**Work Paper WPSDGEREHE0004**

**Revision 0.3**

**San Diego Gas & Electric**

**Energy Efficiency Engineering**

**Tier 2 Audio Visual (AV) Advanced Power Strip**

**At-a-Glance Summary**

|  |  |
| --- | --- |
| Applicable Measure Codes: | PG&E: PG023  SCE: CE- 56727  SDG&E: 463070 |
| Measure Description: | Tier 2 Audio Visual (AV) Advanced Power Strip |
| Base Case Description: | Standard power strip |
| 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: | * California Technical Forum Approval (CALTF) on 2/26/2015 * Ex-Ante Review (EAR) Team Approval on 08/06/2015   + EUL was revised from 8 years down to 5 years   + Energy savings was revised from 246 kWh down to 212 kWh using a weighted average approach to consider the 9 operational mode samples with the 33 log mode samples.   + Peak demand reduction was proportional reduced from 34.6W down to 31.3W. |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | MM/DD/YY | Author/Affiliation | Summary of Changes |
| 0 | 04/21/2015 | Martin Vu/RMS Energy Consulting, LLC | Original work paper template for 2015 |
| 0 Dot Rev1 | 4/28/2015 | Peter Ford, SDG&E | Minor language changes to WP per meeting on 4/21/2015 (Reynoso, Madison, Ford, Smith, and Vu). WP Revision to remain as “0” and the 0.1 designation is provided to denote a minor change only and is disregarded in ex-ante data. |
| 0 Dot Rev 2 | 7/22/2015 | Martin Vu/RMS Energy Consulting, LLC | WP Revision to remain as “0” and the 0.2 designation is provided to denote a minor change only and is disregarded in ex-ante data.   * Added 2013 California Fire Code (605.4) to measure requirements * Additional detail on EUL * Updated the Net-to-Gross section * Updated measure cost for downstream, midstream, and upstream delivery channels |
| 0 Dot Rev 3 | 8/25/2015 | Martin Vu/RMS Energy Consulting, LLC | WP Revision to remain as “0” and the 0.3 designation is provided to denote a minor change only and is disregarded in ex-ante data.   * EUL was revised from 8 years down to 5 years based on analysis performed by CALTF staff. * Energy savings was revised from 246 kWh down to 212 kWh using a weighted average approach to consider the 9 operational mode samples with the 33 log mode samples. * Peak demand reduction was proportional reduced from 34.6W down to 31.3W based on the inclusion of the 9 operational samples. * Reference to ongoing measurement and verification during program deployment is included. |

# 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 Advanced Power Strip (APS) in residential audio visual (AV) home entertainment 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/Solution Code | Measure Name |
| PG&E | PG023 | Tier 2 AV Advanced Power Strip |
| SCE | CE- 56727 | Tier 2 Advanced Power Strip |
| SDG&E | 463070 (Direct Install) | Tier 2 AV Advanced Power Strip |

### 1.1a Measure Description

This work paper documents the cost-effectiveness parameters for a Tier 2 AV APS that can monitor and control the energy use of various plug load devices in residential home entertainment systems, which consist of equipment such as televisions, stereo systems, and DVD players without requiring any user interference to achieve energy efficiency gains.

Although it is recognized that game consoles represent a significant amount of energy consumption for plug devices found in residential AV environments, this workpaper does not account for game consoles in its energy savings calculations. However, when more field trials and studies are made available, the workpaper may be updated at that time to consider game consoles into the energy savings estimates.

There are no industry standards or specifications that currently define or certify Tier 2 AV 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 AV 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 AV APS definition, CALPLUG developed a go-to-market Tier 2 AV 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 AV APS Roadmap

The CALTF supports the go-to-market roadmap for the Tier 2 AV APS product category and has requested that field trials be conducted on all new products within this category. See attached embedded file – February 2015 CALTF meeting notes – pages 15-16.

As the sensing, power analysis and control algorithms will vary by device it is important to assess the energy saving potential of individual Tier 2 AV APS products in the field as they will likely vary by device.

Table 2. Tier 2 AV APS Product Features

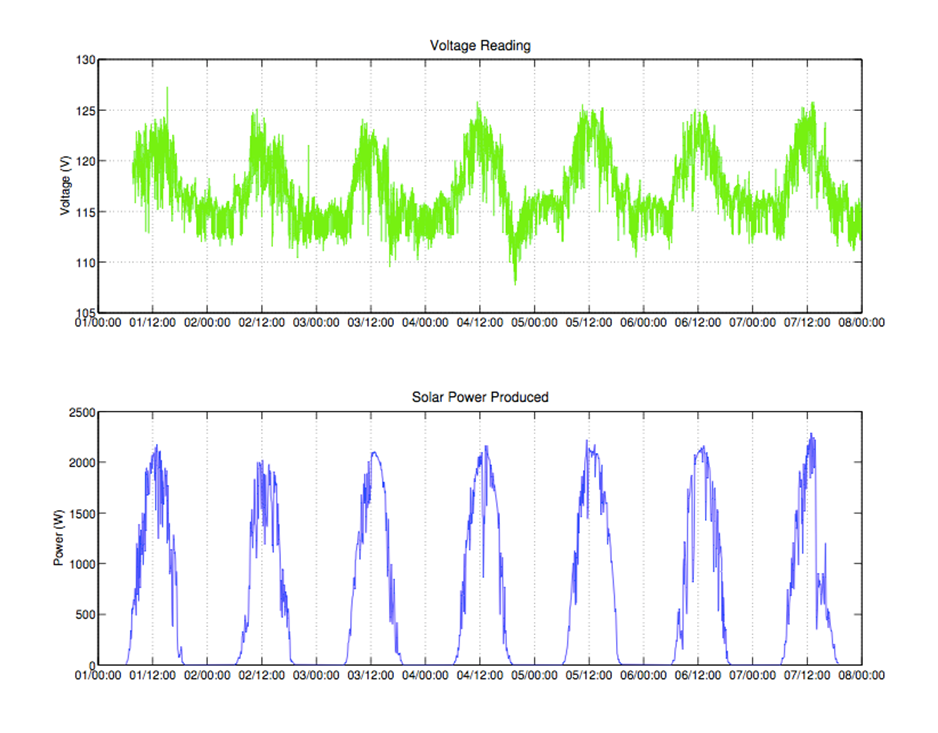
|  |  |  |
| --- | --- | --- |
| **Product Features** | **Tier 2 AV APS** | **Tier 2 AV APS Description** |
| **Sensing Technology** | True RMS Power Sensing | * Facilitates learning capability with a changing connected AV environment to ensure persistence of an Effective Useful Life (EUL). * Senses 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. |
| **Additional Sensing** | IR sensing with IR filtering (hardware & firmware) | * Determines periods of device inactivity to deliver more savings. * Ensures rogue IR (CFL’s and sunlight) do not create false positive IR readings through IR filtering. |
| **Control Approach** | Master-less | * Does not rely on the use of a single device in an AV environment to supply power to other device. * Reads the power consumption of all connected controlled devices to ensure system is not switched on via spurious non AV equipment IR and left on when no equipment is being used. * All connected devices are power monitored. |
| **Energy Savings** | All controlled devices (including TV) + Idle Mode | * Ensures energy savings are achieved on all devices connected to the switched outlets without requiring a “master” device operational state to determine user activity. * Will not leave devices on in a passive standby state if IR is sensed but no equipment is being used for more than 1 hour. * Delivers energy savings to the devices connected to the switched outlets after 1 hour of inactivity. |
| **Additional Features** | * Automatically adjustable switching threshold * LED brightness adjustment * Minimum 1 hour idle mode timeout setting * Linking communications with energy efficiency | * Automatically adjustable switching threshold adjusts to changes in connected equipment loads without manual user adjustment * LED brightness adjustment enables the LED brightness in via the IR sensor to be adjusted for different room lighting to ensure no user nuisance and deliver device persistence. * A minimum of 1 hour setting for idle mode is critical for delivering maximum energy saving potential as tested in all Tier 2 AV APS field trials. * Wireless communication capabilities in Tier 2 AV APS can potentially link energy efficiency with demand response, address the energy/water nexus, and deliver automated and auditable retention assessment across 100% of deployed systems in real time. |

##### **Tier 2 AV Sensing Technology**

Tier 2 AV APS devices use true Root Mean Squared (RMS) power sensing, which is achieved by sensing both current and voltage every second to determine the real power of the connected environment. True RMS power sensing enables the Tier 2 AV APS device to learn various power levels of the connected equipment and adjust automatically as the AV environment changes. True RMS power sensing measures outlet voltage every second enabling automatic adjustment to switching thresholds and compensates for changes in outlet voltage. Outlet voltage fluctuation alters the current and power being consumed by the connected equipment.

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[[1]](#endnote-1). As voltage fluctuates, the current being consumed by the electronic device will also fluctuate.

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 AV APS device. 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.



**Figure 2.** Correlation between Grid Voltage and Solar Energy Generation

Tier 2 AV APS will monitor both current and voltage and determine the true RMS power of all the connected equipment to be controlled. Additionally, a 64k microprocessor with software algorithms is typically required to compute second-by-second true RMS power information acquired by the Tier 2 AV APS. This computation capability ensures the correct switching decisions of the connected equipment are made by sampling the connected equipment load each second.

##### **Tier 2 AV Additional Sensing**

Tier 2 AV APS devices can sense true RMS power and sense IR signals to determine user activity with their AV devices. IR can be emitted from a number of sources beyond remote controls of AV equipment. IR can also be emitted from sunlight and Compact Fluorescent Lights (CFL’s), which many have been deployed in homes through prior energy efficiency efforts. Using IR to sense user activity should be done intelligently to not be confused by IR not coming from actual AV equipment usage.

A Tier 2 AV APS that uses IR sensing should also employ IR shielding via both hardware, preferably but not limited to a metallic cover over the IR sensor, and firmware to filter rogue non remote control IR interference filters.   
  
Adequate IR sensing capabilities will filter spurious non AV remote related IR such as that from CFL’s and sunlight to avoid incorrect switching events. Understanding that IR can come from numerous sources, filtering out erroneous IR is imperative to effectively make use of IR inputs and avoid problematic equipment control scenarios for users. This is achieved via hardware filters and software filters in the firmware to block erroneous IR signals and can be easily determined if these features are present through physical observation of the Tier 2 AV APS device.

##### **Tier 2 AV Control Approach**

Tier 2 AV APS incorporates a “master-less” controlled mechanism. With master-less control mechanism, there is no longer the need for a “master” device, normally the TV, to be sensed via either current or true RMS power. Rather, all devices are on the same sensing circuit, and all devices can be used individually. Energy savings will occur when any one device being used is then switched off. Tier 2 AV APS devices will sense the power being consumed by all devices that are in the controlled outlets.

Without the ability to sense all controlled connected devices, the APS device cannot determine when to switch power off to the entire circuit after one or more devices have been switched off.

##### **Tier 2 AV Energy Savings**

Because Tier 2 AV APS devices are master-less, Tier 2 devices control the power to all connected AV devices including the television. Tier 2 AV APS devices save energy to connected equipment when the equipment has been left on but are not being used by the user. This control approach delivers a significant level of additional energy savings. However, this feature must be accompanied by proper sensing and data computation from the Tier 2 AV APS device to ensure no nuisance switching for the user.

Regarding energy savings, Tier 2 AV APS devices have the ability to control the TV and determine when to switch off power to connected devices unintentionally left on. This Idle Mode feature needs to be accompanied by other additional features, outlined in the next section, to ensure user convenience is not compromised because of the increased level of control and device switching.

##### **Tier 2 AV Additional Features**

Tier 2 AV APS devices’ ability to control the television using a master-less controlled approach provides greater application opportunity in households where the Tier 2 AV APS device will likely be installed into more AV environments in different rooms throughout the house. Therefore, it is important that the increased level of control does not add additional nuisance factors for end users that will lead to potential consumer de-installation. Below is a list of additional Tier 2 AV APS product features that can limit annoyance and ensure retention:

* **Idle Mode Timer Adjustment:** Depending on user preferences, some users watch longer programs than others and may want the Idle Mode period to be extended from 1 to 2 hours. This period is adjustable on the Tier 2 AV APS device to ensure user convenience.
* **Automatic Adjustable Switching Threshold:** Tier 2 AV APS devices can determine the appropriate base load power level of the connected environment. Having an automatic adjustable switching threshold that learns the connected equipment base loads ensure that the Tier 2 AV APS device always work in a frequently changing AV environments as connected equipment and their respective power levels also change.
* **Controlled Device Power Isolation Period:** Before an Idle Mode event occurs, it is advantageous for there to be an appropriate level of warning period for the user. A ten minute notification period, via the LED flashing on the IR sensor of an Idle Mode event, is sufficient to ensure the user does not miss the Idle Mode warning before the connected equipment is switched off.
* **LED Brightness Adjustment:** The LED light on the IR sensor will flash at the user to communicate when power to the connected equipment is about to be isolated. Depending on the size and illumination in the room, the brightness of the LED light can cause a nuisance such as in bedroom environments. Thus, being able to adjust the brightness of the LED light will ensure the Tier 2 AV APS is tailored for living rooms and bedroom environments to ensure device retention.
* **Automated Tier 2 AV APS Retention Assessment:** Tier 2 AV APS use more advanced processors and have the ability to use additional communication capabilities that will assist in delivering against a number of California Public Utility Commission (CPUC) outlined and Energy Saving Assistance (ESA) program implementation considerations. One important deliverable is leveraging communication to assist in verifying installation and ensuring device retention of Tier 2 AV APS devices, proving persistence.

### 1.1b Delivery and Incentive Mechanism

The applicable incentive delivery methods are as follows:

* Financial Support / Direct Install

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 AV APS direct install programs should require that a valid installation control at least 2 AV devices with one being the television. Given this requirement, an AV environment consisting of a television and DVD player would be eligible for a Tier 2 AV APS installation.

### 1.1c Measure Requirements

Qualifying Tier 2 AV APS products must follow CALPLUG’s 4-Phase Go-to-Market Tier 2 AV 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 AV APS products must incorporate performance specifications that follow CALPLUG’s Tier 2 AV 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.

The following section describes the minimum Tier 2 AV APS Performance Specifications, which adhere to CALPLUG’s recommended definition for a Tier 2 AV APS and will deliver the energy saving performance detailed in this work paper.

Tier 2 AV 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 total power being consumed by all controlled devices;
  + Sense IR and true RMS power to determine device usage of AV equipment;
  + Hardware or software IR filtering technology and firmware, preferably but not limited to using metallic IR sensor shielding, to filter out rogue non AV equipment IR interference from compact fluorescent lights and sunlight;
  + Provide adjustable Idle Mode capability with a potential minimum setting of 1 hour;
  + Deliver a minimum ten minute count down Idle Mode warning to avoid nuisance switching; and
  + Use an automatically adjustable power switching threshold
  + 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 measure. |
| 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 ex-ante database.

**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 field trial studies were used in the development of this work paper to help analyze energy use and confirm percent reduction saving opportunities for Tier 2 AV APS in AV environments. Two in situ field trial studies that have regional significance include one from CALPLUG completed in May of 2014 and San Diego Gas & Electric’s (SDG&E) Emerging Technologies Program (ETP) completed in December of 2014.

##### **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 AV APS device in question.”[[2]](#endnote-2) As highlighted by CALPLUG, pre/post metering is subject to significant errors due to variability in device usage patterns within the same household 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 using the aforementioned field trial methodology will determine the energy saving performance in terms of the percentage of energy that can be reduced from the target environment through the use of the field tested Tier 2 AV APS. 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 AV APS device.

CALPLUG’s assumption is that given the consistency in the percentage of energy saved from total energy used across all in-situ field trials, this percentage reduction can then be uniformly applied over total annual kWh usage in the target region to determine an annual average kWh savings through the use of the Tier 2 AV APS being tested.

Given these challenges, the CALPLUG study devised a Tier 2 AV APS in situ field trial methodology, which was used across 53 sites. This field trial methodology significantly reduced the variability in pre/post device installation metering. The field trial approach had the following requirements:

* Occurred in actual targeted environments (i.e. households);
* Required minimal or no change in householder’s interaction with their devices;
* Provided a detailed understanding of equipment usage patterns in the field trial environments;
* Acquired data each second for each in situ field trial environment to allow for detailed analysis of household energy and device usage and Tier 2 AV APS device functionality;
* The Tier 2 AV APS device were set to “log mode” and equipment connected to the energy saving device was monitored but not controlled by the Tier 2 AV APS device;
* The APS device recorded its decision points second by second to track when the energy saving mode was enacted (i.e., the power to the connected equipment was switched “off”), Note - The 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 were date and time stamped (synchronized) to facilitate a high level of data interrogation of the power consumption data acquired.

This field trial approach enabled real time monitoring of power consumption and energy savings while the energy saving device simulated its actual operation. Furthermore, this logging approach allowed for the monitoring of the actual power usage trends and the potential impact of the Tier 2 AV APS device without distorting the equipment usage characteristics of the household by the Tier 2 AV APS device itself.

##### **CALPLUG Field Trial Findings**

CALPLUG used their methodology with the following key parameters obtained:

* A total of 53 households were field trialed with an average of 15.61 days per home of second by second data retrieved.
* Low, medium and high AV user types were trailed across this sample set with a 36% / 28% / 36% user type distribution across the sample set respectfully.
* Average annualized energy consumed was 880 kWh across these trial homes.
  + Outliers were removed from the sample set to reach an adjusted annualized energy consumption average of 679 kWh across all user types.
* Average energy reduction percentage (ERP) ranged from 48% to 54% across all user types with an average of 51%.
* Applying the ERP of 51% against the adjusted annual energy consumption (679 kWh) across all user types delivered an annual average energy saving of 346 kWh.

The relative performance of Tier 2 AV APS devices assessed the overall average ERP from the targeted residential AV environments. CALPLUG’s study showed a consistent average ERP of 51% of total energy use for residential AV environments. Thus, CALPLUG’s study concluded that the overall ERP performance of this Tier 2 AV APS device was of statistically high confidence with over 53 in-situ residential field trial sites and 100’s of millions of data points attained.

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

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

• Date & Time (local)

• Mains power level (voltage)

• Connected equipment current consumption

• Connected equipment power use (W)

• IR signals determined by the IR sensor on the Tier 2 AV APS (if an IR sensing Tier 2 AV APS)

• Count down timer settings of the Tier 2 AV APS device

• Mechanical relay logged state of the Tier 2 AV APS

• Energy saved - cumulative watt hours

• Energy saved - instantaneous watt seconds

• Energy used - cumulative watt hours

• Energy used - instantaneous watt seconds

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

##### **SDG&E Field Trial Findings**

The results from the SDG&E field trial further confirmed the percentage of energy that can be reduced through the use of the Tier 2 AV APS tested. Noticeably this trial also found that on average a reduction of 50.5% of total energy used can be achieved from the use of Tier 2 AV APS devices. Additional information regarding the SDG&E field trial is shown below:

* A total of 42 households were field trialed with an average of 15.86 days per home of second by second data retrieved.
* Average annualized energy consumed was 463 kWh across these trial homes.
  + It is worth noting that many of these homes were SDG&E employee homes, so their energy usage was expected to be lower than the Californian annual average of 600 kWh because of their awareness of energy efficiency and energy conservation.
  + This has been factored into the data evaluation calculations.
* Average ERP across all samples was 50.5%, which is within the range of all previous field trials conducted on this Tier 2 AV APS device in the US and other countries.
* Seven household samples were found to have annual energy consumption of less than 200 kWh, which only two household samples had annual energy consumption of more than 1,000 kWh.
* Applying a normalization adjustment factor to the annualized AV energy usage obtained from the trial delivers an annual average energy saving figure of 234 kWh.
  + Normalization baselines are provided as additional 3rd party documents (CEC and NRDC data).
* The average ERP of 50.5% seen in the SDG&E trial, and the average ERP found in the CALPLUG study of 51% on Tier 2 AV APS devices, provides further confidence in the assessment performance assessment approach outlined by CALPLUG for Tier 2 AV APS devices with identical feature sets.

Using the CALPLUG energy saving assessment approach, the SDG&E trial found an overall average ERP of 50.5%. Applying this average ERP to the average total kWh usage per Californian home TV environment in 2009 (600kWh) would equate to an annual energy saving of 303 kWh. (Please see the 2009 residential AV Energy Use Baseline Forecast described at the end of Section 2 of the workpaper)

## 1.3 Code Analysis

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

## 1.4 Measure Effective Useful Life

There are no studies that provide a data point to inform a measured effective useful life (EUL) value for Tier 2 AV APS because the product category is new. The DEER 2014 EUL Update table was used as the starting point for the best available information to use for EULs. The Plug-OccSensEUL ID was selected for the Tier 2 AV APS measure. An analysis of EUL’s for other regions has also been conducted and found that these EUL’s were not based on measured values.

A literature search for customer persistence was performed to identify if consumers removed their Tier 2 AV APS products. A 2012 Australian study telephoned 1,000 respondents who received the Tier 2 AV APS devices. Out of a total of 2,611 total installed Tier 2 AV APS units, 429 or 16.4% were removed at post-installation across all APS devices.

The study had a pie chart that further suggested 28% of the products were removed for various reasons with a majority within the first 3 months. However, the pie chart did not clearly specify the total number of units removed. Nor did the pie chart reference having any connection to the 429 removal number or its subset. The removal of Tier 2 AV APS devices included different manufacturers in the study but that breakdown was not provided in the study.

An additional Australian study also comprising of varying manufacturers found that the removal rate was 33%. Despite not having solid evidence to show a connection between the 28% removal rate and the 16.4% of units actually removed at the post-installation, or detailed analysis on the 33% removal rate in another study, **this work paper assumes a 33% removal rate to build in conservative estimates** until future studies are made available to capture regionally relevant customer retention rates.

Therefore, an EUL measure life of 5 years is proposed.The proposed measure life is calculated as follows:

* 8 year measure life in DEER (despite data from 2004-2005 DEER Final Report (Itron Study – fn 8 that indicates EUL is 10 years);
* 33% Product removal rate (2014 Australian Study); and
* Results in 5.36 year measure life, rounded down to 5 year EUL.

The workpaper may be revised at a point when additional EUL information is made available. As part of an ongoing measurement and verification process during program deployment, retention rates will be evaluated to provide further insight into the EUL. Refer to the Ex-Ante Database for the EUL values.

**Table 5** DEER14 EUL Value/Methodology

|  |  |  |  |
| --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure |
| Plug-OccSens | Residential | AppPlug | Tier 2 Advance Power Strip |

## 1.5 Net-to-Gross Ratios for Different Program Strategies

ET project number ET14SDGE8021 “Tier 2 Advanced Power Strips in Residential and Commercial Applications”, directly contributed to the development of this work paper measure because the goal of that study was to determine energy savings and demand reduction of recent generation advanced power strips in residential audio visual (AV) systems.

The study concluded that the total resource cost and benefits to society could be significant if a Tier 2 APS program is effective. One effective program approach using typical methods could be a direct install program free to residential customers. Thus, the following Net-to Gross IDs are used based on the ET program’s direct contribution to this measure. Refer to the Ex-Ante Database for the NTG values.

**Table 6** Net-to-Gross Ratio

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID |
| ET-Default | Emerging Technologies approved by ED through work paper review | All | Any | All |

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 7 TOU Summary

|  |  |
| --- | --- |
| Measure | % |
| Tier 2 Advance Power Strip | 0 |

# Section 2. Energy Savings & Demand Reduction Calculations

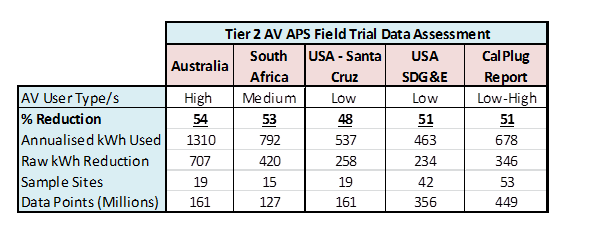
## 2.1 Energy Savings & Demand Reduction Calculations

### Energy Savings Calculation Methodology

#### Field Trial Data Sets on Tier 2 AV APS

**Table 8** provides an assessment of all in-situ field trials including the 2014 SDG&E trial on Tier 2 AV APS devices, which meet the Tier 2 AV APS product specification outlined in this work paper. **Table 8** is an overview of the independent field trials conducted on a Tier 2 AV APS device across multiple geographies with varying types of connected AV equipment and usage patterns.

Table 8 Tier 2 AV APS Field Trial Data Outcomes



To verify the performance of Tier 2 AV APS devices, the residential AV trials in both the CALPLUG and SDG&E’s ETP Scaled Field Placement studies assessed the performance and correlation in performance from other field trial studies conducted on the identical Tier 2 AV APS devices to remove variability between trials. Both the CALPLUG and SDG&E field trials conducted the same methodology across varying user types to determine whether there was consistency in the average ERP.

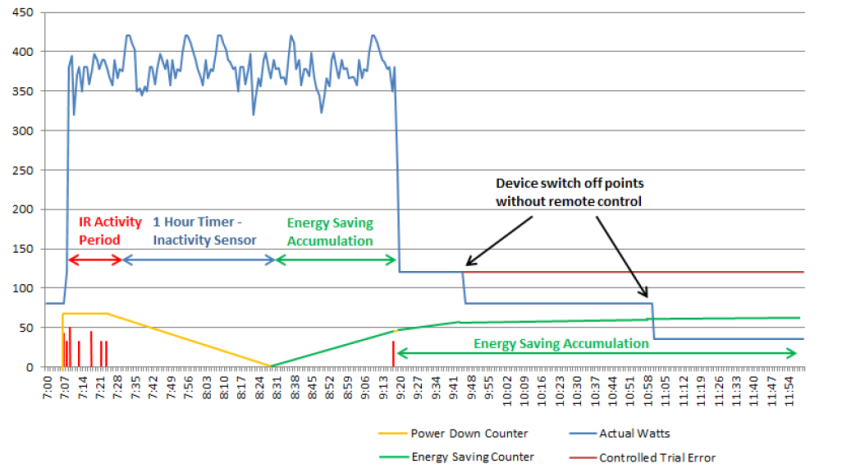
Based on the field trial results, connected equipment and usage behavior from one period to the next varied overall kWh consumption but had little effect on the average ERP for trials conducted on identical Tier 2 AV APS devices. As evidenced, the type of AV user or installed equipment did not materially affect the average ERP across each trial. Rather, the Tier 2 AV APS affected the total annualized baseline energy used by consistently reducing the usage by approximately 50%.

CALPLUG’s study showed a consistent average ERP of 51% across 53 in-situ residential AV environments. SDG&E’s ET Scaled Field Placement study showed an average ERP of 50.5% across 42 field trial sites, which is consistent with prior trials on the same Tier 2 AV APS technology. At a 90% statistical confidence interval level, the SDG&E field trial baseline usage ranged from 381 to 544 kWh with an average annual baseline energy consumption of 463 kWh. The annual energy savings ranged from 187 to 280 kWh with an average annual energy savings of 234 kWh.

Although total baseline energy consumption varied across different environment types, the average ERP across all geographies, user types, and number of connected equipment were consistent across all trials and on average ranged between 48% - 54%. Both CALPLUG’s and SDG&E’s field trial studies corroborated with all field trial studies and confirmed that the Tier 2 AV APS consistently reduced energy usage by approximately 50%.

Using CALPLUG’s field trial methodology, **Figure 3** highlights certain data points providing a clear illustration as to the events in the monitored AV environment. Some observations included:

* Real time power fluctuations of the connected equipment (shown in blue);
* IR activity (shown in red);
* Device switch off points (depicted where there is a clear prolonged power change in power);
* Energy saving Idle Mode timer using inactivity sensor (shown in orange); and
* Accumulated energy saved (shown in green) Rate of incline denotes rate of energy being saved which is a factor of the instantaneous power level (Watt seconds) being monitored.



**Figure 3.** Data Plot Using CALPLUG Tier 2 AV APS Field Trial Methodology

Therefore, assuming products have followed CALPLUG’s 4-phase Go-to-Market Tier 2 AV APS roadmap and adhere to CALPLUG’s recommended Tier 2 AV APS definition, it is reasonable that the average ERP be applied to any targeted region’s baseline annual energy consumption and consistently arrive at a number at or near 50%.

**CALTF’s Annual Energy Savings Recommendation**

Although both the CALPLUG and SDG&E field trial studies provided reliable and consistent information, the California Technical Forum (CALTF) rendered the SDG&E field trial annual energy savings more appropriate as the results more closely aligned with the Santa Cruz field trial.   
  
  
Despite having a greater number of household samples across a broader AV user type base consisting of low, medium and high AV energy users; the CALTF mainly chose not to go with CALPLUG’s final numbers because the CALPLUG approach considered field trials from jurisdictions outside of California.

However, the CALTF reasoned that both the SDG&E and Santa Cruz field trials provided statistically significant data that was also regionally relevant and more representative to California’s population base. The CALTF felt that averaging the annual energy savings from both the Santa Cruz (258 kWh) and SDG&E (234 kWh) field trial studies would be the most appropriate approach for ex-ante savings estimates. The simple average of the two field trial studies would amount to an average annual energy savings of 246 kWh per AV environment.

**Ex-Ante Review (EAR) Team’s Technical Review**

The EAR team conducted its technical review and requested that further evaluation be undertaken on the 9 pre/post operation mode samples collected during the SDG&E field trial. At the EAR team’s request, an evaluation found that variances in baseline energy usage and metered hours of AV inactivity during pre and post installation periods could not be assessed due to limitations in the pre/post operation mode approach. This evaluation was consistent with the findings from both the SDG&E ET and CALPLUG field trials concerning the two different data collection methods.

Although the remaining 33 log mode samples, in the SDG&E field trial, did not suffer from the operation mode data collection constraint, the workpaper uses a weighted average approach to include the 9 operation mode samples with the remaining 33 log mode samples. As shown in Table 9, the **weighted average annual energy savings yielded 212.57 kWh per AV environment.**

Table 9 Weighted Average of 9 Operations Mode Samples with 33 Log Mode Samples



The two key factors that influence both energy savings and retention rates include:

1. the variability in control and sensing strategies of different T2 APS products, and
2. the inability to adjust for critical operational parameters in small scale pre/post assessment of Tier 2 APS.

However, the pre/post field trial method (Operation Mode) cannot capture the critical variability parameters that significantly influence the results of the energy savings estimates from one period to the next, which include:

* Total AV system on time (user unengaged and user engaged hours);
* Total AV system on but not being used time (user un-engaged hours); and
* Average hours of cumulative on time (includes user unengaged and user engaged hours).

To illustrate this point, Figures 4 and 5 outline the variability in total average AV system on time (user engaged and user un-engaged hours) and total average AV system on but not being used time (user un-engaged hours). Both scatter plots illustrate the metered data collected for the 9 operation mode samples during log mode between week 1 and week 2, which cannot be captured using the pre/post field trial method.

It should be noted that the CALPLUG log mode method captures energy savings based on actual AV equipment usage as opposed to assuming identical AV equipment usage from one period to the next, which is a critical assumption for the pre/post metering energy saving calculation method. To address this variability concern, CALTF recommends ongoing monitoring and data collection during program implementation to support the energy saving claims on an individual T2 APS product basis.



**Figure 4.** Variability of Average AV System “On-Time” (Hours) for the 9 Samples from Week 1 to Week 2



**Figure 5.** Variability of Average AV System “Unengaged Time” (Hours) for the 9 Samples from Week 1 to Week 2

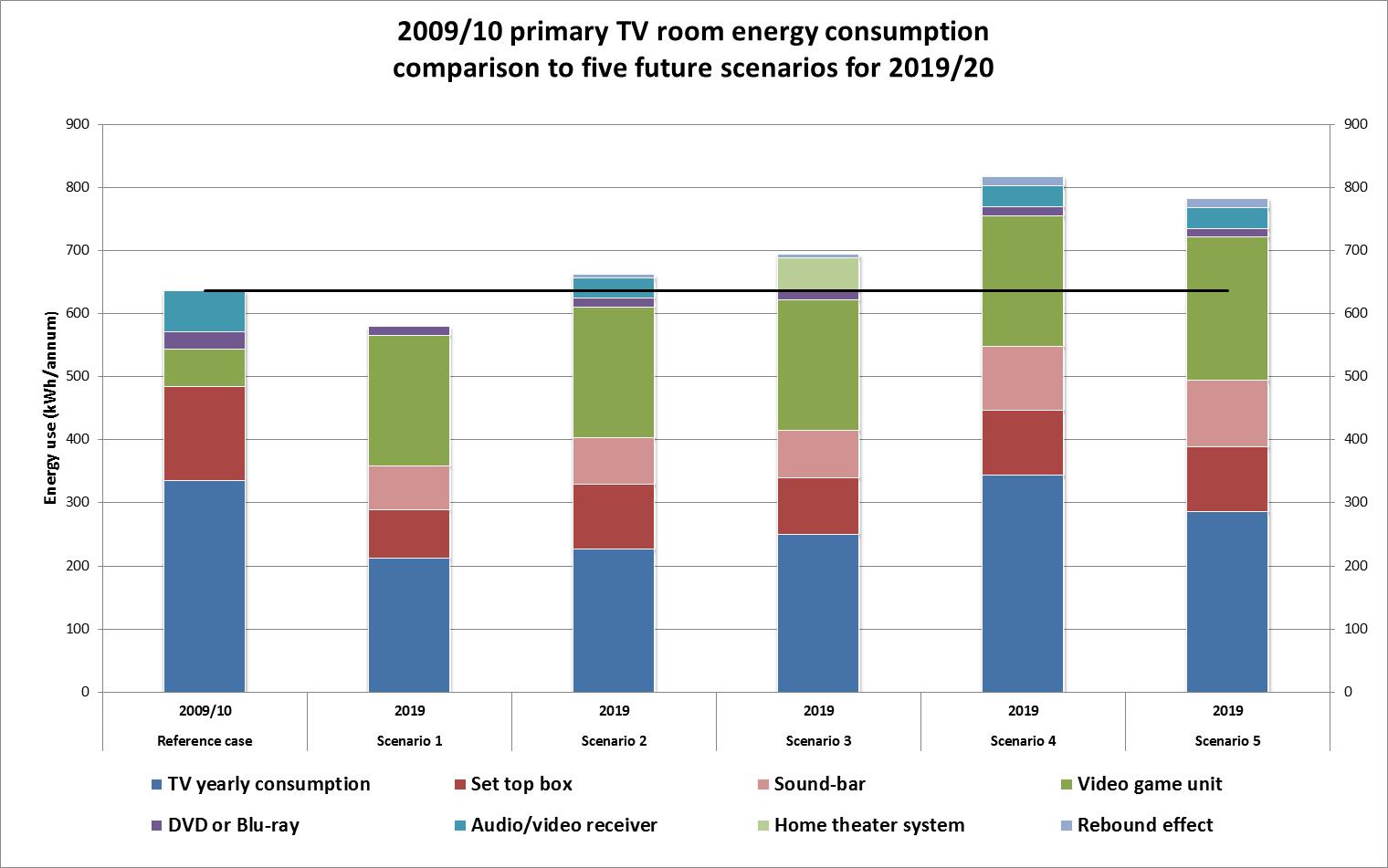
##### **Energy Use Baseline Forecast**

The potential impact that prescriptive energy efficiency standards of electronic appliances have on the total energy consumptions across the whole household AV environments has also been considered in determining long term energy savings. A detailed baseline AV energy use forecast assessment has also been conducted with the detailed paper provided as an attachment within this document. The paper establishes the position that introducing appliance standards will have limited overall impact on total AV energy usage. Despite the increasing and tightening of regulations, households are more likely to see energy consumption remain steady or increase over the next five to ten years.

The paper reflects on six key factors that collectively act to undermine the efficiency gains through the introduction of energy efficiency improvements and performance standards. These six factors all supported with publically available information and data include:

* **Factor one** – screen size is increasing;
* **Factor two** - the increasing quantity of household devices;
* **Factor three** - standards are slow to enact, slow to amend and may not keep pace with new products;
* **Factor four** - the rebound effect;
* **Factor five** - new features, new products, more energy; and
* **Factor six** - TVs and computers are being used for longer periods throughout the day.

Finally, the paper constructs five future scenarios for the year 2019. In four of the five situations, the six factors work to increase the overall energy consumption in AV environments despite rigid TV energy performance standards introduced by the California Energy Commission and voluntary standards agreed to by set top box manufacturers. **Figure 6** is an extract from the paper illustrating the change in baseline TV environment energy use across 5 varying scenarios.



**Figure 6.** Comparing 2009/10 Energy Use with Future Looking 2019/20 Energy Use

An alternate method to determining baseline energy consumption has been established through the detailed data collected during the SDG&E field trial. The field trial data found a strong correlation between the average system load (Watts), and the annual average energy consumed (kWh). On average, for each additional 1 Watt of controlled device power load leads to an additional 2.4 kWh of annual energy being consumed in the targeted environment.[[3]](#endnote-3) During the programs’ ongoing measurement and verification, this correlation finding will assist in determining the average annual energy savings that can be delivered from the Tier 2 APS device tested.

#### Energy Interactive Effects

Tier 2 AV APS measures do have HVAC interactive effects, but DEER does not include energy interactive effects specifically for Tier 2 AV APS measures at this time. Thus, Tier 2 AV 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.

### Peak Demand Reduction

Although CALPLUG’s field trial approach required taking energy measurements of the APS in all modes including: idle, passive standby, and power, the focus of the CALPLUG field trial methodology study was to capture energy savings and not peak demand reduction. However, the SDG&E field trial captured this information. The SDG&E ET field trial study outlined an average peak demand reduction of 34.6 Watts.

However, based on the EAR team’s technical review, the average peak demand reduction results were proportional reduced from 34.6W down to 31.3W based on the inclusion of the 9 operational samples as shown in **Equation 1**. Using the variance between the weighted average energy savings (212 kWh) with the energy savings from all 42 samples (234 kWh) delivers a proportionally reduced **average DEER on-peak demand reduction of 31.3W.**

Average Peak Demand Reduction = x (Peak Demand Reduction All Sites)

**Equation 1.** Average Peak Demand Reduction Formula

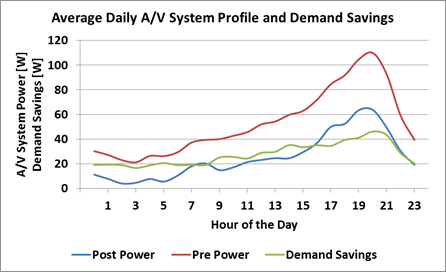
Average Peak Demand Reduction = 212kWh / 234kWh = 90.6%

= 90.6% x 34.6 Watts

= **31.3 Watts**

**Equation 2.** Average Peak Demand Reduction Results

In addition to the above values, **Figure 7** plots the average daily profile averaged across all sites. Patterns show increasing usage and demand savings as the day progresses starting at 7 AM, with sharp drop-off around 9 PM.



**Figure 7.** Average daily demand profile across all sites

#### Demand Interactive Effects and Diversity Factors

Tier 2 AV APS measures do have HVAC demand interactive effects, but DEER does not include demand interactive effects specifically for Tier 2 AV APS measures at this time. Thus, Tier 2 AV APS measures will use the DEER HVAC demand interactive effects and coincident 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 AV APS measures do have HVAC negative therm interactive effects, but DEER does not include factors specifically for Tier 2 AV APS measures at this time. Thus, Tier 2 AV 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 interactive effect values.

## 2.3 Gross Savings Installation Adjustment/In-Service Rate

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 10** below.

Table 10 Gross Savings Installation Adjustment (GSIA) IDs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA\_ID** | **Description** | **Sector** | **BldgType** | **UseCategory** | **TechType** |
| Def-GSIA | Default GSIA values | Any | Any | AppPlug | OccSensPlug |

# 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 DEER:RefrgFrzr\_HighEff. See **Table 11** for a list of all Building Types and Load Shapes.

Table 11 Building Types and Load Shapes

|  |  |
| --- | --- |
| Building Type | Load Shape |
| Residential | DEER:RefrgFrzr\_HighEff |
| Residential Mobile Home | DEER:RefrgFrzr\_HighEff |
| Residential Multi-family | DEER:RefrgFrzr\_HighEff |
| Residential Single Family | DEER:RefrgFrzr\_HighEff |

# 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 (REA) 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 AV APS is approximately $45. 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: GMC = Measure Equipment Cost

**Table 12 Measure Cost**

|  |  |
| --- | --- |
| **Measure** | **GMC ($/unit)** |
| Tier 2 AV APS Measure Equipment Cost | $45.00 |
| Labor Cost | See ex-ante database |
| Gross Measure Costs | $45.00 + DI labor cost |

## 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



# References

1. http://openpowerquality.org/technology/g1-pilot-study.html [↑](#endnote-ref-1)
2. “Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive” (CALPLUG 2014) [↑](#endnote-ref-2)
3. Tier 2 Advanced Power Strips in Residential and Commercial Applications – Page 30 [↑](#endnote-ref-3)