Work Paper SCE13HC050

**Revision 2**

**Southern California Edison**

**Variable Speed Drive on HVAC Fan Control**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | AC-97352 |
| **Measure Description** | Install a variable frequency drive and associated controls on an existing constant speed HVAC supply or return fan. |
| **Base Case Description** | Source: DEER2014, Legacy Measure ID: D03-051  The baseline fans are simulated as forward curved fans with discharge dampers [26]. |
| **Units** | Per fan motor HP |
| **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** | 15 years (DEER EUL ID: HVAC-VSDSupFan) |
| **Measure Installation Type** | Retrofit Add-on (REA) |
| **Net-to-Gross Ratio** | 0.6 (DEER NTGR ID: Com-Default>2yrs)  0.85 (DEER NTGR ID: Com-Default-HTG-di) |
| **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 | 1/14/14 | Brian V. O’Keefe/SCE | -New template for 2015 program year. |
| 1 | 7/10/14 | Bach Tsan/SCE | -Adapted PG&E WP to SCE template  -Used DEER 2014 savings |
| 2 | 1/28/16 | Ryan Cho/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 |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
|  |  |  |  |  |  |

Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This measure involves the installation of a variable speed drive (also called a variable frequency drive, VFD) and associated controls on a motor driving a ventilation fan.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Install a variable frequency drive and associated controls on an existing constant speed HVAC supply or return fan. |
| Existing Condition | Source: DEER2014, Legacy Measure ID: D03-051  The baseline fans are simulated as forward curved fans with discharge dampers [26]. |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | AC-97352 |  | Variable Speed Drive on HVAC Fan Control |

**Measure Requirements**

* VFD must be applied to existing HVAC supply or return air fans only.
* Throttling devices, such as inlet vanes or bypass dampers and throttling valves, must be removed or permanently disabled.
* Fans must be ≤ 100 hp.
* Replacement multiple-speed or variable speed motors (VSM) are not eligible.
* VFDs on cooling towers fans are not eligible.

## 1.2 Technical Description

## Energy usage in constant-speed HVAC systems can be reduced by installing electronic VFDs on ventilation fans. VFDs are a more efficient method of regulating speed or torque than throttling valves, inlet vanes, and fan dampers. Installing a VFD on the fan motor will enable the fan to slow down more efficiently whenever the building load allows it, saving fan energy. Due to the fan affinity laws, a small reduction in fan speed results in significant energy savings.

## 1.3 Installation Types and Delivery Mechanisms

The delivery methods for this workpaper are:

* Financial Support Downstream Incentive – Deemed
* Financial Support – Direct Install
* Partnership Downstream Incentive – Deemed
* Partnership Direct Install.

The Program Type for this workpaper is REA (Retrofit Add-on)

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Retrofit Add-on (REA) | Above Customer Existing | N/A | EUL | N/A |

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

**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. |
| Partnership | The program implements projects through a partnership between the utility and an institutional, government, or community-based organization. |

**Incentive Method Descriptions**

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

## 1.4 Measure Parameters

### 1.4.1 DEER Data

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | Yes |
| DEER Measure Case | Yes |
| DEER Building Types | Yes |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | DEER 2014 |
| Reason for Deviation from DEER | No Deviation |
| DEER Measure IDs Used | D03-051 |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI 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** |
| Com-Default-HTR-di | All other EEM with no evaluated NTGR; direct install to hard-to-reach only. | Com | Any | DirInstall | 0.85 |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | Any | 0.6 |

Direct install measures that are not hard-to-reach will use the default NTG value.

This work paper includes measures that are offered via direct install activities into hard-to-reach (HTR) customer facilities. “Final Resolution E-4700”, dated December 18, 2014, defines specific criteria to classify customer facilities as HTR and also states that two criteria are sufficient to identify HTR customers if one of the criteria met is the geographic criteria.

SCE’s Commercial Direct Install program delivers free and low cost energy efficiency hardware retrofits through installation contractors to reduce peak demand and energy savings for small and medium commercial customers. The barriers for customer participation include limited capital resources, lack of expertise and understanding of the understanding of the benefits of energy efficiency, a suspicion of the “free offer” and its legitimacy, and language and cultural barriers. The program also addresses the ongoing concern with “split incentives”, where the customer is not the owner of the property, and therefore, lack incentive to improve their energy usage. SCE’s Commercial Direct Install program will track the following three (3) customer data points to identify direct install activities in HTR customer facilities. If geography and business size criteria are satisfied, SCE will identify the customer as HTR. If geography and language criteria are satisfied, SCE will identify the customer as HTR. Other measures in the Commercial Direct Install program will receive default NTG (NTGR\_ID: Com-Default>2), unless otherwise specified in DEER.

o **Business Size** – Customer must have less than ten employees

o **Language** – Customer’s primary language spoken is not English

o **Geography** – Businesses in areas other than the United States Office of Management and Budget (OMB) Combined Statistical Areas (CSA) of the San Francisco Bay Area, the Greater Los Angeles Area and the Greater Sacramento Area or the OBM metropolitan statistical areas or San Diego County

The “Required Corrections to Measure Level Input Parameters Identified by Commission Staff per D.14-10-046 Order Paragraph 16”, dated November 3, 2014, includes additional clarification for the geographic criteria:

“Notes on OMB CSA designations:

The OMB has designated a 12-county CSA titled the San Jose-San Francisco-Oakland, CA Combined Statistical Area which includes the nine counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma which border the San Francisco Bay plus the three counties of San Joaquin, Santa Cruz, and San Benito that are economically tied to the nine counties that that border the San Francisco Bay.”

The OMB definition of this CSA includes Los Angeles, Orange, San Bernardino, Riverside and Ventura counties.

The OMB definition of this CSA includes Sacramento, Yolo, El Dorado, Placer, Sutter, Yuba, and Nevada counties.”

**Spillage Rate**

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

**Installation Rate**

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

Please note that since this measure is a retrofit add on onto an existing system the RUL of the existing system is used as the EUL for the measure

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HVAC-VSDSupFan | VSD Supply Fan Motors | Com | HVAC | 15 | 5 |

### 1.4.2 Codes and Standards Analysis

**Title 20:** This measure does not fall under Title 20 of the California Energy Regulations.

**Title 24:** This measure falls under Title 24 of the California Energy Regulations. Under this regulation, the following is required to meet prescriptive compliance:

1. DX [>=75,000 Btu/hr] and chilled water [>=1 HP] cooling systems that control the capacity of the mechanical cooling directly based on occupied space temperature shall (i) have a minimum of 2 stages of fan control with no more than 66 percent speed when operating on stage 1; and (ii) draw no more than 40 percent of the fan power at full fan speed, when operating at 66 percent speed.
2. All other systems, including but not limited to DX cooling systems and chilled water systems that control the space temperature by modulating the airflow to the space, shall have proportional fan control such that at 50 percent air flow the power draw is no more than 30 percent of the fan power at full fan speed.
3. Systems that include an air side economizer to meet 140.4(e)1 shall have a minimum of two speeds of fan control during economizer operation.

However, installing a VFD is not required to meet performance compliance of the 2013 Title 24 regulations, nor is it a mandatory measure.

**Federal Standards:** This measure does not fall under Federal DOE or EPA Energy Regulations.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2013) | Section 140.4(c) & (e) | July 1, 2014 |

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

N/A

## 1.6 Data Quality and Future Data Needs

N/A

# Section 2. Calculation Methodology

The following table indicates which measures are taken directly from or created with the DEER READI tool.

READI Data Used

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **Measure Name** | **READI Data** |
| AC-97352 | Variable Speed Drive on HVAC Fan Control |  |

# 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 shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Education – Secondary School | DEER:HVAC\_Split-Package\_AC | NON\_RES |
| Education – Community College | DEER:HVAC\_Split-Package\_AC | NON\_RES |
| Education – University | DEER:HVAC\_Split-Package\_AC | NON\_RES |
| Health/Medical – Hospital | DEER:HVAC\_Split-Package\_AC | NON\_RES |
| Health/Medical – Nursing Home | DEER:HVAC\_Split-Package\_AC | NON\_RES |
| Lodging - Hotel | DEER:HVAC\_Split-Package\_AC | NON\_RES |
| Office – Large | DEER:HVAC\_Split-Package\_AC | NON\_RES |
| Retail – Multistory Large | DEER:HVAC\_Split-Package\_AC | NON\_RES |

# Section 4. Costs

## 4.1 Base Case Cost

For REA measures, the base case cost is zero.

## 4.2 Measure Case Cost

The measure cost is from the DEER 2008 cost table [215] for cost case ID “D08-NE-HVAC-VSDSupFan-ge10HP”: $176.68.

The per-hour labor rates were updated in DEER 2011. The “LaborRate” table in the DEER2014 database provides an hourly labor rate for the installation of HVAC equipment as $67.88. However, the labor cost needed to be normalized to a cost per horsepower (hp) value. The average labor hours per VFD hp was estimated using the total labor hours by VFD hp size provided in 2014 RS Means Mechanical Cost Data [413]. By multiplying the average labor hours/hp by the labor cost/hour, the normalized labor cost/ VFD hp is $84.94. This calculation is in Attachment 1, tab “Normalized Labor Cost.”

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

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

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** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| AC-97352 | REA | $261.62 | $261.62 | N/A |

# Attachments

1. 

# References



|  |  |
| --- | --- |
| [26] | 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study - Final Report - Itron Inc. - Dec. 2005 |
| [215] | Revised DEER Measure Cost Summary |
| [413] | RS Means Mechanical Cost Data 2014 Book |