Home Energy Score
Scoring Methodology

Fall 2016
Table of Contents

1. Background ..............................................................................................................................3
   1.1 Purpose, Goal, Audience .................................................................................................3
   1.2 Historical Context .............................................................................................................4
   1.3 Asset vs. Operational Ratings ........................................................................................5
       1.3.1 What is an asset rating? .........................................................................................5
       1.3.2 What is an operational rating? ..............................................................................6

2. Scoring Methodology .............................................................................................................6
   2.1 How are homes scored? .....................................................................................................6
       2.1.1 Scale ....................................................................................................................6
       2.1.2 How does the Scoring Tool compensate for differences in home size, location, and other factors? .................................................................................................................7
       2.1.3 The Home Energy Score Scale: Bin Definitions ......................................................7
       2.1.4 Site to Source Conversion Factors ..........................................................................8
       2.1.5 Cost savings: What utility rates are assumed? .......................................................8
       2.1.6 Carbon Savings: Carbon Conversion Factors .......................................................8
   2.2 How are recommendations generated by the Home Energy Score? ............................8

3. Building Simulation Model .......................................................................................................11
   3.1 What models are used in the Home Energy Scoring Tool? .............................................11
       3.1.1 Heating and Cooling ...............................................................................................11
       3.1.2 Water Heater Model .............................................................................................11
       3.1.3 Infiltration Model ..................................................................................................11
       3.1.4 Weather ................................................................................................................11
       3.1.5 Model Defaults ......................................................................................................11
   3.2 User Inputs .......................................................................................................................12
       3.2.1 About This House .................................................................................................12
       3.2.2 Roof, Attic, Foundation .......................................................................................13
       3.2.3 Walls ....................................................................................................................13
       3.2.4 Windows and Skylights .......................................................................................13
       3.2.5 Heating, Cooling and Hot Water .........................................................................13
   3.3 Access to the Scoring Tool through an application-programming interface (API) ........14
1. Background

1.1 Purpose, Goal, Audience
Like a miles-per-gallon rating for a car, the Home Energy Score is an easy-to-produce rating designed to help homeowners and homebuyers gain useful information about a home’s energy performance. Based on an in-home assessment that can be completed in less than an hour, the Home Energy Score not only lets a homeowner understand how efficient the home is and how it compares to others, but also provides recommendations on how to cost-effectively improve the home’s energy efficiency. The Home Energy Score uses a simple 1-to-10 scale where a 10 represents the most energy efficient homes (Figure 1).

The mission of the Home Energy Score program is to build market value for home energy efficiency among single-family and townhomes. Home Energy Score accomplishes this by valuing, understanding, and allowing for financing of home energy efficiency with nationwide household recognition.

The Scoring Tool is designed to support the existing marketplace for energy analysis tools and services by providing a substantially lower-cost entry-level assessment, which can help the qualified Assessor establish the potential for energy savings, as well as the value of pursuing a more comprehensive assessment and retrofit recommendation report (Figure 2).
1.2 Historical Context

In 2009 the Vice President and the White House Council on Environmental Quality called upon the Department of Energy (DOE) to create a home energy rating system. The White House’s 2009 report, *Recovery through Retrofit*, identified the lack of straightforward and reliable information about homes’ energy use as a key barrier to homeowner investment in home energy upgrades or improvements.

To address this barrier, DOE developed a voluntary program to help homeowners understand their home’s energy use and prioritize cost-effective energy improvements. The goal was to allow homeowners to easily and affordably find out how their home’s energy performance compares with other homes in the same area, much like the vehicle mile-per-gallon rating. According to guiding principles, the system must be:

a.) Credible, reliable and replicable  
b.) Transparent and easy to understand  
c.) Affordable  
d.) Subject to effective quality control

DOE sought to utilize an online tool (the Home Energy Simulation Training), developed by DOE’s Lawrence Berkeley National Laboratory, to train candidate Assessors to collect and input the data into the online Scoring Tool. The result would be a report or label that provides the following information:
• A Home Energy Score on a scale of 1 to 10 (where a “10” is a home that uses less energy than 90% of homes in the U.S.), presented with clear and simple graphics to help homeowners understand their home’s energy performance and how it compares to other homes;
• An estimate of how much money could be saved on energy bills by making the recommended energy improvements; and
• An individualized list of recommended energy retrofit improvements that are estimated to payback in ten years or less.

After a year of industry research, analysis and development, DOE launched a pilot program to test the Home Energy Score. Building on the results of the pilots and other research, including industry factors and homeowner motivations, DOE officially launched the Home Energy Score nationwide in 2012. It became the first national asset rating method that allows all US regions to opt into a simplified and standardized energy assessment process that complements existing advanced home energy audit methods.

1.3 Asset vs. Operational Ratings

1.3.1 What is an asset rating? The Home Energy Score is an asset rating. An asset rating seeks to quantify the energy efficiency of a building based solely upon the inherent components of the house. The Scoring Tool captures data on insulation levels and the heating equipment efficiencies, but does not take into account thermostat settings, appliances, or plug loads because the energy used to operate these components can vary widely depending on occupant behavior. The way the Scoring Tool defines “home assets” for Home Energy Score is displayed in Figure 3.
An asset score allows homes to be compared on an “apples to apples” basis because it compares houses to one another based on their assets and not how occupants operate the houses. The Home Energy Scoring Tool assesses the effect of changes in a home’s assets, while the occupant-dependent factors and behaviors are assumed to be somewhat constant.

1.3.2 What is an operational rating?
An operational rating normalizes the measured energy use of a building (e.g. energy bills) so that it can be compared to the measured energy use of a similar building type, such as a single-family home, school or office. Differences within building type, such as size, number of occupants, climate or hours of operation, may be used to normalize the measured energy use to facilitate an equitable comparison. Operational ratings can be used to prioritize a group of buildings for efficiency improvement based on the poorest measured energy performance. Home Energy Score is not an operational rating, but can be paired with operational assessments to further refine recommendations for each home.

2. Scoring Methodology

2.1 How are homes scored?
A qualified Assessor inspects each home on-site and enters 50 data points into the online Home Energy Scoring Tool. The data collection sheet with the list of data elements and possible values can be found here. After entering all necessary data, the Scoring Tool will provide a summary of inputs for review and prompts the assessor to create the label (Figure 1). After creating the label, data inputs are locked and cannot be changed. The Home Energy Score label can be immediately printed or emailed to the customer. DOE approved, third-party software allows Assessors to submit appropriate fields through an application-programming interface (API) and receive the Score and calculated results.

2.1.1 Scale
When developing the scoring system, DOE considered many factors and data sources to fairly compare the energy performance of existing homes. DOE sought to develop a simple system that allows consumers to understand how a home compares to other homes regardless of location and weather patterns. The current methodology is applicable to single-family homes and townhomes or duplexes in the continental U.S. and Alaska. The Scoring Tool scores a home on a 10-point scale, where a 10 corresponds to greatest efficiency (lowest energy use) and a 1 corresponds to the least efficient (highest energy use). Each point on the scale corresponds to a small range of energy use estimates within the full 10-point range.
2.1.2 How does the Scoring Tool compensate for differences in home size, location, and other factors?

2.1.2.1 **Home Size** – A home’s energy use depends on a variety of factors, one of which is its size. Larger homes have more surface area, which translates into greater energy requirements for heating and cooling. A home’s Score is based on estimated annual energy use, not energy per square foot; so, given all other things equal, a larger home will score lower than a smaller home.

2.1.2.2 **Climate of Location** – Home Energy Score uses TMY3 climate data. It maps the zip code for the house address to the nearest weather station. Each weather station has its own definition of Score ranges based on local weather.

2.1.3 **The Home Energy Score Scale: Bin Definitions**
The Home Energy Score’s scale is based on RECS 2009 data, which is a survey of residential energy consumption by the Energy Information Administration (EIA). The scale was designed to reflect existing housing stock and also allow for mobility on the scale to encourage home energy retrofits. Seventy-five percent of U.S. score between 2 and 9 on the scale, and a home that uses an average amount of energy – in the 50th percentile range of energy use – scores a 5. An example of the MBtu cutoffs between Score bin values is included below, although actual values vary by geographic region and local weather patterns.

- The source energy scoring bins are sized to produce consistent scores based on performance level, as both low efficiency and high efficiency homes have large differences in source energy use based on weather severity.
- The maximum and minimum energy cut-offs corresponding to 1 and 10 on the scale also reflect the different types of housing stock found in various parts of the country.

<table>
<thead>
<tr>
<th>Weather Station #</th>
<th>Weather Station Name</th>
<th>1 greater than</th>
<th>2 up to</th>
<th>3 up to</th>
<th>4 up to</th>
<th>5 up to</th>
<th>6 up to</th>
<th>7 up to</th>
<th>8 up to</th>
<th>9 up to</th>
<th>10 less than</th>
</tr>
</thead>
<tbody>
<tr>
<td># Name</td>
<td></td>
<td>148</td>
<td>147</td>
<td>132</td>
<td>118</td>
<td>103</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000+ locations</td>
<td>x MBtus</td>
<td>x MBtus</td>
<td>x MBtus</td>
<td>x MBtus</td>
<td>x MBtus</td>
<td>x MBtus</td>
<td>x MBtus</td>
<td>x MBtus</td>
<td>x MBtus</td>
<td>x MBtus</td>
<td>x MBtus</td>
</tr>
</tbody>
</table>
2.1.4 Site to Source Conversion Factors
Home Energy Score is based on the asset source energy used by the home, which accounts for the inefficiencies related to processing and transporting energy. For example, there are significant losses associated with generating and providing electricity that do not exist with on-site energy generation. The conversion from the site energy value (as calculated by the energy model) and the source energy value is based on national averages conversion factors. Those factors are the same as those used in the U.S. EPA Portfolio Manager.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>3.14</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>1.05</td>
</tr>
<tr>
<td>LPG</td>
<td>1.01</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>1.01</td>
</tr>
<tr>
<td>Wood</td>
<td>1.01</td>
</tr>
</tbody>
</table>

2.1.5 Cost savings: What utility rates are assumed?
The Scoring Tool uses the most recent state average utility rates as provided by the DOE’s Energy Information Agency to determine the estimated energy savings displayed on the first and last pages.

2.1.6 Carbon Savings: Carbon Conversion Factors
To calculate the home’s carbon footprint (measured in CO₂), the Scoring Tool multiples the annual energy for each fuel type by the emissions factor for the respective fuel (see Carbon Emissions Factors Table 33 and 34). Natural gas and fuel emission factors are derived from DOE (1994), while the LPG emission factor is from DOE (1996). U.S. EPA’s Emissions & Generation Resource Integrated Database (eGRID) provides electricity grid emission factors. eGRID contains emissions and resource mix data for virtually every power plant and company that generates electricity in the United States (US EPA, 2009).

2.2 How are recommendations generated by the Home Energy Score?
In keeping with the asset-based methodology, a consistent set of upgrade recommendations are considered for each home’s assets, given the home’s location. Variations occur as a function of home characteristics, cost-effectiveness, etc. Upgrades considered in the Scoring Tool include improvements to the house envelope and major equipment (the “assets”), but not to upgrades of lighting, appliances or behavioral changes (e.g. change thermostat settings). Unlike other rating tools, the Scoring Tool applies a fixed, standardized retrofit cost (from the NREL National Residential Efficiency Measures Database) and generates recommendations that provide the highest performance level with a payback
time of 10 years or less. Recommendations considered during the improvements analysis are as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basement wall insulation</td>
<td>R11, R19</td>
</tr>
<tr>
<td>Central air conditioner</td>
<td>Energy Star (SEER 14)</td>
</tr>
<tr>
<td>Attic insulation</td>
<td>R19, R30, R38, R49, R60</td>
</tr>
<tr>
<td>Cool roof</td>
<td>High Slope - 15% reflectivity</td>
</tr>
<tr>
<td>Foundation wall insulation</td>
<td>R11, R19</td>
</tr>
<tr>
<td>Duct insulation</td>
<td>R6</td>
</tr>
<tr>
<td>Duct sealing</td>
<td>Reduce leakage to 3% of total airflow</td>
</tr>
<tr>
<td>Floor insulation</td>
<td>R11, R19, R25</td>
</tr>
<tr>
<td>Gas boiler</td>
<td>Energy Star (85% AFUE)</td>
</tr>
<tr>
<td>Gas Furnace</td>
<td>Energy Star (90% AFUE)</td>
</tr>
<tr>
<td>Heat pump</td>
<td>Energy Star (SEER 14.5, HSPF 8.2)</td>
</tr>
<tr>
<td>Envelope/Air sealing</td>
<td>75% of existing leakage (25% reduction)</td>
</tr>
<tr>
<td>Oil boiler</td>
<td>Energy Star (85% AFUE)</td>
</tr>
<tr>
<td>Oil furnace</td>
<td>Energy Star (85% AFUE)</td>
</tr>
<tr>
<td>Propane furnace</td>
<td>Energy Star (90% AFUE)</td>
</tr>
<tr>
<td>Propane Boiler</td>
<td>Energy Star (85% AFUE)</td>
</tr>
<tr>
<td>Room air conditioner</td>
<td>Energy Star v 3.0 (EER 11.3)</td>
</tr>
<tr>
<td>Roof EPS insulation</td>
<td>Add R5 exterior foam sheathing</td>
</tr>
<tr>
<td>Skylights</td>
<td>Energy Star (Double-pane solar-control low-E argon gas wood frame)</td>
</tr>
<tr>
<td>Wall insulation</td>
<td>R13</td>
</tr>
<tr>
<td>Water heater, electric</td>
<td>Energy Star (heat pump, EF 2.76)</td>
</tr>
<tr>
<td>Water heater, natural gas storage</td>
<td>Energy Star (0.67 energy factor)</td>
</tr>
<tr>
<td></td>
<td>Premium Efficiency (energy factor 0.81, 88% recovery efficiency)</td>
</tr>
<tr>
<td>Water heater, propane storage</td>
<td>Energy Star (0.67 energy factor)</td>
</tr>
<tr>
<td>Windows</td>
<td>Energy Star (Double-pane solar-control low-E argon gas wood frame)</td>
</tr>
</tbody>
</table>
These recommendations are provided in two categories:

**Type 1 improvements** can help the homeowner save energy immediately. These include:

- Attic insulation
- Basement wall insulation
- Basement/crawlspace floor insulation
- Crawlspace wall insulation
- Air tightness
- Exterior walls
- Duct sealing
- Duct insulation

The Type 1 energy savings are achieved by moving between the baseline home and the upgrade recommendation. The cost used for the cost-benefit analysis is the full cost of installation.

**Type 2 improvements** are recommendations that should be implemented when it is time to replace specific equipment or building materials. These include:

- Central air conditioner
- Boiler, furnace or heat pump
- Room air conditioner
- Roof - reflectance
- Roof - insulated sheathing
- Skylights
- Siding - insulated sheathing
- Water heater
- Windows

Type 2 improvements are recommended at the time of product replacement. The incremental cost between equipment that meets the standard and the cost of the installed equipment is used in cost-benefit analysis.

It is important to note that the sum of the savings from each measure recommended does not equal the total savings for the package of selected upgrades (the number shown on the label). This difference is due to interactive effects of some energy improvements. For example, insulation will reduce heat and cooling energy use. This will reduce the potential savings available to the heating/cooling system upgrade. This difference will be reflected in the total savings number on the Home Energy Score label.
3. Building Simulation Model

3.1 What models are used in the Home Energy Scoring Tool?

3.1.1 Heating and Cooling – DOE2 is a widely used and accepted freeware building energy analysis program that can predict the energy use and cost for all types of buildings. DOE-2 uses a description of the building layout, constructions, operating schedules, conditioning systems (lighting, HVAC, etc.) and utility rates, along with weather data, to perform an hourly simulation of the building and to estimate utility bills. The DOE 2.1E documentation can be found here.

3.1.2 Water Heater Model – Total hot water used is the sum of clothes washer, dishwasher and fixture related usage. These are determined based on the estimated number or occupants in the house. The modeled water use is based on Danny Parker’s and James Lutz’s, “Estimating Daily Domestic Hot Water Use in North American Homes”. The numbers are then used in the equations provided here to calculate the domestic hot water use.

3.1.3 Infiltration Model – The Home Energy Scoring Tool uses the Residential Diagnostics Database developed by Lawrence Berkley National Lab to model the house infiltration rates. Information on that model can be found here. The implementation of the model into Home Energy Score can be found here.

3.1.4 Weather – Home Energy Score uses TMY3 data to account for the local weather. The house zip code is mapped to the closest TMY3 weather station to calculate energy use.

3.1.5 Model Defaults – Home Energy Score is an asset rating; therefore, the influence of the occupants must be standardized so houses can be compared on an apples-to-apples basis. To do this, Home Energy Score assumes the following default characteristics for each house.

3.1.5.1 Occupancy is determined based on the number of bedrooms using this equation (0.59 * number of bedrooms + 0.87) from the Building America Simulation Protocols (Hendron & Engebrecht, 2010). Using this method, the number of bedrooms directly affects the household’s amount of estimated domestic hot water consumption. Further, occupancy is used to determine miscellaneous electric loads such as television.

3.1.5.2 Stove, oven and clothes drying are assumed to be electric.
3.1.5.3 Electric load calculations are based on Updated Miscellaneous Electricity Loads and Appliance Energy Usage Profiles for Use in Home Energy Ratings, the Building America Benchmark Procedures and Related Calculations (Parker, Fairey & Hendron, 2010). Testing of refinements in this model showed much better predications for total home energy than with fixed occupancy and no dependence on floor area.

<table>
<thead>
<tr>
<th>Electricity Consumption Type</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscellaneous Electric Load (kWh)</td>
<td>= (0.91)*(conditioned floor area)</td>
</tr>
<tr>
<td>Interior Lighting (kWh)</td>
<td>= 455 + (0.8)*(conditioned floor area)</td>
</tr>
<tr>
<td>Exterior Lighting (kWh)</td>
<td>= 50 + (0.05)*(conditioned floor area)</td>
</tr>
<tr>
<td>TV Energy Use (kWh)</td>
<td>= (-3)<em>(# of bedrooms)^2 + (89)</em>(# of bedrooms) + 390</td>
</tr>
</tbody>
</table>

3.1.5.4 The building length and width are fixed to a 5:3 aspect ratio.

3.1.5.5 The thermostat schedule is defined in the table below and is based on the information in Determining Appropriate Heating and Cooling Thermostat Set Points for Building Energy Simulations for Residential Buildings in North America (Parker, 2013).

<table>
<thead>
<tr>
<th>Type</th>
<th>Weekday</th>
<th>Temp. °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>11:00 pm - 6:00 am</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>6:00 am - 5:00 pm</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>5:00 pm - 11:00 pm</td>
<td>68</td>
</tr>
<tr>
<td>Cooling</td>
<td>11:00 pm - 6:00 am</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>6:00 am - 5:00 pm</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>5:00 pm - 11:00 pm</td>
<td>76</td>
</tr>
<tr>
<td>Weekend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating</td>
<td>11:00 pm - 6:00 am</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>6:00 am - 5:00 pm</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>5:00 pm - 11:00 pm</td>
<td>68</td>
</tr>
<tr>
<td>Cooling</td>
<td>11:00 pm - 6:00 am</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>6:00 am - 5:00 pm</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>5:00 pm - 11:00 pm</td>
<td>76</td>
</tr>
</tbody>
</table>

3.1.5.6 To calculate estimated energy savings in dollars, the Tool uses state average utility rates as provided by DOE’s Energy Information Administration.

3.2 User Inputs

3.2.1 About This House

1. Assessment date
2. Year built
3. Number of bedrooms
4. Stories above ground
5. Interior floor-to-ceiling height
6. Conditioned floor area
7. Direction faced by front of house
8. Measured or estimated air leakage rate
9. Whether Home was professional air-sealed

3.2.2 Roof, Attic, Foundation
10. Attic Area
11. Roof construction
12. Roof color
13. Attic or ceiling type
14. Foundation Area
15. Insulation level of the attic floor
16. Foundation type
17. Foundation insulation level
18. Insulation level of the floor above the basement or crawlspace

3.2.3 Walls
19. Building type; townhouse or otherwise
20. Building position; required if type is townhouse
21. Walls construction same on all sides (yes/no)
22. Front; Back; Right; Left (if type is townhouse adjoining wall(s) set by system)
23. Materials
24. Insulation levels

3.2.4 Windows and Skylights
25. Does house have skylights? (yes/no)
26. Skylight size
27. Skylight type
28. Glazing, frames, fill
29. U-Factor
30. Solar heat gain coefficient
31. Window areas
32. Window types are same on all sides
33. Front; Back; Right; Left
34. Glazing, frames, fill
35. U-Factor
36. Solar heat gain coefficient

3.2.5 Heating, Cooling and Hot Water
37. Percentage of conditioned floor area served by system
38. Type of heating system
39. Heating system efficiency
40. Year heating system installed  
41. Type of cooling system  
42. Cooling system efficiency  
43. Year cooling system installed  
44. Duct location; up to three  
45. Percentage of total ducts in each location  
46. Duct insulation  
47. Duct sealing  
48. Water heater type  
49. Year water heater installed  
50. Water heater Energy Factor

### 3.3 Access to the Scoring Tool through an application-programming interface (API)

A software provider interested in including the Home Energy Score as part of the report output provided by their software may use the API provided by PNNL. Full documentation can be found [here](#).

**3.3.1.1** The software provider must supply information to DOE about how the Home Energy Score will be used and by whom (e.g. Is the software being used for a single client or multiple clients?). DOE needs to be able to keep track of who is using what software to maintain/verify continued data compliance.

**3.3.1.2** DOE will provide the API evaluation keys, API documentation and implementation support. DOE will provide data manipulation rules and test scenarios.

**3.3.1.3** The software provider will build the API functionality within their tool and include any logic necessary to implement the data manipulation rules. If using the HPXML file format to submit the house characteristics, these rules are already built into the “translator” and thus the software provider does not need to build this logic.

**3.3.1.4** When that has been completed, the software provider will enter the test scenarios into their tool and provide those runs to the Home Energy Scoring Tool through the API. They will also provide proof of entry and example output for these runs to DOE.

**3.3.1.5** DOE will confirm the data was properly manipulated and transferred.

**3.3.1.6** When this is confirmed, the software provider will receive the production API and qualified assessors may begin using that tool.