

A solid blue horizontal bar with a decorative geometric pattern on the right side, consisting of overlapping blue shapes.

## **Better Buildings Residential Network Peer Exchange Call Series:**

*We Love Our National Labs: Research Results Part 1*  
February 14, 2019

# 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 28<sup>th</sup>: We Love Our National Labs: Research Results (Part 2)
- March 14<sup>th</sup>: Efficiency and Resilience Improvements with PACE Financing
- March 28<sup>th</sup>: 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](mailto:bbresidentialnetwork@ee.doe.gov), or go to [energy.gov/eere/bbrn](http://energy.gov/eere/bbrn) & click Join*



**André Desjarlais**  
**Oak Ridge National Laboratory**

# 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



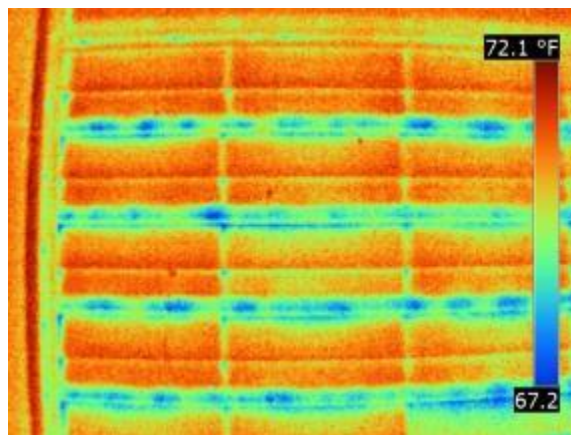
Sources: [http://www.jmofnb.com/\\_media/image/wall.JPG](http://www.jmofnb.com/_media/image/wall.JPG);  
<http://www.greenbuildingadvisor.com/blogs/dept/guest-blogs/window-installation-tips-deep-energy-retrofit>;

# 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.

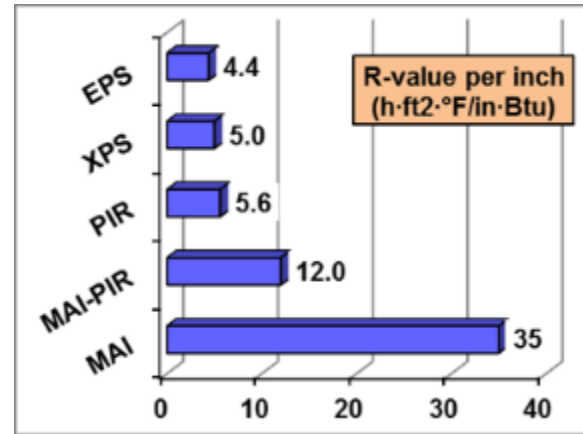
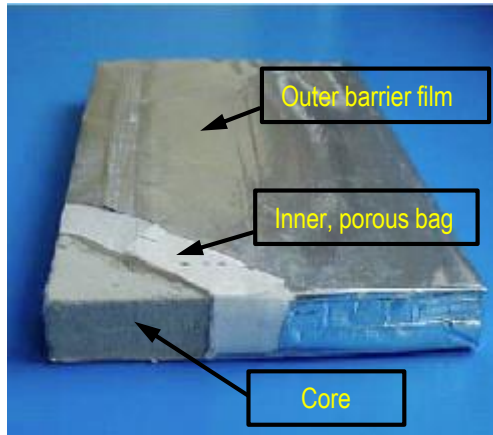


Siding profile (left) and mating MAI panel (top)



IR image comparing insulated sections with joints

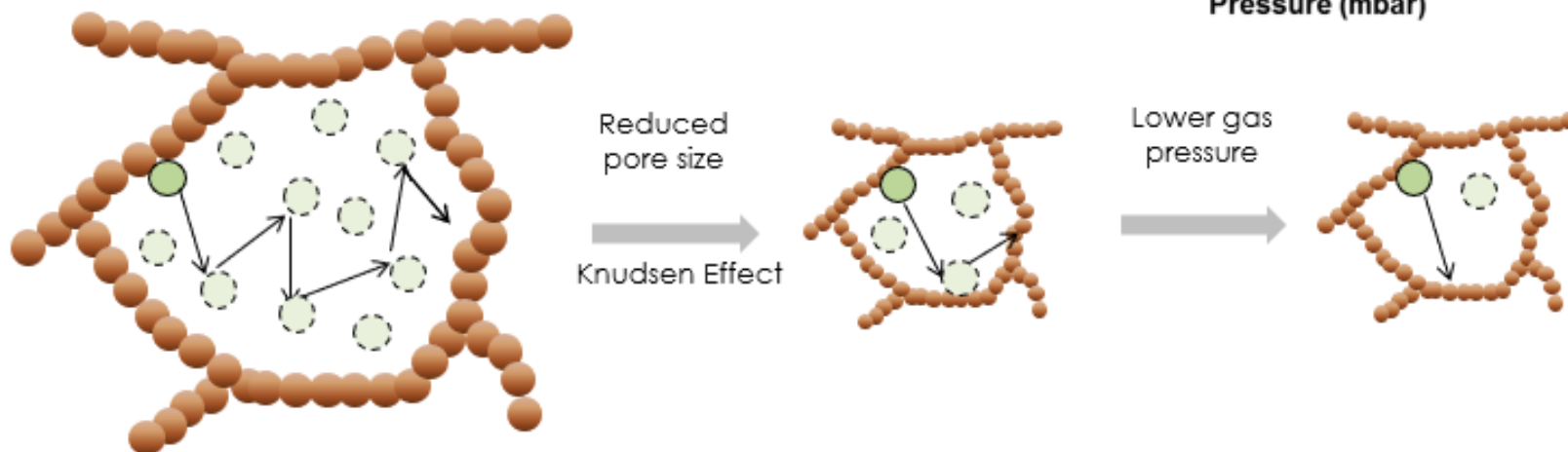
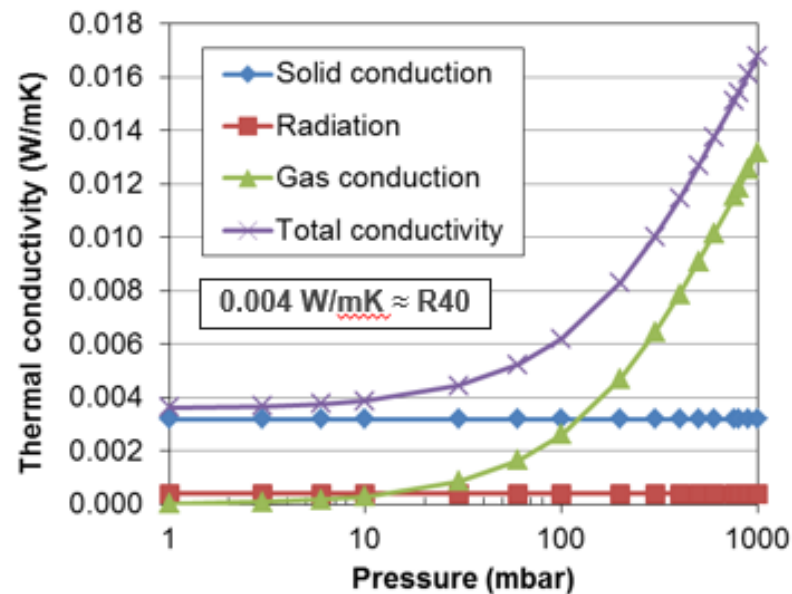
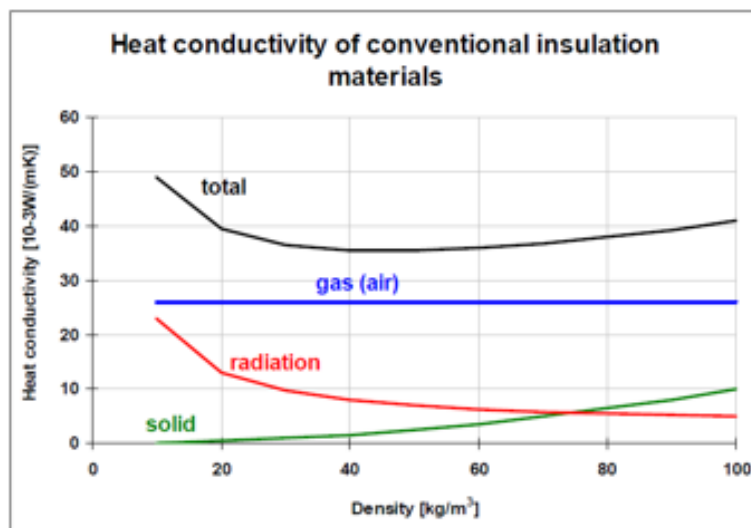
# Technology being developed based on Vacuum Insulation Panels (VIPs)



- Modified Atmosphere Insulation (MAI) is a lower cost variant of VIPs.
- VIPs provide a significantly higher R-value than current insulation 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 ( $\sim 5$  mbar).

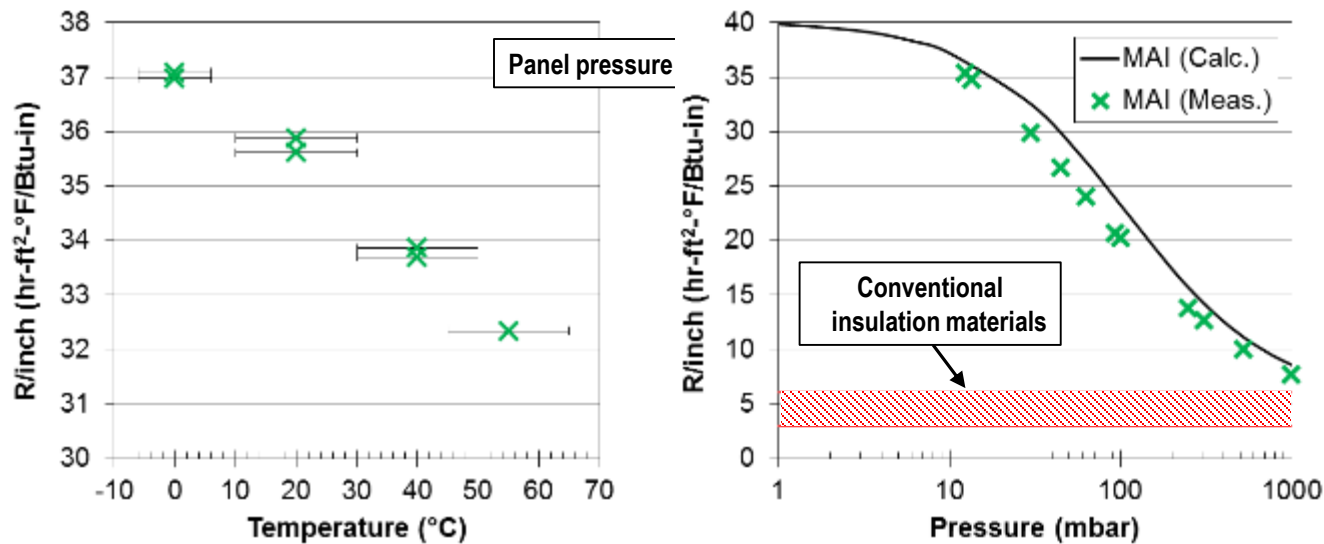


# Heat transfer in insulation materials





# Thermal performance tests



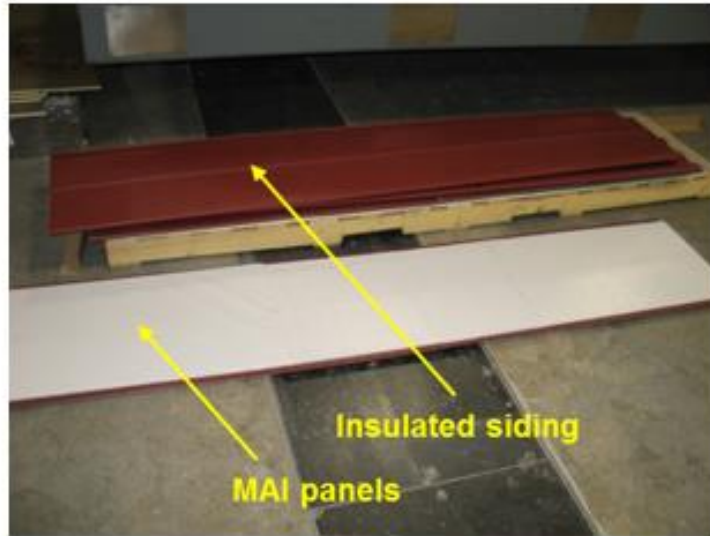
- Even with complete loss of vacuum, MAI panels expected to have higher R/inch than conventional insulation materials.

# 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.

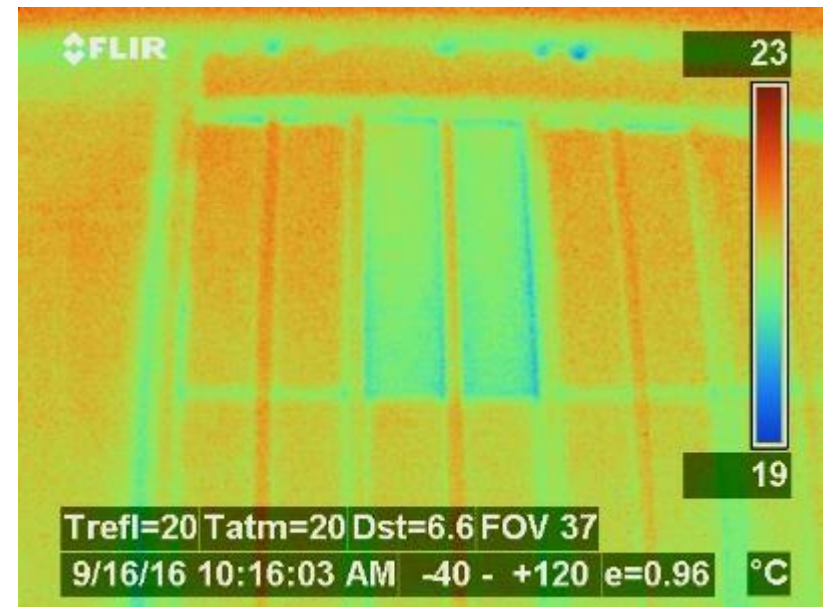


# Hot box test wall preparation

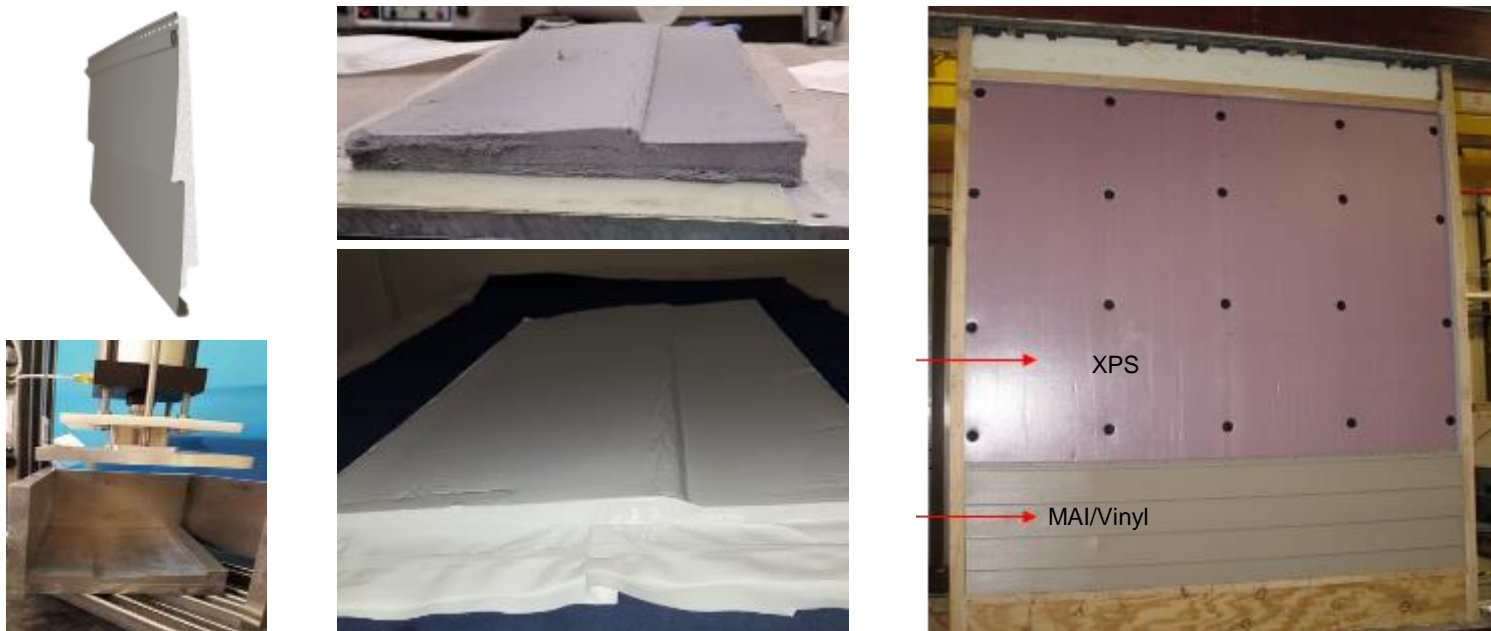


# Thermal performance

- 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.



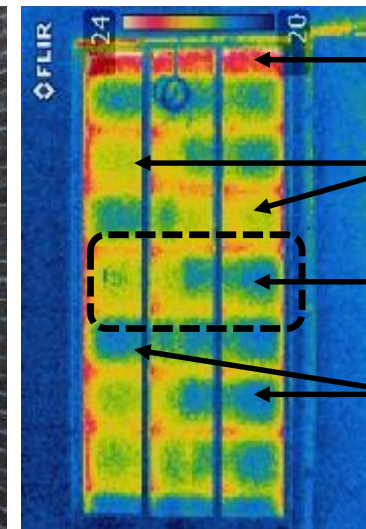
# NET facility field exposure experiments

- “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

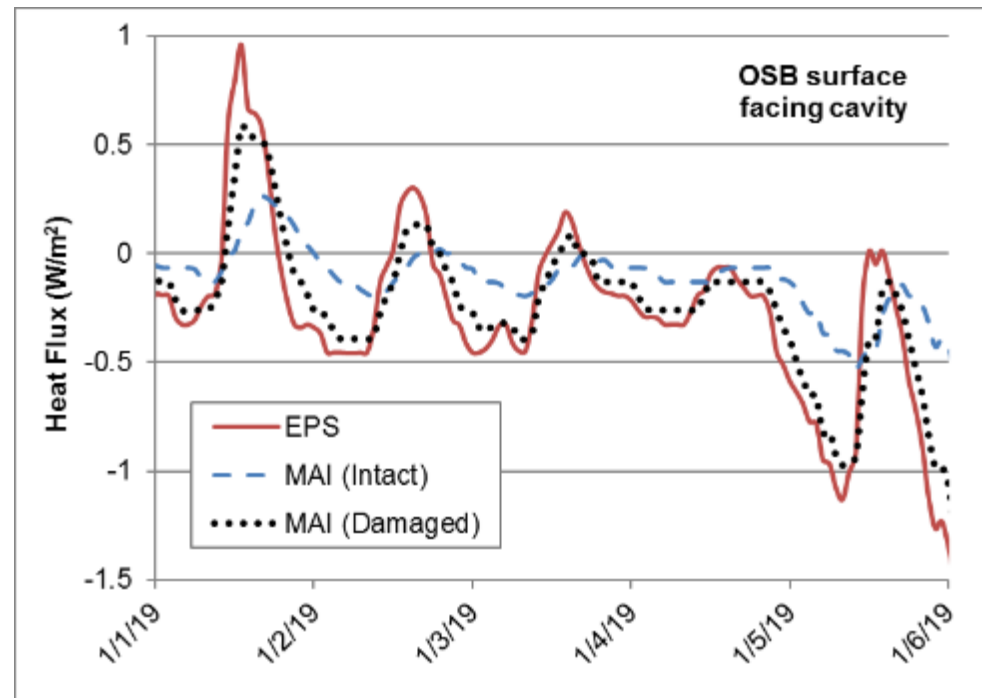
- 2x4 stud wall with R13 fiberglass insulation with interior and exterior sheathing.
- XPS insulation over exterior sheathing.
- MAI-siding/EPS-siding on the exterior.





# 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?



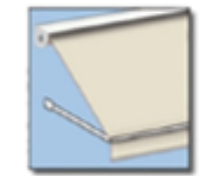
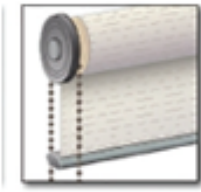
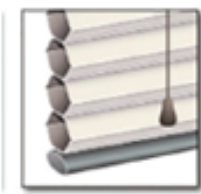
**Katie Cort**  
**Pacific Northwest National Laboratory**

# PNNL Lab Homes: Window Attachments and High-R Windows

Katie Cort, Senior Economist



# What are Window Attachments?



	Insulation	Airtightness	Solar Heat Control	Winter Comfort	Summer Comfort	Condensation Resistance	Ventilation	Low Product Cost	Low Installation Cost	Durability/Service Life
<b>Exterior Attachments</b>										
Storm Windows (including low-e)	●	●	◐	●	◐	◐	●	◐	○	●
Awnings	○	○	●	○	●	○	●	○	◐	◐
Roller Shades	○	○	●	○	●	○	◐	◐	◐	○
Roller Shutters	◐	○	●	○	●	○	○	◐	◐	●
<b>Interior Attachments</b>										
Conventional Roller Shades	○	○	◐	◐	◐	○	○	●	●	○
Conventional Drapes	○	○	◐	◐	◐	○	○	●	●	○
Louvered Blinds	○	○	◐	○	◐	○	◐	●	●	○
Window Panels (including low-e)	●	●	◐	●	◐	◐	◐	◐	●	○
Insulated Cellular Shades	●	◐	◐	●	◐	◐	○	○	◐	◐
Window Quilts	●	◐	◐	●	◐	◐	◐	○	◐	○
Surface-Applied Films	◐	○	◐	◐	◐	○	○	◐	◐	○
<b>Other</b>										
Solar Screens	○	○	●	○	◐	○	◐	◐	●	◐

<sup>1</sup>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<sup>2</sup>
- 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<sup>2</sup> (13%) window area with double-pane clear glass aluminum-framed windows



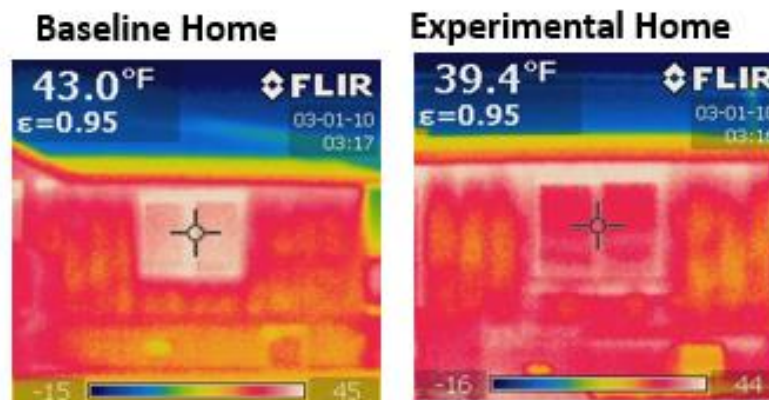


# Lab Homes – Low-E Storm Windows Impact on Energy Savings

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



## Infrared Images – Interior Storm Windows





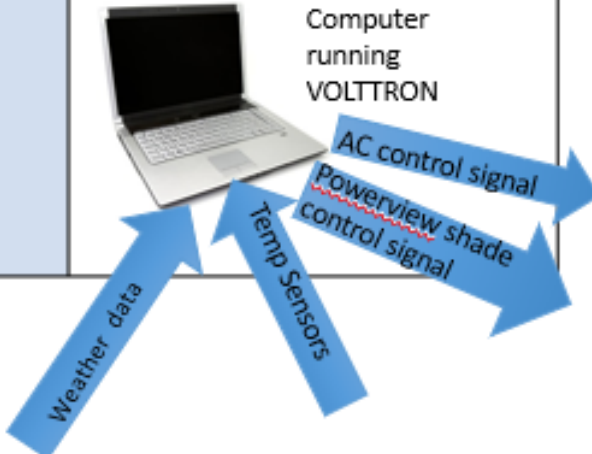


# Lab Homes – Triple Cell Cellular Shades Impact on Energy Savings (2015-2016 Testing)



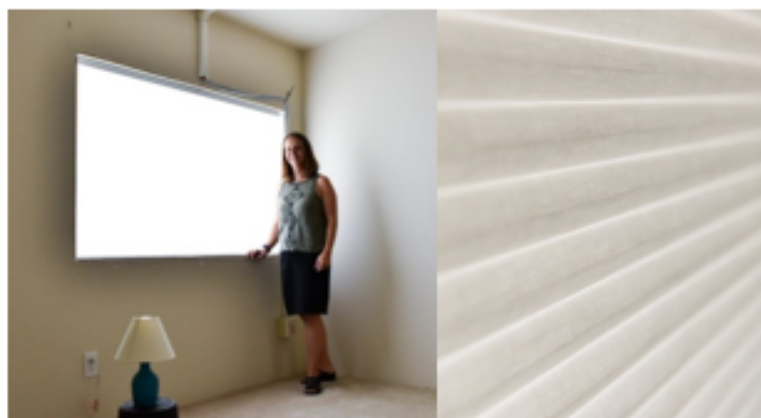
Technology (experiment)	Baseline and Experiment Description	Energy Savings (%)
<b>High Efficiency Cellular Shades:</b> Static Operation – always down (Hunter Douglas)	Blinds remain closed for the duration of experiment. Compared to standard vinyl blinds remaining closed for full experiment.	Cooling: <b>13.3 ±2.8%</b> Heating: <b>10.5 ±3.0%</b>
<b>High Efficiency Cellular Shades:</b> 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: <b>10.4 ±6.5%</b> Heating: <b>16.6 ±5.3%</b>
<b>High Efficiency Cellular Shades:</b> 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: <b>14.8 ±2.1%</b> Heating: <b>14.4 ±2.0%</b>

# 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.	
VOLTRON™ application platform	VOLTRON is an lab-developed open source application platform (e.g., like Android or iOS) for distributed sensing and control applications.	

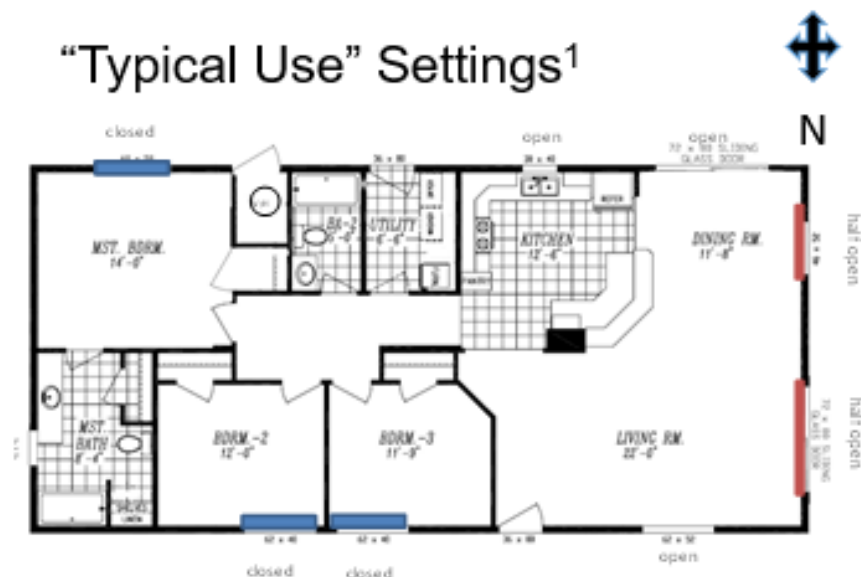
# Thermal Performance of Double-Cell Cellular Shades compared to the most Common Window Coverings

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

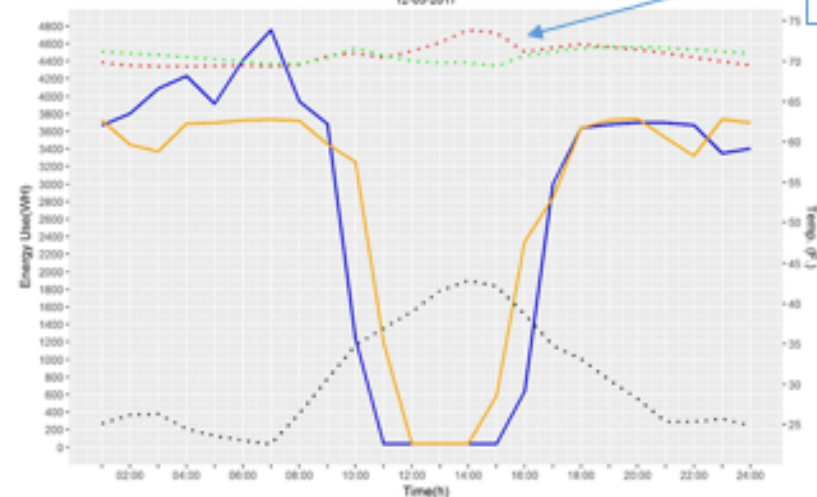


<sup>1</sup>D&R International. 2013. *Residential Windows and Window Coverings: A Detailed View of the Installed Base and User Behavior*  
[http://energy.gov/sites/prod/files/2013/11/f5/residential\\_windows\\_coverings.pdf](http://energy.gov/sites/prod/files/2013/11/f5/residential_windows_coverings.pdf).

# Heating Season: Shades drawn down (always) versus “optimal” operation

Indoor LabHome A  
Indoor LabHome B  
Outside Temperature  
Mains LabHome A  
Mains LabHome B

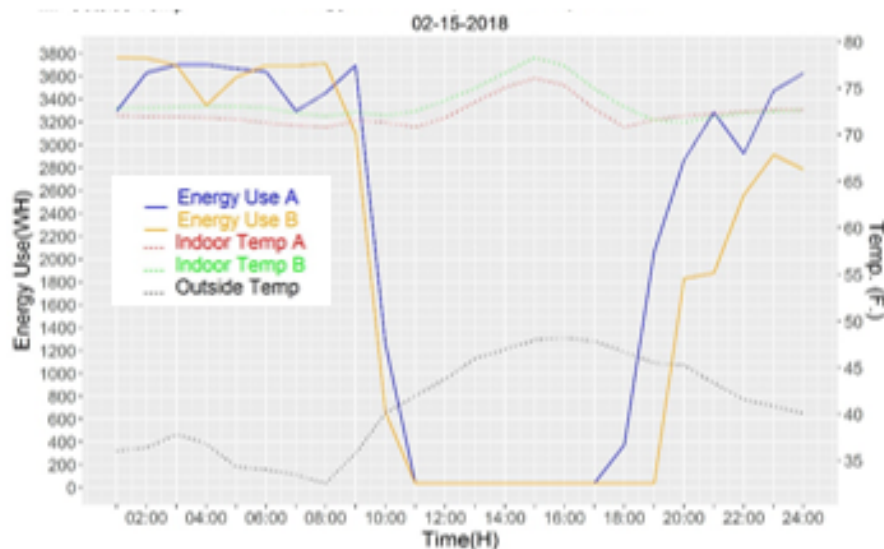
Whole House Energy Consumption  
12-05-2017



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

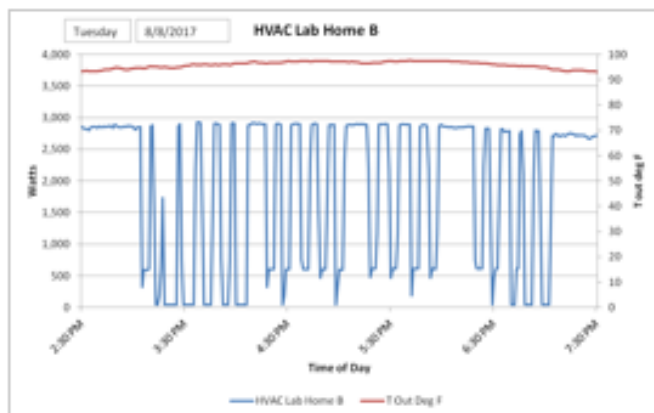
- **Optimal Operation Scenario:** Cellular shades up during some portion of the day and closed at night (3 operating scenarios tested).
- **Results:** Achieved consistent HVAC savings between 5% to 9% compared to the home with blinds operated with typical settings.

- **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.

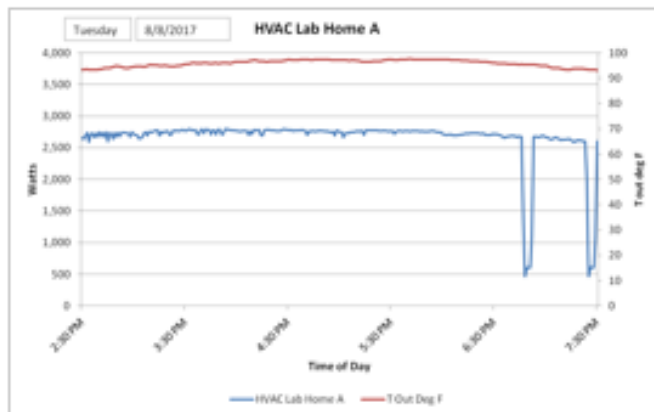


# Demand Response (DR) – Combining Thermostat Adjustments with Shading

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



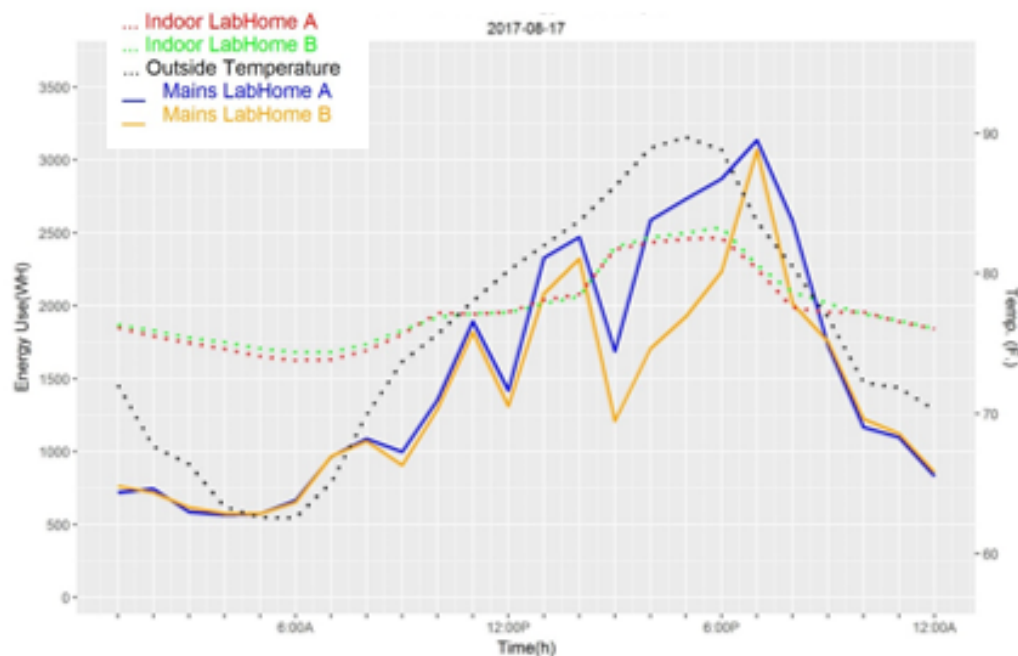
Lab Home B: DR participant (with cellular shades drawn down during peak event)



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.



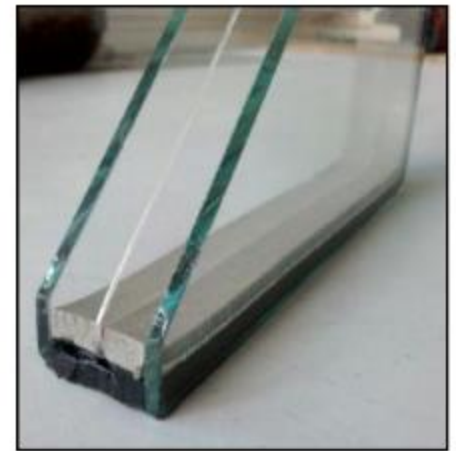
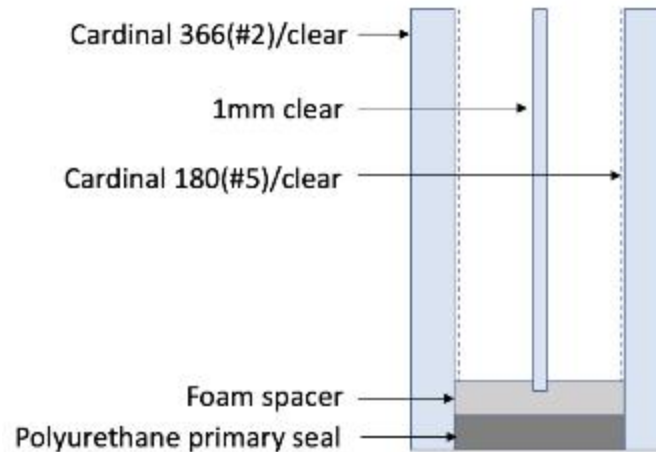


# Upcoming 2019-2020 Window Experiments in PNNL Lab Homes



## 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



**Lena Burkett**  
**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

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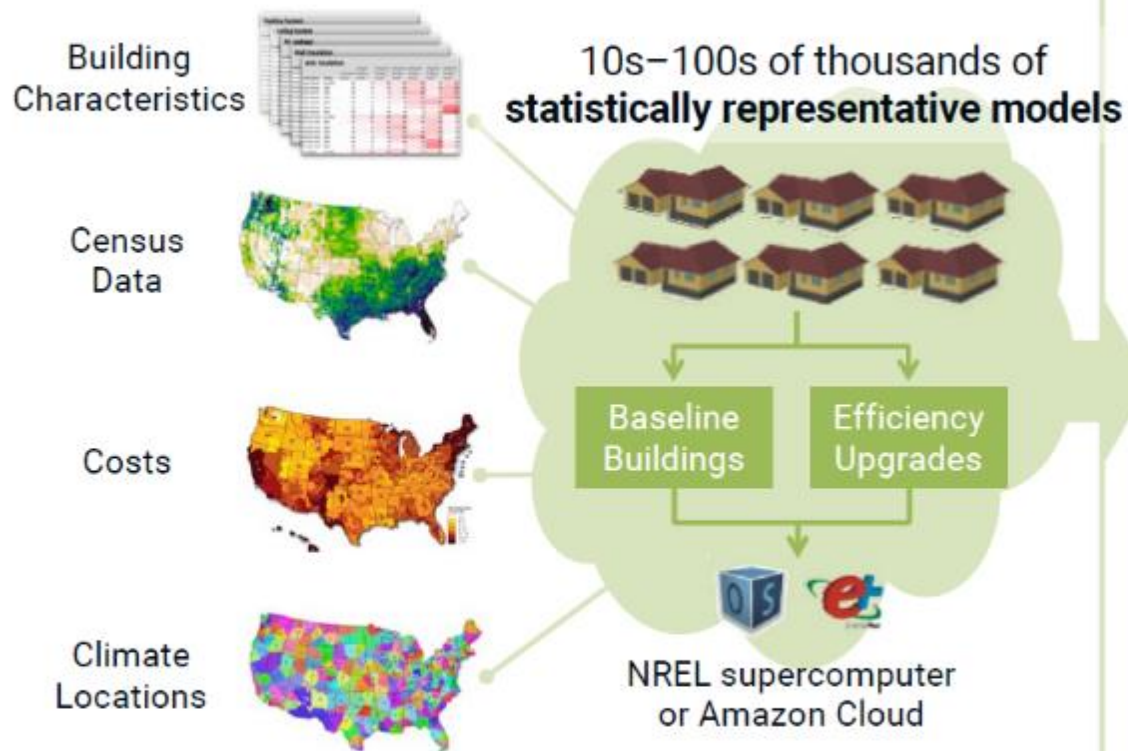
Finding the best  
opportunities for states  
and communities



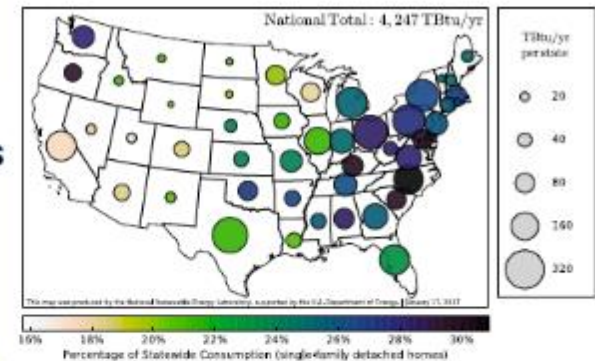
**Res**  
Stock



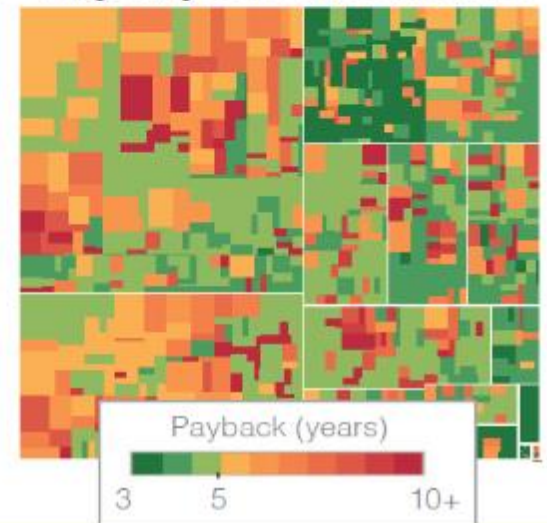
# ResStock: Conceptual Overview



## State-by-state Potential



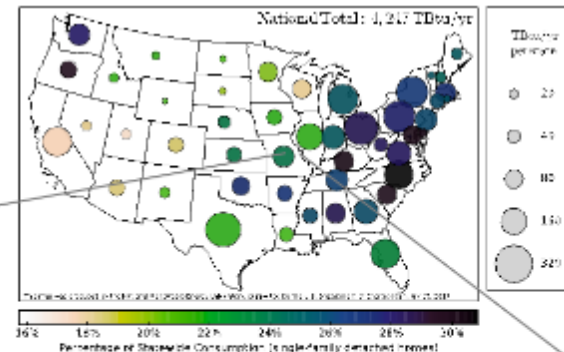
## Targeting Cost-effectiveness





# Actionable results for states, cities, counties

<https://resstock.nrel.gov/>



## Cost-effective savings for Virginia

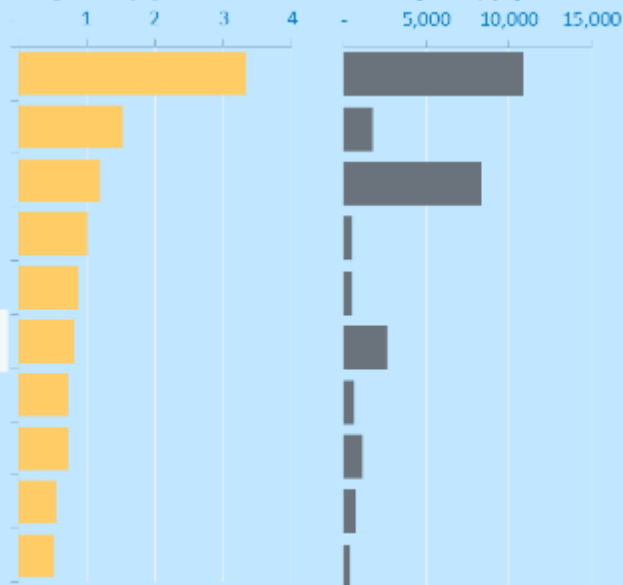
### Top 10 Upgrades

Statewide Electricity Savings [TWh/yr]

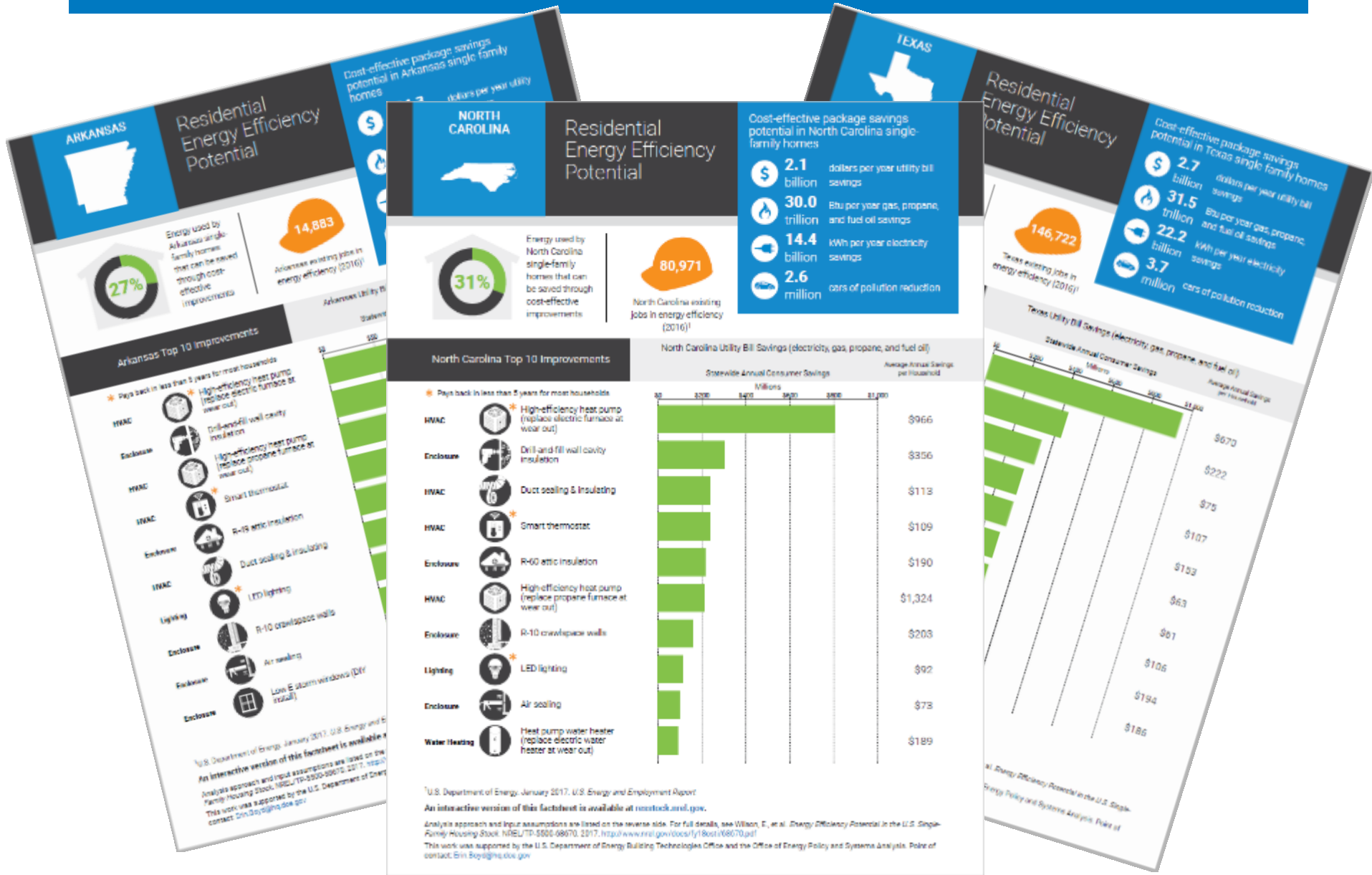
Per-House Electricity Savings [kWh/yr]

- Upgrade Electric Furnace (and AC) to High-Eff. Heat Pump at wear out
- Drill-and-Fill Wall Cavities
- Ductless Heat Pump (displaces electric baseboard)
- LED Lighting
- Smart Thermostat
- Upgrade Electric WH to HPWH
- Duct Sealing & Insulating
- Foundation Wall Ins. (Bsmt, Crawl)
- R-49 Attic Ins.
- Air Sealing

Utility bills  
**1.5**  
billion dollars per year



# 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

California



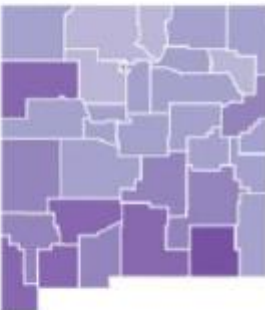
Georgia



Minnesota



New Mexico



Ohio

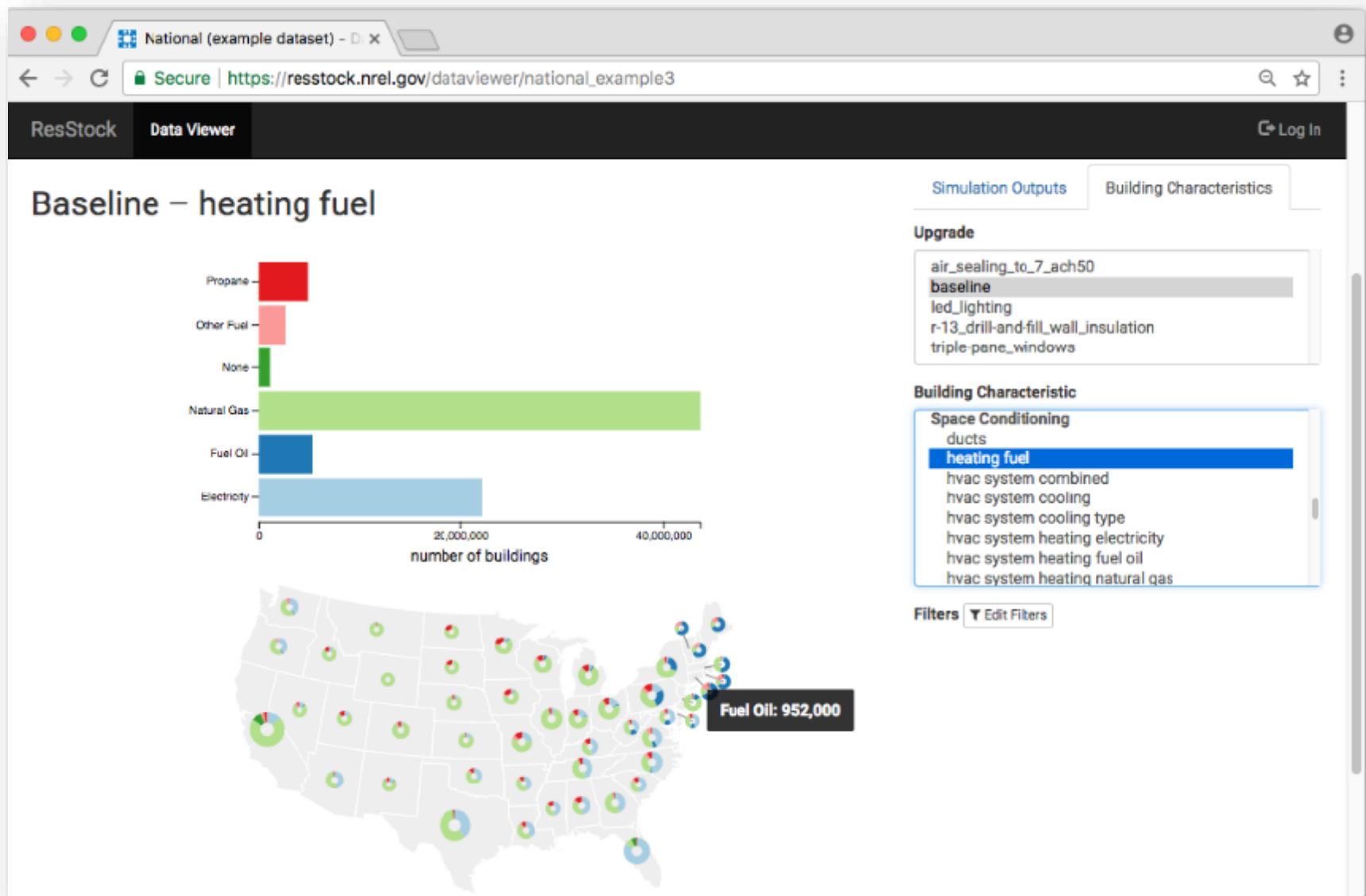


Washington

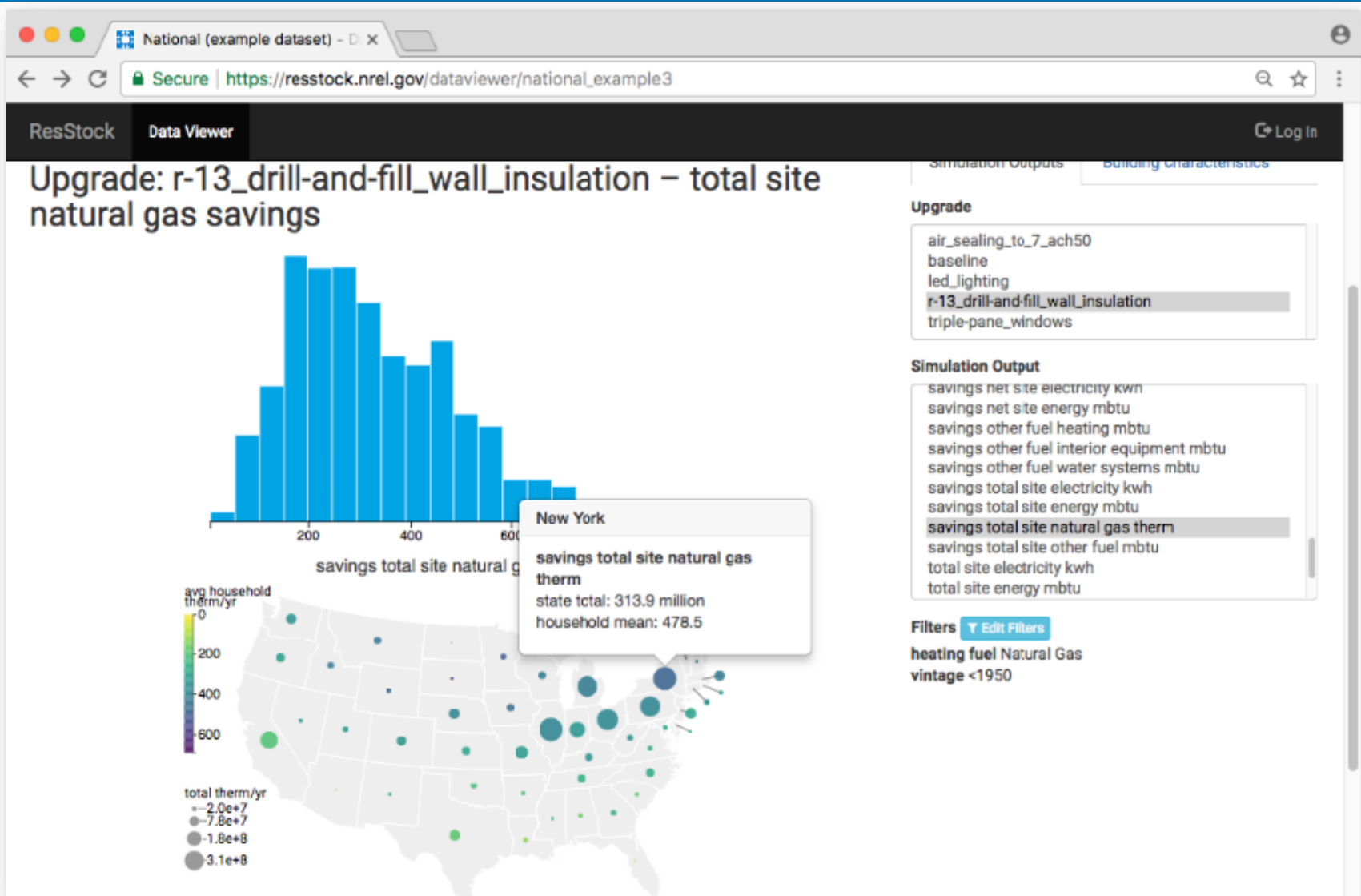


**Figure 1:** Percentage primary (source) energy savings resulting from packages tailored to maximize NPV in each simulated home, by county in six U.S. states

# Interactive Web Visualizations



# Interactive Web Visualizations



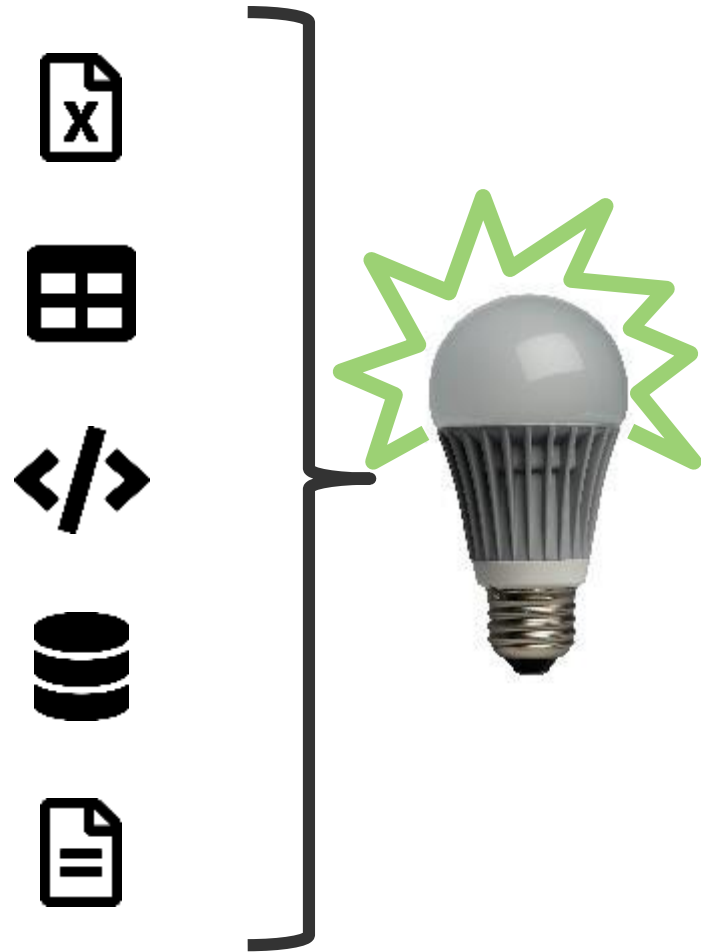
# hpxml

data dictionary + transfer standard



Home  
Performance  
Coalition





Icons by Font Awesome, (CC 4.0)

# Where are we now?

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The HPXML landscape today

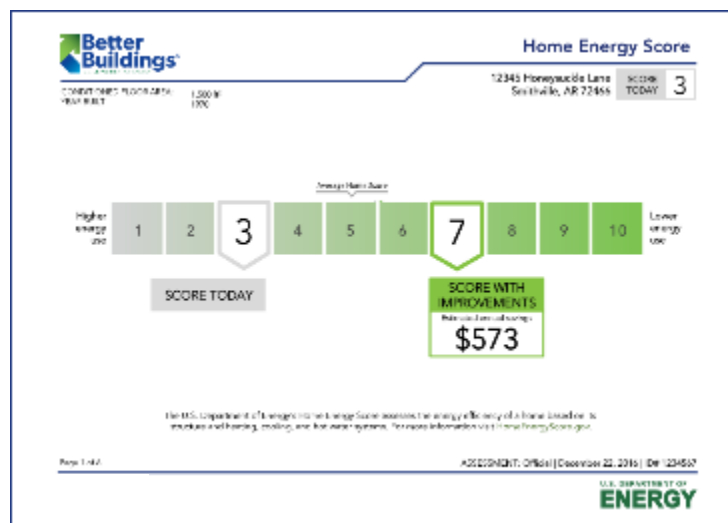
# Software using HPXML

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

The screenshot shows the HPXML Toolbox website. At the top, there's a blue header with 'HPXML Toolbox' on the left and the NREL logo on the right. Below the header is a dark navigation bar with links for 'Validator', 'Data Dictionary', 'Mapping', and 'Search', along with 'Sign Up' and 'Login' buttons. The main content area has a large blue banner with the text 'HPXML Toolbox' and 'The tools you need to implement Home Performance XML (HPXML) in your workflow.' Below this is a search bar. The page is divided into three columns: 'Validator' (with a description and buttons for 'Interactive Validator' and 'API Docs'), 'Data Dictionary' (with a description and a 'Data Dictionary' button), and 'HPXML Resources' (with links to 'HPXML Online', 'GitHub Repository', and 'Implementation Guide').

HPXML Toolbox

NREL  
NATIONAL RENEWABLE ENERGY LABORATORY

Validator Data Dictionary Mapping Search Sign Up Login

## HPXML Toolbox

The tools you need to implement Home Performance XML (HPXML) in your workflow.

Search

### Validator

Upload an HPXML file or choose one of our examples and get a detailed validation of the schema and each of several use cases. See your HPXML file rendered as a easy-to-navigate tree.

Use our API to incorporate the HPXML use case validation into your workflow.

[Interactive Validator →](#) [API Docs →](#)

### Data Dictionary

Navigate the schema to see what's available in HPXML, the standard use cases, and how it all lines up with other data standards.

[Data Dictionary →](#)

### HPXML Resources

- [HPXML Online](#)
- [GitHub Repository](#)
- [Implementation Guide](#)

<http://hpxml.nrel.gov>





# World-Class Expert Guidance...

Building America Solution Center  
[BASC.energy.gov](http://BASC.energy.gov)



## ...At Your Fingertips

## 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

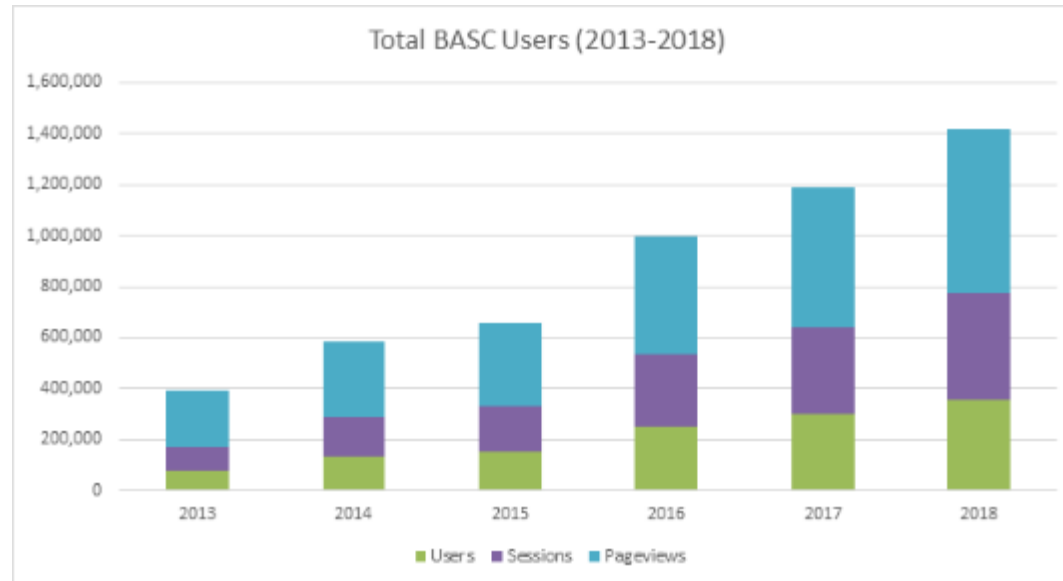
## Access to:

- 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



The screenshot shows the BASC Simple Interface website. At the top is a dark blue header with the "Department of ENERGY" logo on the left and "Log In | Register" on the right. Below the header is a "Solution Center" section with a search bar. The main content area features a grid of tiles: "Building Components", "Guides A-Z", "Library", "Sales Tool", "Climate Packages", "Program Checklists", "Existing Homes", "Code Briefs", "Website Widget", and "Mobile App". Below this grid is a "Recently Added Content" section with three items, each with a title and a "GAD File Posted: November, 2017" date. At the bottom is a "Partners" section with logos for "The American Energy" and "U.S. Department of Energy".

# Impact



*“The Building America Solution Center is full of best practices. Every guide in there is based on the right way to do things.”*

**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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**[www.nrel.gov](http://www.nrel.gov)**

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

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- [Proven Practices](#) posts - include lessons learned, examples, and helpful tips from successful programs.
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