Energy Efficiency and the Three Rs: Resistance, Resilience, and Recovery

MICHAEL BAECHLER AND THERESA GILBRIDE

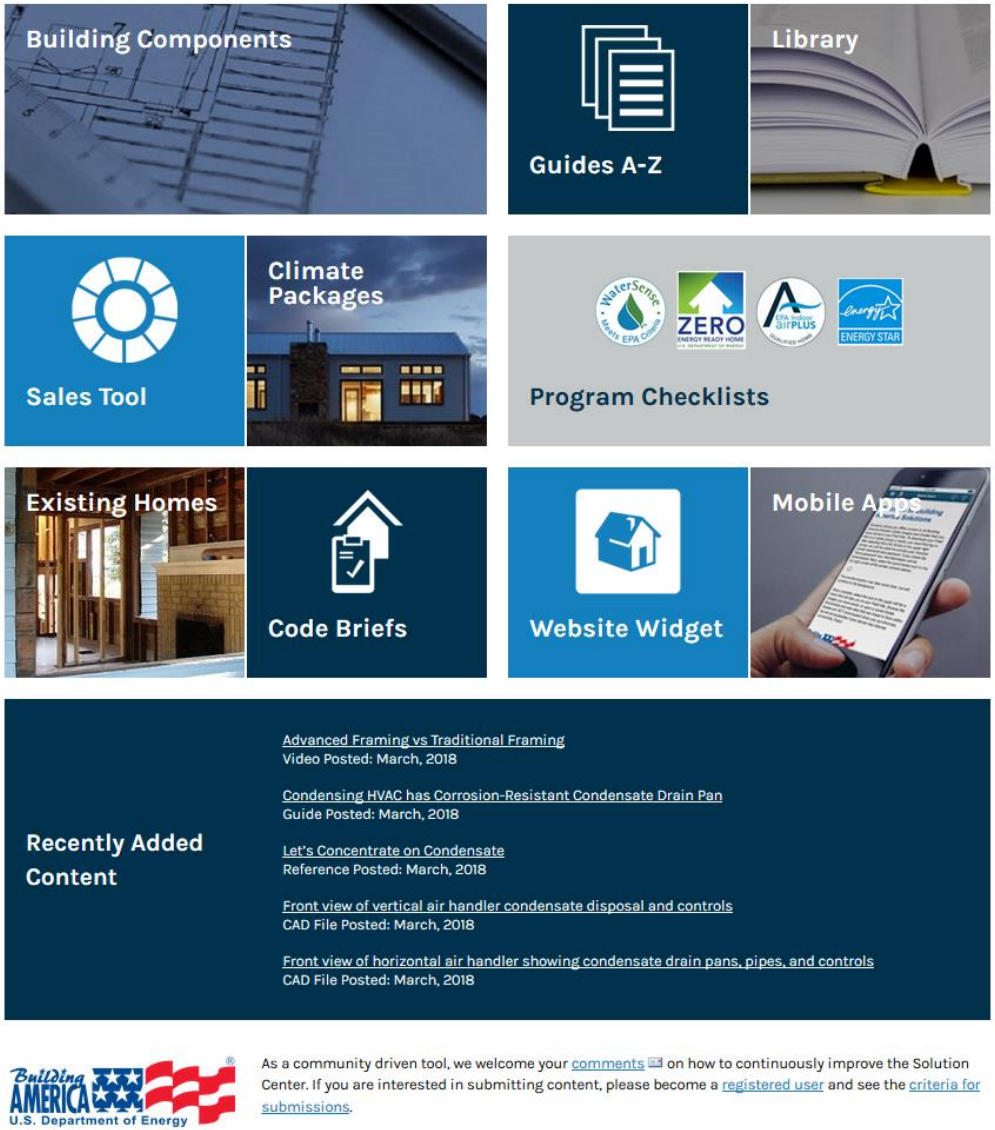
Pacfic Northwest National Laboratory

BASC.energy.gov
Easy Access to Expert Guidance

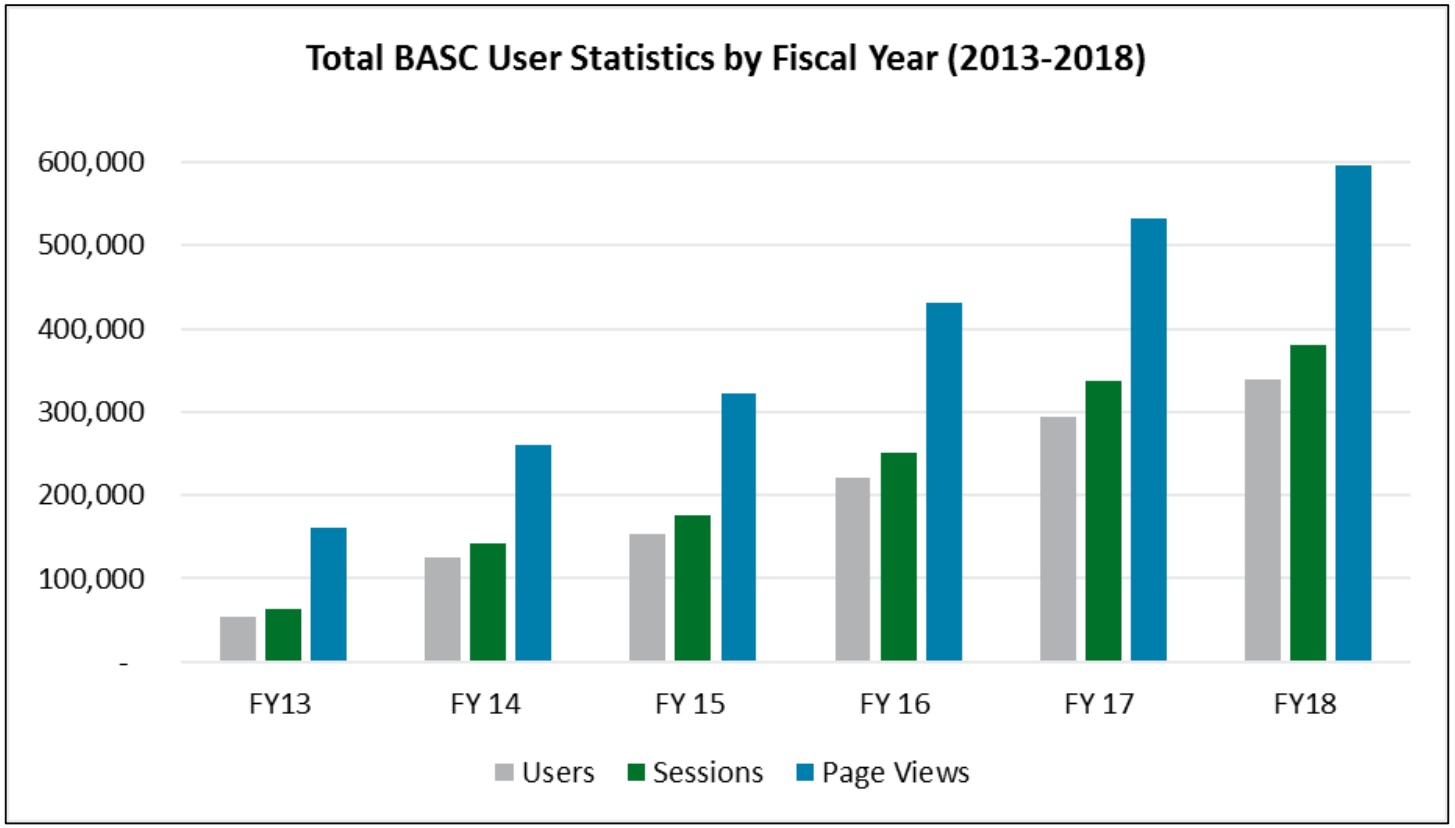
Pacific Northwest NATIONAL LABORATORY

Access to:

- 252 Guides
- 1,700+ Images
- 330+ Proven Performance Case Studies
- 130+ CAD Drawings
- 980+ Building Science References & Resources
- 30+ Code Compliance Briefs
- 110+ Videos
- 40+ Sales Briefs



BASC.energy.gov
Easy Access to Expert Guidance



"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)

Code Compliance Briefs

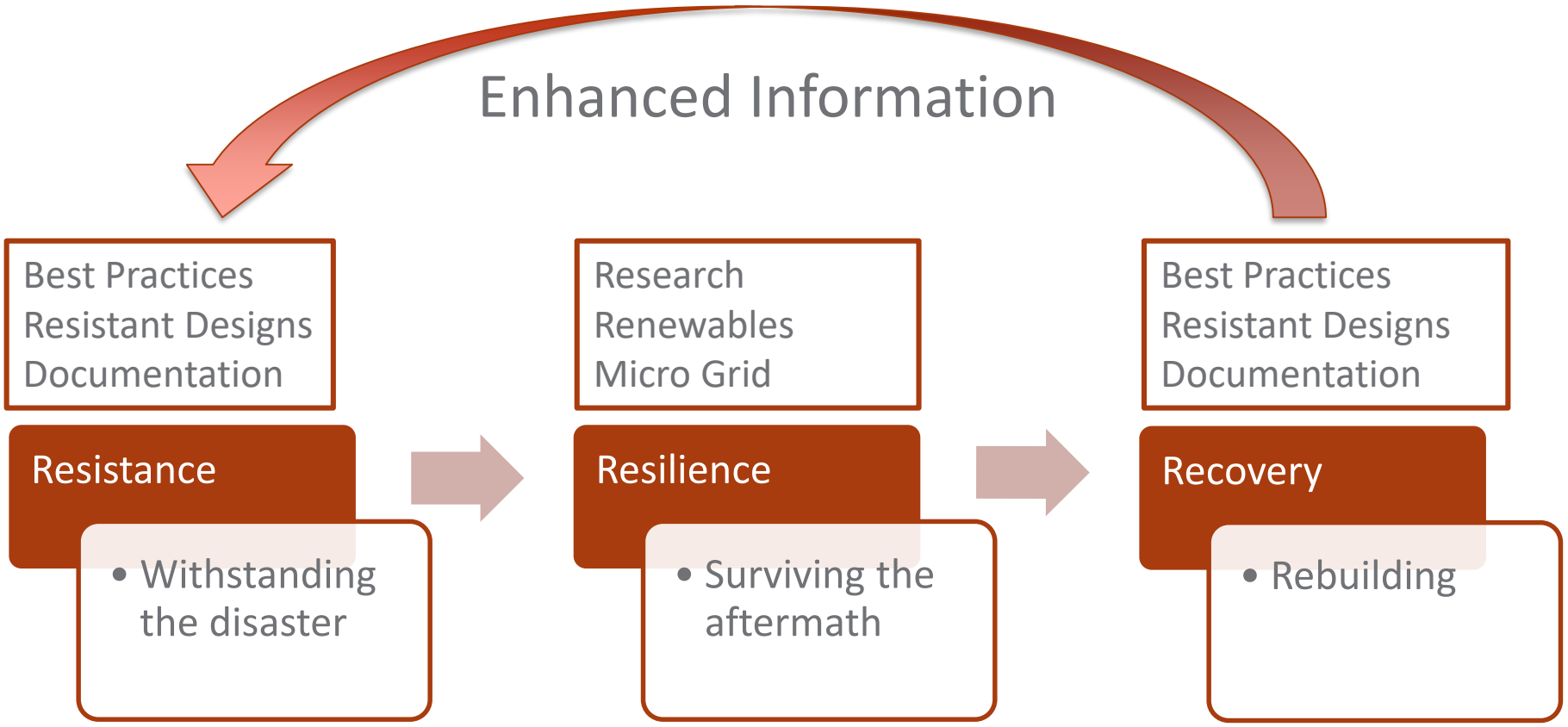
31 code briefs on innovative technologies and practices to help with code compliance and technology validation.

Controlling Moisture in Unvented Attics - Code Compliance Brief

Overview:

The intent of this brief is to provide code-related information about controlling moisture in unvented attics by installing a vapor diffusion port/vent that would convey water vapor from an unvented attic to the outside when air-permeable insulation materials are installed and can be verified as being in compliance with the related codes and standards for residential construction. Providing consistent information to document compliance with codes and standards to all relevant parties responsible for verifying compliance (e.g., code officials, builders, contractors, designers, etc.) is expected to result in increased compliance and more timely, less challenging and more uniform plan review and field inspections.

Redefine What it Means to be a High-Performance Home



Historic Perspective
The 80s: Blinded With Science

Energy Efficiency		Wind Disaster Resistance
U.S. DOE established in 1977 – U.S. blower door developed in 1979	1979	Frederick AL – first FEMA post disaster evaluation. FEMA established.
Congress passes NW Power Planning Act. First ACEEE Summer Study.	1980	Mobile County adopts code measures. FEMA: first Coastal Construction Manual.
BPA limits tightening in weatherization program to avoid IAQ issues. First EEBA conference in 1982.	1981	
BPA mitigates radon and formaldehyde in new homes. Establishes 5pCi/l radon action level and funds AAHXs in 1984.	1983	Alicia TX – TX develops inspection process for wind damage.
EPA sets 4pCi/l radon action level.	1986	
BPA launches new energy-efficient home program in 1988.	1989	Hugo PR & SC – FEMA first building performance assessment team.
	1992	Andrew FL – recognized the importance of the building envelope. Prompted FL code.

In Hurricanes Its All About the Leaks

"Keeping water out of the structure is a primary goal; all too often water leaks into the house through openings that are not adequately sealed during construction. Exterior wall penetrations such as electrical outlets, electrical panels, dryer vents, and plumbing lines can provide a "water superhighway" when not adequately sealed at the time of installation. Additionally, water intrusion through soffit vents, ridge vents, off ridge vents, gable end vents, and doors and windows can be a major source of unwanted moisture in the house…."

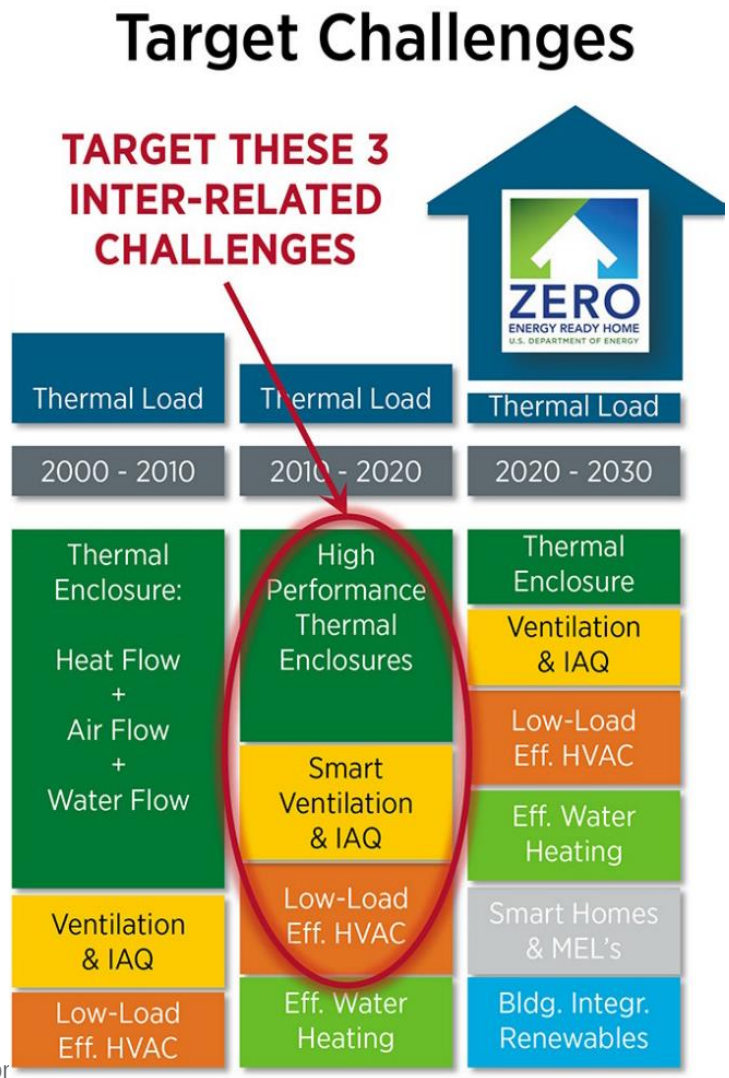
Insurance Institute for Business and Home Safety

Fortified Home™ *Builders Guide* (2008)

Building America

- Building America will provide high-performance construction and retrofit solutions that manage moisture risks, reduce mold potential, and improve building durability. *
- Previous priorities included control layers for
  - Heat flow
  - Air flow
  - Water flow*

*Building America Research-to-Market Plan, 2015. www.buildingamerica.gov



The Benefits of Cross Collaboration

To Energy Efficiency

- Owners, rate payers and tax payers loose their investment in the event of disaster
- Some measures (e.g. passive cavity vents) will benefit from disaster resilience guidance
- Greater value to consumers
- Greater value and less confusion for industry and market partners
- Combined efforts at code, standard, and test method adoption
- Save more lives

To Disaster Resistance

- Some EE measures can degrade resistance (e.g. overhangs, improperly vented – or non-vented - crawlspaces)
- Some EE measures can enhance resistance (e.g. non-vented attics, spray foam insulation, ventilation)
- Greater value to consumers
- Greater understanding of market transformation
- Combined efforts at code, standard, and test method adoption

Sample Recommendations from latest FEMA Coastal Construction Guide

- Vestibule - weatherstrip the doors - water-resistant finishes (e.g., tile) - floor drain. Exterior threshold trench drains.
- Door swing in to protect weatherstripping.
- Pan flashing - prevents water penetration into subflooring.
- Door/wall integration
- Weatherstripping
- Moisture barrier – felt or housewrap (also self sticking membranes, liquid, and tape systems)
- Continuous sheathing (area for discussion)

Comparison with Building America Best Practices

- Vestibule – not addressed but beneficial. Sloping ground and drain to daylight or drywell.
- Door swing – not addressed but may be beneficial
- Pan flashing – heavy emphasis along with flashing, overhangs, gutters, drains, and slopes
- Weather stripping
- Door/wall integration & moisture barrier – continuous control layers for air, moisture, thermal, including capillary breaks
- Continuous sheathing – advanced framing update?

Vulnerability of Vents to Wind-Blown Embers
Stephen I. Quarles, 2017 IBHS

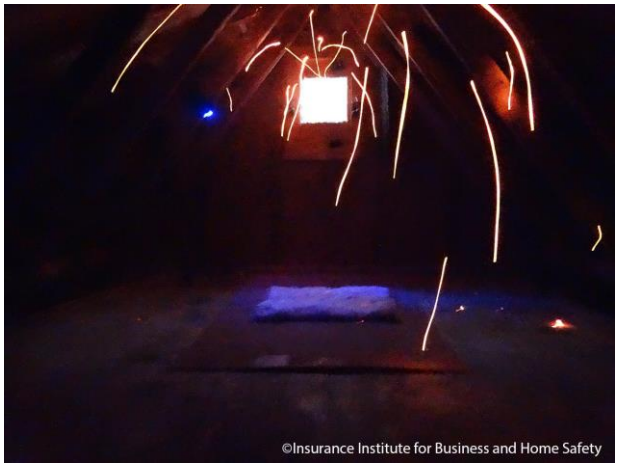
Pacific Northwest NATIONAL LABORATORY

Limit Ember Entry

- >2 million homes in CA have high to extreme risk of wildfire
- Inlet vents in soffited-eaves
- ¼-in. (6 mm) mesh screening is too big
- Wildfire-resistant vents used in the gable end better than screen mesh alone.
- gable end vents should be avoided.
- Avoid non-wildfire-resistant off-ridge and ridge vents
- Keep vents clean

Under-Eave Vents and Examples of Ember Intrusion Through Gable and Eave Vents

Between-Rafter Bird Block Vents



Soffit Vents

Unvented Attics

- An unvented attic may block embers and avoid water intrusion.
- This is a Building America supported innovation developed by Building Science Corporation

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES PROGRAM

BUILDING AMERICA TOP INNOVATIONS HALL OF FAME PROFILE

INNOVATIONS CATEGORY:
1. Advanced Technologies and Practices
1.1 Building Science Solutions

Unvented, Conditioned Attics

The additional heat loss and gain of ducts in unconditioned, vented attics increases energy use for heating and cooling 10%. Additionally, duct air leakage has been measured to commonly exceed 20% of conditioned air flow, which results in a significant energy loss when ducts are in unconditioned space. In addition to influencing builders across the country to adopt unvented, conditioned attics, Building America research has helped influence code acceptance of this innovation since 2006.

BUILDING AMERICA TOP INNOVATIONS

Recognizing Top Innovations in Building Science – The U.S. Department of Energy's Building America program was started in 1995 to provide research and development to the residential new construction and remodeling industry. As a national center for world-class research, Building America funds integrated research in market-ready technology solutions through collaborative partnerships between building and remodeling industry leaders, nationally recognized building scientists, and the national laboratories. Building America Top Innovation Awards recognize those projects that have had a profound or transforming impact on the new and retrofit housing industries on the road to high-performance homes.

The preference for a large segment of the U.S. housing industry has been to locate HVAC systems in unconditioned attics, but this is highly inefficient. Building America research has demonstrated unvented, conditioned attics can substantially improve energy performance while allowing home builders to continue locating HVAC systems in the attic space.

Traditionally, building codes have required attic ventilation. The intended purpose was to allow warm air and moisture to escape. Vented attics can be effective, as long as HVAC ducts are not located in them and the ceiling deck is well air sealed and insulated. These are significant challenges. First, the housing industry has demonstrated a strong preference for locating HVAC systems in attic spaces above insulated ceilings to accommodate design and cost concerns. Second, typical roof slopes often leave inadequate height at the top plates for full-depth insulation. Third, there are extensive penetrations and cracks that require air sealing and air barriers including attic hatches, flues, piping, lighting, wiring, chases, attic eaves, dropped ceilings, and knee walls. Air leakage that is not addressed can lead to several problems. The loss of conditioned air increases heating and cooling demand. Humid indoor air that escapes into the attic can condense on cold roof sheathing, resulting in potential moisture problems. Warm air that escapes into the attic in winter can warm the roof deck and increase the risk of ice dams.

When the HVAC system is located in a vented attic, it is exposed to extremes of hot and cold. The energy needed for air conditioning and heating typically goes up 10% when ducts are in the attic (Ueno 2003). Furthermore, leaky ducts can lose as much as 20% of conditioned air flow to the attic (BSC 2009). Oversized heating and cooling units are often installed to make up for the inefficiency of leaky ducts, further increasing the purchase cost and energy bills. Leaky ducts can also contribute to condensation and mold.

"Unvented attics make a lot of sense. In humid climates, venting attics brings a great deal of moisture into the structure. In cold climates, venting attics brings in a great deal of snow. Not venting makes these problems go away."

Joe Lstiburek,
Building Science Corporation

Spray Foam Insulation

- 2-part, closed cell, spray polyurethane foam or AFG-01 rated adhesive may be used on interior retrofits to secure the roof deck and seal against water intrusion.*
- Has been shown to increase wind-uplift capacity of pre-1994 code-minimum wood roof panels by as much as 250–300%.**

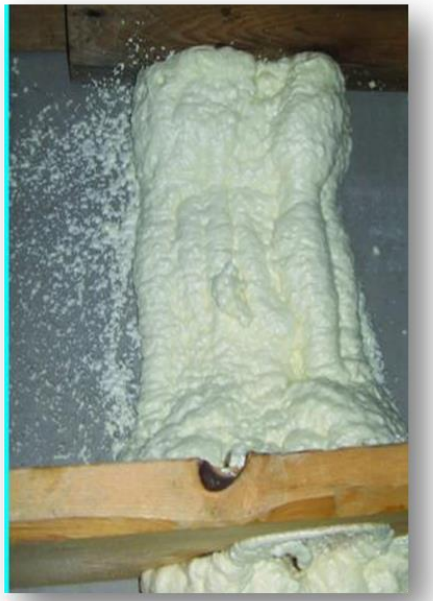
Photo courtesy of FEMA 2010.

*FEMA. 2010. FEMA P-804/December 2010

**Datin, et al, 2011. Journal of Architectural Engineering

Spray Foam for Air Sealing and Inslation

- Critical to unvented attics
- Also used in other cavities
- Foam must be thick enough to avoid condensation.

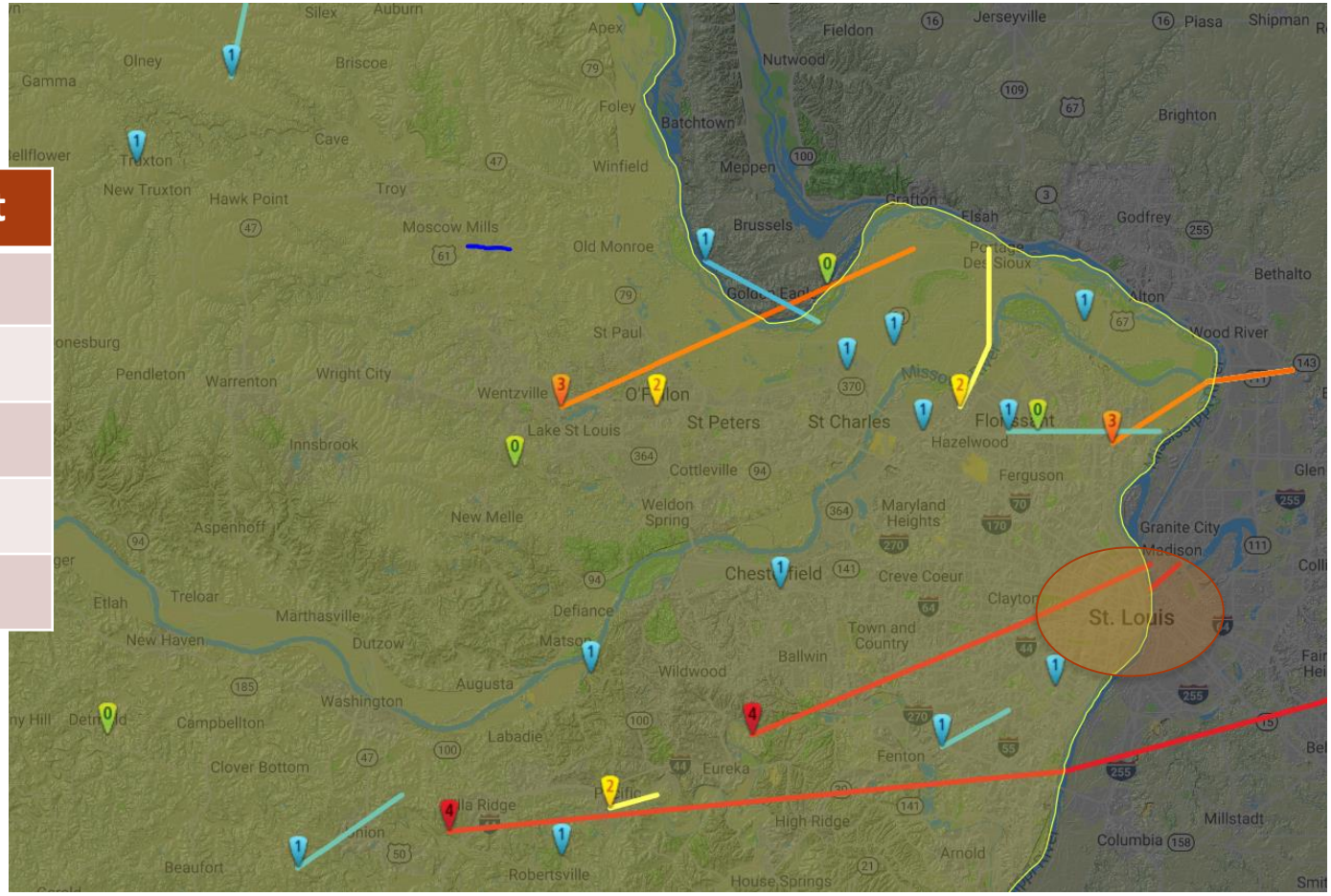


Other Measures

- Exterior rigid foam insulation and ventilated wall cavities
- Conditioned (unvented) crawlspaces
- Overhangs
- Advanced framing
- Use of spray foam insulation in a flood resistant wall system.

Tornados Near St. Louis 1950 - 2016

F or EF	Count
0	4
1	14
2	3
3	2
4	2



Tornadohistoryproject.com

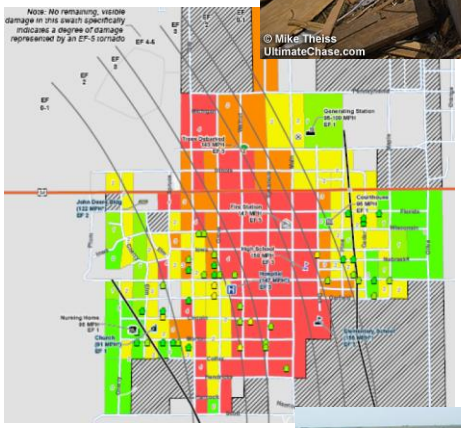
Greensburg, Kansas 2007

- A tornado destroyed or damaged 95% of the homes and The town turned disaster into opportunity with a sustainable rebuild.
- DOE provided resources to help develop and implement this plan.*
- Commercial buildings are saving a combined total of $200,000 in energy costs per year
- 10 wind turbines supply 12.5 megawatts of renewable power to the town

*NREL. Disaster Resiliency and Recovery Example Project: Greensburg, Kansas. https://www.nrel.gov/energy-solutions/greensburg-ks.html

Most High-Wind Guidance is for Hurricanes

- Wind designs developed for building code in hurricane-prone areas would provide protection for nearly all tornados classified EF3 and lower.
- 23 out of 25 tornados in St Louis area were EF3 or less.
- Outer edges of tornados have lower EF ratings.
- In tornado-prone areas, need windborne debris protection because of numerous high speed missiles.

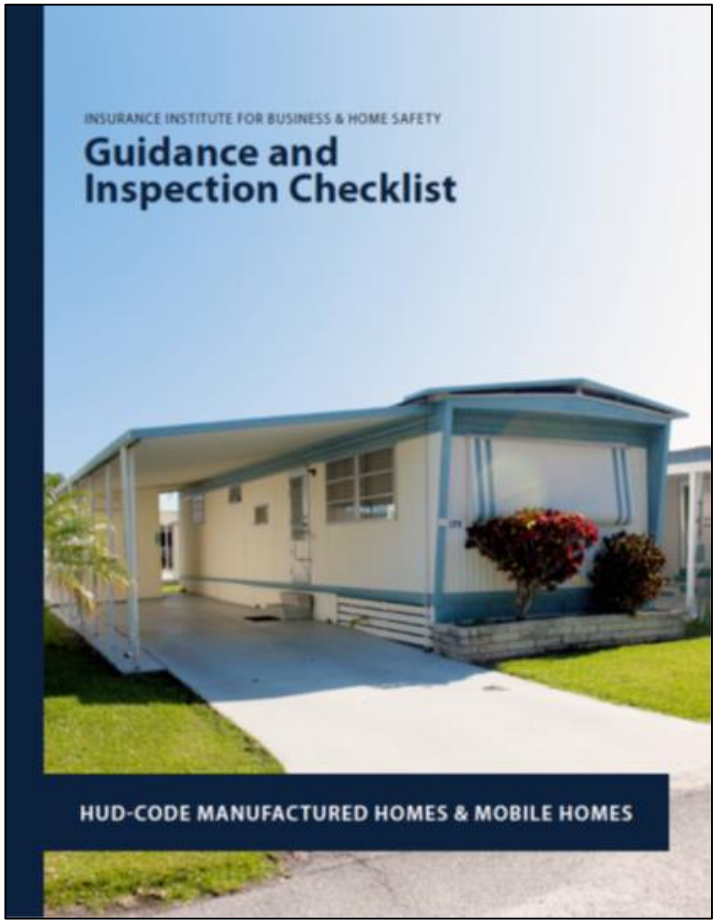


URS Group. 2007. Tornado Damage Investigation Greensburg, Kansas. 169 DR-KS. FEMA

Photo: Mike Theiss, UltimateChase.com, and FEMA

Manufactured Homes

- The damage caused to manufactured homes by EF0, EF1 and most EF2 tornado winds can be greatly reduced*
  - Select homes built to HUD Code Wind Zone III Exposure D
  - Installed on permanent foundations.
- “These homes will actually be considerably stronger than most conventional wood frame housing built in the middle of the country”*
- Never try to ride out a storm inside a HUD Code home.
- Evaluate attached structures for a continuous load path.



*Dr. Tim Reinhold, chief engineer and senior vice president of research, IBHS, 2015.

What's Next

- The Zero Energy Ready Home Program already recommends that builders apply IBHS Fortified Home™ building criteria
- Building America is committed to expanding disaster resistance content in the Building America Solution Center as resources allow
  - Begin to redefine "High Performance"
  - More consistent messaging to builders and remodelers
  - More clear sources of information
- Continue to respond after disasters with expert guidance for reconstruction
- But there may be more we can do by treating advocates of the three Rs as market allies…

Similar Market Barriers

- U.S. mortgage underwriting standards do not enable appraisers and lenders to properly value enhanced efficiency and safety features.*
  - Adoption of numerical scores e.g. HERS and HES
  - Training and certifications for appraisers
  - Energy efficient loans

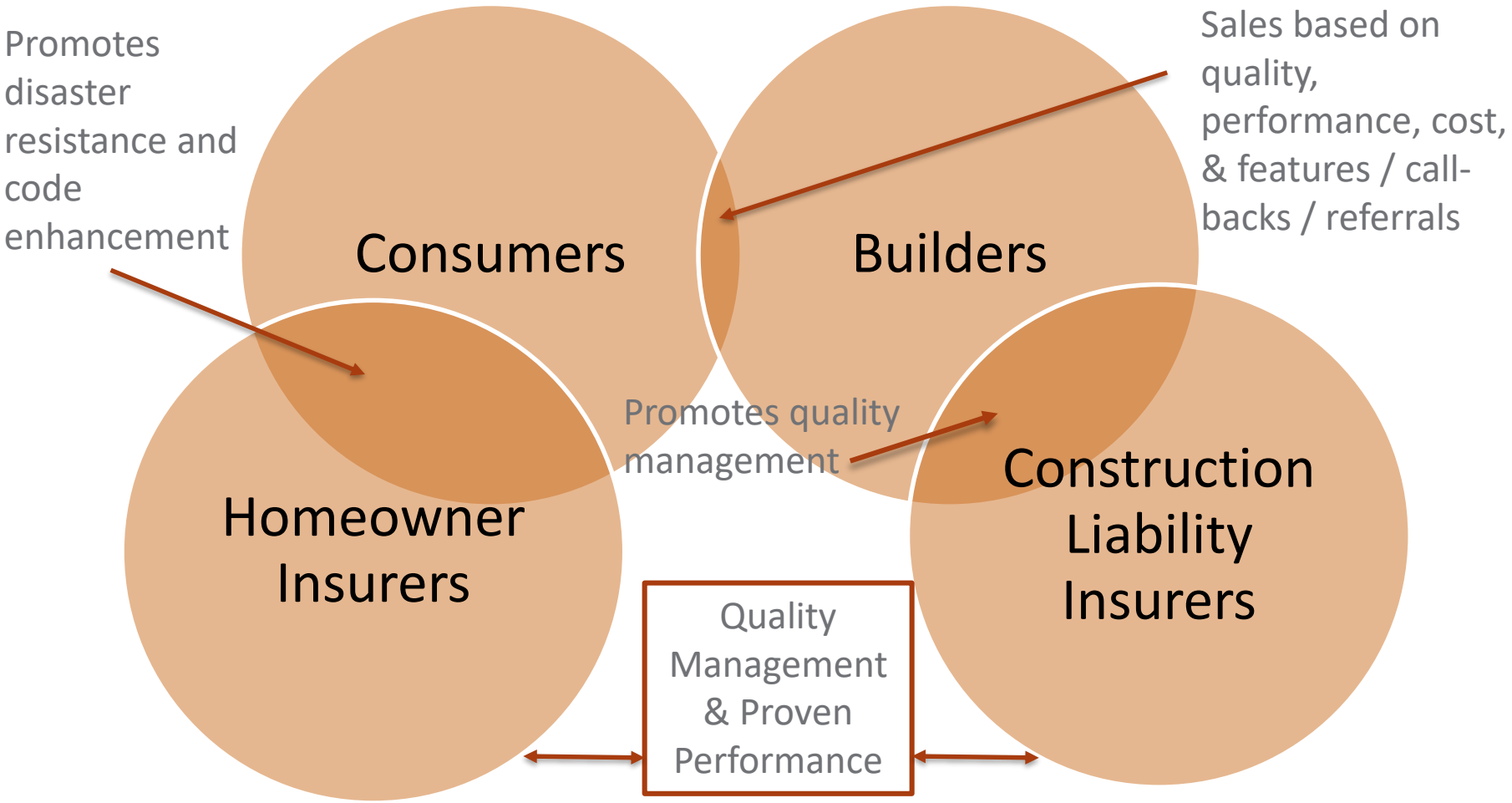
*Vaughn and Turner. Undated. The Value and Impact of Building Codes, IBHS

Developing Building Codes

State	IBHS Score for Safe Residential Construction			Energy / Capita Rank*	IECC Code Versions and Compliance Notes Where Available
	2012	2015	2018		
Texas	18	36	34	6	Based on 2015 IECC. Adopted by 63 large cities and 19 smaller cities. Even in comparison to the new code, only duct sealing and lighting were below 50% compliance. Air sealing was next at 60%.
Mississippi	4	28	28	13	No statewide mandatory code
Alabama	18	26	27	8	Based on 2015 IECC. Not mandatory. Duct sealing, lighting, and air sealing were the only measures below 90% compliance.
Delaware	17	17	17	29	Based on 2012 IECC. Not mandatory.

*EIA, State Total Energy Rankings, 2016, https://www.eia.gov/state/?sid=US

Insurers: Unlocking the Puzzle to Potential Market Allies

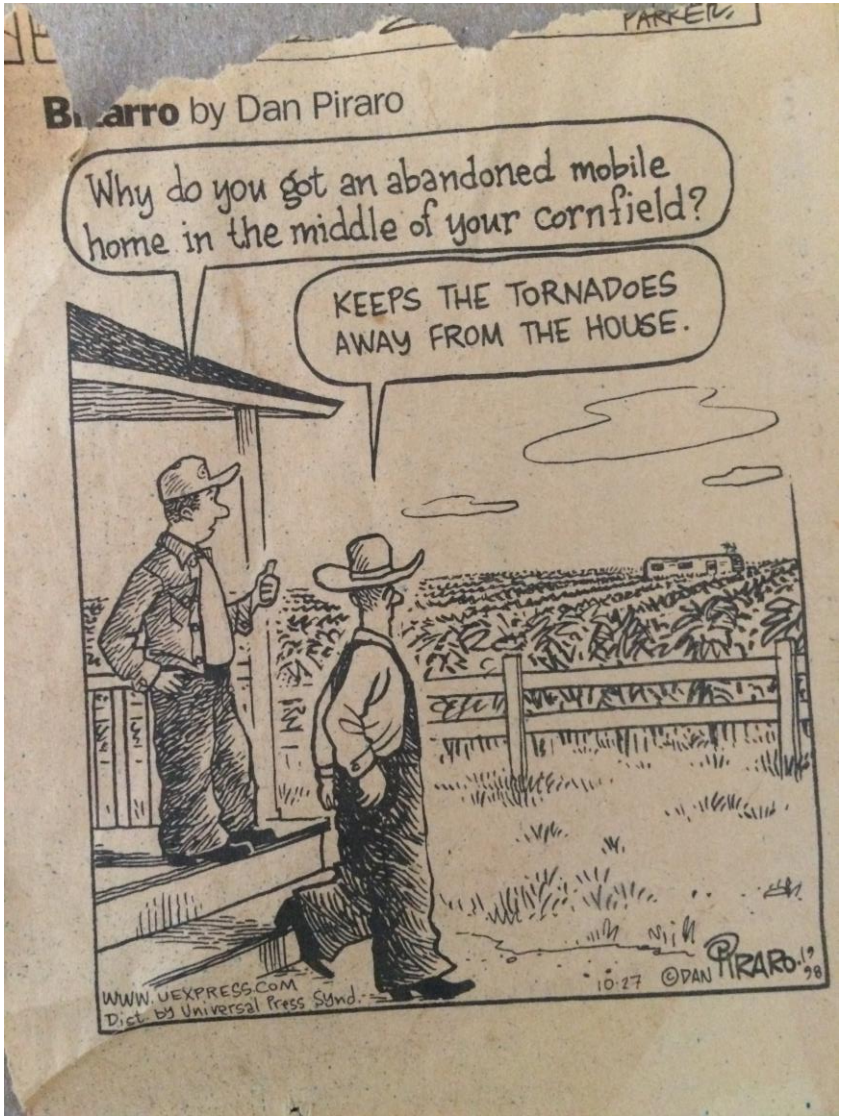


Disaster Recovery Reform Act of 2018

- Code Implementation and Enforcement (Section 1206): Authorizes FEMA to provide assistance to state and local governments for building code and floodplain management ordinance administration and enforcement.
- According to a 2017 National Institute of Building Sciences report, the nation saves six dollars in future disaster costs for every one dollar invested in mitigation activities.

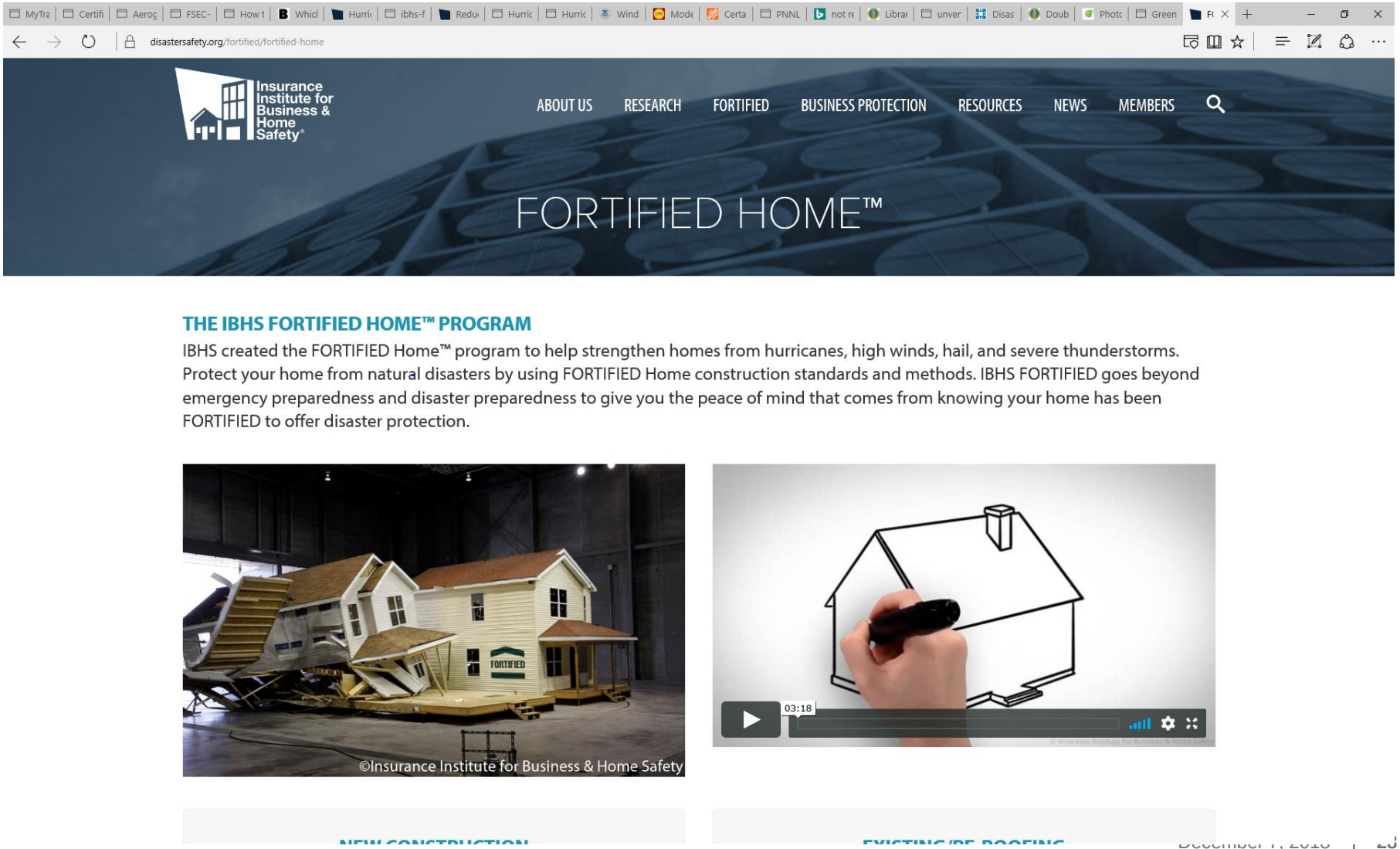
Alternate Strategies

I’ve had this Bizarro cartoon kicking around my office for 20 years.



Check out the Fortifed Home Program https://disastersafety.org/fortified/fortified-home/

Pacific Northwest NATIONAL LABORATORY



World-Class Best Practices…

Michael Baechler: michael.baechler@pnnl.gov
Theresa Gilbride: theresa.gilbride@pnnl.gov
Chrissi Antonopoulos: chrissi.antonopoulos@pnnl.gov

Building America Solution Center

BASC.energy.gov

…At Your Fingertips