**Work Paper PGECOHVC163**

**Advanced Direct Evaporative**

**Coolers- Residential**

**Revision # 1**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Advanced Direct**

**Evaporative Coolers - Residential**

**Measure Code: HB25, HB26**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | HB25, HB26 |
| **Measure Description:** | The installation of direct evaporative coolers displaces compressor based space cooling in both residential and non-residential buildings. |
| **Energy Impact Common Units:** | Savings/household |
| **Base Case Description:** | SCE residential: existing customer equipment. PG&E residential & SCE non-res: code/standard vapor compression air conditioning system. |
| **Base Case Energy Consumption:** | DEER2014 does not yet provide the base case energy consumption, only impact savings are provided. |
| **Measure Energy Consumption:** | DEER2014 does not yet provide the base case energy consumption, only impact savings are provided. |
| **Energy Savings**  **(Base Case – Measure):** | Source: DEER 2014 and Engineering Calculations  Varies depending on climate zone, building type, vintage, and system capacity. |
| **Costs Common Units:** | $/household |
| **Base Case Equipment Cost ($/unit):** | Source: DEER2008 and Engineering Calculations.  Varies depending on system capacity. |
| **Measure Equipment Cost ($/unit):** | Source: DEER2008 and Engineering Calculations.  Varies depending on system capacity. |
| **Gross Measure Cost ($/unit)** | Source: DEER2008 and Engineering Calculations.  Varies depending on system capacity. |
| **Measure Incremental Cost ($/unit):** | Source: DEER2008 and Engineering Calculations.  Varies depending on system capacity. |
| **Effective Useful Life (years):** | Source: DEER 2014.  15 years (EUL ID: HV-Evap) |
| **Measure Application Type:** | SCE residential: retrofit add-on (REA). PG&E residential: replace on burnout (ROB).  SCE non-res: replace on burnout (ROB). |
| **Net-to-Gross Ratios:** | Source: DEER2011  Residential: if direct install program (NTGR\_ID=Res-Default-HTG-di) 0.85, else (NTGR\_ID=Res-Default>2) 0.55.  Non-residential: (NTGR\_ID=Com-Default>2yrs) 0.6. |
| **Important Comments:** | This is a SCE lead workpaper (SCE workpaper # SCE13HC017.1) |

## Work Paper Approvals

|  |  |
| --- | --- |
|  |  |
| The following Manager(s) approved this work paper through the PG&E Electronic Data Routing System under Routing Requisition # \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |
| |  | | --- | |  | | **Grant Brohard**  Manager, Engineering Services (Technical Product Support) | | **Carolyn Weiner**  Manager, Core Products | |  |

# Document Revision History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Workpaper and Revision # | Tech. Revision | MM/DD/YY | Author/Affiliation | Summary of Changes |
| SCE13HC013.0 | Yes | 04/17/12 | Scott Mitchell/DES | Converted WPSCREHC0013 Revision 4 into new workpaper template.  Changed Installation Type to RET – Add-on.  Updated vintage weighting with DEER 2008  Incorporated PG&E climate zones for residential measures |
| Yes | 6/18/12 | Alfredo Gutierrez/EEG | Updated the load shape for the Residential sector from “Reduce\_Cooling\_Load-RET” to “DEER:HVAC\_Eff\_AC.”  Updated the load shape for the Non-Residential sector from “New\_AC – Ret” to “DEER:HVAC\_Split-Package\_AC.” |
| SCE13HC013.1 | Yes | 4/7/2014 | Amber Buhl/PECI | * Work paper updated for reporting period, effective 7/1/2014 – 12/31/2014. * Updated to latest template “SCE EAS Work Paper Template 2013-14 v0.docx” from SCE13HC013.0 * Updated the base case sq ft/ton estimate to reference new DEER measure “‘NE-HVAC-airHP-SpltPkg-65to109kBtuh-11p5eer-3p4cop’” for non-res. * Updated the adjustment factors and calc. method based on new DEER weather data and peak demand periods. * Updated retrofit add-on measures to include a human error adjustment factor (HEAF) similar to workpaper SCE15HC026. * Changed Program Type/Application Type for PG&E Residential to ROB per PG&E workpaper PGECOHVC163. |
| Yes | 6/17/2014 | Alfredo Gutierrez/SCE | * Changed installation type for SCE Non-Res measure (AC-19317) to ROB from RET. * Added “(Res)” to solution code AC-17382. * Lodging – Guest Rooms has been changed to Lodging – Hotel as DEER no longer has the Lodging –Guest Room building type. |
|  | Yes | 7/8/14 | SCE Lead workpaper  Chris Li (PG&E) |  |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper details the installation of direct evaporative coolers to displace compressor based DX space cooling in both residential and non-residential buildings. The operation of direct evaporative coolers provides necessary cooling capacity and comfort with a fraction of the energy required for traditional DX cooling. Direct evaporative cooling is achieved by passing outdoor air over a cooling media that is saturated with water and distributing it into the indoor space.

For the residential sector in Southern California Edison (SCE), this measure assumes that direct evaporative coolers are added equipment to the home, i.e., they are not replacing any existing central air conditioning equipment. The evaporative coolers are used to displace the use of an existing central air conditioning system when cooling is required and the ambient dew point is less than 55 F. The residential measures in this work paper are applicable to all Southern California Edison climate zones and the associated building types shown in Table 10.

For the residential sector in Pacific Gas & Electric (PG&E), this measure assumes that direct evaporative coolers are replacing an existing, whole house vapor-compression air conditioning system. The residential measures are applicable only for multifamily dwellings in climate zones 11, 12 and 13.

Energy savings for the residential sector is reported for both cases i.e. with and without pressure relief dampers. The use of pressure relief dampers negates the need to open windows and discharges air into the attic, keeping the attic cool and reduces heat gain in the house.

For the non-residential sector in Southern California Edison, the direct evaporative coolers are replacing an existing air conditioning system. Pacific Gas & Electric does not include this measure for the non-residential sector. This measure is only applicable for Southern California Edison climate zones 9, 10, 13, 14, and 15 and the associated building types shown in Table 9.

Table 1 lists the measures contained within this work paper.

Table 1 Measure Names

|  |  |  |
| --- | --- | --- |
| PG&E Measure Code | SCE Solution Code | Measure name |
| HB26 | AC-17382 | (Res) With Damper Direct Evap Cooler |
| NA | AC-19317 | (Non Res) Direct Evap Cooler |
| HB25 | AC-78424 | (Res) Direct Evap Cooler |

In addition, for the non-residential sector, direct evaporative coolers must not have a “constant bleed” option. An advanced evaporative cooler (AEC) must have a rigid, manufactured evaporative media with a rated saturation effectiveness of 0.85 or better (a natural fiber pad is not allowed – the rigid media is generally 12” thick), and be equipped with water quality management system that provides positive removal of sump water on a regular interval (a bleed system is not allowed).

**Southern California Edison**

**Home Energy Efficiency Rebate Program Requirements (Residential)**

This rebate is part of the Home Energy Efficiency Rebate Program. To qualify, your new evaporative cooling system must:

1. Appear on the list of qualifying products that can be found at [www.sce.com/rebates](http://www.sce.com/rebates)
2. Be installed by February 28, 2015
3. Be permanently installed.
4. Have UL recognized electrical components.
5. Come with a water quality management system that provides positive removal of sump water on a regular interval (a bleed system is not allowed).
6. Have a single duct or multi ducted distribution system.
7. Have either:

* A multi-function manual control switch which offers high and low fan speed, pump on or off and the unit control of on or off. When a multifunction manual control switch is used, pressure relief dampers are not required.
* A thermostat specifically designed for evaporative coolers which automatically controls the unit operation based on the indoor temperature, fan speed, and pump operation. The automatic thermostat must be mounted remotely from the cooler. If new pressure relief dampers are installed, they must be indicated on your proof of purchase.

1. Note: Evaporative coolers mounted through a window do not qualify for this rebate.

**Express Solution Rebate Program Requirements (Non-residential)**

Replacement of a vapor-compression air condition system with an evaporative cooler will use rigid, manufactured evaporative media and will be equipped with water quality management systems that provide positive removal of sump water at regular intervals.

**Express Solution Qualifying Questions**

The answer should be “Yes” to every applicable question in a solution category for a project to qualify for that incentive. If you answer “No” to any question in the Express Solution section, instead consider a Customized Solution.

* Is an existing, vapor-compression air conditioning system being replaced? If not, will the existing compressor be made inoperative? If an existing evaporative cooler is being replaced, is the unit 15 years or older?
* Will retrofitted system not have “constant bleed” option? Constant bleed systems use constant draining to prevent mineral buildup and can use as much 5 gallons of water per hour. Advanced evaporative coolers should include a “sump dump system” that removes water and mineral buildup from the sump every 6 hours of operation. Optionally, water treatment systems may also be used in areas where water is high in mineral content.
* Is the project site in climate zones 9, 10, 13, 14, or 15?
* Is tonnage on Incentives Application based on the capacity of the package unit that is being replaced? For evaporative coolers, one equivalent ton of cooling is defined as 1,300 cfm of 0.1" static pressure. The invoice should contain information describing what is being replaced.
* Does the advanced evaporative cooler (AEC) have a rigid, manufactured evaporative media with a rated saturation effectiveness of 0.85 or better (a natural fiber pad is not allowed—the rigid media is generally 12” thick), and is equipped with water quality management system that provides positive removal of sump water on a regular interval not to exceed 1 time for every 6 hours of operation (a bleed system is not allowed)?

**Pacific Gas and Electric (Residential)**

An Advanced Evaporative Cooler Level 1 (AEC-1) must have a rigid media direct stage, manufactured evaporative media with a rated saturation effectiveness of 0.85 or better (a natural fiber pad is not allowed – the rigid media is generally 8” or 12” thick), a two speed fan, a multi-position control switch that allows two fan speed operation and fan only operation and a water quality management system that provides positive removal of sump water on a regular interval (a bleed system is not allowed).

To be eligible for these measures, customers must be a PG&E electric customer, live in a multifamily dwelling and live in Climate Zones 11, 12 or 13. PG&E currently does not offer a rebate for customers living a single family or mobile homes.

## 1.2 Technical Description

Direct evaporative cooling is achieved by passing outdoor air through a wetted media and distributing it into the indoor space. Evaporating water from this media removes sensible heat from the airstream, lowering its dry bulb temperature. At the same time, moisture is added to the airstream, raising its relative humidity, which can sometimes reach uncomfortable levels. However, for most conditions throughout a typical cooling season, direct evaporative cooling can adequately meet cooling loads and maintain reasonable humidity levels.

## 1.3 Measure Application Type

The delivery method is Financial Support – Down-Stream – Deemed and Financial Support – Direct Install.

The program type/application type for these measures varies by IOU and building sector as shown in table 2 below.

Table 2 Program Type by Utility and Sector

|  |  |  |
| --- | --- | --- |
| IOU | Building Sector | Program Type/Application Type |
| Southern California Edison | Residential | Retrofit Add-On (REA) |
| Southern California Edison | Non-Residential | Replace on Burn-out (ROB) |
| Pacific Gas and Electric | Residential | Replace on Burn-out (ROB) |

Note: See Appendix A for a comparison of the application types used by and incorporated into SCE systems versus the application types available in the newest revision of DEER 2014. Appendix A will serve as a translation between the outputs of this workpaper and application types used by the DEER READi tool.

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

**Residential Sector:**

This measure is included in the 2014 DEER READI tool, version 2.0.1. DEER measure ID D03-405 was used for estimating the savings. DEER Run IDs can be found in the embedded Excel workbook in the Attachment section. Because DEER assumes HVAC unit replacement, and the SCE program measures are designed to supplement the HVAC unit operation, the DEER values for the SCE measure are adjusted as indicated in Section 2 below. Because DEER presents savings on 1,000 sqft basis and PG&E savings are reported on a per household basis, the DEER values for the PG&E measures are adjusted as indicated in Section 2 below. In both cases the full DEER costs are used as indicated in Section 4.

Table 3 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | Yes |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | SCE: Energy and demand adjustment factors applied as the DEER savings values assume replacement whereas the program assumes an add on.  PG&E: DEER savings values converted to a per household basis. |
| DEER Version | DEER 2014 |
| DEER Run ID and Measure Name (Sample) | D03-405 |

**Non-Residential Sector:**

DEER 2014 does not provide savings values for direct evaporative coolers installed in nonresidential facilities. Section 2 discusses the methodology used for the non-residential sector.

**Net-to-Gross**

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 5 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [351]. The relevant NTGR for this measure is shown in Table 3 below.

Table 4 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Res | Any | All | 0.55 |
| Res-Default-HTG-di | All other EEM with no evaluated NTGR; direct install hard-to-reach only. | Res | Any | DirInstall | 0.85 |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | All | 0.6 |

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

Note that for the direct install delivery mechanism, a distinction between hard to reach and non-hard to reach markets will be made on a project by project basis. This work paper shows the NTG associated with a hard to reach direct install delivery mechanism and the residential defaulted NTG value, where in fact, a measure offered through direct install and is not “hard to reach” will receive a default NTG value.

**Installation Rate**

The installation rate (IR) is identified in the calculation attachment. 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 workpaper 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 5 below.

Table 5 Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | GSIAValue\* |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |
| Com-AC-SCE | Non-Res AC Replacement; Annual Installation Rate | Com | Any | NonUpStrm | 1 |

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

**Spillage Rate**

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

**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 workpaper. For a full set of values associated with the measures in the workpaper refer to the Excel calculation template.

Table 6 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this workpaper |
| Measue Case UseCategory | HVAC |
| Measure Case UseSubCats | Space Cooling (SpaceCool) |
| Measure Case TechGroups | Evaporative Cooling Equipment (EvapCool\_eq) |
| Measure Case TechTypes | Residential Evaporative Cooler (ResEvap); Commercial Evaporative Cooler (ComEvap) |
| Base Case TechGroups | dX AC Equipment (DxAC\_equip) |
| Base Case TechTypes | SEER rated Split AC System (SpltSEER) |

### 1.4.2 Codes and Standards Analysis

There are no energy efficiency standards or energy design standards for this measure. The Title 24 2013 Residential Compliance Manual (attached) provides indirect and indirect-direct evaporative coolers with compliance credits, but does not allow compliance credit for direct evaporative coolers.

2014 Title 20 [422] does not cover evaporative coolers, and gives the following language, “There are no energy efficiency standards or energy design standards for spot air conditioners, evaporative coolers, whole house fans, or residential exhaust fans.”

Table 7 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | N/A | N/A |
| Title 20 (2014) | N/A | N/A |

### 1.4.3 Non-DEER Study Review

No other studies were used or reviewed in preparation for this workpaper.

### 1.4.4 Measure and Base Case Effective Useful Life

DEER14 update documentation provides EUL and RUL information to be used for the 2015 program cycle extension on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “DEER2014-EUL-table-update\_2014-02-05.xlsx” provides the RUL value as a flat 1/3 of the EUL value. The RUL value will only be applied to the first baseline period for retrofit measures that have applicable code that will affect the energy savings. In all other installation types and retrofit with no applicable code that affects the energy savings, the RUL is not applicable to either the first or second baseline period.

To obtain the EUL value the DEER14 update documentation, “DEER2014-EUL-table-update\_2014-02-05.xls” [436] was consulted. Table 8 below identifies the value/methodology used for the measures in this work paper. The EUL for the residential sector was used as a proxy for the non-residential sector as DEER does not give a EUL value for non-residential applications.

This workpaper uses DEER EUL\_ID HV-Evap.

Table 8 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| HV-Evap | Residential | HVAC | Direct Evaporative Cooler | 15 | 5 |
| HV-Evap | Non-Residential | HVAC | Direct Evaporative Cooler | 15 | 5 |

# Section 2. Energy Savings & Demand Reduction Calculations

The savings methodology varies by IOU and sector. The methodology is described below for each.

**Residential Sector**

**Southern California Edison**

The residential SCE savings values are represented by the equations below:

*Annual energy savings = DEER 2014 kWh Savings \* ESAF \* HEAF*

*Demand reduction = DEER 2014 kW reduction \* PDAF \* HEAF*

where: DEER 2014 savings are from the READi tool v.2.0.1, measure D03-405

ESAF is the Energy Savings Adjustment Factor

PDAF is the Peak Demand Adjustment Factor

HEAF is the Human Error Adjustment Factor

The annual energy and demand savings for the residential sector are based on the full DEER measure savings from D03-405, taken directly from the DEER 2014 READi Tool,multiplied by the appropriate adjustment factor to account for the air conditioning system runtime during the year (see embedded Excel workbook titled “SCE15HC0130\_Res\_Rev 4.xlsx”). Where dampers are installed, 38 kWh per home is added (see embedded Excel workbook titled “Calculation Template 2015 v6”, worksheet “Impact Matrix”, column BE). This value was derived from the 2004-2005 incentive program direct evaporative cooler savings values, as given in workpaper SCE13HC013.0.

There are three adjustment factors: The energy savings adjustment factor (ESAF) which is multiplied by the annual energy savings (DEER field: ACustWBkWh), the peak demand adjustment factor (PDAF) which is multiplied by the demand reduction (DEER field: ACustWBkW) and the human error adjustment factor (HEAF) which is multiplied by both the annual energy savings and the demand reduction.

**Human Error Adjustment Factor (HEAF)**

This measure requires that only one mechanical system at a time can operate, and this will be made clear to the customer. However, the customer may forget to do so and end up operating both DX and evaporative systems simultaneously. Therefore, a human error adjustment factor is required to de-rate savings. As there have been no studies performed to measure this particular factor, the HEAF will be arbitrarily set at 75% until a study yields a more conclusive value. This implies that up to 25% of the savings will be lost due to non-ideal operation of the evaporative cooler and DX system.

**Energy Savings and Peak Demand Adjustment Factors (ESAF & PDAF)**

The ESAF and PDAF varies by climate zone and was estimated using hourly dry bulb, wet bulb, humidity ratio, and atmospheric pressure from the DEER2014 supporting Excel workbook CompareWeatherData-v4.xls. The workbook ‘Weather Data - ESAF and PDAF - REV 3.xlsx’ contains the estimation of these values and is attached. Two data filters were used to determine when the direct evaporative cooler would be effective.

* Filter #1 (Column G, worksheet ‘Summary Table’): The total number of hours that the dry bulb temperature is greater than or equal to 80°F was determined by filtering Ambient Dry-Bulb Temp (Column N, worksheet ‘hourly weather data’) and then counting the number of hours that met this condition. This gives the total number of hours that cooling is needed (tcool).
* Filter #2 (Column H, worksheet ‘Summary table’): This filter determines the number of cooling hours that can be satisfied by the direct evaporative cooler (tdir evap). It repeats Filter #1 (T>=80°F), air delivered temperature (ADT) less than or equal to 75°F, and dew point temperatures below 55°F. The next two bullets further describe the calculation methodology and reasoning behind these additional filters.
* ADT: This value represents the estimated potential cooler delivered air temperatures from the corresponding hourly temperatures using the above equation.

Column AD of worksheet ‘hourly weather data’ calculates the wet bulb depression (WBD):

Column AE calculates the achievable air delivery temperature (ADT):

The chart in Figure 1 is a summary tabulation of air temperatures that a direct evaporative cooler can deliver, derived from the psychometric chart using an 85% approach to the wet bulb depression [D]. As indicated in the highlighted boxes, 75°F is estimated to be the highest deliverable temperature in the optimum conditions range.



Figure 1 Direct Evaporative Cooler Operating Range

* Dew point temperature: This criterion originates from the fact that direct evaporative coolers are most effective at relatively dry outdoor conditions. If the outside dew point is >55°F, a direct evaporative cooler will likely not be able to adequately cool the space, and the indoor humidity level may rise to an unacceptable level. This filter gives the number of cooling hours that can be satisfied by the direct evaporative cooler (tdir evap).

The humidity ratio (w) in units of lb water per lb dry air, and the total atmospheric pressure (p) in units of inches Hg is used to calculate the vapor pressure. The vapor pressure (pv) in units of hPa is calculated from these two values based on this humidity ratio formula [E]:

The same equation written to solve for the vapor pressure of water (pv) and converting to hPa as required for the dew point temperature calculation (column AG, worksheet ‘hourly weather data’):

Next the dew point temperature (°C) is calculated in column AH, of worksheet ‘hourly weather data’ [C]:

Where m, A, and Tn are constants.

This is converted to Fahrenheit (T, °F) in column AI, worksheet ‘hourly weather data’:

* The energy savings adjustment factor (ESAF) is calculated as the ratio of the total cooling hours that may be satisfied by a direct evaporative cooler to the total number of hours in the year that may require cooling:

The calculated ESAF for SCE climate zones is shown in column E of worksheet ‘Summary Table’ and in Table 9.

* Finally, the peak demand adjustment factor (PDAF) was determined by applying these same filters but only for the three-day peak heat wave as given by DEER for each climate zone. For example, climate zone 6 would require that the filters are applied only between the hours of 2:00 p.m. and 5:00 p.m from September 1st – 3rd. The PDAF was calculated by the ratio of the total cooling hours that may be satisfied by a direct evaporative cooler during the peak demand hours to the total number of peak demand hours (9). The calculated PDAF for SCE climate zones is shown in column F of worksheet ‘Summary Table’ and in Table 8.

Table 9 ESAF and PDAF Summary Table

|  |  |  |
| --- | --- | --- |
| CZ | ESAF | PDAF |
| 6 | 56% | 33% |
| 8 | 33% | 33% |
| 9 | 26% | 0% |
| 10 | 48% | 0% |
| 13 | 65% | 0% |
| 14 | 88% | 100% |
| 15 | 57% | 11% |

**Pacific Gas and Electric**

PG&E only offers this measure for multifamily dwellings in climate zones 11, 12, 13. Therefore, the savings are only calculated for instances meeting these criteria (column AR, worksheet ‘EnergyImpacts\_RES\_EvapCool’). The calculation of the energy savings and demand savings follows the methodology described above for Southern California Edison, except for the following differences:

1. PG&E savings values are based on the above code savings (DEER field: AStdWBkWh and AStdWBkW) for DEER measure D03-405. The above code savings are used as PG&E offers this measure as a complete retrofit (as ROB) and not a retrofit add-on as SCE does. Also for this reason no adjustment factors are applied.
2. The savings are presented on a per household basis. Since PG&E uses household as the unit measure, DEER savings were converted to per household unit instead of the DEER common unit of per 1,000 sqft by multiplying the savings values by the number of common units.

All residential calculations are shown in the embedded Excel file (SCE13HC0130\_Res\_Rev 4.xlsx).

**Non Residential Sector**

**Southern California Edison**

The DEER database does not have energy savings values for the Direct Evaporative Cooler (DEC) measure in the non-residential sector. Therefore, the following methodology was adopted to estimate the annual energy and peak demand savings. Calculation results are documented in the embedded Excel workbook (SCE13HC013 0\_NonRes\_Rev 4.xlsx). Below is the detailed description of the calculation steps:

* Climate zones included in this work paper are 9, 10, 13, 14, and 15 based on SCE’s program implementation area.
* Efficiency of the base case system was calculated as a weighted average across vintages of the Title 24 code based EER rating (column E, worksheet ‘Non Residential\_2014’). The vintage specific weights are shown on worksheet ‘Vintage Weighting (SCE)’ and are from the DEER 2014 Excel workbook DEER2014-EnergyImpact-Weights-Tables-v2.xls.
* The annual full load operating hours for both the base and measure case equipment was obtained DEER 2014 using “NE-HVAC-airHP-SpltPkg-65to109kBtuh-11p5eer-3p4cop” as the basis. The hours were found by dividing the kWh by the kW for both the existing and above code savings. This DEER measure is also used to find the sq-ft/ton estimates explained below.
* Typical sq-ft/ton estimates for existing buildings, including the building types shown in Table 10 and the above listed climate zones, are calculated from DEER 2014 EnergyImpactID ‘NE-HVAC-airHP-SpltPkg-65to109kBtuh-11p5eer-3p4cop’. The sq-ft/ton values are the same as DEER 2014 EnergyImpactID ‘NE-HVAC-airHP-SpltPkg-110to134kBtuh-11p5eer-3p4cop’. These values are shown in column AP on worksheet ‘DEER 2014 sf per ton’.
* Base case average kW demand per 1000 Sq-ft is calculated using the following equation (column J, worksheet ‘Non Residential\_2014’).
* DEC units are typically specified by the cubic feet per minute airflow. The efficiency of the DEC units was obtained by averaging the efficiency of currently available DEC systems in the market. DEC efficiency values are shown in column F of worksheet ‘DEC Efficiency’ and were obtained from the California Energy Commission’s appliance database [A]. Only units above 6500 cfm were selected because they are the ones that typically replace 5 ton unitary AC units or larger unitary AC units (one ton of cooling is typically equivalent to 1300 cfm in a DEC unit). Efficiency values expressed in Evaporative Cooling Efficiency Ratio (ECER) were then converted to watts per cfm by using the following formula which was obtained from the Title 20 [356, 422], Table D-1 of section 1604(d).



Where ε is the measured saturation effectiveness divided by 100. In the absence of any relevant M&V study to measure the saturation effectiveness values, it is assumed to be 85% in this analysis to be consistent with the Express Solution Rebate Program minimum requirement.

* Next, the measure case average kW demand per 1000 sq-ft for the DEC system is obtained using following equation.

Where the ton/sq-ft is calculated per building type and climate zone and the CFM/ton is assumed to be 1300 as previously discussed.

* The annual energy and peak demand savings is calculated using the following equations.

Where unit is per 1000 sq. ft cooled area and ESAF and PDAF are calculated as explained in the SCE residential sector energy savings calculation section above.

* The annual energy savings and peak demand savings is converted to savings per ton cooling by multiplying by the sq. ft/ton value described above and dividing by 1,000 sq. ft (column T & U, worksheet ‘Non Residential\_2014’).

All Non-Residential calculations are shown in the embedded Excel file SCE13HC0130\_NonRes\_Rev 4.xlsx.

**Pacific Gas & Electric**

Pacific Gas & Electric does not offer this measure to non-residential customers.

# 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:HVAC\_Eff\_AC” load shape for Residential target sector and “DEER:HVAC\_Split-Package\_AC” for the Non-residential target sector. See Table 10 for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

Table 10 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Assembly | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Education - Primary School | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Education - Secondary School | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Education - Community College | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Health/Medical - Clinic | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Health/Medical - Hospital | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Manufacturing - Light Industrial | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Industrial | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Lodging - Hotel | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Office - Small | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Restaurant - Fast-Food | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Restaurant - Sit-Down | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Retail - Small | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Retail - Single-Story Large | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Storage - Conditioned | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Residential Single Family | RES | DEER:HVAC\_Eff\_AC |
| Residential Mobile Home - Double-Wide | RES | DEER:HVAC\_Eff\_AC |
| Residential Multi-family | RES | DEER:HVAC\_Eff\_AC |

# Section 4. Base Case & Measure Costs

## 4.1 Base Case Cost

**Residential Sector**

**Southern California Edison (REA)**

For this measure category, the base case cost is taken from DEER documentation [26] which gives a cost of $839.17/1000 sq ft.

**Pacific Gas and Electric (ROB)**

The base case costs for PG&E are given on a per household basis. The DEER cost values [26] are converted from per 1000 sq ft to per household using the methodology outlined in section 2 for the energy savings.

**Non-Residential Sector**

**Southern California Edison (ROB)**

The base case cost for DEER legacy measure D03-081 is used as a proxy for the base case for the non-residential sector as the savings are based off of D03-081. The base case cost is $837.81/Ton.

## 4.2 Measure Case Cost

The measure case costs were taken from DEER documentation [26] and are further described in the following section.

**Residential Sector**

**Southern California Edison (REA)**

A cost of $96.10 per 1,000 sq. ft was added to the measure case cost to account for additional water usage typically associated with evaporative cooling measures. The water costs represent an average over the life of the measure, including inflation, from a sampling of water rate sheets from climate zones 6, 9 and 15. The details of this calculation can be found in the attached Excel workbook ‘SCE15HC0130\_Res\_Rev 4’, worksheet ‘Water Costs’. Rate schedules are attached.

**Pacific Gas and Electric (ROB)**

A cost of $70.14 per household was added to the measure case cost to account for additional water usage typically associated with evaporative cooling measures. The water costs represent the average usage over the life of the measure, including inflation, for climate zone 12. The details of this calculation can be found in the attached Excel workbook ‘SCE15HC0130\_Res\_Rev 4’, worksheet ‘Water Costs’. Rate schedules are attached.

**Non-residential Sector**

A cost of $124.15 per ton was added to the measure case cost to account for additional water usage typically associated with evaporative cooling measures. The water costs represent an average over the life of the measure, including inflation, from a sampling of water rate sheets from climate zones 9, 14 and 15. This brings the total measure cost to $493.74. The details of this calculation can be found in the attached Excel workbook ‘SCE15HC0130\_NonRes\_Rev 4’, worksheet ‘Water Costs’. Rate schedules are attached.

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost

**Residential Sector**

**Southern California Edison (REA)**

The measure costs in DEER are per the common unit of 1000 ft2. This was calculated according to the following equation with specific calculations available in the last version of this workpaper.

[Installed Cost (CZ,Vintage)] ÷ [Number of Common Units (CZ, Vintage)] = $/1000sqft

To obtain a per 1000 ft2 that is consistent across the residential building types, the measure case costs described above were averaged for the three building types. The result is an average $1,723.66/1000sqft.

For installations that include pressure relief dampers, an additional fixed cost of $200 per cooler was added. The company Climate Control Systems, ([www.updux.com](http://www.updux.com), CA Contractors Lic.# 782461) offers a package of six “Up-dux” pressure relief dampers for $284. Thus, installing three dampers per site would cost $142 plus $58 for installation labor and miscellaneous parts. This can be found in the attachment labeled “Calculation Template 2015 v6”.

For direct install, SCE directly utilizes one or more contractors as part of the program. The actual cost can vary by contractor, the date in which the work occurred, and by the volume of business. Contractor costs are confidential information and are based upon contractually agreed upon pricing as established in their purchase order with SCE; therefore, the SCE program tracking system is the only source for this data.

**Pacific Gas and Electric (ROB)**

For measures specific to PG&E climate zones (ROB), the costs were calculated as described above with the following differences:

1. Gross measure costs are equal to the incremental measure cost as described below.
2. Gross measure costs are converted to a per household basis.

This calculation can be found in the attachment labeled “SCE15HC0130\_Res\_Rev 4.”

**Non-Residential Sector**

**Southern California Edison (ROB)**

Measure costs were derived from RS Means [B]. Two entries were found in the RS Means manual that closely matched the assumed equipment specifications in the analysis. We forecasted the measure costs based on the two entries, as shown in the table below.

Table 11 Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| RS Means Ref# | Description CFM | Total Cost (incl O&P) | $/CFM |
| 23.76.13.10.0320 | 11,715 | $3,450 | $0.2945 |
| 23.76.13.10.0340 | 14,140 | $3,900 | $0.2758 |
| Average | | | $0.2843 |

Average costs per 1000 sq- ft were obtained by converting $/cfm to $/ton (using 1 ton equal to 1,300 cfm) as described in Non-residential Sector section of Section 2 above. All values and calculations are shown in the attachment labeled “SCE15HC0130\_NonRes\_Rev 4.”

### 4.3.2 Incremental Measure Cost

Both the measure equipment and measure labor costs are taken from DEER and can be seen in the embedded file for all measure applications.

**Residential Sector**

**Southern California Edison (REA)**

For REA measures (i.e SCE in this case), the Incremental Measure Cost (IMC) is defined as follows:

Measure Equipment Cost + Measure Labor Cost

**Pacific Gas and Electric (ROB)**

For ROB measures (i.e. PG&E in this case), the Incremental Measure Cost (IMC) is defined as follows:

Measure Equipment Cost – Base Case Equipment Cost

**Non-Residential Sector**

**Southern California Edison (ROB)**

For RET measures, the Incremental Measure Cost (IMC) is defined as follows:

Measure Equipment Cost – Base Case Equipment Cost

The incremental cost is only used to help determine program incentives. It is not affected by the first and second baseline periods and may differ from the cost used for cost effectiveness calculations.

# Attachments

See accompanying files

# References

See accompanying files

* [26]
* [31]
* [100]
* [208]
* [213]
* [351]
* [356]
* [422]
* [436]

[A] <http://www.appliances.energy.ca.gov/QuickSearch.aspx>; accessed on 05-05-09.

[B] RS Means Mechanical Cost Data 2009, 31st Annual Edition, Reed Construction Data, Inc.

[C] Vaisala Oyj (2013). Humidity Conversion Formulas. [www.vaisala.com](http://www.vaisala.com)

[D] California Energy Commission, Consumer Energy Center. (2013, April 26). Evaporative cooling. Retrieved from <http://www.consumerenergycenter.org/home/heating_cooling/evaporative.html>

[E] 2013 Fundamentals. ASHRAE Handbook. I-P Edition.

# Appendix A – SCE/ED Application Types

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SCE Program Type | ED Application Type | 1st Baseline Savings | 2nd Baseline Savings | 1st Baseline Cost | 2nd Baseline Cost | 1st Baseline Life | 2nd Baseline Life |
| New | New Construction (Nc) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Replace on Burnout (ROB) | Replace on Burnout (Rob)/Normal Replacement (NR) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Retrofit (RET) | Early Replacement (ER) | Above Cust. Existing | Above Code/Standard | Full Cost | Incremental Cost | RUL | EUL-RUL |
| Retrofit – First Baseline Only (REF) | Early Replacement RUL (ErRul) | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |
| Retrofit Add-on (REA) | N/A | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |