**Work Paper PGECOHVC126**

**Unitary Air-Cooled Commercial A/C and H/P <65kBtu/h**

**Revision #5**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Packaged and Split Air- Cooled Commercial Air Conditioner and Heat Pump Units, less than 65k Btu/h**

**Measure Codes: HV241, HV242, HV243, HV244, HV245, HV246, HV247, HV248, HV249, HV250, HV251, HV252, HV253, HV254, HV255, HV256, HV257, HV258, HV259, HV260, HV261, HV262, HV263, HV264, HV265, HV266, HV267, HV268, HV269, HV270, HV271, HV272, HV273, HV274, HV275, HV276**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | HV241, HV242, HV243, HV244, HV245, HV246, HV247, HV248, HV249, HV250, HV251, HV252, HV253, HV254, HV255, HV256, HV257, HV258, HV259, HV260, HV261, HV262, HV263, HV264, HV265, HV266, HV267, HV268, HV269, HV270, HV271, HV272, HV273, HV274, HV275, HV276 |
| **Measure Description:** | Air cooled air conditioning or heat pump units with cooling capacities less than 65 kBtuh, for use in non-residential buildings, meeting the minimum efficiency requirements listed in Table 2. |
| **Energy Impact Common Units:** | kW/ton, kWh/ton, therms/ton of cooling |
| **Base Case Description:** | Air cooled air conditioning or heat pump units with cooling capacities less than 65 kBtuh, for use in non-residential buildings, meeting the federal minimum efficiency standard of 14 SEER. |
| **Base Case Energy Consumption:** | Source: DEER2015 READi (Version 2.1.0) |
| **Measure Energy Consumption:** | Source: DEER2015 READi (Version 2.1.0) |
| **Energy Savings**  **(Base Case – Measure):** | Source: DEER2015 READi (Version 2.1.0)  Varies by climate zone |
| **Costs Common Units:** | $/ton of cooling. |
| **Base Case Equipment Cost ($/unit):** | Source: DEER2008 and Engineering Calculations.  Varies depending on system capacity. |
| **Measure Equipment Cost ($/unit):** | Source: DEER2008 and Engineering Calculations.  Varies depending on system capacity. |
| **Gross Measure Cost ($/unit)** | Source: DEER2008 and Engineering Calculations.  Varies depending on system capacity. |
| **Measure Incremental Cost ($/unit):** | Source: DEER2008 and Engineering Calculations.  Varies depending on system capacity. |
| **Effective Useful Life (years):** | Source: DEER 2014.  15 years, based on Nonresidential “Air Conditioners/Heat Pumps (split and unitary)” |
| **Measure Application Type:** | Replace on Burnout (ROB) and New Construction (NC) |
| **Net-to-Gross Ratios:** | Source: DEER2011.  NTG = 0.85, NonRes-sAll-mHVAC-DX-up for “All package and split system AC & HP replacements.” |
| **Important Comments:** |  |

# Work Paper Approvals

The following Manager(s) approved this workpaper through the PG&E Electronic Data Routing System under Routing Requisition # \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |
| --- |
|  |
| **Grant Brohard**  Manager, Engineering Services  (Technical Product Support) |
| **Carolyn Weiner**  Manager, Core Products |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | Revision Date | Author (Affiliation) | Summary of Changes |
| 0 | 5/16/2012 | Alex MacCurdy/Elizabeth Joyce (Energy Solutions) | Updated to SCE Work Paper Template 2013 v0.1  Updated scaling factor calculation for Tiers 2, 3 and 4.  Added Heat Pump Units |
| 1 | 11/18/2013 | Alfredo Gutierrez (SCE) | Updated the work paper with the following:   * New delivery early retirement delivery method which includes Added 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 |
| 2 | 1/27/2014 | Alfredo Gutierrez (SCE) | Added in the following building type to be consistent with the ED filed REV 0 of this work paper:   * Miscellaneous Commercial * RET Measures have been separated into two new solution codes. |
| 3 | 4/17/2014 | Jason Wang (SCE) | - Work paper updated for the reporting period, effective 7/1/14 – 12/31/14  - Updated savings and scaling factors using DEER 2014 values  - Split measures into the <55 kBtuh and 55-64 kBtuh ranges  - Added SEER 14.5 HP measures (SCE13HC019 was merged into this work paper)  - Added SEER 18 AC and HP measures  - Added the Com building type for PG&E  - Added all building types available from DEER that were not already present in the work paper |
| 4 | 1/1/2015 | Jason Wang (SCE) | Updated work paper for DEER 2015 measures and federal code 430.32:   * Most measures now using DEER savings directly; SEER 15, 16, 17, and 18 measures were added to DEER 2015. * Removed SEER 14 AC, SEER 14 HP, and SEER 14.5 HP measures due to code and DEER direction. * Created new capacity ranges to accommodate EER and two-speed fan requirements. These align with DEER measures. * Used scaling of DEER measures to determine SEER 18 Packaged HP savings. * Calculated To Code savings using DEER measures (RET savings minus ROB savings). * Updated costs with values from WO017. |
| 5 | 1/27/2015 | Chris Li (PG&E) | * SCE lead workpaper. |

# Section 1: General Measure & Baseline Data

## 1.1 Measure Description & Background

**Measure Description:** Air cooled air conditioning or heat pump units with cooling capacities less than 65 kBtuh, for use in non-residential buildings, meeting the minimum efficiency requirements listed in Table 2 below.

**Base Case Description:** Air cooled air conditioning or heat pump units with cooling capacities less than 65 kBtuh, for use in non-residential buildings, meeting the federal minimum efficiency standard of 14 SEER.

Table 1: Measures and Codes

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Code | Measure Name |
| AC-50375 | HV241 | <55kBtuh 15 SEER (12 EER) Packaged Air Conditioner |
| AC-81566 | HV242 | <55kBtuh 16 SEER (12.4 EER) Packaged Air Conditioner |
| AC-37735 | HV243 | <55kBtuh 17 SEER (13 EER) Packaged Air Conditioner |
| AC-31588 | HV244 | <55kBtuh 18 SEER (14 EER) Packaged Air Conditioner |
| AC-87532 | HV245 | 55to65kBtuh 15 SEER (12 EER) Packaged Air Conditioner |
| AC-77878 | HV246 | 55to65kBtuh 16 SEER (12.4 EER) Packaged Air Conditioner |
| AC-22408 | HV247 | 55to65kBtuh 17 SEER (13 EER) Packaged Air Conditioner |
| AC-75087 | HV248 | 55to65kBtuh 18 SEER (14 EER) Packaged Air Conditioner |
| AC-46105 | HV249 | <45kBtuh 15 SEER (12.5 EER) Split System Air Conditioner |
| AC-83486 | HV250 | <45kBtuh 16 SEER (13 EER) Split System Air Conditioner |
| AC-26490 | HV251 | <45kBtuh 17 SEER (13.5 EER) Split System Air Conditioner |
| AC-50319 | HV252 | <45kBtuh 18 SEER (14 EER) Split System Air Conditioner |
| AC-70613 | HV253 | 45to55kBtuh 15 SEER (12.5 EER) Split System Air Conditioner |
| AC-97648 | HV254 | 45to55kBtuh 16 SEER (13 EER) Split System Air Conditioner |
| AC-66543 | HV255 | 45to55kBtuh 17 SEER (13.5 EER) Split System Air Conditioner |
| AC-96580 | HV256 | 45to55kBtuh 18 SEER (14 EER) Split System Air Conditioner |
| AC-69747 | HV257 | 55to65kBtuh 15 SEER (12.5 EER) Split System Air Conditioner |
| AC-86967 | HV258 | 55to65kBtuh 16 SEER (13 EER) Split System Air Conditioner |
| AC-61866 | HV259 | 55to65kBtuh 17 SEER (13.5 EER) Split System Air Conditioner |
| AC-87169 | HV260 | 55to65kBtuh 18 SEER (14 EER) Split System Air Conditioner |
| AC-97980 | HV261 | <55kBtuh 15 SEER (12 EER) Packaged Heat Pump |
| AC-92105 | HV262 | <55kBtuh 16 SEER (12.4 EER) Packaged Heat Pump |
| AC-59729 | HV263 | <55kBtuh 17 SEER (13 EER) Packaged Heat Pump |
| AC-65475 | HV264 | <55kBtuh 18 SEER (14 EER) Packaged Heat Pump |
| AC-99784 | HV265 | 55to65kBtuh 15 SEER (12 EER) Packaged Heat Pump |
| AC-60134 | HV266 | 55to65kBtuh 16 SEER (12.4 EER) Packaged Heat Pump |
| AC-65806 | HV267 | 55to65kBtuh 17 SEER (13 EER) Packaged Heat Pump |
| AC-62068 | HV268 | 55to65kBtuh 18 SEER (14 EER) Packaged Heat Pump |
| AC-73283 | HV269 | <55kBtuh 15 SEER (12.5 EER) Split System Heat Pump |
| AC-89637 | HV270 | <55kBtuh 16 SEER (13 EER) Split System Heat Pump |
| AC-53855 | HV271 | <55kBtuh 17 SEER (13.5 EER) Split System Heat Pump |
| AC-61202 | HV272 | <55kBtuh 18 SEER (14 EER) Split System Heat Pump |
| AC-62602 | HV273 | 55to65kBtuh 15 SEER (12.5 EER) Split System Heat Pump |
| AC-71681 | HV274 | 55to65kBtuh 16 SEER (13 EER) Split System Heat Pump |
| AC-94444 | HV275 | 55to65kBtuh 17 SEER (13.5 EER) Split System Heat Pump |
| AC-89435 | HV276 | 55to65kBtuh 18 SEER (14 EER) Split System Heat Pump |
| AC-67740 | N/A | <55kBtuh To Code Savings Portion Packaged Air Conditioner |
| AC-69545 | N/A | 55to65kBtuh To Code Savings Portion Packaged Air Conditioner |
| AC-50853 | N/A | <45kBtuh To Code Savings Portion Split System Air Conditioner |
| AC-56930 | N/A | 45to55kBtuh To Code Savings Portion Split System Air Conditioner |
| AC-75420 | N/A | 55to65kBtuh To Code Savings Portion Split System Air Conditioner |
| AC-83228 | N/A | <55kBtuh To Code Savings Portion Packaged Heat Pump |
| AC-73081 | N/A | 55to65kBtuh To Code Savings Portion Packaged Heat Pump |
| AC-53523 | N/A | <55kBtuh To Code Savings Portion Split System Heat Pump |
| AC-98919 | N/A | 55to65kBtuh To Code Savings Portion Split System Heat Pump |

**Implementation Requirements**

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

* These Early Retirement measures will only claim the savings remaining after the HVAC Upstream Program has already claimed the Replace on Burnout (ROB) and New Construction (NEW) savings.
* 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.
* Pre-inspection and verification will be used to ensure that the proper application type is selected. The program will require pre-inspections on 75% of installations for the first 3 months but will work toward a 100% inspection rate. Pre-inspections will inspect nameplate information such as manufacturing year, visual verification of unit operation, and/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.

**Documentation Requirements**

Certain evidence must be provided to participate in the early retirement 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.

**Efficiency Requirements**

The minimum tier efficiency requirements are listed in Table 2. Tier 1 specifications are derived from the Tier 2 CEE Commercial Unitary Air Conditioner Specifications. Tiers 2, 3 and 4 have been added to promote higher efficiency units offered by the HVAC industry.

Table 2: Minimum Efficiency Requirements

|  |  |  |  |
| --- | --- | --- | --- |
|  | Program Tier | Minimum SEER | Minimum EER |
| **Packaged Air Conditioner** | Code | 14.0 | 11.6 |
| Tier 1 | 15.0 | 12.0 |
| Tier 2 | 16.0 | 12.4 |
| Tier 3 | 17.0 | 13.0 |
| Tier 4 | 18.0 | 14.0 |
| **Split System Air Conditioner** | Code | 14.0 | 12.0 |
| Tier 1 | 15.0 | 12.5 |
| Tier 2 | 16.0 | 13.0 |
| Tier 3 | 17.0 | 13.5 |
| Tier 4 | 18.0 | 14.0 |
| **Packaged Air Cooled Heat Pump** | Code | 14.0 | 11.6 |
| Tier 1 | 15.0 | 12.0 |
| Tier 2 | 16.0 | 12.4 |
| Tier 3 | 17.0 | 13.0 |
| Tier 4 | 18.0 | 14.0 |
| **Split System Air Cooled Heat Pump** | Code | 14.0 | 12.0 |
| Tier 1 | 15.0 | 12.5 |
| Tier 2 | 16.0 | 13.0 |
| Tier 3 | 17.0 | 13.5 |
| Tier 4 | 18.0 | 14.0 |

In order to qualify for the program, units must meet either the SEER or EER requirement; units are not required to meet both specifications.

**Eligibility Requirements**

* All unitary DX equipment is eligible. Central systems and DHW systems are not eligible.
* Replacement must be like for like: HP for HP; AC-only for AC-only.
* 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.
* All non-residential building types and vintages are eligible for the upstream rebate.

## 1.2 Technical Description

A unitary system is an air conditioning system that cools one or a few spaces, in contrast to a centralized system where a chiller serves most or all of the building. Unitary systems use direct expansion, are usually factory designed, and are available as packaged or split systems for commercial use. A split system consists of an indoor unit (fan, cooling coil, heating elements, filter) connected by refrigerant piping to an outdoor unit (fan, compressor, condenser, expansion valve). A packaged system incorporates all the equipment into a single unit that is typically mounted on the roof. Heat pumps allow the refrigeration cycle to run in reverse and can therefore provide heating or cooling to the conditioned space.

## 1.3 Application Types and Delivery Mechanisms

See Appendices A and B for definitions of application types and delivery mechanisms.

The delivery method is Upstream Programs – Up-Stream Incentive. Incentives are provided to the HVAC equipment distributor, who provides site installation information for each unit.

The application types for the Upstream Prescriptive rebate are:

* Replace-on-Burnout (ROB)
* New Construction (NEW).

Additionally, an early retirement measure 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.

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

Most of the measures in this work paper are directly from DEER. DEER 2015 contains measures for up to 18 SEER packaged ACs, split system ACs, and split system HPs, and up to 17 SEER packaged HPs. Scaling was done for 18 SEER packaged HPs.

Table 3: DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Referenced versions of DEER and READI | DEER 2015, READI v2.1.0 |
| Summary of deviation from DEER | Most measures are from DEER. SEER 18 Packaged HP measures are linearly scaled from SEER 16 and 17. To Code measures are derived using SEER 15 measures. |
| DEER measures scaled? | Yes |
| DEER eQUEST prototypes used? | No |
| DEER operating hours used? | No |

**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.

Table 4: 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 | Com | PreRebUp | 0.85 |

Note: Direct install measures that are not hard-to-reach will use the default NTG value.

**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.

Table 5: Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA ID | Description | Sector | BldgType | ProgDelivID | GSIAValue |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**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.

**Technology Fields**

The Technology Fields were obtained from the Ex Ante Database Specification. The relevant Use Category, Use Sub-category, Technology Group, and Technology Type values for the measures in this work paper are in the table below.

Table 6: Technology Fields

|  |  |
| --- | --- |
| Classification | Value |
| Measure Case UseCategory | HVAC |
| Measure Case UseSubCats | Space Cooling, Space Heating and Cooling |
| Measure Case TechGroups | dX AC Equipment, dx HP Equipment |
| Measure Case TechTypes | SEER Rated Split System AC, SEER Rated Split System HP |
| Base Case TechGroups | dX AC Equipment, dx HP Equipment |
| Base Case TechTypes | SEER Rated Split System AC, SEER Rated Split System HP |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

Table 7: EUL and RUL

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EUL ID | Description | Sector | UseCategory | EUL (Years) | RUL (Years) |
| HVAC-airAC  HVAC-airHP | Air Conditioners / Heat Pumps (split and unitary) | Com | HVAC | 15 | 5 |

### 1.4.2 Codes and Standards Analysis

### Code of Federal Regulations (10 CFR 430.32(c)):

Per Federal Register technical amendment to the Code of Federal Regulations [393], the SEER 14 standard will apply to conventional [single phase] central air conditioners and heat pumps manufactured on or after January 1, 2015:

|  |
| --- |
|  |

### California Title 20 2014:

Appliance Efficiency Regulations [422] under California Code of Regulations Title 20, Section 1605.1 (c) (1) states “The EER, SEER, COP, HSPF, and SCOP, as applicable, of all central air conditioners, including computer room air conditioners, shall be not less than the applicable values shown in Tables C-2, C-3, C-4, C-5, and C-6.”

|  |
| --- |
|  |

### California Title 24 2013:

Title 24 [355] does not address the measures in this work paper; it provides requirements for unitary AC and HP units ≥ 65k Btu/h.

Table 8: Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Code of Federal Regulations | 10 CFR 430.32(c)(3), (5) | January 1, 2015 |
| Title 20 (2014) | Section 1605.1(c)(1) Table C-2 | January 1, 2015 |

### 1.4.3 Non-DEER Study Review

No Non-DEER studies were referenced in the work paper.

# Section 2: Calculation Methodology

Of the 45 measures in this work paper, 34 are directly from DEER. Table 9 shows which measures have exact matches in DEER and which are calculated separately using existing DEER values.

Table 9: DEER Measures Used

|  |  |
| --- | --- |
| Measure Name | DEER Measures Used |
| <55kBtuh 15 SEER (12 EER) Packaged Air Conditioner | NE-HVAC-airAC-Pkg-lt55kBtuh-15p0seer |
| <55kBtuh 16 SEER (12.4 EER) Packaged Air Conditioner | NE-HVAC-airAC-Pkg-lt55kBtuh-16p0seer |
| <55kBtuh 17 SEER (13 EER) Packaged Air Conditioner | NE-HVAC-airAC-Pkg-lt55kBtuh-17p0seer |
| <55kBtuh 18 SEER (14 EER) Packaged Air Conditioner | NE-HVAC-airAC-Pkg-lt55kBtuh-18p0seer |
| 55to65kBtuh 15 SEER (12 EER) Packaged Air Conditioner | NE-HVAC-airAC-Pkg-55to65kBtuh-15p0seer |
| 55to65kBtuh 16 SEER (12.4 EER) Packaged Air Conditioner | NE-HVAC-airAC-Pkg-55to65kBtuh-16p0seer |
| 55to65kBtuh 17 SEER (13 EER) Packaged Air Conditioner | NE-HVAC-airAC-Pkg-55to65kBtuh-17p0seer |
| 55to65kBtuh 18 SEER (14 EER) Packaged Air Conditioner | NE-HVAC-airAC-Pkg-55to65kBtuh-18p0seer |
| <45kBtuh 15 SEER (12.5 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-lt45kBtuh-15p0seer |
| <45kBtuh 16 SEER (13 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-lt45kBtuh-16p0seer |
| <45kBtuh 17 SEER (13.5 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-lt45kBtuh-17p0seer |
| <45kBtuh 18 SEER (14 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-lt45kBtuh-18p0seer |
| 45to55kBtuh 15 SEER (12.5 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-45to55kBtuh-15p0seer |
| 45to55kBtuh 16 SEER (13 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-45to55kBtuh-16p0seer |
| 45to55kBtuh 17 SEER (13.5 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-45to55kBtuh-17p0seer |
| 45to55kBtuh 18 SEER (14 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-45to55kBtuh-18p0seer |
| 55to65kBtuh 15 SEER (12.5 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-55to65kBtuh-15p0seer |
| 55to65kBtuh 16 SEER (13 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-55to65kBtuh-16p0seer |
| 55to65kBtuh 17 SEER (13.5 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-55to65kBtuh-17p0seer |
| 55to65kBtuh 18 SEER (14 EER) Split System Air Conditioner | NE-HVAC-airAC-Split-55to65kBtuh-18p0seer |
| <55kBtuh 15 SEER (12 EER) Packaged Heat Pump | NE-HVAC-airHP-Pkg-lt55kBtuh-15p0seer-8p2hspf |
| <55kBtuh 16 SEER (12.4 EER) Packaged Heat Pump | NE-HVAC-airHP-Pkg-lt55kBtuh-16p0seer-8p5hspf |
| <55kBtuh 17 SEER (13 EER) Packaged Heat Pump | NE-HVAC-airHP-Pkg-lt55kBtuh-17p0seer-9p0hspf |
| <55kBtuh 18 SEER (14 EER) Packaged Heat Pump | **Scaled by multiplying** NE-HVAC-airHP-Pkg-lt55kBtuh-17p0seer-9p0hspf by the ratio between RE-HV-ResHP-18p0S-9p7H and RE-HV-ResHP-17p0S-9p4H. |
| 55to65kBtuh 15 SEER (12 EER) Packaged Heat Pump | NE-HVAC-airHP-Pkg-55to65kBtuh-15p0seer-8p2hspf |
| 55to65kBtuh 16 SEER (12.4 EER) Packaged Heat Pump | NE-HVAC-airHP-Pkg-55to65kBtuh-16p0seer-8p5hspf |
| 55to65kBtuh 17 SEER (13 EER) Packaged Heat Pump | NE-HVAC-airHP-Pkg-55to65kBtuh-17p0seer-9p0hspf |
| 55to65kBtuh 18 SEER (14 EER) Packaged Heat Pump | **Scaled by multiplying** NE-HVAC-airHP-Pkg-55to65kBtuh-17p0seer-9p0hspf by the ratio between RE-HV-ResHP-18p0S-9p7H and RE-HV-ResHP-17p0S-9p4H. |
| <55kBtuh 15 SEER (12.5 EER) Split System Heat Pump | NE-HVAC-airHP-Split-lt55kBtuh-15p0seer-8p7hspf |
| <55kBtuh 16 SEER (13 EER) Split System Heat Pump | NE-HVAC-airHP-Split-lt55kBtuh-16p0seer-9p0hspf |
| <55kBtuh 17 SEER (13.5 EER) Split System Heat Pump | NE-HVAC-airHP-Split-lt55kBtuh-17p0seer-9p4hspf |
| <55kBtuh 18 SEER (14 EER) Split System Heat Pump | NE-HVAC-airHP-Split-lt55kBtuh-18p0seer-9p7hspf |
| 55to65kBtuh 15 SEER (12.5 EER) Split System Heat Pump | NE-HVAC-airHP-Split-55to65kBtuh-15p0seer-8p7hspf |
| 55to65kBtuh 16 SEER (13 EER) Split System Heat Pump | NE-HVAC-airHP-Split-55to65kBtuh-16p0seer-9p0hspf |
| 55to65kBtuh 17 SEER (13.5 EER) Split System Heat Pump | NE-HVAC-airHP-Split-55to65kBtuh-17p0seer-9p4hspf |
| 55to65kBtuh 18 SEER (14 EER) Split System Heat Pump | NE-HVAC-airHP-Split-55to65kBtuh-18p0seer-9p7hspf |
| <55kBtuh To Code Savings Portion Packaged Air Conditioner | **Derived from** NE-HVAC-airAC-Pkg-lt55kBtuh-15p0seer |
| 55to65kBtuh To Code Savings Portion Packaged Air Conditioner | **Derived from** NE-HVAC-airAC-Pkg-55to65kBtuh-15p0seer |
| <45kBtuh To Code Savings Portion Split System Air Conditioner | **Derived from** NE-HVAC-airAC-Split-lt45kBtuh-15p0seer |
| 45to55kBtuh To Code Savings Portion Split System Air Conditioner | **Derived from** NE-HVAC-airAC-Split-45to55kBtuh-15p0seer |
| 55to65kBtuh To Code Savings Portion Split System Air Conditioner | **Derived from** NE-HVAC-airAC-Split-55to65kBtuh-15p0seer |
| <55kBtuh To Code Savings Portion Packaged Heat Pump | **Derived from** NE-HVAC-airHP-Pkg-lt55kBtuh-15p0seer-8p2hspf |
| 55to65kBtuh To Code Savings Portion Packaged Heat Pump | **Derived from** NE-HVAC-airHP-Pkg-55to65kBtuh-15p0seer-8p2hspf |
| <55kBtuh To Code Savings Portion Split System Heat Pump | **Derived from** NE-HVAC-airHP-Split-lt55kBtuh-15p0seer-8p7hspf |
| 55to65kBtuh To Code Savings Portion Split System Heat Pump | **Derived from** NE-HVAC-airHP-Split-55to65kBtuh-15p0seer-8p7hspf |

Since DEER does not have measures for 18 SEER packaged heat pumps, those savings were determined through scaling. As mentioned in the Commission Staff’s December 2011 Phase 2 Workpaper Review (Attachment 4), the relative improvements between commercial equipment are assumed to be similar to the improvements between the same residential units. Therefore the savings for commercial 18 SEER Packaged HPs were calculated by multiplying the savings for commercial 17 SEER Packaged HPs by the ratio of residential 18 SEER and 17 SEER Packaged HPs.

Example: <55kBtuh 18 SEER (14 EER) Packaged Heat Pump, SCE, Assembly, CZ 06

DEER savings:

|  |  |  |  |
| --- | --- | --- | --- |
| EnergyImpactID | AStdWBkWh | AstdWBkW | AStdWBtherm |
| NE-HVAC-airHP-Pkg-lt55kBtuh-17p0seer-9p0hspf | 407 | 0.128 | -0.0148 |
| RE-HV-ResHP-17p0S-9p4H | 42.83 | 0.032 | -0.0012 |
| RE-HV-ResHP-18p0S-9p7H | 59.1 | 0.050 | -0.0012 |

kWh Savings = 407 \* (59.1 / 42.83) = **562 kWh**

kW Reduction = 0.128 \* 0.050 / 0.032 = **0.196 kW**

therm Savings =-0.0148 \* -0.0012 / -0.0012 **= -0.0148 therm** (no change)

**To Code Savings Portion Measures**

The To Code Savings Portion measures in this work paper are the savings from retrofitting customer existing equipment (various SEER values) to 14 SEER code-compliant equipment. The savings were determined by subtracting the “AStdWB” savings from the “APreWB” savings for 15 SEER ACs and HPs. The result was the difference between customer existing equipment and 14 SEER equipment. The To Code measure savings are attributed to the early retirement mechanism (RET), while all other measures savings (ROB, NEW) are attributed to the Upstream HVAC program.

Example: <55kBtuh To Code Savings Portion Packaged Air Conditioner, SCE, Assembly, CZ 06

DEER savings:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| EnergyImpactID | APreWBkWh | APreWBkW | APreWBtherm | AStdWBkWh | AStdWBkW | AStdWBtherm |
| NE-HVAC-airAC-Pkg-lt55kBtuh-15p0seer | 560 | 0.293 | -3.12 | 129 | 0.0454 | -1.2 |

kWh Savings = 560 - 129 = **431 kWh**

kW Reduction = 0.293 - 0.0454 = **0.2476 kW**

therm Savings = -3.12 - (-1.2) = **-1.92 therms**

All savings values are listed in Attachment 1, and the calculations are in Attachment 2.

# 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.

Table 10: Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Agricultural | NON\_RES | DEER:HVAC\_Split-Package\_AC, DEER:HVAC\_Split-Package\_HP |
| Assembly |
| Education - Primary School |
| Education - Secondary School |
| Education - Relocatable Classroom |
| Education - Community College |
| Education – University |
| Food Store |
| Grocery |
| Health/Medical – Hospital |
| Health/Medical - Nursing Home |
| Health/Medical – Clinic |
| Lodging – Hotel |
| Manufacturing - Bio/Tech |
| Manufacturing - Light Industrial |
| Industrial |
| Misc – Commercial |
| Office – Large |
| Office – Small |
| Restaurant - Fast-Food |
| Restaurant - Sit-Down |
| Retail - Multistory Large |
| Retail - Single-Story Large |
| Retail – Small |
| Storage – Conditioned |
| Transportation - Communication - Utilities |
| Warehouse – Refrigerated |
| Com |

# Section 4: Base Case & Measure Costs

## 4.1 Base Case Cost

The 2010–2012 WO017 Ex Ante Measure Cost Study [475] provided per-installation and per-unit equipment and labor costs for split and packaged AC units (13 and 14 SEER only) and HP units (13, 14, and 15 SEER only). These costs were first converted to per-ton costs and then linearly extrapolated to determine costs for up to 18 SEER units. Miscellaneous “non-equipment installation costs” costs were also provided but not used in this work paper.

All measures except the To Code measures use the 14 SEER costs as base case costs; see the following table. The To Code measures use the 13 SEER costs as base case costs.

Table 11: WO017 Baseline Cost Data, Per-ton

|  |  |  |
| --- | --- | --- |
| Description | Material Cost | Labor Cost |
| Pkg AC SEER = 13.0 (< 55 kBtuh), EER = 11.06, Clg EIR = 0.2557, Supply Fan W/cfm = 0.379; no Econo; 1-spd Fan assumed 3 ton | $1,012.79 | $891.21 |
| Pkg AC SEER = 14.0 (< 55 kBTUh), EER = 12.04, Clg EIR = 0.2456, Supply Fan W/cfm = 0.306; no Econo; 1-spd Fan assumed 3 ton | $1,133.38 | $891.21 |
| Pkg AC SEER = 13.0 (55-64 kBtuh), EER = 11.06, Clg EIR = 0.2557, Supply Fan W/cfm = 0.379; no Econo; 2-spd Fan assumed 5 ton | $762.89 | $565.19 |
| Pkg AC SEER = 14.0 (55-64 kBtuh), EER = 12.04, Clg EIR = 0.2456, Supply Fan W/cfm = 0.306; no Econo; 2-spd Fan assumed 5 ton | $835.25 | $565.19 |
| Split AC SEER = 13.0 (< 55 kBtuh), EER = 11.06, Clg EIR = 0.2557, Supply Fan W/cfm = 0.379; no Econo; 1-spd Fan assumed 24,000 BtuH | $468.67 | $572.80 |
| Split AC SEER = 14.0 (< 55 kBTUh), EER = 12.04, Clg EIR = 0.2456, Supply Fan W/cfm = 0.306; no Econo; 1-spd Fan assumed 24,000 BtuH | $606.86 | $572.80 |
| Split AC SEER = 13.0 (55-64 kBtuh), EER = 11.06, Clg EIR = 0.2557, Supply Fan W/cfm = 0.379; no Econo; 2-spd Fan assumed 60,000 BtuH | $386.20 | $572.80 |
| Split AC SEER = 14.0 (55-64 kBTUh), EER = 12.04, Clg EIR = 0.2456, Supply Fan W/cfm = 0.306; no Econo; 2-spd Fan assumed 60,000Btuh - same as baseline | $441.47 | $572.80 |
| Pkg HP SEER = 13.0 (< 55 kBTUh), EER = 11.07, HSPF = 7.70, COP = 3.28; no Econo; 1-spd Fan assumed 36 MBH | $1,109.03 | $565.88 |
| Pkg HP SEER = 14.0 (< 55 kBTUh), EER = 11.6, HSPF = 8.00, COP = 3.52; no Econo; 1-spd Fan assumed 36 MBH | $1,250.99 | $565.88 |
| Pkg HP SEER = 13.0 (55-64 kBTUh), EER = 11.07, HSPF = 7.70, COP = 3.28; w/Econo; 2-spd Fan assumed 60 MBH | $808.80 | $565.88 |
| Pkg HP SEER = 14.0 (55-64 kBTUh), EER = 11.6, HSPF = 8.00, COP = 3.52; w/Econo; 2-spd Fan assumed 60 MBH | $893.98 | $565.88 |
| Split HP SEER = 13 assumed 36,000 BtuH | $594.87 | $570.03 |
| Split HP SEER = 14.0 (< 55 kBTUh), EER = 12.00, HSPF = 8.50, COP = 3.74; no Econo; 1-spd Fan assumed 36,000 BtuH | $777.64 | $570.03 |
| Split HP SEER = 13 assumed 59,000 BtuH | $594.75 | $570.03 |
| Split HP SEER = 14.0 (55-64 kBTUh) - Combined SEER 13 and SEER 14.5 hp assumed 59,000 BtuH | $706.27 | $570.03 |

## 4.2 Measure Case Cost

Costs for 15, 16, 17, and 18 SEER ACs and 16, 17, and 18 SEER HPs were linearly extrapolated using SEER value as the independent variable, using costs from WO017.

Example: <55kBtuh 15 SEER (12 EER) Packaged Air Conditioner

Equipment cost = $1,133.38 + ($1,133.38 - $1,012.79) = $1,253.97

Table 12 shows a sample of costs extrapolated for packaged AC units <55 kBtuh:

Table 12: Sample WO017 and Extrapolated Measure Costs, Per-ton

|  |  |  |
| --- | --- | --- |
| Description | Packaged AC | Split System AC |
| Pkg AC SEER = 13.0 (< 55 kBtuh), EER = 11.06, Clg EIR = 0.2557, Supply Fan W/cfm = 0.379; no Econo; 1-spd Fan assumed 3 ton | $1,012.79 | $891.21 |
| Pkg AC SEER = 14.0 (< 55 kBTUh), EER = 12.04, Clg EIR = 0.2456, Supply Fan W/cfm = 0.306; no Econo; 1-spd Fan assumed 3 ton | $1,133.38 | $891.21 |
| **Extrapolated:** Pkg AC SEER = 15.0 (< 55 kBtuh) | $1,253.97 | $891.21 |
| **Extrapolated:** Pkg AC SEER = 16.0 (< 55 kBtuh) | $1,374.56 | $891.21 |
| **Extrapolated:** Pkg AC SEER = 17.0 (< 55 kBtuh) | $1,495.15 | $891.21 |
| **Extrapolated:** Pkg AC SEER = 18.0 (< 55 kBtuh) | $1,615.74 | $891.21 |

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost (GMC)

For ROB and NEW, GMC is represented by the equation below:

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

For RET, GMC is represented by the equation below:

GMC = Measure Equipment Cost + Measure Labor Cost

Table 13 shows GMCs for several measures. The To Code costs will be reported for the early retirement mechanism (RET), while the other costs (ROB, NEW) will be reported for the Upstream HVAC program.

Table 13: Sample GMC and IMC, Per-ton

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Measure | Base Case Cost | Base Labor Cost | Measure Cost | Measure Labor Cost | GMC | IMC |
| <55kBtuh 15 SEER (12 EER) Packaged Air Conditioner | $1,133.38 | $891.21 | $1,253.97 | $891.21 | $120.59 | $120.59 |
| <55kBtuh 16 SEER (12.4 EER) Packaged Air Conditioner | $1,133.38 | $891.21 | $1,374.56 | $891.21 | $241.18 | $241.18 |
| <55kBtuh 17 SEER (13 EER) Packaged Air Conditioner | $1,133.38 | $891.21 | $1,495.15 | $891.21 | $361.77 | $361.77 |
| <55kBtuh 18 SEER (14 EER) Packaged Air Conditioner | $1,133.38 | $891.21 | $1,615.74 | $891.21 | $482.36 | $482.36 |
| <55kBtuh To Code Savings Portion Packaged Air Conditioner | $1,012.79 | $891.21 | $1,133.38 | $891.21 | $2,024.59 | $0.00 |

### 4.3.2 Incremental Measure Cost (IMC)

For ROB and NEW, the Gross Measure Cost and Incremental Measure Cost are the same; see Table 13.

For RET measures, the IMC is equal to $0 in order to avoid double counting the costs.

All cost calculations are in Attachment 3.

# Attachments

Savings calculations are found in the accompanying calculation spreadsheet.

# References



[355] 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24)

[393] Code of Federal Regulations Title 10 - Energy

[422] 2014 Appliance Efficiency Regulations (Title 20)

[475] 2010–2012 WO017 Ex Ante Measure Cost Study Final Report

# Appendix A: Application Types

This table compares the application types in SCE’s systems with those in DEER.

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

# Appendix B: Delivery Mechanisms

A delivery mechanism is a delivery method paired with an incentive method. SCE’s delivery methods include:

* Appliance Turn-in and Recycling
* Audit/Information
* Commissioning
* Financial Support
* Innovative Design
* Midstream Programs
* Partnership
* Upstream Programs

The following table describes the incentive methods.

|  |  |
| --- | --- |
| Incentive Method | Description |
| Direct Install | The utility program performs an assessment of the customer’s facility, provides recommendations, and implements energy efficiency measures for free. |
| Down-Stream Incentive - Deemed | 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. |
| Exchange - Replacement | The utility program holds events where customers can trade functional equipment for similar but more energy efficient equipment, free of charge. |
| Giveaway | The utility program provides customers with energy efficient equipment for free. |
| Mid-Stream Incentive | The utility program offers buydowns and incentives to third parties (typically retailers, distributors, and contractors), who then stock, promote, lower prices on, and/or sell energy efficient equipment. Contractors install energy efficiency equipment, sometimes using specified quality procedures, at the customer’s property. |
| On-bill Finance - loan | Customers can finance energy efficiency projects at 0% interest and repay the loan through their monthly utility bill. |
| Testing Services / Other | The utility program performs free testing services or assessments of the customer’s facility and provides information and recommendations for potential energy efficiency measures. |
| Up-Stream Buy Down, Up-Stream Incentive | The utility program offers buydowns and incentives to vendors (typically manufacturers and distributors), who then manufacture, stock, promote, lower prices on, and/or sell energy efficient equipment. There is some overlap between the mid-stream and up-stream approaches. |