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The Building Science Advisor: A Web-Based Tool to Assess the Durability of Building Envelope Components

Michael Lubliner, Oak Ridge National Laboratory
Wednesday, March 27, 2024 - Lynwood WA
Washington State Residential Energy Code Workshop
Washington State Association of Building Officials (WABO)

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U.S. DEPARTMENT OF
ENERGY

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Moisture and buildings

Moisture is involved in almost all building envelope performance problems.

- Energy inefficiency
- Mold (IAQ)
- Corrosion
- Wood rot
- Termites
- Staining



BSA objective: Assist in reducing or mitigating the impact that moisture plays on the buildings industry.

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Problem

- Uncertainty regarding moisture risk of high-performing envelope systems hinders rapid adoption.
- New building envelope assemblies are less tolerant of design and installation flaws.
- Builders lack access to simplified credible guidance on durable, energy-efficient wall assemblies.

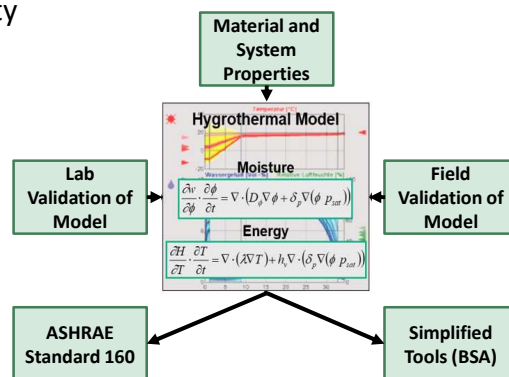


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ORNL RD&D approach

- Hygrothermal (heat and mass) material and system property characterization.
- Validating the accuracy of hygrothermal models.
- Field measurements show wall retrofits do not cause hygrothermal problems.
- Contribute to ASHRAE Standard 160.
- Simplified tools to assess hygrothermal performance (Building Science Advisor).



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Builder's perspective

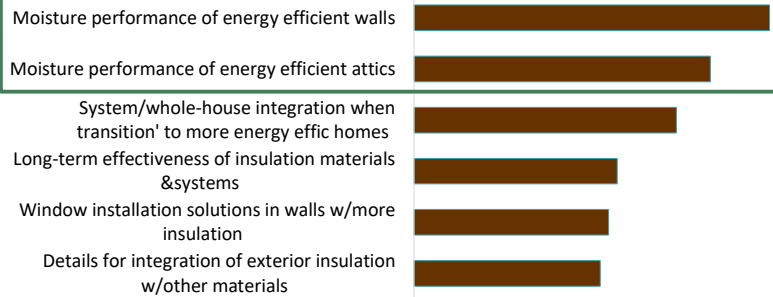


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Builder's reaction...

Home Innovation
RESEARCH LABS



*Total of 14 issues and challenges presented to respondents

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Manufacturer's perspective

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The Olympian

Business

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WED

MARKETS IN BRIEF

10,727.19
80.61
DOW
2965.42
21.67
NASDAQ
1,480.48
5.96
S&P 500

BUSINESS IN BRIEF

WALL STREET

Paper, aluminum
lead stocks higher
Old Economy stocks
came out on top Tuesday
as two stalwarts of tradi-
tional businesses — pa-
per and aluminum — led
the market higher, with a
little help from an upbeat
speech from Federal Re-

_____ makes offer in defective siding lawsuit

THE ASSOCIATED PRESS
FEDERAL WAY — The _____ Co. expects to pay as much as \$82 million to homeowners around the country to settle claims of defective exterior hardboard siding.
The settlement proposed Monday by the forest products giant is intended to resolve a class-action lawsuit filed in 1998 in Superior Court in San Francisco and similar litigation pending in Oregon, Iowa, South Carolina and Texas. The dismissal of a similar case in Washington state is on appeal.

_____ is taking an \$82 million charge after taxes in the second quarter to cover claims by homeowners who installed the siding between Jan. 1, 1981, and Dec. 31, 1999, said Bob Dowdy, vice president and general counsel. _____ stepping up to the plate to solve problems with one of its prod-

ucts," said Christopher L. Brain of Seattle, one of the principal lawyers representing homeowners.
Deterioration of the half-inch board, a tightly squeezed composite of wood chips, fiber, resin and wax, took many forms, including swelling, warping, splitting, rotting and even sprouting mushrooms, Brain said.
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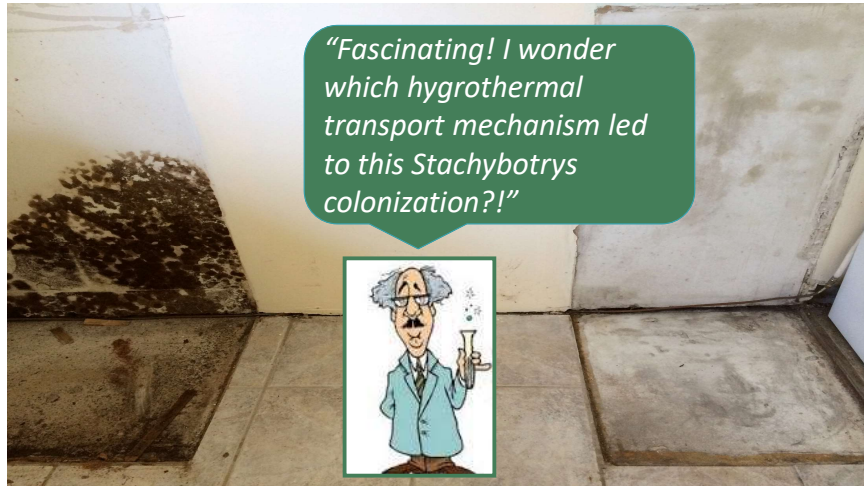
Building scientist's perspective



What building scientists think...



What building scientists think...



Homeowner's perspective



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What homeowners are thinking...



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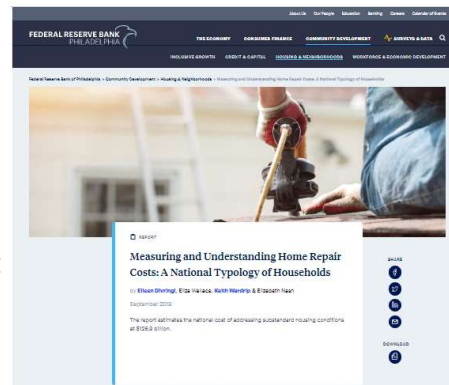
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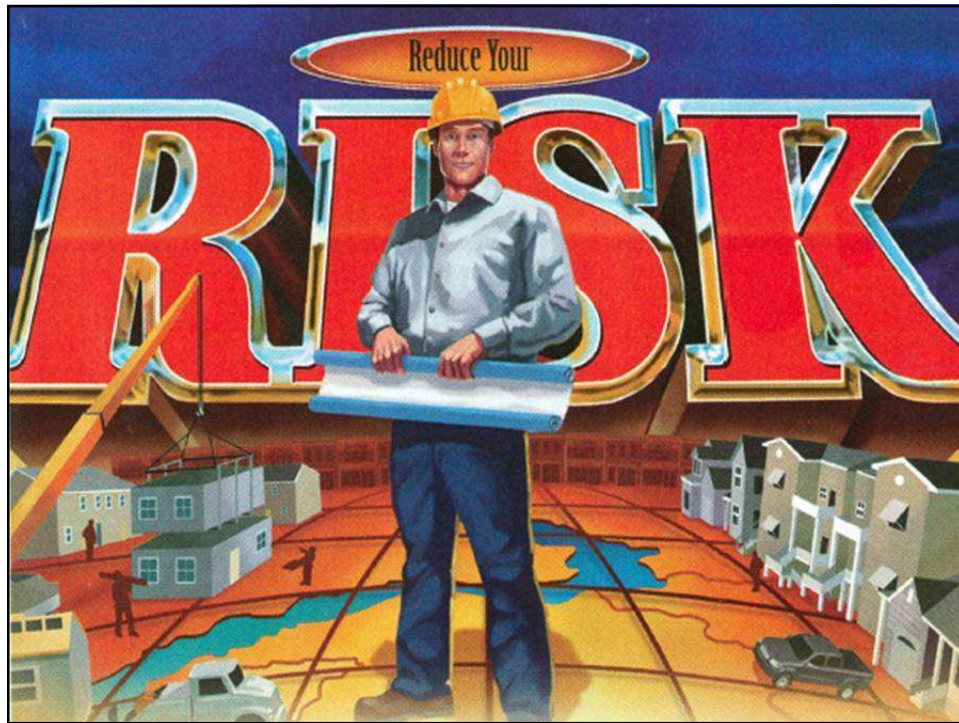
What homeowners are thinking...



What is the magnitude of the problem?

- In 2018, home repairs due to leaks and mold cost \$32B and were more acute for low-income families (Federal Reserve Bank).
- New code and proposed retrofit requirements take builders out of their “tried and true” comfort range.
- Building science required to reduce risk associated with modern building envelope and retrofit strategies.





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How to help builders manage risk

- Pay building scientists to write more books that builders won't read?
- Hold all building permits until we teach building science to every construction worker?
- Compel builders to consult a building science expert before every design change?



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Approach

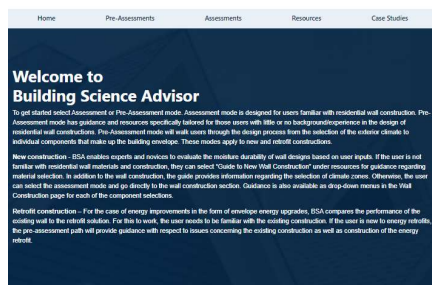
Give every building professional instant access to the knowledge of the industry's best researchers and building scientists.

Distinctive Characteristics:

- Web-based.
- First application of expert system for moisture management.
- Articulates guidance for durable wall systems based on expert consensus, field data, and hygrothermal modeling.



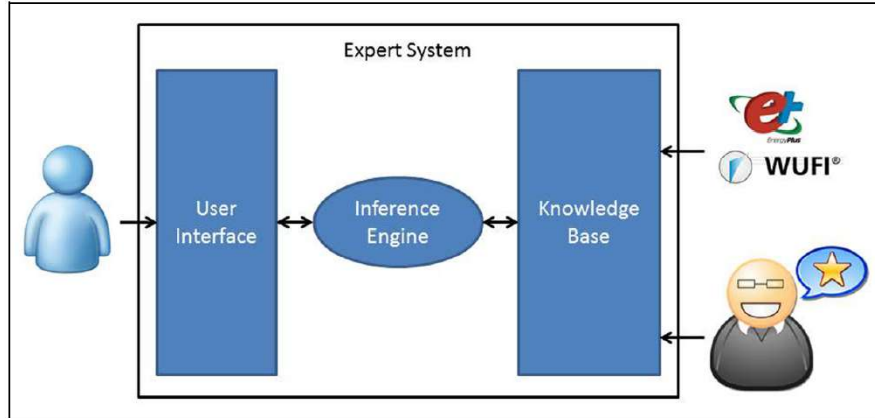
The Building Science Advisor



Building Science Advisor (BSA) is a website that provides expert advice on building envelope system performance from industry's best researchers and building scientists. This knowledge tool provides better-informed decisions regarding energy efficient and moisture durable building envelope solutions for new and retrofit constructions. BSA communicates uncertainty associated with moisture durability in a simplified manner. Please refer to the Security & Privacy Notice before using Building Science Advisor.

- Provides user with sources of information to consider prior to new construction or performing an energy retrofit.
- User defines wall he wants to construct or existing assembly.
- Tool rates its energy and moisture performance.
- Tool makes recommendations regarding improvements.
- bsa.ornl.gov

BSA is an expert system



How does it work – inference engine

The inference engine translates user input into a combination of appropriate material properties needed to assess the moisture durability.

Wall component	Material type	Material property
Cladding	Brick	Absorptive
	Stucco	
	Stone	
	Untreated clapboard Untreated shakes	
Cavity insulation	Fiber cement siding Vinyl Treated clapboard Treated shakes Metal siding	Non-absorptive
	Fiberglass batt Fiberglass loose fill Cellulose loose fill Open-cell spray foam	High permeance, > 10 perm (570 ng/s·m ² ·Pa)
	Expanded polystyrene foam (EPS)	Medium permeance, > 1 to < 10 perm
	Closed-cell spray foam Flash and batt	Low permeance, < 1 perm (57 ng/s·m ² ·Pa)

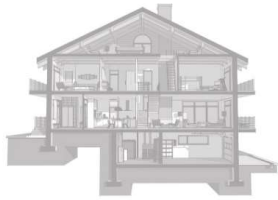
Wall component	Material type	Material property
Water/air barrier	Impermeable fully adhered membrane Insulated sheathing	< 1 perm
	Building paper Spun-bonded polyolefin Liquid-applied coating Permeable fully adhered membrane Uninsulated sheathing Closed-cell spray foam	≥ 1 perm
Sheathing	Plywood Oriented strand board (OSB) Fiberboard Mineral fiberboard	High permeance
	Expanded polystyrene foam (EPS) Polysocyanurate (PIR)	Medium permeance
	Extruded polystyrene foam (XPS)	Low permeance
	Interior vapor retarder	Polyethylene sheet Aluminum foil
Kraft paper Smart vapor retarder		Class II VR, > 0.1 to < 1 perm (57 ng/s·m ² ·Pa) Class III VR, ≥ 1 perm
None		No VR
Interior finish		Vapor barrier paint Latex paint

Pre-assessments

Home	Pre-Assessments	Assessments	Resources	Case Studies
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Building Envelope Components
 When planning an energy retrofit or replacing damaged and/or deteriorated materials of your building envelope (the components of the house serving as a thermal and weather barrier between the inside and the outside), there are various aspects to consider. Among many things, the main areas are your roof, exterior walls, windows, basement/crawl space, and how airtight your building is. What approach to take depends on the condition of the building and your needs. Click on the items below to view more information on the specified retrofit categories, or select Next to launch the BSA.

- Roofs and Attics
- Exterior Walls
- Windows and Attachments
- Basements, Crawl Spaces and Foundations
- Building Airtightness



Other than exterior walls, the building science advisor is currently not setup to analyze the moisture durability of other types of retrofits. In addition, does not account for air leakage which contributes to energy loss and moisture intrusion in the building envelope. The links provide guidance regarding how best to approach these other types of retrofits together with their associated benefits.

To learn more about the details and construction of the building envelope please refer to additional resources:

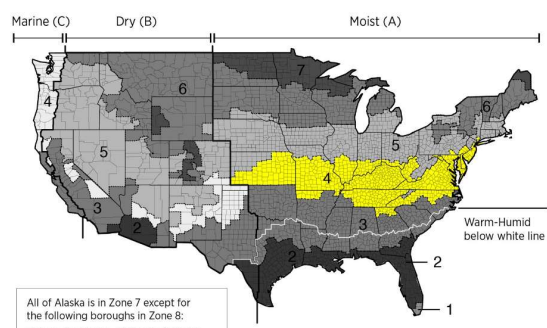
- [Solar Decathlon Building Science Education](#)
- [Whole Building Design Guide](#)
- [Building Enclosure](#)

Most important, before taking on an exterior retrofit make sure that the demolition and reconstruction follow local, regional and federal code requirements as it pertains to fire, hazardous materials and the impact changes will have on the structure's performance and surrounding property and neighbors. Make sure to check with local code officials regarding permitting requirements prior to the start of construction.

- Provides user with sources of information to consider prior to performing an energy retrofit.

Select climate zone

Climate Zone * 4A - Mixed-Humid




All of Alaska is in Zone 7 except for the following boroughs in Zone 8: Bethel, Northwest Arctic, Dellingham, Southeast Fairbanks, Fairbanks N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands


Analysis type

Home Pre-Assessments Assessments Resources Case Studies


Approach
For new walls, designers have flexibility in the selection of material types since they are starting from a clean slate. However, retrofit may be less flexible depending on the existing wall construction. Retrofit involves building enclosure modifications to improve energy performance and durability. Contractors and homeowners have several options to retrofit the building enclosure. Improvements can be made to the exterior, interior or both. In some cases, the exterior and interior elements of the enclosure can be completely removed starting with the structural elements. This type of retrofit is referred to as a "gut retrofit." Select one or more of the retrofit options by clicking on the appropriate image below.




o No Construction



o Exterior Retrofit



o Interior Retrofit



• Gut Retrofit

Our Results
The gut retrofit considers both the interior and exterior sheathings supporting the structural elements from both sides. In this case, general insulation options, condensation control, and the addition of water resistive and vapor barriers can be used to provide an optimized design for both energy performance and durability. This approach currently provides more flexibility in design.

File	Case
Greater flexibility in design to achieve optimal energy and durability performance	Construction in building enclosures
Ability to manage a range of construction levels to meet all local and national	Case


Previous **Next**

Defining the wall assembly

Wall Name *

ASHRAE Wall

▶ Exterior Cladding	Vinyl/Metal Siding
▶ Air Space	Drained/Ventilated
▶ Continuous Insulation	None
▶ Continuous Insulation Thickness	None
▶ Water Resistive Barrier	Housewrap/Building Paper (>= 10 per
▶ Exterior Sheathing	Plywood/OSB/Fiberboard/Wood Plank
▶ Wall Structure	2 x 4 16 inch o.c. Wood Frame
▶ Cavity Insulation	Fiberglass/Cellulose/Open Cell Foam (
▶ Interior Vapor Retarder	Polyethylene Sheer/Aluminum Foli
▶ Interior Finish	Drywall/Latex Paint



Previous **Next**

Recommendations and filters

Home Pre-Assessments Assessments Resources Case Studies

Recommendations

The table below contains all the components in the gut retrofit apart from the framing material. Starting from left to right (exterior to interior) the table lists the cladding, continuous insulation, insulation thickness, weather resistive barrier, exterior sheathing, vapor retarder and interior finish. Using the drop-down menus, you can select your preference of materials or no preference. Once the selection is complete a list of recommendations will be updated by order of performance based on insulation and durability values. For more detailed information on the performance of a specific retrofit wall assembly select the radio button adjacent to the recommendation and then select Next to go to the results page.

Preferences:

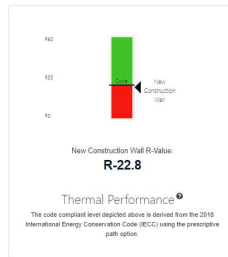
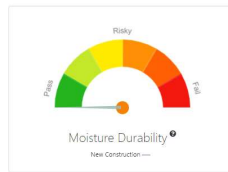
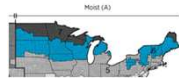
ID	Cladding Unfinished Wood Board/Shakes	Air Space None	Cont. Insulation Expanded Polystyrene	Insulation Thickness 1 in.	Weather Resistive Barrier Impermeable Coating/Membrane (<= 1 Perm)	Exterior Sheathing Plywood(OSB) /Fiberboard/Wood Plank	Cavity Insulation Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)	Vapor Retarder Polyethylene Sheet/Aluminum Foil	Interior Finish Drywall/Latex Paint
<input type="radio"/>	Unfinished Wood Board/Shakes	None	Expanded Polystyrene	1 in.	Impermeable Coating/Membrane (<= 1 Perm)	Plywood(OSB) /Fiberboard/Wood Plank	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)	Polyethylene Sheet/Aluminum Foil	Drywall/Latex Paint
<input type="radio"/>	Unfinished Wood Board/Shakes	None	Expanded Polystyrene	1 in.	Housewrap/Building Paper (>= 10 perm)	Plywood(OSB) /Fiberboard/Wood Plank	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)	Polyethylene Sheet/Aluminum Foil	Drywall/Latex Paint
<input type="radio"/>	Unfinished Wood Board/Shakes	None	Expanded Polystyrene	1 in.	Impermeable Coating/Membrane (<= 1 Perm)	Plywood(OSB) /Fiberboard/Wood Plank	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)	Kraft Paper	Drywall/Latex Paint
<input type="radio"/>	Unfinished Wood Board/Shakes	None	Expanded Polystyrene	1 in.	Housewrap/Building Paper (>= 10 perm)	Plywood(OSB) /Fiberboard/Wood Plank	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)	Kraft Paper	Drywall/Latex Paint

New construction example (climate zone 6A)

New - GAR19 2x6, R5 CI with drainage, Kraft
Climate Zone: 6A - Cold

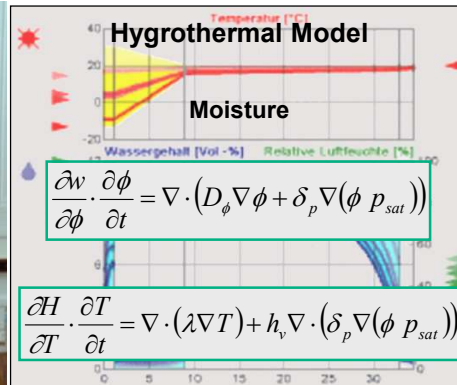
New Wall Construction

Exterior Cladding	Vinyl/Side Siding
Air Space	Dimpled/vented
Continuous Insulation	Extruded Polystyrene
Insulation Thickness	1 in.
WRB Air Barrier	Housewrap/Building Paper (>= 10 perm)
Exterior Sheathing	Plywood(OSB) /Fiberboard/Wood Plank
Wall Structure	2 x 6 1/2 inch o.c. Wood Frame
Cavity Insulation	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)
Interior Vapor Retarder	Kraft Paper
Interior Finish	Drywall/Latex Paint



- New construction with vinyl siding, XPS continuous insulation, housewrap, OSB, and 2 by 6 studs with R21 kraft-faced batts.
- Moisture durability is acceptable.

Building Science Advisor does not replace...



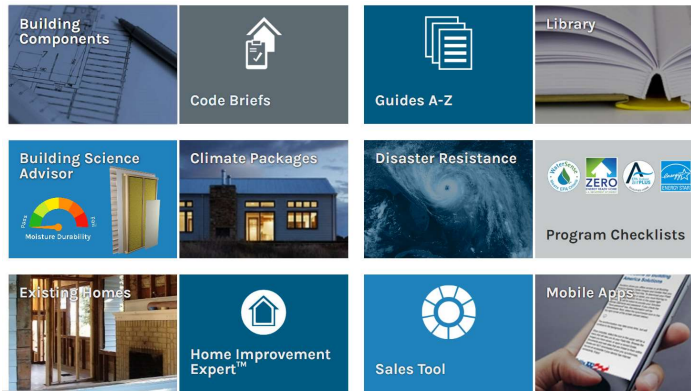
- Experts and modeling still required for atypical systems and improved precision.

Conclusions

- Moisture durability causes virtually all building envelope failures and is the major concern of architects, designers, and builders.
- Having recommendations instantly available is highly desirable.
- Tool uses an expert system to develop results and recommendations.
- Increasing the knowledge base to include a greater variety of assemblies and boundary conditions is planned.

Building Science Advisor (BSA) is a “tool/book” in the Building America Solution Center “toolbox/library”

<https://basc.pnnl.gov/>
<https://bsa.ornl.gov/>



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Questions?

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Visit our website: www.ornl.gov/buildings



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