Work Paper SCE17HC060

**Revision 1**

**Southern California Edison**

**Classroom HVAC Occupancy Sensor**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | AC-68775, AC-20492, AC-20489, AC-72229, AC-20493, AC-20490 |
| **Measure Description** | Thermostat with occupancy sensor controlling packaged HVAC systems |
| **Base Case Description** | Thermostat without occupancy sensor controlling packaged HVAC system |
| **Units** | Per Rated Ton |
| **Energy Savings** | Refer to Excel Calculation Attachment |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Effective Useful Life** | HVAC-ProgTStats: EUL 11yrs, RUL 3.7yrs |
| **Measure Installation Type** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratio** | K-12School-ComCollege: 0.85 |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 11/4/16 | Jay Schuyler/TRC | * This work paper is an update of SCE13LG060.2 * Updated chapter section references for Title 24 2016 Standards and referenced ASHRAE HVAC Applications Handbook 2015. The code language in the work paper was updated. * New calculation template for 2017 program year. |
| 1 | 07/11/18 | Akhilesh Endurthy/ Lincus, Inc. | * Install type changed to NR based on ED’s disposition on custom projects replacing thermostats * Technology type revised from shutting down the AC unit to unoccupied temperature setbacks * Revise the calculations using DEER eQuest models and unoccupied temperature setbacks * Removed Education-Universities and Education-Community Colleges from eligible building types * Update the costs section and considered Incremental Measure Cost as the eligible cost. * Added new four solution codes to clarify specific building types |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
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|  |  |  |  |  |  |

Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper details the estimated electrical and natural gas energy and peak demand savings for a classroom with an occupancy sensor controlled HVAC system. The base and measure cases are as follows:

Base Case: A programmable thermostat without occupancy sensor controlling Packaged HVAC unit serving classrooms. This thermostat has unoccupied setback temperature control during closed hours (evenings, weekends, furlough days and holidays).

Measure Case: A programmable thermostat with occupancy sensor controlling Packaged HVAC unit serving classroom. Like the base case, this thermostat has unoccupied setback temperature control during closed hours (evenings, weekends, furlough days and holidays). Additionally, this thermostat goes to unoccupied setback temperatures when there is no occupancy sensed for a certain predetermined duration.

This work paper considers the following two types of packaged HVAC systems:

**Heat Pump:** Electric cooling and heating

**DX Furnace:** Electric cooling and natural gas heating

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Thermostat with occupancy sensor controlling packaged HVAC systems |
| Existing Condition | Thermostat without occupancy sensor controlling packaged HVAC system |
| Code/Standard | Thermostat without occupancy sensor controlling packaged HVAC system |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | AC-20492 |  | Classroom DX Furnace Occupancy Sensor Control - Education - Relocatable Classroom |
|  |  | AC-20489 |  | Classroom DX Furnace Occupancy Sensor Control - Education - Secondary School |
|  |  | AC-68775 |  | Classroom DX Furnace Occupancy Sensor Control - Education - Primary School |
|  |  | AC-20493 |  | Classroom Heat Pump Occupancy Sensor Control - Education - Relocatable Classroom |
|  |  | AC-20490 |  | Classroom Heat Pump Occupancy Sensor Control - Education - Secondary School |
|  |  | AC-72229 |  | Classroom Heat Pump Occupancy Sensor Control - Education - Primary School |

The measure is only for classrooms in Education Primary Schools, Education Secondary Schools and Education Re-locatable Classrooms. This measure is not applicable for Education Community Colleges and Education Universities, unless these buildings have relocatable classrooms with packaged units.

The measure requires installation of an HVAC occupancy sensing thermostat in the classroom. This control equipment includes, but is not limited to:

An occupancy sensing thermostat

An occupancy sensor (wired or wireless)

Wiring (if wired)

Signal receiver and power pack (if wireless)

## 1.2 Technical Description

Energy Savings from this measure are a result of reduced run time of the HVAC system (fans, compressors, furnaces) due to the temperature setpoints setback to unoccupied mode when there is no occupancy during the school hours. The unoccupied mode temperature set points are 86 oF for cooling and 62 oF for heating. The HVAC units cycle on/off to meet the temperature setpoints.

## 1.3 Installation Types and Delivery Mechanisms

The measure install type is Replace on Burnout (ROB).

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code/ ISP | N/A | EUL | N/A |

The delivery method is Financial Support – Direct Install.

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.

**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. |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

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 | Yes |
| DEER Version | N/A |
| Reason for Deviation from DEER | DEER does not contain this measure. |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

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

**Net-to-Gross Ratio**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| K-12School-ComCollege | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | 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.

**Gross Savings and Installation Adjustment**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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 READI tool. 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.

**Effective and Remaining Useful Life**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HVAC-ProgTStats | Setback Programmable Thermostats | Com | HVAC | 11 | N/A |

### 1.4.2 Codes and Standards Analysis

Chapter 4.5.1.1 of California’s Title 24 2016 Non-Residential Compliance Manual [498] requires that zone thermostatic controls must be provided for each space-conditioning zone to control the supply of heating and cooling energy within that zone. The setpoint may be adjustable either locally or remotely, by continuous adjustment or by selection of sensors.

4.5.1.4 Section A requires that each space-conditioning system must be provided with controls that can automatically turn-off the equipment during unoccupied hours. The control device can be an automatic time switch, manual override abilities, an occupancy sensor, etc.

Section B requires that when shut down, the controls shall automatically restart the system to maintain:

1. A setback heating thermostat setpoint, if the system provides mechanical heating.

*Exception:* Thermostat setback controls are not required in nonresidential buildings in areas where the Winter Median of Extremes outdoor air temperature is greater than 32°F.

2. A setup cooling thermostat setpoint, if the system provides mechanical cooling.

*Exception:* Thermostat setup controls are not required in nonresidential buildings in areas where the Summer Design Dry Bulb 0.5 percent temperature is less than 100°F.

From the ASHRAE Standard 90.1-2013 [A], the thermostat must be capable of temperature setback down to 55°F and a temperature setup of 90°F during unoccupied hours.

ASHRAE HVAC Applications 2015 handbook [499] states that science classrooms (or school laboratories) may require fume hoods with special exhaust systems. If there are no fume hoods, a room exhaust system is recommended for odor removal, depending on the type of experiments conducted in the room and whether animals are kept within the room. Any associated storage and preparation rooms are generally exhausted continuously to remove odors and vapors emanating from stored materials.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | 2016 Non-Residential Compliance Manual, Section 4.5.1.1 Zone Thermostatic Controls, Section 4.5.1.4 Shut-off and Temperature Setback/Setup | January 1, 2017 |
| ASHRAE | Standard 90.1-2013 | 2013 |

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

N/A

## 1.6 Data Quality and Future Data Needs

N/A

# Section 2. Calculation Methodology

This section provides the step by step calculation methodology for estimating the electrical and natural gas energy savings and peak demand savings for a classroom with an occupancy sensor controlled HVAC system.

1. DEER Prototypes are downloaded from MAS Control v3.00.27, the last version of MAS Control with prototypes having HVAC Packaged units. The versions after v3.00.27 do not have prototypes with HVAC packaged units.
2. The prototypes are downloaded for the following building types where the measure is eligible. Education Universities and Education Community Colleges were not considered for the measures in this work paper because these building types typically have Building Automation System (BAS) and there were minimal if no instances where the occupancy reduces to less than 50%. The case option selected in MAS Control is customer average (Cav).

|  |  |
| --- | --- |
| **Eligible building type DEER Anonym** | **Building Description** |
| ERC | Education – Relocatable Classrooms |
| ESe | Education – Secondary |
| EPr | Education – Primary |

1. This measure is applicable to all the vintages. However, for the analysis only vintage 2003 is considered. This is because, per DEER2014 Building Weights, the weights are relatively high for vintages 1996 and 2003 as per the table below. Being conservative, vintage 2003 is chosen over 1996.

|  |  |  |  |
| --- | --- | --- | --- |
| **Bldg** | **Vintage** | **Sum of weights SCE** | **Sum of weights all IOU** |
| ERC | 1996 | 7.22 | 25.12 |
| ERC | 2003 | 6.12 | 20.12 |
| ERC | 2007 | 1.71 | 5.82 |
| ERC | 2011 | 1.71 | 5.82 |
| ERC | 2014 | 0.86 | 2.91 |

1. The downloaded prototypes were input into eQuest version 3-65 and then simulated. To begin, the prototypes for all (16) climate zones were run for building type ERC for HVAC Type AC and HP. This was done using batch processing. The output from batch processing was used as the baseline energy usage and DEER peak demand for each climate zone. Please note that in DEER prototypes, the electric rates are set-up with $1 per kWh for the DEER peak period of each climate zone and $0 for the reaming hours. Hence, the electric utility charges from the batch processing output file is the kW during the (9) DEER peak hours. Dividing this by 9 provides the average DEER peak usage for each climate zone.
2. For the measure case energy usage, the thermostat cooling and heating set points are setback to unoccupied mode, 86 oF for cooling and 62 oF for heating, for the hours described below. When implemented, the setback will happen when there is no occupancy sensed like lighting occupancy sensors. This could happen anytime during the classroom hours. However, in eQuest, the minimum interval at which the thermostat settings can be changed is only hourly. Hence, it is assumed that on average, the setbacks happen for two hours on weekdays and four hours on Saturday towards the closing hours of the classroom when the occupancy factor is less than or equal to 0.5. The table below summarizes the setback schedules.

|  |  |  |  |
| --- | --- | --- | --- |
| **Building Type** | **Setback Hours** | **Occupancy Factor** | **Schedule name in DEER Prototype** |
| ERC | Monday to Friday: 2PM to 4PM (close hour) | 0.5 | S1 Sys1 (PVVT) Cool S2 WD  S1 Sys1 (PVVT) Heat S2 WD |
| Saturday: Noon to 4PM (close hour) | 0.3 | S1 Sys1 (PVVT) Cool S2 Sat  S1 Sys1 (PVVT) Heat S2 Sat |
| Ese and EPr | Monday to Friday: 5PM to 7PM (close hour) | 0.5 | S1 Sys1 (PVVT) Cool S2 WD  S1 Sys1 (PVVT) Heat S2 WD |
| Saturday: 1PM to 5PM (close hour) | 0.3 | S1 Sys1 (PVVT) Cool S2 Sat  S1 Sys1 (PVVT) Heat S2 Sat |

1. After the thermostats settings are modified as explained above, batch processing is run on these prototypes to determine the measure case energy usage and DEER peak demand.
2. The difference between the base case and measure case energy usage and DEER peak demand are the end and demand savings respectively.
3. The savings are normalized per rated ton of HVAC capacity. The total tonnage of the units, (2) units in ERC building, is determined from REPORT- SV-A of the .SIM files for each of the climate zone. Please refer to Attachment#2 for calculations described above and Attachment#4 for the required eQuest models.
4. To determine the savings for other building types, EPr and ESe, the electric savings, for climate zones 08 and 09 are compared with ERC and it is observed that the kWh savings/ton for AC and Heat Pump are with-in 8% coefficient of variation (Cv). Therefore, it is assumed that kWh savings/ ton is similar for the three building types in this work paper. Climate Zones 08 and 09 are selected for this comparison as these climates zones have relatively high weights for ERC, EPr and ESe building types, referring to DEER2014 weights for commercial buildings. Please refer to Attachment#3 for the savings comparison analysis.

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Education – Primary School | Occupancy Sensor | K\_thru\_12\_School |
| Education – Secondary School | Occupancy Sensor | K\_thru\_12\_School |
| Education – Relocatable Classroom | Occupancy Sensor | K\_thru\_12\_School |

# Section 4. Costs

## 4.1 Base Case Cost

The base case cost includes Programmable Thermostat without occupancy sensor equipment cost and installation labor cost. To determine the base case cost and measure cost, seven (7) thermostat product manufacturers were contacted over phone/ email. Three (3) of the vendors responded and provided the cost estimate. The cost estimate per unit of programmable thermostat with and without thermostat were approximately the same from among the manufactures.

The base case equipment cost is $169/unit and labor cost is $156/unit. Approximately 2-hours of labor is required as per the vendors. The average labor cost is determined to be $78/hour based on 2018 RSMeans under low voltage controllers.

Please note that the unit for energy savings is per rated ton of HVAC unit. Hence, the cost data which is $/programmable thermostat is converted to $/ton. For CZ09 and CZ08, for which the savings are compared among building types, the total tonnage of all the units and the number of HVAC units are determined from the eQuest files. The total cost for programmable thermostat for all HVAC units is calculated and then divided by total tonnage to determine the cost per ton. The variation of $/ton between the two climates zones is within 20%. Hence, the average cost of the two climate zones is used as climate zone independent $/ton. This approach is also used for the measure case.

## 4.2 Measure Case Cost

The measure case cost is the cost of Programmable Thermostat with occupancy sensor and installation labor cost. Similar to the base case, the measure case cost was also obtained from the (3) product vendors.

The measure case equipment cost is $349/unit. This includes, $169/unit of bare thermostat, $170/unit for the occupancy sensor controls and $10 for wiring. As per the vendors, the programmable thermosets are pre-programmed to setback when there is no occupancy and the labor cost is same as installing a standard programable thermostat.

The cost per ton is calculated as explained in the above section. Please refer to Attachment#3 for the cost analysis. A summary of the cost per ton are listed below for the different building types:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **FMC($)/ton** | | | **BASE Cost($)/ton** | | | **IMC($)/ton** | | |
|  | **Material** | **Labor** | **Total** | **Material** | **Labor** | **Total** | **Material** | **Labor** | **Total** |
| **ERC** | $79 | $35 | $114 | $38 | $35 | $73 | $41 | $0 | $41 |
| **ESe** | $50 | $22 | $72 | $24 | $22 | $46 | $26 | $0 | $26 |
| **EPr** | $42 | $19 | $61 | $20 | $19 | $39 | $22 | $0 | $22 |

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| NR/ROB | MEC+MLC-(BEC+BLC) | MEC+MLC-(BEC+BLC) | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure** | **Building Type** | **Installation Type** | **Incremental Measure Cost/rated ton** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| AC-20492 | ERC | NR | $41 | $41 | N/A |
| AC-20489 | ESe | NR | $26 | $26 |
| AC-68775 | EPr | NR | $22 | $22 |
| AC-20493 | ERC | NR | $41 | $41 |
| AC-20490 | ESe | NR | $26 | $26 |
| AC-72229 | EPr | NR | $22 | $22 |

# Attachments

1. SCE17HC060.1 Calculation Template-EPr – 082018

SCE17HC060.1 Calculation Template-ERC – 082018

SCE17HC060.1 Calculation Template-ESe - 082018

2. SCE17HC060.1 - Savings Analysis

3. SCE17HC060.1 - Savings Scaling and Cost Analysis

4. SCE17HC060.1 – eQuest models

# References



[499]

[498]

[A] ASHRAE Standard 90.1-2013