Work Paper PGE3PHVC156

**Revision 4**

**Pacific Gas & Electric**

**Condenser Coil Cleaning**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | HV393, HV394 |
| **Measure Description** | Clean condenser coils on qualifying units. |
| **Base Case Description** | Uncleaned, functional condenser coil. |
| **Units** | Per ton cooling capacity, Cap-Tons. |
| **Energy Savings** | Refer to Excel Calculation Attachment |
| **Full Measure Cost ($/unit)** | $19.51/ton |
| **Incremental Measure Cost ($/unit)** | N/A |
| **Effective Useful Life** | 3 years (DEER EUL ID: NonRes-RCx-Operational, capped EUL per E-4818) |
| **Measure Installation Type** | Retro-Commissioning (RC), (RC, previously known as Retrofit Add-on (REA)) |
| **Net-to-Gross Ratio** | 0.73 (DEER NTGR ID: NonRes-sAll-mHVAC-RCA) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| Revision 0 | 06/01/2012 | Tai Voong (PG&E) | Update WP Format |
| Revision 0 | 8/28/2012 | Tai Voong (PG&E) | At-A-Glance Measure List: Changed Building Vintage, Unit Definition from “Ton” to “Cap-Tons” and added Building Type “RES”. |
| Revision 1 | 7/11/2013 | Christopher Li (PG&E) | * Revised savings, NTG, and ISR to comply with ED’s Disposition on the HVAC Quality Maintenance/AirCare Plus Workpapers dated on the March 2, 2013 and May 16, 2013 disposition. * Only the PG&E executive summary savings template was updated. Workpaper language will be updated later. * For updated Savings values, see file PGE3PHVC156 R1\_CondenserCoilCleaning(chl7v2).xlsx |
| Revision 2 | 10-8-15 | Matt Tyler (CLEAResult), Sherry Hu (PG&E) | * Work paper was updated according to Workpaper Disposition for Nonresidential HVAC Rooftop Quality Maintenance and WO32 * Removed measure code S46 and added four. |
| Revision 3 | 11/30/18 | Tai Voong (PG&E) | * Retroactive updates to EUL for BRO measures per Resolution E-4952 and E-4818. Retroactive to 1/1/2018. |
| Revision 4 | 12/20/2018 | Phil Jordan (CLEAResult), Tai Voong (PG&E) | * Measure cost analysis was updated to use current information * Work paper content was updated according to Resolution E-4818 including Installation Type * UES basis changed to DEER RCA measures |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
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Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This statewide work paper details cleaning condenser coils on existing nonresidential split-system and unitary HVAC equipment. This is one of eight that cover specific HVAC Quality Maintenance (QM) treatments formerly combined into the measures described in the Revision 0 version of the June 26, 2012 Work Paper PGECOHVC138 Nonresidential HVAC RTU Quality Maintenance[[1]](#endnote-1) and the Revision 3 version of the December 26, 2014 Work Paper SCE13HC037 Comprehensive Commercial HVAC Rooftop Unit Quality Maintenance[[2]](#endnote-2). All HVAC Quality Maintenance treatments are now covered by the following work papers:

* Condenser Coil Cleaning (PGE3PHVC156R3)
* Economizer Controls (PGE3PHVC152R5)
* Economizer Repair (PGE3PHVC151R4)
* Evaporator Coil Cleaning (PGE3PHVC158R3)
* Refrigerant Charge Adjustment (PGE3PHVC160R3)
* Unoccupied Fan Control (PGE3PHVC157R2)
* *Programmable Thermostat (PGE3PHVC153R3)*

Separation of this HVAC QM treatment, Condenser Coil Cleaning, into a statewide measure was performed using guidance from the document WORKPAPER DISPOSITION FOR Non-Residential HVAC Rooftop Quality Maintenance[[3]](#endnote-3)(Disposition) and supplementary spreadsheet: 20132014-CommercialHVACMaintenance-SavingsValues-April2013-v1-2.xlsx[[4]](#endnote-4).

Table 1 Base, Standard, and Measure Cases

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Clean condenser coils on qualifying units. |
| Existing Condition | Uncleaned, functional condenser coil. |
| Code/Standard | N/A |
| Industry Standard Practice | Standard 180-2008, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems[[5]](#endnote-5) |

Table 2 Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  |  | HV393 | Condenser Coil Cleaning on Small Pkg AC system with No TXV |
|  |  |  | HV394 | Condenser Coil Cleaning on Small Pkg AC system with TXV |
|  |  |  |  |  |
|  |  |  |  |  |

This statewide work paper supports HVAC QM programs as well as HVAC tune-up programs in multiple programs and service territories. Refer to programs that offer the measure for specific restrictions and guidelines in addition to those described herein.

The target market for this measure is non-residential buildings served by unitary direct expansion (DX) and split systems which do not serve process or refrigeration loads. The measure is defined for all non-residential building types and all 16 California climate zones. Savings are calculated based on multipliers applied to Database for Energy Efficient Resources (DEER19) Refrigerant Charge Adjustment (RCA) UES values. DEER RCA UES values are for a weighted average of seven DEER vintages using utility-specific weightings. The multipliers used to derive Coil Cleaning UES values from the DEER RCA UES are detailed in the Disposition.

Participating contractors must ensure the customer facility is physically located within the service territory of the Investor Owned Utility (IOU) administering the program, and that the customer receives electric services from that IOU. Other terms and conditions are set by individual programs.

This measure requires field documentation of the existing conditions that verify the measure was necessary and that the measure was successfully applied.

## 1.2 Technical Description

Dirty or fouled condenser coils restrict air flow, reduce heat transfer efficiency and compressor efficiency, and can increase compressor run time. Coil cleaning eliminates air blockages between fins and can remove leaves, dust, grime, and other contaminants from the fin and tube heat transfer surfaces thus improving heat transfer efficiency, decreasing compressor run time, and increasing efficiency.

## 1.3 Installation Types and Delivery Mechanisms

An installation type describes the program scenario in which the measure is applied, thus guiding energy savings and measure cost methodology. The installation type is retrocommissioning and operational programs in commercial settings (RC, previously known as REA in the table below, but terminology updated per CPUC Resolution E-4818[[6]](#endnote-6)) since the baseline is the existing unit as described in **Table 3**.

Table 3 Installation Type Descriptions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |
| Retrofit or Early Replacement (RET/ER) | Above Customer Existing | Above Code or Standard | RUL | EUL-RUL |
| Retrofit First Baseline Only (REF) | Above Customer Existing | N/A | EUL | N/A |
| Retrofit Add-on (REA) | Above Customer Existing | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings. See **Table 4** and **Table 5** below for descriptions of available delivery methods and incentive methods, respectively.

**SCE Delivery Mechanism:** Financial Supportpaired withDirect Install, Down-Stream Incentive – Deemed, or Mid-Stream Incentive

**PG&E Delivery Mechanism:** Financial Support paired with Direct Install, Down-Stream Incentive – Deemed, or Mid-Stream Incentive

Table 4 Delivery Method Descriptions

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Appliance Turn-in and Recycling | The program motivates customers, through financial incentives, to recycle appliances that are functional but inefficient. This prevents the continued use of those appliances, by both the current owner and potential future owners. |
| Audit/Information/Testing Services | The program performs a free assessment of a customer’s facility and provides the customer with information and guidance on energy efficiency opportunities. |
| Commissioning and Retrocommissioning | The program modifies or repairs existing equipment to ensure that it works as intended. |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Innovative Design | The program funds new ideas that meet reasonable scientific scrutiny for potential energy savings. These innovative measures typically have small market penetration (less than 5%) or are targeted toward relatively unreached market segments. |
| New Construction | The program offers financial incentives and/or design assistance to customers involved with new building construction. This is intended is to motivate customer to exceed Title 24 building energy efficiency requirements (residential or nonresidential). |
| Partnership | The program implements projects through a partnership between the utility and an institutional, government, or community-based organization. |
| Performance Based | The program offers financial incentives that vary based on the energy efficiency performance of specific projects. |
| Up-Stream Programs | See Up-Stream Incentive and Up-Stream Buy Down in the Incentive Method table. |

Table 5 Incentive Method Descriptions

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Mid-Stream Incentive | The program gives a financial incentive to a midstream market actor, such as a retailer or contractor, to encourage the promotion of efficient measures. The incentive may or may not be passed on to the end-use customer. |
| Up-Stream Incentive | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, to encourage the manufacture, provision, or distribution of an efficient measure. The incentive may or may not be passed on to the end-use customer. |
| Up-Stream Buy Down | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, with specific requirements to pass down the incentive to the end use customer. Such an incentive buys-down the cost of an efficient measure for the end-use customer by at least the amount of the financial incentive. |
| Giveaway | The program provides customers with energy efficiency equipment or services for free. |
| Exchange/Replacement | The utility program holds events where customers can trade functional equipment for similar but more energy efficient equipment, free of charge. |
| On-bill Finance/Loan | The program offers financing for the cost an efficient measure as part of the utility bill. This can be an add-on option to an existing program or can serve as an organizing principle for its own program. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

DEER was referenced on October 2, 2018 for any updates that would impact this measure. A DEER 2019 update to DEER RCA measures has occurred[[7]](#endnote-7) and is incorporated into this Condenser Coil Cleaning measure. This measure is not included in the DEER19 but is derived from DEER 19 RCA measures.

Table 6 DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Work Paper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | Yes |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | No |
| DEER Version | DEER 2019, READI v2.5.1 |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTGR values were obtained using the DEER READI tool[[8]](#endnote-8). The relevant NTGR values for the measures in this work paper are shown in **Table 7**.

Table 7 Measure Net-to-Gross Ratios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| NonRes-sAll-mHVAC-RCA | HVAC Maintenance: Refrigerant Charge Adjustment (RCA) | Com | Any | DirInstall, NonUpStrm | 0.73 |

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in **Table 8** below.

Table 8 Installation Rates

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

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for a RC measure with an applicable code baseline. Per Resolution E-4818, measures resulting in performance that does not exceed the nominal efficiency of the pre-existing equipment have an effective useful life not to exceed three years, and for this reason the EUL and RUL of this measure is capped at three years. The relevant EUL and RUL values for the measures in this work paper are shown in **Table 9** below.

Table 9 EUL and RUL

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| NonRes-RCx-Operational | Clean Condenser Coils - Commercial | Com | Service | 3 | 3 |

### 1.4.2 Codes and Standards Analysis

These maintenance measures are not governed by either state or federal codes and standards. The document Standard 180-2008, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems5 may be used by QM programs as a guide for measure implementation. Only licensed California contractors will participate in the program. As required by the California State Licensing Board, contractors will be responsible for meeting all applicable codes. In general, maintenance and repairs do not require permits.

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

Studies of significant importance to the measure development in this work paper are described in the following section.

### 1.5.1 WORKPAPER DISPOSITION FOR Non-Residential HVAC Rooftop Quality Maintenance3

Completion date: 5-2-2013

Author: California Public Utilities Commission, Energy Division

This Disposition outlines revision requirements to the existing work papers that cover discrete roof-top unit (RTU) QM service tasks and suites of service tasks for non-residential QM programs. Of direct concern in this work paper, the Disposition collectively assigns 25% of the DEER Refrigerant Charge Adjustment (RCA) energy and demand unit energy savings (UES) to the three non-RCA treatments which include Condenser Coil Cleaning, Evaporator Coil Cleaning, and Air Flow Adjustment. The Disposition further splits the initial 25% DEER RCA UES, assigning 50% to Condenser Coil Cleaning, 25% to Evaporator Coil Cleaning, and 25% to Airflow Adjustment. The three resulting UES multipliers to be applied to DEER RCA UES are given below.

* Condenser Coil Cleaning UES Values multiplier = 0.125
* Evaporator Coil Cleaning UES Values multiplier = 0.0625
* Air Flow Adjustment UES Values multiplier = 0.0625

## 1.6 Data Quality and Future Data Needs

Additional study of the impacts of condenser coil cleaning may be warranted. The improvements that condenser coil cleaning can bestow on HVAC system efficiency are highly dependent on the existing condition of the coil. Claims range to as high as 25% energy savings and are realistic for highly fouled or clogged coils. The Disposition UES multiplier of 0.125 results in very conservative savings. For example, estimated demand savings range from 0.14% to 1.4% savings based on nominal system capacity. These values very likely underestimate savings for an HVAC system with moderately to extremely fouled condenser coils.

# Section 2. Calculation Methodology

Energy savings and demand reduction estimations for Condenser Coil Cleaning are determined herein according to the prescriptive method presented in the Disposition. The Disposition states that UES values for Condenser Coil Cleaning shall be derived from DEER RCA UES values by applying the multipliers described in the previous section. There are four DEER 2019 RCA measures addressing either increasing charge from an undercharged state or decreasing charge from an overcharged state on units with thermal expansion valves (TXV) or without TXVs. The Disposition multipliers discussed above are applied to the two DEER RCA measures for increasing charge from an undercharged state.

Because the starting point for calculating Condenser Coil Cleaning UES values is DEER vintage-weighted RCA UES values, there is no discussion in this work paper of base case and measure case calculations.

## 2.1 Electric Energy Savings Estimation Methodologies

Electric energy savings are calculated by applying the Disposition mandated multiplier of 0.125 for Condenser Coil Cleaning to DEER vintage weighted electric energy UES values.

A sample calculation using a PG&E territory vintage-weighted small office with package AC and no TXV located in climate zone 16 is provided below.

Because both the RCA and Condenser Coil Cleaning are RC measures, only a single baseline calculation is required.

## 2.2 Demand Reduction Estimation Methodologies

Demand reduction savings are calculated by applying the Disposition mandated multiplier for Condenser Coil Cleaning of 0.125 to DEER vintage weighted electric energy UES values.

A sample calculation using a PG&E territory vintage-weighted small office with package AC and no TXV located in climate zone 16 is provided below.

Because both the RCA and Condenser Coil Cleaning are RC measures, the incremental cost is equal to the gross measure cost and only a single baseline calculation is required. .

## 2.3 Gas Energy Savings Estimation Methodologies

There are no natural gas energy savings associated with this measure.

## 2.4 Vintage Weighted Average

Vintage weighting procedures are not used directly in this Work Paper. Instead, DEER utility-specific, vintage-weighted RCA UES values are used to directly calculate corresponding utility-specific, vintage-weighted Condenser Coil Cleaning UES values.

# Section 3. Load Shapes

Load shapes are used for portfolio lifecycle cost analysis. A load shape indicates the distribution of a measure’s energy savings over one year. A load shape is a set of fractions summing to unity, with one fraction per hour (or other time period). Multiplying a savings value by the load shape value for any particular hour yields the energy savings for that particular hour.

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 **Table 10** below.

Table 10 Building Types and Load Shapes

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

# Section 4. Costs

Due to the age of the cost resources from the prior revision of this workpaper, a cost survey was conducted of active, program-participating contractors and technicians (attached). The *2010-2012 WO017 Ex Ante Measure Cost Study Final Report* [[9]](#endnote-9) (Measure Cost Update) and the DEER Measure Cost Data Users Guide [[10]](#endnote-10) were also referenced. Because both the RCA and Condenser Coil Cleaning are RC measures, the incremental cost is equal to the gross measure cost.

## 4.1 Base Case Cost

The base case is the customer’s existing equipment without Condenser Coil Cleaning; therefore, the base case cost is $0.00.

## 4.2 Measure Case Cost

Equipment and labor costs for cleaning condenser coils were derived from a cost survey conducted of active, program-participating contractors and technicians (attached). The costs per-ton cooling for cleaning condenser coils are $0.72 for material and $18.79 for labor.

## 4.3 Full and Incremental Measure Cost

Table 11 Full and Incremental Measure Cost Equations

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |
| RET/ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |
| REF | (MEC + MLC) – (BEC + BLC) | MEC + MLC | N/A |
| RC | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

Table 12 Full and Incremental Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| RC | $0.72 +$18.79 = $19.51 | $0.72 +$18.79 = $19.51 | N/A |

# Attachments

# References

1. Judith Jennings, et al, Pacific Gas and Electric Company (2012,06,26). Work Paper PGECOHVC138 Nonresidential HVAC RTU Quality Maintenance,. [↑](#endnote-ref-1)
2. Andres Fergadiotti, Southern California Edison (2014,12,26). Work Paper SCE13HC037 Comprehensive Commercial HVAC Rooftop Unit Quality Maintenance [↑](#endnote-ref-2)
3. California Public Utilities Commission, Energy Division, WORKPAPER DISPOSITION FOR Non-Residential HVAC Rooftop Quality Maintenance, 5-2-2013. [↑](#endnote-ref-3)
4. California Public Utilities Commission, Energy Division, Spreadsheet: *20132014-CommercialHVACMaintenance-SavingsValues-April2013-v1-2.xlsx,*submitted as addendum to WORKPAPER DISPOSITION FOR Non-Residential HVAC Rooftop Quality Maintenance. [↑](#endnote-ref-4)
5. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. and Air Conditioning Contractors of America. (© ASHRAE and ACCA, 2008). *Standard 180-2008, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems*. [↑](#endnote-ref-5)
6. Public Utilities Commission of the State of California (2017, March 3). Energy Division Resolution E-4818. Retrieved from <http://docs.cpuc.ca.gov/ResolutionSearchForm.aspx>. [↑](#endnote-ref-6)
7. Database for Energy Efficient Resources, http://www.deeresources.com/index.php/deer-versions/deer2019-and-june-2017-updates [↑](#endnote-ref-7)
8. James J. Hirsch & Associates. READi tool, V2.5.1. Developed for California Energy Commission. [↑](#endnote-ref-8)
9. Itron. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. San Francisco, CA (2014, May 27). Retrieved 8/26/2015 at http://www.energydataweb.com/cpucFiles/pdaDocs/1100/2010-2012%20WO017%20Ex%20Ante%20Measure%20Cost%20Study%20-%20Final%20Report.pdf. [↑](#endnote-ref-9)
10. DEER Measure Cost Data Users Guide found on www.deeresources.com under DEER2011 Database Format hyperlink, DEER2011 for 13-14, spreadsheet ‘SPTdata\_format-V0.97.xls’. [↑](#endnote-ref-10)