Emerging Technologies Research Report; Advanced Power Strips for Office Environments

prepared for the

Regional Evaluation, Measurement, and Verification Forum

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Preface

The Regional Evaluation, Measurement and Verification Forum (EM&V Forum or Forum) is a project facilitated by Northeast Energy Efficiency Partnerships, Inc. (NEEP). The Forum's purpose is to provide a framework for the development and use of common and/or consistent protocols to measure, verify, track, and report energy efficiency and other demand resource savings, costs, and emission impacts to support the role and credibility of these resources in current and emerging energy and environmental policies and markets in the Northeast, New York, and the Mid-Atlantic region. For more information, see www.neep.org/emv-forum.

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Brian McCowan of ERS managed the project and for this primary research component was assisted by ERS Senior Engineer Frank Arena. For the overall project, additional ERS contributing staff included Todd Winner, Richard Doughty, Sarah Eckstein, and Jill Rogers. Additional research was conducted by Dunsky Energy Consulting, Livingston Energy Innovations, and Opinion Dynamics.

Elizabeth Titus and Julie Michals of the EM&V Forum coordinated the project with management assistance from Chris Neme of Energy Futures Group.

The primary research portion of this project would not have been possible without the cooperation and assistance of Efficiency Vermont Program Director Lara Bonn; Carl Uthe of Embertec; and the staff at both World Learning Center and National Life Insurance. The project team thanks them for their efforts.

The project team also wishes to acknowledge the EM&V Forum project subcommittee, which provided valuable input during the development of this project.

Executive Summary

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This report presents the results of primary research conducted to better determine the potential for energy savings through the utilization of advanced power strips (APS) in commercial environments, and to determine appropriate methodologies for assessing the savings. The primary research conducted is part of a continuing effort to assess several emerging technologies and innovative program approaches by the Regional Evaluation, Monitoring and Verification Forum (EM&V Forum or Forum) managed by the Northeast Energy Efficiency Partnerships (NEEP).

Prior to conducting this primary research, secondary research was conducted for several emerging technologies, one of which was APS. Other technologies investigated include: ductless heat pumps, heat pump water heaters, set-top boxes for home entertainment, LED lighting, and biomass pellet heating systems.[1] The goals of the secondary research were to provide performance and savings guidelines allowing the Forum members to develop measures and programs that realize measurable savings, and to identify knowledge gaps that require further study to close. APS was one of two technologies (ductless heat pumps being the other) selected by the Forum membership for primary research.

APS products can be utilized to control a variety of residential and commercial plug loads. The focus of this effort is on commercial office applications. The primary field research for this study was conducted at two commercial office buildings in the State of Vermont. Twenty workstations in each building were monitored for power consumption patterns for a period of 2 weeks. The collected data was uploaded to custom spreadsheet tools, and the potential savings for Tier 1 APS systems were evaluated. The results demonstrate that there are obtainable savings, but the savings are relatively small given the current state of APS Tier 1 technology and the challenges associated with both the interface with PC operating systems and commercial office work environments.

Although this trial was focused on commonly available Tier 1 APSs, emerging Tier 2 APS devices promise a number of advantages over Tier 1 in terms of interfacing with PCs and

[1] The Emerging Technology Report also includes M&V approaches for comprehensive whole-building, retro-commissioning, and lighting design programs. The full report is available at www.neep.org/emv-forum.

energy savings potential. The data collected for this study could potentially be further analyzed to identify the additional savings potential of Tier 2 devices. The results from Tier 1 APS are summarized below.

1.1 APS Products and Research focus

APS generally describes a plug-in power strip that is designed to control plug loads by automatically turning off currently inactive devices. Although there are no official designations, APS units can generally be categorized as:

- Tier 1 APS – A plug-in power strip containing one "control" outlet, which allows a device such as a television or a PC to act as a "master control." Multiple "controlled" outlets automatically interrupt power to controlled devices when the "control" device is off or in a low-power standby mode. Additional uncontrolled outlets allow some devices to be left on regardless of the status of the control device. Throughout this report, unless otherwise specified, the term APS refers to currently available Tier 1 APS products.
- Tier 2 APS – These strips incorporate other features in addition to the control/controlled outlets of Tier 1, allowing more advanced control of plug loads. The additional capabilities may include: occupancy/vacancy sensing; adaptive calibration for the sensing of standby power usage; and associated software for PC installations. Tier 2 units are currently being introduced to the U.S. market, and/or are in development stages.
- Other plug load controls – Plug load controls are also available that operate on an occupancy/vacancy basis only, or an adjustable timer basis, turning off power to controlled devices when the space is vacant, or when the anticipated inactive time period occurs. As examples, Wattstopper markets an occupancy/vacancy controlled strip and Tricklestar markets a strip that is timer controlled.

Research Focus on Tier 1 APS – The focus of both the secondary and primary research for this project is the savings potential and evaluation procedures associated with Tier 1 APS units. Further analysis of the logged usage data could be performed that would allow the assessment of the potential savings associated with the enhanced capabilities of Tier 2 APS units.

1.2 Potential Savings & Cost

The calculated potential savings associated with the two sites is presented both as the average savings for the monitored workstations and the range of savings from individual workstations at each site. The savings, presented below, vary by the threshold setting, which is defined as the amount of power consumption at the control outlet that is intended to trigger an interruption or a return of power to the controlled outlets. Most APS units incorporate an adjustable threshold setting. Higher threshold settings can result in higher savings if the power consumption at the

control outlet during inactive time periods is somewhat below the selected higher threshold. Please see Section 7 for more detail and caveats regarding the predicted savings at the 20-watt threshold settings.

1.2.1 Calculation Methodology

The algorithm utilized to calculate the potential savings is as follows:

$$kWh\ savings = CPE_{WD} \times 230\ days + CPE_{NWD} \times 135\ days$$

where,

kWh savings = Annual savings (kWh/year)

CPE_{WD} = Average energy consumption of peripheral equipment coincident with workday time periods when energy consumption of the control device (PC) is lower than the APS threshold setting.

CPE_{NWD} = Average energy consumption of peripheral equipment coincident with non-workday time periods when energy consumption of the control device (PC) is lower than the APS threshold setting.

1.2.2 Predicted Savings

The following represents the predicted savings for the two buildings at 10 and 20 W APS threshold settings:

- Predicted average annual savings of the monitored workstations at each site:
  - Office building 1:
    - Average annual savings at 10 W threshold setting – 13.3 kWh
    - Average annual savings at 20 W threshold setting – 26.9 kWh
  - Office building 2:
    - Average annual savings at 10 W threshold setting – 3.5 kWh
    - Average annual savings at 20 W threshold setting – 4.7 kWh
- Predicted range of savings associated with individual monitored workstations:
  - Office building 1:
    - Annual savings range at 10 W threshold setting – 0-32.4 kWh
    - Annual savings range at 20 W threshold setting – 0-46.0kWh
  - Office building 2:
    - Annual savings range at 10 W threshold setting – 0-30.5* kWh

- Annual savings range at 20 W threshold setting – 0-30.5* kWh

*The savings range is identical for the two threshold savings for building 2 because the minimum savings are associated with a PC that is left on 24/7 and the maximum savings are associated with a PC that is turned fully off during non-work hours and never enters a power-saving sleep or hibernation mode.

1.2.3 Tier 1 APS Cost

Informal research of pricing from online retailers such as Amazon and Office Max as well as the local retail stores Staples and Best Buy indicated that retail prices for Tier 1 APS products average about $30 per strip. Online retailer Energy Federation Inc. (EFI) offers several different models ranging from $26.25 to $54.95. Installation of the devices if included in a direct install program is estimated to be $5 per unit or less.

1.3 Additional Conclusions and Recommendations

Perhaps more significant than the actual monitored data is the operational information that the project team learned about APS, PC operating systems, and various workstation configurations. The conclusions and recommendations are detailed in Section 9, but they can be summarized in the following way:

- The APS strategy of disconnecting power to peripherals upon shutting down, or entering a "sleep" mode works reliably with most PC and peripheral configurations.
- Current APS products are targeted primarily at home entertainment systems. Current manufacturer instructions included with APS products focus solely on those installations.
- In order to harvest significant savings, PC operating system power settings, including power saving settings, must be understood and adjusted to assure compatibility with APS operation.
- Many staff members continue to leave their PCs operating when they are out of the office. In some cases this is associated with remote access to the PC, but it is also associated with an outdated belief that PC operation is more reliable with 24/7 operation, and/or an incorrect assumption that an operating screensaver provides a power-saving function.
- Laptop PCs with docking stations are workable configurations for APS, as undocking the laptop automatically drops the power at the control outlet to a very low level (+/- ½ watt), thereby disabling power to the peripherals.
- Manufacturers of peripheral equipment such as printers and monitors are continuing to reduce the power consumption during standby modes. Modern flat-screen monitors consume less than 1 W on standby, with the current ENERGY STAR rating for monitors

requiring a maximum power draw of 0.5 W on standby. Recently introduced laser and inkjet printers consume 1 to 6 W on standby, according to independent product tests performed by services such as CNET[2]. The 2014 ENERGY STAR rating for standard and large-size printers limits standby power to 0.6 and 2.5 W, respectively. This is a positive development for energy efficiency, yet it limits the potential savings associated with APS products.

- Because of the above limitations, upstream program approaches for Tier 1 APS devices are not likely to be valuable for commercial office environments. Direct install or approaches that engage facility and IT staff offer more potential for success because appropriate workstations can be identified and power savings settings on operating systems can be optimized for use with the APS devices.
- M&V for APS installations can be approached by a variety of accepted methods. However, simply verifying that they have remained in place and reviewing the savings predictions is not likely to generate accurate results.
- Short-term persistence of APS units was reported to be very good with this study. After 3 months, no units had been removed or altered, and staff members did not report any disruption of work activities.
- Threshold settings for Tier 1 devices were tested to be inaccurate, and reliable savings cannot be predicted above 10-watt threshold settings.
- There appears to be some free-driver effect with the installation of APS units, as some staff members reported that it made them more aware of plug loads and caused them to turn off devices that were not in use.

[2] http://reviews.cnet.com/printers/

Technology Overview

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This section presents a brief description of APS product types that were assessed for this project. Further details are available in the Phase I Report (http://neep.org/emv-forum/forum-products-and-guidelines/index#emergingtechnologies) as well as in the final report of the NEEP coordinated Advanced Power Strip Data Working Group (http://www.neep.org/Assets/uploads/files/market-strategies/NEEP-APS-Deemed-Savings-Report-4-30-12.pdf).[3]

APS units resemble standard power strips but have additional outlets with different functionalities. There are two main types:

1. **Tier 1 APS** – Tier 1 strips are the focus of this research report. The typical Tier 1 strip has one "control" outlet, which controls four to six controlled outlets. Two or more outlets are uncontrolled and are always on. The control outlet operates as a master outlet that supplies power to an electronic device, such as a television or computer, which is used in conjunction with one or more peripheral devices. When a control (master) device is turned off or enters a low-power (sleep or hibernation) mode, the strip interrupts power to the controlled peripherals: items such as monitors, printers, speakers, and media players. When power is returned to the control device, the controlled outlets are automatically re-powered. Peripherals that may need to be on (or available) at all times, such as fax machines, telephones, and DVRs, are typically plugged into the outlets that are always on.
2. **Tier 2 APS –** These strips incorporate additional features, allowing more advanced control of plug loads. The additional capabilities may include: occupancy/vacancy sensing; adaptive calibration for the sensing of standby power usage; and associated software for PC installations. Tier 2 units are currently being introduced to the U.S. market and/or are in development stages. Some manufacturers are introducing Tier 2 products that are specifically designed for office environments.

[3]Additional sources of information that may be useful to program administrators interested in including APSs in energy efficiency programs include: Earle, L. and B. Sparn, "Results of Laboratory Testing of Advanced Power Strips." ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D.C., 2012. NEEP Testing Working Group. "Advanced Power Strips Testing Protocol, version 0.1," forthcoming in 2013.

3. **Other plug-load controls** – Two other types of plug-load controls are worthy of mention. The first is a power strip with an occupancy sensor that has a typical configuration of six occupancy controlled outlets and two outlets that are always on. The occupancy sensor, rather than the status of a master device, controls the power to the controlled outlets. The occupancy sensor is designed to be installed in such a manner as to only respond to occupancy/vacancy in the immediate area of the device. A user-adjustable time delay prevents short cycling of equipment during brief periods of vacancy. When vacancy is detected after the time delay, the strip disconnects power to the controlled devices. Power is re-established when the occupant returns. The second is also an occupancy/vacancy controlled system, but it is hardwired to electrical outlets in the space. Typically one-half of the outlets in an office space are controlled by the system's occupancy sensor.

None of the plug-load control devices discussed above is intended to have any impact on the usability of electronic devices; they achieve savings only by reducing the power consumption of controlled devices to zero during inactive periods.

Again, the focus of the research and this report is the savings associated with Tier 1 APS; however, the results do help inform the potential for products and strategies that offer enhanced capabilities.

Primary Research Goals

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The overriding goal of the primary research conducted was to close the knowledge gaps identified during the first (secondary research) phase of this project, particularly concerning the potential for APS savings in commercial office settings. Areas identified for investigation during primary research included:

- **Suitability for commercial office environments** – APS products are widely promoted and sold for residential applications. Within that sector, home entertainment systems are considered to be the main target market. Additionally, many efficiency program administrators have introduced this measure for residential applications, and much study has been conducted on the potential savings. Little program experience and/or research knowledge is associated with APS for commercial office applications. As such, an important research goal is to determine the degree to which currently available APS products are suitable for commercial environments.
- **Compatibility with common computers and peripherals** – Because APS products are so closely associated with home entertainment equipment, we sought to identify any potential conflicts with typical office workstation equipment and operating systems.
- **Potential conflicts with IT protocols** – Many businesses rely on IT departments, or IT firms, to make all decisions regarding computer-based systems and to be fully responsible for system performance and maintenance. A project goal was to determine what, if any, challenges installing APS products would present for IT personnel.
- **Suitability for upstream program distribution** – Many efficiency programs feature "upstream" marketing approaches that engage market actors early in the product supply stream. For example, an upstream lighting program might pay an incentive to a distributor for stocking an item, rather than paying an incentive to the end user. Valuable feedback from the Forum members during the first phase of this project included the recognition that most program administrators sought to learn the potential for supporting the upstream distribution of APS products. An objective of the primary research effort was to identify barriers to upstream programmatic efforts.

- **Persistence factors** – With plug-in technologies, the persistence of savings is a major consideration. The ease to which products can be removed or configurations altered potentially degrades persistent savings, especially if operational difficulties and/or user frustration is encountered.
- **Actual field performance compared with identified potential performance** – The NEEP APS working group primarily focused its research on the potential savings of Tier 1 APS products in home entertainment and home office applications. The goals of this phase of the project included the measurement of actual field performance of APS in commercial workstations.
- **Identifying any additional market or technological barriers** – Interviewing participants before and after the installation of APS units afforded the opportunity to record any barriers encountered that could be factors in implementing programs promoting APS products.

APS Operational Modes for Workstations 4

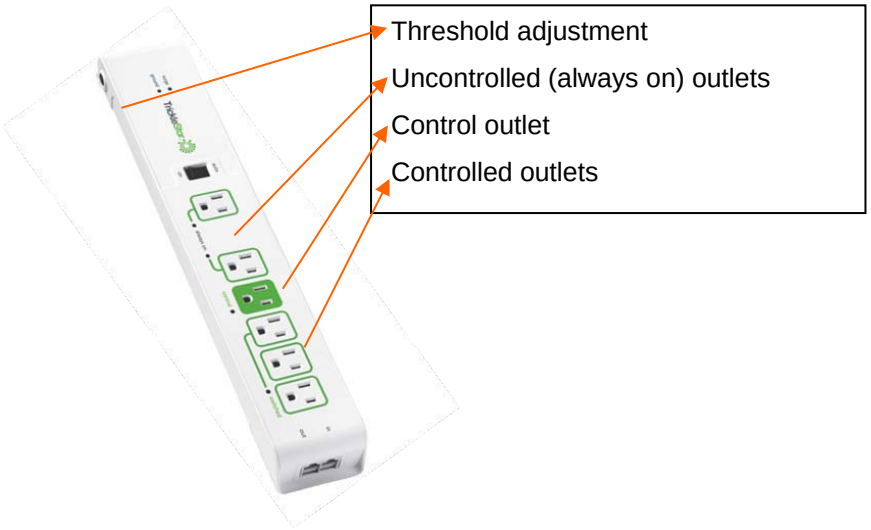
The following sections describe the operational modes of typical APS units when used to control power usage for workstation environments.

4.1 APS Configuration

Tier 1 APS products, as illustrated in Figure 4-1, designed to control equipment based on the status of a "control" outlet are typically configured as follows:

- **Control outlet** – One outlet is designated as the "control" outlet, and power consumption associated with this outlet is monitored.
- T**hreshold control** – This control is used to adjust the power consumption level at which controlled outlets are automatically switched on or off. There are three common strategies:
    1. A stepped control offering with typically three preset thresholds. The threshold levels of the units we encountered were 10, 20, and 40 W.
    2. An adjustable potentiometer allowing the threshold to be set at any level between approximately 10 and 40 W.
    3. An adaptive threshold that is intended to automatically adjust the threshold based on the usage patterns encountered.
- **Controlled outlets** – Typically three to five outlets are controlled by the control outlet and the threshold setting.
- **Uncontrolled outlets** – One or more outlets that are not automatically controlled are included in the power strip.

Figure 4-1
Typical Tier 1 APS Device



4.2 Typical APS Setup for Workstations

In most cases, APS products installed in commercial office spaces are utilized to turn off peripheral equipment when the occupant's PC is not actively in use. The typical setup is as follows:

- ❑ Connect the workstation PC to the "control outlet."
- ❑ Connect monitor(s), printers, powered speakers, and other peripherals only used when actively using the PC to the "controlled" outlets.
- ❑ Connect telephones, network devices, and task lighting (if used during times when the PC is inactive) to "uncontrolled" outlets.

4.3 APS Threshold Settings

The most common APS devices utilize three threshold settings; typically 10, 20, and 40 W. In order to maximize savings while avoiding operational challenges, the threshold needs to be set such that when the PC is inactive for a significant period of time, and/or is turned off by the operator, the controlled peripherals are automatically turned off. The setting selected will depend on the power consumption of the particular PC installed, the occupant work patterns, and the software power settings of the operating system.

4.4 APS Sequence of Operation

The actual operation of the APS is very simple:

1. Operator turns on the PC.

2. When the power consumption of the PC reaches the threshold setting the peripherals that are switched to the "on" position are activated. Typically, the computer booting procedure draws enough power to reach the threshold.
3. While someone is operating the computer the peripherals remain on unless they are turned off at their switch.
4. When the computer is idle, the peripherals will remain on, or be turned off, depending on the power-saving settings selected in the PC's operating system software and the threshold setting of the APS.
5. When computer activity is resumed the peripherals are again powered on. Peripherals with "momentary contact" switches (one-button push-on and push-off) may need to be turned back on at the switch. Momentary contact can actually increase total savings, but could also lead to user frustration.
6. When the user turns off the computer and/or selects a "hibernation" or "sleep" mode, the peripherals will be turned off. The peripherals remain unavailable until the PC is reactivated.

Primary Research Methodology

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After the secondary research phase was concluded, the decision was made to secure two commercial office locations that included workstations that are occupied for typical office hours. Efficiency Vermont volunteered their services and worked with their business program customers in locating two sites for monitoring workstation power usage patterns. In addition, ERS tested the functionality of the three most commonly available APS brands in their offices to assess operational functionality (one model from each of the three brands was tested). The results of the testing are presented in Section 8 of this report.

5.1 Monitored Site 1

The first site monitored by the project team is occupied by the administrative support offices of a nonprofit educational organization offering a variety of educational and leadership programs for high school, undergraduate, and graduate students. The campus is located in Brattleboro, Vermont, with the administrative offices located in a restored three-floor Victorian building. The workstations occupy a variety of spaces including small private offices and larger open areas containing several open -plan desks or half-height partitions.

The building incorporates thirty-one workstations of varied configurations. After the elimination of five workstations that were inactive due to vacations, work travel, etc., twenty workstations were selected for monitoring. Of the twenty selected, twelve consisted of laptop PCs with docking stations and eight included desktop PCs. All workstations included a landline phone that connected via Ethernet port through the docking station for laptops or an Ethernet card for desktop machines.

Information technology (IT) services are handled by in-house staff, and there is no established policy for operating system power management settings. A 7:00 a.m. tour of the offices allowed the survey team to observe inactive computer settings with three systems operating in screen-saver mode. The remaining PCs were fully shut down as the result of either a manual shutdown or an automatic power saving, either of which would interrupt power to peripherals if the computer were properly connected to an APS device.

The IT department is gradually replacing the remaining desktop machines with laptops, and a full conversion is anticipated within the next year. The tour and later discussions with

staff revealed that about half of the laptop machines are un-docked and taken home on any given evening.

Although a variety of configurations were encountered, the most representative workstations at this facility consisted of the following control and controlled items:

- One laptop with docking station
- One 20" flat screen monitor
- One additional item (this varied greatly: local printer, task lights, powered speakers, electric picture frames, etc.)

5.2 Monitored Site 2

The second monitored site is a large office building located in Montpelier, Vermont, that consists of six floors of modern office space with more than 500 workstations. In 2009 the building received a LEED Silver rating from the U.S. Green Building Council under the existing building program (LEED EB), and the building owners actively pursue energy efficiency improvements promoted by Efficiency Vermont.

Working with facility staff, the survey team decided to focus on the first- and fifth-floor offices, because they provided a representative mix of commercial office equipment and work schedules. The first floor contains the accounts payable department, which maintains regular 9-to-5 office hours. The workstations on this floor all include desktop PCs. A survey/tour revealed that about half of the staff on this floor turn off their computers at the end of the workday, while the others only "log off," leaving their machines operating. Only one of the staff members interviewed accessed their machine from a remote location during off-hours.

By contrast, the fifth-floor offices are primarily staffed by customer service representatives who often access their machines from remote locations and during time periods outside of the typical 9-to-5 workday. Most of the workstations on this floor are equipped with desktop PCs. A small percentage of the staff utilizes laptop PCs with docking stations. The staff in this department utilize a remote access system called pcAnywhere that allows them to access their office machines from a remote PC, and they routinely do so both from home and while travelling. This requires that the office PCs remain on while the workstation is vacant. Utilizing "sleep" or "hibernation" modes does not resolve the issue, as returning to an active mode requires the user to log on to the office machine. A review of the software documentation for pcAnywhere and a discussion with the facilities staff did not reveal a methodology that would allow the office PCs to hibernate while still allowing remote access. Eight desktop PCs and two laptop PCs with docking stations were monitored on this floor.

Nearly all workstations in both departments included two flat-screen monitors. There were some local printers, but most staff accessed shared server connected printers. A variety of other plug loads ranging from powered speakers to decorative string lights were observed. The most representative workstations at this facility consisted of the following control and controlled items:

- One desktop PC
- Two 20" flat-screen monitors
- One additional item (this varied greatly: local printer, task lights, powered speakers, electric picture frames, etc.)

Monitoring Procedure

6

The monitoring procedure followed was systematic and consistent with an effort to record the potential savings at the workstations without modifying or influencing any staff behavioral patterns or equipment settings. The procedure followed consistently across both sites is outlined in this section.

- **Selection of monitoring equipment** – Typically, site data logging is performed with recording power meters that monitor a circuit or an individual piece of equipment. For APS applications this is not ideal, as the intent is not to monitor the APS device, but to monitor the power usage of devices that can potentially be controlled by the APS. As such, the monitoring procedure could be described as modeling the operation of an APS unit and recording the consumption of both the control (PC) and controlled (peripherals) devices. We worked with Embertec, an Australian firm which has developed an energy monitoring device specifically designed to record the usage patterns and power consumption of plug loads. The Embertec Saving Verification System (SVS), shown in Figure 6-1, monitors and records the power consumption of the PC and the peripheral devices simultaneously at 1-second intervals. The logged data is stored on memory cards and/or is uploaded to a server via a wireless connection. During the monitoring period the PC user continues to operate their PC and peripherals without any change in routine.

Figure 6-1
Embertec Savings Verification System (SVS) Data Logging Device

- **Pre-monitoring interview and tour** – With the assistance of Efficiency Vermont personnel, ERS visited each site prior to the installation of data logging equipment. During these visits we met with both facility and IT personnel. Discussions focused on the general staff routines, IT procedures, and a thorough description of the data logging procedure. A tour of the facilities assisted in selecting departments from which to select participant workstations. A frequently asked questions (FAQ) document was distributed to all participating personnel.
- **Data logger installation –** In order to create as little disruption as possible and to allow the observation of PC settings during off-hours, the installation team began installations as early in the morning as possible. The following procedure was followed:
    1. The make and model numbers of the PC and peripherals were recorded.
    2. A power meter was used to record power consumption of PC and peripherals for reference to recorded data.
    3. The Embertec SVS data logger was installed and proper operation confirmed, including the establishment of a wireless data connection where available.
    4. Each staff member was informed about the purpose and operation of the logging device and assured that no change in work habits was needed. The FAQ was also redistributed at this time.
- **Data logger removal** – Following 2 weeks of data logging at each site, we revisited and:
    - Surveyed the installations and verified that all data loggers had remained in place and operational.
    - Removed the data loggers and replaced them with a Tricklestar™ Tier 1 APS unit, describing the products operation and leaving the manufacturers' instruction sheet with the participating staff member.

Figure 6-2
Tricklestar – Tier 1 APS Device

- **Follow-up site visits** – Approximately 3 months following the installation of the Tricklestar Tier 1 APS units, we returned to the two sites in order to interview the staff regarding their experiences with the APS product and to observe installation persistence. We met with the facilities director at each site and toured the facility, interviewing staff at their workstations, and found the following:
  - No complaints or concerns regarding operation of the APS units had been communicated by staff to the facility managers.
  - 100% persistence; all APS units were still installed and were operational.
  - The staff had limited awareness of the functionality of products at their workstations.
  - A majority of the staff found the APS devices to be unobtrusive, with typical responses being "I forgot it was there" and "Sometimes I notice it turning off my (printer/task light/monitor) if I shut down."
  - A few staff members reported that they had been modifying their work habits to some degree in order to take advantage of the APS functionality. Exploring this with the interviewee revealed that some staff members, who had previously left their computers running, were now shutting them down at the end of the day.
  - No staff members reported adjusting, or being motivated to adjust the power saving modes on their PCs. Some mentioned that they already had an operational screensaver, believing that was a power saving setting. (Screensavers are designed to prevent the "burn-in" of static images on monitors, and they maintain PCs in an operational mode with power being consumed to generate the screensaver images.)

- Many participants, especially in the customer service department of building 2, expressed that they were worried that if they attempted to take advantage of the APS potential, they would be unable to access their PCs from remote locations when needed.

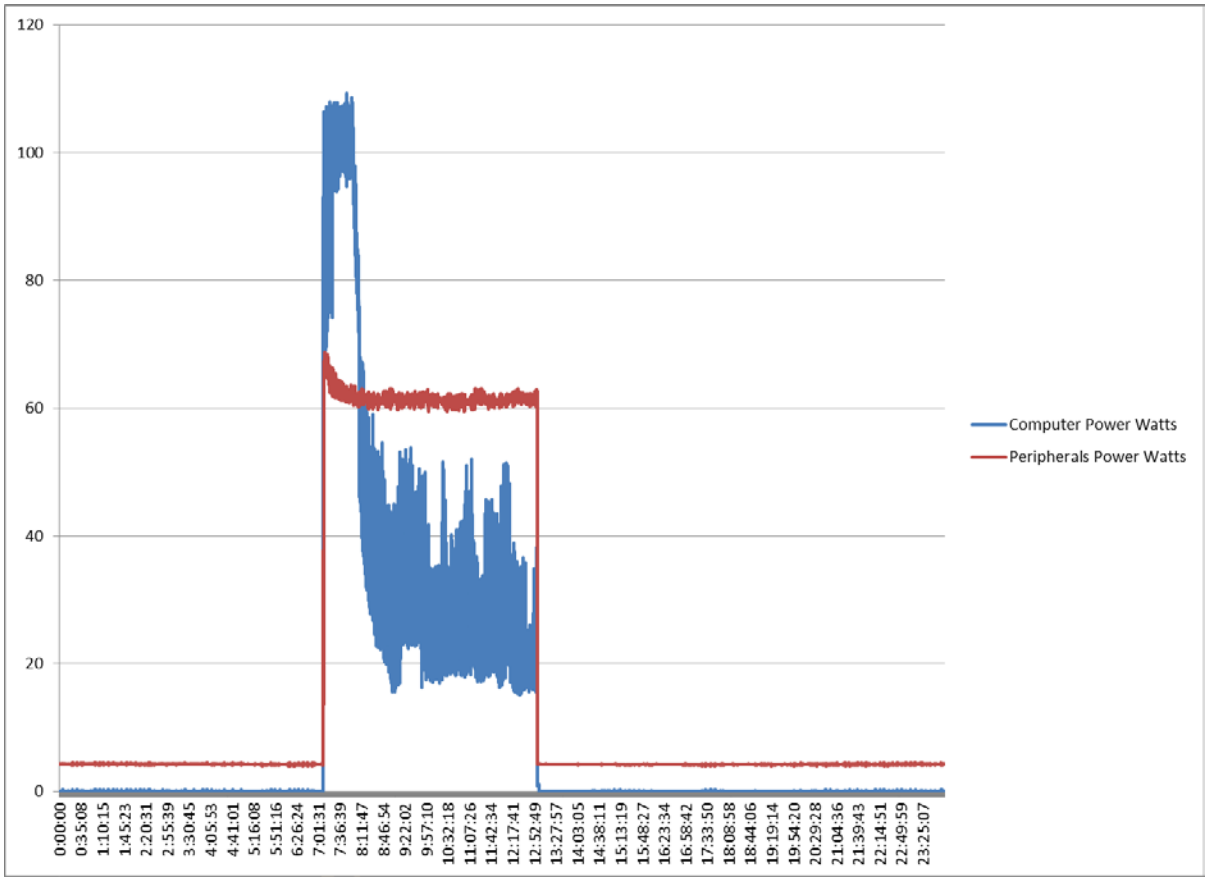
Site Data Analysis

7

Following the field monitoring at both sites, the data was uploaded to a spreadsheet tool by Embertec and checked for consistency with the site-recorded power loads at each workstation. Embertec identified the potential annualized savings at a 10-watt control threshold and delivered those results and the raw logged data to the project team.

Given the 1-second intervals for recorded power consumption, data sets were extremely large, but they offered the valuable ability to search for any aberrations that would potentially bias the data results. ERS examined the data sets, removing any such aberrant data. Very little data was excluded and it was associated with the failure of one logging device and a few spikes in the recorded power consumption that was likely caused by a technical irregularity in the data monitoring or transfer process. Figure 7-1 presents the raw logged data for a 24-hour period for one of the workstations. The data illustrates that upon boot-up of the computer, the peripheral equipment operates at just over 60 W. It can also be seen that the PC uses the most power during and immediately following the boot-up period. This is likely because the hard drive is active while the staff person executes a morning routine, which might include checking and deleting emails, accessing the Web, opening documents, etc. When the computer is shut down, the peripherals enter standby mode and consume just under 5 W of power. The potential savings from Tier 1 APS, for this time period, can be assumed to be the standby power of the peripherals from the computer shutdown at 1 p.m. until the computer is next rebooted.

Figure 7-1
Logged Data from a Single Workstation



A spreadsheet tool was developed that allowed the 1-second interval data to be imported and consolidated for analysis. The tool allowed the project team to evaluate the potential savings for three control threshold settings: 10, 20, and 40 W. In order to accurately predict annual savings from 2 weeks of recorded data, weekday and weekend data was analyzed separately with the results then extrapolated for annual savings.

Analysis of the interval data and testing of Tier 1 APS units led to a conclusion that the 40 W setting could not reliably be used for PCs, as the power consumption of the PC straddled the 40 W threshold during normal computing tasks. The resulting on/off cycling of power delivered to the peripherals would not be acceptable to workstation occupants. We have included savings calculated at the 20 W threshold setting, as that level is compatible with most PC power consumption patterns. However, our testing of APS products raised questions regarding the accuracy of both the 20 and 40 W threshold settings of currently available APS units. See Section 8 of this report for more information on the testing of threshold settings.

Although we identified barriers to obtaining reliable savings at a 20 W control threshold, we are presenting those savings figures, in addition to the 10 W threshold savings, as those barriers are easily overcome and product improvements should readily close this gap.

The calculated potential savings associated with the two sites is summarized as:

- Predicted average savings of the monitored workstations at each site:
  - Office building 1:
    - Average annual savings at 10 W threshold setting – 13.3kWh
    - Average annual savings at 20 W threshold setting – 26.9 kWh
  - Office building 2:
    - Average annual savings at 10 W threshold setting – 03.5 kWh
    - Average annual savings at 20 W threshold setting – 04.7 kWh
- Predicted range of savings associated with individual monitored workstations:
  - Office building 1:
    - Annual savings range at 10 W threshold setting – 0–32.4 kWh
    - Annual savings range at 20 W threshold setting – 0–46.0 kWh
  - Office Building 2:
    - Annual savings range at 10 W threshold setting* – 0–30.5 kWh
    - Annual savings range at 20 W threshold setting* – 0–30.5 kWh

* The savings range is identical for the two threshold savings for building 2, as the minimum savings are associated with a PC that is left on 24/7 and the maximum savings are associated with a PC that is turned fully off during non-work hours and never enters a power-saving sleep or hibernation mode.

Table 7-1 presents the average annual savings calculated for the monitored workstations at the two sites, including simple payback calculations.

Table 7-1
Calculated Average Savings

Building 1		
Average Annual Savings @ 10 W Threshold Setting	13.3	kWh
Average Annual $ Savings @ $0.14/kWh	$1.86	
Average Tier 1 APS Cost	$30.00	
Simple Payback	16.1	Years
Average Annual Savings @ 20 W Threshold Setting	26.9	kWh
Average Annual $ Savings @ $0.14/kWh	$3.76	
Average Tier 1 APS Cost	$30.00	
Simple Payback	8.0	Years
Building 2		
Average Annual Savings @ 10 W Threshold Setting	3.5	kWh
Average Annual $ Savings @ $0.14/kWh	$0.49	
Average Tier 1 APS Cost	$30.00	
Simple Payback	61.2	Years
Average Annual Savings @ 20 W Threshold Setting	4.71	kWh
Average Annual $ Savings @ $0.14/kWh	$0.66	
Average Tier 1 APS Cost	$30.00	
Simple Payback	45.5	Years

Table 7-2 presents the range of savings calculated for the monitored workstations at the two sites, including simple payback calculations.

Table 7-2
Calculated Range of Savings

Building 1		
Annual Savings Range @ 10 W Threshold Savings	1.4-32.4	kWh
Average Annual $ Savings Range @ $0.14/kWh	$ 0.19 - 4.53	
Average Tier 1 APS Cost	$30.00	
Simple Payback Range	6.6 - 157	Years
Annual Savings Range @ 20 W Threshold Savings	2.4 - 46.0	kWh
Average Annual $ Savings Range @ $0.14/kWh	$ 0.34 - 6.44	
Average Tier 1 APS Cost	$30.00	
Simple Payback Range	4.7 - 88	Years
Building 2		
Annual Savings Range @ 10 W Threshold Savings	0-30.5	kWh
Average Annual $ Savings Range @ $0.14/kWh	$ 0 - 4.27	
Average Tier 1 APS Cost	$30.00	
Simple Payback Range	≥ 7	Years
Annual Savings Range @ 20 W Threshold Savings	0 - 30.5	kWh
Average Annual $ Savings Range @ $0.14/kWh	$ 0 - 4.27	
Average Tier 1 APS Cost	$30.00	
Simple Payback Range	≥ 7	Years

7.1 Savings Associated with Various Workstation Configurations

Although the sample size for many of the configurations we encountered is not large enough to support statistical analysis, we are able to make some comparative judgments regarding the potential savings for the workstations we encountered, as follows:

- **Laptop machine with docking station, monitor, and at least one peripheral** – This configuration offers the largest savings potential. When laptop PCs are removed from their docks, to be taken home for the evening or weekend or for working off-site, the power to the "control" outlet automatically drops below any APS power threshold, thereby turning off the controlled peripherals. Oft-heard claims that the laptop chargers continue to consume significant energy are unfounded, as our tests showed that these chargers/power supplies consumed less than 0.5 W when inactive.
- **Desktop machines with monitor and at least one peripheral** – Not surprisingly, workstations with multiple peripherals also offer significant savings. Laser printers typically consume more energy than inkjet printers. Multiple monitors, scanners, fax machines, powered speakers, electronic picture frames, etc., can all add to the controllable loads.
- **Workstations with minimal peripherals** – We encountered many workstations that contained very little in controllable plug loads. At 0.3–0.6 W for a modern flat-screen monitor, and the same for a modern printer, in standby modes, it is hard to justify APS controls. Although office environments are continually adding to overall plug loads, the electronics industry is trending toward better automatic control of standby losses as built-in features.
- **Remotely accessed PCs** – Given the current configurations of remote-access PC operating systems, there are very little savings obtainable with Tier 1 APS using the PC status as the controlling device. Possible solutions include combining occupancy sensing and/or PC activity monitoring in next-generation APS products. However, if current trends toward "cloud" computing continue, remote access PC setups are likely to become less prevalent.

Operational Testing of APS Units

8

Although the scope of this project did not include systematic technical testing of APS units, it was determined that limited testing of the operation of APS units would help inform the potential of APS for office environments and assist in interpreting the logged field data.

ERS purchased two each of the three APS products that are most prevalent in the local marketplace and/or available online. The configuration of the three products is described as follows:

1. **APS with one "control" outlet, four "controlled" outlets, and two "always on" outlets –** Three threshold settings are user-selectable: 10, 20, and 40 W.
2. **APS with one "control" outlet, four "controlled" outlets, and two "always on" outlets –** The threshold setting is user-selectable on a scale of approximately 10 to 40 W, with no presets.
3. **APS with one "control" outlet, five "controlled" outlets, and two "always on" outlets –** Threshold setting is not user-selectable but is intended to auto-calibrate, sensing when the equipment is active and when it is off or in a steady low-power state such as occurs during sleep or hibernation modes.

Utilizing an Ensupra™ plug load monitor (Figure 8-1), we were able to test the functionality of the Tier 1 APS units at various threshold levels.

- Test Methodology I:
  - Plug the plug load monitor into the "control" outlet.
  - Plug the PC into the plug load monitor.
  - Plug a task light into one of the "controlled" outlets.
  - Operate the PC through a variety of normal functions, including word processing, spreadsheet data entry, and Web browsing.
  - Activate sleep and hibernate settings in Microsoft Windows 7 Professional.
  - Observe the power consumption of the PC and the status of the task light throughout the test procedure.

- Test Methodology II:
  - Plug the plug load monitor into the "control" outlet.
  - Plug a portable power tool motor speed controller into the plug load monitor to act as a variable wattage dimmer for a 60 W incandescent lamp.
  - Plug a lamp socket with a 60 W incandescent lamp into the speed control/dimmer.
  - Plug a task light into one of the "controlled" outlets.
  - Using the motor speed control, vary and monitor the power consumption of the 60 W lamp.
  - Observe the power consumption of the test lamp and the status of the task light throughout the test procedure to determine the accuracy of the threshold settings.

Figure 8-1
Plug Load Power Monitor

8.1 Test Conclusions

The testing demonstrated that all three types worked very reliably, turning off controlled outlets when the power draw dropped below approximately 10 – 15 W. However, at higher power thresholds, we observed issues with all of the products. When testing the two units incorporating adjustable threshold settings, and with the lowest setting selected, the peripheral task light was turned off whenever the PC was turned off, or entered a sleep or hibernation mode. However, setting the threshold to higher settings had little or no effect on the power consumption level for turning off the controlled outlets. Despite the changed settings, the controlled outlets remained powered until the power consumed at the control outlet dropped below 10 W. The threshold for turning on power to the controlled outlets did respond to changing the settings, but there are no additional savings associated with a higher turn-on threshold setting.

The APS unit with the auto-calibration setting turned off the controlled outlets when 10 – 15 W was reached. We were not able to observe automatic turn-off of the controlled outlets at steady states above 15 W. More extensive testing, beyond the scope of this project, would be needed to definitively determine if the auto-calibration feature operates as intended and would adapt to changing standby power levels over time.

Conclusions and Recommendations

9

The primary research portion of this project has allowed us to better understand the potential for Tier 1 APS products in commercial office settings, and to refine savings predictions and associated M&V methodologies given the value in recording and analyzing detailed second by second data at the monitored workstations.

Our overall conclusion is that there are certainly obtainable savings associated with controlling workstation plug loads with APS products. However, the savings are modest with the average calculated annual savings for the two office spaces monitored reported at 13.26 and 3.5 kWh. At these savings levels, the average installation would not meet the cost-effectiveness criteria of Forum member efficiency programs. Carefully selecting the workstations for installations, and providing operational instructions, including PC power savings set-up instruction, would produce improved results. We further conclude that the full potential for savings with Tier 1 APS technology cannot be realized without modifications to products and product instructions, and that careful deployment is a key factor.

Further development of Tier 1 products and the emergence of Tier 2 APS products should expand the viability of APS for commercial office environments.

9.1 Product Limitations & Emerging APS Opportunities

Tier 1 APS products commonly available today were primarily designed for home entertainment usage. In most cases, the television is the controlling piece of equipment, and equipment typically not used without the television being on is controlled. In these cases, the television when turned off is in a standby mode, drawing very little power, and associated peripherals such as DVD players, VCRs, receivers, powered speakers, etc., remain off while the television is in standby.

Workstation environments however, experience inactive time periods when the PC is not necessarily turned off. These periods may extend for several minutes or several days depending on work habits, PC setups, software settings, and company policies. In order for Tier 1 APS technology to reach their savings potential, they will need to be accurately calibrated, or include more sophisticated automatic calibration features that facilitate the powering down of peripheral equipment when computer activity is idle. Emerging Tier 2 APS devices designed to

specifically target plug loads in computer environments are intended to exploit the savings opportunities associated with idle computer activity. The data collected for this study could be useful in assessing the savings potential of Tier 2 APS devices; however, that has not been the focus of this effort. Embertec, who assisted with this study, has been analyzing data from this and other field trial studies in order to assess the potential performance factors of Tier 2 products. They have agreed to provide analysis results to the Forum upon request.

9.1.1 Manufacturer-Supplied Instructions

Although current Tier 1 APS products, including the three we tested, are promoted as appropriate for office environment, it is clear from our review of the instructions that the emphasis is on the home entertainment market. Instruction manuals focus on using the television to control entertainment peripherals such as DVD players and game consoles. Although the typical setup for PCs can be intuitively determined, instructions specific to office environments are needed to assure that purchasers understand PC power settings and can determine which peripherals can be controlled without work disruption.

9.2 PC Power Settings Considerations

A basic function of Tier 1 APS units is that when the equipment plugged into the "control" outlet is turned off, the controlled peripherals are turned off. This functionality works very well in a workstation environment. However, many PC operators do not shut down their systems during inactive periods. These inactive periods may include lunch breaks, meetings away from the workstation, daily off-time, and even vacation and other leave periods. This situation can be attributed to a number of reasons including: adherence to outdated protocols which encourage 24-hour operation of PCs, lack of awareness of power consumption, and a lack of awareness or understanding of PC operating system power-saving settings. At one of our participant sites, this situation was further affected by the staff usage of remote-access software that required host machines to remain operating.

Many of the participant staff members that we interviewed incorrectly assumed that their machines were entering a power-saving mode when the screensaver was activated. However, screensaver modes are not designed to save power and, in fact, they increase power consumption in order to operate the graphics displayed on the screen. In addition, some screensavers actually block sleep and hibernation modes regardless of the power-saving settings. "Locking" the system also does not save power; it simply disables the keyboard and mouse from communicating with the PC until the password is re-entered.

Depending on the particular operating system in use, either sleep or hibernation modes, or both, are included in Windows and Apple Macintosh operating systems. The two modes are very similar, with the typical variation being that sleep modes utilize a small amount of power

to maintain work in progress, while hibernation modes write the current activities to a hard disk and power down the system. For both modes, the intention is to bring the system back to its previous state upon returning to an active mode.

Sleep and hibernation modes can be instantly selected from the start menu; however, the maximum savings is achieved when the sleep mode is configured for automatic operation. The setup is menu driven and typically allows the user to select from many combinations of time delay before the sleep mode is deployed. For example, with Windows 7, the power-saving mode can be adjusted in Control Panel under Power Settings. Automatic delay periods for entering sleep mode are selectable from a minimum of 1 minute to a maximum of 5 hours, or the user can choose to disable all automatic power-saving modes. In most cases, setting the sleep delay within 5 minutes to 1 hour works well with APS units, allowing for significant savings without undue cycling of peripheral machines.

9.3 Other Workstation Considerations

Additional workstation considerations include the way peripherals are used and the desire to access the PC from remote locations. Typically controlling a monitor(s) and a local printer based on the PC operational status presents little difficulty. However, other peripherals may not be so readily adaptable. For example, workers may wish to have the use of task lights, adding machines, fax machines, etc. when their PCs are powered down or in a sleep mode. Current Tier 1 APS units incorporate no override, so either the plug would need to be moved, or the PC activated to power on peripherals under these circumstances.

Of particular concern is PC access from remote locations. As discussed in Section 5.2, Symantec's pcAnywhere™ was in use by virtually all the customer service representatives at building 2. Powering down the PCs or selecting power savings modes in that department is not an option due to policies regarding log-on passwords. Logging in to servers from remote locations utilizing virtual private networking (VPN) does not present the same obstacles.

9.3.1 Home Office Environments

It is not within the scope of the primary research phase of this project to assess the viability of APSs for home office environments. However, the results do lead to some conclusions that may be helpful in determining programmatic support of APS for home offices:

- **Product instructions should include home office applications** – As discussed for commercial office applications, the instructions provided with Tier 1 APS products are focused on home entertainment systems. Instructions regarding the use of APS with PCs and common peripheral equipment would be helpful for home office applications. The instructions should include recommended settings for PC operating system power-saving features.

- **Home office configurations likely offer higher savings potential** – It is a safe assumption that, on average, there are more computer peripherals per PC operating in home offices than in commercial offices, as there is little sharing of network printers, fax machines, copiers, etc. And it is also likely that those peripheral machines used in home offices are not replaced as often. Most home offices include a printer, scanner, and fax machine, or an "all-in-one" multi-function machine. Older machines use significantly more power on standby than do newer peripherals. These factors contribute to significantly higher potential for savings.
- **Longer standby times also may lead to higher savings –** Operating hours for most home offices are shorter than for commercial offices. The resulting longer standby times also suggest higher potential APS savings for home offices.

9.4 Facility Staff Cooperation

For most larger firms, equipment operational protocols and policies are established by management and/or IT departments. During our field trials we received excellent cooperation from facility management. Without such cooperation it would be much more difficult to successfully deploy APSs throughout a commercial office environment. Program models that coordinate installations with facility staff will likely obtain larger savings than will upstream market approaches.

9.5 Savings Persistence

Of particular concern with plug-in technologies is the potential persistence of the savings. As with other plug-in technologies, APS units can be easily removed, and/or the PC and the peripherals can be plugged in to the wrong outlets. Situations that might lead to early retirement of APSs include:

- User frustration if control of peripherals presents workflow issues, as might occur if inappropriate peripherals are controlled or threshold settings are adjusted incorrectly.
- Installation of new computer or peripheral hardware that might be plugged in to the wrong outlets and/or may require an adjustment of the power threshold.
- Renovation of spaces, or refreshment of workstation peripherals or PCs themselves.
- APS partial or total failure (there are anecdotal reports of premature failure of some APS units).

A positive sign regarding the persistence of savings is that all of the Tier 1 APS units that were installed following the monitoring remained in place and operational for at least the first 3 months. User frustration with newly introduced technology is likely to occur early in the adoption phase, and no such frustration was reported.

9.6 Programmatic Deployment Considerations

For a number of reasons, including the size of the potential savings per unit, many program administrators have expressed interest in, and/or have begun upstream incentive mechanisms for the deployment of Tier 1 APS. Our experience with this field trial leads us to a conclusion that upstream mechanisms that engage the market at the distribution level present too many challenges for commercial office environments. The majority of staff members are simply not going to be familiar enough with the operation of the products and the operation of the PCs at their workstations. Confusion and frustration are likely to lead to a delivered product that does not get installed, and/or installations that are retired early. Instead, we encourage program administrators to consider adding APS to direct-install offerings, where trained installers would ensure higher rates of persistent savings.

9.7 M&V Considerations for Impact Evaluations

The methodology utilized for this study produces accurate and defensible results for the small number of sampled sites given the detailed second-by-second data that was obtained during the trial. However, we recognize that impact evaluation time and budget constraints may require simplified procedures. The following considerations are intended to assist in developing M&V plans that will produce accurate results.

9.7.1 Savings Estimates

Whether we are estimating savings or reviewing previous estimates, our testing of the power consumption of modern computer peripheral equipment in use in our own offices and at the two participant sites suggests that program administrators and evaluators should be cautious about estimating the savings potential of interrupting the power from peripheral equipment that would otherwise be in standby mode. We found that typical flat-screen monitors draw an average of just below 1 watt in standby mode, with the most recent models reducing that to 0.5 W.

Modern local inkjet and laser printers in standby mode consume in the range of 2 to 10 W. With the growing popularity of CFL and LED task lighting, the associated power draw has also been recently reduced. As a final caution, the manufacturer's rated wattage of a piece of equipment should not be used for calculating APS savings, as the rated wattage is the wattage that the equipment is designed to safely handle, not the average watts used. Standby mode wattage can usually be found in manufacturers' online documentation or on technology review websites such as CNET (www.cnet.com).

Note: Tier 1 APS units also consume a small amount of power, and do so 24/7. For the ones we tested, the power consumption is approximately0.5 W. However, in many cases, including our sample sites, APS units include surge protection and when replacing a standard surge protection strip, the net effect can be considered negligible.

9.7.2 Evaluation Site Visits

Field observation of APS installations is an important aspect of evaluating measure performance. Verifying that the APS products are in place is not sufficient. The "control" and "controlled" outlets are clearly labeled and are typically color coded. Verifying that the proper plug connection configurations have been maintained is a key factor, as is the status of operating system power saving settings.

9.7.3 Post-Installation Monitoring with Control Group

Although this study monitored both PC and peripheral usage patterns and consumption, there is no need to do so to obtain overall savings figures. Data loggers can be used to monitor the power consumption at individual workstations or to monitor a circuit associated with the plug loads for a group of workstations. By logging the consumption of a similarly staffed and equipped control group along with a group utilizing APSs, a valid savings estimate can be generated. When extrapolating the data from the monitor period to annual savings, we recommend calculating weekday and weekend savings separately, and instead of logging during vacation times, use the average annual vacation time of the staff to adjust the savings.

9.7.4 PC Power Logging

Another workable M&V methodology involves using a power monitor and a power data logger. The procedure would be to record the standby mode power consumption of each peripheral that is plugged into a controlled outlet, as well as the threshold setting of the APS. After those results are recorded, the power consumption of the PC would be recorded over a period of several days. The recorded power consumption could then be used to calculate the differential between the standby power consumption and the consumption of the peripherals when turned off by the APS.

9.8 APS Product Development Status

Manufacturers of APS products are continuing to develop new products that promise to improve the functional performance of plug load controls. This project focused on the readily available Tier 1 APS devices. A new generation of products termed Tier 2 by the industry is now beginning to reach the marketplace. Although there is no specific definition, or operational configuration of Tier 2 APS units at this time, it can be said that they are plug-in plug-load controls that incorporate additional features not available in Tier 1 APS products. Some of the features being introduced and/or being discussed, include:

- **Combining occupancy/vacancy control with Tier 1 power-sensing control** – Many possible configurations and strategies are possible that would allow peripherals to be turned off both upon shutdown/hibernation and vacancy.

- **Advanced sensing of user activity levels** – In addition to sensing power draw, this strategy would monitor PC usage patterns, making it possible to interrupt power to peripherals without forcing the PC to be disabled.
- **Sensing of power/current profiles** – Further developing auto-calibration capabilities also may allow the shutdown of peripherals without disabling PCs.
- **Combined hardware & software products** – This strategy would incorporate the installation of an APS device with an associated software tool. The software tool would likely replace or work in conjunction with the operating system's power-saving settings.

The logged data that was analyzed for the potential savings of Tier 1 APS devices may also be useful in determining the potential additional savings available through the installation of Tier 2 APSs. Embertec is utilizing the data collected, along with data from additional field trials to inform the development of Tier 2 APS products that they are introducing to U.S. markets. Preliminary analysis of this data will be made available, by Embertec, to the Forum upon request.

The continuing development of APS products is certain to make available units that are more specifically designed for office environments, taking advantage of the power-saving capabilities present in PC operating systems.