computers without receiving a rebate. Nine of 22 participants installed power management software on PCs without receiving the PSE rebate, accounting for nearly 25,000 additional installations and slightly less than 3,200,000 kWh in energy savings. Eight of 20 participants with laptops also installed power management software on their laptops, resulting in slightly fewer than 2,000 laptop installations and nearly 124,000 kWh in energy savings.

Comparing Energy Savings Results to the RTF Deemed Savings

The Regional Technical Forum (RTF) provisionally deemed desktop savings at 148 kWh per workstation (computer and monitor) in May 2010. The RTF calculated PCPM saved 11 kWh per monitor. Our study found savings of 117 kWh per desktop computer. When added to RTF's estimate of 11 kWh savings per monitor, this resulted in 128 kWh savings per workstation, which is slightly higher than the RTF estimate. The RTF also estimated savings for laptops at 64 kWh per computer. We estimated savings for laptops at 62 kWh per computer.

Laptops

Based on metered data, Cadmus estimated PCPM software installed on networked laptops not taken offsite would save 62 kWh per computer per year. This was roughly half as much as savings seen from installing PCPM software on desktop computers, due to the lower power draw required for laptops in the active/idle state. Because Cadmus found large spillover in the program, we recommend PSE not extend the rebate to laptop computers, as it appears program participants are purchasing additional licenses on their own.

Additional Opportunities for Savings

Additional savings could be realized by "curing insomnia" on computers not entering a standby/off mode during nights and weekends. Some participant computers rarely, if ever, were found in standby/off mode. Although some of these computers may have been used during nighttime and weekend hours, computers not in use should not remain in active/idle states during that time. Program participants should be encouraged to review software reports, either identifying computers where software does not operate correctly and troubleshoot the problem, or consider more aggressive settings for computers not in use on weekends and nighttimes. One way PSE could encourage sites to regularly review PCPM software reports would be to request the software report one month its installation.

Sites with longer operating hours have lower savings because computers normally are used more than at other sites; therefore, fewer hours are available when they could be in a lower power mode. PSE may want to consider targeting building types with hours typical of a normal office, focusing less on recruiting businesses (such as call centers) with longer weekday operating hours or often occupied during weekends. Many companies also do not have a policy of turning off their computers, with many always left on. Those sites could be strong program great candidates and would likely realize above-average savings.

Another option for encouraging participation could be to consider some of the available free solutions, and examine whether PSE’s existing incentive structure could allow rebates for free solutions. Free solutions often address specific power management elements, and are usually not as comprehensive as purchased software; therefore, savings may not be as high, but the incentive structure could be adjusted to account for this.

Next Step

In March 2011, Cadmus will present this study’s results to the RTF. We will coordinate the presentation with Avista and Ecos, which are performing similar studies. The Bonneville Power Administration and the Northwest Power and Conservation Council have also been involved in analyzing Ecos data to update the RTF deemed savings number. Cadmus will work with all interested parties to collaborate on deemed savings recommendations for desktop computers with PCPM software.

1. Introduction

Personal computer power management (PCPM) software offers energy savings for customers with computer networks. The software automatically puts computers and monitors into a low power mode when they are not in use, thereby reducing energy consumption, while allowing software updates. In the software's absence, the IT department has limited control over computer sleep and low-power mode settings. Free software solutions are available (such as EZ GPO through ENERGY STAR®), as are commercial software options. Commercial products offer turnkey solutions, packaging sleep activation settings with that can wake computers at night for updates. In addition, commercial solutions often offer computer use monitoring, and provide accurate savings estimates. Commercial software solutions also define computer "inactivity" more broadly, 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]

In August 2008, Puget Sound Energy (PSE) began offering rebates for commercial PCPM software purchased, installed, and configured by PSE's customer 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 as they use less energy than desktops, and do not offer the same savings potential if taken off-site in evenings and weekends.[2] Rebates pay up to $8.00 per license, not to exceed 100 percent of the software cost.

Program Status

Program participants largely have been school districts and state and local governments, along with a few commercial customers. Table 2 shows 22 customers, most with multiple facilities, participating in the program since 2008. These facilities installed PCPM on over 24,000 desktop computers. In 2007, the Regional Technical Forum (RTF), an advisory committee in the Pacific Northwest developing standards to verify and evaluate conservation savings, approved deemed savings of 170 kWh per workstation[3] with PCPM installed The program's claimed savings, based on this number, have been just over 4 million kWh per year.[4]

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[1] An overview of commercially available software packages can be found on the ENERGY STAR Web site. ENERGY STAR®, Activating Power Management: Commercial Software Packages: http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_comm_packages

[2] The average standard desktop computer uses 69 Watts in active mode, while a standard laptop computer uses 21 Watts in active mode. These values have been derived from the most recent ENERGY STAR power management calculator. Downloaded June 21, 2010. http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_management

[3] Northwest Power and Conservation Council. Sixth Northwest Electric Power and Conservation Plan. http://www.nwcouncil.org/energy/powerplan/6/default.htm

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

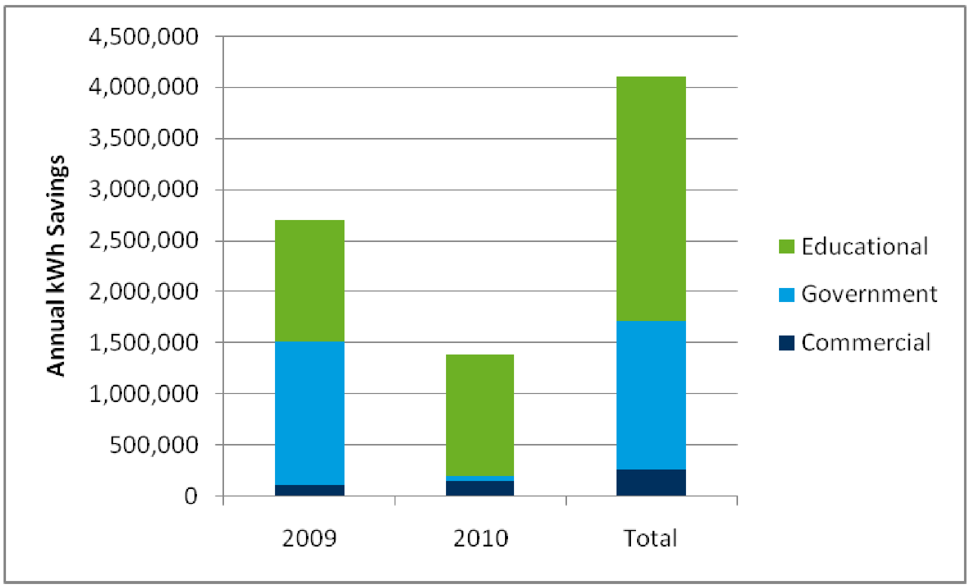
Table 2. Overview of Program Participation through August 2010

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	206	24,081	4,093,770

*PSE paid the first rebates in 2009. The 2010 data include rebates paid through August.

Figure 1 shows annual energy savings per year, by customer segment. Most savings (66 percent) occurred from projects rebated in 2009. Overall, school districts and community colleges (educational) accounted for 58 percent of energy savings; local and state government (government) buildings accounted for 36 percent of the savings; and all other commercial buildings accounted for 6 percent. The program largely has targeted educational and government buildings, but recognizes substantial potential exists in the commercial sector, and plans to target those customers moving forward.

Figure 1. Annual and Overall Energy Savings Achieved by Customer Segment



Energy Savings Background

In 2002, Lawrence Berkeley National Laboratory (LBNL) performed a study to measure energy savings from PCPM software.[5] Based on this study's results, the RTF initially deemed PCPM software savings to be 200 kWh per workstation (computer plus monitor).[6] Deemed savings were

[5] Lawrence Berkeley National Laboratory. *Energy Use and Power Levels in New Monitors and Personal Computers*, July 2002. Downloaded from http://enduse.lbl.gov/info/LBNL-48581.pdf

[6] Northwest Power and Conservation Council. Fifth Northwest Electric Power and Conservation Plan. http://www.nwcouncil.org/energy/powerplan/5/Default.htm

revised downward, based on the same data, to 170 kWh in 2007.[7] In May 2010, the RTF provisionally deemed savings at 148 kWh, based on study results by Ecos Consulting in 2006.[8] Deemed savings were provisionally reduced to account for 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: 1) upgrade to a new ENERGY STAR® computer; and 2) installed PCPM software on the new ENERGY STAR® computer. Table 3 provides an overview of energy savings resulting from previous PCPM software studies. Note: some studies targeted specific sectors or tested only one software vendor, which could explain some variability in the numbers.

Table 3. Overview of Energy Savings from Different Studies

Source	Year of Study	Energy Savings (kWh)	Notes
Lawrence Berkeley National Laboratory (LBNL)	2002	200 or 170	Savings were calculated by the RTF, based on LBNL data. RTF changed deemed savings to 170 kWh in 2007.
Northwest Energy Efficiency Alliance (NEEA)	2002	200	Tested Verdiem Surveyor software.
Southern California Edison (SCE)	2005	330	Tested Verdiem Surveyor software.
Ecos Consulting	2008	148	Savings were calculated by RTF in 2010, based on data collected by Ecos.
ENERGY STAR® calculator	2009	337	Result with all default settings, except the percentage of time computers were turned off was changed to 36%. Savings calculations were based on LBNL data.

Computer features and operating system features constantly change, warranting a new metering study on PCPM software savings as part of the evaluation of the PSE rebate program. Unlike Windows XP, Power Management in Windows Vista and Windows 7 can be controlled at the machine level, rather than be user based. This means any settings changed, whether by the user or through Group Policy will be applied to the system regardless of who logs in.[9] Microsoft reported Windows 7 would use as much as 30 percent less energy than a similar computer running Windows XP.[10]

Additionally, ENERGY STAR® Version 5.0 Specification for Computers, in effect since July 2009, has power management requirements.[11] As part of this evaluation, Cadmus metered desktop computers' energy consumption with and without PCPM software to validate PSE program savings and to compare with the RTF's provisionally deemed energy savings value. The

[7] Northwest Power and Conservation Council. Sixth Northwest Electric Power and Conservation Plan. http://www.nwcouncil.org/energy/powerplan/6/default.htm

[8] Ecos Consulting study for the Northwest Power and Conservation Council. See the file named "Deemed Measure Detailed Reviews" on the Council's Web site: http://www.nwcouncil.org/energy/rtf/subcommittees/deemed/Default.htm

[9] http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_enterprises_winVista

[10] http://www.businessgreen.com/bg/news/1803193/exclusive-microsoft-windows-energy-savings

[11] http://www.energystar.gov/index.cfm?c=revisions.computer_spec

previous version of the ENERGY STAR® specification, Version 4.0, went into effect in July 2007, which was after the LBNL and SCE studies, but before the Ecos work.[12] Version 3.0 applied from July 200 through July 2007, and concentrated solely on low-power sleep modes. Version 4.0 and 5.0 were more comprehensive, addressing power consumption during active modes as well as power supply efficiency.

Evaluation Goals

The PSE PCPM rebate program evaluation had the following goals:

1. Measure energy use of nonparticipant and participant computers, and use these data to quantify the program's energy savings. Calculated energy savings were compared to energy savings estimated by the PCPM software and to the RTF-deemed savings value.
2. Assess program satisfaction through participant surveys, and, if necessary, make recommendations for improving program satisfaction.
3. Determine how to tailor the PCPM rebate, based on IT policies, processes, and purchasing patterns reported by participants and nonparticipants.
4. Recommend whether PSE should include incentives for PCPM installed on laptop computers, based on measured energy use of laptops without PCPM installed.

Organization of Report

This report is organized into five chapters:

- Chapter 1 is this introduction.
- Chapter 2 discusses the evaluation methodology and sample sizes for customer surveys and computer energy usage metering.
- Chapter 3 discusses survey results.
- Chapter 4 summarizes metered data results, including the program's validated energy savings.
- Chapter 5 presents conclusions and recommendations drawn from the evaluation activities.

[12] http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Computer_Spec_Final.pdf

2. Measurement and Verification Methodology

For evaluating the PCPM rebate program, Cadmus conducted two main activities:

1. Surveys of program participants and nonparticipants; and
2. Monitoring energy consumption for a sample of desktop and laptop computers at participating and nonparticipating facilities.

This section discusses the survey methodology, computer energy consumption monitoring, and metered data analysis.

Surveys

Cadmus conducted phone interviews with program participants and nonparticipants to:

1. Gather data about computer usage;
2. Collect data about IT policies and processes;
3. Assess program satisfaction, freeridership, and spillover; and
4. Recruit facilities for metering.

Freeriders are participants who would have installed the measure even without the rebate. Spillover measures are those program participants installed without receiving a rebate. Survey instruments we developed for participants and nonparticipants were approved by PSE. Appendix A and Appendix B contain participant survey instruments; Appendix D and Appendix E contain nonparticipant survey instruments. We interviewed a representative from each of the 22 participating customers. PSE also provided a list of nonparticipants from the same three customer segments (school districts and community colleges, local and state government customers, and commercial customers), and we interviewed representatives from 16 of 19 nonparticipants from that list (see Table 4). Five nonparticipants installed commercial PCPM software without receiving PSE rebates. One nonparticipant installed a free PCPM software package.

Table 4. Survey Disposition

Sample Group		Target Sample	Actual Sample
Participants	Educational	10	10
	Government	8	8
	Commercial	4	4
	Total	22	22
Nonparticipants	Educational	10	8
	Government	7	6
	Commercial	2	2
	Total	19	16

To examine differences in computer equipment and operation, Cadmus asked participants and nonparticipants some of the same.

The participant survey captured the following information:

- Commitment to power management software;
- Participation drivers (incentive analysis, spillover, freeridership);
- Pre-implementation power policies;
- IT computer and software purchasing policies;
- Typical computer configurations (software and hardware);
- Percentage of staff typically in the office at any given time; and
- Satisfaction with PCPM software.

Nonparticipants were asked about:

- IT computer and software purchasing policies;
- Typical computer configurations; and
- Adoption barriers.

We also asked whether nonparticipants implemented any other energy-savings measures. Those with PCPM software already installed were asked why they did not participate in PSE's rebate program.

Both participants and nonparticipants were asked computer configuration questions, collecting the following information relevant to energy use:

- Number of on-site desktops and laptops;
- Seasonal use variation (especially for schools);
- Time of use averages, time of use ranges, and whether different building areas had different usage profiles;
- Percentage of laptops remaining networked at night versus those taken off-site or unplugged during unoccupied hours;
- Percentage of computers remaining on at night;
- Computer operating systems (e.g., Windows 7 has some built-in efficiency measures);
- Patching policies and normal time-of-day to push updates;
- Use of remote desktops; and
- Use of wake-on LANs, allowing computers to be awakened using a network message.

During the survey, we recruited facilities for computer energy consumption metering. All participant buildings were eligible for site visits, but nonparticipant buildings were screened on two criteria:

1. Whether they primarily used desktop computers or laptops; and
2. Whether they already had PCPM software installed on their computers.

As the study focused on measuring savings from PCPM software installed on desktop computers, nonparticipant sites mainly using laptops were excluded. Nonparticipant customers were used to estimate baseline energy usage; so those with PCPM already installed were also excluded from the metering sample.

A comprehensive IT representative interview was completed during the site visit to validate computer configuration data collected during the preliminary interview, and to collect IT policies and practices for that particular site.

Figure 2 and Figure 3 show flow diagrams for the nonparticipant and participant metering recruitment process.

Figure 2. Nonparticipant Recruitment Flow Diagram

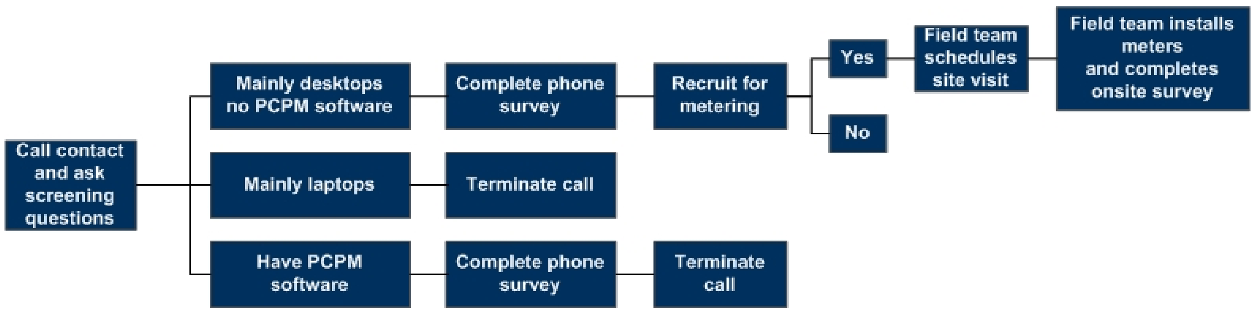
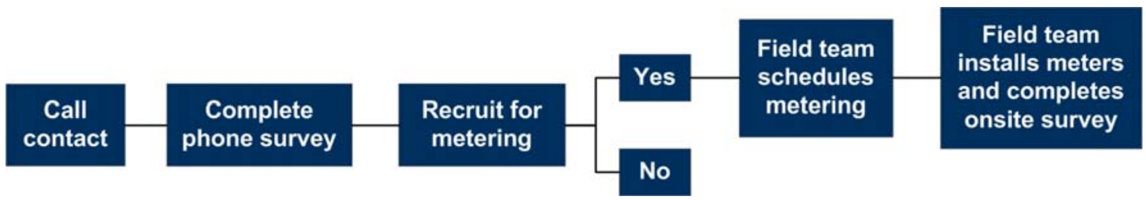


Figure 3. Participant Recruitment Flow Diagram



Survey Data Analysis

Cadmus compiled survey responses into two Excel workbooks: one for participants, and another for nonparticipants. Responses were then binned appropriately. For multiple-choice questions, responses were binned based on respondents' answers. For open-ended questions, Cadmus looked for answers' common themes, using those themes as bins.

Cadmus split the nonparticipant sample into "Nonparticipant—Without Software" and "Nonparticipant—With Software." This reflected several nonparticipant respondents installing PCPM software independently, without participating in PSE's program, and separately analyzed these groups. Six of 16 nonparticipant respondents installed some form of PCPM software, including one metered nonparticipant using the free ENERGY STAR® EZ GPO tool.

On-site survey data were combined with data collected from phone surveys to provide a more comprehensive view of energy use at metered facilities. The on-site survey included several questions not included on the phone survey, but it also had portions that overlapped with the phone survey. This was designed to capture site-specific information for explaining potential energy usage differences between two metered sites from the same customer (e.g., different schools within the same school district). As overlapping on-site questions had already been answered by phone survey respondents, Cadmus applied certain guidelines for evaluation of these answers. In cases where phone and on-site responses provided conflicting answers, on-site survey response was prioritized (this did not apply to questions the on-site respondent did not or could not answer). In cases where one customer granted two on-site surveys (from two separate respondents), when both on-site respondents were able to answer, these answers rarely disagreed. In one situation where a significant difference occurred between answers from two separate facilities, regarding numbers of computers set to go enter a sleep mode after a period of inactivity, a weighted average was calculated to allow answers to be combined as a single response, representative of both facilities.

Computer Energy Consumption Monitoring

Cadmus monitored computer energy consumption at participant and nonparticipant sites. This section details how we designed the sample and collected metered data.

Sample Size

The population included all participants and nonparticipants with whom we conducted phone surveys. From this population, we selected a sample of participant and nonparticipant computers for metering. The sample size depended on expected population distributions of parameters of interest, which included:

- Number of networked desktop and laptop computers.
- Typical computer usage groups at the sites (e.g., computer lab computers, administrative staff computers, IT staff computers, computers running high resource software) and numbers of computers within each group.
- Typical range in hours of use per computer usage group.

Statistical properties of these variables important for determining sample size included:

1. Expected population mean.
2. Standard deviation.
3. Coefficient of variation (CV).

As hours-of-use was the measurement with the greatest expected CV, this parameter drove sample size selection for achieving a given confidence and precision. We assumed a very large population to discount any finite population correction for the sample.

In determining which computers to meter, Cadmus followed a cluster sample design. We first selected buildings within each sector to visit from survey respondents agreeing to metering, and then chose specific computers to meter within each building, based on the usage group. Usage group information was collected during phone interviews, during metering recruitment.

The sample was stratified by schools, institutions, and commercial sectors, minimizing variance of the mean. Cadmus used PSE program data to determine computer allocations within each sector and to adjust sample sizes, based on total numbers of participating computers, as needed.

Sample sizes for each stratum *h* was given by:

$$n_h = n \frac{N_h S_h}{\sum N_h S_h}$$

Where n_h was the sample size in each stratum, n the overall sample size, N_h the number of units in the population in each stratum, and S_h the standard deviation of energy use in each stratum.

Table 5 shows total numbers of desktop computers targeted to achieve a sample size (*n*) needed to calculate mean energy (kWh) use, with margins of error of 10 percent at a 95 percent confidence interval, assuming a 50 percent coefficient of variance. This sample size was designed so direct comparison between participants and nonparticipants could be made for calculating energy savings. The sample size represented the number of desktop computers for metering. To achieve sample size goals, Cadmus expected to visit approximately 15 buildings, stratified among sectors, as previously described. We worked with PSE's project manager to identify nonparticipating customers who would allow us to meter their computers' energy use; actual metered computers were slightly less than our targets, as explained in Section 4.

Table 5. Estimated Desktop Computer Sample Sizes for Differences in Means Between Participant and Nonparticipants, 95/10 Confidence and Precision with a CV of 50 Percent

	Participants	Nonparticipants	All
Target Number of Computers	174	174	348
Actual Number of Computers*	162	152	314

*Meters were installed on 354 computers, but some data were deemed invalid, and those computers were removed from the actual sample count. Numbers in the table represent numbers of computers for which Cadmus received valid data.

PSE was also interested in monitoring laptop computer energy use. Currently, the PSE does incent laptops as they use approximately three times less energy[13] than desktops; so installing power management software was expected to result in much lower savings. However, estimated savings for laptops remains unknown; so PSE requested Cadmus meter laptops, and estimate potential energy savings from power management software. This information would inform PSE's decisions regarding addition of laptops to its program, and, if laptops were added, would help PSE determine appropriate incentive amounts.

Cadmus targeted up to 68 participant and 68 nonparticipant laptops from all buildings selected for desktop monitoring. This was based on a 90 percent confidence/10 percent precision, with a 50 percent CV, as shown in Table 6. The laptop metered sample was limited to networked laptops at each site selected for desktop metering. As laptops taken off networks at night, whether unplugged or removed from the site (e.g., taken home), were considered to have little to no savings potential, they were not metered. When recruiting for metering, Cadmus found very few customers left their computers networked at night and on weekends; therefore, we were not able to reach the maximum target sample size.

[13] The average standard desktop computer uses 69 Watts in active mode, while a standard laptop computer uses 21 Watts in active mode. These values come from the most recent ENERGY STAR power management calculator. Downloaded June 21, 2010. http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_management

Table 6. Estimated Laptop Sample Sizes for Difference in Means between Participants and Nonparticipants, 90/10 Confidence and Precision with a CV of 50 Percent

	Participants	Nonparticipants	All
Target	68	68	136
Actual*	13	35	48

*Meters were installed on a total of 64 computers, but some data were deemed invalid, and those computers were removed from the actual sample count. Numbers in the table represent computers for which Cadmus received valid data.

Site Visits and Meter Installation

Site visits had two goals:

1. Gather information on PCPM software performance at participant sites; and
2. Examine baseline computer settings and energy use in a group of nonparticipants without power management software installed.

Analyses of these data provided a better understanding of computer operating hours within different building types and usage groups, both for computers with and without power management software.

Cadmus used one Watts up? PRO or Watts up? .Net meter to record each computer's power at 1-minute intervals. Additionally, as Watts up? meters would not record time stamps, an Onset U12 meter was used to record time, and data were matched by the current measurement on each data-logger. Meters remained on computers for two to three weeks. As monitors would already have activated power management, energy savings from PCPM software installation would be minimal;[14] so we did not meter monitors.

Because building usage tended to vary by location (e.g., computer labs versus administrative offices), we used preliminary phone survey results to determine numbers of computers within each usage group for metering at each site.[15] During site visits, we gathered additional information on each monitored workstation, including:

- Computer make, model, and vintage.
- Processor speed.
- Sleep settings.
- Computer power use when turned off and in low-power, standby modes.

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[14] RTF analysis of ECOS data found less than 10 kWh savings per year for monitors attached to computers with PCPM software. See the file: "Deemed Measure Detailed Reviews" on the Northwest Power and Conservation Council's Website, http://www.nwcouncil.org/energy/rtf/subcommittees/deemed/Default.htm

[15] Survey results for average numbers of computers within each usage group can be found in Appendix C for participants and in Appendix E for nonparticipants.

Metered Data Analysis

The metered data analysis' overall goal was to calculate energy and peak demand savings by comparing participant and nonparticipant computer energy consumption profiles. Cadmus' methodology—used to quantify total energy usage for each computer during the metered period, extrapolated to average annual energy consumption, and to estimate energy savings—is outlined below for desktops and laptops.

Desktop Analysis

The first step in analyzing metered data was to define 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,[16] 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): A low-power state the computer can automatically enter after inactivity or by manual selection. A computer with sleep capability can quickly "wake" in response to network connections or user interface devices.
- Off Mode: Power consumption is at lowest level, which cannot be switched off (influenced) by the user, and may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with manufacturers' instructions.

Field engineers used Watts up? meters to record a computer's power draw when turned off (off mode) and again in low-power standby. It was assumed participant computers (Table 7) and nonparticipant computers (Table 8) operated within similar power ranges in each mode; this measurement was related to the computer itself and not affected by PCPM software. Data confirmed this, as indicated in Table 7, Table 8, and Table 9; the average instantaneous (spot) power measurements in each mode were very similar between nonparticipant and participant computers. For measured power in standby and off modes, ranges overlapped, meaning some computers used less power in standby than others did while off. However, mean power in standby was higher than in off, also 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.

[16] http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Version5.0_Computer_Spec.pdf

Table 7. Spot Measurements of Participant Desktop Computer Power in Standby and Off Modes

Participants n=162	Minimum Power (W)	Maximum Power (W)	Mean Power (W)
Standby	0.8	9.0	3.9
Off	0.0	8.7	2.3

Table 8. Spot Measurements of Nonparticipant Desktop Computer Power in Standby and Off Modes

Nonparticipants n=152	Minimum Power (W)	Maximum Power (W)	Mean Power (W)
Standby	0.8	9.2	2.7
Off	0.0	9.1	1.7

When examining these spot measurement data for analyzing operations in different modes, we found many computers were nearly indistinguishable between off and standby modes. Further, instantaneous spot measurement thresholds did not always match long-term average power, as found in results from metered data. Consequently, we were not able to distinguish between standby and off modes. For this analysis, we characterized computers as operating in a higher power, active or idle state, or in a low-power, standby or off mode.

Spot measurements taken when computer were turned on idle found metered data proved more reliable than a one-time power measurement. The exact threshold between the higher and lower power modes varied by computer, and was determined by using spot measurements for low-power modes in combination with metered data power to find the ratio between higher and lower power modes caused by computers turning on. In most cases, this ratio was accurate, although we had to manually set the threshold for a few, outlier computers.

This ratio was used to calculate percentages of weekdays and weekends given computer operated in higher and lower power modes as well as average power in both modes. Table 9 shows average active/idle power for desktops, only on weekdays. We found computers operated within about a 10 W range in either active or idle states; if, for example, a computer drew 50 W in idle, it usually ranged up to about 60 W when in use throughout the day. Active/idle power varied greatly by computer, and a few computers were found to operate at more than 100 W, on average, when active/idle. Table 9's first two columns represent computers operating at the highest and lowest average power in active/idle states. In other words, one nonparticipant desktop computer operated at 146.1 W, on average, when active/idle state.

Although minimum power seemed low for a desktop computer, we used the model number to verify computers operating in the 20 W range were, in fact, desktop units.

Table 9. Metered Average Active/Idle Desktop Computer Power Weekdays

Sample Group	Minimum Average Power (W)	Maximum Average Power (W)	Mean Average Power (W)
Participant Desktop (n=162)	19.6	89.6	57.4
Nonparticipant Desktop (n=152)	19.7	146.1	63.2

Next, the analysis cleaned and analyzed 1-minute interval power data for each computer. Two meters were used for each compute: a Watts up? to measure power; and an Onset U12 to record time. Cleaning involved downloading data from data-loggers and matching Watts up? data to U12 data for each computer. Each data set was examined for completeness, to confirm no data were missing (possibly indicating a failed meter).

After cleaning data and eliminating data from failed meters, we developed average load shapes for participant and nonparticipant computers during weekdays and weekends. We quantified the percentage of time participant and nonparticipant computers were in standby/off mode during weekdays and weekends, which could then be used to extrapolate three weeks of energy consumption data to the entire year. To extrapolate to annual energy consumption, we assumed each computer would not be used for an average of three weeks, due to vacation and sick days each year, plus seven holidays. We assumed nonparticipants would operate their computers the same way when gone as they would during weekends. We weighted each computer’s usage the same and used overall average weekday and weekend usage to calculate annual participant and nonparticipant energy consumption. We then took differences between average annual participant and nonparticipant energy consumption to determine energy savings.

Laptop Analysis

Cadmus found sites chosen for metering had very few laptops networked at night or weekends; therefore, we were not able to meter many laptops we felt were strong candidates for PCPM software. Additionally, most laptops we metered at participant sites did not have PCPM software installed.[17] Consequently, we could not estimate savings by comparing participant laptop energy consumption to nonparticipant laptop energy consumption. Rather, we estimated savings for laptops based on measured active/idle power and standby/off power, and assumed hours laptop computers were in the active/idle state and standby/off mode were the same as those measured for desktop computers with and without software.

We examined laptop computers’ characteristics the same way as for desktop computers. As Table 10 shows, nonparticipant laptop computers were used for either administrative purposes or as office computers. All these laptops ran on the Windows XP operating system.

Table 10. Number of Nonparticipant Laptop Computers by Usage Group

Usage Group	Number of Nonparticipant Laptops
Administrative	21
Standard Office	14
Grand Total	35

All laptops in this sample used some power when off, as shown in Table 11. Mean power in standby and off modes was similar to that in desktop computers. However, active power was much lower for laptops than desktops.

[17] Participant survey data showed many participants had laptops with PCPM software installed; however, we first chose metering sites based on sector, and then desktop usage groups. We only metered one site with laptops having installed PCPM software.

Table 11. Nonparticipant Laptop Spot Power Measurements in Standby and Off Modes

Nonparticipants n=35	Minimum Power (W)	Maximum Power (W)	Mean Power (W)
Standby	0.4	5.0	2.3
Off	1.0	5.0	1.4

Although we did spot measure laptop computer power in idle, we found, as with desktops, that metered data were more accurate than a one-time power measurements; so we used metered data to calculate average active/idle power, as shown in Table 12. As expected, data in the table indicated laptop active power would be lower than mean desktop computer power. Maximum average laptop power in active/idle was only 39.8W, which was considerably less than desktop power.

Table 12. Nonparticipant Laptop Metered Average Active/Idle Power Weekdays

Sample Group	Minimum Power (W)	Maximum Power (W)	Mean Power (W)
Nonparticipant Laptop (n=35)	18.1	39.8	24.3

3. Survey Findings

Findings from participant and nonparticipant interviews are summarized below. Appendix A contains the participant phone survey guide; Appendix B contains the participant on-site survey guide; and Appendix C contains participant response frequency tables. Appendix D contains the nonparticipant phone survey guide; Appendix E contains the corresponding on-site survey guide; and Appendix F contains the response frequency tables.

Computer Characteristics

Questions Cadmus asked participants and nonparticipants questions about computers at their facilities addressed: numbers of desktop and laptop computers; numbers within each usage group; and purchasing patterns, including energy-efficiency options. This section reports the average number of computers at the sector level. For more detailed results, including the average number of computers within each usage group, are included in Appendix C and Appendix F. Table 13 summarizes the average number of computers per sector, reported separately across sectors for participants and nonparticipants, both with and without PCPM software.

The facility count in parentheses shows the number of facilities where data were reported for desktops. As a respondent may have offered this information for 0, 1, or 2 facilities, this count differs from the overall number of survey respondents. Values reported represent the average number of computers among reported facilities. Average values less than one have been rounded up. Although a respondent may have had PCPM software installed on desktops, this did not necessarily mean the same facility had PCPM software installed on laptops.

Table 13. Number of Desktop and Laptop Computers by Respondent-Group

Category	Facility Type	Program Participants	Nonparticipants	
			No PCPM	With PCPM
Average Number of Desktops (number of facilities)	Educational	224 (9)	326 (4)	224 (5)
	Government	366 (9)	105 (7)	-
	Commercial	682 (2)	-	850 (2)
	Total	334 (20)	185 (11)	403 (7)
Average Number of Laptops Used as Desktops (number of responses)	Educational	1000 (1)	14 (4)	37 (6)
	Government	89 (2)	29 (6)	-
	Commercial	360 (1)	1300 (1)	163 (2)
	Total	384 (4)	139 (11)	68 (8)
Average Number of Laptops Left in Office (number of responses)	Educational	200 (1)	8 (4)	22 (6)
	Government	41 (2)	26 (6)	-
	Commercial	288 (1)	975 (1)	104 (2)
	Total	142 (4)	106 (11)	42 (8)
Average Number of Laptops Plugged and Networked (number of responses)	Educational	200 (1)	8 (4)	22 (6)
	Government	41 (2)	23 (6)	-
	Commercial	288 (1)	650 (1)	106 (2)
	Total	142 (4)	74 (11)	43 (8)

Program participants averaged 334 desktops at their facilities; nonparticipants with PCPM software averaged 403 desktops, while nonparticipants without PCPM software installed averaged only 185 desktops, roughly half the number for facilities with installed PCPM software. Commercial facilities tended to have the most desktops, averaging 682 for participants and

850 for nonparticipants with PCPM software. No respondent-group average for educational or governmental facilities had greater than 400 desktops.

In educational facilities, computer labs had the most frequent use of desktops for all three respondent groups. In government facilities, the majority of computers were used by administrative staff for both relevant respondent groups. The majority of desktops in participating commercial facilities were used in standard office use (the only nonparticipating commercial facilities reporting total number of desktops could not provide a breakout by usage group). Overall, and perhaps due to differing proportions of facility sectors across participation groups, participating facilities tended to have more administrative computers, whereas a more even mix of usage groups occurred among nonparticipants. The appendices show reported numbers of computers in each usage group. Section 4 provides more information about usage groups for metered computers.

Program participants used laptops as substitutes for desktops more often than nonparticipants. Participating facilities used an average of nearly 400 laptops similarly to desktops, and kept just under 150 in the office, plugged in, and networked overnight; this well-exceeded numbers nonparticipants reported.

Purchasing Patterns

Survey respondents were asked to report minimum standards their organizations considered when purchasing new computers, as processing speeds and other criteria could affect energy consumption. All respondents aware of their organizations' purchasing patterns reported they instituted minimum equipment standards. A small number of respondents were not aware of their organizations' purchasing patterns.

Respondents were asked to report specific purchasing standards their organizations implemented regarding processing speeds, memory sizes, and hard drive sizes as well as any additional standards. Table 14 shows both program participants and nonparticipants commonly require minimum new computer processing speeds ranging from 1 GHz to 3 GHz.

Table 14. Minimum Processing Speeds Incorporated into Respondents' Purchasing Decisions, by Respondent-Group

	Participant		Nonparticipant Without Software		Nonparticipant With Software	
Minimum Processing Speed	Count	Percent	Count	Percent	Count	Percent
1 GHz	0	0%	1	10%	0	0%
2 GHz	4	18%	1	10%	2	33%
3 GHz	5	23%	4	40%	1	17%
Don't Know	8	36%	2	20%	3	50%
No Response	5	23%	2	20%	0	0%
Total	22	-	10	-	6	-

Table 15 shows minimum memory requirements. While the majority of respondents in all participant-groups reported a purchasing standard, minimum memory requirements levels varied, indicating organizations opting to implement some form of PCPM seemed to require more advanced machines. For both program participants and nonparticipants with installed PCPM software, new computers most commonly required 4 GB of memory, while nonparticipants without software installed more commonly required only 2 GB of memory for new machines.

Table 15. Minimum Memory Requirements Incorporated into Respondents' Purchasing Decisions, by Respondent-Group

Minimum Memory	Participant		Nonparticipant Without Software		Nonparticipant With Software	
	Count	Percent	Count	Percent	Count	Percent
1 GB	2	9%	0	0%	0	0%
2 GB	5	23%	4	40%	2	33%
3 GB	0	0%	1	10%	0	0%
4 GB	10	45%	1	10%	4	67%
Don't Know	5	23%	2	20%	0	0%
No Response	0	0%	2	20%	0	0%
Total	22	-	10	-	6	-

Table 16 shows minimum hard drive sizes required by survey respondents. For all three participant groups, response distributions seemed to center around minimum standards of 80 to 160 GB.

Table 16. Minimum Hard Drive Sizes Incorporated into Respondents' Purchasing Decisions, by Respondent-Group

Minimum Hard Drive Size	Participant		Nonparticipant Without Software		Nonparticipant With Software	
	Count	Percent	Count	Percent	Count	Percent
Smallest Available	1	5%	0	0%	0	0%
40 GB	1	5%	1	10%	0	0%
80 GB	6	27%	1	10%	0	0%
160 GB	3	14%	3	30%	2	33%
300 GB	2	9%	1	10%	0	0%
Don't Know	3	14%	2	20%	4	67%
No Response	6	27%	2	20%	0	0%
Total	22	-	10	-	6	-

As shown in Table 17, a large number of respondents in all groups responded affirmatively when asked if their organizations considered ENERGY STAR®-qualified products for new computer purchases. Program participants were also asked to list any other purchasing requirements they might apply. Common responses included preferences for specific manufacturers, multiple-core processors, power supply standards (such as 80+), and hardware components. Nonparticipants were not asked about power supply standards.

Table 17. Energy-Related Purchasing Standards Incorporated into Respondents' Purchasing Decisions, by Respondent-Group

Energy-Related Purchasing Standards	Participant		Nonparticipant Without Software		Nonparticipant With Software	
	Count	Percent	Count	Percent	Count	Percent
ENERGY STAR® Desktops	10	45%	5	50%	5	83%
ENERGY STAR® Laptops	9	41%	8	80%	6	100%
Minimum Power Supply	3	14%	N/A	-	N/A	-

Table 18 shows PCPM software types each participant respondent installed on their computers. Verdiem was the most prevalent, followed by Faronics Power Save and Light Speed. PCPM software installed at participant sites selected for metering included: Verdiem (three participants at six sites); Light Fix (one participant at two sites); and Big Fix (one participant at two sites). One participant designed their own power management software.

Table 18. PCPM Software by Respondent

PCPM Software	Count
Verdiem	9
Faronics Power Save	4
Light Speed	3
Lake Sight's SysTrack Power Management	1
Adaptiva	1
Night Watchman	1
Microsoft Systems Center- Configuration Center	1
Big Fix	1
In-house product	1
Total	22

Program Participant Satisfaction

In general, program participants were satisfied with both the power management software they installed and the PSE incentive program. As shown in Table 19, 16 of 22 participants reported being satisfied or extremely satisfied with the software, and 19 of 22 reported being satisfied or extremely satisfied with the PSE incentive program. Additionally, 18 of 22 respondents did not notice a difference in performance between PCs with power management software installed and those without, and one respondent stated computers with power management software performed better than those without due to antivirus and pop-up blocker features. Only one respondent reported displeasure with the software, stating nearly 25 percent of the facility's computers were unusable because of the software (though their IT staff were working with the vendor to solve the problem). A couple participants complained about the energy savings report, saying it was lacking in outputs they wanted to see, not generated frequently enough, or could not be customized. Half of participants (11 of 22) did not know or did not have a record of energy savings expected from the software installation. Three participants were able to provide savings reports generated by the PCPM software, and one of the three said the report indicated the software worked and the facility was achieving expected savings.

Table 19. Participant Satisfaction with Power Management Software and PSE Incentive Program

Response	Satisfaction with Power Management Software Frequency (n = 22)	Satisfaction with PSE Incentive Program Frequency (n = 22)
5 – Extremely Satisfied	4	16
4 – Satisfied	12	3
3 – Neutral	4	1
2 – Dissatisfied	1	0
1 – Extremely Dissatisfied	0	0
Don't Know	1	2
Total	22	22

Program Participant Decision Drivers

Program participants reported several factors influencing their decisions to purchase and install power management software. As shown in Table 20, participants cited energy savings or efficiency and power management, costs, and environmental concerns most often when asked which factors influenced their decisions. Respondents also identified several information sources playing a role in their purchasing and installing power management software. Most commonly, respondents cited recommendations from other companies using the software and a variety of vendor resources as important information sources. Respondents mentioned presentations from PSE staff twice, and the PSE Website once.

Table 20. Factors Influencing Participants' Decisions to Purchase and Install Software

Response	Frequency (n=22)*
Environmental Reasons	11
Cost Savings	9
Energy Savings / Efficiency and Power Management	10
Customers Wanted It	1
Easier Than having Staff Turn Off Computers	2
Ease of Use	5
Good Relationship with Vendor	2
Spam/Web Filtering and Antivirus Capabilities of Product	5
Security Benefits	2
Qualified for Rebate	2
Mandate/Grant	1
Don't Know	1
Total	51

*Multiple responses allowed.

Program Participant Freeridership and Spillover

To determine program freeridership—the percentage of savings that would have occurred in the program's absence, Cadmus asked participants a series of questions about the PSE rebate's influence on their decisions to purchase power management software. Cadmus scored participants (Yes, No, Partial) based on their responses to the three questions detailed in Table 21, resulting in 40 percent program freeridership. Educational facilities had the lowest freeridership, at 10 percent (n=10). Commercial and government facilities had higher freeridership at 69 percent (n=4) and 64 percent (n=8), respectively.

Table 21. Freeridership Scoring Matrix

Free Ridership Survey Question	Responses				
1. On a scale from 1 to 5 with 1 being very unlikely and 5 being very likely, how likely would you have been to purchase [SOFTWARE NAME] without the PSE rebate?	1 (No)	2 (No)	3 (Partial)	4 (Yes)	5 (Yes)
2. If the PSE rebate had not been available would you have purchased the same number of software licenses?	Yes (Yes)	No (No)			
3. If the PSE rebate had not been available would you have purchased the software licenses at the same time, earlier, or later?	Same Time (Yes)	Earlier (Yes)	Later (No)	Never (No)	Phases (Partial)

Half of respondents surveyed reported they would have likely installed power management software without the PSE rebate (Table 22). Of these 11 respondents, eight reported they would have installed the same number of licenses without the rebate, and seven reported they would have purchased licenses at the same time or earlier. However, of 11 respondents likely to purchase software without the PSE rebate, three stated they would not have purchased the same number of licenses, and three reported they would have purchased the software at a later date or in stages. Five respondents stated software installation would have been unlikely without the PSE rebate.

Table 22. Likelihood of Purchasing Power Management Software without PSE Rebate

Likelihood of Purchasing Software without PSE Rebate	Would You Have Purchased the Same Number of Licenses?			Would You Have Purchased the Licenses at the Same Time?						
	Yes	No	Don't Know	Same Time	Earlier	Later	Never	In Phases	Don't Know	No Response
4 or 5 – Likely (n = 11)	8	3	0	6	1	1	0	2	0	1
3 (n = 5)	2	3	0	2	0	2	0	1	0	0
1 or 2 Unlikely (n = 5)	2	3	0	0	0	2	2	1	0	0
Don't Know (n = 1)	0	0	1	0	0	0	0	0	1	0
Total (n=22)	12	9	1	8	1	5	2	4	1	1

Program participants were also asked if they had installed PCPM software on additional computers without receiving a rebate. Nine of 22 participants installed power management software on PCs did not receive the PSE rebate, accounting for nearly 25,000 additional installations. Eight of 20 participants with laptops also installed power management software on the laptops, resulting in just less than 2,000 laptop installations.[18] As shown in Table 23, high

[18] Only one of eight sites that reported installing PCPM on laptops was visited for metering, as the metered sample was selected based on desktop computers.

potential existed for additional spillover. A majority of participants planned to purchase both desktop (14 of 22) and laptop (12 of 22) computers over the next 12 months. Although installation of power management software on these machines is not guaranteed, high satisfaction with software purchased through PSE program increases the likelihood of additional installations.

Table 23. Number of Computers Participants Plan to Purchase in the Next Year

Number of Computers	Desktops (n=22)	Laptops (n=22)
1-50	2	6
51-100	6	3
101-200	4	1
201-500	0	1
501-1000	1	1
1001+	1	0
None	1	2
Don't Know	2	2
No Response	5	6
Total	22	22

Potential within Nonparticipants

Cadmus asked nonparticipants if they had taken any actions to save energy on their computers. Some nonparticipants reported installing PCPM software, while others reported using other tools available through Windows operating systems. Both responses are described in more detail below.

Nonparticipants with PCPM Software

As discussed earlier, six of 16 nonparticipants surveyed (including PSE) implemented some form of PCPM software. All six reported they installed the technology on over 1,000 machines, with the highest number of nonparticipant installations being 1,600. Four of these respondents provided a breakout between desktops and laptops: two organizations had PCPM technology on roughly 400 laptops, one on 24 laptops, and one solely on desktops.

Nonparticipants with installed PCPM technology reported being generally satisfied with their software. Of four respondents providing a rating, two reported their satisfaction as a five out of five, one as a four, and one as a three.

In general, this group of respondents did not implement PCPM with a clear idea of energy savings they could expect. Four of six respondents surveyed did not know how much energy savings they could expect from the program, and another said they had no expectation for energy savings as the power management capability was a bonus feature of the software (some PCPM software includes other capabilities, such as antivirus, spam prevention, and Web filtering). The group's sixth respondent did not answer this question.

Four respondents in this group reported they were aware of PSE's PCPM incentive program. When asked why they had not participated in the PSE PCPM incentive program, two said they planned to participate soon. Another respondent did not participate because his organization had installed free software, and one did not respond to the question. One respondent reported installing PCPM software in 2008; another reported installing it before 2008. As the PSE program began in August 2008, either one or both of these nonparticipants installed their software before the program's inception.

Energy-Efficiency Actions Already Taken by Those without PCPM Software

Of 10 nonparticipants not installing PCPM software, six reported their organizations had discussed implementing it. Three were still actively considering or planning to install PCPM software.

Four nonparticipants in this group claimed to be aware of the PSE PCPM incentive program; two of these four had considered installing PCPM software.[19]

When asked about any energy-savings methods respondents applied, four pointed to sleep settings or Microsoft Group Policies, both available through Microsoft operating systems, with an additional respondent reporting they only used these settings on monitors. Another respondent reported his facility planned to purchase 1,000 smart strips to plug computers into, eliminating phantom loads when computers were turned off. Three nonparticipants in this group reported each new computer was configured with power management activated; one stated users were asked to program sleep settings manually; and a sixth reported settings were applied automatically or manually, depending on the computer's usage group.

[19] This does not include Puget Sound Energy, which was surveyed as part of the nonparticipants without PCPM group but was not asked about program awareness, as it was not thought to be applicable.

4. Metered Data Results

This section summarizes findings from metered data, reporting annual and peak demand savings. Detailed findings can be found in Appendix G.

Computer Usage Characterization

As noted in an earlier section, Cadmus metered 418 computers. As shown in Table 24, our analysis used 362 of these data sets, or 87 percent of total computers metered. Laptop computers have been categorized by those located at participant sites ("participant laptops") and those at nonparticipant sites ("nonparticipant laptops"), but not all laptops at participant sites had PCPM software installed.

When reviewing on-site survey data, we discovered one nonparticipant site had installed a free PCPM software solution. We excluded this site from comparison analysis as we had defined the baseline case as computers without PCPM software.

Table 24. Computers Metered and Used in Analysis

	Participant Desktops	Nonparticipant Desktops	Participant Laptops	Nonparticipant Laptops	Total
Installed Meters	175	179	14	50	418
Attrition	13	27	1	15	56
Used in Analysis	162	152	13	35	362

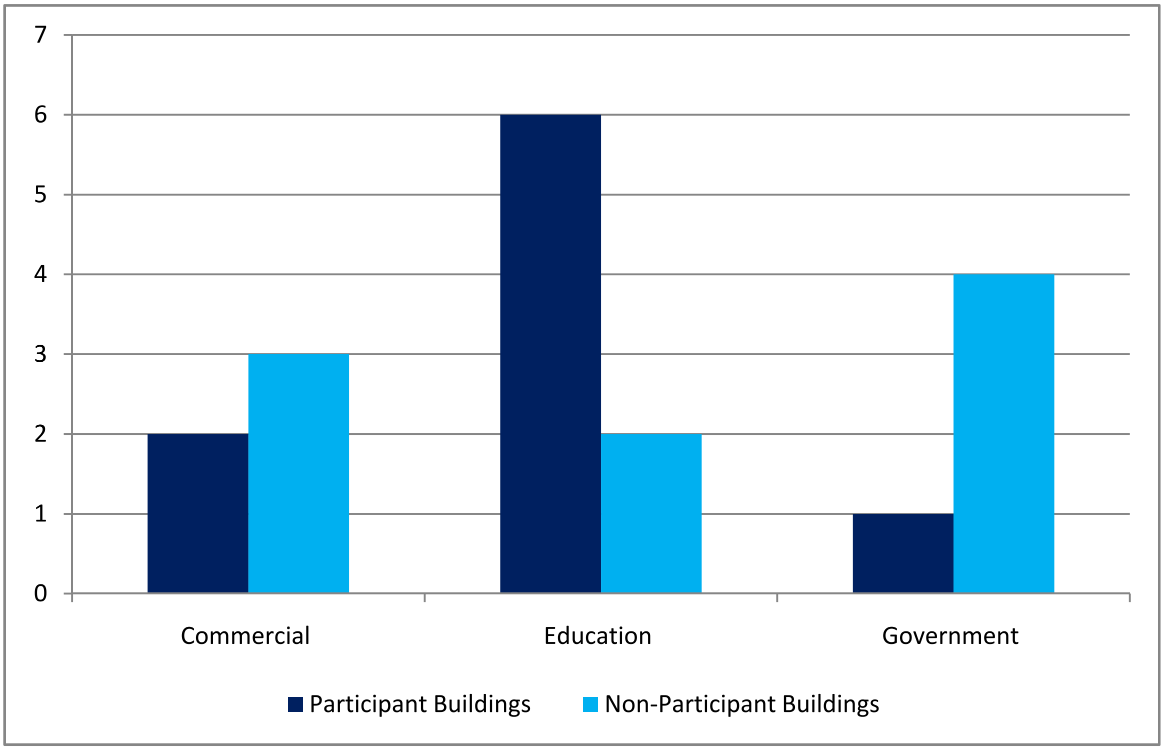
Table 25 shows the number of computers metered within each building sector (educational, government, and commercial) and used in the analysis.

Table 25. Metered Computers by Building Sector

	Participant Desktops	Nonparticipant Desktops	Participant Laptops	Nonparticipant Laptops
Educational	110	56	6	1
Government	28	73	2	18
Commercial	24	23	5	16
Totals	162	152	13	35

Cadmus installed meters at and analyzed data from a nine participant buildings and nine nonparticipant buildings, as shown in Figure 4. In some cases, Cadmus installed meters in two buildings part of the same organization—for example, a middle school and high school in the same school district—and, therefore, likely to have similar IT practices.

Figure 4. Number of Metered Sites by Building Type



Before installing meters, we asked our contacts at each site to estimate numbers of computers within each usage group; so we could select a representative sample at each site. Most computers were used administratively, in computer labs, or as standard office computers. Some IT and teachers' computers were also metered.

Table 26. Number of Desktop Computers per Usage Groups for Metered Participants and Nonparticipants

	Participant Desktops	Nonparticipant Desktops	Total
Administrative	19	48	67
Computer Lab	56	46	102
Drafting Lab	5	0	5
Media Lab	9	0	9
IT	5	2	7
Advanced Office	4	6	10
Standard Office	51	49	100
Teacher	13	1	14
Totals	162	152	314

Table 27 summarizes usage groups by building type. Although we examined savings by usage group, the IT sample was too small, and savings for the other two groups were nearly identical. Computer labs included drafting and media labs. Office/administrative computers included teacher computers.

Table 27. Number of Metered Computers per Usage Group by Sector

Usage group	Commercial		Educational		Government		Total
	Non-part	Part	Non-part	Part	Non-part	Part	
IT	0	0	0	0	2	5	7
Computer Lab	2	2	44	68	0	0	116
Office/Admin	21	22	12	42	71	23	191
Total	23	24	56	110	73	28	314

All but two participant computers had Windows XP operating systems. The majority of nonparticipant computers had Windows XP, though some also had Windows7, Windows Server 2008, and Windows Vista, as shown in Figure 5 and Figure 6. Although Windows Server 2008 would not normally be considered a desktop operating system, as these computers were located in a computer lab, they were included in the metering analysis. Generally, we did not find correlations between active/idle power and operating systems, except for the four computers with Windows Vista–Enterprise; these computers drew significantly higher power, on average, than desktops with the other operating systems. We also looked at processor speeds, and compared it to active/idle power, but did not find a correlation. Appendix G contains results from those analyses.

Figure 5. Participant Operating Systems

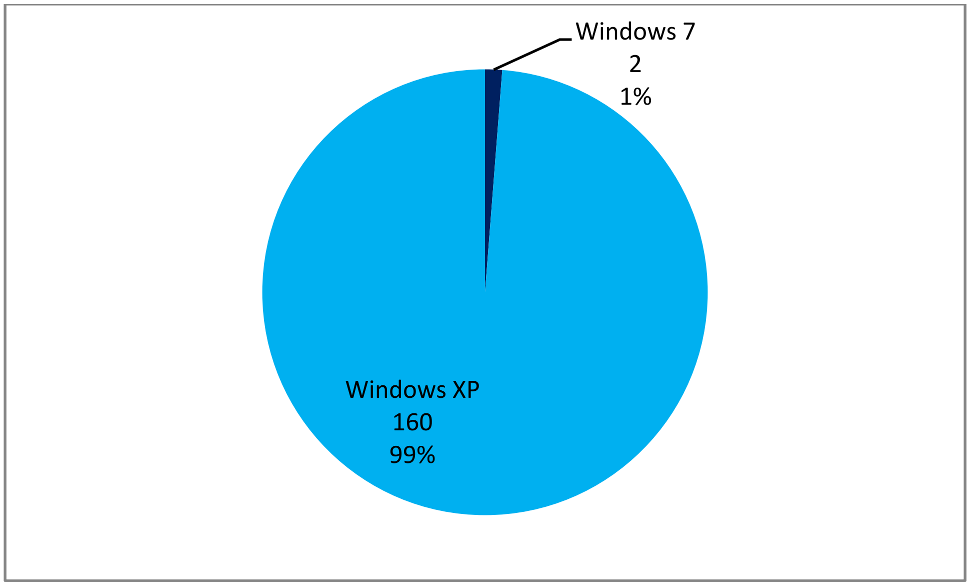
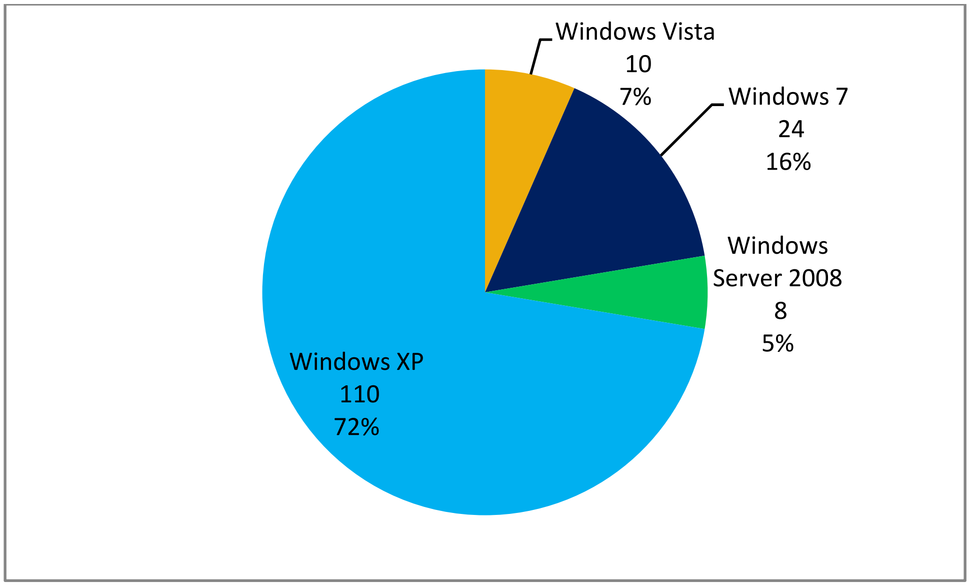


Figure 6. Nonparticipant Operating Systems



Desktop Computer Energy Consumption

In this study, desktop computer power ranged from 20 to 150 W, with most computers using 40 to 70 W when active/idle. Figure 7 shows overall numbers of metered participant and nonparticipant computers within each power range, and Figure 8 shows distributions in power consumption by sector. Each bar represents the number of computers within each bin, with the label on the x-axis showing the range of power for each bin. Figure 8 shows educational computers tended to be 40 to 60 W, while governmental computers tended to be 60 to 70 W.

Figure 7. Distribution of Average Active/Idle Power for Participant and Nonparticipant Desktop Computers

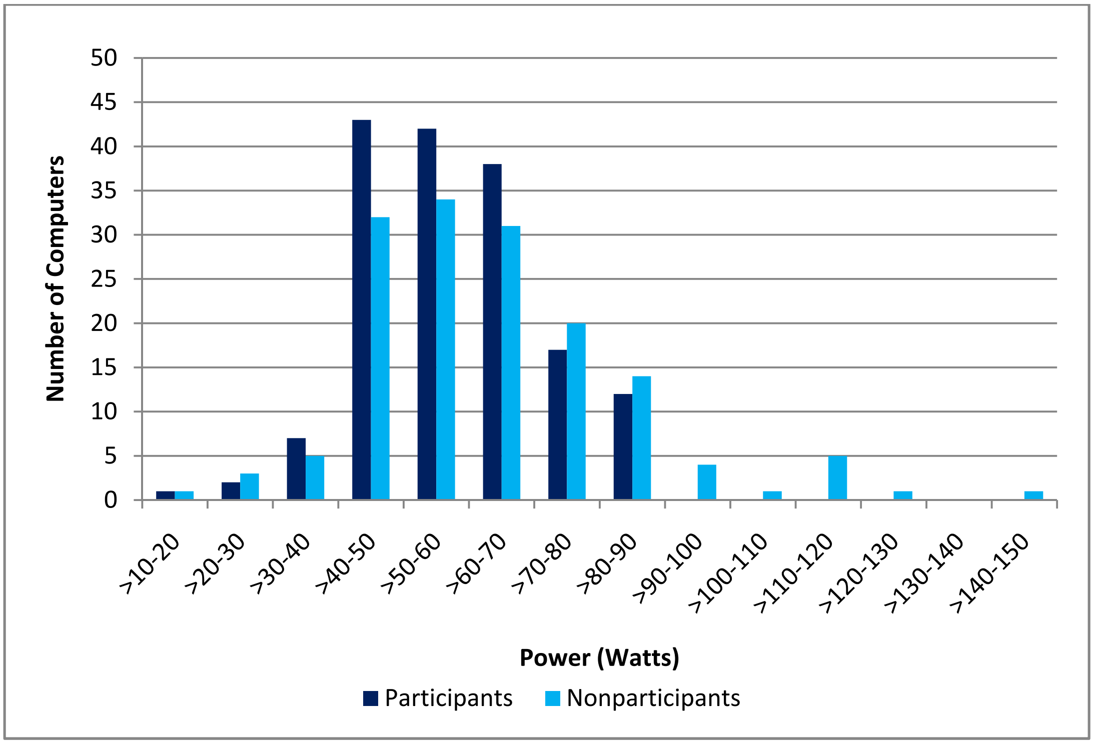
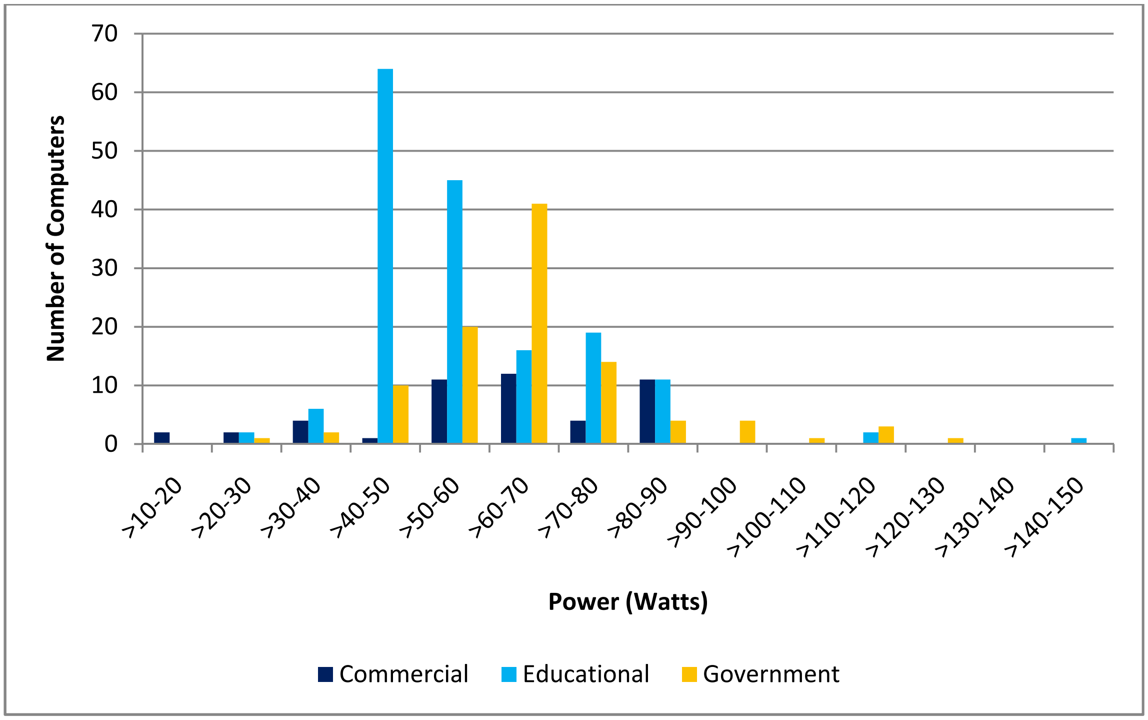


Figure 8. Distribution of Average Active/Idle Power for Desktop Computers by Sector



ENERGY STAR®-Requirements and Computer Efficiency Improvements

In the past, computers commonly drew as much as 250 W power in use. However, as computers have evolved, power draws have decreased. This has affected potential overall savings as differences between power required for the active/idle states and standby/off modes have decreased.

The ENERGY STAR®- Version 5.0 Specification for Computers[20] went into effect July 1, 2009. To meet these specifications, an average qualified computer uses 46 W. To meet the Version 4.0 Specification, which went into effect July 2007, an average qualified computer uses 67 W. Version 4.0 took effect after the LBNL and SCE studies, but before the Ecos work. Most computers in this study, as shown in Figure 7, met Version 4.0, and many met Version 5.0 specifications for power consumed in the active/idle state. On the whole, sampled computers used much less power than older computers.

Computer Operating Characteristics

As described earlier, we were unable to distinguish between standby and off modes in metered data analysis because thresholds between the two modes often fell within 0.1 W. Therefore, we categorized computers as either the higher-power active or idle state or the lower-power standby or off mode. One way to determine whether or not PCPM software worked on participant computers (while examining savings potential for nonparticipant computers) was to look at percentages of computers in low power modes during weekday nights and weekends. We examined a two-hour window on weeknights and during weekends, when computers were not in use. Some networks pushed software updates in the middle of the night; so examined times when this was not happening.

Metered data showed computers in standby/off mode operated at an average of 2 W. On weeknights, 94 participant computers and 49 nonparticipant computers operated at 5 W or less. As shown in Figure 9 and Figure 10, on weekends, 120 participant computers and 65 nonparticipant computers operated at 5 W or less. Notably, some facility operating hours did include nights and weekends.

[20]http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Version5.0_Computer_Spec.pdf

Figure 9. Distribution of Average Weekday Nighttime Power for Participant and Nonparticipant Desktop Computers

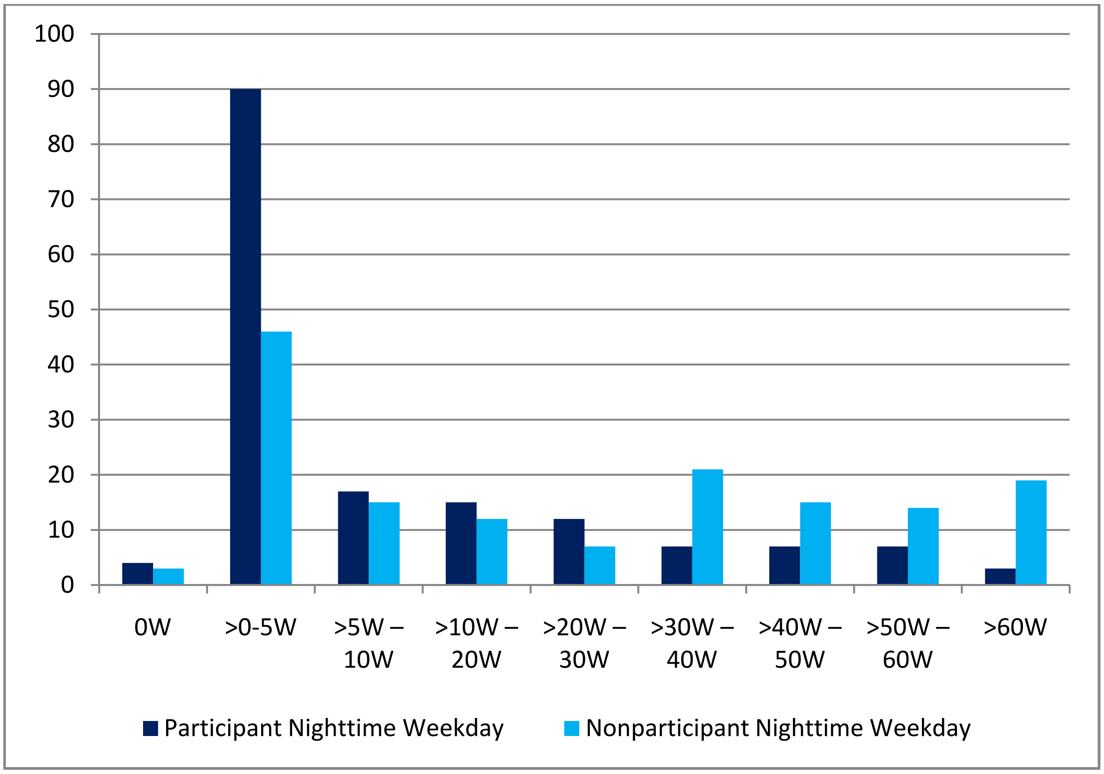


Figure 10. Distribution of Average Weekend Power for Participant and Nonparticipant Desktop Computers

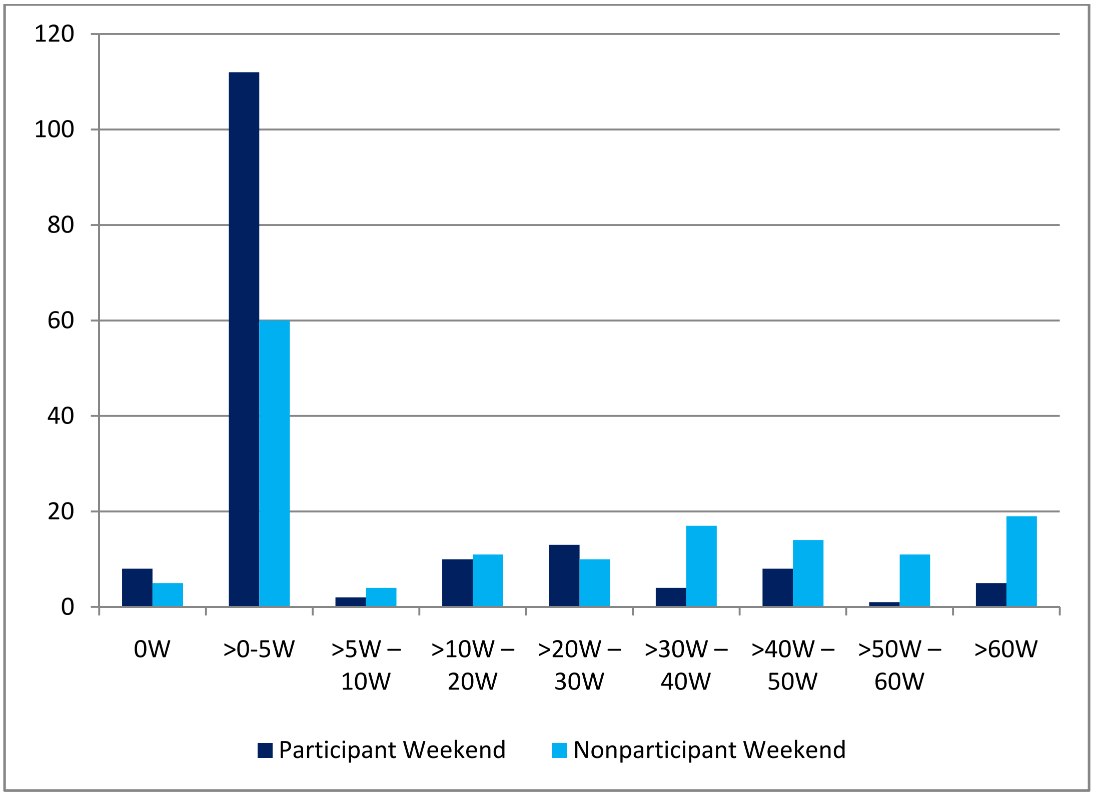
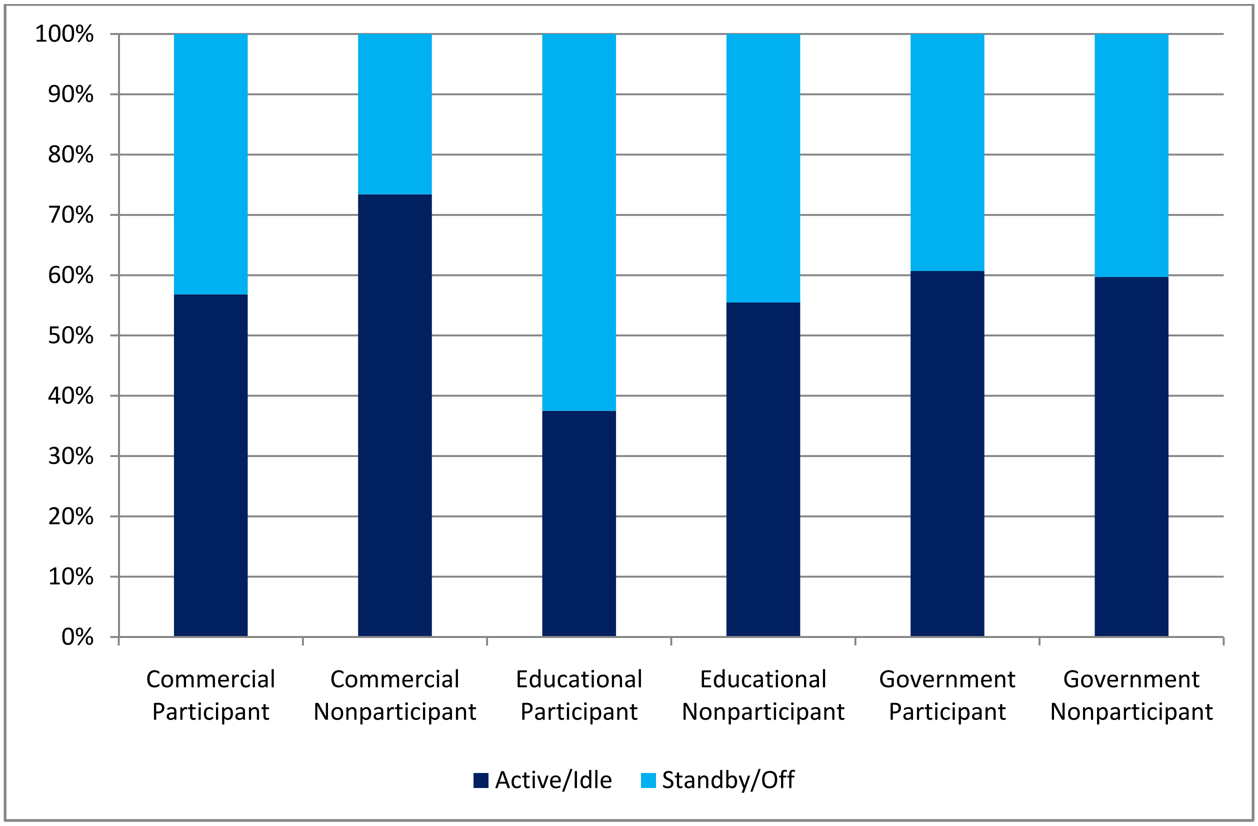


Figure 11 shows average percentages of time on weekdays computers within each sector operated in active/idle state (dark blue) or standby/off mode (light blue).

Figure 11. Percent of Time Desktop Computers are Active/Idle versus Standby/Off on Weekdays

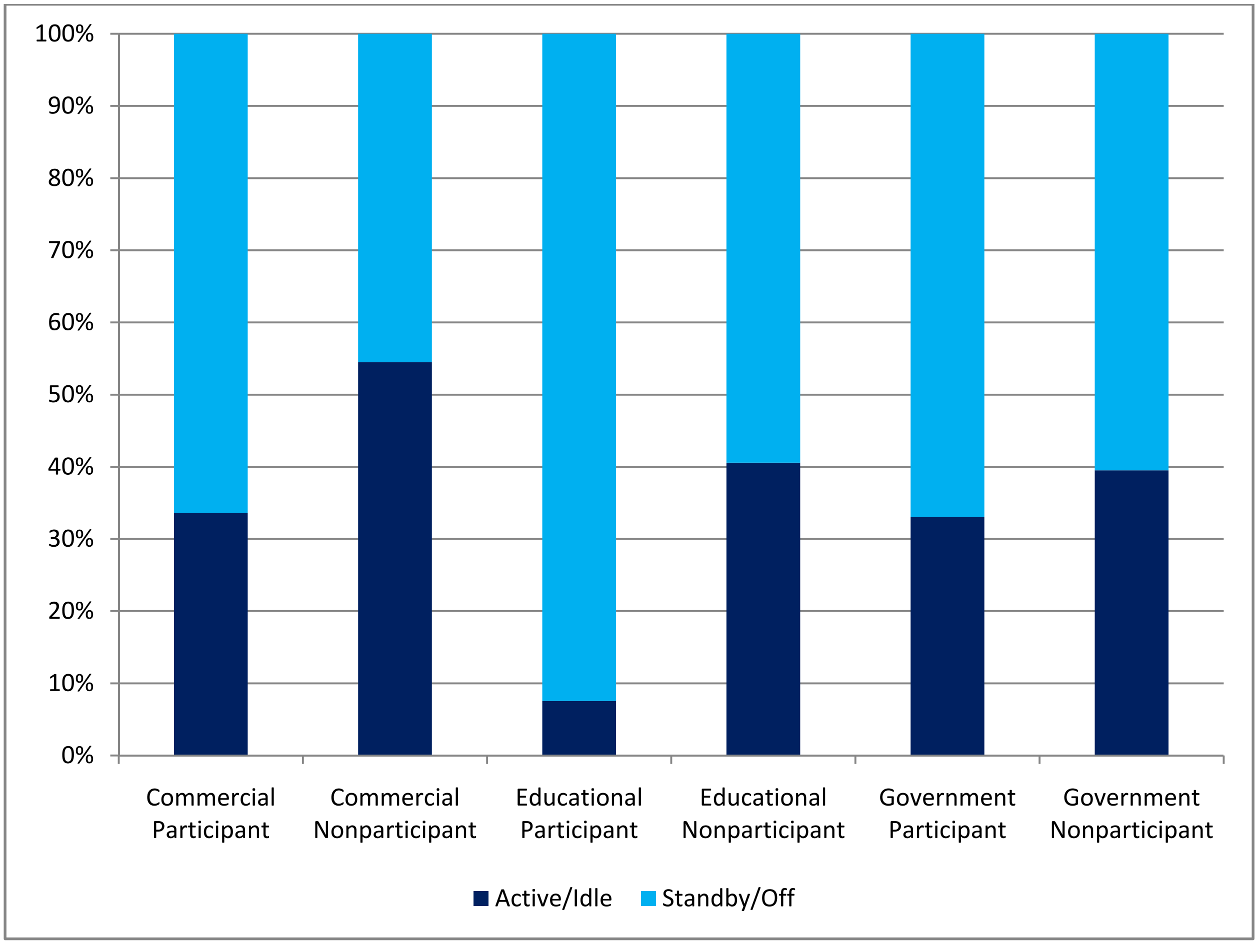


We metered only one government participant building, and, as shown in Figure 11, its PCPM software did not appear to be working; its computers were active/idle nearly the same percentage of time as nonparticipant site computers without PCPM. We followed up with this site, learning they have configured PCPM to only turn off monitors in some computers. Given this less aggressive PCPM approach, we removed computers this site. After the change, average percent times in 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 we were able to conduct pre/post monitoring to examine usage changes. Metering equipment remained in place for three weeks before implementation of facility-installed PCPM software, and we used this period to establish baseline usage. Three weeks after PCPM software installation, we removed the meters, and analyzed post-installation energy consumption, which was higher than expected. The site’s operating hours, however, were much longer than for a typical office, running from 5:00 a.m. to 11:00 p.m. weekdays, and the same hours on weekends. For comparison, we examined pre- and post-installation meter data for a second site from the same company, which had business hours of 8:00 a.m. to 6:00 p.m., Monday through Friday (and closed on the weekends). PCPM software at the second site provided more than four times the savings at the first site, likely due to shorter operating hours and computers at the first site operating at higher active/idle powers.

As seen in Figure 11, commercial and educational buildings differed between participant and nonparticipant computers. This difference proved even more evident in percent usage on weekends, shown in Figure 12. However, if PCPM software placed all participant computers into low-power modes when not in use, we would expect standby/off mode percentage times to be less than 10 percent during unoccupied hours.

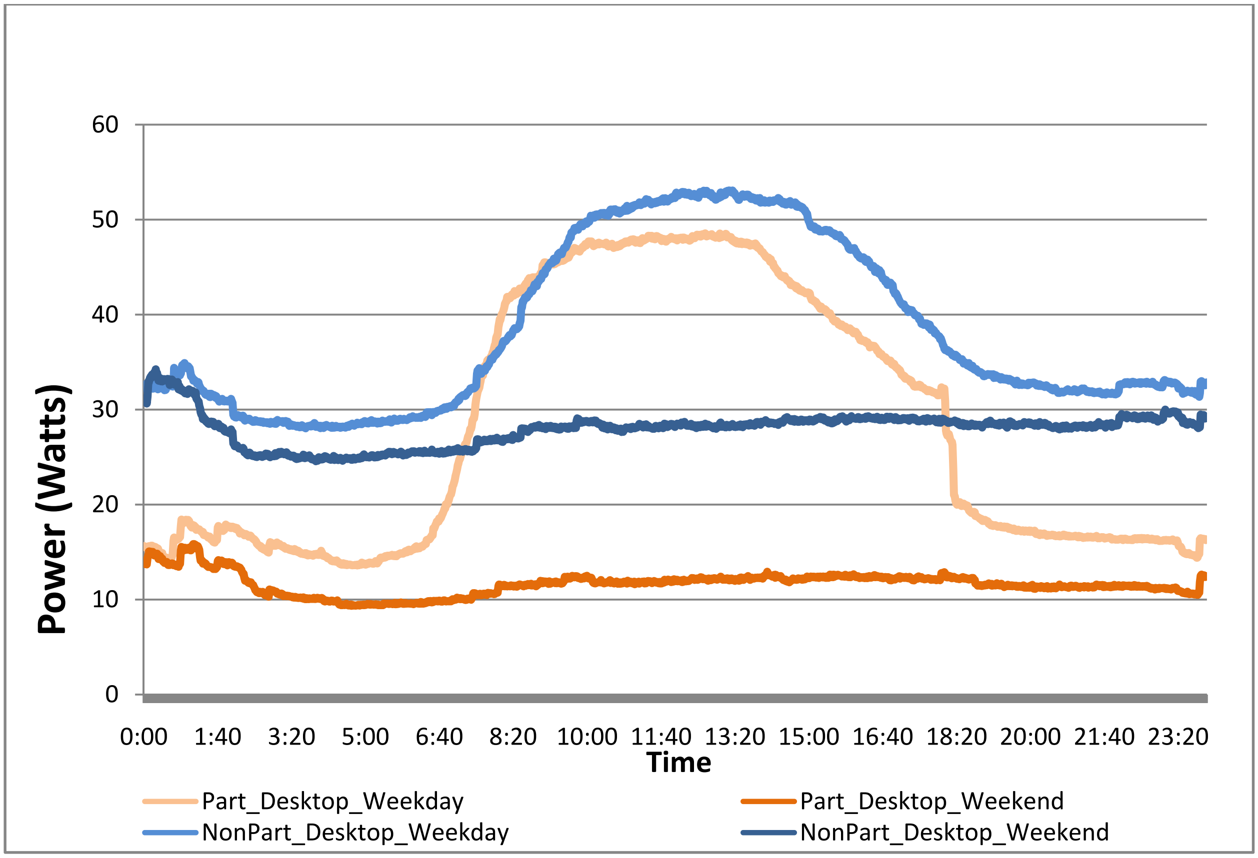
Figure 12. Percent of Time Desktop Computers are Active/Idle versus Standby/Off on Weekends



Load Shapes

We created load shapes for desktop computers by averaging power for each computer during each minute over all metered days. As weekdays and weekends often had different profiles, we separately examined shapes for each, as shown in Figure 13. The orange shaded lines represent participant desktop average usage and weekend usage. Blue lines represent nonparticipant computers, with the same shading pattern.

Figure 13. One-Minute Load Profiles for Desktop Computers



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

This finding was supported by examination of average percentages of time participant and nonparticipant computers went into standby/off mode during weekdays and weekends, as shown in Table 28. For common business hours of 8:00 a.m. to 6:00 p.m. weekdays, participant desktop computers remained in standby/off about 10 percent longer than 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, differences were even greater—almost all participant computers remained, on average, in standby/off, compared to slightly more than half of nonparticipant computers.

Table 28. Percent of Time Computers are in Standby/Off Mode Weekdays and Weekends

Time Period	Participant Desktops (n=162)	Nonparticipant Desktops (n=152)
8 a.m. – 6 p.m. weekdays	44%	34%

6 p.m. – 8 a.m. weekdays	78%	53%
Saturday and Sunday	85%	55%

Laptop Computers Energy Consumption

As noted, participant laptops were defined as laptops located at participant sites, and only about half of 13 participant site laptops actually had PCPM software installed. This sample was large enough to draw conclusions regarding comparisons between participants to nonparticipants. We analyzed metered data from 35 laptops at nonparticipant sites, examining all 35 units as a group, without stratifying by building type.

In this study, laptop computers ranged from 10 to 40 W, with most computers using 20 to 30 W when active/idle. Figure 14 shows numbers of metered participant and nonparticipant computers within each category. Each bar represents the number of computers within each bin, with the label on the x-axis showing power range for each bin.

Figure 14. Average Active/Idle Power for Laptops

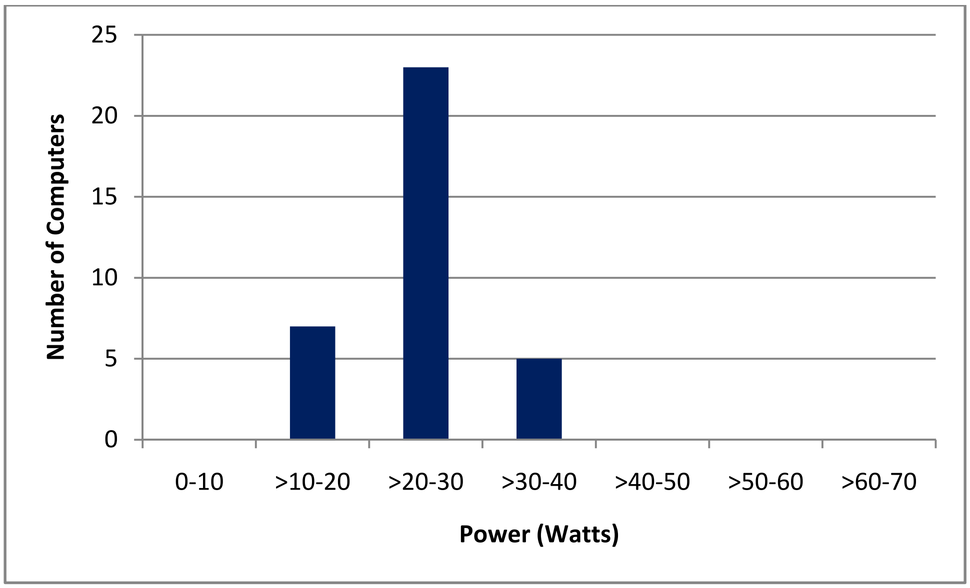


Table 29 shows nonparticipant laptops remained in standby/off nearly the same percentage of time as nonparticipant desktop computers (Table 28, above). This suggests these laptops were used similarly to desktop computers metered in this study.

Table 29. Percent of Time Laptops in Standby/Off Modes Weekdays and Weekends

Time Period	Nonparticipant Laptops (n=35)
8 a.m. – 6 p.m. weekdays	36%
6 p.m. – 8 a.m. weekdays	56%
Saturday and Sunday	58%

PCPM Energy Savings

Cadmus extrapolated metered data to estimate annual energy savings. We also estimated peak demand savings using average power for participant and nonparticipant computers during PSE's peak load hours.

Annual Energy Savings—Desktops

For each building type with desktop data, we calculated energy consumption for five weekdays, plus two weekend days, and summed these to arrive at total weekly energy consumed, as shown in Table 30. The government sector showed a relatively small difference between participants and nonparticipants as 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 30. 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

We assumed computers, on average, were not in use three weeks per year, to compensate for vacation and sick days plus an additional seven holidays, for total annual usage of 48 weeks. Nonparticipant computers were assumed to operate at the same power on vacations and holidays as on weekends. Applying this algorithm to values shown in Table 30, we calculated average annual savings as 117 kWh per computer, as shown in Table 31. When added to the RTF estimate of 11 kWh savings per monitor, resulting savings were 128 kWh per workstation (computer and monitor). These numbers may differ slightly for educational facilities, where some sites had summer breaks, and many have computer labs. Cadmus also examined savings by general usage groups of office/administrative, computer lab, and IT, but did not find significant differences in the first two groups, and did not have a large enough sample in the third. Results can be found in Appendix G.

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 total average weekly energy usage calculated across all sectors.

Table 31. 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

We also calculated average power and percentage of hours in standby/off and active/idle for both participants and nonparticipants; so this study could be easily compared to RTF's methodology: Table 32 presents results, representative of one week (includes both weekdays and weekends).

Table 32. 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 (conf/prec)	Participant Share of Hours (conf/prec)
Overall	Standby/Off	2.0	45% (90/10)	64% (95/10)
	Active/Idle	60.2	55% (90/10)	36% (95/10)

Annual Energy Savings—Laptops

The very small sample of laptop computers was metered at participant sites; and we could not confirm PCPM was installed on those computers. Thus, to calculate annual energy savings for laptops, we assumed desktops and laptops had the same sleep settings, and then calculated the percentage difference between participant and nonparticipant computers for weekdays and weekends, as shown in Table 33.

Table 33. Average Percent of Time in Standby/Off Mode on Weekdays and Weekends

Time Period	Nonparticipant Laptops (n=35)	Participant Desktops (n=162)	Difference
Weekdays	48%	63%	15%
Saturday and Sunday	58%	85%	27%

For nonparticipant laptop annual energy usage, the baseline was used (calculated with the same assumptions as for desktops). Participant laptop energy usage was estimated by applying differences from Table 33 to baseline usage in Table 34. We estimated 62 kWh annual savings for PCPM software installed on networked laptops, not taken off-site.

Table 34. Nonparticipant Laptop Annual Energy Usage and Savings

Sample Group	Weekday	Weekend	Weekly	Annual Energy Usage (kWh)
Nonparticipant Laptops	1.82	0.53	2.34	120
Participant Laptops (Estimated)	1.55	0.39	1.94	58
Annual Energy Savings	0.27	0.14	0.41	62

Peak Demand Savings

Puget Sound Energy's peak load occurs in winter, from 7:00 a.m. to 9:00 a.m. and 6:00 p.m. to 8:00 p.m. on weekdays. For metered desktop computers in this study, we found no morning peak demand savings, but did find 15 W savings in the evening, as shown in Table 35.

Table 35. Peak Demand Savings Desktops

Sample Group	7-9 a.m. Weekdays	6-8 p.m. Weekdays
Nonparticipant Desktop	36 W	35 W
Participant Desktop	36 W	20 W
Peak Demand Savings	0 W	15 W

Comparison to Deemed Savings Value

As discussed in the introduction, the RTF provisionally deemed savings for desktops were 148 kWh per workstation (computer and monitor), with 137 kWh savings per computer and 11 kWh per monitor. Our study found savings of 117 kWh per desktop computer. When this was added to the RTF estimate, slightly higher savings of 128 kWh per workstation resulted. The RTF also estimated laptop savings at 64 kWh per computer. We estimated laptop savings at 62 kWh per computer.

5. Conclusions and Recommendations

Program Energy Savings

Since August 2008, the PCPM program has provided incentives for energy-saving software installed on more than 24,000 desktop computers. Program claimed savings were 4,093,770 kWh, based on 2007 RTF-deemed savings value of 170 kWh per workstation. Validated savings per workstation, based on Cadmus' finding of 117 kWh savings per computer and the 2010 RTF estimate of 11 kWh savings per monitor, were 128 kWh per workstation. Validated program savings were 3,082,368 kWh, resulting in a 75 percent realization rate.

Lower savings largely resulted from lower power consumption in the active/idle state for newer computers versus higher power consumption of computers in use three to five years ago (but since discarded). Savings could have also been lower due to nonparticipants reporting using Microsoft Group Settings and configuring sleep settings. Cadmus' metered data verified 128 kWh in most recent savings.

Cadmus also quantified peak demand savings. PSE's peak load occurred from 7:00 a.m. to 9:00 a.m. and 6:00 p.m. to 8:00 p.m. in the winter during weekdays. For computers metered in this study, we did not find morning peak demand savings, but we did find 15 W savings in evenings. Applying this to all computers in the program resulted in a 361 kW peak demand reduction.

Table 36. Claimed and Validated Annual kWh Savings

Year	Number of Computers	Claimed Annual kWh Savings	Validated Annual kWh Savings	Validated Peak Demand Reduction (kW)
2009	15,900	2,703,000	2,035,200	238
2010	8,181	1,390,770	1,047,168	123
Total	24,081	4,093,770	3,082,368	361

Freeridership and Spillover

Cadmus asked participants a series of questions about how influential the PSE rebate was in their decision to purchase power management software. Cadmus scored participants (Yes, No, Partial) based on their responses to three questions, and calculated program freeridership at 40 percent.

Program participants were also asked if they had installed PCPM software on additional computers without receiving a rebate. Nine of 22 participants installed power management software on PCs not receiving the PSE rebate, accounting for nearly 25,000 additional installations, and just less than 3,200,000 kWh in energy savings. Eight of 20 participants with laptops also installed power management software on laptops, resulting in just less than 2,000 laptop installations, and nearly 124,000 kWh in energy savings.

Program and Software Satisfaction

Generally, program participants were satisfied with both the power management software they installed and the PSE incentive program. Sixteen of 22 participants reported being satisfied or extremely satisfied with the software, and 19 of 22 reported being satisfied or extremely satisfied with the PSE incentive program. Additionally, 18 of 22 respondents did not notice a difference in performance between PCs with power management software installed and those without; one respondent stated computers with power management software performed better than those without. Only one respondent reported displeasure with the software, stating nearly 25 percent of the facility’s computers were no longer working because of the installation, though IT staff was working with the vendor to resolve these issues.

Additional Opportunities for Savings

Metered data analysis showed average power for computers in standby/off modes fell between 2 and 3 W. Although most participant computers operated in a low power mode at nighttime and on weekends, some computers rarely, if ever, were found in these modes. Some of these computers may be IT computers, required to operate all night, or may be located in computer labs with nighttime usage, but computers not in use should not be in active/idle states during this time. An opportunity exists to realize additional savings by adjusting computer settings to “cure this insomnia” or encouraging IT administrators to implement more aggressive settings for computers not in use on weekends and nighttimes.

PCPM software may be able to further reduce evening and weekend usage, as participant computers still drew an average of 10 W throughout weekends. If all computers were in standby/off, average power would be less than 5 W. Savings may also be available for nonparticipant computers in those same time frames, as they used 25 to 30 W over those periods. Seven participant computers and 26 nonparticipant computers remained in active/idle 100 percent of the time, and 38 nonparticipant computers remained active/idle 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. And there may be an opportunity for weeknight and weekend savings, where just over half of nonparticipant computers were not in standby/off mode.

Additional education may help participants fully realize their potential savings. PSE may want to consider requiring each participant site to send the PCPM software actual savings report one month following software 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, “insomnia” rates should decrease, resulting in higher program energy savings.

Second, PSE would be able to amass data on all computers in the program, and examine PCPM software success rate in future installations.

Sites with longer operating hours will have lower savings because these computers are normally used more than at other sites; therefore, fewer hours are available in which they could be in lower power mode. PSE may want to consider targeting building types with hours typical of a normal office, focusing less on recruiting businesses (such as call centers) with longer weekday operating hours or often occupied during weekends. In addition, many companies do not have a policy of turning off their computers, resulting in many always left on. Those sites could be strong candidates for this program, and would likely realize above-average savings.

Another option for encouraging participation would be considering some available, free solutions, examining whether PSE’s existing incentive structure could allow rebates for free solutions. Free solutions often address specific power management elements, and usually are not as comprehensive as purchased software; therefore, savings may not be as high, but incentive structures could be adjusted to account for this.

Laptops

Based on metered data, Cadmus estimated PCPM software installed on laptops would save 62 kWh per computer per year. This is roughly half the savings seen from installing PCPM software on desktop computers, due to lower power draws required for laptops in active/idle. Given that Cadmus found large spillover rates for this program, we recommend PSE not extend the rebate to laptop computers, as it appears program participants purchase additional licenses on their own.

Next Step

Cadmus will present study results to the RTF in March 2011. We will coordinate this presentation with Avista and Ecos, as they are performing similar studies. The Bonneville Power Administration and the Northwest Power and Conservation Council have also been involved in analyzing Ecos data to update the RTF deemed savings number. Cadmus will work with all interested parties to collaborate on recommendations for desktop computer deemed savings.

Evaluation Report Response

Program: PC Power Management

Program Manager: Joe Schmutzler

Study Report Name: Puget Sound Energy PC Power Management Rebate Program: Impact Evaluation Results

Report Date: February 4, 2011

Evaluation Analyst: The Cadmus Group

Date of ERR: April 7, 2011

PC Power Management

Evaluation Report Response Summary:

The PC Power Management Rebate Program Impact Evaluation Results completed on February 4, 2011 provided the following findings:

1. Savings were found to be 117 kWh for desktops alone and 15 W of winter evening peak demand.

2. The realization rate for the energy savings was 75%.

3. Freeridership was determined to be 40%. However, there were large spillover effects at the organizations that were part of the study. The savings due to program spillover at these few sites were determined to be greater than our claimed savings for the entire program.

4. Customer education could help to increase savings by implementing more stringent management settings.

5. Savings for laptops were found to be high enough to warrant a rebate. However, spillover to these units was high enough that it was deemed to be unnecessary.

Response to Findings

Business Energy Management (BEM) response to findings is:

It has been decided, after long deliberation, that the best course of action to address the shortcomings of this program would be the following:

1. Adjust savings based on impact evaluation and RTF provisional findings of May 4, 2010 to 115 kWh per desktop.

2. Laptops will continue to be disallowed in the program.

3. PC Power Management shall be in operation for a minimum of 30 days prior to incentive payment. Customer shall provide a monitoring report demonstrating software has managed full workstation power (PC and monitor) to minimize energy usage for 30 days. Customer shall agree to make subsequent reports available to PSE upon request. Requests will be limited to a maximum of one per each six month period after installation during the four-year life of the measure.

4. Develop an educational letter for customers that have gone through the program to encourage them to maximize savings by implementing even more stringent protocols. This letter will be sent to customers sometime after 6 months of installing PC Power Management. The information will also be furnished to the Resource Conservation Manager (RCM) Program to use to educate customers who are both RCM Program and PC Power Management Program participants.

Date of Program Action: Upon re-implementation of PC Power Management Program. This is expected to happen by April 11, 2011.

A new business case is in the process of being completed. When it is implemented it will use the new savings of 115 kWh per desk top and disallow laptops. The Program Manger will develop a method of verifying that customers continue to manage PCs consistently and of educating them in order to maximize savings with more stringent protocols.