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| WHOLE BUILDING  SWWB006-01 High performance crawlspace |

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Measure Name

High Performance Crawlspace

Statewide Measure ID

SWWB006-01

Technology Summary

Crawl spaces are vacant areas found under some homes, between the ground and the floor of the home. They can be categorized as conditioned or unconditioned, and vented or unvented. Unconditioned crawl spaces have no air transfer between HVAC systems and living spaces, and usually have vents leading to the outside, which are meant to allow for passive ventilation. Unconditioned crawl spaces sometimes have insulation under living space floors, between the crawl spaces and living spaces. In some cases, unconditioned crawl spaces may have vapor barriers installed on their earthen floors, to reduce thermal transfer to the soil, moisture transfer from the soil, and radon gas influx. The homes with vented crawl spaces tend to have the highest leakage rates, especially if ductwork is located in the crawl spaces. It is reported at approximately 14.6 and 5.5 air changes per hour at 50 Pascals (ACH50) for existing and new construction residences (after 2000)[[1]](#footnote-1), respectively.

Sealed, conditioned crawl spaces have vapor barriers on their earthen floors, insulation on their crawl space walls, and pathways enabling conditioned air to circulate. The sealing measure improves building envelope air tightness, reduces duct leakage loads, reduces humidity levels, and improves overall air quality. Energy savings from this measure stem from:

1. Reduction in HVAC system cooling load, due to circulating cool air from crawlspace,
2. Reduction in building infiltration and containment of duct leakage inside conditioned space,
3. Increased R-value between stem wall,
4. Reduction in sensible heat load, and
5. Reduction in latent heat load due to reduced humidity transfer from crawlspace to conditioned space from vapor barrier.

Measure Case Description

This measure case is defined as a residential crawlspace retrofit, including ALL of the following:

1. A vapor barrier that covers the entire crawl space ground and wall area,
2. The crawlspace becomes part of the conditioned envelope. Therefore, rigid spray foam sealing and insulation applied on the crawl space interior walls, over the vapor barrier. The crawlspace becomes part of the conditioned envelope. Therefore,
3. For any external crawl space entries, an insulated cover with a tight-fitting gasket, to complete sealing integrity while still allowing exterior access,
4. An airflow path through the conditioned crawlspace, using transfer registers, ductwork, and/or fans.

The Southern California Edison (SCE) Emerging Products (EP) group conducted a field study[[2]](#footnote-2) to evaluate and compare the energy savings and demand reduction potential of a vented, unconditioned crawlspace (base case) compared to an unvented, conditioned crawlspace (measure case).This study demonstrated energy savings for this measure, but its sample size was not large enough to provide usable cost or energy savings values. For this measure, those values are obtained through recognized cost estimating data and energy simulation modeling.

Base Case Description

The base case is defined as a vented, unconditioned crawlspace on an existing single-family residence. The base case has no vapor barrier or airflow path for the heating and air conditioning (HVAC) system.

Code Requirements

Title 24 2019, Part 2.5, Section R408 stipulates that crawl spaces can be vented or unvented. If a crawl space is unvented, exposed earthen floors must have a continuous vapor barrier and must be either mechanically ventilated or have a supply of conditioned air with a return to the living area at a rate of 1 ft3/min per 50 ft2 of floor area.

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 | Part 2.5, Section R408 | January 1, 2020 |
| Federal Standards | None. | n/a |

Normalizing Unit

Square foot of living space area

Program Requirements

Measure Implementation Eligibility

All measure application type, delivery type, and sector combinations 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.

Implementation Eligibility

|  |  |  |
| --- | --- | --- |
| **Measure Application Type** | **Delivery Type** | **Sector** |
| Add-On Equipment | DnDeemed | SFm |
| Add-On Equipment | DnDeemdDI | SFm |

Eligible Products

This measure is a retrofitted crawlspace area with a ground and wall vapor barrier, rigid spray foam sealing and insulation applied on the crawl space interior walls, insulated cover with a tight-fitting gasket for any external crawl space entries, and an airflow path using transfer registers, ductwork, and fans. All four components are required for eligibility.

Eligible Building Types and Vintages

This measure is applicable for Single-Family Residential building type of any vintage.

Eligible Climate Zones

This measure is applicable only to California climate zone 15.

Program Exclusions

Used or rebuilt equipment is not eligible. The residence must be equipped with a central HVAC system with distribution ducting located in the crawlspace area.

Data Collection Requirements

The Program Administrator (PA) is encouraged to collect additional information from deemed measure sites, including total floor area, floor area over the crawlspace, material and labor costs, and HVAC system type.

Use Category

Whole Building (WhlBldg)

Electric Savings (kWh)

The unit energy savings (UES) of this measure were derived from simulations performed using California Building Energy Code Compliance – Residential (CBECC-Res) 2019. A single-family residence was modeled using the DEER 2005 residential prototype characteristics for single family residences equipped with crawl spaces in climate zone 15. The baseline scenario was modeled to the characteristics outlined in Table 1 below.

Table 1 Overview of DEER prototype model characteristics

|  |  |
| --- | --- |
| Total Floor Area | 1,555 |
| Number of Stories | 1 |
| Occupants | 3 |
| Roof Type | Roofing, shingle |
| Floor Type | Over Crawl Space |
| Ceiling Overall R-Value | 6.89 |
| Wall Overall R-Value | 6.68 |
| Floor Overall R-Value | 5.51 |
| Glass Area (% floor) | 17.2 |
| Vertical Fenestration U-Factor | 1.23 |
| Vertical Fenestration SHGC | 0.87 |
| Cooling SEER | 8.5 |
| Heating AFUE | 0.70 |
| Total Duct Leakage (%) | 15 |
| Building Leakage (ACH50) | 14.6 |
| Effective Supply Duct R | 2.8 |
| Ducting Location | Crawlspace |
| Vintage | Before 1978 |

The measure case scenario altered the following:

1. The building leakage, expressed in air/changes/hour at 50 Pascals differential pressure (ACH50) from 14.6 to 3 per the 2015 International Energy Conservation Code R402.4 recommendations.
2. The duct location was changed from crawlspace to conditioned space.
3. The effective floor R-value was changed from 5.51 to R-19. This reflects going from the baseline uninsulated floor to the addition of rigid spray foam insulation to the crawlspace walls.

The hourly output from the simulation was generated for both case scenarios for each orientation (North, East, South, and West). An average of these values was taken due to the small variance observed. Energy savings from this measure stem from 1) reduction in HVAC system cooling load, due to circulating cool air from crawlspace, 2) reduction in building infiltration and containment of duct leakage inside conditioned space, 3) increased R-value of the stem wall, 4) reduction in sensible heat load, and 5) reduction in latent heat load due to reduced humidity transfer from crawlspace to conditioned space from vapor barrier. The average UES (and peak demand reduction) are calculated as the difference between the baseline and measure case UEC (and peak demand).

Peak Electric Demand Reduction (kW)

The peak demand savings were derived from the hourly CBECC-Res 2019 simulation output. The peak demand values represent the demand reduction during the DEER peak period of 4 p.m. to 9 p.m. weekdays,[[3]](#footnote-3) thus a coincident demand factor (CDF) was not applied.

Gas Savings (Therms)

The same simulation outlined in the sections above was used to determine the gas savings associated with this suite of measures. The average gas savings are calculated as the difference between the baseline and measure case whole building gas usage.

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 of this measure was determined as the remaining useful of the host equipment divided by three. The host equipment was identified as the existing floor insulation, determined to have an EUL of 20 years per DEER 2014 BldgEnv-FlrIns. There is no RUL associated with this add on equipment measure.

Effective Useful Life and Remaining Useful Life

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| EUL (yrs) | 6.67 | Host Equipment EUL/3, where host equipment EUL is 20 years per DEER BldgEnv-FlrIns |
| RUL (yrs) | n/a | n/a |

Base Case Material Cost ($/unit)

There is no associated base case material cost for add on equipment measures, as the alternative would be to maintain the in-situ conditions at the residence.

Measure Case Material Cost ($/unit)

Measure case equipment prices were provided by the vendor used during the SCE EP study. The total cost of installation for the application of 2” of closed cell spray foam insulation on the foundation and crawlspace side-wall and rim joist area, as well as the installation of the vapor barrier is $5.05 per square foot up to 900 square feet, with an additional rate area of $4.25 per square foot. Additionally, the cost for HVAC redistribution was provided as a minimum of $500 per site. For the prototype developed, an average cost per square foot of $4.71 was determined. RSMeans 2019 data was used to develop an estimated labor cost, as the cost provided by the vendor was inclusive of labor. An estimate of two insulation laborers, for a two-day period was estimated as $2,736. Therefore, a calculated material cost was calculated as $4,592.75, or $2.95 per square foot. The material cost was determined to fall within the average range based on online resources of similar projects completed across the nation. One online resource[[4]](#footnote-4) determined the average cost to be between $5,000 and $7,000, while a second resource[[5]](#footnote-5) found an average of $5,500. Material cost of $5,500 was therefore used for the measure, or $3.54 per square foot.

Base Case Labor Cost ($/unit)

There is no associated base case material cost for add on equipment measures, as the alternative would be to maintain the in-situ conditions at the residence.

Measure Case Labor Cost ($/unit)

RSMeans 2019 data was used to develop an estimated labor cost, as the cost provided by the vendor was inclusive of labor. An estimate of two insulation laborers, for a two-day period was estimated as $2,736, or $1.76 per square foot.

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 was determined by DEER 2019 as 0.28, per Res-sSF-mShellIns as this was determined to be the most applicable NTG ID for the suite of measures.

Net to Gross Ratios

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| NTG | 0.85 | ET-Default |

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. This GSIA rate is the current for DEER ID Res-Ins-All.

Gross Savings Installation Adjustment Rate

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| GSIA | 0.865 | DEER 2011 Res-Ins-All |

Non-Energy Impacts

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

DEER Differences Analysis

The table below summarizes the inputs and methods that are and are not based upon the Database for Energy Efficient Resources (DEER).

DEER Difference Summary

| **DEER Item** | **Comment / Used for Workpaper** |
| --- | --- |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | Yes |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | Yes |
| DEER Version | n/a |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Measure IDs Used | n/a |
| NTG | Source: ET Default |
| GSIA | Source: DEER 2011 Res-Ins-All |
| EUL/RUL | Source: DEER BldgEnv-FlrIns |

Revision History

Measure Characterization Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision Number** | **Date** | **Primary Author, Title, Organization** | **Revision Summary and Rationale for Revision**  **Effective Date and Approved By** |
| 1 | 7/17/2019 | Fernando Miramontes, AESC | New Measure |

1. Sherman & Chan. 2013. *Air-Tightness of U.S. Dwellings*. [↑](#footnote-ref-1)
2. Southern California Edison (SCE), Emerging Products. 2018. *Residential Crawl Space Conditioning and Sealing Retrofits.* ET14SCE1100. [↑](#footnote-ref-2)
3. California Public Utilities Commission (CPUC). 2018. Resolution E-4952. October 11. OP 1. [↑](#footnote-ref-3)
4. <https://home.costhelper.com/crawl-space-sealing.html> [↑](#footnote-ref-4)
5. <https://www.homeadvisor.com/cost/foundations/install-crawl-space-encapsulation/#encapsulation> [↑](#footnote-ref-5)