# HVAC

## EVAPORATIVE PRE-COOLER SYSTEM AND CONTROLS FOR PACKAGED HVAC UNIT

SWHC042-01

CONTENTS

## MEASURE NAME

Evaporative Pre-Cooler System and Controls for Packaged HVAC Unit

## STATEWIDE MEASURE ID

SWHC042-01

## TECHNOLOGY SUMMARY

HVAC packaged units are the most common type of mechanical system and provide an estimated 75% of the cooling to commercial buildings in California[1]. A main trade-off is that due to their low cost, packaged units typically only meet minimum code requirements for energy efficiency which results in higher electricity costs. Since in many cases it is not financially feasible to replace an existing packaged unit before the end of its useful life, a preferred solution is to implement measures that will improve the performance and efficiency of the unit.

Installing an evaporative pre-cooling system is one possible method of improving a packaged unit's performance, as shown in the Emerging Technology (ET) study "Laboratory and Field Testing of RTU Optimization Package Combining a Condenser-Air Pre-Cooler with Compressor Speed Reduction"[2] conducted by Southern California Edison (SCE) in 2018. This system is installed directly on the unit and connected to the building's main cold-water supply line. Water flows through an evaporative media attached to the condenser air intake to pre-cool the entering air. The increased change in temperature between the condenser and precooled air improves heat rejection, which in turn results in higher unit efficiency and performance. The evaporative pre-cooling system consists of three main components:

- Direct Evaporative Condenser Pre-Cooler and Sump
    - This component consists of a steel enclosure attached to the condenser section of the packaged unit and contains the evaporative media as well as an integrated water reservoir with submersible circulation pump.
- Bleed System
    - The bleed system limits the concentration of minerals and contaminants by draining the water before the minerals can build up in the evaporative media and the coil. The bleed rate is determined by measuring the hardness content of the supply water and is updated by the control system based on the operating conditions. A filter is installed upstream of the bleed valve to prevent clogging.
- Controls
    - An integrated thermostat is included with the system to activate the circulation pump when the ambient air wet-bulb temperature exceeds a set point value.

[1] Itron, California Energy Commission. 2006. *California Commercial End-Use Survey*.

[2] Emerging Technologies Coordinating Council. 2018. *Laboratory and Field Testing of RTU Optimization Package Combining a Condenser-Air Pre-Cooler with Compressor Speed Reduction.*

## MEASURE CASE DESCRIPTION

The measure case is defined as a HVAC packaged unit with an evaporative pre-cooler installed on the condenser air intake.

## BASE CASE DESCRIPTION

The base case is defined as an existing or new Title 24 compliant HVAC packaged unit without an existing evaporative pre-cooler.

## CODE REQUIREMENTS

California and federal codes do not require or address evaporative pre-coolers. However, base case system efficiencies adhere to the 2019 California Building Energy Efficiency Standards (Title 24) requirements.

### Applicable State and Federal Codes and Standards

| Code | Applicable Code Reference | Effective Date |
|---|---|---|
| CA Building Energy Efficiency Standards – Title 24 (2019) | Section 110.2(a) Table 110.2-A | January 1, 2020 |
| CA Appliance Efficiency Regulations – Title 20 (2019) | Section 1605.1(c)(1) Table C-4 | January 1, 2019 |
| Federal Standards – Code of Federal Regulations (2018) | 10 CFR §431.97, Table 3 | January 1, 2018 |

Title 24 (2019), Section 110.2(a) Table 110.2-A1

*TABLE 110.2-A AIR CONDITIONERS AND CONDENSING UNITS – MINIMUM EFFICIENCY REQUIREMENTS*

| Equipment Type | Size Category | Efficiency [a, b] | | Test Procedure[c] |
|---|---|---|---|---|
| Air conditioners, air cooled both split system and single package | ≥ 65,000 Btu/h and < 135,000 Btu/h | | 11.2 EER<br>12.9 IEER | ANSI/AHRI 340/360 |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | | 11.0 EER<br>12.4 IEER | ANSI/AHRI 340/360 |
| | ≥ 240,000 Btu/h and < 760,000 Btu/h | | 10.0 EER<br>11.6 IEER | |
| | ≥ 760,000 Btu/h | | 9.7 EER<br>11.2 IEER | |
| Air conditioners, water cooled | ≥ 65,000 Btu/h and < 135,000 Btu/h | | 12.1 EER<br>13.9 IEER | ANSI/AHRI 340/360 |
| | ≥135,000 Btu/h and < 240,000 Btu/h | | 12.5 EER<br>13.9 IEER | ANSI/AHRI 340/360 |
| | ≥240,000 Btu/h and < 760,000 Btu/h | | 12.4 EER<br>13.6 IEER | ANSI/AHRI 340/360 |
| | ≥ 760,000 Btu/h | | 12.2EER<br>13.5 IEER | ANSI/AHRI 340/360 |
| Air conditioners, evaporatively cooled | ≥65,000 Btu/h and < 135,000 Btu/h | 12.1 EER[b]<br>12.3 IEER[b] | | ANSI/AHRI 340/360 |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | 12.0 EER[b]<br>12.2 IEER[b] | | ANSI/AHRI 340/360 |
| | ≥240,000 Btu/h and < 760,000 Btu/h | 11.9 EER[b]<br>12.1 IEER[b] | | ANSI/AHRI 340/360 |
| | ≥ 760,000 Btu/h | 11.7 EER[b]<br>11.9 IEER[b] | | ANSI/AHRI 340/360 |
| Condensing units, air cooled | ≥ 135,000 Btu/h | 10.5 EER<br>11.8 IEER | | ANSI/AHRI 365 |
| Condensing units, water cooled | ≥ 135,000 Btu/h | 13.5 EER<br>14.0 IEER | | |
| Condensing units, evaporatively cooled | ≥ 135,000 Btu/h | 13.5 EER<br>14.0 IEER | | |

[a] IEERs are only applicable to equipment with capacity control as as specified by ANSI/AHRI 340/360 test procedures

[b] Deduct 0.2 from the required EERs and IEERs for units with a heating section other than electric resistance heat.

[c] Applicable test procedure and reference year are provided under the definitions.

Title 20 (2019), Section 1605.1(c)(1) Table C-4

Table C-4 (continued)

| *Equipment Type* | *Cooling Capacity* | *Sub-category* | *Heating Type** | *Efficiency Levels* | *Compliance date: Equipment manufactured starting on* |
|---|---|---|---|---|---|
| Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled) | ≥ 135,000 Btu/h and < 240,000 Btu/h | AC | E-N | EER = 11.0 | January 1, 2010[1] |
| | | | | IEER = 12.4 | January 1, 2018[2] |
| | | | | IEER = 14.2 | January 1, 2023 |
| | | | A-O | EER = 10.8 | January 1, 2010[1] |
| | | | | IEER = 12.2 | January 1, 2018[2] |
| | | | | IEER = 14.0 | January 1, 2023 |
| | | HP | E-N | EER = 10.6<br>COP = 3.2 | January 1, 2010[1] |
| | | | | IEER = 11.6<br>COP = 3.2 | January 1, 2018[2] |
| | | | | IEER = 13.5<br>COP = 3.3 | January 1, 2023 |
| | | | A-O | EER = 10.4<br>COP = 3.2 | January 1, 2010[1] |
| | | | | IEER = 11.4<br>COP = 3.3 | January 1, 2018[2] |
| | | | | IEER = 13.3<br>COP = 3.4 | January 1, 2023 |

Code of Federal Regulations -10 CFR §431.97, Table 3

TABLE 3 TO § 431.97—UPDATES TO THE MINIMUM COOLING EFFICIENCY STANDARDS FOR AIR CONDITIONING AND HEATING EQUIPMENT—Continued

[Not including single package vertical air conditioners and single package vertical heat pumps, packaged terminal air conditioners and packaged terminal heat pumps, computer room air conditioners, variable refrigerant flow multi-split air conditioners and heat pumps, and double-duct air-cooled commercial package air conditioning and heating equipment]

| Equipment type | Cooling capacity | Sub-category | Heating type | Efficiency level | Compliance date: Equipment manufactured starting on . . . |
|---|---|---|---|---|---|
| Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled). | ≥135,000 Btu/h and <240,000 Btu/h. | AC .. | Electric Resistance Heating or No Heating. | IEER = 12.4<br>IEER = 14.2 | January 1, 2018.[1]<br>January 1, 2023. |
| | | ........ | All Other Types of Heating. | IEER = 12.2<br>IEER = 14.0 | January 1, 2018.[1]<br>January 1, 2023. |
| | | HP .. | Electric Resistance Heating or No Heating. | IEER = 11.6<br>IEER = 13.5 | January 1, 2018.[1]<br>January 1, 2023. |
| | | | All Other Types of Heating. | IEER = 11.4<br>IEER = 13.3 | January 1, 2018.[1]<br>January 1, 2023. |

## NORMALIZING UNIT

Capacity (Tons)

## PROGRAM REQUIREMENTS

### *Measure Implementation Eligibility*

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

*Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.*

Implementation Eligibility

| Measure Application Type | Delivery Type | Sector |
|---|---|---|
| Add-on Equipment (AOE) | DnDeemDI | Commercial |
| Add-on Equipment (AOE) | DnDeemed | Commercial |
| Add-on Equipment (AOE) | DnDeemDI | Industrial |
| Add-on Equipment (AOE) | DnDeemed | Industrial |
| Add-on Equipment (AOE) | DnDeemDI | Agricultural |
| Add-on Equipment (AOE) | DnDeemed | Agricultural |
| New Construction (NC) | DnDeemDI | Commercial |
| New Construction (NC) | DnDeemed | Commercial |
| New Construction (NC) | DnDeemDI | Industrial |
| New Construction (NC) | DnDeemed | Industrial |
| New Construction (NC) | DnDeemDI | Agricultural |
| New Construction (NC) | DnDeemed | Agricultural |

### *Eligible Products*

The HVAC packaged units and the evaporative pre-cooler system and controls must meet the following requirements:

- Host packaged unit must have a cooling capacity at least 20 tons
- For the Add-on Equipment (AOE) measure, the existing packaged unit on which the evaporative pre-cooler system will be installed must be less than 10 years old
- A water treatment system must be used in conjunction with the evaporative pre-cooler system to maintain water quality and performance
- Real time monitoring of the evaporative pre-cooler system must be implemented to ensure the system is working properly
- As a standard procedure, the contractor must perform condenser coil cleaning prior to installation of the pre-cooler system.

### *Eligible Building Types and Vintages*

This measure is applicable for the nonresidential buildings served by unitary direct expansion (DX) systems listed below. This measure applies to existing building vintages.

| Building Type | BT Code |
|---|---|
| Assembly | Asm |
| Community College | ECC |
| University | EUn |
| Grocery | Gro |
| Hospital | Hsp |
| Nursing Home | Nrs |
| Hotel | Htl |
| Bio/Tech Manufacturing | MBT |
| Light Industrial Manufacturing | MLI |
| Large Office | OfL |
| Small Office | OfS |
| Sit-Down Restaurant | RSD |
| Fast-Food Restaurant | RFF |
| Department Store | Rt3 |
| Big Box Retail | RtL |
| Small Retail | RtS |
| Conditioned Storage | SCn |
| Refrigerated Warehouse | WRf |

### *Eligible Climate Zones*

This measure is applicable only in Climate Zone 15.

## PROGRAM EXCLUSIONS

Building types and climate zones not described above are excluded from this measure.

Packaged units with cooling capacity less than 20 tons are excluded from this measure.

## DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

## USE CATEGORY

HVAC

## ELECTRIC SAVINGS (KWH)

The electric unit energy savings (UES) of this measure were derived from the baseline and measure case electric unit energy consumption (UEC) estimated using eQUEST version 3.65 energy modeling software. The software uses the DOE2.3 energy modeling simulation engine for most building types but uses DOE-2.2R energy modeling simulation engine for the Grocery and Refrigerated Warehouse models. All modeling was performed using the CZ2010 weather files.

DEER2020 prototypes from the Database of Energy Efficient Resources (DEER) were utilized for the building energy use simulations. The DEER 2020 prototypes were generated using MASControl3. The DEER 2020 prototypes for existing era building vintages for the existing measures specified in the table below were used to develop base and measure case unit energy consumption (UEC) and demand estimates.

#### DEER Prototype Tech ID by Measure

| Measure | DEER Prototype Tech ID |
|---|---|
| Evaporative Pre-cooler on Variable Volume AC Unit with Gas Heat | **All:** NE-HVAC-airAC-SpltPkg-240to759kBtuh-10p8eer_SZ MASControl v3.00.00 |

### Baseline and Measure Case Energy Use Simulations

The baseline model from the extracted DEER2020 measure was used for the baseline for both the AOE and NC applications and was adopted without changes. This baseline model (cDXGF-PkgAC2SpP-240to760-E9.8) uses the 2019 Title 24 standard 9.8 EER for its unit efficiency. As such, this baseline is conservative for the AOE application type due to the degradation of efficiency and lower performance of the existing older vintage packaged units.

The baseline models were modified to simulate the measure case energy use. The required modifications to the eQUEST default keywords within the DEER prototypes are summarized in the table below.

#### Summary of Modifications for Measure Case Simulations

| eQUEST Keyword | Unmodified DEER Prototype Baseline Value | Modified Measure Value |
|---|---|---|
| SYSTEM: CONDENSER-TYPE | AIR-COOLED | EVAP-PRECOOLED |
| SYSTEM: EVAP-PCC-EFF | n/a | 0.7[3] |
| SYSTEM: EVAP-PCC-SCH | n/a | EvapCoolAvail Sch |

Simulating the evaporative pre-cooler in eQuest does not change the capacity curve ("DX-Cool-Cap-fEWB&OAT") that is default from the DEER models. However, when the pre-cooler is in operation the entering wet bulb and outdoor dry bulb will be lower than the base case, resulting in improved EIR of the system. Due to eQuest limitations in Hourly Reporting Blocks there are no parameters available, such as entering WB, OAT, or pre-cooler effectiveness, that would be used to verify how eQuest simulates pre-cooler performance in order to compare eQuest with the ET study. [4]

[3] Emerging Technologies Coordinating Council. 2018. *Laboratory and Field Testing of RTU Optimization Package Combining a Condenser-Air Pre-Cooler with Compressor Speed Reduction.*

[4] Emerging Technologies Coordinating Council. 2018. *Laboratory and Field Testing of RTU Optimization Package Combining a Condenser-Air Pre-Cooler with Compressor Speed Reduction.*

A 70% evaporative precooler effectiveness was selected based on the ET study "Laboratory and Field Testing of RTU Optimization Packaged Combining a Condenser-Air Pre-Cooler with Compressor Speed Reduction"[5].

Condenser coil surface area is directly related to unit efficiency (EER). The workpaper uses standard code baseline efficiency. No new efficiency tiers based on baseline condenser coil sizes at this time. The analysis may be updated at a later date based on the results of data collection outlined in this workpaper.

The ET study set the activation temperature setpoint for the evaporative pre-cooler at 76°F wet bulb.[6] However, eQuest does not allow the use of wet bulb temperatures when creating schedules. As an alternative, the CZ2010 Climate Zone 15 weather file was analyzed on an hourly basis. The lowest dry bulb temperature that coincided with the 76°F wet bulb was found and used as the activation setpoint temperature, shown in the table below and can be found in the attached DataSpec[7].

### Mean Coincident Wet-bulb Values for Climate Zone 15

| Climate Zone | Wet Bulb Activation Setpoint (°F) | Dry Bulb Activation Setpoint (°F) |
|---|---|---|
| CZ15 | 76 | 84 |

The eQuest evaporative pre-cooler availability schedule was set to enable the evaporative pre-cooler at a specified temperature as was modeled as an ON/OFF/TEMP schedule in eQuest. The schedule is set to activate the evaporative precooler whenever the ambient dry bulb temperature is at or above 84°F. A sample schedule for a day in June is shown below.

### Sample EvapCoolAvail Schedule

| Hour | Wet Bulb Activation Setpoint (°F) | Dry Bulb Activation Setpoint (°F) | Precooler Enabled |
|---|---|---|---|
| 1 | 58 | 75 | No |
| 2 | 58 | 75 | No |
| 3 | 57 | 72 | No |
| 4 | 56 | 71 | No |
| 5 | 51 | 68 | No |
| 6 | 51 | 66 | No |
| 7 | 50 | 69 | No |
| 8 | 53 | 74 | No |
| 9 | 54 | 76 | No |
| 10 | 56 | 79 | No |
| 11 | 58 | 83 | No |

[5] Emerging Technologies Coordinating Council. 2018. *Laboratory and Field Testing of RTU Optimization Package Combining a Condenser-Air Pre-Cooler with Compressor Speed Reduction.*

[6] Emerging Technologies Coordinating Council. 2018. *Laboratory and Field Testing of RTU Optimization Package Combining a Condenser-Air Pre-Cooler with Compressor Speed Reduction.*

[7] Southern California Edison (SCE). 2019. " SWHC042-01 MeasureDataSpec 11-20-19.xlsm", Activation pt and Water Calcs Tab

| | | | |
|---|---|---|---|
| 12 | 58 | 84 | Yes |
| 13 | 59 | 86 | Yes |
| 14 | 59 | 88 | Yes |
| 15 | 61 | 91 | Yes |
| 16 | 61 | 91 | Yes |
| 17 | 62 | 91 | Yes |
| 18 | 62 | 90 | Yes |
| 19 | 62 | 90 | Yes |
| 20 | 63 | 89 | Yes |
| 21 | 61 | 84 | Yes |
| 22 | 61 | 80 | No |
| 23 | 60 | 78 | No |
| 24 | 58 | 75 | No |

## Vintage Weighted Average

Baseline and measure simulations used the DEER 2020 building vintages[8] (below).

### DEER Building Vintage Codes and Descriptions

| DEER Vintage Code | Description |
|---|---|
| Ex | Non-Mobile Homes 2002 - 2016; default vintage for existing buildings |
| V03 | Existing building stock built between 2002 and 2005 |
| V07 | Existing building stock built between 2006 and 2009 |
| V11 | Existing building stock built between 2010 and 2013 |
| V15 | Existing building stock built between 2014 and 2016 |
| 2020 (New) | New Construction (not yet built) |

DEER 2020 vintage weighting tables and procedures were used to appropriately weight all measure electric and demand reduction savings according to each vintage per IOU, building type for Climate Zone 15. The following equation describes the weighting methodology.

$$final\ weighted\ value\ = (\sum_{i=75}^{7} W_i \times V_i)/(\sum_{i=75}^{7} W_i)$$

*final weighted value =* *Reported energy savings value (kWh/ton, kW/ton, or therms/ton)*

*i =* *Vintage*

*W =* *Weight for a given vintage i*

*V =* *Unit energy savings value for a given vintage (kWh/ton, kW/ton, or therms/ton)*

[8]Southern California Edison (SCE). 2019. "SWHC042-01 Energy Savings.xlsx"

## Electric Unit Energy Savings

The electric UES was calculated as the difference between the vintage weighted baseline and measure case UEC. The electric UES (kWh per year per ton) was calculated by dividing the total energy savings by the total building HVAC cooling capacity.

$$ES = EC_{Base} - EC_{Measure}$$

$$UES_{Tons} = \frac{ES}{Cap.Tons}$$

| | |
|---|---|
| *ES =* | *Total energy savings (kWh)* |
| *EC =* | *Modeled energy consumption of the base case and measure case units (kWh)* |
| $UES_{Ton}$ = | *Unit energy savings (kWh/Ton)* |
| *Cap. Tons =* | *Total cooling capacity of the model's HVAC system (Tons)* |

## Sample Calculation

The following is an example of the energy savings calculations for a Large Office building (OfL) for vintage 2011.

$$EC_{Base} = \ 2{,}158{,}040.00\ kWh$$

$$EC_{Measure} = \ 2{,}027{,}500.00\ \ kWh$$

$$Cap.Tons = 635.1\ Tons$$

$$ES = \quad 2{,}158{,}040.00\ kWh - \ 2{,}027{,}500.00\ kWh = \quad 130{,}540.00\ kWh$$

$$UES_{Ton} = \frac{130{,}540.00\ kWh}{635.1\ Tons} = 205.54\ {}^{kWh}/_{Ton}$$

## PEAK ELECTRIC DEMAND REDUCTION (KW)

Peak demand reduction is calculated as the difference between the modeled baseline and measure case peak demand from the simulations summarized in the Electric Savings section. Peak demand was calculated as the average of the electrical power draw between 4:00 p.m. – 9:00 p.m. in conformance with the Database for Energy Efficiency Resources (DEER) peak definition.[9] The peak power was calculated by averaging the 15 DEER peak hours, that was taken from this five-hour period on three consecutive weekdays, from the 8760-hour load profile extracted from the eQuest models.

The calculation used to determine peak demand reduction is shown below. Note that the peak demand savings were weighted based on the same methodology used for the electric unit savings.

$$PeakDemandSav = PeakDemand_{Base} - PeakDemand_{Measure}$$

$$UnitPeakDemandSav_{Tons} = \frac{PeakDemandSav}{Cap.Tons}$$

*PeakDemandSav* = *Total peak demand reduction (kW)*
*PeakDemand* = *Modeled peak demand for base case and measure case units (kW)*
$UnitPeakDemandSav_{Ton}$ = *Unit energy savings (kW/Ton)*
*Cap. Tons* = *Total cooling capacity of the model's HVAC system (Tons)*

### Sample Calculation

The following is an example of the peak electric demand savings calculations for a Large Office building (OfL) for vintage 2011.

$$PeakDemand_{Base} = 347.19087\ kW$$

$$PeakDemand_{Measure} = 303.78353\ kW$$

$$Cap.Tons = 635.1\ Tons$$

$$PeakDemandSav = 347.19087\ kW - 303.78353\ kW = 43.40734\ kW$$

$$UnitPeakDemandSav_{Ton} = \frac{43.40734\ kW}{635.1\ Tons} = 0.06835\ {}^{kW}/_{Ton}$$

## GAS SAVINGS (THERMS)

The energy model simulations for this measure reported negligible natural gas impacts. Since natural gas consumption is not expected to be impacted by this measure, no gas impacts are approved. Not applicable.

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[9] California Public Utilities Commission. 2018. "Resolution E-4952. Approval of the Database for Energy-Efficient Resources updates for 2020 and revised version 2019 in Compliance with D.15-10-028, D.16-08-019, and Resolution E-4818."

## LIFE CYCLE

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The methodology to calculate the RUL conforms with Version 5 of the Energy Efficiency Policy Manual, which recommends "one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values."[10] This approach provides a reasonable RUL estimate without requiring any prior knowledge about the age of the equipment being replaced.[11] Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised add-on measures so that the EUL of the measure is equal to the lower of the RUL of the modified system or equipment or the EUL of the add-on component." [12]

The EUL and RUL specified for this measure are presented below. The EUL for a new construction (NC) installation is set to the EUL of the equipment, while the EUL for an add-on equipment (AOE) installation is set as the RUL of the host HVAC packaged unit. The RUL is only applicable to the first baseline period for an AOE offering.

### Effective Useful Life and Remaining Useful Life

| Parameter | Value | Source |
|---|---|---|
| EUL (yrs) (*EUL ID: HV-Evap*) | 15.0 | California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx." |
| RUL (yrs) (RUL ID: HV-Evap) | n/a | |
| Host Equipment: EUL (yrs) (*EUL ID: HVAC-airAC*) | 15.0 | California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx." |
| Host Equipment: RUL (yrs) (RUL ID: *HVAC-airAC*) | 5.0 | California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx." |

## BASE CASE MATERIAL COST ($/UNIT)

The base case costs for both the AOE and the NC application types assume that the evaporative pre-cooler equipment is installed on an existing or new packaged unit without an existing pre-cooler. As such, this measure is akin to an AOE measure on a new piece of equipment. The baseline packaged unit in either case is not included in the cost. Therefore, the base cost is $0.

[10] California Public Utilities Commission, Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

[11] KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

[12] California Public Utilities Commission. 2016. Resolution E-4807. December 16. Page 13.

## MEASURE CASE MATERIAL COST ($/UNIT)

The measure case material installed costs were obtained from a confidential vendor quote. The measure case material costs include material, labor, and associated infrastructure costs (water piping, water treatment system, booster pumps, controllers, etc.). The costs were provided based on installations for single packaged units and systems with multiple packaged units. Some costs, such as piping and water treatment infrastructure, shared across multiple units result in reduced implementation costs. Costing was requested from an additional vendor but was not received. Additional costing information from a UC Davis Western Cooling Efficiency Center[13] for evaporative precooling was reviewed for reasonableness, but not directly used in this workpaper.

The average unit capacity for large packaged units (≥240,000 Btuh) installed in the state of California is 29.4 Tons, according the California Commercial Saturation Survey conducted by Itron, Inc[14]. As a result, the average implementation cost for a 30-ton evaporative pre-cooler system was selected for this measure[15].

The measure case material cost, based on a 30-ton packaged unit, is $686.50/ton[16].

## BASE CASE LABOR COST ($/UNIT)

The base case costs for both the AOE and the NC application types assume that the evaporative pre-cooler equipment is installed on an existing or new packaged unit without an existing pre-cooler. Therefore, the base cost is $0.

## MEASURE CASE LABOR COST ($/UNIT)

The measure case labor cost was included in the measure case material cost estimate, see Measure Case Material Cost section.

## NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. The NTG value (*ET-Default*) is used for measures supported by emerging technologies trough workpaper review.

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[13] UC Davis Western Cooling Efficiency Center. 2013. *Condenser Air Pre-Cooler Retrofits for Rooftop Units.* Page 4.

[14] Itron, Inc. 2014. *California Commercial Saturation Survey.* Page 9-22

[15] Southern California Edison (SCE). 2019. " SWHC042-01 MeasureDataSpec 11-20-19.xlsm", Measure Specific Constants Tab

[16] Southern California Edison (SCE). 2019. " SWHC042-01 MeasureDataSpec 11-20-19.xlsm", Measure Specific Constants Tab

### Net-to-Gross Ratios

| Parameter | Value | Source |
|---|---|---|
| NTG – *ET-Default* | 0.85 | Itron, Inc. 2011. DEER Database 2011 Update Documentation. Prepared for the California Public Utilities Commission. Page 15-4 Table 15-3. |

## GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. This GSIA rate is the current default rate, specified for measures for which an alternative GSIA has not been estimated and approved.

### Gross Savings Installation Adjustment

| Parameter | Value | Source |
|---|---|---|
| GSIA – *Def-GSIA* | 1.0 | CPUC, Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 31. |

## NON-ENERGY IMPACTS

This measure achieves energy savings by flowing water through an evaporative media in order to pre-cool air flowing through the condenser of a packaged unit. As a result, the building water consumption will increase. Daily water consumption data was estimated using the 2013 case study, "*Condenser Air Pre-Cooler Retrofits for Rooftop Units*" conducted by the UC Davis Western Cooling Efficiency Center[17].

Annual non-energy impacts in the form of increased water consumption for this measure are expected to be 169 gal/ton[18].

## DEER DIFFERENCES ANALYSIS

This section provides a summary of inputs and methods based upon the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

### DEER Difference Summary

| DEER Item | Comment |
|---|---|
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |

[17] UC Davis Western Cooling Efficiency Center. 2013. *Condenser Air Pre-Cooler Retrofits for Rooftop Units.* Page 4.

[18] Southern California Edison (SCE). 2019. " SWHC042-01 MeasureDataSpec 11-20-19.xlsm", Activation pt and Water Calcs Tab

| DEER Item | Comment |
|---|---|
| DEER eQUEST Prototypes | Yes (MASControl version 3 for existing vintage) |
| DEER Version | n/a |
| Reason for Deviation from DEER | n/a |
| DEER Measure IDs Used | n/a |
| NTG | Source: DEER2011 (DEER2011_NTGR_2012-05-16.xls). Value of 0.85 is associated with NTG ID: *ET-Default* |
| GSIA | Source: DEER READI. The value of 1.0 is associated with GSIA ID: *def-GSIA* |
| EUL/RUL | Source: DEER. The EUL value of 15.0 years with EUL ID: HV-Evap<br>Source: DEER. The EUL value of 15.0 years with RUL ID: HVAC-airAC<br>Source: DEER. The RUL value of 5.0 years with RUL ID: HVAC-airAC |

## REVISION HISTORY

### Measure Characterization Revision History

| Revision Number | Date | Primary Author, Title, Organization | Revision Summary and Rationale for Revision<br>Effective Date and Approved By |
|---|---|---|---|
| 01 | 11/20/2019 | Sergio Corona,<br>Lake Casco PE<br>TRC | First draft of consolidated text for this statewide measure is based upon:<br>ET15SCE1250 (March 2018) |