**Work Paper SCE13HC050**

**Revision 1**

**Southern California Edison Company**

**Variable Speed Drive on HVAC Fan Control**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable 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]. |
| **Energy Impact Common Units:** | Per fan motor HP |
| **Energy Savings :** | Refer to Excel Calculation Attachment |
| **Gross Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Measure Incremental Cost ($/unit):** | Refer to Excel Calculation Attachment |
| **Effective Useful Life (years):** | EUL ID HVAC-VSDSupFan: 15 years |
| **Measure Application Type:** | Retrofit Add On (REA) |
| **Net-to-Gross Ratios:** | Com-Default>2yrs: 0.6  Com-Default-HTG-di: 0.85 |
| **Important Comments:** | **This work paper document does not contain a data set in conformance with the 4/1/14 CPUC Ex Ante Database Specification; SCE will provide that data set separately.** |

# Document Revision History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Workpaper and Revision # | Tech. Revision | MM/DD/YY | Author/Affiliation | Summary of Changes |
| SCE13HC050.0 | No | 1/14/2014 | Brian V. O’Keefe/SCE | -New template for 2015 program year. |
| SCE13HC050.1 | Yes | 7/10/2014 | Bach Tsan/SCE | -Adapted PG&E WP to SCE template  -Used DEER 2014 savings |

# 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.

Table 1 Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| 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 Measure Application Type

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)

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

The energy savings in this work paper are taken directly from DEER Measure ID D03-051.

Table 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | No |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | No |
| Deviation from DEER | No |
| DEER Version | DEER14 |
| DEER Run ID and Measure Name (Sample) | D03-051 |

**Net to Gross**

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 5 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [351]. The relevant NTGR for this measure is shown in Table 3 below.

Table 3 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| 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 | All | 0.6 |
| Com-Default-HTG-di | All other EEM with no evaluated NTGR; direct install to hard-to-reach only. | Com | Any | DirInstall | 0.85 |

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

Note that for the direct install delivery mechanism, a distinction between hard to reach and non-hard to reach markets will be made on a project by project basis. This work paper shows the NTG associated with a hard to reach direct install delivery mechanism and the non-residential defaulted NTG value, where in fact, a measure offered through direct install and is not “hard to reach” will receive a default NTG value.

**Installation Rate**

The installation rate (IR) is identified in the calculation attachment. This value is obtained from the support table available in READi. Currently there is no versioning on the installation rate table. To address appropriate selection of the installation rate the date of the workpaper will serve as the last date checked for updated IR values. The installation rate varies by end use, sector, technology, application, and delivery method. The relevant IR values for this measure are shown in Table 4 below.

Table 4 Installation Rate

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

**Spillage Rate**

Spillage rate will also be applied to measures however the values will not be tracked in the workpapers. The spillage rate will be tracked in an external table to be supplied to the Energy Division.

**READi Technology Fields**

To support the development of the ED ex ante tables, select fields from the ex ante database will be identified in the workpaper. For a full set of values associated with the measures in the workpaper refer the Excel calculation template.

Table 5 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this workpaper |
| Measue Case UseCategory | HVAC |
| Measure Case UseSubCats | Ventilation and Air Distribution |
| Measure Case TechGroups | HVAC Air Distribution |
| Measure Case TechTypes | HVAC Ventilation Fan - General Purpose Motor |
| Base Case TechGroups | HVAC Air Distribution |
| Base Case TechTypes | HVAC Ventilation Fan - General Purpose Motor |

### 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.

Table 6 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | Section 140.4(c) & (e) | 7/1/2014 |

### 1.4.3 Non-DEER Study Review

There were no specific EM&V studies used or reviewed in the preparation of this workpaper that did not come from DEER or from code.

### 1.4.4 Measure and Base Case Effective Useful Life

DEER14 update documentation provides EUL and RUL information to be used for the 2013-14 program cycle on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “DEER2014-EUL-table-update\_2014-02-05.xlsx” provides the RUL value as a flat 1/3 of the EUL value. The RUL value will only be applied to the first baseline period for retrofit measures that have applicable code that will affect the energy savings. In all other installation types and retrofit with no applicable code that affects the energy savings, the RUL is not applicable to either the first or second baseline period.

To obtain the EUL value the DEER14 update documentation, “DEER2014-EUL-table-update\_2014-02-05.xlsx” [436], was consulted. Table 7 below identifies the value/methodology used for the measures in this work paper.

Table 7 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| HVAC-VSDSupFan | Non-Residential | HVAC | VSD Supply Fan Motors | 15 | 5 |

# Section 2. Energy Savings & Demand Reduction Calculations

Table 8 contains the data files for measures that are taken directly from the DEER 2014 READi Tool or were created using the READi Tool. These results have not been modified and are only being included in the workpaper for reference.

Table 8 READi Tool Outputs

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Name | READi Results |
| AC-97352 | Variable Speed Drive on HVAC Fan Control |  |

All energy savings values are taken directly from D03-051 without adjustment. See Attachment 1 for all savings.

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# 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\_Split-Package\_AC load shape. See Table 9 for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

Table 9 Building Types and Load Shapes

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

# Section 4. Base Case & Measure 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.”

Table 10 Measure Cost

|  |  |  |
| --- | --- | --- |
| Equipment Cost ($ per VFD) | Labor/Installation Cost  ($ per VFD) | GMC/IMC  ($ per VFD) |
| $176.68 | $84.94 | $261.62 |

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost

The Gross Measure Cost (GMC) for REA measures is the full measure cost indicated in Table 10.

### 4.3.2 Incremental Measure Cost

The Incremental Measure Cost (GMC) for REA measures is the same as the gross measure cost indicated in Table 10.

# Attachments

1. 

# References



|  |  |
| --- | --- |
| [26] | 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study - Final Report - Itron Inc. - Dec. 2005 |
| [31] | Load Shape Update Initiative - KEMA / JJ Hirsch and Assoc. / Itron Inc. - November 17, 2006 |
| [215] | Revised DEER Measure Cost Summary |
| [351] | Energy Efficiency Policy Manual-Version 5 |
| [413] | RS Means Mechanical Cost Data 2014 Book |
| [436] | 2014 DEER EUL Table - Update |

# Appendix A – SCE/ED Application Types

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SCE Program Type | ED Application Type | 1st Baseline Savings | 2nd Baseline Savings | 1st Baseline Cost | 2nd Baseline Cost | 1st Baseline Life | 2nd Baseline Life |
| New | New Construction (Nc) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Replace on Burnout (ROB) | Replace on Burnout (Rob)/Normal Replacement (NR) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Retrofit (RET) | Early Replacement (ER) | Above Cust. Existing | Above Code/Standard | Full Cost | Incremental Cost | RUL | EUL-RUL |
| Retrofit – First Baseline Only (REF) | Early Replacement RUL (ErRul) | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |
| Retrofit Add-on (REA) | N/A | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |