### Wall and Ceiling/Attic Insulation

###### Description

Insulation is added to wall cavities, and/or attic. This measure requires a member of the implementation staff evaluating the pre and post R-values and measure surface areas. The efficiency of the heating and cooling equipment in the home should also be evaluated if possible.

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 empty wall cavities and little or no attic insulation.

###### 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.

###### 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\_wall) \* A\_wall \* (1-Framing\_factor\_wall) + (1/R\_old - 1/R\_attic) \* A\_attic \* (1-Framing\_factor\_attic)) \* 24 \* CDD \* DUA) / (1000 \* ηCool)) \* ADJWallAtticCool

R\_wall = R-value of new wall assembly (including all layers between inside air and outside air).

R\_attic = R-value of new attic assembly (including all layers between inside air and outside air).

R\_old = R-value value of existing assemble and any existing insulation.

(Minimum of R-5 for uninsulated assemblies[[5]](#footnote-5))

A\_wall = Net area of insulated wall (ft2)

A\_attic = Total area of insulated ceiling/attic (ft2)

Framing\_factor\_wall = Adjustment to account for area of framing

= 25%[[6]](#footnote-6)

Framing\_factor\_attic = Adjustment to account for area of framing

= 7%[[7]](#footnote-7)

24 = Converts hours to days

CDD = Cooling Degree Days

= dependent on location:[[8]](#footnote-8)

|  |  |
| --- | --- |
| **Climate Zone**  **(City based upon)** | **CDD 65** |
| 1 (Rockford) | 820 |
| 2 (Chicago) | 842 |
| 3 (Springfield) | 1,108 |
| 4 (Belleville) | 1,570 |
| 5 (Marion) | 1,370 |
| Weighted Average[[9]](#footnote-9) | 947 |

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

= 0.75 [[10]](#footnote-10)

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:[[11]](#footnote-11)

|  |  |
| --- | --- |
| **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 |

ADJWallAtticCool = Adjustment for cooling savings from basement wall insulation to account for prescriptive engineering algorithms overclaiming savings[[12]](#footnote-12).

= 80%

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

= ((((1/R\_old - 1/R\_wall) \* A\_wall \* (1-Framing\_factor\_wall)) + (1/R\_old - 1/R\_attic) \* A\_attic \* (1-Framing\_factor\_attic)) \* 24 \* HDD] / (ηHeat \* 3412)) \* ADJWallAtticHeat

HDD = Heating Degree Days

= Dependent on location:[[13]](#footnote-13)

|  |  |
| --- | --- |
| **Climate Zone**  **(City based upon)** | **HDD 60** |
| 1 (Rockford) | 5,352 |
| 2 (Chicago) | 5,113 |
| 3 (Springfield) | 4,379 |
| 4 (Belleville) | 3,378 |
| 5 (Marion) | 3,438 |
| Weighted Average[[14]](#footnote-14) | 4,860 |

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[[15]](#footnote-15)

| **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 |

3412 = Converts Btu to kWh

ADJWallAtticHeat = Adjustment for wall and attic insulation to account for prescriptive engineering algorithms overclaiming savings[[16]](#footnote-17).

= 60%

For example, a single family home in Chicago with 990 ft2 of R-5 walls insulated to R-11 and 700 ft2 of R-5 attic insulated to R-38, 10.5 SEER Central AC and 2.26 (1.92 including distribution losses) COP Heat Pump:

ΔkWh = (ΔkWh\_cooling + ΔkWh\_heating)

= (((((1/5 - 1/11) \* 990 \* (1-0.25)) + ((1/5 - 1/38) \* 700 \* (1-0.07))) \* 842 \* 0.75 \* 24)/ (1000 \* 10.5)) \* 0.8) + ((((((1/5 - 1/11) \* 990 \* (1-0.25)) + ((1/5 - 1/38) \* 700 \* (1-0.07))) \* 5113 \* 24) / (1.92 \* 3412)) \* 0.6)

= 224 + 2181

= 2405 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%[[17]](#footnote-19)

29.3 = kWh per therm

For example, a single family home in Chicago with 990 ft2 of R-5 walls insulated to R-11 and 700 ft2 of R-5 attic insulated to R-38, with a gas furnace with system efficiency of 66% (for therm calculation see Natural Gas Savings section):

ΔkWh = 216.4 \* 0.0314 \* 29.3

= 199.1 kWh

###### Summer Coincident Peak Demand Savings

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

Where:

FLH\_cooling = Full load hours of air conditioning

= Dependent on location as below:[[18]](#footnote-20)

|  |  |  |
| --- | --- | --- |
| **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[[19]](#footnote-21) | 629 | 564 |

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

= 68%[[20]](#footnote-22)

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

72%%[[21]](#footnote-23)

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

= 46.6%[[22]](#footnote-24)

For example, a single family home in Chicago with 990 ft2 of R-5 walls insulated to R-11 and 700 ft2 of R-5 attic insulated to R-38, 10.5SEER Central AC and 2.26 COP Heat Pump:

ΔkWSSP = 224 / 570 \* 0.68

= 0.27 kW

ΔkWPJM = 224 / 570 \* 0.466

= 0.18 kW

###### Natural Gas Savings

If Natural Gas heating:

ΔTherms = ((((1/R\_old - 1/R\_wall) \* A\_wall \* (1-Framing\_factor\_wall)) + ((1/R\_old - 1/R\_attic) \* A\_attic \* (1-Framing\_factor\_attic))) \* 24 \* HDD) / (ηHeat \* 100,067 Btu/therm) \* ADJWallAtticHeat

Where:

HDD = Heating Degree Days

= Dependent on location:[[23]](#footnote-25)

|  |  |
| --- | --- |
| **Climate Zone**  **(City based upon)** | **HDD 60** |
| 1 (Rockford) | 5,352 |
| 2 (Chicago) | 5,113 |
| 3 (Springfield) | 4,379 |
| 4 (Belleville) | 3,378 |
| 5 (Marion) | 3,438 |
| Weighted Average[[24]](#footnote-26) | 4,860 |

ηHeat = Efficiency of heating system

= Equipment efficiency \* distribution efficiency

= Actual.[[25]](#footnote-27) If unknown assume 72%.[[26]](#footnote-28)

Other factors as defined above

For example, a single family home in Chicago with 990 ft2 of R-5 walls insulated to R-11 and 700 ft2 of R-5 attic insulated to R-38, with a gas furnace with system efficiency of 66%:

ΔTherms = ((((1/5 - 1/11) \* 990 \* (1-0.25)) + ((1/5 - 1/38) \* 700 \* (1-0.07))) \* 24 \* 5113) / (0.66 \* 100,067) \* 0.60

= 216.4 therms

###### Water Impact Descriptions and Calculation

N/A

###### Deemed O&M Cost Adjustment Calculation

N/A

###### Measure Code: RS-SHL-AINS-V06-160601

**Illinois Statewide**

**Technical Reference Manual**

**for Energy Efficiency**

**Attachment A**

**Illinois Statewide**

**Net-to-Gross**

**Methodologies**

**February 24th, 2015**

**FINAL**

**Effective for Evaluation:**

**June 1st, 2015**

**Table of Contents**

[I. Illinois Statewide Net-to-Gross Methodologies 776](#_Toc411554693)

[A. Policy Context for this Information 776](#_Toc411554694)

[B. Programs Currently Covered in this Document 777](#_Toc411554695)

[C. Updating the IL-NTG Methods 778](#_Toc411554696)

[D. Diverging from the IL-NTG Methods 778](#_Toc411554697)

[E. Procedure for Non-Consensus Items 779](#_Toc411554698)

[II. Attribution in Energy Efficiency Programs in General 780](#_Toc411554699)

[III. Attribution within the Commercial, Industrial, and Public Sectors 783](#_Toc411554700)

[A. Standard/Prescriptive and Custom Programs 783](#_Toc411554701)

[1. Free Ridership 783](#_Toc411554702)

[2. Spillover 784](#_Toc411554703)

[IV. Attribution within the Residential and Low Income Sectors 785](#_Toc411554704)

[A. Appliance Recycling Programs 785](#_Toc411554705)

[1. Free Ridership 785](#_Toc411554706)

[2. Secondary Market Impacts 787](#_Toc411554707)

[3. Induced Replacement 788](#_Toc411554708)

[4. Integrating Free Ridership, Secondary Market Impacts, and Induced Replacement 789](#_Toc411554709)

[5. Participant Spillover 791](#_Toc411554710)

[6. Nonparticipant Spillover 791](#_Toc411554711)

[B. Residential Upstream Lighting Programs 792](#_Toc411554712)

[1. Free Ridership 792](#_Toc411554713)

[2. Participant Spillover 795](#_Toc411554714)

[3. Nonparticipant Spillover 795](#_Toc411554715)

[4. Method Advantages and Disadvantages 795](#_Toc411554716)

[V. Appendix A: Overview of NTG Methods 796](#_Toc411554717)

[A. Survey-Based Approaches 796](#_Toc411554718)

[1. Self-Report Approach 796](#_Toc411554719)

[2. Econometric/Revealed Preference Approach 797](#_Toc411554720)

[B. Randomized Control Trials (RCT) and Quasi-Experimental Designs 797](#_Toc411554721)

[C. Deemed or Stipulated NTG Ratios 798](#_Toc411554722)

[D. Common Practice Baseline Approaches 798](#_Toc411554723)

[E. Market Analyses 798](#_Toc411554724)

[F. Structured Expert Judgment Approaches 799](#_Toc411554725)

[G. Program Theory-Driven Approach 799](#_Toc411554726)

[H. Case Studies Design 800](#_Toc411554727)

[VI. Appendix B: References 801](#_Toc411554728)

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. An estimate based on review of Madison Gas and Electric, Exterior Wall Insulation, R-value for no insulation in walls, and NREL's Building Energy Simulation Test for Existing Homes (BESTEST-EX). [↑](#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. Ibid. [↑](#footnote-ref-7)
8. National Climatic Data Center, Cooling Degree Days are based on a base temp of 65°F. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois. [↑](#footnote-ref-8)
9. Weighted based on number of occupied residential housing units in each zone. [↑](#footnote-ref-9)
10. This factor's source is: Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research”, p31. [↑](#footnote-ref-10)
11. 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-11)
12. 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-12)
13. National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in “Statistical Analysis of Historical State-Level Residential Energy Consumption Trends,” 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois. [↑](#footnote-ref-13)
14. Weighted based on number of occupied residential housing units in each zone. [↑](#footnote-ref-14)
15. 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-15)
16. 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-17)
17. 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-19)
18. Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois. [↑](#footnote-ref-20)
19. Weighted based on number of occupied residential housing units in each zone. [↑](#footnote-ref-21)
20. Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory. [↑](#footnote-ref-22)
21. 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-23)
22. 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-24)
23. National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in “Statistical Analysis of Historical State-Level Residential Energy Consumption Trends,” 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois. [↑](#footnote-ref-25)
24. Weighted based on number of occupied residential housing units in each zone. [↑](#footnote-ref-26)
25. Ideally, the System Efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (<http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf>) or by performing duct blaster testing. [↑](#footnote-ref-27)
26. Based on average Nicor PY4 nameplate efficiencies derated by 15% for distribution losses. [↑](#footnote-ref-28)