DEEMED SAVINGS TECHNICAL ASSUMPTIONS

Product: Insulation and Air Sealing Rebate

Description:
Residential natural gas and/or electric customers receive a cash rebate for installing insulation in their existing single-family home or one-to-four unit property.

Wall Insulation Equations:

\[ \text{Customer Dth} = \frac{1}{R_{\text{Wall_Base}}} - \frac{1}{R_{\text{Wall_Proposed}}} \cdot \frac{\text{Wall Area}}{HDD} \cdot 24 \cdot 1,000,000 \cdot \text{Heating Eff_Gas} \]

\[ \text{Cooling kWh} = \frac{1}{R_{\text{Wall_Base}}} - \frac{1}{R_{\text{Wall_Proposed}}} \cdot \frac{\text{Wall Area}}{CDD} \cdot 24 \cdot 3,412 \cdot \text{Cooling Eff} \]

\[ \text{Heating kWh} = \frac{1}{R_{\text{Wall_Base}}} - \frac{1}{R_{\text{Wall_Proposed}}} \cdot \frac{\text{Wall Area}}{HDD} \cdot 24 \cdot 3,412 \cdot \text{Heating Eff_Elec} \]

\[ \text{Gross Annual kWh Saved at Customer} = \text{Cooling kWh} + \text{Heating kWh} \]

\[ \text{Customer kW (Gross kW)} = \frac{\text{Gross Annual kWh Saved at Customer}}{\text{Cooling Hours + Heating Hours}} \]

\[ \text{Customer PckW} = \frac{\text{Cooling kWh}}{\text{Cooling Hours}} \]

Attic Insulation Equations:

\[ \text{Customer Dth} = \frac{1}{(2 + R_{\text{Attic_Base}}) - \frac{1}{(2 + R_{\text{Attic_Proposed}})} \cdot \frac{\text{Attic Area}}{HDD} \cdot 24 \cdot 1,000,000 \cdot \text{Heating Eff_Gas} \]

\[ \text{Cooling kWh} = \frac{1}{(2 + R_{\text{Attic_Base}}) - \frac{1}{(2 + R_{\text{Attic_Proposed}})} \cdot \frac{\text{Attic Area}}{CDD} \cdot 24 \cdot 3,412 \cdot \text{Cooling Eff} \]

\[ \text{Heating kWh} = \frac{1}{(2 + R_{\text{Attic_Base}}) - \frac{1}{(2 + R_{\text{Attic_Proposed}})} \cdot \frac{\text{Attic Area}}{HDD} \cdot 24 \cdot 3,412 \cdot \text{Heating Eff_Elec} \]

\[ \text{Gross Annual kWh Saved at Customer} = \text{Cooling kWh} + \text{Heating kWh} \]

\[ \text{Customer kW (Gross kW)} = \frac{\text{Gross Annual kWh Saved at Customer}}{\text{Cooling Hours + Heating Hours}} \]

\[ \text{Customer PckW} = \frac{\text{Cooling kWh}}{\text{Cooling Hours}} \]

Air Sealing Equations:

\[ \text{Customer Dth} = \frac{\text{CFM50 Baseline} - \text{CFM50 Proposed}}{N_{\text{Summer}} \cdot \text{ATF} \cdot \text{HDD} / 24 \cdot 3,412 \cdot \text{Heating Eff_Gas}} \]

\[ \text{Cooling kWh} = \frac{\text{CFM50 Baseline} - \text{CFM50 Proposed}}{N_{\text{Summer}} \cdot \text{ATF} \cdot \text{CDD} / 24 \cdot 3,412 \cdot \text{Cooling Eff}} \]

\[ \text{Heating kWh} = \frac{\text{CFM50 Baseline} - \text{CFM50 Proposed}}{N_{\text{Winter}} \cdot \text{ATF} \cdot \text{HDD} / 24 \cdot 3,412 \cdot \text{Heating Eff_Elec}} \]

\[ \text{Gross Annual kWh Saved at Customer} = \text{Cooling kWh} + \text{Heating kWh} \]

\[ \text{Customer kW (Gross kW)} = \frac{\text{Gross Annual kWh Saved at Customer}}{\text{Cooling Hours + Heating Hours}} \]

\[ \text{Customer PckW} = \frac{\text{Cooling kWh}}{\text{Cooling Hours}} \]

Variable ID | Value | Description
--- | --- | ---
R_Wall_Base | 4.41 | R-Value for baseline wall insulation, calculated assuming no cavity insulation
R_Wall_Proposed | 13.09 | R-Value for proposed wall insulation, calculated assuming R-11 cavity insulation
WallArea | Customer Input | Square footage of wall insulation added, provided by customer
R_Attic_Base | Customer Input | R-Value for baseline attic insulation, provided by customer
R_Attic_Proposed | Customer Input | R-Value for proposed attic insulation, provided by customer
AtticArea | Customer Input | Square footage of attic insulation added, provided by customer
Heating_Eff_Gas | See Table 1 | Heating efficiency is determined based on the customer's heating system type
Cooling_Eff | See Table 2 | Cooling efficiency is determined based on the customer's cooling system type
Heating_Eff_Elec | See Table 1 | Heating efficiency is determined based on the customer's heating system type
CFM50_Baseline | Customer Input | Blower Door test air leakage rate at 50 pascals maintained pressure, measured in cubic feet per minute. The contractor will capture actual readings.
CFM50_Proposed | Customer Input | Blower Door test air leakage rate at 50 pascals maintained pressure, measured in cubic feet per minute. The contractor will capture actual readings.
N_Winter | See Table 3 | Conversion factor used to relate actual measured CFM leakage rate (taken at a reference pressure of 50 pascals) to a natural CFM of infiltration. (Reference 2)
N_Summer | See Table 3 | Conversion factor used to relate actual measured CFM leakage rate (taken at a reference pressure of 50 pascals) to a natural CFM of infiltration. (Reference 2)
ATF | See Table 4 | Air Transfer Factor is a conversion factor for calculating BTU/hour from airflow in CFM
HDD | See Table 4 | Heating Degree Days base 65, based on TMY3 data.
CDD | See Table 4 | Cooling Degree Days base 65, based on TMY3 data.
Cooling Hours | 329 | Full load cooling hours per Residential Heating program
Heating Hours | 1159 | Full load heating hours per Residential Heating program
Conversion from Btu to Dth | 1,000,000 | 1 Dth = 1,000,000 Btuh
Conversion from Btu to kWh | 3,412 | 1 kWh = 3,412 Btuh
Incremental Cost | Customer Input | Cost of the insulation or air sealing is provided by the customer
Measure Lifetime | See Table 5 | (Reference 1)
### Table 1: Heating Efficiency

<table>
<thead>
<tr>
<th>Heat Source</th>
<th>Heating Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>2.26</td>
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<tr>
<td>Electric Resistance</td>
<td>1.00</td>
</tr>
<tr>
<td>Ground Source Heat Pump</td>
<td>3.30</td>
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<tr>
<td>Natural Gas</td>
<td>0.78</td>
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</tbody>
</table>

### Table 2: Cooling Efficiency

<table>
<thead>
<tr>
<th>Heat Source</th>
<th>Cooling Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Conditioner</td>
<td>3.93</td>
</tr>
<tr>
<td>Evaporative Cooler</td>
<td>0.00</td>
</tr>
<tr>
<td>Ground Source Heat Pump</td>
<td>4.13</td>
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</tbody>
</table>

### Table 3: Stories

<table>
<thead>
<tr>
<th>Stories</th>
<th>Front Range</th>
<th>Western Slope</th>
<th>Mountain</th>
<th>Front Range</th>
<th>Western Slope</th>
<th>Mountain</th>
</tr>
</thead>
</table>

### Table 4: Energy Usage

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Front Range</th>
<th>Western Slope</th>
<th>Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td>YrF</td>
<td>5.529</td>
<td>6.506</td>
<td>9.813</td>
</tr>
<tr>
<td>HDD</td>
<td>6.016</td>
<td>5.580</td>
<td>9.015</td>
</tr>
<tr>
<td>CDD</td>
<td>1.116</td>
<td>1.452</td>
<td>434</td>
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</tbody>
</table>

### Table 5: Lifetime

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>Front Range</th>
<th>Western Slope</th>
<th>Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Insulation</td>
<td>20</td>
<td>Reference 1</td>
<td></td>
</tr>
<tr>
<td>Attic Insulation</td>
<td>20</td>
<td>Reference 1</td>
<td></td>
</tr>
<tr>
<td>Air Sealing</td>
<td>10</td>
<td>Reference 1</td>
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</tr>
</tbody>
</table>

### References:

2. ASHRAE 2013 Fundamentals, Chapter 16, Equations (41) defining Equivalent Air Leakage Area and (48) defining airflow rate from infiltration.
5. 2013 ASHRAE Fundamentals; Page 16.23 Table 4 Defining Stack Coefficient C_s
6. 2013 ASHRAE Fundamentals; Page 16.24 Table 6, defining basic model Wind Coefficient, C_w. Assumed Colorado is classified as Shelter Class 3.
7. R-Value estimate for wall insulation based on 2013 ASHRAE Fundamentals; Page 26.20, Table 10

### Changes from Recent Filing:

- Updated heating and cooling efficiencies for consistency

### Assumptions:

1. For minimum attic R-value, we are assuming non-vented attic for a minimum R-value of 4.74. Any inputs into the calculator that are under 2.74 will use 4.74 instead (2.74+2)
2. Roof assembly R-value approximated to R=2. Asphalt Shingles, Sheathing, and Air space may or may not apply depending on attic ventilation.