

**Work Paper PGE3PHVC159
Duct Test & Seal: Residential
Revision # 4**

Pacific Gas & Electric Company
Customer Energy Solutions

**Duct Test & Seal:
Residential**

Measure Code: H768, HV286

December 01, 2017

At-a-Glance Summary

Applicable Measure Codes:	H768, HV286
Measure Description:	Duct Test and Seal for residential, air-cooled, direct expansion, air conditioner and heat pump units.
Energy Impact Common Units:	kW, kWh and Therms Per Household
Base Case Description:	Source: DEER2017 READi (Version 2.4.7) Duct leakage greater than 15% of system airflow.
Base Case Energy Consumption:	Source: DEER2017 READi (Version 2.4.7) Varies based on climate zones and building types
Measure Energy Consumption:	Source: DEER2017 READi (Version 2.4.7) Varies based on climate zones and building types
Energy Savings (Base Case – Measure):	Source: DEER2017 READi (Version 2.4.7) Varies based on climate zones and building types
Costs Common Units:	\$ per Household
Base Case Equipment Cost (\$/unit):	\$0
Measure Equipment Cost (\$/unit):	Source: 2010-2012 WO017 Ex-Ante Measure Cost Study \$30.62 for Mobile Homes \$71.45 for Single family and Multifamily
Gross Measure Cost (\$/unit)	Source: 2010-2012 WO017 Ex-Ante Measure Cost Study \$30.62 for Mobile Homes \$71.45 for Single family and Multifamily
Measure Incremental Cost (\$/unit):	Source: 2010-2012 WO017 Ex-Ante Measure Cost Study \$109.16 for Mobile Homes \$252.69 for Single family and Multifamily
Effective Useful Life (years):	Source: DEER2014 18 years EUL and 6 years RUL
Measure Application Type:	Retro-Commissioning (RC)
Net-to-Gross Ratios:	0.78 Source: DEER 2014
Important Comments:	

Document Revision History

Revision #	Revision Date	Section-by-Section Description of Revisions	Author (Company)
Revision 0	06/01/2012	Update DEER2011	Tai Voong (PG&E)
Revision 0	08/28/2012	At-A-Glance Measure List: Changed Building Vintage.	Tai Voong (PG&E)
Revision 1	04/23/2014	<ul style="list-style-type: none"> Update savings based on DEER2015 READi Tool. Update ISR to reflect new recommended ISR from the May 16, 2013 ED disposition. 	Chris Li (PG&E)
Revision 2	11/20/2015	<ul style="list-style-type: none"> Add new high leakage reduction measure (40/35% to 12/15%) Use WO017 for cost Added Direct Install only language Added Program Restrictions and Guidelines language to address "Other" comment in Preliminary Review dated 8/7/2015 Grayed out DEER impacts from ex ante submittal 	Chris Li (PG&E) Jim Wyatt (PG&E)
Revision 3	04/01/2016	<ul style="list-style-type: none"> Ex Ante format change 	Tai Voong (PG&E)
Revision 4	12/01/2016	<ul style="list-style-type: none"> DEER2017 Update 	Tai Voong (PG&E)

Section 1. General Measure and Baseline Data

1.1 Product Measure Description & Background

Table 1: Base and Measure Cases

Typical Base Case Description from DEER	<p>Base case description for High Duct Leakage:</p> <ul style="list-style-type: none"> • 40% (20% Supply/20% Return) Leakage (single- and multi-family) • 35% Supply Leakage (mobile home) <p>Base case description for Medium Duct Leakage:</p> <ul style="list-style-type: none"> • 24% (12% Supply/12% Return) Leakage (single- and multi-family) • 25% Supply Leakage (mobile home)
Typical Measure Description From DEER	<p>Measure case description for High Duct Leakage Reduction:</p> <ul style="list-style-type: none"> • Residential: Duct Sealing (Total Leakage Reduced from High (35/40%) to Low (15/12%) (35% to 15% for mobile home and 40% to 12% for single- and multi- family) <p>Measure case description for Medium Duct Leakage Reduction:</p> <ul style="list-style-type: none"> • Residential: Duct Sealing (Total Leakage Reduced from High (25/24%) to Low (15/12%) (25% to 15% for mobile home and 24% to 12% for single- and multi- family)

The following air conditioners, heat pumps, and furnaces are eligible under the Upstream HVAC program for residential customers:

Table 2: Measure Names

PG&E Measure Codes	SCG / SDG&E Codes	SCE Solution Code	Measure name
HV286			Residential: Duct Sealing (Total Leakage Reduced from (40/35%) to (12/15%))
H768			Residential: Duct Sealing (Total Leakage Reduced from (25/24%) to (15/12%))

Catalog Description –

The measures presented on this work paper are not in the rebate catalog, they are promoted under our direct install HVAC program. The Duct Test and Seal Programs for residential mobile homes, multi-family homes, and single family homes are part of a comprehensive direct-install approach. Up to two duct tests are conducted; the first or “Test-in” is a system check to determine whether the unit’s duct system tightness meets the California Title 24 specifications. If the first check shows that duct tightness exceeds minimum tightness specifications, and the technicians correct the situation, a second test or “Test-out” is conducted to verify proper duct tightness was achieved. The Test-out procedure has assigned energy savings, whereas the “Test-in” procedure has no energy savings.

Program Restrictions and Guidelines

This product is part of the direct install program and the incentives are provided to the third party implementer and HVAC contractors. Measures are applied to any residential building throughout PG&E territory that uses air-cooled, direct expansion cooling. 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 design and target market for this measure strictly applies to existing residential HVAC systems, with immediate efforts focusing solely on existing equipment maintenance scenarios as part of a current AC Tune-Up program offering within the Direct Install Mobile Homes Program. To identify these measures as part of existing HVAC systems, the current program design establishes and records existing duct leakage through comprehensive field testing. The duct sealing is then performed while the system is pressurized using a duct blaster fan, ensuring the target leakage thresholds are achieved and documenting work is being performed on an existing system via photos and test results.

Terms and Conditions

Customer must have electricity or gas distributed by PG&E to the installation address. The customer must meet all terms and conditions as described on the program specifications.

Market Applicability

This measure is applicable to duct testing and sealing in residential mobile homes, single family, and multifamily properties containing two or more units.

1.2 Product Technical Description

This work paper covers energy savings for the duct seal measure.

The duct seal measure involves duct tightness testing and sealing of central forced air residential, direct expansion (DX) HVAC systems. When an HVAC system's 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.

1.3 Measure Application Type

The Delivery Mechanism of these measures is the Direct Install Program. The incentives are provided to the third party implementer and HVAC contractors.

The Program Type/Application Type of these measures is Retro-Commissioning (RC). RC uses the effective useful life (EUL) for the measure life basis.

Table 3: Measure Application Type

Code	Description	Comment
RC	Retro-Commissioning	Measure applied as part of retro-commissioning; Above Pre-Existing energy impacts are applied for the associated EUL period, Full Cost of measure technology used.

Note: See Appendix A for a comparison of the application types used by and incorporated into SCE systems versus the application types available in the newest revision of DEER 2017. Appendix A will serve as a translation between the outputs of this workpaper and application types used by READi.

1.4 Product Base Case and Measure Case Data

1.4.1 DEER Base Case and Measure Case Information

The DEER2017¹ data cited in this work paper include: peak demand reduction, electric savings, interactive gas savings, equipment useful life, net-to-gross and measure load shapes.

Table 4: DEER Difference Summary

DEER Difference Summary Table	
Modified DEER Methodology	No
Scaled DEER Measure	No
DEER Building Prototypes Used	Yes
Deviation from DEER	None
DEER Version	DEER2017 READi v.4.4.7
DEER Run ID and Measure Name (Sample)	Res-DuctSeal-HighToLow-wtd; Res-DuctSeal-MedToLow-wtd

Net to Gross

The NTG ratio was obtained from the “DEER2011_NTGR_2012-05-16.xls” spreadsheet under the “DEER2011 NTGr Values” tab on the www.deeresources.com website. Table 6 below summarizes all applicable DEER based Net-to-Gross ratios for programs that may be used by this measure.

See Section 1.1 Terms and Conditions and Market Applicability to reference the type of program delivery mechanism and customer status used to determine this entry.

Table 5: Net-to-Gross Ratio

NTGR_ID*	Description*	Sector*	BldgType*	ProgDelivID*	NTG*
Res-sAll-mDuctSeal	Duct Sealing	Res	Any	PreReb	0.78

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

Installation Rate (GSIA)

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 6 below.

Table 6: Installation Rate

GSIA_ID*	Description*	Sector*	BldgType*	ProgDelivID*	GSIAValue*
Res-DuctSeal-PGE	Residential Duct Sealing; Annual Installation Rate	Res	Any	Any	0.584

*Denotes that the column is taken from the DEER GSIA Table.

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. (In the event that the READi IDs do not support the technology in this workpaper simply indicate “Non-DEER”.)

Table 7: READi Tech IDs

READi Field Name	Air Conditioner
Measure Case UseCategory	HVAC
Measure Case UseSubCats	VentAirDist
Measure Case TechGroups	HV_AirDist
Measure Case TechTypes	DuctLeak
Base Case TechGroups	HV_AirDist
Base Case TechTypes	DuctLeak

Effective Useful Life / Remaining Useful Life:

DEER14 update documentation provides EUL and RUL information to be used for the 2015 program year on www.deeresources.com. The DEER documentation “DEER2014-EUL-table-update_2014-02-05.xlsx” provides the RUL value as 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 used. Table 8 below identifies the value/methodology used for the measures in this work paper.

Table 8: EUL/RUL Value/Methodology

READi EUL ID	Description	Sector	Enduse	EUL (Years)	RUL (Years)
HV-DuctSeal	Duct Sealing	Res	HVAC	18	6

1.4.2 Codes & Standards Requirements Base Case and Measure Information

Table 9: Code Summary

Code	Applicable Code Reference	Effective Dates
Title 24 (2013)	Title 24, 2013 (Residential Compliance Manual-Building HVAC Requirements) Section 120.4, 140.4(1), Table 150.0, and RA3.1.	January 1, 2015
Title 20 (2014)	Does not fall under Title 20	
Federal Codes (DOE / EPA)	Does not fall under Federal DOE or EPA Energy Regulations	

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

Title 24: This measure does fall under Title 24 2013 of the California Energy Regulations. Under this

regulation, the following is required for any new installation of air-cooled air conditioners and air-source heat pumps:

Duct systems must be sealed and verified if >40 feet of ducts in unconditioned space. Duct system leakage must be $\leq 15\%$ in total, or $\leq 10\%$ to the outside. Or, if unable to meet the sealing requirements, all accessible leaks must be sealed and verified by a 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: CZ1-10 and 12-13: R-6 CZ11 and 14-16; R-8. HERS verification is required for insulated ducts in conditioned space.

In all climate zones, when new duct systems are installed in unconditioned space, leakage must be $\leq 6\%$ of the air handler airflow.

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

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

Several studies have been performed concerning the energy savings potential through DTS. The key reports are summarized in this section.

LBNL April 2002 Study²

“Comparison between Predicted Duct Effectiveness from Proposed ASHRAE Standard 152 and Measured Field Data for Residential Forced Air Cooling Systems”; LBNL-50008; Siegel, McWilliams, Walker; April 2008.²

The study 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 152³ gives a method for calculating overall duct distribution system efficiency for HVAC systems. The results of the 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.

ACEEE Summer 1999 Study⁴

“National Energy Savings Potential from Addressing Residential HVAC Installation”; 1999 ACEEE Summer Study Proceedings; Neme, Proctor, Nadel; February 1999.⁴

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%.

LBLN December 1997 Study⁵

“Field Investigation of Duct System Performance in California Light Commercial Buildings;” LBNL-40102; Delp, Matson, Tschudi, Modera, Diamond; December 1997.⁵

Duct system performance in fifteen 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/sq ft of conditioned area.

SCE Light Commercial DTS and RCA Study⁶

“A Campaign to Reduce Light Commercial Peak Load in the Southern California Edison Service Territory through Duct Sealing and A/C Tune-Ups”; Modera, Proctor; October 2002.⁶

Light commercial duct systems were tested and sealed in SCE territory. The study includes 447 units tested with 367 sealed. Tests show an average initial leakage rate of 36% with an average post retrofit leakage rate of 6%. Calculated savings per the ASHRAE Standard 152 method are 25% for cooling and 15% for heating.

1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

There are no further data or calculations provided for the support of the measures in this work paper. The savings were downloaded from DEER2015 directly.

Section 2. Calculation Methods

Table 10 contains the data files for measures that are taken directly from the DEER 2017 READi Tool with NormUnit as Cap-Tons. The DEER 2017 READi files (EnergyImpacts_RB-HV-MHDuctSeal-25pct-15pct, EnergyImpacts_RB-HV-MFDuctSeal-40pct-12pct, EnergyImpacts_RB-HV-SFDuctSeal-40pct-12pct) were used to modify the NumUnit to reflect the units of “per household”.

Table 10 READi Tool Outputs

PG&E Measure Code	SCG and SDG&E Solution Code	SCE Solution Code	Measure Name	READi Results
HV286			Residential: Duct Sealing (Total Leakage Reduced from (40/35%) to (12/15%))	PGE3PHVC159 R4 1-12-2016
H768			Residential: Duct Sealing (Total Leakage Reduced from (25/24%) to (15/12%))	PGE3PHVC159 R4 1-12-2016

Install/Program Type	Measure Life Basis	First Baseline Period Gross Measure Cost (RUL)	Second Baseline Period Gross Measure Cost (EUL – RUL)
<i>RC</i>	EUL	Calculated as Full Measure Cost	N/A

Note: For RC measure, First Baseline is the baseline for the full EUL. There is no second baseline.

2.1 Electric Energy Savings Estimation Methodologies

Energy savings for the duct leakage reduction (Impact ID: Res-DuctSeal-MedToLow-wtd and Res-DuctSeal-HighToLow-wtd) measure were downloaded from the DEER2017 READI tool (v2.4.7). This measure includes HVAC interactive effects savings. *The DEER 2017 READi files (EnergyImpacts_RB-HV-MHDuctSeal-25pct-15pct, EnergyImpacts_RB-HV-MFDuctSeal-40pct-12pct, EnergyImpacts_RB-HV-SFDuctSeal-40pct-12pct) were used to modify the NumUnit to reflect the units of “per household”.*

Specified values vary by building types and climate zones. For this work paper, a building type of residential single family, multifamily, and mobile homes was chosen, along with using “existing (weighted DEER vintages)” building vintage and all PG&E nine (9) California Climate Zones.

See accompanying calculation spreadsheet for complete list of measure case savings.

2.2. Demand Reduction Estimation Methodologies

Demand savings for the duct leakage reduction (Impact ID: Res-DuctSeal-MedToLow-wtd and Res-DuctSeal-HighToLow-wtd) measure were downloaded from the DEER2017 READI tool (v2.4.7). This measure includes HVAC interactive effects savings. *The DEER 2017 READi files (EnergyImpacts_RB-HV-MHDuctSeal-25pct-15pct, EnergyImpacts_RB-HV-MFDuctSeal-40pct-12pct, EnergyImpacts_RB-HV-SFDuctSeal-40pct-12pct) were used to modify the NumUnit to reflect the units of “per household”.*

Specified values vary by building types and climate zones. For this work paper, a building type of residential single family, multifamily, and mobile homes was chosen, along with using “existing (weighted DEER vintages)” building vintage and all PG&E nine (9) California Climate Zones.

See accompanying calculation spreadsheet for complete list of measure case savings.

2.3. Gas Energy Savings Estimation Methodologies

Gas savings for the duct leakage reduction (Impact ID: Res-DuctSeal-MedToLow-wtd and Res-DuctSeal-HighToLow-wtd) measure were downloaded from the DEER2017 READI tool (v2.4.7). This measure includes HVAC interactive effects savings. *The DEER 2017 READi files (EnergyImpacts_RB-HV-MHDuctSeal-25pct-15pct, EnergyImpacts_RB-HV-MFDuctSeal-40pct-12pct, EnergyImpacts_RB-HV-SFDuctSeal-40pct-12pct) were used to modify the NumUnit to reflect the units of “per household”.*

Specified values vary by building types and climate zones. For this work paper, a building type of residential single family, multifamily, and mobile homes was chosen, along with using “existing (weighted DEER vintages)” building vintage and all PG&E nine (9) California Climate Zones.

See accompanying calculation spreadsheet for complete list of measure case savings.

Section 3. Load Shapes

3.1 Base Case 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_Eff_AC load shape. See the KEMA report⁷ for a more thorough discussion regarding the load shapes for this measure.

Building Types and Load Shapes

Building Type	E3 Alt. Building Type	Load Shape
Residential	RES	26 = Res. Central Air Conditioning

3.2 Measure Load Shapes

The measure load shape is the same as the base case load shape, 26 = Res. Central Air Conditioning

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)
RC	EUL	Calculated as Full Measure Cost	N/A

Note: For RC measure, First Baseline is the baseline for the full EUL. There is no second baseline.

4.1 Base Case(s) Costs

This is a service measure. There are no base case costs.

4.2 Measure Case Costs

The 2010-2012 WO017 Ex-Ante Measure Cost Study⁸ was used in determining the costs of these measures. The following Transaction types are appropriate to these measures. The Base Case Costs are:

Measure Code	Building Type	Transaction	Baseline	Equipment Cost	Labor / Installation Cost	Maintenance / Other Cost	Total Measure Case Cost
H768, HV286	SFM, MFM	RC	Ex	\$71.45	\$181.24	\$0.00	\$252.69
H768, HV286	DMO	RC	Ex	\$30.62	\$78.54	\$0.00	\$109.16

All costs are noted as \$ per household.

4.3 Incremental & Full Measure Costs

Install/Program Type	Gross Measure Cost (RUL Period/First Baseline)	Gross Measure Cost (EUL-RUL Period/Second Baseline)	Incremental Measure Cost
RC	EUL	Calculated as Full Measure Cost	N/A

Note: For RC measure, First Baseline is the baseline for the full EUL. There is no second baseline.

4.3.1 Full Measure Cost

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

This measure transaction type is: RC, so the Full Measure Cost (FMC) is represented by the equation below:

$$\text{FMC} = \text{Measure Equipment Cost} + \text{Measure Labor Cost}$$

*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 Costs

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 straight forward definition depending on the install type, the equation does vary.

This measure transaction type is: RC so the Incremental Measure Cost (IMC) is represented by the equation below:

$$\text{IMC} = \text{Measure Equipment Cost} + \text{Measure Labor Cost}$$

*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.

Summary Table for Section 4

Measure Code	Building Type	Transaction	Baseline	Equipment Cost	Labor / Installation Cost	Maintenance / Other Cost	Total Measure Case Cost
H768, HV286	SFM, MFM	RC	Ex	\$71.45	\$181.24	\$0.00	\$252.69
H768, HV286	DMO	RC	Ex	\$30.62	\$78.54	\$0.00	\$109.16

All costs are noted as \$ per household.

Input Appendices

Code	Description	Comment
RC	Retro-commissioning	Single baseline (above code), full costs

Notes: For RC measure, First Baseline is the baseline for the full EUL. There is no second baseline.

A. (1.4.1) DEER Base Case and Measure Case Information

Electric Savings (ΔW):

The following table shows impact savings for mobile homes in climate zone 11 for the measures listed in this program and work paper.

Measure ID	Building type	Bldg Vintage	Climate Zone	Electric Savings Watts (kW)	Deer units	DEER Version	Impact IDs
H768	DMO	Ex	Z11	0.2741	Household	DEER2017	Res-DuctSeal-MedToLow-wtd
HV286	DMO	Ex	Z11	0.5810	Household	DEER2017	Res-DuctSeal-HighToLow-wtd

See accompanying calculation spreadsheet for complete list of measure case savings.

Annual Electric Savings (ΔkWh):

The following table shows impact savings for mobile homes in climate zone 11 for the measures listed in this program and work paper.

Measure Code	Building type	Bldg Vintage	Climate Zone	Electric Savings kWh	DEER units	DEER Version	Impact IDs
H768	DMO	EX	Z11	241.5	Household	DEER2017	Res-DuctSeal-MedToLow-wtd
HV286	DMO	EX	Z11	525.0	Household	DEER2017	Res-DuctSeal-HighToLow-wtd

See accompanying calculation spreadsheet for complete list of measure case savings.

Gas Savings (ΔTh):

The following table shows impact savings for mobile homes in climate zone 11 for the measures listed in this program and work paper.

Measure Code	Building type	Bldg Vintage	Climate Zone	Interactive Only? Yes / No	Gas Savings Therms	DEER units	DEER Version	Impact IDs
H768	DMO	EX	Z11	Yes	15.16	Household	DEER2017	Res-DuctSeal-MedToLow-wtd
HV286	DMO	EX	Z11	Yes	33.29	Household	DEER2017	Res-DuctSeal-HighToLow-wtd

See accompanying calculation spreadsheet for complete list of measure case savings.

Hours of Operation:

Building type	Bldg Vintage	Climate Zone	Hours of Operation hrs/yr	DEER Version	Impact IDs
SFM, MFM, DMO	Ex	PGE	DEER hours (EFLH)	DEER2017	Res-DuctSeal-MedToLow-wtd
SFM, MFM, DMO	Ex	PGE	DEER hours (EFLH)	DEER2017	Res-DuctSeal-HighToLow-wtd

Base Case Costs and Measure Case Costs

Building type	Bldg Vintage	Climate Zone	Costs (\$)			DEER Version	Impact IDs
			Base Case	Measure Case	IMC		
SFM, MFM	Ex	PGE	\$0	\$71.45	\$181.24	WO017 report	Res-DuctSeal-MedToLow-wtd
DMO	Ex	PGE	\$0	\$30.62	\$78.54	WO017 report	Res-DuctSeal-HighToLow-wtd

All costs are noted as \$ per household.

Effective Useful Life/ Remaining Useful Life:

Building type	Bldg Vintage	Climate Zone	EUL (yrs)	RUL (yrs)	DEER Version	Impact IDs
SFM, MFM, DMO	Ex	PGE	18	6	DEER2015	Res-DuctSeal-MedToLow-wtd; Res-DuctSeal-HighToLow-wtd

In service rate:

Building type	Bldg Vintage	Climate Zone	In service rate	DEER Version	Impact IDs
SFM, MFM, DMO	Ex	PGE	0.584	DEER2015	Res-DuctSeal-MedToLow-wtd; Res-DuctSeal-HighToLow-wtd

References

- ¹ JHirsch & Associates, “2015 Database for Energy Efficiency Resources”, Version 2.1.0, October 2014.
www.deeresources.com
- ² Siegel, McWilliams, Walker, “Comparison Between Predicted Duct Effectiveness from Proposed ASHRAE Standard 152 and Measured Field Data for Residential Forced Air Cooling Systems.” LBNL-50008; April 2008.
- ³ 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.
- ⁴ Neme, Proctor, Nadel, “National Energy Savings Potential From Addressing Residential HVAC Installation.” ACEEE Summer Study Proceedings; February 1999.
- ⁵ Delp, Matson, Tschudy, Modera, Diamond, “Field Investigation of Duct System Performance in California Light Commercial Buildings.” LBNL-40102, December 1997.
- ⁶ Modera, Proctor, “A Campaign to Reduce Light Commercial Peak Load in the Southern California Edison Service Territory Through Duct Sealing and A/C Tune-Ups,” October 2002.
- ⁷ KEMA Inc., JJ Hirsch and Assoc., Itron Inc, Final Report - Load Shape Update Initiative, Prepared for the California Public Utility Commission Under contract to Pacific Gas and Electric Company, revised 11/17/2006
- ⁸ Iron, Inc. “2010-2012 WO017 Ex Ante Measure Cost Study- Draft Report”, February 28, 2014.
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