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HVAC

DUCT SEAL, RESIDENTIAL

SWSV001-02

CONTENTS

MEASURE NAME

Duct Seal, Residential

STATEWIDE MEASURE ID

SWSV001-02

TECHNOLOGY SUMMARY

The duct sealing measure involves duct tightness testing and sealing of central forced air residential, direct expansion (DX) Heating, Ventilation, and Air Conditioning (HVAC) systems. When a HVAC duct system is leaky on the supply side it will fail to deliver conditioned air to the appropriate spaces, with much of that leakage going directly to the outdoors, thus wasting energy. Return air leakage brings in hot outdoor and attic air which reduces the cooling capacity of the system.

Several studies have examined energy savings potential through duct testing and sealing:

Comparison between Predicted Duct Effectiveness from Proposed ASHRAE Standard 152 and Measured Field Data for Residential Forced Air Cooling Systems (Siegel, McWilliams, and Walker; 2008).[1] This study, conducted by Lawrence Berkeley National Lab (LBNL), focused on comparing calculated results from the 2002 version of ASHRAE Standard 152P, "Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems," with field test data. Field tests were performed on cooling systems in 11 homes in California, Nevada, and Texas. Some homes had vented attics with ceiling insulation, and some had non-vented attics with roof insulation. The systems were tested under various summer conditions and with various amounts of duct leakage. In some cases, holes were cut in the duct work to simulate higher leakage rates.

ASHRAE Standard 152[2] gives a method for calculating overall duct distribution system efficiency for HVAC systems. The results of the 2008 LBNL study showed that the difference between measured duct system delivery effectiveness and that calculated per ASHRAE Standard 152 is approximately 5% if weather data, duct leakage, and air handler flow are well known.

National Energy Savings Potential from Addressing Residential HVAC Installation (Neme, Proctor, and Nadel; 1999).[3] This paper summarizes several studies on various HVAC unit installation problems. For duct sealing, 19 separate studies are cited. Sample sizes vary from three to over 10,000 units. The methods of calculating savings and the sealed tightness of the duct systems vary between the studies. Average duct leakage to outdoors is 270 cfm and energy savings potential is 17%.

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[1] Siegel J., J. McWilliams, and I. Walker. 2002. "Comparison Between Predicted Duct Effectiveness from Proposed ASHRAE Standard 152 and Measured Field Data for Residential Forced Air Cooling Systems." *ASHRAE Transactions.* Vol. 109. LBNL-50008.

[2] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, "Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems." ISSN 1041-2336, ANSI/ASHRAE Standard 152-2004.

[3] Neme, C., J. Proctor, and S. Nadel. 1999. *Energy Savings Potential From Addressing Residential Air Conditioner and Heat Pump Installation Problems*. Report Number A992. February.

Field Investigation of Duct System Performance in California Light Commercial Buildings (Delp, Matson, Tschudi, Modera, and Diamond;1997).[4] Duct system performance in 15 HVAC systems in eight Northern California buildings was evaluated. All of the buildings had ducts located in the cavity between the dropped ceiling and the roof deck. In 50% of the buildings, the cavity was functionally outside the building's air and thermal barrier. The average leakage rate was determined to be 90 cfm/ton or 259 cfm/ft^2 of conditioned area.

A Campaign to Reduce Light Commercial Peak Load in the Southern California Edison Service Territory through Duct Sealing and A/C Tune-Ups (Modera and Proctor; 2002).[5] Light commercial duct systems of buildings in the Southern California Edison (SCE) service area were tested and sealed. The study includes 447 units tested with 367 sealed. Tests showed an average initial leakage rate of 36% with an average post-retrofit leakage rate of 6%. Calculated savings per the ASHRAE Standard 152 method were 25% for cooling and 15% for heating.

MEASURE CASE DESCRIPTION

This measure is defined as duct sealing to reduce total leakage from "high" or "medium" leakage rate to a "low" leakage rate, as specified by residence type (single family, multifamily, and double-wide mobile home). Both measure cases are to go to a "low" leakage rate after the duct is sealed. The "low" leakage rate is defined as a 12% leakage rate for single family (SFm) and multifamily (MFm), and a 15% leakage rate for double-wide mobile home (DMo). The energy and demand impacts of this measure also vary by climate zone.

Measure Case Specification

Statewide Measure Offering ID	Base Case Leakage Rate Tier	Residence Type	"Low" Measure Case Leakage Rate
SWSV001F SWSV001H	High to Low	Single family Multifamily	12%
SWSV001D		Double-wide mobile home	15%
SWSV001E SWSV001G	Medium to Low	Single family Multifamily	12%
SWSV001C		Double-wide mobile home	15%

[4] Delp, Matson, Tschudy, Modera, Diamond. 1997. *Field Investigation of Duct System Performance in California Light Commercial Buildings*. LBNL-40102.

[5] Modera, M. and Proctor, J. 2002. *A Campaign to Reduce Light Commercial Peak Load in the Southern California Edison Service Territory Through Duct Sealing and A/C Tune-Ups*. Prepared for Southern California Edison. October.

BASE CASE DESCRIPTION

The base case is defined as a single family, multifamily, or double-wide mobile home with high or medium duct leakage rate as specified by residence type (single family, multifamily, and double-wide mobile home). The baseline for the "high" leakage rate of the existing duct is a 40% leakage rate for SFm/MFm, and a 35% leakage rate for DMo. The "medium" leakage rate of the existing duct is a 24% leakage rate for SFm/MFm and a 25% leakage for DMo.

Base Case Specification

Statewide Measure Offering ID	Base Case Leakage Rate Tier	Residence Type	Base Case Leakage Rate
SWSV001F SWSV001H	High	Single family Multifamily	40% (20% supply/20% return)
SWSV001D		Double-wide mobile home	35% (supply)
SWSV001E SWSV001G	Medium	Single family Multifamily	24%
SWSV001C		Double-wide mobile home	25%

CODE REQUIREMENTS

This measure is subject to the California Building Energy Efficiency Standards (Title 24) [6] which stipulates the following duct system requirements for any *new* installation of air-cooled air conditioners and air-source heat pumps:

- For alterations and extensions of existing duct work duct systems must be sealed and verified if > 40 feet of ducts in unconditioned space. Duct system leakage must be ≤ 15% in total, or ≤ 10% to the outside. Or, if unable to meet the sealing requirements, all accessible leaks must be sealed and verified by a Home Energy Rating System (HERS) rater.
- Mandatory duct insulation requirements (R-6) apply to all new or replacement ducts (not existing or unaltered ducts).
  - When replacing > 40 feet of ducts in unconditioned space in climate zones 1 through10 and in climate zones 12 and 13, R-6 is required.
  - When replacing > 40 feet of ducts in unconditioned space in climate zones in climate zones 11 and 14-16, R-8 is required.
- HERS verification is required for insulated ducts in conditioned space.
- In all climate zones, where new duct systems are installed in unconditioned space, leakage must be ≤ 5% of the air handler air flow.

This measure does not fall under federal regulations.

[6] California Energy Commission (CEC). 2018. *2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*. CEC-400-2018-020-CMF.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	None.	n/a
CA Building Energy Efficiency Standards – Title 24 (2019)	Section 120.4, 140.4(1), and RA3.1.	January 1, 2020
CA Building Energy Efficiency Standards – Title 24 (2019)	Section 150.2(b) 1D Altered Duct Systems – Duct Sealing	January 1, 2020
CA Building Energy Efficiency Standards – Title 24 (2019)	Section 10.103 Permits, Fees, Applications, and Inspections	January 1, 2020
Federal Standards	None.	n/a

NORMALIZING UNIT

Tons of cooling capacity (Cap-Tons)

Note: For the DEER Res-DuctSeal-HighToLow-wtd and Res-DuctSeal-MedToLow-wtd measures that serve as the bases for the measures in this workpaper, the normalizing unit for the furnace-only savings (where BldgHVAC = "rNCGF") is set to Cap-Tons, which does not make sense for a furnace-only system that has no cooling capacity. A request is being made outside of this workpaper for the "rNCGF" savings for these measures to be updated in DEER using a different normalizing unit. Until then, programs are advised to apply a conversion as follows per recommendation from CPUC staff[7]. The heating capacity of the installed furnace can be converted to Cap-Tons by multiplying the appropriate Heat/Cool Cap Ratio from the table below to the heating capacity of the installed furnace; i.e.:

$$Units\ for\ rNCGF\ savings\ in\ CapTons = Heating\ Capacity\ of\ Installed\ Furnace\ (kBtu/h) \times Heat/Cool\ Cap\ Ratio$$

The converted capacity is then multiplied by the DEER per Cap-Ton savings to determine the claimable savings.

Heat/Cool Cap Ratio

Building Type	Heat/Cool Cap Ratio
SFm	0.05349
MFm	0.05349
DMo	0.06364

For example, suppose the duct leakage is reduced from medium to low in a single family residence in CZ01 having a furnace-only system with 40 kBtu/h heating capacity. The per Cap-Ton savings from DEER for this scenario (Duct Seal and Test, Residential, Medium (25% to 15%), SFm, CZ01, rNCGF) are 3.090 kWh/yr and 4.420 Therm/yr. To determine the claimable savings, the *Units for nCGF savings in CapTons* is determined using the equation above as follows:

[7] J. McWilliams (personal communication, October 24, 2020)

$$Units\ for\ rNCGF\ savings\ in\ CapTons = 40\ (kBtu/h) \times 0.05349\ (ton/kBtu/h) = 2.14\ ton$$

The converted capacity is then multiplied by the DEER per Cap-Ton savings to determine the claimable savings:

$$kWh/yr\ Savings = 2.14\ ton \times 3.090\ (\frac{kWh}{yr})/ton = 6.61\ kWh/yr$$

$$Therm/yr\ Savings = 2.14\ ton \times 4.42\ (\frac{Therm}{yr})/ton = 9.46\ Therm/yr$$

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility

Measure Application Type	Delivery Type	Sector
BRO-RCx	DnDeemDI	Res (SFm & MFm 2006 & post)
BW	DnDeemDI	Res (DMo)
BW	DnDeemDI	Res (SFm & MFm pre-2006)

Eligible Products

The duct test and seal programs for residential mobile homes, multifamily homes, and single-family homes eligible for a direct-install delivery approach. Up to two duct tests must be conducted: the first or "test-in" is a system check to determine whether the duct system tightness meets the California Title 24 specifications. If the Test-in shows that duct leakage exceeds minimum tightness specifications, and the technicians correct the situation, then a second test or "test-out" must be conducted to verify proper duct tightness was achieved. Energy savings are associated with the test-out procedure; energy savings are not assigned to the "test-in" procedure.

To identify these measures as part of an existing HVAC system, the program implementer must record existing duct leakage through comprehensive field testing. The testing can be performed while the system is pressurized using a duct blower fan to ensure the target leakage thresholds are achieved. Duct sealing shall be performed on the unpressurized system. After installation, testing shall be performed to ensure the target leakage thresholds are achieved. Photos and test results can serve as documentation that the work was performed on an existing HVAC system.

Programs often bundle Quality Maintenance (QM) measures. The following prerequisites must be met before the QM treatments, such as airflow adjustments, can be implemented to ensure an HVAC system is running optimally.

- The unit and system must be capable of delivering a supply air flow rate of at least 350 cfm/ton after treatments related to air flow are completed and before refrigerant charge is tested and/or adjusted.
- The unit must be drawing power.
- The unit must have a condenser over ambient temperature (COAT) of at least 3 degrees.
- An assessment and report are required in accordance with Air Conditioning Contractors of America (ACCA) Standard 4[8] prior to any treatments being applied to determine the baseline conditions and to develop QM treatment recommendations.

The 350 cfm/ton air flow requirement ensures that the refrigerant system can be properly diagnosed and charged. 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 some or all of the QM treatments related to air flow. If it is determined that the supply fan and duct system in place do not have the capability to deliver 350 cfm/ton after the air flow treatments have been performed, refrigerant charge cannot be properly diagnosed, rendering the QM process incomplete and the savings in this work paper invalid.

If some or all of the existing ductwork is beyond repair and sections must be replaced, the sections that must be replaced must be less than 40 linear feet in total per Section 150.2(b) of the 2019 California Building Energy Efficiency Standards (Title 24),[9] or the replaced ductwork must be installed and tested in accordance with the applicable requirements in 2019 Title 24 Section 150.2(b)1D.

Eligible Building Types and Vintages

This measure is applicable for any existing single family, multifamily with two or more units, or mobile home that uses air-cooled, direct expansion (DX) cooling and gas heating, heat pump, or gas heating with no cooling.

Eligible Climate Zones

This measure is applicable in all California climate zones. In coastal climates (i.e. climate zone 1, 3 & 5) cooling requirements will generally be less than the inland zones (i.e. climate zone 2, 4, 11, 12 & 13).

PROGRAM EXCLUSIONS

None.

[8] Air Conditioning Contractors of America (ACCA). 2013. Maintenance of Residential HVAC Systems. ANSI/ACCA Standard 4 QM – 2013.

[9] California Energy Commission (CEC). 2018. 2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. CEC-400-2018-020-CMF.

DATA COLLECTION REQUIREMENTS

Data requirements are to be determined.

USE CATEGORY

Service

ELECTRIC SAVINGS (KWH)

The electric energy savings from the residential duct testing and sealing measure were drawn directly from the Database of Energy Efficient Resources (DEER), version DEER 2020 (D20v0 & D20v1). The savings of this measure includes HVAC interactive effects savings. The results were reported in the Remote Ex-Ante Database Interface (READI) tool. The Impact IDs are:

Statewide Measure Offering ID	Energy Impact ID	Measure Description	MAT	DEER Version
SWSV001C	RB-HV-DuctSeal-MedToLow	Duct Seal and Test, Residential, Medium (25% to 15%) for DMo	BW	DEER 2020
SWSV001D	RB-HV-DuctSeal-HighToLow	Duct Seal and Test, Residential, High (35% to 15%) for DMo	BW	DEER 2020
SWSV001E	RB-HV-DuctSeal-MedToLow	Duct Seal and Test, Residential, Medium (24% to 12%) for SFm MFm Pre 2006	BW	DEER 2020
SWSV001F	RB-HV-DuctSeal-HighToLow	Duct Seal and Test, Residential, High (40% to 12%) for SFm MFm Pre 2006	BW	DEER 2020
SWSV001G	RB-HV-DuctSeal-MedToLow	Duct Seal and Test, Residential, Medium (24% to 12%) for SFm MFm 2006 and post 2006	BRO-RCx	DEER 2020
SWSV001H	RB-HV-DuctSeal-HighToLow	Duct Seal and Test, Residential, High (40% to 12%) for SFm MFm 2006 and post 2006	BRO-RCx	DEER 2020

Note that the measure impacts are based on recent DEER2020 updates that affect “APreWBkWh” for energy, “APreWBkW” for peak demand and “APreWBtherm”.Savings values were reported by building type (residential single family, multifamily, and mobile home), climate zone, and HVAC system type. For this measure, the “existing (weighted DEER vintages)” building vintage was specified.

PEAK ELECTRIC DEMAND REDUCTION (KW)

The peak demand reduction for the residential duct testing and sealing measure were drawn directly from the Database of Energy Efficient Resources (DEER), version DEER 2020 (D20v0 & D20v1). The

impacts of this measure account for HVAC interactive effects savings. The results were reported in the Remote Ex-Ante Database Interface (READI) tool. The Impact IDs are:

Res-DuctSeal-MedToLow
Res-DuctSeal-HighToLow

Peak demand reduction was reported by building type (residential single family, multifamily, and mobile home), climate zone, and HVAC system type. For this measure, the "existing (weighted DEER vintages)" building vintage was specified.

GAS SAVINGS (THERMS)

The gas energy savings for the residential duct testing and sealing measure were drawn directly from the Database of Energy Efficient Resources (DEER), version DEER 2020 (D20v0 & D20v1). The results were reported for the following DEER Impact IDs:

Res-DuctSeal-MedToLow
Res-DuctSeal-HighToLow

Savings values were reported by building type (residential single family, multifamily, and mobile home), climate zone, and HVAC system type. For this measure, the "existing (weighted DEER vintages)" building vintage was specified.

LIFE CYCLE

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The EUL and RUL specified for duct testing and sealing are presented below. The EUL value for the BRO-RCx MAT was stipulated in Resolution E-4952,[10] which updated the Database for Energy Efficient Resources (DEER) for 2019 and 2020. The EUL updates in Resolution E-4952 complies with Decision 16-08-019[11] issued by the California Public Utilities Commission in 2016, which created the Behavioral, Operational, and Retrocommissioning (BRO) measure classification and the associated EUL values of one to three years; this Decision assigned an EUL of three years for BRO retrocommissioning measures (BRO-RCx).

The EUL value for the building weatherization (BW) measure application type (MAT) was stipulated in Resolution E-5082, which reclassified duct sealing for pre-2006 buildings. Per Resolution E-5082, the BW

[10] California Public Utilities Commission (CPUC). 2018. *Resolution E-4952.* October 11. Page A-36, A-37.

[11] California Public Utilities Commission (CPUC). 2016. *Decision 16-08-019 in the Order Instituting Rulemaking Concerning Energy Efficiency Rolling Portfolios, Policies, Programs, Evaluation, and Related Issues (R.13-11-005).* August 18.

MAT shall only be eligible for measures installed in buildings constructed pre-2006.[12] For buildings constructed after January 1, 2006, the BRO EUL of three years per Resolution E-4952 will remain in effect. Furthermore, Resolution E-5082 stipulates that duct sealing in all mobile homes shall be classified as BW types, since mobile homes do not have a requirement for duct sealing under the U.S. Department of Housing and Urban Development code.

The RUL for this measure conforms with Version 5 of the Energy Efficiency Policy Manual, which recommends "one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values."[13] This approach provides a reasonable RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.[14] Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised retrofit add-on (REA) measures so that the EUL of the measure is equal to the lower of the RUL of the modified system or equipment or the EUL of the add-on component."[15]

Prior to issuance of Resolution E-4952, the EUL of residential duct sealing was based upon several retention studies documented for the DEER 2014 update.[16]

Effective Useful Life and Remaining Useful Life

Parameter	MAT	Value	Source
EUL (yrs)	BRO-RCx	3.0	California Public Utilities Commission (CPUC). 2018. *Resolution E-4952*. October 11. Page A-36, A-37.
RUL (yrs)	BRO-RCx	1.0	
EUL (yrs)	BW	18.0	California Public Utilities Commission (CPUC). 2020. *Resolution E-5082*. August 27. Page 13.
RUL (yrs)	BW	6.0	

BASE CASE MATERIAL COST ($/UNIT)

Because duct testing and sealing is a service measure, the base case material cost is $0.00.

[12] California Public Utilities Commission (CPUC), 2020. *Resolution E-5082*. August 27. Page 13.

[13] California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

[14] KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

[15] California Public Utilities Commission (CPUC). 2016. Resolution E-4807. December 16. Page 13.

[16] California Public Utilities Commission (CPUC), Energy Division. 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx"

Pacific Gas & Electric Company. 2006. *Retention Study of Pacific Gas & Electric Company's 1996 and 1997 Residential New Construction Energy Efficiency Programs*. PG&E Study ID number: 386R2 CALMAC Study ID number: PGE0247.01.

Itron, Inc. 2004. *1994 Residential New Construction Ninth-Year Retention Evaluation (Energy Advantage Home Program) Study Number 716A*. Prepared for Southern California Gas Company.

GDS Associates, Inc. 2007. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group (SPWG).

MEASURE CASE MATERIAL COST ($/UNIT)

The measure case material and labor cost for residential duct testing and sealing were drawn from 2010-2012 WO017 Ex-Ante Measure Cost Study conducted by Itron, Inc.[17] This study reports costs for a "typical" duct sealing measure and does not distinguish between "high to low" and "medium to low" leakage as is defined for this measure. Therefore, the material cost for both measure offerings are assumed to be the same. The equipment cost documented in this study was developed from data from two direct installation contractors and benchmarked against RSMeans data.

The cost data were updated to 2020 values using RSMeans Historical Cost Index. The RSMeans Historical Cost Index can be used to compare costs of projects between different cities and years. The ratio of cost indexes provides the percent change expected in the price between the specified years. A comparison of the cost indexes for 2012 and 2020 for Los Angeles (207.2 and 251.5, respectively) reveals a cost increase of 21.4%. This percentage increase value was applied to the WO017 data to reflect 2020 costs.

Finally, duct sealing costs per dwelling are converted to system capacity tons. The average system capacity is based upon a single family residence and is weighted by climate zone and vintage. Inputs to develop the measure case material costs are specified below.

Measure Case Material and Labor Cost Inputs

Input	Value	Source
Duct sealing material cost ($/dwelling)	$71.45	Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission.
Duct sealing labor cost ($/dwelling)	$181.24	
Price index adjustment (%)	21.4%	Gordian. (n.d.) "RSMeans Cost Index.pdf."
Average system capacity (tons/dwelling)	3.27	Program data (proprietary).

Measure Case Material and Labor Cost Outputs

Measure Description	Material Cost ($/ton)	Labor Cost ($/ton)	Total Cost ($/ton)
Duct Seal	$26.52	$67.29	$93.81

BASE CASE LABOR COST ($/UNIT)

Because duct testing and sealing is a service measure, the base case labor cost is $0.

[17] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. Prepared for the California Public Utilities Commission.

MEASURE CASE LABOR COST ($/UNIT)

See Measure Case Material Cost.

NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. The NTG value for this measure, documented in the DEER Database 2011 Update study conducted by Itron, Inc., can be traced to the 2008 version of DEER. While the *original* source of this NTG value remains unknown, an evaluation of the 2006 – 2008 California programs estimated NTG for residential duct sealing that varied across the investor-owned utility programs from 0.54 to 0.96.[18]

Net-to-Gross Ratios

Parameter	Value	Source
NTG	0.55	DEER2019 - exante database tables: NTG2020 - Res-Default>2

GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. The GSIA rate specified for duct testing and sealing is specified below. This statewide GSIA was calculated as the gross-savings weighted average of installation rates across all investor-owned utility service areas, as reported in an evaluation study of the 2006-2008 program year.[19]

Gross Savings Installation Adjustment Rates

Parameter	GSIA	Source
GSIA	0.463	KEMA, Inc., The Cadmus Group, Inc., and Summit Blue Consulting, LLC. 2010. *Evaluation Measurement and Verification of the California Public Utilities Commission HVAC High Impact Measures and Specialized Commercial Contract Group Programs. 2006 – 2008 Program Year. Final Consultant Report. Volume 1*. Prepared for the California Public Utilities Commission. February 10. Page 15-16, Table 3-5.

[18] Itron, Inc. 2011. *DEER Database 2011 Update Documentation.* Prepared for the California Public Utilities Commission. Page 12-3 Table 12-1.

KEMA, Inc., The Cadmus Group, Inc., and Summit Blue Consulting, LLC. 2010. *Evaluation Measurement and Verification of the California Public Utilities Commission HVAC High Impact Measures and Specialized Commercial Contract Group Programs. 2006 – 2008 Program Year. Final Consultant Report. Volume 1*. Prepared for the California Public Utilities Commission. February 10.

[19] KEMA, Inc., The Cadmus Group, Inc., and Summit Blue Consulting, LLC. 2010. *Evaluation Measurement and Verification of the California Public Utilities Commission HVAC High Impact Measures and Specialized Commercial Contract Group Programs. 2006 – 2008 Program Year. Final Consultant Report. Volume 1*. Prepared for the California Public Utilities Commission. February 10. Page 15-15, Table 3-5.

NON-ENERGY IMPACTS

Non-energy impacts for this measure have not been quantified.

DEER DIFFERENCES ANALYSIS

This section provides a summary of inputs and methods from the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

Table 1. DEER Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	n/a
DEER Measure Case	n/a
DEER Building Types	Yes
DEER Operating Hours	n/a
DEER eQUEST Prototypes	n/a
DEER Version	DEER2020 READi v.4.4.7
Reason for Deviation from DEER	n/a
DEER Measure IDs Used	Res-DuctSeal-HighToLow-wtd Res-DuctSeal-MedToLow-wtd
NTG	The NTG of 0.55 is associated with NTG ID: *Res-Default>2*
GSIA	DEER2011. The GSIA value of 0.463 is associated with GSIA ID: *Res-DuctSeal-All*
EUL/RUL	The value of 3 years is associated with EUL ID: BRO-RCx. The value of 18 years is associated with EUL ID: *BW per E-5082.*

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	06/30/2018	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: SCE17HC029, Revision 1 (May 22, 2018) PGE3PHVC159, Revision 5 (June 2, 2017) PGE3PHVC159, Revision 4 (December 1, 2016) PGE3PHVC159, Revision 2 (March 9, 2015) Consensus reached among Cal TF members.
	04/29/2019	Adan Rosillo, PG&E Jennifer Holmes Cal TF Staff	Revisions for submittal of version 01.
	07/02/2019	Ayad Al-Shaikh, Cal TF Staff	Update DEER IDs
02	09/18/2020	Phil Jordan, CLEAResult Tai Voong, PG&E	Update per Resolution E-5082 (MAT & EUL) & CPUC's comments. DMo & pre-vintages of 2006 for SFm & MFm (MAT=BW, EUL=18 years, & EUL ID=HV-DuctSeal-BW) 2006 & post-vintages of 2006 for SFm &MFm (MAT= BRO-RCx, EUL=3 years, & EUL ID=HV-DuctSeal) Update energy impact for Res-DuctSeal-HighToLow-wtd & Res-DuctSeal-MedToLow-wtd by DEER dated September 2020 Update cost using RSMeans Cost Index DEER data energy impact 9/17/2020
	11/05/2020	Tai Voong, PG&E	Update per CPUC Comments on 10/5/2020