Work Paper WPSDGENROE0002
Revision 0

San Diego Gas & Electric
Energy Efficiency Engineering

Tier 2 Information Technology (IT) Advanced Power Strip (APS) for non-residential and commercial

May 5, 2015

AT-A-GLANCE SUMMARY

Applicable Measure Codes:	TBD
Measure Description:	Tier 2 IT Advanced Power Strip (APS) for commercial Information Technology (IT) or Personal Computer (PC) environments
Base Case Description:	Standard power strip for non- residential IT or personal computer environments.
Energy Impact Common Units:	Each
Energy Savings :	Refer to Ex-Ante Database
Gross Measure Cost ($/unit)	Refer to Ex-Ante Database
Measure Incremental Cost ($/unit):	Refer to Ex-Ante Database
Effective Useful Life (ID):	Plug-OccSens
Measure Application Type:	Retrofit Add-On (REA)
Net-to-Gross Ratios (ID):	All-Default<=2yrs ET-Default
Important Comments:	

DOCUMENT REVISION HISTORY

Revision #	MM/DD/YY	Author/Affiliation	Summary of Changes
0	05/05/15	Rocaciano Vega/RMS Energy Consulting, LLC	Original work paper template for 2015

SECTION 1. GENERAL MEASURE & BASELINE DATA

1.1 MEASURE & DELIVERY DESCRIPTION

This work paper details the replacement of a standard power strip with a new Tier 2 IT Advanced Power Strip (APS) in non-residential Information Technology (IT) or Personal Computer (PC) environments. **Table 1** describes the measure name and associated product or solution code for each of the program administrators.

Table 1 Measure Names

Program Administrator	Product Code	Measure name
PG&E	TBD	Tier 2 IT Advanced Power Strip
SCE	TBD	Tier 2 IT Advanced Power Strip
SDG&E	TBD	Tier 2 IT Advanced Power Strip

1.1a Measure Description

This work paper documents the cost-effectiveness parameters for a Tier 2 IT APS that can monitor and control the energy use of various plug load devices in non-residential and commercial IT equipment, which consist of electronics such as personal computers, monitors and printers without requiring any user interference to achieve energy efficiency gains.

There are no industry standards or specifications that currently define or certify Tier 2 APS devices. However, the University of California, Irvine's California Plug Load Research Center (CALPLUG) has led an effort to help provide the industry with a Tier 2 definition. CALPLUG recommends that a Tier 2 APS device be defined with the following features:

- **Usage Sensing** – to provide at least one method to sense and determine consumer utilization and usage pattern;
- **Advanced Power Analysis** – to perform advanced power analysis in addition to voltage and current sensing. These power measurement and analysis may include, true root mean square (RMS) power, power factor analysis and other load signature detection; and
- **Control Algorithms** - to perform automated power management of connected devices based on data and information acquired.

Beyond CALPLUG's Tier 2 APS definition, CALPLUG developed a go-to-market Tier 2 APS roadmap, as shown in **Figure 1**, which helps ensure that manufacturers clearly demonstrate energy savings in both lab and field trials before products are considered as an offering in utility rebate programs.

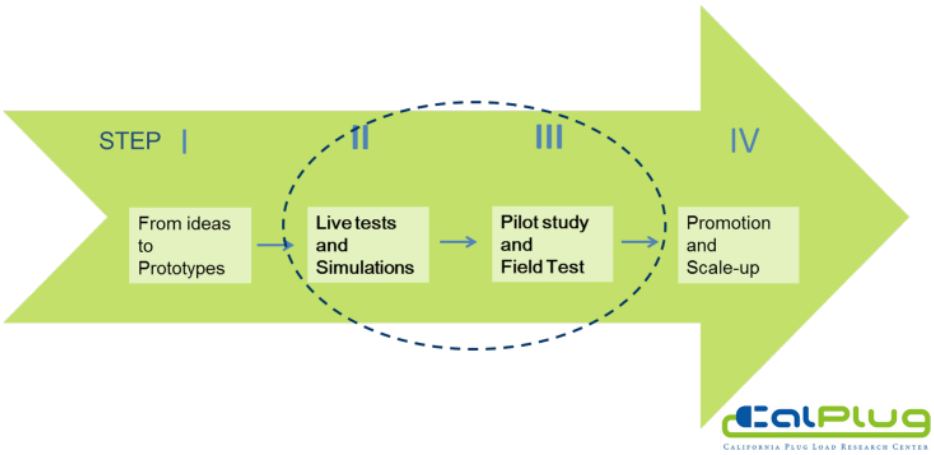


Figure 1 CALPLUG's 4-Phase Go-to-Market Tier 2 APS Roadmap

Tier 2 IT APS technologies use true Root Mean Squared (RMS) power sensing and PC monitoring software. Tier 2 IT APS devices use advanced sensing capabilities and intelligent algorithms to monitor and determine the operational mode power levels of the connected PC automatically and will dynamically adjust as the PC is upgraded or replaced in the future. Sensing user inactivity, Tier 2 IT APS have the ability to place the PC into a lower power state and isolate power to peripheral devices also. This class of device will deliver energy savings to the PC, its peripherals and works with laptops installations also.

Table 2: Tier 2 IT APS Product Features

Product Features	Tier 2 IT APS	Tier 2 IT APS Description
Sensing Technology	True RMS Power Sensing	- Facilitates learning capability with a changing connected IT environment to ensure persistence of an Effective Useful Life (EUL). - Senses voltage to ascertain when voltage has altered connected equipment energy use to ensure the APS device does not incorrectly switch the connected devices on or off. - Functions with desktop and **laptop** PC's to ensure EUL.
Additional Sensing	PC Usage Assessment	- Establishes when the PC is on but inactive to place PC into a lower power state and remove power to peripheral devices when inactive. - ***Note***: *PC on mode inactivity makes up over 60% of the PC's total state by time in non-residential environments.*

Control Approach	Controlling PC and Peripherals	- Energy savings from controlling the PC itself. - ***Note:*** *Field trials indicate that 80% of the energy savings in IT environments is directly attributed to PC control.*
Energy Savings	All controlled devices (including the PC)	- Higher energy savings through active monitoring and management of the PC and through longer periods of peripheral equipment control.
Additional Features	- Works with Desktop and Laptop PC's - Linking Communications with Energy Efficiency	- Ensures the EUL is achieved due to functioning with any type of desktop and laptop PC automatically without user adjustment. - Communication capabilities in Tier 2 IT APS can potentially provide greater levels of energy control in addition to real time auditable retention assessment by device.

Tier 2 IT Sensing Technology

Tier 2 IT APS devices use true Root Mean Squared (RMS) power sensing that monitors both current and voltage every second to determine the real power of the PC. True RMS Power Sensing enables Tier 2 IT APS to reliably determine the actual power level by operational state of the connected PC through learning the actual power consumption of the PC in its various operational states. True RMS sensing is fundamental to enabling Tier 2 IT APS to correctly control switching of peripheral devices and all types of PCs. It also enables Tier 2 IT APS devices to automatically self-adjust as the PC is upgraded or replaced; including in environments where laptops are installed.

Measuring both current and voltage is important because as voltage fluctuates, the current being consumed by the electronic device will also fluctuate. Therefore, using current sensing alone to determine the operational state of the connected equipment assumes that outlet voltage is always fixed. However, this is not the case with respect to the electricity grid where voltage is permitted to fluctuate between 114 and 126 volts.

Given that this fluctuation will alter the current consumption of connected equipment, continuously adjusting switching thresholds based on outlet voltage variations is central to ensuring a reliable Tier 2 APS device. True RMS power sensing will detect voltage in real time and adjust switching thresholds accordingly. This is perhaps even more important as solar continues its nationwide deployment, which has a direct link to outlet voltage variation as seen in **Figure 2** where voltage is seen to fluctuate between 107-127 Volts[i].

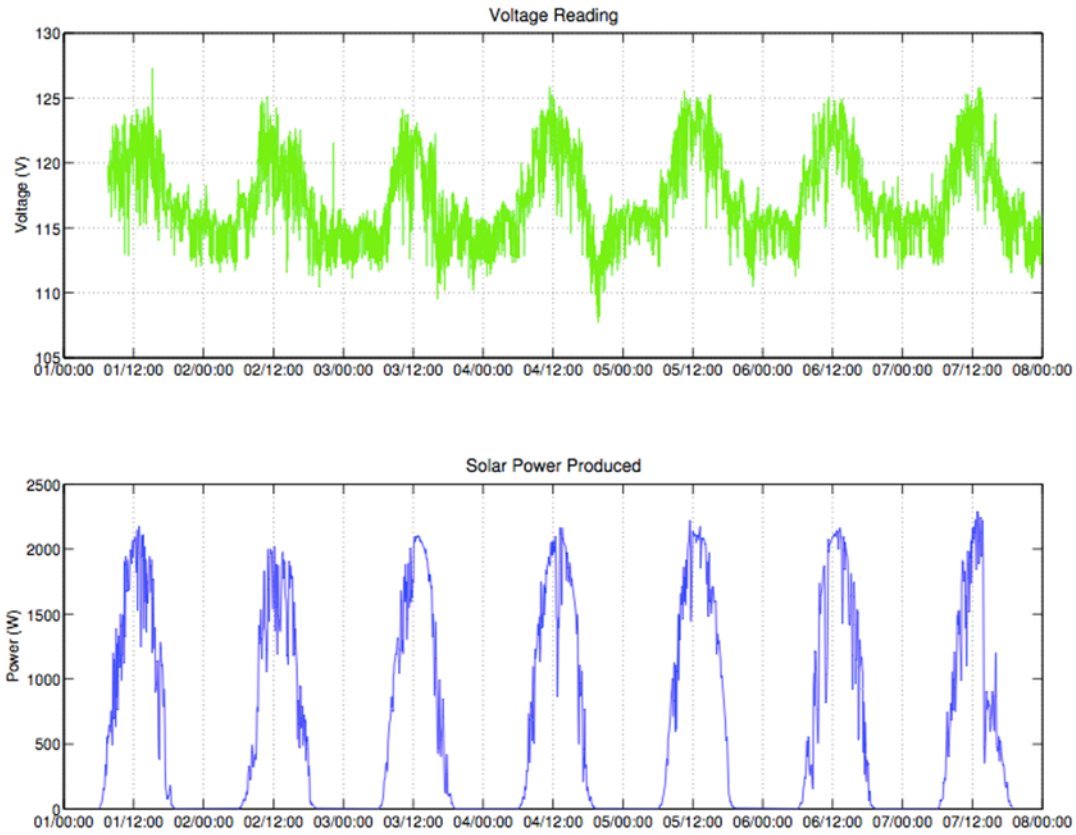


Figure 2 Correlation between Grid Voltage and Solar Energy Generation

Tier 2 IT APS microprocessors need to handle the advanced algorithms, memory needs and computational speed requirements to compute second-by-second true RMS power information.

Tier 2 IT APS Additional Sensing:

Tier 2 IT APS devices also employ additional sensing capabilities through the use of PC software. A Tier 2 IT APS working in conjunction with PC monitoring software will enhance the ability of the APS to correctly map different operational states to power levels. The additional sensing capabilities subsequently increase energy savings through more accurate control of both the peripheral devices and the PC itself. This additional sensing feature also provides extra "checks and balances" as to what is occurring in the IT environment. Without this feature incorrect control decisions will occur that can ultimately leads to consumer nuisance and APS de-installation.

Tier 2 IT APS Control Approach:

Tier 2 IT APS devices monitor actual PC usage and control both the energy being consumed by the PC peripherals and most importantly the PC itself.

Tier 2 IT APS Energy Savings:

Tier 2 IT APS devices control both the PC and the PC Peripherals. This control approach leads to a catalyst effect in terms of energy savings. The effect is achieved by the Tier 2 unit first placing the PC into a lower power state when it is not being used and then removing power to the peripheral devices in that environment.

Wireless communications capabilities may further provide additional control and energy saving benefits as well as provide program implementers and utilities with measurement and verification capabilities.

1.1b Delivery and Incentive Mechanism

The applicable incentive delivery methods are as follows:

- Financial Support / Down-Stream Incentive - Deemed
- Financial Support / Direct Install
- Midstream Programs / Mid-Stream Incentive

The installation type for this measure is retrofit add-on (REA).

1.1c Program Implementation Requirements

To ensure energy savings are achieved for each installation, utility Tier 2 IT APS direct install programs should require that a valid installation control at least 2 IT devices with one being a computer or laptop. Given this requirement, an IT environment consisting of a computer and monitor would be eligible for a Tier 2 IT APS installation.

1.1d Measure Requirements

Qualifying Tier 2 APS products must follow CALPLUG's 4-Phase Go-to-Market Tier 2 APS roadmap to ensure that manufacturers clearly demonstrate energy savings in both lab and field trials before products are considered as an offering in utility rebate programs. Additionally, Tier 2 IT APS products must incorporate performance specifications that follow CALPLUG's Tier 2 IT APS recommended definition that features:

- **Usage Sensing** – to provide at least one method to sense and determine consumer utilization and usage pattern;
- **Advanced Power Analysis** – to perform advanced power analysis in addition to voltage and current sensing. These power measurement and analysis may include, true root mean square (RMS) power, power factor analysis and other load signature detection; and
- **Control Algorithms** - to perform automated power management of connected devices based on data and information acquired.

Below is an overview of the minimum Tier 2 IT APS Performance Specifications, which will deliver the energy saving performance detailed in this work paper.

Tier 2 IT APS Minimum Product Specifications:

- Feature a resettable circuit breaker
- Incorporate power switching electromechanical relays rated for 100,000 switching cycles at full 15 amp load (equivalent to over 10 years of use)

- Consume less than 1 Watt at all times unless delivering wireless communication features
- Sense true RMS power to determine operational state of the PC and device usage of peripheral IT equipment
- Provide adjustable idle mode capability
- Manage the operational state of the PC
- Control the power to PC peripheral devices through having the ability to place the PC into a sleep or standby mode
- Function with both Desktop and Laptop PC's
- Use an automatically adjustable power switching threshold to ensure the device functions with both desktop and laptop PCs.
- Must comply with the 2013 California Fire Code (605.4).

1.2 DEER DIFFERENCES ANALYSIS

Table 3 DEER Difference Summary

DEER Difference Summary Table	
Modified DEER Methodology	No
Scaled DEER Measure	No
DEER Building Prototypes Used	No
Deviation from DEER	DEER does not contain this home office or home entertainment center power strip measures. DEER05 will be used for office plug load power strips.
DEER Version	DEER05
DEER Run ID and Measure Name (Sample)	N/A

READi Technology Fields

To support the development of the ED ex ante tables, select fields from the ex-ante database will be identified in the work paper. For a full set of values associated with the measures in the work paper refer the Excel calculation template. (In the event that the READi IDs do not support the technology in this work paper simply indicate "Non-DEER".)

Table 4 READi Tech IDs

READi Field Name	Values included in this work paper
Measure Case UseCategory	Appliance or Plug Load
Measure Case UseSubCats	Consumer Electronics
Measure Case TechGroups	Electronics
Measure Case TechTypes	OccSensPlug
Base Case TechGroups	Electronics
Base Case TechTypes	AllEquip

Non-DEER Study Review

Non-DEER field in situ trial studies were used in the development of this work paper to help analyze energy use and confirm the energy saving potential for Tier 2 IT APS in non-residential commercial IT environments. Two independent in situ field trial evaluations on Tier 2 IT APS were conducted, these include:

- Energy Resource Solutions – Vermont (October 2012)
- San Diego Gas and Electric – Emerging Technology Program (ETP) – San Diego (December 2014)

Lending further support to the energy savings opportunities for Tier 2 IT APS is a report by the University of California, Irvine's California Plug Load Research Center (CALPLUG) completed in May of 2014 on PC usage[1].

UCI's CALPLUG Study – Data Collection Approach

As outlined by CALPLUG, "it is appropriate that these devices should be field tested in-situ using a statistically appropriate methodology to determine the energy saving performance of the individual Tier 2 APS device in question."[ii] As highlighted by CALPLUG, pre/post metering is subject to significant errors due to variability in device usage patterns within the same IT environment from one period to the next. This leads to pre/post installation metering to require very large sample sizes and longer trial periods to deliver a level of confidence in the energy saving performance of the device being field tested.

CALPLUG's thesis is that their field trial methodology allows energy saving performance to be evaluated in terms of the percentage of energy that can be reduced from the target environment through the use of the field tested Tier 2 APS device. CALPLUG's study further expected that differences in connected equipment types, loads and usage patterns will not affect the overall average percentage reduction in total energy usage delivered by a given Tier 2 APS device.

CALPLUG's Tier 2 APS evaluation approach outlines that consistency in the energy reduction percentage (ERP) from total energy used across in-situ non-residential field trials, can then be uniformly applied against total annual kWh usage in the target region. This enables a determination of the annual average kWh savings through the use of the Tier 2 APS being tested.

Given this objective, CALPLUG devised a Tier 2 APS in situ field trial methodology to attain this information. This field trial methodology has been adopted to establish energy savings of Tier 2 IT APS across 51 unique IT workstations in the San Diego region. This included 26 desktop PC systems operating in computer labs and 25 desktop PC systems installed in traditional office settings. This field trial methodology significantly reduced the variability in pre/post device installation metering. The field trial approach has the following requirements:

- The field trial is conducted in actual targeted environments (*i.e.* offices and computer labs);
- The field trial approach requires minimal to no change in a person's interaction with their devices;

[1] Pixley, Joy E.; Stuart A. Ross. (University of California, Irvine). 2014. ***Monitoring Computer Power Modes Usage in a University Population***. California Energy Commission. Publication number: CEC-500-2014-092

- The field trial study must provide a detailed understanding of equipment usage patterns in the tested environments;
- Data is to be collected at one second intervals for each in-situ field trial environment to allow for detailed analysis of energy and device usage and Tier 2 IT APS device functionality;
- The Tier 2 IT APS device is to be set to log mode and equipment connected to the energy saving device is to be monitored but not controlled by the Tier 2 IT APS device;
- The Tier 2 IT APS device must record its decision points second by second based on sensed inputs to track when the energy saving mode was enacted (i.e., the power to the connected equipment was switched "off"), Note - The Tier 2 IT APS device must be configured to not turn off the equipment but to monitor when it would have isolated power to the connected devices; and
- All data threads are to be date and time stamped (synchronized) to facilitate a high level of data interrogation of the power consumption data acquired and decisions points of the Tier 2 IT APS device.

This field trial approach enables real time monitoring of power consumption and energy savings while the energy saving device simulates its actual operation. This logging approach allows for the monitoring of the actual power usage trends and the potential impact of the Tier 2 IT APS device in normal day to day operation. This approach monitors what would have happened in the IT environment had the Tier 2 IT APS device been controlling the electronic equipment.

SDG&E ETP Scaled Field Placement Study – Data Collection Approach

To verify the performance of Tier 2 IT APS devices, SDG&E's ETP undertook a scaled field placement trial in non-residential IT environments to assess the performance and correlation in performance from other studies conducted on Tier 2 IT APS devices. The data measured and logged throughout the SDG&E trial included second by second measurements of:

- Date & Time (local)
- Mains power level (voltage)
- Connected PC power (W)
- Connected peripheral (controlled) equipment (W)
- Connected equipment current consumption
- Connected equipment power use (W)
- Count down timer settings of the Tier 2 IT APS device
- Mechanical relay logged state of the Tier 2 IT APS
- Energy saved for both the computer and the controlled peripherals - cumulative watt hours
- Energy saved for both the computer and controlled peripherals - instantaneous watt seconds
- Energy used for both the computer and the controlled peripherals - cumulative watt hours
- Energy used for both the computer and the controlled peripherals - instantaneous watt seconds
- Total connected equipment energy saved - cumulative watt hours
- Total connected equipment energy saved - instantaneous watt seconds
- Total connected equipment power used (W)
- Total connected equipment power saved (W)

The SDG&E field trial did not simply look at total power consumption over a period of time. More importantly, the trial monitored the power usage levels of all IT devices in the targeted environment as well as other operational parameters each second. This provided highly accurate time of use information and confidence in the measurement, accuracy and effectiveness of the Tier 2 IT APS installed during the trial.

SDG&E Field Trial Findings

The SDG&E non –residential commercial field trial targeted two IT environments, office workstations and computer labs. Both are non-residential environments; however the way individuals engage with the equipment in each environment may vary. The field trial therefore aimed to understand what the level of usage and savings differences are in each of the different settings. **Figure 3** shows the top level results for baseline energy use and energy savings across each of the measured systems.

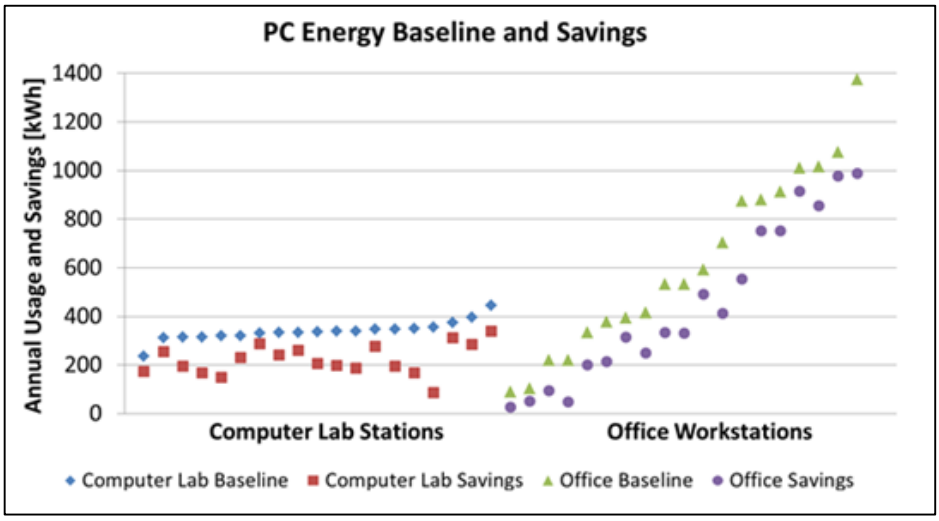


Figure 3 Annualized energy use and energy saving

The figure demonstrates that in computer laboratory environments there is consistent baseline energy level ranging between approximately 300 and 400 kWh annually. The consistency is attributed to the computer lab environment having consistent hours of operation and having similar types of desktop PCs each connected to a single 17 inch LCD monitor. Office baseline energy use by comparison is more variable, driven by:

- the number of peripheral devices used in each desktop set-up;
- an individual's computer usage profile;
- the application of the CPU's energy savings settings; and
- the relative CPU power and peripheral device power draw across disparate types of equipment (for example the type/size monitors, printers and CPUs)

Despite the energy variability between the different targeted environments the field trial results shown in **Table 5** confirmed that the percentage of energy saved through the use of the Tier 2 IT APS consistent, irrespective of location. The trial found that on average across all measured IT systems a reduction of 77.5% of total energy used can be achieved with Tier 2 IT APS devices. The total energy savings was greater for office environments by approximately 241 kWh per annum compared with computer lab environments.

However it is worth noting that the ERP across different environment types and usage patterns is quite similar at 79.5% savings for an office setting and 74% savings for a computer laboratory setting.

Table 5 Average energy savings results for the SDG&E PC trial

	Trial period (days)	Weekly Active Use time (hours)	Baseline annual usage (kWh)	Annual energy savings (kWh)	% Savings
Office settings	12	19.6	621.5	494.0	79.5%
Computer labs	13	28.3	342.9	253.5	73.9%
Combined	13	24.0	479.5	371.4	77.5%

Additional information

Below is a list of additional relevant information regarding the SDG&E field trial:

- A total of 51 desktop PCs were included in the field trialled with an average trial period of 12.8 days per computer of second by second data collected.
- The average load over the trial period was 61 W
  - PC lab = 40W
  - Office = 80W
- The average load of the PC and peripheral equipment when users are active was 111 W
  - PC lab = 68 W
  - Office = 180 W
- The average ERP across all samples was 77.5%.
- One office site was found to have annual energy consumption of less than 200 kWh and eight had an annual energy consumption of more than 1,000 kWh.

Table 7 provides a statistical summary of the SDG&E IT field trials for annual energy consumption and measured energy savings for each of the three technologies.

Table 7 Statistical summary by APS technology type

	Annual energy consumption (kWh / year)	*Tier 2 IT APS energy savings (kWh / year)*
Confidence Level (90.0%)	109	98
Lower bound	367	238
Upper bound	585	434

Using the CALPLUG energy saving assessment approach, the SDG&E trial had an overall average ERP of 76.7%.

Also included in this analysis were an assessment of PC environments with a small number of peripherals (computer labs with one monitor) and a high incidence of networked power saving settings in these environments also. This provided an ability to assess the lower bound of energy savings that would be attained from the Tier 2 IT APS device. In the computer laboratory environment, 65% of installations had pre-existing energy savings settings operating on the computers.

1.3 Code Analysis

There are no federal, state, or regional code requirements that apply to this measure.

1.4 Measure Effective Useful Life

The Plug-OccSensEUL ID was selected for the Tier 2 APS measure. Refer to the Ex-Ante Database for the EUL values.

Table 8 DEER14 EUL Value/Methodology

READi EUL ID	Market	End use	Measure
Plug-OccSens	Non-residential/commercial	AppPlug	Tier 2 IT Advanced Power Strip

1.5 Net-to-Gross Ratios for Different Program Strategies

Refer to the Ex-Ante Database for the NTG values.

Table 9 Net-to-Gross Ratio

NTGR_ID*	Description*	Sector*	BldgType*	ProgDelivID
ET-Default	Emerging Technologies approved by ED through work paper review	All	Any	All
Res-Default-HTG-di	All other EEM with no evaluated NTGR; direct install hard-to-reach only.	Res	Any	DirInstall
All-Default<=2yrs	All other EEM with no evaluated NTGR; new technology in program for 2 or fewer years	All	Any	All

*Denotes that the column is taken from the DEER NTG Table

Spillage rate will also be applied to measures however the values will not be tracked in the work papers. The spillage rate will be tracked in an external table to be supplied to the Energy Division.

1.6 Time-of-Use Adjustment Factor

As directed by the CPUC in decision 06-06-063 dated June 29, 2006, time-of-use (TOU) adjustment factors are to be applied for residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Since this is not an A/C measure, the TOU adjustment factor is 0. Additionally, if a measure is assigned a DEER08 load shape, i.e. the load shape starts with "DEER:" the TOU assigned to that measure should also be zero.

Table 10 TOU Summary Table

Measure	%
Tier 2 Advance Power Strip	0

SECTION 2. ENERGY SAVINGS & DEMAND REDUCTION CALCULATIONS

2.1 ENERGY SAVINGS & DEMAND REDUCTION CALCULATIONS

Energy Savings Calculation Methodology

Field Trial Data Sets on Tier 2 IT APS

SDG&E's ETP Scaled Field Placement study assessed the performance and correlation in performance from other field trial studies conducted on the identical Tier 2 IT APS device. **Table 11** provides an overview of all non-residential Tier 2 IT APS field trials that employed the field trial methodology outlined by CALPLUG. The table compares the results of the SDG&Es ETP Scaled Field Placement study alongside the results of other independent field trials in the state of Vermont[2].

Table 11 Tier 2 IT field trial comparisons

Tier 2 IT APS Field Trial Data Assessment					
	Vermont Commercial Office	**SDG&E Commercial Office**	**SDG&E Computer Lab**	**SDG&E Computer Average**	**Weighted Average**
% kWh reduced	69.0%	79.5%	73.9%	77.5%	74.7%
KWh used	705.0	621.4	342.9	476.5	533.3
kWh reduced	484.0	494.1	253.5	371.4	398.2
Sample sites	16.0	25.0	26.0	N/A	N/A
Data points (millions)	135	237	220	N/A	N/A

Table 11 demonstrates that between different field trials and target environments, there was a correlation in respect of the percentage of energy savings Tier 2 IT APS delivered to non-residential IT environments. The results demonstrate that despite varying total kWh usage (driven by PC environment type and connected equipment load) there remains a very consistent savings result ranging between 69% and 79% with an average reduction across the trials of 74.7%. These energy savings are achieved due to two main drivers:

- the ability for Tier 2 IT APS devices to place the PC into a lower energy state; and
- the ability to reduce the amount of energy wasted while the PC is on but not actively being used (PC Idle Time).

The methodology established by CALPLUG and used in field trials has proved to be robust in proving Tier 2 IT APS device performance in terms of establishing an average ERP that can be applied to different energy baselines. Additionally, CALPLUG's evaluation method is more reliable than simply extracting kWh saving figures from a single field trial sample set given the prevailing risk in a sample set being

[2] The Vermont field trial was a collaborative effort conducted and managed by ERS, NEEP, Energy Futures Group and Efficiency Vermont.

skewed in terms of energy usage. **Using California data alone, the average annual energy savings across all installations was 371 kWh.**

PC idle time

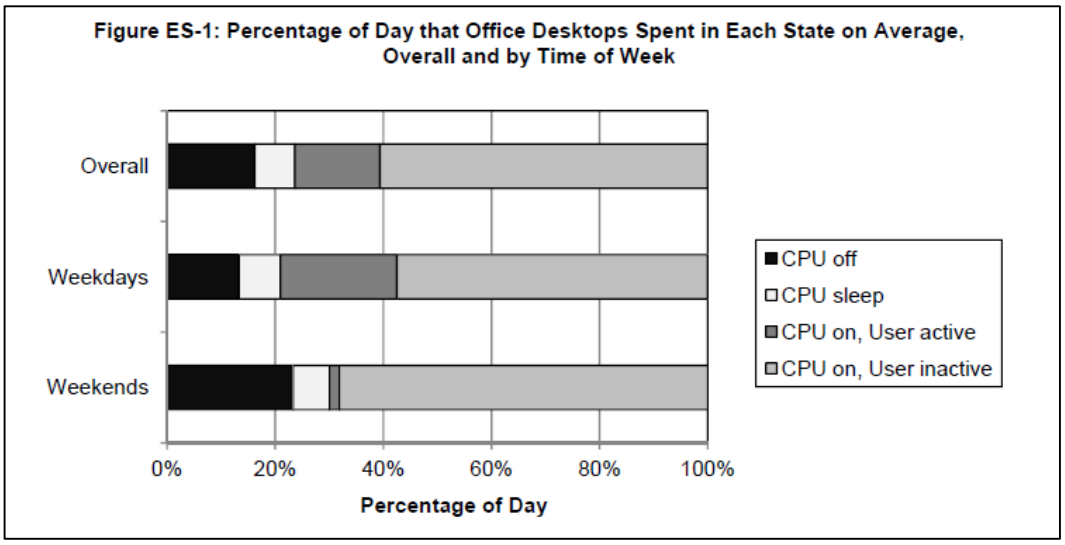
Another conclusion that can be drawn from the SDG&E trial and others is that for a large portion of the day most computers are left on but are not actively being used (PC idle time). In general, energy savings delivered by a Tier 2 IT APS will depend on the actual power draw of the PC and that of any peripheral equipment (*i.e*. Monitors, printers, speakers, etc.) but will be proportional to the PC idle time. In simple terms, Tier 2 IT APS deliver energy savings by reducing the period of time that the PC sits idle. Deeper energy savings will be realized in IT workstations that remain on for extended periods and/or where PC power management settings are not being utilized effectively.

A recent study (Oct 2014)[3] that was commissioned by the California Energy Commission (CEC) and completed by CALPLUG evaluated computer usage behaviors in office settings. The study, which evaluated 119 workstations, measured the actual PC usage across operational modes and found that in office settings computers are:

- On 76 percent of the day (more than 18 hours);
- Only being used 16 percent of the day (3.8 hours);
- In sleep mode for only 7 percent of the day; and
- On and not being used (PC Idle Time) 61 percent of the time (14.6 hours).

[3] Pixley, Joy E.; Stuart A. Ross. (University of California, Irvine). 2014. *Monitoring Computer Power Modes Usage in a University Population*. California Energy Commission. Publication number: CEC-500-2014-092.

The summary results from the CALPLUG study clearly outlines how CPU operation varies throughout a day.



Source: Pixley, Joy E.; Stuart A. Ross. (University of California, Irvine). 2014. *Monitoring Computer Power Modes Usage in a University Population*. California Energy Commission. Publication number: CEC-500-2014-092.

Figure 3 Daily CPU power modes

As a point of comparison, the SDG&E field trial data was used to evaluate CPU active, idle, and sleep/off periods. The results shown in **Figure 4** provides confidence that the energy savings attained in the SDG&E field trial are representative of what can be expected in other commercial PC environments. This is due to CPU usage state duration largely determining the energy saving effects of the Tier 2 IT APS device.

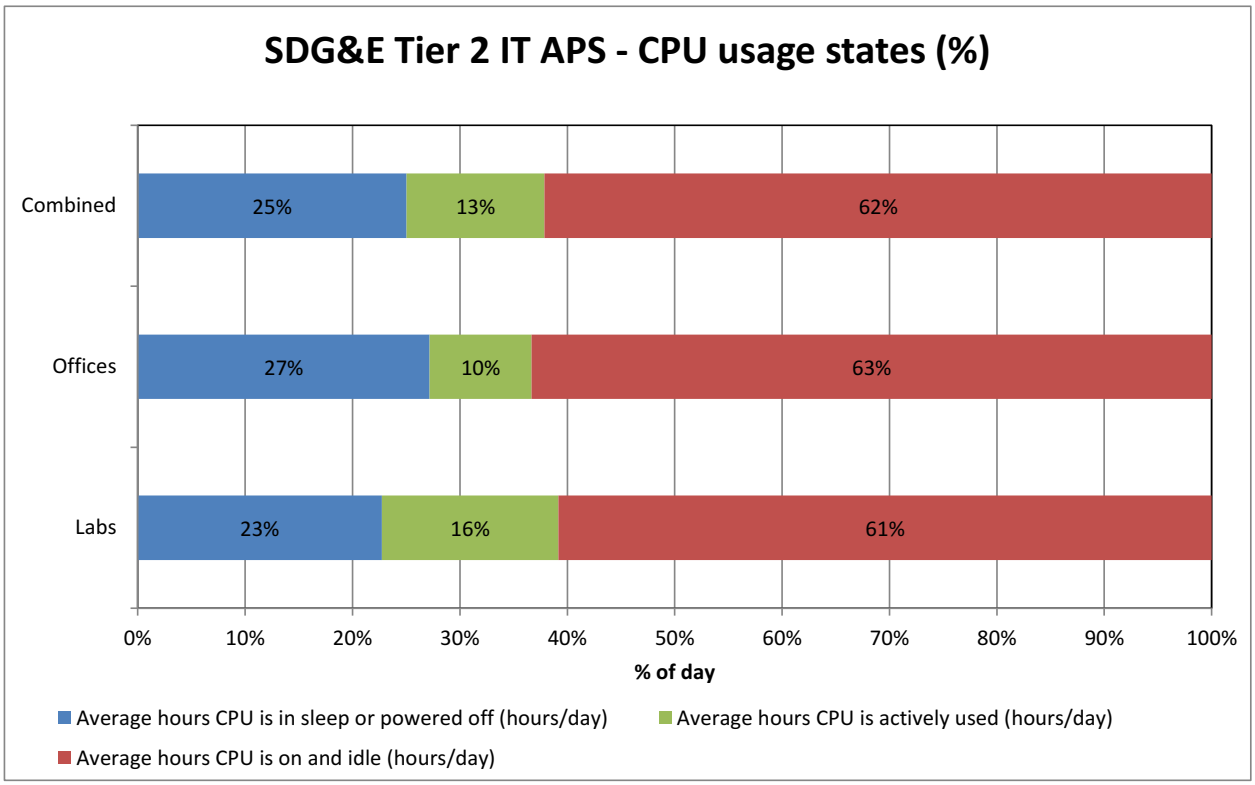


Figure 4 SDG&E field trial CPU power modes

The period of time reported by CALPLUG (**Figure 3**) where the CPU was on but not being used (idle time) was 61% in office environments. The SDG&E field trial results are almost identical to the findings of the CEC study with values of 63% for offices, 61% for labs and a 62% average across both. Between both these data sets over 170 sites were monitored in California in the last 9 months to provide a level of confidence that the field trial sites are representative of how office workstations are typically being used.

Power Management Settings

The results found in both the CALPLUG study and the SDG&E Tier 2 IT field trial clearly demonstrate the sporadic use of power management settings. Power management settings were either being employed manually by the user (*i.e*. placing the PC into a lower power setting at the end of the day) or through enabling automated power management settings on the PC. Poor power management leads to a pervasive amount of energy being wasted and highlights the genuine need for better power management control of computers.

Currently, the best option available for individuals to address and reduce PC idle time is to enable a PCs power management options. Indeed, in another report (Oct 2014)[4] by CALPLUG that surveyed more

[4] Pixley, Joy E., Stuart A. Ross, Ankita Raturi, and Alan C. Downs. (University of California, Irvine). 2014. ***A Survey of Computer Power Modes Usage in a University Population.*** California Energy Commission. Publication number: CEC-500-2014-093

than 2,000 individuals about personal computer usage, respondents claimed that some sort of automated power management was enabled in 84% of PCs environments. However, when a subset of those same PCs was actually measured, only 20% had any energy management settings enabled at all.

None of those 20% had settings enabled that would automatically remove power to the PC. This highlights the issue that power management settings are rarely being applied despite people claiming that they are. This also demonstrates the value of metered studies in providing more accurate results compared with studies that rely solely on user responses.

The measured results of the Tier 2 IT APS clearly establish the technology as capable of reducing wasted energy attributed to PC idle time and as a robust alternative to relying on users enabling PC power management settings. Tier 2 IT APS is also simple to use and will significantly reduce wasted energy from the PC as well as to that of the controlled peripheral devices.

Consideration was given to assessing the energy saving effects of the Tier 2 IT APS device in PC environments with only one peripheral device (computer laboratory with one monitor). In addition these environments also utilized existing networked power saving settings in many (65%) of the laboratory installations. This provided an ability to assess the lower bound of energy savings that would be delivered by the Tier 2 IT APS, as existing energy saving features in the trial environments did not contribute to the measured energy saving performance of the Tier 2 IT APS device.

Energy Interactive Effects

Tier 2 IT APS measures do have HVAC interactive effects, but DEER does not include energy interactive effects for Tier 2 APS measures at this time. Thus, Tier 2 IT APS measures will use the DEER HVAC interactive effects values used in lighting power applications. Please refer to the ex-ante database for actual energy savings values that include energy interactive effects.

Peak Demand Reduction

Although CALPLUG's field trial approach required taking energy measurements, the focus of the field trial methodology was to capture energy savings and not peak demand reduction. However, the SDG&E field trials did capture this information. Based on SDG&E's field trial study, peak demand reduction results were averaged across all sites as shown in **Table 12**.

Table 12 Peak Demand Reduction

Dataset	Computer Labs	Office workstations	Combined
Avg. baseline demand (W)	54.3	104.1	80.6
Avg. demand savings (W)	32.7	72.1	54.0
Avg. % demand savings	60.2%	69.2%	67.0%
Avg. baseline on-peak demand[a] (W)	56.9	124.9	90.9
Avg on-peak demand savings (W)	24.0	56.5	40.2
Avg. on-peak % demand savings	42.2%	45.2%	44.2%
Avg DEER on-peak baseline demand[b]	57.1	124.4	90.7

Avg. DEER on-peak demand savings (W)	26.0	54.5	40.3
Avg DEER on-peak % demand savings	45.5%	43.4%	44.4%

[a] *On-peak defined by the timeframe of 11 AM and 6 PM*
[b] *DEER on-peak defined as 2 PM to 5 PM (CPUC, 2013)*

In addition to the above values, **Figure 5** plots the average weekday demand profile and demand savings profile averaged across all workstations. Patterns show increasing demand during business hours from 8 AM to 5 PM.

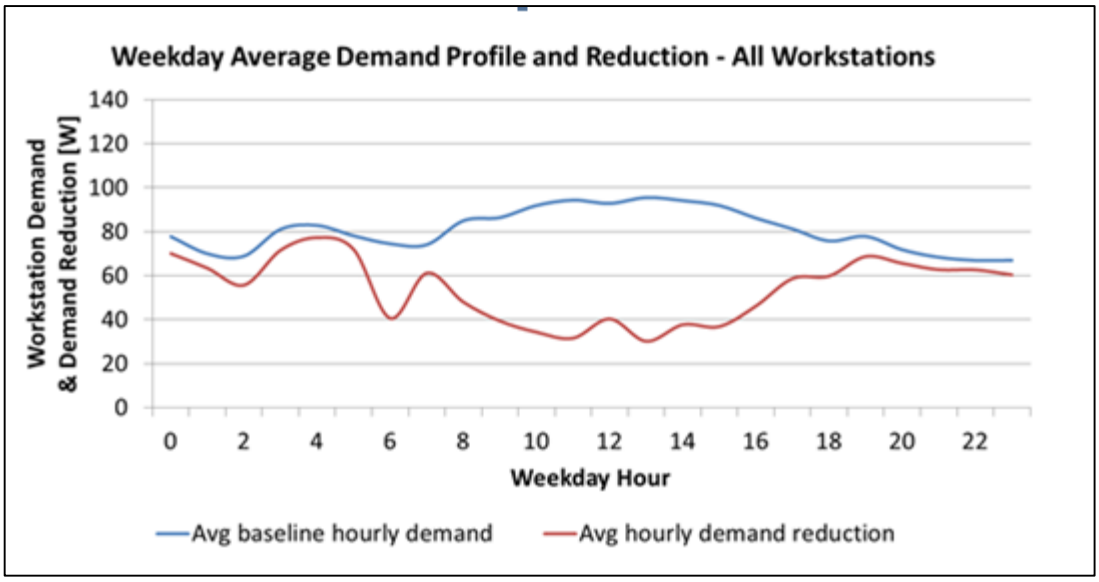


Figure 5 Weekday average demand profile and savings

Demand Interactive Effects and Diversity Factors

Tier 2 APS measures do have HVAC demand interactive effects, but DEER does not include demand interactive effects for Tier 2 APS measures at this time. Thus, Tier 2 APS measures will use the DEER HVAC demand interactive effects and diversity factors used in lighting power applications. Please refer to the ex-ante database for actual peak demand reduction values.

2.2 Gas Energy Savings Estimation Methodologies

Tier 2 IT APS measures do have HVAC negative therm interactive effects, but DEER does not include factors for Tier 2 APS measures at this time. Thus, Tier 2 IT APS measures will use the DEER HVAC negative therm values used in lighting power applications. Please refer to the ex-ante database for actual negative therm values that include negative therm interactive effects.

2.3 Gross Savings Installation Adjustment

The installation rate (IR) is identified in ex-ante database. This value is obtained from the support table available in READi. Currently there is no versioning on the installation rate table. To address appropriate

selection of the installation rate the date of the work paper will serve as the last date checked for updated IR values. The installation rate varies by end use, sector, technology, application, and delivery method. The relevant IR values for this measure are shown in **Table 13** below.

Table 13 Gross Savings Installation Adjustment (GSIA) IDs

GSIA_ID	Description	Sector	BldgType	UseCategory	TechType
Def-GSIA	Default GSIA values	Any	Any	AppPlug	OccSensPlug

2.4 MEASUREMENT AND VERIFICATION

Measurement and verification is critical for program managers, implementers and manufacturers to respond to issues, improve technology, deliver better services and confirm energy savings. To date, APS verification has primarily relied on qualitative information provided through consumer surveys. Surveys are often conducted months after installation and while they can provide reasonable insight into product retention and capture some consumer feedback they do not provide much insight into actual energy savings.

Ongoing measurement and verification during program implementation will provide robust verification of energy saving goals being attained. The ongoing measurement and verification should be assessed against the following, which:

- APS products are installed and functioning correctly;
- APS products are installed into areas with suitable sized IT controlled loads (for example the average controlled load measured in the trials was 61 Watts on average and 111 Watts during active use);
- APS devices remain installed/retained by consumers; and
- Confirmation of the energy savings delivered by the Tier 2 IT APS is attained.

For Program Administrators, confidence that each of the above performance metrics is being met requires more than consumer subjectivity. Tier 2 IT APS programs should be administered with a robust measurement and verification process to obtain quantitative data on an ongoing basis. Such an approach will reduce the risk that one or more of the above elements are not being achieved that will have an adverse effect on energy saving goals.

Program administrators should develop appropriate processes and methodologies to ensure energy savings can be substantiated throughout the deployment of Tier 2 IT APS programs where possible.

SECTION 3. LOAD SHAPES

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, the closest load shape chosen for this measure is the 01-ALC-AllCommercial-OffEquip. See **Table 14** for a list of all Building

Types and Load Shapes. See the KEMA report for a more thorough discussion regarding the load shapes for this measure.

Table 14 Building Types and Load Shapes

Building Type	SDG&E Load Shape	SCE/PG&E Load Shape
Assembly	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Commercial	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Education - Primary School	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Education - Secondary School	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Education - Relocatable Classroom	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Education - Community College	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Education - University	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Grocery	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Health/Medical - Hospital	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Health/Medical - Nursing Home	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Lodging - Hotel	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Lodging - Motel	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Manufacturing Biotech	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Manufacturing Light Industrial	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Office - Large	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Office - Small	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Restaurant - Fast-Food	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Restaurant - Sit-Down	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Retail - Multistory Large	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Retail - Single-Story Large	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Retail - Small	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Storage - Conditioned	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Storage - Unconditioned	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database
Warehouse - Refrigerated	01-ALC-AllCommercial-OffEquip	Refer to ex-ante database

SECTION 4. BASE CASE & MEASURE COSTS

4.1 BASE CASE COST

The assumed base case is a standard power strip. Therefore, for this measure category, the base case cost is assumed to be zero because these are discretionary modifications (retrofit add-on) to the customers' existing equipment. The alternative is to make no changes to their existing system.

4.2 GROSS MEASURE COST

For retrofit add-on measures, the gross measure cost (GMC) is the full measure cost including the measure equipment cost and the measure labor cost.

Per manufacturer cost quotes, the measure equipment cost for a Tier 2 IT APS ranges between $45 - $80. For downstream deemed, upstream and midstream delivery channels, there are no labor costs associated. For the direct install delivery channel, labor rates may vary across different implementers. Please refer to the ex-ante tables for actual labor costs.

GMC is represented by the equation below:

GMC = Measure Equipment Cost + Measure Labor Cost

Table 15 Measure Cost

Measure	GMC ($/unit)
Tier 2 APS Measure Equipment Cost	$80.00
Gross Measure Costs	$80.00

4.3 INCREMENTAL MEASURE COST

Incremental Measure Cost (IMC) is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. For retrofit add-on measures, the IMC is equal to the gross measure cost, as there exists no base case from which to compare the measure.

ATTACHMENTS

150101 - Monitoring Computer Power Mod

2015-06-23 Tier2 Commercial APS CalTI

REFERENCES

[i] http://openpowerquality.org/technology/g1-pilot-study.html
[ii] "Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive" (CALPLUG 2014)