**Work Paper PGECOHVC164**

**Advanced Direct-Indirect**

**Evaporative Coolers-**

**Residential**

**Revision # 1**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Advanced Direct-Indirect Evaporative Coolers - Residential**

**Measure Code: H172**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | H172 |
| **Measure Description:** | Direct-indirect or two-stage evaporative coolers (measure) in residential buildings |
| **Energy Impact Common Units:** | Savings/household |
| **Base Case Description:** | Standard compressor based direct-expansion (DX) split type air conditioning units. |
| **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:** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratios:** | Source: DEER2011.  0.55 (Res-Default>2) |
| **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 |
| SCE13HC017.0 | No | 5/23/2012 | Rafik Sarhadian/SCE | - This is the original work paper for the 2013-2014 cycle and is based off of WPSCREHC0017.0. 9 climate zones covering PG&E territory have been added. |
| SCE13HC017.1 | Yes | 6/2/2014 | Alfredo Gutierrez/SCE | -Work paper updated for the reporting period, effective 7/1/14 – 12/31/14.  -Changed installation type from RET to ROB. |
| PGECOHVC164 R1 | Yes | 7/2/14 | SCE lead workpaper update  Chris Li (PG&E) |  |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper outlines energy savings due to replacing standard compressor based direct-expansion (DX) split type air conditioning units (baseline) with direct-indirect or two-stage evaporative coolers (measure) in residential buildings. The saving values are based on Database for Energy Efficient Resources (DEER) 2014 READI tool, v.2.0.1.

Table 1 Measure Names

|  |  |  |
| --- | --- | --- |
| PGE Measure Code | SCE Solution Code | Measure name |
| H172 | AC-50888 | Two-stage (Indirect-Direct) Evap Cooler replacing standard compressor-based DX space cooling |

The measures contained within this work paper are applicable only for the building types listed in Table 9 (all residential) and for all Southern California Edison and Pacific Gas & Electric climate zones. Please see below for utility specific requirements.

**Southern California Edison (SCE)**

**Home Energy Efficiency Rebate Program Requirements**

This rebate is part of the Home Energy Efficiency Rebate Program. To Qualify, Your New Evaporative Cooling System Must:

1. Be permanently installed.
2. Have UL recognized electrical components.
3. Come with a water quality management system that provides positive removal of sump water on a regular interval (a bleed system is not allowed).
4. Have a single duct or multi ducted distribution system.
5. 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.

**Pacific Gas and Electric (PG&E)**

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 home.**

An Advanced Evaporative Cooler Level 2 (AEC-2) must have an indirect evaporative stage, rigid media direct stage, manufactured evaporative media with a rated saturation effectiveness of 0.95 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 be equipped with water quality management system that provides positive removal of sump water on a regular interval (a bleed system is not allowed).

## 1.2 Technical Description

The operation of direct-indirect evaporative coolers consists of two stages, direct and indirect stage. These units provide necessary cooling capacity and comfort with a fraction of the energy required for traditional DX cooling. The indirect evaporative cooling is accomplished through a heat exchanger, either plate and frame or tube type. In this stage, cooling is accomplished by reducing the outdoor air temperature without adding moisture. Direct cooling in second stage is achieved by passing the air from indirect stage over the cooling media that is saturated with water. The result of two stage evaporative cooling process is cooler and drier supply air than that compared to a single-stage evaporative cooler [434].

According to the Public Interest Energy Research (PIER) program’s White Paper on “Advanced Evaporative Cooling,” the projected annual cooling savings average 93% over the 8 climate zones, and demand savings average 84%[434]*.*

## 1.3 Measure Application Type

The delivery mechanism used for the measures within this work paper is Financial Support – Downstream Incentives – Deemed.

The install type for the measure within this work paper is Replace-on-Burnout (ROB) for both SCE and PG&E.

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

This specific measure is included in the DEER 2014 READi tool, v.2.0.1. Therefore, DEER data was used as a basis for establishing electrical energy savings and demand reductions, as well as natural gas energy savings. DEER 2014 data was also used to obtain the effective useful life (EUL) and cost for this measure. Specifically, DEER measure ID D03-407 was used.

Table 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | Weighting of Savings using DEER normalizing units to get per Home values for PG&E. |
| DEER Version | DEER 2014 |
| DEER Run ID and Measure Name (Sample) | D03-407 ; Direct-Indirect Evaporative Cooler |

**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 3 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 | Any | 0.55 |

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

**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 4 below.

Table 4 Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID\* | GSIAValue\* |
| Res-AC-SCE | Res AC Replacement; Annual Installation Rate | Res | Any | NonUpStrm | 1 |
| Def-GSIA (PG&E) | Default GSIA values | Res | Any | Any | 1 |

\*Denotes that the column is taken from the DEER GSIA 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 the Excel calculation template.

Table 5 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) |
| Base Case TechGroups | dX AC Equipment (dxAC\_equip) |
| Base Case TechTypes | SEER Rated Split System AC (splitSEER) |

### 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 [355] provides indirect and indirect-direct evaporative coolers with compliance credits, but does not allow compliance credit for direct evaporative coolers.

The 2014 Title 20 [422] Appliance Efficiency Standards 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.” Please note that Title 20 also specifies that air cooled air conditioners must be 13.0 SEER effective June 15, 2008. This requirement impacts the energy savings as the baseline used for the measures is a SEER 13 air conditioner.

Table 6 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | N/A | N/A |
| Title 20 (2014) | Table C-3  Standards for Air-Cooled Air Conditioners and Air-Source Heat Pumps Subject to EPAct  (Standards Effective January 1, 2010 Do Not Apply To Single Package Vertical Air Conditioners) | June 15, 2008 |

### 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

DEER2014 update documentation provides EUL and RUL information to be used for the 2013-14 program cycle 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.xlsx [436], was consulted. Table 7 below identifies the value/methodology used for the measures in this work paper.

Table 7 DEER14 EUL Value/Methodology

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

# Section 2. Energy Savings & Demand Reduction Calculations

The energy savings for the measure contained within this work paper were taken directly from the 2014 DEER READi tool, v.2.0.1. SCE offers the measure on a per 1,000 sq ft basis, so the energy savings are taken directly from DEER. PG&E, however, offers the measure on a per home basis, which requires the application of building weights to convert the units. These weights are found in the same DEER READi export under column “K” titled “NumUnit.” Please see below for a sample calculation.

**Single Family Home in Climate Zone 4:**

2014 DEER Database kWh: 206 kWh/1,000 sq ft

NumUnit: 1,710 sq ft/home

The same calculations are done for both kW and therm savings.

Table 8 contains the data files for measures that are taken directly from the DEER 2014 READi Tool or were created using the READi Tool. These results have not been modified and are only being included in the workpaper for reference.

Table 8 READi Tool Outputs

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Name | READi Results |
| AC-50888 | Two-stage (Indirect-Direct) Evap Cooler replacing standard compressor-based DX space cooling |  |

# 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. See Table 9 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 9 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Residential – Single Family | RES | DEER: HVAC\_Eff\_AC |
| Residential – Multi-Family | RES | DEER: HVAC\_Eff\_AC |
| Residential – Double-wide Mobile Home | RES | DEER: HVAC\_Eff\_AC |

# Section 4. Base Case & Measure Costs

## 4.1 Base Case Cost

The base case cost for the measures contained within this work paper was taken from DEER for D03-407. Although the measure is included within the 2014 DEER READi Tool, the additional cost documentation “Revised DEER Measure Cost Summary (05\_30\_2008) Revised (06\_02\_2008).xls” only gives the material cost as $0.27 and does not clarify on the normalizing unit, therefore it is not clear what the cost of the equipment actually is. As such, DEER 2005 was consulted to obtain a cost of $839.17 per 1,000 sq ft which is used directly for SCE’s climate zones. As PG&E uses units of per home, the value is converted in a similar manner as the energy savings.

## 4.2 Measure Case Cost

The measure case cost for the measures contained within this work paper was taken from DEER. Similar to the base case cost, the measure case cost was found from DEER 2005 to be $1,553.00 per 1,000 sq ft for SCE and converted to a per home basis for PG&E.

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost

For replace on burnout measures, the equipment being replaced/installed is assumed to have failed in place or is past its useful life. In this scenario the customer is in the situation of having to purchase new equipment. The customer is faced with either purchasing standard efficiency or code baseline equipment versus energy efficient equipment. Because the customer will be spending money to replace their equipment anyway, the gross cost for the energy efficient measure is the premium paid above the non-efficient or code baseline equipment.

For ROB, the Gross Measure Cost is represented by the equation below:

*GMC =* *Measure Equipment Cost – Base Case Equipment Cost*

For SCE, the GMC is $713.83 per 1,000 sq ft. For PG&E, since the measure unit is per household, the cost data is converted according to the methodology described in Section 2.

### 4.3.2 Incremental Measure Cost

For this measure category, the incremental measure cost is used strictly for providing insight to program managers to assist in determining rebates for deemed measures.

For ROB, the Incremental Measure Cost is equal to the gross measure cost reported in section 4.3.1.

# Attachments

See accompanying files

# References

See accompanying files

[31]

[351]

[355]

[422]

[434]

[436]

# 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 |