Earning HERS Points for Quality HVAC Design & Installation

Tuesday, February 26, 2019
Introduction
Installation defects in HVAC systems are commonplace

- Improper airflow.
- Incorrect refrigerant charge.

<table>
<thead>
<tr>
<th>Study Author</th>
<th>State</th>
<th>Sample Size</th>
<th>Average Airflow &lt;350 cfm</th>
<th>Airflow w/10% of 400ton</th>
<th>Energy Savings Potential Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blasnik et al. 1996a</td>
<td>NV</td>
<td>New 30</td>
<td>38% 5% 59%</td>
<td>17%</td>
<td>Est @ 67% combined charge/air flow correction benefits</td>
</tr>
<tr>
<td>Blasnik et al. 1996b</td>
<td>CA</td>
<td>New 10</td>
<td>31% 14% 61%</td>
<td>18%</td>
<td>Est @ 67% combined charge/air flow correction benefits</td>
</tr>
<tr>
<td>Blasnik et al. 1996</td>
<td>AZ</td>
<td>New 22</td>
<td>18% 4% 78%</td>
<td>21%</td>
<td>Est @ 67% combined charge/air flow correction benefits</td>
</tr>
<tr>
<td>Farzad &amp; O’Neal 1993</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>5%</td>
<td>Lab test of TXV; 8% loss @20% overcharge, 2% loss @20% undercharge</td>
</tr>
<tr>
<td>Farzad &amp; O’Neal 1993</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>17%</td>
<td>Lab test of Orifice; 13% loss @20% overcharge, 21% loss @ 20% undercharge</td>
</tr>
<tr>
<td>Hammarslund et al. 1992</td>
<td>CA</td>
<td>New 12</td>
<td>31% 14% 61%</td>
<td>12%</td>
<td>Single family results</td>
</tr>
<tr>
<td>Hammarslund et al. 1992</td>
<td>CA</td>
<td>New 66</td>
<td>31% 14% 61%</td>
<td>12%</td>
<td>Multi-family results</td>
</tr>
<tr>
<td>Katz 1907</td>
<td>NC/SC</td>
<td>New 22</td>
<td>22% 14% 64%</td>
<td>23%</td>
<td>Charge measured in 22 systems in 13 homes</td>
</tr>
<tr>
<td>Proctor &amp; Pernick 1992</td>
<td>CA</td>
<td>Existing 175</td>
<td>44% 33% 23%</td>
<td>17%</td>
<td>Results from PG&amp;E Model Energy Communities Program</td>
</tr>
<tr>
<td>Proctor 1991</td>
<td>CA</td>
<td>Existing 15</td>
<td>44%</td>
<td>17%</td>
<td>Fresno homes</td>
</tr>
<tr>
<td>Proctor et al. 1995a</td>
<td>CA</td>
<td>Existing 30</td>
<td>11% 33% 56%</td>
<td>17%</td>
<td>Lab test of TXV; 6% loss at both 20% overcharge &amp; 21% undercharge</td>
</tr>
<tr>
<td>Proctor et al. 1997a</td>
<td>NJ</td>
<td>New 52</td>
<td>31% 14% 61%</td>
<td>17%</td>
<td>Lab test of Orifice EER; 7% loss @20% overcharge, 22% loss @ 20% undercharge</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Typical operation of an HVAC system

1. Warm indoor air is blown over a cold refrigerant coil.
2. The air’s heat is transferred to the refrigerant.
3. Outdoor air is blown over the hot refrigerant coil.
4. The refrigerant’s heat is transferred to the outdoor air.
The installation process impacts airflow and refrigerant charge

- Airflow is impacted by the installation:
  - Fan-speed setting
  - Components attached to the system (like the filter)
  - Duct system installed

- Refrigerant charge is impacted by the installation:
  - Length of refrigerant line
Why is this relevant to HERS / ERI ratings?

• Today, installation faults have zero impact on a HERS or ERI rating.
• Not only do these faults impact efficiency, they impact performance.
• ENERGY STAR has promoted quality installation since 2011.
• However, uniform and practical procedures for Raters to assess systems will be a more effective approach.
• And, HERS / ERI points can be granted in exchange.
A standard is born

- ACCA initiated a proposal that RESNET include an evaluation of HVAC design and installation in the HERS index.
- In Summer 2016, EPA started leading a working group.
- The working group encompasses a diverse set of stakeholders interested in solving this problem:

<table>
<thead>
<tr>
<th>Jim Bergman, Measure Quick</th>
<th>Laurel Elam, RESNET</th>
<th>Brian Mount, Tempo Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tommy Blair, AE</td>
<td>Philip Fairey, FSEC</td>
<td>Dave Roberts, NREL</td>
</tr>
<tr>
<td>Michael Brown, ICF</td>
<td>Dean Gamble, EPA</td>
<td>Dennis Stroer, CalcsPlus</td>
</tr>
<tr>
<td>Greg Cobb, EI</td>
<td>Dan Granback, EI</td>
<td>Iain Walker, LBNL</td>
</tr>
<tr>
<td>Wes Davis, ACCA</td>
<td>James Jackson, Emerson</td>
<td>Dan Wildenhaus, TRC</td>
</tr>
<tr>
<td>Brett Dillon, IBS Advisors</td>
<td>Rob Minnick, Minnick’s Inc.</td>
<td>Jon Winkler, NREL</td>
</tr>
</tbody>
</table>


Guiding principles of the standard

• Take a ‘carrot’ rather than a ‘stick’ approach.
• Reward incremental improvement by HVAC professionals and Raters.
• Rely upon procedures that deliver value in and of themselves.
Conceptual overview of standard

Follow the insulation quality-installation model:

- **Grade III:**
  - The default.
  - HVAC system installation quality is not assessed.
  - No HERS points earned (but no penalty either).

- **Grade II:**
  - Rater assesses HVAC system.
  - HVAC system installation quality is so-so.
  - Some HERS points are earned.

- **Grade I:**
  - Rater assesses HVAC system.
  - HVAC system installation quality is pretty good.
  - Full HERS points are earned.
A standard will be born..

- RESNET and ACCA have reviewed a nearly final draft.
- Currently working to address their comments and create a final draft.
- Then we proceed to public comment.
- Once the standard is final:
  - An implementation date will be set.
  - Raters will be trained.
  - Software will be updated.
Overview of Standard 310: Standard for Grading the Installation of HVAC Systems
Std. 310: Standard for Grading the Installation of HVAC Systems
Task 1: Design Review
Task 1: Evaluating the design of the forced-air system

1. Rater collects design documentation for the dwelling with the HVAC system under test.

2. Rater reviews design documentation for completeness and compares it to the dwelling to be rated. Key features must fall within tolerances defined in the standard. For example:

<table>
<thead>
<tr>
<th>Floor Area</th>
<th>Outdoor Design Temps</th>
<th>Insulation Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window Area</td>
<td># Occupants</td>
<td>Infiltration Rate</td>
</tr>
<tr>
<td>Indoor Design Temps</td>
<td>Window SHGC</td>
<td>Ventilation Rate</td>
</tr>
</tbody>
</table>

3. If tolerances are met, proceed to next task. Otherwise stop here.

ENERGY STAR Partners are already doing this!
Task 2: Total Duct Leakage
Task 2: Evaluating the total duct leakage

1. Rater measures total duct leakage according to Std. 380, evaluates the results, and assigns a grade:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Test Stage</th>
<th># Returns</th>
<th>Total Leakage Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Rough-In</td>
<td>&lt; 3</td>
<td>4 CFM/100 sqft or 40 CFM</td>
</tr>
<tr>
<td></td>
<td>Rough-In</td>
<td>≥ 3</td>
<td>6 CFM/100 sqft or 60 CFM</td>
</tr>
<tr>
<td></td>
<td>Final</td>
<td>&lt; 3</td>
<td>8 CFM/100 sqft or 80 CFM</td>
</tr>
<tr>
<td></td>
<td>Final</td>
<td>≥ 3</td>
<td>12 CFM/100 sqft or 120 CFM</td>
</tr>
<tr>
<td>II</td>
<td>Rough-In</td>
<td>&lt; 3</td>
<td>6 CFM/100 sqft or 60 CFM</td>
</tr>
<tr>
<td></td>
<td>Rough-In</td>
<td>≥ 3</td>
<td>8 CFM/100 sqft or 80 CFM</td>
</tr>
<tr>
<td></td>
<td>Final</td>
<td>&lt; 3</td>
<td>10 CFM/100 sqft or 100 CFM</td>
</tr>
<tr>
<td></td>
<td>Final</td>
<td>≥ 3</td>
<td>14 CFM/100 sqft or 140 CFM</td>
</tr>
<tr>
<td>III</td>
<td>N/A</td>
<td>N/A</td>
<td>No Limit</td>
</tr>
</tbody>
</table>

2. If Grade I or II is achieved, proceed to next task. Otherwise stop here.

ENERGY STAR Partners are already doing this!
Task 3: Blower Fan Airflow
Task 3: Evaluating the Blower Fan Volumetric Airflow

- Raters measure the total volumetric airflow going through the blower fan using one of four test methods:
  A. Pressure Matching
  B. Flow Grid
  C. Flow Hood
  D. OEM Static Pressure Table
- This is just a single measurement. It is not measuring the airflow from each register and summing those.
Task 3: Evaluating the Blower Fan Volumetric Airflow

A. Pressure Matching

1. Measure static pressure created in supply plenum during operation of HVAC system.

2. Turn off HVAC system, connect a fan-flowmeter at the return or at the blower fan compartment.

3. Turn on the HVAC system and the flowmeter fan and adjust to achieve same static pressure in supply plenum.

4. Determine HVAC airflow by recording airflow of flowmeter fan.
Task 3: Evaluating the Blower Fan Volumetric Airflow

A. Pressure Matching

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses equipment many Raters already own</td>
<td>Can’t reach high flows for big systems: needs extrapolation</td>
</tr>
<tr>
<td>Accurate: +/- 3%</td>
<td>Need at least one large return duct or must connect at equipment</td>
</tr>
<tr>
<td></td>
<td>Requires hole in supply plenum</td>
</tr>
</tbody>
</table>
Task 3: Evaluating the Blower Fan Volumetric Airflow

B. Flow Grid

1. Measure static pressure created in supply plenum during operation of HVAC system.
2. Install flow grid in filter slot.
3. Measure pressure difference at flow grid and convert to airflow.
4. Re-measure static pressure in same location as Step 1, and correct airflow.
Task 3: Evaluating the Blower Fan Volumetric Airflow

B. Flow Grid

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy/simple for many systems</td>
<td>Multiple filter slots in a single system require multiple flow grids</td>
</tr>
<tr>
<td>Can work at higher flows</td>
<td>Need to make sure a good seal is achieved around the plate perimeter</td>
</tr>
<tr>
<td></td>
<td>Slightly less accurate +/- 7%</td>
</tr>
<tr>
<td></td>
<td>Requires hole in supply plenum</td>
</tr>
</tbody>
</table>
Task 3: Evaluating the Blower Fan Volumetric Airflow

C. Flow Hood

1. Turn on HVAC system.
2. Connect flow hood to return grille.
3. Turn on flow hood and allow reading to stabilize. This may require an additional step to account for back-pressure.
4. Resulting airflow of flow hood determines HVAC airflow.
### Task 3: Evaluating the Blower Fan Volumetric Airflow

#### C. Flow Hood

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate: +/- 3%</td>
<td>Can be heavy/unwieldy</td>
</tr>
<tr>
<td>Easy to use</td>
<td>Can be sensitive to placement</td>
</tr>
<tr>
<td>Does not require hole in supply plenum</td>
<td>Can be expensive</td>
</tr>
<tr>
<td></td>
<td>Will not always fit around air inlet</td>
</tr>
</tbody>
</table>
Task 3: Evaluating the Blower Fan Volumetric Airflow

D. OEM Static Pressure Table

1. Turn on HVAC system.
2. Measure external static pressure of system’s supply side and return side.
3. Determine fan-speed setting through visual inspection.
4. Using blower table information, look up total external static pressure and fan-speed setting to determine airflow.
Task 3: Evaluating the Blower Fan Volumetric Airflow

D. OEM Static Pressure Table

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inexpensive equipment</td>
<td>Rater required to get OEM Blower Table for installed equipment</td>
</tr>
<tr>
<td>Works for systems of all sizes and airflows</td>
<td>Needs carefully-placed hole in supply-side and return-side, sometimes in equipment housing</td>
</tr>
</tbody>
</table>
Task 4: Blower Fan Watt Draw
Task 4: Evaluating the Blower Fan Watt Draw

• Raters evaluate the watt draw of the blower fan using one of three test methods:
  A. Plug-In Watt Meter
  B. Clamp-On Watt Meter
  C. Utility Meter
Task 4: Evaluating the Blower Fan Watt Draw

A. Plug-In Watt Meter

1. Plug in the watt meter and blower fan equipment into standard electrical receptacle.
2. Turn on equipment in required mode.
3. Record reading from portable watt meter.
Task 4: Evaluating the Blower Fan Watt Draw

A. Plug-In Watt Meter

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple</td>
<td>Not usable with hard-wired equipment</td>
</tr>
<tr>
<td>Direct measurement of equipment</td>
<td></td>
</tr>
</tbody>
</table>
Task 4: Evaluating the Blower Fan Watt Draw

B. Clamp-On Watt Meter

1. Turn on equipment in required mode.
2. Connect clamp-on watt meter to measure voltage and current at either the service disconnect or through a service panel (not at breaker panel).
3. Record reading from clamp-on watt meter.
### Task 4: Evaluating the Blower Fan Watt Draw

**B. Clamp-On Watt Meter**

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useable with hardwired equipment that has service panel or service disconnect</td>
<td>Requires proper training and safety equipment</td>
</tr>
<tr>
<td>Direct measurement of equipment</td>
<td></td>
</tr>
</tbody>
</table>
Task 4: Evaluating the Blower Fan Watt Draw

C. Utility Meter

1. Turn off all circuits except air handler’s.
2. Turn on equipment in required mode.

For a digital utility meter:
3. Record watt draw from utility meter.

For an analog utility meter:
3. For 90+ seconds, record the number of meter revolutions and time.
4. Calculate watt draw.
Task 4: Evaluating the Blower Fan Watt Draw

C. Utility Meter

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Works with all equipment</td>
<td>Indirect measurement, and some meters are less sensitive to low watt draw.</td>
</tr>
<tr>
<td>No new equipment needed</td>
<td>Turning off all other circuits can be disruptive</td>
</tr>
</tbody>
</table>
Task 5: Evaluating Refrigerant Charge
Task 5: Evaluating the Refrigerant Charge

- Raters evaluates the refrigerant charge of the system using one of two test methods:
  A. Non-Invasive Test
  B. Weigh-In Verification - Only for select equipment and conditions
Task 5: Evaluating the Refrigerant Charge

A. Non-Invasive Test

- Non-invasive = No refrigerant gauges
- Triage systems into two bins
  - Grade I – Probably OK
  - Grade III – Not good
- Only flags really bad systems
Task 5: Evaluating the Refrigerant Charge

A. Non-Invasive Test

- How close is the actual refrigerant line temperature to the calculated target?
## Task 5: Evaluating the Refrigerant Charge

### A. Non-Invasive Test

| Step 1       | Determine Equipment Characteristics:  
               | Need SEER, and manufacturer specified superheat / subcooling. |
|--------------|------------------------------------------------------------------------------------------|
| Step 2       | Measure Air Temperatures:  
               | Need outdoor air and return air temperatures.                                             |
| Step 3       | Calculate Target Refrigerant Line Temperatures:  
               | Calculated for suction line and liquid line.                                             |
| Step 4       | Measure Actual Refrigerant Line Temperatures:  
               | Measuring both suction line and liquid line with a temperature probe.                    |
| Step 5       | Compare & Evaluate:  
               | Compare the target line temperatures to the measured temperatures,  
               | if they are too far apart, then the system is not properly charged.                     |
Task 5: Evaluating the Refrigerant Charge

A. Non-Invasive Test

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>No refrigerant handling certification needed</td>
<td>New procedure to learn</td>
</tr>
<tr>
<td>No risk of refrigerant contamination and leaks</td>
<td>Minimum outdoor air temperature required</td>
</tr>
<tr>
<td>Less Rater liability</td>
<td></td>
</tr>
</tbody>
</table>
Task 5: Evaluating the Refrigerant Charge

B. Weigh-In Verification

1. Contractor provides:
   1. Weight of refrigerant added / removed
   2. Line length and diameter
   3. Default line length from factory charge (usually 15 feet)
   4. Factory supplied charge
   5. Geotagged photo of scale with weight added / removed

2. Rater then:
   1. Measures line length and diameter
   2. Uses lookup table to determine how much refrigerant should have been added / removed

3. Rater verifies the following:
   1. Deviation between lookup and contractor value within tolerance
   2. Location of geotagged photo matches “in the judgment of the party conducting the evaluation” the location of the equipment
## Task 5: Evaluating the Refrigerant Charge

### B. Weigh-In Verification

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>No refrigerant handling certification needed</td>
<td>Requires information from contractor</td>
</tr>
<tr>
<td>Works at any outdoor temperature</td>
<td>Not a true performance test</td>
</tr>
</tbody>
</table>
Std. 310: Standard for Grading the Installation of HVAC Systems

1. Design Review
   - Tolerances Not Met
   - Tolerances Met

2. Total Duct Leakage
   - Grade I or II

3. Blower Fan Airflow
   - Grade I or II
   - Flow Grid
   - Pressure Matching
   - Flow Hood
   - Static Press. Table

4. Blower Fan Watt Draw
   - Grade I or II
   - Plug-In Watt Meter
   - Clamp-On Watt Meter
   - House Utility Meter

5. Refrigerant Charge
   - Grade I
   - Non-Invasive Temp.
   - Weigh-In Verification

Grade III
Field Test Results
Field Test: Overview

- Select six providers to give field procedures a quick spin:
  - **18 systems** evaluated
  - **63 individual tests** performed
- Goals:
  - Were there any obstacles or anything unclear in the procedures?
  - Did they have any major concerns with the procedures?
  - How long did it take to conduct each test?
  - Did different test procedures for the same parameter get similar results?
  - Did the systems they tested receive Grade I, II, or III?
Field Test: Required time to test

- Required HVAC warm-up time is 15 minutes, but Raters can do other tasks during this time. Then they can proceed with testing.
- Average time for all tests among participants was 26 minutes.
### Field Test: Required time to test

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Average Time (minutes)</th>
<th># Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blower Fan Airflow</td>
<td>9</td>
<td>28</td>
</tr>
<tr>
<td>Blower Fan Watt Draw</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Refrigerant Charge</td>
<td>11</td>
<td>17</td>
</tr>
</tbody>
</table>
Field Test: Consistency between tests

Multiple Airflow Tests on Same System

- These were the first tests done, without training, so this could improve.
- For consistency with a contractor, Raters may need to coordinate on test procedures and equipment.
- However, Grade bins were made to be relatively large to accommodate some variability.
Field Test: What grades were achieved?

Blower Fan Airflow
- Grade I: 71%
- Grade II: 25%
- Grade III: 4%

Blower Fan Watt Draw
- Grade I: 59%
- Grade II: 29%
- Grade III: 12%

Refrigerant Charge
- Grade I: 80%
- Grade II: 20%
Field Test: Qualitative feedback

- No major hurdles were identified.
- Several refinements were suggested (e.g., equipment calibration frequency).
- Some participants found parts of the procedures confusing at first, or time-consuming to follow, but these tests were conducted without training.
- Overall, feedback was positive:
  - “Draft procedures were clear, and [represent] common test protocols in the HERS industry”
  - “The 310 standard offers a lot of benefits to the homebuilding industry and its homeowners, it gives a quantifiable way to confirm that a healthy HVAC system was installed and should minimize warranty issues in this category.”
Summary
Summary

• Standard 310 will be a new standard for evaluating the design and installation quality of HVAC systems.
• The standard should be final before we get together at next year’s RESNET conference.
• If you’re doing ENERGY STAR today, this new standard will look very familiar to you. The key difference will be the field tests.
• This should allow ENERGY STAR builders to get more HERS points for things that they’re already doing today.
• This will be a major step towards unifying the ENERGY STAR program and HERS ratings.
Potential HERS Points
Estimating the ERI Point Potential of Quality Installation

David Roberts
Jon Winkler
RESNET Building Performance Conference
February 26, 2019
• Jon Winkler, Ph.D.
  – Senior Research Engineer
  – Building Energy Science Group
  – National Renewable Energy Laboratory
Overview

RESNET 310
(Grading installation quality)

RESNET 301
(ERI calculation standard)

• Objectives
  – Implement an approach accounting for HVAC installation defects in building energy simulations
  – Estimate the ERI impact of various defect scenarios
Approach

• Two defects of primary interest
  – Refrigerant charge
  – Indoor airflow

• Key steps
  1. Implement air conditioner and heat pump defect correlations in BEopt/EnergyPlus
  2. Construct appropriate new construction house models
  3. Simulate various defect scenarios in multiple climate zones
  4. Estimate the ERI impact
Defect Correlations

**Refrigerant Charge**
- *NIST Technical Note 1848*
- Experimental testing on one heat pump system
- Inputs: charge level and indoor and outdoor temperatures

**Indoor Airflow**
- *NREL Report 5500-56354*
- Manufacturer data on 460 AC and HP systems
- Input: fraction of rated airflow
Simulation Methodology

  – Impact of the defect was evaluated on a timestep basis
• General approach can be leveraged by other software programs
House Parameters

New construction, single-family home
• 3 bed + 2 bath; 2,500 sq. ft
• Construction based on IECC 2009
• Construction and foundation type varied by climate
• Simulations followed RESNET Standard 301

Simulated Locations
• CZ 2 – Houston, TX
• CZ 3 – Atlanta, GA
• CZ 4 – Washington, DC
• CZ 5 – Chicago, IL
**Equipment Assumptions**

**Equipment types**
- SEER 14 air conditioner and gas furnace
- SEER 14, 8.2 HSPF central heat pump

**Equipment assumptions**
- 0.5 W/cfm fan efficiency
- Manufacturer recommended airflow is 400 cfm/ton
Defect Scenarios

- Percent deviation from manufacturer recommended value
- We included the default defects recommended by the RESNET 310 working group
  - -25% defect → Grade III
  - 0% defect → Grade I

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airflow defect level</td>
<td>0%</td>
<td>-25%</td>
<td>0%</td>
<td>-25%</td>
</tr>
<tr>
<td>Refrigerant charge defect level</td>
<td>0%</td>
<td>0%</td>
<td>-25%</td>
<td>-25%</td>
</tr>
</tbody>
</table>
Methodology Caveat

• RESNET 310 proposes to apply default defect levels to the *Reference Home*

• We applied defects to the *Rated Home* and assumed the reference home did not have defects

• ERI impact should be similar
Point Potential – Air Conditioners

Climate Zone 2
- Business As Usual: Energy Rating Index 75
- Grade I Install: Energy Rating Index 60
  5 points

Climate Zone 3
- Business As Usual: Energy Rating Index 70
- Grade I Install: Energy Rating Index 67
  3 points

Climate Zone 4
- Business As Usual: Energy Rating Index 74
- Grade I Install: Energy Rating Index 72
  2 points

Climate Zone 5
- Business As Usual: Energy Rating Index 80
- Grade I Install: Energy Rating Index 79
  <1 point
Point Potential – Heat Pumps

Climate Zone 2

- Business As Usual: Energy Rating Index 68
- Grade I Install: Energy Rating Index 60

6 points

Climate Zone 3

- Business As Usual: Energy Rating Index 75
- Grade I Install: Energy Rating Index 67

7 points

Climate Zone 4

- Business As Usual: Energy Rating Index 72
- Grade I Install: Energy Rating Index 65

7 points

Climate Zone 5

- Business As Usual: Energy Rating Index 70
- Grade I Install: Energy Rating Index 65

6 points
## Estimated ERI Impact

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<th>0% Airflow -25% Charge</th>
<th>-25% Airflow -25% Charge</th>
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</table>
Trends (for an IECC 2009 Home)

• Air conditioners
  – Potential to earn more points in hotter climates

• Heat pumps
  – Potential to earn more points in mixed climates
  – Interactions between the heat pump and supplemental heat are important to consider

• Heat pumps have potential to earn more points than air conditioners
Summary

• Previous work
  – Working group estimated initial point potential based on cursory modeling
  – Air conditioners: Hot climates ~3 points; Mixed climates ~2 points; Cold climates ~1 point
  – Heat pumps: Low point potential in cold climates (non-intuitive)

• Our approach
  – Similar trends for air conditioners (higher point potential due to lower efficiency home)
  – More intuitive results for heat pumps
  – Lays the groundwork for HERS software programs to ensure installation quality impacts get modeled in a consistent manner
Questions?
ENERGY STAR Certified Homes

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