**Work Paper PGECOHVC139**

**Residential HVAC Quality Maintenance**

**Revision # 6**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Residential HVAC Quality Maintenance**

**Measure Codes: TK07, TK10, TK12, TK101, TK102, HV374, HV375, HV376, HV377, HV287**

# At-A-Glance Summary

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | TK07 | TK10 | TK12 | TK101 | TK102 | HV374, HV375, HV376, HV377 | HV287 |
| **Measure Description:** | ANSI/ACCA Standard 4 System Assessment and Report. Includes condenser coil cleaning. | Blower Motor Retrofit | 1-Year QM Service Agreement | Single Measure Kicker | Comprehensive Kicker | Refrigeration System Assessment w/Savings | Airflow Adjustment |
| **Energy Impact Common Units:** | CAP-TONS | CAP-TONS | Per Installation | Per Installation | Per Installation | CAP-TONS | CAP-TONS |
| **Base case Description:** | Central Air Conditioner/Heat Pump system is not treated or maintained in a residential dwelling. | | | | | | |
| **Base case Energy Consumption:** | Source: DEER | | | | | | |
| **Measure Energy Consumption:** | Central Air Conditioner/Heat Pump system is not treated or maintained in a residential dwelling. | | | | | | |
| **Energy Savings (Base case – Measure)** | Source: DEER and Engineering calculations.  Varies by climate zone | | | | | | |
| **Costs Common Units:** | $ per Ton | $ per Ton | $ per Installation | $ per Installation | $ per Installation | $ per Ton | $ per Ton |
| **Base case Equipment Cost ($/unit):** | Source: WO017 measure cost study and Manufacturer data  $0/unit | | | | | | |
| **Measure Equipment Cost ($/unit):** | Source: WO017 measure cost and Manufacturer data  Varies based on climate zone (which drives AC unit capacity or tonnage). | | | | | | |
| **Measure Incremental Cost ($/unit):** | Source: WO017 measure cost and Manufacturer data  Varies based on climate zone (which drives AC unit capacity or tonnage). | | | | | | |
| **Effective Useful Life (years):** | Source: DEER  Varies | | | | | | |
| **Program Type:** | Retro-Commissioning (RC) | | | | | | |
| **Net-to-Gross Ratios:** | Source: DEER2011  0. 78, Res-sAll-mHVAC-RCA, “HVAC Maintenance: Refrigerant Charge Adjustment (RCA):  0.55, Res-Default>2, “All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years” | | | | | | |
| **Important Comments:** |  | | | | | | |

**Revision # Date Description Author (Company)**

|  |  |  |  |
| --- | --- | --- | --- |
| Revision 0 | **03/12/2012** | **Residential HVAC Quality Maintenance – PGECOHVC139 R0** | **Christopher Li (PG&E), Marshall Hunt (PG&E) and Janice Peterson (PECI)** |
| **Revision 0** | **06/26/2012** | **Update NTG to reflect 2012 NTG ratio** | **Christopher Li (PG&E)** |
| **Revision 0** | **08/29/2012** | **Update At-A-Glance Table** | **Christopher Li (PG&E)** |
| **Revision 1** | **1/08/2014** | * **Removed Expected Values Analysis** * **Removed TK08 and TK09 measure codes** * **Add TK101, TK102, and TK103 measure codes** * **Add Multifamily (MFM) and Mobile Homes (DMO) building types for Blower Motor measure (TK10) using scaling method.** * **Update all NTG, ISR, EUL** | **Christopher Li (PG&E)** |
| **Revision 2** | **4/8/2014** | * **Update impact values to include new CEC title 24 weather files (CZ2010)** | **Christopher Li (PG&E)** |
| **Revision 3** | **11/12/2015** | * **Add new airflow correction/adjustment measure to workpaper** * **Update Measure Cost using WO017 study** * **Per workpaper review, revised energy savings values for blower motor retrofit measure to adopt 2013 Res HVAC QM disposition values.** * **Removed measures TK07, TK101, TK102, and TK12 from ex-ante tables.** | **Christopher Li (PG&E)**  **Jia Huang (PG&E)** |
| **Revision 4** | **11/28/2016** | * **Updated savings estimates due to DEER 2017 and DEER 2018.** | **Jia Huang (PG&E)** |
| **Revision 5** | **6/6/2017** | * **Added savings for condenser coil cleaning to measure code TK07.** * **Revised energy savings for HV287 to include incidence fraction.** | **Jia Huang (PG&E)** |
| **Revision 6** | **12/7/2017** | * **Revised energy savings estimates for refrigerant charge for DEER 2018. Measure code TK103 replaced with measures HV374, HV375, HV376, and HV377** | **Jia Huang (PG&E)** |
| **Revision 6 v2** | **12/6/2018** | * **Retroactive updates to EUL for BRO measures per Resolution E-4952 and E-4818. Retroactive to 1/1/2018.** | **Jia Huang (PG&E)** |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

Table 1 Base and Measure Cases

|  |  |
| --- | --- |
| **Typical Base Case Description** | * Central Air Conditioner/Heat Pump system is not treated or maintained in a residential dwelling. |
| **Typical Measure Description** | * Maintain Central Air Conditioner/Heat Pump system with treatments/measures to restore the system to a higher level of efficiency and performance. |

The following table shows treatments/measures under the residential quality maintenance program:

Table 2: Residential Quality Maintenance Measures

|  |  |  |  |
| --- | --- | --- | --- |
| PG&E Measure Codes | SCG / SDG&E Codes | SCE Solution Code | Measure name |
| TK07 |  |  | ACCA 4 System Assessment and Report. Condenser Coil Cleaning |
| TK10 |  |  | Blower Motor Retrofit |
| TK12 |  |  | 1-Yr QM Service Agreement |
| TK101 |  |  | Single Measure Kicker |
| TK102 |  |  | Comprehensive Kicker |
| HV374 |  |  | Increase Refrigerant Charge - System with thermal expansion valve (TXV) - Typical (8% rated charge) |
| HV375 |  |  | Increase Refrigerant Charge - System with No thermal expansion valve (TXV) - Typical (8% rated charge) |
| HV376 |  |  | Decrease Refrigerant Charge - System with thermal expansion valve (TXV) - Typical (8% rated charge) |
| HV377 |  |  | Decrease Refrigerant Charge - System with No thermal expansion valve (TXV) - Typical (8% rated charge) |
| HV287 |  |  | Airflow Adjustment |

***Catalog Description***

The Residential HVAC Quality Maintenance (QM) Program for residential dwellings is a customer based program delivered through PG&E’s QM and Third-Party ImplementersM. The PG&E QM and 3P Implementers contract specifies the program performance criteria, marketing tasks, rules for recruiting contractors, and required training of licensed HVAC contractors and their technicians to offer comprehensive quality maintenance service to the customers. The service scope is defined on ACCA 4B,[[1]](#endnote-2) Quality Maintenance Standard. The qualified HVACH technician performs system assessment service and blower motor retrofit. The QM program also offers an incentive for the resident and/or homeowner to purchase an optional “one-year service agreement” with the qualified HVAC contractor. In addition, the QM program offers two bonus incentive options for the resident and/or homeowners, Single Measure (TK101) or Comprehensive Measure (TK102) Kicker for completing the Blower Motor Retrofit (TK10) and/or Refrigerant Charge Correction (HV374, HV375, HV376, and HV377) measures. Currently, PG&E’s Third-Party Program only offers the TK10 Blower motor retrofit and Refrigerant charge adjustment (HV374, HV375, HV376, HV377) measures in their program.

***Program Restrictions and Guidelines***

***Terms and Conditions:***

Measures/treatments are applied to residential buildings located in PG&E’s nine (9) climate zones 1, 2, 3, 4, 5, 11, 12, 13, and 16 and cooled using a central air conditioner or heat pump meeting in accordance with ANSI/AHRI Standard 210/240-2008.A This standard covers both split (condenser outside and evaporator inside) and packaged (condenser and evaporator in the same exterior mounted package) air conditioners and heat pumps.

The blower motor retrofit measure is offered to residential homes, including single family, multifamily, and mobile homes located in PG&E’s nine (9) climate zones 1, 2, 3, 4, 5, 11, 12, 13, and 16.

***Eligibility Requirements:***

The customer must be an electric customer of Pacific Gas and Electric Company (PG&E)L at the installation service address.

Under the residential quality maintenance program, the rebate is downstream which is provided to the customer at the time of installation upon receipt of installation.

Under the third-party program, the incentive goes to the third-party program implementers, which is considered as a direct install program.

## 1.2 Product Technical Description

This work paper covers Residential HVAC Quality Maintenance (QM) program, and Brushless Permanent Magnet (BPM) Blower Motor retrofit. The QM measure contains multiple treatments, whereas the Motor retrofit applies to the replacements of blower fan motor. PG&E’s Third-Party program offers the TK10, HV374, HV375, HV376, HV37, and HV287 measures listed in this workpaper.

In response to the long standing problem of there not being a clear definition of what maintenance activities should be done to maintain residential HVAC equipment, the industry developed ANSI/ACCA Standard 4B - Maintenance of Residential HVAC Systems. This standard applies to HVAC contractors and technicians to determine what is required to properly maintain residential HVAC systems.

The Residential HVAC QM program provides criteria that must be met to receive rebates for treatments that save energy by restoring the system to a higher level of efficiency and performance. After the service system performance can be sustained with the execution of an ACCA Standard 4 compliant service agreement. This may not apply to the third-party program.

Deemed energy savings from the implementation of QM maintenance measures were determined using the DEER READi tool. Energy savings for the blower motor retrofit were estimated separately using eQUEST simulation models and engineering calculations. In some cases, quantities of measures have negative therm impacts due the reduction of blower motor heat being introduced to the supply air stream.

The components of the QM measures are composed of six measures/treatments, which are listed in Table 3. Measure code TK07 is a market transformation measure known as “System Inventory & Assessment” and implements the requirements of ACCA Standard 4 with the treatment being the technician’s inventory and assessment work. TK12 is also a market transformation measure that supports the purchase of an ACCA Standard 4 complying service agreement. TK101 and TK102 are bonus incentive measures known as “Single Measure Kicker and Comprehensive Kicker”, these measures are also part of market transformation, which provides the homeowner an incentive to perform treatments TK10, HV374, HV375, HV376, HV377, and/or HV287.

Measure TK10 is a single treatment and is the retrofit of a high efficiency blower motor and is discussed in Section 2 below. HV374, HV375, HV376, and HV377 refer to refrigerant charge correction, where it improves the systems performance when system is correctly charged to manufacturer’s recommendation. HV287 is a treatment/measure that corrects the airflow in a conditioned space by refurbishing the ducts, duct sealing, and replacing the filters. When measurement uncertainty is considered there is a ±10% of correct refrigerant charge range where savings from charge correction is uncertain. Many if not a majority of systems will fall within this the range so no charge corrections will be needed.

Table 3: Estimation Methods for QM Measure Treatments

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Code** | **Treatment Number** | **Treatment** | **Estimation Method** |
| TK07 | 1 | System Inventory & Assessment | Market Transformation. Energy savings claimed for condenser coil cleaning. |
| TK10 | 2 | Permanent Magnet Blower Motor Retrofit | CFM/watts blower efficiency |
| TK12 | 3 | One-year Service Agreement | Market Transformation – No Savings |
| TK101 | 4 | Single Measure Kicker | Market Transformation – No Savings |
| TK102 | 5 | Comprehensive Kicker | Market Transformation – No Savings |
| HV374, HV375, HV376, HV377 | 6 | Refrigerant Charge Correction | System EER Improvement |
| HV287 | 7 | Airflow Adjustment | Increased airflow |

## 1.3 Measure Application Types

The Delivery Mechanism of these measures under the residential quality maintenance program is Downstream and Mid-Stream Direct Installed Program.

The Program Type/Application Type of these measures is Retro-Commissioning (RC). RC uses the remaining useful life (RUL) of the air conditioning equipment being treated.

Table 4: Measure Application Type

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| RC | Retro-Commissioning | Measure applied as part of retro-commissioning; Above Pre-Existing energy impacts are applied for the associated RUL period, Full Cost of measure technology used. |

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 2015. Appendix A will serve as a translation between the outputs of this workpaper and application types used by READi.

## 1.4 Product Base Case and Measure Case Data

### 1.4.1 DEER Base Case and Measure Case Information

The DEER data cited in this work paper include: peak demand reduction, electric savings, interactive gas savings, equipment useful life (EUL), remaining useful life (RUL), and Net-to-Gross.

Table 5: DEER Difference Summary

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| DEER Difference Summary Table | | | | |
| Measure Description | Refrigerant Charge Adjustment | Blower Motor Retrofit | Airflow Adjustment | Condenser Coil Cleaning |
| Modified DEER Methodology | No | Not in DEER | Not in DEER | No |
| Scaled DEER Measure | No | Not in DEER | Not in DEER | No |
| *DEER Building Prototypes Used* | *Yes* | *Yes* | *Yes* | *Yes* |
| Deviation from DEER | None | Yes | Yes | None |
| DEER Version | DEER 2018, D17 v2 | Not in DEER | Not in DEER | DEER2014 |
| DEER Run ID and Measure Name (Sample) | RE-HV-RefChrg-Inc-TXV-typ,  RE-HV-RefChrg-Inc-NoTXV-typ,  RE-HV-RefChrg-Dec-TXV-typ,  RE-HV-RefChrg-Dec-NoTXV-typ | None | None | HV-ResAC-CleanCoil (Clean Condenser Coils – Residential) |

**Net to Gross**

The NTG ratio was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” spreadsheet under the “DEER2011 NTGr Values” tab on the [www.deeresources.com](http://www.deeresources.com) website. Table 6 below summarizes all applicable DEER based Net-to-Gross ratios for programs that may be used by this measure.

See Section 1.1 Terms and Conditions and Market Applicability to reference the type of program delivery mechanism and customer status used to determine this entry.

Table 6: Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID\* | NTG\* |
| Res-sAll-mHVAC-RCA | HVAC Maintenance: Refrigerant Charge Adjustment (RCA) | Res | Any | PreReb | 0.78 |
| 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.

**Installation Rate (GSIA)**

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 7 below.

Table 7: Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID\* | GSIAValue\* |
| Res-RCA-PGE | Residential Refrigerant Charge & Airflow Adjustment; Annual Installation Rate | Res | Any | NonUpStrm | 0.54 |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1.0 |

\*Denotes that the column is taken from the DEER GSIA Table.

**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. (In the event that the READi IDs do not support the technology in this workpaper simply indicate “Non-DEER”.)

Table 8: READi Tech IDs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| READi Field Name | Refrigerant Charge Adjustment | Blower Motor Retrofit | Airflow Adjustment | Condenser Coil Cleaning |
| Measure Case UseCategory | HVAC | HVAC | HVAC | HVAC |
| Measure Case UseSubCats | SpaceCool | VentAirDist | SpaceCool | HtRej |
| Measure Case TechGroups | dxAC\_equip | HV\_AirDist | dxAC\_equip | dxAC\_equip |
| Measure Case TechTypes | spltSEER | VentFanMtr | spltSEER | spltSEER |
| Base Case TechGroups | dxAC\_equip | HV\_AirDist | dxAC\_equip | dxAC\_equip |
| Base Case TechTypes | spltSEER | VentFanMtr | spltSEER | spltSEER |

**Effective Useful Life / Remaining Useful Life:**

Table 9: EUL/RUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **READi EUL ID** | **Description** | **Sector** | **Enduse** | **EUL (Years)** | **RUL (Years)** |
| HV-RefChrg | Refrigerant Charge – Residential | Res | HVAC | 3 | 1 |
| HV-ResAC-CleanCoil | Clean Condenser Coils - Residential | Res | HVAC | 3 | 1 |
| Res-RCx-Operational | Residential HVAC assessment report & maintenance contract | Res | HVAC | 3 | 1 |

### 1.4.2 Codes & Standards Requirements Base Case and Measure Information

**Title 20[[2]](#endnote-3):**

These measures are not governed by either state or federal codes and standards.

**Title 24[[3]](#endnote-4):**

These measures are not governed by either state or federal codes and standards.

Title 24 does not deal with “quality maintenance” issues. This program requires the HVAC contractor to be licensed by the California State Licensing Board (CSLB) and the HVAC technicians to be EPA certified. Under state code, performance of maintenance and repairs does not require the homeowner to obtain a building permit.

In regards to the blower motor retrofit measure, the mechanical code states that the replacement of any component part or assembly of an appliance that does not alter its original approval and complies with other applicable requirements of the mechanical code is exempt from the requirement to obtain a mechanical permit. In the event that a replacement motor requires a different voltage or number of phases than the original motor, the installation is to include disconnects not present on the original equipment, or the installation will alter the electrical system in any other way an electrical permit must be obtained pursuant to Title 24, Part 3 California Electrical Code.

***Federal Standards:***

These measures are not governed by either state or federal codes and standards.

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

Several studies have been performed concerning the energy savings potential through RCA correction. The key reports are summarized in this section.

**1.4.3.1 Robert Mowris & Associates 2004 Study[[4]](#endnote-5)**

“Field Measurements of Air Conditioners with and without TXVs”, 2004 ACEEE Summer Study Proceedings, Robert Mowris and Associates, Anne Blankenship, and Ean Jones, 2004.

This study summarizes the field measurements of 4,168 air conditioners units with and without thermostatic expansion valves (TXVs). The report does not specify whether these are residential or commercial units, but the sizes studied were between three (3) and five (5) tons which is common for residences. Based on the results, approximately 72% of the units had improper refrigerant charge and 44% had improper airflow. The study also found that the EER measurement of air conditioners with improper refrigerant charge and airflow has a unit efficiency gain of 21% ±7% for units with TXV and an increase of 17.1% ±2.8% for units without TXV. Additionally, out of all the sampling, it was found approximately 25% of the units had TXVs, while 75% did not. Based on the results from the field data, the overall weighted average of savings for refrigerant charge and airflow correction is 18% (17.1×0.75 + 21×0.25 = 18%). The average energy savings for correcting the refrigerant charge and airflow in the units are 12.6% ±2.3%, this percentage was calculated by multiplying the overall weighted average of 18% by the numbers of units with improper refrigerant charge of 72%.

The direct airflow measurements were also quantified, but the actual corrected airflow measurement was taken by using the temperature split method. The results from the pre-retrofit airflow measurement were found to be 279 ± 10 cfm/ton for units without TXV and 308 ± 17 cfm/ton for units with TXV. The average airflow improvement was calculated to be 9.8% ± 2.5%.

The dataset of field measurements from this study were taken to derive the Refrigeration Impact Factor (RIF) as stated on Appendix B below.

**1.4.3.2 PG&E 2001 Study[[5]](#endnote-6)**

“Influence of the Expansion Device on the Performance of a Residential Split-System Air Conditioner”, Robert Davis, PG&E Performance Testing and Analysis Unit Technical and Ecological Services, January 2001.

A series of tests were conducted on a residential split-system air conditioner to determine the differences in the performance due to the type of expansion device used. The study examined both direct expansion and TXV units installed in the same system over various system conditions. The tests simulated different outside air conditions, inside air conditions and refrigerant charge levels. The tests concluded that at 20% overcharge with an outside air temperature of 95ºF, the EER for both types of systems was reduced by 5%. At 30% undercharge, the EER was reduced by 7% for the TXV and 28% for the fixed orifice system. Another thing to note is based on the data provided, system EER increases by approximately 1% for every 1ºF decrease in outside air temperature. Figure 2 below gives a graphical summary of the test results.6

Figure 1: Normalized EER vs. Charge and Outside Temperature



### 1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

There are no further data or calculations provided for the support of the measures in this work paper.

# Section 2. Calculation Methods

Table below contains the data files for the refrigerant charge, airflow adjustment, and condenser coil cleaning measures that were taken directly or modified from the DEER 2018 READi Tool. The savings for the refrigerant charge measure were taken directly from DEER. The savings for the airflow adjustment and condenser coil cleaning measures were derived from the DEER estimates for refrigerant charge adjustment using direction from the 2013-2014 Residentia HVAC Quality Maintenance Disposition. The blower motor retrofit measure was based on using the eQUEST modeling tool.

Table 10: READi Tool Outputs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **PG&E Measure Code** | **SCG and SDG&E Solution Code** | **SCE Solution Code** | **Measure Name** | **READi Results** |
| TK07 |  |  | Condenser Coil Cleaning | See accompanying calculation spreadsheet |
| HV374, HV375, HV376, HV377 |  |  | Adjust refrigerant charge in residential AC unit | See accompanying calculation spreadsheet |
| TK10 |  |  | Blower Motor Retrofit | See accompanying calculation spreadsheet |
| HV287 |  |  | Airflow Adjustment | See accompanying calculation spreadsheet |

|  |  |  |  |
| --- | --- | --- | --- |
| **Install/Program Type** | **Measure Life Basis** | **First Baseline Period Gross Measure Cost (RUL)** | **Second Baseline Period Gross Measure Cost (EUL – RUL)** |
| ***RC*** | EUL | Calculated as Full Measure Cost | N/A |

Note: For RC measure, First Baseline is the baseline for the full EUL. There is no second baseline.

## 2.1 Electric Energy Savings Estimation Methodologies

Energy savings for the refrigerant charge correction (Impact ID: Res-RefrigCharge-wtd) measure were downloaded from the DEER2018 READI tool (v2.4.7), DEER version D17 v1.0, directly. This measure includes HVAC interactive effects impacts.

Specified values for the refrigerant charge correction measure vary by building types, building vintages, and climate zones. For this work paper, a building type of residential single family, multifamily, and mobile homes was chosen, along with using “existing (weighted DEER vintages)” building vintage and all 16 California Climate Zones.

Energy savings for the airflow adjustment measure is based on an equation provided by CPUC Energy Division’s May 16, 2013[[6]](#endnote-7) disposition for residential quality maintenance. The disposition stated that any non-charged related services (including coil cleaning and airflow adjustments) may account for an additional 25% savings on top of the DEER RCA impact savings. The following is the equation ED provided for non-charge related remedies:

Gross Non-Charge Adjustment Savings = DEER values x 0.25

Where,

DEER values = DEER2018 impact savings for RCA measure

The savings for the specific measures are apportioned as follows:

Condenser Coil Cleaning: 50% of the total

Evaporator Coil Cleaning: 25% of the total

Air Flow Adjustment: 25% of the total.

In addition, the following incidence fractions are applied:

Condenser Coil Cleaning: 0.80

Evaporator Coil Cleaning: 0.60

Air Flow Adjustment: 0.60

The blower motor retrofit measure is not included in the DEER2018 READI tool (v2.4.7) database. Energy savings impacts for the blower motor retrofit measure are obtained from the Energy Division’s 2013-2014 Residential HVAC Quality Maintenance Disposition (May 16, 2013).

## 2.2 Demand Reduction Estimation Methodologies

Demand savings for the refrigerant charge correction (Impact ID: Res-RefrigCharge-wtd) measure were downloaded from the DEER2018 READI tool (v2.4.7), DEER version D17 v1.0, directly. This measure includes HVAC interactive effects impacts.

Specified values for the refrigerant charge correction measure vary by building types, building vintages, and climate zones. For this work paper, a building type of residential single family, multifamily, and mobile homes was chosen, along with using “existing (weighted DEER vintages)” building vintage and all 16 California Climate Zones.

Demand savings for the airflow adjustment measure is based on an equation provided by CPUC Energy Division’s May 16, 2013[[7]](#endnote-8) disposition for residential quality maintenance. The disposition stated that any non-charged related services (including coil cleaning and airflow adjustments) may account for an additional 25% savings on top of the DEER RCA impact savings. The following is the equation ED provided for non-charge related rememdies:

Gross Non-Charge Adjustment Savings = DEER values x 0.25

Where,

DEER values = DEER2018 impact savings for RCA measure

The savings for the specific measures are apportioned as follows:

Condenser Coil Cleaning: 50% of the total

Evaporator Coil Cleaning: 25% of the total

Air Flow Adjustment: 25% of the total.

In addition, the following incidence fractions are applied:

Condenser Coil Cleaning: 0.80

Evaporator Coil Cleaning: 0.60

Air Flow Adjustment: 0.60

The blower motor retrofit measure is not included in the DEER2018 READI tool (v2.4.7)[[8]](#endnote-9) database. Demand savings impacts for the blower motor retrofit measure are obtained from the Energy Division’s 2013-2014 Residential HVAC Quality Maintenance Disposition (May 16, 2013).

## 2.3 Gas Energy Savings Estimation Methodologies

See section 2.1 for refrigerant charge correction, airflow adjustment, condenser coil cleaning, and motor retrofit energy savings and the methodology.

# Section 3. Load Shapes

## 3.1 Base Case 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. The closest load shapes for measures in theis workpaper are shown below. See the KEMA report[[9]](#endnote-10) for a more thorough discussion regarding the load shapes for this measure.

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| Residential | RES | RES:DEER: HVAC\_Refrig\_Charge |
| Residential | RES | PGE:DEER:HVAC\_Eff\_AC |

## 3.2 Measure Load Shapes

The measure load shape is the same as the base case load shape.

# Section 4. Base Case & Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Install/Program Type** | **Gross Measure Cost**  **(RUL Period/First Baseline)** | **Gross Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
| ***RC*** | EUL | Calculated as Full Measure Cost | N/A |

Note: For RC measure, First Baseline is the baseline for the full EUL. There is no second baseline.

## 4.1 Base Case(s) Costs

These are service type measures. There are no base case costs.

## 4.2 Measure Case Costs

The 2010-2012 WO017 Ex-Ante Measure Cost Study[[10]](#endnote-11) was used in determining the costs of these measures. The following Transaction types are appropriate to these measures. The Base Case Costs are:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Building Type** | **Transaction** | **Baseline** | **Equipment Cost \*** | **Labor / Installation Cost \*** | **Maintenance / Other Cost \*** | **Total Measure Case Cost \*** |
| TK07 | SFM, MFM, DMO | RC | Ex | $6.73 | $25.65 | $0.00 | $32.38 |
| HV374, HV375, HV376, HV377 | SFM, MFM, DMO | RC | Ex | $9.92 | $26.78 | $0.00 | $36.70 |
| TK10 | SFM, MFM, DMO | RC | Ex | $69.30 | $26.31 | $0.00 | $95.60 |
| HV287 | SFM, MFM, DMO | RC | Ex | $24.90 | $63.15 | $0.00 | $88.05 |

*\*All costs are noted as an average in a per tonnage basis. See accompanying savings spreadsheet for complete details on the costs.*

The measure case costs for refrigerant charge correction were determined from 2010-2012 WO017 Measure Cost Study, whereas the costs for the Airflow adjustment measure is based on the same study but using the duct testing and sealing measure for the measure costs. As for the blower motor retrofit, the material cost of a ½ horsepower motor was set at $198.88/motor from the MARS- Motors & Armatures, Inc.[[11]](#endnote-12) distributor data sheet and the labor cost of $75.50/hr for installation was derived from the RS Means.

## 4.3 Incremental & Full Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Install/Program Type** | **Gross Measure Cost**  **(RUL Period/First Baseline)** | **Gross Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
| ***RC*** | EUL | Calculated as Full Measure Cost | N/A |

Note: For RC measure, First Baseline is the baseline for the full EUL. There is no second baseline.

### 4.3.1 *Full Measure Cost*

Full Measure Cost is the cost to install an energy efficient measure per the CPUC calculators. This definition implies a different meaning depending on the Measure Application type.

This measure transaction type is: RC, so the Full Measure Cost (FMC) is represented by the equation below:

FMC = Measure Equipment Cost + Measure Labor Cost

\*Note: Various complicated price fluctuations are not addressed in these equations, such as future costs due to inflation in labor, future costs due to deflation in material cost, and other variables that cannot be accurately described at this time.

### 4.3.2 Incremental Measure Costs

Incremental Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. While IMC has a straight forward definition depending on the install type, the equation does vary. For these measures, the IMC is the same as the Full Measure Cost.

This measure transaction type is: RCso the Incremental Measure Cost (IMC) is represented by the equation below:

IMC = Measure Equipment Cost + Measure Labor Cost

\*Note: Various complicated price fluctuations are not addressed in these equations, such as future costs due to inflation in labor, future costs due to deflation in material cost, and other variables that cannot be accurately described at this time.

**Summary Table for Section 4**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Building Type** | **Transaction** | **Baseline** | **Equipment Cost \*** | **Labor / Installation Cost \*** | **Maintenance / Other Cost \*** | **Total Measure Case Cost \*** |
| TK07 | SFM, MFM, DMO | RC | Ex | $6.73 | $25.65 | $0.00 | $32.38 |
| HV374, HV375, HV376, HV377 | SFM, MFM, DMO | RC | Ex | $9.92 | $26.78 | $0.00 | $36.70 |
| TK10 | SFM, MFM, DMO | RC | Ex | $69.30 | $26.31 | $0.00 | $95.60 |
| HV287 | SFM, MFM, DMOR | RC | Ex | $24.90 | $63.15 | $0.00 | $88.05 |

*\*All costs are noted as an average in a per tonnage basis. See accompanying savings spreadsheet for complete details on the costs.*

# Glossary of Terms and Acronyms

The following definitions will be used throughout this workpaper.

1. ANSI/AHRI Standard 210/240-2008 – The purpose of this standard is to establish, for Unitary Air-Conditioners and Air-Source Unitary Heat Pumps: definitions, classifications, test requirements, rating requirements, minimum data requirements for published ratings, operating requirements, marking and nameplate, and conformance conditions. This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors, and users.

1. Air Conditioning Contractors of America, Standard 4 (ACCA 4) – The ANSI/ACCA Standard 4 Maintenance of Residential HVAC Systems-2008. The purpose of this standard is to establish minimum inspection requirements in the maintenance of HVAC equipment found in one-family and two-family dwellings of three stories or less.
2. Base case cost - The cost for base case equipment/treatment per common unit.
3. CPUC Energy Division (ED) - The California Public Utilities Commission (CPUC) regulates privately owned electric communications, electric, natural gas, water, railroad, rail transit, and passenger transportation companies. The CPUC's Energy Division develops and administers energy policy and programs “to serve the public interest”, advise the Commission, and ensure compliance with the Commission decisions and statutory mandates.
4. eQUEST (DOE2) – Software to perform detailed comparative analysis of building designs and technologies by applying sophisticated building energy use simulation techniques. PG&E requires that eQUEST version 3.64 or newer shall be used for this work.

<http://doe2.com/eQUEST/>

1. Databases for Energy Efficient Resources (DEER) - The DEER provides estimates of the energy-savings potential for a variety of technologies of measures in residential and nonresidential applications. <http://www.deeresources.com/>
2. DEER Single Family Prototype - The DEER Single Family Prototype describes a single site configuration, including one or multiple building shells served by one or more HVAC system types. Prototype characteristics correspond to eQUEST building “creation wizard” inputs, where the characteristics were developed specifically for DEER analysis. <http://www.doe2.com/download/DEER/MAStool/>
3. HVAC - The heating, ventilation and air conditioning system(s) in a home used for heating, cooling, and maintaining the home at a controlled temperature, surrounded by fresh air, at a humidity level that is safe and comfortable for the building and its contents.
4. Incremental Measure Cost (IMC) - The value of the incremental cost of the measure (measure equipment cost less base equipment cost) per common unit.
5. Labor cost – The cost of labor to perform the work of specific measures/treatments.
6. Measure Case Cost – The cost for measure case equipment/treatment per common unit.
7. PG&E – Pacific Gas and Electric Company.
8. QM Implementer - A QM Implementer is a company that provides documented verification of work performed by licensed HVAC contractors performing a specified type of work or service. In the context of the Program, the service which the QM Implementer is to follow a program performance specification, market, recruit, and train licensed HVAC contractors and their technicians to offer the comprehensive quality maintenance service to the customers.
9. Quality Maintenance (QM) – ACCA Standard 4 defines what must be done to implement Quality Maintenance on residential HVAC systems. Using multiple treatments/measures the HVAC system and its elements are maintained on a regular interval to provide the intended thermal comfort and energy efficiency.
10. Workpaper (WP) - A document developed by the utility that documents the product description, savings methodology, measure costs, effective useful life, and net-to-gross ratios.

# References and Endnotes

1. ACCA, “Maintenance of Residential HVAC Systems” - ANSI/ACCA Standard 4, 2008.

   <https://www.acca.org/industry/ansi-standards> [↑](#endnote-ref-2)
2. California Energy Commission (CEC). “California Code of Regulations, Title 20. Public Utilities and Energy.” CEC-140-2014-002. March 2014.

   <http://www.energy.ca.gov/2014publications/CEC-140-2014-002/CEC-140-2014-002.pdf> [↑](#endnote-ref-3)
3. California Energy Commission (CEC). “Title 24: Building Energy Efficiency Standards.” CEC-400-2012-004-CMF-REV2. May 2012.

   <http://www.energy.ca.gov/2012publications/CEC-400-2012-004/CEC-400-2012-004-CMF-REV2.pdf> [↑](#endnote-ref-4)
4. Robert Mowris & Associates, Anne Blankenship, and Ean Jones. “Field Measurements of Air Conditioners With and Without TXVs”, paper for 2004 ACEE Summer Study Proceedings, 2004.

   <http://aceee.org/proceedings-paper/ss04/panel01/paper19> [↑](#endnote-ref-5)
5. PG&E Performance Testing and Analysis Unit Technical and Ecological Services, “Influence of the Expansion Device on the Performance of a residential split system air conditioner”, Report # 491-01.4, January 2001. [↑](#endnote-ref-6)
6. CPUC Energy Division, “Workpaper Disposition for Residential Quality Maintenance (2010-2012 Cycle), May 16, 2013. [↑](#endnote-ref-7)
7. CPUC Energy Division, “Workpaper Disposition for Residential Quality Maintenance (2010-2012 Cycle), May 16, 2013. [↑](#endnote-ref-8)
8. Itron, Inc. “2018 Database for Energy Efficiency Resources (DEER)”, v.2.4.7 , November 2016.

   <http://www.deeresources.com/> [↑](#endnote-ref-9)
9. KEMA, The Cadmus Group, and Summit Blue Consulting. “Evaluation Measurement and Verification of the California Public Utilities Commission HVAC High Impact Measures and Specialized Commercial Contract Group Programs.” CPUC. February 10, 2010.

   <http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/> [↑](#endnote-ref-10)
10. Iron, Inc. “2010-2012 WO017 Ex Ante Measure Cost Study- Draft Report”, February 28, 2014.

    <https://www.pge.com/regulation/EnergyEfficiency2015-BeyondRollingPortfolios/Reports/ED/2014/EnergyEfficiency2015-BeyondRollingPortfolios_Report_ED_20140311_298640Atch01_298641.pdf> [↑](#endnote-ref-11)
11. ControlsCentral.com for MARS- Motors & Armatures, Inc. on a ½ hp high efficiency BPM motor.

    <http://controlscentral.com/eCatalog.aspx?SearchID=5&SearchValue=azure&SearchPartNumber=Part+Number&SearchManufacturer=MARS+-+Motors+%26+Armatures%2c+Inc.&ViewType=2> [↑](#endnote-ref-12)