Work Paper SCE17CS014

**Revision 0**

**Southern California Edison**

**Tier 2 Advanced Smart Connected Power Strips**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | SCE Solution Code: CE-18633 |
| **Measure Description** | Tier 2 Advanced Smart Connected Power Strips |
| **Base Case Description** | Standard Power Strip |
| **Units** | Each |
| **Energy Savings** | Refer to Ex-Ante Database |
| **Full Measure Cost ($/unit)** | Refer to Ex-Ante Database |
| **Incremental Measure Cost ($/unit)** | Refer to Ex-Ante Database |
| **Effective Useful Life** | Res-Plug-AdvPwrStrip |
| **Measure Installation Type** | REA |
| **Net-to-Gross Ratio** | ET-Default |
| **Important Comments** | * The Tier 2 Advanced Smart Connected Power Strip (wireless communications) provides the ability to read real time power consumption of electronic equipment connected to the power saving sockets of the Tier 2 APS device via a smart device application for both Android and iOS devices. * This SCE field study supports the claimed savings, in this workpaper, and used a pre-post metering approach across 46 household samples via a wireless Bluetooth enabled and communicating Tier 2 APS in conjunction with IR sensing only, master-less true RMS power monitoring, and control across all controlled devices. * This workpaper is differentiated from WPSDGEREHE0004.1 as this Tier 2 Smart Connected APS is an energy management technology (EMT), as defined in Assembly Bill 793 (AB 793). The technology allows a customer to better understand and manage electricity or gas use in the customer’s home or place of business. |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 10/12/2017 | RMS Energy Consulting, LLC | Original work paper. |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
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# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

### 1.1a Assembly Bill 793 (AB 793) Background

Assembly Bill 793 (AB 793) was signed into law by Governor Brown on October 8, 2015, adding Section 717 to the Public Utilities Code (P.U. Code). The statute requires the Commission to order electric and gas corporations to develop a program no later than January 1, 2017, to provide incentives to residential or small and medium business (SMB) customers to acquire energy management technologies (EMTs), and develop a plan to educate customers about the incentive program by September 30, 2016.

AB 793 directed the investor-owned electric and natural gas utilities (IOUs) to develop a program in their demand side management (DSM) portfolios to provide incentives to residential and small and medium business (SMB) customers to acquire energy management technologies (EMTs)[[1]](#footnote-1) by January 1, 2017. AB 793 also required the IOUs to develop a plan by September 30, 2016, to educate residential and SMB customers about incented EMT offerings available to them. These EMTs could be products, services, or software that provides information and education to consumers about their energy use and ways to better manage it.

### 1.1b Measure Description

This workpaper documents the cost-effectiveness parameters and details the replacement of a standard power strip with a new Tier 2 Advanced Smart Connected Power Strip in residential audio visual (AV) home entertainment environments. This workpaper is differentiated from the non-communicating Tier 2 APS workpaper (WPSDGEREHE0004.1) because this wireless communicating device is an EMT, which allows a customer to better understand and manage electricity use in the customer’s home or place of business as defined in AB 793.

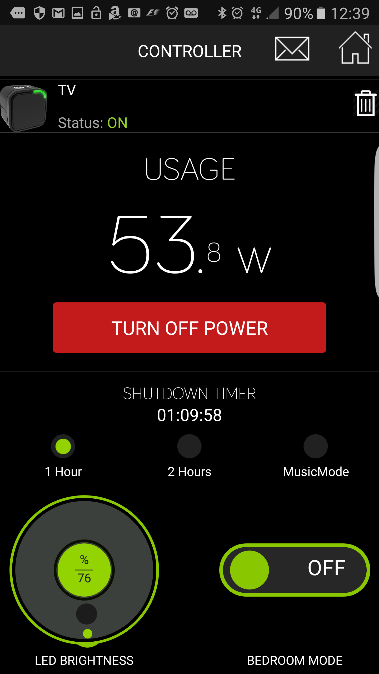
### 1.1c Measure Differentiating Features and Benefits

The wireless communicating enabled feature within this device provides a number of consumer and utility program implementation benefits above and beyond non-communicating Tier 2 APS devices, which promote a greater focus on the connected home.

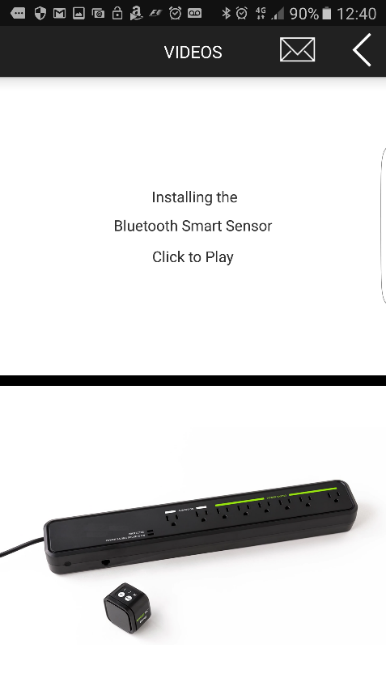
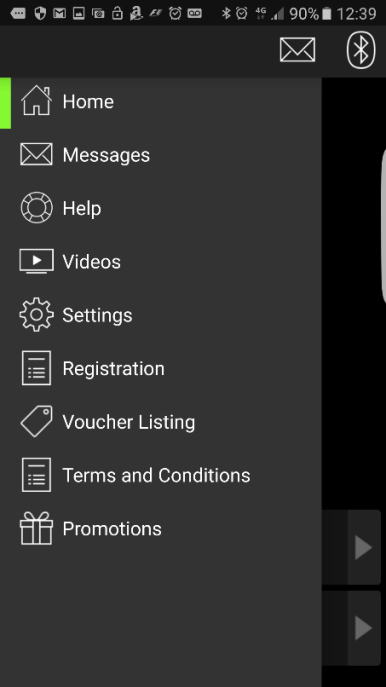
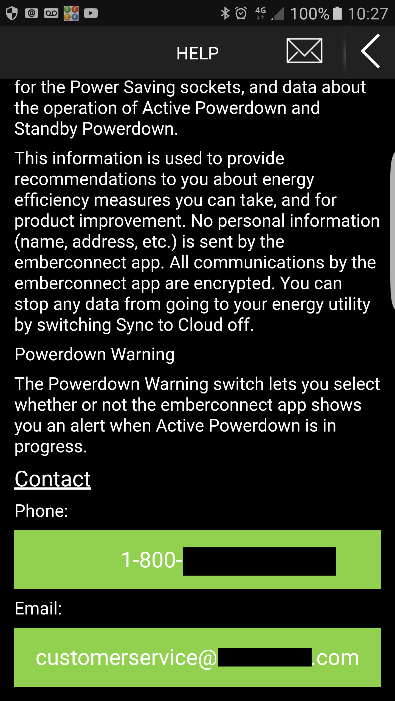
**Consumer Benefits**

The wireless communication enabled feature within this Tier 2 APS device can be used to benefit consumers by:

* providing households with the capability to monitor and provide real time plug load connected and controlled power data wirelessly, via both Android and iOS software applications (**Figure 1**); and
* assisting households in understanding, managing and ultimately reducing the energy use of various plug load devices (**Figure 2**) through the use of such options as but not limited to:
  + a control interface allowing user adjustment settings;
  + two-way direct messaging via the smart device application from the consumer to manufacturer for product assistance and frequently asked questions (FAQs); and
  + informative “how to install” and “how to use” videos.



**Figure 1:** User Adjustment Control Interface via Android and iOS Software Applications

**Figure 2:** Installation Videos and Two-Way Direct Messaging Smart Application for Product Assistance and FAQs

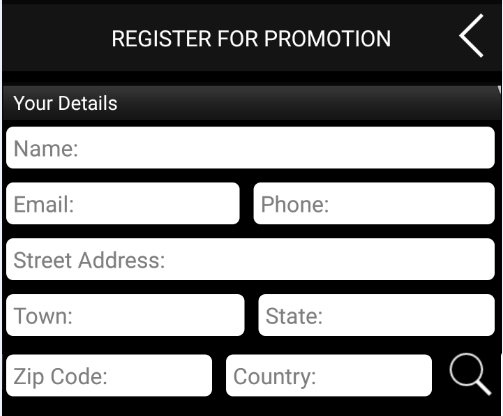
##### **Utility Program Implementation Benefits**

The wireless communication enabled feature within this device can be used to provide a number of utility programmatic and implementation benefits through:

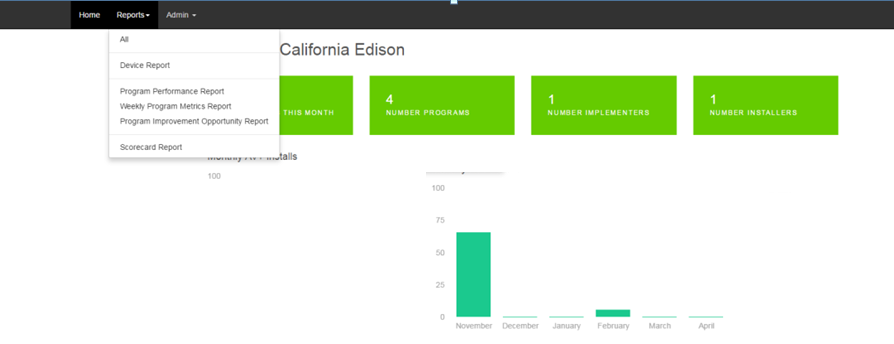
* validating device installations wirelessly beyond Direct Install implementation strategies;
* collecting device power, energy usage and savings data, approved through a household

opt-in option;

* providing households with energy data on commonly used household electronic equipment; and
* engaging households through two-way direct messaging via the smart device application, in order to recommend energy efficient monitoring products and service solutions.



**Figure 3:** Promotional Opt-In-Option to Participate in 2-Week Baseline Log Mode Monitoring



**Figure 4:** Validating Device Installations Wirelessly After Product Registration

**Tables 1** **and 2** describe the measure name and associated product or solution code for each of the program administrators.

**Table 1: Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Tier 2 Advanced Smart Connected Power Strip |
| Existing Condition | Standard Power Strip\* |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |

\*Note: The 2016 SCE ET field study, herein (SCE Report), collected instantaneous pre-post power and energy use measurements in five-minute intervals across 92 residential households. During the trial, it was confirmed that all resident participants had standard power strips as the baseline condition.

Table 2: Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| N/A | TBD | CE-18633 | TBD | Tier 2 Advanced Smart Connected Power Strip |

### 1.1d Measure Eligibility Requirements

Tier 2 APS devices on the market use varying hardware sensing components and software control algorithms. Currently, these devices are uniquely designed by each manufacturer. For this reason, CALPLUG developed a 4-Phase Go-to-Market Tier 2 AV APS roadmap (**Figure 5**) to ensure that manufacturers clearly demonstrate energy savings in both laboratory assessments and field trials before devices are considered as an offering in utility rebate programs. Additionally, Tier 2 AV APS devices must incorporate minimum 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 detections; and
* **Control Algorithms** - to perform automated power management of connected devices based on data and information acquired.



**Figure 5:** CALPLUG’s 4-Phase Go-to-Market Tier 2 AV APS Roadmap

The California Technical Forum (CALTF) supports CalPlug’s 4-Phase 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.

##### **AB 793 EMT’s Eligibility Requirements**

To meet the intent of AB 793’s EMT definition, qualifying Tier 2 Advanced Smart Connected Power Strip devices must incorporate the following feature:

* **Smart device (smart phone or tablet) application user interface** – to provide wireless control interfacing between the Tier 2 APS device, and the user’s smart device (phone or tablet) that exhibits live power data information and educate consumers about their energy use and ways to better manage it.

### 1.1e Implementation and Installation Requirements

#### Direct Install Delivery Channel

Tier 2 Advanced Smart Connected Power Strip devices delivered through utility direct install programs require:

* **Energy Savings Performance:** an independent utility field trial within the U.S. as outlined in CALPLUG’s 4-Phase Go-to-Market Tier 2 AV APS roadmap (**Figure 5**) and conforms to the product eligibility requirements specified in 1.1f.
* **Device Accuracy Validation:** built-in power metering equipment monitoring accuracy with all connected loads to validate the product measures True RMS Power to within +/- 3.0%.
* **Data Reporting Capability:** provide field study pre/post data to support the Energy Reduction Percentage (ERP) analysis.
* **Valid Installation:** A valid installation comprises the control of 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 Advanced Smart Connected Power Strip installation.)

#### Downstream Delivery Channel

Before incentives or rebates are paid, Tier 2 Advanced Smart Connected Power Strip devices delivered through utility downstream deployment programs require the following:

* **Product Installation Validation:** Every product must validate installation via an electronic registration process.
* **Data Metering and Reporting:** The validation process must meter and report the total True RMS Power from devices connected to the controlled outlets of the Tier 2 Advanced Smart Connected Power Strip.

### 1.1f Product Eligibility Requirements

Tier 2 Advanced Smart Connected Power Strip Minimum Product Specifications:

* + Must be independently field trialed within the U.S. as identified in phase 4 of CalPlug’s go-to-market roadmap (**Figure 5**).
  + Field trial must demonstrate that product achieves annual energy and peak demand reduction savings no less than 95% of 240 kWh and 52.89 Watts, respectively.
  + Must adhere to AB 793 requirements by providing wireless control interfacing between the Tier 2 APS device, and the user’s smart device (phone or tablet).
  + Must provide the option to stream real time power data directly to the smart device (i.e. directly from the Tier 2 APS device to smart phone or tablet) to ensure power data privacy.
  + 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 and transmit total power being consumed by all devices connected to controlled outlets on the Tier 2 APS device.
  + Sense true RMS power of all connected controlled devices to determine AV device usage.
  + Hardware and/or software IR filtering technology and firmware 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.
  + Use an automatically adjustable power switching threshold.
  + Must comply with the 2013 California Fire Code (605.4).

For further information on the product tested please review the SCE Tier 2 APS Report in the appendix section of this work paper.

## 1.2 Technical Description Of Tier 2 Smart Connected Power Strip Device Tested

Tier 2 Advanced Smart Connected Power Strip devices use an external sensor paired with a configurable countdown timer to manage both active and standby power loads for controlled devices in a complete system. These wireless communicating devices operate by sensing the power of all devices connected to the controlled sockets.

The external sensor of the Tier 2 Advanced Smart Connected Power Strip, tested in the SCE’s field trial, used an infrared (IR) only sensor to determine device inactivity. The external sensor also uses IR filtering to prevent inappropriate switching events, which may have otherwise resulted from natural interference such as sunlight or CFL light bulbs.

## 1.3 Installation Types and Delivery Mechanisms

The installation type for this measure is Retrofit Add-on (REA).

**Table 3: Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Retrofit Add-on (REA) | Above Code or Standard | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings. The applicable incentive delivery methods are as follows:

* Financial Support / Direct Install
* Financial Support/ Down-Stream Incentive

**Table 4: Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |

**Table 5: Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

Table 6: DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | DEER 2017 READi v 2.4.7 |
| Reason for Deviation from DEER | DEER does not contain Tier 2 Advanced Smart Connected Power Strip devices. |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER 2016 READI tool version 2.4.7.

**Table 7: Net-to-Gross Ratios**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| ET-Default | Emerging Technologies approved by ED through work paper review | Any | Any | Any | 0.85 |

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in the table below.

**Table 8: GSIA Table**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER 2016 READI tool version 2.4.7. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

**Table 9: Effective and Remaining Useful Life Table**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| Res-Plug-AdvPwrStrip | Tier 2 Advance Power Strip | Res | AppPlug | 5 | 1.67 |

### 1.4.2 Codes and Standards Analysis

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

Table 10: Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | N/A | January 1, 2017 |
| Title 20 (2014) | N/A | July 1, 2014 |
| Federal Standards | N/A | N/A |

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

Tier 2 APS emerging technology studies have been performed including SDG&E ET Project: ET14SDG8021 Phase 1 Study and PG&E ET Project: ET13PGE1441 Phase 2 Study. The SDG&E Phase 1 ET study focused on the Tier 2 APS IR technology. The PG&E Phase 2 ET study focused on the Tier 2 APS IR-OS technology. SDG&E subsequently developed the workpaper that documented the cost-effectiveness parameters based on the ET study findings. The energy savings disposition outcome is summarized in the next section.

#### June 10, 2016 CPUC Staff Response to Early Opinion Request on Proposed Revisions to WPSDGEREHE0004 Revision 0.3 Tier 2 Advanced Power Strips

The CPUC June 10, 2016 Disposition provided final savings values for non-communicating Tier 2 APS device and indicated

*“CPUC staff is concerned that the AESC phase 2 research did not include a pre-post investigation of IR T2APS even though the phase 1 investigation indicated significantly lower savings than the simulation mode. CPUC staff is reluctant to direct higher savings values for one technology type over another for measures that serve fundamentally the same purpose. For example, HVAC manufacturers incorporate different technologies to achieve high SEER ratings for air conditioners, but there is only one set of approved savings values that apply to all air conditioners of one particular SEER rating. For these reasons, CPUC staff recommends that SDG&E revise the savings values for T2APS to be the average of the approved values, discussed above, for the two available technologies. This will result in savings values of 130 kWh and 0.018 kW*.”

# Section 2. Calculation Methodology

##### SCE adopted the pre/post metering approach for this trial, as opposed to the savings verification system (SVS) simulated metering approach used in earlier studies. This was largely due to Energy Division requesting that Infra-Red/Master-less Power sensing Tier 2 APS should undertake additional metering using a pre/post method.

##### The APS tested in this field trial adds Bluetooth for communicating energy usage data to households comply with AB 793 requirements. The APS tested also facilitates the collection of power and energy data in compliance with 2013 California Fire Code 605.4. The calculation method used for this workpaper entails validating the energy savings associated with a Tier 2 APS with Bluetooth in Residential Applications.

##### **Study Scope and Technical Approach/Field Testing Methodology**

The 2016 SCE ET field study, herein (SCE Report), collected instantaneous pre-post power and energy use measurements in five-minute intervals across 92 residential households. A key difference between the SCE ET Study compared to Phases 1 and 2 was the way the study was implemented.

Unlike Phase 1 and 2, the SCE ET study was implemented as part of an existing residential direct install program that deployed other energy efficiency measures including the Wireless Bluetooth Enabled and Communicating Tier 2 IR only sensing APS device. Thus, the Tier 2 APS devices were deployed in Operation Mode where SCE’s 3rd party residential direct install implementers installed the Tier 2 APS devices and educated households on how the devices worked. As part of the education during installation, households were advised of an opt in request to participate in the “pre” period phase of the field trial. Thus, the program design deployed a larger sample was deployed because it anticipated that a number of participants would not opt in to this “pre” period when requested.

The SCE ET study was conducted approximately two weeks before and after the Thanksgiving Holiday during November to December of 2016. AESC performed the data analysis for the SCE Report to determine key metrics such as energy and peak demand reduction savings. The “pre” case refers to the baseline without activated A/V controls.

The “post” case refers to the APS with activated control (Operation Mode). The APS A/V Operation Mode controls were activated during the initial monitoring period. The APS A/V Operation Mode controls were subsequently turned off during the second half of the testing period to estimate baseline usage.

##### **Pre-Post Operations Mode versus Savings Verification Systems (SVS) Simulation Mode**

Similar to Phase 1 and 2, the SCE Report indicated that the pre-post field testing method provides a more comprehensive view of energy savings by including the effect of the user’s interaction with the IR sensor in the activated Operations Mode. However, the SCE Report also acknowledged that the pre-post field testing approach does not allow for significant variations in usage patterns compared to the Savings Verification Systems (SVS Mode) approach. Thus, as recommended and implemented in prior field trials, the pre-post monitoring period was extended to two weeks in both the baseline and post cases to minimize the effect of usage pattern variability.

##### **Sample Sizes**

Although 92 residential host sites opted to participate in the study, the SCE Report indicated that 46 sites opted to participate in both “pre” and “post” periods that had data deemed sufficient for inclusion in the analysis. While the median data collection interval was five-minutes, the SCE Report did not include data for half of the host sites because these sites did not participate in both “pre” and “post” periods as described above.

In some instances, these sites exhibited a few gaps of several hours or days in which no 5 minute interval power data was transmitted. The SCE Report indicated that the reason for the data gaps was unknown. However,themanufacturer reported that the source of these data gaps was due to gaps in global system mobile (GSM) signals to transmit a steady stream of data at all times in some installations. Although this led to power data gaps, it did not influence the total energy metered, which is calculated locally on the Tier 2 APS device similar to a standard energy meter.

##### **Data Analysis for Applicable Dataset**

The SCE Report indicated that the data for the 46 usable sites were adjusted by removing days with significant collection gaps to avoid biasing results towards any particular time of day. Due to the prevalence of data gaps in some sites, removing days with only partial data decreased the effective monitoring period.

###### **Pre-Installation Baseline and Post-Installation Monitoring Periods**

To illustrate, the SCE Report indicated that the 46 sites used in the analysis were monitored for an average of 16.4 days in the baseline and 22.0 days in the post period. However, after days with significant data transmission gaps were removed from the data set, the average number of complete days for these sites was 13.3 days in the pre-installation case and 16.2 days in the post-installation case. Days before, during and after Thanksgiving were also removed from the data set to remove any potential biasing or skewing of energy usage and savings during these periods.

Although there were 13.3 baseline days with consecutive five- minute data collections, the total energy used counters were still operating for 16.4 days in the baseline period. Despite some data blackouts occurring during the 16.2 baseline days, the energy counters continued to accrue within the APS device, which was logged and reported when connection resumed. Thus, despite any gaps in the 5 minute transmission of power usage data, there was no data loss on total energy used in either pre or post periods.

**Weekday and Weekend Data Normalization**

For the purpose of maintaining consistency among the sampled group, the SCE Report indicated that weekdays and weekends were also differentiated in the analysis. The SCE Report indicated that to be included in the data analysis, each site required to have data for at least five complete weekdays and two complete weekend days in both the pre-installation and post-installation monitoring periods.

The SCE Report indicated that average energy impacts were calculated for both weekday and weekend days at each site using data from complete weekdays and complete weekend days. These site averages were scaled to determine energy savings over a standardized two-week period with exactly ten weekdays and four weekend days. A similar extrapolation was used to determine annual energy savings for each site. The SCE Report indicated that using this method ensures that annual results were not biased towards weekend or weekday data despite gaps in usable data over the monitoring period.

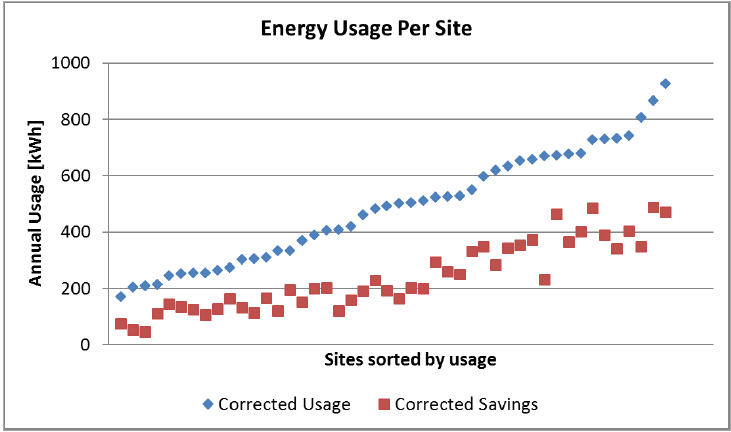
##### **Study Results**

The SCE Report indicated that the average baseline and savings for the corrected dataset are shown in **Table 11**. The 90% confidence intervals for baseline energy consumption and energy savings are 487 ± 48 kWh and 240 ± 30 kWh, respectively.

**Table 11: Average Energy Savings Results for the A/V Trial**

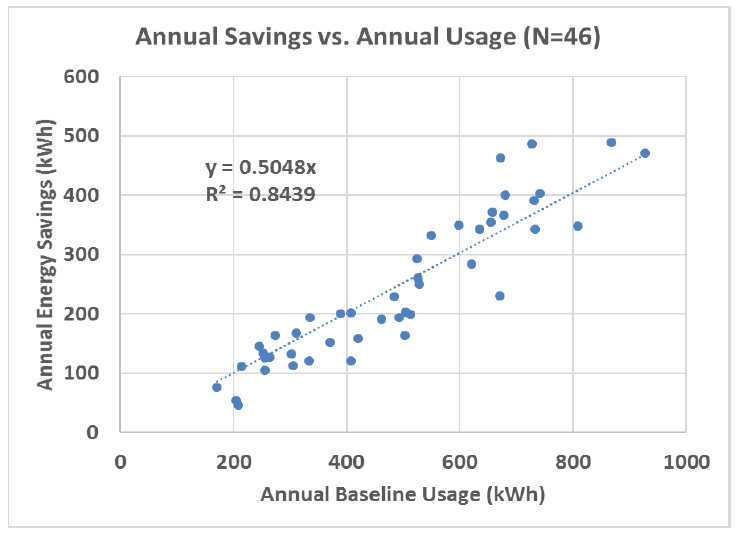
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **# of Sites** | **Baseline Annual Usage (kwh)** | **Baseline Standard Deviation (kwh)** | **Annual Savings (kWh)** | **Annual Savings Standard Deviation (kwh)** |
| 46 | 487.4 | 197 | 240.4 | 5 |

The SCE Report indicated that energy savings per site were found to be well correlated with baseline energy consumption overall. The corrected baseline and energy savings for each of the 46 sites were plotted in **Figure 6**. The SCE Report indicated that baseline usage and savings were fairly linear across the range of sites monitored, suggesting that annual baseline usage and savings were related and have a linear relationship. This demonstrates that variation in baseline energy usage will not influence the Energy Reduction Percentage (ERP).



**Figure 6: Energy Usage and Savings by Site**

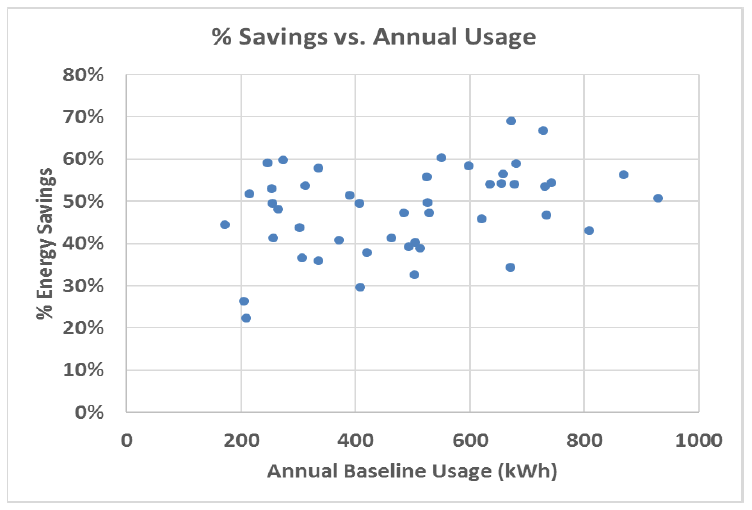
The SCE Report plotted the annual calculated savings as a function of annual use, which had a linear trend line slope of about 0.5, or approximately 50% savings as shown in **Figure 7**.



**Figure 7: Annual Energy Savings as a Function of Baseline Energy Usage**

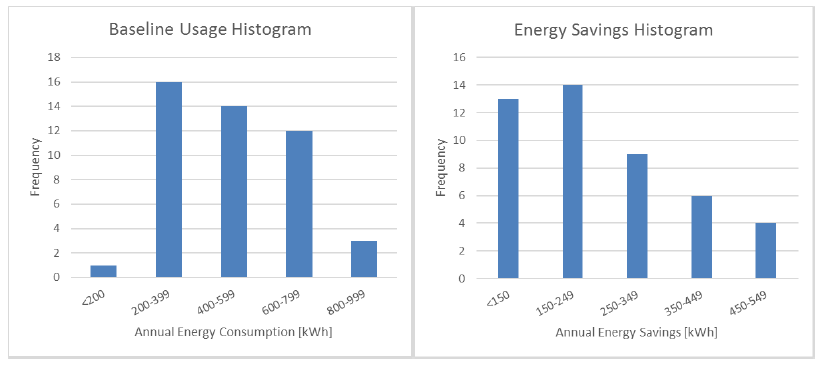
The SCE Report identified that this Wireless Communicating Smart Connected Tier 2 APS device delivered an Energy Reduction Percentage (ERP) range between 22% and 69%, with an average ERP per site of 49% from baseline conditions. However, the SCE Report indicated that the ERP did not have a correlation with baseline energy use; thus, ERP did not influence the baseline energy usage. The ERP was primarily dictated by user behavior, which is highly variable site to site. As a result, the SCE Report indicated that the effect of this user behavior variability was minimized by extending the monitoring period to two weeks in both the pre and post cases as discussed in Phases 1 and 2.

Based on the SCE Report, **Figure 8** shows the ERP savings of the corrected dataset by baseline usage showing no correlation between percent savings per site and annual baseline usage. The SCE Report indicated that although sites with larger baseline energy usage generally achieved greater energy savings, the realized ERP savings was not proportional to annual baseline usage. Therefore, a larger baseline energy usage level had no influence and would not increase the demonstrated ERP.



**Figure 8: Annual ERP Savings as a Function of Baseline Energy Usage**

The SCE Report provided histograms for the baseline usage and energy savings, which are shown in **Figure 9**. Energy savings per site ranged from a minimum of 47 kWh/year to a maximum of 489 kWh/year.



**Figure 9: Annual ERP Savings as a Function of Baseline Energy Usage**

##### **Accuracy of Tier 2 APS Projected Annual Energy Use**

Prior to deployment into SCE’s 3rd party residential direct install programs, the Wireless Communicating Tier 2 Smart Connected APS devices were tested at SCE’s Technology Test Center (TTC) laboratories using several common entertainment system plug load devices including a TV, sound system, and streaming device. SCE’s TTC labs tested these devices using a Yokogawa WT1800 Precision Power Analyzer and an Elgar DW1251P AC power source power supply to confirm device measurement accuracy of the Tier 2 Smart Connected APS was within acceptable accuracy ranges.

###### **Pre-Installation and Post-Installation Average Daily Usage Discussion**

In the SCE Report, AESC indicated that

The results of this study should be tempered by the fact that the average number of uses declined sharply from the pre-installation to post-installation period. Note that a “use” was defined by the analysis as a continuous period with greater than 50W of power consumption. While the total time in use would be expected to decrease since the APS is designed to turn off devices that are not in use, the total number of uses per day would be expected to remain constant. The data shows that both the average time of use and average number of uses per day decrease significantly from the baseline to the post period.

This significant change in A/V usage may have resulted from the fact that pre- and post-installation periods were collected over nearly identical 2-3 week periods at all 46 sites. As a result, it is possible that more popular television programming was scheduled during the pre-installation period, which led to an increase in A/V operation during this period.

These results highlight the fact that it is difficult to control for changes in usage patterns when conducting any monitoring study and this issue can be best addressed by extending the monitoring period in future studies. If post-installation annual energy consumption is normalized to consider this change in average daily uses, the energy savings impact of the technology is decreased, as shown in **Table 12**. However, even after adjusting for usage, the energy impacts measured in this study were significant. Annual energy usage was observed to decrease significantly in all 46 analyzed sites.

**Table 12: Adjusted Annual Energy Savings to Consider Changes in Usage Patterns**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Unadjusted Energy Consumption (kWh)** | **Average Daily Uses** | **Adjusted Energy Consumption (kWh)** |
| Pre-Installation | 487.4 | 2.4 | 487.4 |
| Post-Installation | 247.0 | 2.0 | 305.2 |
| Savings | 240.4 |  | 182.1 |
| % Reduction | 49% |  | 37% |

###### **Review and Analysis of Average Daily Use between Pre and Post Installation Dataset**

The SCE Report stated that “*While the total time in use would be expected to decrease since the APS is designed to turn off devices that are not in use, the total number of uses per day would be expected to remain constant*.” The SCE Report further stated that “*the data shows that both the average time of use and average number of uses per day decrease significantly from the baseline to the post period*.” The SCE Report hypothesized that the number of daily uses in the post period decreased because the device was designed to turn off devices not in use as intended. Additionally, the SCE Report hypothesized that the average daily use increased in the pre period because the households were using the TV more during the pre-period compared to the post period.

The SCE Report further states, “*If post-installation annual energy consumption is normalized to consider this change in average daily uses, the energy savings impact of the technology is decreased*.” However, the SCE Report did not test this hypothesis or provide further analysis on whether this variance between the average daily uses (from the pre 2.4 to the post 2.0) was driven by higher usage in the pre period. Without testing the hypothesis, it is not clear on how higher daily use would validly result in increasing the adjusted energy consumption for the post period and ultimately lowering energy savings as shown in **Table 12**. Thus, a detailed review of the AESC’s dataset was undertaken to test whether more popular television programming led to an increase in average A/V uses during the pre-installation period.

As shown in **Table 13**, the SCE Report hypothesizes in its Discussion section that increases in average daily uses per site was driven by an increase in equipment usage, which would lead to:

1. increases in average daily use hours in the pre-period;
2. causing the pre period to have higher baseline energy consumption; and
3. resulting in the potential of higher energy savings opportunity.

**Table 13: SCE Report Average Daily Use Increase Hypothesis and Potential Skewing Calculation Results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Average Daily Use** | **Average Daily Use Hours** | **Energy Consumption** | **Potential Skewing in Energy Savings Calculation** |
| Pre Period Hypothesis |  |  |  |  |
| Post Period Normalization Effect |  |  |  |  |

A data analysis was conducted for each of the 46 sites to test this hypothesis on whether the data would demonstrate that both the average time of use and average number of uses per day decreased significantly from the baseline to the post period. Based on this hypothesis, an increase in daily uses in the pre period would lead to an increase in the baseline energy consumption in the pre period and increase the energy savings calculation. If the hypothesis holds true, then the samples with the lowest variability in daily uses between post and pre periods will have the lowest calculated energy savings including being lower than the average savings of 240 kWh spanning across the total sample set (46).

As shown in the top chart of **Figure 10**, forty (40) out of the forty-six (46) sites showed that increases in average daily uses per day in the pre period typically correlated to increases in average daily use hours for the pre period. The average ERP and associated annual energy savings for these forty (40) sites amounted to 49% and 251.33 kWh, respectively.

**Figure 10: Pre and Post Average Number of Daily Uses and Average Daily Use Hours Plot**

However, as shown in **Table 14**, the daily use increases in the pre period over the post period for six (6) of the forty-six (46) sites were on average not related to increases in device usage hours, baseline energy use, energy savings or the energy reduction percentage. These six (6) sites had significant increases (> 100% difference) in daily use variability between the pre period compared to the post period. These six (6) sites exhibited an average daily use variability of 1.9 daily uses over the post period or an average daily use increase of 137.5% in the pre period over the post period.

If the hypothesis held true, then the average annual kWh and ERP values across these 6 sites would be expected to be well above the field trial average of 240 kWh and 49%, respectively. However, the average of these 6 sites are completely the opposite of the hypothesis, exhibiting an annual kWh saving and ERP value of 170.53 kWh and 40.8%, respectively.

**Table 14: SCE Report Average Daily Use Increase Theory**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Site** | **Pre # of Daily Use** | **Post # of Daily Use** | **Daily # of Uses Over Post Period** | **Pre Daily Use Hours** | **Post Daily Use Hours** | **Daily # Use Hours Over Post Period** | **Pre Annual kWh Usage** | **Post Annual kWh Usage** | **Energy Reduction Percentage From Baseline** | **Annual Energy Savings** |
| 5 | 3.00 | 1.44 | 1.56 | 9.49 | 6.75 | 2.74 | 333.84 | 214.12 | 35.9% | 119.72 |
| 6 | 5.21 | 1.64 | 3.57 | 8.21 | 7.12 | 1.09 | 208.33 | 161.9 | 22.3% | 46.45 |
| 18 | 3.00 | 1.25 | 1.75 | 8.63 | 5.09 | 3.53 | 452.76 | 269.78 | 40.4% | 182.98 |
| 36 | 2.60 | 1.09 | 1.51 | 9.76 | 3.42 | 6.34 | 669.04 | 213.35 | 68.1% | 455.69 |
| 71 | 2.79 | 1.35 | 1.44 | 9.29 | 5.90 | 3.39 | 255.60 | 149.71 | 41.4% | 105.81 |
| 72 | 3.21 | 1.51 | 1.70 | 10.29 | 7.58 | 2.71 | 305.87 | 193.37 | 36.8% | 112.50 |
| Average Across 6 Highest Variable Sites | 3.3 | 1.4 | 1.9 | 9.3 | 6.0 | 3.3 | 370.91 | 200.38 | 40.8% | 170.53 |
| Average Across All 46 Sites | 2.4 | 2.0 | 0.4 | 8.9 | 5.1 | 3.8 | 487.4 | 247.00 | 49.0% | 240.4 |

###### **Pre-Installation and Post-Installation Average Daily Usage Conclusion**

After testing the hypothesis, the data evidences that increases in average daily uses were not linked to an increase in daily usage hours. Therefore, the hypothesis that the baseline energy consumption and ERP were influenced by an increase in device uses in the pre period would overstate energy savings is not correct.

**Table 14** exhibits and concludes that the increase in average daily uses in the pre period over the post period for these six (6) sites was not due to an increase in AV usage hours in the pre period. Rather, the increase in the average daily uses in the pre period is likely due to a behavioral influence from the Tier 2 APS, which educated trial participants to switch off their equipment between viewing programs in the pre period. As such, switching off equipment when it is not being used (i.e. at the culmination of viewing a program) would then require the household to switch the equipment back on to watch another program, which increases daily uses in the pre period.

As shown in **Table 14**, the increase in daily uses in the pre period over the post period did not increase energy savings because it was not linked to an increase in equipment usage. Rather, as shown in **Table 14**, the increase in daily uses was due to more efficient appliance usage by the household. Thus, any normalization adjustment in the energy savings and ERP values for these 46 samples should result in increased energy savings and energy reduction percentage values as supported by the data analysis. Therefore, a conservative view would be to leave both the annual energy savings and ERP values at the 240 kWh and 49%, respectively.



Original Hypothesis Trend Line

**Figure 11: Effect of Daily Use Increase in the Pre Period on the kWh Saved**

To further test the SCE Report hypothesis, an analysis was conducted to assess the effect of increasing daily uses from the pre to post period at the same site with respect to the ERP. If this hypothesis was true, a positive trend line slope (illustrated in red) is expected because a positive trend line would demonstrate that as the pre period daily uses increased over the post period, the pre period energy usage and annual calculated energy reduction percentage would also increase.

However, **Figure 11** demonstrates that there is no linear or positive relationship between the daily uses and the energy reduction percentage. Thus, the data effectively disproves the untested SCE report hypothesis and supports an Energy Reduction Percentage (ERP) and kWh saving from the 46 samples sites of 49% and 240 kWh respectively. Contrastingly, the data demonstrated an increase in daily uses, in the pre period compared to the post period, was more likely due to efficient device usage, which lowered pre-period baseline consumption, calculated energy savings and ERP. Therefore, the data supports that users were likely behaving more efficiently in the pre period increasing daily uses attributed to switching off equipment when not being used and then switching equipment back on at a later time.

***Energy Interactive Effects***

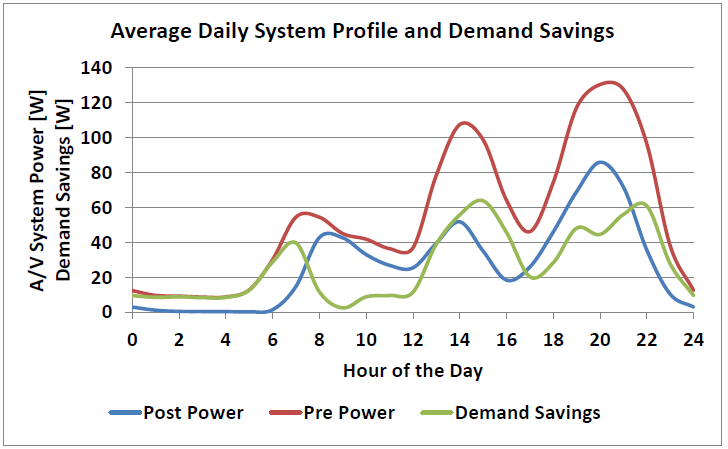
Tier 2 Advanced Smart Connected Power Strip devices do have HVAC interactive effects. However, DEER does not include energy interactive effects specifically for this measure at this time. Thus, this measure will use the DEER HVAC interactive effects values used in residential indoor lighting power applications. Please refer to the ex-ante database for actual energy savings values.

***Peak Demand Reduction***

In addition to energy savings, the APS devices tested in this study also achieved some demand reduction. In both the pre-installation and post-installation cases, the demand profile experiences a brief dip that roughly coincides with the DEER peak demand period of 2:00-5:00pm. This trend suggests that many participants in the study were away from home during on-peak hours. The associated demand savings are most likely due to standby demand reduction rather than turning off equipment that had been accidentally left on.

**Figure 12** plots the daily baseline demand profile, post-installation daily demand profile (including weekday and weekend), and demand reduction, as averaged across all complete host sites over the measurement period. Note that the baseline demand fluctuates throughout the day, but peaks at 7am, 2pm and at 8pm. This daily demand profile differs from previous studies that reported a lone baseline demand peak at around 9pm. This inconsistency with previously reported findings suggests that demographics or APS usage characteristics in this analysis may differ from other studies.

As **Figure 12** illustrates, on average, positive demand savings were achieved for each hour of the day, with a maximum savings of approximately 64W occurring at around 3pm. It should also be noted that the demand savings is about 10W during off hours. Average demand savings across the entire day were about 27W. On-peak demand and demand savings were calculated by averaging the demand between 2pm and 5pm on complete weekdays. Nearly all surveyed sites exhibited savings during this DEER peak period, although two sites showed a slight increase in energy consumption during the period, likely due to varying use patterns. Overall, there was significant variation in peak demand period savings, ranging from -8W to 155W. The demand impacts are summarized in **Table 15**.



**Figure 12: Average Host Site System Load Profile, Including Data from Weekdays and Weekends**

**Table 15: Average Weekday On-Peak Period Savings**

|  |  |
| --- | --- |
|  | **Average** |
| DEER on-peak baseline demand (W) | 88.85 |
| DEER on-peak measure case demand (W) | 35.96 |
| DEER on-peak demand savings (W) | 52.89 |
| DEER on-peak % demand savings | 60% |

***Demand Interactive Effects***

Interactive effects for 2017 were provided ahead of time by the EAR team to help estimate the savings values in specific locations and building types statewide. The savings are included in a support table in the attachments.

## 2.2 Gas Energy Savings Estimation Methodologies

## Tier 2 Advanced Smart Connected Power Strip devices do have HVAC negative therm interactive effects. However, DEER does not include factors specifically for this measure at this time. Thus, this measure will use the DEER HVAC negative therm values used in indoor residential lighting power applications. Please refer to the ex-ante database for actual negative therm interactive effect values.

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The CFL load shape was reviewed but because of the 24/7 operation of the equipment the closest load shapes that are applicable to the measures in this work paper are listed in the table below.

**Table 16: 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. 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. The alternative is to make no changes to their existing system.

## 4.2 Measure Case Cost

Per manufacturer cost quotes, the measure equipment cost for a Tier 2 AV APS is approximately $60. 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 17: Measure Cost**

|  |  |
| --- | --- |
| **Measure** | **GMC ($/unit)** |
| Tier 2 AV APS Measure Equipment Cost | $60 |
| Labor Cost | See ex-ante database |

## 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 this measure, the IMC is equal to the gross measure cost as there exists no base case from which to compare the measure.

**Table 18: Incremental Costs**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| REA | $60 | $60 | N/A |

# Attachments

1. A1 - 2017-08-22 Tier 2 APS Results - Master
2. A2 - Tier 2 APS Report 04062017
3. A3 - CalTF Notes
4. A4 - SMART Power Strips EUL Justification
5. A5 - TIER 2 Smart Connected Power Strip Calculations

# References

1. Tier 2 Advanced Power Strips with Bluetooth® in Multifamily Residential Applications (2017).
2. Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive CalPlug (2014).
3. SDG&E ET Project: ET14SDG8021 Phase 1 Study Tier 2 Advanced Power Strips Residential and Commercial Applications SDG&E (2014).
4. WPSDGEREHE0004.0.3 Tier 2 Advanced Power Strips Workpaper SDG&E (2015).
5. PG&E ET Project: ET13PGE1441 Phase 2 Study (2016).
6. CPUC Staff Response to Early Opinion Request on Proposed Revisions to WPSDGEREHE0004 Revision 0.3 Tier 2 Advanced Power Strips (2016).

1. For the purposes of AB 793, “energy management technology” may include products, services, or software that allow customers to better understand and manage electricity or natural gas use in the their homes or places of business. [↑](#footnote-ref-1)