Building America webinar

December 17, 2014

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

Building America: Research for Real World Results

ERIC WERLING

Building America Program Coordinator

Building Technology Office

The Past

- Homebuilders Didn't Innovate
- "Consumers Won't Pay for Energy Efficiency"
- Renewable Energy Isn't "Cost Effective"

Recent History

- **Pace of Innovation is picking up**

Building America Innovations

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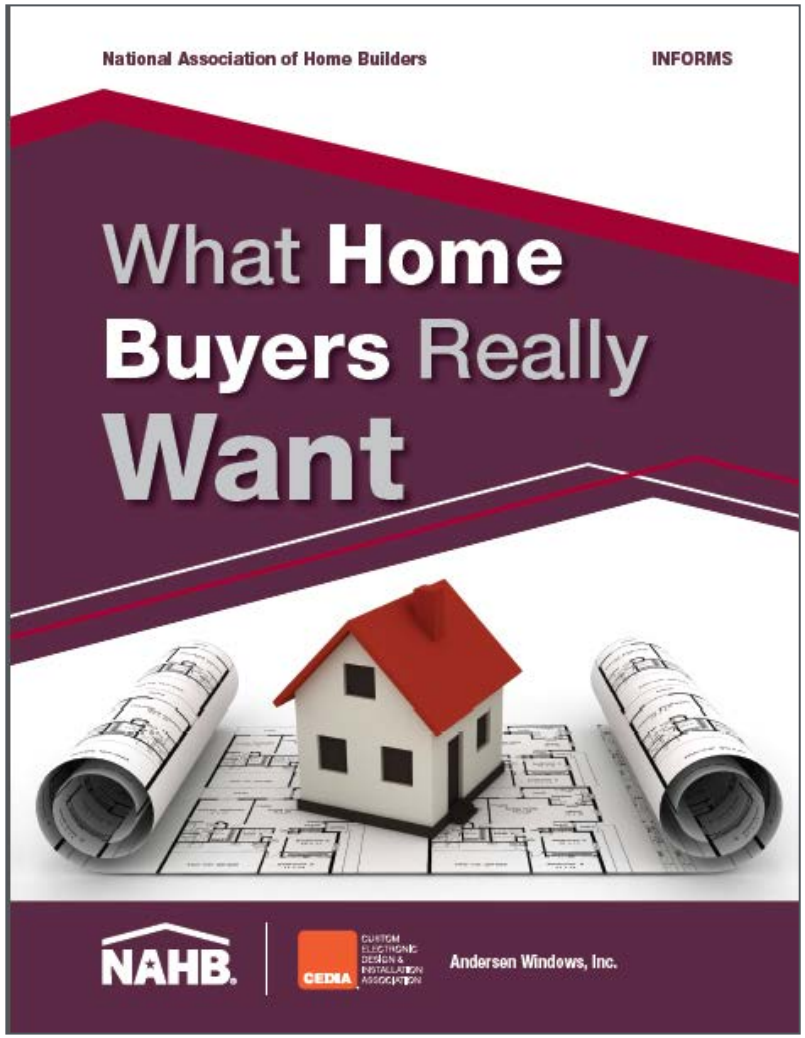
ADVANCED TECHNOLOGIES	HOUSE-AS-A-SYSTEM BUSINESS CASE	EFFECTIVE GUIDANCE AND TOOLS	INFRASTRUCTURE DEVELOPMENT
			
Building Science Solutions	New Homes with Whole-House Packages	High Performance Home Solutions	Educating Professionals
Energy Efficient Components	Existing Homes with Whole-House Packages	High Performance Home Metrics	Recognizing Value in Transaction Process
Assured Health and Safety	Whole-House Program Support	Research Tools	Informing Codes and Standards

Recent History

- **Pace of Innovation is picking up**

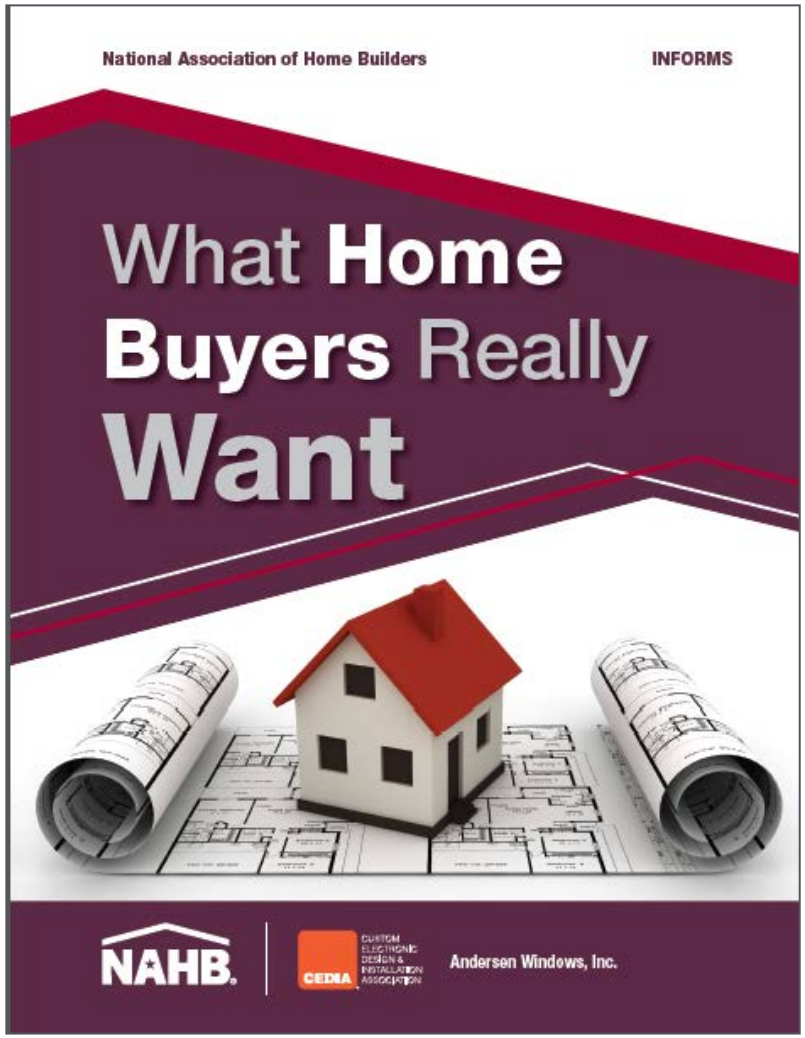
- **Consumers are now demanding "Green" and energy efficiency**

Recent NAHB Report...



"Most buyers want an energy efficient home, and on average would pay an additional $7,100 up front if it would save them $1,000 a year in utility costs."

Recent NAHB Report...



Of more than 120 features rated as "essential/must have," "desirable," "indifferent," or "do not want," a total of **11 are wanted** (i.e. rated essential or desirable) **by 85 percent or more of home buyers**. This "most wanted" list includes **three features dealing with Energy-star ratings**, two in the kitchen, and two in the bathroom. Energy-star rated appliances appear at the top, followed closely by the laundry room.

Recent History

- **Pace of Innovation is picking up**

- **Consumers are now demanding "Green" and energy efficiency**

...

- **PV costs are going down fast**

>half way to 2020 goal

We Are On The Path To …

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What Does Success Look Like?

- **Net Zero Homes** become common place
- Builders offer extended **Warranties** (>30 years)
- All housing **Trades offer Energy Efficiency** services
- **"House Doctor"** businesses emerge
- **Home Asset Management** businesses emerge
- Americans pay for **Preventative Maintenance** for their Homes

Economic Impact

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~$2,200: Average Annual Household Energy Bill

>113,000,000: Housing Units in America

>$240 Billion: Amount spent on home utility bills per year.

if we make our houses 50% more efficient

>$120 Billion: Available to the economy

Opportunity

- **>100 Million Homes**
- **Jobs** (millions of U.S. housing jobs)
- **Energy Independence** (NZE Homes use No foreign energy)
- **Clean Air & Healthier Households** (we spend >60% indoors)

How Can Uncle Sam Help?

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

Innovation Pipeline	Guidance & Tools	Improved Infrastructure	Market Recognition
Building America R&D Roadmap	Building America Solution Center	Building Science Education	Zero Energy Ready Homes
New Construction	Program Specifications	Sales Communication	Student Design Competition
Existing Home Improvement	Risk Management Tools	Market Valuation	Partner Recognition
		Codes & Standards	

How Can Uncle Sam Help?

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

Innovation Pipeline	Guidance & Tools	Improved Infrastructure	Market Recognition
Building America R&D Roadmap			
New Construction			
Existing Home Improvement			

Long Term Goals

- New Homes Goal

  Demonstrate at scale market-relevant strategies for *new* homes offering savings of 50% or more by 2025

- Existing Homes Goal

  Demonstrate at scale market-relevant strategies offering existing home savings of:

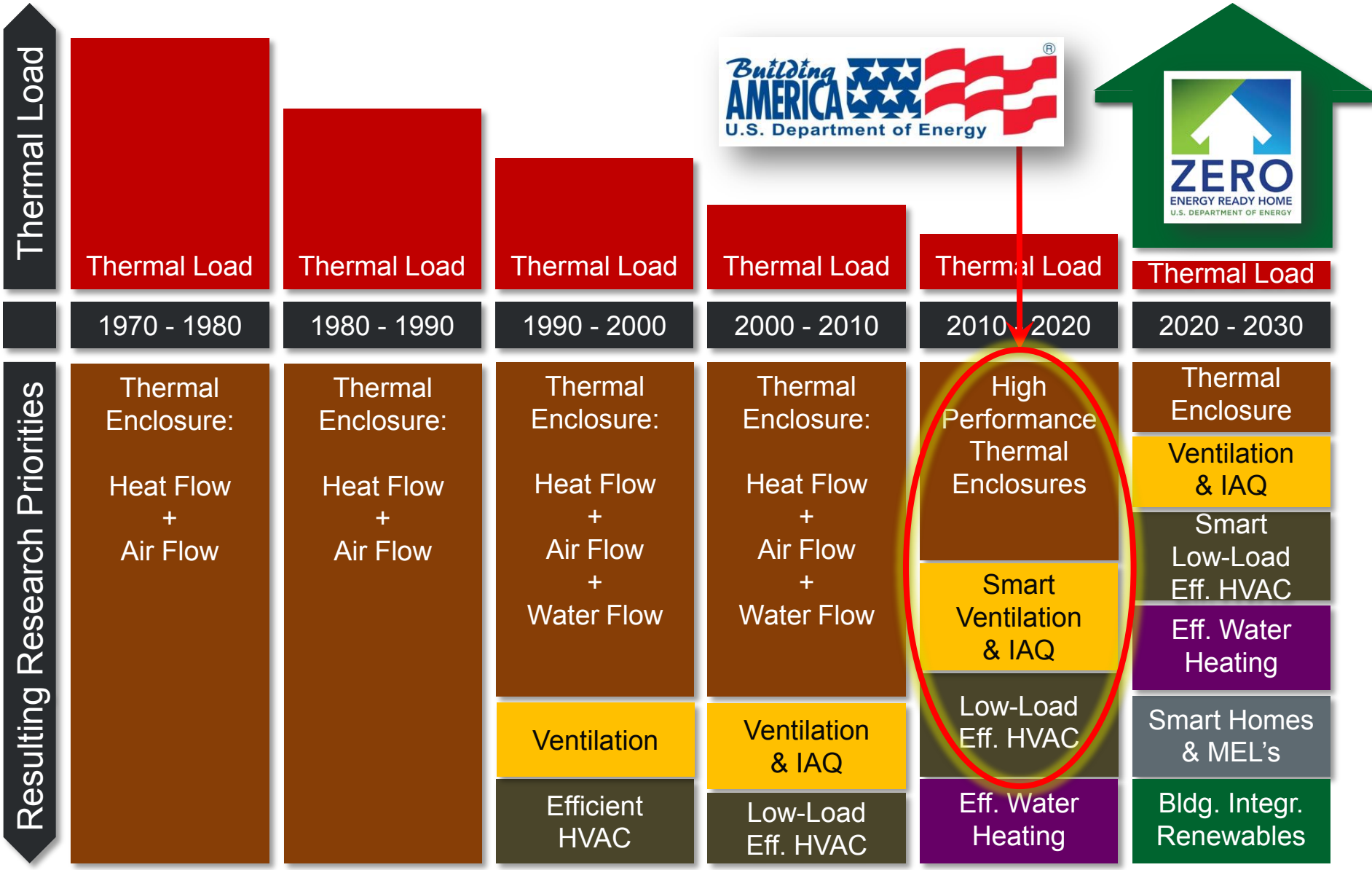
  – 20% or more by 2020

  – 25% or more by 2025, and

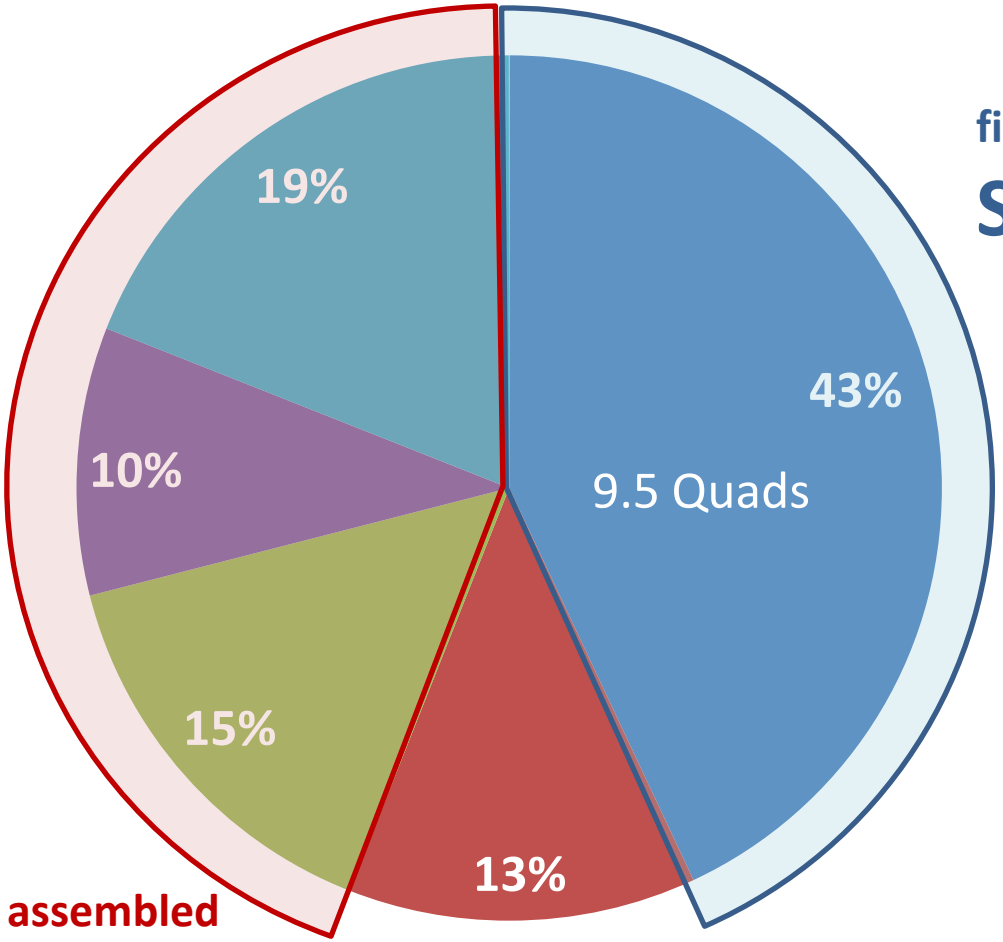
  – 40% or more by 2030

Building America R&D Roadmap

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



U.S. Residential Buildings
Primary Energy Consumption (22 Quads)*



field assembled

Systems

- Comfort (Envelope & HVAC)
- Water Heating
- Other Appliances
- Lighting
- Misc. End Uses

Building AMERICA
U.S. Department of Energy

factory assembled

Products

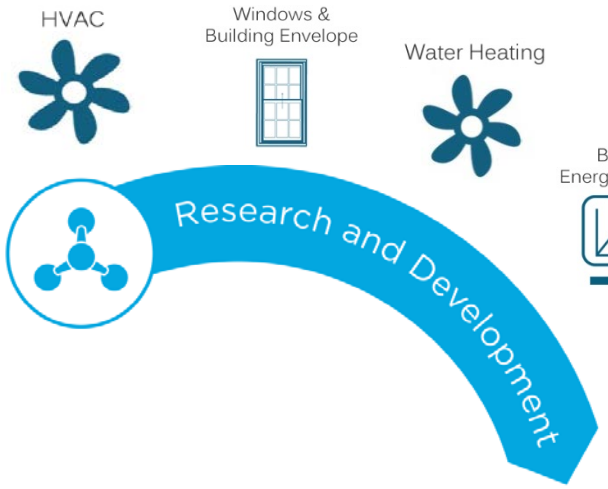
* Source: U.S. EIA

New Building America R&D Strategy

"v2"

- Focused on reducing heating & cooling energy use in new & existing homes (highest impact end use)
- RD&D of low-risk, high performance envelopes, optimized HVAC systems, & IAQ solutions
- FY15-17 FOA's: new Building America Industry Teams will demonstrate solutions in real world houses
- New detailed strategic roadmaps will link Building America strategy to BTO Ecosystem
- Stakeholder Meetings will refine strategic roadmaps and leverage industry commitment for impact

BTO Ecosystem



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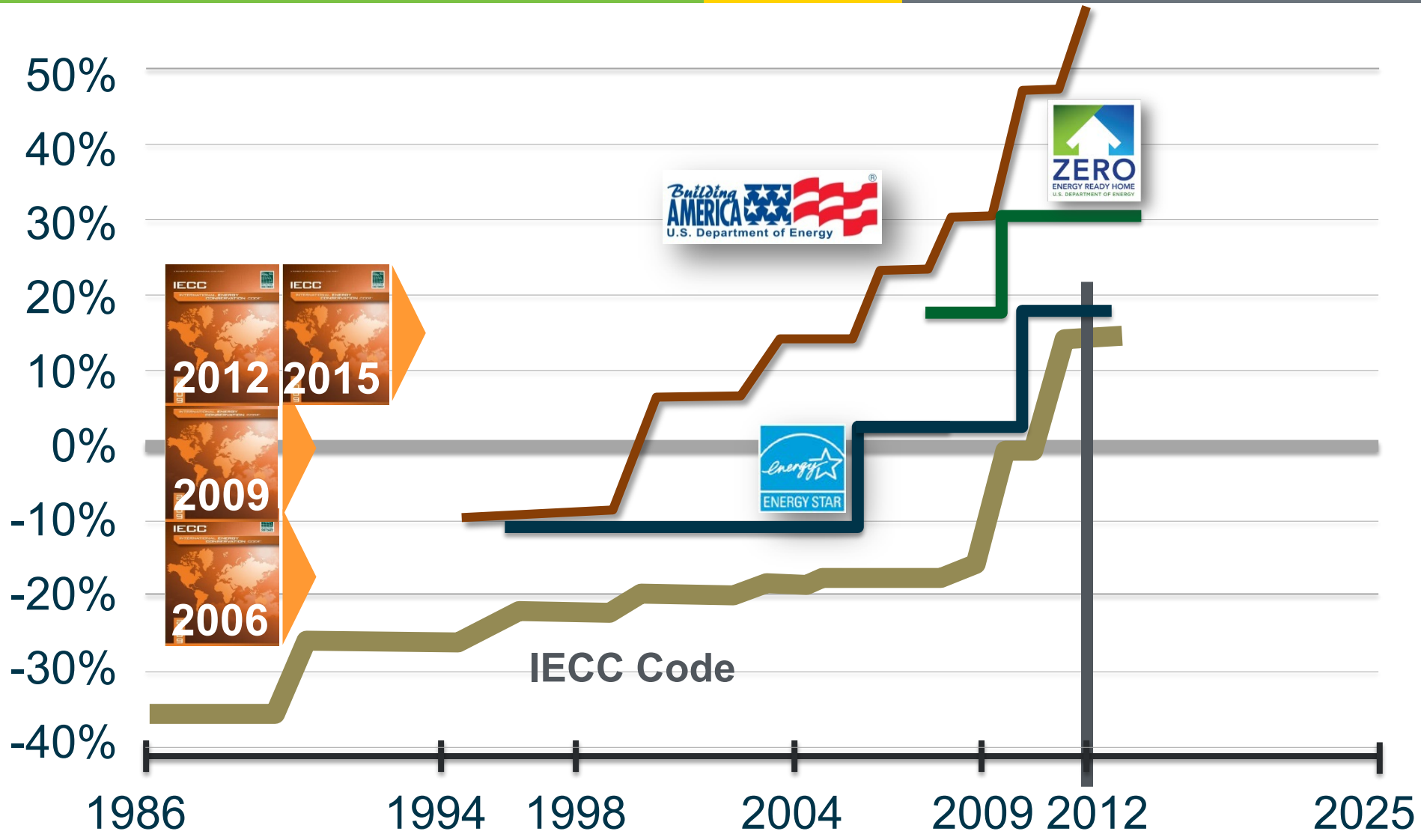
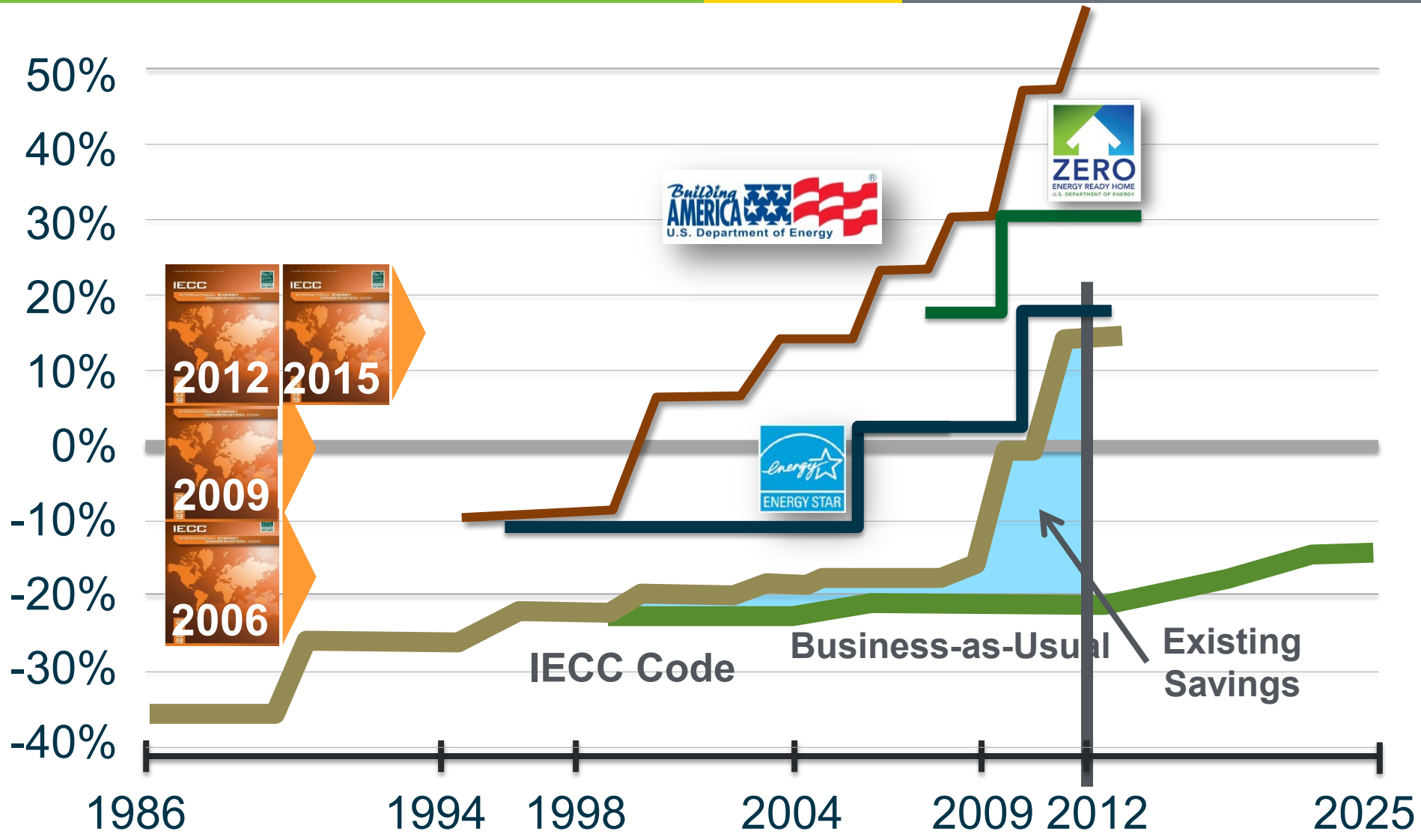
BTO Ecosystem

BTO Ecosystem in Action



BTO Ecosystem in Action

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



* Which ultimately sets the bar for future existing homes infrastructure

BTO Ecosystem in Action

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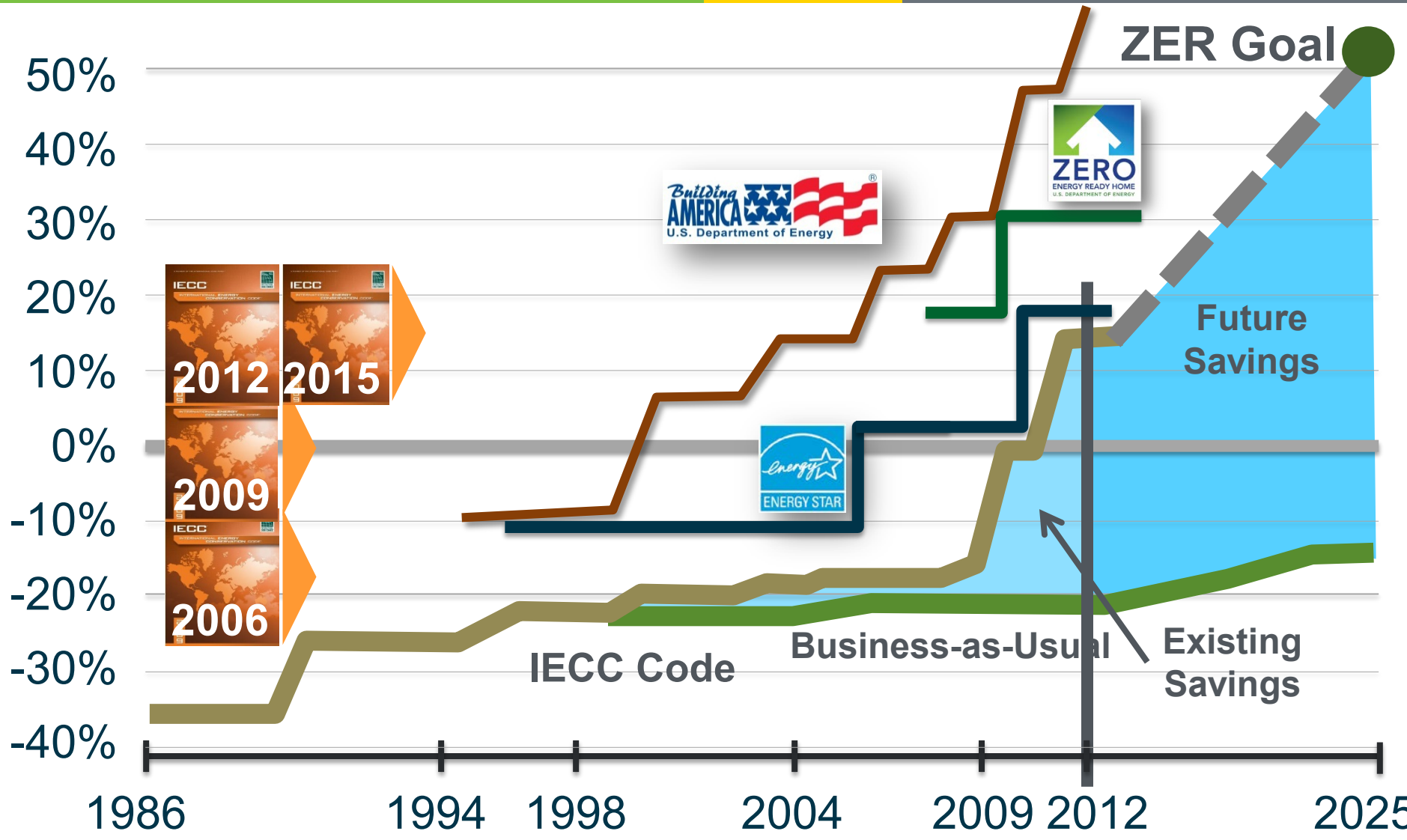
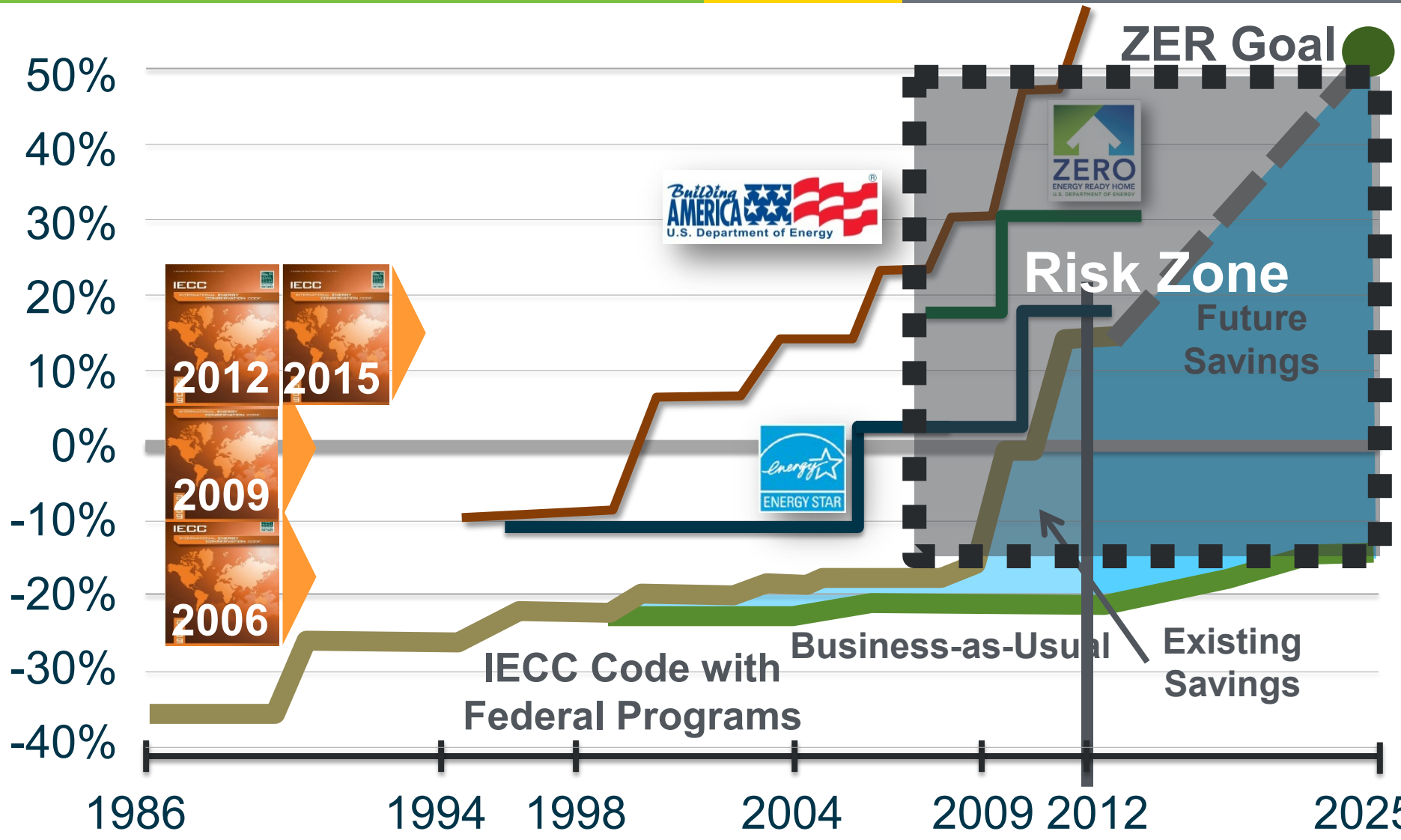


* Which ultimately sets the bar for future existing homes infrastructure

But Wait!!



* Which ultimately sets the bar for future existing homes infrastructure

Greater Risk of Building Failures

Energy Efficient New and Existing Homes…

- **Are More Likely to Stay Wet**
  Increased insulation levels and air tightness can elevate risk of condensation and substantially limit drying potential inside building assemblies

- **Have Lower Airflow & Higher Indoor RH**
  Lower loads reduce air flow, increase latent load, extend swing seasons

- **Need Assured Adequate Fresh Air**
  Added air tightness demands improved source control, dilution, and filtration

If these performance issues are not solved, energy efficient homes will have comfort and durability problems, builders will not go further than current code, and future energy code advancement will be prevented.

Energy Efficient New and Existing Homes with …

Moisture Managed High-R Envelopes

- Are Less Likely to Stay Wet
  High performance homes with increased insulation, reduced infiltration, reduced risk of condensation, & adequate drying potential inside building assemblies

Optimized Low-Load Comfort Solutions

- Effectively Manage Airflow & Indoor RH for Comfort
  High efficiency comfort systems for homes with low thermal loads, including optimal efficiency, managed air flow and RH control at all part load conditions

Smarter Indoor Air Quality Solutions

- Control Fresh Air Supply & Contaminant Removal
  Added tightness with improved source control, dilution, and high efficiency filtration, with little or no energy penalty

High Performance Thermal Enclosures

A. HIGH PERFORMANCE, MOISTURE MANAGED ENVELOPE SOLUTIONS

High-R assemblies are the largest potential home energy saving measures (heating & cooling loads are nearly 50% of home energy use). But high-R without assured performance increases moisture risk. Current solutions are expensive or unfamiliar to industry and some solutions are limited by IRC code barriers (fire, structural).

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STRATEGIC ROADMAPS

I. Envelope System Moisture Risk Management

II. High Performance Envelope Solutions

Roadmap Objectives:

- Codes and standard practice as endpoints
- Tools & guidance to help industry manage risks & minimize problems of adoption for high performance envelopes
- Address optimal performance, cost-effectiveness, & buildability
- Address codes & standard barriers to adoption of high performance envelope systems in new and existing homes

Low-Load Eff. HVAC

B. OPTIMAL COMFORT SYSTEMS FOR LOW LOAD HOMES

Installed performance of HVAC systems, especially distribution system effects and latent performance, is typically sub-optimal, which is a critical risk in low-load homes; duct system & RH optimization are not "owned" by manufacturers or required by codes/standards, & current solutions are labor intensive and/or expensive.

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STRATEGIC ROADMAPS

I. Optimal HVAC System Design Standards

II. HVAC Equipment Gaps for Low Load Homes

<u>Roadmap Objectives:</u>

- Industry Standards, Codes & New Technologies as Endpoints
- Priority Issues/Barriers to Address:
  - High performance HVAC system solutions needed for low load homes
  - HVAC system standards don't adequately address indoor RH and airflow
  - HVAC system design, installation and maintenance faults lead to 20-70% system degradation
  - Current state of the art design standards rarely used & labor intensive
  - HVAC performance measurement technology limited and expensive

Smart Ventilation & IAQ

C. OPTIMAL VENTILATION SYSTEMS & IAQ SOLUTIONS FOR LOW LOAD HOMES

Basic ventilation has become standard in some areas, but current solutions are limited (climate, controls, sources, costs) & standards do not help optimize either IAQ or energy performance; significant IAQ risks remain, especially in low-load homes & envelope retrofits.

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STRATEGIC ROADMAPS

I. Targeted Pollutants/Non-Dilution Solutions

II. Smart Ventilation Technology Solutions

III. IAQ Valuation & Equivalence in Standards

Roadmap Objectives:

- Industry Standards, Codes & New Technologies as Endpoints
- Priority Issues to Address:
  - Health effects of PM2.5 exposure is high, while control technologies & standards are missing/limited (i.e., kitchen range hoods & advanced filtration)
  - Current state of the art ventilation technologies limited in flexibility for energy & DR management, do not adequately address RH & airflow, and are expensive
  - Combustion safety testing standards are expensive & can lead to both false negatives & false positives for health risks
  - Industry ventilation standard limited in flexibility, doesn't adequately address sources, RH & airflow, and is not universally adopted by building codes

FY16 Strategy Development Plan

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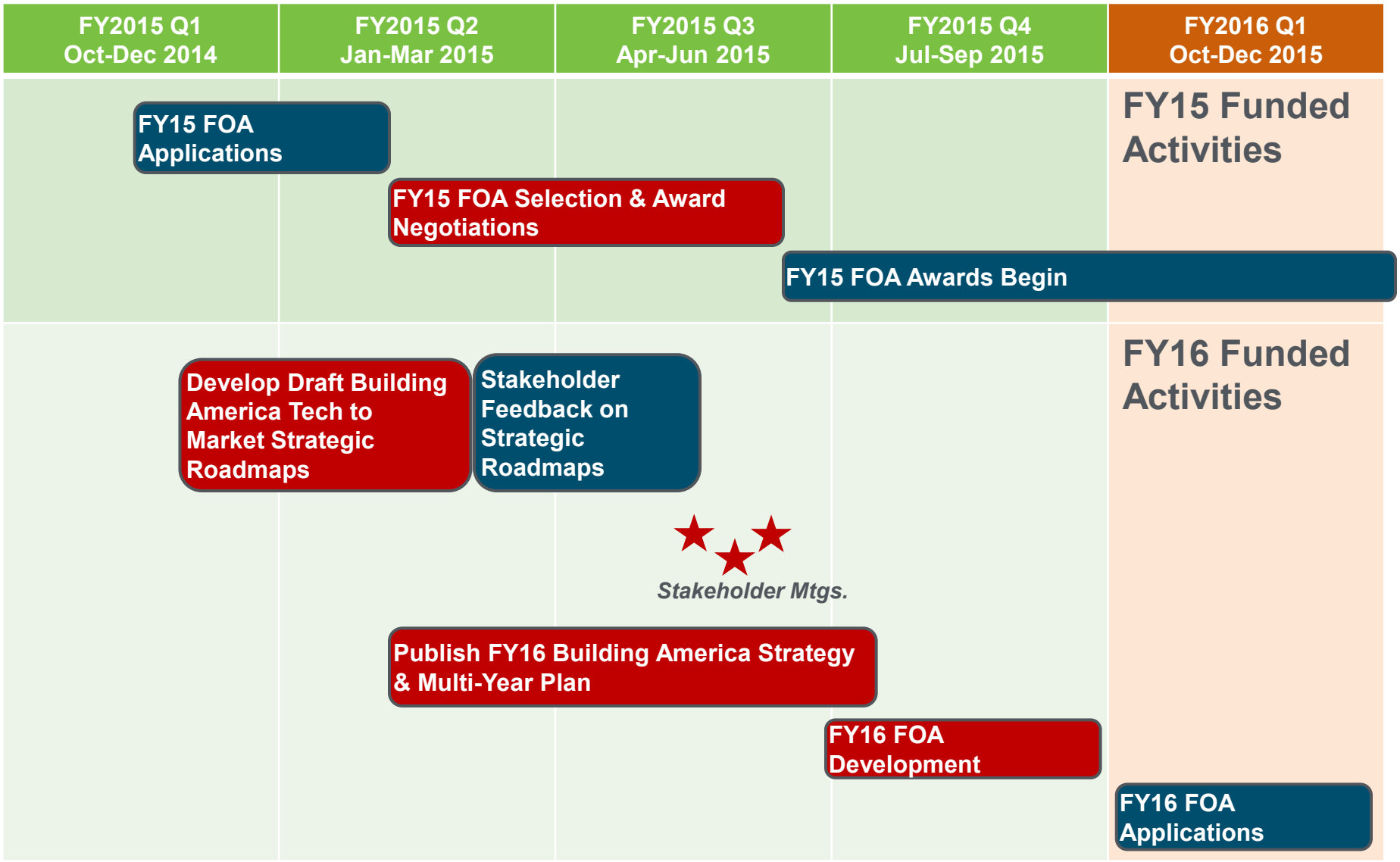

Building America Planned FOA Schedule (subject to appropriations)

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	FY2015				FY2016				FY2017				FY2018				FY2019			
Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
NREL contract down select (FY15 bridge-funding)	$ High-R																			
	$ Comfort																			
	$ IAQ																			
	FOA15			FY15 FOA Award #1																
				FY15 FOA Award #2, etc.																
					FOA16			FY16 FOA Award #1												
								FY16 FOA Award #2												
								FY16 FOA Award #3, etc.												
									FOA17			FY17 FOA Award #1								
												FY17 FOA Award #2								
												FY17 FOA Award #3, etc.								

Notes:

1. All FOA's are fully funded up front
2. No. of awards each year will depend on award negotiations and budget.

How Can Uncle Sam Help?

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

Innovation Pipeline	Guidance & Tools	Improved Infrastructure	Market Recognition
Building America R&D Roadmap			
New Construction			
Existing Home Improvement			

New Homes: a Clear Path to Zero

- ***Emerging Technologies*** & manufacturers develop advanced materials and component technologies
- ***Appliance Standards*** increase required efficiency for major home equipment
- ***Building America*** demonstrates early adoption of optimized integrated systems (i.e., Envelope & HVAC), using market ready technology
- Energy Star & ***Zero Energy Ready Home*** programs accelerate adoption, through market stimulation
- ***Building Energy Code*** advancement locks in proven whole house savings at scale

A Market Transformation System

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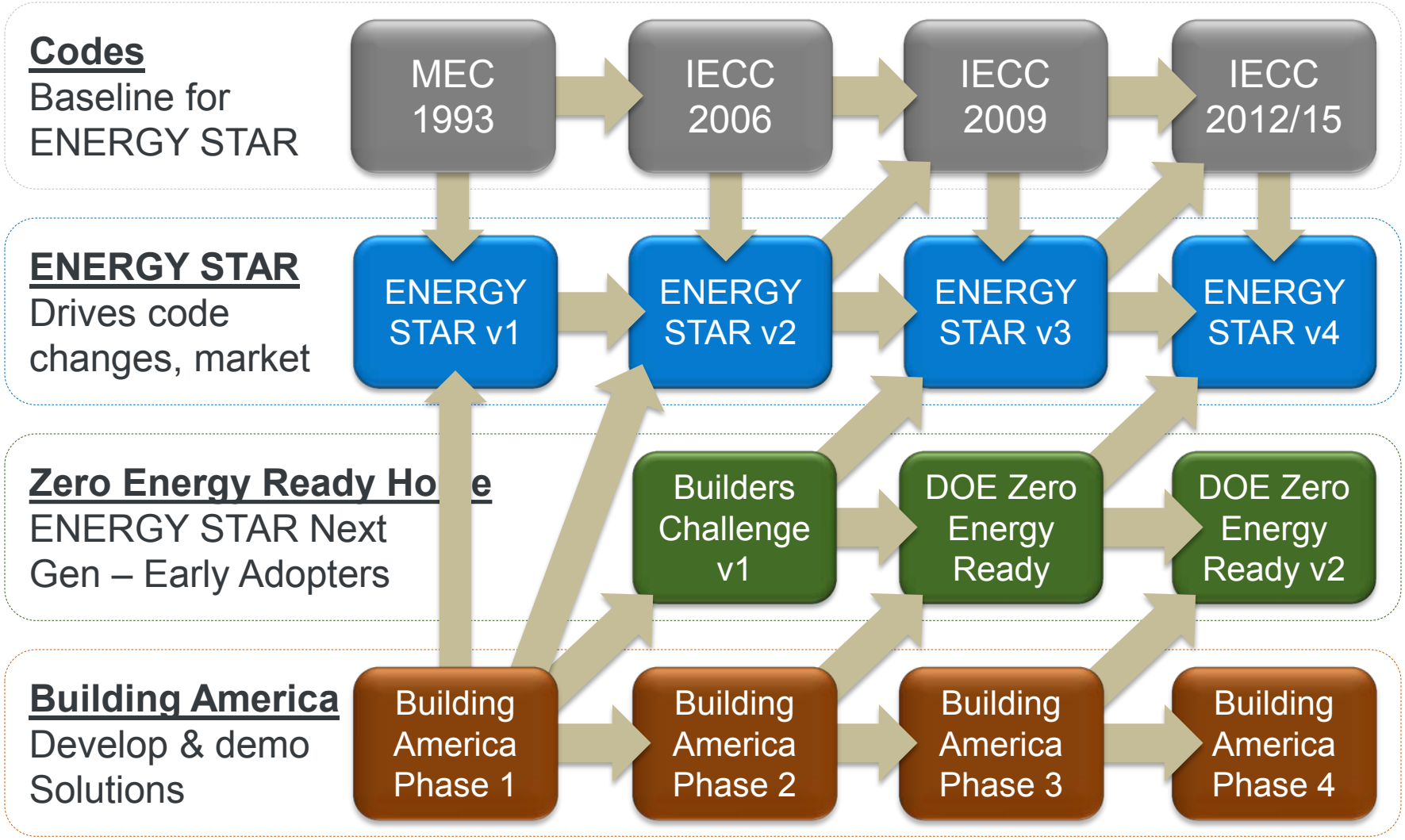


Zero Energy Ready Home Spec

Optimized Enclosure

Risk Management:

Optimized Comfort System

Complete Water Protection

Comprehensive IAQ System

Zero Differentiation:

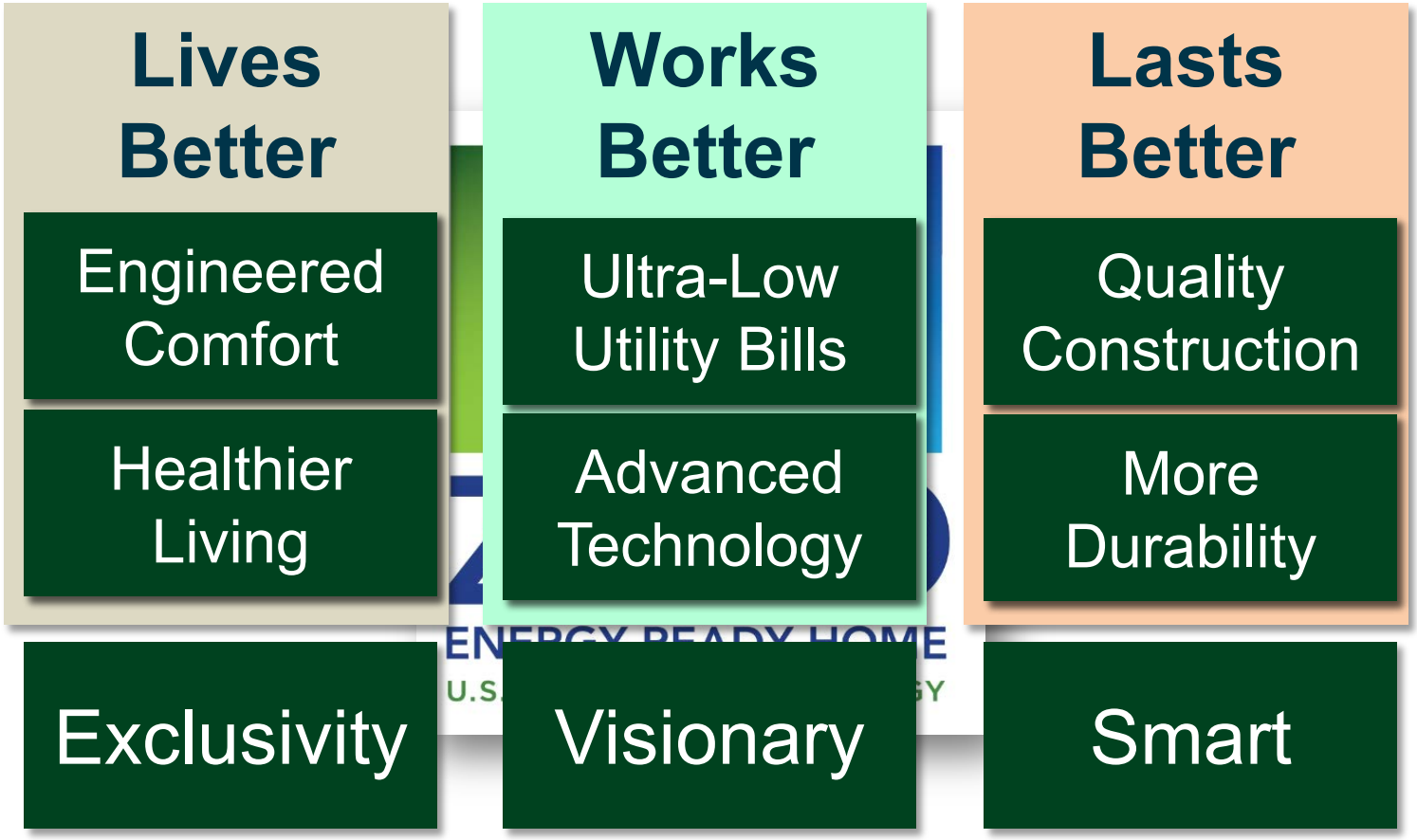
Efficient Components

Solar Ready Construction

Zero Energy Ready Home Defined

High-performance home, so **energy efficient,** all or most annual energy consumption can be offset by renewable energy.

Zero Energy Ready Home Value



ZERH Value is Clear

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Front Cover | Inside Spread | Flap | Back Cover

ZERH Value is Clear: the details

New Town Builders
Lives Better: **Healthful Environment**

- Fresh Air:
  - Supply Fresh Air System
  - Odor and Moisture Control Fans
  - High-Capture Filtration Technology
- Quiet:
  - Quiet Window Technology
  - Quiet Wall Technology
- Moisture Control:
  - Dry-by-Design Construction
  - Moisture Control System – Whole House
  - Moisture Controlled Comfort System
  - Moisture Controlled Windows
  - Moisture Controlled Lower Level
- Pest Control:
  - Bug Control Barrier
  - Pest Screened Home
- Outdoor Contaminant Control:
  - Contaminant Sealed Construction
  - Contaminant Sealed Comfort Delivery
  - Dust and Pollen Barrier
  - Radon Controlled Home
- Chemical Control:
  - Formaldehyde Controlled Home
  - VOC Controlled Home
- Fume Control:
  - Carbon Monoxide Controlled Equipment
  - Carbon Monoxide Controlled Fireplace
  - Fume Controlled Garage

ZERH Value is Clear & Simple!

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How Can Uncle Sam Help?

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Innovation Pipeline	Guidance & Tools	Improved Infrastructure	Market Recognition
Building America R&D Roadmap			
New Construction			
Existing Home Improvement			

What's Next?

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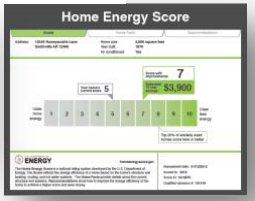
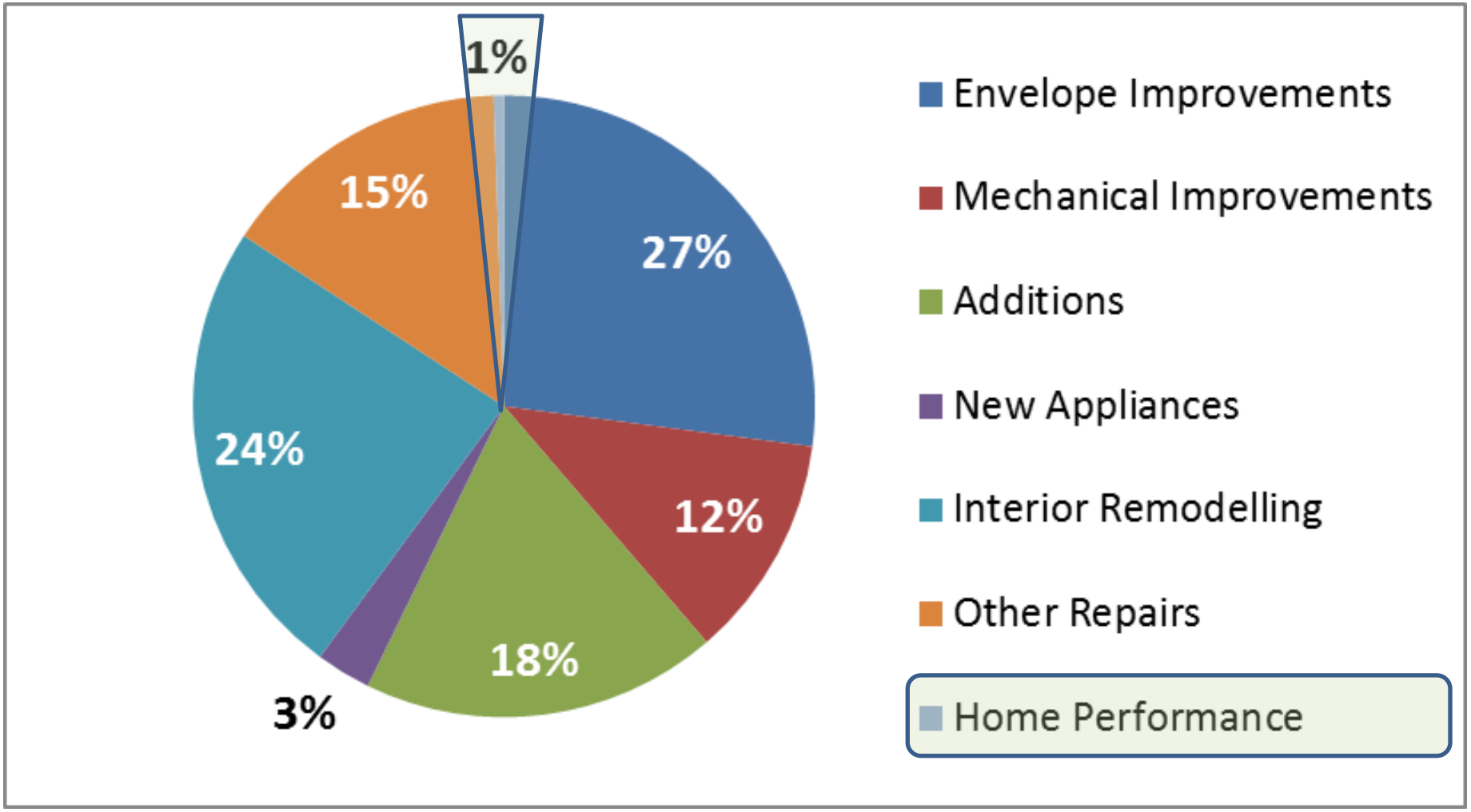
Better Buildings NEIGHBORHOOD PROGRAM U.S. DEPARTMENT OF ENERGY

HOME PERFORMANCE WITH ENERGY STAR



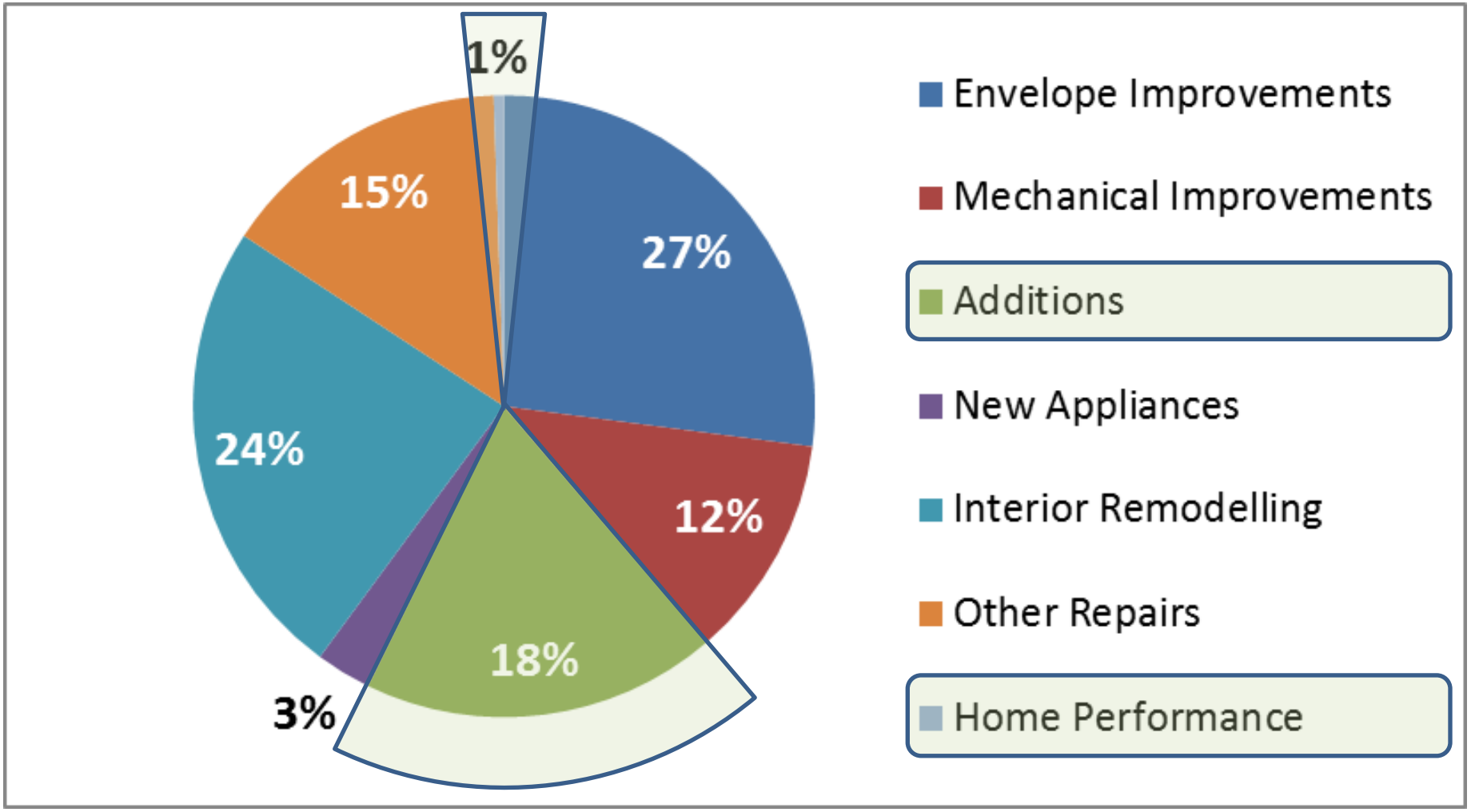
Home Improvement Industry Annual Revenues by Project Type



Existing homes path is not so clear

- We need a better link between New Construction technology advancement and existing home deployment – Remodeling **Additions** are the home improvement sector that provides a direct link.
- EPA Energy Star for Homes is the obvious starting point…
- But, **Additions** are still <20% of the Home Improvement market activity

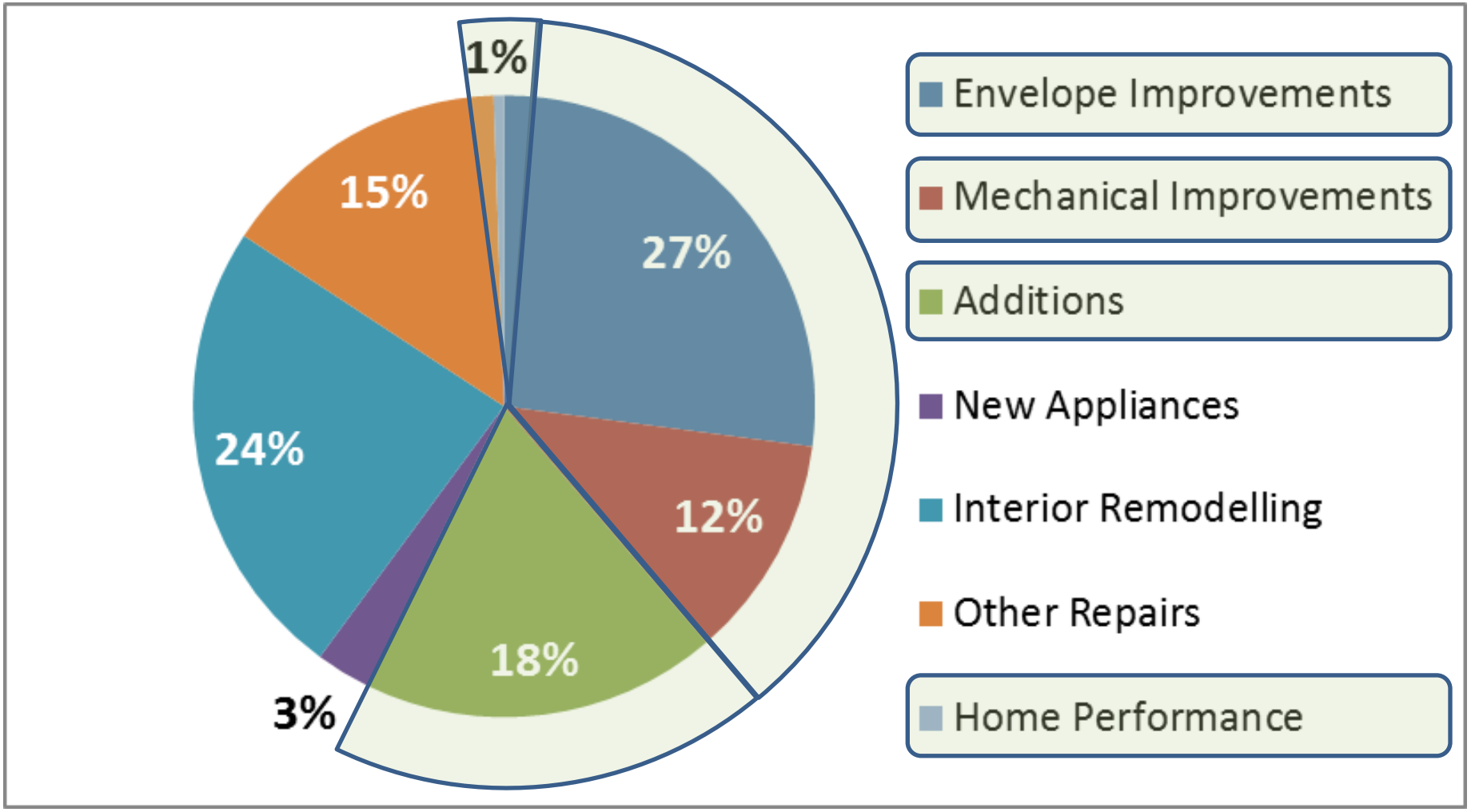
Home Improvement Industry Annual Revenues by Project Type



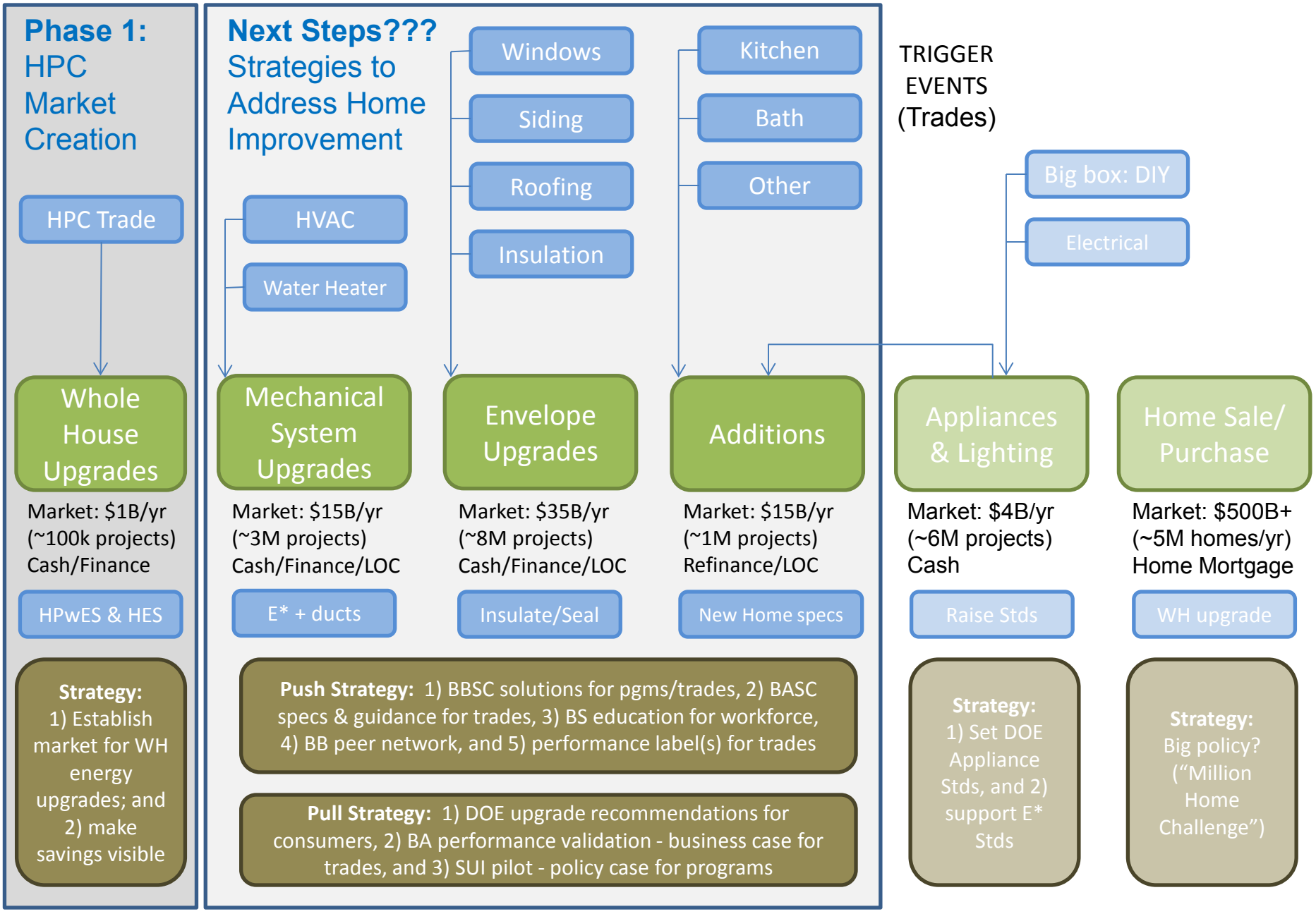
Existing homes path is not so clear

- We should also figure out how to improve home energy efficiency during these common transactions:
  - HVAC Replacements & Repairs
  - Envelope Improvements

Home Improvement Industry Annual Revenues by Project Type



Next Steps for Existing Homes?



How Can Uncle Sam Help?

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

Innovation Pipeline	Guidance & Tools	Improved Infrastructure	Market Recognition
	Building America Solution Center		
	Program Specifications		
	Risk Management Tools		

World-Class Expert Guidance…

Building America Solution Center

BASC.energy.gov

…At Your Fingertips

BASC Component Explorer

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Walls/Openings
- Water Managed Walls
- Minimum Thermal Bridging
- Insulation
- Air Sealing
- Fully Aligned Air Barriers

Fully Aligned Air Barriers
- Behind Showers and Tubs
- Behind Fireplaces
- Attic Knee Walls
- Skylight Shaft
- Walls Adjoining Porch
- Double Walls
- Garage Rim/Band Joist

BASC Guide: Attic Knee Wall

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Solution Center Home
Component Explorer
Checklist Manager
Building Science Explorer
Browser
- Guides
- CAD Files
- Case Studies
- Image Gallery
- References

Attic Knee Walls

Please Register or Login to Provide Feedback.

Scope | Description | Ensuring Success | Climate | Training | CAD | Compliance | More Info.

Scope

Fully Aligned Air Barrier

A. Install a top and bottom plate or blocking at the top and bottom of all knee wall cavities.
B. Back attic knee walls with a rigid air barrier or other supporting material to prevent insulation from sagging and create a continuous thermal barrier*
C. Seal all seams, gaps, and holes of the air barrier with caulk or foam.
D. Install insulation without misalignments, compressions, gaps, or voids in all knee wall cavities.

* ENERGY STAR recommends using a rigid air barrier, but it is not a requirement.

Notes:

MOBILE FIELD KIT

The Building America Field Kit allows you to save items to your profile for review or use on-site.

Sign Up
or
Log In

Scope: Clearly defines and bounds the topic in a way builders and remodelers can contractually obligate their subcontractors.

BASC Guide: Attic Knee Wall

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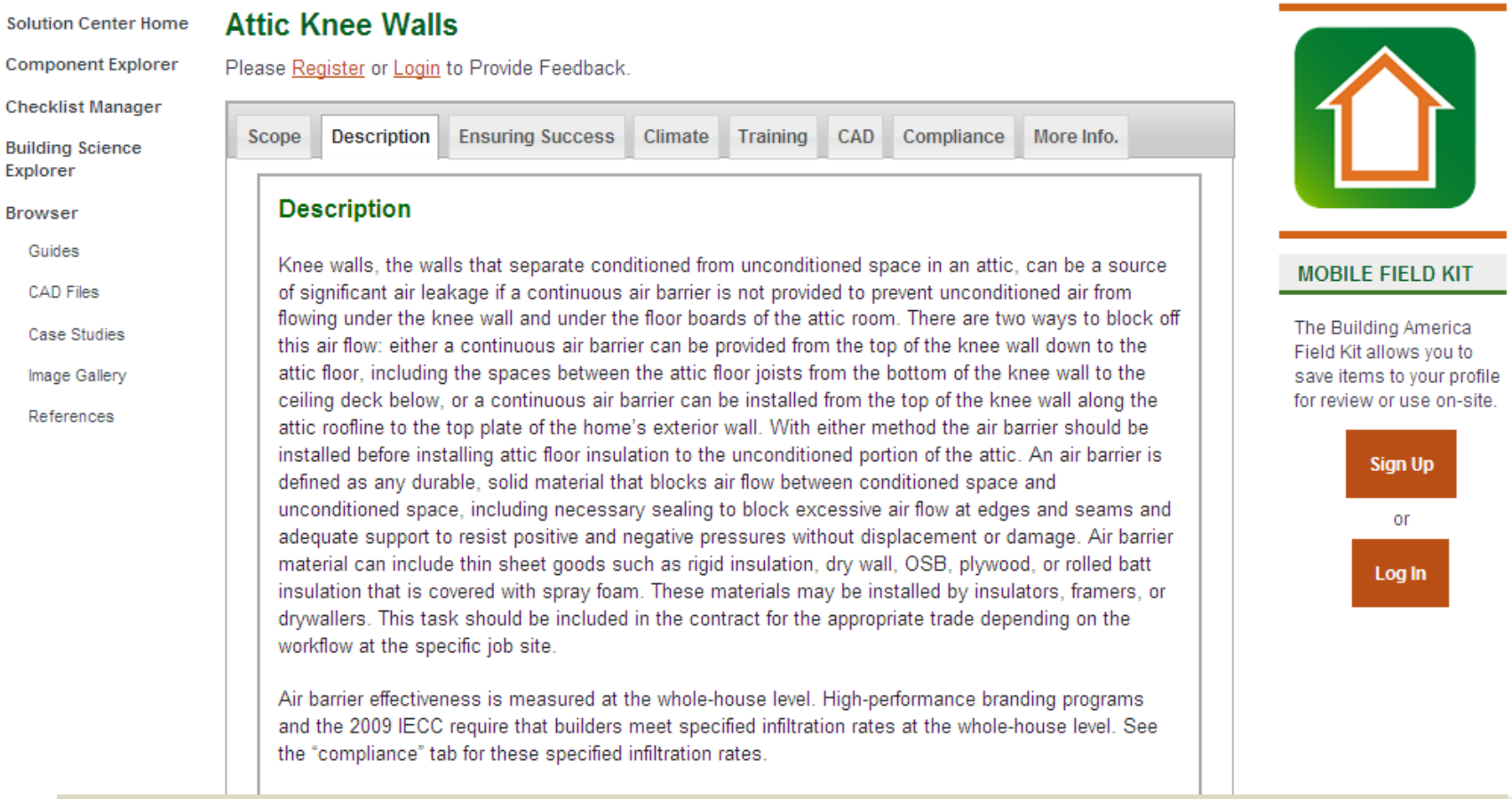

Description: Provides an explanation of the building topic and in some cases specific "how-to" implementation steps.

BASC Guide: Attic Knee Wall

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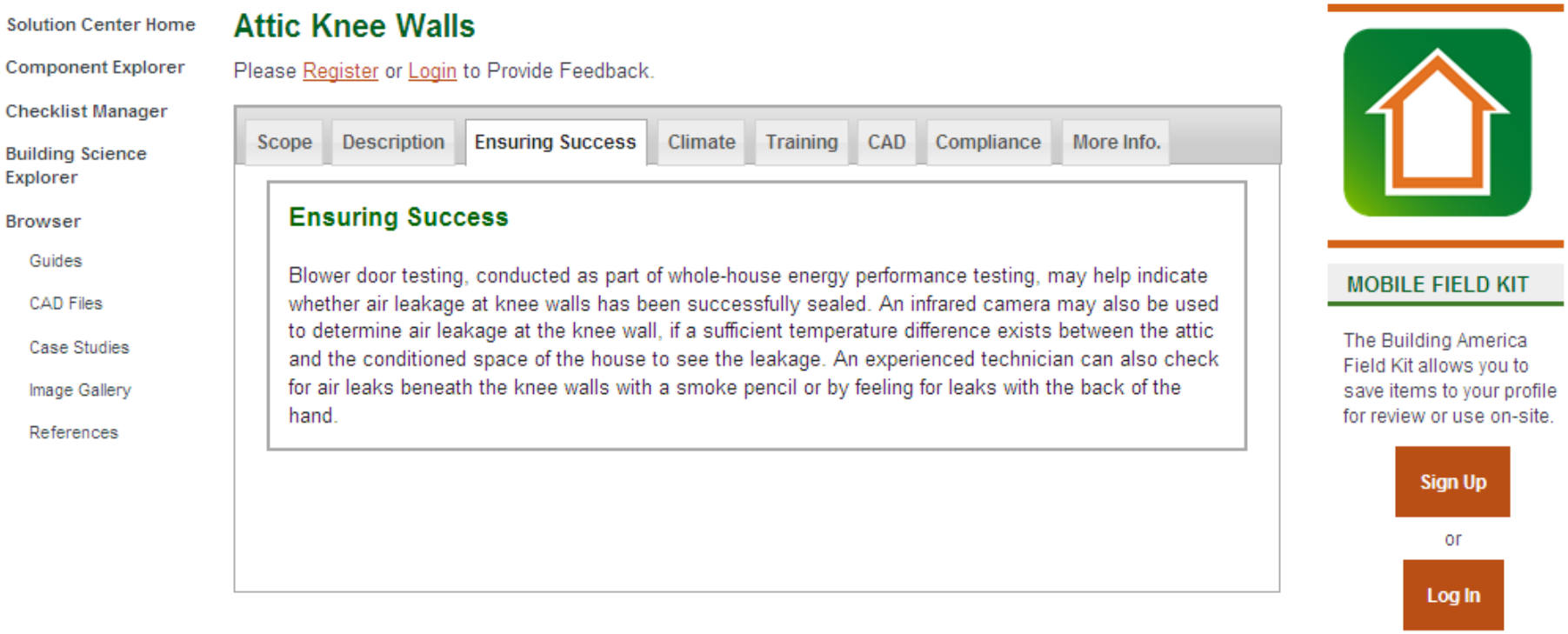


Ensuring Success: Related health, safety, durability, performance issues, test-in/test-out requirements, and scheduling and sequencing considerations.

BASC Guide: Attic Knee Wall

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

Solution Center Home
Component Explorer
Checklist Manager
Building Science Explorer
Browser
- Guides
- CAD Files
- Case Studies
- Image Gallery
- References

Attic Knee Walls

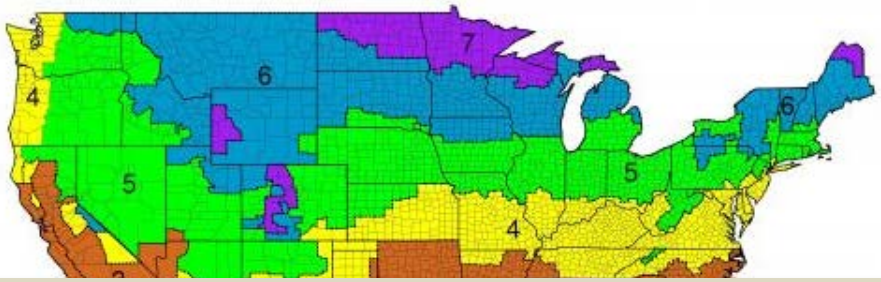
Please Register or Login to Provide Feedback.

Scope | Description | Ensuring Success | Climate | Training | CAD | Compliance | More Info.

Climate

ENERGY STAR Version 3, (Rev. 6)
Thermal Enclosure Checklist, Fully-Aligned Air Barriers. A complete air barrier shall be provided that is fully aligned with the insulation at exterior surface of walls in all climate zones; and also at interior surface of walls for Climate Zones 4-8.

DOE Challenge Home
Exhibit 2: DOE Challenge Home Target Home. Infiltration (ACH50): Zones 1-2: 3; Zones 3-4: 2.5; Zones 5-7: 2; Zone 8: 1.5. Envelope leakage shall be determined by an approved verifier using a RESNET-approved testing protocol.



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Climate: Climate-specific codes, standards, ENERGY STAR, and Challenge Home guidance.

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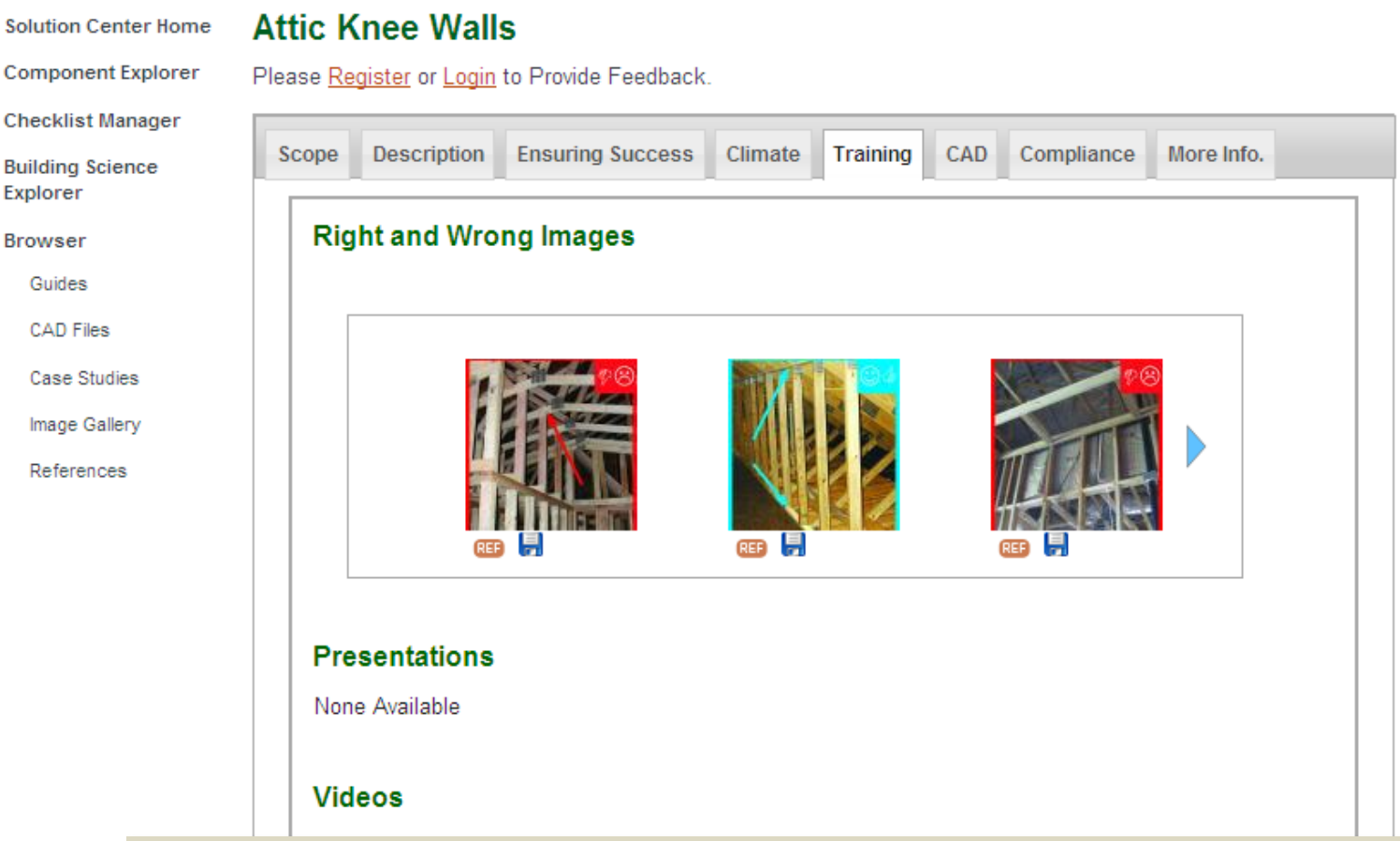

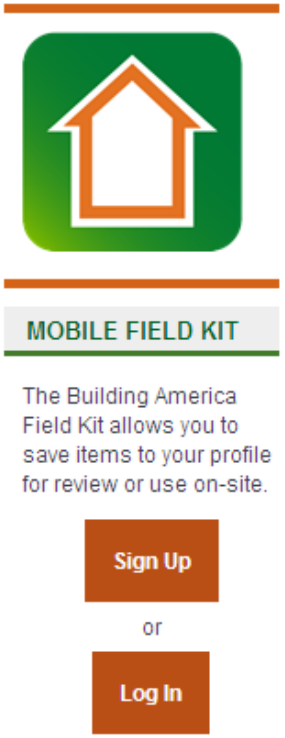

Training: resources such as Right and Wrong/ Sequencing installation images.

COMING: Videos and presentations

BASC Guide: Attic Knee Wall

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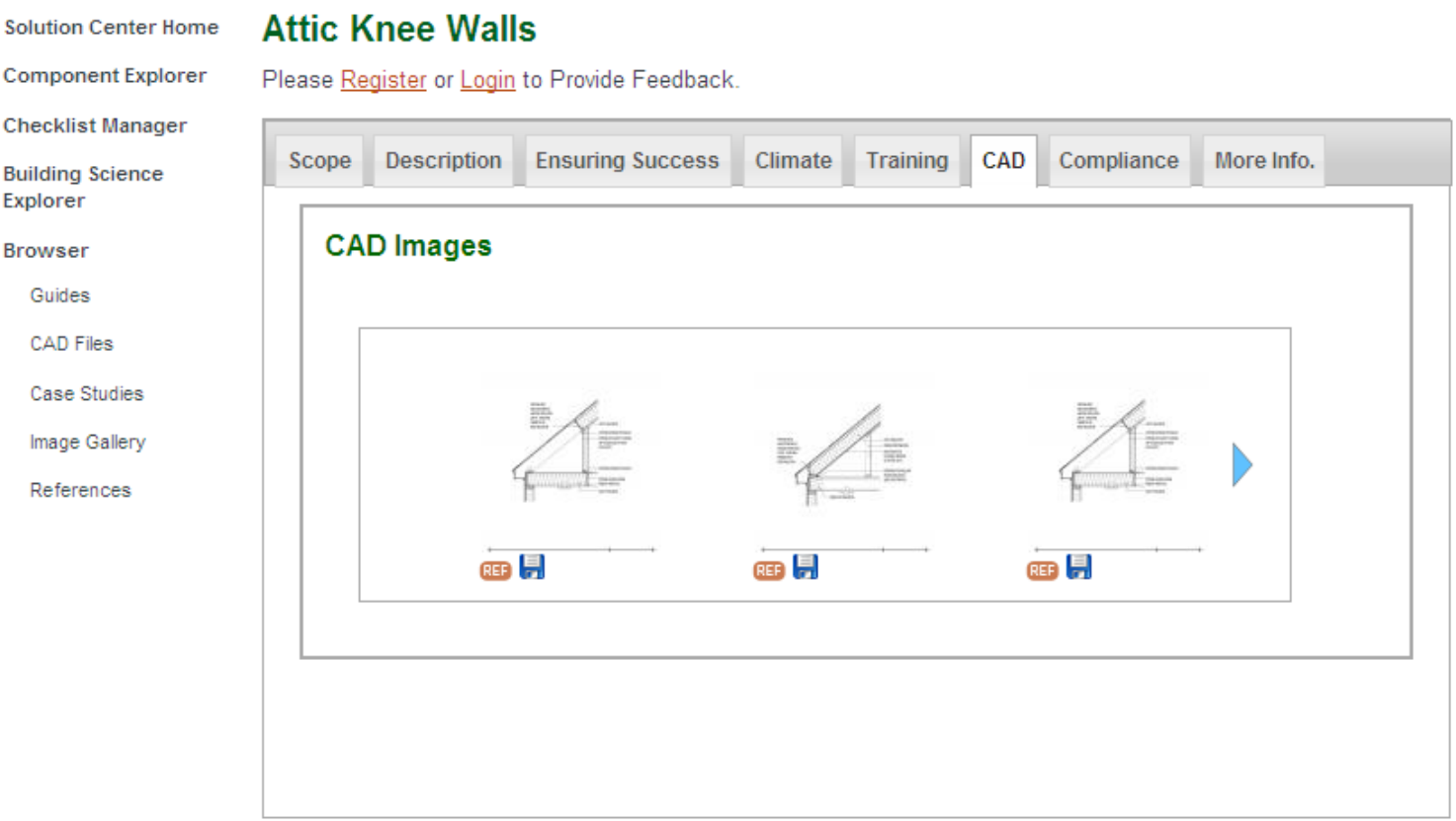

CAD: Architectural CAD files of the building topic in DWG and PDF forms.

BASC Guide: Attic Knee Wall

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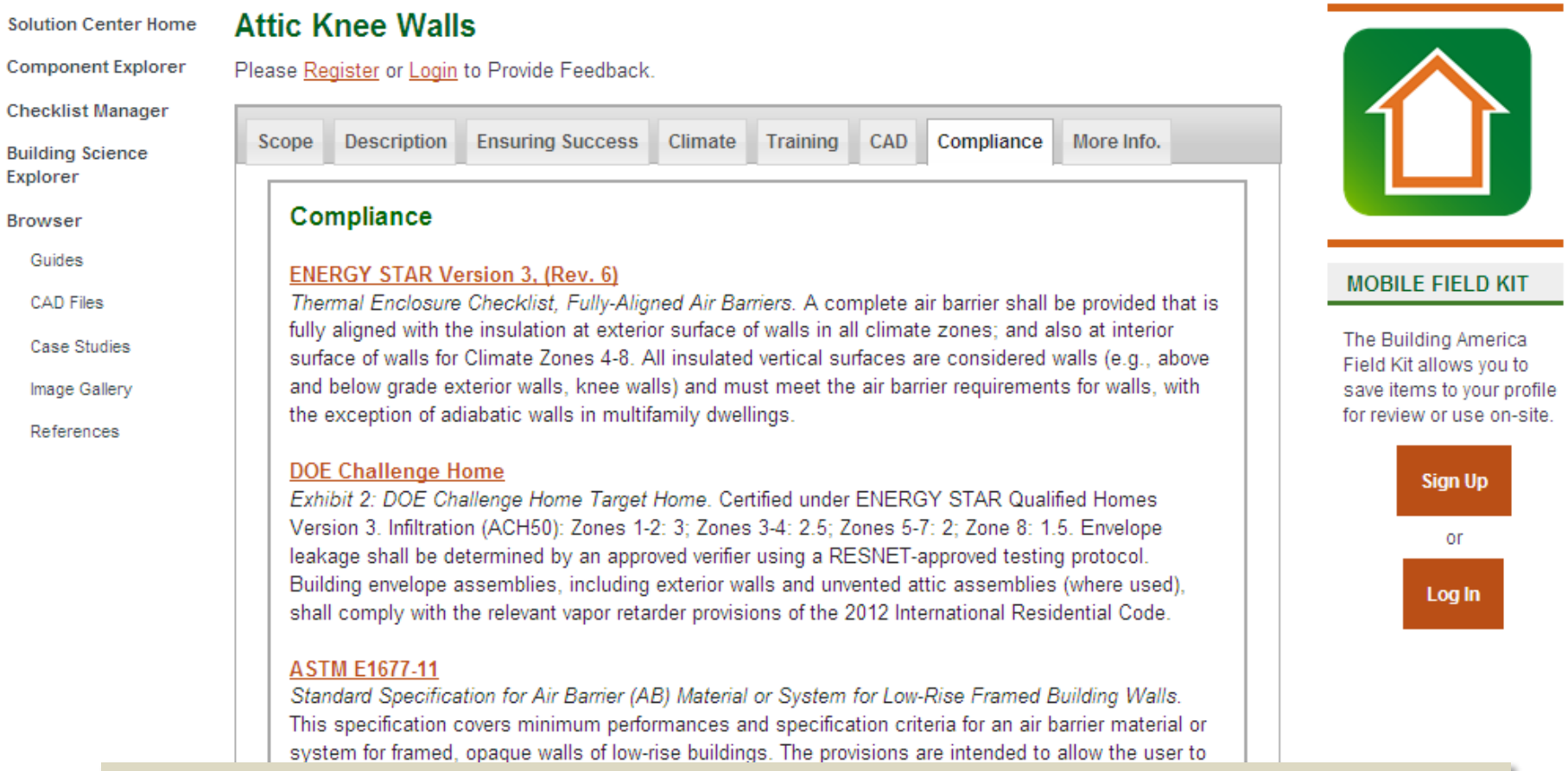

Compliance: Specific compliance references/links from applicable codes and standards.

BASC Guide: Attic Knee Wall

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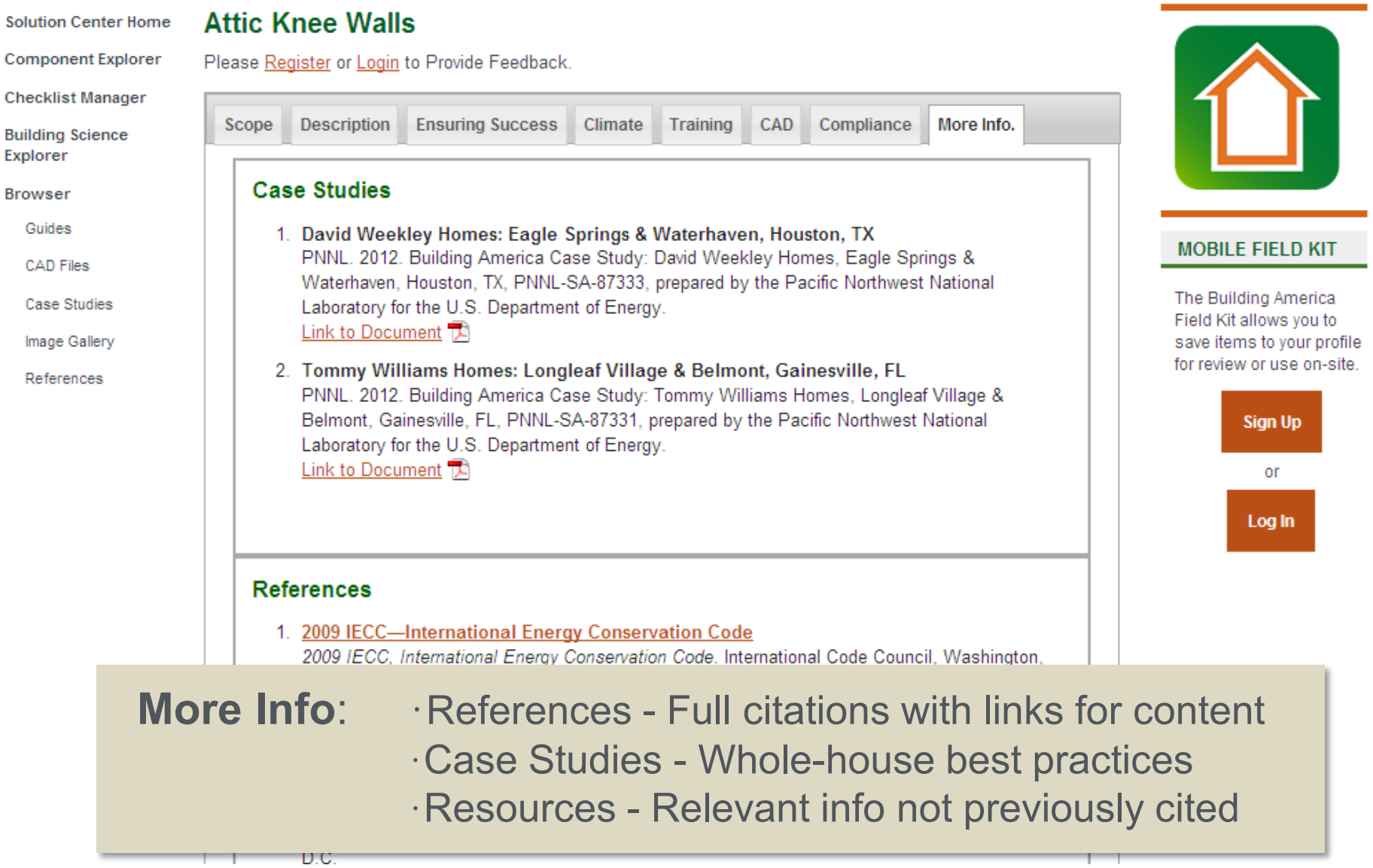
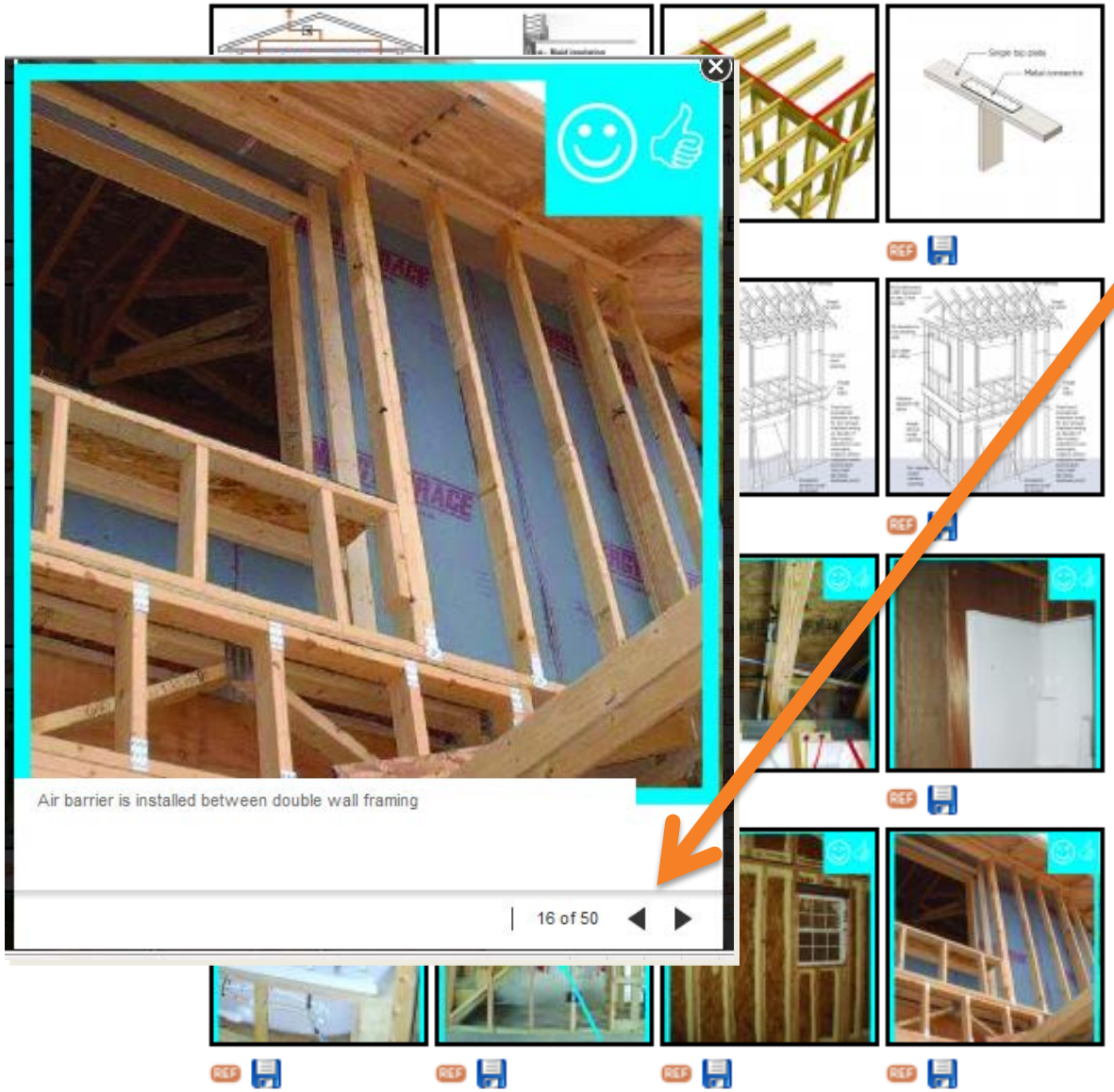


More Info:

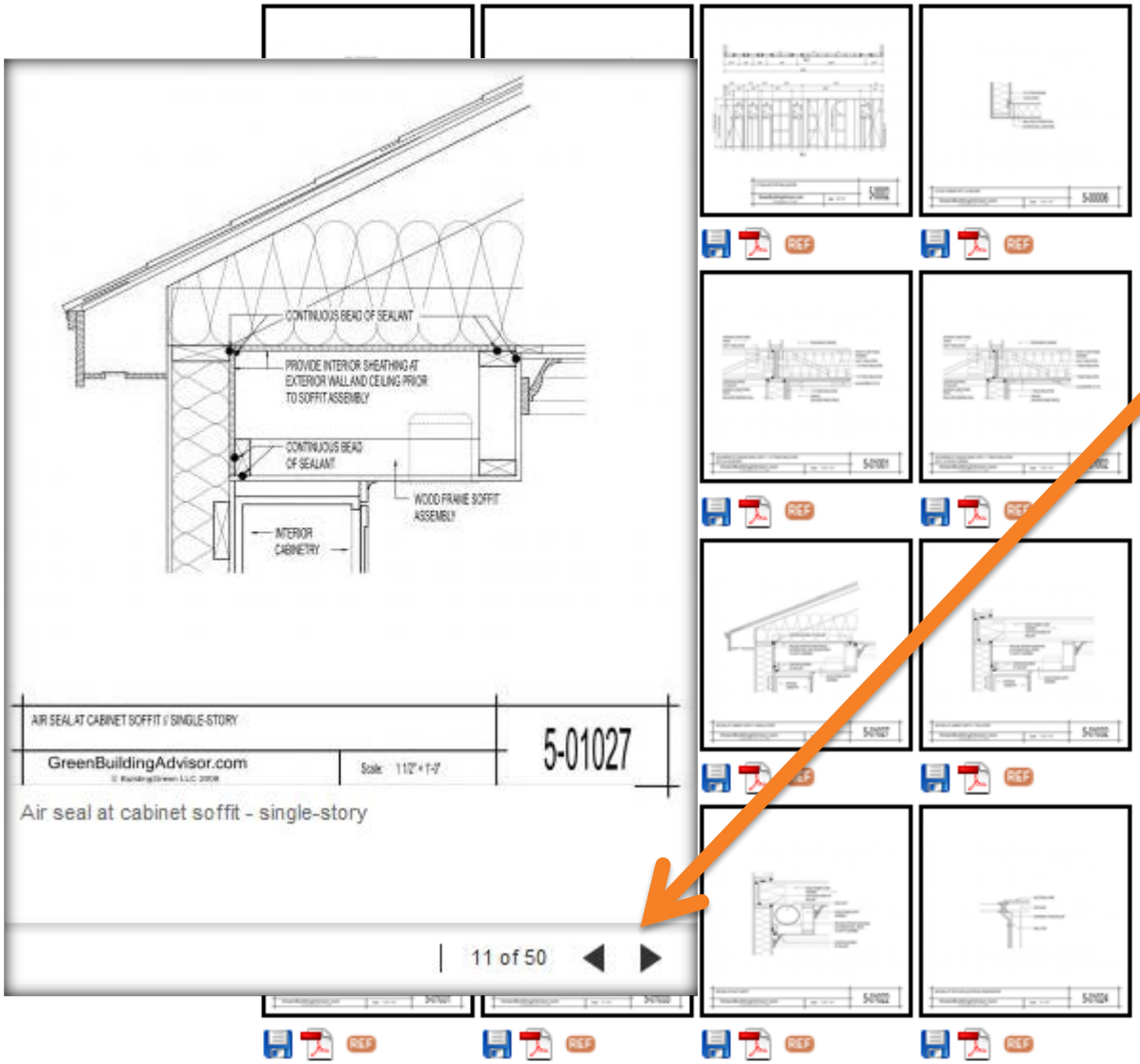
- References - Full citations with links for content
- Case Studies - Whole-house best practices
- Resources - Relevant info not previously cited

BASC Browser Image Gallery



- Click an image to enlarge in a sliding window.

BASC Browser Cad Files

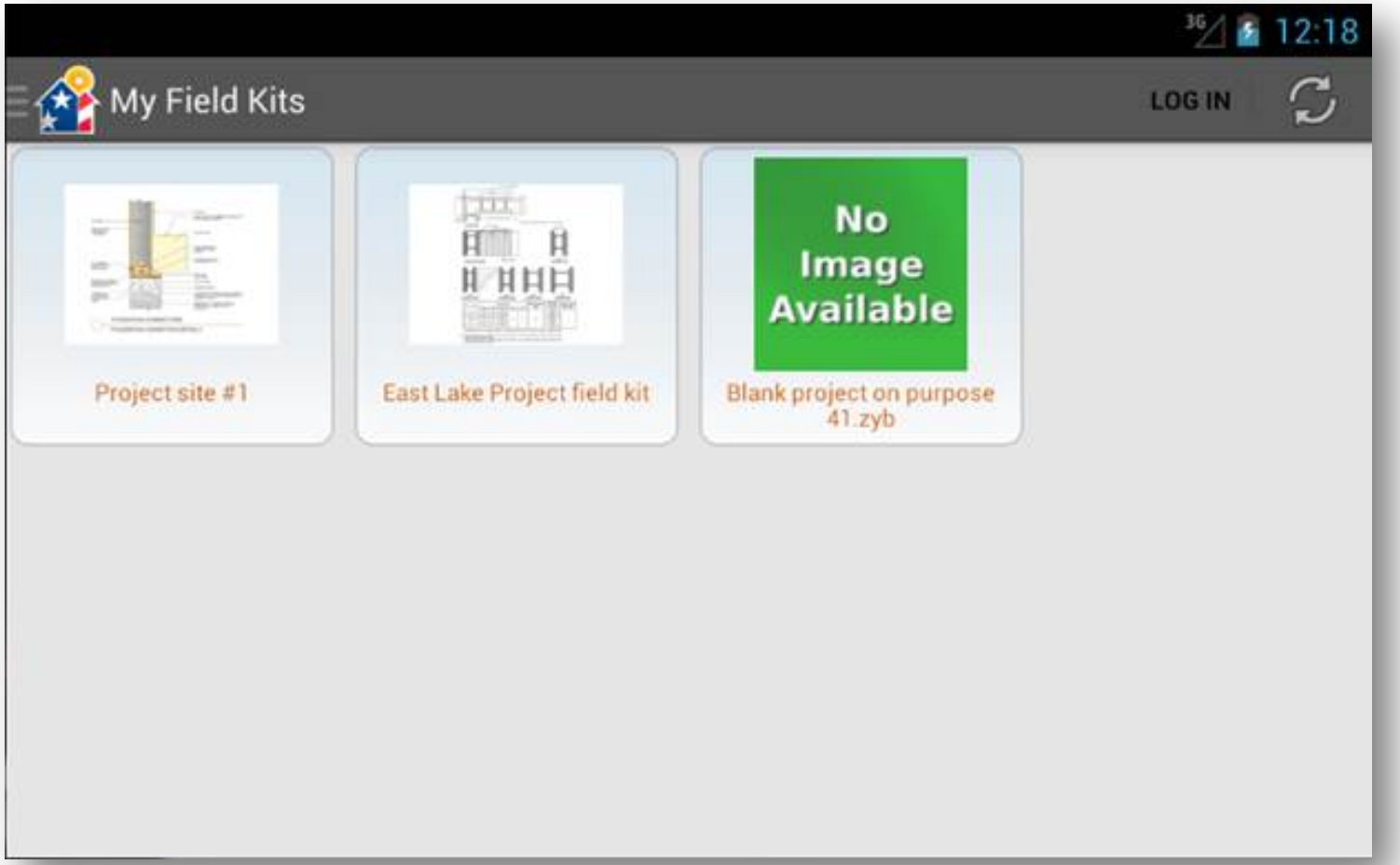


Air seal at cabinet soffit - single-story

- Click the CAD file image to load in a slider window.

BASC Mobile Application

BASC Mobile Application



How Can Uncle Sam Help?

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

Innovation Pipeline	**Guidance & Tools**	Improved Infrastructure	Market Recognition
	Building America Solution Center		
	Program Specifications		
	Risk Management Tools		

BASC Checklist Manager

Building America Solution Center

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Solution Center Home

About

FIND YOUR TOPIC BY:

- Building Components
- Guides A-Z
- Program Checklists
  - ENERGY STAR
  - Challenge Home
  - Indoor airPlus
  - Solar Ready PV
  - Solar Ready Hot Water

RESOURCES:

- References
- CAD Files
- Images
- Case Studies
- Videos
- Presentations

Building Science Publications

Program Checklists

ENERGY STAR Qualified Homes, Version 3 (Rev. 6) Checklist into the Checklist Manager. Additional ENERGY STAR program requirements and information can be found at the ENERGY STAR Website.

DOE Challenge Homes National Program Requirements (Rev. 02). DOE Challenge Home offers both a Prescriptive Path and Performance Path to meet program requirements. Additional Information can be found at the DOE Challenge Home Website.

EPA's Indoor airPLUS Program checklist helps builders construct homes with improved indoor air quality. This checklist is a component of the Challenge Home Checklist. Additional information can be found at the EPA Indoor airPLUS Program Website.

The Renewable Energy Ready Home Solar Photovoltaic Checklist was designed for builders constructing single family homes with pitched roofs. This checklist is a component of the Challenge Home Checklist. Additional information can be found at the EPA Renewable Energy Ready Homes Website.

The Renewable Energy Ready Home Solar Water Heating Checklist was designed for builders constructing single family homes with pitched roofs. This checklist is a component of the Challenge Home Checklist. Additional information can be found at the EPA Renewable Energy Ready Homes Website.

MOBILE FIELD KITS

Field Kit Number 1 Title
12 items

BASC Checklist Manager

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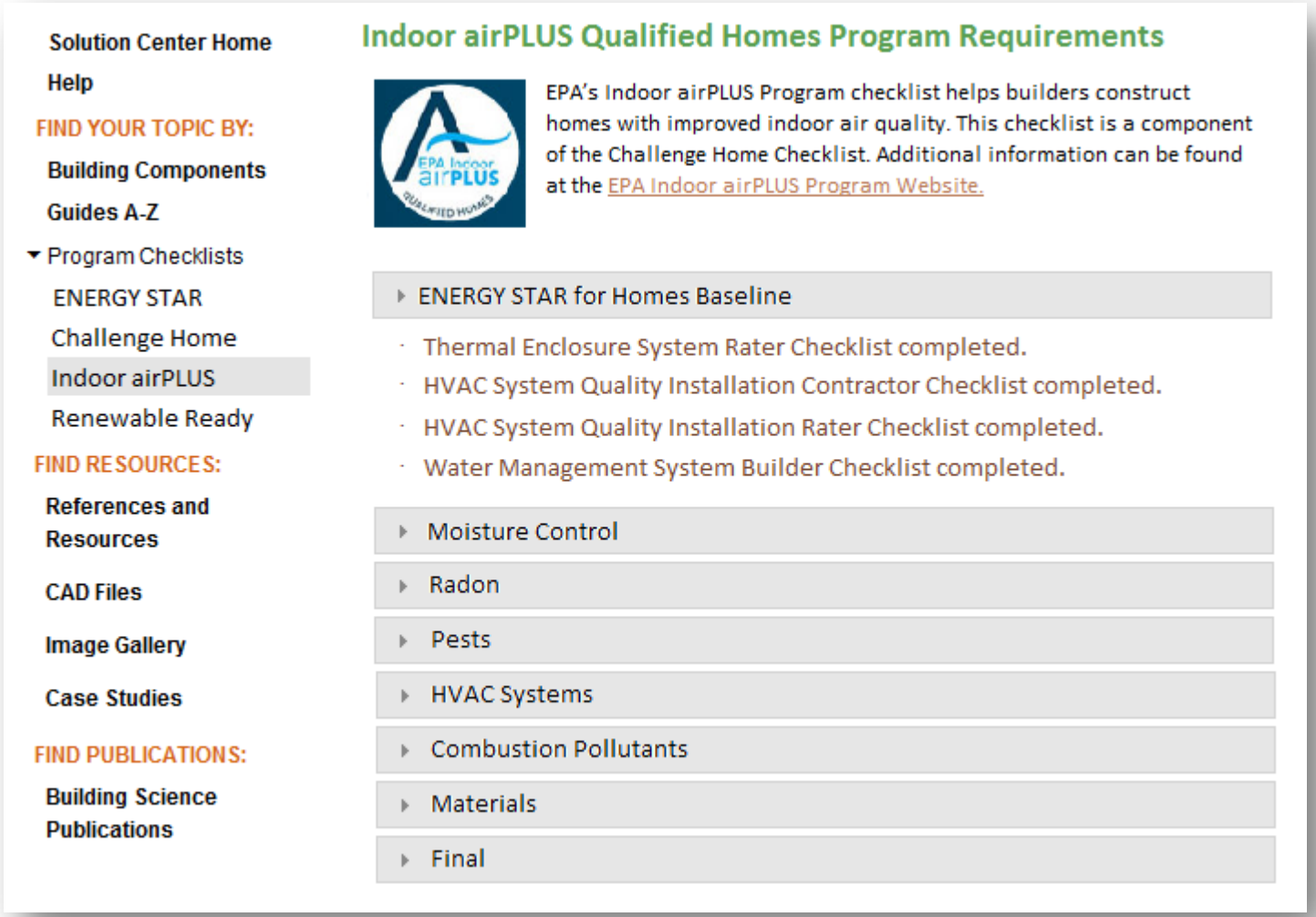
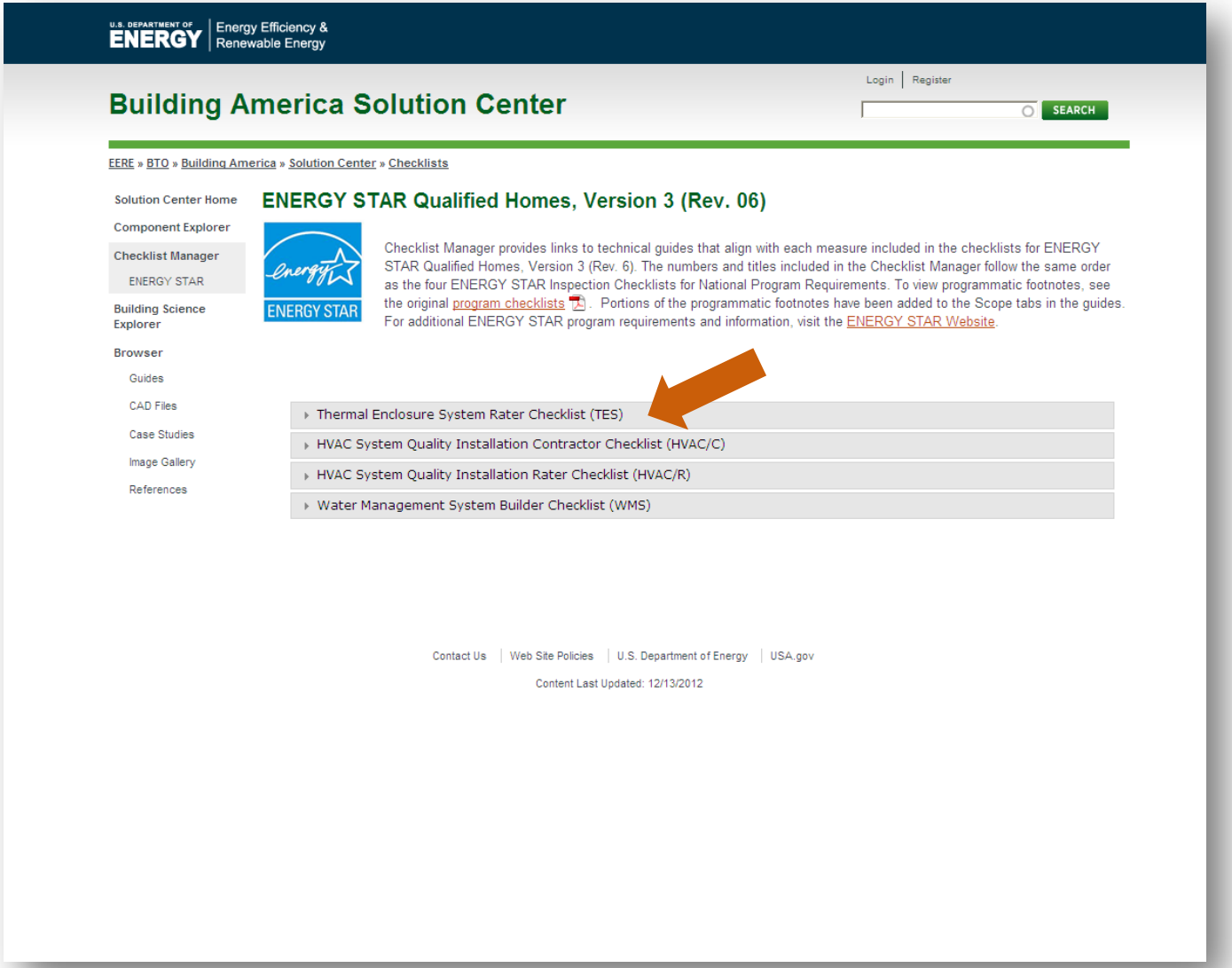
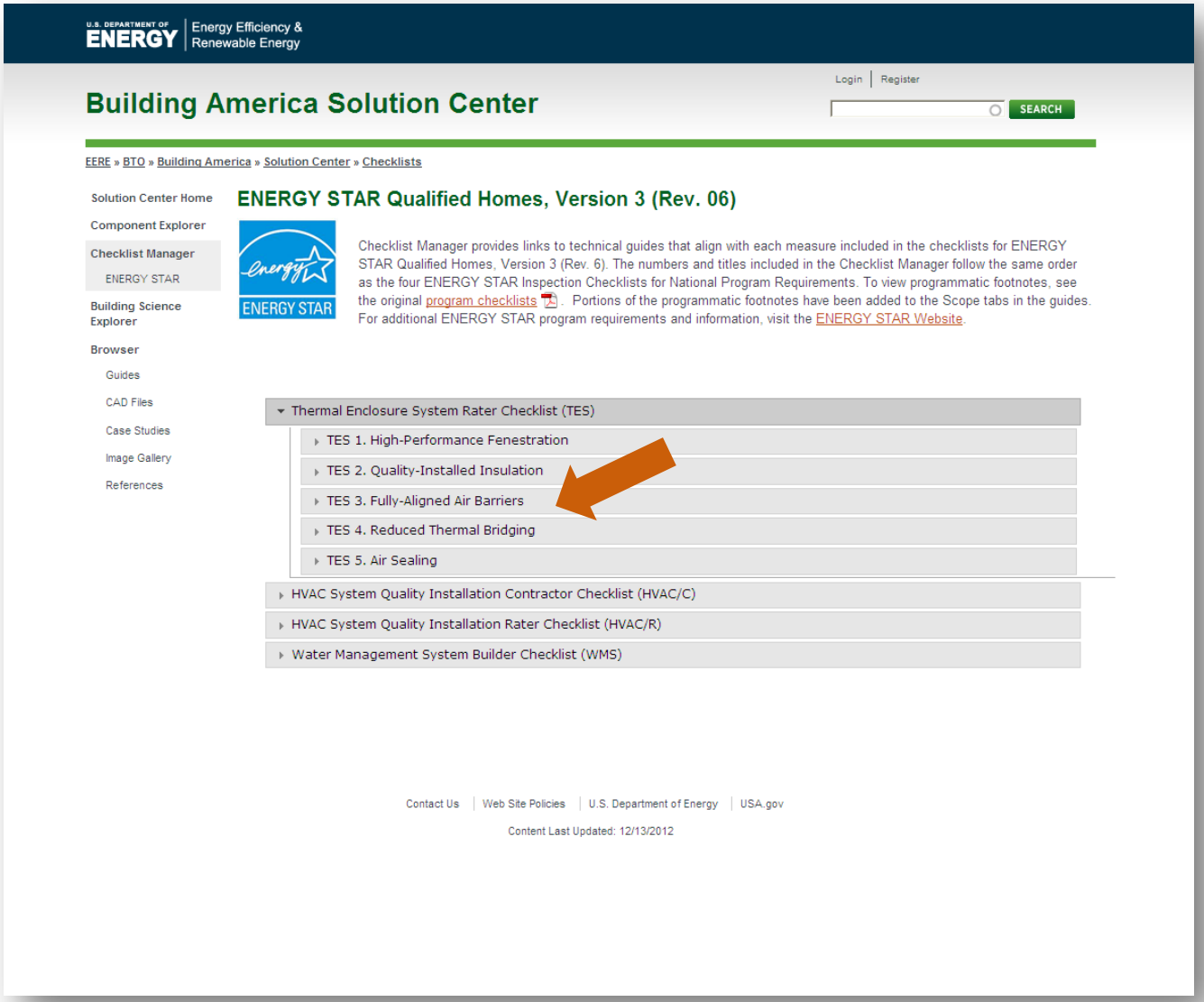
BASC Checklist Manager



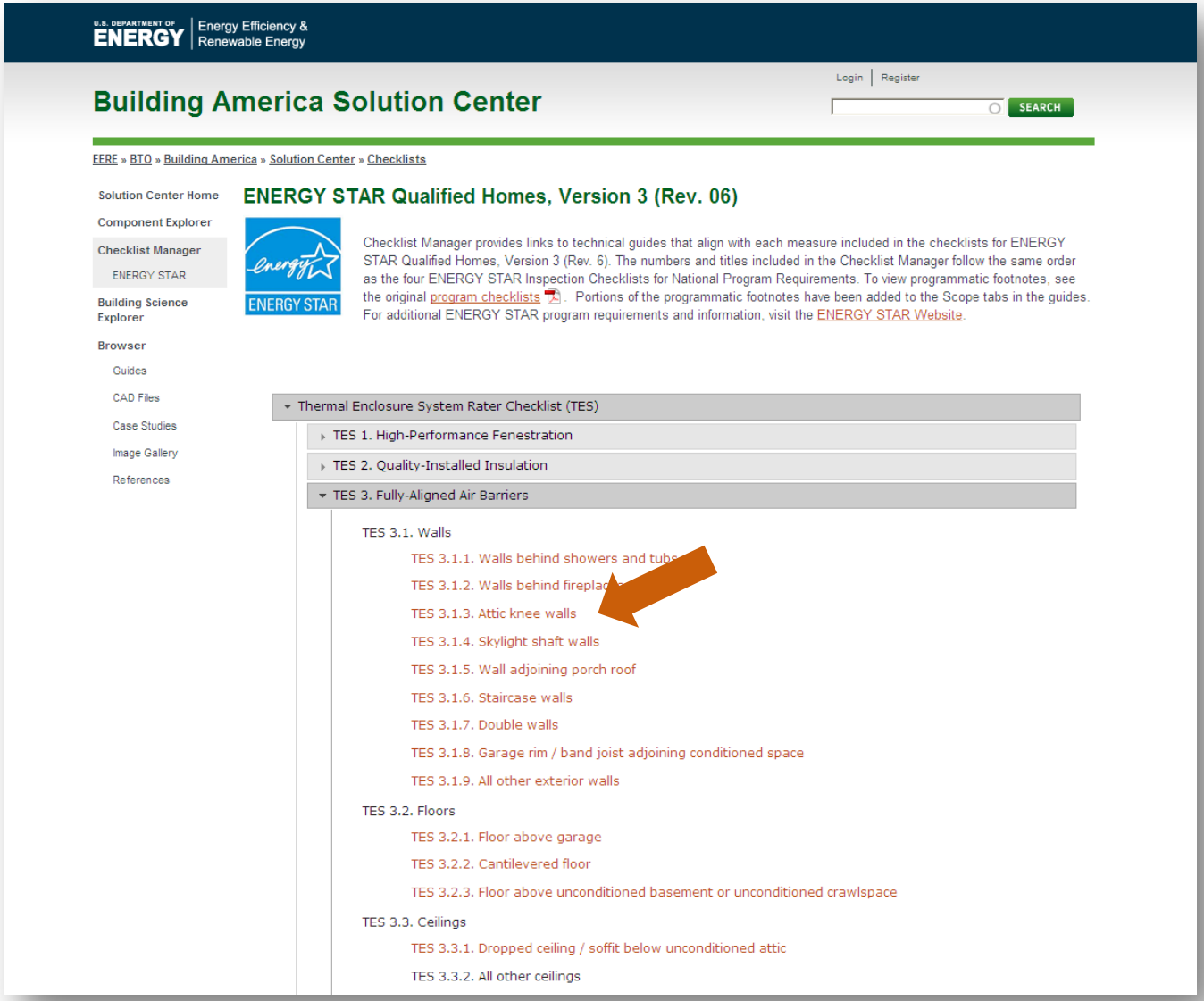
BASC Checklist Manager



BASC Checklist Manager



BASC Checklist Manager



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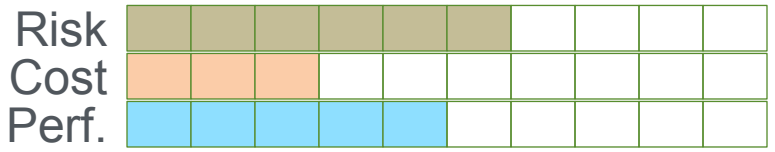
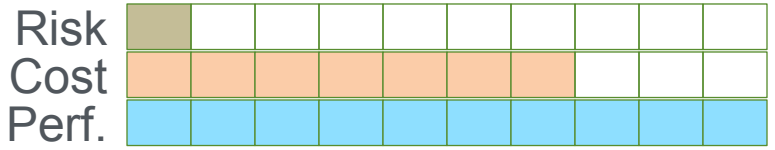
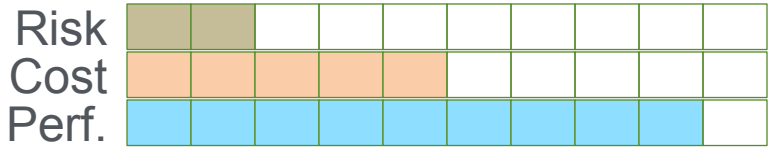
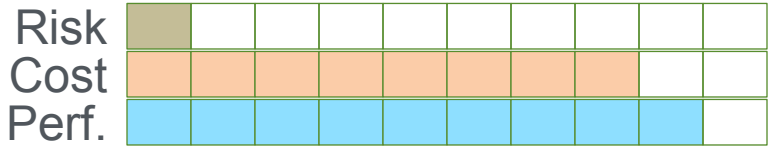
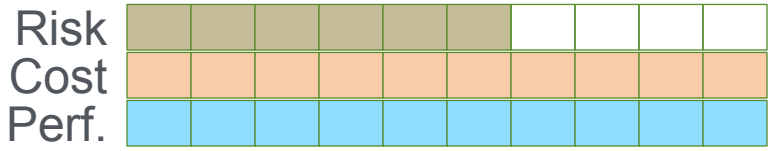
Innovation Pipeline	Guidance & Tools	Improved Infrastructure	Market Recognition
	Building America Solution Center		
	Program Specifications		
	Risk Management Tools		

Risk Management Tools???

Latest concept from the …

Thermal Enclosure Options: Walls Climate Zones 6-7

The following guidance for selecting wall assemblies is based on research from the DOE Building America program. Risk is based on degree of moisture management issues associated with each assembly. Cost is based on research of post-learning curve experiences with production builders. And performance is based on the energy savings results with detailed modeling analyses.

Advanced Framing	
Exterior Rigid Insulation With Advanced Framing	
Exterior Rigid Insulation Extended Plate and Beam	
Structural Insulated Panel	
Double-Wall Construction	

IAQ: Whole-House Ventilation Climate Zones 6-7

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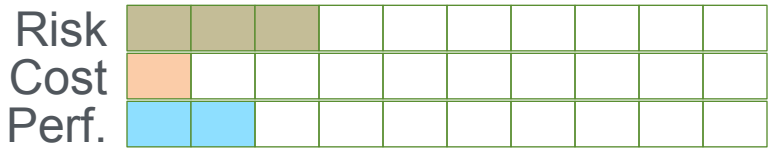
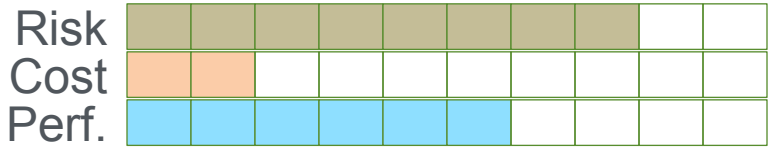
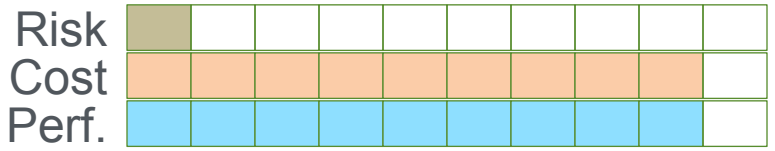
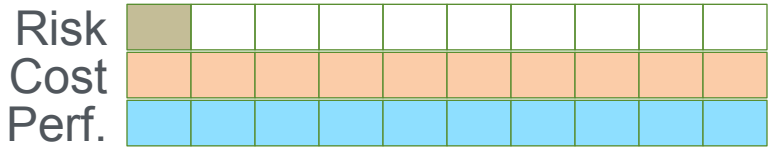
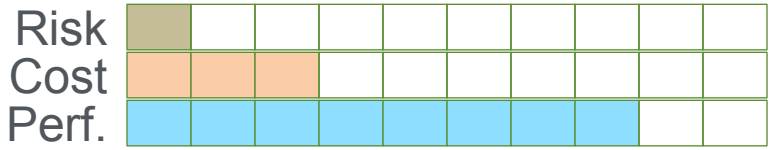
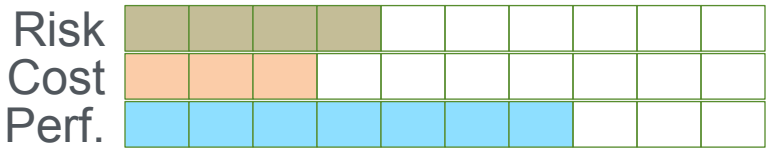
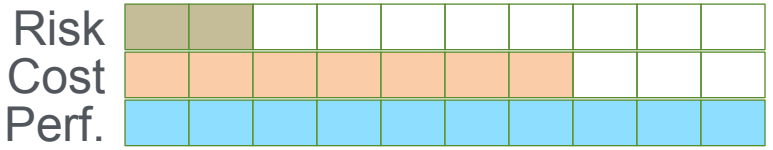
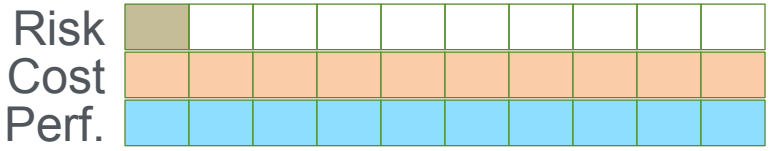
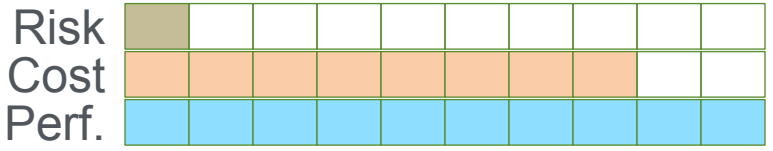
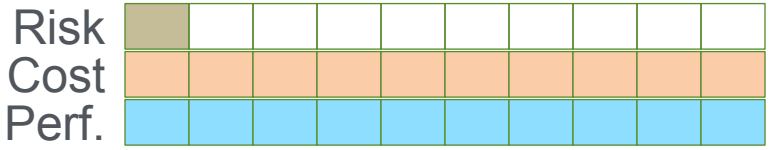
The following guidance for selecting ASHRAE 62.2 compliant whole-house ventilation is based on research from the DOE Building America program. Risk is based on degree of IAQ issues associated with each option. Cost is based on research of post-learning curve experiences with production builders. And performance is based on the energy of effective dilution through-out home and persistence.

Exhaust Only Fan	
Central Fan Integrated System with Controller	
Heat Recovery Ventilation (HRV)	
Energy Recovery Ventilation (ERV)	
Combined Exhaust Only and CFIS System	

Optimized Low-Load Comfort System Hot-Humid/Warm-Humid

The following guidance for selecting comfort systems is based on research from the DOE Building America program. Risk is based on potential for comfort complaints by occupants . Cost is based on research of post-learning curve experiences with production builders. And performance is based on effective mixing of air that provides control of heat, cooling, and relative humidity.

Two-Speed Heat Pump	
Variable-Speed Heat Pump	
Variable-Speed Heat Pump with CFIS & Dehumidifier	
Variable –Speed High-Velocity Heat Pump	
Variable-Speed Gas Furnace/AC & Dehumidifier	

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Innovation Pipeline	Guidance & Tools	Improved Infrastructure	Market Recognition
		Building Science Education	
		Building Science Translator	
		Value of Performance	
		Codes & Standards	

Building America® U.S. Department of Energy

ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

Codes & Standards Innovation

- *Building America Solution Center* ***Code Compliance Briefs***
- ***Building America R&D projects*** *validate high performance alternatives, addressing:*
  - Fire Code issues
  - Vapor Barrier issues in Building Codes
  - Ventilation Standard issues
- ***Building America R&D Roadmaps*** *will* address codes and standards barriers:
  - Remaining Building Code issues
  - Next generation Ventilation Standard
  - Design Standard issues
  - Etc.

How Can Uncle Sam Help?

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

Innovation Pipeline	Guidance & Tools	Improved Infrastructure	Market Recognition
			Zero Energy Ready Homes
			Student Design Competition
			Partner Recognition

Vision

Engage college students across the U.S.
to integrate building science in design projects
so they are better prepared for the future…

zero energy buildings.

Framework

- Annual competition
- Teams sponsored by a collegiate institution
- At least three students and a faculty advisor
- Multidisciplinary team with industry advisor(s)
- Options:
  - redesign existing floor plan, or
  - create a new house design to project requirements
- Design target is DOE Zero Energy Ready Home

Design Challenge

- Cost-effective from the buyer's perspective {P-I-T-I-U-M}
- Demonstrate integration of building science principles
- Take Building Science Course or online course and pass online test

Submissions

2014:

- 340+ Students
- 26 Universities
- 28 Teams

New for 2015!

2014:

- 340+ Students
- 26 Universities
- 28 Teams

2015:

- 33 Universities
- 40 Teams
- Including Canada, China, & Norway teams
- Carl Franklin Homes committed to build winning designs

Thank You

Building AMERICA U.S. Department of Energy

ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

For More Information:

http://energy.gov/eere/buildings/building-america

http://energy.gov/eere/buildings/us-department-energy-race-zero-student-design-competition