Better Buildings Residential Network
Peer Exchange Call Series:
We Love Our National Labs: Research Results Part 1

February 14, 2019

Agenda and Ground Rules

- Agenda Review and Ground Rules
- Opening Poll
- Residential Network Overview and Upcoming Call Schedule
- Featured Speakers:
  - **André Desjarlais**, Oak Ridge National Laboratory
  - **Katie Cort**, Pacific Northwest National Laboratory
  - **Lena Burkett,** National Renewable Energy Laboratory
- Open Discussion
- Closing Poll and Announcements

Ground Rules:

1. **Sales of services and commercial messages are not appropriate** during Peer Exchange Calls.
2. Calls are a safe place for discussion; **please do not attribute information to individuals** on the call.

The views expressed by speakers are their own, and do not reflect those of the Dept. of Energy.

Better Buildings Residential Network

Join the Network

Member Benefits:

- Recognition in media and publications
- Speaking opportunities
- Updates on latest trends
- Voluntary member initiatives
- Solution Center guided tours

Commitment:

- Members only need to provide *one number*: their organization's number of residential energy upgrades per year, or equivalent.

Upcoming calls:

- February 28th: We Love Our National Labs: Research Results (Part 2)
- March 14th: Efficiency and Resilience Improvements with PACE Financing
- March 28th: The Next Frontier: Energy Storage and Batteries

Peer Exchange Call summaries are posted on the Better Buildings website a few weeks after the call

For more information or to join, for no cost, email bbresidentialnetwork@ee.doe.gov, *or go to* energy.gov/eere/bbrn *& click Join*

André Desjarlais
Oak Ridge National Laboratory

U.S. DEPARTMENT OF ENERGY

Seeking Solutions to Cost Effectively Insulate an Existing Wall Assembly

André Desjarlais, Kaushik Biswas, PhD, and Jerry Atchley

Building Envelope and Urban Systems Research
Oak Ridge National Laboratory

ORNL is managed by UT-Battelle, LLC for the US Department of Energy

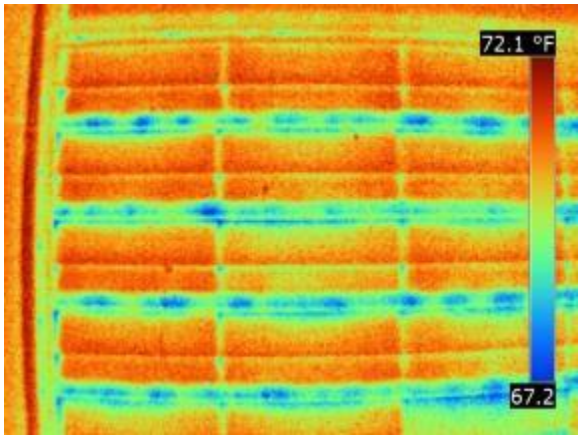
Today's wall retrofit options

Sources: http://www.jmofnb.com/_media/image/wall.JPG;
http://www.greenbuildingadvisor.com/blogs/dept/guest-blogs/window-installation-tips-deep-energy-retrofit;

Overview

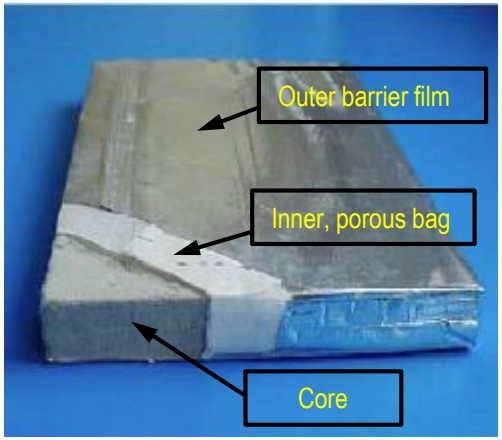
- Current insulated siding is limited to R2.
- MAI-vinyl composite siding can yield R10 within ~1 inch thickness, making it an attractive recladding option for homeowners.
- Current project objectives:
  - Critical review and feedback on design, handling and installation of the MAI-vinyl siding by industry professionals.
  - Perform long-term field testing in a natural exposure test facility in Charleston, SC.

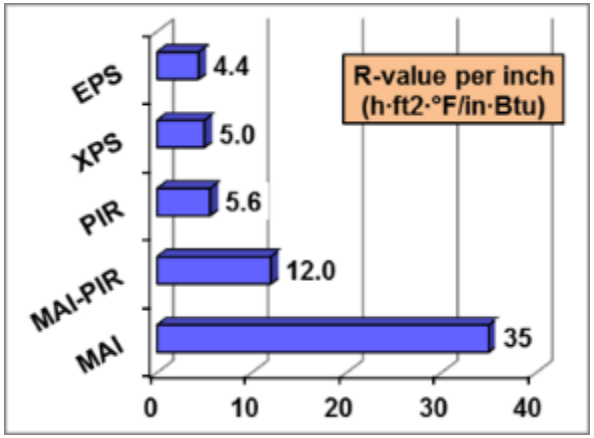
Siding profile (left) and mating MAI panel (top)



IR image comparing insulated sections with joints

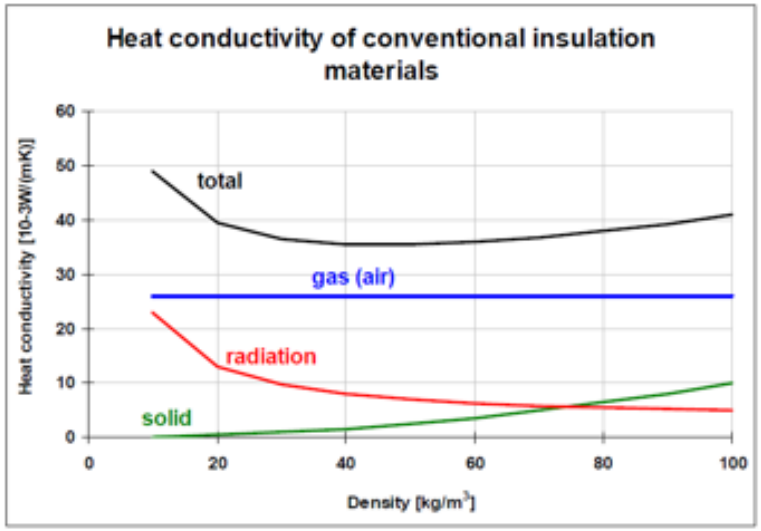
Technology being developed based on Vacuum Insulation Panels (VIPs)

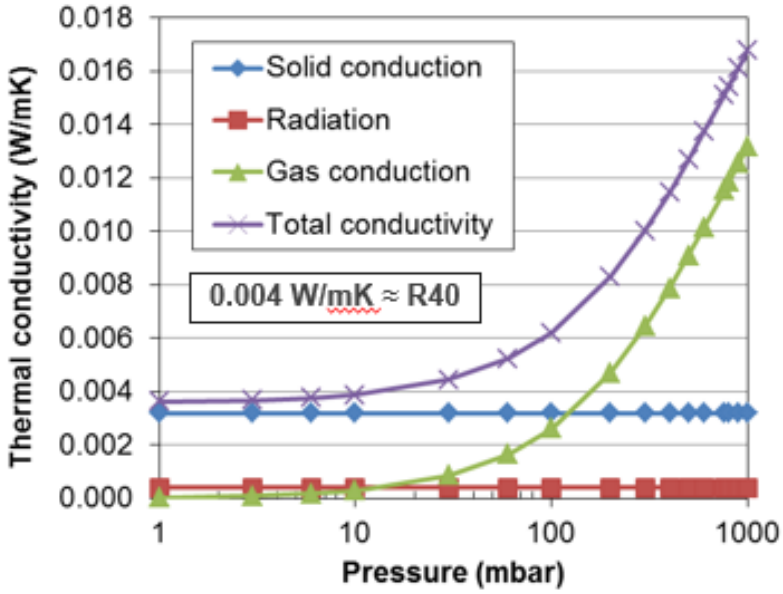


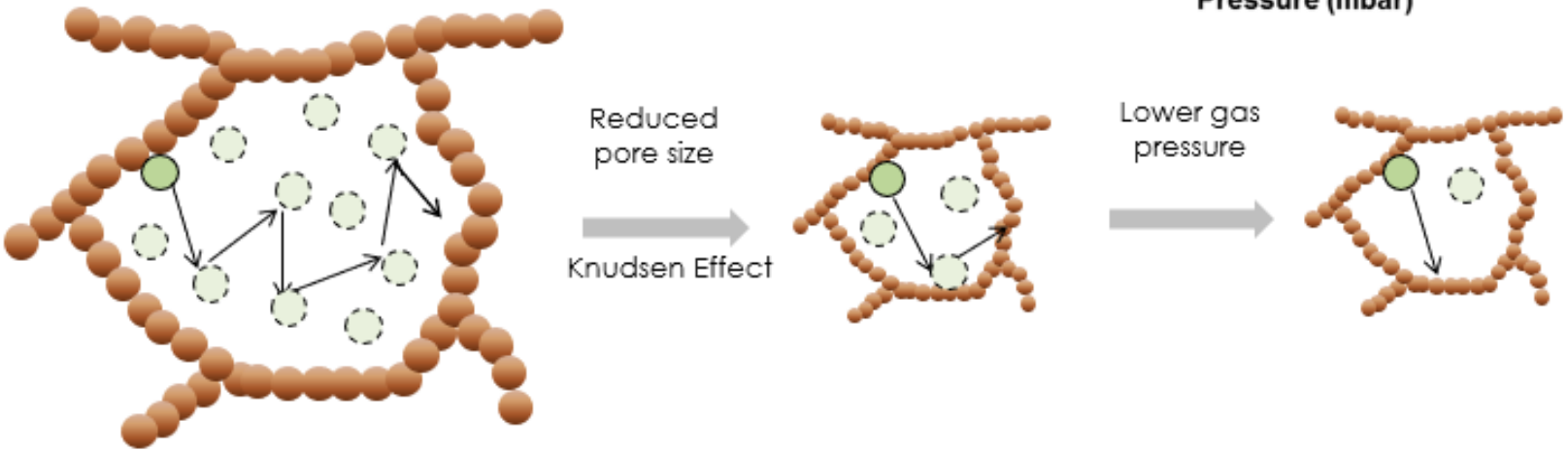


- Modified Atmosphere Insulation (MAI) is a lower cost variant of VIPs.
- VIPs provide a significantly higher R-value that current insulations materials.
- VIPs usually comprise of a nano-/micro-porous core (e.g., fumed silica) encapsulated in an air and vapor impermeable barrier film and evacuated (~ 5 mbar).

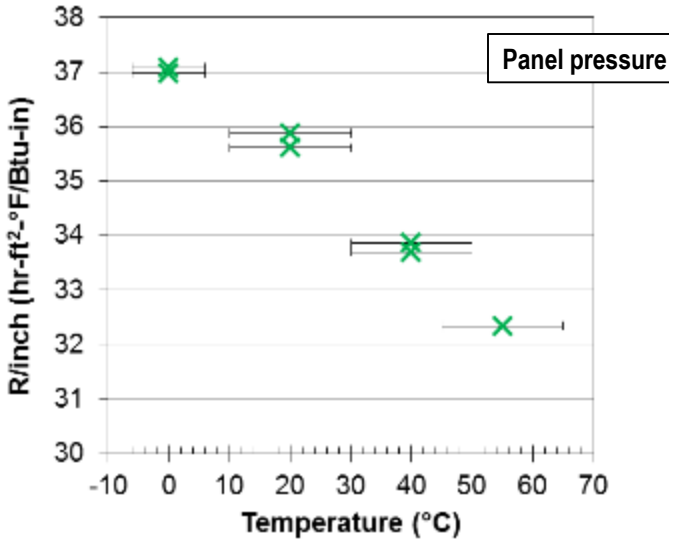
Heat transfer in insulation materials

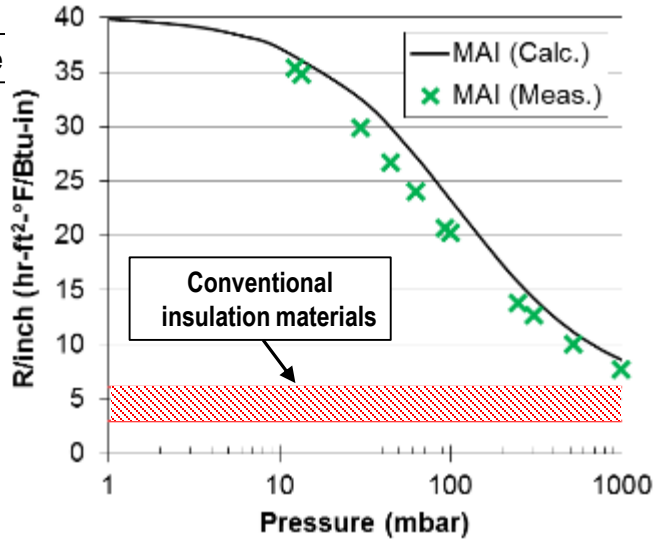


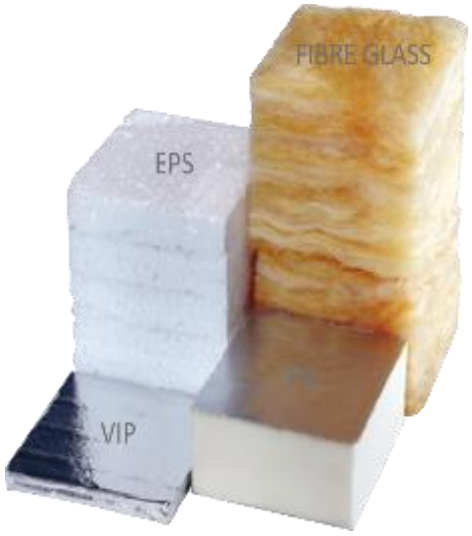




Thermal performance tests



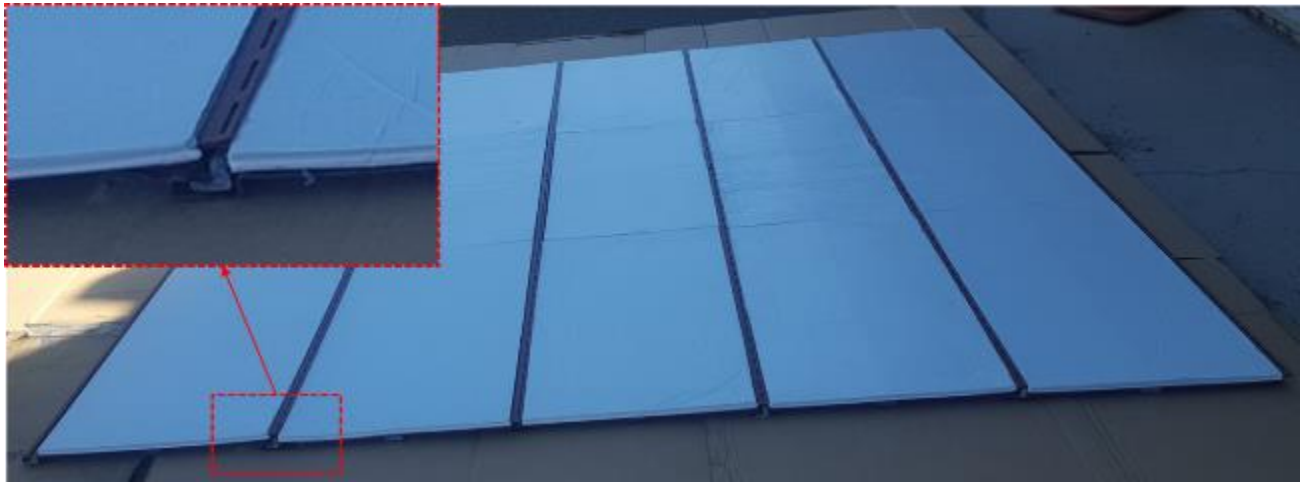




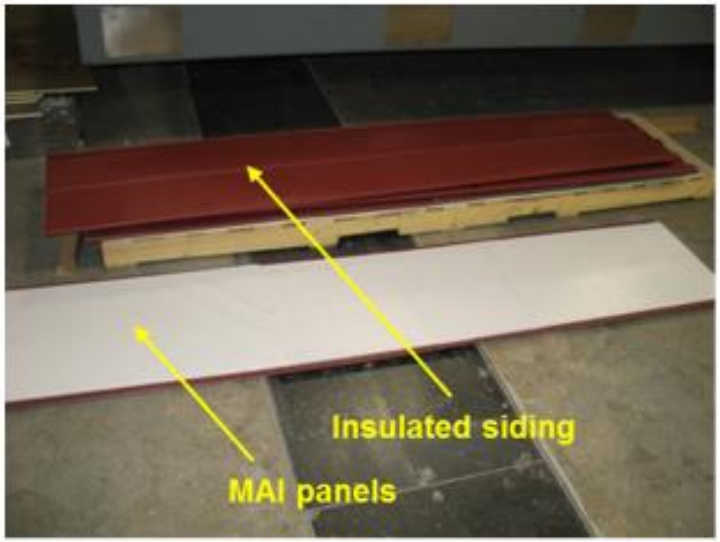
- Even with complete loss of vacuum, MAI panels expected to have higher R/inch than conventional insulation materials.

MAI panels and MAI-vinyl siding composite

- MAI panels – 18.5" high by 32" long by 0.5" thick.
- Five (5) composite siding pieces and fifteen (15) MAI panels.

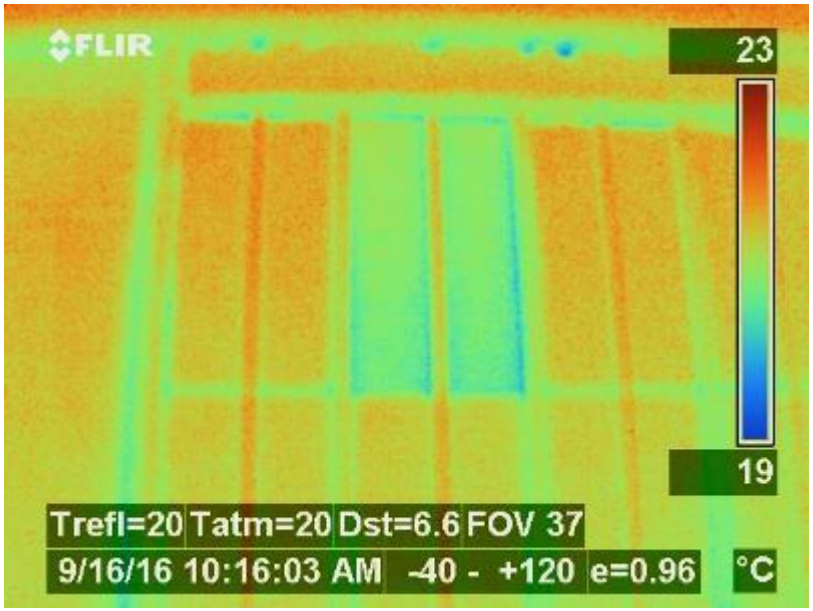


Hot box test wall preparation

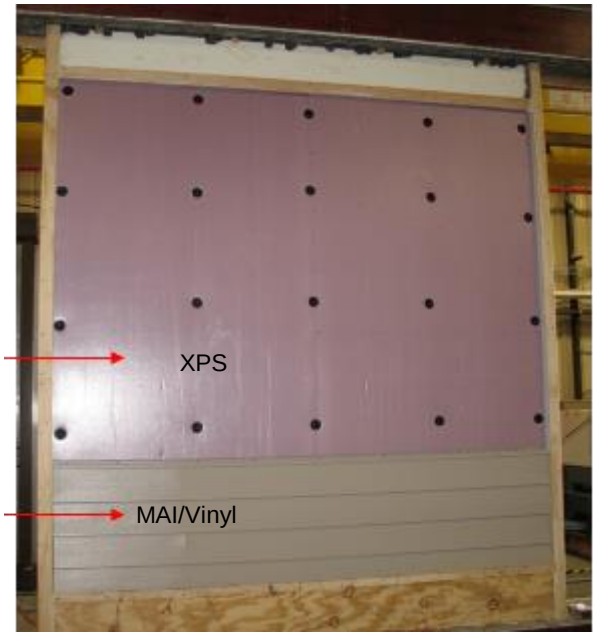


Thermal performance

- Created 8’ x 8’ MAI-siding system and tested in ORNL’s guarded hot box according to ASTM C1363. R-value of vinyl siding with MAI is R11.7.



More conventional shaped siding produced



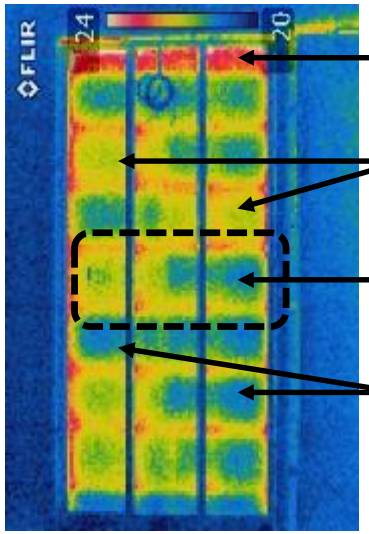
- Tested in ORNL's guarded hot box according to ASTM C1363. R-value of vinyl siding with MAI is R12.9.

NET facility field exposure experiments

- "Double 6" vinyl siding with MAI panels manufactured.
- Two panels to be constructed; one with MAI and one with EPS.
- Installation in November 2018.

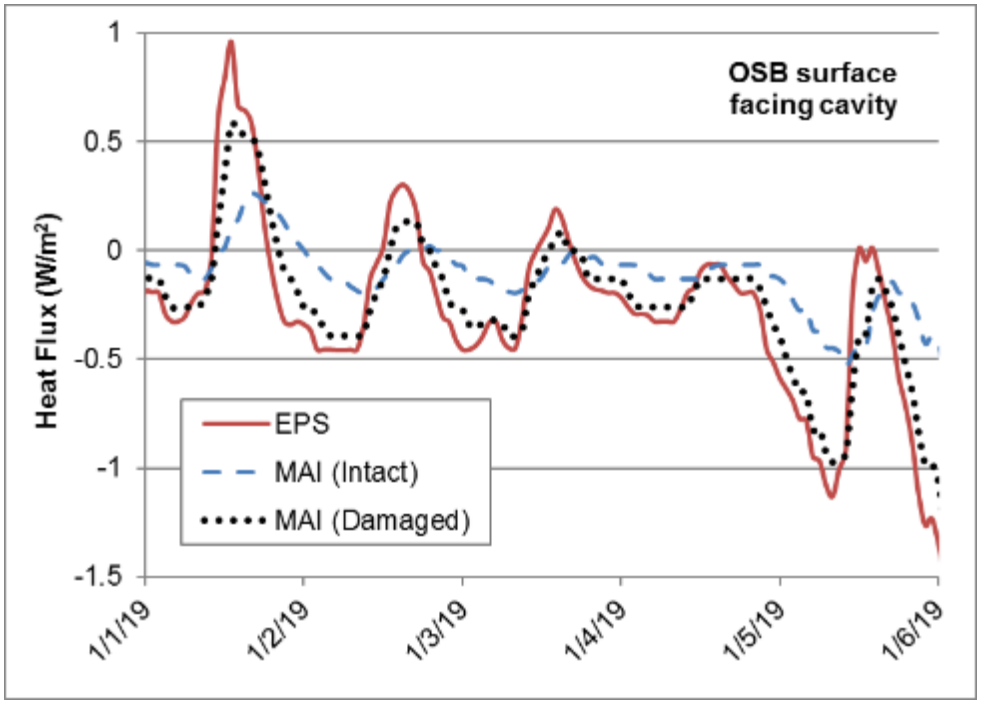
Wall construction

- 2x4 stud wall with R13 fiberglass insulation with interior and exterior sheathing.
- XPS insulation over exterior sheathing.
- MAI-siding/EPS-siding on the exterior.



Field test data

- Measured heat flux peaks.
  - Intact MAI < Damaged MAI < EPS
- Nominal R/inch:
  - EPS – R4/inch
  - MAI – R35/inch
  - Damaged MAI – R8/inch



Other activities (not enough time to share)

- Compatibility of MAI panel/vinyl siding adhesive evaluated.
  - Significant differences in thermal expansion coefficients
  - High temperatures (particularly for dark colored siding
- High-level economic analyses.
- Aging of MAI panels.
  - How much thermal drift
  - Can we develop an accelerated process
- What do builders and contractors think?

Key Points

- To date, energy-efficient wall retrofit options have been limited.
- ORNL has been researching the development of efficient and cost-effective paneling using MAI panels and MAI-vinyl siding composites.
- Work remains to be done, including further research and high-level economic analyses, but results so far are promising.

Katie Cort
Pacific Northwest National Laboratory

U.S. DEPARTMENT OF ENERGY

PNNL Lab Homes: Window Attachments and High-R Windows

Katie Cort, Senior Economist

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

AERC Attachments Energy Rating Council

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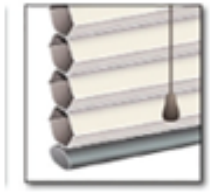
ENERGY STAR

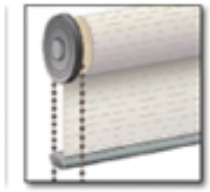
BONNEVILLE POWER ADMINISTRATION

SILICON VALLEY POWER CITY OF SANTA CLARA

CEE Consortium for Energy Efficiency

What are Window Attachments?





● "Greatest Benefit" ◑ "Moderate Benefit" ○ "Neutral or Average" ⊘ "Undetermined[1]" ◑ "Emerging products – Unverified benefits"	Insulation	Airtightness	Solar Heat Control	Winter Comfort	Summer Comfort	Condensation Resistance	Ventilation	Low Product Cost	Low Installation Cost	Durability/Service Life
Exterior Attachments										
Storm Windows (including low-e)	●	●	◑	●	◑	◑	●	◑	○	●
Awnings	○	○	●	○	●	○	●	○	⊘	◑
Roller Shades	○	○	●	○	●	○	◑	◑	◑	○
Roller Shutters	◑	○	●	○	●	○	○	⊘	⊘	●
Interior Attachments										
Conventional Roller Shades	○	○	◑	◑	◑	○	○	●	●	○
Conventional Drapes	○	○	◑	◑	◑	○	○	●	●	○
Louvered Blinds	○	○	◑	○	◑	○	◑	●	●	○
Window Panels (including low-e)	●	●	◑	●	◑	◑	⊘	◑	●	○
Insulated Cellular Shades	●	◑	◑	●	◑	⊘	○	○	◑	◑
Window Quilts	●	◑	◑	●	◑	⊘	⊘	○	⊘	○
Surface-Applied Films	◑	○	◑	◑	◑	○	○	◑	◑	○
Other										
Solar Screens	○	○	●	○	◑	○	◑	◑	●	◑

[1]The benefits of this technology for the given attribute are not generalized and should be examined on a case-by-case basis

PNNL Lab Homes Testing Platform in Richland, Washington

Lab Homes Characteristics

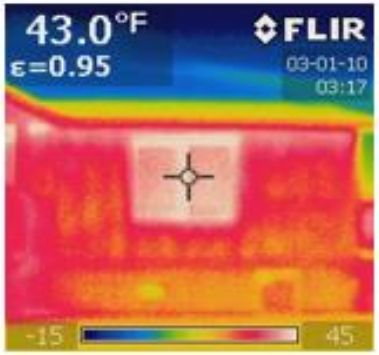
- Specified to represent existing manufactured and stick-built housing
- 3 BR/2BA, ~1500 ft^2
- All-electric with 13 SEER/7.7 HSPF heat pump central HVAC + alternate Cadet fan wall heaters throughout
- R-22 floors, R-11 walls & R-22 ceiling with composition roof
- 195.7 ft^2 (13%) window area with double-pane clear glass aluminum-framed windows

Lab Homes – Low-E Storm Windows Impact on Energy Savings

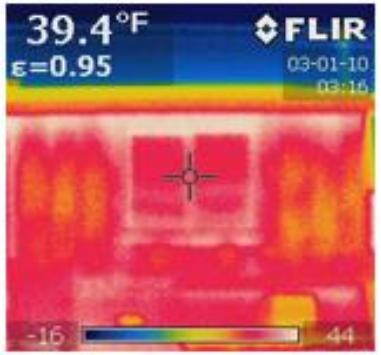
Technology (experiment)	Baseline and Experiment Description	Energy Savings (%)	Example Photos
Exterior low-e storm windows, 2014 (Larson Manufacturing)	Double-pane metal-frame clear glass windows (no window coverings)	Average Annual Savings: **10.1 ±1.4%**	 
Interior low-e storm windows, 2015 (Quanta Technologies)	Covering 74% of window area over double-pane metal-frame clear glass windows	Average Annual Savings: **7.8 ±1.5%**	

Infrared Images – Interior Storm Windows

Baseline Home



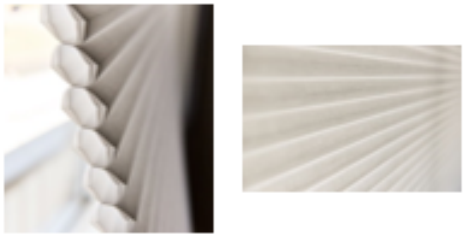
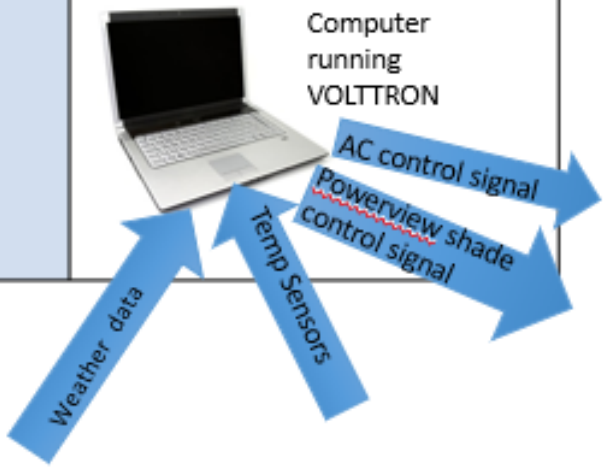
Experimental Home



Lab Homes – Triple Cell Cellular Shades Impact on Energy Savings (2015-2016 Testing)

Technology (experiment)	Baseline and Experiment Description	Energy Savings (%)
High Efficiency Cellular Shades: Static Operation – always down (Hunter Douglas)	Blinds remain closed for the duration of experiment. Compared to standard vinyl blinds remaining closed for full experiment.	Cooling: **13.3 ±2.8%** Heating: **10.5 ±3.0%**
High Efficiency Cellular Shades: Optimum Operation Comparison (Hunter Douglas)	Blinds operated per the Hunter Douglas recommended energy-saving schedule. Compared to standard vinyl blinds operated with same schedule.	Cooling: **10.4 ±6.5%** Heating: **16.6 ±5.3%**
High Efficiency Cellular Shades: Optimum Operation (Hunter Douglas)	Blinds operated per the Hunter Douglas recommended energy-saving schedule. Compared to no blinds in baseline home (double-pane clear glass windows)	Cooling: 14.8 ±2.1% Heating: **14.4 ±2.0%**

Double-Cell Cellular Shades Thermal Performance and Control Experiments – (2017-2018)

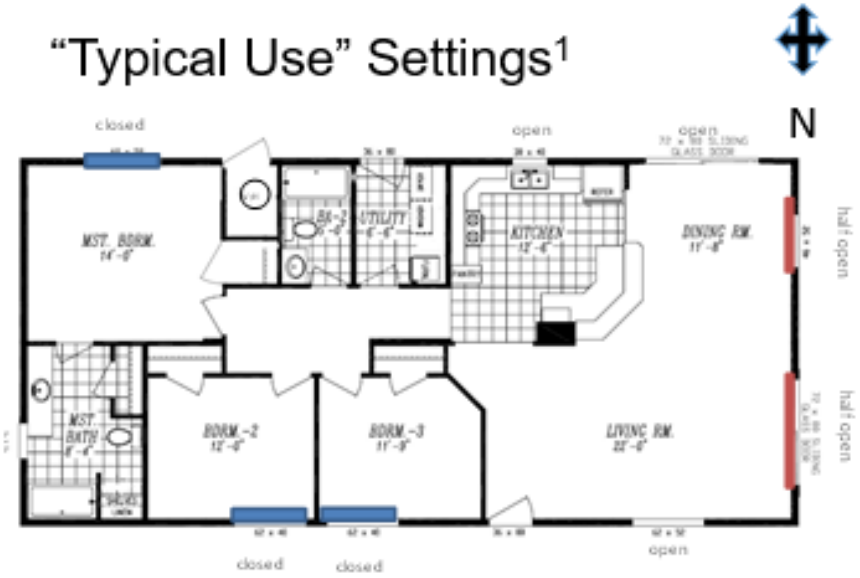
Technologies	Description	Picture
Cellular Shades (Hunter Douglas)	Hunter Douglas Duette® Architella®Elan honeycomb fabric shades. Designed as a double-cell (cell within a cell) structure made with 3 insulating air pockets. Inner cell is transparent and allows light to pass through. One of Hunter Douglas's highest selling products.	
PowerView Motorization	Hunter Douglas's programmable wireless control system with battery-powered motor that operates (opens and shuts) shades on command or according to programmed schedule.	
VOLTTRON™ application platform	VOLTTRON is an lab-developed open source application platform (e.g., like Android or iOS) for distributed sensing and control applications.	

Thermal Performance of Double-Cell Cellular Shades compared to the most Common Window Coverings

Experiment	Season	HVAC Savings % (+/- 95% confidence)	Average W-hr/day Savings
All Shades Down: Cellular Shades versus Vinyl Venetian Blinds	Cooling	13.3 (±1.3)	2,650
	Heating	9.3 (±1.9)	7,011
Typical Use: Cellular Shades versus Vinyl Venetian Blinds	Cooling	5.8 (±0.5)	1,487
	Heating	2.0 (±1.3)	1,505

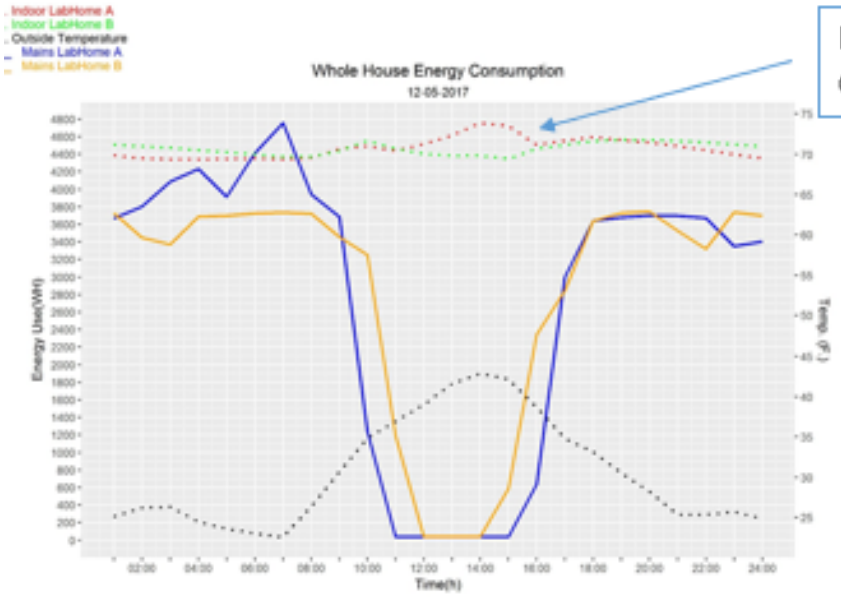
Semi-opaque double-cell shade pulled down (left) allows filtered natural light into north-side bedroom. Close-up view of same shade (right).

"Typical Use" Settings[1]



[1]D&R International. 2013. *Residential Windows and Window Coverings: A Detailed View of the Installed Base and User Behavior* http://energy.gov/sites/prod/files/2013/11/f5/residential_windows_coverings.pdf.

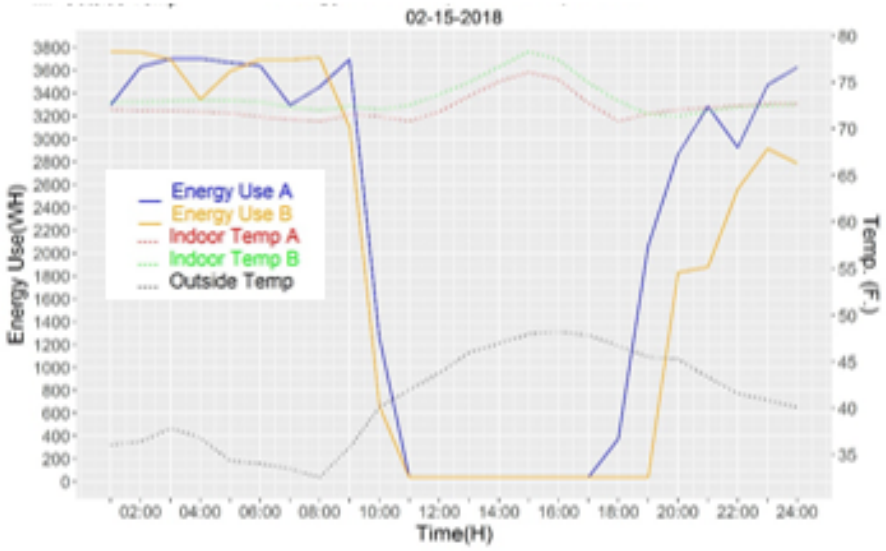
Heating Season: Shades drawn down (always) versus "optimal" operation



Beneficial heat gains not fully realized when shades are drawn down during the day (Sunny day, avg. temp 31° F)

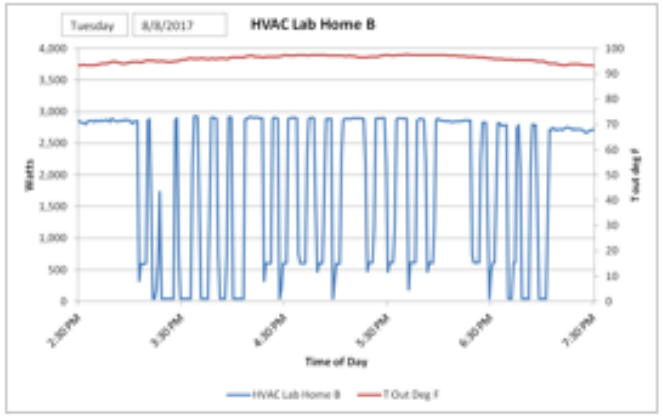
- **Closed Shades Scenario**: Cellular shades covering all windows in Lab Home B (experimental home) and no shades on Lab Home A (control home) windows
- **Results:** Modest average savings (2%) when shades down all the time. Average of 5% savings recorded on very cloudy days, but negative savings on some sunny days.

- **Optimal Operation Scenario:** Cellular shades up during some portion of the day and closed at night (3 operating scenarios tested).
- **Results:** Achieved consistent HVAC savings between 5% to 9% compared to the home with blinds operated with typical settings.

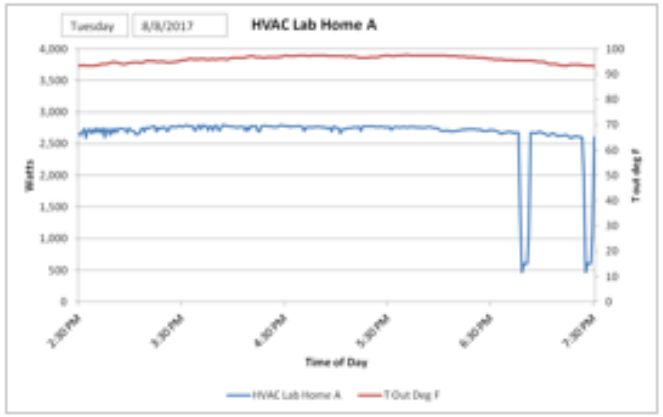


Demand Response (DR) – Combining Thermostat Adjustments with Shading

HVAC Cycling during Peak Period:
DR Participant vs Non-Participant



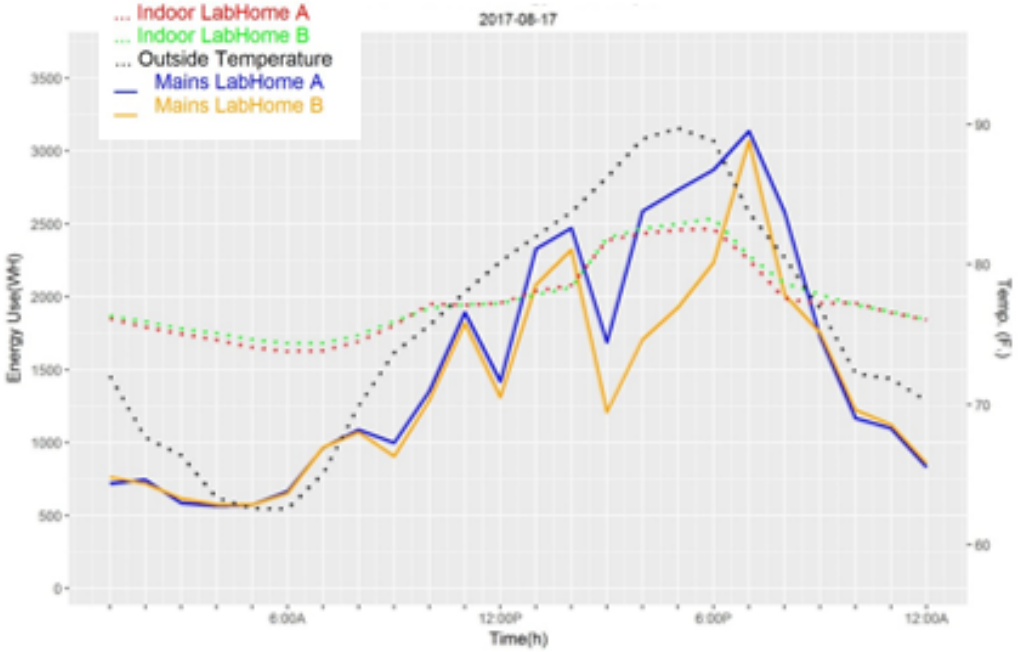
Lab Home B: DR participant (with cellular shades drawn down during peak event)



Lab Home A: Typical blinds, typical use and no participation in DR during peak event

Whole House Energy Use Comparison

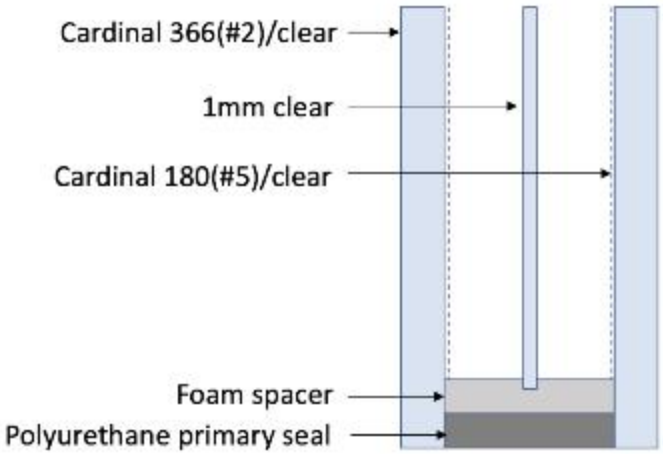
Both homes participating in DR (i.e., thermostat setback during peak period), but only Lab Home B pulls down cellular shades in living room during peak event. HVAC savings = 3,936 W-hrs with cellular shades on this day.

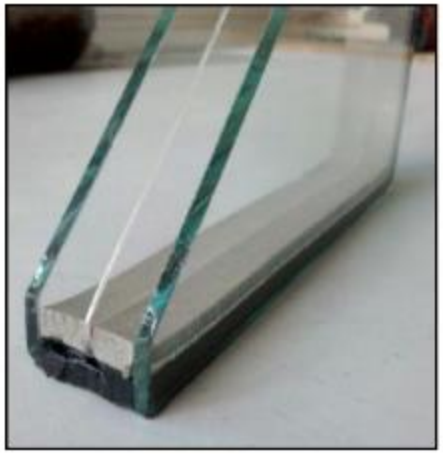


Upcoming 2019-2020 Window Experiments in PNNL Lab Homes

Exterior Shades (Summer 2019)

- Cooling season benefits
- Solar-powered automation





Drop-In “Thin Lightweight Triple-Pane Windows” (2019-2020)

- Thin float glass as center pane
- 2 low-e coatings
- Krypton gas fill

Key Points

- PNNL has been evaluating novel window attachments for potential energy savings in several test homes.
- Low-E storm windows delivered average annual energy savings of 10.1% (exterior windows) and 7.8% (interior windows).
- Similarly, high-efficiency cellular window shades delivered substantial heating and cooling savings.

Lena Burkett
National Renewable Energy Laboratory

U.S. DEPARTMENT OF ENERGY

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL's Buildings Research

Lena Burkett
National Renewable Energy Laboratory
February 14, 2019

Impact

NREL's core R&D strengths advance building science integration and engineering, significantly **impacting building efficiency, resiliency, the grid, and the nation.**

Increasing Building Innovation Pace and Scale

Create Economic Ops

Developing software to identify efficiency and integration at multiple scales

Support Innovation

Validating and helping commercialize U.S. technologies

Strengthen Energy Security

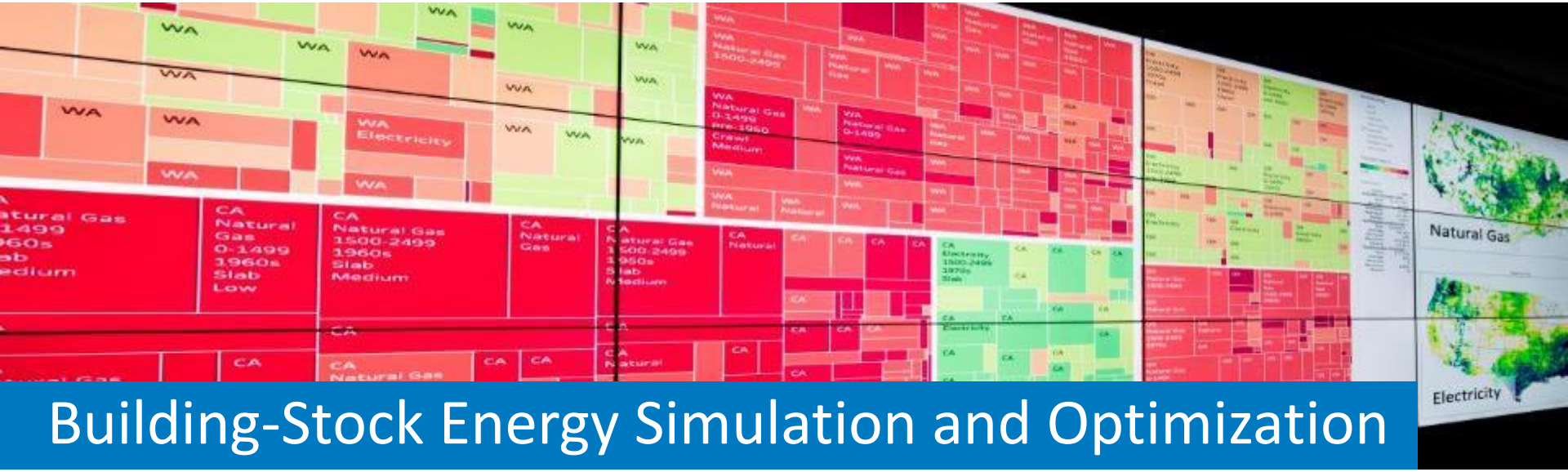
Ensuring grid reliability and stability through advanced sensors and controls

Develop Emerging Technologies

Developing advanced building data and tools and low-TRL technologies

Energy Efficient Residential Buildings

Finding the best opportunities for states and communities

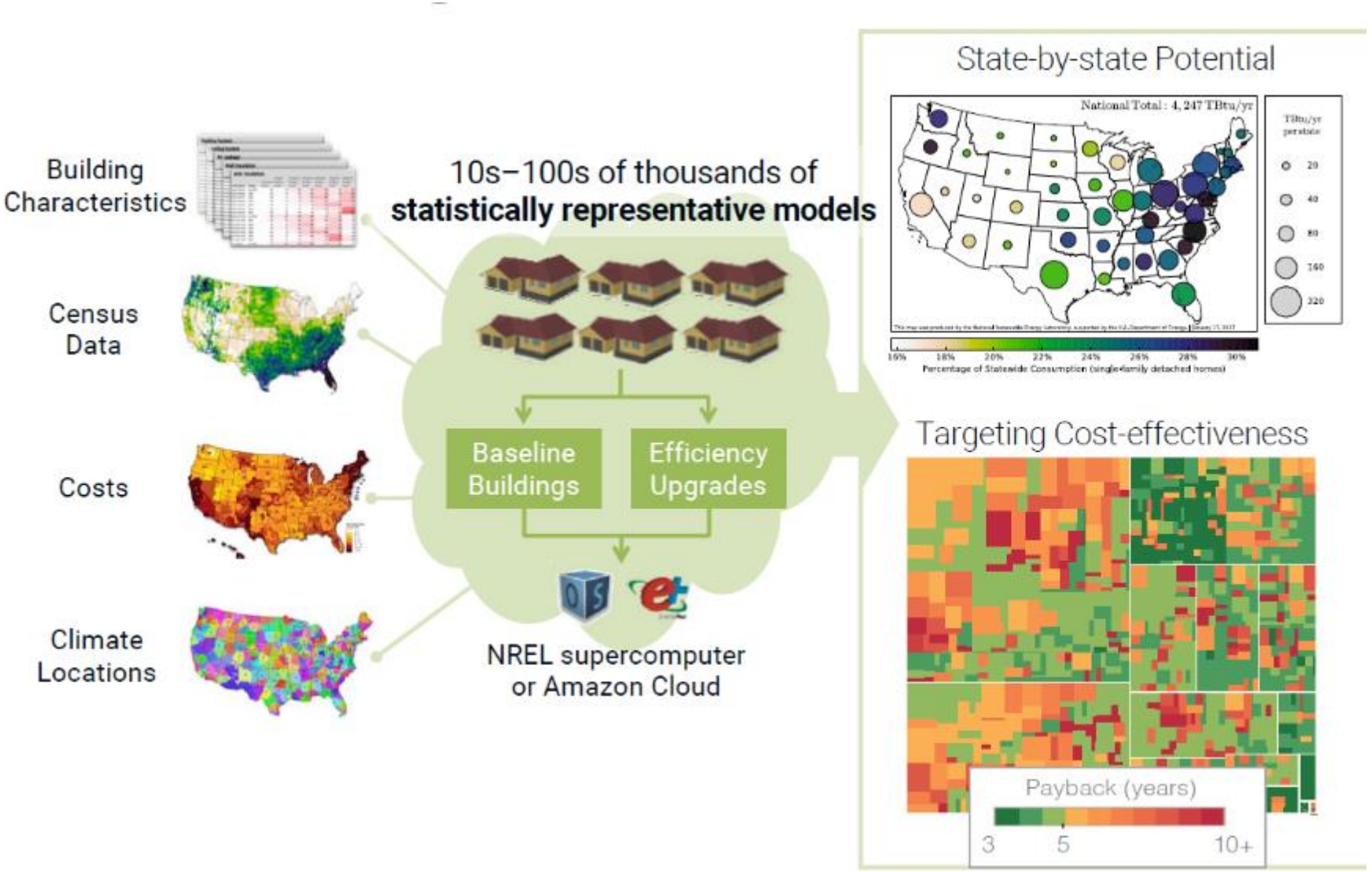


Building-Stock Energy Simulation and Optimization

ResStock is helping states, municipalities, utilities, and manufacturers identify which home improvements save the most energy and money

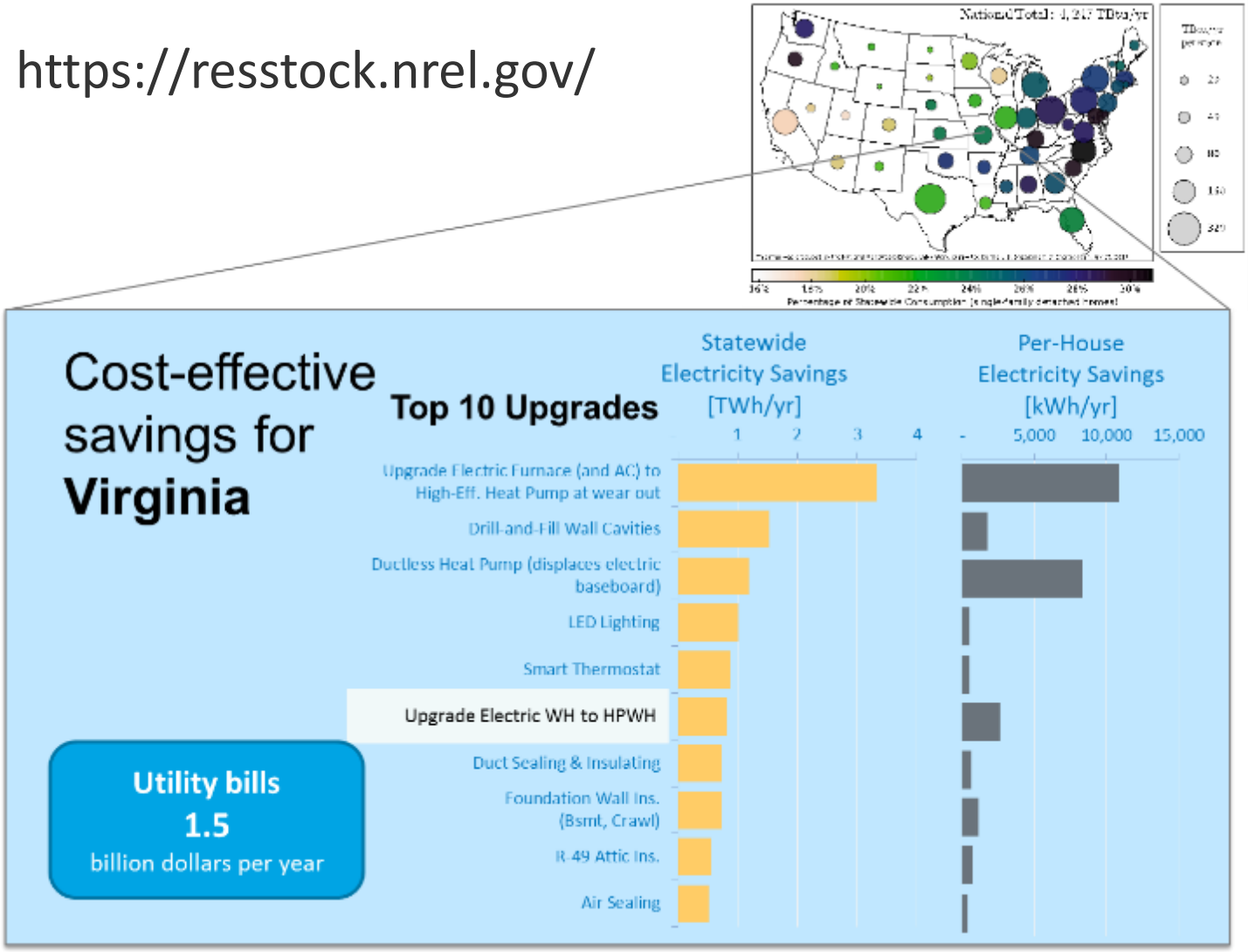
Res Stock

ResStock: Conceptual Overview

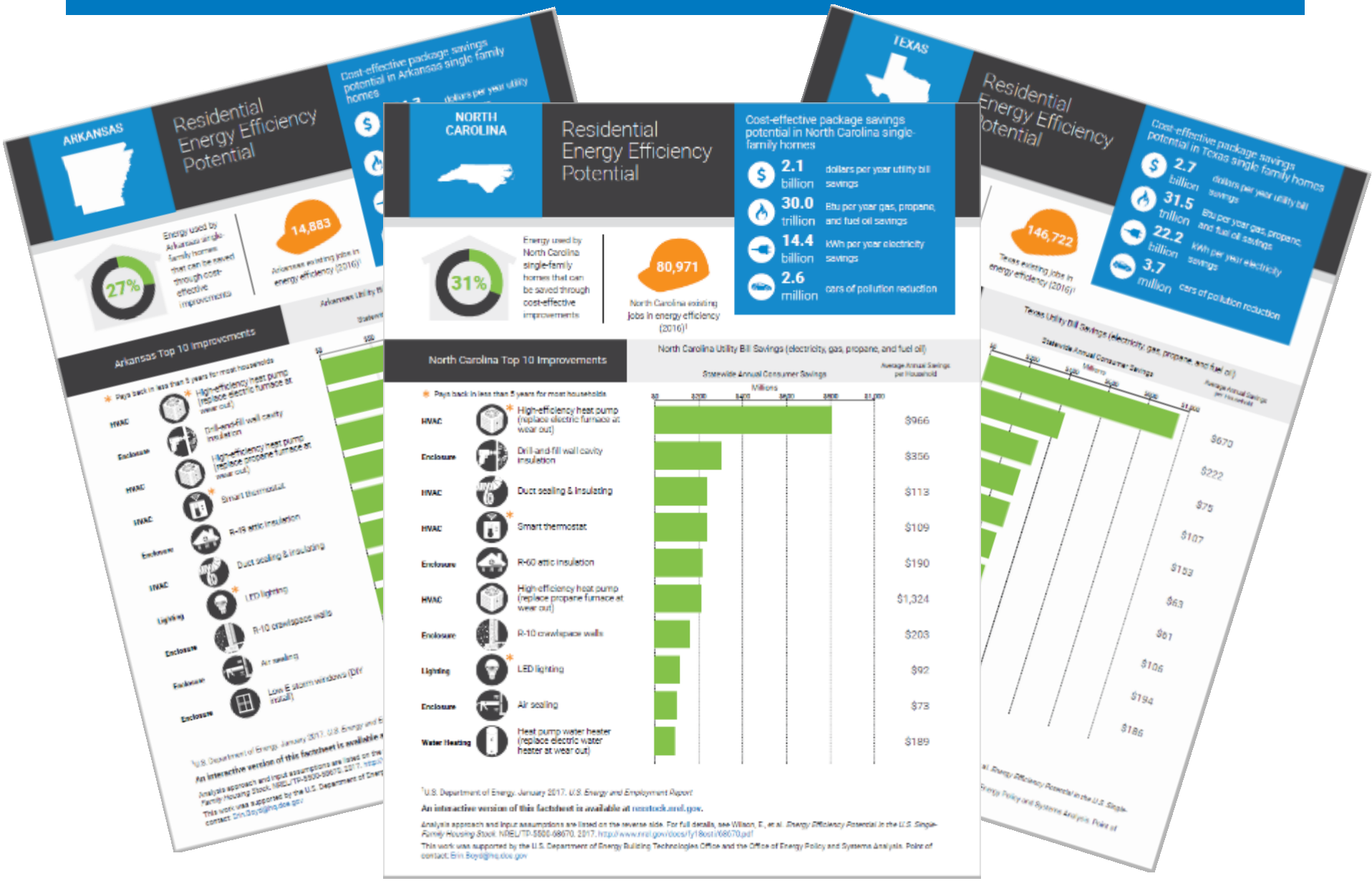


Actionable results for states, cities, counties

https://resstock.nrel.gov/



State Fact Sheets: resstock.nrel.gov/factsheets/



County-Specific Results

Savings values are normalized as a percentage of the consumption or expenditures in that income bin and county

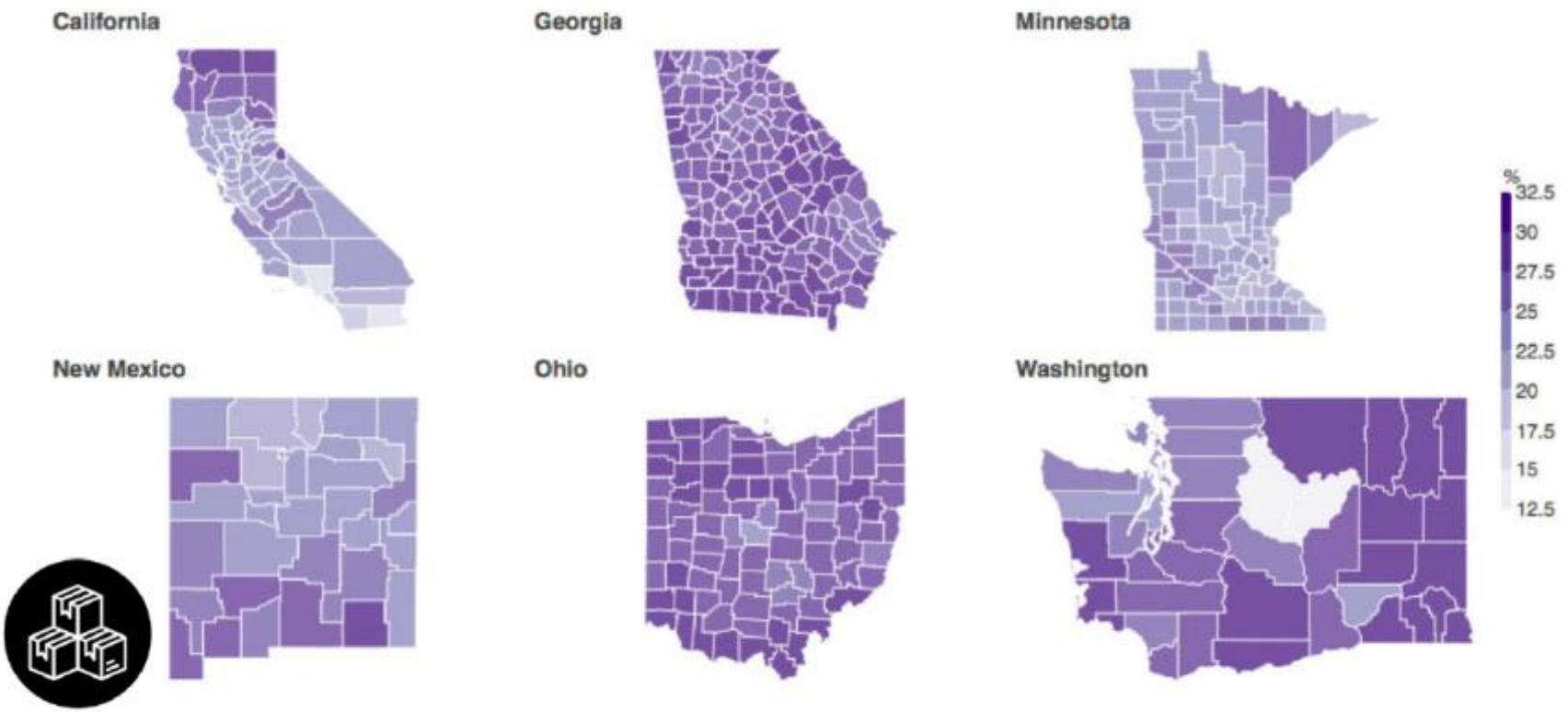
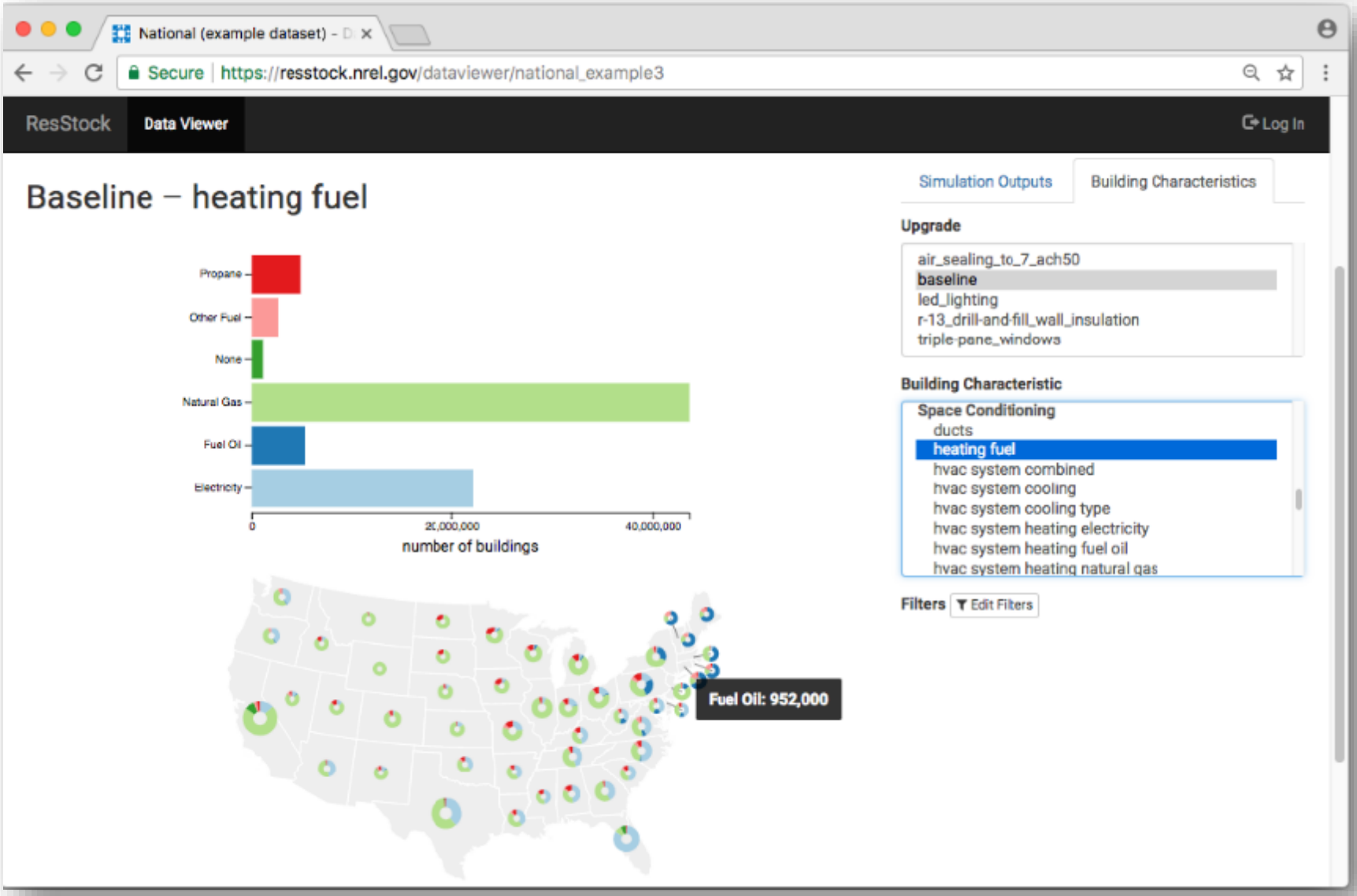


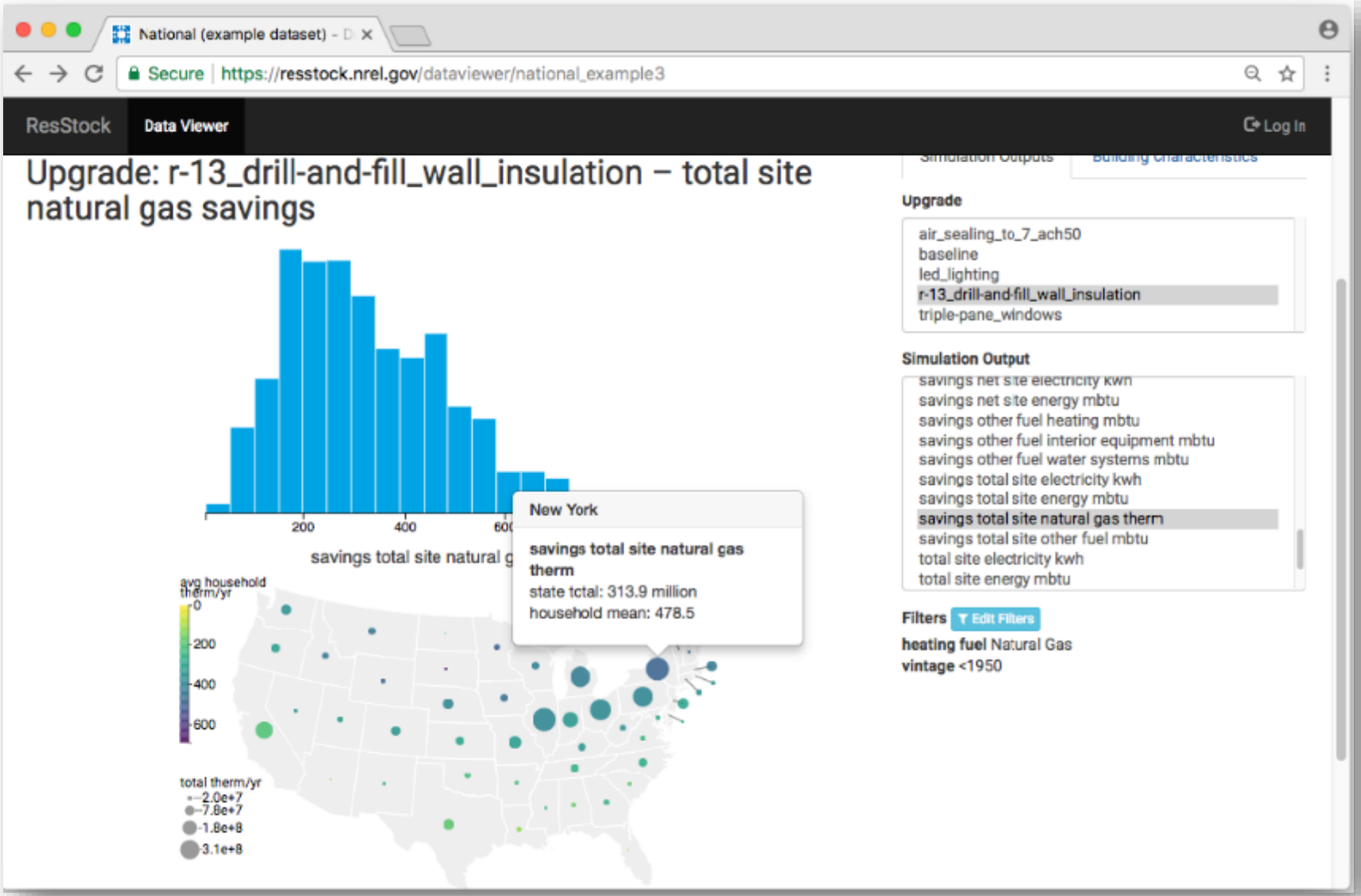
Figure 1: Percentage primary (source) energy savings resulting from packages tailored to maximize NPV in each simulated home, by county in six U.S. states

packages by Chameleon Design from the Noun Project

Interactive Web Visualizations



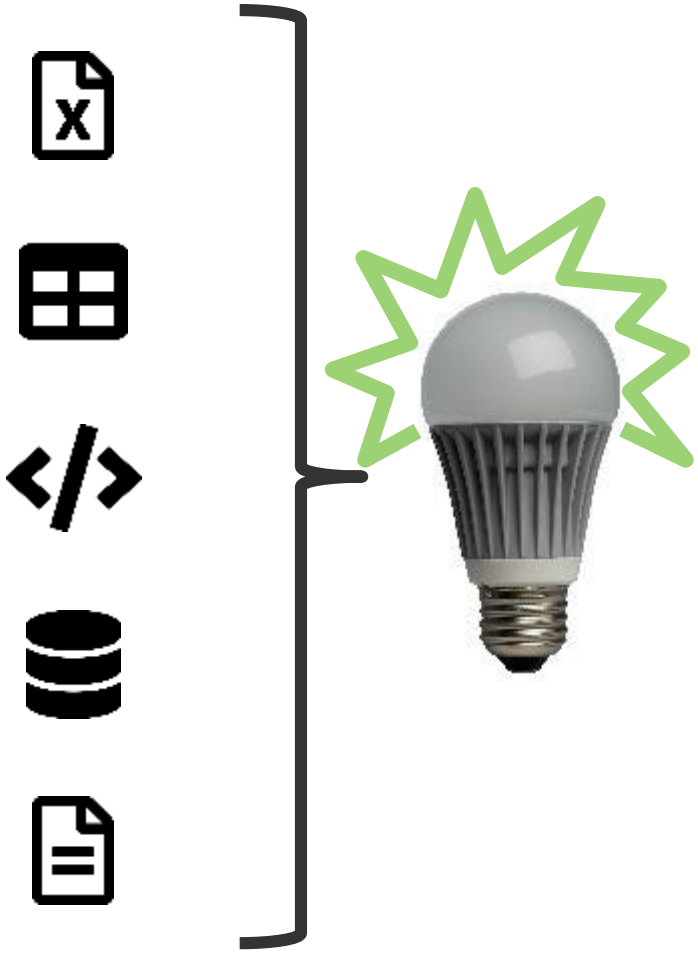
Interactive Web Visualizations



hpxml

data dictionary + transfer standard

Home Performance Coalition



Where are we now?

The HPXML landscape today

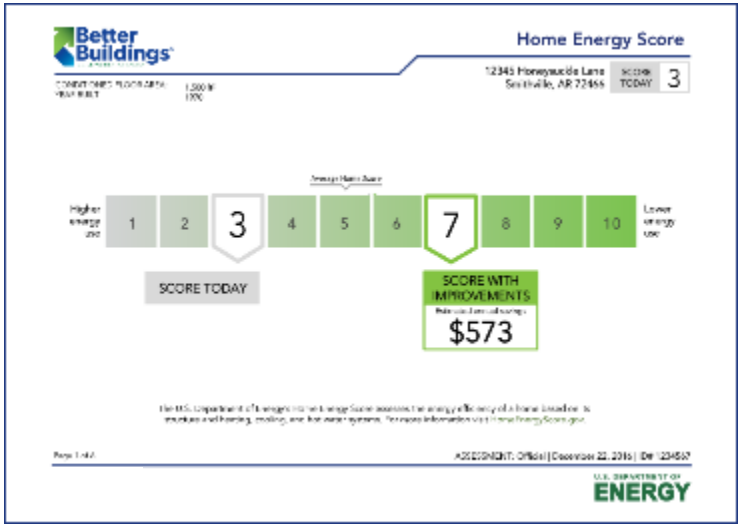
Software using HPXML

Auditor
BEopt
CakeSystems
ECOS*
Energy Orbit
EnergySavvy
ENERGYSTAR Home Advisor
GreenPro
Home Energy Score
NEAT*
OpenEE Meter
OptiMiser
Pivotal Energy*
REM*
SEED
TREAT
SnuggPro

*planned or in progress

HPXML in Home Energy Score

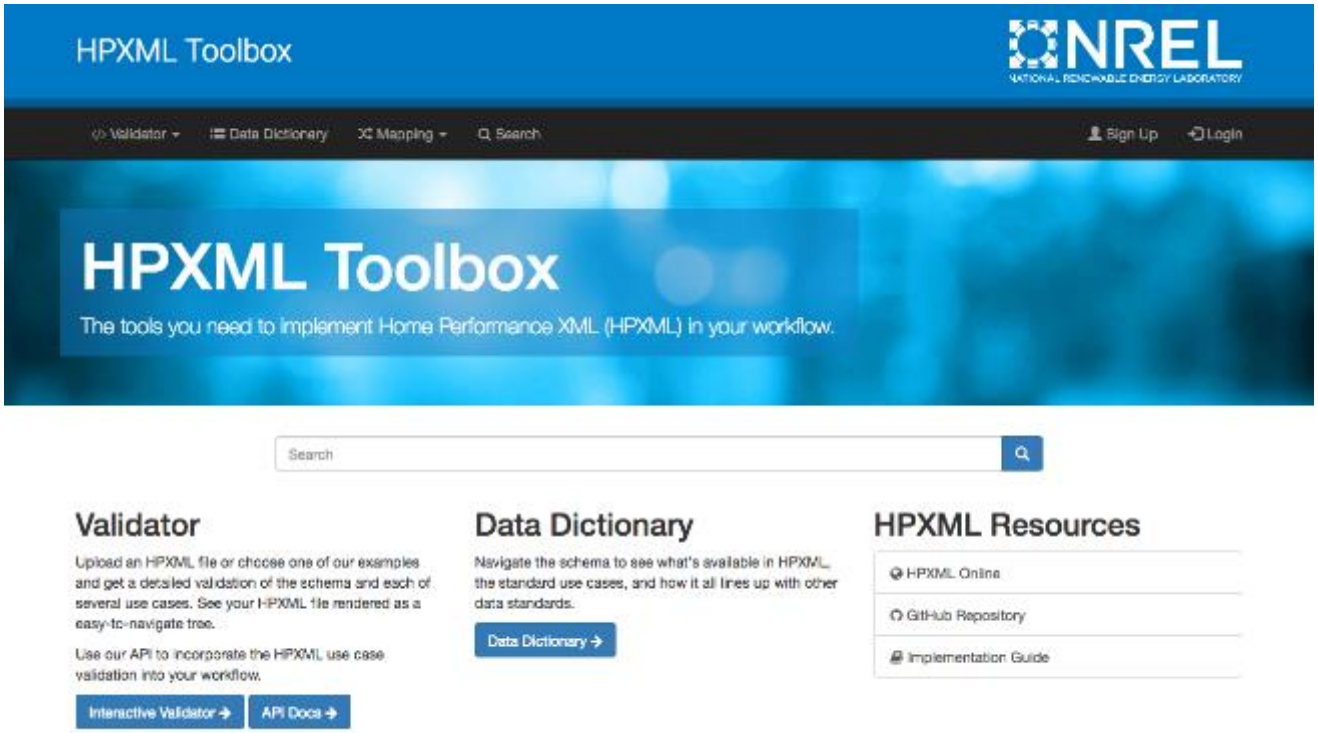
- A translator automatically simplifies complex, HPXML-formatted home data into inputs to generate a Home Energy Score
- Built into the Home Energy Score API
- Minimizes need to customize assessment software



HPXML in Standard Energy Efficiency Database Platform (SEED)

HPXML **import and export** functionality to support use of the SEED platform for residential **building data aggregation** and auto-population of **efficiency data in real estate listings**.

How to start using HPXML



http://hpxml.nrel.gov

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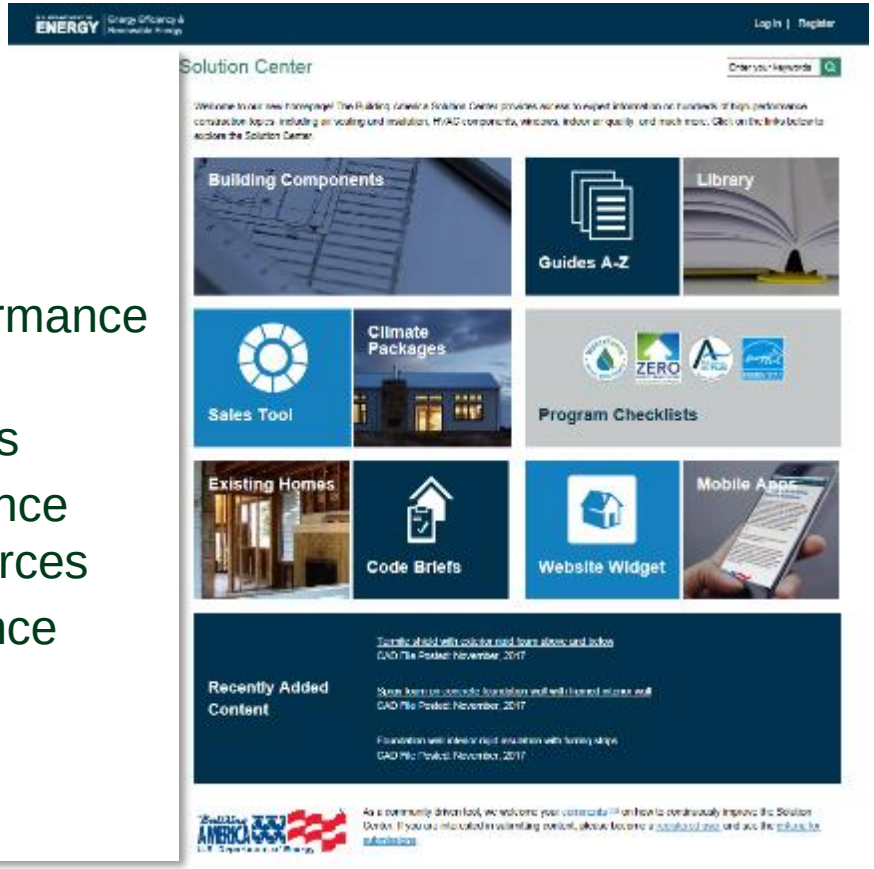
BASC Overview

- Continuously Improved vs. Fixed Content
- Fast, Free and Reliable Best Practices
- Focus on ‘Guides’ for Applying Best Practices
- Browsing Capability for Galleries of Content
- User Feedback
- Customizable Content

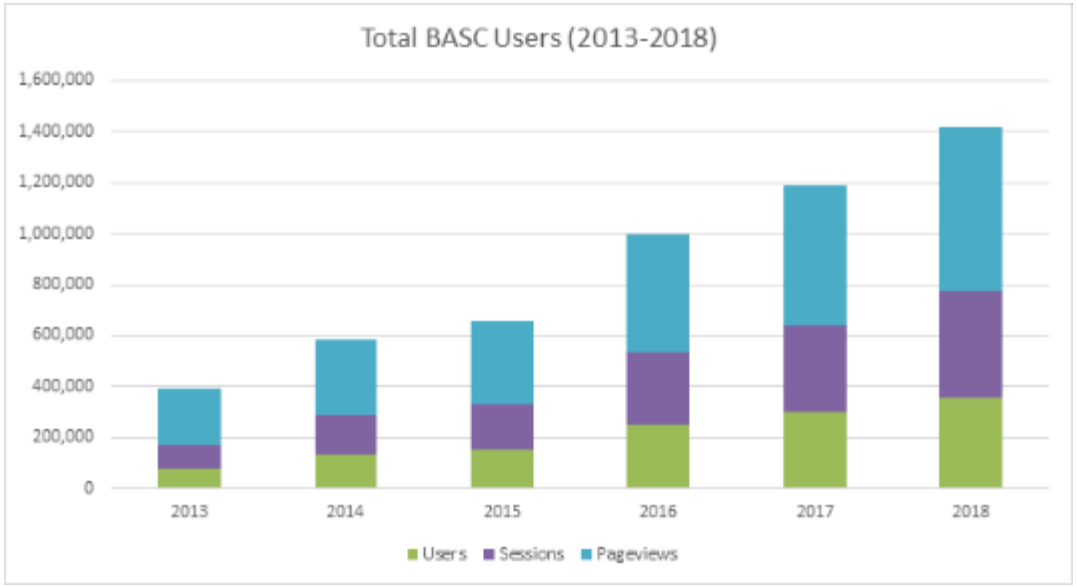
BASC Simple Interface

Access to:

- 254 Guides
- 2,100+ Images
- 330+ Proven performance case studies
- 130+ CAD drawings
- 990+ Building Science references & resources
- 30+ Code compliance briefs
- 110+ Videos
- 40+ Sales briefs



Impact



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C.R. Herro
V-P of Environmental Affairs, Meritage Homes

"We built our business on the shoulders of giants, including the Building America Solution Center."

Gene Myers
CEO, Thrive Home Builders
(Professional Builder Magazine Builder of the Year)

Thank you

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Key Points

- NREL has supported the development of several tools for the evaluation and improvement of building efficiency performance.
- ResStock, a simulation and optimization tool, is helping various entities identify which home improvements save the most energy and money.
- The HPXML data dictionary and transfer standard allows for the collection, analysis and transmission of home performance data in a uniform format.

Explore the Residential Program Solution Center

Resources to help improve your program and reach energy efficiency targets:

- Handbooks - explain *why* and *how* to implement specific stages of a program.
- Quick Answers - provide answers and resources for common questions.
- Proven Practices posts - include lessons learned, examples, and helpful tips from successful programs.
- Technology Solutions NEW! - present resources on advanced technologies, **HVAC** & **Heat Pump Water Heaters**, including installation guidance, marketing strategies, & potential savings.

https://rpsc.energy.gov

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