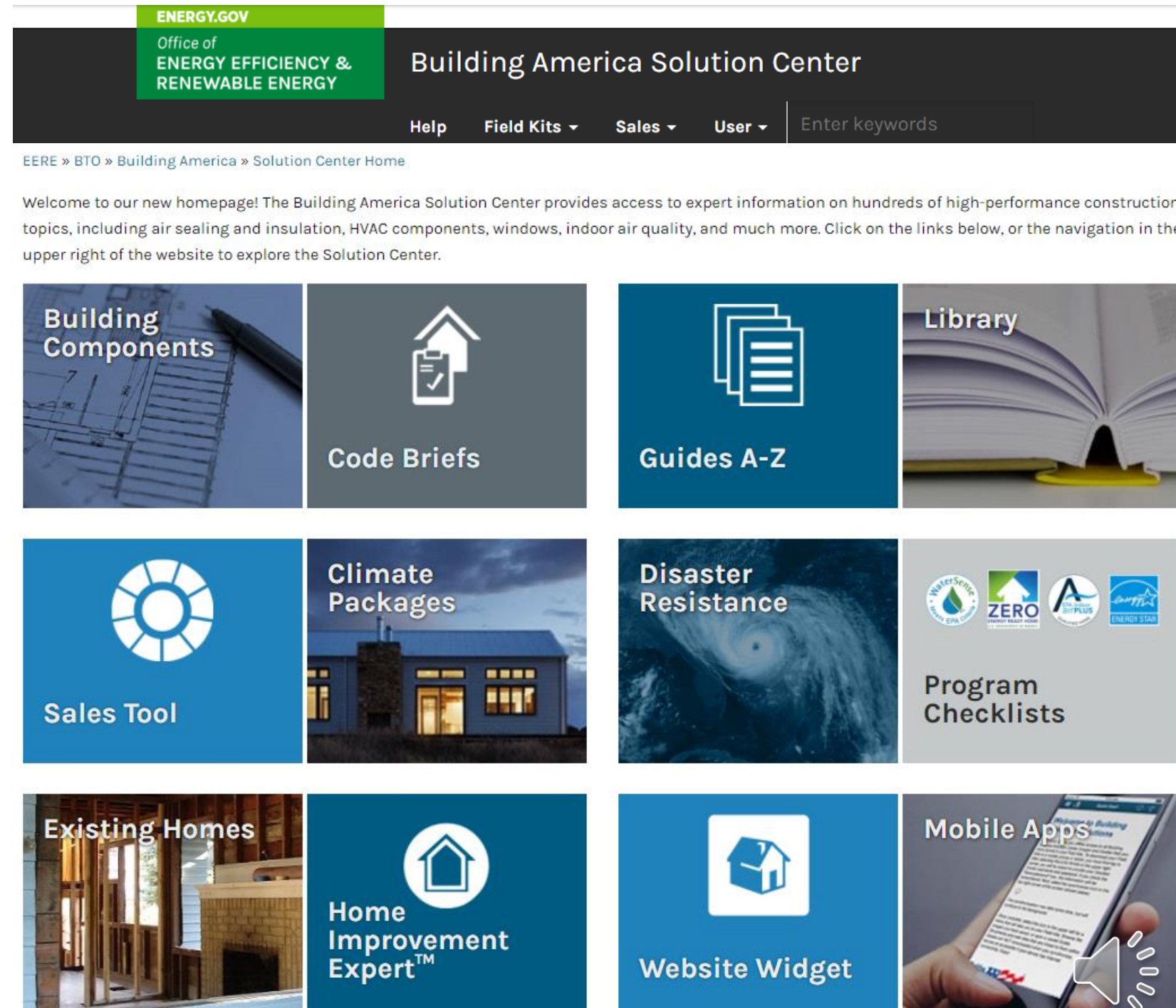


Building America Solution Center, basc.pnnl.gov

- Provides info for new construction, restoration, and renovation.
- Provides an overview of essential construction practices and detailed guides for specific measures.
- Leverages many programs to synthesize energy-efficient and resilient construction: IBHS Fortified Homes, DOE Building America, FEMA, HUD, etc.



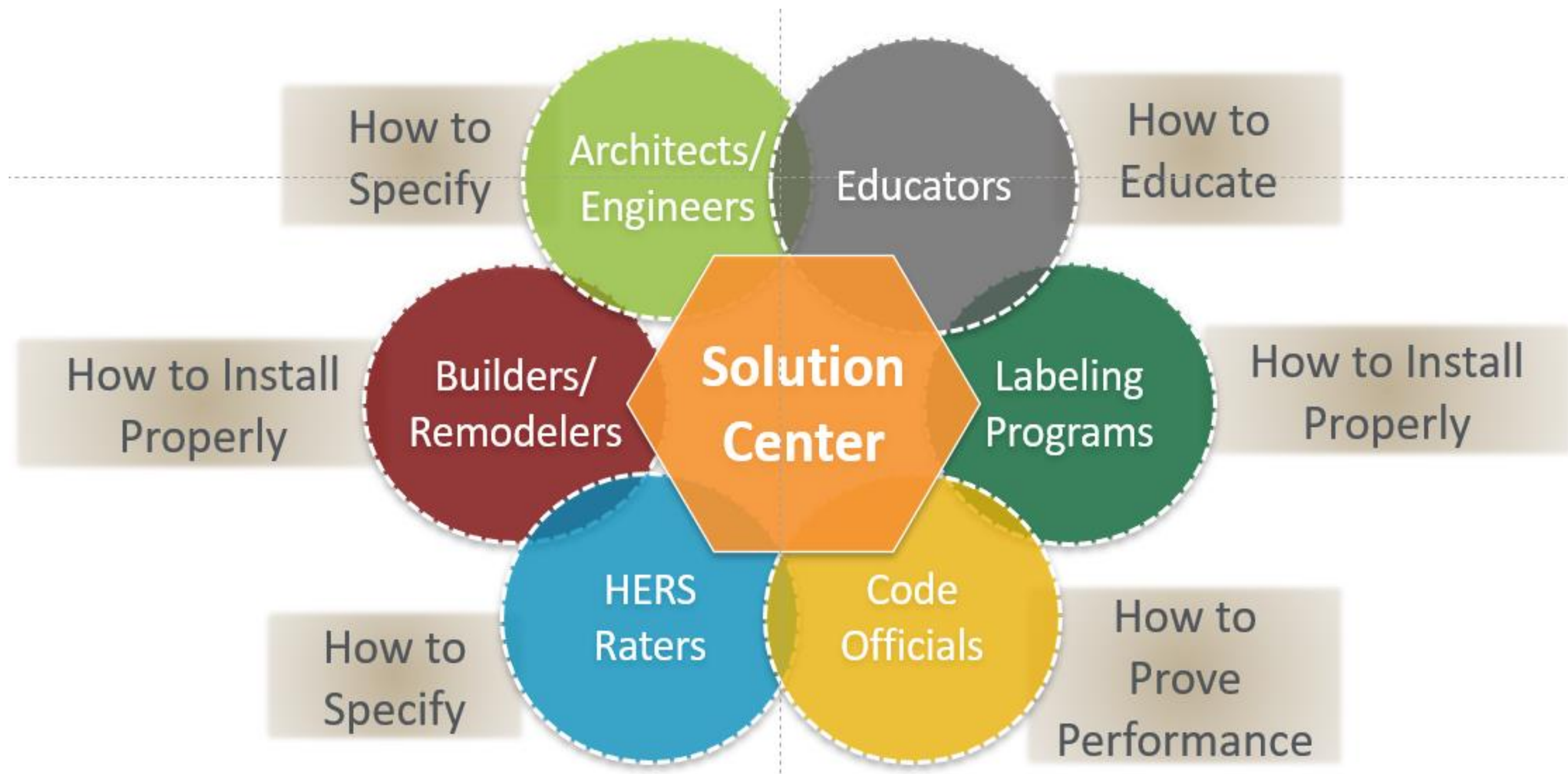
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BASC.energy.gov



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Resources for you: Free to Use, Copy, Download

- 324 Guides
- 4,137 Images
- 533 Videos
- 584 case studies
- 168 CAD drawings
- 2,063+ Building Science references & resources
- 32 Code compliance briefs



EERE » BTO » Building America » Solution Center Home » Building Components

Building Components



Whole-Building
Design Strategies



Water Heaters,
Appliances &
Lighting



Walls & Openings



Roofs, Attics &
Ceilings



Renewables



HVAC



Foundations &
Floors



Effective
Construction
Processes



Business
Processes

EERE » BTO » Building America » Solution Center Home » Existing Homes

Existing Homes

Welcome to the Existing Homes tool. Here you will find installation guidance for making existing homes more energy efficient, comfortable, and less expensive to operate. The tool is designed around common upgrades. Steps are numbered to indicate priorities from a health and safety standpoint. If you are doing a comprehensive renovation you may be interested in all the listed steps. If you are doing a more limited project, such as insulating an attic, reroofing, or replacing a water heater, you may focus on just a few steps.

It is worth visiting the first section no matter what project you have in mind. Nine assessment guides are listed to help gauge whether a home is safe and sound for upgrades plus a guide to help consumers plan a series of upgrades over time. These guides may help ensure that projects (and bids and contracts) cover related upgrades and are completed in the correct sequence.



Step 1: Ensure Safe
and Durable



Step 2: Ensure
Fresh Air



Step 3: Ensure
Moisture
Protection



Step 4: Ensure
Draft Free



Step 5: Ensure
Thermal Comfort




Anytime:
Equipment
Upgrades

EERE » BTO » Building America » Solution Cent

Program Checklists

The Building America Solution Center supp designed to aid construction of comfortable you install and specify the measures in each

Add guides to your Field Kits, for easy access whenever and wherever you need them. Visit




Only a select group of t

program. The Zero Energy

efficient that with the i

More about the program



ENERGY STAR Single-Fa

delivering energy efficie

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Indoor airPLUS helps bu

on the foundation of EP

comprehensive indoor



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ENERGY STAR Single-Family New Homes (Version 3/3.1, Revision 11)



To certify a home to ENERGY STAR, the builder's home must meet the mandatory requirements listed in the five checklists below and achieve a Home Energy Rating System (HERS) score that is better than the HERS Target score for a Reference Design Home.

A Reference Design Home is a theoretical home built to

Water Management System Builder Requirements +

Rater Design Review Checklist and Rater Field Checklist +

• HVAC Design Report

• HVAC Commissioning Checklist

Water Management System Builder Requirements +

Rater Design Review Checklist and Rater Field Checklist

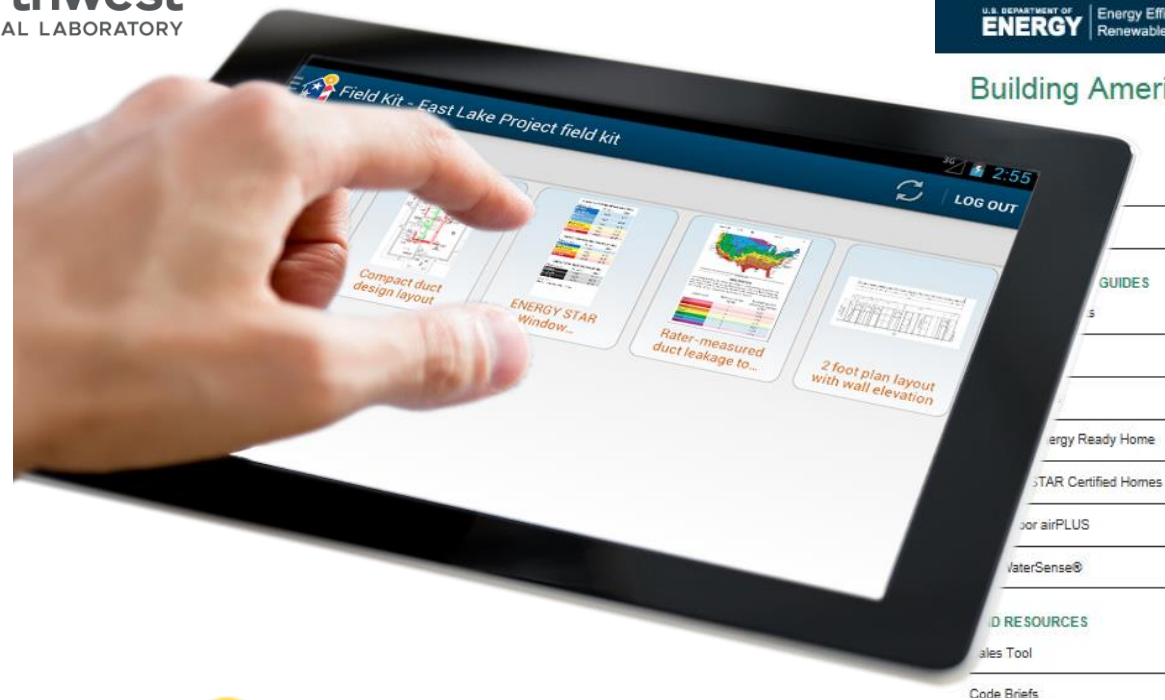
Rater Design Review Checklist

Rater Field Checklist

Thermal Enclosure System

- 1. High-Performance Fenestration & Insulation
 - 1.1 Fenestration meets or exceeds levels specified in Item 2.1 of the Rater Design Review Checklist
 - 1.2 Insulation meets or exceeds levels specified in Item 3.1 of the Rater Design Review Checklist
 - 1.3 All insulation achieves RESNET-defined Grade I installation
- 2. Fully-Aligned Air Barriers
 - 2.1 Dropped ceilings/soffits below unconditioned attics, and all other ceilings
 - 2.2 Walls behind showers, tubs, staircases, and fireplaces
 - 2.3 Attic knee walls and skylight shaft walls
 - 2.4 Walls adjoining porch roofs or garages
 - 2.5 Double-walls and all other exterior walls
 - 2.6 Floors above garages, floors above unconditioned basements or crawlspaces, and cantilevered floors
 - 2.7 All other floors adjoining unconditioned space (e.g., rim/band joists at exterior wall or at porch roof)
- 3. Reduced Thermal Bridging
 - 3.1 For insulated ceilings with attic space above (i.e., non-cathedralized), Grade I insulation extends to the inside face of the exterior wall below and is $\geq R-21$ in C7 1-5; $\geq R-$

Mobile Access Anywhere



“Solutions” mobile app
for iOS through the
Apple store and Android
via:

<https://basc.energy.gov/solutions>

Field kits can also be accessed from
computers


U.S. DEPARTMENT OF
ENERGY

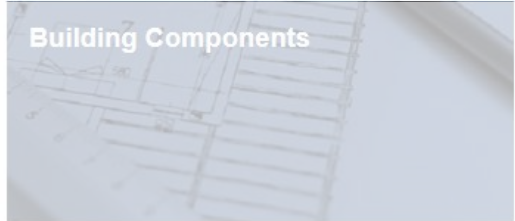
Energy Efficiency &
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Building America Solution Center

Enter your keywords

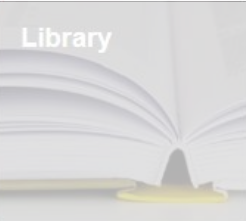
Welcome to our new homepage! The Building America Solution Center provides access to expert information on hundreds of high-performance construction topics, including air sealing and insulation, HVAC components, windows, indoor air quality, and much more. Click on the links below to explore the Solution Center.




Building Components




Guides A-Z



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Program Checklists




Existing Homes



Code Briefs



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Mobile Apps

Recently Added Content

Termite shield with exterior rigid foam above and below
CAD File Posted: November, 2017

Spray foam on concrete foundation wall with framed interior wall
CAD File Posted: November, 2017

Foundation wall interior rigid insulation with furring strips
CAD File Posted: November, 2017

New BASC Disaster Resistance Tool

- Comprehensive guidance for new construction, renovation, and post-disaster recovery.
- Integrates IBHS Fortified Home checklists
- Includes Building America best practices for high performance
- Free, publicly accessible tool and content



BASC Disaster Resistance Tool

Disaster Types

- Hurricane/High Winds
- Flooding/Coastal Flooding
- Earthquake
- Wildfire
- Pests
- Winter Weather
- Extreme Heat





Disaster Resistance Tool basc.pnnl .gov

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Building America Solution Center

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**Hurricanes /
High Winds /
Tornadoes**



**Flooding /
Coastal Flooding**



Earthquakes



Wildfires



Pests



Winter Weather



Extreme Heat

Tool Organization

Walls

- **Moisture-, Impact-, Fire-, and Pest-Resistant Exterior Siding**
Guide describing how to select the siding materials best suited to the home is likely to face within its lifetime.
- **Fire-Resistant Wall Assemblies**
Guide describing wall assemblies and materials that are resistant to wildfires.

Windows

- **Windows Have Impact-Rated Glass, Fire-Resistant Glass, or Plywood**
Guide describing how to strengthen or protect windows against wind debris during high-wind events including hurricanes and tornados

Doors

- **Exterior Doors Are Insulated, Impact Rated, and Fire Rated**
Guide describing the use of doors that are impact rated or have protection for hurricane and high wind zones.

Overview

Design

Roof

Walls / Windows / Doors

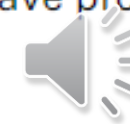
Building Attachments

Foundation / Site

Operations / Equipment



Wildfires



Overview Guides

- Provide general best practices and building science for resilient construction & recovery.
- Highlight Fortified Home requirements.
- Identify primary resources.
- Link to other governmental efforts (e.g., FEMA).
- Highlight additional resources.

EERE » BTO » Building America » Solution Center Home » Guides A-Z » Design for Wildfire Resistance

Design for Wildfire Resistance



Homeowners may feel hopeless in the face of an oncoming fire (Figure 1) but there is actually a lot that builders and homeowners can do in advance to improve the survivability of a home in wildfire-prone areas. They can select a home site in an area with topography that is more protected from wildfire-spreading winds. They can establish defensible space around the home with landscaping that is planned to minimize fuel near the home. And they can design and construct the home to minimize combustible surfaces and combustion-prone features on the exterior of the home.



Figure 1. Homes located in the Wildland Urban Interface should be designed and constructed with fire resistance in mind (Source: Ready.gov).

Siting of the Home

Good wildfire defense begins with siting of the home. FEMA provides the following guidance to help builders and property owners to reduce the potential for damage when choosing a home site in the wildland urban interface (WUI) (FEMA P-737 2008).

- Avoid selecting a construction site along a gully or in a narrow canyon.
- Avoid selecting a construction site in or adjacent to a saddle or narrow mountain pass.
- Avoid constructing a home adjacent to or on a steep slope (Figure 2). If a ridgetop site is selected, choose an area that allows for a minimum 50-foot setback from wildland vegetation on the downslope side.
- Increase the setback at sites with heavier fuels such as in a forested environment.
- Orient the narrowest wall of the building toward the likely path of a wildfire to minimize the risk of structural ignition.
- Orient the building based on wind and fuels so that debris, embers, and firebrands are less likely to accumulate next to the building's walls, especially near the inside corners of entries and other off-set walls.
- Minimize the number of windows on the side of the building facing the likely path of a wildfire to reduce the risk of radiant heat or firebrands and flying debris breaking the windows.
- Establish defensible space around the building.
- Provide two-way access to the house and turn-around space for fire-fighting vehicles near the home.



Tool Organization

Walls

- **Moisture-, Impact-, Fire-, and Pest-Resistant Exterior Siding**
Guide describing how to select the siding materials best suited to the home is likely to face within its lifetime.
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Guide describing the use of doors that are impact rated or have protection for hurricane and high wind zones.

Overview

Design

Roof

Walls / Windows / Doors

Building Attachments

Foundation / Site

Operations / Equipment



Wildfires

Scope Tab

- 324 measure-specific guides.
- Provides a general scope for the measure.
- Specifies primary construction techniques.
- Highlights installation strategies.
- Can be used as a scope of work on a bid, contract, plan, or other construction documentation.


Disaster Resistance
Wildfires > Walls / Windows / Doors > Windows

Windows Have Impact-Rated Glass, Fire-Resistant Glass, or Protective Coverings

View
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Revisions

Print
Field Kits 0

Scope	Description	Success	Climate	Training	Compliance	Retrofit	More
Scope	<p>Protect exterior glazed openings (windows and glass doors) against wind pressures, windborne debris, hail, and heat during hurricanes, wildfires, and severe storms by installing impact-resistant glazing or by installing hurricane shutters or storm panels to protect the glazing. In wildfire-prone areas, use dual-pane, tempered-glass windows.</p> <p>In wildfire-prone areas,</p> <ul style="list-style-type: none"> Determine if glazed opening protection is required. Determine the most suitable type of opening protection. Properly install products in accordance with the manufacturers' installation instructions and all applicable building codes including any specific product approval requirements. If replacing windows or installing shutters is not an option, suggest deployable coverings. Remind the homeowners to manage vegetation and combustible materials around the home. Remind the homeowners to close operable windows before evacuating a home due to a wildfire threat, if there is time to do so. <p>See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE's Zero Energy Ready Home program, ENERGY STAR Certified Homes, and EPA Indoor airPLUS.</p>						



Windows Protected by Hurricane Shutters.



Description Tab

- Provides building science background and research, pros and cons, options.
- Details step-by-step installation instructions.

Disaster Resistance

Wildfires > Walls / Windows / Doors > Windows

Windows Have Impact-Rated Glass, Fire-Resistant Glass, or Protective Coverings

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Field Kits 0

Scope

Description

Success

Climate

Training

Compliance

Retrofit

More

Description

In natural disasters, windows are the most vulnerable elements in the building envelope. Broken windows leave the home vulnerable to the entry of windborne rain and wildfire embers, smoke, and debris. The wind itself can be a destructive force if it enters the home through a broken window and pressurizes the building, blowing out additional windows, doors, or walls.

Windows can be protected by shutters or storm coverings as described below. Or the windows themselves can be made of more break-resistant glass.

Different types of glass are available, including annealed, tempered, laminated, and impact resistant. Annealed glass is the “softer” glass most windows are made of. Tempered glass is glass that has been subjected to high temperatures followed by rapid cooling, which compresses the surface and edges of the glass making the tempered glass up to five times stronger than traditional glass. If tempered glass does break, it does not break into large shards like regular glass, but instead shatters into small pebble-sized bits without dangerous edges that can cut or damage.

Laminated glass is created by bonding together two or more panes of annealed glass with a thin layer of film or vinyl in between. This inner layer works as an adhesive film that holds the glass together should it break or crack.

Impact-resistant windows may use both tempered and laminated glass and the panes are often installed in stronger heavy-duty frames, allowing the windows to withstand the blunt force of strong winds, windborne debris, and fire.



Climate Tab

- Maps
- Climate-Specific Information
- Disaster-Resistant Info

Disaster Resistance

Wildfires > Walls / Windows / Doors > Windows

Windows Have Impact-Rated Glass, Fire-Resistant Glass, or Protective Coverings

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Field Kits 0

Scope	Description	Success	Climate	Training	Compliance	Retrofit	More
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Climate

Hurricane-Prone Regions

The [International Residential Code 2018](#) requires exterior glazing in buildings located in windborne debris regions (Figure 1) to be protected from windborne debris and to meet the requirements of the Large Missile Test of ASTM E1996 and ASTM E1886. As an exception, windows can be covered with plywood structural panels that are at least 7/16-inch thick and are fastened with screws as described in IRC Table R301.2.1.2., "Windborne Debris Protection Fastening Schedule for Wood Structural Panels."

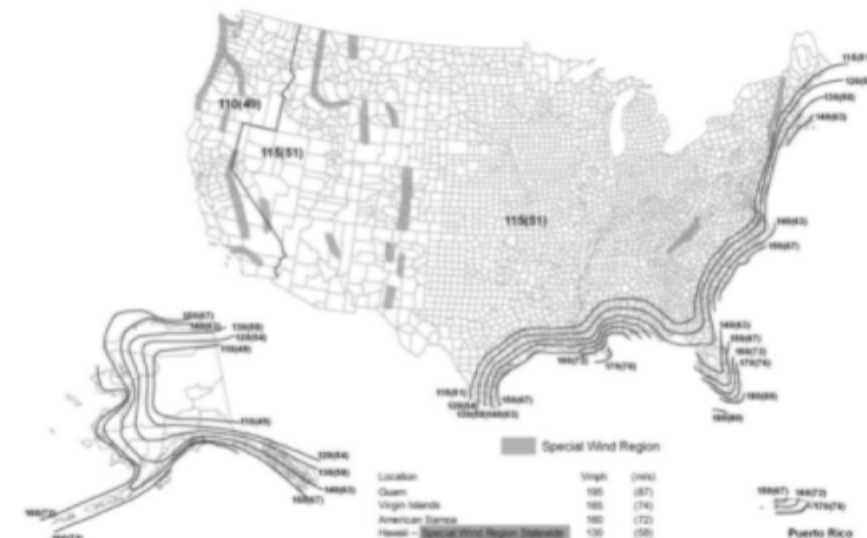


Figure 1. Wind Regions of the United States (Source: IRC 2018, Figure R301.2(5)A).



Training Tab

- Right and Wrong Photos
- Presentations
- Videos

Disaster Resistance

Wildfires > Walls / Windows / Doors > Windows


Windows Have Impact-Rated Glass, Fire-Resistant Glass, or Protective Coverings

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[Print](#) [Field Kits 0](#)

[Scope](#) [Description](#) [Success](#) [Climate](#) [Training](#) [Compliance](#) [Retrofit](#) [More](#)


Right and Wrong Images




Videos




Opening Protection Systems - Doors, Windows, Garages
Publication Date: February, 2015
Courtesy Of: IBHS Fortified Home Website
Video showing proper attic ventilation systems for hurricane-prone regions compliant with IBHS Fortified Home standards.



Protect Your Windows & Doors from High Winds
Publication Date: September, 2008
Courtesy Of: FLASH Strong Homes Videos
Video showing damage that can occur during high wind times from poor window and door installments that lead to a weak points in the home's envelope and how to fix these problems per FLASH Strong Homes guidelines.



How To Strengthen Your Home for Under \$10,000 - Roof, Walls, Windows, and Doors
Publication Date: September, 2014
Courtesy Of: FLASH Strong Homes Videos
Video interview explaining some basic guidelines to make your home more ready for severe weather for under \$10,000. Recommendations from FLASH Strong Homes.



Compliance Tab

- IECC
- IRC
- Fortified Home
- ENERGY STAR
- DOE ZERH Home
- EPA Indoor airPLUS
- EPA WaterSense

Disaster Resistance

Wildfires > Walls / Windows / Doors > Windows

Windows Have Impact-Rated Glass, Fire-Resistant Glass, or Protective Coverings

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Scope

Description

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Retrofit

More

Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

2009, 2012, 2015, 2018, and 2021 International Residential Code (IRC)

Chapter 3 Building Planning

Section R301.2.1.2 Protection of openings. Exterior glazing in buildings located in windborne debris regions shall be protected from windborne debris. Glazed opening protection for windborne debris shall meet the requirements of Large Missile Test of ASTM E1996 and ASTM E 1886 as modified in Section 301.2.1.2.1.

Section R308.3.1 Impact test. Where required by other sections of the code, glazing shall be tested in accordance with CPSC 16 CFR 1201. Glazing shall comply with the test criteria... indicated in Table R308.3.1(1).

Retrofit: 2009, 2012, 2015, 2018, and 2021 IRC

Section R102.7.1 Additions, alterations, or repairs. Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with the requirements of this code, unless otherwise stated. (See code for additional requirements and exceptions.)

Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.

2009, 2012, 2015, 2018, and 2021 International Wildland-Urban Interface Code (IWUIC)

When the building in the WUI is required to be constructed to Class 1 or Class 2 ignition-resistant construction as deemed by Section 503.1 Table 503.1



More Tab

- Building America library
- Reports
- Research studies
- Standards
- Case studies

Disaster Resistance

Wildfires > Walls / Windows / Doors > Windows

Windows Have Impact-Rated Glass, Fire-Resistant Glass, or Protective Coverings

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Field Kits 0

Scope Description Success Climate Training Compliance Retrofit More

More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

References and Resources*

2018 IRC - International Residential Code for One and Two Family Dwellings

Author(s): International Code Council

Organization(s): ICC

Publication Date: August, 2017

2018 edition of code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less, bringing together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

Protection of Openings-Shutters and Glazing, FEMA Technical Fact Sheet No. 6.2

Author(s): Federal Emergency Management Agency

Organization(s): FEMA

Publication Date: December, 2010

Technical fact sheet describing the selection and installation of storm shutters and impact-resistant glazing and other types of opening protection in windborne debris regions; also published in FEMA P-499 "Home Builder's Guide to Coastal Construction: Technical Fact Sheet Series."

Fortified Home Hurricane Standard

Author(s): Insurance Institute for Business & Home Safety

Organization(s): IBHS

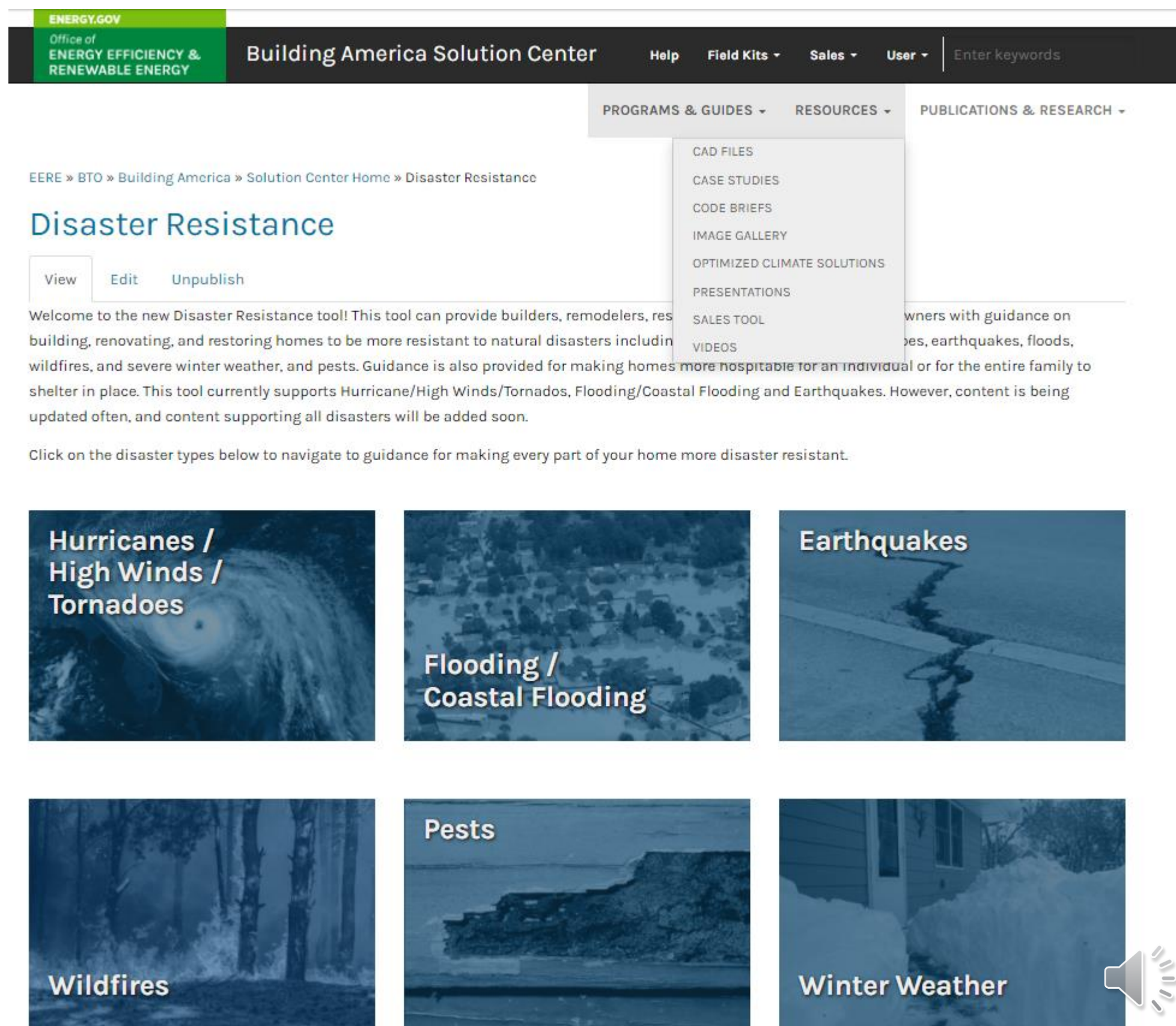
Publication Date: May, 2019

Guide describing the requirements by FORTIFIED Home™ for improving the home's resistance in severe thunderstorms, straight-line wind events, and high winds at the outer edges of tornadoes.



Resources

- 324 Guides
- 4,137 Images
- 533 Videos
- 584 case studies
- 168 CAD drawings
- 2,063+ Building Science references & resources
- 195 presentations



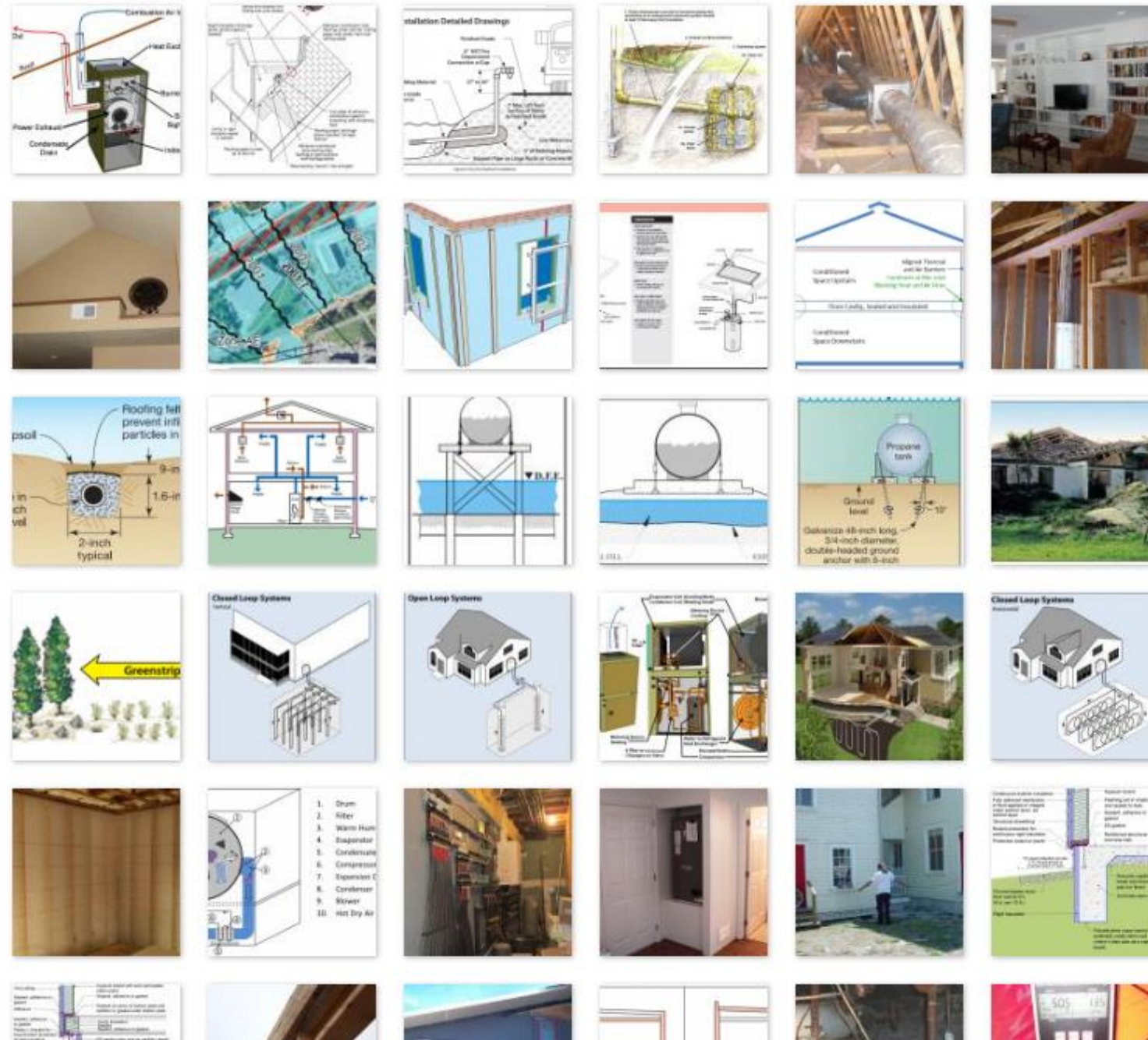
The screenshot shows the 'Building America Solution Center' website. The header includes the 'ENERGY.GOV' logo, 'Office of ENERGY EFFICIENCY & RENEWABLE ENERGY', and navigation links for 'Help', 'Field Kits', 'Sales', and 'User'. A search bar is also present. The main navigation menu includes 'PROGRAMS & GUIDES', 'RESOURCES', and 'PUBLICATIONS & RESEARCH'. The 'RESOURCES' dropdown menu is open, showing options like 'CAD FILES', 'CASE STUDIES', 'CODE BRIEFS', 'IMAGE GALLERY', 'OPTIMIZED CLIMATE SOLUTIONS', 'PRESENTATIONS', 'SALES TOOL', and 'VIDEOS'. The main content area is titled 'Disaster Resistance' and includes a breadcrumb trail: 'EERE » BTO » Building America » Solution Center Home » Disaster Resistance'. Below the title are 'View', 'Edit', and 'Unpublish' buttons. A welcome message states: 'Welcome to the new Disaster Resistance tool! This tool can provide builders, remodelers, res... building, renovating, and restoring homes to be more resistant to natural disasters including... wildfires, and severe winter weather, and pests. Guidance is also provided for making homes more hospitable for an individual or for the entire family to shelter in place. This tool currently supports Hurricane/High Winds/Tornados, Flooding/Coastal Flooding and Earthquakes. However, content is being updated often, and content supporting all disasters will be added soon.' Below this is a prompt: 'Click on the disaster types below to navigate to guidance for making every part of your home more disaster resistant.' The page features six large, blue-tinted image tiles with white text labels: 'Hurricanes / High Winds / Tornadoes', 'Flooding / Coastal Flooding', 'Earthquakes', 'Wildfires', 'Pests', and 'Winter Weather'. A speaker icon is visible in the bottom right corner.

Image Gallery

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KEYWORDS

- ☐ Advanced Framing (204)
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- ☐ Bedrooms (20)
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- ☐ Ducts (395)

Videos

Showing results 51 - 100 of 533

Building Enclosure: Window Installation

Courtesy Of: [NAHB Research Center](#)



Building Science Insights: To Vent or Not to Vent

Publication Date: February, 2014

Author(s): [Lstiburek](#)

Organization(s): [Owens Corning](#)



Video presentation describing proper attic venting design for energy efficiency and weather resistance.

Building with Indoor airPLUS

Publication Date: June, 2009

Courtesy Of: [EPA](#)



Video describing how builders can incorporate Indoor airPLUS plus guidelines to help improve indoor air quality.

Building with SIPs in Alaska

Publication Date: April, 2015

Author(s): [Cold Climate Housing Research Center](#)

Organization(s): [CCHRC](#)



Video from Cold Climate Housing Research Center on SIP construction and how to build with these materials.

Cabin in the Woods Part 13: Installing Standing Seam Metal Roof

Publication Date: July, 2020

Author(s): [RR Buildings](#)

Organization(s): [RR Buildings](#)



Video from RR Buildings on installing a metal roof to protect the home moisture and outside elements.

Capillary Break Beneath Slab - Polyethylene Sheeting or Rigid Insulation Over Aggregate

Publication Date: July, 2015

Courtesy Of: [Train2Build](#)



Video describing how to install a capillary break beneath concrete slabs.

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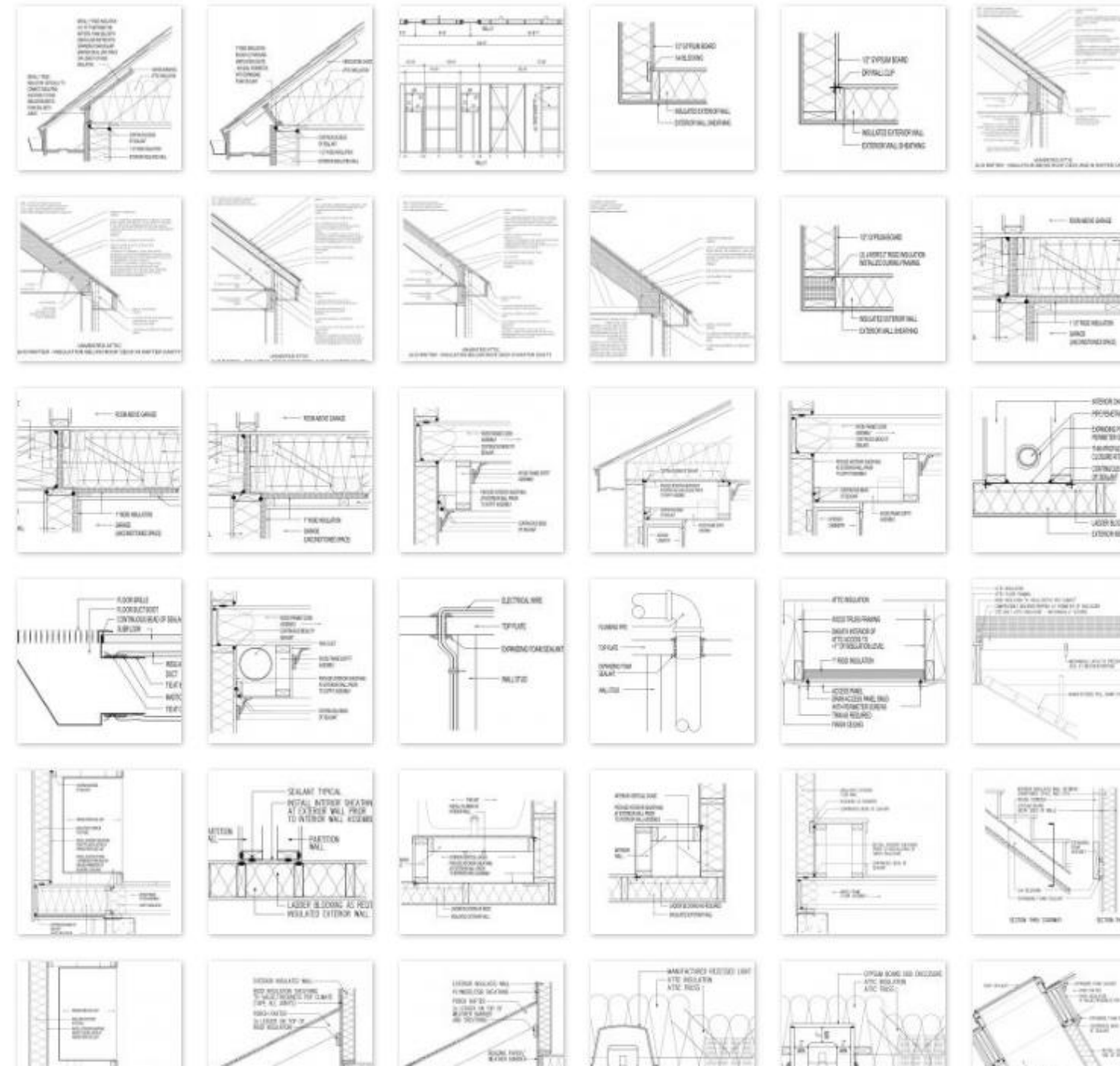
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KEYWORDS

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Resources

- All guides and resources can be filtered and searched.

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PROGRAMS & GUIDESRESOURCESPUBLICATIONS & RESEARCH

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BASC Search

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attic knee wall

Attic Knee Walls

Publication Date: July, 2015
Courtesy Of: Risinger Homes

Video describing how to insulate and air seal attic knee walls.

VIDEO

Attic Knee Walls

This guides describes how to insulate and air seal attic knee walls and floor joist cavities under knee walls.

GUIDE

Install an air barrier on the exterior of attic knee wall insulation and to block open floor joist cavities under attic knee walls.

Reference: Thermal Enclosure System Rater Checklist Guidebook
Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.

Publication Date
Fri, 10/28/2011 - 12:00

IMAGE

Air Sealing and Insulating Attic Knee Walls - Code Compliance Brief

Air sealing and insulating attic knee walls to code.

CODE COMPLIANCE BRIEF

Attic knee walls are insulated with rigid foam and sealed with spray foam to help form a continuous draft barrier around attic rooms.

Courtesy Of: Knaggs Construction
Publication Date
Fri, 01/01/2016 - 12:00

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☐ Case Study (3)
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☐ Home Improvement Expert™ Checklist (3)
☐ Image (6)
☐ Information Guide (2)
☐ Video (1)

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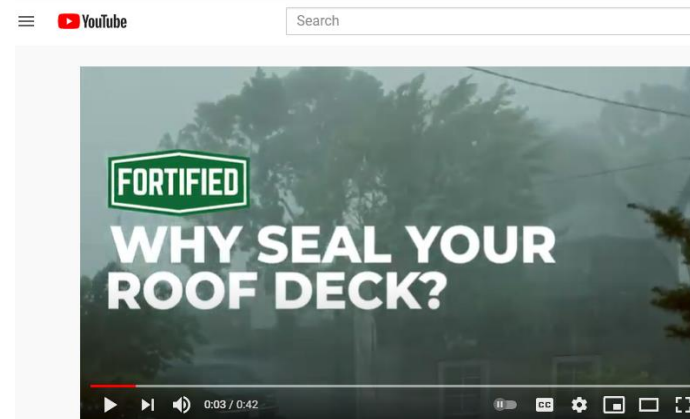
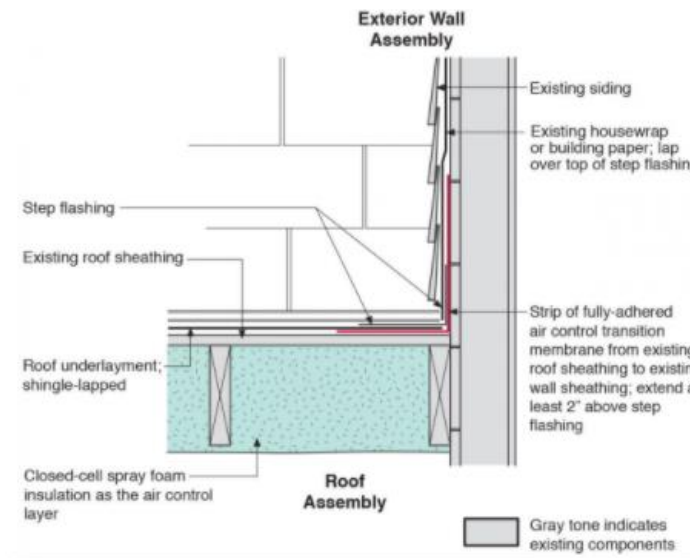
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FILTER BY BASC CLIMATE ZONE

Disaster Resistant Content Added

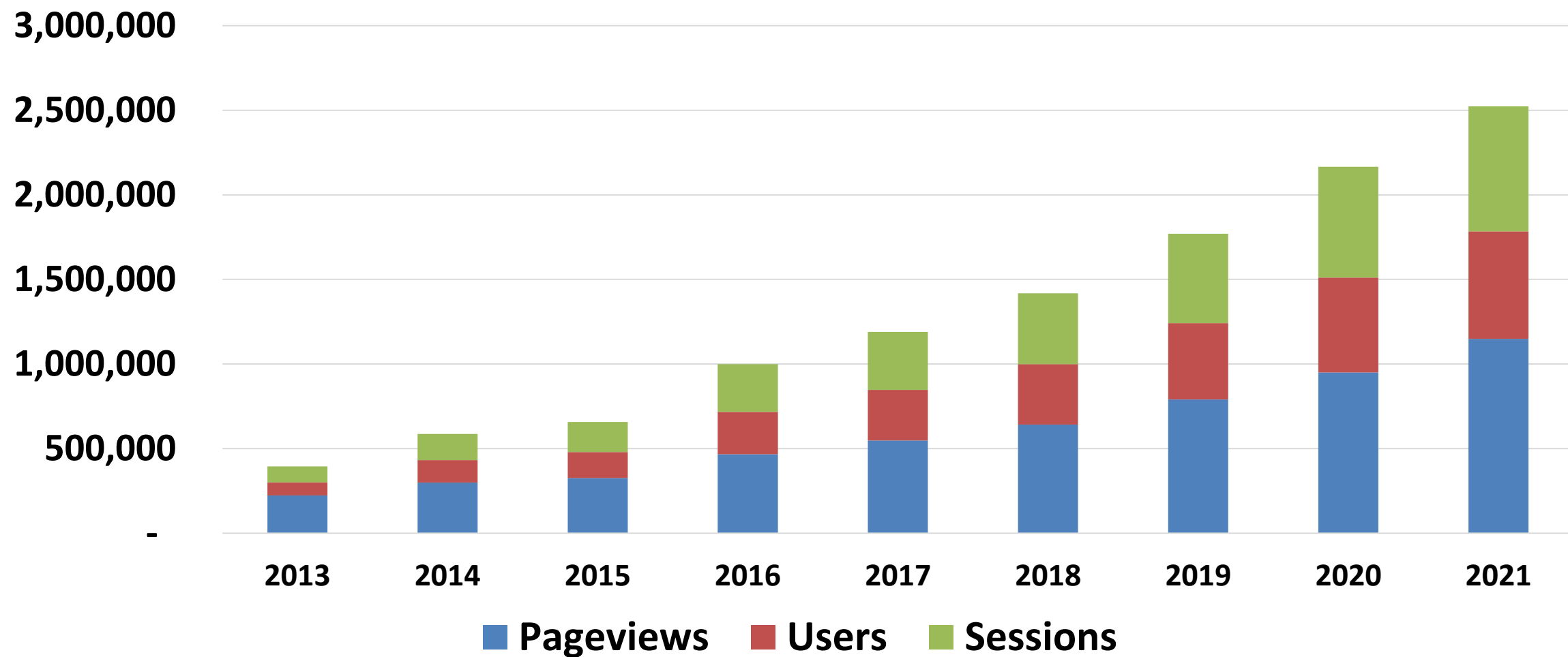
- 105 full guides
- 20 information guides
- 80 revised guides
- 1,084 photos and drawings in the image gallery
- 281 videos
- 16 case studies
- 18 CAD files
- 22 presentations
- 786 references

Disaster Resistance - Wildfires



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Thank you

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