



U.S. Department of Energy  
Energy Efficiency and Renewable Energy

**Building**  
**AMERICA**  <sup>SM</sup>  
U.S. Department of Energy  
***Research Toward Zero Energy Homes***



**2007 ACEEE Market Transformation**

*Washington, DC*

**George S. James**  
*U.S. Department of Energy*

[www.buildingamerica.gov](http://www.buildingamerica.gov)



# What is a Zero Energy Home?

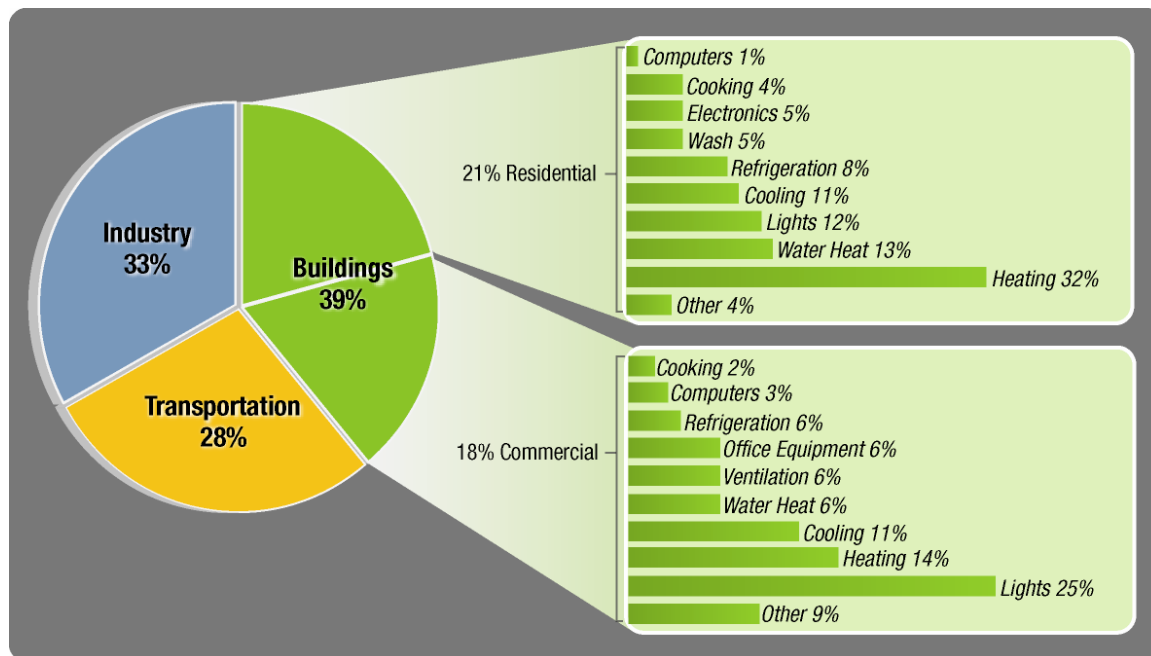
- Zero (net) energy
- Zero peak load
- Zero emissions
- Zero complaints (from homebuyers)
- Zero cost (83% in nat. survey of 1700 indicated that positive cash-flow with mortgage & utility bills is fine)



# Why Are We Interested in Zero Energy Homes?

**Buildings consume 39% of total U.S. energy**

- **71% of electricity**
- **53% of natural gas (primary consumption)**



Developing cost neutral net-zero energy homes (ZEH) is a critical part of ongoing DOE efforts to increase U.S. energy efficiency.



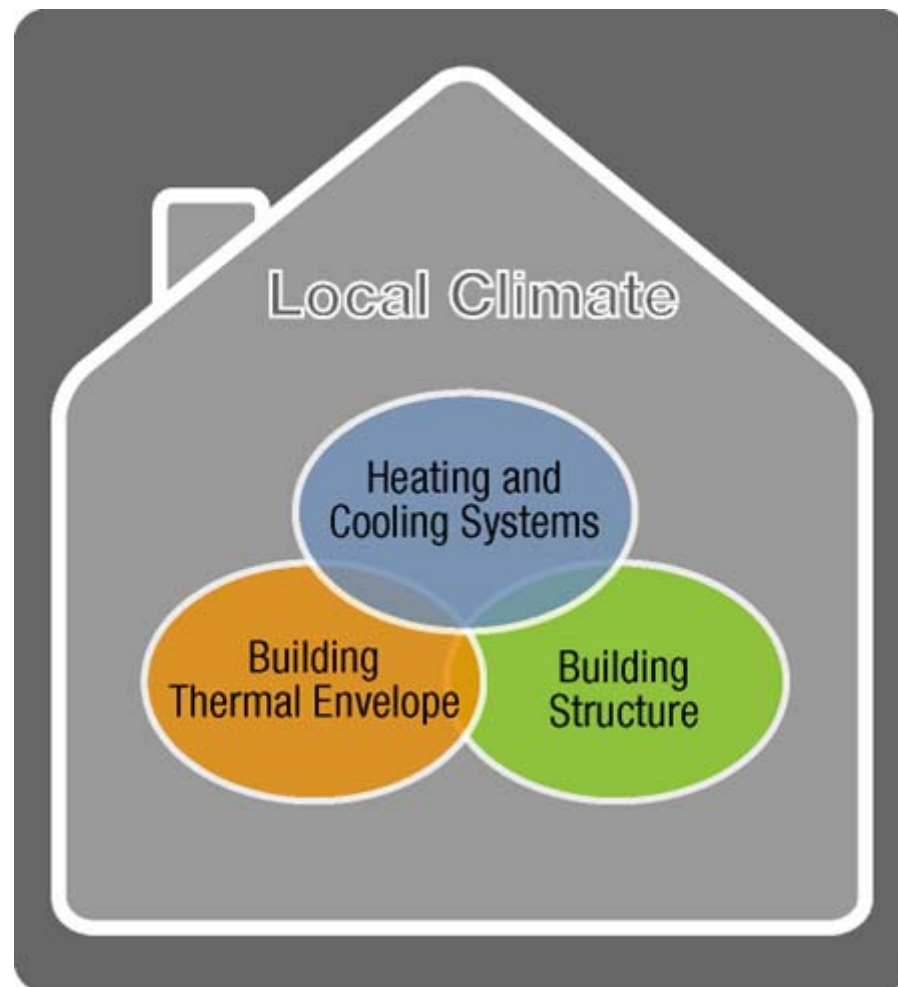
# What is Building America?

- Public/private partnership sponsored by DOE and cost-shared with industry
  - Research and development
  - Technology implementation
  - Technical support
- Conducts “whole-house” systems research to
  - Improve overall housing performance
  - Increase durability and comfort
  - Reduce energy use
  - Increase energy security for America’s homeowners



# Whole-House Approach

Systems engineering approach considers performance and interactions of all building components and systems



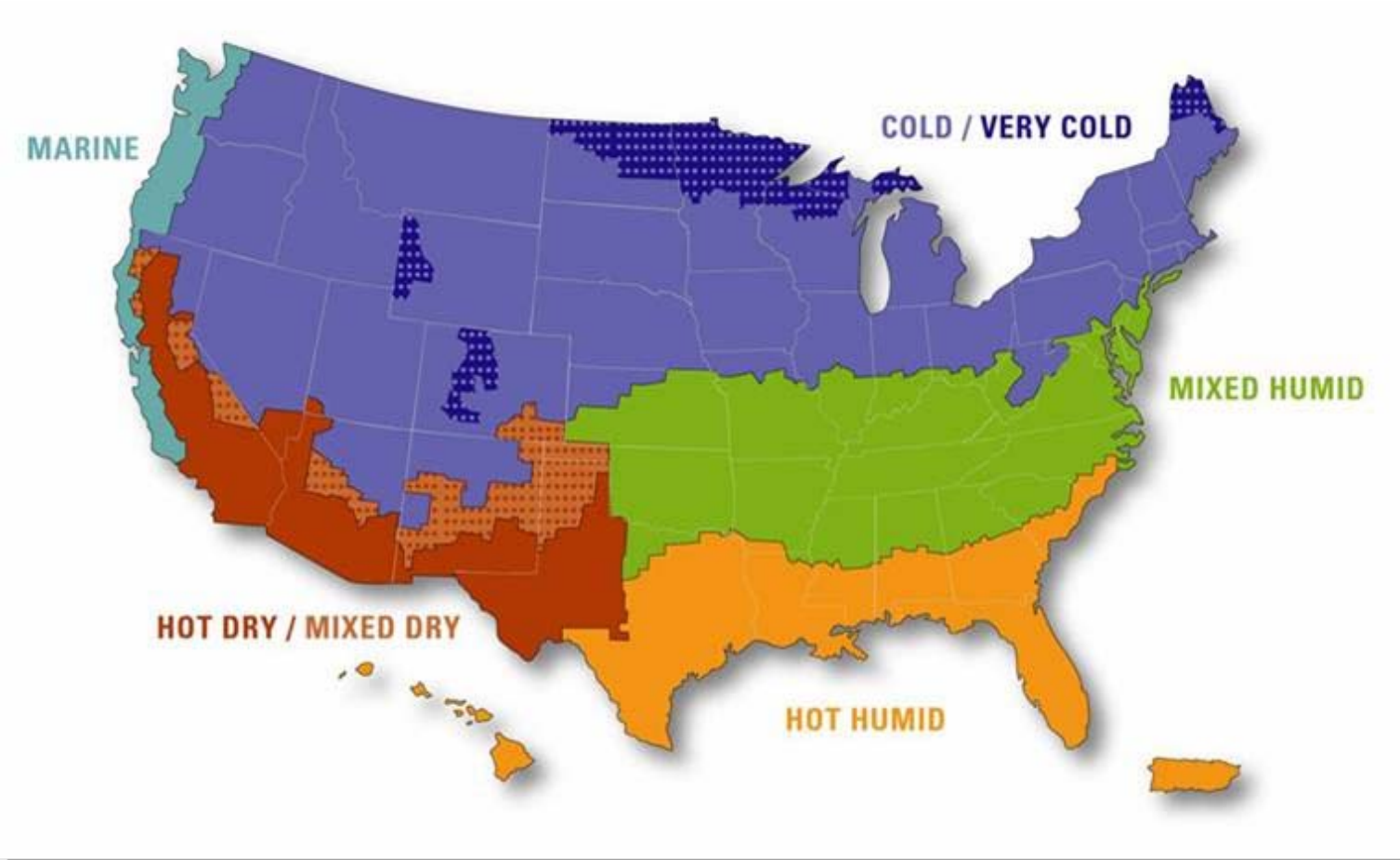


# A **Green** Building is a building that...

- ✓ creates **comfortable** environments that are:
  - Aesthetically pleasing
  - Plenty of day-lighting
  - Draft-free
- ✓ creates **healthy** environments
- ✓ creates **durable** environments that are:
  - Built to last
  - Provide moisture control and forgiving building envelopes
- ✓ creates **energy efficient** environments that:
  - Are affordable to operate
  - Use materials to their maximum potential
  - Minimize or eliminate waste

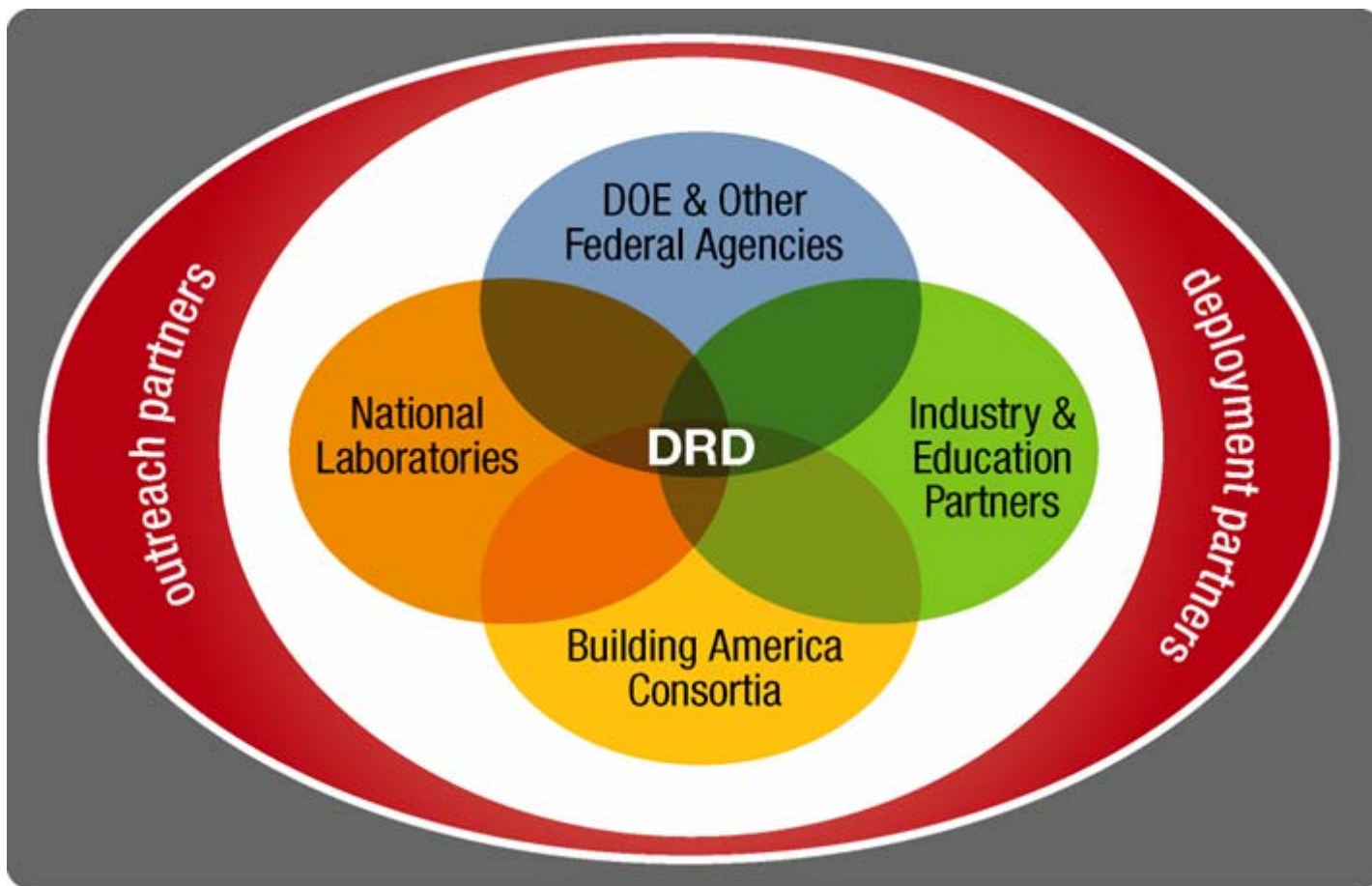


# Systems Engineering Research Goals Consider Moisture and Thermal Climate Zones





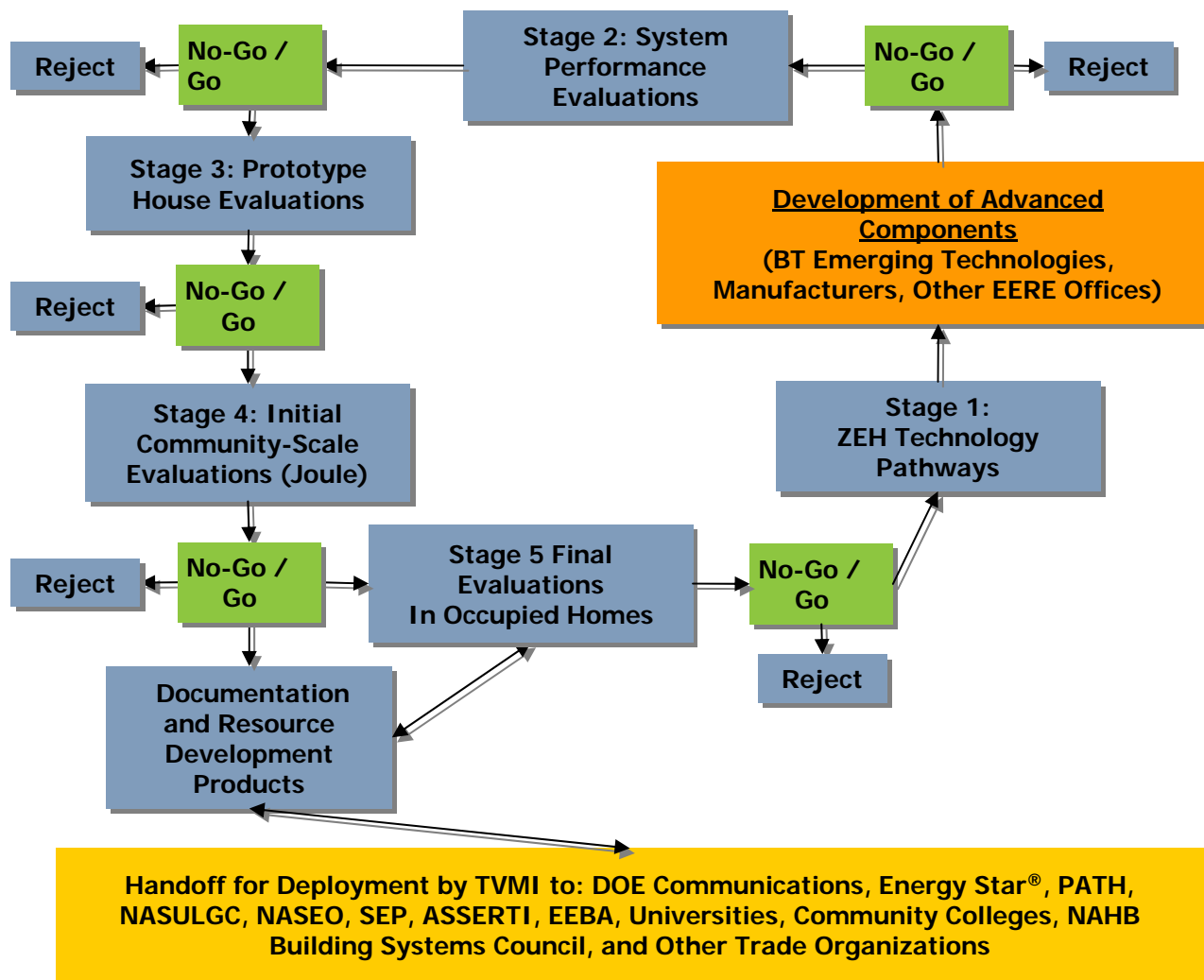
# Building America Research Community







# Building America Systems Research Process





# The Teams

Seven teams of experts provide technical assistance – to date, working with more than 500 housing industry partners

- Building Science Corporation (BSC)
- Buildings Industry Research Alliance (BIRA)
- Consortium for Advanced Residential Buildings (CARB)
- Davis Energy Group (DEG)
- Integrated Building and Construction Solutions (IBACOS)
- Industrialized Housing Partnership (IHP)
- National Association of Home Builders - Research Center (NAHB-RC)



# Copper Moon

1,618 sq ft



**Building Science Consortium**

*Architecture and Building Science*

## Features

- ✓ Un-vented cathedral attic
- ✓ Low-E<sup>2</sup> spectrally selective windows
- ✓ Sealed ducts with mechanical ventilation
- ✓ Stack framing
- ✓ Blown cellulose wall and ceiling insulation

Tucson, Arizona



# Cost Summary for Copper Moon

## Tucson, Arizona

Un-vented roof	+ \$ 750
NOT installed roof vents	– \$ 500
High performance windows	+ \$ 300
Controlled ventilation system	+ \$ 150
Downsize air conditioner by 2 tons	– \$ 1000
Sealed combustion furnace	+ \$ 400
<b><i>TOTAL PREMIUM</i></b>	<b>+ \$ 100</b>



# Program Activities

- Finding performance solutions for
  - New and existing homes
  - Integrating clean onsite energy systems
- Providing Building America “best practices” assistance for homebuilding industry



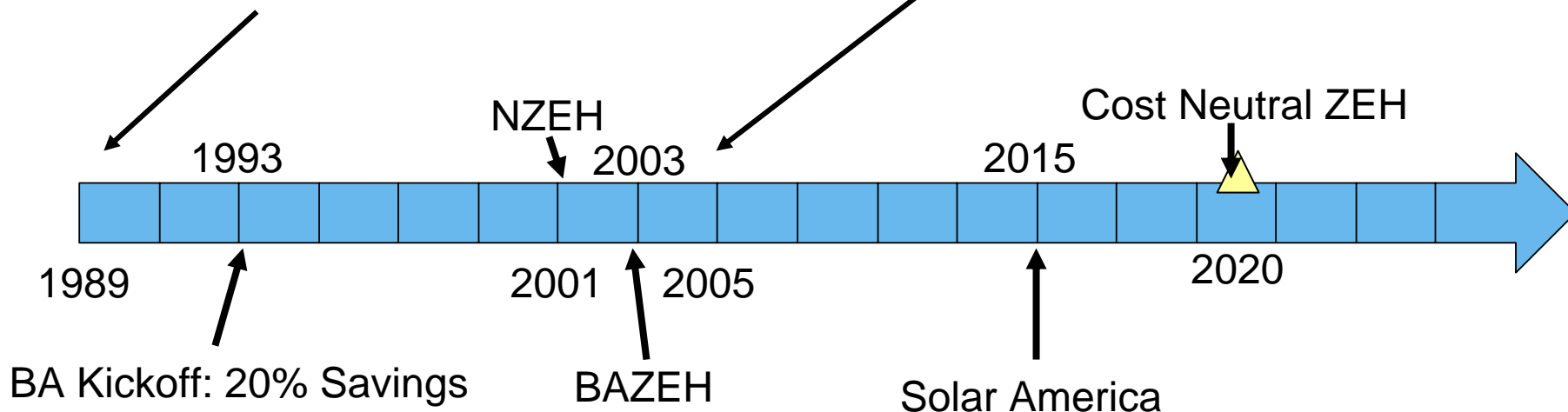


# Brief History of BA Residential Innovation

GE Living Environments



Denver Habitat ZEH



Over 33,000 BA homes completed



# Van Geet Residence

## Features

- ✓ High mass construction
- ✓ Integrated mechanical system
- ✓ High efficiency appliances & lighting
- ✓ Active solar hot water system for DHW & radiant space heating
- ✓ Propane backup heat & generator
- ✓ Off-grid powered 1.2 kW photovoltaics

3,176 sq ft



Idaho Springs, Colorado





# Georgia Parks Dept. – SIPS Cottage

1,700 sq ft



**Building Science Consortium**

*Architecture and Building Science*

## Features

- ✓ 5 kW photovoltaics
- ✓ Solar hot water heating
- ✓ Design for passive cooling and heating
- ✓ Ducts in conditioned space
- ✓ Controlled ventilation
- ✓ High performance envelope, windows and integrated HVAC system
- ✓ Advanced framing with SIPs

Near Okefenokee Swamp, Georgia





# Research Results



*ZEH2 August 2004*  
**TOTAL energy bill**  
**\$14.52**



*ZEH3*  
**Entire heating season**  
**<\$40.00**



*ZEH4*  
**Only used \$.41/day for**  
**all offsite energy**



# Habitat House - 1<sup>st</sup> Zero-Energy House

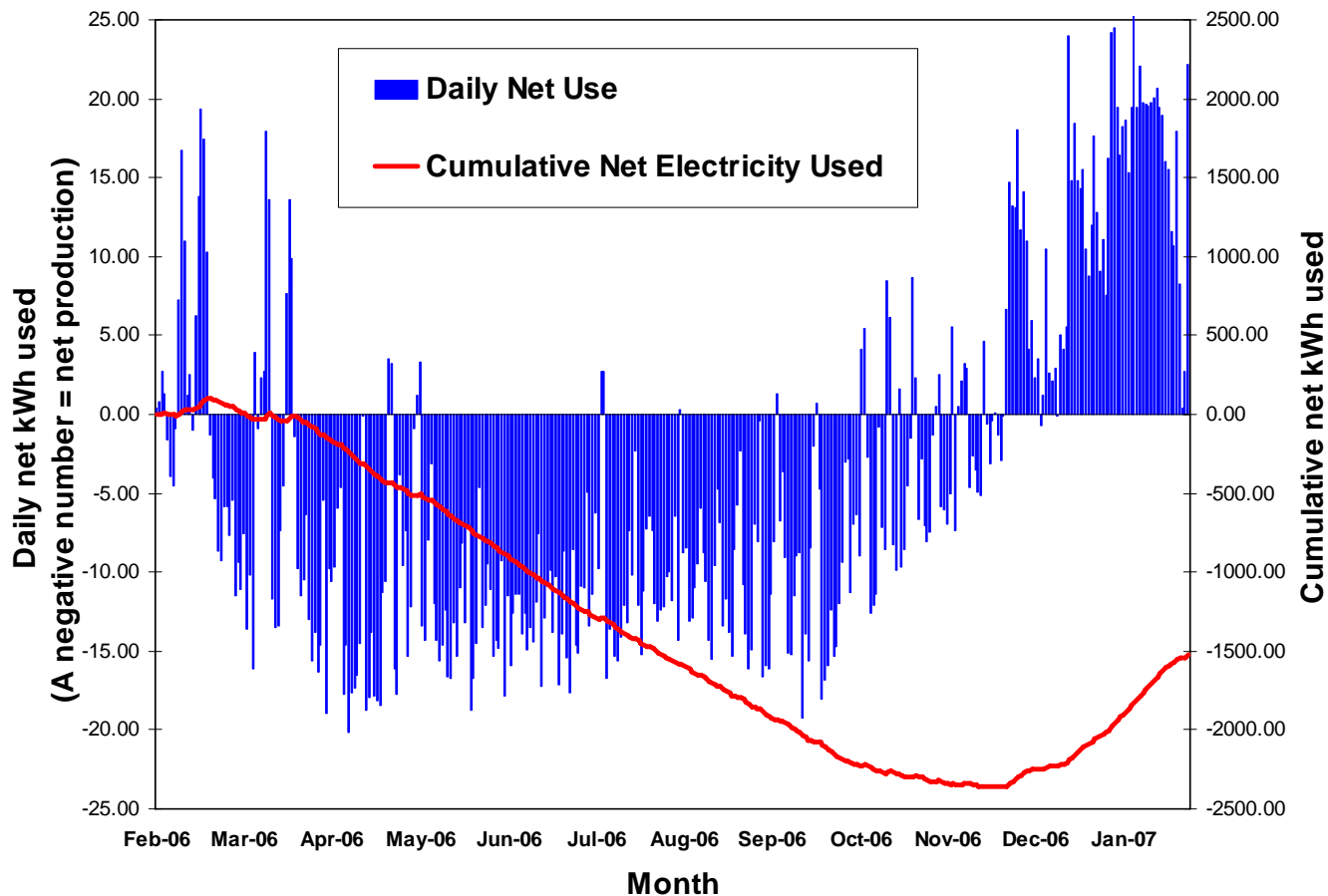
## Features

- ✓ 2x4 double stud walls with 3 layers of R-13 fiberglass
- ✓ Fiber cement over house wrap under siding
- ✓ More insulation in attic (R-60) & floors (R-30)
- ✓ 100% florescent lighting
- ✓ Ventilation with energy recovery dedicated ductwork
- ✓ 4KW PV system
- ✓ Gas-fired space heater with electric baseboard (no ducts)





# Zero energy homes are technically proven today





# North Texas Prototype House

## Features

- ✓ 8-kW roof-mounted photovoltaics
- ✓ High-performance solar windows
- ✓ Vented, reflective metal roofing
- ✓ 90% fluorescent lighting
- ✓ Solar hot water system and tankless water heater
- ✓ Passive heating/cooling/natural ventilation



3,800 sq ft

**Building Science Consortium**

*Architecture and Building Science*

Frisco, Texas



U.S. Department of Energy  
Energy Efficiency and Renewable Energy



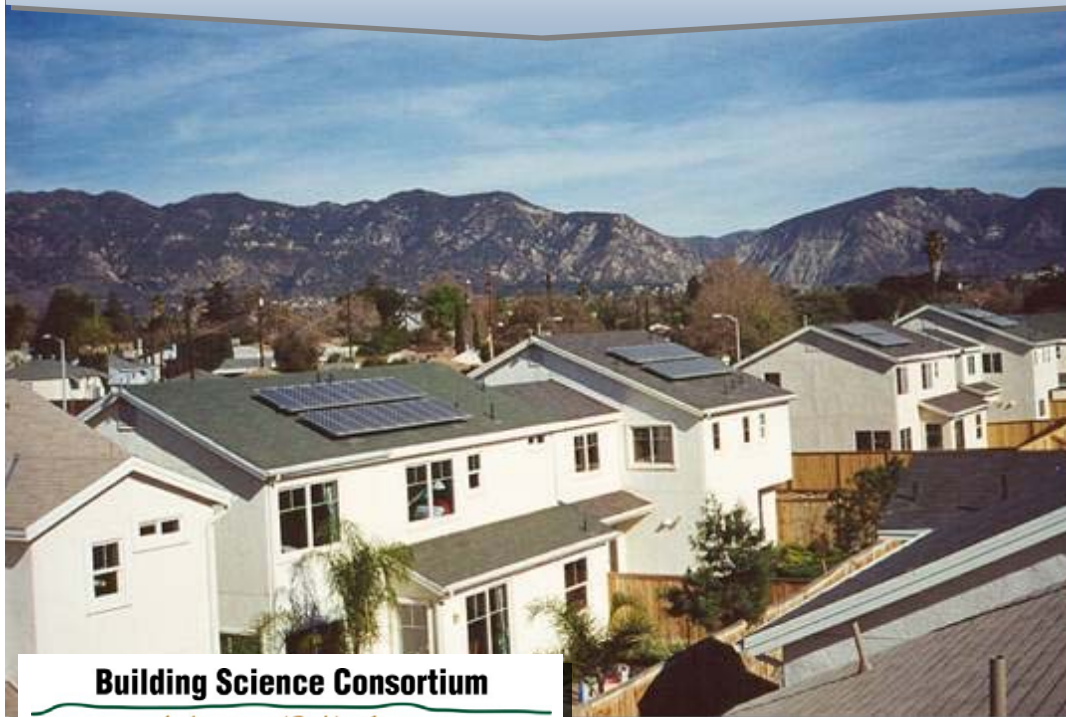
# 2007 New American Home





# Village Green Community

74 units of 1,700 sq ft



**Building Science Consortium**

*Architecture and Building Science*

Sylmar, California

## Features

- ✓ Solar control glazing
- ✓ Integrated ventilation system
- ✓ High efficiency framing
- ✓ Gas cooling to minimize electric load
- ✓ Grid-connected 1.4 kW photovoltaics



# Building America Communities

**Aerial view of Premier Homes**



**Photovoltaic solar cells**





# Energy Efficiency Features

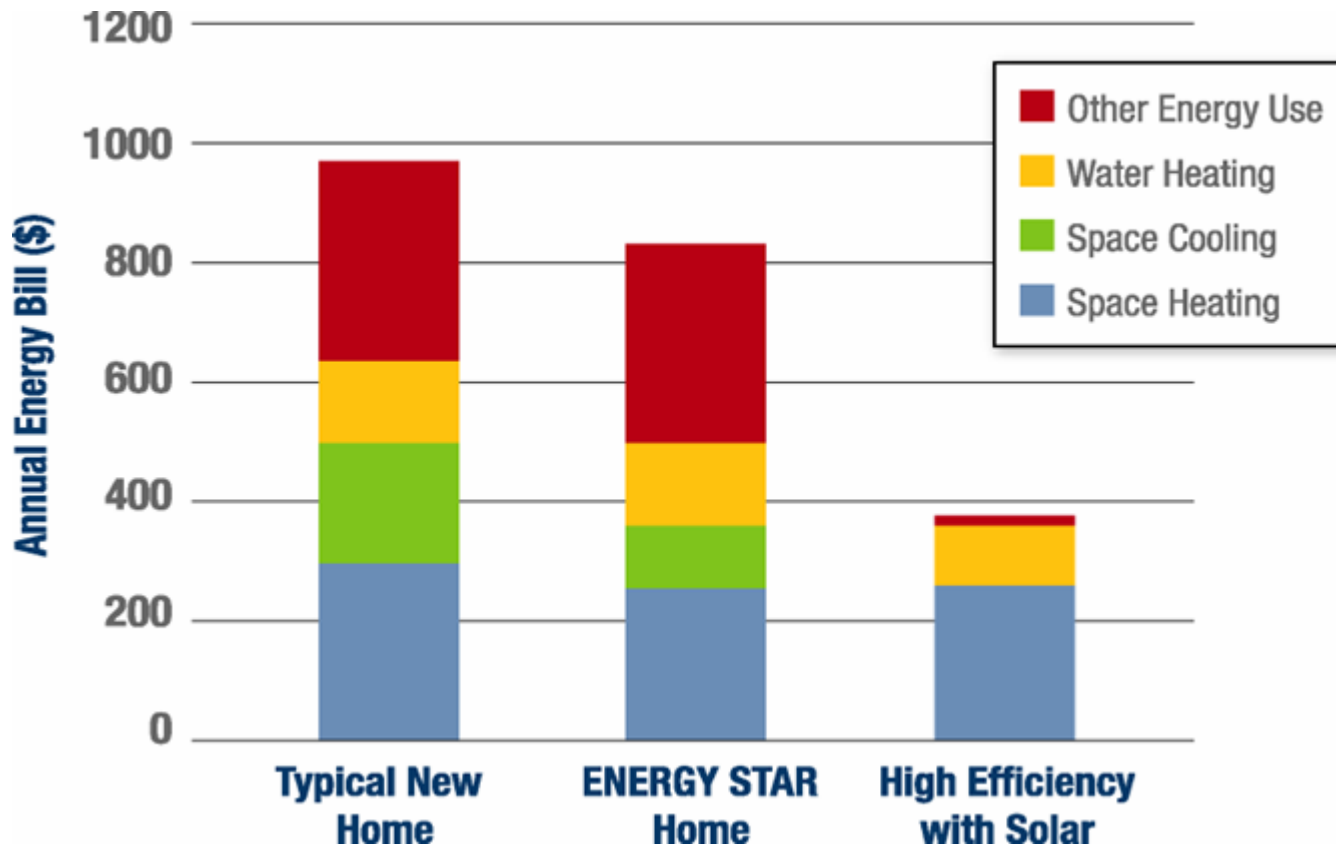
	<u>Non-ZEH</u>	<u>Premier</u>
Walls	<i>R-13 + 1" Foam with Stucco</i>	
Ceiling Ins.	R-30	R-38
Windows	<i>Vinyl-Framed Low-E2</i>	
AFUE	80	92
SEER	10	14 w/TXV
Air Flows	Normal	ACCA - Tested
Ducts (attic)	R-4.2	Buried in ceiling Ins
Duct Sealing	Normal	Sealed
Air Infiltration	Normal	<3 SLA, tested
Water Heater	40gal 0.60EF	Tankless 0.82EF
Lights	Incandescent	Fluorescent
Solar	None	2.4kW BIPV





# Annual Energy Bill Comparison

(typical Premier home in column 3)



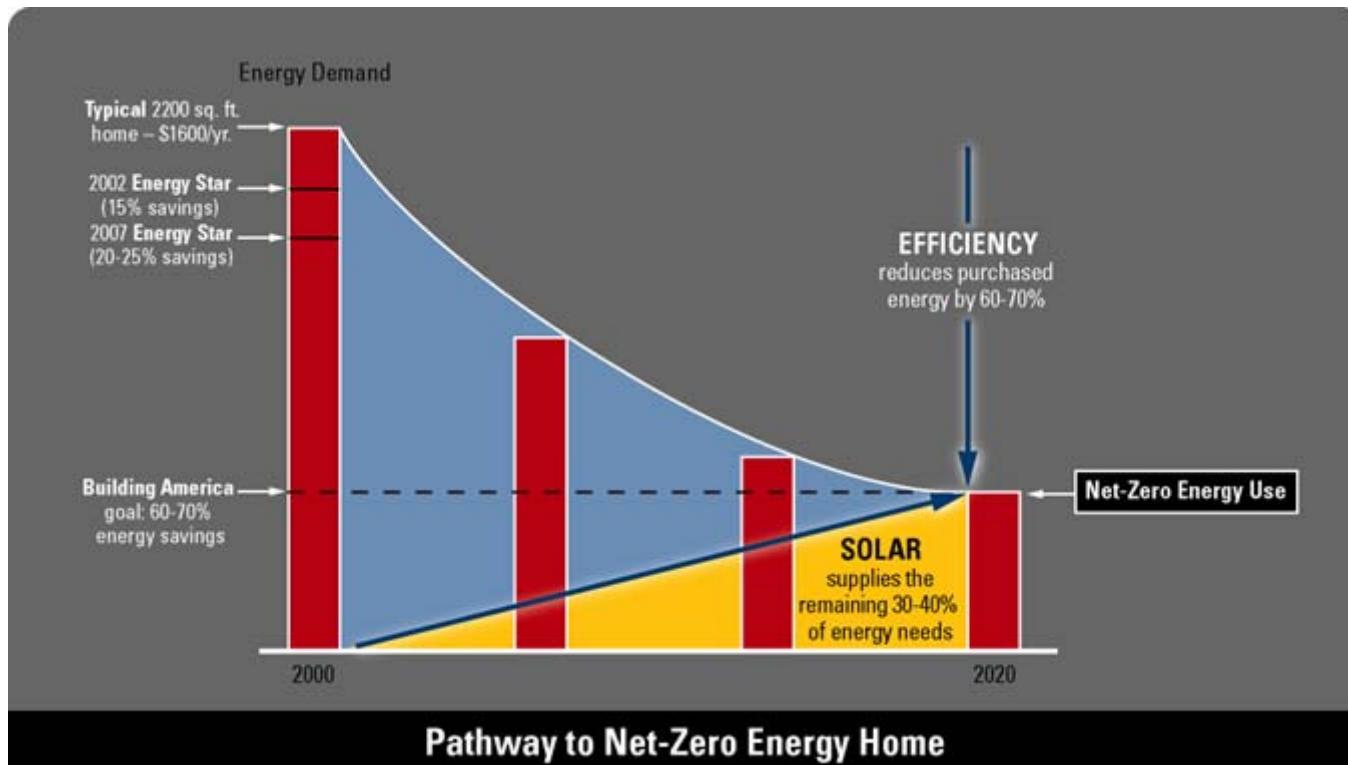


# ZEH Developments in California

Builder	Location	# ZEH	PV	Savings
SheaHomes	San Diego	16	2.4 kw	62%
Premier Homes	Sacramento	99	2.4 kw	56%
Premier Homes	Sacramento	50	2.4 kw	57%
Clarum Homes	Watsonville	257	Varied	47%
Centex Homes	San Ramon	32	3.5 kW	58%



# How Far Can We Go?



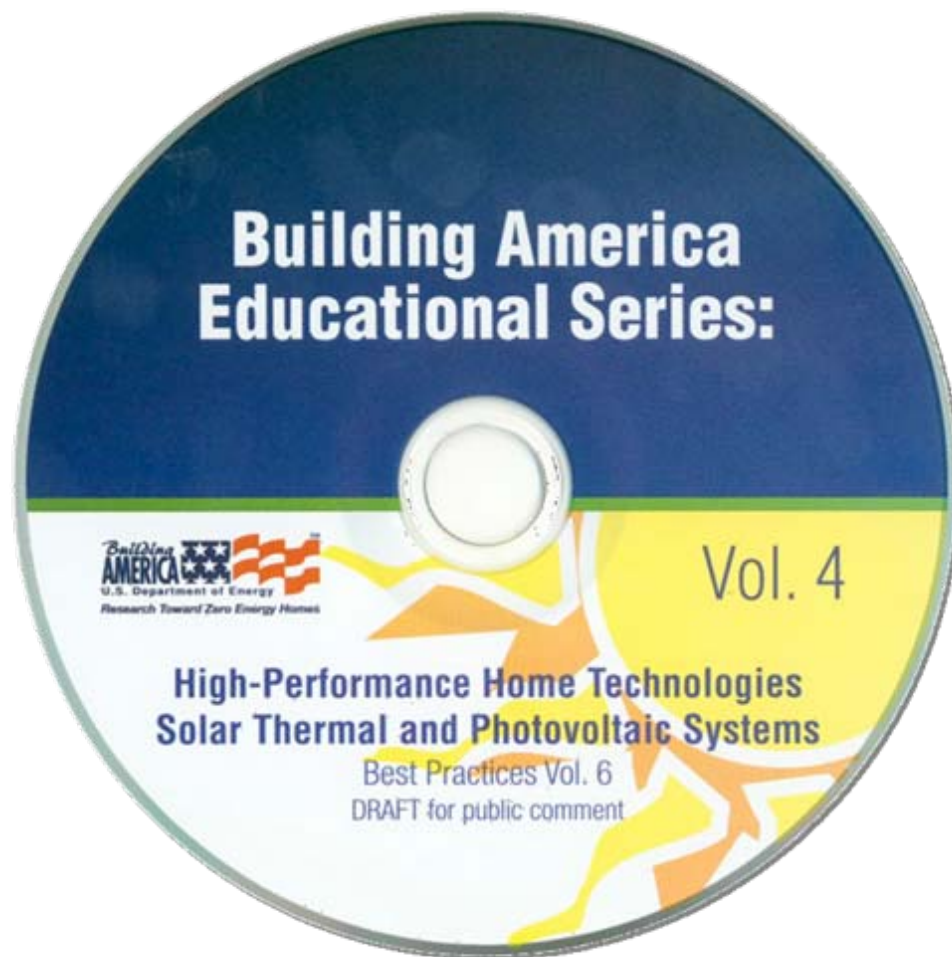
Building America research is driving toward affordable zero energy homes by 2020



U.S. Department of Energy  
Energy Efficiency and Renewable Energy



# Building America Best Practices Series





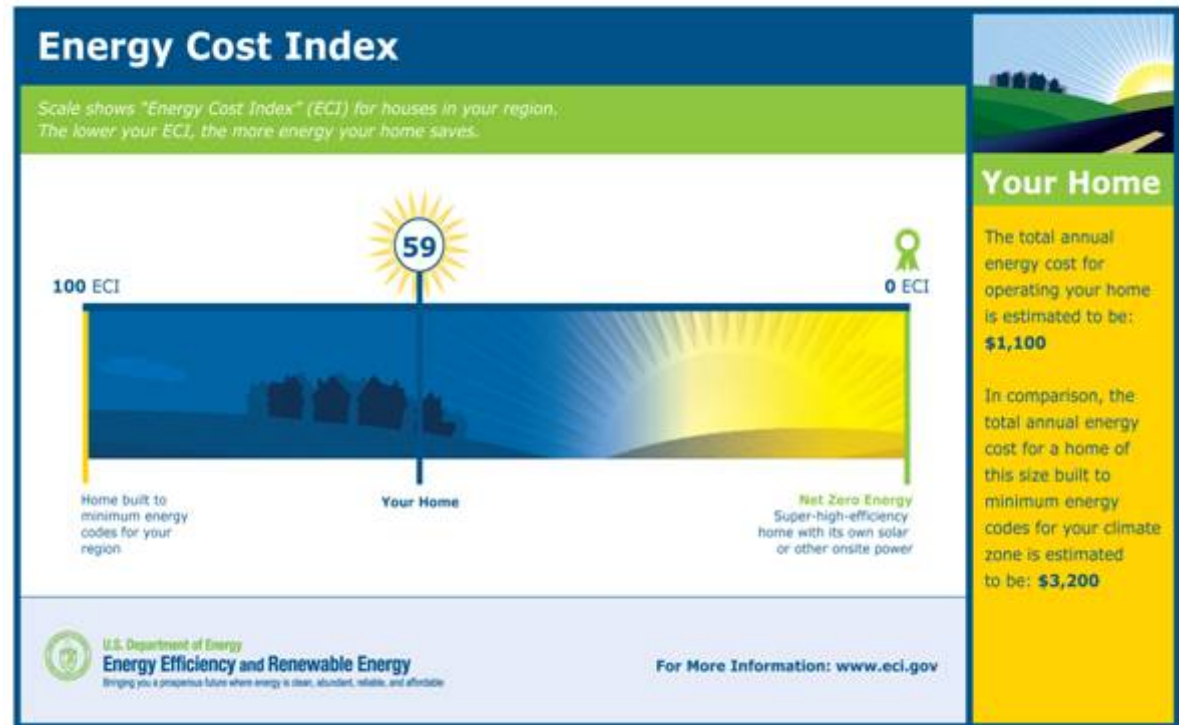
# Other Energy Efficiency Programs

- ENERGY STAR<sup>®</sup> new homes program
  - Builders can certify their new homes offer an average annual energy savings of 15%.
- Environments for Living<sup>®</sup> program
  - Strict pre-construction plan review provides limited guarantees on heating and cooling portion of utilities
- Residential Energy Services Network (RESNET)
  - Provides IRS-approved raters that verify homes meet qualifications to receive new federal tax credit for energy efficient homes
    - Gives consumers more buying power with energy efficient mortgages



# Preliminary Concept for Energy Scale

- Clear, objective information on home energy costs
- Driving informed consumer demand, and continuous improvement toward zero energy





U.S. Department of Energy  
Energy Efficiency and Renewable Energy

October 12 - 20, 2007  
[www.solardecathlon.org](http://www.solardecathlon.org)





# Solar Decathlon Objectives

- Education
  - Students
  - General public
  - Professional builders and architects
  - Energy service providers
  - Decision makers
- Research and development
  - Largest housing experiment ever held
  - Testing and redesign
- Outreach







U.S. Department of Energy  
Energy Efficiency and Renewable Energy

*Building*  
**AMERICA**  <sup>SM</sup>  
U.S. Department of Energy  
*Research Toward Zero Energy Homes*



[www.buildingamerica.gov](http://www.buildingamerica.gov)



# 2007 New American Home





Carnegie Mellon University, *Pittsburgh, PA*

Cornell University, *Ithaca, NY*

Georgia Institute of Technology, *Atlanta, GA*

Kansas State University, *Manhattan, KS*

Lawrence Technological University, *Southfield, MI*

Massachusetts Institute of Technology, *Cambridge, MA*

New York Institute of Technology, *Old Westbury, NY*

Santa Clara University, *Santa Clara, CA*

Team Montréal (École de Technologie Supérieure,  
Université de Montréal, McGill University), *Montreal,*  
*CANADA*

Technische Universität Darmstadt, Darmstadt, GERMANY

Texas A&M University, College Station, TX

The Pennsylvania State University, University Park, PA

Universidad de Puerto Rico, Río Piedras and Mayagüez, PR

Universidad Politécnica de Madrid, Madrid, SPAIN

University of Cincinnati, Cincinnati, OH

University of Colorado, Boulder, CO

University of Illinois at Urbana-Champaign, Urbana, IL

University of Maryland, College Park, MD

University of Missouri-Rolla, Rolla, MO

University of Texas at Austin, Austin, TX