**Work Paper WPSDGEREHC1065**

**Revision 3**

**San Diego Gas & Electric (SDG&E)**

**Energy Efficiency Engineering**

**Residential HVAC Quality Maintenance Airflow Adjustment Correction and Motor Retrofit**

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | MM/DD/YY | Author/Affiliation | Summary of Changes |
| 0 | 06/26/2012 | Peter Ford (SDGE) | Adopted PECI Workpaper SDGEREHC002\_0 by Janice Peterson, PECI, dated 29 January 2012. Updated NTG to DEER 2011, converted to SDG&E numbering and changed minor formatting. Embedded savings & measures files for reference |
| 1 | 01/23/2014 | Phillip Hasley/Hasley Consulting | -Updated workpaper to be in compliance with CPUC ED Disposition dated May 2, 2013  -Broke out Duct Sealing measure as a separate measure from Quality Maintenance  -Changed EUL to 5 years  -Changed NTG to 0.70  -Updated savings values to conform to ED Disposition approved values  -Removed Restore and Improve Duct System Insulation treatment per ED Disposition  -Updated workpaper to new Template |
| 1.1 | 06/23/2014 | Judelson Enriquez / RMS Energy Consulting | INTERNAL REVISIONS ONLY – no material changes made  Revised EUL and NTG IDs to match Program Builder data. Added GSIA ID.  Revised calculation spreadsheet to include Mark M.’s additional columns and remove CZ cost factors. |
| 2 | 07/12/2016  Corrected 09/02/2016 | Martin Vu / RMS Energy Consulting  Peter Ford/SDG&E | - Updated workpaper to be in compliance with CPUC ED Disposition dated May 2, 2013 and include 2014 Weather Data from the D14v1.2\_Measure\_Energy-Impacts\_SDG.zip file.  - Updated Delivery Type to Direct Install only  - Updated Measure Description from HVAC Quality Maintenance to Airflow Adjustment Correction  - Removed HVAC Duct Test and Seal measure from the workpaper.  Corrections:  Eliminated duct sealing as being part of this workpaper. Request that CPUC Staff add or change EUL ID. (See Sec.1.4) |
| 3 | 02/28/18 | Keith Valenzuela / SDGE Contractor | - Updated Delivery Type to include downstream  -Removed Airflow Adjustment Correction measure. This measure has been moved to WPSDGEREHC0032 Rev0\_SF\_Res Refrigerant Charge.  -Updated Program Type from REA to ROB  -Updated measure cost |

# Section 1. General Measure & Baseline Data

## 1.1 Measure & Delivery Description

**NOTE**: READI does not appear to contain a proper EUL\_ID for this measure. SDG&E requests that Energy Division either change the Sector for the two EUL\_IDs below to Any or provide a new EUL\_ID that is for these measures in the residential sector. (See Sec. 1.4)

### 1.1a Measure Description

This work paper details the Residential HVAC Motor Retrofit measure for packaged and split system HVAC units. The work paper the installation of a brushless direct current (BDC) motor (Motor Retrofit) with selectable speed control designed to directly replace a permanent split capacitor (PSC) motor in a residential direct drive blower fan application. The measure in this work paper apply only to residential single family building types with central air conditioning (direct expansion) and gas heat.

Based on the Residential QM disposition of May 2, 2013, this workpaper includes references to other HVAC QM measures such as condenser coil cleaning, duct sealing and refrigerant charge adjustment; however, the ex-ante values and the methodology within this workpaper are intended to document motor replacements only.

This work paper includes the following possible measures and treatments:

1. HVAC Brushless Direct Current Blower Motor Replacing Standard Eff Motor
   * Measure 1 is a motor retrofit that is likely to be installed in only a small percentage of homes.

The level of maintenance by technicians on a typical air conditioner unit is minimal with service being performed at an unacceptable level. This may eventually lead to unit failure and/or poor performance, forcing premature equipment replacement. In response to this problem, Air Conditioner Contractors of America (ACCA) developed Standard 4 for “Maintenance of Residential HVAC Systems” [1][[1]](#footnote-1). For the measures contained in this work paper, an assessment and report is required in accordance with ACCA Standard 4 prior to any treatments being applied to determine the baseline conditions and to develop treatment recommendations.

Proper maintenance of the unit enables an air conditioner to operate at or near its optimal efficiency. The Quality Maintenance measure consists of several treatments designed to increase the unit’s ability to deliver heating and cooling efficiently and to provide increased thermal comfort. The blower fan retrofit also increases energy efficiency by lowering the amount of electrical energy needed to deliver heating and cooling to the home.

The measure names are listed below in **Table 1**.

Table Measure Names

|  |  |
| --- | --- |
| Product Code | Measure name |
| 420149 | New Blower Motor ( Direct Install) |
| 464290 | New Blower Motor - Downstream |

### 1.1b Delivery and Incentive Mechanism

The delivery method for the measure is Financial Support – Direct Install or downstream. The program type for the new blower motor measure is ROB.

### 1.1c Measure Requirements

Measures are to be applied to residential single family homes in San Diego Gas and Electric (SDG&E) climate zones 6, 7, 8, 10, 14, and 15 that use central air-cooled direct expansion cooling and gas heating. The participant must have electricity distributed by SDG&E to the installation service address. Additionally, the following pre-requisites must be met before the Quality Maintenance measure can be implemented:

The motor replacement measure is to be applied after the quality maintenance airflow has been completed and is optional. The motor replacement measure applies to units with shaded pole or permanent split capacitor motors currently installed. As stated previously, the replacement blower motor is to be a brushless direct current motor with selectable speed control designed to replace a PSC motor in a residential direct drive fan application.

## 1.2 DEER Differences Analysis

Table 2 DEER QM Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | No |
| Deviation from DEER | CPUC ED deemed assumptions for non-DEER components |
| DEER Version | 2014 |
| DEER Run ID and Measure Name (Sample) | Res-RefrigCharge-wtd; Res-CondCoilClng |

The motor retrofit treatments are not included in the Database for Energy Efficient Resources (DEER).[3] The deemed savings analysis for the motor retrofit measure used in this work paper uses DEER single family prototype file for DOE2 (eQUEST) batch runs. Modifications were made to the input assumptions in the eQUEST simulation model to assess the impact of treatments for quality maintenance on an air conditioner unit. The eQUEST methodology for the motor retrofit measures uses the results from the eQUEST QM measures, which separates the evaporator blower motor usage and run time hours.

### Energy Simulation with eQUEST

eQUEST [5, G] is a DOE2 based simulation software package used to produce estimates of energy use of prototype residential building models. DEER single family prototypes [6] were used as the basis for all eQUEST simulations.

To reach an overall measure energy savings EV within a single climate zone using only eQUEST would require simulation runs for each treatment in each of the baselines as well as for each possible combination of treatments within the measure. This quickly adds up to hundreds of runs even without considering multiple permutations of each treatment. In order to reduce the number of runs and maintain a proper analysis of interaction complexity, a Design of Experiments (DoEx) process was used to specify a reduced number of runs that can be handled by using the batch process capability of eQUEST. To model all possible combinations of parameters for either the base case or QM case would require 112,500 simulation runs. With DoEx this number was reduced to 68 runs needed for a statistically valid result when comparing to the results from running the eQUEST simulation.

Table 3 DEER Motor Replacement Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | No |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | DEER does not contain this type of measure package. |
| DEER Version | N/A |
| DEER Run ID and Measure Name (Sample) | N/A |

## 1.3 Code Analysis

The energy code does not specify the required blower motor type for residential AC units. It is assumed based on cost, a typical blower motor replacement would include the cost-effective PSC motor.

Table 4 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2016) | Title 24, Part 6 California Energy Code | January, 2017 |
| Title 20 (2016) | Title 20, Appliance Efficiency Regulations | January, 2017 |

## 1.4 Measure Effective Useful Life

To obtain the EUL value, the updated CPUC ED EUL table documentation issued on February 5, 2014, “DEER2014-EUL-table-update\_2014-02-05.xlsx”, was consulted. **Table 5** below identifies the value/methodology used for the measures in this work paper. As indicated in the May 2, 2013 Disposition, the blower motor is an addition to an existing system. Program rules limit the EUL of maintenance on an existing system to no more than system’s RUL. By rule, this is 1/3 of the 15 year EUL for direct expansion HVAC system, or 5 years.

Table 5 DEER EUL Value/Methodology

SDG&E was unable to find a proper EUL\_ID in the current list available in READI. As part of this workpaper review, SDG&E requests that Energy Division either change the Sector for the two EUL\_IDs below to Any or provide a new EUL\_ID that for these measures in the residential sector.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **EUL\_ID** | **Measure Description** | **Sector** | **Bldg Type** | **Bldg Loc** | **Basis Type** | **Version** |
| HVAC-RepEcono | Repair Economizer | Com | Any | Any | Rated Years | DEER2014 |
| HVAC-2Spd | Two-Speed Fan | Com | Any | Any | Rated Years | DEER2014 |

## 

## 1.5 Net-to-Gross Ratios for Different Program Strategies

Although the “DEER2015-2016-NTG-Update-2015-10-20.xls” [[[2]](#endnote-1)] spreadsheet provides the latest NTGR, the May 2, 2013 Disposition indicated that the NTG for this measure shall be 0.70. This workpaper uses the NTGR\_ID of Res-Default>2yrs, which current Support Table values indicate as 0.55.

**Table 6** Net-to-Gross Ratio

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NTGR\_ID\*** | **Description\*** | **Sector\*** | **BldgType\*** | **ProgDelivID\*** |
| Res-Default>2yrs | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Any | Any | Any |

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

## 1.6 Time-of-Use Adjustment Factor

As directed by the CPUC in decision 06-06-063 dated June 29, 2006, time-of-use (TOU) adjustment factors are to be applied for residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. The specific TOU adjustment factors are inherent in the avoided-cost calculation performed in the E3 calculator. Since the load shape used for all measures is a new DEER load shape, i.e. the load shape starts with the prefix “DEER:”, the TOU for purposes of the E3 calculator should remain 0% as shown in **Table 7**.

Table 7 TOU Summary Table

|  |  |
| --- | --- |
| Measure | % |
| HVAC Brushless Permanent Magnet Blower Motor Replacing Standard Eff Motor | 0 |
|  |  |

# Section 2. Energy Savings & Demand Reduction Calculations

Estimated savings were revised by CPUC ED Disposition dated May 2, 2013. The Disposition revised the Blower Motor Replacement savings based on ED staff research. The Disposition savings values can be found in attachments “20132014-ResidentialHVACMaintenance-SavingsValues-April2013-v1-2-rev-SDGE-01-24-14.xlsx” and “20132014ResBlowerRaplacementDisposition-v1-2.xlsx.”

## 2.1 **HVAC Brushless Direct Current Blower Motor Replacing Standard Efficiency Motor**

The quality maintenance measure energy savings (including duct sealing) were originally calculated using eQUEST building simulation models. The brushless direct current blower motor retrofit was then modeled as an iterative retrofit to the quality maintenance measure. The quality maintenance measure energy savings were revised in the CPUC ED Disposition dated May 2, 2013 to be based on values from the DEER database and duct sealing was broken out as a separate measure (not a part of this workpaper). However, the brushless direct current blower motor retrofit still uses eQUEST savings calculations with adjustments by the ED Disposition. Therefore, the iterative eQUEST brushless direct current blower motor retrofit calculations are used as a basis for the savings for this measure.

The eQUEST calculation methodology for quality maintenance is discussed below. These savings calculations are only used as a basis for the brushless direct current blower motor retrofit measure. Since the quality maintenance measure consisted of multiple treatments having interactive effects an analysis method that takes all of the treatment and interaction effects into account was required. The steps taken to achieve this are listed below.

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1. Estimation methods were developed that would allow simulation of the quality maintenance improvements.
2. Seven factors that significantly impact energy usage in homes were selected for the purpose of building multivariate regressions to predict electric energy usage, electric peak demand, and gas energy usage for one and two story homes in each of the climate zones. Some of the factors also have the ability to be adjusted to accomplish the estimation methods developed in step 1.
3. The highest and lowest likely values of each factor were determined as well as a midpoint value. A design of experiment approach was used to select 68 unique combinations of the 7 factors for one and two story homes in each climate zone.
4. Each of the 7 factors was translated into eQUEST [G] inputs, and the 68 runs defined in step 2 were run using eQUEST’s batch processing capability for one and two story homes in each climate zone.
5. The kWh, kW, and therm annual use results from the 68 runs were used to develop regressions. Regression statistics were calculated to ensure the ability of the regressions to predict the responses.
6. For each of the 7 factors, probability distributions were developed for the range of values in the base case and after quality maintenance has been performed.
7. The probability distributions of the 7 factors were used in the regression equations to determine the probability distribution of kWh, kW, and therms in the base case and QM case for one and two story homes in each climate zone. The expected value (EV), or weighted average of the kWh, kW, and therms for the QM case was subtracted from the EV of the base case to determine the EV of the savings for one and two story homes in each climate zone.
8. The EV savings calculated in step 8 were normalized by cooling capacity in tons. The one and two story savings for each climate zone were then weighted by the percentage of one and two story homes in the climate zone.
9. Additional eQuest runs were made with randomly generated values of the 7 factors. The results of these runs were compared to the regression predictions using the same randomly generated values for the 7 factors to test the ability of the regressions to predict energy usage for values of the 7 factors that were not included in the 68 runs used to create the regressions.

**Table 8** lists each of the possible treatments in the quality maintenance measure and a short description of the estimation method used to represent the effect of the treatment.

Table 8 Estimation Methods for QM Measure Treatments

|  |  |
| --- | --- |
| **Treatment** | **Estimation Method** |
| Refurbish Ducts | Airflow improvement, EER, and Cooling Capacity Improvement |
| Restore and Improve Duct Insulation | Duct heat transfer coefficient reduction (R-Value improvement) |
| Duct Seal | Duct leakage reduction |
| Clean Evaporator Coil and Blower | Airflow improvement and evaporator heat transfer improvement resulting in EER and cooling capacity improvement |
| New Air Filter to Match the Blower | Airflow improvement, EER improvement, and cooling capacity improvement |
| Clean Condenser Coil | Condenser heat transfer improvement resulting in Cooling Capacity improvement and EER improvement |
| Thermal Expansion Valve (TXV) Bulb Insulation and Attachment Correction or Replacement | EER and Cooling Capacity Improvement |
| Refrigerant Charge Correction | EER and Cooling Capacity Improvement |

Seven factors were selected that would significantly affect home energy usage, would adequately represent the possible range of homes in each climate zone and would allow for adjustment to represent the estimation methods. Distributions of the possible values of each of the 7 factors were then developed using various sources and methods.

**Table 9** lists the factors and a short description of the source of each factor’s distribution of possible values. A more detailed description of the factors, the methods used for translation to eQUEST inputs to reflect the estimation methods, and the development of the base case and quality maintenance case distributions for each factor can be found in “*Expected Values Analysis.docx*.”

Table 9 Factors Affecting Energy Usage and Methods of Estimating Distribution of Factors

|  |  |  |
| --- | --- | --- |
| **Type** | **Unit** | **Method/Source for Estimating Distributions** |
| Refrigeration Impact Factor (RIF) | % energy impact | Robert Mowris data set [12] analysis. RIF is the factor representing the % energy impact resulting from airflow and refrigeration corrections in a sample of 56 residential units. RIF accounts for both airflow and refrigeration corrections and interaction effects between the two. |
| Duct Leakage | % of Airflow | Data set from Verified field studies [13], over 6,500 data points |
| Duct UA | Btu/(hr ° F) | DEER prototypes for area [4]; code and assumed levels of degradation for U-values |
| Tstat offset | ° F | RASS data transformed to 24 hr average setpoint [14] |
| Nominal SEER | Btu/(Watt-hr) | DEER values weighted by vintage [16] |
| AFUE | % Efficiency | Average Value provided by SDG&E from program data, assumed distribution |
| Shell UA | Btu/(hr ° F) | Wall/window/roof areas from prototype model; U-values from DEER [15] – change for each climate zone and vintage; includes infiltration |

In order to determine the expected savings that would result from upgrading a blower motor to a brushless direct current motor after quality maintenance has been performed, 7 quality maintenance factors resulting in the expected QM kWh, kW, and therms for the one and two story homes in each climate zone were derived from the expected value analysis. DEER single family home prototypes were then modified to reflect the expected value of the factors and the prototypes were simulated in eQUEST. Conversion of factors to eQUEST inputs followed the same methodologies that were used for QM. The process of converting the factors to eQUEST inputs and performing the baseline and retrofit case runs is detailed in “*Blower Motor Retrofit.docx*”.

With the 7 factors defined, the next step was to determine the impact that the full range of those seven factors could have on energy consumption and demand. In order to represent the full range of possibilities a design of experiment approach was used to select combinations of the highest and lowest values for each factor that are likely to be encountered in the population of homes. By using the highest and lowest level of each factor the full possible effect of the factor is represented in the response.

Starting with DEER single family home prototypes developed in eQUEST, 68 runs with the selected combinations of high and low factors were run for both one and two story homes in each of the SDG&E climate zones.

Originally the intention was to use the prototypes representing the QM case as the base case for the blower motor upgrade, however it was discovered that the motor power (expressed in Watts/cfm at 1” of water column) used in the DEER prototypes is far lower than the power for motors typically found in residential HVAC units. The DEER assumption for blower motor power is 0.365 W/cfm at 1” of water column. [3] A PIER report, “Characteristics and Opportunities for New California Homes” [18], determined the average blower motor power for 45 HVAC systems with PSC motors to be 0.65 W/cfm.

Two other studies conducted by Pigg at the Wisconsin Energy Center [17] found that PSC motors in residential supply fan applications use 0.517 to 0.528 W/cfm and that electronically commutated motors use 0.320 to 0.341 W/cfm. Based on these studies it was determined that the QM case would be used to represent the system after the motor retrofit was performed with a blower motor power of 0.365 W/cfm at 1” of water column, and a blower motor power of 0.65 W/cfm at 1” of water column would be modeled to represent the base case for the blower motor retrofit. None of the 7 factors were changed from the base case to the retrofit case, just the motor power.

Electric energy, peak demand, and gas energy savings were then calculated by subtracting the retrofit case kWh, kW, and therms from the base case.

The ED Disposition revised the supply air blower motor replacement measure energy savings as described below.Base savings values for the supply air blower motor replacement were taken from previous IOU Quality Maintenance workpaper supporting documents. Savings are for single family air conditioning systems with gas heat only. Other residential building types or HVAC systems are not covered. Savings are by climate zone alone and are the same across all IOUs. The ED Disposition adjusted savings values as described below.

1. Energy Division claims that the efficiency difference between PSC and BPM motors falls to zero as the motor rated capacity reaches 1 horsepower (hp). Efficiency differences provided in the workpapers are acceptable for motors with capacities of ½ hp or less.
2. The supply air blower motor capacity by unit nominal cooling capacity assumed by Energy Division is provided in **Table 10**.

Table 10 - Assumed Supply Air Blower Motor Horsepower

|  |  |
| --- | --- |
| Capacity | hp |
| ≥ 3.5 tons | 1/2 |
| 4 tons | 3/4 |
| 5 tons | 1 |

1. Energy Division assumes the efficiency differences between PSC and BPM ¾ hp motors is assumed to produce half the savings claimed in workpapers. The PSC and BPM 1 hp motors are assumed to operate at the same efficiency.
2. The distribution of nominal cooling capacities for residential cooling systems was estimated from the database of units in the 2006-2008 evaluation of air conditioner replacement programs. Other program evaluation data were examined for RCA and DTS, but much of it was for multi-family sites not covered by the QM programs. From the 2006-2008 data, the distribution of units by nominal cooling capacity is provided in **Table 11**.

Table 11 - Distribution of Cooling Equipment by Nominal Cooling Capacity

|  |  |
| --- | --- |
| Capacity | hp |
| ≥ 3.5 tons | 50.9% |
| 4 tons | 30.3% |
| 5 tons | 18.8% |

1. Based on the distribution of units provided in **Table 11**, and the assumed efficiency declines noted in Item 3, Energy Division believes that workpaper UES values should be reduced by 33.9%. This assumes that there are only ½ the benefit for 30.3% of the motors replaced (4 ton units) and no benefit for 18.8% of the motors replaced (5 ton units).

## 2.2 Gross Savings Installation Adjustment (GSIA)

The GSIA IDs for the two measures are as follows:

1. Blower motor replacement = Def-GSIA .

# Section 3. Load Shapes

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, the closest load shape chosen for this measure is the DEER:HVAC\_Eff\_AC load shape. See **Table 12** for a list of all Building Types and Load Shapes. See the KEMA report [19] for a more thorough discussion regarding the load shapes for this measure.

Table 12 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Residential Single Family | RES | DEER:HVAC\_Eff\_AC |

# Section 4. Base Case & Measure Costs

### Blower Motor

The estimated equipment measure cost for the motor retrofit was derived from HVAC distributor, Graingerwebsite [10], 2011 RS Means [11]for labor hours and WO17 [9] for labor cost.

Table 17 Total Cost for Motor Retrofit

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cost Case Description | Material Cost | Installation Man Hours - Retrofit | Installation Labor Cost Per hour - Retrofit | Measure Cost |
| Baseline (PSC motor) | $164.86 | 1.501 | $70.78 | $271.10 |
| Measure (Brushless motor) | $319.61 | 1.501 | $70.78 | $425.85 |

Table 18 Motor Retrofit Cost per Ton (assuming 3 tons)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cost Case Description | Tons | Materials/ton | Labor/ton | Cost /ton |
| Baseline (PSC motor) | 3 | $54.95 | $35.41 | $90.37 |
| Measure (Brushless motor) | 3 | $106.53 | $35.41 | $141.95 |

Table 19 Cost IDs

|  |  |  |
| --- | --- | --- |
| Cost Case Description | Cost ID | Cost/ton |
| Baseline (PSC motor) | SDG-Res\_SupFanMtr\_PSC | $90.37 |
| Measure (Brushless motor) | SDG-Res\_SupFanMtr\_Brushless | $141.95 |

## 4.3 Incremental Measure Cost

The Incremental Measure Cost (IMC) for this measure is the difference between the measure cost and the baseline cost.

Table 20 IMC Cost per Ton

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cost Case Description | Tons | Materials/ton | Labor/ton | Total/ton |
| IMC | 3 | $51.58 | $0.00 | $51.58 |

# Glossary of Terms and Acronyms

The following definitions are used throughout this work paper.

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.
2. **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.
3. **Base case cost -** The cost for base case equipment/treatment per common unit.
4. **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.
5. **Decision Programming Language (DPL)** – The software package DPL is a decision support software tool used to perform calculations and generate graphics illustrating the inputs and results. <http://www.syncopation.com/?gclid=CJXd6Nfp1qoCFVMZQgodwHBO7w>
6. **Design of Experiments (DoEx)** – A software tool used for statistical process, resulting in a statistically valid regression model which accounts for the full range of treatment interactions for this quality maintenance work paper. See “*Design of Experiment.docx*”for statistical process.<http://www.statease.com/dx8descr.html>
7. **eQUEST (DOE2)** – Software to perform detailed comparative analysis of building designs and technologies by applying sophisticated building energy use simulation techniques. SCE 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. **Expected Value Analysis (EV)** – Using the DPL software, the measure package value is determined by probability based analysis to make an expert projection of what the likely states for parameters might be with a reasonable estimation of their probability. The “expected value” is a weighted value based on multiple parameters.
4. **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.
5. **Incremental Measure Cost (IMC)** - The value of the incremental cost of the measure (measure equipment cost less base equipment cost) per common unit.
6. **Labor cost** – The cost of labor to perform the work of specific measures/treatments.
7. **Measure Case Cost** – The cost for measure case equipment/treatment per common unit.
8. **SDG&E**– San Diego Gas and Electric.
9. **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.
10. **Regression Fit Model** – Regression is a term for all methods that fit a mathematical model to observed data in order to quantify the relationship between independent and dependent variables. The fitted model is then used to describe the relationship between the two groups of variables and to predict new values of the dependent variable.
11. **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.
12. **Work Paper (WP)** - A document developed by the utility that documents the product description, savings methodology, measure costs, effective useful life, and net-to-gross ratios.

# Attachments

 

 

# References

1. ACCA, “Maintenance of Residential HVAC Systems” - ANSI/ACCA Standard 4, 2008. <https://www.acca.org/industry/ansi-standards>

2.Title 24 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings,

3. Itron, Inc. “2008 Database for Energy Efficiency Resources”, Version 2008.2.05, December 2008. <http://www.deeresources.com/>

4. Database for Energy Efficiency Resources (DEER) Single Family Prototype Input File. <http://www.doe2.com/download/DEER/MAStool/>

5. eQUEST – Building Energy Use and Cost Analysis Software, developed by James J. Hirsch & Associates (JJH), version 3.64 was the latest release. <http://www.doe2.com/>

6. DEER Single Family Prototypes with adjusted inputs. Adapted from 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, prepared for Southern California Edison by Itron, Inc. with support from J. J. Hirsch and Associates, December 2005.

7. Measure Costs Analysis spreadsheet, January 2013.



8. Mike Yim, Summit Blue Consulting, e-mail message on duct seal cost, July 25, 2011.



9. Itron. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. San Francisco, CA (2014, May 27). Accessed on February 28, 2018 at <http://www.energydataweb.com/cpucFiles/pdaDocs/1100/2010-2012%20WO017%20Ex%20Ante%20Measure%20Cost%20Study%20-%20Final%20Report.pdf>.

10. Grainger.com. (accessed on February 28, 2018)



11. RS Means Company. “2011 Building Construction Cost Data – 69th Annual Edition”. Motors Applications Category, page 554. 2011

12. Mowris’ dataset of field measurements for 56 residential units 2004 and derivation of RIF,



13. MDSS\_PGE\_duct leak\_Distribution\_Analysis, June 2011



14. Tstat probability\_v4, June 2011



15. DEER SFRes Properties- Capacity-SEER, November2011



16. *Vintage Distribution of Home Type, November 2011*

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17. Pigg, Scott, Central Air Conditioning in Wisconsin: A Compilation of Recent Field Research, ECW Report Number 241-1, May 2008.

18. Results are summarized in “Table 14 – Mean System Airflow…” of the PIER report Efficiency Characteristics and Opportunities for New California Homes by Proctor, Chitwood and Wilcox for the CEC.

19. 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/>

1. Bracketed letters refer to the Glossary and bracketed numbers refer to the References and Endnotes [↑](#footnote-ref-1)
2. [] DEER2011 Update Net-To-Gross table (05/16/2012) <http://www.deeresources.com/files/DEER2011/download/DEER2011_NTGR_2012-05-16.xls> [↑](#endnote-ref-1)