Work Paper SCE17HC026

**Revision 1**

**Southern California Edison**

**Window Evaporative Coolers**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | AC-29859 Window Evap Cooler |
| **Measure Description** | This work paper details the installation of window-mounted direct evaporative coolers to displace DX air conditioning (AC) systems in residential buildings. The base case is a residential building with a code compliant (14 SEER) DX central AC. In the measure case, one or more window evaporative coolers are added to the building. They do not replace the central AC. |
| **Base Case Description** | The base case is a residential building with a code compliant (14 SEER) DX central AC. |
| **Units** | Per installed evaporative cooler (per unit) |
| **Energy Savings** | See Attachment 1 |
| **Full Measure Cost ($/unit)** | See Attachment 3 |
| **Incremental Measure Cost ($/unit)** | See Attachment 3 |
| **Effective Useful Life** | REA:5 years (1/3 of EUL ID:HV-Evap) in accordance with Draft Resolution [510] |
| **Measure Installation Type** | Retrofit – Add-On (REA) |
| **Net-to-Gross Ratio** | 0.55 (Res-Default>2) |
| **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 | 10/24/2016 | Lake Casco  TRC | * New calculation template for 2017 program year * Update costs based on new (2016) pricing from online retailers (material) and 2015 RS Means Mechanical (labor) * Provided language to acknowledge the use of 2013 T24 baseline |
| 1 | 5/15/2018 | Joseph Ling  AESC | * Updated Labor Cost to 2018 * Updated Material Costs to current pricing from online sources * Updated Water Cost to 2018 * Updated references to Title 20 2018 * Removed HTR language * Updated ESAF and PDAF worksheet and relevant calculations. |
| 11/2/2018 | Jay Madden SCE | * Updated Section 1.6 Data Quality and Future Data Needs section with SCE’s proposed standard practice study to inform a future workpaper update. |

# 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 installation of window-mounted direct evaporative coolers to displace DX air conditioning (AC) systems in residential buildings. The base case is a residential building with a code compliant (14 SEER) DX central AC. In the measure case, one or more window evaporative coolers are added to the building. They do not replace the central AC.

For this measure, the occupant is expected to enable the window evaporative cooler for cooling the space. During very high ambient temperatures and/or humidity and in the event that the evaporative cooler cannot satisfy the cooling setpoint in the space, the occupant is expected to disable the evaporative cooler and enable the DX central AC.

Under specific ambient air conditions (specified in Section 2), direct evaporative cooling can provide sufficient cooling capacity and comfort while using much less energy than is required for traditional DX cooling. Since the evaporative coolers are meant to displace DX cooling, not replace it, the existing central AC must be turned off before evaporative cooling is used.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Window-mounted direct evaporative coolers |
| Existing Condition | DX air conditioning (AC) systems (14 SEER) |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| N/A | N/A | AC-29859 | N/A | Window Evap Cooler |

The measure in this work paper is applicable for all Southern California Edison climate zones and all Residential building types.

This measure is part of the Home Energy Efficiency Rebate Program. To qualify for the program, a window evaporative cooler must meet the following requirements:

**Installation requirements**

* Be permanently installed.
* Have UL-recognized electrical components.
* Provide minimum airflow in accordance with the Air Movement and Control Association (AMCA), Standard 210:

Minimum Air Movement Requirements for Evaporative Coolers

|  |  |  |
| --- | --- | --- |
| **Minimum Air Movement (CFM/sf)\*** | | |
| **Climate Zones** | **Direct** | **Indirect/Direct** |
| 1 – 9 | 1.5 | 1.2 |
| 10 – 13 | 3.2 | 1.6 |
| 14 – 15 | 4.0 | 2.0 |
| 16 | 2.6 | 1.3 |
| \*If backup air conditioning is installed, the minimum air movement for all climate zones is 1.0 CFM/sf | | |

**Capacity requirements**

* Be able to provide cooling for up to 1000 square feet (sf).
* Have a rating of at least 3000 CFM. This is based on the following assumptions:
  + From the DEER 2005 Update Final Report [26]: The evaporative cooler cooling supply flow is three times the flow used for the baseline and code baseline buildings. The direct effectiveness is 0.85.
  + Assuming that a residential home requires 400 CFM/ton of cooling from a central AC system, an evaporative cooler will need to provide: 400 \* 3 = 1200 CFM/ton. The window unit should be capable of cooling up to 1000 sf, so assuming 1.0 CFM/sf, a 1000 sf area will need: 1000 / 400 = 2.5 tons of cooling. This corresponds to: 2.5 \* 1200 = 3000 CFM required for the window evaporative cooler.

**Operational requirements**

* This measure is eligible for single-family, multi-family, and mobile homes. It is assumed that the thermostat of the baseline AC unit will have a cooling setpoint of 78°F as specified in the DEER single- and multi-family prototypes.
* Expected sequence of operation: When the building (space) temperature is in the order 78-degree F, it is assumed that the occupant will enable the window evaporative cooler for cooling the space. In the event that the evaporative cooler cannot satisfy the cooling setpoint (e.g., during very high ambient temperatures and/or humidity), the occupant is expected to disable the evaporative cooler and enabled the DX central AC.
* The evaporative cooler is expected to operate effectively when the dry bulb outside air temperature is 78°F or higher, the dew point is less than 55°F, and the air delivery temperature is less than or equal to 75°F.
* This measure assumes there will be no hard-wired “interlock” to control the operation of the DX and evaporative systems and/or the enabling/disabling of the systems. Therefore, the actual system operation is dependent on human behavior and it can be difficult to predict. Four scenarios can occur: (a) only the evaporative cooler is on, (b) only the DX unit is on, (c) both are on, or (d) both are off. The measure assumes that in most cases the two systems will not operate concurrently. However, acknowledging the unpredictability of human behavior and the possibility of scenario (c) using more energy than in the base case, a Human Error Adjustment Factor is used to derate savings (see Section 2).
* Since evaporative cooling brings in outdoor air, this air needs a way to escape. When the evaporative cooler is on, the customer is required to open at least one exterior window or door in the dwelling. The customer can direct the flow of cooled air through proper selection of which window or door to open.

**Unit quantity requirements**

* For single family homes: If the home is larger than 1000 sf, two or more window units, each in a different room, can be installed. If the home is 1000 sf or less, only 1 unit is allowed.
* For multi-family: One window unit can be installed.
* For double-wide mobile homes: One window unit can be installed.

**Water considerations**

* Water usage: Evaporative coolers require a supply of water to keep the evaporative pads wet, and they can use 3–15 gallons/day depending on weather conditions, unit size, and water drainage [D]. This may be an issue in locations where the water supply is low.
* Supply water brought into the evaporative cooler contains minerals which may create scale or deposits on the pads. This will degrade pad efficiency and reduce their useful life. Periodic pad washing, rotation, and replacement are required to avoid pad degradation, air quality issues (pollen, dirt, dust, odor), and health issues (mold, mildew, bacteria). Additionally, there are several options for water treatment:
  + Install a bleed valve to flush out part of the recirculating water and lower mineral concentration. This uses a significant amount of water and therefore is not allowed for this measure.
  + Install a sump-dump (blow-down) system which periodically removes water and collected dirt from the sump.
  + Install another type of water treatment mechanism: electromagnetic, electrostatic, catalytic or mechanical.
* Wastewater from water treatment can be used for irrigation but may be an environmental concern if the mineral content is too high.

## 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 Installation Types and Delivery Mechanisms

The delivery mechanisms are Financial Support – Downstream Incentive – Deemed and Financial Support – Direct Install.

The Install Type is Retrofit – Add-on (REA).

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Retrofit Add-on (REA) | Above Customer Existing | 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.

**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. |
| 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

A direct evaporative cooler (not window-mounted) measure is included in the DEER READI tool, version 2.4.8; the measure ID is D03-405. It is assumed that a window-mounted unit will have energy usage characteristics similar to that of a central direct evaporative cooling system, so D03-405 was used as a starting point for savings calculations. The DEER measure assumes HVAC unit replacement, but since the work paper measure supplements an existing HVAC unit, the DEER values are adjusted as indicated in Section 2 below.

Energy impacts for this measure are based on “above code/standards” savings estimated in DEER 2005 using a SEER 13 baseline equipment D03-405 efficiency. Measure impacts will be updated once the evaporative cooling measure (D03-405) is updated by the DEER team.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | Yes |
| Scaled DEER measure | Yes |
| DEER Base Case | Yes |
| DEER Measure Case | Yes |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | No |
| DEER Version | 2005 |
| Reason for Deviation from DEER | See Section 2  Deviation from DEER because evaporative cooler is being added to existing HVAC system, not replacing it as assumed in DEER. |
| DEER Measure IDs Used | D03-405 Direct Evaporative Cooler |

**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.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| 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 |

**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.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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 EUL for an REA installation type as 1/3 of the EUL value, in accordance with Draft Resolution [510]. As this measure is only available as an REA installation type, there is no applicable RUL.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HV-Evap | Window Evaporative Cooler | Residential | HVAC | 5 | NA |

### 1.4.2 Codes and Standards Analysis

Title 24 2016 [496] does not provide energy efficiency standards or energy design standards for this measure.

Title 20 2018 [493] covers test methods for packaged direct and direct/indirect evaporative coolers, but does not mention window evaporative coolers.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | N/A | January 1st, 2017 |
| Title 20 (2018) | N/A | July 1st, 2018 |
| DOE | N/A | N/A |

## 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

# SCE’s proposed standard practice study, if approved by the CPUC, will investigate the existing customers’ operation of evaporative coolers, when installed in parallel to their existing DX cooling system. The Human Error Adjustment Factor (HEAF) 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 has been set at 75% until this proposed study yields a more conclusive value. This version of the workpaper assumes that up to 25% of the savings will be lost due to non-ideal operation of the evaporative cooler and DX system.

# Section 2. Calculation Methodology

**Calculation Formulas**

The savings values are represented by the equations below:

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

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

*Annual therm savings = DEER therm savings \* ESAF \* HEAF*

where: DEER savings are from the READi tool v.2.4.8, measure D03-405

ESAF is the Energy Savings Adjustment Factor

PDAF is the Peak Demand Adjustment Factor

HEAF is the Human Error Adjustment Factor

These DEER energy impacts are found in both attachments “EnergyImpacts\_D03-405” and [Attachment 1] below. Measures impacts were last updated in 2005 under the DEER2005 cycle. Measure’s baseline will be updated once it is updated in DEER. Presently, DEER uses a 13 SEER baseline and adjustments are made to account for Title 24 2016 14 SEER baseline. Energy savings should be updated once DEER has been updated.

**Energy Savings Adjustment Factor (ESAF) and Peak Demand Adjustment Factor (PDAF)**

The ESAF and PDAF varies by climate zone and was estimated using weather data from CZ2010 reference locations for each climate zone. Attachment #9 Weather Data – ESAF and PDAF 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 W of worksheet ‘hourly weather data’ calculates the wet bulb depression (WBD):

Column X 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 [B]. As indicated in the highlighted boxes, 75°F is estimated to be the highest deliverable temperature in the optimum conditions range.

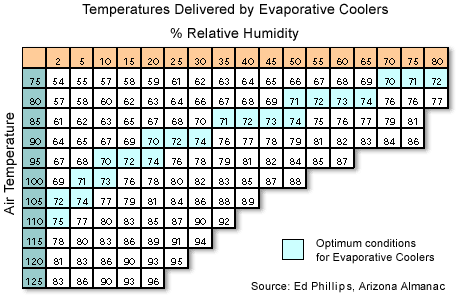


Figure 1

Direct Evaporative Cooler Operating Range [D]

* 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).

Previously, the dew point temperature was calculated and derived using TMY3 weather data. Dew point in CZ2010 data is a measured value and no calculation is required. However, wet bulb temperature is not provided in the updated CZ2010 data and it was necessary to calculate this using the given data.

Wet bulb temperature (°C) was calculated with the following equation [A]:

This is converted to Fahrenheit (T, °F) within the same equation, 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 below.

* 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 and PGE climate zones is shown in column D of tab ‘ESAF\_&\_PDAF\_Summary’ in Attachment #2 and in table below.

ESAF and PDAF Summary Table

|  |  |  |  |
| --- | --- | --- | --- |
| **IOU** | **CZ** | **ESAF** | **PDAF** |
| PG&E | 1 | 100% | 100% |
| PG&E | 2 | 100% | 100% |
| PG&E | 3 | 100% | 100% |
| PG&E | 4 | 100% | 100% |
| PG&E | 5 | 100% | 100% |
| SCE | 6 | 56% | 33% |
| SCE | 8 | 32% | 22% |
| SCE | 9 | 26% | 0% |
| SCE | 10 | 48% | 0% |
| PG&E | 11 | 100% | 100% |
| PG&E | 12 | 100% | 100% |
| Both | 13 | 62% | 0% |
| SCE | 14 | 87% | 89% |
| SCE | 15 | 55% | 11% |
| Both | 16 | 96% | 89% |

**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.

**Example Calculation**

The DEER savings for the Direct Evaporative Cooler measure in SFM, CZ06 are:

DEER kWh savings: 172.3 kWh

DEER kW reduction: 0.76446 kW

DEER therm savings: -28.3 therms

Using the calculations formulas shown at the beginning of Section 2:

kWh savings: 172.3 kWh \* 0.561 ESAF \* 0.75 HEAF = 72.47 kWh

kW reduction: 0.76446 kW \* 0.3333 PDAF \* 0.75 HEAF = 0.19112 kW

therm savings: -28.3 therms \* 0.444 ESAF \* 0.75 HEAF = -11.90 therms

The magnitude of negative therm savings within DEER seems excessive for a measure that provides cooling during the summer only, but were applied to the calculations.

**2016 Title 24 Baseline Adjustment**

Energy and demand savings have been adjusted to account for changes on Energy Standards baseline from SEER13 to SEER14. Measure impacts from DEER Residential SEER rated Split-System Air Conditioner (RE-HV-ResAC-14S) were used for this adjustment. See Attachment 2 for details.

The following table indicates which measures are taken directly from or created with the DEER READI tool.

READI Data Used

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **Measure Name** | **READI Data** |
| AC-29859 | Window Evap Cooler |  |

Latest DEER 2018 (READI v2.4.8) database was reviewed to confirm availability of measure updates.

# 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** |
| Residential Single Family | DEER:HVAC\_Eff\_AC | RES |
| Residential Multi-Family | DEER:HVAC\_Eff\_AC | RES |
| Residential Mobile Home - Double-Wide | DEER:HVAC\_Eff\_AC | RES |

# Section 4. Costs

## 4.1 Base Case Cost

For REA measures, base case cost is not used.

## 4.2 Measure Case Cost

**Measure Equipment Cost**

Measure equipment cost was updated as part of the 2018 program updates using (2018) on-line retail documentation. Measure equipment cost was determined by finding the average dollars per CFM of several window evaporative coolers from 3,000 CFM to 3,500 CFM, from multiple online retailers and using this cost to estimate (normalized) average cost for a 3,000 CFM unit. The average (normalized) cost was found to be $543.84 per unit.

**Water Usage Cost**

A cost totaling $171.19 was added to the Measure 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 in 2017. Water rates were adjusted to account for a slightly increase in water rates from previous version of the workpaper using evaluation of California Water Rates [F]. See [Attachment 3] for details.

**Labor Cost**

No measure for residential window evaporative coolers was found in WO17, thus the labor cost was updated using RS Means Mechanical 2018: $215.00 [498]. See [Attachment 3] for details. There will be maintenance costs associated with the measure primarily due to build-up of sediment and minerals. Evaporative coolers need a major cleaning every season and may need routine maintenance several times during the cooling season

Water Cost Calculations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Climate Zone** | **Annual Cooling Load (Btu)** | **ESAF** | **BTU/lb water evaporated** | **lb water/ft3** | **Water Rates/100 ft3** | **Total** |
| 6 | 8,317,221 | 44% | 1000 | 62.4 | 4.35 | $ 2.80 |
| 9 | 17,584,000 | 27% | 1000 | 62.4 | 2.96 | $ 2.47 |
| 15 | 77,573,000 | 60% | 1000 | 62.4 | 2.24 | $ 18.36 |
| Average | | | | | | $ 7.88 |
| Added water costs over life of measure (15 yr Measure Life; 2.5% annual rate of inflation) | | | | | | $ 171.19 |

## 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** |
| REA | MEC + MLC | MEC + MLC | 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** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| AC-29859 | REA | $930.03 | $930.03 | N/A |

# Attachments

1. SCE17HC026.1 A1 - Calculation Template.xlsm
2. SCE17HC026.1 A2 - Window Evaporative Cooler Calculations.xlsx
3. SCE17HC026.1 A3 - Window Evaporative Coolers Cost Calculations.xlsx
4. SCE17HC026.1 A4 - SFM Cooling Load CZ09.pdf
5. SCE17HC026.1 A5 - CZ 15 Water RateSheet Domestic.pdf
6. SCE17HC026.1 A6 - SFM Cooling Load CZ15.pdf
7. SCE17HC026.1 A7 - WaterRateAdjustmentNotice.pdf
8. SCE17HC026.1 A8 - CZ9 Water-sewer rate schedule.pdf
9. SCE17HC026.1 A9 - Weather Data - ESAF and PDAF - REV 4.xlsx

# References

[26]

[493]

[496]

[498]

[A] National Solar Radiation Data Base. http://rredc.nrel.gov/solar/old\_data/nsrdb/1991-2005/tmy3/

[B] Stull, Roland – University of British Columbia, Vancouver, British Columbia, Canada. (2011). Wet-Bulb Temperature from Relative Humidity and Air Temperature.

[C] Bucklin, R. A., Leary, J. D., McConnell, D. B., & Wilkerson, E. G. (1993, December 01). Publication #CIR1135. Fan and pad greenhouse evaporative cooling systems. Retrieved from http://edis.ifas.ufl.edu/ae069

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

[E] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (2009). 2009 ASHRAE Handbook, Fundamentals. Appendix: Design Conditions for Selected Locations. Atlanta, GA: ASHRAE

[F] Survey Examines California Water Rates, Black & Veatch Enterprise Management Solutions (EMS) Division. Retrieved from http://www.waterworld.com/articles/print/volume-22/issue-8/news-briefs/survey-examines-california-water-rates.html