Building America System Innovations:

Accelerating Innovation in Home Energy Savings

Building America System Research

Eric Werling, DOE
Ren Anderson, NREL
eric.werling@ee.doe.gov, 202-586-0410
ren.anderson@nrel.gov, 303-384-7443
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Project Relevance

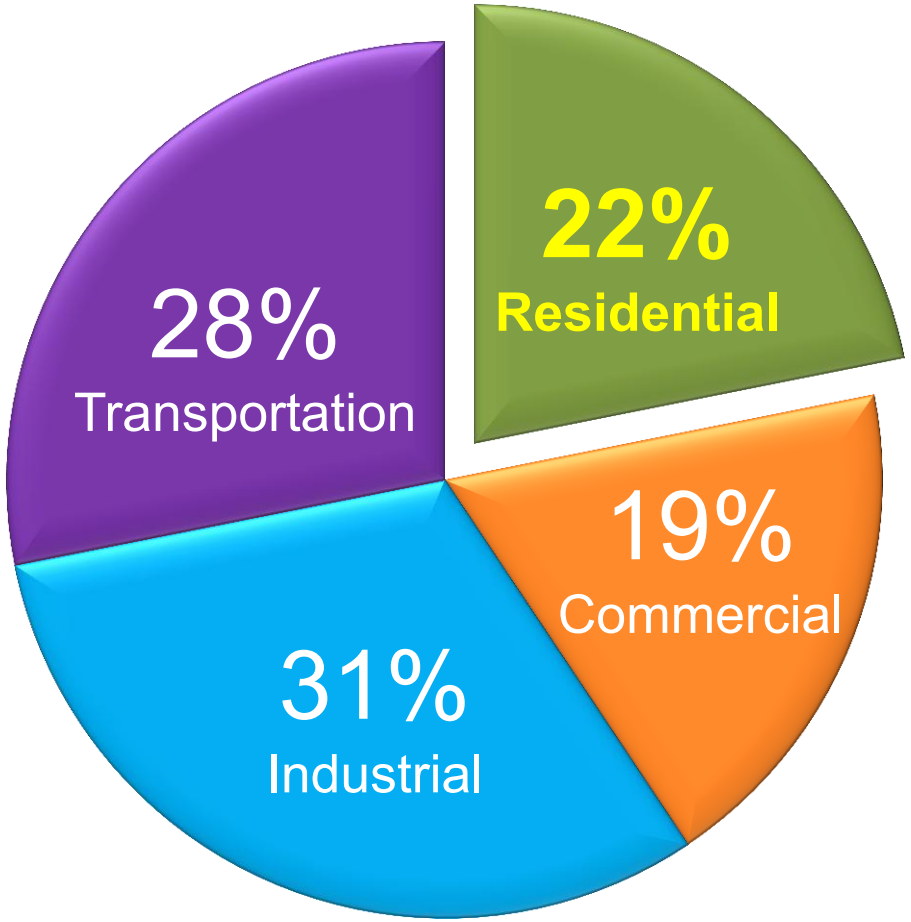
Building America Fills Market Need for a

High-Performance Homes

HUB of Innovation

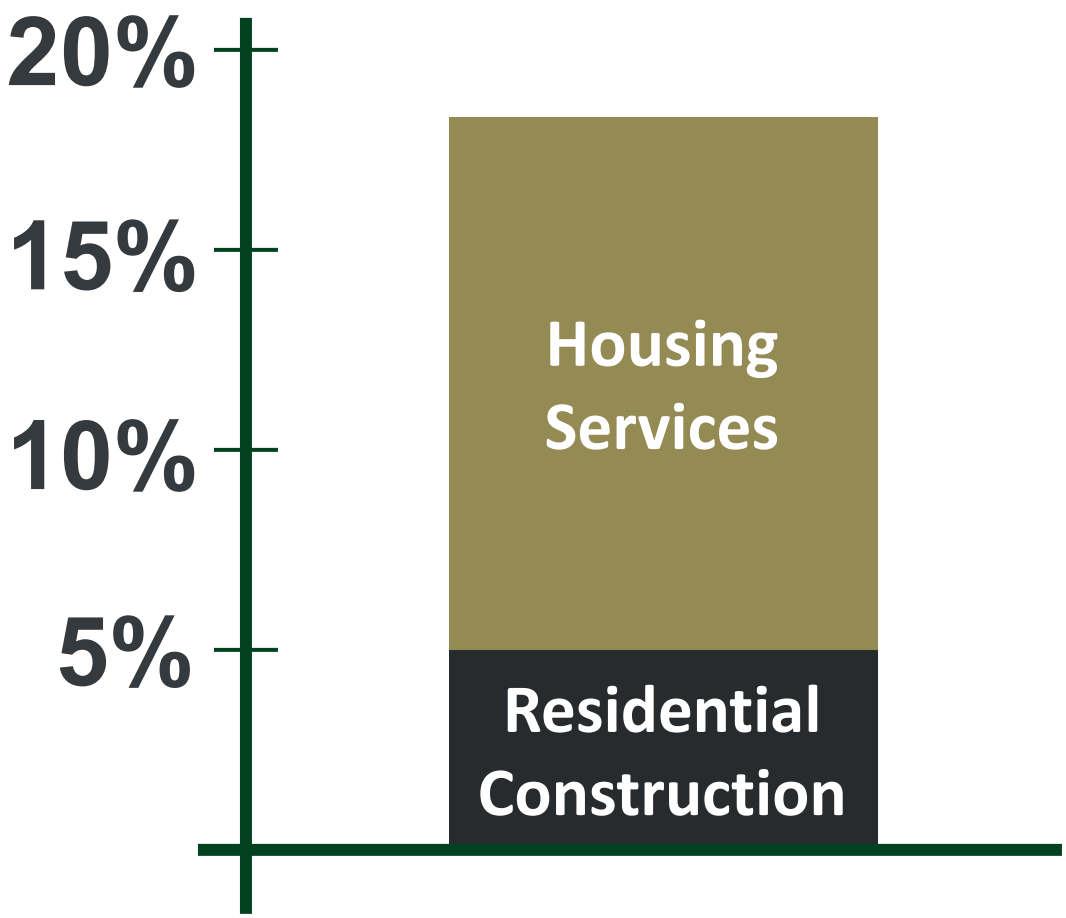
Building America® U.S. Department of Energy

Residential Energy Use Significant



U.S. Energy Consumption

Housing Industry Economic Impact



Housing Sector Percent of GNP

Source: NAHB data through Q1 2012

Home Energy Economic Impact

~$2,200: Average Annual Household Energy Bill

>113,000,000: DOE Housing Units in America

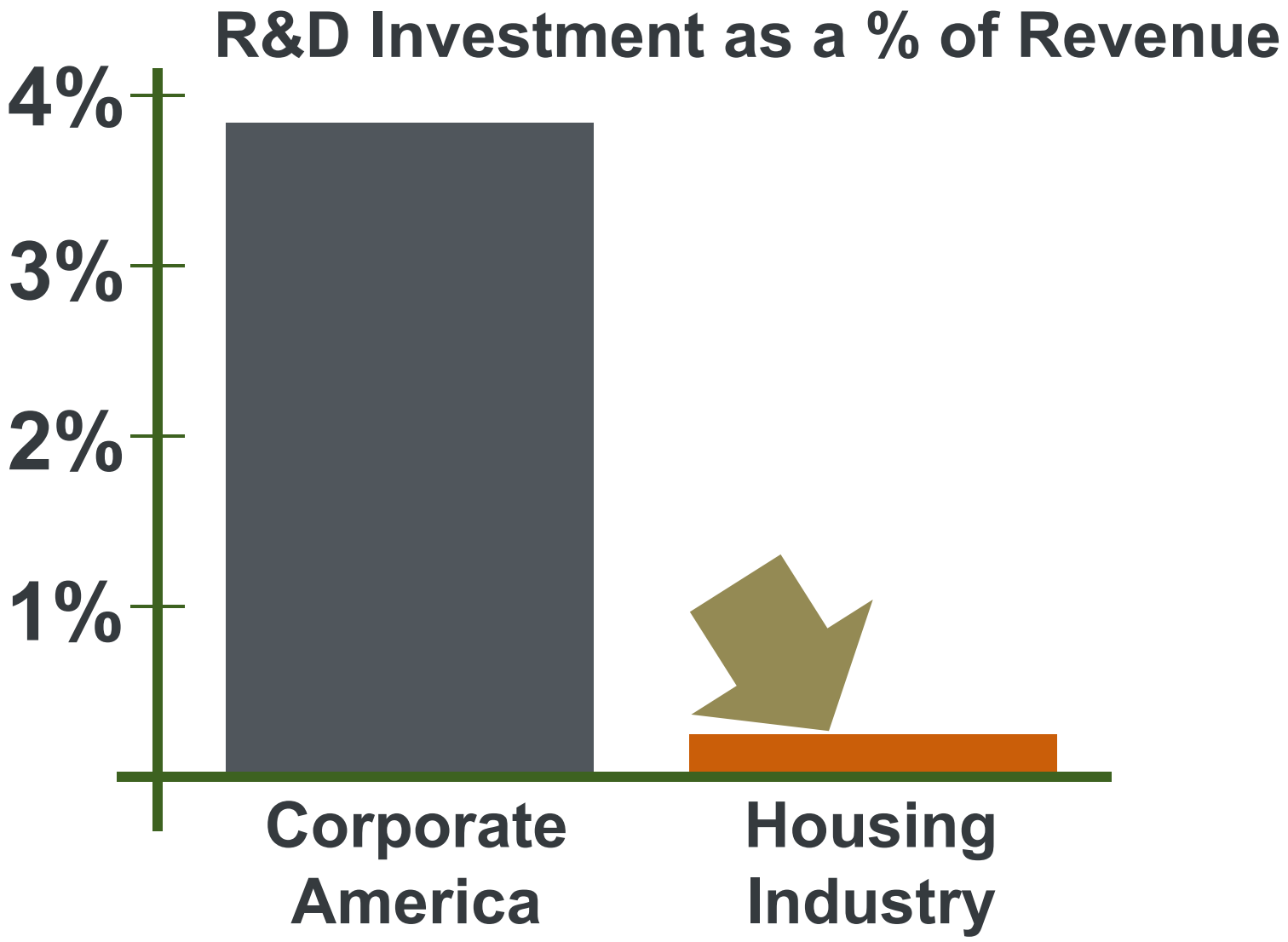
>$240 Billion: Amount spent on home utility bills per year.

>$120 Billion: Available to the economy

if we make our houses 50% more efficient

(i.e., President SOTU address)

Housing Underinvests in R&D



Value Proposition

$2,200: Average Annual Household Energy Bill

$1,100 Annual Value of **50% Savings**

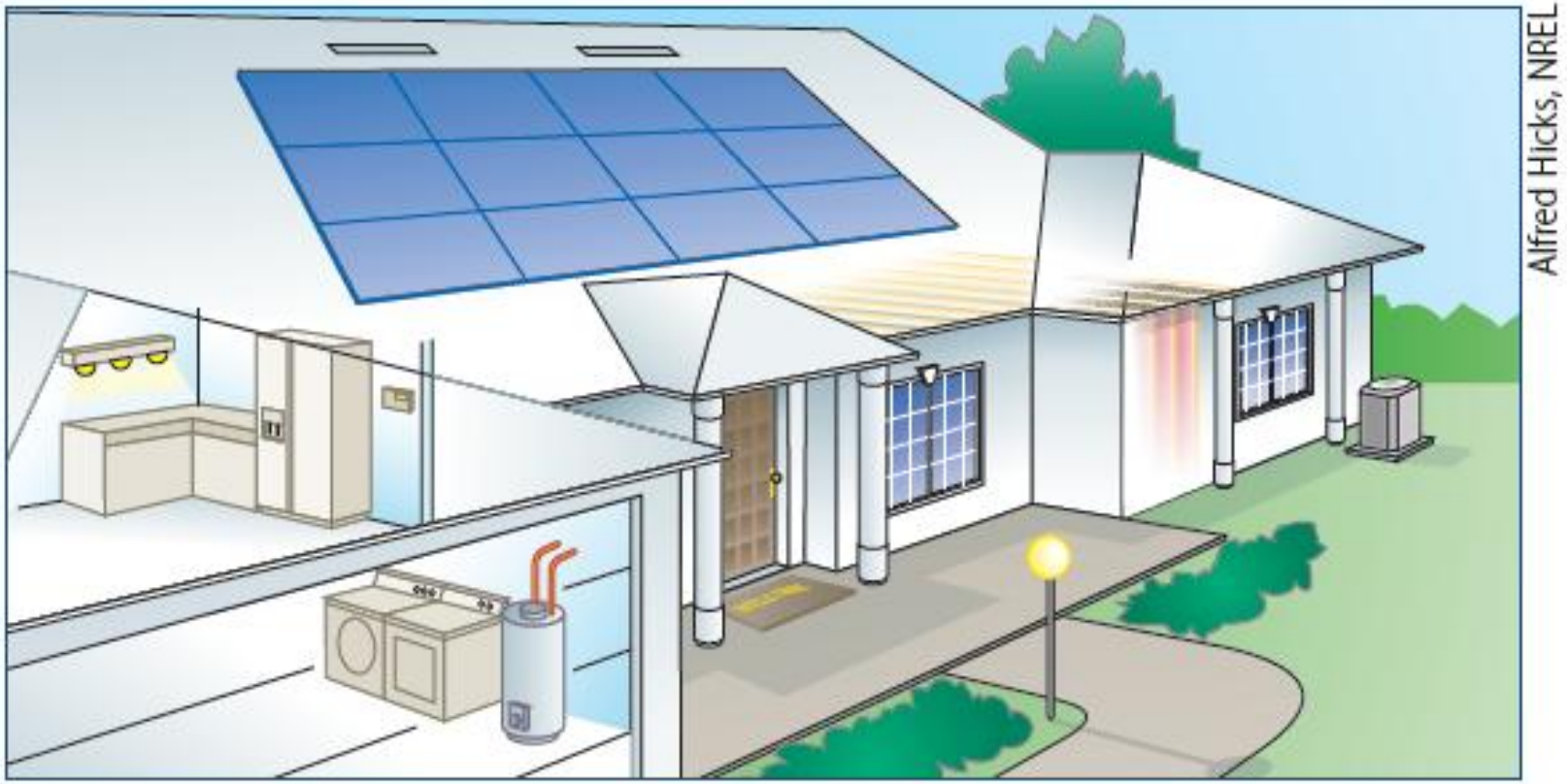
<$20M: DOE Building America R&D Budget

~200M: U.S. Taxpayers

Annual Cost per Taxpayer less than:

Purpose & Objectives

Problem Statement: *Low industry R&D investments and System-level risks and barriers slow the rate of energy innovation in the residential building sector.*



Purpose & Objectives

Project Focus: *Building America focuses on "whole house" system-level research required to resolve early market entry barriers to innovation.*

BTO Portfolio Element

Research to develop Integrated Residential System Innovations that deliver 50% Whole House Savings

Approach/Project Management

Building America Strategy: Research to Market Transformation

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

Program Management

Manage Impact

Create Innovation Culture

Research

Strategic

Effective

Systems

Building AMERICA
U.S. Department of Energy

Product Development

Customer focused

Solution Center

Sales

Customer based

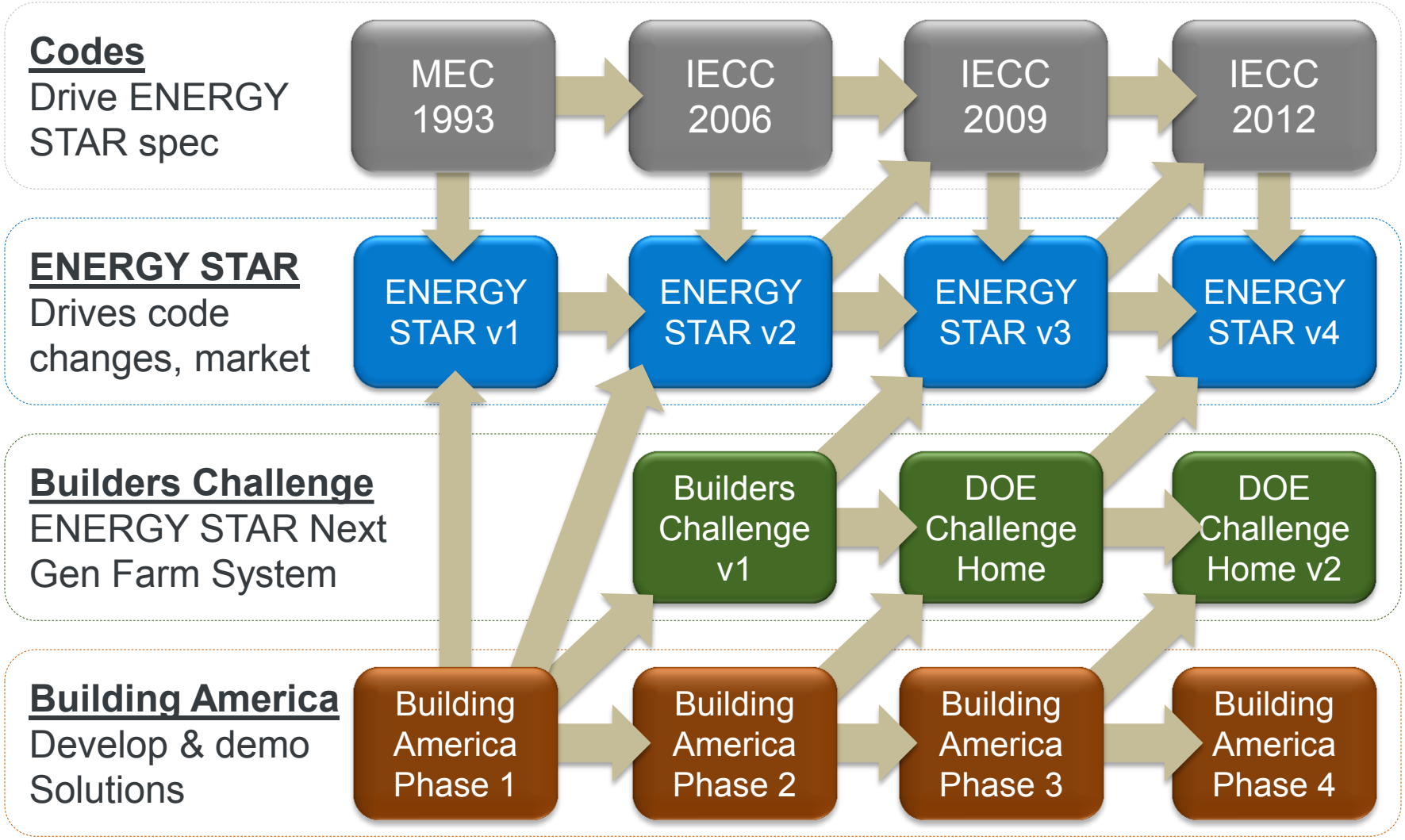
Market Delivery

U.S. DEPARTMENT OF ENERGY CHALLENGE HOME

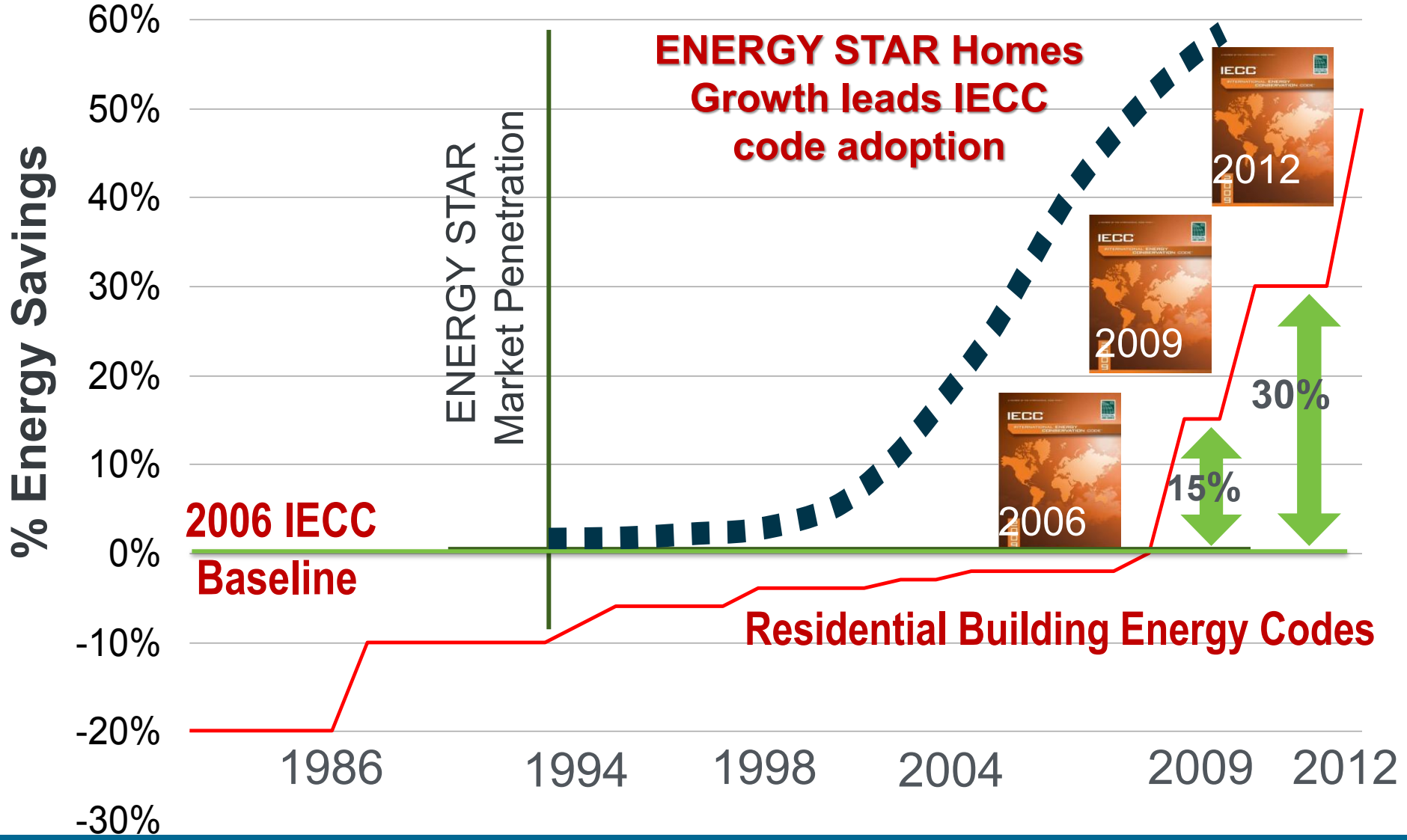
HOME PERFORMANCE WITH ENERGY STAR

Market Transformation Process

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



Market Transformation Results



Building America Objectives

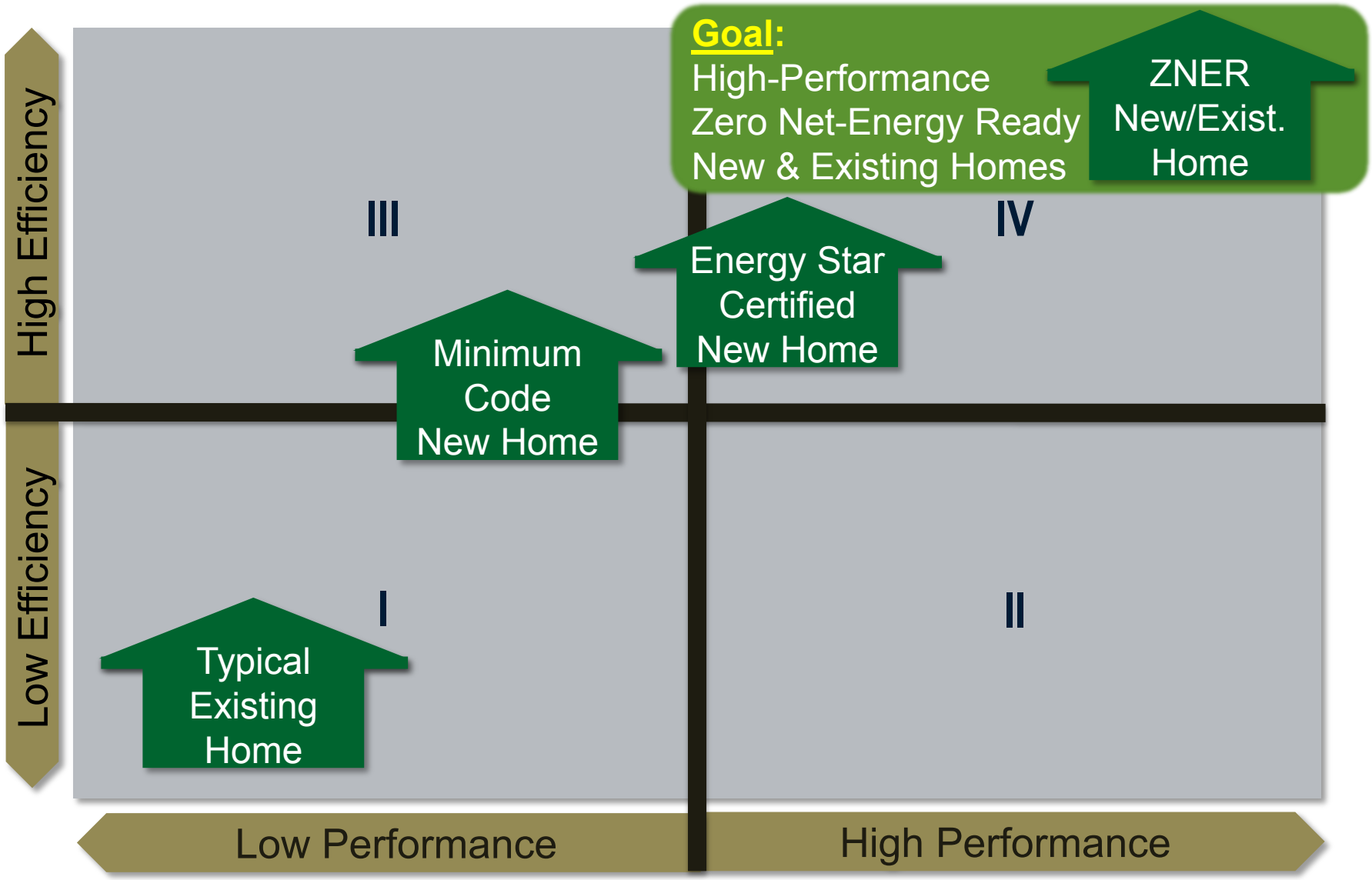
1. Efficiency

- Thermal Enclosure ("Envelope")
- Low-Load HVAC
- Efficient Components

2. Performance

- Comfort
- Health
- Durability
- Renewable Readiness/Integration
- Water Conservation
- Disaster Resistance

Building America Goal

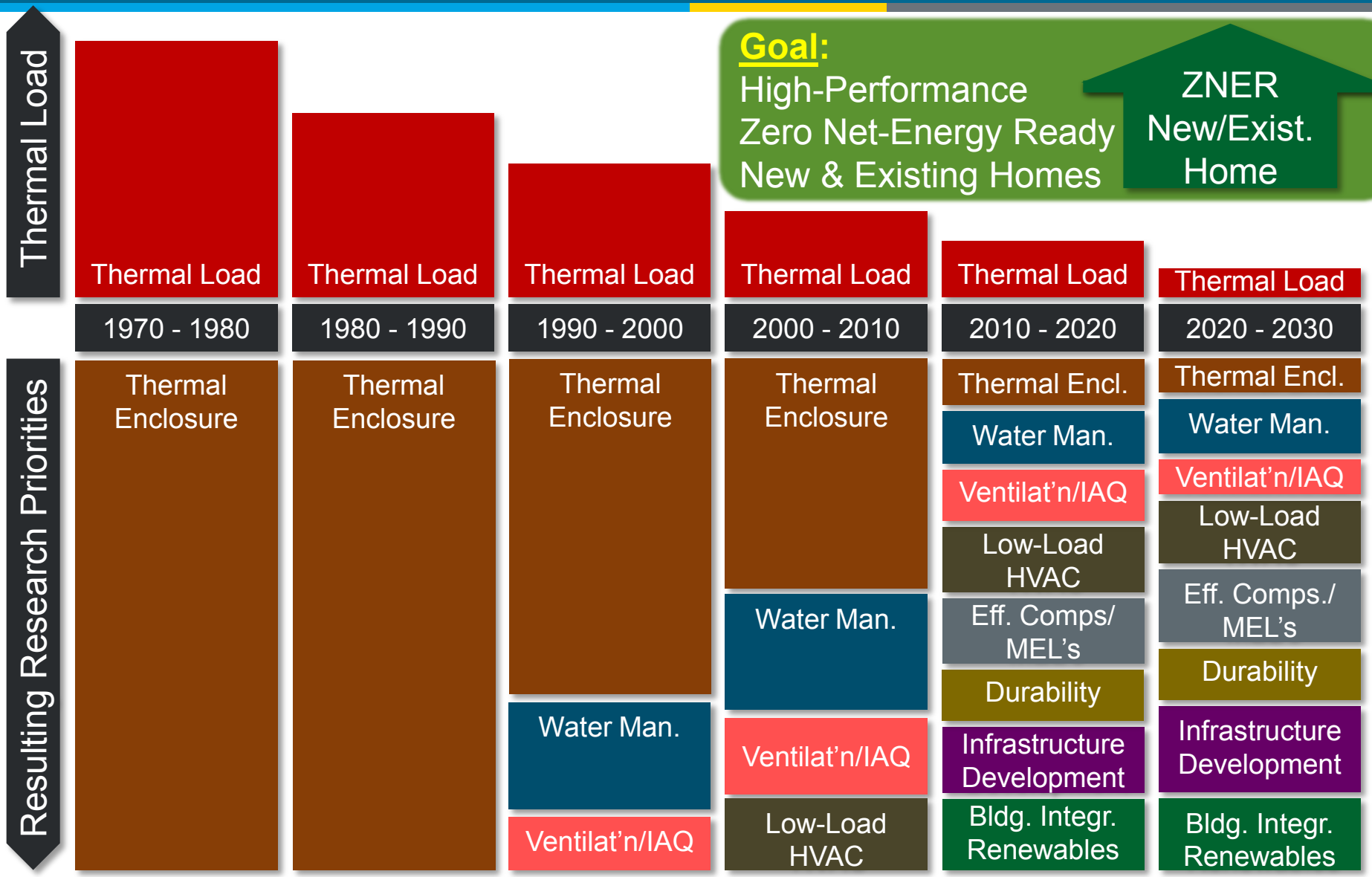


Building America Technology Path

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

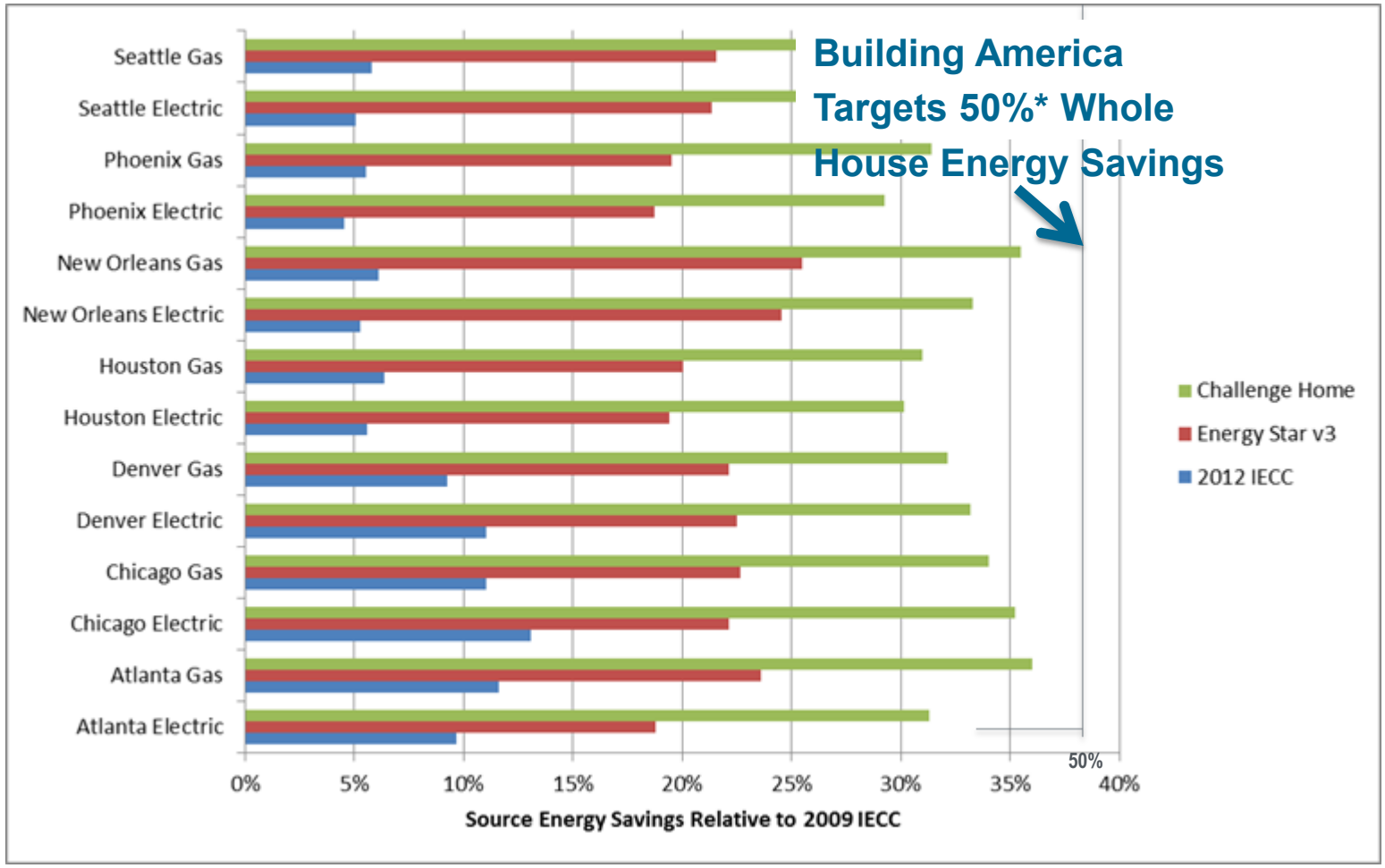
Goal:
High-Performance
Zero Net-Energy Ready
New & Existing Homes

ZNER New/Exist. Home



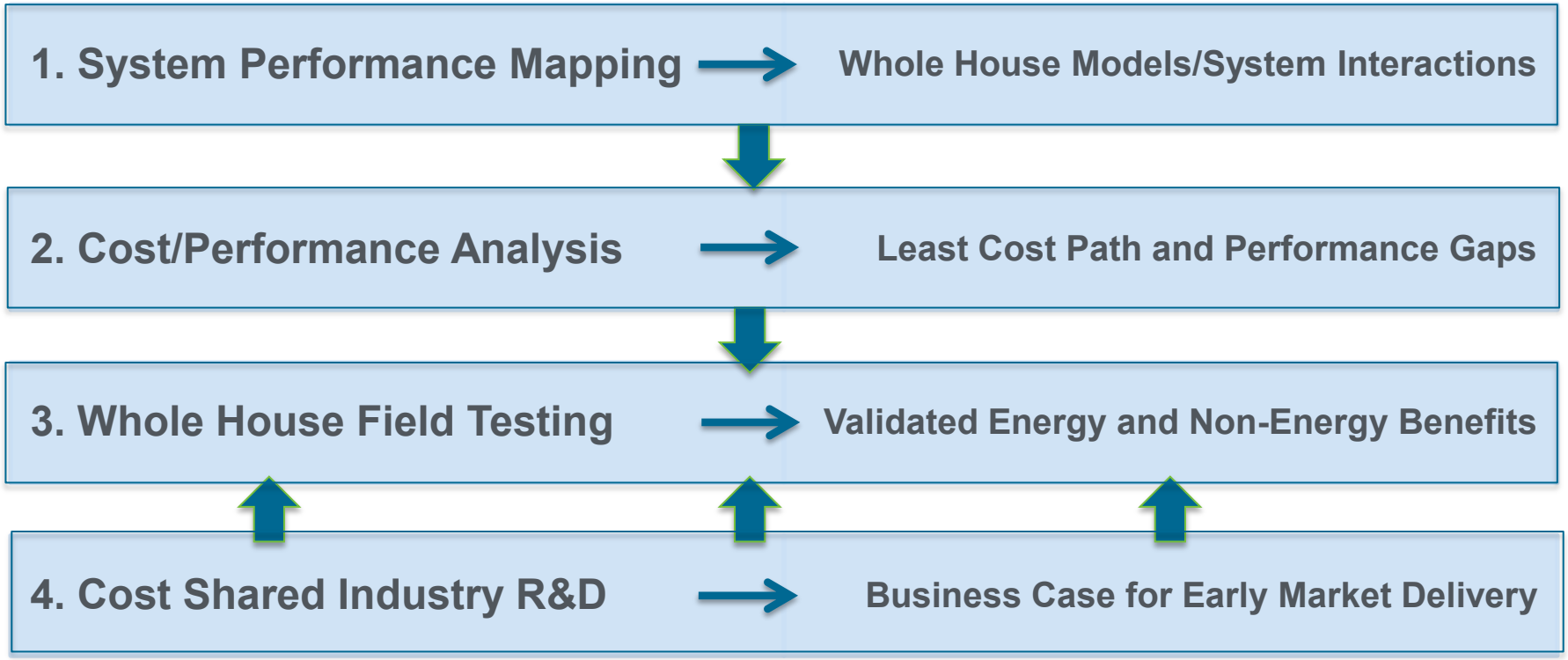
System Research Goals

Impact of Project: *Whole house system innovations, leading to* ***50% energy savings in new and existing homes.***



System Research Approach

System Research Approach: *Building America system research portfolio includes four key elements (project types):*



System Research Approach

System Research: 50% Savings

Early Market Delivery

System Innovations

System Test, Evaluation, & Performance Validation

Catalyst Point: Market Leaders Accept System Risks* vs. Benefits

Industry R&D Partnerships

Building America U.S. Department of Energy

National Labs Research

Implementation Tools

Building America Solution Center

Deployment Initiatives

U.S. Department of Energy Challenge Home

U.S. Department of Energy Solar Decathlon

Better Buildings Neighborhood Program U.S. Department of Energy

Home Performance with ENERGY STAR

IECC Codes

*Risks that limit broad market acceptance include issues with durability, reliability, and costs

The residential program is grounded on technology and systems research. This research is translated into implementation tools to make solutions accessible to practitioners. Finally, deployment initiatives promote speed and scale to successfully transform the market.

System Research Approach

Key Issues: *Key system research issues include moisture management and cladding attachment in high R wall systems and development of low load HVAC and distribution systems for homes with 50% smaller loads than current homes.*

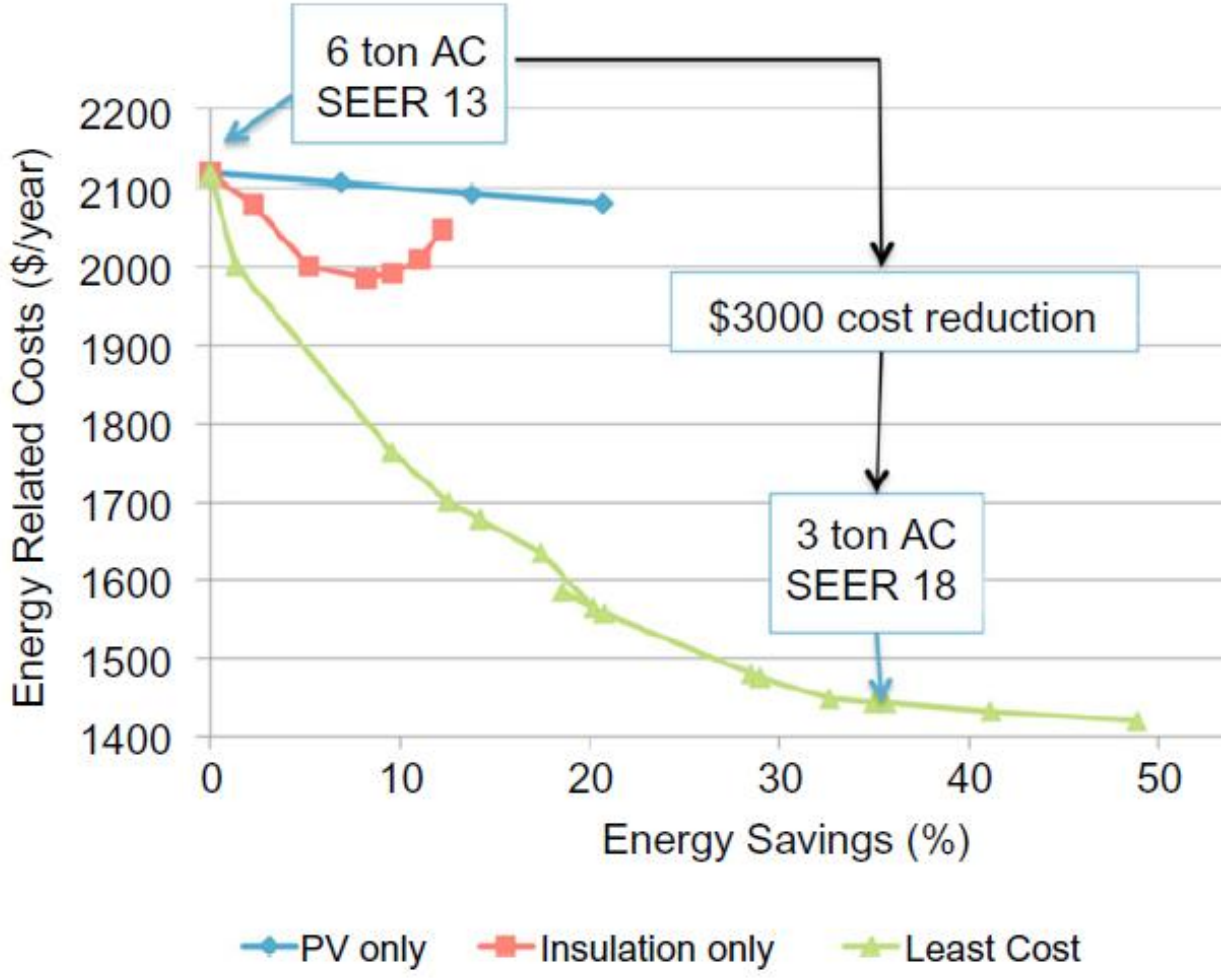
Vapor Retarder Definitions

The 2009 IRC R601.3 gives the following definitions and examples for vapor retarder classes:

Class	Definition	Examples
I	≤ 0.1 perm	Sheet polyethylene, sheet metal, non-perforated aluminum foil, foil-faced insulation sheathing
II	> 0.1 to < 1.0 perm	Kraft-faced fiberglass batts or low-perm paint, unfaced expanded polystyrene, fiber-faced polyisocyanurate
III	> 1.0 perms	Latex or enamel paint

System Research Approach

Distinctive Characteristics: *Using a system approach, Building America analyzes tradeoffs to maximize incremental value & minimize incremental cost.*



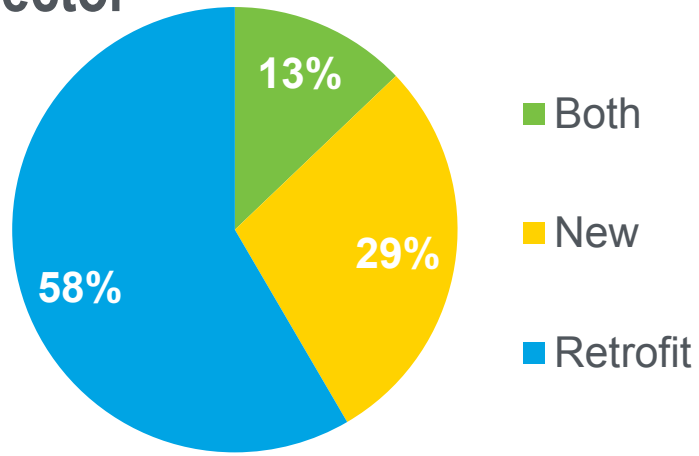
Systems approach out-performs single measure approach

Phoenix, 2500 ft2, 2-story, $9000 first cost increase.

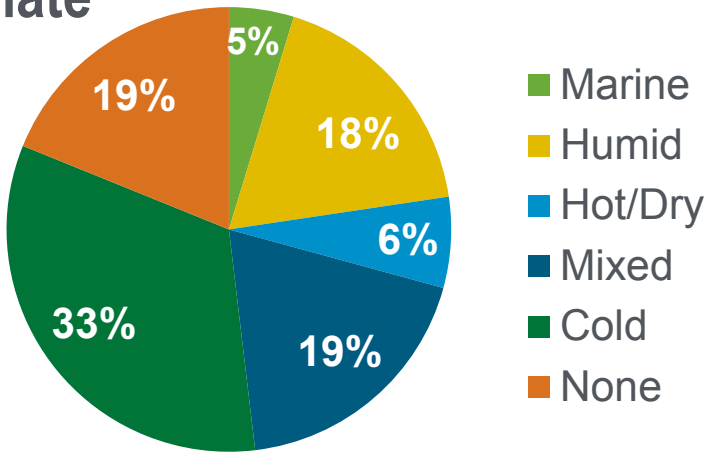
Building America Project Portfolio: 2012 funded projects …

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

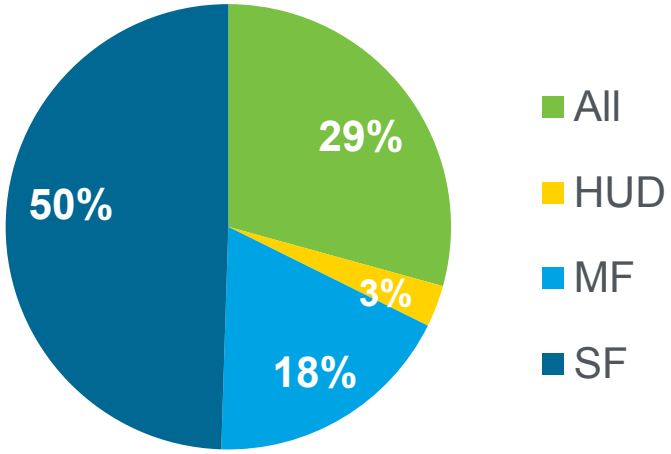
by Sector



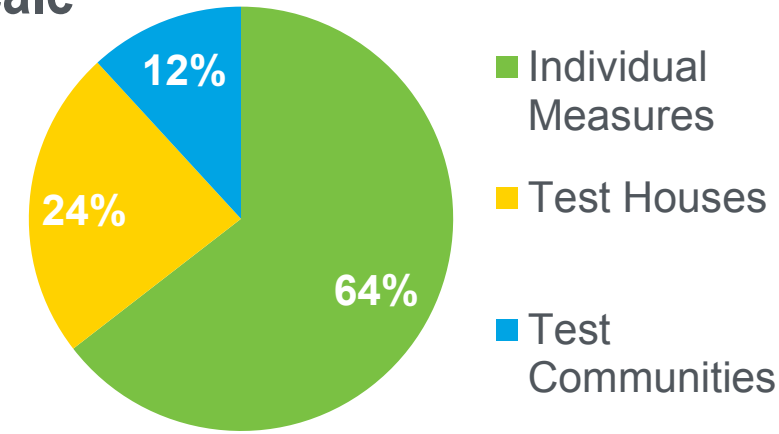
by Climate



by House Type



by Scale



Targeted Innovation Gaps - 2013

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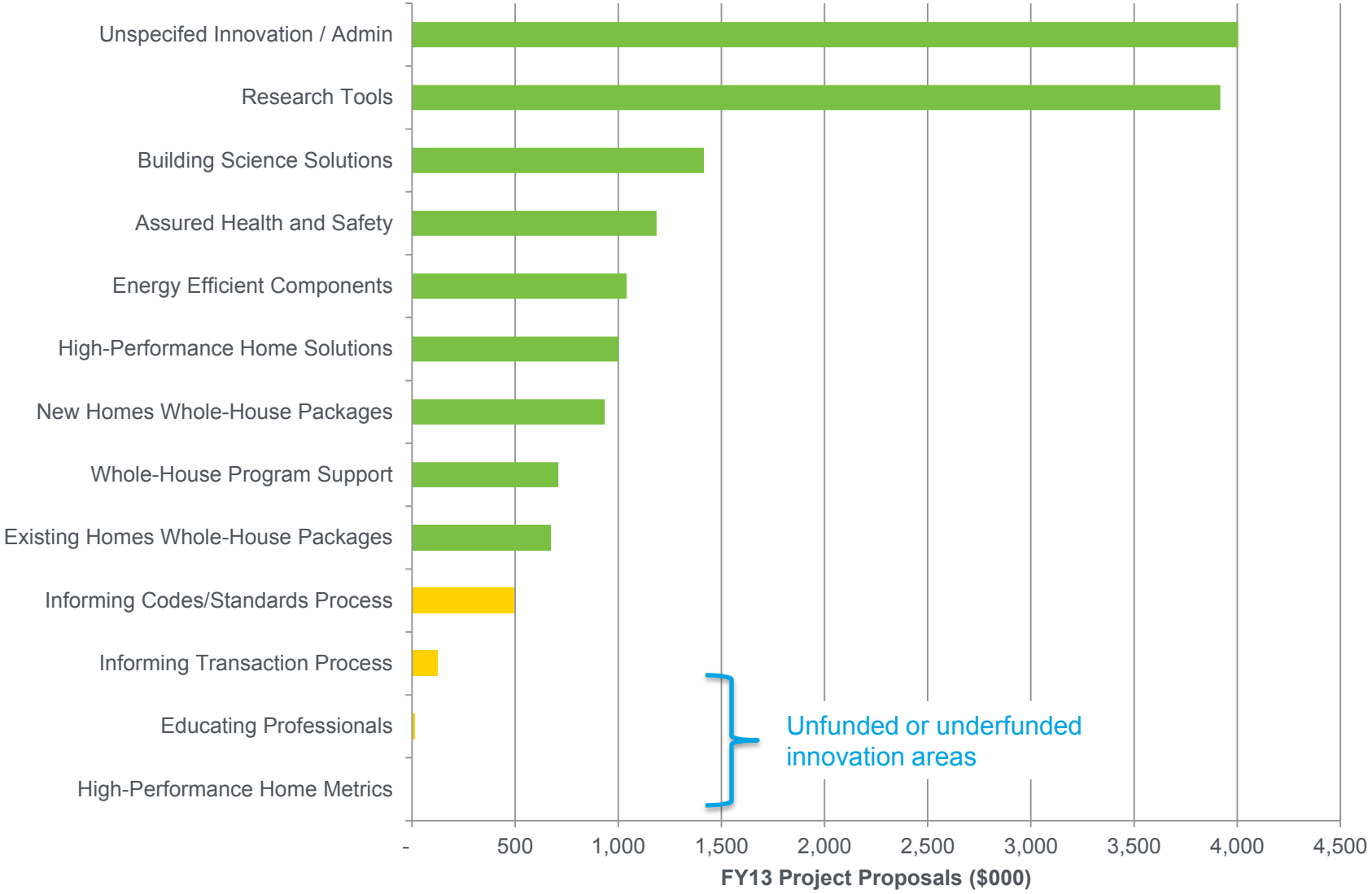


World Class Building Systems Research

Building America Solution Center
BASC.energy.gov

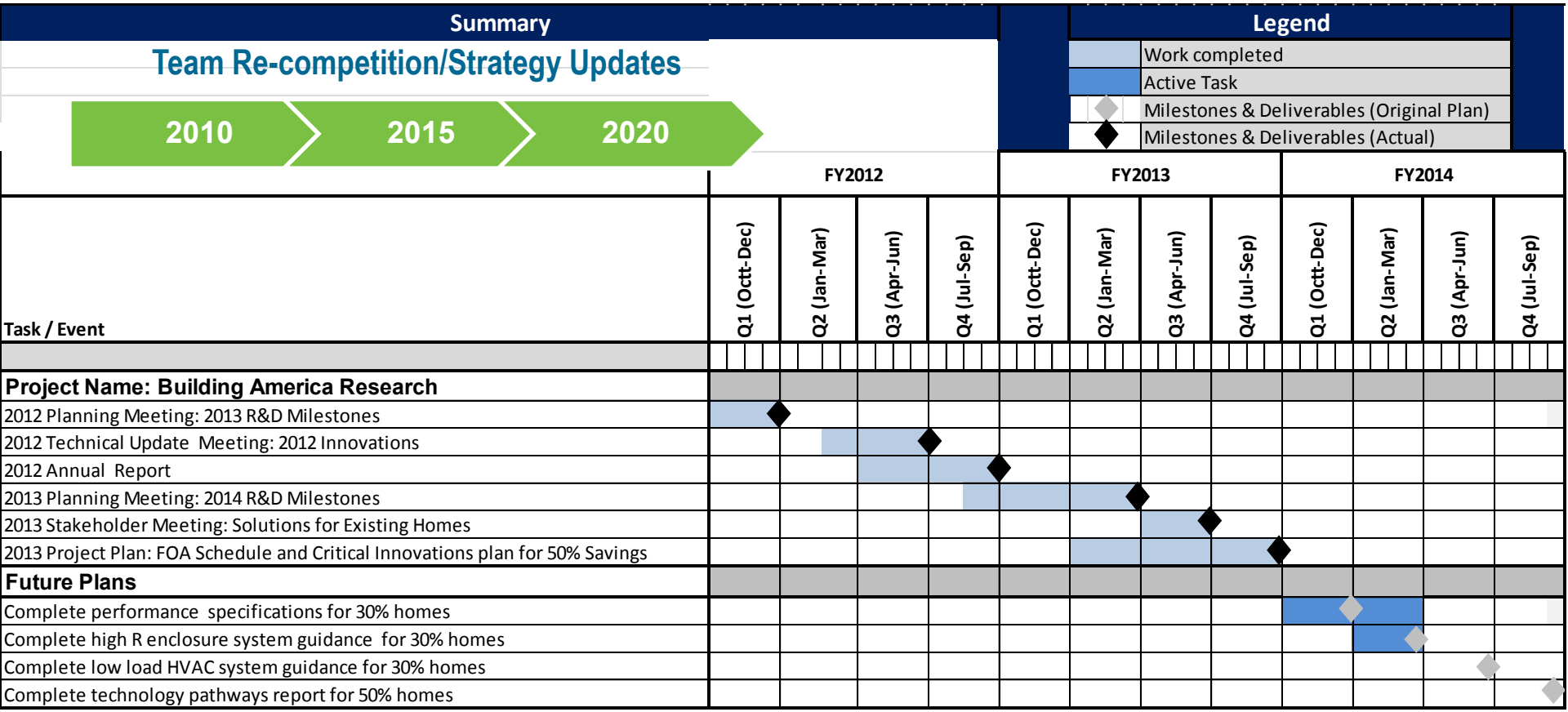
At Your Fingertips!

http://www1.eere.energy.gov/buildings/residential/ba_solution_center.html

Project Plan & Schedule

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

Project original initiation date: 1/1/2010
Project planned completion, 30% savings: 12/31/2014
Project planned completion, 50% savings: 12/31/2020



Project Budget

Variances: *None*

Cost to Date: *Expenditures are on track with annual spending plan: 50% costed at 50% point.*

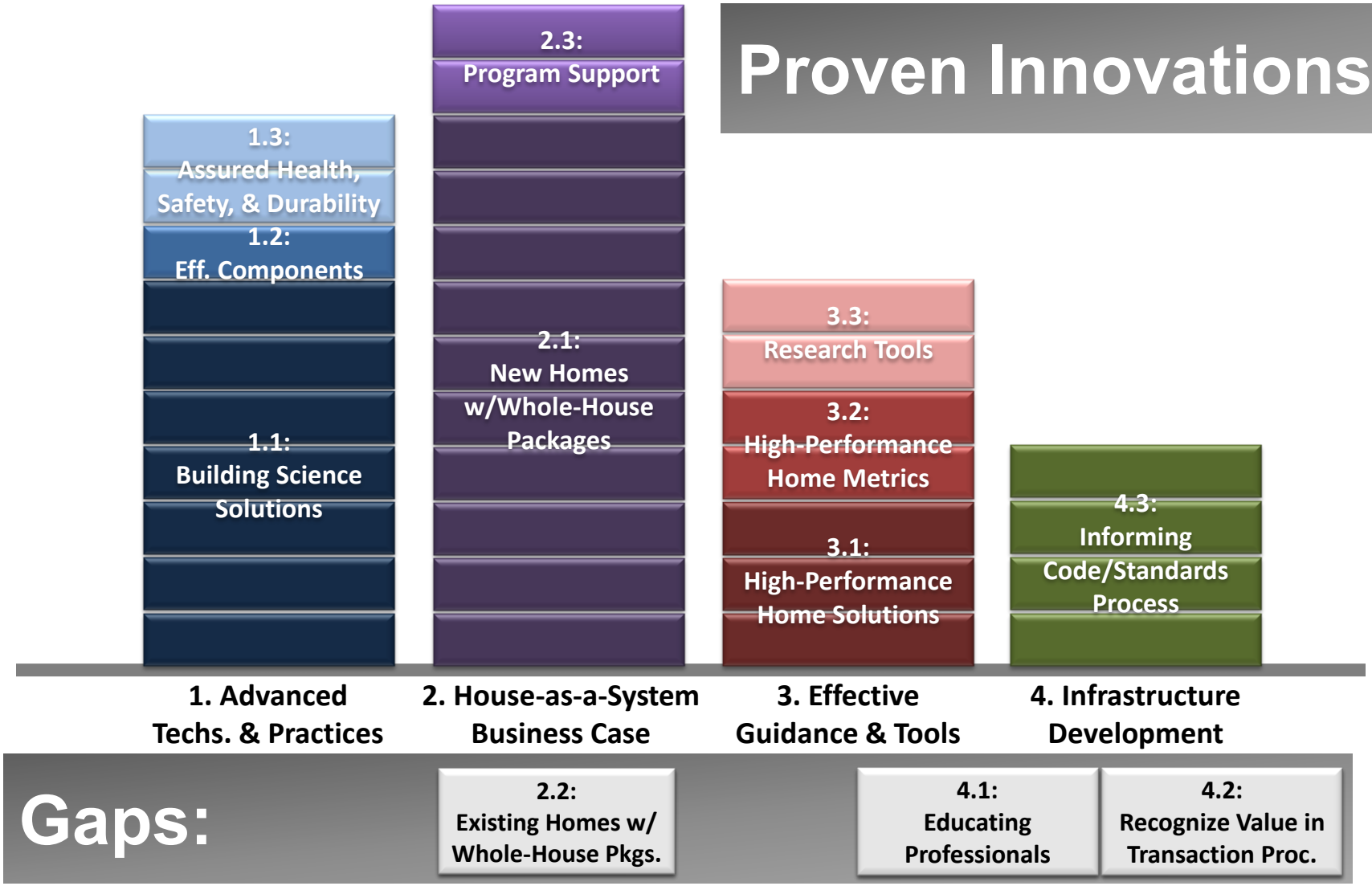
Additional Funding: *Cost share from industry partners averages 20% of total project cost including building materials and labor for test houses and in kind .*

Budget History					
FY2010		FY2011		FY2012	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$30 million	$6 million	$20 million	$4 million	$15 million	$3 million

10 industry teams, 4 universities, 4 national laboratories

Progress and Accomplishments

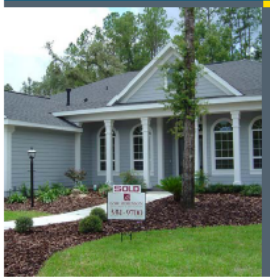
Proven Innovations



32 Top Innovation Profiles:

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

BUILDING TECHNOLOGIES PROGRAM



BUILDING AMERICA TOP INNOVATIONS 'HALL OF FAME' PROFILE

INNOVATIONS CATEGORY:
2. House-as-a-System Business Case
2.3 Program Support

ENERGY STAR for Homes Support

GW Robinson, a production home builder in Gainesville, Florida, worked with Building America to build all 290 units at its Cobblefield development to ENERGY STAR criteria. The builder was one of several featured in a series of guides produced by Building America to help builders achieve ENERGY STAR with climate-appropriate energy-efficiency measures (Baechler et al. 2004-06).

ENERGY STAR for Homes performance metrics gave evidence of a profound impact on our nation's housing: in 2011 alone 30% of builders (8,500 builder partners) built over 1.3 million ENERGY STAR homes that delivered $23 billion in energy cost savings and avoided 210 million tons of green-house emissions. Strong technical underpinnings from Building America have been critical to this success.

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.

ENERGY STAR for Homes, with critical support from DOE's Building America program, has been transformative, leading the U.S. housing industry to high-performance homes and driving the development of a national Home Energy Rating System (HERS) infrastructure.

ENERGY STAR is a joint program of the U.S. Environmental Protection Agency (EPA) and DOE, helping U.S. citizens save money and protect the environment through energy-efficient products and practices. Through ENERGY STAR for New Homes, the DOE and EPA have worked to increase the energy efficiency of the nation's new homes (EPA 2012a). More than 127,000 new homes earned the ENERGY STAR in 2011, bringing the total number of certified homes to more than 1.3 million (EPA 2012a).

ENERGY STAR for new homes was first offered late in 1995. At that time, the ENERGY STAR guidelines targeted "low-hanging fruit," improvements such as high-performance windows, improved air sealing, tightly sealed ducts, and efficient heating and cooling equipment. Homes qualified to ENERGY STAR for Homes Version 1 were 30% more efficient than a home built to the 1993 Model Energy Code (MEC). These initial guidelines stayed in effect for 10 years, with some regional modifications to reflect more rigorous local codes or construction practices (EPA 2012a).

The development of a national Home Energy Rating System infrastructure was a major by-product of ENERGY STAR for Homes during the initial Version 1 specification phase. When EPA first introduced ENERGY STAR for homes, the HERS industry had just started and was not ready to support a national program. The Building America Program stepped in to fill this critical gap with much needed technical support by deploying research teams to work directly with the nation's leading builders to develop energy-efficiency innovations. These teams successfully engaged hundreds of builders to join ENERGY STAR for Homes. This early support proved to be the critical jump start needed to build ENERGY STAR's initial momentum while allowing the HERS industry time to mature. Thus, Building America and ENERGY STAR dovetailed perfectly to help transform the building industry to energy-efficient building practices (EPA 2005).

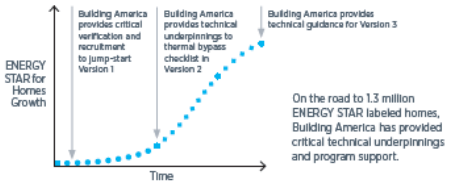
In 2006, EPA developed more stringent guidelines (ENERGY STAR Version 2). The updated guidelines added a Thermal Bypass Checklist, right-sized HVAC systems, and use of efficient lighting and appliances. These guidelines were substantially derived

BUILDING AMERICA TOP INNOVATIONS 'HALL OF FAME' PROFILE

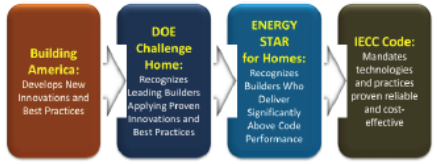
from best practices advocated by Building America. They became effective on January 1, 2007, and the Thermal Bypass Checklist soon after was substantially adopted in the 2009 International Energy Conservation Code (IECC).

In response to increasing code requirements and improving construction practices, EPA released a third-generation of guidelines (ENERGY STAR for Homes Version 3) that took full effect on July 1, 2012. Homes built to ENERGY STAR for Homes Version 3 are approximately 15% more efficient than those built to the 2009 IECC. More importantly, these latest specifications ensure comprehensive building science with detailed checklists substantially informed by Building America research. In addition, DOE is teaming with EPA by making the vast expertise of Building America research teams available for ongoing guidance on the wide array of technical issues and questions required to maintain these specifications.

In October 2010, DOE began developing the 2012 specifications for the DOE Challenge Home in coordination with EPA. The goal was to fully align the old Builders Challenge program with ENERGY STAR for Homes to ensure a unified federal government voice and process for promoting advanced building science. DOE envisions the effort as an opportunity to "road-test building science measures targeted for the next new homes specification" while providing an opportunity to "promulgate technologies and best practices successfully established in their Building America research program" (EPA 2010).



On the road to 1.3 million ENERGY STAR labeled homes, Building America has provided critical technical underpinnings and program support.



Building America, DOE Challenge Home, and ENERGY STAR for Homes are examples of how "good government" programs can work together as a system, creating a highly effective market transformation process that culminates in code adoption of new innovations.

ENERGY STAR HOMES

More than 1.3 million homes nationwide have earned the ENERGY STAR label, as of March 2012.

REFERENCES

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

DOE Building Technologies Program
www.buildings.gov

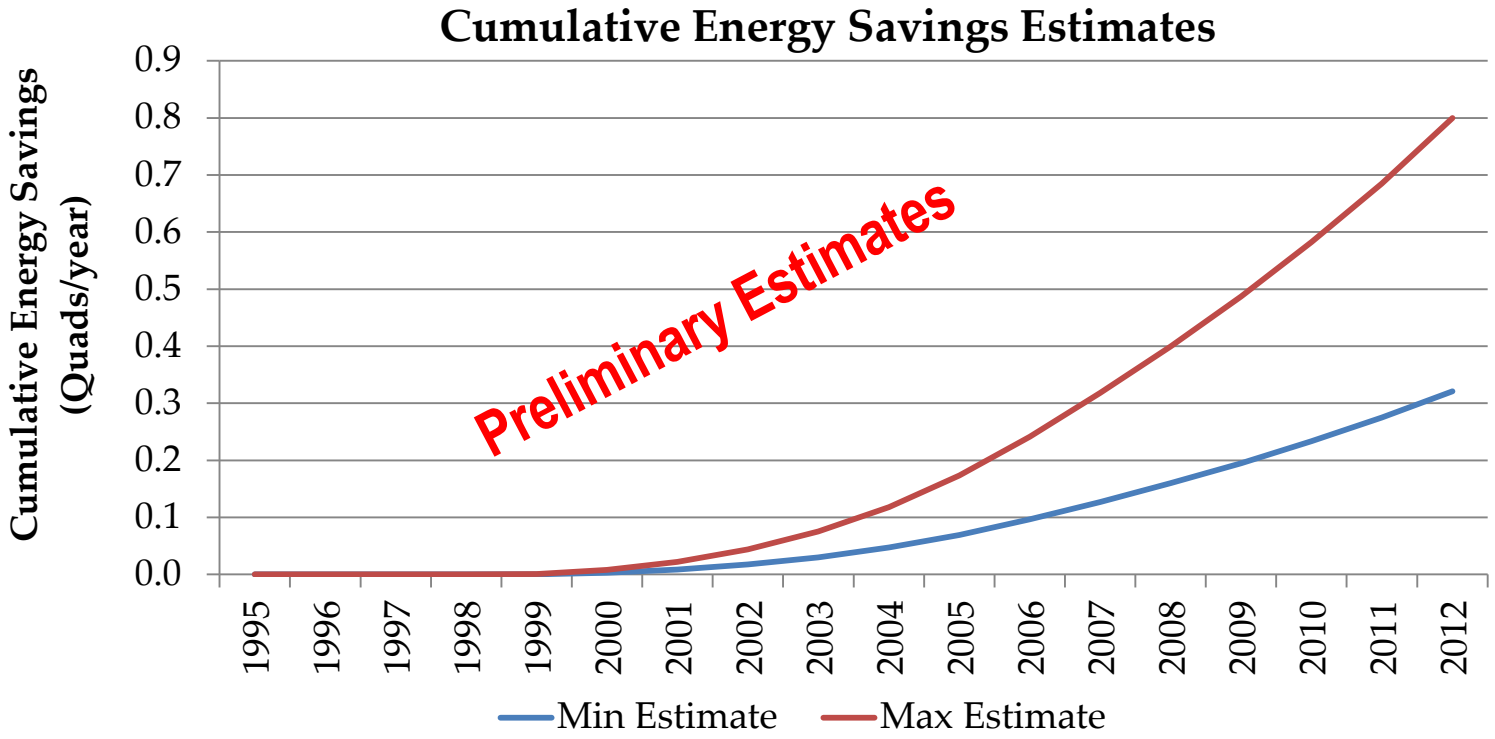
Building America Solutions Center
www.buildingamerica.gov/solutionscenter

PNNL-SA-90561 November 2012

Building America U.S. Department of Energy
www.BuildingAmerica.gov

Accomplishments and Progress

Since 1995, Building America Innovations have resulted in approximately 0.32-0.80 quads of cumulative energy savings for U.S. homeowners and continue to grow each year (new construction market impacts only).



These energy savings correspond to a cumulative utility cost savings of approximately $6.3-$15.8 Billion.*

* Based on 1990-2015 estimates from 2011Building Energy Data Book, Table 2.3.1

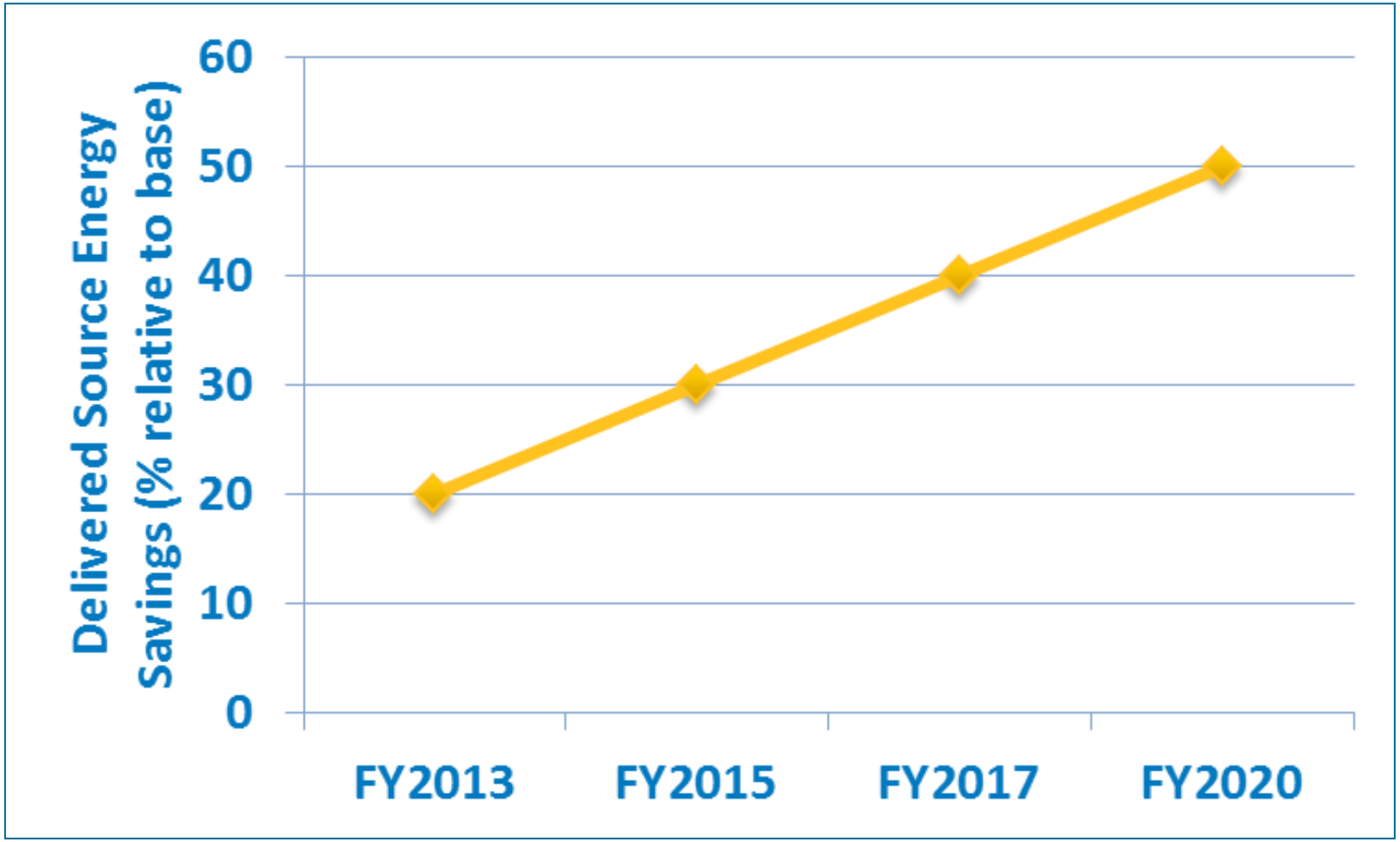
Accomplishments and Progress

"Builders do not have the technical resources to evaluate manufacturer's claims. Building America is the only source of independent research on new technologies. Adoption of BA research has provided real benefits to our customers." Building America Industry Partner (Top 10 Builder)

Activity	Outcome
System Cost/Performance Analysis, System Performance Maps and Field Studies	Validation of delivered system energy savings and non-energy* costs and benefits
Performance Feedback to Research Partners	Increased system reliability and performance Reduced system risks and costs
Knowledge Outreach: Technical support for codes and standards, development of supply chains, performance rating, and building science education	Accelerated market delivery of buildings as systems

Accomplishments and Progress

Progress on Goals: *The project is on track to produce validated energy systems that deliver 30% energy savings by 2015 and 50% energy savings by 2020.*



Example: Duct System Innovation

Ducts in Conditioned Space:

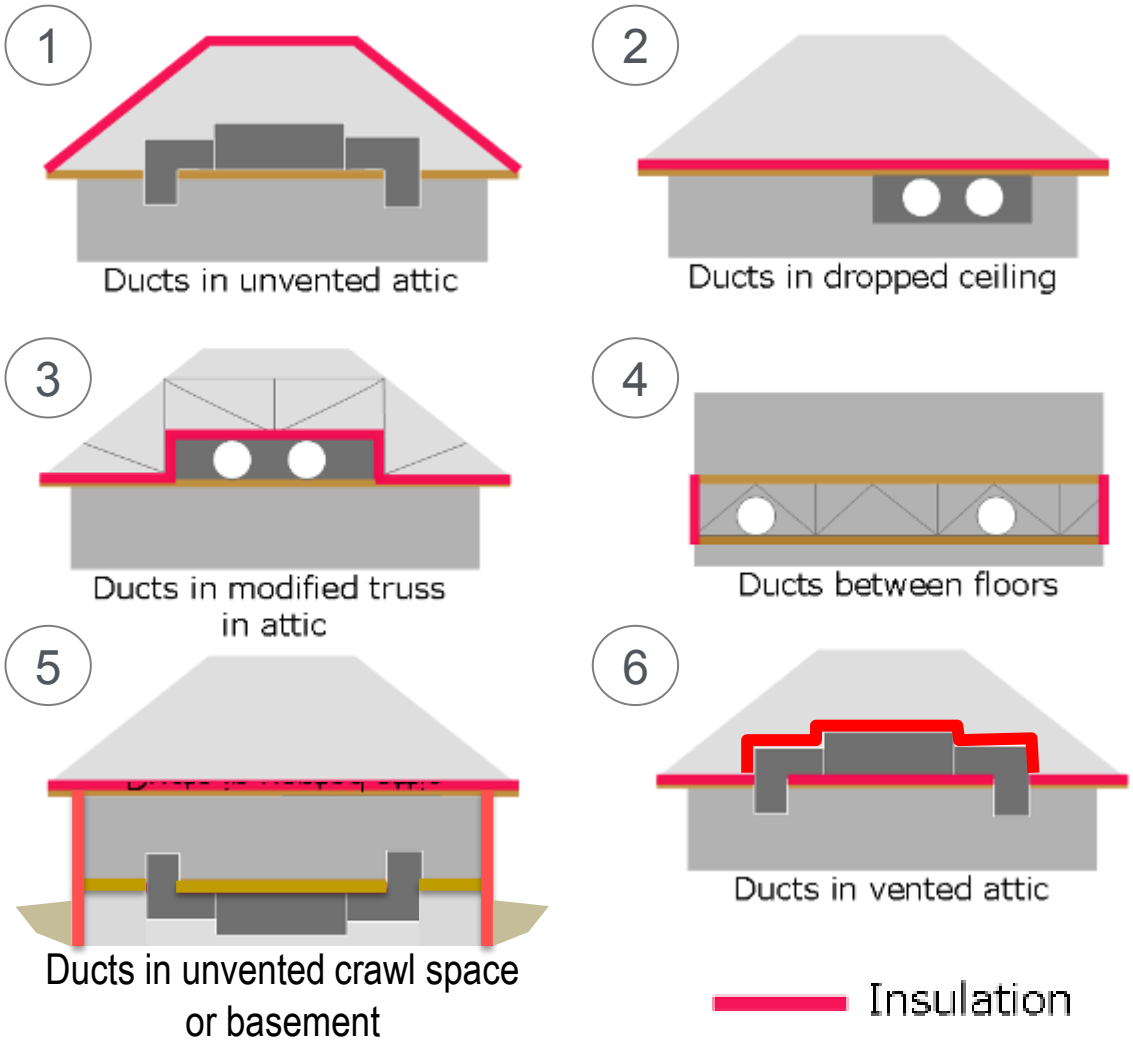
Building America provided proven solutions for locating ducts in conditioned space that are being adopted by builders across the country.

- ~8 – 15% savings on air conditioning bills
- 1,000's of homes

Example: Duct System Innovation

Ducts in Conditioned Space:

Building America developed and demonstrated 6 different cost-effective solutions for locating ducts inside conditioned space. All are being adopted by builders across the country.



Example: Duct System Innovation

Figure 20. Ductwork well-sealed to sheetrock with ccSPF

Figure 21. Rigid insulation inserted under ductwork to serve as a substrate and provide insulating value

Figure 22. Varying thickness of ccSPF and interference from cross bracing

Figure 23. Varying application thicknesses shown on rectangular (left) and round (right) ducts

Example: WH Retrofit System Innovation

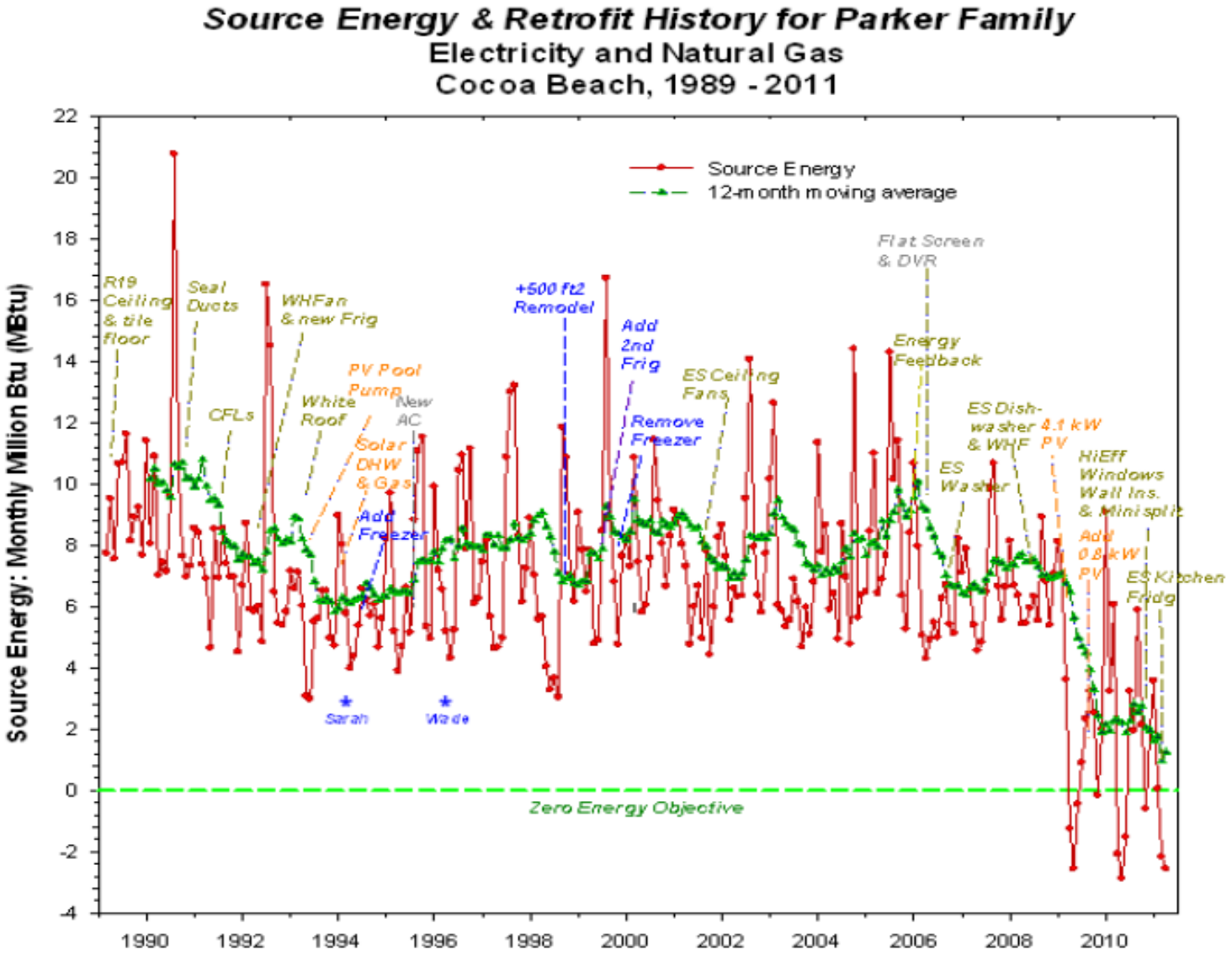
Phased

Deep Energy Retrofits:

Building America is currently investigating strategies for phased whole house retrofits to achieve deep energy savings (>50%).

- Parker residence achieved “Net Positive” in 2012, through incremental cost effective retrofits

Example: WH Retrofit System Innovation



Awards/Recognition: *Annual innovation awards were initiated in 2012 and 32 innovations were awarded. 10-20 additional innovation awards are expected each year.*

BUILDING AMERICA TOP INNOVATIONS

Recognizing Top Innovations in Building Science

http://www1.eere.energy.gov/buildings/residential/ba_innovations.html

Collaborations, Tech Transfer, and Market Impact

Partners, Subcontractors, and Collaborators:

Building America SM U.S. Department of Energy

Industry Research Teams

BA-PIRC

BARA BUILDING AMERICA RETROFIT ALLIANCE

ARIES Collaborative

Alliance for Residential Building Innovation

NorthernSTAR

CARB Consortium for Advanced Residential Buildings

bsc Building Science Corporation

IBACOS | Home Quality + Performance |

NAHB RESEARCH CENTER SM

PARR The Partnership for Advanced Residential Retrofit

+

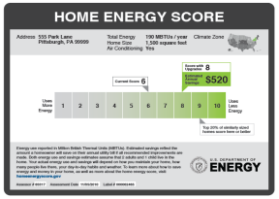
National Labs: NREL, PNNL, ORNL, PNNL

http://www1.eere.energy.gov/buildings/residential/ba_research.html

Project Integration, Collaboration & Market Impact

Deployment Program Partnerships:

- DOE Challenge Home & Energy Star: All new construction projects
- Home Performance w/Energy Star: 13 Projects (BSC, FSEC, IBACOS, NAHBRC, PARR)
- Better Buildings Neighborhood Partnership grantees: 3 projects (FSEC)
- Better Buildings Challenge: 6 projects (IBACOS)
- Home Energy Score Pilots: 5 projects (DEG, FSEC, IBACOS)
- Weatherization Assistance Program: 3 projects (DEG, UMN)



Technology Transfer, Deployment, Market Impact: Building science knowledge is integrated into real world projects and the Building America Solution Center

ENVIRONMENTS FOR Living®

BUILDING SCIENCE.

IT'S ALL ABOUT BUILDING A BETTER, GREENER HOME.

California Public Utilities Commission

Fact Sheet

Energy Efficiency Zero Net Energy Program

SheaHomes®

Caring since 1881

What Is *SheaXero*?

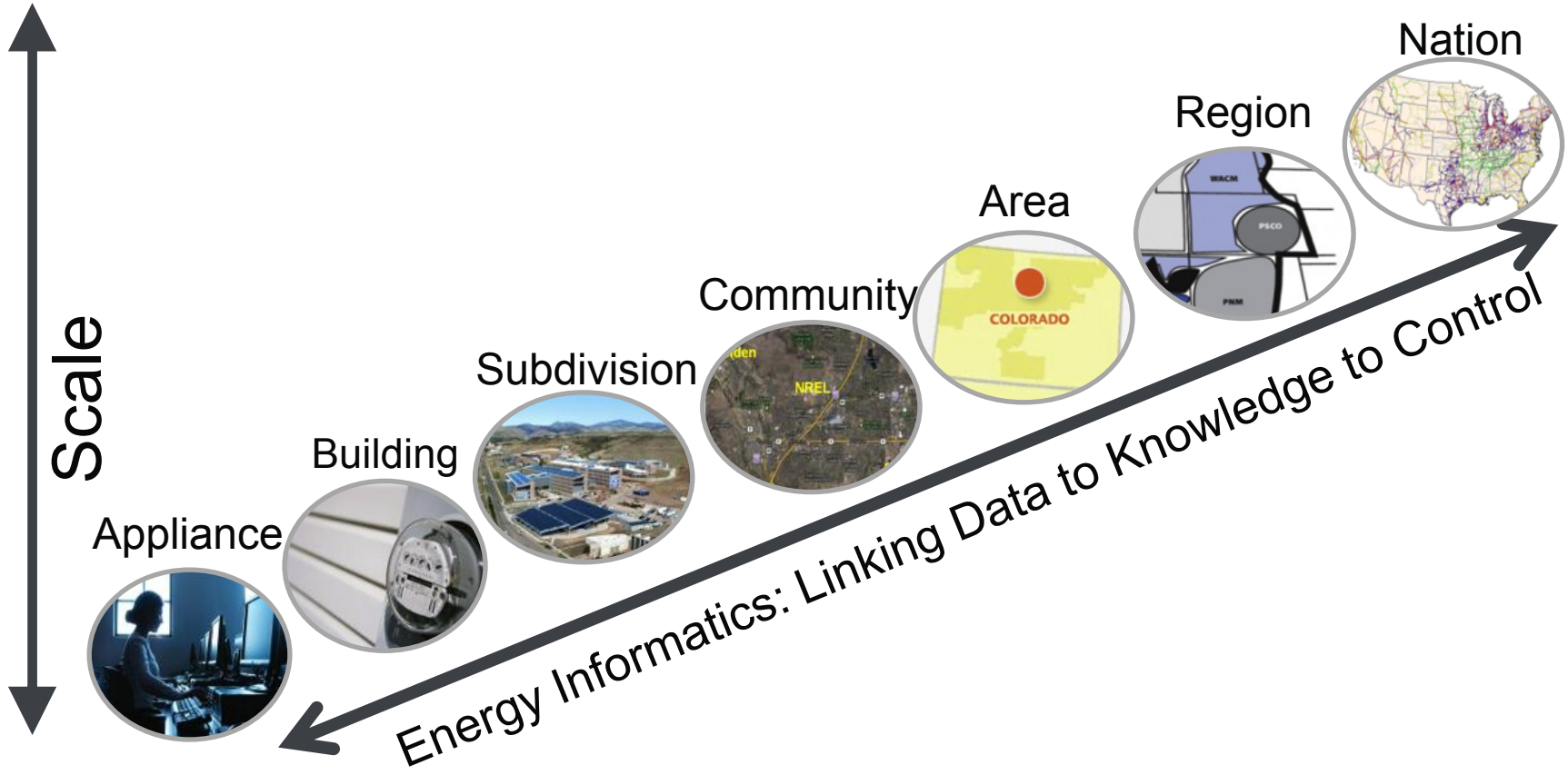
SheaXero is a state-of-the-art package, available for a limited time at no extra cost, which combines a solar power system with energy-efficient features to eliminate your electric bill.

No bills. No gimmicks. No kidding.

Next Steps and Future Plans

Next Steps and Future Plans:

- Future research will focus on developing the innovations required to deliver 50% savings and enable net zero energy ready homes at community-scale.
- A FOA will be issued by DOE in October, 2014 to select the industry research teams for 2015-2020.



Next Steps and Future Plans

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

Public Records and Census Data

Floor Area, Bedrooms, Foundation Type Year Built

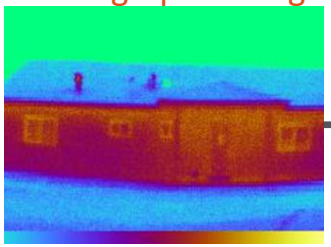
Monthly Bills
High-Interval Meter Data

Data for Automated Calibration and/or Inverse Modeling

Satellite Imagery

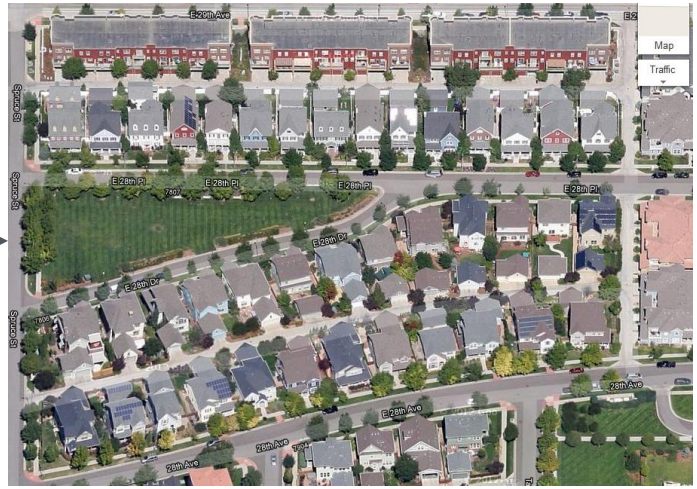
Footprint, Orientation & Shading

Drive-By Infrared Themographic Imagery



Thermal Properties & Geometry

Data-Driven, Physics-Based Simulation and Optimization Software



Community scale optimization

Community scale energy savings potential

Targeted deployment at scale