**Workpaper PGECOHVC125 (PG&E)**

**Workpaper WPSCNRHC0031.0 (SCE)**

**Variable Speed Motor Air Handler – Non-Residential**

**Revision # 4**

**Pacific Gas & Electric Company**

**Southern California Edison Company**

**Customer Energy Solutions**

**Replacement Multiple-speed Brushless Blower Motors**

**Nonresidential**

**Measure code H182**

# At-A-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | **H182 – Replacement Multiple-speed Brushless Permanent Magnet Blower Motors** |
| **Measure Description:** | Replacement Multiple-speed Brushless Permanent Magnet Motor Blower for CZ 6, 8, 9, 10,11, 12, 13, 14, 15, 16 |
| **Energy Impact Common Units:** | Per air handler unit |
| **Base Case Description:** | Nonresidential air handler unit with a permanent split capacitor motor.  Source: Measure terms and conditions. |
| **Base Case Energy Consumption:** | Various. Refer to Appendix G.  Source: Engineering Calculations. |
| **Measure Energy Consumption:** | Various. Refer to Appendix G.  Source: Engineering calculations. |
| **Energy Savings (Base Case – Measure)** | Various. Refer to Appendix G.  Source: Engineering Calculations. |
| **Costs Common Units:** | Per air handler unit |
| **Base Case Equipment Cost ($/unit):** | **$1,567.02/unit**  Source: Manufacturer benchmarking[[1]](#endnote-1) and DEER 2014 |
| **Measure Equipment Cost ($/unit):** | **$1,921.82/unit**  Source: Manufacturer benchmarking and DEER 2014 |
| **Full Measure Cost ($/unit)** | **$354.80/unit**  Source: Manufacturer benchmarking and DEER 2014 |
| **Measure Incremental Cost ($/unit):** | **$354.80/unit**  Source: Manufacturer benchmarking and DEER 2014 |
| **Effective Useful Life (years):** | EUL: 15yrs  RUL: 5yrs  Source: DEER 2014 EUL/RUL Values and Summary Documentation |
| **Program Type:** | ROB |
| **Net-to-Gross Ratios:** | 0.60  Source: DEER 2011 NTG Values – Commercial; All other EEMs with no evaluated NTGR; existing EEM programs with same delivery mechanism for more than 2 years |
| **Important Comments:** | Full measure cost is assumed to be the same as the incremental measure cost. |

# Work Paper Approvals

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

|  |
| --- |
|  |
| **Grant Brohard**  Manager, Technical Product Support |
| **Carolyn Weiner**  Manager, Core Products |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Revision Date** | **Section-by-Section Description of Revisions** | **Author (Company)** |
| **Revision 0** | **04/15/2008** | **Original work paper:**  **VSM Non-Res PGECOHVC125 R0** | **Nicolas Fauchier Magnan (kW Engineering)** |
| **Revision 1** | **05/01/2009** | **VSM Res PGECOHVC125 R1.doc** | **Tim Conroy (PG&E)** |
| **Revision 2** | **03/10/2010** | **VSM Res PGECOHVC125 R2.doc** | **Tim Conroy (PG&E)** |
| **Revision 3** | **05/17/2012** | **VSM Res PGECOHVC125 R2.doc**  **Updated references and expanded energy savings across eligible PG&E and SCE territories.** | **Jon Aldrich (kW Engineering) for**  **Judith Jennings (PG&E)** |
| **Revision 3** | **08/28/2012** | **PGECOHVC125 R3 VSM Nonres v3.docx**    **Revised cover and footer date, changed building types and vintages to DEER standards, updated GRRs to 1, corrected errors in text, corrected cross-references** | **Judith Jennings (PG&E)** |
| **Revision 4** | **04/18/2014** | **PGECOHVC125 R4 VSM Nonres v4.docx**  **Updated cost and energy savings values based on new weather data. Formatted workpaper to new template.** | **Curtis Lee (kW Engineering)** |

# Table of Contents

[At-A-Glance Summary i](#_Toc386034162)

[Work Paper Approvals ii](#_Toc386034163)

[Document Revision History iii](#_Toc386034164)

[Table of Contents iv](#_Toc386034165)

[List of Tables v](#_Toc386034166)

[*Section 1. General Measure & Baseline Data* 2](#_Toc386034167)

[1.1 Product Measure Description & Background 2](#_Toc386034168)

[1.2 Product Technical Description 2](#_Toc386034169)

[1.3 Measure Application Type 3](#_Toc386034170)

[1.4 Product Base Case and Measure Case Data 3](#_Toc386034171)

[1.4.1 DEER Base Case and Measure Case Information 3](#_Toc386034172)

[1.4.2 Codes & Standards Requirements Base Case and Measure Information 5](#_Toc386034173)

[1.4.3 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Info. 5](#_Toc386034174)

[1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases 5](#_Toc386034175)

[1.4.5 Time-of-Use Adjustment Factor 6](#_Toc386034176)

[1.5 Summary of Inputs for Savings Calculations 7](#_Toc386034177)

[*Section 2. Calculation Methods* 8](#_Toc386034178)

[2.1 Electric Energy Savings Estimation Methodologies 8](#_Toc386034179)

[2.2. Demand Reduction Estimation Methodologies 10](#_Toc386034180)

[2.3. Gas Energy Savings Estimation Methodologies 11](#_Toc386034181)

[*Section 3. Load Shapes* 11](#_Toc386034182)

[3.1 Base Case Load Shapes 11](#_Toc386034183)

[3.2 Measure Load Shapes 11](#_Toc386034184)

[*Section 4. Base Case & Measure Costs* 12](#_Toc386034185)

[4.1 Base Case(s) Costs 12](#_Toc386034186)

[4.2 Measure Case Costs 13](#_Toc386034187)

[4.3 Incremental & Full Measure Costs 14](#_Toc386034188)

[4.3.1 Gross Measure Costs 14](#_Toc386034189)

[4.3.2 Incremental Measure Costs 14](#_Toc386034190)

[Index 15](#_Toc386034191)

[References 16](#_Toc386034192)

# 

# List of Tables

[Table 1 - Measure Application Type 3](#_Toc387053051)

[Table 2 - Net-to-Gross Ratios 3](#_Toc387053052)

[Table 3 - TOU Adjustment Factors 6](#_Toc387053053)

[Table 4 - Baseline by Measure Application Type 7](#_Toc387053054)

[Table 5 - BIN Simulation Inputs and Assumptions 8](#_Toc387053055)

[Table 6 - Base Case Building Types and Load Shapes 10](#_Toc387053056)

# *Section 1. General Measure & Baseline Data*

## 1.1 Product Measure Description & Background

**Catalog Description**

* H182 Replacement Multiple-speed Brushless Permanent Magnet Blower Motors.

**PG&E Program Restrictions and Guidelines**

This work paper documents the rationale for the savings methodologies and assumptions for multiple-speed brushless permanent magnet blower motors as listed in the Heating, Ventilation and Air Conditioning (HVAC) Rebate Catalog. The HVAC Rebate Catalog is part of Pacific Gas and Electric Company’s Customer Energy Efficiency Program. PG&E offers incentives to non-residential customers for installing qualifying, high-efficiency equipment.

**Terms and Conditions:**

Requirements from Heating, Ventilation and Air Conditioning Rebate Catalog:

* Supply air blower with a new super-efficient direct replacement brushless permanent magnet blower motor with built-in controller must replace the existing permanent split capacitor motor.
* Motor must be 10 horsepower or less to be eligible for this rebate.
* Motor must be capable of plugging into existing control board.
* Rebate only available to customers residing in climate zones (CZ) 11, 12, 13, and 16.
* Installation address must have a commercial electric account with PG&E.
* A variable frequency drive (VFD) is not eligible for this rebate.

The rebate is downstream provided to the customer at the time of installation upon receipt of application and invoice. This is not a direct install program.

**Market Applicability:**

This measure is applicable to all non-residential buildings that are equipped with a central air conditioner system. Applicable business types include (but are not limited to) offices, restaurants, retail, school, colleges, hotels, motels, and recreational facilities.

## 1.2 Product Technical Description

Most existing small-scale commercial heating, ventilation and air conditioning (HVAC) blowers use low cost, low efficiency, single speed motors. These motors usually range in power between 0.3 hp and 2 hp. They turn on and off as required by thermostat control. This results in temperature variations and high energy consumption of the air handler motor.

Most major HVAC manufacturers are now offering variable-speed motor air handlers. These motors have integrated electronic controls that modulate the motor and fan speed based on the cooling or heating load of the system; they run at lower speed most of the time. These motors provide much more efficient operation, and improve the quality of the air distribution; however, they come at a price premium. Please note that variable speed motors are different from variable frequency drives (VFD); a VFD is an electronic drive added to a motor, while a multiple speed brushless motor is a motor with built-in speed-modulating capability.

This measure is designed to encourage the installation of such variable-speed motor air handlers in small commercial buildings. Because of the theoretical cubic relationship between fan power and fan speed, a small reduction in fan speed can result in large energy savings.

## 1.3 Measure Application Type

The DEER measure application types are defined in the table below:

Table 1 - Measure Application Type[[2]](#endnote-2)

*Identifies the measure application type in the Measure Implementation table in DEER2014.*

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ER | Early retirement | *Measure is more efficient than code/std; Dual baseline, full measure costs required* |
| ROB | Replace on Burnout | *Single baseline (above code), incremental or full costs* |
| NC | New Construction | *Single baseline (above code), incremental or full costs* |
| REA | Retrofit Add On | *Single baseline (above pre-existing), full measure costs required* |

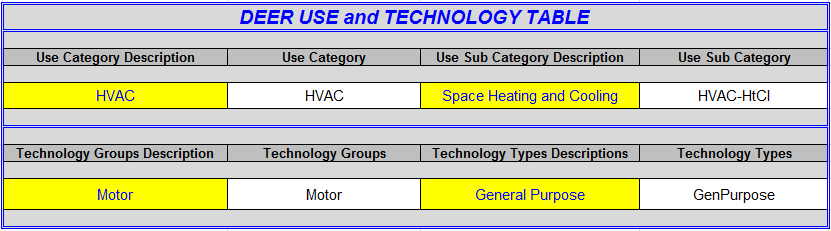
Measure H182 is applicable to commercial installations. The savings for all measures are calculated assuming that the installation is replace-on-burnout (ROB).

## 

## 1.4 Product Base Case and Measure Case Data

## 1.4.1 DEER Base Case and Measure Case Information

The DEER 2014 database does not contain an exact match for the multi-speed motor measure. The closest similar measure in DEER is for variable-frequency drives (VFDs), but the DEER measure for VFDs does not accurately represent the energy impacts for multi-speed motors applications. Therefore, custom temperature bin calculations have been used to estimate energy savings for multi-speed motors as explained in Section 2 of this workpaper. However, the DEER 2014 data does contain acceptable information for equipment-useful-life, net-to-gross, and in-service-rate for equipment and measures similar to measure H182.



**Net-to-Gross Assumption:**

Table 2 below summarizes all applicable DEER based Net-to-Gross ratios[[3]](#endnote-3) for programs that may be used by these measures.

Table 2 – DEER Net-to-Gross Ratios

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **DEER Spreadsheet** | |
| Program Approach | NTG | File name | Cell # |
| Com-Default>2yrs | 0.6 | Appendix C - DEER2014 NTGR | 47 |

The NTG Ratios in Table 2 are appropriate for the measures because:

* Measures are for commercial applications
* No evaluated NTGR available for this measure
* Equipment has the same delivery mechanism for more than two years

**Effective Useful Life:**

The Effective Useful Life estimates were downloaded from DEER[[4]](#endnote-4).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Building Type** | **Building Vintage** | **Climate Zone** | **EUL (yrs)** | **RUL (yrs)** | **DEER Version** | **EUL IDs** | **Description** |
| ALL | EX | PG&E | 15 | 5 | DEER2014 | Motors-fan | HVAC Fan Motors |

The EUL and RUL values in the table above are appropriate for the measures because:

* Measures are for commercial applications
* Measure description matches Use Category, Use Sub Category, and Tech Group

**In-service rate/first year installation rate:**

In-service rate was not found in DEER or any supporting documentation. We have therefore assumed that the ISR is 1.0 for all measures based on engineering judgment.

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

***Title 20:*** These measures do not fall under Title 20 of the California Energy Regulations.

***Title 24:*** These measures do not fall under Title 24 of the California Energy Regulations.

***Federal Standards:*** The Energy Independence and Security Act (EISA) 2007, effective December 19, 2010, mandates that motors manufactured or imported into the United States must meet at a minimum NEMA Premium™ Efficiency Levels. These levels are defined by the NEMA Standards Publication MG 1-2009, Revision 1-2010, Part 12, Page 35, Table 12-12 for motors 1 to 200 hp, design A&B. The standard applies to NEMA design A and B, integral horsepower, general purpose, ODP and TEFC motors (1200, 1800, and 3600 RPMs) from 1-200 hp.10

The applicable codes and standards for these measures do not dictate associated hours of operation, measure or baseline costs, EUL, NTG, or in-service rate for the equipment involved.

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

There are no M&V or other studies which apply to these measures. Information on the base and measure case is found in the sub-sections of 1.4.

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

The following assumptions from other sources were used to estimate savings.

**Energy Savings Assumption (ΔW):**

* Maximum cooling and heating loads were calculated based on climate-zone-specific design heating and cooling temperatures, obtained from the ASHRAE climatic design information.[[5]](#endnote-5)
* Proposed case fan speed is equal to the load on the heating or cooling coil as a percentage of total capacity on the heating or cooling coils. Multiple speed brushless fan motors are 10% more efficient than the base case based on a DOE document on variable speed motors.[[6]](#endnote-6)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **Interactive Only?**  **Yes / No** | **Electric Savings kW** | **Units** | **Reference** |
| ANY | EX | 6 | No | 0.240 | EA | Appendix A |
| ANY | EX | 8 | No | 0.292 | EA | Appendix A |
| ANY | EX | 9 | No | 0.116 | EA | Appendix A |
| ANY | EX | 10 | No | 0.036 | EA | Appendix A |
| ANY | EX | 11 | No | 0.036 | EA | Appendix A |
| ANY | EX | 12 | No | 0.051 | EA | Appendix A |
| ANY | EX | 13 | No | 0.036 | EA | Appendix A |
| ANY | EX | 14 | No | 0.036 | EA | Appendix A |
| ANY | EX | 15 | No | 0.036 | EA | Appendix A |
| ANY | EX | 16 | No | 0.116 | EA | Appendix A |

RUL savings are not applicable to this measure because this measure only covers ROB measure types.

**Hours of Operation**:

* The assumed hours of operation are based on a building operating schedule of 8AM to 6PM Monday through Friday.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Building type** | **Building Vintage** | **Climate Zone** | **Hours of Operation hrs/yr** | **Reference** |
| ANY | EX | 6, 8, 9, 10,11, 12, 13, 14, 15, 16 | 2,607 | N/A |

**Base Case Costs and Measure Case Costs**

The base and measure case costs were estimated based on a vendor survey performed in 2008. Inflation rates were applied to adjust costs to 2014 values.[[7]](#endnote-7)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **Costs ($)** | | |
| **Base Case** | **Measure Case** | **IMC** |
| ANY | EX | CZ6 | $1,543.89 | $1,893.45 | $349.56 |
| ANY | EX | CZ8 | $1,578.87 | $1,936.35 | $357.48 |
| ANY | EX | CZ9 | $1,670.30 | $2,048.48 | $378.18 |
| ANY | EX | CZ10 | $1,536.74 | $1,884.68 | $347.94 |
| ANY | EX | CZ11 | $1,615.44 | $1,981.20 | $365.76 |
| ANY | EX | CZ12 | $1,606.70 | $1,970.48 | $363.78 |
| ANY | EX | CZ13 | $1,461.21 | $1,792.05 | $330.84 |
| ANY | EX | CZ14 | $1,477.11 | $1,811.55 | $334.44 |
| ANY | EX | CZ15 | $1,562.18 | $1,915.88 | $353.70 |
| ANY | EX | CZ16 | $1,617.83 | $1,984.13 | $366.30 |

## 1.4.5 Time-of-Use Adjustment Factor

We are required by CPUC decision 06-06-063 dated June 29, 2006 to apply time-of-use (TOU) adjustment factors on residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. This measure has a DEER08 load shape, i.e. the load shape starts with “DEER:”, and the TOU adjustment factor assigned to that measure should be zero. See Section 3.1 for further detail regarding the load shape for this measure.

Table 3: TOU Adjustment Factors2

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure** | ***kWAC*** | ***kWTotal*** | **%** |
| Multiple Speed HVAC Fan Motors | 0 | 0 | 0 |

## 1.5 Summary of Inputs for Savings Calculations

The following sections provide the inputs for calculation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Base Case 1 Average Value** | **Base Case 2 Average Value** | **Measure Case Average Value** | **Reference Section** |
| **Electric Usage (kWh)** | CZ | 376.1 | N/A | 213.3 | *2.1* |
| **Gas Usage (Therms)** | CZ | N/A | N/A | N/A | *2.3* |
| **Hours of operation** | None | 2,706 | N/A | 2,706 | *1.4.4* |
| **Full Cost** | CZ | N/A | N/A | $354.80 | *4.3.1* |
| **Incremental Cost** | CZ | N/A | N/A | $354.80 | *4.3.2* |
| **EUL /RUL** | None | 15/5 | N/A | 15/5 | *1.4.1* |
| **NTG** | None | 0.6 | N/A | 0.6 | *1.4.1* |
| **ISR** | None | 1 | N/A | 1 | *1.4.1* |

# *Section 2. Calculation Methods*

**Table 4 - Baseline by Measure Application Type**

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period: Energy Savings Baseline** | **Second Baseline Period: Energy Savings Baseline** |
| ***ER* (early retirement)** | **RUL/EUL-RUL** | Customer Average Baseline | Code Baseline |
| ***ROB* (Replace on Burnout)** | **EUL** | Code Baseline | N/A |
| ***NC* (New Construction)** | **EUL** | Code Baseline | N/A |
| ***REA (retrofit add on)*** | **EUL** | Code Baseline | N/A |

Notes:

* For ROB, First Baseline is the baseline for the full EUL. There is no second baseline.

**H182 – Replacement Multiple-speed Brushless Permanent Magnet Blower Motors**

Qualifying supply air blower motors must replace permanent split capacitor motors. Motors must also be less than 10-hp and be capable of plugging into an existing control board. The controller must be set up to control the motor speed. This measure is only applicable for climate zones 6, 8, 9, 10, 11, 12, 13, 14, 15, and 16. Variable Frequency Drives (VFDs) are not included in this measure. DEER has no savings data available that matches these criteria. We have performed custom temperature bin calculations to estimate the savings for this measure.

## 2.1 Electric Energy Savings Estimation Methodologies

There are no DEER measures that match catalog measure H182. Therefore, we used customized weather temperature bin simulations to estimate energy savings. The following assumptions were made to estimate energy savings:

* The electric savings were estimated using customized weather bin simulations (Appendix G[[8]](#endnote-8)).
* Air handler fan was assumed to be operating to meet cooling and heating loads
* Cooling and heating loads were based on climate data and were assumed to vary linearly with outside air temperature.
* Base case fan runtime is equal to the load as a percentage of total capacity on the heating or cooling coils.
* Multiple Speed fan motors behave similarly to fan motors equipped with variable frequency drives.
* Assumed 0.5-hp air handler motor and a supply air flowrate of 500 cfm.[[9]](#endnote-9)

Table 5 – BIN Simulation Inputs and Assumptions



**∆kWh per kBTUh for H182:**

The energy savings (kWh per unit) for measure H182 is calculated using a weather temperature bin simulation. The following relationships between speed and energy consumption were used to determine baseline and measure case energy consumption. The energy savings is calculated as follows:

Where:

*= energy savings, kWh*

*= baseline energy consumption of the fan per temperature bin, kWh*

*= baseline energy consumption of the fan per temperature bin, kWh*

Baseline energy consumption for each temperature bin is estimated as follows:

Where:

*A = 0.21976, constant, determined from the CEC Guidebook*5*, no units*

*B = -0.8748, constant, determined from the CEC Guidebook*5*, no units*

*C = 1.65259, constant, determined from the CEC Guidebook*5*, no units*

*= baseline fan speed, % of nominal speed*

*HP = 0.5, fan horsepower, hp*

*C = 0.746, hp to kW conversion, kW/hp*

*PF = 0.80, assumed power factor, no units*

*= 0.77, baseline efficiency* *based on the NEMA efficiency tables**[[10]](#endnote-10), no units*

*AH = annual operating hours for temperature bin, hours*

The measure case energy consumption for each temperature bin is estimated as follows:

Where:

*= measure fan speed, % of nominal speed*

*= 0.85, measure case efficiency* *assuming a 10% efficiency increase6, no units*

**Example for H182:**

The baseline and measure energy consumption for one temperature bin is:

After summing energy consumption across all temperature bins, the energy savings is estimated as:

## 2.2. Demand Reduction Estimation Methodologies

There are no DEER measures that match catalog measure H182. Therefore, we used customized weather temperature bin simulations to estimate demand reduction. See below for further explanation.

**∆kW per kBTUh for H182:**

The demand reduction (kW per unit) for measure H182 is calculated using a weather temperature bin simulation. The following relationships between speed and energy consumption were used to determine baseline and measure case energy consumption. The energy savings is calculated as follows:

Where:

*= demand reduction, kW*

*= baseline maximum demand, kW*

*= measure maximum demand, kW*

The baseline demand for the highest temperature bin is estimated as follows:

The measure case demand for the highest temperature bin is estimated as follows:

**Example for H182:**

## 2.3. Gas Energy Savings Estimation Methodologies

There is no gas energy savings associated with this measure.

# *Section 3. Load Shapes*

## 3.1 Base Case Load Shapes

The closest load shape chosen for this measure is the DEER:HVAC\_Split-Package\_AC load shape. See Table 6 for a list of all Building Types and Load Shapes.

Table 6 - Base Case Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| ANY | NON\_RES | DEER:HVAC\_Split-Package\_AC |

## 3.2 Measure Load Shapes

There are no measure case load shapes applicable to this measure. The base case shapes are to be used in the cost avoidance calculation.

# 

# *Section 4. Base Case & Measure Costs*

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period Gross Measure Cost (RUL)** | **Second Baseline Period Gross Measure Cost (EUL – RUL)** |
| **NC** (New Construction) | EUL | Calculated as Incremental Measure Cost | N/A |
| **ROB** (Replace on Burnout) | EUL | Calculated as Incremental Measure Cost | N/A |
| **ER** (Early Retirement) | RUL/  EUL-RUL | Calculated as Full Gross Measure Cost | Calculated as Negative Full Gross Base Case Cost |
| ***REA (retrofit add on)*** | EUL | Calculated as Full Gross Measure Cost | N/A |

## 4.1 Base Case(s) Costs

The following Measure Application Types are appropriate to these measures. The Base Case Costs are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Measure Application Type** | **Baseline** | **Average Equipment Cost** | **Average Labor / Installation Cost** | **Maintenance / Other Cost** | **Average Total Base Case Cost** |
| H182 | ROB | Title 24 compliant 3-ton air handler | $1,567.02 | Included in Equipment Cost | $ N/A | $1,567.02 |

*All costs are noted as $ per unit*

The Base Case Costs for H182 were not available in DEER cost data. There is no DEER data available for this measure. The costs estimates were based on a survey of equipment performed among two HVAC installers, looking at three different air handler models, to assess the base cost of the measure. This cost survey was performed in April 2008 and was adjusted to account for inflation between 2008 and 2014.

Material and labor costs were not separated in the estimates from the HVAC installers. Therefore, the total installed cost of the equipment was multiplied by an average of the material and labor climate multipliers to account for cost variation in each climate zone. See below for further explanation.

**Base Case Costs for H182:**

The Base Case Costs ($ per kBTUh) for measure H182 is based on three cost estimates from two HVAC installers for single speed fan motors. Costs were averaged and adjusted for inflation.

Where,

BC = Base Case Cost, $

ABC = Average Base Case costs, $ per unit

CRI = 8.6, Cumulative Rate of Inflation from 2008 to 2014, %

**Example for H182:**

per unit

## 4.2 Measure Case Costs

The following Measure Application Types are appropriate to these measures. The Measure Case Costs are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Measure Application Type** | **Baseline** | **Average Equipment Cost** | **Average Labor / Installation Cost** | **Maintenance / Other Cost** | **Average Total Measure Case Cost** |
| H182 | ROB | Title 24 compliant 3-ton air handler | $1,921.82 | Included in Equipment Cost | $ N/A | $1,921.82 |

*All costs are noted as $ per unit*

The Measure Case Costs for H182 were not available in DEER cost data. There is no DEER data available for this measure. The costs estimates were based on a survey of equipment performed among two HVAC installers, looking at two different air handler models, to assess the measure cost of the measure. This cost survey was performed in April 2008 and was adjusted to account for inflation between 2008 and 2014.

Material and labor costs were not separated in the estimates from the HVAC installers. Therefore, the total installed cost of the equipment was multiplied by an average of the material and labor climate multipliers to account for cost variation in each climate zone. See below for further explanation.

**Measure Case Costs for H182:**

The Measure Case Costs ($ per kBTUh) for measure H182 is based on two cost estimates from two HVAC installers for variable speed fan motors. Costs were averaged and adjusted for inflation.

Where,

MC = Measure Case Cost, $ per unit

AMC = Average Measure Costs, $ per unit

**Example for H182:**

per unit

## 

## 4.3 Incremental & Full Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Full Measure Cost**  **(RUL Period/First Baseline)** | **Full Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
| ER | Measure Equipment Cost  +Measure Labor Cost | (-1)x(Base Equipment Cost  + Base Labor Cost) | Measure Equipment Cost  – Base Case Equipment Cost |
| ROB | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |
| NC | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |
| REA | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |

## 4.3.1 Full Measure Costs

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 Application Types is: **ROB,** so the Full Measure Cost (FMC) is represented by the equation below:

**FMC** = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

**Example:**

FMC = $1,921.82/unit - $1,567.02/unit = $ 354.80/unit

## 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 straightforward definition depending on the Measure Application type, the equation does vary.

This Measure Application Types is: **ROB,** so the Incremental Measure Cost (IMC) is represented by the appropriate equation below:

**IMC** = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

**Example:**

IMC = $1,921.82/unit - $1,567.02/unit = $ 354.80/unit

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Measure Application Types** | **Average Base Case Total Cost** | **Average Measure Case Total Cost** | **Average Full Measure Case Cost** | **Average Incremental Measure Cost** |
| H182 | ROB | $1,567.02 | $1,921.82 | $354.80 | $354.80 |

*All costs are noted as $ per unit*

# Index

DEER 12, 13

load shape 11

NEMA 9

New Construction 3, 8, 12

NTG Ratios 3, 4

Replace on Burnout 3, 8, 12

Title 20 5

Title 24 5

# References

1. Appendix A – Summary and Cost Savings PGECOHVC125 R4 [↑](#endnote-ref-1)
2. Appendix B – DEER2014 Measure Type [↑](#endnote-ref-2)
3. Appendix C – DEER NTG Values [↑](#endnote-ref-3)
4. Appendix D – DEER2014 EUL [↑](#endnote-ref-4)
5. Appendix E – 2009 ASHRAE Fundamentals Handbook – pages 14.18 and 14.19, Appendix: Design Conditions for Selected Locations. [↑](#endnote-ref-5)
6. Appendix F – Energy Consumption Characteristics of Commercial Building HVAC Systems - Volume III: Energy Savings Potential, July, 2002. [↑](#endnote-ref-6)
7. <http://www.usinflationcalculator.com/> [↑](#endnote-ref-7)
8. Appendix G – Energy Savings Calculations [↑](#endnote-ref-8)
9. Appendix H – Goodman Air Conditioning and Heating – Product specifications, Variable and Multiple-Speed Blowers – cooling capacity 1.5 to 5 tons. [↑](#endnote-ref-9)
10. Appendix I – National Electrical Manufacturers Association (NEMA) Nominal Full Load Efficiencies. [↑](#endnote-ref-10)