

Becoming a 10: A Closer Look at the U.S. Department of Energy Home Energy Score's Updates, Improvements, and Expansion

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ABSTRACT

The U.S. Department of Energy (DOE)'s Home Energy Score™ provides homeowners, buyers, and renters directly comparable and credible information about a home's estimated energy use and costs. Home Energy Score Assessors conduct low-cost assessments to provide each home a 1–10 score alongside a set of cost-effective upgrades to improve the score. As of February 2022, hundreds of assessors have delivered over 175,000 scores to homes across the country. Home Energy Score was originally released in 2012 using DOE2.1e as the modeling backend, and a new version was released in 2021 using DOE's flagship energy modeling software, EnergyPlus®. The updated architecture leverages modeling advancements and enables new building technologies to be added to the Scoring Tool. The new release represents a leap forward in harmonizing modeling assumptions across DOE and industry programs.

In this paper we discuss the rigorous approach to compare the modeling systems with those prior to the update, using test homes and real homes from the Home Energy Score database to strike a balance among consistency, speed, and accuracy for energy predictions. We also discuss additional capabilities made possible with the software transition, including improvements to the upgrade recommendations methodology, the inclusion of an energy cost estimate metric based on ResStock™ data for use in home appraisals, and improved data analysis for quality assurance. The entire effort has made Home Energy Score a more robust tool that more quickly delivers highly accurate energy modeling predictions and more cost-effective efficiency recommendations to residents. Finally, we look at the impact Home Energy Score has had over the last decade and its future potential as its uptake in state energy plans, local ordinances, utility programs, and real estate data continues to grow.

Introduction and Background

Home Energy Score™ (HEScore) is a low-cost home energy assessment tool used by homeowners, buyers, sellers, the mortgage industry, and others. After an initial pilot in 2011, HEScore was launched in 2012 as a U.S. Department of Energy (DOE) program. The goal of the program is to have an intuitive, comparable metric that is designed for the existing homes market in the United States with similar market recognition to miles-per-gallon ratings for vehicles or nutrition facts labels for food. The score is on a simple 1–10 scale, where homes that score a 1

are modeled to use more energy than 85% of U.S. homes, and homes that score a 10 are modeled to use less energy than 90% of U.S. homes, after normalizing for local climate. The use and applicability of HEScore has grown over time to support utility efficiency programs, state and local residential programs, real estate transaction disclosure ordinances, energy efficiency financing, and more.

Home Energy Score assessors calculate each score by collecting a limited set of information about a home's fixed energy-relevant assets, such as size, insulation, air infiltration, windows, water heating equipment, and heating, ventilating, and air conditioning (HVAC). Features related to the occupants of the home such as thermostat set points and occupancy schedules are not collected because the goal is to provide an assessment of home efficiency irrespective of its current residents. Assessors use this information to create a detailed physics-based building energy model of the house by filling in the necessary details using known properties of the materials and equipment, occupant behavior assumptions, and typical-year weather for the building location. The result is a predicted annual energy use for the house, which is then used to determine a 1–10 score relative to other houses in the same climate. The scoring tool evaluates up to 32 potential energy efficiency upgrades for the house and their associated energy savings, proposes a package of upgrades with a simple payback of less than 10 years, and calculates the HEScore the home could achieve if those upgrades were made.

Users can access the HEScore program through a collection of online web services known as the HEScore Gateway. The Gateway provides access through an application programming interface (API) and graphical user interface (GUI) that enables program administrators, partners, quality assurance providers, and assessors to interact with the tool and data. This design provides flexibility so that some programs and users interact directly with the GUI while others can integrate HEScore into their own software services through the API.

HEScore was originally based on the DOE2.1e building energy modeling engine and was developed as part of Lawrence Berkely National Laboratory's Home Energy Saver suite of tools (Mills et al. 2014). Since 1997, DOE has been developing EnergyPlus®, DOE2.1e's successor, as an open-source, whole-building energy modeling engine (Crawley et al. 2001). With releases two times per year and continual development from DOE, national labs, and the private sector, EnergyPlus is regularly updated and can simulate a wider variety of building equipment and constructions than was previously possible. Recent efforts have augmented EnergyPlus to be capable of modeling the unique building technologies found in residential buildings and have made it perform faster. With businesses and programs across the country using HEScore, some limitations in the DOE2.1e modeling tool set became apparent. Several newer building technologies were not available in the older modeling engine, and workarounds to make those technologies available were more difficult to develop and maintain. Additionally, with other proprietary home energy assessments and rating systems in the market, users wanted to align assumptions and defaults to increase program comparability. Upgrading the underlying modeling engine also presented an opportunity to harmonize residential building energy modeling with other programs and tools, building trust with users by enabling them to compare energy use and savings predictions across programs.

In the following sections we will discuss the technical approach and methodology for modernizing HEScore's energy modeling backend, improvements to the upgrade recommendations, and the impact of HEScore and how it is being used across the country to drive market change and valuation of energy efficiency in residential buildings. Finally, we will discuss the future opportunities for HEScore.

Migrating to EnergyPlus

To migrate from DOE2.1e to OpenStudio[®]/EnergyPlus (OS/E+), several competing priorities had to be met:

- Maintain feature parity with the existing HEScore tool
- Maintain compatibility with the previous version of HEScore for end users and consumers
- Maintain the same API for a seamless transition
- Minimize impact to user experience, especially runtime
- Align modeling assumptions with the existing HEScore model
- Align modeling assumptions with industry (i.e., ANSI/RESNET/ICC Standard 301 (RESNET 2019) used for Energy Rating Index (ERI) calculations)
- Ensure certain buildings are not unduly penalized/rewarded from model changes
- Maintain consistency in scores
- Improve modeling capabilities and enhance energy modeling accuracy as allowed by the new engine and architecture.

Meeting all these priorities required an iterative, data-driven approach. The first step was creating a detailed comparison of modeling assumptions between the existing HEScore model and ANSI/RESNET/ICC Standard 301 to bring as many of the assumptions into alignment with Standard 301 as possible. Each difference in assumption was ranked in order of impact based on engineering judgement, with a preference to align and harmonize with Standard 301.

During the project several improvements were made to EnergyPlus to improve its ability to model residential buildings and improve its runtime performance. We developed a robust model articulation framework built on top of OpenStudio and Home Performance XML (HPXML) to create the detailed EnergyPlus models from the limited HEScore assessor inputs. By using HPXML, an industry standard, several different tools can interface with the framework, which is now used across several DOE and industry programs, including HEScore, Energy Rating Index (ERI), ENERGY STAR[®], ResStock[™], URBANopt[™], and (soon) Weatherization Assistant (WAP). By building on top of the OpenStudio-HPXML model articulation code base, we were able to leverage existing capability and intentionally align modeling assumptions and approaches in a systematic way. Figure 1 illustrates how the architecture combines EnergyPlus for energy modeling, OpenStudio for model articulation and workflow management, various rule sets depending on application, and HPXML as the building data transfer format to build consistent modeling workflows.

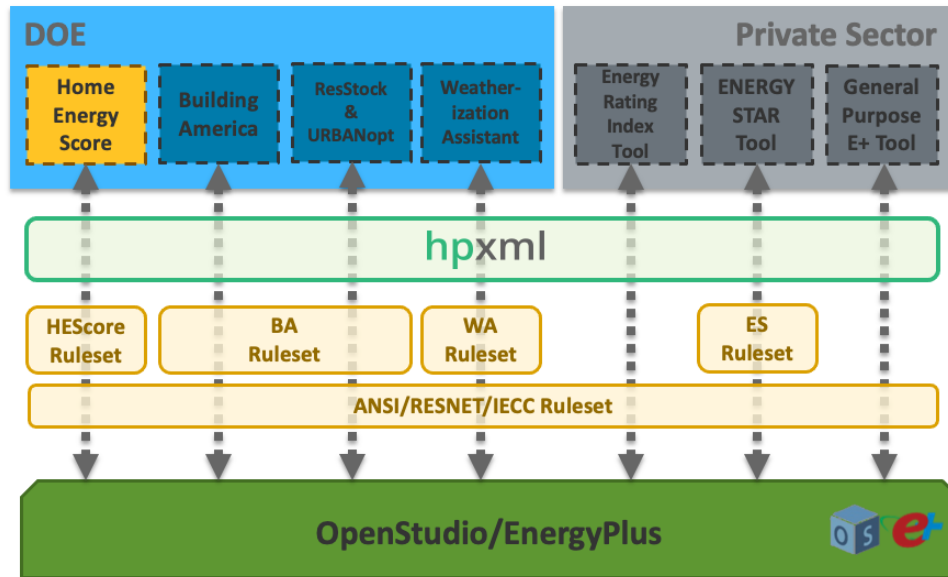


Figure 1. Diagram of OpenStudio-HPXML architecture including HEScore.

Data-Driven Modeling Comparisons

Once we had a working version of the HEScore model built on OS/E+ that could accept the same inputs as the old HEScore model, we set up comparative test cases to better understand how energy prediction results would change between versions. The first set of tests was ~175 regression test buildings that exercised each input to the model across the range of available inputs. Next, a sampling of 10,000 HEScores of real houses was used to compare how the results would change for real homes in the program. Finally, of those 10,000 homes, we subsampled around 700, with about 50 in each climate zone where data were available, which allowed us to iterate faster and represent climate zones equally.

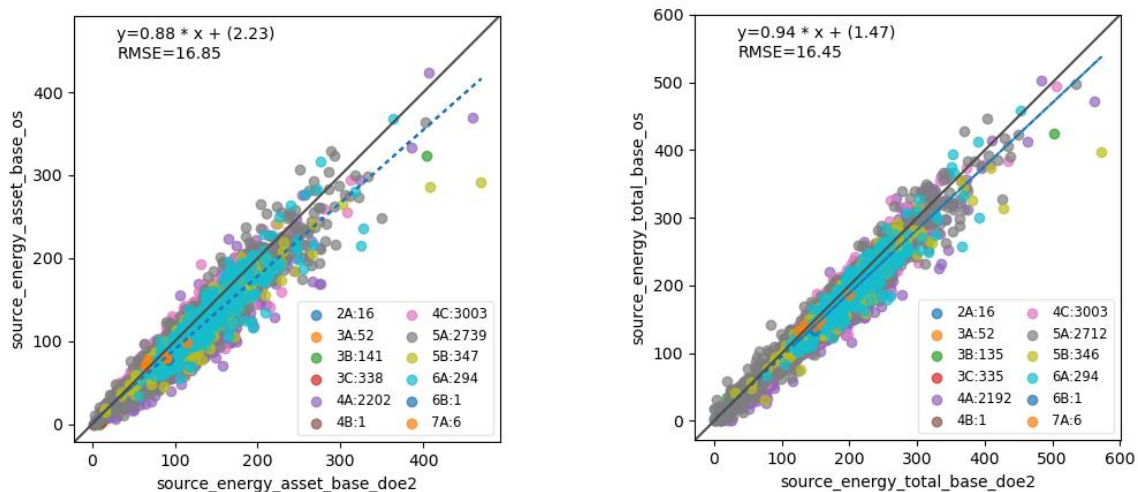


Figure 2. Plots of energy use of the base building for the 10,000 sample set before and after the switch from DOE2.1e (x-axis) to OS/E+ (y-axis) by IECC climate zone with root-mean square error (RMSE). (Left) Distribution of asset source energy use (used to determine the HEScore), which comprises space heating, cooling, and hot water end uses. (Right) Distribution of total source energy use.

Figure 2 shows energy prediction comparisons between the two versions using 10,000 historic HEScore homes. Overall, there is comparable alignment between versions, with slightly lower energy consumption predictions when running EnergyPlus HEScore models. The differences can be attributed to changes in modeling assumptions, improvements to modeling methodology, or other inconsistencies observed in the old/new HEScore engine.

Modeling assumption changes are one of the key factors that lead to energy prediction differences between the two versions of HEScore. Table 1 lists the modeling assumption changes from DOE2.1e HEScore to OS/E+ HEScore.

Table 1. Modeling assumption changes before (Source = HEScore) and after (Source = ERI) the switch from DOE2.1e to OpenStudio/EnergyPlus

ASSUMPTION	SOURCE	HOUSE SIZE		
		Small (1 bed / 1000 sqft)	Medium (3 bed / 1800 sqft)	Large (5 bed / 2,500 sqft)
Appliance Electric Load (kWh/yr)	HEScore	4,503	6,522	8,340
	ERI	4,586	6,550	8,338
Occupancy	HEScore	1	2	3
	ERI	1	3	5
Internal Gains (Btu/hr) Sensible / Latent	HEScore	1,454 / 374	2,235 / 639	2,952 / 896
	ERI	1,539 / 285	2,558 / 691	3,514 / 1,096
Hot Water Loads (gpd)	HEScore	45.5	68.3	91.1
	ERI	40.2	69.0	95.8

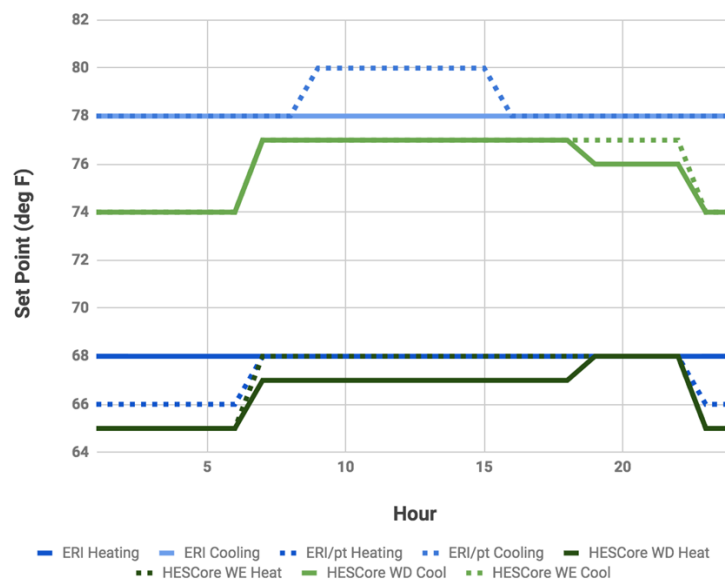


Figure 3. Set point differences before (Source = HEScore) and after (Source = ERI) switch from DOE2.1e to OpenStudio/EnergyPlus. ERI/pt refers to the set points when a programmable thermostat is present, and WD/WE refer to weekday and weekend.

In addition to the assumption changes in Table 1, another crucial modeling difference between DOE2.1e HEScore and OS/E+ HEScore is the thermostat set points. The OS/E+ workflow uses ERI set points (RESNET 2019), which are higher overall than the legacy HEScore set points. These set point changes lead to a higher heating energy prediction and a lower cooling energy prediction. The DOE2.1e HEScore applies additional adjustments to set points: conditioned basements set points are adjusted by $\pm 5^\circ$, set points of zonal HVAC systems are adjusted by $\pm 2^\circ$. Figure 3 shows the different set point settings on the two modeling engines.

This rigorous data analysis also led to corrective action to address modeling errors in the software systems. Examples of fixes include:

- Corrected infiltration for homes with more than 2 stories to use appropriate building height
- Corrected window air conditioner sizing that was previously fixed capacity
- Improved assumptions for ambient conditions of water heaters (including heat pump water heaters)
- Corrected water heating energy use with multiple combination hot water and space heating boilers
- Corrected water heating energy use with combi boiler plus non-boiler system
- Corrected evaporative coolers incorrectly affecting heating energy use
- Improved water heater recovery efficiency defaults for condensing systems
- Used more accurate energy use estimates for tankless propane water heaters
- Used more accurate boiler heating energy use
- Used more accurate cooling energy use for some homes due to infiltration.

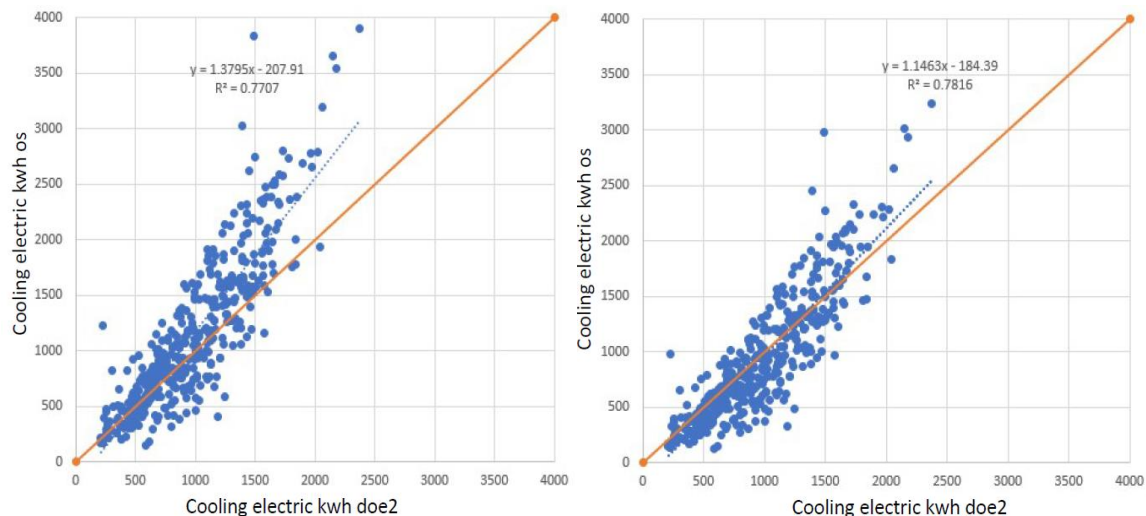


Figure 4. Cooling electricity (in kilowatt-hours [kWh]) before (left) and after (right) fixing window air conditioner issue in OS/E+ model.

For example, we identified an issue related to window air conditioners by using machine learning regression algorithms (Merket 2018) to identify the most important building characteristics that drive the energy prediction differences between the two versions. In the

feature importance study, most building characteristics are justified easily based on model or assumption changes, but cooling system type was an exception. We examined the issue and disaggregated cooling energy results by cooling system type. We found that OS/E+ HEScore yielded a higher cooling energy load prediction than DOE2.1e HEScore for window air conditioners, particularly for homes with larger cooling demand, as shown in Figure 4.

The suspicious window air conditioner cooling energy was tracked down to issues in both versions. In the DOE2.1e HEScore, window air conditioners were fixed in size at 12,000 Btu (1 ton), even when the home required a larger system capacity. Therefore, most houses with window air conditioners as the only cooling source exhibit a significant number of undercooled hours. This led to a severe underestimated annual cooling energy consumption on the DOE2.1e model for homes with larger cooling demand. In this case, we also found an issue in the OS/E+ HEScore model, where one of the window air conditioner performance curves was not normalized to 1.0 at rated conditions as it should have been. The improper curve resulted in a small overestimated annual cooling energy use in the OS/E+ model. After fixing these issues on both sides, the two versions showed better agreement.

OS/E+ also offers broader availability to model technologies in an integrated whole-building model, which enables modeling improvements in different areas by switching. Table 2 lists the modeling improvements in system and envelope areas.

Table 2. System and envelope modeling improvements before and after switch from DOE2.1e to OpenStudio/EnergyPlus

AREA	DOE-2	ENERGYPLUS
Overall	External modules for DHW, PV, and appliances outside DOE-2	Integrated, whole building model in EnergyPlus
Heat pump water heaters	Located outside - no indoor temperature interaction	Located in basement or garage. Indoor temperature interaction
Hot water distribution	No distribution losses	Distribution losses per ANSI 301
Combi boilers	Workaround using DHW load added to boiler heat load; baseboards modeled with fixed capacity	Uses boiler model providing both space heating and water heating
Evaporative coolers	Requires separate version of DOE-2	Uses built-in evaporative cooler model
Ground source heat pumps	Workaround using air source heat pump	Detailed model using ground loop and heat exchanger
Foundations	Effective U-factors and fictitious insulation layers	Kiva: Two-dimensional finite difference heat transfer
Ducts	ASHRAE 152 simple model	Log Mean Temperature Different (LMTD) detailed model
Infiltration	ASHRAE Basic model	ASHRAE Enhanced model
Radiant barriers	Simple R-value adjustment	Emissivity property change

We evaluated the impact of each assumption difference or modeling improvement by eliminating them one at a time. For example, we set up the DOE2.1e HEScore to use ERI set points and then re-simulated each of the 700 subsampled homes and compared the difference with the pre-modified results. The subplots in Figure 5 show the cooling energy predictions

before and after eliminating foundation heat transfer, which reflects the impact of different foundation heat transfer models between DOE2.1e HEScore and OS/E+ HEScore.

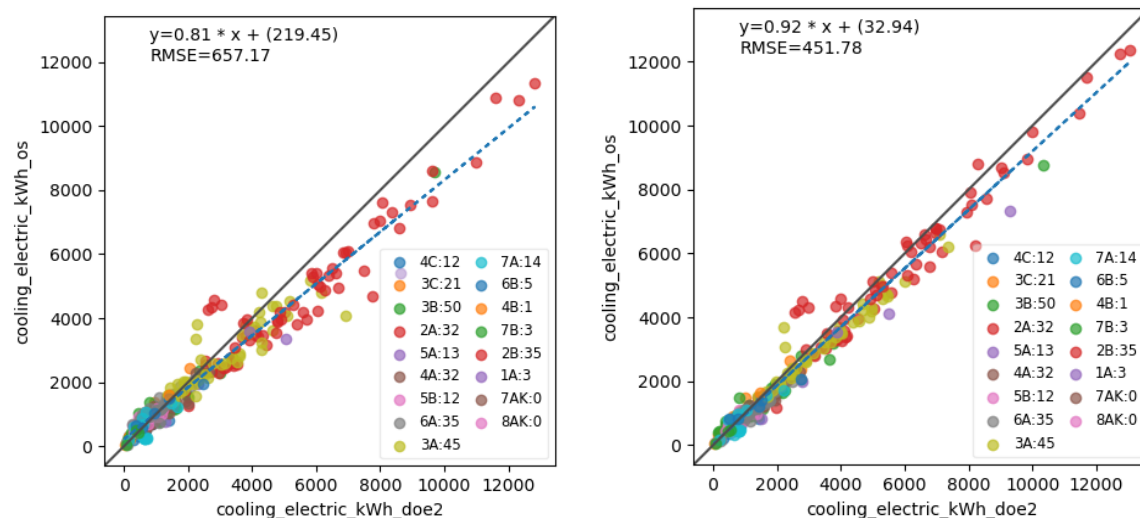


Figure 5. Cooling electricity (in kWh) before (left) and after (right) eliminating foundation heat transfer (switch to vented crawlspace with highly insulated floor above).

New Modeling Features

New releases of HEScore take advantage of the OS/E+ version capabilities to provide modeling features long requested by users. These features include modeling of attic knee walls, low-e/clear storm window upgrades, upgrade options for higher efficiency heat pumps, more granular R-value choices for envelope constructions, duct blaster measurement inputs, hourly outputs, and more. Looking forward, future HEScore priorities include adding building types (e.g., manufactured homes and low-rise multifamily), incorporating an approach for decarbonization upgrade package recommendations, and redefining score bins using higher-fidelity ResStock analysis.

Scoring Methodology

A unique feature of HEScore is the score itself. It communicates an easy-to-understand metric for energy efficiency relative to other homes in the same climate. A score is assigned by calculating the total “asset” source energy use calculated by the model, which comprises the space heating, space cooling, and domestic hot water end uses.

The asset source energy use is then binned into 10 bins based on location to determine a score. The bins for the previous version of HEScore were originally defined by fitting a lognormal distribution to the EIA Residential Energy Consumption Survey 2009 microdata. The bins correspond to percentile cutoffs distributed as follows: >85th percentile of energy use is a 1, <10th percentile of energy use is a 10, and 50th percentile of energy use is a 5. The scoring bins in between those cutoffs are cut into equal-width bins. The bins are scaled for each weather location based on a set of calibration simulations of a typical natural gas and electrically heated home.

Switching to the OS/E+ model yielded statistically lower energy predictions due to changes in the assumptions and model, so the scoring bins needed to be recalibrated to maintain the distribution of scores. This was accomplished by rescaling the bins for each weather station

using the sample of 700 homes with representation from each climate zone. An unconstrained Nelder-Mead optimization of the scoring bins used an optimization function calculated as the sum of the absolute value of the difference of scores between the old and new version for the sample set. The parameters searched across were the average cutoff for the “1” bin (85th percentile), the average cutoff for the “10” bin (10th percentile), the middle of bin “5” (median), a scaling factor to adjust the multipliers for each weather location, and scaling factors for heating and cooling degree days for each weather location (base 65°F and 70°F, respectively).

When the new scoring bins were applied to the larger testing data set of 10,000 homes, 47% of scores calculated with EnergyPlus and the new scoring bins were the same as the scores for the same homes calculated with DOE2.1e and the old scoring bins. 87% of the scores were within ± 1 , as shown in Figure 6. The overall distribution of scores was fundamentally unchanged and continued to yield the expected number of homes with each score based on the scoring methodology as shown in Figure 7.

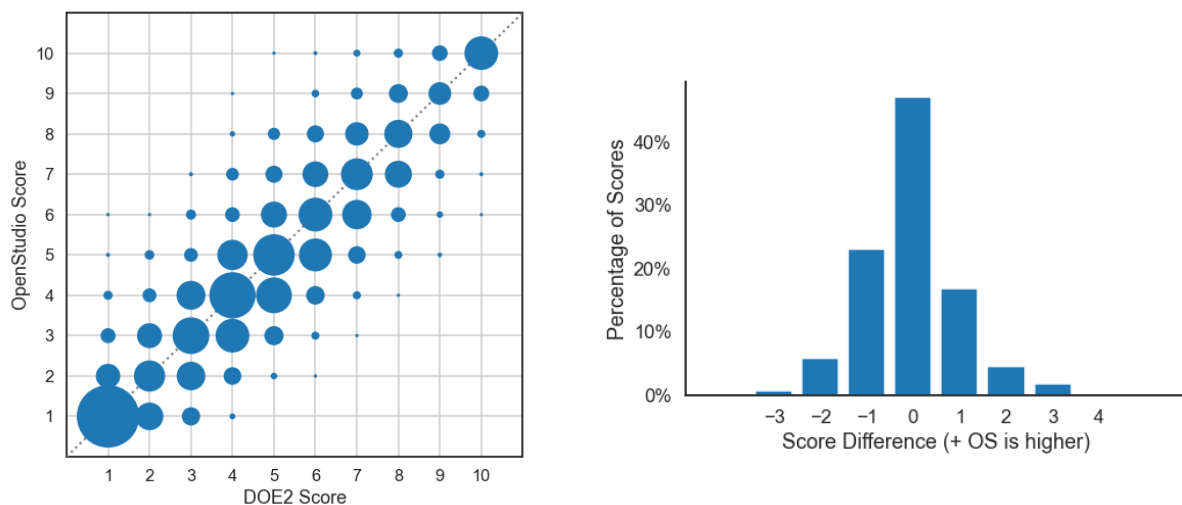


Figure 6. (Left) Distribution of scores for the 10,000-home sample before and after the switch from DOE2.1e to OpenStudio/EnergyPlus. (Right) Differences in scores for the 10,000-home sample before and after the switch from DOE2.1e to OpenStudio/EnergyPlus. A positive number here indicates that the OpenStudio/EnergyPlus score was greater.

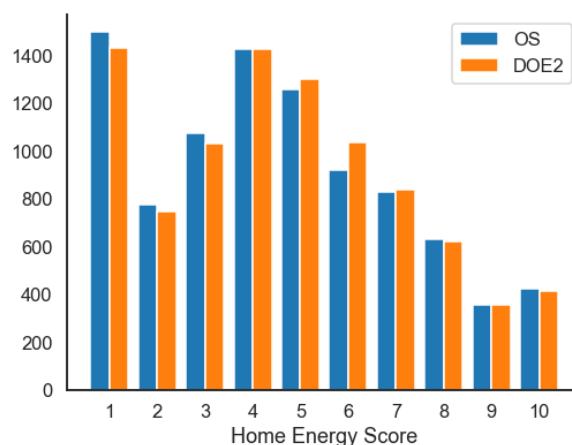


Figure 7. Distribution of scores of 10k sample in the DOE2.1e version (DOE2) and the OpenStudio/EnergyPlus (OS) version of HEScore.

Minimizing the Impact on Users

The switch from DOE2.1e to OpenStudio/EnergyPlus was accomplished without changing the HEScore Gateway's API, so third-party software providers did not need to change their code.

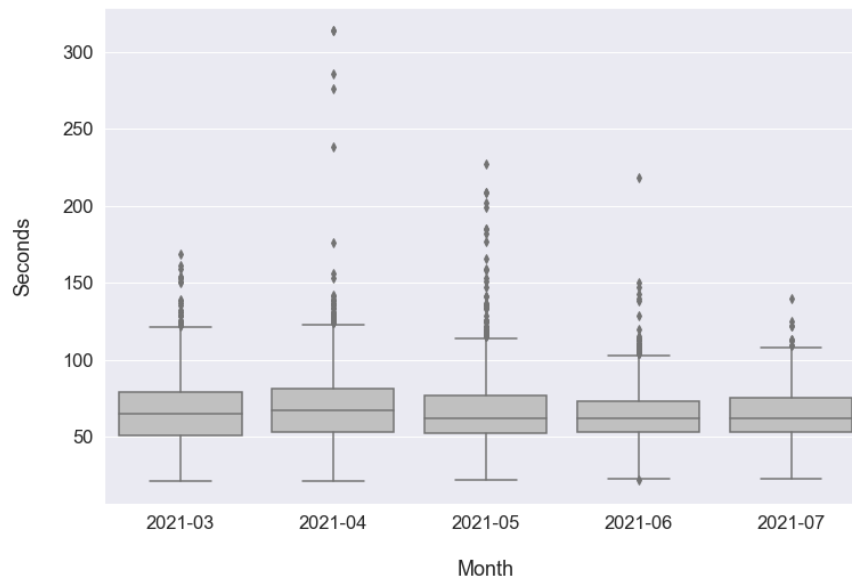


Figure 8. The distribution of the time to generate a score for the months surrounding the switch from DOE2.1e to OS/E+ based on actual scores in the HEScore database. The switch occurred on May 12, 2021, and did not cause an increase in run time.

Since the OpenStudio/EnergyPlus modeling calculations are inherently more computationally intensive than the DOE2.1e calculations, there was concern that the time required to generate a score could become unacceptably high from a user-experience perspective; the median time was already roughly a minute and considered an annoyance. To respond to this concern, optimization efforts were made on three different levels. First, we optimized the modeling code to reduce the amount of computation required. Second, we ran the calculations for the different modeled improvements in parallel rather than sequentially. Third, we upgraded the AWS deployment to accommodate the parallelism and to use faster CPUs. As a result, the time required to generate scores remained very similar, as shown in Figure 8.

Other New Capabilities

Upgrade Recommendations Improvements

HEScore provides energy upgrade recommendations by modeling all suitable upgrades selected from a fixed set of 32. Those upgrades that have a simple payback of 10 years or less are then combined into a package, which is modeled to account for the interactive effects between the upgrades. This process always results in a package with a payback of less than 10 years, but often significantly less—the median payback of all homes scored in 2020 was less than 5 years. The package of measures optimizes source energy regardless of fuel type. Future versions will

have the ability to recommend electrification upgrades. This conservative “cream skimming” approach can leave a significant amount of potential savings on the table. To remedy the situation, an optimized package was developed that uses the excess cost savings of the best upgrades to pay for additional upgrades. The optimized package is the one with the highest total cost savings that has a total payback period of less than 10 years. This new optimized package increased mean savings by 23% and median savings by 38% over the old simple package while the number of recommended upgrades increased by almost 70%. Distributions of the additional savings and payback times are shown in Figure 9.

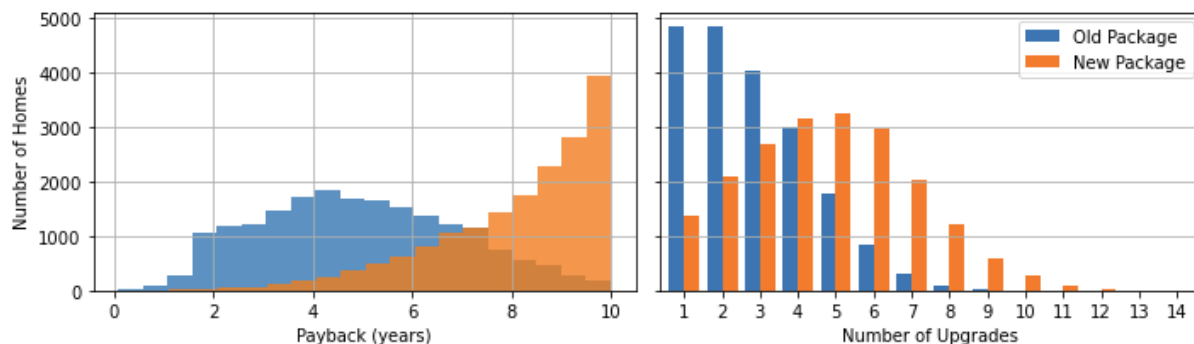


Figure 9 (Left) Distribution of upgrade package payback times in years. (Right) Distribution of the number of cost-effective upgrades in each package. Data are from 20,000 homes in the HEScore database.

Energy Cost Estimate

Another new addition to the HEScore report is an estimate of energy use for a comparable home of similar vintage, conditioned floor area, heating type, cooling type, and foundation type. This estimate was developed to be a comparison between the home being scored and a typical unimproved home in the same climate. The data for this estimate are derived from ResStock (Wilson et al. 2017) and allow for a comparable home to be found that can be used in appraisal and financing decision-making.

Quality Assurance Data Analysis

Certified HEScore assessors gather approximately 50 inputs for each home to generate an HEScore label. HEScore partners have quality assurance (QA) assessors that rescore homes that have already been assessed, typically sampled at a rate of 5% of official assessments for each assessor. In some cases, the number of QA rescores falls short of that sampling rate. To better ensure and track assessment quality, we are developing a web application tool for HEScore QA to help QA assessors identify inconsistencies in assessments. This tool can be used to statistically quantify anomaly information from the HEScore database and to identify industrywide inconsistencies. Some examples of common inconsistencies are unexpected score differences between similar homes in similar climate zones, unreasonably high or low HVAC/domestic hot water efficiency, and mismatched building asset information such as foundation type, building envelope insulation level, duct insulation level, air sealing, etc.

Our primary goal for developing the QA analysis tool is to improve the consistency and accuracy of assessments and to improve the efficiency and effectiveness of the assessors' participation and processes. HEScore administrators will be better able to visualize the data that

indicates which partners are meeting their QA rescore sampling requirements (overall) and help alert partners to which assessors may need additional QA sampling or guidance and support with specific assessment inputs. An additional goal is to further develop the QA tool user interface for partner use, so that they can better track their own QA efforts. Ideally, this QA analysis tool would also someday contribute to the green building certification and home energy labeling industry, guiding future HEScore rule set amendments and education, and setting an example for other labels and/or certifications to use.

Impact

The DOE's move to EnergyPlus as HEScore's modeling engine reduces confusion in the market by enabling comparable data outputs—like a home's energy use and cost estimates—from rating systems like HEScore and Home Energy Rating System (HERS), which previously could not be easily compared. This will make it easier for homeowners, buyers, and renters to compare homes, enable more state and local disclosure policies to gain traction, and aid lenders and appraisers in properly valuing and comparing homes. Home Energy Scores are currently being performed at a rate of approximately 2,000 per month and are on track to continue expanding in monthly volume going forward—likely approaching 200,000 scores by the end of 2022. While there are many implementation models from around the country, some of the most compelling include partner activities in Connecticut (48,000+ scores), Oregon (31,000+ scores), New Jersey (28,000+ scores), and California (14,000+ scores).

Home Energy Score Use in Utility, State, and Municipal Programs

Since its launch in 2012, HEScore has steadily gained recognition and today is considered the gold standard for states, municipalities, and others for providing reliable energy use estimates and comparable asset data for single-family detached and attached homes throughout the United States. As the earliest adopters of HEScore, several utilities' energy efficiency programs have incorporated the score into existing programs, in most cases requiring little additional data beyond what was already required. Some utilities have made it their policy to include the HEScore with all home energy assessments (City of Fort Collins n.d.; City of Columbia n.d.; Better Buildings n.d.); others have chosen an opt-in approach (Energize Connecticut n.d.), and an opt-out approach presents another potential path. One utility provides the HEScore when equipment is replaced as part of its rebate program to see if customers want further energy efficiency improvements (Better Buildings 2015).

Following the early years of the program when utilities were the focus, municipalities and states began using the HEScore as a reliable, government-backed tool for use in real estate disclosure policies and as a strategy for meeting local climate action plans—and that interest has been steadily growing. In 2015, the city of Berkeley, California, was the first municipality to include HEScore in a local ordinance. Through its Building Energy Saving Ordinance,¹ the HEScore was required in real estate transactions at time of sale. Berkeley updated its policy in 2021 to require the HEScore *prior* to sale in real estate listings, recognizing the value in providing home energy information to prospective buyers (City of Berkeley n.d.). Throughout the rest of the San Francisco Bay Area, the HEScore is offered on a voluntary basis, with

¹ In 2021, the city of Berkeley changed the name of its ordinance from the Building Energy Saving Ordinance to the Building Emissions Saving Ordinance.

incentives, through the Bay Area Regional Energy Network. In 2018, the city of Portland, Oregon, became the first municipality in the country to require an HEScore in real estate listings (City of Portland n.d.). In developing its ordinance, the city was able to build upon the state of Oregon's existing administrative rules for voluntary home energy labeling that stipulate that a home energy label produced in Oregon must include certain elements, including an HEScore. The state's framework and Portland's experience implementing an HEScore ordinance paved the way for other municipalities in Oregon and elsewhere in the country to follow suit (City of Milwaukie n.d.; City of Hillsboro n.d.; City of Piedmont 2022).

In Connecticut, in addition to the state partnering with utilities through Energize Connecticut to offer the HEScore with the utilities' Home Energy Solutions program, legislation was introduced that would require home energy labels—HEScore being one approved option—in real estate and rental listings.² The state of Missouri has a Home Energy Certification Program in which an HEScore or HERS index can be used to earn a home a silver or gold certificate (Missouri Department of Natural Resources 2017). HEScore partners are developing an API that customizes HEScore outputs—allowing for customization of energy upgrade recommendations—to align with statewide goals and help facilitate local reach code ordinance development, with potential to increase HEScore use.

In 2021, the city of Gainesville, Florida, became the first HEScore partner to use the score in a rental ordinance, requiring rental properties to receive an HEScore as part of rental inspections every 4 years and requiring minimum energy efficiency standards (City of Gainesville 2022). Using HEScore in rental policies can provide transparency on estimated energy costs for lower-income households, which spend a disproportionate percentage of income on energy bills (ACEEE 2020). Including HEScore in local rental policies provides an easy way for renters to understand home operating costs and help hold rental property owners accountable for meeting minimum energy performance standards.

Interest in HEScore among state and local governments continues to expand, as a growing number consider the HEScore as part of their home energy labeling and real estate disclosure efforts. Disclosure policies have been aided by the growth of home energy data repository infrastructure that is able to share data like HEScore in real estate listings or appraisal comparisons. The Green Building Registry, developed by Earth Advantage, and Home Energy Labeling Information eXchange, developed by Clearly Energy for Northeast Energy Efficiency Partnerships (NEEP n.d.), have assisted states and municipalities in consolidating residential energy information and making it available to the real estate market, facilitating the implementation of policies that require disclosure of home performance data.

Even though much of the HEScore's state, regional, and local activity began prior to the upgrade of the calculation engine to EnergyPlus, this transition has facilitated continued use of the HEScore, adaptation of its most useful elements for a wide variety of partner implementation models, and bolstered confidence in the utility and integrity of the HEScore.

Home Energy Score Use in Financing

HEScore provides concise information that can motivate homeowners to make energy improvements and document the value once improvements have been made. But without adequate access to financing options, energy upgrades can be financially out of reach for many.

² Connecticut [H.B. 5041](#) for renters and [S.B. 14](#) for buyers were introduced in the General Assembly in February 2022.

Energy efficiency financing products, while gaining traction, have yet to transform the broader U.S. market and drive more homeowners to invest in upgrades. Updated policies and products from major mortgage institutions like Fannie Mae, the Federal Housing Administration (FHA), and Freddie Mac, hold promise to change that.

Recognizing the credibility of a robust, government-backed home energy rating system, Fannie Mae, FHA, and Freddie Mac have incorporated HEScore in policies and products to simplify financing retrofits and reward borrowers with energy efficient homes. FHA's Energy Efficient Homes policy allows lenders to provide a 2% stretch on debt-to-income ratios for borrowers purchasing a home, refinancing a home, or financing improvements with an HEScore of 6–10 (HUD 2015). Fannie Mae's HomeStyle® Energy Mortgage Loan and Freddie Mac's GreenCHOICE Mortgages® allow borrowers to finance up to 15% of the “as-completed” home value for energy and water efficiency improvements with purchase or refinance. HEScore is one of the approved home energy reports required when financing more than \$3,500 (for HomeStyle Energy) or \$6,500 (for GreenCHOICE) worth of improvements (Fannie Mae 2022; Freddie Mac n.d.). Because the HEScore report already includes a list of cost-effective recommended improvements with ≤10-year payback, Fannie Mae and Freddie Mac don't require a separate cost-effectiveness test (as traditional energy efficient mortgages do).

Additionally, Fannie Mae and Freddie Mac have worked with stakeholders to recommend updates to the Uniform Residential Appraisal Report (Uniform Mortgage Data Program 2021), which includes recommendations to better account for energy efficiency using HEScore as a data point for valuation. To support appraisers in valuing HEScore, the label report now includes a comparable energy cost estimate for similar homes. Incorporation of HEScore information in appraisals will help advance the energy efficient mortgage market and help show the value of energy performance, driving consumer interest in energy efficiency.

Home Energy Score Inclusion in Bipartisan Infrastructure Law

HEScore is named as a requirement for residential energy efficiency loans as part of the Revolving Loan Fund provision of the Infrastructure Investment and Jobs Act (also known as the Bipartisan Infrastructure Law). The Energy Efficiency Revolving Loan Fund Capitalization Grant Program will establish a \$250 million revolving loan fund within the State Energy Program with capitalization grants to state energy offices for commercial and residential energy efficiency loan funds and audits (Infrastructure Investment and Jobs Act 2021, Sec. 40502). This is the first time HEScore has been included in federal legislation, a testament to its growing recognition and impact in the market. HEScore use is anticipated to grow as states begin to make Revolving Loan Funds available for home energy retrofits.

Conclusion

Ten years after program launch, HEScore is just getting started. Modernizing the energy modeling architecture has positioned the program to respond more quickly to new technologies as they come onto the market and to give predictions and assessments more in line with other DOE and industry programs. At the same time, HEScore is gaining traction all over the country through utility programs, state energy offices, municipal ordinances, and mortgage financing. Moving forward, HEScore will be available to more homeowners, renters, buyers, and sellers to accelerate the valuation of energy efficiency in the marketplace and nudge the U.S. housing stock toward a more energy-efficient future.

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