4.7.6 Roof Insulation for C&I Facilities

**Description**

Energy and demand saving are realized through reductions in the building cooling and heating loads. This measure was developed to be applicable to the following program types: RF and NC.

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

**Definition of Efficient Equipment**







The efficient condition is above code and should be determined by the program.

**Definition of Baseline Equipment**

The retrofit baseline condition is adopted from Ohio Energy Technical Reference Manual and expanded to cover all type of commercial buildings in the state of Illinois as follows.

For retrofits, the R-value for the entire assembly:

| **Building Type** | **Retrofit Assembly R-Value** |
| --- | --- |
| Assembly | 13.5 |
| Assisted Living | 13.5 |
| College | 13.5 |
| Convenience Store | 13.5 |
| Elementary School | 13.5 |
| Garage | 13.5 |
| Grocery | 13.5 |
| Healthcare Clinic | 13.5 |
| High School | 13.5 |
| Hospital | 13.5 |
| Hotel/Motel | 13.5 |
| Manufacturing Facility | 12 |
| MF - High Rise | 13.5 |
| MF - Mid Rise | 13.5 |
| Movie Theater | 13.5 |
| Office - High Rise | 13.5 |
| Office - Low Rise | 13.5 |
| Office - Mid Rise | 13.5 |
| Religious Building | 13.5 |
| Restaurant | 13.5 |
| Retail - Department Store | 13.5 |
| Retail - Strip Mall | 13.5 |
| Warehouse | 12 |
| Unknown | 13.5 |

For new construction use R-value from IECC 2012 or ASHRAE – 90.1 – 2010, or use IECCC 2015 or ASHRAE – 90.1 – 2013, depending on the IECC in effect on the date of the building permit.

R-Values: ASHRAE – 90.1 – 2010

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **IL TRM Zones 1, 2, & 3 [ASHRAE/IECC Climate Zone 5 (A, B, C)]** | | | |
| **Nonresidential** | | **Semiheated** | |
| **Assembly Maximum** | **Insulation Min. R-Value** | **Assembly Maximum** | **Insulation Min. R-Value** |
| **Insulation Entirely Above Deck** | 0.048 | R-20 c.i. | U-0.119 | R-7.6 c.i. |
| **Metal Building (Roof)** | 0.055 | R-13.0 + R-13.0 | U-0.083 | R-13.0 |
| **Attic and Other** | 0.027 | R-38.0 | U-0.053 | R-19.0 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **IL TRM Zones 4 & 5 [ASHRAE/IECC Climate Zone 4 (A, B, C)]** | | | | Table Notes  c.i. = continuous insulation |
|  | **Nonresidential** | | **Semiheated** | |
|  | **Assembly Maximum** | **Insulation Min. R-Value** | **Assembly Maximum** | **Insulation Min. R-Value** |
| **Insulation Entirely Above Deck** | 0.048 | R-20.0 c.i. | 0.173 | R-5.0 c.i. |
| **Metal Building (Roof)** | 0.055 | R-13.0 + R-13.0 | 0.097 | R-10.0 |
| **Attic and Other** | 0.027 | R-38.0 | 0.053 | R-19.0 |

R-Values: ASHRAE – 90.1 – 2010

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **IL TRM Zones 1, 2, & 3 [ASHRAE/IECC Climate Zone 5 (A, B, C)]** | | | |
| **Nonresidential** | | **Semiheated** | |
| **Assembly Maximum** | **Insulation Min. R-Value** | **Assembly Maximum** | **Insulation Min. R-Value** |
| **Insulation Entirely Above Deck** | 0.032 | R-30.0 c.i. | 0.063 | R-15 c.i. |
| **Metal Building (Roof)** | 0.037 | R-19 + R-11 Ls or  R-25 + R-8 Ls | 0.082 | R-19 |
| **Attic and Other** | 0.021 | R-49 | 0.034 | R-30 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **IL TRM Zones 4 & 5 [ASHRAE/IECC Climate Zone 4 (A, B, C)]** | | | | Table Notes  c.i. = continuous insulation  Ls = linear system, a continuous vapor barrier liner installed below the purlins and uninterrupted by framing members |
| **Nonresidential** | | **Semiheated** | |
| **Assembly Maximum** | **Insulation Min. R-Value** | **Assembly Maximum** | **Insulation Min. R-Value** |
| **Insulation Entirely Above Deck** | 0.032 | R-30.0 c.i. | 0.093 | R-10 c.i. |
| **Metal Building (Roof)** | 0.037 | R-19 + R-11 Ls or  R-25 + R-8 Ls | 0.082 | R-19 |
| **Attic and Other** | 0.021 | R-49 | 0.034 | R-30 |

**Deemed Lifetime of Efficient Equipment**

The measure expected useful life (EUL) is assumed to be 20 years per DEER 2008. This is consistent with SDG&E’s 9th Year Measure Retrofit Study (1996 & 1997 Residential Weatherization Programs), CPUC’s Energy Efficiency Policy Manual v.2, and GDS’s Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures (June 2007).

**Deemed Measure Cost**

Per the W017 Itron California Measure Cost Study[[1]](#footnote-1), the material cost for R-30 insulation is $0.59 per square foot. The installation cost is $0.81 per square foot. The total measure cost, therefore, is $1.40 per square foot of insulation installed. However, the actual cost should be used when available.

**Loadshape**

Loadshape C03: Commercial Cooling

**Coincidence Factor**

CFSSP = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [[2]](#footnote-2)

CFPJM = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [[3]](#footnote-3)

**Algorithm**

**Calculation of Energy Savings**

**Electric Energy Savings**

Electric energy savings is calculated as the sum of energy saved when cooling the building and energy saved when heating the building

∆kWh = ∆kWh\_cooling + ∆kWh\_heating

If central cooling, the electric energy saved in annual cooling due to the added insulation is

∆kWh\_cooling = ((1/R\_existing) - (1/R\_new)) \* Area \* EFLHcooling \* ΔTAVG,cooling / 1,000 / η\_cooling

Where:

R\_existing = Roof heat loss coefficient with existing insulation [(hr-⁰F-ft2)/Btu]

R\_new = Roof heat loss coefficienty with new insulation [(hr-⁰F-ft2)/Btu]

Area = Area of the roof surface in square feet. Assume 1000 sq ft for planning.

EFLHcooling = Equivalent Full Load Hours for Cooling [hr] are provided in Section 4.4, HVAC end use

ΔTAVG,cooling = Average temperature difference [⁰F] during cooling season between outdoor air temperature and assumed 75⁰F indoor air temperature

| **Climate Zone**  **(City based upon)** | **OAAVG,cooling [°F][[4]](#footnote-4)** | **ΔTAVG,cooling [°F]** |
| --- | --- | --- |
| 1 (Rockford) | 81 | 6 |
| 2 (Chicago) | 81 | 6 |
| 3 (Springfield) | 81 | 6 |
| 4 (Belleville) | 82 | 7 |
| 5 (Marion) | 82 | 7 |

1,000 = Conversion from Btu to kBtu

η\_cooling = Seasonal energy efficiency ratio (SEER) of cooling system (kBtu/kWh). Use actual if possible, if unknown and for planning purposes assume the following:

|  |  |
| --- | --- |
| **Year Equipment was Installed** | **SEER estimate** |
| Before 2006 | 10 |
| After 2006 | 13 |

If the building is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the added insulation is

∆kWh\_heating = [(1/R\_existing) - (1/R\_new)] \* Area \* EFLHheating \* ΔTAVG,heating / 3,412 / η\_heating

Where:

EFLHheating = Equivalent Full Load Hours for Heating [hr] are provided in Section 4.4, HVAC end use

ΔTAVG,heating = Average temperature difference [⁰F] during heating season between outdoor air temperature and assumed 55⁰F heating base temperature

| **Climate Zone**  **(City based upon)** | **OAAVG,heating [°F][[5]](#footnote-5)** | **ΔTAVG,heating [°F]** |
| --- | --- | --- |
| 1 (Rockford) | 32 | 23 |
| 2 (Chicago) | 34 | 21 |
| 3 (Springfield) | 35 | 20 |
| 4 (Belleville) | 36 | 19 |
| 5 (Marion) | 39 | 16 |

3,142 = Conversion from Btu to kWh.

η\_heating = Efficiency of heating system. Use actual efficiency. If not available refer to default table below.

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

If the building is heated with a gas furnace, there will be some electric savings in heating the building attributed to extra insulation since the furnace fans will run less.

∆kWh\_heating = ∆Therms \* Fe \* 29.3

Where:

∆Therms = Gas savings calculated with equation below.

Fe = Percentage of heating energy consumed by fans, assume 3.14%

29.3 = Conversion from therms to kWh

**Summer Coincident Peak Demand Savings**

∆kW = (∆kWh\_cooling / EFLH\_cooling) \* CF

Where:

EFLHcooling = Equivalent full load hours of air conditioning are provided in Section 4.4, HVAC end use

CFSSP = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [[6]](#footnote-6)

CFPJM = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [[7]](#footnote-7)

**Natural Gas Savings**

If building uses a gas furnace, the savings resulting from the insulation is calculated with the following formula.

∆Therms = ((1/R\_existing) - (1/R\_new)) \* Area \* EFLHheating \* ΔTAVG,heating / 100,000 / η\_heat

Where:

R\_existing = Roof heat loss coefficient with existing insulation [(hr-⁰F-ft2)/Btu]

R\_new = Roof heat loss coefficienty with new insulation [(hr-⁰F-ft2)/Btu]

Area = Area of the roof surface in square feet. Assume 1000 sq ft for planning.

EFLHheating = Equvalent Full Load Hours for Heating are provided in Section 4.4, HVAC end use

ΔTAVG,heating = Average temperature difference [⁰F] during heating season (see above)

100,000 = Conversion from BTUs to Therms

η\_heat = Efficiency of existing furnace. Assume 0.78 for planning purposes.

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**Measure code: CI-HVC-RINS-V02-160601**

1. Measure costs are from the W017 Itron California Measure Cost Study, accessed via <http://www.energydataweb.com/cpuc/search.aspx>. The data is provided in a file named “MCS Results Matrix – Volume I”. [↑](#footnote-ref-1)
2. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility’s peak hour is divided by the maximum AC load during the year. [↑](#footnote-ref-2)
3. 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-3)
4. National Solar Radiation Data Base -- 1991- 2005 Update: Typical Meteorological Year 3

   <http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html> [↑](#footnote-ref-4)
5. National Solar Radiation Data Base -- 1991- 2005 Update: Typical Meteorological Year 3

   <http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html> [↑](#footnote-ref-5)
6. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility’s peak hour is divided by the maximum AC load during the year. [↑](#footnote-ref-6)
7. 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-7)