Work Paper SCE13HC040

**Revision 2**

**Southern California Edison Company**

**Cogged V-Belt Non-Residential HVAC Fans**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Solution and Measure Codes:**** | PG&E: SA13 - HVAC Fans Cogged V-belt Replacement for Gas packs,  SA14 - HVAC Fans Cogged V-belt Replacement for Heat Pumps,  SA15 - HVAC Fans Cogged V-belt Replacement for Packaged VAV  SCE: AC-46275 - HVAC Fan Cogged V-Belt replacing Smooth V-Belt |
| **Measure Description:** | The replacement of smooth V-belts in non-residential package rooftop HVAC systems with cogged V-belts |
| **Base Case Description:** | Typical existing smooth fan belts |
| **Units:** | per ton |
| **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:** | 2.7 to 5 years, depending on building type - EUL ID: HV-CoggedBelt (Not available for all building types) |
| **Measure Application Type:** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratio:** | 0.85 - NTG ID: Com-Default-HTR-di or 0.6 - NTG ID: Com-Default>2yrs |
| **Important Comments:** | “OTR”-This code stands for “Other” building type and it is only used when the customer doesn’t select a building type in the application or the building type doesn’t fall under any of the DEER approved building types. “OTR” building type savings are calculated using the "minimum kwh savings row" of valid DEER building types. If all kwh are zero, use minimum kw row. If all kwh and kw are zero, use minimum therm. For a lighting measure with all building types, the “MTL” building type will be equivalent to OTR because it is the lowest hours of operation. This is a PG&E Administrative type, additional to any DEER types listed.  **This work paper document does not contain a data set in conformance with the 4/1/2014 Ex Ante Database Specification provided by the California Public Utilities Commission (CPUC) Commission Staff (CS); SCE will provide that data set separately.**  Note that DEER does not support EUL IDs on all building types addressed in workpaper as of 3/202/015.  Further, it has been requested from ED on 03/20/2015 that all building types supported in this workpaper are added to corresponding EUL ID in READI. |

Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | Revision Date | Author (Affiliation) | Summary of Changes |
| 0 | 4/19/2012 | Janice Peterson, PECI | Original work paper for 2013 PC |
| 1 | 4/14/2014 | Matt Tyler, PECI | -Work paper updated for the reporting period, effective 7/1/14 – 12/31/14.  Updated energy and demand savings using updated weather files, included all 16 climate zones, additional building types added |
| 2 | 2/4/2015 | Nick Bengtson, CLEAResult | -Workpaper updated to include Grocery and Lodging – Motel building types.  - Updated Table 6 Technology Fields |

# Section 1: General Measure & Baseline Data

This state-wide work paper for SCE and PG&E territories details the replacement of smooth v-belts in non-residential unitary (packaged) rooftop HVAC systems and split system HVAC units with cogged v-belts as shown in Table 1 and Table 2. The base case is a rooftop unit (RTU) that contains one or more smooth v-belts. The measure replaces them with new cogged (notched) v-belts. The savings are calculated for 21 building types and three system types in all California climate zones. The PG&E measures specify three applicable system types: gas packs, unitary AC-only, and heat pumps. The SCE measure does not specify system type. The savings are based on only the electric portion of the gas pack system type.

## 1.1 Measure Description & Background

**Measure Description:** This measure is the replacement of smooth v-belts with cogged v-belts in nonresidential package rooftop HVAC systems. The downstream rebate is provided to the contractor or customer at the time of installation and upon receipt of application and invoice.

**Basecase Description:** Typical existing smooth fan belts.

Table 1 PG&E Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| SA13 | HVAC Fans Cogged V-belt Replacement for Gas Packs |
| SA14 | HVAC Fans Cogged V-belt Replacement for Heat Pumps |
| SA15 | HVAC Fans Cogged V-belt Replacement for Unitary AC-Only |

Table 2 SCE Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| AC-46275 | HVAC Fan Cogged V-Belt replacing Smooth V-Belt |

**Eligibility Requirements:** The participant must have electricity distributed by SCE or PG&E to the installation service address. This measure does not apply if the RTU already has cogged V-belts.

**Implementation Requirements:** This measure can be applied to supply air and return air fans in RTUs that do not already have a cogged V-belt installed.

**Documentation Requirements:** The installer must certify that the existing unit does not have a cogged v-belt in place to qualify. Other requirements are set by each program that offers the measure.

## 1.2 Technical Description

A v-belt typically connects the motor and the supply air fan. Some of the larger unitary equipment may also have a v-belt between the return air motor and fan.

The typical smooth v-belts are usually referred to in five basic groups:

* “L” belts are low end belts that are for small, fractional horsepower motors and these are not used in RTUs.
* “A” and “B” belts are the two types typically used in RTUs. The “A” belt is ½ inch width by 5/16 inch thickness. The “B” belt is larger, 21/32 inch wide and 12/32 inch thick so it can carry more power. V-belts come in a wide variety of lengths where 20 to 100 inches is typical.
* “C” and “D” belts are primarily for industrial applications with high power transmission requirements.

V-belts are available from various vendors. The cogged version of these belts typically have an “X” added to the designation or model number. For this HVAC Fans Cogged V-Belt Replacement measure, only the “A” and “B” v-belts are considered. A typical “A” v-belt is replaced by a cogged “AX” v-belt and a “B” is replaced by a “BX.” In general, smooth v-belts have an efficiency of 90% to 98% while cogged v-belts have an efficiency of 95% to 98%. Because cogged v-belts are more flexible they are compatible with smaller diameter pulleys and they have less resistance to bending. Lower bending resistance increases the power transmission efficiency, lowers the waste heat, and allows the belt to last longer than a smooth belt.

In particular, four research papers [A][B][C][D] show that the cogged v-belt efficiency is 0.4% to 4.8% better than a typical smooth v-belt. A fifth paper by USDOE’s Energy Efficiency and Renewable Energy [E] group reviewed most of the earlier literature and recommended using a conservative 2% overall efficiency improvement of the supply fan, motor and drive for energy savings for calculations.

A review of the online Grainger [F] pricing for “A,” “B,” “AX” and “BX” v-belts showed the incremental cost to be about 20% more per belt in sizes typical for RTUs.

## 1.3 Application Types and Delivery Mechanisms

See Appendices A and B for definitions of application types and delivery mechanisms. Appendix A will serve as a translation between the outputs of this workpaper and application types used by READi.

**SCE Delivery Mechanism:** Direct Install, Down-Stream Incentive – Deemed, or Mid-Stream Incentive. Currently the measure is offered by SCE in the Commercial Quality Maintenance and Commercial Quality Renovation programs, but may be added to other programs at the discretion of SCE.

**SCE Program type:** ROB

**PG&E Delivery Mechanism:** Financial Support – Direct Install or Customer Rebate

**PG&E Program type:** ROB

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

This measure is not addressed in any version of the Database for Energy Efficient Resources (DEER05, DEER08, DEER11, or DEER14)[[1]](#footnote-1). This measure does use DEER2014 prototypes generated using MASControl v3.00.19. The prototypes were generated using the Customer Average (CAv) case option for the following tech IDs:

* D08-NE-HVAC-airAC-SpltPkg-110to134kBtuh-11p0eer
* D08-NE-HVAC-airHP-SpltPkg-110to134kBtuh-11p5eer-3p4cop
* D08-NE-ILtg-Power-Exit-60pct (for “Lodging – Motel” building type only)

The first two tech IDs are able to create Customer Average prototypes for every building type except “Lodging – Motel” with a gas pack or heat pump system type. Selecting the tech IDs with the “110to134kBtuh” simulated system cooling capacity provides the greatest number of prototype models while staying close to the assumed cooling capacity range for units within the utility programs. The “Lodging – Motel” building type was created for both system types using the third tech ID.

Table 3 DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Difference Summary Table** | |
| Modified DEER Methodology | No |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | N/A |
| DEER Version | N/A |
| DEER Run ID and Measure Name | N/A |

**Net-to-Gross Ratio**

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 the table below.

Table 4: Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR ID | Description | Sector | BldgType | ProgDelivID | NTG |
| 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; Customer Rebate | Com | Any | Any | 0.6 |

Note: 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.”

**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 the table below.

Table 5: Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA ID | Description | Sector | BldgType | ProgDelivID | GSIAValue |
| Def-GSIA | Default GSIA value | Any | Any | Any | 1.0 |

**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.

**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 6: Technology Fields

|  |  |
| --- | --- |
| Classification | Value |
| Measue Case UseCategory | HVAC |
| Measure Case UseSubCats | Space Cooling |
| Measure Case TechGroups | dX AC Equipment |
| Measure Case TechTypes | Non-DEER |
| Base Case TechGroups | dX AC Equipment |
| Base Case TechTypes | Non-DEER |

**Effective and Remaining Useful Life**

DEER14 update documentation provides EUL and RUL information to be used for the 2015 program cycle extension on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “Summary of EUL-RUL Analysis for the April 2008 Update to DEER” 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.

However, it does not apply to fan v-belt life. A v-belt has a life based on fan run hours which varies by building type based primarily on occupancy schedule because the fans have to run continuously during all occupied hours. The supply and return fans will also run a few hours during unoccupied hours for heating and cooling as needed. Unoccupied fan hours for cooling are essentially zero in southern California due to thermostat set up and the major reduction in internal cooling loads (appliances off, lighting reduced to emergency only, and no people). In spite of thermostat setbacks, unoccupied fan hours for heating can be significant in cold climates since internal heat gains are small. In most SCE climate zones the majority of non-residential buildings have a low heating requirement. Therefore, the fan belt life can be based on the occupancy schedule.

*Equation 1 EUL = Belt Life / Occupancy Hours per year*

*Where:*

*Belt Life is 24,000 hours [A]*

*Occupancy Hours per year from Table 7 below.*

The EUL for the measure is 24,000 hours divided by the annual hours from the eQUEST run report “SS-L Fan Energy/Hours”. This analysis was applied to 21 DEER Building Prototypes as listed in Table 7 below. The eight building types marked by an asterisk (\*) are the large buildings and they have central supply air systems usually with variable volume. DEER2014 EUL ID values based on the previous revision of this work paper are also included in the table below. The previous revision had fewer building types, and therefore the DEER2014 EUL ID are not available for the additional building types. For the additional building types the EUL ID is reported as “Non-DEER”

Table 7 EUL Based on DEER Prototype Occupancy Hours

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Market** | **End Use** | **DEER Building Prototype** | **Occupancy Hours per Year\*\*** | **EUL (Years)** | **EUL ID** |
| Non-residential | HVAC | Assembly | 5,110 | 4.7 | HV-CoggedBelt |
| Non-residential | HVAC | Education – Community College\* | 3,828 | 6.3 | HV-CoggedBelt |
| Non-residential | HVAC | Education – Primary School | 2,616 | 9.2 | HV-CoggedBelt |
| Non-residential | HVAC | Education – Secondary School\* | 2,840 | 8.5 | HV-CoggedBelt |
| Non-residential | HVAC | Education – University\* | 4,671 | 5.1 | HV-CoggedBelt |
| Non-residential | HVAC | Education – Relocatable Classroom | 5,012 | 4.8 | HV-CoggedBelt |
| Non-residential | HVAC | Health/Medical – Hospital \* | 8,760 | 2.7 | HV-CoggedBelt |
| Non-residential | HVAC | Lodging – Hotel\* | 8,760 | 2.7 | HV-CoggedBelt |
| Non-residential | HVAC | Lodging – Motel\* | 8,760 | 2.7 | HV-CoggedBelt |
| Non-residential | HVAC | Manufacturing - Bio/Tech | 3,514 | 6.8 | HV-CoggedBelt |
| Non-residential | HVAC | Manufacturing – Light Industrial | 3,514 | 6.8 | HV-CoggedBelt |
| Non-residential | HVAC | Health/Medical – Nursing Home\* | 8,760 | 2.7 | HV-CoggedBelt |
| Non-residential | HVAC | Office – Large\* | 3,974 | 6.0 | HV-CoggedBelt |
| Non-residential | HVAC | Office – Small | 3,371 | 7.1 | HV-CoggedBelt |
| Non-residential | HVAC | Restaurant - Fast-Food | 6,935 | 3.5 | HV-CoggedBelt |
| Non-residential | HVAC | Restaurant - Sit-Down | 5,110 | 4.7 | HV-CoggedBelt |
| Non-residential | HVAC | Retail - Multistory Large\* | 4,482 | 5.4 | HV-CoggedBelt |
| Non-residential | HVAC | Retail - Single-Story Large | 5,475 | 4.4 | Non-DEER |
| Non-residential | HVAC | Retail – Small | 4,745 | 5.1 | HV-CoggedBelt |
| Non-residential | HVAC | Storage – Conditioned | 4,707 | 5.1 | HV-CoggedBelt |
| Non-residential | HVAC | Grocery | 6,570 | 3.7 | HV-CoggedBelt |
| \* DEER Building Prototypes marked with an asterisk do not have RTUs but have central HVAC systems with variable air flow and a combination of Single zone VAV, Fan Coil, and VAV Reheat.  \*\*Occupancy hours derived from eQUEST SIM report SS-L Fan Energy. | | | | | |

### 1.4.2 Codes and Standards Analysis

Title 24 (2013) [355] Title 20 (2014) [422] include some content related to non-residential package and split HVAC systems, which are the target system types for this measure. However, these requirements do not directly affect the fan belt or its operating characteristics and thus do not impact the assumptions that quantify the demand reduction and energy savings methodologies for each measure. Title 24 does not deal with maintenance issues. HVAC contractors should be licensed by the California State Licensing Board (CSLB) and the HVAC technicians should be EPA certified. Under state code, performance of maintenance and repairs does not require a building and/or job permit.

Table 8 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 20 (2010) | N/A | N/A |
| Title 24 (2013) | N/A | N/A |

### 1.4.3 Non-DEER Study Review

The efficiency improvement is a conservative estimate based on an engineering review of research literature as shown in Table 9. This is in agreement with USDOE’s assessment of the same literature as shown in their Motor Systems Tips #5 [E] where they suggest 2% as a median value for fan system efficiency improvement in HVAC systems with Type A and Type B cogged v-belts only.

Table Fan System Efficiency Improvement

|  |  |
| --- | --- |
| **Reference Source** | **Range of Efficiency Improvement** |
| [A] | 3% |
| [B] | 3% |
| [C] | 1% to 2% |
| [D] | 0.4% to 4.8% |
| [E] | 2% |
| Consensus Median | 2% |

# Section 2: Calculation Methodology

Energy savings and demand reduction were estimated by performing eQUEST [G] simulations. This is because these are non-DEER measures. The simulations used the DEER prototypes described in Section 1.4.1 as the baseline case. Keyword changes were then completed to simulate an improvement in fan system efficiency, and corresponding reduction in fan heat added to the airstream.

## 2.1 Energy Simulation with eQUEST

eQUEST is a DOE2[[2]](#footnote-2) based simulation software package used to produce estimates of energy and demand in buildings. The DEER non-residential building prototypes were simulated using eQUEST-3.64, consisting of 21 different building types. The 21 DEER non-residential building types were simulated with three different HVAC unit types: AC Only, Gas Packs, and Heat Pumps. The only building type that does not have all three HVAC unit types available through MASControl is the “Education – Relocatable Classroom” which can only be produced with a gas pack. All 21 DEER non-residential building types are below in Table 10 with an “X” indicating when the building type was simulated with the corresponding HVAC unit type. The AC Only unit type was not simulated, instead using the results from the Gas Pack simulations and ignoring the therm energy use.

Table DEER Prototype Non-residential Building Types Simulated per HVAC Type

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Building  Type** | **Abbreviated Building Types** | **AC Only** | **Gas Pack** | **Heat Pump** |
| Assembly | Asm | **X** | **X** | **X** |
| Education - Community College | ECC | **X** | **X** | **X** |
| Education - Primary School | EPr | **X** | **X** | **X** |
| Education - Relocatable Classroom | ERC | **X** | **X** |  |
| Education - Secondary School | ESe | **X** | **X** | **X** |
| Education - University | EUn | **X** | **X** | **X** |
| Grocery | Gro | **X** | **X** | **X** |
| Health/Medical - Hospital | Hsp | **X** | **X** | **X** |
| Lodging - Motel | Mtl | **X** | **X** | **X** |
| Lodging - Hotel | Htl | **X** | **X** | **X** |
| Manufacturing - Bio/Tech | MBT | **X** | **X** | **X** |
| Manufacturing - Light Industrial | MLI | **X** | **X** | **X** |
| Health/Medical - Nursing Home | Nrs | **X** | **X** | **X** |
| Office - Large | OfL | **X** | **X** | **X** |
| Office - Small | OfS | **X** | **X** | **X** |
| Restaurant - Fast-Food | RFF | **X** | **X** | **X** |
| Restaurant - Sit-Down | RSD | **X** | **X** | **X** |
| Retail - Multistory Large | Rt3 | **X** | **X** | **X** |
| Retail - Single-Story Large | RtL | **X** | **X** | **X** |
| Retail - Small | RtS | **X** | **X** | **X** |
| Storage - Conditioned | SCn | **X** | **X** | **X** |

The 21 prototypes were simulated for each of the six non-residential vintages shown in Table 11 below. Each vintage has a different cooling load and may have different building and system component properties based either on code or standard practice at the time.

Table DEER Prototype Non-residential Vintages

|  |  |
| --- | --- |
| **Vintage** | **Years Represented** |
| Vintage 75 | Before 1978 |
| Vintage 85 | 1978 to 1992 |
| Vintage 96 | 1993 to 2001 |
| Vintage 3 | 2002 to 2005 |
| Vintage 7 | 2006 to 2011 |
| Vintage 11 | After 2011 |

Each of the building prototypes were run through eQUEST with the 16 CZ2010 (i.e. DEER 2014)[[3]](#footnote-3) weather files as shown in Table 12 below.

Table Weather Files

|  |  |  |
| --- | --- | --- |
| **California Climate Zone** | **Weather File Name** | **Representative City** |
| CZ-01 | cz01.bin | Arcata |
| CZ-02 | cz02.bin | Santa Rosa |
| CZ-03 | cz03.bin | Oakland |
| CZ-04 | cz04.bin | Sunnyvale |
| CZ-05 | cz05.bin | Santa Maria |
| CZ-06 | cz06.bin | Long Beach |
| CZ-07 | cz07.bin | San Diego |
| CZ-08 | cz08.bin | El Toro |
| CZ-09 | cz09.bin | Burbank |
| CZ-10 | cz010.bin | Riverside |
| CZ-11 | cz011.bin | Red Bluff |
| CZ-12 | cz012.bin | Sacramento |
| CZ-13 | cz013.bin | Fresno |
| CZ-14 | cz014.bin | China Lake |
| CZ-15 | cz015.bin | El Centro |
| CZ-16 | cz016.bin | Mount Shasta |

To simulate the HVAC Fans Cogged V-Belt Replacement measure in eQUEST, keyword values were changed to represent an improvement in fan efficiency and the corresponding reduction of fan heat entering the air stream. Table 13 indicates the required keyword(s) values to change per each HVAC system in the prototype model:

Table List of Modified eQUEST Keywords

|  |  |
| --- | --- |
| **HVAC Unit Type** | **Keyword** |
| Gas Pack | SYSTEM:SUPPLY-KW/FLOW |
| Gas Pack | SYSTEM:SUPPLY-DELTA-T |
| Heat Pump | SYSTEM:SUPPLY-EFF |

The base case for each DEER non-residential prototype model requires no changes to the existing keyword values. The modifications required for simulating the HVAC Fans Cogged V-Belt Replacement measure case depend on the eQUEST keywords being utilized by default within each DEER prototype. The HVAC Fans Cogged V-Belt Replacement measure case for prototypes with Gas Pack units required modifying the supply fan energy per air flow and using that value to update any dependent keywords, as shown in the following calculations:

*Measure Case SYSTEM:SUPPLY-KW/FLOW = Base Case SYSTEM:SUPPLY-KW/FLOW \* 0.98*

*Measure Case SYSTEM:SUPPLY-DELTA-T = Measure Case SYSTEM:SUPPLY-KW/FLOW \* 3090*

*Where 3090 is the default factor to approximate temperature rise as a function of supply fan energy according to the eQUEST DOE-2 Dictionary.*

The HVAC Fans Cogged V-Belt Replacement measure case for prototypes with Heat Pump units required directly modifying the supply fan efficiency, as shown in the following calculation:

*Measure Case SYSTEM:SUPPLY-EFF = Base Case SYSTEM: SUPPLY-EFF \* 1.02*

## 2.2 Electric Energy Savings Estimation Methodologies

The calculation of electric energy use for the base case and measure case followed the methodology discussed in Section 2.0. The savings for the HVAC Fans Cogged V-Belt Replacement measure are estimated as follows.

*Fan System Energy Savings [kWh/ton-year] = Base Case Annual Fan System Energy Use – Measure Case Annual Fan System Energy Use*

*Where:*

*Base Case Annual Fan System Energy Use = Output from eQUEST runs*

*Measure Case Annual Fan System Energy Use = Output from eQUEST runs*

### Base Case

The base case is the existing system as described by the unmodified DEER prototype models as described in Section 1.4.1 DEER Measure and Base Case Analysis.

## 2.3 Demand Reduction Estimation Methodologies

The electric demand reduction for the HVAC Fans Cogged V-Belt Replacement measure is estimated according to the DEER peak demand period definitions. The DEER peak demand period methodology requires taking the average hourly peak demand during a defined time period for both the baseline and measure case. DEER has identified the peak time period for each climate zone, as shown in Table 14.

Table DEER 2014 Peak Demand Periods

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CZ | Start Month | Start Day | End Month | End Day | Start Hour | End Hour |
| 1 | September | 16 | 9 | 18 | 15 | 17 |
| 2 | July | 8 | 7 | 10 | 15 | 17 |
| 3 | July | 8 | 7 | 10 | 15 | 17 |
| 4 | September | 1 | 9 | 3 | 15 | 17 |
| 5 | September | 8 | 9 | 10 | 15 | 17 |
| 6 | September | 1 | 9 | 3 | 15 | 17 |
| 7 | September | 1 | 9 | 3 | 15 | 17 |
| 8 | September | 1 | 9 | 3 | 15 | 17 |
| 9 | September | 1 | 9 | 3 | 15 | 17 |
| 10 | September | 1 | 9 | 3 | 15 | 17 |
| 11 | July | 8 | 7 | 10 | 15 | 17 |
| 12 | July | 8 | 7 | 10 | 15 | 17 |
| 13 | July | 8 | 7 | 10 | 15 | 17 |
| 14 | August | 26 | 8 | 28 | 15 | 17 |
| 15 | August | 25 | 8 | 27 | 15 | 17 |
| 16 | July | 8 | 7 | 10 | 15 | 17 |

The electric demand reduction for the HVAC Fans Cogged V-Belt Replacement measure is then estimated as follows:

*Fan System Demand Reduction [kW/ton-year] = Base Case Peak Demand – Measure Case Peak Demand*

*Where:*

*Base Case Peak Demand = Average Hourly DEER-defined Peak Demand from eQUEST Hourly Output*

*Measure Case Peak Demand = Average Hourly DEER-defined Peak Demand from eQUEST Hourly Output*

## 2.4 Gas Energy Savings Estimation Methodologies

For the PG&E Gas Pack measure, gas savings were estimated by taking the difference in therms used between the measure case and the base case. The SCE measure does not distinguish between system type and therefore does not estimate gas savings.

# 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 15 for a list of all Building Types and Load Shapes. A more thorough discussion regarding the load shapes for this measure is available [31]. The closest load shape chosen is indicated below:

Table 15: Building Types and Load Shapes

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

# Section 4: Base Case & Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Install/Program Type** | **Measure Life Basis** | **First Baseline Period Gross Measure Cost (RUL)** | **Second Baseline Period Gross Measure Cost (EUL – RUL)** |
| ROB | EUL | Full Measure Cost | Incremental Measure Cost |

## 4.1 Base Case Cost

The following Transaction type is appropriate to this measure. The Base Case Costs are:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Transaction** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Base Case Cost** | |
|  | ROB | Industry Practice | $ 1.59 | $ 5.10 | $ - | | $ 6.69 |

*All costs are noted as $ per measure unit*

Costs were calculated from information from industry sources. It is assumed that the majority of units serviced will be 6 tons or under. Costs were provided for the most common models by field service technicians, using pricing per <http://aaa-electric.net/>. See *Notched and Regular Belt Price Comparison14* for details.

## 4.2 Measure Case Cost

The following Transaction type is appropriate to this measure. The Measure Case Costs are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Transaction** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** |
|  | ROB | Existing Belt | $ 1.98 | $ 5.10 | $ - | $7.08 |

*All costs are noted as $ per measure unit*

Costs were calculated from information from industry sources. It is assumed that the majority of units serviced will be 6 tons or under, which is in alignment with program data to date. Costs were provided for the most common models by field service technicians, using pricing per <http://aaa-electric.net/>

. See *Notched and Regular Belt Price Comparison*14 for details.

## 4.3 Gross and Incremental Measure Cost

|  |  |  |  |
| --- | --- | --- | --- |
| **Install/Program Type** | **Gross Measure Cost** | **Gross Measure Cost** | **Incremental Measure Cost** |
|  | (RUL Period/First Baseline) | (EUL-RUL Period/  Second Baseline) |  |
| **ROB** | **Measure Equipment Cost – Base Case Equipment Cost** | **Measure Equipment Cost – Base Case Equipment Cost** | **Measure Equipment Cost – Base Case Equipment Cost** |

### 4.3.1 Gross Measure Cost (GMC)

Gross Measure Cost is the cost to install an energy efficient measure per the CPUC calculators. This definition implies a different meaning depending on the install type.

This measure transaction type is **ROB**, so the Gross Measure Cost (GMC) is represented by the equation below:

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

*(Base Case Equipment Cost + Base Case Labor Cost)*

\*Note: We assume that, unless stated otherwise, the measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

GMC = Measure Equipment Cost – Base Case Equipment Cost

*GMC = $ per (unit) - $ per (unit) = $ per unit*

\*Note: Various complicated price fluctuations are not addressed in these equations, such as future costs due to inflation in labor, future costs due to deflation in material cost, and other variables that cannot be accurately described at this time.

### 4.3.2 Incremental Measure Cost (IMC)

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 install type, the equation does vary.

This measure transaction type is **ROB** so the Gross Measure Cost (GMC) is represented by the equation below:

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

*(Base Case Equipment Cost + Base Case Labor Cost)*

\*Note: Unless stated otherwise the measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

IMC = Measure Equipment Cost – Base Case Equipment Cost

*IMC = $ per (unit) -- $ per (unit) = $ per (unit)*

Summary Table for Section 4

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Transaction Type** | **Base Case**  **Total Cost** | **Measure Case Total Cost** | **Gross Measure Case Cost** | **Incremental Measure Cost** |
|  | ROB | $6.69 | $7.08 | $7.08 | $0.39 |

# Attachments

The measure calculation spreadsheets are attached here.

1. 

**Cost Data**

1. 

# References



[31]

[351]

[355]

[422]

1. Jim Cole, "Summary of Findings of CIEE Technology Assessment of Energy-Efficient Belt Transmission," Cogged V-belts typical efficiency improvement of 3%... University of California Berkeley, Memorandum, August 17, 1994. Attached paper by Almeida, Anibal De, University of Coimbra, and Steve Greenberg, Lawrence Berkeley laboratory.
2. "Gates Corporation Announces New EPDM Modeled Notch V-belts, June 2010 (Assumed 3% efficiency improvement) http://www.gates.com/news/index.cfm?id=11296$show=newsitem&location \_id=753&view=Gates
3. Ula, Sadrul, Larry E. Birnbaum, Don Jordan, "Energy Efficient Drivepower: An Overview," Electrical Engineering Dept, University of Wyoming, for Bonneville Power Administration, (1% to 2% page 33).
4. "Energy Loss and Efficiency of Power Transmission Belts," Advanced Engineering Research, Belt Technical Center, Carlisle Power Transmission Products, Third Work Energy Engineering Congress, Association of Energy Engineers, 1977. (Conclusion: "…classical B-section cogged belts ...demonstrated the largest energy savings, ranging from 3 to 6 percent."
5. Motor System Tip Sheet #5, Replace V-belts with Cogged or Synchronous Belt Drives,” USDOE-EERE, September 2005. (Specified 2% based on review of same references) <http://www1.eere.energy.gov/industry/bestpractices/pdfs/replace_vbelts_motor_systemts5.pdf>
6. Grainger catalog on-line web-site for Dayton V-belt pricing <http://www.grainger.com/Grainger/ecatalog/N-1z0r596/Ntt-V-belts>
7. eQUEST – building energy use and cost analysis software, developed by James J. Hirsch & Associates, version 3.64.

# Appendix A: Application Types

This table compares the application types in SCE’s systems with those in DEER.

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

# Appendix B: Delivery Mechanisms

A delivery mechanism is a delivery method paired with an incentive method. SCE’s delivery methods include:

* Appliance Turn-in and Recycling
* Audit/Information
* Commissioning
* Financial Support
* Innovative Design
* Midstream Programs
* Partnership
* Upstream Programs

The following table describes the incentive methods.

|  |  |
| --- | --- |
| Incentive Method | Description |
| Direct Install | The utility program performs an assessment of the customer’s facility, provides recommendations, and implements energy efficiency measures for free. |
| Down-Stream Incentive - Deemed | 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. |
| Exchange - Replacement | The utility program holds events where customers can trade functional equipment for similar but more energy efficient equipment, free of charge. |
| Giveaway | The utility program provides customers with energy efficient equipment for free. |
| Mid-Stream Incentive | The utility program offers buydowns and incentives to third parties (typically retailers, distributors, and contractors), who then stock, promote, lower prices on, and/or sell energy efficient equipment. Contractors install energy efficiency equipment, sometimes using specified quality procedures, at the customer’s property. |
| On-bill Finance - loan | Customers can finance energy efficiency projects at 0% interest and repay the loan through their monthly utility bill. |
| Testing Services / Other | The utility program performs free testing services or assessments of the customer’s facility and provides information and recommendations for potential energy efficiency measures. |
| Up-Stream Buy Down, Up-Stream Incentive | The utility program offers buydowns and incentives to vendors (typically manufacturers and distributors), who then manufacture, stock, promote, lower prices on, and/or sell energy efficient equipment. There is some overlap between the mid-stream and up-stream approaches. |

1. www.deeresources.com [↑](#footnote-ref-1)
2. www.doe2.com [↑](#footnote-ref-2)
3. www.deeresources.com [↑](#footnote-ref-3)