Effectiveness of energy rating systems in evaluating Solar Decathlon homes

Elizabeth Buechler¹,2, Alicen Kandt², and Joe Simon²
¹ Tufts University, Medford, MA ² National Renewable Energy Laboratory, Golden, CO

Introduction

What is the U.S. Department of Energy Solar Decathlon?
- A competition managed by NREL. Every two years, approximately 20 teams compete to build the most energy-efficient solar home.
- The custom homes use unique systems and designs that are uncommon in standard homes.

What are energy rating systems?
- Tools used by homebuilders and homeowners to measure home energy efficiency.

Research Questions:
- Are energy rating systems appropriately designed to evaluate Solar Decathlon homes, and do the ratings accurately reflect energy performance?
- What recommendations can be made to energy rating system designers to accommodate future progress in home energy efficiency?

Energy rating systems:
1. U.S. Department of Energy Home Energy Score (HEScore)
2. RESNET Home Energy Rating System (HERS Index)
3. USGBC LEED for Homes Certification

Process

Home Selection:
- Eight homes from the Solar Decathlon 2013 that used a variety of building materials, construction designs and HVAC systems were selected:

<table>
<thead>
<tr>
<th>Participating Universities</th>
<th>Team Name</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>University of Nevada Las Vegas</td>
<td>Las Vegas</td>
<td>UNLV</td>
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<tr>
<td>Southern California Institute of Architecture and California Institute of Technology</td>
<td>SCI-Arc/Caltech</td>
<td>SCICAL</td>
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<tr>
<td>University of North Carolina at Charlotte</td>
<td>North Carolina</td>
<td>UNCC</td>
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<td>Middlebury College</td>
<td>Middlebury</td>
<td>MIDO</td>
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<td>Queen's University, Carleton University, and Algipquin College</td>
<td>Team Ontario</td>
<td>ONT</td>
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<td>Czech Technical University</td>
<td>Czech Republic</td>
<td>CTU</td>
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<tr>
<td>Vienna University of Technology</td>
<td>Vienna Austria</td>
<td>VUT</td>
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Energy Rating System Selection:
- HEScore, HERS Index, and LEED indicators.
- These rating systems were chosen because they have been extensively used/studied, have sufficient documentation, award a numerical score, and represent a variety of calculation approaches and input designs.

Score Calculation:
- Initial examination of homes with LEED indicated further analysis would not be beneficial for this study.
- HEScore and HERS Indexes (with and without effects of photovoltaics) were calculated for each home.
- Scores were calculated using the Home Energy Scoring Tool website (HEScore) and REMRate v4.6.1 (HERS Index). Solar Decathlon project manuals, construction drawings, manufacturer’s websites, product specification sheets and rating system documentation were used to determine housing characteristics.

Conclusions & Future Work

Design of Energy Rating Systems:
- Key home characteristics (thermal insulation, HVAC systems) were not defined accurately for the HEScore due to the simple data input design.
- Almost all home characteristics except the most unique HVAC systems were defined accurately for the HERS Index due to the more complex data input design.

Energy Rating System Scores:
- The high HEScores obtained by the studied homes suggest the rating system was not designed to assess very efficient homes.
- The sensitivity of the HEScore to HWS inputs may amplify existing model inaccuracies arising from the HEScore's inability to model solar thermal systems.
- All homes consistently scored well with the HEScore, but received HERS Indexes representing energy performance ranging from very efficient to slightly worse than a new home built to minimum code requirements.
- Some homes showed consistent energy performance with different rating systems, but other did not, perhaps due to inaccurate modeling and different calculation methods.

Solar Decathlon Homes:
- Solar Decathlon homes use HVAC systems, DHW systems, and thermal insulation techniques that are not necessarily typical in standard homes.

Possible Future Work:
- Perform on-site home evaluations and specific end use metering at future Solar Decathlon competitions to provide more reliable home data for later studies.
- Conduct a similar analysis of net-zero homes in the current housing market to provide further insight into applying energy rating systems to energy-efficient homes.

Acknowledgements

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