Home Energy Score Scoring Methodology

September 2021

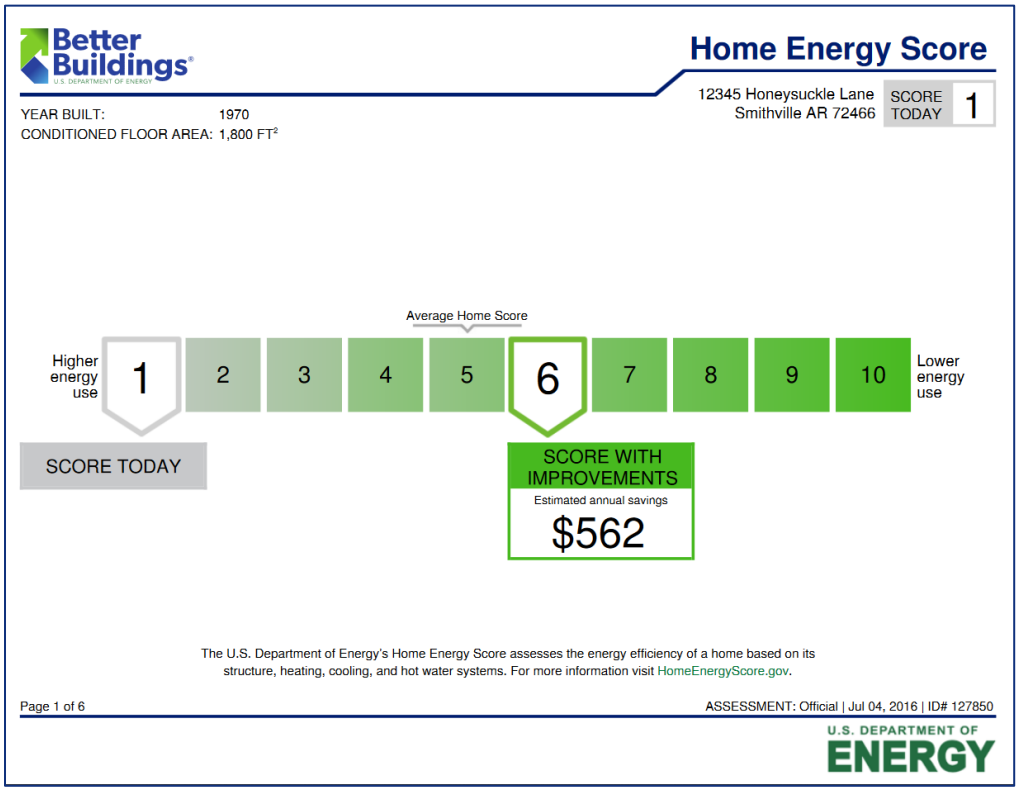
Table of Contents

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).

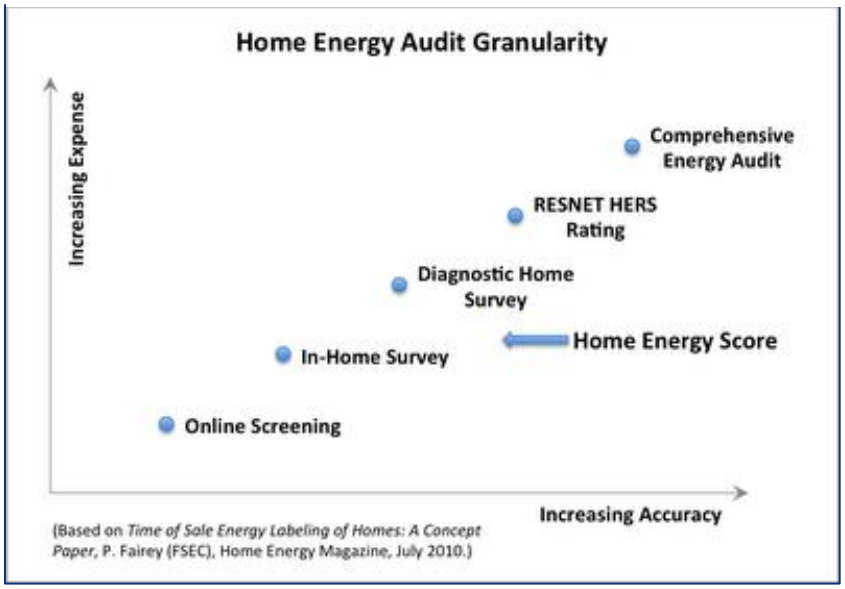
Figure 1. Home Energy Score Label Example



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).

Figure 2. Home Energy Audit Granularity



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

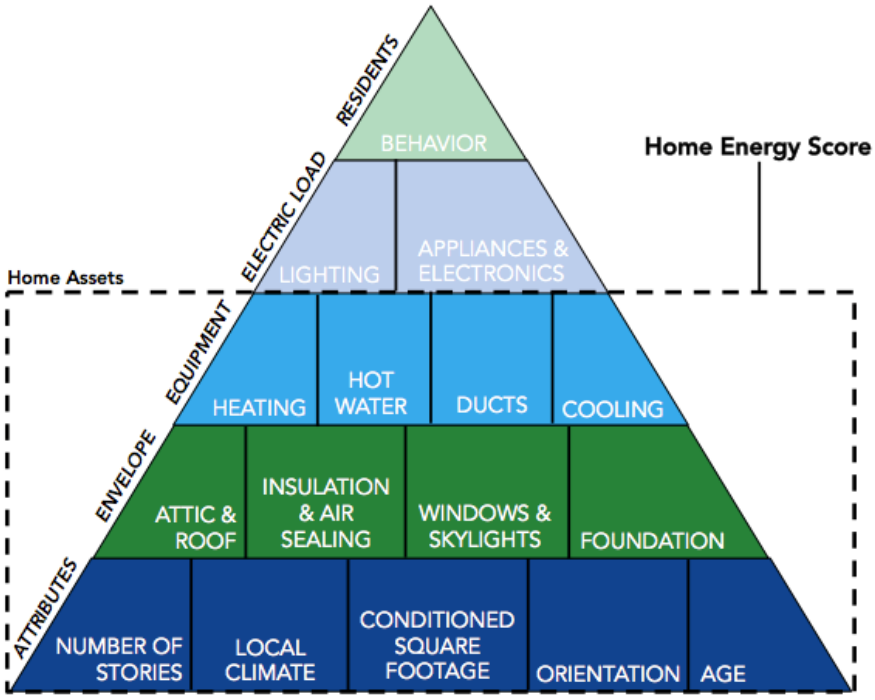
homeowner motivations, DOE officially launched the Home Energy Score nationwide in 2012. It became the first national asset rating method that allows all US regions to opt into a simplified and standardized energy assessment process that complements existing advanced home energy audit methods.

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.

Figure 3. Home Energy Use Pyramid



An asset score allows homes to be compared 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 lowest energy use and a 1 corresponds to 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 Compensating for differences in home size and location?

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 as 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 bin 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. homes 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.

Example Scoring Bin Format											
Weather Station #	Weather Station Name	**1** greater than	**2** up to	**3** up to	**4** up to	**5** up to	**6** up to	**7** up to	**8** up to	**9** up to	**10** less than
#	Name	148	147	132	118	103	90	80	70	60	50
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
#	1000+ locations	x MBtus	x MBtus	x MBtus	x MBtus	x MBtus	x MBtus	x MBtus	x MBtus	x MBtus	x MBtus

2.1.4 Site to Source Conversion Factors

Home Energy Score is based on the source energy for heating, cooling and hot water. Source energy 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. These factors reflect updated technical guidance from DOE's Office of Energy Efficiency and Renewable Energy as of October 2016 updated using 2019 values.

Fuel	Conversion Factor
Electricity	2.56
Natural Gas	1.05
LPG	1.01
Fuel Oil	1.01
Wood	1.01

2.1.5 Accounting for Residential Solar Installations

Given that a photo-voltaic system (PV) is one of many energy-related home assets, a home's PV system is credited to the home's Score. With the release of v. 2017 (Feb 2017), the Home Energy Scoring Tool accounts for PV in three metrics: the Score, estimated electricity usage, and estimated energy costs.

2.1.5.1 ***The Score -*** Home Energy Score Assessors collect PV data consistent with NREL's PV Watts tool to estimate the system's annual energy production. To generate a Home Energy Score, the Scoring Tool will subtract the estimated PV annual production (in MBtu) from the estimated energy required to meet the home's heating, cooling, and hot water needs (i.e., asset loads). This new MBtu value is used to determine the home's Score – one that reflects all of the home's major energy-related assets, including PV.

2.1.5.2 ***Estimated Electricity Use -*** The Home Energy Score Report includes a number of additional metrics and values that reflect how much energy is used by and generated at the home. These metrics and values do not include transmission, distribution, and generation losses. The user can distinguish site from source numbers because all MBtu numbers are source; all energy specific units are site energy. For example, the kWh value shown on the Home Energy Score Report is the estimated amount of electricity required on site to meet all of the home's electricity needs, including plug load. If a home has PV, the total kWh generated by the system is subtracted from the total kWh required to meet the home's electricity needs.

2.1.5.3 ***Estimated Electricity Cost -*** When a home has PV, Home Energy Score estimates the home's total electricity costs by offsetting the contribution of the PV system from the home's modeled electricity use using the state average utility rate.

2.1.6 Cost savings: What utility rates are assumed?

The Scoring Tool uses the most recent state average utility rates as provided by the DOE's EIA to determine the estimated cost savings displayed on the first and last pages. The total energy cost for a home with PV will reflect the offset provided by all of the electricity generated by the PV system.

2.1.7 Carbon Savings: Carbon Conversion Factors

To calculate the home's carbon footprint (measured in lbs CO_2), 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, fuel oil and LPG emission factors are derived from DOE EIA . The 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, based on 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 fewer. Recommendations considered during the improvements analysis are as follows:

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

These recommendations are provided in two categories:

"Repair Now" 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 wall insulation
- Duct sealing
- Duct insulation

Repair Now 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.

"Replace Later" 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

Replace Later improvements are recommended at the time of product replacement because the incremental cost between the minimum efficiency equipment and the cost of the high efficiency equipment is used in the payback analysis.

The Home Energy Scoring Tool does not include PV as an automatic recommendation for homes to improve their Scores. If an Assessor believes a home is a good candidate to improve their Score by adding a PV system, they can utilize the Tool's "Alternative EEM" feature to showcase the home's Score with Improvements with PV included.

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.

Building Simulation Model

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

2.3.1 Heating and Cooling – EnergyPlus™ is a is free, open-source, cross-platform, whole building energy simulation program that engineers, architects, and researchers use to model energy consumption for heating, cooling, ventilation, lighting and plug and process loads, and water use in buildings. EnergyPlus™ uses a description of the building layout, constructions, operating schedules, conditioning systems (lighting, HVAC, etc.) with weather data, to perform an hourly simulation of the building and to estimate utility use. The EnergyPlus™ documentation is here.

2.3.2 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. e+ calculates the domestic hot water use using the ANSI/RESNET/ICC 301-2019 standard

2.3.3 Infiltration Model – EnergyPlus™ uses the AIM-2 "ASHRAE Enhanced" model to calculate the effects of infiltration on energy use. (See page 436, 8.3.4 in the EnergyPlus™ Engineering Reference).

2.3.4 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.

2.3.5 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.

2.3.5.1 Occupancy is determined based on the number of bedrooms using this equation (#bedrooms + 1, from the ANSI/RESNET/ICC 301-2019 standard).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.

2.3.5.2 Stove, oven and clothes dryer are assumed to be electric.

2.3.5.3 Appliance, lighting and miscellaneous plug loads are calculated in EnergyPlus™ using the ANSI/RESNET/ICC 301-2019 standard.

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

2.3.5.5 The thermostat schedule is defined based on the ANSI/RESNET/ICC 301-2019 standard where heating is 68° F and cooling is 78° F with a 2° offset for eight hours per day.

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

2.4 User Inputs

2.4.1 About This House

1) Address
2) Assessment Date
3) Year Built
4) Number of Bedrooms
5) Stories Above Grade
6) Floor to Ceiling Height
7) House Orientation
8) Blower Door Test Reading (Y/N)
    a. If so, CFM50 reading
9) Professional Whole Home Air Sealing (Y/N)

2.4.2 Roof, Attic, Foundation

10) Attic Area
11) Roof Type and Finish (may describe 2)
12) Roof Insulation R-value
13) Roof Color
14) Attic Type
15) Attic Insulation R-value

16) Foundation Type (may describe 2)
17) Insulation R-value Above Basement or Crawlspace
18) Foundation Insulation R-value

2.4.3 Walls

19) Townhouse or Duplex (Y/N)
    a. If Yes, Relative Position (L, M, R)
20) Wall Construction (may describe 4)
21) Exterior Cladding
22) Cavity R-value

2.4.4 Windows and Skylights

23) Skylights (Y/N)
    a. If Yes, same info as follows for windows
24) Window Area for Front, Back, Left, Right
25) Solar Shade Screen (Y/N)
26) # Panes
27) Frame Type
28) Glazing Type
    a. Or provide U-Factor and SHGC

2.4.5 Heating, Cooling and Hot Water

29) Heating System Type (may describe 2)
30) Heating System Efficiency (preferred) or Manufacture Date
31) Cooling System Type (may describe 2)
32) Cooling System Efficiency (preferred) or Manufacture Date
33) Duct Location (may describe 3)
34) % Ducts in Location
35) Ducts Sealed (Y/N)
36) Ducts Insulated (Y/N)
37) Water Heater Type
38) Water Heater Efficiency (preferred) or Manufacture Date

2.4.6 Photovoltaic System

39) Year Installed
40) Orientation
41) System Capacity (kW) or **#** of Panels

2.5 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.

2.5.1 Use - 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.

2.5.2 Access - DOE will provide a user account, API evaluation keys, API documentation and implementation support. DOE will provide test scenarios for verification/certification.

2.5.3 Programming - The software provider will build the API functionality within their tool, including HPXML data submissions. .

2.5.4 Testing - When that is complete, the software provider will enter the test scenarios into their tool and provide access to their tool and those runs to DOE staff. DOE staff will verify that what the Home Energy Scoring Tool received through the API was as expected based on the inputs into the 3rd party tool. DOE staff will provide test results to the software provider and work with them to correct errors until the data transfers are as expected.

2.5.5 Certification - When confirmed, DOE will provide the production API key to the 3rd party software provider and qualified assessors may begin using that tool.