### Floor Insulation Above Crawlspace

**Description**

Insulation is added to the floor above a vented crawl space that does not contain pipes or HVAC equipment. If there are pipes, HVAC, or a basement, it is desirable to keep them within the conditioned space by insulating the crawl space walls and ground. Insulating the floor separates the conditioned space above from the space below the floor, and is only acceptable when there is nothing underneath that could freeze or would operate less efficiently in an environment resembling the outdoors. Even in the case of an empty, unvented crawl space, it is still considered best practice to seal and insulate the crawl space perimeter rather than the floor. Not only is there generally less area to insulate this way, but there are also moisture control benefits. There is a “Basement Insulation” measure for perimeter sealing and insulation. This measure assumes the insulation is installed above an unvented crawl space and should not be used in other situations.

This measure was developed to be applicable to the following program types:  RF.

If applied to other program types, the measure savings should be verified.

**Definition of Efficient Equipment**

This measure requires a member of the implementation staff or a participating contractor to evaluate the pre and post R-values and measure surface areas. The requirements for participation in the program will be defined by the utilities.

**Definition of Baseline Equipment**

The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be no insulation on any surface surrounding a crawl space.

**Deemed Lifetime of Efficient Equipment**

The expected measure life is assumed to be 25 years.[[1]](#footnote-1)

**Deemed Measure Cost**

The actual installed cost for this measure should be used in screening.

**Deemed O&M Cost Adjustments**

N/A

###### Loadshape

|  |
| --- |
| Loadshape R08 - Residential Cooling |
| Loadshape R09 - Residential Electric Space Heat |
| Loadshape R10 - Residential Electric Heating and Cooling |

**Coincidence Factor**

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM’s Forward Capacity Market.

CFSSP = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 68%[[2]](#footnote-2)

CFSSP = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[[3]](#footnote-3)

CFPJM   = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[[4]](#footnote-4)

**Algorithm**

**Calculation of Savings**

**Electric Energy Savings**

Where available savings from shell insulation measures should be determined through a custom analysis. When that is not feasible for the program the following engineering algorithms can be used with the inclusion of an adjustment factor to de-rate the heating savings.

ΔkWh = (ΔkWh\_cooling + ΔkWh\_heating)

Where:

ΔkWh\_cooling = If central cooling, reduction in annual cooling requirement due to insulation

= ((((1/R\_old - 1/(R\_added+R\_old)) \* Area \* (1-Framing\_factor)) \* 24 \* CDD \* DUA) / (1000 \* ηCool))) \* ADJFloorCool

R\_old = R-value value of floor before insulation, assuming 3/4” plywood subfloor and carpet with pad

= Actual. If unknown assume 3.96 [[5]](#footnote-5)

R\_added = R-value of additional spray foam, rigid foam, or cavity insulation.

Area = Total floor area to be insulated

Framing\_factor = Adjustment to account for area of framing

= 12% [[6]](#footnote-6)

24 = Converts hours to days

CDD = Cooling Degree Days

|  |  |
| --- | --- |
| **Climate Zone**  **(City based upon)** | **Unconditioned**  **CDD[[7]](#footnote-7)** |
| 1 (Rockford) | 263 |
| 2 (Chicago) | 281 |
| 3 (Springfield) | 436 |
| 4 (Belleville) | 538 |
| 5 (Marion) | 570 |
| Weighted Average[[8]](#footnote-8) | 325 |

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [[9]](#footnote-9)

1000 = Converts Btu to kBtu

ηCool = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following:[[10]](#footnote-10)

|  |  |
| --- | --- |
| **Age of Equipment** | **ηCool Estimate** |
| Before 2006 | 10 |
| 2006 - 2014 | 13 |
| Central AC After 1/1/2015 | 13 |
| Heat Pump After 1/1/2015 | 14 |

ADJFloorCool = Adjustment for cooling savings from floor to account for prescriptive engineering algorithms overclaiming savings[[11]](#footnote-11).

= 80%

ΔkWh\_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= ((((1/R\_old - 1/(R\_added + R\_old)) \* Area \* (1-Framing\_factor) \* 24 \* HDD)/ (3,412 \* ηHeat)) \* ADJFloorHeat

HDD = Heating Degree Days:[[12]](#footnote-12)

|  |  |
| --- | --- |
| **Climate Zone**  **(City based upon)** | **Unconditioned HDD** |
| 1 (Rockford) | 3,322 |
| 2 (Chicago) | 3,079 |
| 3 (Springfield) | 2,550 |
| 4 (Belleville) | 1,789 |
| 5 (Marion) | 1,796 |
| Weighted Average[[13]](#footnote-13) | 2,895 |

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[[14]](#footnote-14)

|  |  |  |  |
| --- | --- | --- | --- |
| **System Type** | **Age of Equipment** | **HSPF Estimate** | **ηHeat (Effective COP Estimate) (HSPF/3.413)\*0.85** |
| Heat Pump | Before 2006 | 6.8 | 1.7 |
| 2006 - 2014 | 7.7 | 1.92 |
| 2015 on | 8.2 | 2.40 |
| Resistance | N/A | N/A | 1 |

ADJFloorHeat = Adjustment for floor insulation to account for prescriptive engineering algorithms overclaiming savings[[15]](#footnote-15).

= 60%

Other factors as defined above

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

ΔkWh = (ΔkWh\_cooling + ΔkWh\_heating)

= ((((1/3.96 -1/(30+3.96))\*(20\*25)\*(1-0.12)\* 24 \* 281\*0.75)/(1000\*10.5)) \* 0.8 + (((1/3.96 -1/(30+3.96))\*(20\*25)\*(1-0.15) \* 24 \* 3079)/(3412\*1.92)) \* 0.6)

= (37.8 + 641.7)

= 679.5 kWh

ΔkWh\_heating = If gas *furnace* heat, kWh savings for reduction in fan run time

= ΔTherms \* Fe \* 29.3

Fe = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[[16]](#footnote-17)

29.3 = kWh per therm

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 70% efficient furnace (for therm calculation see Natural Gas Savings section):

ΔkWh = 60.4 \* 0.0314 \* 29.3

= 55.6 kWh

**Summer Coincident Peak Demand Savings**

ΔkW = (ΔkWh\_cooling / FLH\_cooling) \* CF

Where:

FLH\_cooling = Full load hours of air conditioning

= Dependent on location:[[17]](#footnote-18)

| **Climate Zone**  **(City based upon)** | **Single Family** | **Multifamily** |
| --- | --- | --- |
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[[18]](#footnote-19) | 629 | 564 |

CFSSP = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[[19]](#footnote-20)

CFSSP = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[[20]](#footnote-21)

CFPJM = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[[21]](#footnote-22)

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

ΔkWSSP = 37.8 / 570 \* 0.68

= 0.045 kW

ΔkWSSP = 37.8 / 570 \* 0.466

= 0.031 kW

###### Natural Gas Savings

If Natural Gas heating:

ΔTherms = (1/R\_old - 1/(R\_added+R\_old)) \* Area \* (1-Framing\_factor)) \* 24 \* HDD) / (100,000 \* ηHeat) \* ADJFloorHeat

Where

ηHeat = Efficiency of heating system

= Equipment efficiency \* distribution efficiency

= Actual. If unknown assume 72%[[22]](#footnote-23)

Other factors as defined above

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 72% efficient furnace:

ΔTherms = (1 / 3.96 – 1 /(30 + 3.96))\*(20 \* 25) \* (1 - 0.12) \* 24 \* 3079) / (100,000 \* 0.72) \* 0.60

= 60.4 therms

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

###### Measure Code: RS-SHL-FINS-V07-160601

1. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007 [↑](#footnote-ref-1)
2. Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory. [↑](#footnote-ref-2)
3. Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’. [↑](#footnote-ref-3)
4. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year. [↑](#footnote-ref-4)
5. Based on 2005 ASHRAE Handbook – Fundamentals: assuming 2x8 joists, 16” OC, ¾” subfloor, ½” carpet with rubber pad, and accounting for a still air film above and below: 1/ [(0.85 cavity share of area / (0.68 + 0.94 + 1.23 + 0.68)) + (0.15 framing share / (0.68 + 7.5” \* 1.25 R/in + 0.94 + 1.23 + 0.68))] = 3.96 [↑](#footnote-ref-5)
6. ASHRAE, 2001, “Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP),” Table 7.1 [↑](#footnote-ref-6)
7. Five year average cooling degree days with 75F base temp from DegreeDays.net were used in this table because the 30 year climate normals from NCDC used elsewhere are not available at base temps above 72F. [↑](#footnote-ref-7)
8. Weighted based on number of occupied residential housing units in each zone. [↑](#footnote-ref-8)
9. Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research”, p31. [↑](#footnote-ref-9)
10. These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. [↑](#footnote-ref-10)
11. As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo “Results for AIC PY6 HPwES Billing Analysis”, dated February 20, 2015. TAC negotiated adjustment factor is 80%. [↑](#footnote-ref-11)
12. National Climatic Data Center, Heating Degree Days with a base temp of 50°F to account for lower impact of unconditioned space on heating system. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois. [↑](#footnote-ref-12)
13. Weighted based on number of occupied residential housing units in each zone. [↑](#footnote-ref-13)
14. These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps. [↑](#footnote-ref-14)
15. As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo “Results for AIC PY6 HPwES Billing Analysis”, dated February 20, 2015. TAC negotiated adjustment factor is 60%. [↑](#footnote-ref-15)
16. Fe is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBtu/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% Fe. See “Programmable Thermostats Furnace Fan Analysis.xlsx” for reference. [↑](#footnote-ref-17)
17. Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, <http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf>, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois. [↑](#footnote-ref-18)
18. Weighted based on number of occupied residential housing units in each zone. [↑](#footnote-ref-19)
19. Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory. [↑](#footnote-ref-20)
20. Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’. [↑](#footnote-ref-21)
21. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year. [↑](#footnote-ref-22)
22. Based on average Nicor PY4 nameplate efficiencies derated by 15% for distribution losses. [↑](#footnote-ref-23)