2024 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
BUILDING TECHNOLOGIES OFFICE

U.S. DEPARTMENT OF ENERGY
Home Energy Score

BTO Peer Review:

Home Energy Score Modeling

Noel Merket, PE
Senior Research Engineer
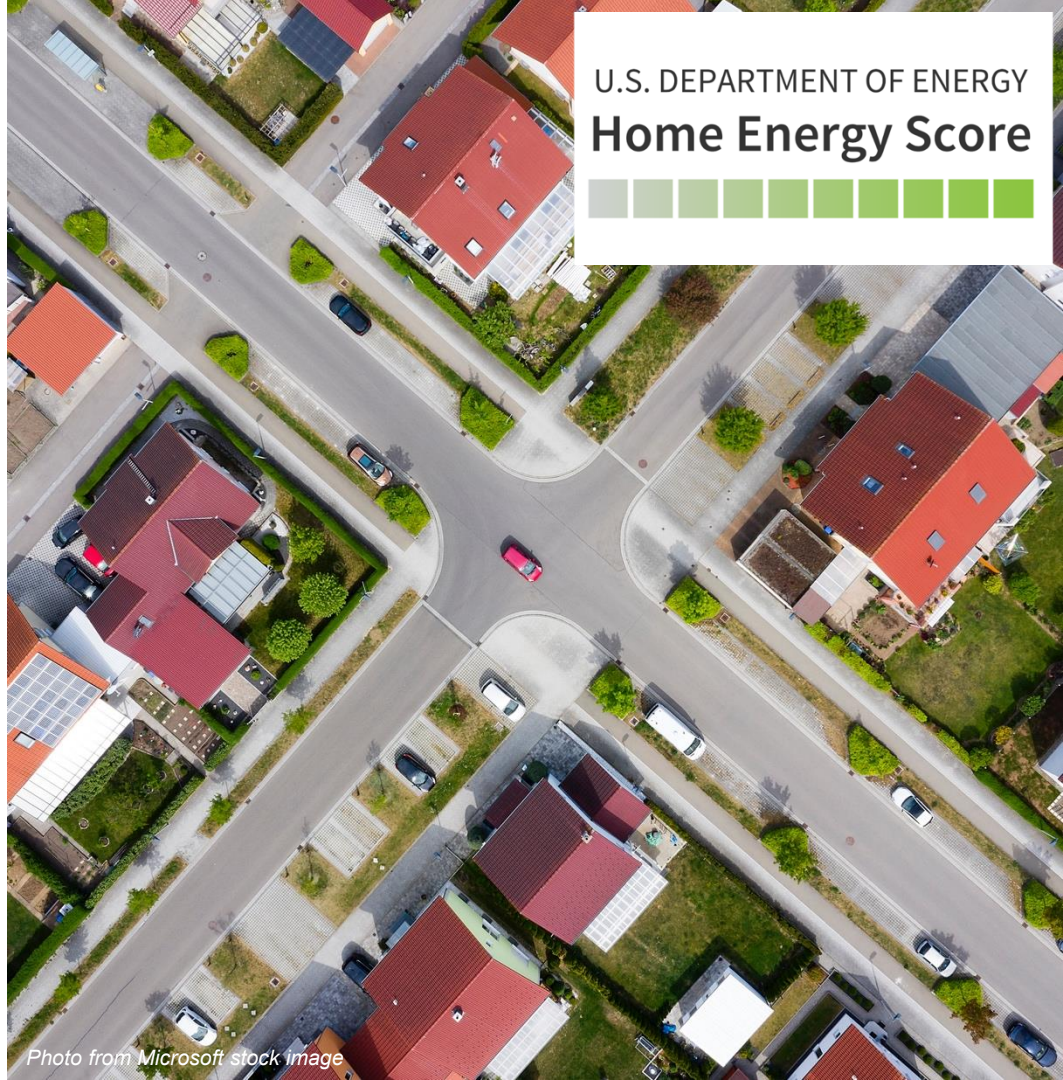Residential Buildings Research Group, NREL

WBS 1.5.1.30

Photo from Microsoft stock image

Project Summary

OBJECTIVE, OUTCOME, & IMPACT
Home Energy Score makes energy efficiency visible, valued, and actionable at scale by applying cutting edge building energy modeling research to homes across the country. NREL's work to develop and deliver the foundational modeling capabilities enables market transformation through this project.

TEAM & PARTNERS
NREL: Noel Merket, Scott Horowitz, Ben Park, Yueyue Zhou
PNNL: Charlie Holly, Prescott Davis, Yan Zhao
DOE: Gilly Plog, Torsten Glidden

STATS
Performance Period: Oct 1, 2023 – Sep 30, 2024

DOE Budget: $450k, Cost Share: $0k

Milestone 1: Energy Cost Estimate API release 9/27/2024
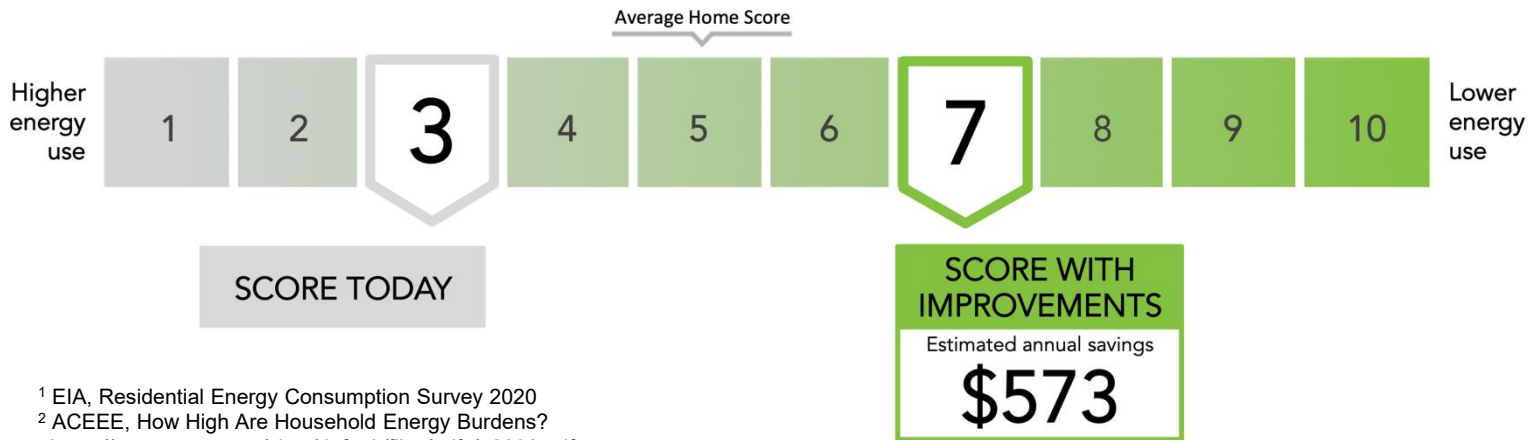
Milestone 2: OpenStudio-HEScore workflow release 9/27/2024

Problem

79% of homes (97.3 million) in the U.S. were built before 2000[1] and are potentially underperforming to meet emissions reduction goals in the Blueprint. 25% of households (30.6 million) are experiencing high energy burden[2].

However, energy efficiency is invisible to homeowners, renters, and buyers, who don't have the information or resources they need *when they need it* to make decisions that will add up to the necessary emissions reductions.

A low-cost energy assessment with trusted, credible, consumer-friendly metrics, and cost-effective upgrade recommendations makes energy efficiency *visible*, *valued*, and *actionable* at scale.

Average Home Score

| Higher energy use | 1 | 2 | **3** | 4 | 5 | 6 | **7** | 8 | 9 | 10 | Lower energy use |

SCORE TODAY

SCORE WITH IMPROVEMENTS

Estimated annual savings

$573

[1] EIA, Residential Energy Consumption Survey 2020
[2] ACEEE, How High Are Household Energy Burdens?
https://www.aceee.org/sites/default/files/pdfs/u2006.pdf

Alignment and Impact

Home Energy Scores Surpass 250,000
SEPTEMBER 5, 2024

Number of Home Energy Scores
- 1–10
- 11–100
- 101–1,000
- 1,001–10,000
- 10,001–100,000

Home Energy Score is catalyzing market transformation through a variety of means:

- Real estate and rental **disclosure ordinances** in 8 cities

- Statewide **labeling frameworks**/programs in 5 states

- **Reach codes** when major renovations are done in 3 cities

- **Utility programs** to encourage additional EE measures & document the value of improvements in 9 programs

- **LMI programs** by community action agencies and non-profits

- **Mortgage products** (Fannie Mae, Freddie Mac, FHA), **MLS listings**, and **appraisal forms**
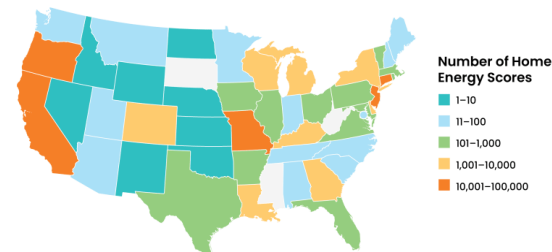
Referenced in IRA- and IIJA- funded programs for use in:

- **Home Energy Rebates** as post-installation certificate and when utility bills aren't available (BPI 2400, Annex E)
- **EE Revolving Loan Fund Program**

Quick Stats
- ~255,000 Scores
- ~400 Assessors
- 27 Partners
- 14 software tool connections

Alignment and Impact

Latest Research Findings

How Does Home Energy Score Affect Home Value and Mortgage Performance?

In cities that require Home Energy Score in real estate listings:

- Higher Home Energy Score was associated with higher purchase price (0.5% higher purchase price for each point increase on Home Energy Score scale)

Energy Labels Affect Behavior on Rental Listing Websites

- Energy labels on a mock rental listing website encouraged renters to select the most efficient listings 21% more often

- Showing listings with a Home Energy Score and the corresponding scale and estimated energy costs led to higher "click" rates of energy efficient properties

**Home Energy Scores drive demand for upgrades**

- Scored households are **10x more likely to pursue an energy conservation measure** from Energy Trust of Oregon than non-Scored homes
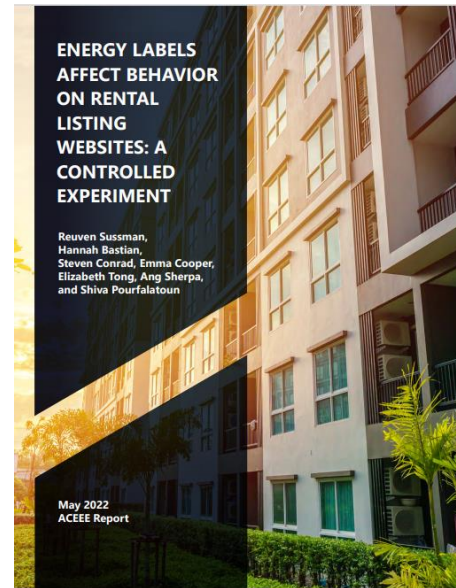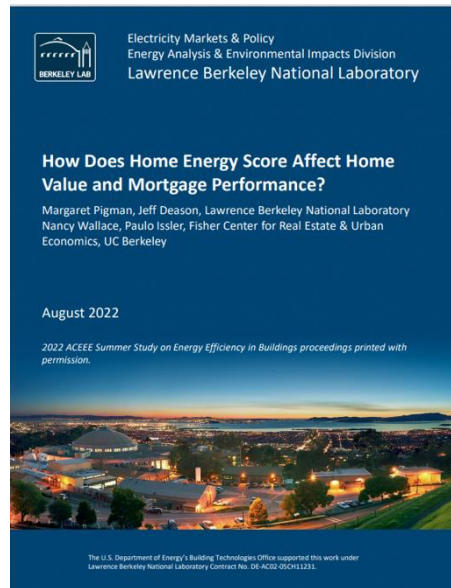
Approach

The Home Energy Score is an *asset rating* of a house. An asset rating allows comparison of energy use between homes independent of who lives there, like a miles-per-gallon rating on a vehicle. Home Energy Score strives to balance the cost of the assessment with providing an accurate prediction of energy use for a typical household. In mature markets the Score costs about $200 per home.
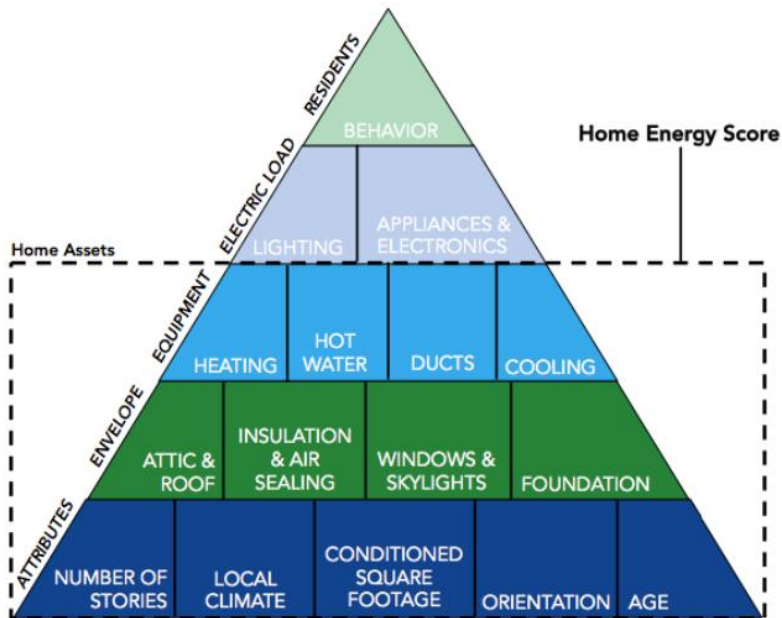
Approach

The Home Energy Scoring Tool is a cloud-based web application and API used by assessors to predict energy use, assign a Score, and recommend cost effective upgrades. NREL primarily develops the foundation of the application that performs the building energy modeling and yields energy predictions.

PNNL

Web Application/API

Database

Cloud Deployment

Assessor/Partner Management

NREL

Home Assessment Data Collection

Building Energy Modeling

✓ Energy Use
✓ Energy Cost
✓ 1-10 Score
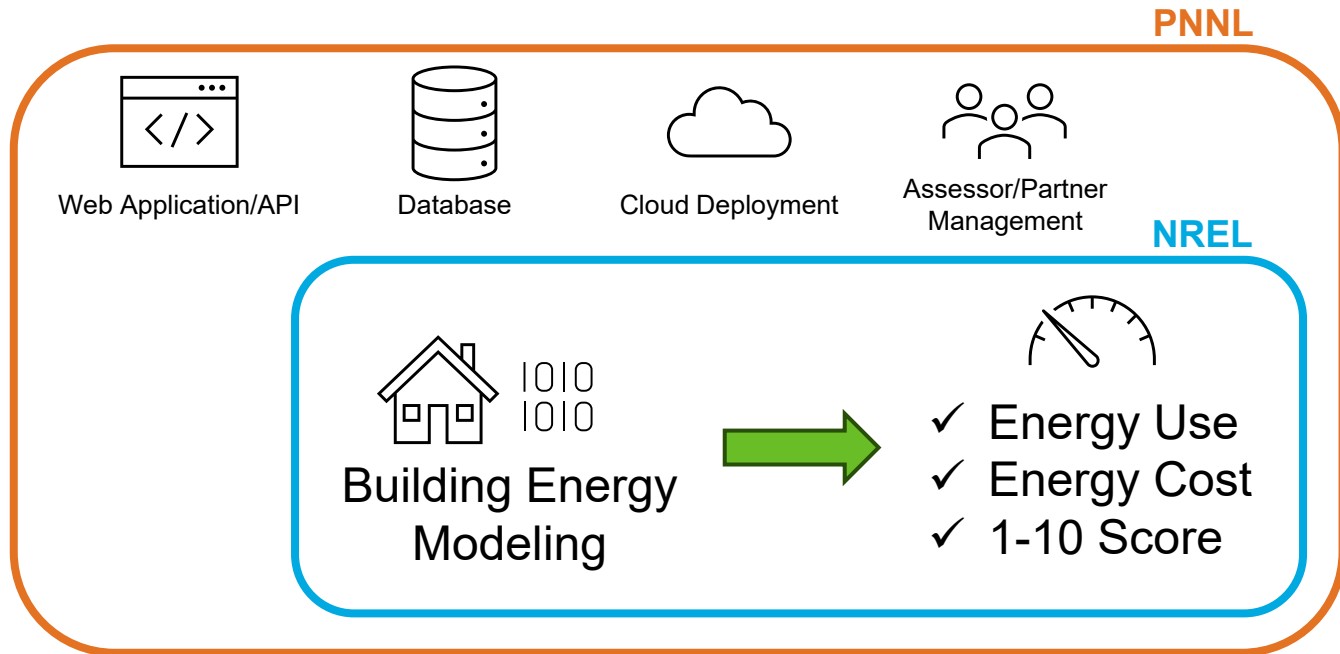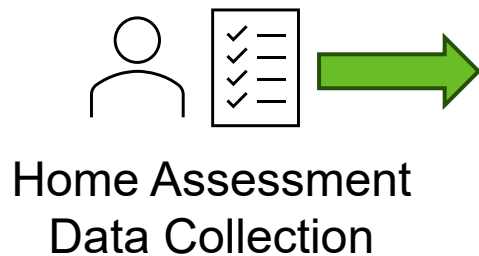
Approach

The Home Energy Scoring Tool is built upon decades of DOE research in building energy modeling. By using the same rulesets and assumptions as other tools in the market, results are consistent and reliable across programs and market segments: new homes, existing home rebate programs, weatherization, and building stock analyses.
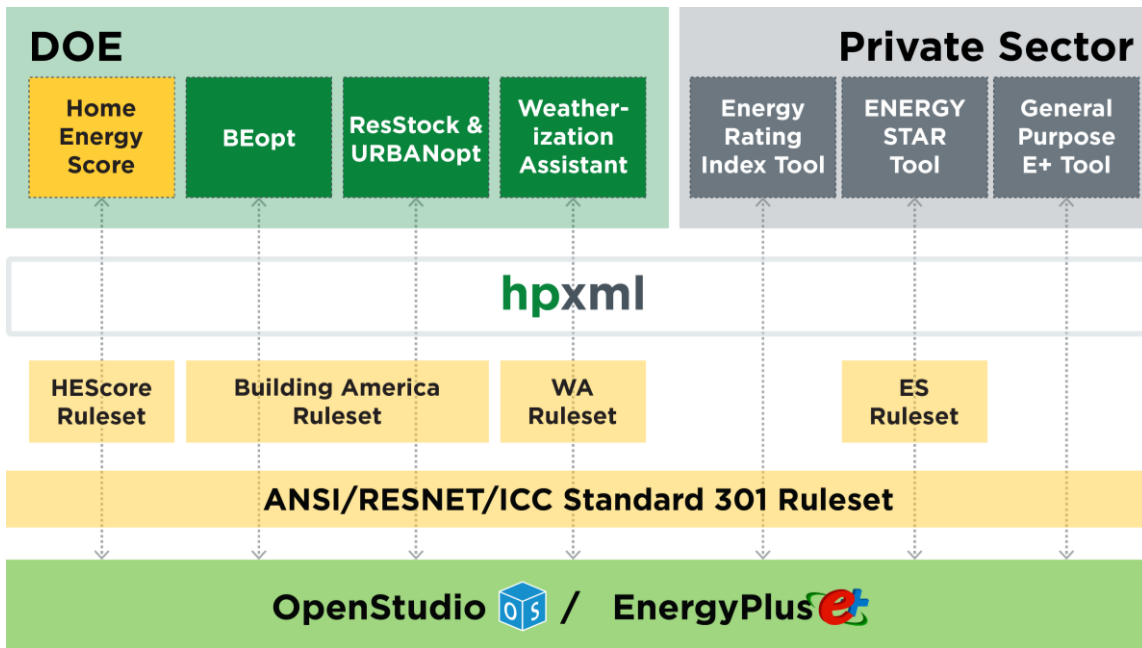
Approach

The **Energy Cost Estimate API** leverages public ResStock building energy data to estimate annual energy costs for a home with a limited number of inputs.

- **Use Cases:** provides a "comparable" reference home's energy use for mortgage appraisals so that energy efficiency features can be valued. Educates homeowners and incentivize retrofits.

- **Inputs:** pulled from the Universal Appraisal Report (Form 1004) which describes high-level details of homes to complete a full property appraisal

- **Model:** regression model trained on a ResStock dataset containing 2 million building energy models with annual energy usage by fuel.

- **Outputs:** a range of likely costs and annual energy usage from the 25th percentile to the 75th percentile

Category	User Input (Form 1004)
Zip Code	80202
House Size (ft²)	1,698
Vintage	2001
Heating Fuel	Natural Gas
Cooling Type	Central AC
Foundation Type	Slab

Annual Energy Cost	$1,018 – $1,312
Electricity	4,789 – 6,393 kWh
Natural Gas	58 – 72 MMBTU
Fuel Oil	0 MMBTU
Propane	0 MMBTU

Progress

2021: Modernize energy modeling

- Replace unmaintained DOE2.1e with state-of-the-art EnergyPlus and OpenStudio

- Align with open standards and rulesets

- Better models: heat pump water heater, ducts, geothermal heat pumps, foundations, etc.

2022: Build on the improved modeling foundation

- High efficiency and cold climate heat pumps, low-e storm windows, knee walls, more constructions for walls and ceilings, etc.

- More comprehensive upgrade recommendations that yield more total savings

2023: Expand the reach, prepare to scale

- Develop multifamily and manufactured homes capabilities

- Modernize software architecture integration in conjunction with PNNL to reduce ongoing maintenance costs and deliver features faster.

Progress

2024: New Housing Types

- Expands the reach of Home Energy Score to more low income and disadvantaged communities.

- **Multifamily Units**: shared walls/floors/ceilings, infiltration assumptions, steel frame walls, flat roofs.

- **Manufactured Homes**: single/double/triple wide geometry, belly and wing foundations, bowstring roofs, aligning modeling with DOE's Weatherization Assistant tools (MHEA). Includes upgrade recommendations to belly and wing foundations and bowstring roofs.


Photo from Microsoft stock image

Photo by Roger Starnes Sr on Unsplash

Progress

2024: Scoring Bins

- New methodology to make the conversion from Btus of source energy to the Score

- Developed from the latest ResStock capabilities and housing stock data.

- Runs a Home Energy Score asset model for a sample of 2 million dwelling units representing the U.S. housing stock.

- New differentiated scoring bins for multifamily units.

Single Family Score

Multifamily Score
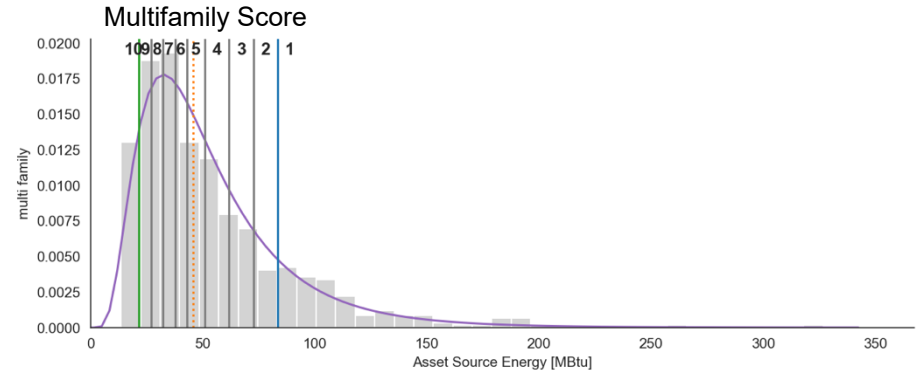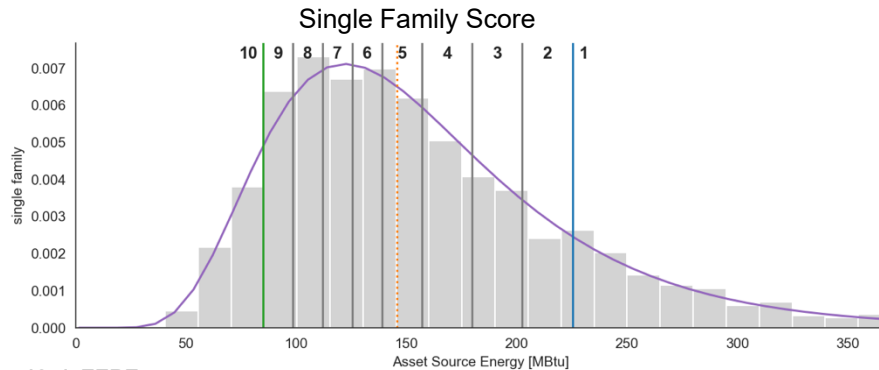
Progress

2024: Modeling Improvements

- Further updated modeling assumptions to better reflect the equipment available on the market today
  - Air source heat pumps
  - Ground source heat pumps
  - Central air conditioners
  - SEER2/HSPF2/CEER/UEF rating inputs

- Duct leakage measurement inputs (when available)

- Air infiltration model improvements

- Foundation heat transfer improvements

- Window interior shading improvements

- Updated to latest ANSI/RESNET/ICC 301-2022 to maintain consistency with industry standards

- Runtime improvements

Progress

2024: Misc

- Energy Cost Estimate API v2
    - Updated and improved machine learning model based on ResStock 2024.1 results
    - Quantification of uncertainty ranges

- Updated utility rates and measure cost data

- Better integration with PNNL application to reduce future development/maintenance costs and enable more frequent updates

- Allow integration with software used for IRA HOMES rebates via HPXML v4 data import, enabling Scores and reports for homes that get a rebate and analysis of the rebates program using Home Energy Score.

Future Work

Modeling Improvements

- Continued improvements to heat pump modeling based on lab data and new emerging technologies

- Dual fuel and ducted mini-split systems

- HVAC system capacity inputs

- Multifamily shared HVAC and domestic hot water systems

- Dual fuel heat pumps

- More flexibility in user input: more than two attics/roofs/floors, HVAC systems flexibility

- Mechanical ventilation systems

- Home batteries

- Smart thermostats

- Garages and equipment in garages

Future Work

Electrification Upgrade Pathway

- Meeting the emissions targets in the Blueprint will require more than just energy efficiency improvements.

- Partners will be able to select the option to offer cost-effective electrification upgrade packages.

- Complex and time of use local utility rates instead of state averages to more accurately calculate energy costs.

Mini-split heat pump inside head unit.
Image from Building America Solution Center.

Ductless heat pump outside compressor.
*Image from Building America Solution Center.*

Ducted heat pump outside compressor.
Image from Building America Solution Center.

Future Work

Carbon emissions score

- The Score today is based on source energy. This can discourage electrification because electricity has a higher site-to-source ratio than natural gas or other fossil fuels.

- We will add a new Score type that will use carbon emissions as the basis.

- Based on RESNET's Carbon Rating Index and methodology defined in ANSI/RESNET/ICC 301.

- Emissions calculations will be from NREL's Cambium database using regional grid data and future grid projections.

- Emissions savings calculation will use long run marginal emissions rates to accurately show emissions savings from avoided generation on the margins.

- Will be able to credit load shifting technologies like batteries and smart thermostats.

Plot from https://cambium.nrel.gov
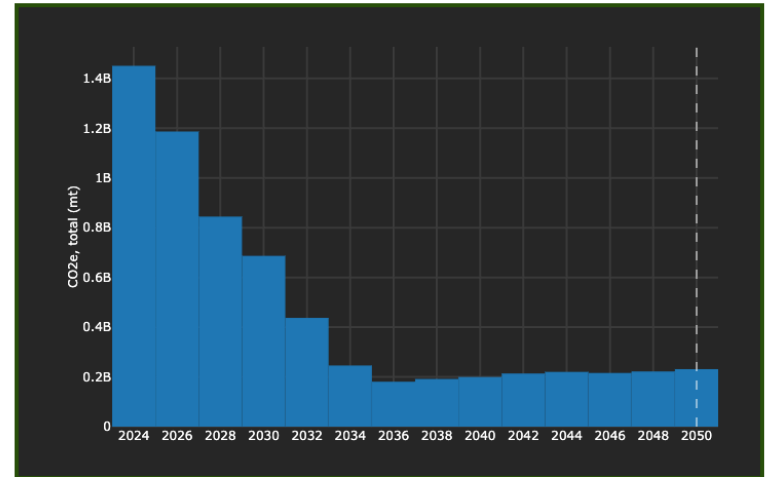
Thank you

NREL

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Reference Slides

Project Execution

	FY2022				FY2023				FY2024			
Planned budget	275k*				292k				400k			
Spent budget	275k*				324k				396k			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Past Work												
OpenStudio-HEScore Software Release v2.0		◆										
OpenStudio-HEScore Software Release 2023.05.0							◆					
OpenStudio-HEScore Software Release 2023.06.0 Beta							◆					
Current/Future Work												
Energy Cost Estimate API v2.0												🔶◆
OpenStudio-HEScore Software Release v2024.09.0												◆

- *In FY22 this project was a task in another project. This is an estimate.
- Staffing constraints caused the Energy Cost Estimate API milestone slippage.

Team

Noel Merket

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Engineer

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