RESNET Summit: What’s Happening With HERS Rating Software

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Acknowledgements

• Dave Roberts graciously gave permission to use materials from his presentation entitled “RESNET Software Accreditation Process – Benefits to Utility Efficiency Programs” given at the 2017 RESNET Conference in Scottsdale, AZ, February 27, 2017.
Some software, more software
Some software, more software

But they all went through the same accreditation process...
Accreditation process

1. ANSI/ASHRAE 140 Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs
2. HERS Reference Home auto-generation test
3. HERS method tests
4. HVAC test
5. Duct distribution system efficiency tests
6. Hot water system performance tests
Accreditation process - BESTEST

BESTEST

• ANSI/ASHRAE 140 Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs
  – Tests building physics
  – Heating/cooling climates
  – Three reference softwares
  – Absolute/delta tests
  – Stress testing
  • High/Low insulation
  • High/Low solar gain
  • High/Low infiltration
  • Etc.
Accreditation process - Results

3.3 Process for Accrediting Software Programs

The RESNET accreditation process provides a suite of verification tests to certify that rating software tools conform to the verification criteria for each test. The software developer shall be required to submit the test results, test runs, and the software program with which the tests were conducted to RESNET. This information may be released by RESNET for review by any party, including competing software developers. This process is expected to result in compliance without a costly bureaucratic review and approval process.
Anatomy of a Home Energy Assessment Tool

**User Interface**
- Typical residential assessment inputs

**Input Translator**
- Assumptions about building details not observed or input

**Simulation Engine**
- Detailed inputs needed to drive simulation*

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**Example: Air Conditioner**

- SEER: 1 input
- Capacity: 1 input
- SHR: 1 input
- Total: 3 inputs

- Many, many lines of software code that translate simplified inputs into detailed inputs

- Air Loop: 19 inputs
- Coil: 28 inputs
- Performance Curves: 50 inputs
- Fan: 13 inputs
- Total: > 100 inputs

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**Estimated influence on variability**
- 40% observation and input
- 50% input translation
- 10% simulation engine

**Keys to Improvement**
- Training and Interface Design
- Common Rules or Shared Software Code
- Validation

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*Similar inputs needed for any detailed simulation engine (e.g., EnergyPlus, DOE-2, ESP-r, etc.).

**Dave Roberts’ generalized observational opinion.

*"Anatomy of a Home Energy Assessment Tool"*
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**Software Testing**
- Many, many lines of software code that translate simplified inputs into detailed inputs

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**Dave Roberts’ generalized observational opinion.**
Standardized operations assumptions

**Standard 301**
- Establishes operational assumptions
- Based on typical/average use
  - Thermostat set points
  - Lighting usage
  - Appliance usage
  - Hot water usage
- Results in average energy usage predictions
- Ideal for publicly-funded programs
Summary & key takeaways

1. All RESNET-accredited software go through same rigorous testing

2. RESNET software testing is based on energy, including energy savings

3. Standardization and additional QA checks address input anomalies

4. Process continues to improve
HERS Software Analytics: New HERS Method Test Results

Taken from
RESNET Analytics Task Group Report

P. Fairey
Objective

• Determine how the change from the MINHERS 2013 Standard to the ANSI/RESNET/ICC 301-2014 Standard is likely to impact HERS Index scores
• Evaluate differences in 2 different climates:
  – Cooling dominated: Las Vegas, NV (Zone 3)
  – Heating dominated: Colorado Springs, CO (Zone 5)
What Changed?

• HERS Reference Home has been aligned with 2006 IECC
  – Instead of IECC 2004 supplement
  – Needed for Reference Home modernization, tax credits and energy code initiatives

• HERS Reference Home has become more efficient
  – Reference Home leakage: 8.9 ach50 → 6.6 ach50 (2-sty, 2,400 ft² home – will vary with home design)
  – A more efficient Reference Home results in a somewhat larger HERS Index (climate dependent)
  – Most impactful in cold climates, smaller to little impact in moderate and warm climates.
What Else Changed

• Hot water use has changed (Addendum A)
  – Quantity of hot water use has decreased, substantially in warm climates
  – Aligns much better with the science and available empirical data

• Hot water system opportunities added
  – Good plumbing design receives substantial credit
  – More efficient dishwashers and clothes washers get credited
  – DWHR systems and hot water recirculation systems are now included in improvement options
Ways the HERS Index is Affected

• Cold climate envelope leakage example (typical 2-sty, 2,400 ft$^2$ home, wsf=0.7):
  – 2013 Reference Home natural ach = 0.43
    • At 60 °F ΔT and 400 equivalent heating hours per year = 3.8 MBtu/y
  – 2014 Reference Home natural ach = 0.32
    • At 60 °F ΔT and 400 equivalent heating hours per year = 2.8 MBtu/y

• Reference Home heating load is reduced by 26% (1.0 MBtu/y)
HERS Index Evaluation Methods

- Define a simple, well-described base case home model using minimum 2015 IECC characteristics
- Construct a suite of tests using a range of common single measure modifications to ensure that confounding, interactive modeling affects are eliminated
- Simulations conducted and results reported by HERS software tool developers to ensure that modeling inputs are as intended by tool developers
- Simulation tests conducted “in the blind”
- Compare results from accredited HERS software tools across 2013 and 2014 standards.
Test Cases (2012 IECC Envelopes)

6) **Base Case**: 1,539 sf, 1-sty, 3-br, frame on crawlspace, gas furnace (80%), gas WH (0.62), default lghts. & elect appl.

7) High-eff gas furnace (96%)
8) Tankless gas WH (0.83)
9) 2-bedroom home
10) 4-bedroom home
11) Gas range/oven & dryer
12) Std. Electric WH (0.95)
13) High-eff elect HPWH (2.5)
14) SEER-21 air conditioner

15) Fan-cycler ventilation
16) **DHW recirc., no control**
17) **DHW recirc., man control**
18) **DWHR, all, equal, 54%**
19) Std. elect heat pump (8.2)
20) High-eff elect HP (10)
21) 75% high-eff lighting
22) Crawlspace ducts, Qn=0.04
2014 HERS Index Results: CO

The bar chart shows the CO HERS Index (2014) for various locations, categorized by EnergyGauge, REM/Rate, and Ekotrope. The index values range from 70 to 105.
HERS Change (2014-2013): CO

![HERS Change Diagram]
2014 HERS Index Results: LV

![Bar chart showing 2014 HERS Index Results for various properties labeled L100AL-06 to L100AL-22. The chart compares EnergyGauge, REM/Rate, and Ekotrope categories.](chart_image.png)
HERS Change (2014-2013): LV

![HERS Change Graph](image)
# HERS Averages, Deltas & Ranges

- HERS averages across cases for each software tool for 2014 and 2013 Standards showing HERS increase (HERS Δ) and HERS range across tools.
- Excludes results from cases 16-18 as these three cases have no meaning in 2013 Standard.

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Causes of Differences

- Acceptance criteria for ASHRAE 140 test suite are quite large
- For example, heating load for 140 L100A base case is acceptable from 48.75 – 79.48 MBtu
- HERS calculation equation uses Total Reference Loads (TRL) as the denominator of the “scoring fraction.”

\[ \text{HERS Index} = \text{PEfrac} \times \left( \frac{\text{TnML}}{\text{TRL}} \right) \times 100 \]
But . . .

- ASHRAE Std. 140 load tests show that each of the software tools is within the range of the Std. 140 test suite criteria
- Std. 140 test results also show the same relationship between the software tools with respect to the criteria range
- ICF, WrightSoft and EnergyPlus (E+) Std. 140 test results are also available for comparison.
Std. 140 Heating Load Tests: CO
(It’s mostly about the windows!)
The Good News

• The HERS Rating System is quite forgiving
• The same differences in software building load simulation exist for both the Reference and the Rated Home
• The impact of these load simulation differences is a second (or third) order affect
• Therefore, the HERS Index range across software tools is small compared to the range across Std. 140 Loads tests.
The Better News

- Hot Water loads are almost identical across software tools
- Rated Home hot water energy consumption is also very consistent across software tools
- Some small differences in Rated Home hot water energy consumption exist but can probably be aligned through software tweaks.
- Variance across softwares is reduced by ANSI/RESNET/ICC 301-2014 Standard
Reference Hot Water Loads: CO

![Bar chart showing CO Ref HW Load (MBtu) for different locations with three categories: EnergyGauge, REM/Rate, Ekotrope.](chart.png)
HERS Variance (σ/mean): CO

The diagram shows the CO HERS Variance (±%mean) for various L100AC numbers from 06 to 22. The data is split into two categories: 2013 Variance represented by orange circles and 2014 Variance represented by blue triangles. The variance values range from 0.0% to 3.5%.
HERS Variance ($\sigma$/mean): LV

![Graph showing HERS Variance for 2013 and 2014 for various L100AC numbers](image)
Conclusions

- Increases in HERS Index are similar to projections announced in 2012
- HERS Index changes are larger for tools with larger Total Reference Loads (may be the windows?)
- Building load simulation differences are a second order impact in the HERS Index calculation method
- 2014 Standard reduced variance across software tools
- Variance in HERS Index across all tools across all tests is less than ±3% of the mean
- Test results should assist software developers in troubleshooting software anomalies, likely bringing HERS Index results into closer alignment.
Questions?