**Work Paper PGECOHVC161**

**Unitary Water/Evap-Cooled AC**

**Revision # 2**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Unitary Water and Evaporatively Cooled Air Conditioners**

**Measure Codes: H136, H137, H138, H707, H708, H709**

# At-a-Glance Summary

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | **H136** | **H137** | **H138** | **H707** | **H708** | **H709** |
| **Measure Description:** | Package/Split Water/Evap Cooled AC <65kBtu/h (14.0 EER) | Package/Split Water/Evap Cooled AC ≥135 kBtu/h and <240 kBtu/h (14.0 EER) | Package/Split Water/Evap Cooled AC ≥65 kBtu/h and <135 kBtu/h (14.0 EER) | Package/Split Water/Evap Cooled AC <65kBtu/h (15.0 EER) | Package/Split Water/Evap Cooled AC <65kBtu/h (16.0 EER) | Package/Split Water/Evap Cooled AC ≥240 kBtu/h (13.0 EER) |
| **Energy Impact Common Units:** | per ton | | | | | | |
| **Base Case Description:** | Source: DEER2014 and Engineering calculations  Water-Cooled Package Air Conditioner | | | | | | |
| **Base Case Energy Consumption:** | Source: DEER2014 and Engineering calculations  Varies based on climate zones and building types | | | | | | |
| **Measure Energy Consumption:** | Source: DEER2014 and Engineering calculations  Varies based on climate zones and building types | | | | | | |
| **Energy Savings**  **(Base Case – Measure):** | Source: DEER2014 and Engineering calculations  Varies based on climate zones and building types | | | | | | |
| **Costs Common Units:** | $ per ton | | | | | | |
| **Base Case Equipment Cost ($/unit):** | Source: DEER2008 and Engineering Calculation.  Varies based on climate zones and building types | | | | | | |
| **Measure Equipment Cost ($/unit):** | Source: DEER2008 and Engineering Calculation.  Varies based on climate zones and building types | | | | | | |
| **Gross Measure Cost ($/unit)** | Source: DEER2008 and Engineering Calculation.  Varies based on unit capacity size | | | | | | |
| **Measure Incremental Cost ($/unit):** | Source: DEER2008 and Engineering Calculation.  Varies based on unit capacity size | | | | | | |
| **Effective Useful Life (years):** | Source: DEER2014  15 years (HVAC-EvapAC) | | | | | | |
| **Measure Application Type:** | Replace on Burnout (ROB) | | | | | | |
| **Net-to-Gross Ratios:** | Source: DEER2016  0.75 (NonRes-sAll-mHVAC-DX-up) | | | | | | |
| **Important Comments:** |  | | | | | | |

# Work Paper Approvals

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

# Document Revision History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Workpaper and Revision # | Tech. Revision | MM/DD/YY | Author/Affiliation | Summary of Changes |
| SCE13HC025.0 | No | 05/03/2012 | James Gowen/Matrix | Updated Work Paper to new template |
| 06/20/2012 | Jason Wang/SCE | Revised work paper based on PG&E comments |
| SCE13HC025.1 | No | 11/21/13 | Andres Fergadiotti/SCE | Updated the work paper with the following:   * New delivery early retirement delivery method which includes RET for all existing measures * Savings and Costs for RET are actually RET-ROB values in order to prevent the HVAC Upstream program from double counting the savings |
| SCE13HC025.2 | Yes | 03/07/2014 | Alfredo Gutierrez/SCE | “Cash for Clunkers” measures have been separated into new solution codes.   * NTG related to ET updated due to duration within the program   Removed the following measures from the calculation spreadsheet:   * RET savings permutations of the Air conditioner with Evaporatively Cooled Condenser measure * RET cost permutations of AC-60596, AC-78142, AC-89109, AC-59893, AC-38549, and AC-43597   Removed “New” installation types from the work paper. |
| SCE13HC025.3 | Yes | 4/17/2014 | Alfredo Gutierrez/SCE | -Work paper updated for reporting period, effective 7/1/2014 – 12/31/2014.  -Updated calculations to incorporate code requirements. These directly impact the scaling factors used in the calculations. |
| PGECOHVC161 R2 | Yes | 12/28/2015 | Jia Huang (PG&E) | - work paper updated for 2016 NTG update for upstream HVAC. Revised cost scaling to reflect 2014 Title 24 requirements. |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper details the replacement of air-cooled AC condensers with evaporatively-cooled AC condensers in the residential sector, and efficiency upgrades of water/evaporatively-cooled AC systems in the non-residential sector.

Table 1 Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| AC-60596 | < 5.4 ton 14 EER Package/Split System Air Conditioner Condenser |
| AC-78142 | < 5.4 ton 15 EER Package/Split System Air Conditioner Condenser |
| AC-89109 | < 5.4 ton 16 EER Package/Split System Air Conditioner Condenser |
| AC-59893 | 5.4 up to 11.3 ton 14 EER Package/Split System Air Conditioner Condenser |
| AC-38549 | 11.3 up to 20 ton 14 EER Package/Split System Air Conditioner Condenser |
| AC-43597 | ≥ 20 ton 13 EER Package/Split System Air Conditioner Condenser |
| AC-32008 | Air conditioner with Evaporatively Cooled Condenser |
| AC-48265 | < 5.4 ton To Code Savings Portion Package/Split System Air Conditioner Condenser |
| AC-44802 | 5.4 up to 11.3 ton To Code Savings Portion Package/Split System Air Conditioner Condenser |
| AC-79234 | 11.3 up to 20 ton To Code Savings Portion Package/Split System Air Conditioner Condenser |
| AC-33742 | ≥ 20 ton To Code Savings Portion Package/Split System Air Conditioner Condenser |

**Non-Residential measure:**

Replace a Title 20 and/or Title 24 standard code base evap-cooled AC system with a high efficiency evap-cooled AC system. This measure is offered through the Utilities’ Upstream HVAC program, which encourage HVAC Distributors to stock premium efficiency equipment. The incentives are paid to the HVAC Distributors who may do what they deem best with the incentive. The Upstream program does not control or restrict the distributor’s use of the funding

The non-residential water and evaporatively cooled system measures are offered in both SCE and PG&E territories. At this time, the Upstream HVAC program does not cover package terminal AC units, which are units manufactured for installation through a wall or window and are usually less than or equal to 2 tons (e.g., 24,000 Btu/h).

**Residential measure (offered by SCE only):**

Replace a base case 13 SEER air-cooled split system AC condenser with an evap-cooled AC condensing unit. For more information about this technology, see the performance evaluation document [A].

The residential evap-cooled condenser measure is only offered in the SCE service territory, climate zones 6, 8, 9, 10, 13, 14, and 15. The evap-cooled condenser must meet compliance requirements approved by the CEC [G].

All unitary DX equipment meeting measure specifications shown in Table 1 above is eligible including but not limited to packaged gas/electric, packaged heatpump, and/or split systems. Replacement must be like for like – e.g., HP for HP; AC for AC-only. Central systems and DHW systems are not eligible.

Specifically under the Early Retirement program applicability, only contractors actively participating in the HVAC Optimization Program are allowed to participate in this Program. Part of the application process will include verification procedures for ensuring that equipment is installed and operational.

Retrofitted HVAC equipment must have cooling capacity (e.g., Btu/h) within +/- 5% of existing equipment OR contractor must provide a load calculation verifying that the new unit is sized correctly for the load.

As applicable, HVAC equipment and refrigeration charge disposal shall follow all applicable regulations including but not limited to EPA’s 608 Refrigerant Recycling Rule. Refrigeration and air-conditioning equipment that is dismantled on-site before disposal has to have the refrigerant recovered in accordance with EPA's requirements for servicing prior to their disposal. There is no additional Eligibility or Implementation Requirements. All non-residential building types and vintages are eligible for the upstream rebate.

For early retirement offerings, identified as “To Code Savings Portion,” within this work paper:

* The HVAC Early Retirement will utilize the CPUC’s Early Retirement (ER) Savings methodology, but only claim the portion of savings that remain after the Replace on Burnout (ROB) savings is claimed by Upstream Program.
* Initial leads for the program will be generated from participants in the Quality Maintenance (QM) and Quality Renovation (QR) Programs. Maintenance records and analyses performed for the QM and QR program will be collected to help verify unit operation. Additional information on existing EER and operating efficiency may be collected on some applications to help document the existing baseline.
* Program requirement including pre-inspection and verification are in place to ensure that equipment is Early Retirement (ER, previously RET) and ROB or New Construction (NEW). The program will require pre-inspections on 75% of installations for the first 3 months, but target a 100% inspection rate. Pre-inspections will inspect nameplate information such as manufacturing year, visual verification of unit operation, or perform verification readings including: amperage, supply air temperature, outdoor air temperature, and mixed air temperature. After 3 months, the program will adjust the inspection percentage based on the pass-fail rates. Two rebates will be paid for Early Retirement Installation, but savings will only be claimed once.
* Certain evidence must be provided to participate in this program, including:
  + Pre-inspection data to evaluate that the units are still operating
  + Customer statement that the existing equipment is still in proper working condition and will continue to operate at least one year
* The evidence below will be asked to be provided by the contractor or customer, but because it may not always be available, will not be a requirement for program participation:
  + Make, model and serial number of existing equipment
  + Records of ongoing equipment maintenance and performance
  + Existing equipment installation dates and invoices
* The above evidence, any other evidence, and the sampling rate of this evidence, will be used to demonstrate the preponderance of evidence of program-induced early retirement through ongoing EM&V coordination. Other evidence may include emails, notes, and customer statements that help demonstrate evidence of how the early retirement program accelerated the early retirement of the existing unit and if any additional drivers other than energy efficiency helped influence the decision for early retirement.

## 1.2 Technical Description

Water source equipment is available up to a 240,000 Btu/hr capacity. It is similar in principle to air-source equipment with the primary exception that water is used for heat rejection instead of air. This yields significant efficiency improvements because of water’s higher heat capacity than air. However, water is more difficult to handle, requiring additional piping and fittings. This extra complexity makes such systems more expensive.

A single-package A/C unit consists of a condensing unit, a compressor, and an indoor fan/coil. The heating section (if one is included) may be either gas-fired or incorporated into the refrigeration circuit as a heat pump. Single-package units are typically installed on the roof of the building and will sit on a "roof-curb" or supporting beams. Down-flow units have the benefit of concealed ducting, thus minimizing the chances of water leaking through a roof penetration. An additional benefit of package units is that there is no need for field-installed refrigerant piping, thus minimizing labor costs and the possibility of contaminating the system with dirt, metal, oxides, or non-condensing gases.

A split system consists of two major parts in separate housings: a remote condensing unit, and an indoor fan/coil. The two system components are connected by a set of refrigerant lines. Where the heating system is gas-fired, the fan/coil will include a furnace section. Typical locations for the fan/coil are the attic space, under-floor, or in a closet or mechanical room. Locating the fan/coil in a conditioned or semi-conditioned space will help the system operate more efficiently by cutting down the thermal gains and losses to the unit and ducting.

Condenser model numbers are used to determine equipment efficiencies for package systems. Equipment efficiencies for split systems will be based on a combination of the condenser and evaporator model numbers provided by the Distributors. Efficiencies will then be verified by the use of the ARI/CEE database or manufacturers specification sheets. Field inspections will be performed to verify the condenser/unit model number for quality assurance purposes.

Split System Efficiencies - Because of the large number of evaporator/ condenser combinations available for split systems (several thousand combinations) some averages and/or minimum efficiencies may be used for certain groups of equipment. For example, if 95% of the evaporators installed with a specified condenser meet the minimum efficiency, it may be possible to reduce the unit energy savings by 5% and accept all evaporators used for this specified condenser. In other words, assume that 5% of units do not qualify, reduce the savings accordingly, and accept all combinations. In many cases the distributors do not know which exact evaporator went with which exact condenser. In addition, the evaporators coils can’t get inspected in the field anyway, so some assumptions will be required for split systems.

## 1.3 Measure Application Type

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 READi.

Delivery mechanism for Water/Evaporative Cooled Systems (Non-Residential):

* Upstream Programs / Up-Stream Incentive

Delivery mechanisms for Air conditioner with Evaporatively Cooled Condenser (Residential):

* Financial Support / Down-Stream Incentive – Deemed
* Financial Support / Direct Install
* Partnership / Direct Install
* Upstream Programs / Up-Stream Buy Down
* Midstream Programs / Mid-Stream Incentive

The install type for SCE measures is Replace-on-Burnout (ROB), except, early retirement measures will also be offered through the HVAC optimization program as Retrofit (RET). In this delivery approach, units identified through the HVAC optimization program as still functional, but needing replacement, will be retired prematurely. The program will provide incentives to the contractor for this to occur.

For PG&E, the install, and/or measure application type is ROB and NEW (New Construction/NC) for all nonresidential measures.

## 1.4 MEASURE and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

All measures in this work paper are either taken directly or scaled from measures in the 2014 Database for Energy Efficient Resources (DEER) v1.0.5.

Table 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | Yes |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | Scaled savings by efficiency to obtain savings for efficiencies not in DEER |
| DEER Version | 2014 DEER READI v1.0.5 |
| DEER Run ID and Measure Name (Sample) | D03-082: H.E. Evap/Water-Cooled Pkg A/C < 65k  D03-083: H.E. Evap/Water-Cooled Pkg A/C >=65k |

**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\* |
| NonRes-sAll-mHVAC-DX-up | All package and split system AC & HP replacements | Com | Any | PreRebUp | 0.75 |
| 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.

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 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 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 | Default GSIA values | Any | Any | Any | 1 |

**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 |
| Measure Case TechGroups | dX AC Equipment |
| Measure Case TechTypes | SEER Rated Package Rooftop AC (<65k)  EER Rated Package Rooftop AC (≥65k) |
| Base Case TechGroups | dX AC Equipment |
| Base Case TechTypes | SEER Rated Package Rooftop AC (<65k)  EER Rated Package Rooftop AC (≥65k) |

### 1.4.2 Codes and Standards Analysis

The 2013 Title 24 [355], effective July 1st of 2014 sets the efficiency of evaporatively cooled air conditioners as follows:

Table 6 2013 Title 24 Code

|  |  |  |  |
| --- | --- | --- | --- |
| Equipment Type | Size Category | Efficiency | Test Procedure |
| Air Conditioners, water cooled | ≥ 65,000 Btu/h and  < 135,000 Btu/h | 12.1 EER\*  12.3 IEER\* | ANSI/AHRI 340/360 |
| ≥ 135,000 Btu/h and  < 240,000 Btu/h | 12.5 EER\*  12.5 IEER\* | ANSI/AHRI 340/360 |
| ≥ 240,000 Btu/h and  < 760,000 Btu/h | 12.4 EER\*  12.6 IEER\* | ANSI/AHRI 340/360 |
| ≥ 760,000 Btu/h | 12.2 EER\*  12.4 IEER\* | ANSI/AHRI 340/360 |
| Air Conditioners, evaporatively cooled | ≥ 65,000 Btu/h and  < 135,000 Btu/h | 12.1 EER\*  12.3 IEER\* | ANSI/AHRI 340/360 |
| ≥ 135,000 Btu/h and  < 240,000 Btu/h | 12.0 EER\*  12.2 IEER\* | ANSI/AHRI 340/360 |
| ≥ 240,000 Btu/h and  < 760,000 Btu/h | 11.9 EER\*  12.1 IEER\* | ANSI/AHRI 340/360 |
| ≥ 760,000 Btu/h | 11.7 EER\*  11.9 IEER\* | ANSI/AHRI 340/360 |

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

The 2014 Title 20 [422] Appliance Efficiency Standards provides the following efficiency for evaporatively cooled air conditioners:

Table 7 Title 20 Standards for Evaporatively-Cooled Air Conditioners (Table C-4)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Appliance | Cooling Capacity (Btu per hour) | Minimum EER | | | |
| Effective Prior to October 29, 2012 | Effective January 10, 2011 | Effective June 1, 2013 | Effective June 1, 2014 |
| Water-cooled air  conditioners and  evaporatively  cooled air  conditioners | < 17,000 | 12.1 | - | - | - |
| Water-cooled air  conditioners and  evaporatively  cooled air  conditioners | ≥ 17,000 and < 65,000 | 12.1 | - | - | - |
| Water-cooled air  conditioners and  evaporatively  cooled air  conditioners | ≥ 65,000 and < 135,000 | 11.5\* | - | 12.1\* | - |
| Water-cooled air  Conditioners | ≥ 135,000 and < 240,000 | 11.0 |  |  | 12.5\* |
| Evaporatively  cooled air  conditioners | ≥ 135,000 and < 240,000 | 11.0 | - | - | 12.0\* |
| Water-cooled air  Conditioners | ≥ 240,000 and < 760,000 | 11.0\* | 11.0\* |  | 12.4\* |
| Evaporatively  cooled air  conditioners | ≥ 240,000 and < 760,000 | 11.0\* | 11.0\* | - | 11.9\* |
| \* Deduct 0.2 from the required EER for units with heating sections other than electric resistance heat. | | | | | |

Table 8 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates\* |
| Title 24 (2013) | 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, Table 110.2-A; Electrically Operated Unitary Air Conditioners and Condensing Units - Minimum Efficiency Requirements | July 1st, 2014 |
| Title 20 (2014) | Table C-4 Standards for Water – Cooled Air Conditioners, Evaporatively Cooled Air Conditioners, and Water – Source Heat Pumps | July 1st, 2014 |

\* note the revised CEC effective date in this table.

Please note that as the DEER measures used in this work paper to scale savings for non-DEER measures are a combination of evaporative and water cooled package air conditioners (D03-082, H.E. Evap/Water-Cooled Pkg A/C < 65k), the more stringent code EER was used in the calculations. For example, Title 24 gives the minimum EER efficiency as 12.5 for water cooled air conditioners within the 135,000 Btu/hr to 240,000 Btu/hr ranges, while it gives a minimum EER of 12.0 for evaporatively cooled air conditioners. IN this case, 12.5 EER would be used in the calculations.

### 1.4.3 Non-DEER Study Review

SCE’s Design and Engineering Services performed tests on evaporatively-cooled condensing units of residential split-systems in a controlled environment room within SCE’s Thermal Test Center in order to evaluate the performance of these condensing units. The results of the baseline data were then compared to the baseline test conducted by manufactures at identical test conditions and were found to closely match. The findings within this study show that evaporatively-cooled condensers are able to provide the same cooling capacity as air-cooled condensers but at lower energy consumption. This study can be found in the attachment section [A].

### 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.xlsx [213], was consulted. Table 9 below identifies the value/methodology used for the measures in this work paper.

Table 9 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| HVAC-evapAC,  HVAC-wtrAC | Non-Residential | HVAC | Air Conditioners (evaporatively-cooled, split and unitary) & Air Conditioners (water-cooled, split and unitary) | 15 | 5 |

# Section 2. Energy Savings & Demand Reduction Calculations

**Non-Residential (Water/Evaporative Cooled System)**

The savings were generated from the DEER 2014 READi Tool v1.0.5 for two measures:

* H.E. Evap/Water-Cooled Pkg A/C  <65kBTU (Measure ID: D03-082)
  + Code Base Case: 13 SEER (11.09 EER) Water-Cooled Package Air Conditioner
  + Measure Case: 14 EER Water-Cooled Package Air Conditioner
* H.E. Evap/Water-Cooled Pkg A/C  >=65kBTU (Measure ID: D03-083)
  + Code Base Case: 10.1 EER Water-Cooled Package Air Conditioner
  + Measure Case: 14 EER Water-Cooled Package Air Conditioner

Please note that the code case mentioned above is from the DEER 2014 READi tool and not from Title 24 [355] or Title 20 [422]. Also, please note that the savings values from the DEER 2014 Code Update READi tool for the measures contained within this work paper (specifically, D03-082 & D03-083) did not change when compared with the DEER 2011 READi tool used for 13-14.

For both measures, there are two exports taken from READi, which are as follows:

1. Measure ID: D03-082, IOU=”All, PGE, SCE, SCG, SDGE”, Vintage=”Ex, New”, All climate zones, and “Any” HVAC type
2. Measure ID: D03-083, IOU=”All, PGE, SCE, SCG, SDGE”, Vintage=”Ex, New”, All climate zones, and “Any” HVAC type

Building Type and Climate Zone Mapping

* Table 10 below identifies which building types are available in DEER, including which are only applicable to SCE, and how SCE building types were mapped to others if they were unavailable in the 2014 DEER READi tool. The last column of Table 10, “Not in DEER…” is not applicable for PG&E mappings. Please see below for details regarding PG&E’s building type mappings.
* For SCE, unavailable building types are mapped to Misc. Commercial, except Grocery which is mapped to Food Store. Then, unavailable climate zones are mapped to the “IOU” climate zone for the relevant building type.
* For PG&E, if a building type is unavailable, the savings are mapped to the “IOU” climate zone for the “Com” building type.
* For PG&E, if a building type is available, any unavailable climate zones for that building type are mapped to the “IOU” climate zone for that building type.
* For PG&E’s NEW/NC measures, any unavailable building types used “Com.”

Table 10 DEER 2014 Building Types

| Building Type | In DEER14 | SCE Weighted BT (Available for SCE CZs only) | Not in DEER and mapped to this building type (SCE) |
| --- | --- | --- | --- |
| Agricultural |  | x |  |
| Assembly | x |  |  |
| Education - Primary School | x |  |  |
| Education - Secondary School | x |  |  |
| Education - Relocatable Classroom | x |  |  |
| Education - Community College | x |  |  |
| Education - University |  |  | Misc - Commercial |
| Grocery |  |  | Food Store |
| Food Store |  | x |  |
| Health/Medical - Hospital | x |  |  |
| Health/Medical - Nursing Home | x |  |  |
| Health/Medical - Clinic |  | x |  |
| Lodging - Hotel | x |  |  |
| Lodging - Guest Rooms |  |  | Misc - Commercial |
| Lodging - Motel |  |  | Misc - Commercial |
| Manufacturing - Bio/Tech | x |  |  |
| Manufacturing - Light Industrial | x |  |  |
| Industrial |  | x |  |
| Misc - Commercial |  | x |  |
| Office - Large |  |  | Misc - Commercial |
| Office - Small | x |  |  |
| Restaurant - Fast-Food | x |  |  |
| Restaurant - Sit-Down | x |  |  |
| Retail - Multistory Large |  |  | Misc - Commercial |
| Retail - Single-Story Large | x |  |  |
| Retail - Small | x |  |  |
| Storage - Conditioned | x |  |  |
| Storage - Unconditioned |  |  | Misc - Commercial |
| Transportation - Communication - Utilities |  | x |  |
| Warehouse - Refrigerated |  |  | Misc - Commercial |

The EERs of the DEER measures mentioned at the beginning of Section 2 do not exactly match the measures offered by the Upstream HVAC program. Therefore, the DEER savings were scaled to meet measure requirements. See Table 11 for a comparison between the program and DEER measures.

Table 11 DEER Measure Scaling Summary

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure | Program Measure Efficiency | DEER Measure Efficiency | Title 20/24 Code Base Efficiency | DEER Code Base Efficiency |
| < 5.4 ton 14 EER Package/Split System Air Conditioner Condenser | 14 EER | 14 EER | 12.1 EER | 11.09 EER |
| < 5.4 ton 15 EER Package/Split System Air Conditioner Condenser | 15 EER | 14 EER | 12.1 EER | 11.09 EER |
| < 5.4 ton 16 EER Package/Split System Air Conditioner Condenser | 16 EER | 14 EER | 12.1 EER | 11.09 EER |
| 5.4 up to 11.3 ton 14 EER Package/Split System Air Conditioner Condenser | 14 EER | 14 EER | 11.5 EER | 10.1 EER |
| 11.3 up to 20 ton 14 EER Package/Split System Air Conditioner Condenser | 14 EER | 14 EER | 11.0 EER | 10.1 EER |
| ≥ 20 ton 13 EER Package/Split System Air Conditioner Condenser | 13 EER | 14 EER | 11.0 EER | 10.1 EER |

**Scaling Methodology**

The DEER measures are scaled by ΔEER, as shown below:

Example savings calculation for water/evap-cooled system <65kBTU with minimum EER of 14.0

For an Assembly building in Climate Zone 6, the savings extracted from DEER for above code energy savings are as follows: 126 kWh, -0.0000099 therms, and 0.06120 kW demand reduction.

kWh Savings calculation:

kW Reduction calculation:

therms Savings calculation:

See the attachment “SCE13HC025.3\_Savings.xlsx" for all savings calculations.

**Residential (Air conditioner with Evaporatively Cooled Condenser)**

Savings for the residential measure were directly available from DEER 2014. The measure name is:

* 17.4 SEER (15.1 EER) Evap-Cooled Split-System Air Conditioner

The measures were extracted from the READI tool for building types DMO, MFM, and SFM. They were filtered by SCE climate zones for Existing Vintage (Ex).

Table 12 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 12 READi Tool Outputs

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Name | READi Results |
| AC-32008 | Air conditioner with Evaporatively Cooled Condenser | See Reference |

For all RET measures contained within this work paper, the savings shown are derived from DEER, as per the methodology above. The only difference, however, is that the values reported are the RET-ROB savings, i.e. 1st baseline (above customer whole building) – 2nd baseline (above standard whole building) which are meant to prevent the double counting of 2nd baseline savings with the Upstream HVAC program for the measures contained within this work paper. Thus the ROB savings will be reported in the upstream HVAC program, and the RET- ROB savings will be reported for the early retirement mechanism. By taking the difference between RET and ROB, the savings would be those of replacing the customers’ existing equipment with code mandated equipment.

# 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\_Split-Package\_AC load shape for non-residential building types and the DEER:HVAC\_Eff\_AC load shape for residential building types. See Table 13 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 13 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Agricultural | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| 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 - Relocatable Classroom | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Education - Community College | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Education - University | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Grocery | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Food Store | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Health/Medical - Hospital | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Health/Medical - Nursing Home | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Health/Medical - Clinic | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Lodging - Hotel | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Lodging - Guest Rooms | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Lodging - Motel | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Manufacturing - Bio/Tech | 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 |
| Misc - Commercial | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Office - Large | 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 - Multistory Large | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Retail - Single-Story Large | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Retail - Small | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Storage - Conditioned | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Storage - Unconditioned | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Transportation - Communication – Utilities | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Warehouse – Refrigerated | NON\_RES | DEER:HVAC\_Split-Package\_AC |
| Residential Single Family | RES | DEER:HVAC\_Eff\_AC |
| Residential Multi-family | RES | DEER:HVAC\_Eff\_AC |
| Residential Mobile Home - Double-Wide | RES | DEER:HVAC\_Eff\_AC |

# Section 4. Base Case & Measure Costs

## 4.1 Base Case Cost

**Non-Residential (Water/Evaporative Cooled System)**

DEER 2005 provides costs for water-cooled packaged ACs (D03-082 and D03-083). These costs are presented on a per ton basis. As stated in Section 2, program measure efficiencies do not exactly match DEER measure efficiencies. Therefore, extrapolation was performed to obtain the desired costs.

**Residential (Air conditioner with Evaporatively Cooled Condenser)**

The base case equipment cost is the purchase price of a unit that meets minimum Federal and State of California appliance standards. The measure and base equipment cost values were data provided from manufacturers. Base equipment costs are estimated at $1100.00/ton [F].

The base case labor and maintenance cost were values provided from contractors. The base case labor costs are $380.00/ton based on an average installation time of 8 hours per a 2 man shift. The labor rate used was $95.00/hr.

Base maintenance cost is estimated at $129.00 per year with an expected useful life of the equipment set at 15 years and a discount rate of 3%, resulting in $352.75/ton per year, for a 4 ton unit. See the NPV calculator for net present value calculation [B]. The base water metric cost is $0, where the base case is an air-cooled condensing unit.

Total base case cost is represented by the equation below:

Base Case Cost = (Base Case Equipment Cost + Base Case Labor Cost + Base Case Maintenance Cost)

Base Case Cost = $1100.00 + $380.00 + $352.75 =$1,832.75/ton

See Table 16 for base case costs, and the “SCE13HC025.3\_Savings.xlsx"; tab “Costs” for cost calculations.

## 4.2 Measure Case Cost

## Non-Residential (Water/Evaporative Cooled System)

## The measure cost for water-cooled packaged ACs (D03-082 and D03-083) measures contained within this work paper are taken from DEER 2005 and are extrapolated using program efficiency as well as DEER efficiencies to find the costs of measures not contained within DEER.

**Residential (Air conditioner with Evaporatively Cooled Condenser)**

The measure case equipment cost is the purchase price of a unit that meets SCE’s program efficiency levels. The measure and base equipment cost values were data provided from manufacturers. Measure equipment costs are estimated at $1833.33/ton [F].

The measure case labor and maintenance cost were values provided from contractors. The measure case labor costs are $427.50/ton based on an average installation time of 9 hours per a 2 man shift. The labor rate used was $95.00/hr.

Measure maintenance cost is estimated at $169.00 per year with an expected useful life of the equipment set at 15 years and a discount rate of 5%, resulting in $396.29/ton per year, for a 4 ton unit. See the NPV calculator for net present value calculation [B]. The base water metric cost varies by climate zone from $26 (climate zone 6) to $176 (climate zone 16).

Total measure case cost is represented by the equation below:

Measure Case Cost = (Base Case Equipment Cost + Base Case Labor Cost + Base Case Maintenance Cost + Water Cost)

For example, the measure case cost in climate zone 6 is as follows:

Measure Case Cost = $1833.33 + $427.50 + $396.29 + $92.00 =$2,749.12/ton

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost

**Non-Residential (Water/Evaporative Cooled System)**

For ROB, the equipment being replaced is assumed to have failed in place or is past its useful life. The customer is faced with either purchasing standard efficiency or code baseline equipment versus energy efficient equipment. Therefore, gross measure cost (GMC) means the cost premium required to install the energy efficient measure over a less efficient piece of equipment. GMC is represented by the equation below:

GMC = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

= (Measure Equipment Cost – Base Case Equipment Cost)

\*Note: Unless stated otherwise the measure case labor and base case labor are assumed to be the same value.

DEER 2005 costs were extrapolated to match program efficiencies. See the “SCE13HC025.3\_Savings.xlsx"; tab “Costs” for the extrapolation calculations and cost summary. These costs can also be seen in the table below.

For RET, GMC is represented by the equation below:

Equation 4: GMC = Measure Equipment Cost + Measure Labor Cost

For all RET measures contained within this work paper, the costs shown are derived per the methodology above. The only difference, however, is that the values reported are the RET-ROB costs, i.e. 1st baseline costs – 2nd baseline costs which are meant to prevent the double counting of 2nd baseline costs with the Upstream HVAC program for the measures contained within this work paper. Thus the ROB costs will be reported in the upstream HVAC program, and the RET- ROB costs will be reported for the early retirement mechanism.

For RET-ROB Costs:

Equation 5: GMC = (Measure Equipment Cost + Measure Labor Cost) – (Measure Equipment Cost – Base Case Equipment Cost)

GMC = Base Case Equipment Cost + Measure Labor Cost

**Residential (Air conditioner with Evaporatively Cooled Condenser)**

**Water Use Metrics and Maintenance**

Analysis Technique:

* 1. Calculate change in EER with respect to condenser air temperature
     + 1-2% change per oF
     + Calculate condenser temperature change per unit of water evaporated
     + Use EER change to calculate extra cooling delivered for the same electricity consumed

Evaporative Cooling Water Use

* + - Cooling potential = mass of water \* heat of vaporization
    - Maintenance Water Use
    - Rule of Thumb: 2/3 evaporation, 1/3 maintenance
  1. The calculation for water consumption of the unit is shown in the Water Usage spreadsheet [C]. Water use cost is shown in Table 15.
  2. The evaporatively cooled condensing system includes additional components over an air-cooled system that is required to pump and handle the water, and these may introduce the potential for higher maintenance costs.
  3. The measure case labor costs are $427.50/ton based on an average installation time of 9 hours per a 2 man shift. The labor rate used was $95.00/hr. The installation of a water service line increases the amount of labor required for the measure case.

Maintenance cost for an evaporatively cooled condensing unit is considered at $169.00 dollars per year with an expected useful life of the equipment set at 15 years and a discount rate of 5%, resulting in $396.29/ton per year, for a 4 ton unit. See the NPV calculator worksheet [B] for calculation of net present value.

Measure water metric costs are calculated based on climate zone with data from the California Water Rate Survey [D, E]. This value is presented in Table 15, under water metric costs.

Table 15 Water Use of ECCU Per Climate Zone

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Total Water Use** | **Water Use Rate** | **Measure Water Metric Cost** | **Measure Water Metric Cost/ton (NPV)** |
| CZ | (gal/hr) | ($/gallon) | ($/year) | ($/ton) |
| 6 | 7.006 | $0.0167 | $26.28 | $92.00 |
| 8 | 7.138 | $0.0136 | $35.91 | $125.75 |
| 9 | 7.458 | $0.0111 | $43.15 | $151.00 |
| 10 | 7.834 | $0.0070 | $34.46 | $120.50 |
| 13 | 7.749 | $0.0130 | $139.50 | $488.50 |
| 14 | 8.272 | $0.0155 | $154.03 | $539.99 |
| 15 | 8.317 | $0.0075 | $175.66 | $614.75 |

The measure equipment costs are estimated at $1833.33/ton [F].

Gross Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure (SEER13).

GMC = (Measure Equipment Cost + Measure Labor Cost + Measure Maintenance Cost + Measure Water Metric Cost) – (Base Case Equipment Cost + Base Case Labor Cost+ Base Maintenance Cost +Base Water Metric Cost)

The base and measure labor costs are different.

Example: GMC Calculation for climate zone 15

GMC = ($1833.33 + $427.50 + $396.29 + $614.75) – ($1100 + $380.00 + $352.75) = $1439.12

Table 16 Gross Measure Cost (Residential Measure)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure | CZ | Measure Cost (per ton) | Base Cost  (per ton) | GMC  (Per ton) |
| Air conditioner with Evaporatively Cooled Condenser | 6 | $2,749.10 | $1,832.75 | $916.35 |
| Air conditioner with Evaporatively Cooled Condenser | 8 | $2,782.81 | $1,832.75 | $950.06 |
| Air conditioner with Evaporatively Cooled Condenser | 9 | $2,808.15 | $1,832.75 | $975.40 |
| Air conditioner with Evaporatively Cooled Condenser | 10 | $2,777.73 | $1,832.75 | $944.98 |
| Air conditioner with Evaporatively Cooled Condenser | 13 | $3,145.71 | $1,832.75 | $1,312.96 |
| Air conditioner with Evaporatively Cooled Condenser | 14 | $3,196.23 | $1,832.75 | $1,363.48 |
| Air conditioner with Evaporatively Cooled Condenser | 15 | $3,271.93 | $1,832.75 | $1,439.18 |

### 4.3.2 Incremental Measure Cost

Incremental Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. The incremental cost is only used to help determine program incentives.

For ROB, the IMC is the same value as GMC.

For the RET measures, as per the comment in section 4.2 about double counting the costs, the Incremental Measure Cost is equal to zero.

# Attachments

See accompanying files

# References

\*See accompanying files

[31]

[213]

[351]

[355]

[422]

[A] Attachment 3 - ET 08.08 Evaporatively-Cooled.pdf

[B] Attachment 4 - NPV\_Calculator.xls

[C] Attachment 5 - Water Usage.xls

[D] 2009 California-Nevada Water Rate Survey, Elizabeth Ytell Kang, Sudhir Pariwala Raftelis Financial Consultants, Inc, California-Nevada Section of the American Water Works Association.

[E] 2006 California Water Rate Survey, Black & Veatch, Copyright 2006.

[F] Attachment 6 - Manufacturer Costs.pdf

[G] Attachment 7 – CEC-400-2006-SF.pdf

# 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 |