Work Paper SCE17HC028

**Revision 1**

**Southern California Edison**

**Brushless Fan Motor for Residential Central AC**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | AC-68273 |
| **Measure Description** | Central brushless fan motors (BFM or DC Motor) specifically configured to be a drop in (“like-for-like”) retrofit for standard permanent split capacitor (PSC) residential HVAC fan motors. |
| **Base Case Description** | Standard PSC residential HVAC fan motors. |
| **Units** | Cap-Ton |
| **Energy Savings** | Refer to Excel Calculation Attachment |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Effective Useful Life** | HV-ResRCx– 5 years  (Source: 5/2/2013 ED Disposition, Attachment 8) |
| **Measure Installation Type** | Replace on Burnout (ROB)  Early Retirement (RET/ER) |
| **Net-to-Gross Ratio** | 0.55. NTG ID: Res-Default>2 |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 02/02/2016 | Andres Fergadiotti/SCE | - New template update for 2016 program year  - WP effective from 1/1/2016 thru 12/31/2016  - Removed SCE building types  - No value modifications  - Language added on Multi-Family Energy Efficiency Rebate (MFEER) Direct Install Program Updated for reporting period, effective 01/01/2015 - 12/31/2015. |
| 1 | 6/01/2018 | Stephen Brett Reno/TRC | - New calculation template for 2017 program year  - This work paper is an update of SCE17HC028.0  - Removed Hard to Reach Install method  - Updated calculation methodology using eQuest (MASControl2) models and CTZ2010 weather data.  - Added RET/ER install type  - Updated Standard Case and Measure Case cost  - Added POE requirements to support AR/RET |
| 12/24/2018 | Jesse Manao/SCE | - Added AR measure net saving calculation with NTG adjustment factor post Resolution E-4952  - Updated DEER READi tool to version 2.5.1 |

# Commission Staff and Cal TF Comments

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

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

Measure Description: Central brushless fan motors (BFM or DC Motor) specifically configured to be a drop in retrofit for standard permanent split capacitor (PSC) residential fan (blower) motors serving central HVAC systems.

Base Case Description: Permanent split capacitor (PSC) residential fan motors serving HVAC system where fan performance (watts/cfm) varies between existing condition and code/standard.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Central brushless fan motors (BFM or DC Motor) |
| Existing Condition | Permanent split capacitor (PSC) residential fan (blower) motors |
| Code/Standard | Permanent split capacitor (PSC) residential fan (blower) motors |
| Industry Standard Practice | Permanent split capacitor (PSC) residential fan (blower) motors |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| N/A | N/A | AC-68273 | N/A | Central HVAC Brushless Fan Motor Replacing Permanent Split Capacitor (PSC) Motor |

This measure can be applied to all residential building types including SFM, MFM, and DMO that use central air-cooled direct expansion cooling and/or furnace HVAC equipment under all IOUs within respective territories (climate zones). The participant must have electricity distributed by applicable IOU to the installation service address. The following requirements must be met under the measure:

* HVAC system must be functional/operable and drawing power.
* HVAC system shall be capable of delivering a supply air flow rate of at least 350 cfm/ton.
* When serving central air-cooled DX HVAC system, unit must have a condenser over ambient temperature (COAT) of at least 3 degrees.
* Replacement BFM motor capacity and rated voltage shall match that of existing fan motor being replace.
* Replacement BFM motor and motor controls assembly shall be “UL Listed.”
* Replacement BFM motor shall have a warranty of at least 2 years from date of installation.
* Measure shall include HVAC system start-up. During the start-up, the installer shall ensure that system maintain programmed level airflows under both cooling and/or heating and that these are adequate.
* Installation (as applicable) shall comply with all applicable regulations including but not limited to California Energy Standards (Title-24), California Electrical Code, and NEC and local jurisdiction
* **Measure only supports HVAC (evaporator) fan motors with nominal capacities of ½-hp and/or less typically serving HVAC systems with nominal capacities of 3.5 ton (or less).**

The minimum 350 cfm/ton airflow requirement ensures that the refrigerant system can be properly diagnosed and charged as part of a maintenance service. If the system is not delivering 350 cfm/ton upon initial inspection, an assessment should be made to determine if the system will be able to deliver 350 cfm/ton by implementing repairs related to airflow. If it is determined that the supply fan and duct system in place do not have the capability to deliver at least 350 cfm/ton with or without airflow repairs, the savings in this work paper are invalid.

The measure applies to units with shaded pole or permanent split capacitor motors currently installed. As stated previously, the replacement 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.

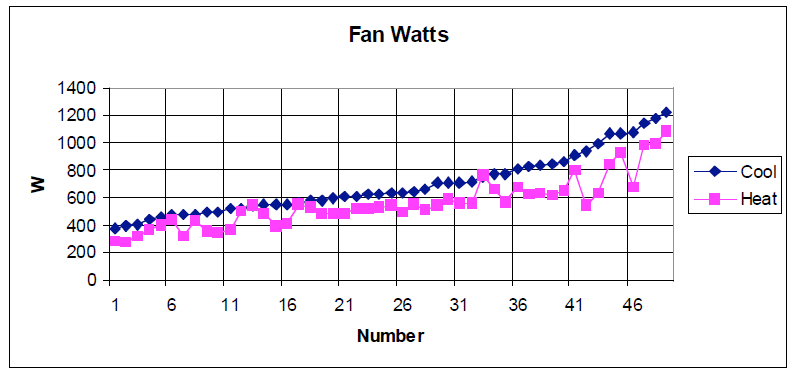
All early retirement measures (RET/ER) shall be supported by data collection procedures/requirements established in POE - Attachment 7. The Early retirement (RET/ER) offering is only allowed for the Direct Installed program with measure implementation supported by an approved Contractor.

## 1.2 Technical Description

**BFM compared to PSC Motor**

A BFM has several advantages over a PSC motor:

* PSC motors are typically used at two speeds, a cooling speed (high speed) and a heating speed (low speed).
* Since a BFM has a higher efficiency at its design rating point and is much more efficient at lower speeds than the PSC, it reduces fan watt draw and saves energy during both heating and cooling. It is also configured to produce the same airflow as the PSC motor it replaces, so these is no loss in performance.
* In cooling mode, a BFM rejects less heat into the airstream (heat that the air conditioner must remove). However, a BFM applied to a gas furnace produces a small increase in gas consumption since the heat normally rejected by the motor into the airstream must be provided by natural gas.
* In cooling mode, it recovers the moisture on the coil as sensible cooling at very low watt draw.
* The mode of operation where a furnace fan runs continuously (independent of compressor operation) is becoming more widespread in residences for the purposes of ventilation and/or added filtration. Therefore, more savings can be realized by the BFM because of these longer operating hours.
* Field tests conducted as part of the PIER Research for the 2008 Standards suggest a median cooling fan power draw of 632 watts for the California New Construction Field Test Furnace Fan Watt Draw – as shown in the figure below (Attachment 9). Other field data has shown median power draws around 510 watts per 1000 cfm (Attachment 10).



Fan Watt Draw – California New Construction Field Test Furnace Fan Watt Draw (Attachment 9)

For this work paper, a BFM is compared to a PSC as if they were both installed on identical systems (duct and furnace) at the same CFM and external static pressure.

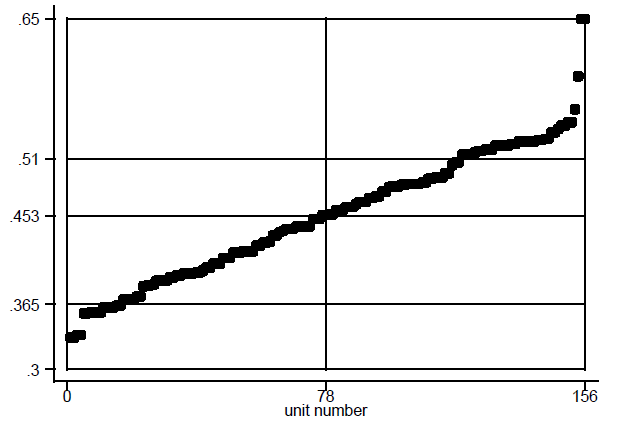
**BFM compared to Electronically Commutated Motor (ECM)**

Compared to an ECM motor the BFM with shut-off time delay has multiple advantages:

* Unlike an ECM motor, the BFM motor does not require a separate speed controller.
* Unlike an ECM motor, the BFM motor is available for retrofitting in existing furnaces.
* An ECM motor is controlled to attempt to produce a given airflow regardless of the amount of power required; on the other hand, a BFM motor is controlled to produce the same airflow as the PSC it replaces, resulting in significantly higher energy and peak savings. LBNL modeling indicates that an ECM motor controlled to produce a given airflow will increase watt draw on units with restrictive duct systems [360].
* A DOE report [361] projected a savings of 75% (three times the savings of an ECM) for a Brushless Motor that was tuned to the capacity of the air conditioner and furnace.
* A BFM motor costs less than an ECM motor.
* A BFM with shut-off time delay recovers moisture on the coil as sensible cooling. This recovery is extremely efficient because the BFM runs at low speed and very low watt draw during the recovery phase.

**2008 California Building Energy Standards Case Study (Attachment 9) - Analysis of Manufacturers’ Data**

* It analyzed manufacturers’ data for 156 model numbers with PSC motors that had the airflow and blower fan watt draw listed at high speed and 0.50 IWC external static pressure. The median power draw for these units was 453 watts per 1000 cfm as shown in the ‘Fan Watt Draw’ figure above.
* As shown in Figure below, the median power draw is substantially higher than the default 365 watts per 1000 cfm. The median power draw is also lower than the typical field measured power draw (510 watts per 1000 cfm).
* Field data show higher external static pressures around 0.80 IWC. The 146 units with manufacturers’ data for 0.80 IWC at high speed are displayed in figure below. The median is 496 watts per 1000 cfm, very close to the field measured 510 watts per 1000.



**High Speed PSC Air Handler/Furnace Power at 0.50 IWC External Static (Attachment 9)**

## 1.3 Installation Types and Delivery Mechanisms

The Program Delivery Method is “Financial Support Down-Stream Incentive - Deemed” and “Financial Support – Direct Install”.

The install types are Replacement on Burnout (ROB) and Early Retirement (RET/ER).

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |
| Early Retirement (RET/ER) | Above Customer Existing | Above Code or Standard | RUL | EUL-RUL |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

The brushless fan motor measure is not included in DEER 2018; thus, energy impacts are not based on DEER READI v2.5.1. The impacts were evaluated and estimated using the DEER (DOE2.3) SFM Residential prototypes. See calculation methodology Section 2 detailing ex-ante procedures for evaluating measure savings.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes |
| DEER Version | DEER READi v2.5.1 |
| Reason for Deviation from DEER | N/A |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI v2.5.1 tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| 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 |

In CPUC Resolution E-4952 – Section 5.4, it was determined that a net-to-gross adjustment factor for below-code savings for accelerated replacement measures are necessary. Recent “Energy Efficient Potential and Goals Study for 2018 and Beyond” (Potential Study) notes that savings for equipment has below-code savings that are already captured through codes and standards. In addition, Potential Study considers the possibility of free ridership in the below-code savings that occurs during the remaining useful life of the early removed equipment. Therefore, the above-code and to-code portion of the savings require separate treatment in the NTG determination (Figure A). It was established that an adjustment of 0.75 for accelerated replacement measures be applied to the below-code portion of savings.

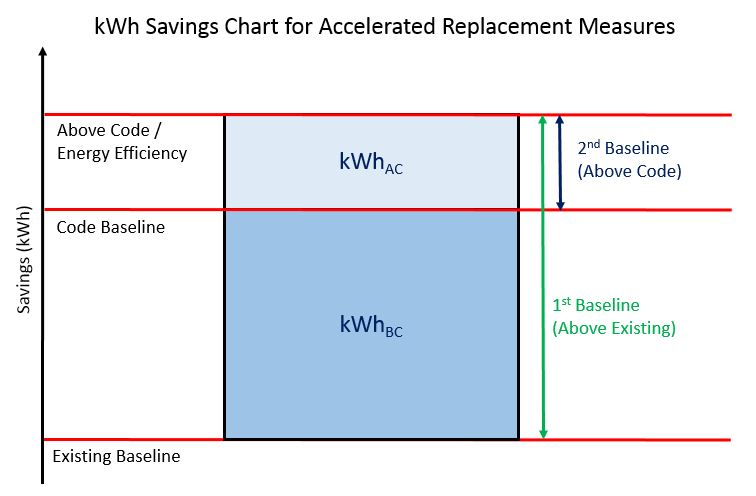


Figure A. AR Measure Savings Chart

Below is an example of a net savings calculation where the adjustment factor is applied to the below-code savings for Solution Code AC-68273 in building type “Residential Multi-Family” in climate zone 9.

Post E-4952 Calculation of Net Savings:

|  |  |
| --- | --- |
| Net 1st Baseline kWh | = (kWhAC \* NTG)+ (kWhBC \* NTG \* NTGBC) |
|  | = (57.98 kWh \* 0.55) + (14.10 kWh \* 0.55 \* 0.75) |
|  | = (57.98 kWh \* 0.55) + (14.10 kWh \* 0.41) |
|  | = 31.89 kWh + 5.78 kWh |
|  | **= 37.67 kWh** |

where, kWhAC = Kilo-Watt-Hour for above-code savings

kWhBC = Kilo-Watt-Hour for below-code savings

NTG = Net-to-Gross

NTGBC = Net-to-Gross for Below Code Savings

**Spillage Rate**

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

**Installation Rate**

The IR values were obtained using the DEER READI v2.5.1 tool. The relevant IR values for the measures in this work paper are in the table below.

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

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using Commission Staff guidance. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET/ER measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

The 5/2/13 ED Disposition for Residential HVAC Quality Maintenance [367] specified a EUL of 5 years for the following reason:

*“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 a direct expansion HVAC system, or 5 years.”*

Table below identifies the value used for the measures in this work paper.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HV-ResRCx | Residential HVAC assessment report & maintenance contract | Residential | Service | 5 | 1.67 |

### 1.4.2 Codes and Standards Analysis

Title 24 (2016) Section 150.0(m)13.B [496] states the following regarding airflow:

**B. Single Zone Central Forced Air Systems.** Demonstrate, in every control mode, airflow greater than or equal to 350 CFM per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy less than or equal to 0.58 W/CFM as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

The California 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.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | Section 150.0(m)13.B California  Mechanical Code  California Electrical Code | January 1, 2017 |

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

### 1.5.1 Non-DEER Study Review

1. A PIER report, “Characteristics and Opportunities for New California Homes” (Attachment 4), determined the average blower motor power for 45 HVAC systems with PSC motors to be 0.650 Watts/CFM. READI assumptions consistent with this referenced report are 0.650 Watts/CFM to represent the base case with a PSC motor and 0.365 Watts/CFM (the DEER default assumption) to represent the measure case with a BPM motor.

The PIER report additionally recommends that the 2013 revision of the Title 24, part 6, residential efficiency standard (Title 24–2013) should make mandatory a confirmed airflow greater than or equal to 400 CFM per ton and a fan watt draw less than or equal to 0.510 watts per CFM.

2. Fan Watt Draw and Air Flow - 2008 California Building Energy Efficiency Standards Furnace Fan Watt Draw and Air Flow in Cooling and Air Distribution Modes (Attachment 9).

# Section 2. Calculation Methodology

Energy savings and demand reductions are calculated using eQuest 3.65, DOE version 2.3. MASControl2 was used to generate DEER prototype for a single family residential building (SFM). Measure evaluated included Building Energy Simulation models for existing case, standard case, and measure case. The models differed primarily in fan-power parameters and characteristics as describe hereafter.

Savings from SFM (on a per ton basis) are mapped without adjustments to other residential building types – MFM and DMO. Equipment (fan) runtime between Residential prototypes (at same vintage and operating characteristics) was evaluated to ensure that fan runtime is consistent among all Residential prototypes and that SFM fan runtime does not significantly exceed that from MFm and DMo.

The eQuest models were simulated for all the 16 climate zones to estimate electric energy (kWh/yr) and demand savings (kW/yr). Hourly reports were generated to estimate DEER peak demand reduction for each climate zone based on DEER2014 peak demand definition.

Measure savings on heating (therms) were evaluated but not documented (e.g., zero out) in ex-ante measure implementation report. Most savings on heating (therms) were nearly zero but negative suggesting a marginal increase on ventilation by the energy model, perhaps, inducing a slightly increase on heating load.

The energy savings and peak demand are normalized based on the average system cooling capacity of 2.71 tons to match characterized cooling capacity by the SFM DEER prototype. Refer to Attachment 1 for energy impacts.

Per previous Energy Division guidance (Attachment 8), efficiency levels supported by measure are only allow for motors with capacities of ½ hp or less [367]. Further, efficiency levels between PSC and BPM ¾ hp motors are assumed to produce half the savings claimed in workpapers. The PSC and BPM 1hp motors are assumed to operate at the same efficiency.

### 2.1.1 Building Energy Simulation Parameters

Measure savings documented herein were evaluated using latest SFM DEER prototype. General building energy simulation characteristics are summarized below.

|  |  |
| --- | --- |
| **Weather** | CZ2010 |
| **Prototype** | SFM DEER/MASControl2 |
| **Vintage** | 2007 (Single Vintage) |
| **MASControl** | SFm-wCZ10-v2007-rDXGF-lt45S14.pd2 (Sample File) |
| **Total COOLING-CAPACITY** | Prototype design capacity 10.84 ton,  System design (average) capacity: 2.71 tons |
| **Fan Power Demand (kW/hp)** | 0.613 kW/0.822 hp at 1.70 static pressure (average)  Source: SV-A System Design Parameters report |

Key input parameters supporting evaluation of measure are summarized below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **DOE2 Key Word** | **SUPPLY-KW/FLOW** | **SUPPLY-MTR-CLASS** | **FAN-EIR-FPLR** | **Motor Technology\*** | **Source** |
| Existing | 0.000632 | Standard | Residential Fix Vol-Fan EIR | PSC | 2008 T24 Case Study, based on median cooling fan power drawn under referenced California new construction field test furnace fan watt drawn [363] |
| Standard | 0.000580 | Prem Eff | TwoSpeedFan | PSC | 2016 T24 Standard [496] |
| Measure | 0.000365 | High Eff | Variable Speed Drive FPLR | ECM | 2008 T24 Case Study’s field test assumptions [363] |
| **Parameter Description** | | | | | |
| **SUPPLY-KW/FLOW** | Design full-load power of the supply fan per unit of supply air flow rate. | | | | |
| **SUPPLY-MTR-CLASS** | Motor class | | | | |
| **FAN-EIR-FPLR** | Takes the U-name of a linear, quadratic, or cubic curve that gives the ratio of fan electric energy to full-load fan electric energy, as a function of part-load ratio. | | | | |

\* Expected motor Technology at indicated (kW/CFM) performance characteristics.

Other parameters including mechanical efficiency of the supply fan (e.g., SUPPLY-MECH-EFF) were kept constant between all cases. Measure’s energy (kWh) and demand (kW) savings, normalized in terms of kWh/ton and kW/ton, are mapped to other applicable residential building types including MFM and DMO.

Building Energy Simulation files used for evaluating measure are packaged as part of Attachment 3.

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shape that is applicable to the measure in this work paper is listed in the table below.

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Residential Single Family | DEER: Res:HVAC\_Eff\_AC | RES |

# Section 4. Costs

Given measure implementation seen by SCE’s Programs in previous years, the vast majority of projects supported replacement and installation of ½ hp motors. Hence, cost documentation below is based on ½ hp (nominal capacity) motor.

Cost information is normalized based on SFM DEER’s prototypes average system capacity of 2.71 tons.

## 4.1 Base Case Cost

The base case equipment cost is estimated to be $112.88 for a ½ hp permanent split capacitor motor. Each case (base and measure) was assigned 6 samples across 3 manufacturers from 2018 grainger.com to estimate standard market prices (Attachment 6).

Labor for installation of a blower motor (PSC or DC) was determined to be $92.32, based on RSMeans electrical cost data 2018 [513]. The labor cost was calculated by multiplying the measure’s associated crew labor hourly cost including O&P ($83.10) by its estimated labor hours (1.111).

|  |  |  |
| --- | --- | --- |
| **Cost Type** | **½ hp Fan Motor Costs**  **($)** | **Costs Normalized to 2.71 ton Unit**  **($/ton)** |
| Equipment | $112.88 | $41.65 |
| Labor | $92.32 | $34.07 |
| Total | $205.20 | $75.72 |

## 4.2 Measure Case Cost

The base case equipment cost is estimated to be $112.88 for a ½ hp permanent split capacitor motor. Each case (base and measure) was assigned 6 samples across 3 manufacturers from grainger.com to estimate standard market prices (Attachment 6). Prices were gathered in Quarter 2 of 2018.

Labor cost for the measure case was determined to be equal to labor cost for the base case ($92.32).

**Measure Case Costs**

|  |  |  |
| --- | --- | --- |
| **Cost Type** | **½ hp Fan Motor Costs**  **($)** | **Costs Normalized to 2.71 ton Unit**  **($/ton)** |
| Equipment | $502.00 | $185.24 |
| Labor | $92.32 | $34.07 |
| Total | $594.32 | $219.31 |

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

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

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

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

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost (per Ton)** | **Full Measure Cost (per Ton)** | |
| **1st Baseline** | **2nd Baseline** |
| AC-68273 | ROB | $143.59 | $143.59 | N/A |
| AC-68273 | RET/ER | $143.59 | $219.31 | $143.59 |

# 

# Attachments

1. SCE17HC028.1 A1 - Calculation Template.xlsm
2. SCE17HC028.1 A2 – Hourly Savings Calc.xlsm
3. SCE17HC028.1 A3 – eQuest Models
4. SCE17HC028.1 A4 – PIER Efficiency Characteristics and Opportunities
5. SCE17HC028.1 A5 – Packaged Rooftop Air Conditioners Precedent
6. SCE17HC028.1 A6 - Cost Calculations
7. SCE17HC028.1 A7 – BFM Data Gathering Requirements & DOE.docx
8. SCE17HC028.1 A8 – Workpaper Disposition for Residential Quality Maintenance
9. SCE17HC028.1 A9 - 2008 T24 Fan Watt Draw and Air Flow
10. SCE17HC028.1 A10 - Hidden Power Drains-Res Htg and Cool Fans Pwr

# References

1. References\_05092018\_135230.xlsx

[360]

[361]

[363]

[367]

[496]

[513]