Work Paper SCE13HC032

**Revision 2**

**Southern California Edison Company**

**Ductless Air Conditioners under 24 kBtu/hr**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Solution and Measure Codes:**** | *AC-49868, AC-54839* |
| **Measure Description:** | 16 and 19 SEER ductless mini-split air conditioning unit in commercial applications under 24 kBtu/hr |
| **Base Case Description:** | 14 SEER, single phase, split system air conditioning unit in commercial applications under 24 kBtu/hr |
| **Units:** | Per Ton |
| **Energy Savings:** | Refer to Excel Calculation Attachment |
| **Gross Measure Cost ($/unit):** | Refer to Excel Calculation Attachment |
| **Measure Incremental Cost ($/unit):** | Refer to Excel Calculation Attachment |
| **Effective Useful Life:** | 15 years, DEER EUL ID: HVAC-airAC |
| **Measure Application Type:** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratio:** | 0.85, DEER NTGR ID: NonRes-sAll-mHVAC-DX-up |
| **Important Comments:** | **This work paper document does not contain a data set in conformance with the 4/1/2014 Ex Ante Database Specification provided by the California Public Utilities Commission (CPUC) Commission Staff (CS); SCE will provide that data set separately.** |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | Revision Date | Author (Affiliation) | Summary of Changes |
| 0 | 05/23/12 | James Russell/PECI | Original work paper for 2013 PC |
| 1 | 04/28/14 | Ryan Cho/SCE | * Work paper updated for reporting period, effective 07/01/14-12/31/14. * Energy Savings and Demand Reduction calculations methodology are updated to be consistent with SCE13HC033. * Added PGE Climate Zones and Additional building types. |
| 2 | 11/14/14 | Ryan Cho/SCE | * Work paper updated for reporting period, effective 1/1/15-12/31/15. * New Template for 2015. * Base Case is changed from 13 SEER to 14 SEER per 2014 Title 20. * Updated base case costs with the 2010-2012 ExAnte Measure Cost Study [475]. * Measure names are updated per code update. |

# Section 1: General Measure & Baseline Data

## 1.1 Measure Description & Background

Measure Description: 16 and 19 SEER ductless mini-split air conditioning unit under 24kBtu/hr in commercial applications.

Basecase Description: 14 SEER, single phase, split system air conditioning unit under 24kBtu/hr in commercial applications.

The ductless mini-split is assumed to replace an air-cooled air conditioning unit (14 SEER in accordance with Title 20) found in commercial applications.

Table 1: Measures and Codes

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Code | Measure Name |
| AC-49868 | N/A | <24 kBtu/hr 16 SEER Ductless AC DX Equipment replacing 14 SEER AC |
| AC-54839 | N/A | <24 kBtu/hr 19 SEER Ductless AC DX Equipment replacing 14 SEER AC |

The equipment installed under this measure should be new and the equipment’s SEER should be determined using methods specified in Section 1604 or otherwise allowed under Section 1603 of the 2014 Appliance Efficiency Regulations.

Equipment distributors that purchase ductless air conditioners directly from manufacturers and sell the equipment to SCE customers are eligible for the upstream incentive. Distributors or contractors should document relevant customer information such as the name of the customer and address where the equipment is installed.

## 1.2 Technical Description

Ductless mini-split air conditioners are cooling systems that combine single zone climate control and ductless distribution to achieve high efficiency and comfort. Ductless mini-splits include a single outdoor unit with a compressor and condenser and one or more indoor air handling units with evaporator coils. Refrigerant is piped from the outdoor unit, through small diameter, insulated refrigerant lines, to the indoor units. Each indoor unit is controlled by a dedicated thermostat. The same conduit that houses the refrigerant tubing also contains a power cable, and a condensate drain. Many of these systems use a variable speed compressor, and combined with a large area for heat exchange, they are able to achieve high SEER ratings, often above 15 SEER and, in some cases, up to 26 SEER.

## 1.3 Application Types and Delivery Mechanisms

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

The Program delivery method for this measure is “Upstream Programs / Up-Stream Incentive”. The application type for this measure is Replacement on Burnout (ROB).

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

READi v.2.1.0, DEER2015 code update database, does not contain the measures presented in this workpaper. SEER-rated split Air Conditioners measures were used as a proxy for ductless split systems.

Table 2: DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Referenced versions of DEER and READI | DEER 2015, READI v2.1.0 |
| Summary of deviation from DEER | DEER includes split systems only, which were used as a proxy for ductless split systems. A scaling factor was used to calculate savings for SEERs not in DEER. |
| 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 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 | 0.85 |

**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 4: 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 5: Technology Fields

|  |  |
| --- | --- |
| Classification | Value |
| Measure Case UseCategory | HVAC |
| Measure Case UseSubCats | SpaceCool |
| Measure Case TechGroups | dxAC\_equip |
| Measure Case TechTypes | spltSEER |
| Base Case TechGroups | dxAC\_equip |
| Base Case TechTypes | spltSEER |

**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 6: EUL and RUL

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EUL ID | Description | Sector | UseCategory | EUL (Years) | RUL (Years) |
| HVAC-airAC | Air Conditioners (air-cooled, split and unitary) | Com | HVAC | 15 | 5 |

### 1.4.2 Codes and Standards Analysis

The measures in this workpaper fall under Title 20 of the California Energy Regulations. Under the Title 20 regulation (CEC-400-2014-009-CMF), the following is required by Section 1605.1. (c) (1), “Central Air Conditioners. The EER, SEER, COP, and HSPF, as applicable, of all central air conditioners shall be not less than the applicable values shown in Tables C-2, C-3, C-4, C-5, and C-6.” The efficiency requirements for air-cooled split-systems and packaged air conditioners less than 65,000 Btu/h (5.4 tons) are identified in Table C-2 (for single-phase power) as being minimum 14.0 SEER. Also, residential and commercial split air-conditioners have additional EER code requirements above and below 45 kBtu/h [422].

The Title 24 Building Energy Efficiency Standards do not specify requirements for air conditioning units less than 65,000 Btu/h (5.4 tons), other than stating that such equipment must comply with Title 20 requirements [422].

A new federal rule sets energy efficiency standards for residential HVAC equipment, including split-system air conditioners under 65,000 Btu/h, at 14.0 SEER in the southwest region that includes California. However, this new rule does not take effect until January 1, 2015 [368].

Table 7: Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | Section 110.1 requires air conditioners under 65 kBtu/h to comply with Title 20 | 7/1/2014 |
| Title 20 (2014) | Section 1605.1 requires air-cooled split-systems and packaged air conditioners under 65 kBtu/h to have a minimum SEER of 14 and additional EER code requirements above and below 45 kBtu/h for split air conditioners only. | 1/1/2015 |
| Federal EPCA Amended Standard (2011) | A recent federal rule requires split-system and packaged air conditioners to have a minimum SEER of 14 | 1/1/2015 |

### 1.4.3 Non-DEER Study Review

A study put together by Proctor Engineering Group showed if supply and return duct leakage are removed from an AC system, peak demand reduction can be reduced up to 25% [370]. Another presentation put together by Robert Mowris and Associates shows that duct sealing (“tight ducts”) has a savings potential between 10% and 18% [369]. Furthermore, in a 2002 report by Carrier-Aeroseal LLC and Proctor Engineering Group, Ltd. on reducing light commercial peak load in SCE territory, the study showed “90% of the systems tested had enough duct leakage to merit sealing (i.e., more than 24% leakage) [371].

# Section 2: Calculation Methodology

READi v.2.1.0, DEER for 2015 Code Update database, does not contain the measures presented in this workpaper and the DEER2015 update provides SEER-rated split AC measures with additional efficiency tiers levels up to SEER 18 replacing SEER 14 AC. SEER-rated split Air Conditioners measures were used as a proxy for ductless split systems and the savings and demand reduction are extrapolated and modified from the savings in DEER 2015 along with assumptions shown below.

Assumptions

* A high efficiency split system AC will provide similar electrical cooling savings to a ductless AC with an equivalent SEER rating.
* The DEER residential AC measures are used to scale the commercial measures. In accordance with ED’s recommendation provided in SCE Workpaper Review 2011 [C], it is assumed that the ratio of savings and demand reduction from residential units is the same as it is for commercial units.

The following table contains data files for measures taken directly from or created with the DEER READI Tool. These results have not been modified and are being included in the workpaper for reference.

Table 8: READI Tool Outputs

|  |  |  |  |
| --- | --- | --- | --- |
| Solution Code | Measure Code | Measure Name | READI Results |
| AC-49868 | N/A | <24 kBtu/hr 16 SEER Ductless AC DX Equipment replacing 14 SEER AC |  |
| AC-54839 | N/A | <24 kBtu/hr 19 SEER Ductless AC DX Equipment replacing 14 SEER AC |  |

**AC-49868 (<24 kBtu/hr 16 SEER Ductless AC DX Equipment replacing 14 SEER AC)**

NE-HVAC-airAC-Split-lt45kBtuh-16p0seer was used as a proxy for AC-49868.

**AC-54839 (<24 kBtu/hr 19 SEER Ductless AC DX Equipment replacing 14 SEER AC)**

NE-HVAC-airAC-Split-lt45kBtuh-18p0seer is the highest efficiency tiers provided in DEER2015 update and a scaling factor was applied to develop SEER 19 equivalent savings. It is assumed that the ratio between a residential 19 SEER unit and 18 SEER unit is the same as the ratio between a commercial 19 SEER unit and 18 SEER unit. There are no gas savings associated with this measure, therefore DEER gas savings are not utilized in this work paper.

Table 9: Scaling Factors

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SEER** | **Average Residential Savings (kWh/ton)** | **Average Residential Demand Reduction (kW/ton)** | **kWh Scaling Factor** | **kW Scaling Factor** |
| 18 | 49.83 | 0.05954 | 1 | 1 |
| 19 | 70.69 | 0.08168 | 1.41861 | 1.37194 |

The savings derivation is described below Misc. Commercial Building Type in climate zone 6:

Average 18 SEER Residential Split AC kWh Savings = 49.83

Average 19 SEER Residential Split AC kWh Savings = 70.69

Scaling factor = 70.69 / 49.83 = 1.41861

18 SEER Commercial Split AC kWh Savings = 365.00

19 SEER Commercial Split AC kWh Savings = 18 SEER Commercial Split AC kWh Savings \* Scaling Factor

= 365.00 x 1.41861

= 517.79 kWh

See the savings calculation spreadsheet for full calculation [A].

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

\*Denotes that Misc. Commercial is for SCE only.

# Section 4: Base Case & Measure Costs

## 4.1 Base Case Cost

The 2010-2012 Ex-ante Measure Cost Study [475] was consulted and the equipment base case costs are estimated based on split-system DX (residential and commercial) equipment price estimates from this study. For split-system DX, predicted prices and incremental costs are systematically lower compared to current and previous DEER estimates by 10-30 percent according this report.

A base case cost of $514.98 per ton and the labor cost of $220.92 were used, based on a 14 SEER split-system air conditioner. [475]

## 4.2 Measure Case Cost

Like the base costs, the measure equipment cost is estimated based on SEER 16 and 19 split air conditioners. Price data was collected from the online source, [www.nextag.com](http://www.nextag.com). The raw price data is shown in the embedded cost spreadsheet below [B].

The raw costs data was converted to a per ton cost for each unit and then the results were averaged. The result of this analysis is an average cost per ton of $954 for the SEER 16 unit and $1,042 for the SEER 19 unit [B]. It is assumed that the measure case labor is same as it is for the base case labor, and the labor cost of $220.93 was used.

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost (GMC)

The Gross Measure Costs (GMC) of the two measures in this work paper are calculated according to the following equation:

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

(Base Case Equipment Cost + Base Case Labor Cost)

Table 11 Gross Measure Cost

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure** | **Base Case Equipment Cost** | **Base Case Labor**  **Cost** | **Measure Case Equipment Cost** | **Measure Case Labor**  **Cost** | **Gross Measure Cost** |
| Ductless Mini-Splits 16 SEER AC | $514.98 | $220.92 | $954 | $220.92 | $439.02 |
| Ductless Mini-Splits 19 SEER AC | $514.98 | $220.92 | $1,042 | $220.92 | $527.02 |

### 4.3.2 Incremental Measure Cost (IMC)

For ROB, the incremental measure cost (IMC) is the same as the gross measure cost. See Section 4.3.1.

# Attachments

1. 2.  3.  4. 

# References



[31]

[213]

[351]

[368]

[369]

[370]

[371]

[422]

[475]

[A] Attachment 2 – SCE13HC032.2 CALCULATIONS PGE & SCE.xlsx

[B] Attachment 3 – SCE13HC032.2 Cost Data.xls

[C] Attachment 4 – ED’s disposition December 2011.docx

# 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. |