

Advanced Residential Building Program Design: Lessons Learned from Building America Research Leading to Zero Energy Homes

Dr. Ren Anderson, NREL

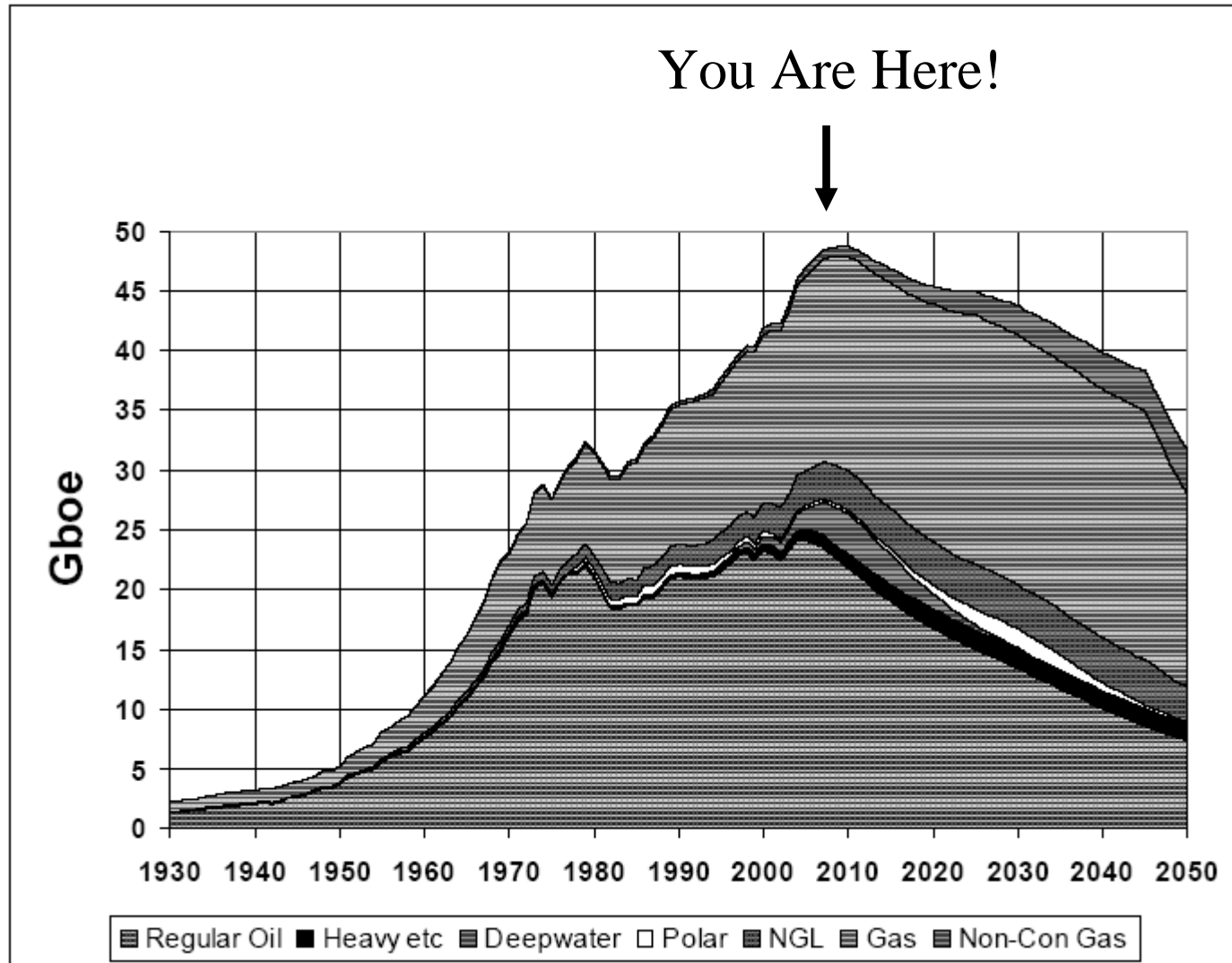
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Communities: Maximizing our Potential
Council of Energy Resource Tribes
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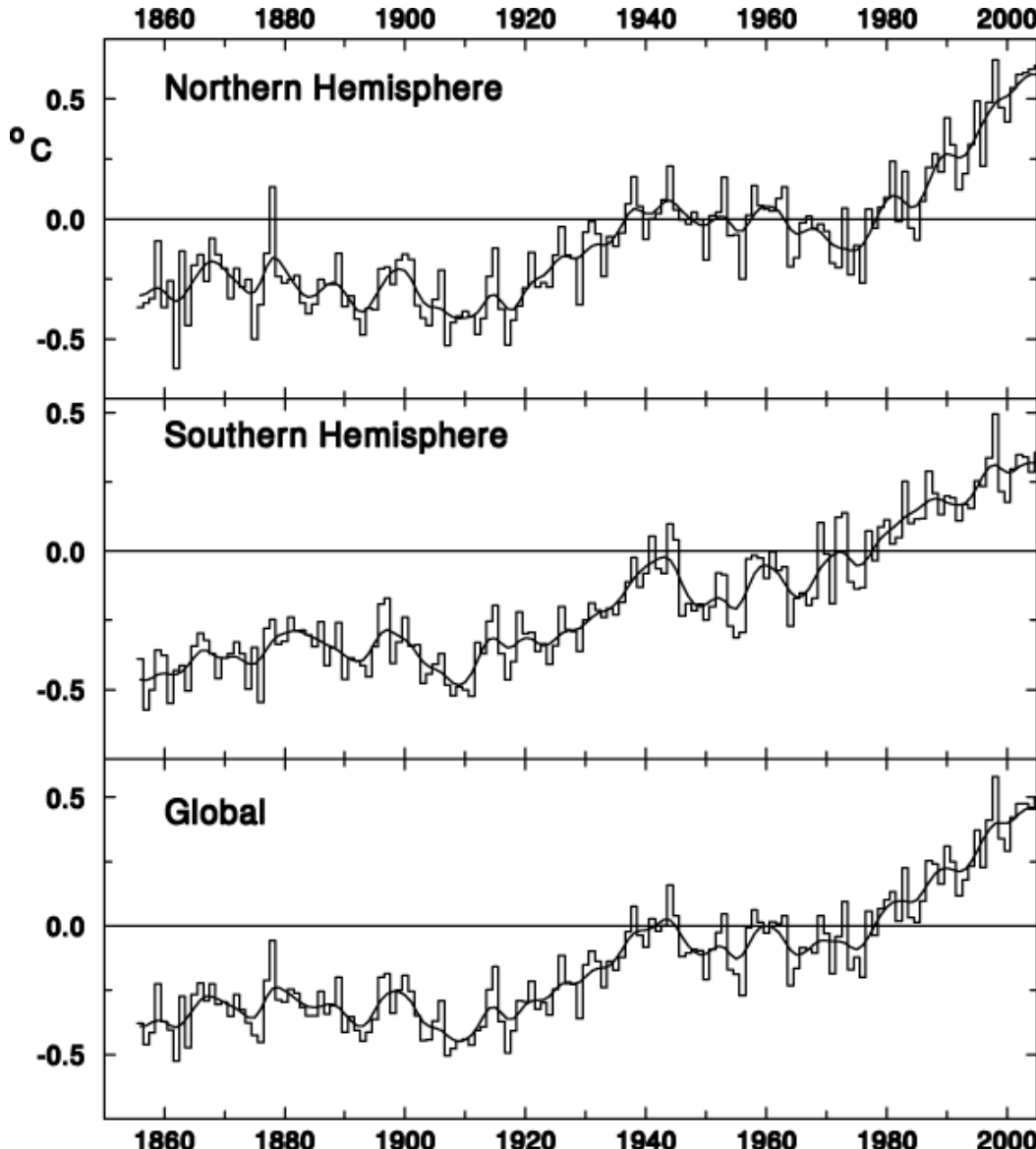
Why is DOE Interested in ZEH?

Development of cost effective Zero Energy Homes (ZEH) is the long term (2020) research goal for the Building America Program, as part of ongoing efforts to increase the efficiency of US energy use.

How Long Will Fossil Fuels Last?



How Hot Will It Get?



“World temperatures keep rising. Climate data show 2005 on track to be hottest on record.”

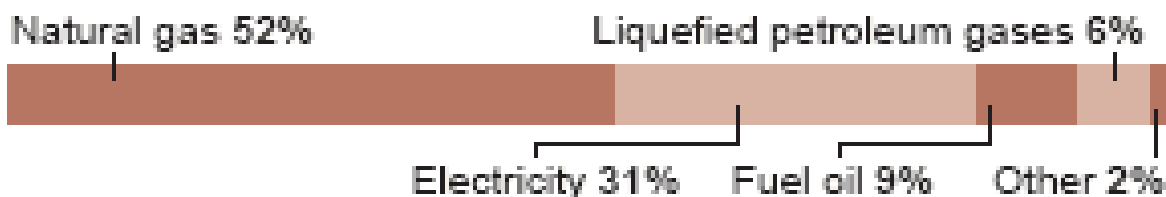


How High Will Utility Bills Go?

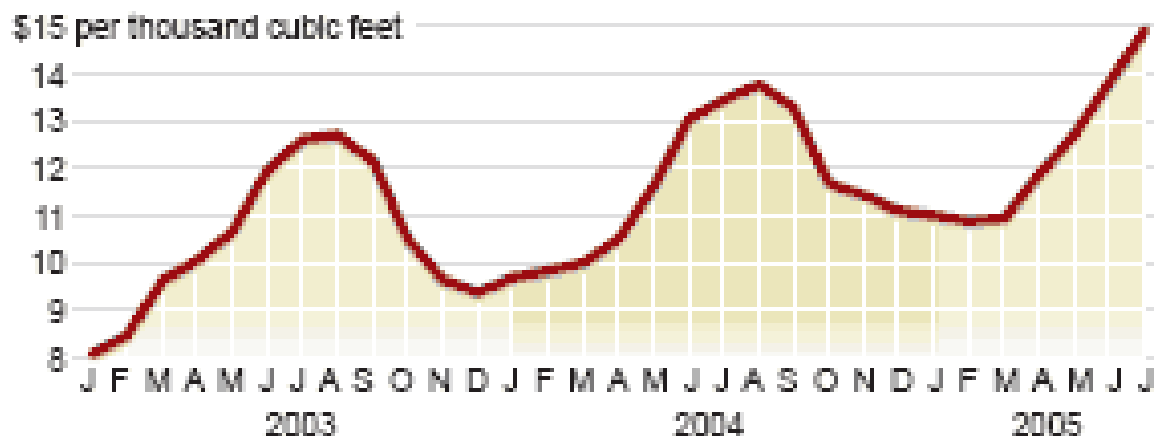
A costly winter for home heating expected

Industry analysts expect higher than normal heating bills this winter. A majority of homes are heated using natural gas.

Type of heating in occupied housing units, 2003



U.S. natural gas residential price

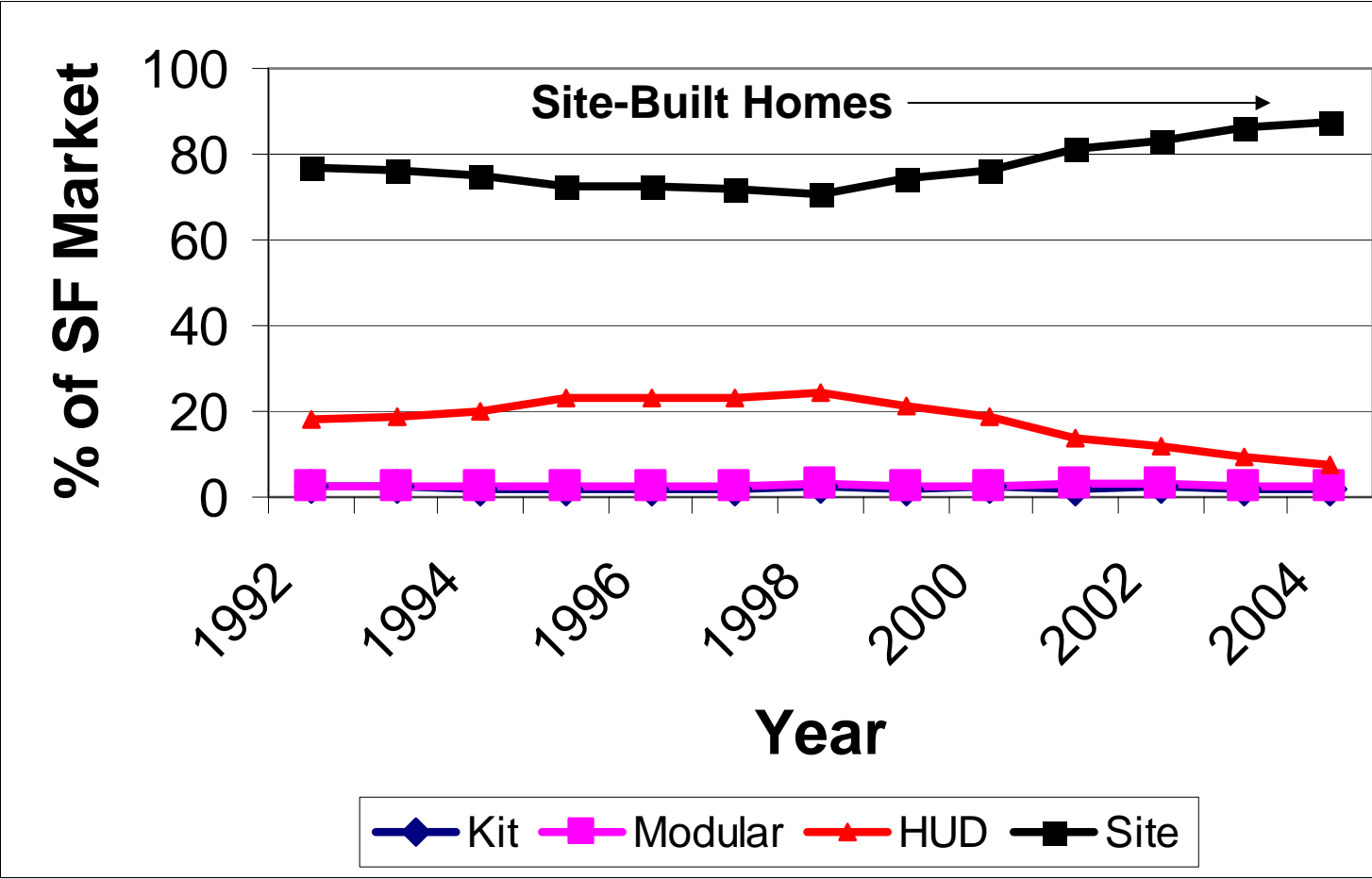


“We tend to seek easy, single factor explanations of success.

For most important things, though, success actually requires avoiding many separate possible causes of failure.”

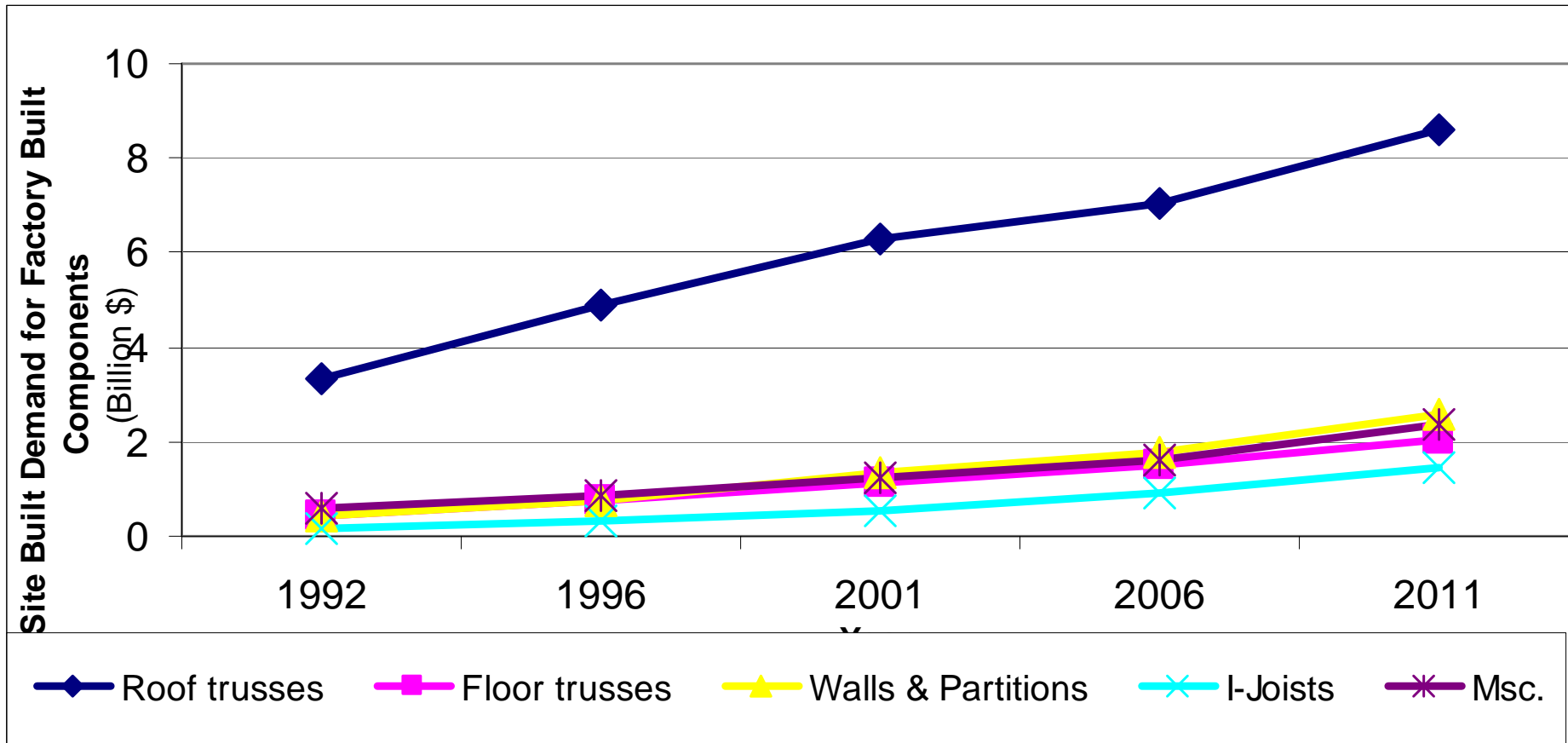
-Jared Diamond

Site Builders Currently Account for Nearly 90% of All New Homes Built in the US Each Year



U. S. Census Bureau, Residential Construction Characteristics

Builders are Rapidly Shifting to the Use of Standardized, Pre-Manufactured Components to Reduce Onsite Labor and Speed the Construction Process



"The Factory Built Components Industry Is Almost as Large as the Softwood Lumber Industry", Al Schuler, **STRUCTURAL BUILDING COMPONENTS MAGAZINE**, April 2003.

Residential construction is based on:

-A multi-step construction process that is managed across multiple homes, and

-”Just in Time” delivery of the systems, skills, and materials required for each step of the construction process

Builders Tend to Avoid Changes That :

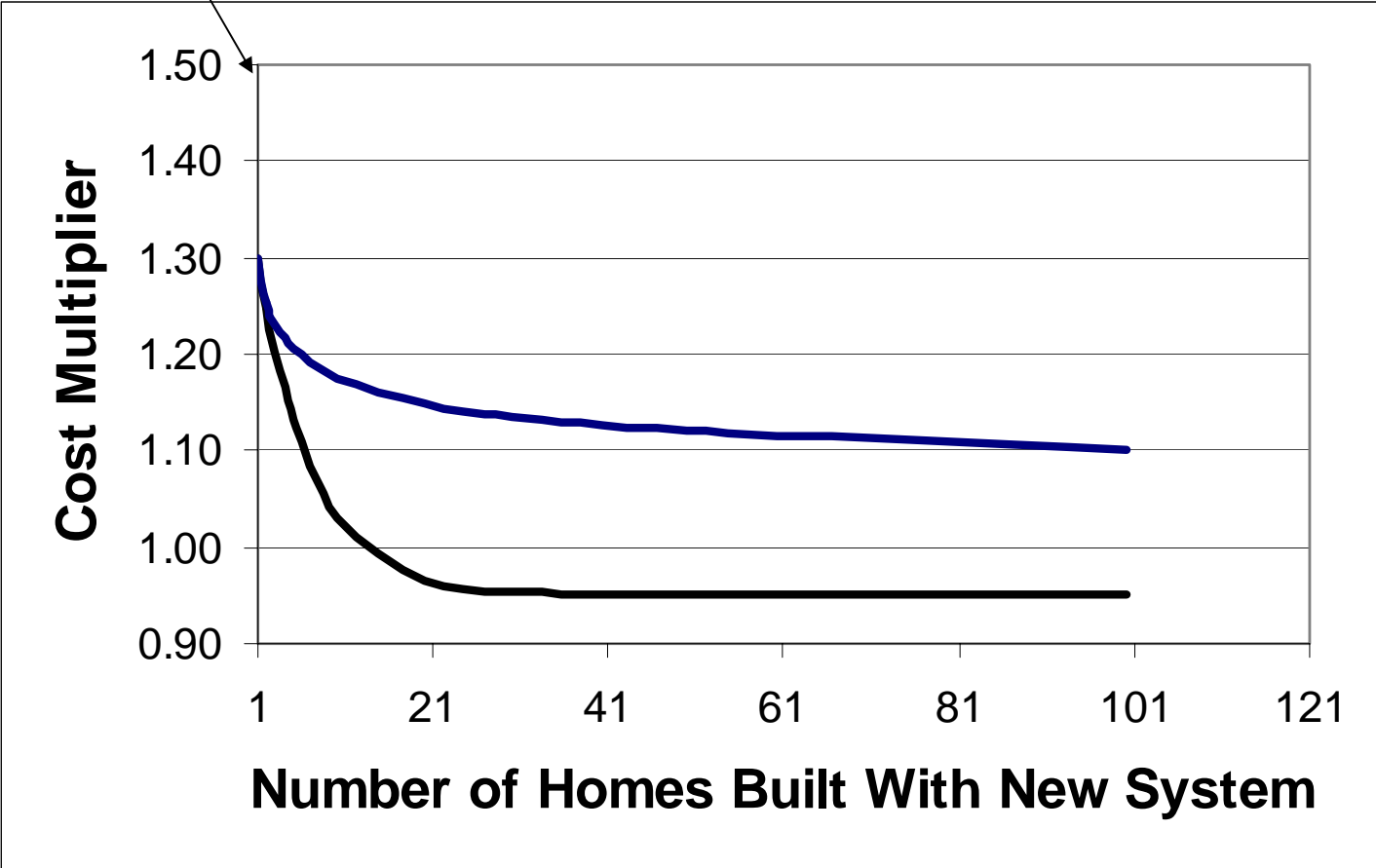
- Increase risks,
- Increase costs,
- Have the potential to cause complaints,
- Require additional training or oversight
- Require use of new and unfamiliar suppliers, materials and/or equipment, or
- Require additional planning steps approvals

Builders Tend to Embrace Changes That :

- Reduce risks,
- Reduce costs,
- Reduce complaints,
- Reduce training requirements
- Increase the reliability of suppliers, materials and equipment, and
- Reduce planning steps or approvals

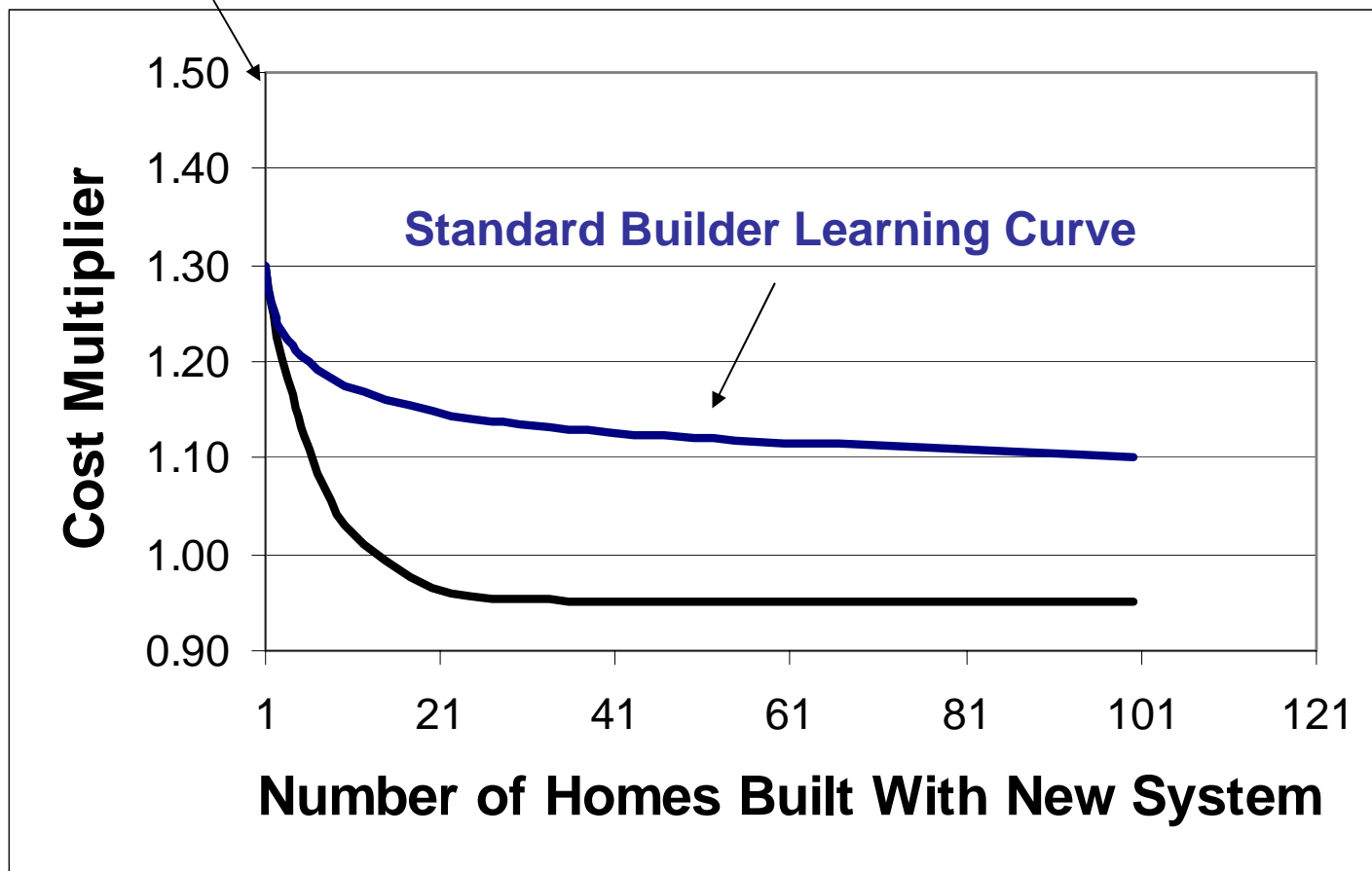
New Systems Increase the Cost of High Performance Building Projects

Cost of Using New System Relative to Current System



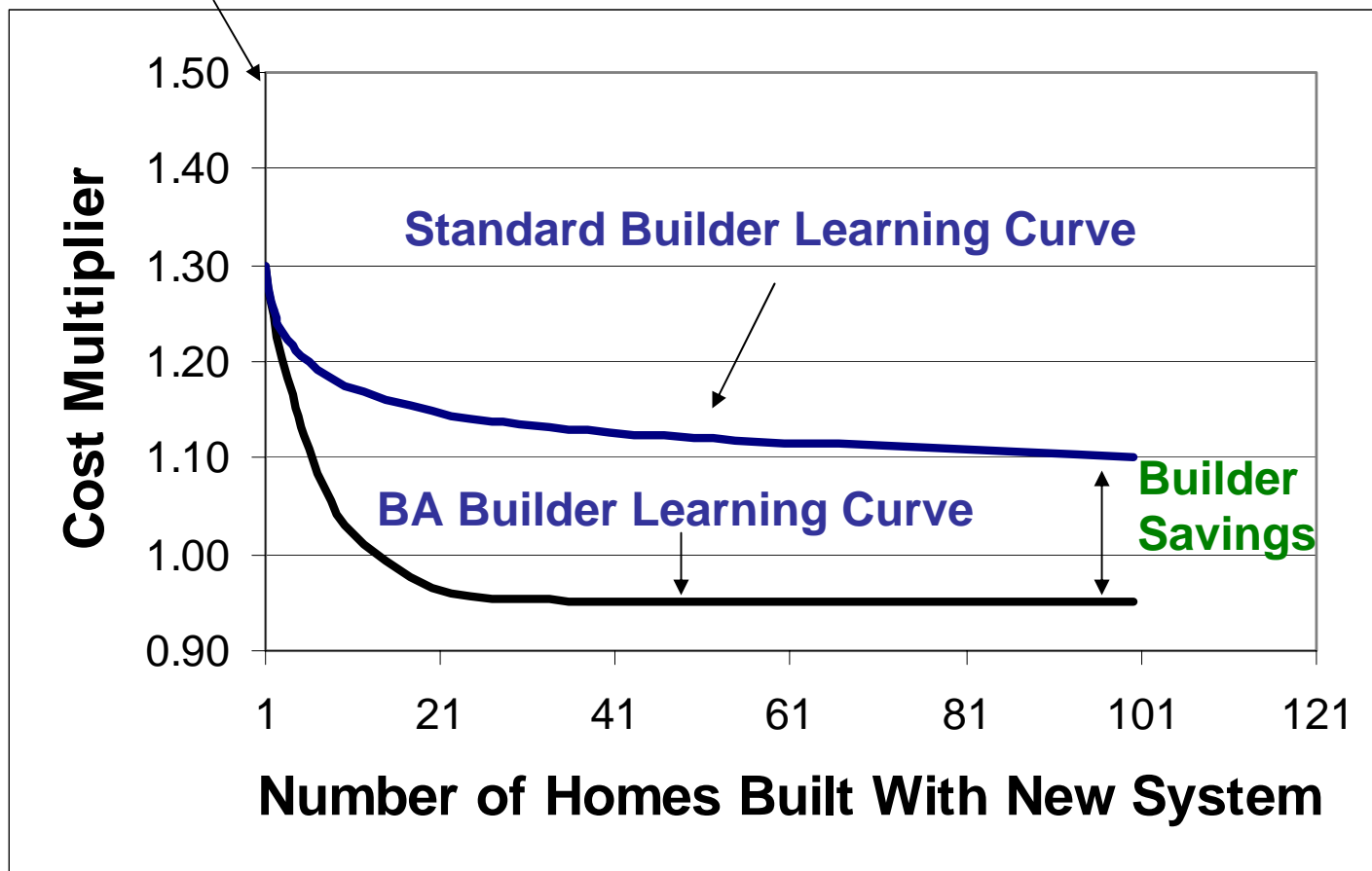
Reducing Risks Associated with Use of New Systems Accelerates Development of High Performance Building Projects

Cost of Using New System Relative to Current System



Reducing Risks Associated with Use of New Systems Accelerates Development of High Performance Building Projects

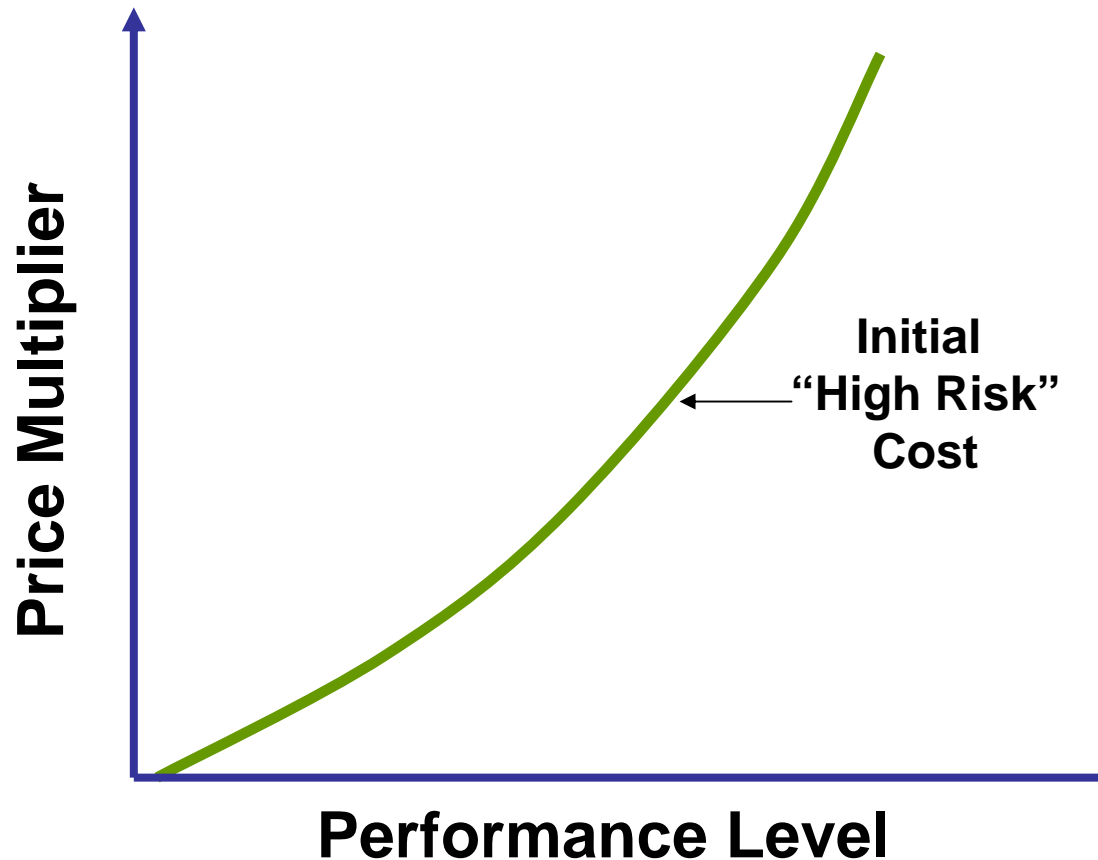
Cost of Using New System Relative to Current System



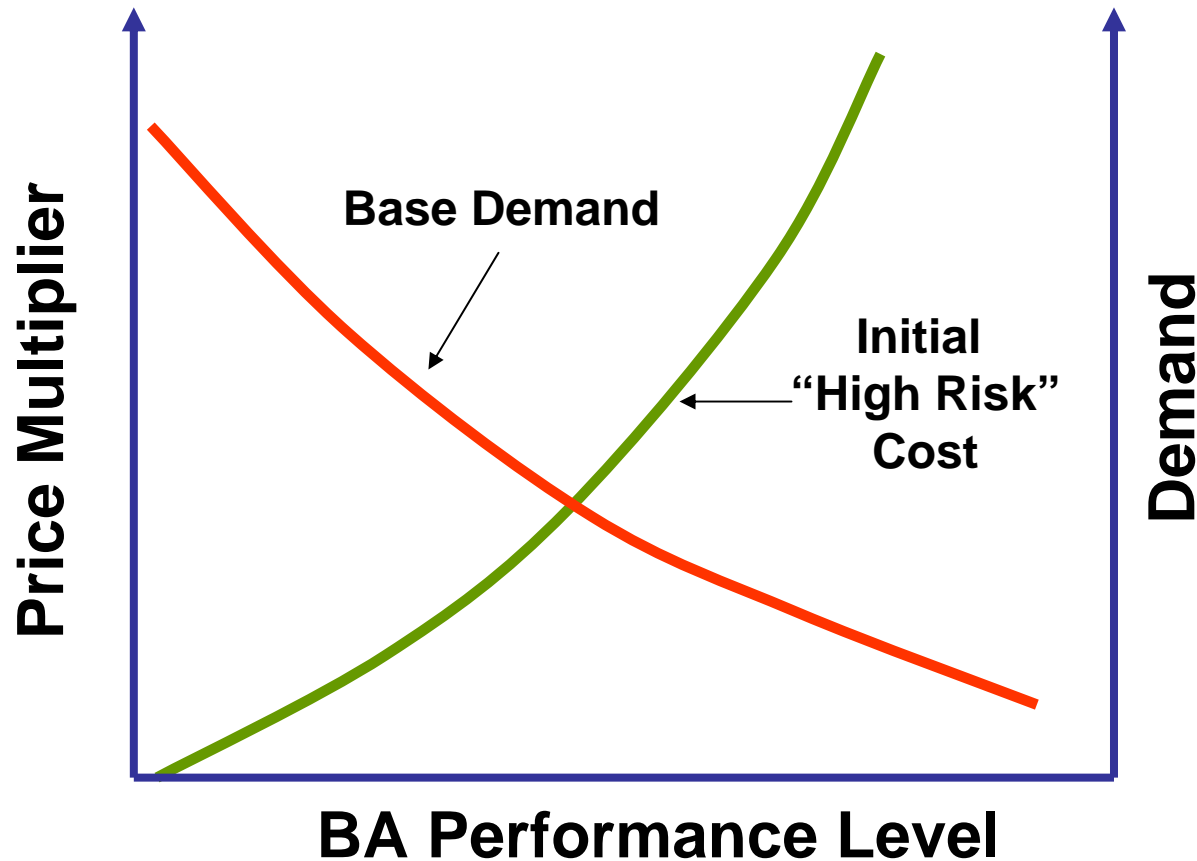
Conclusion:

Risk minimization is a major key to success in the development of high performance housing programs

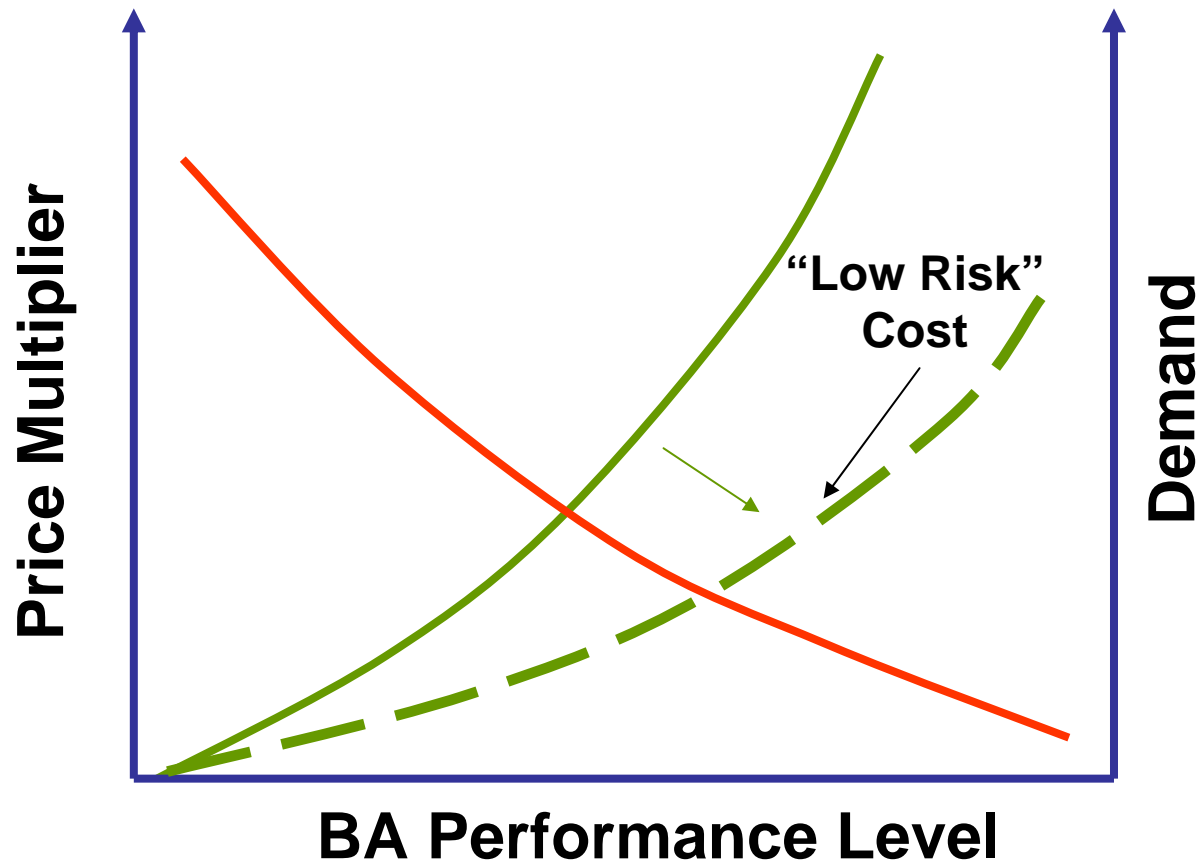
Risk Minimization Approach: Base Cost of Performance



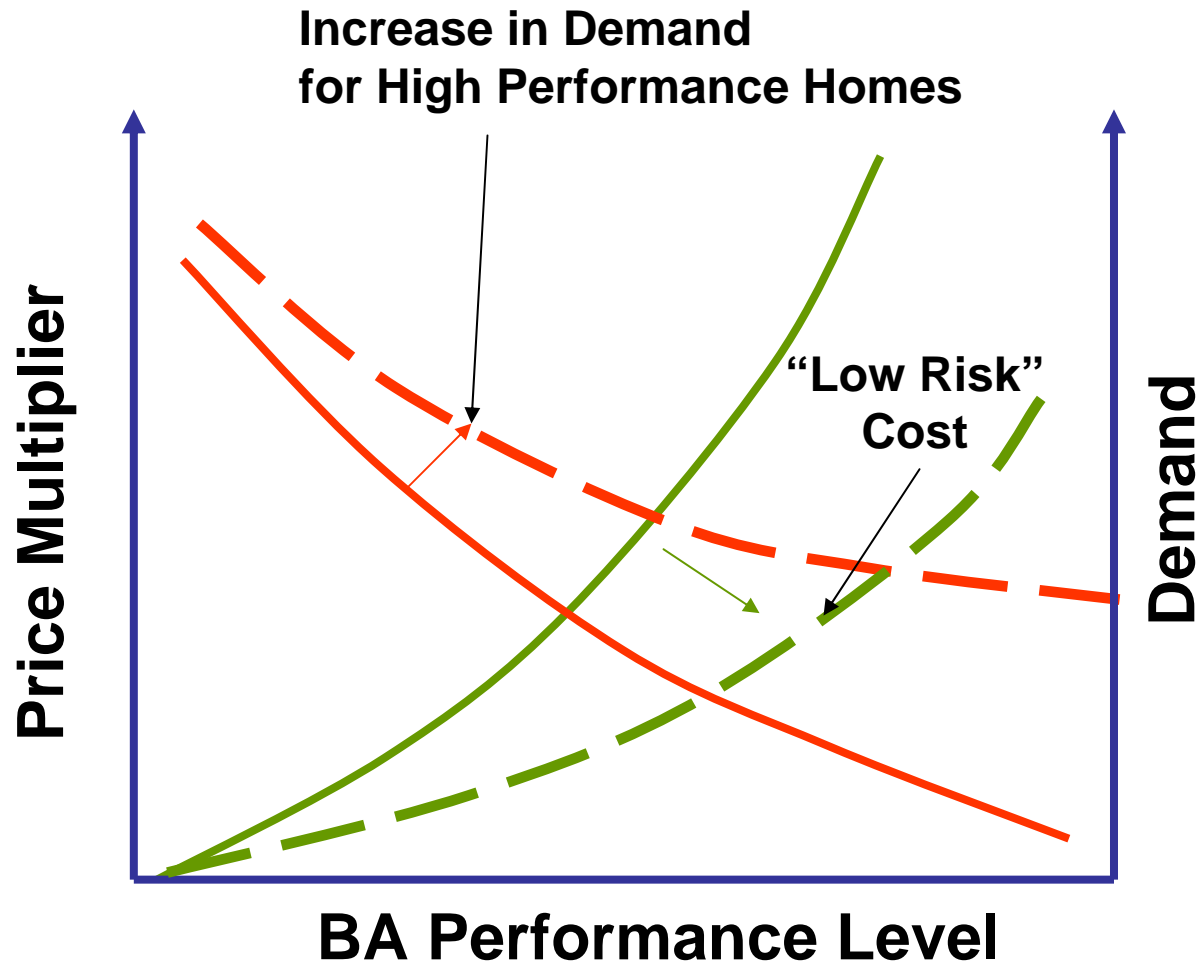
Risk Minimization Approach: Base Demand



Risk Minimization Approach: Cost Reduction



Risk Minimization Approach: Increase in Demand



Cold Climate Cost Reduction Example

Example BA Project Cost Summary: Cold Climate

Advanced Framing	- \$250
High performance windows	+ \$250
Controlled ventilation system	+ \$150
Power vented gas water heater	+ \$300
Simplified duct distribution	- \$250
Downsize air conditioner by 1 ton	- \$350
Net Benefit	- \$150

BEopt Analysis: “Least Cost” Energy Savings

The screenshot displays the BEopt software interface, showing optimization results for various building components and orientation. The interface is divided into several sections:

- Building:** Orientation (highlighted in blue)
- Envelope:** Walls, Ceiling, Thermal Mass, Infiltration
- Foundation:** Slab, Basement, Crawl Space
- Windows & Shading:** Glass Type, Total Window Area, Window Area per Wall, Eaves
- Appliances & Lighting:** Refrigerator, Cooking Range, Dishwasher, Clothes Dryer, Clothes Washer, Lighting
- Equipment:** Air Conditioner, Furnace, Heat Pump, Cooling Capacity

Optimization results are shown as horizontal bars with numbers 1-8, indicating the selected option for each component. The selected options are highlighted in blue:

- Orientation: 4
- Walls: 6
- Ceiling: 4
- Thermal Mass: 4
- Infiltration: 2
- Slab: 6
- Basement: 6
- Crawl Space: 3
- Glass Type: 7
- Total Window Area: 5
- Window Area per Wall: 2
- Eaves: 4
- Refrigerator: 2
- Cooking Range: 2
- Dishwasher: 3
- Clothes Dryer: 2
- Clothes Washer: 3
- Lighting: 4
- Air Conditioner: 8
- Furnace: 2
- Heat Pump: 8
- Cooling Capacity: 8

Orientation

Options: (Select to include in optimization)

- 1) South-facing
- 2) West-facing
- 3) North-facing
- 4) East-facing

Residential Energy Saving Options

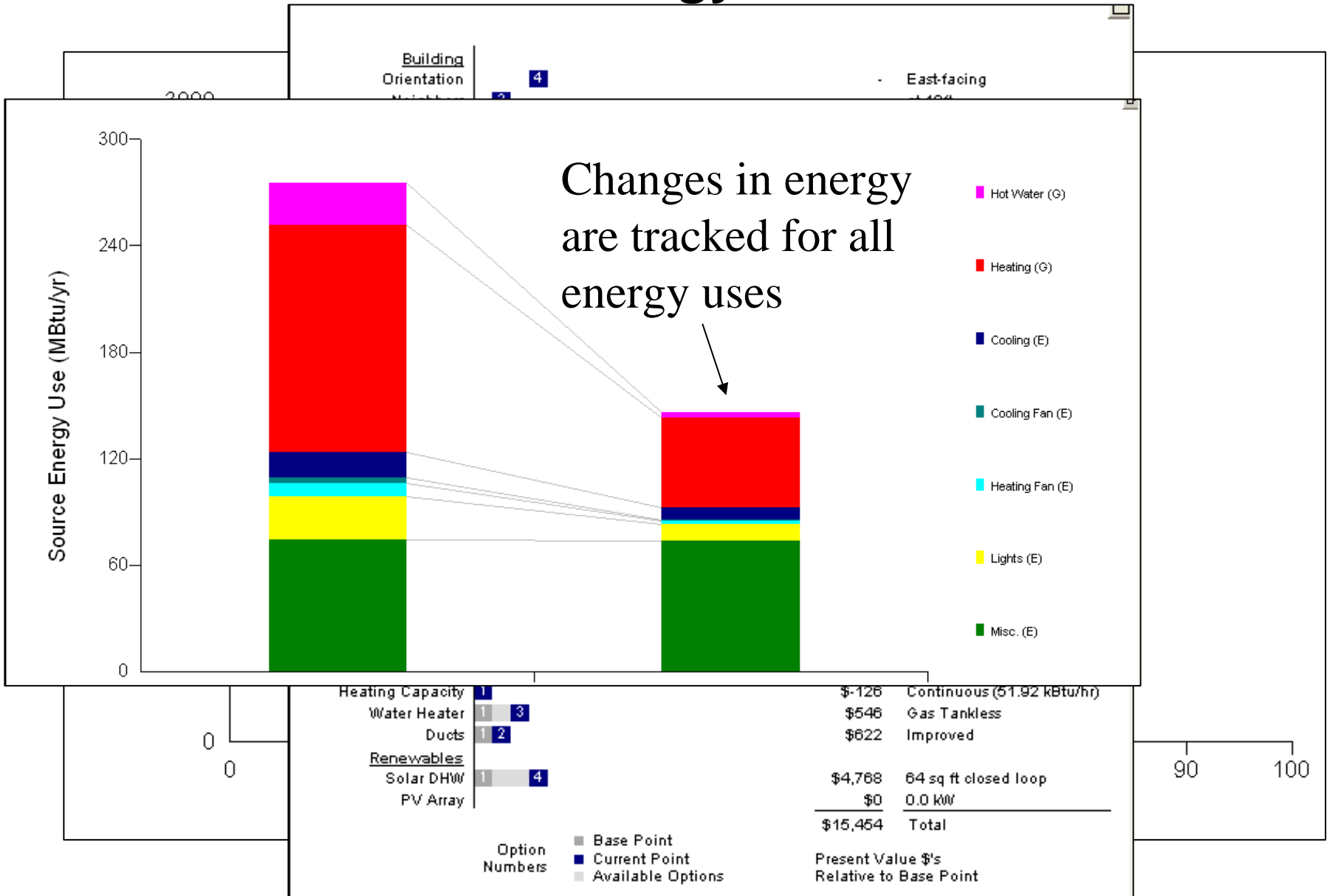
- [-] **Building**
 - Orientation
 - Neighbors
- [-] **Envelope**
 - Walls**
 - Ceiling
 - Thermal Mass
 - Infiltration
- [-] **Foundation**
 - Slab
 - Basement
 - Crawl Space
- [-] **Windows & Shading**
 - Glass Type
 - Total Window Area
 - Window Area per Wall
 - Eaves
- [-] **Appliances & Lighting**
 - Refrigerator
 - Cooking Range
 - Dishwasher
 - Clothes Dryer
 - Clothes Washer

Walls

Options: (Select to include in optimization)

	Framing Factor	Lifetime (years)	Unit Cost (\$/sq ft)
1) R11 batts, 2x4, 16"oc	0.25	30	\$3.15
2) R13 batts, 2x4, 16"oc	0.25	30	\$3.17
3) R11 batts, 2x4, 16"oc + 1" foam sheathing	0.25	30	\$3.92
4) R19 batts, 2x6, 24"oc	0.20	30	\$3.28
5) R19 batts, 2x6, 24"oc + 1" foam sheathing	0.20	30	\$4.05
6) R19 batts, 2x6, 24"oc + 2" foam sheathing	0.20	30	\$4.24

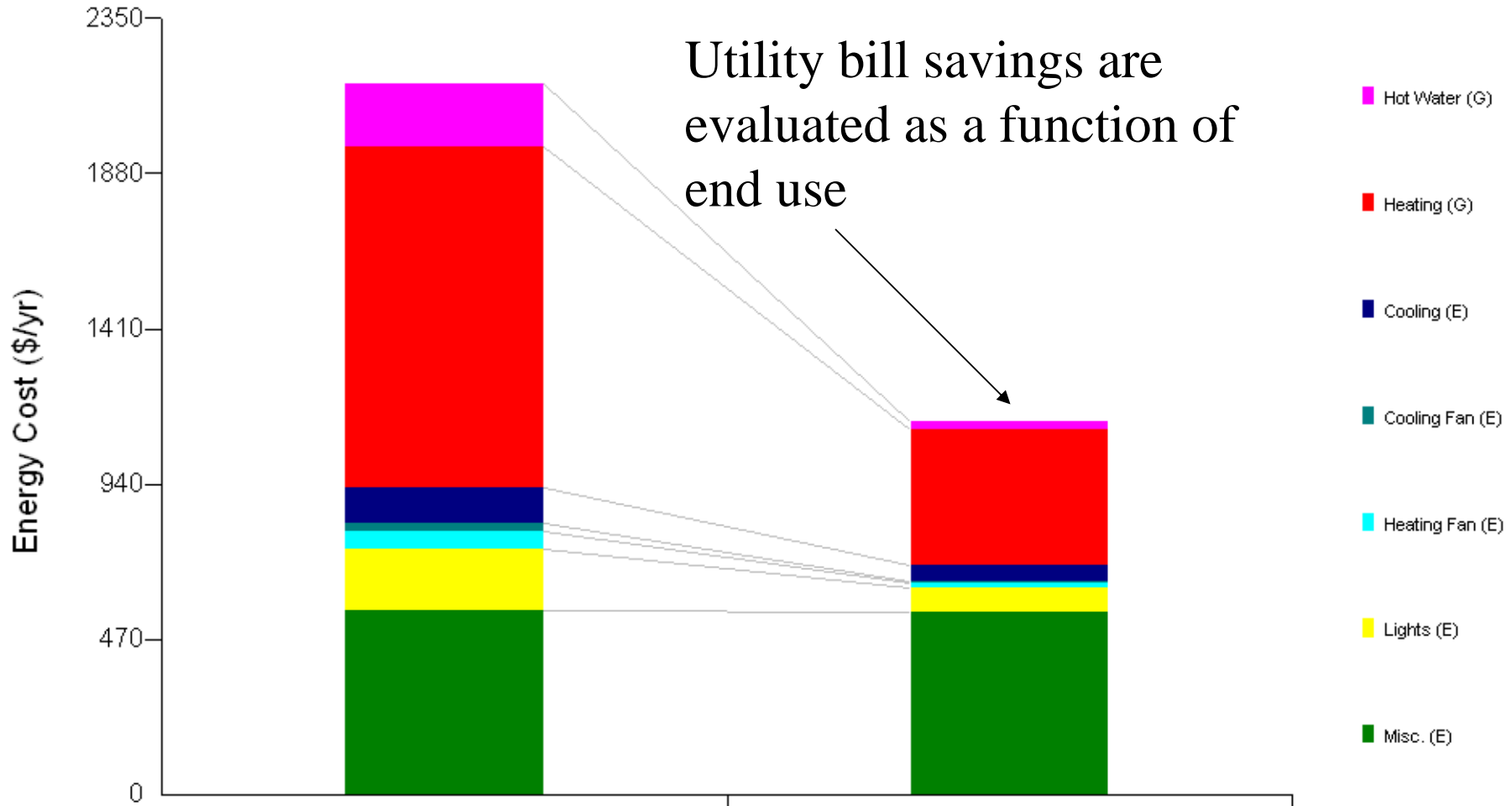
Determining Incremental Costs and Benefits for Energy Efficient Homes



Determining Incremental Costs and Benefits for Energy Efficient Homes

3000

Utility bill savings are evaluated as a function of end use

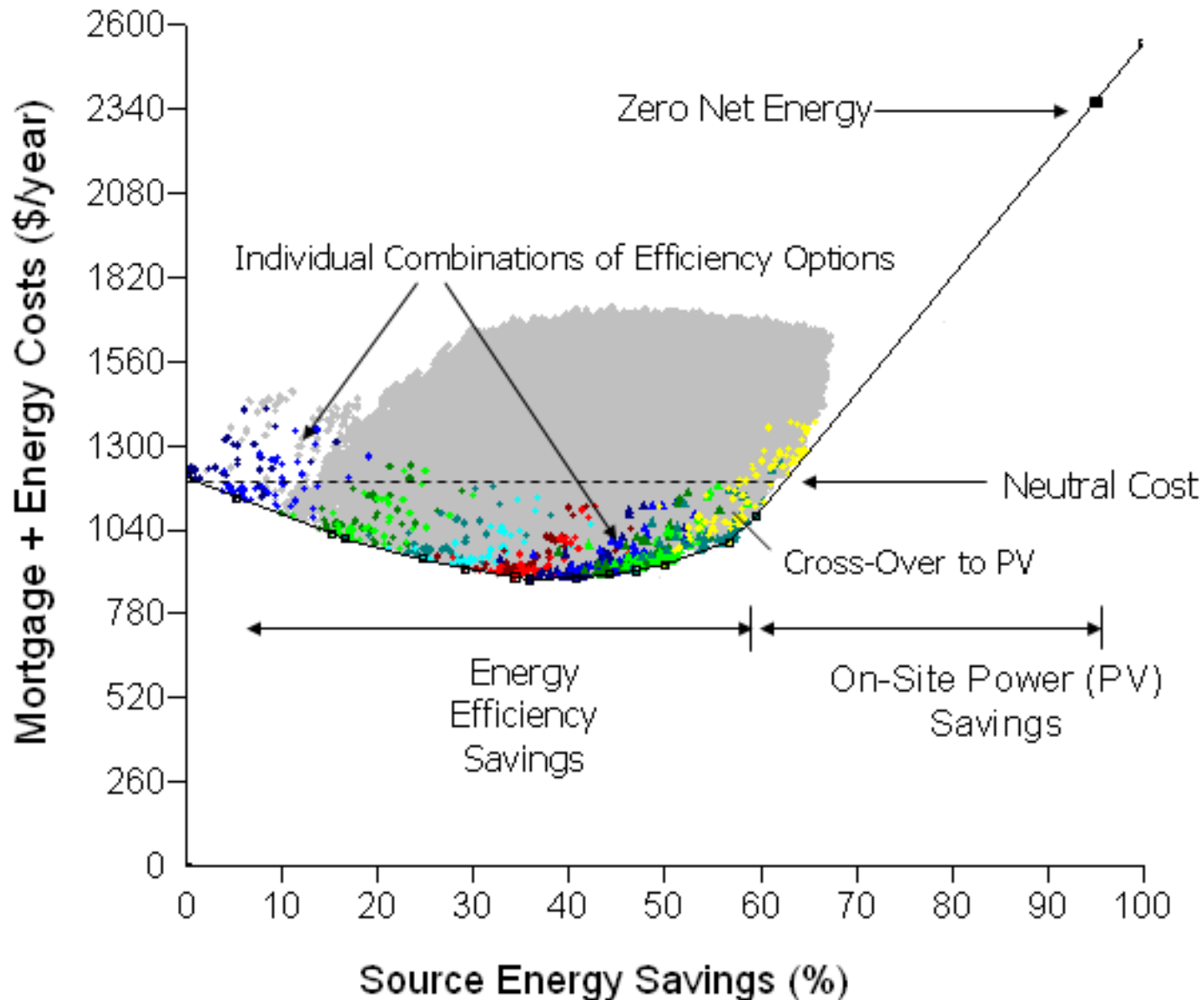


Option Numbers

- Base Point
- Current Point
- Available Options

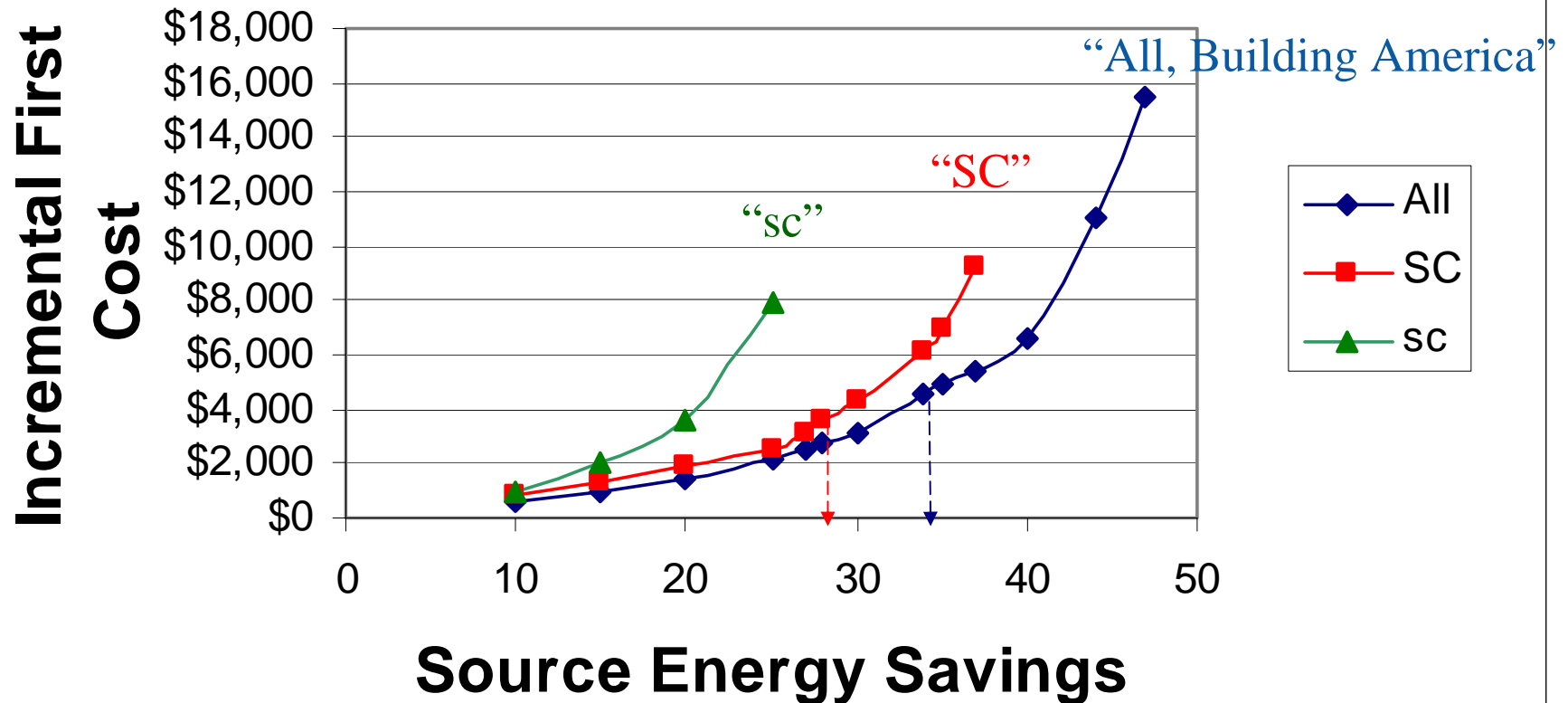
Present Value \$'s Relative to Base Point

Determining Incremental Costs and Benefits for Energy Efficient Homes



Comparison of Energy Saving Strategies: First Cost

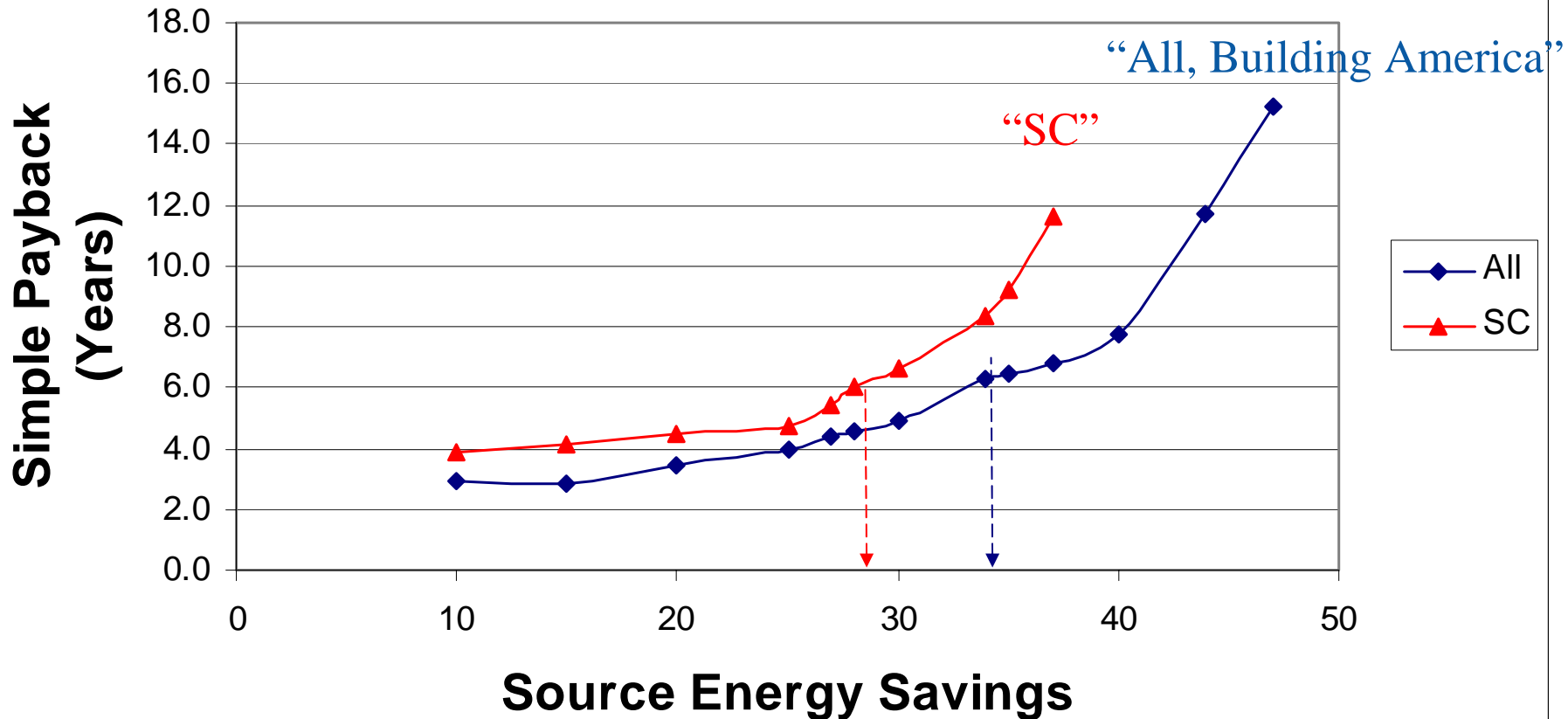
Chicago First Cost Comparison



2600 ft2, 2 Story, basement

Comparison of Energy Saving Strategies: Simple Payback

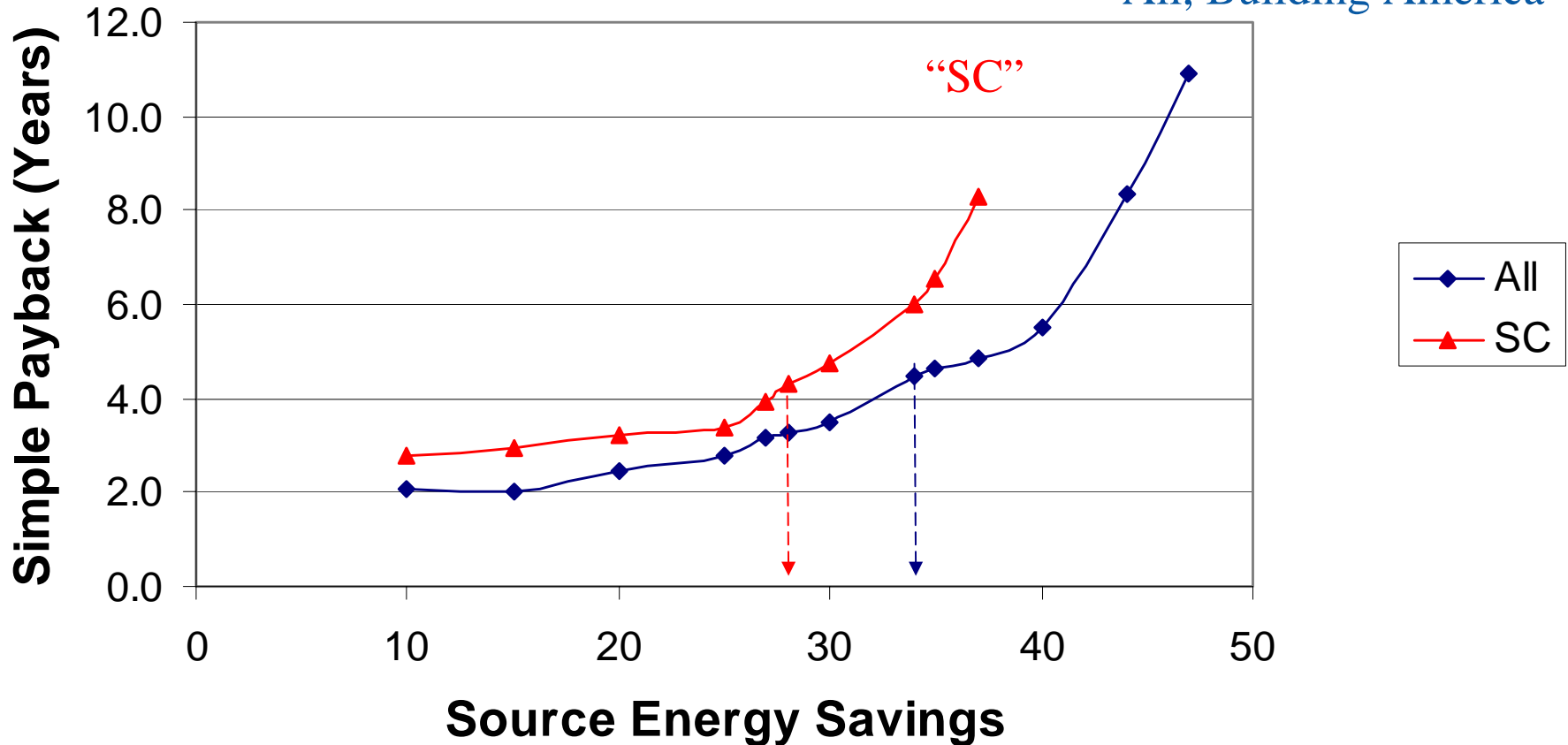
Chicago Simple Payback
(\$0.80/Therm, \$0.08/kWh)



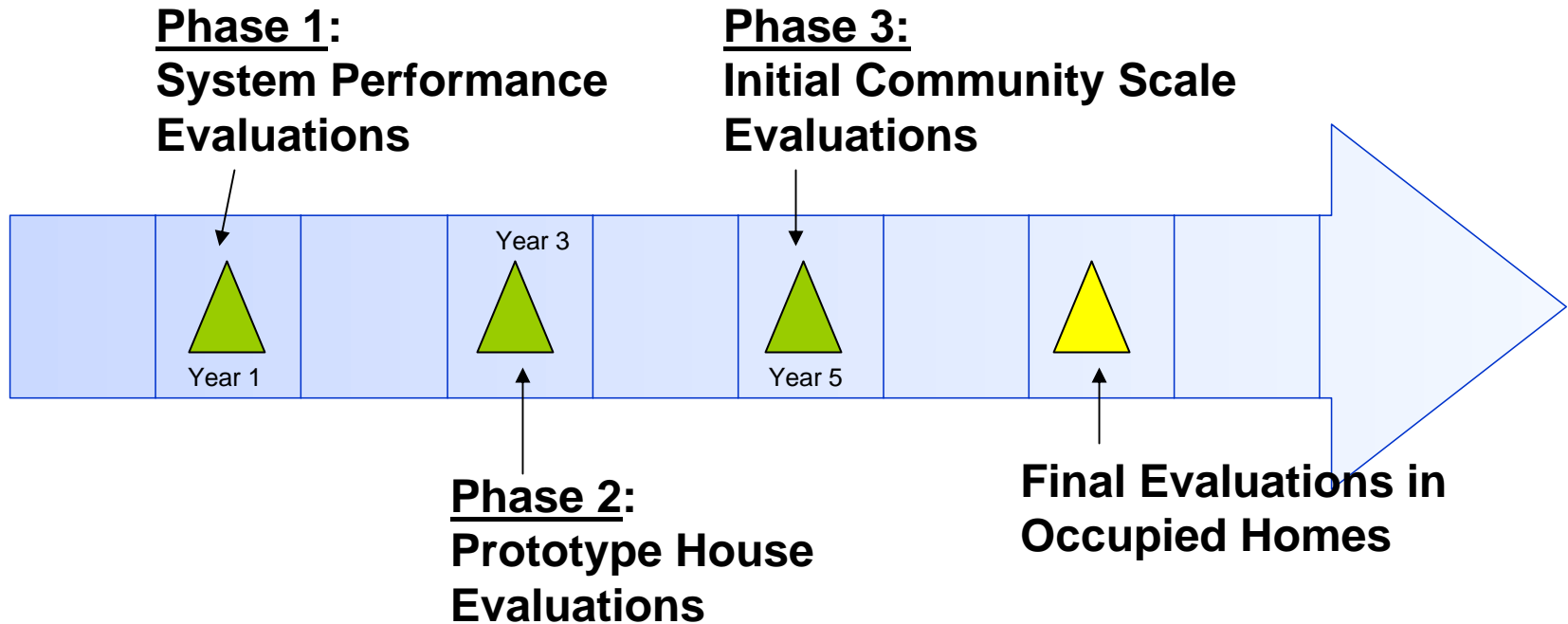
Comparison of Energy Saving Strategies: Impact of Energy Cost on Simple Payback

Chicago Simple Payback
(40% Cost Increase: \$1.12/Therm, \$0.112/kWh)

“All, Building America”



Risk Minimization Strategy: Three Phase Process

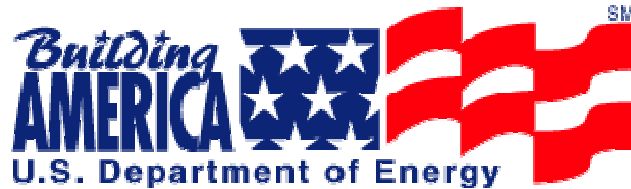


Bottom Line Results from Risk Minimization Approach:

- Houses that cost less to build
- Houses that cost less to maintain
- Houses that cost less to heat and cool

In other words, houses that work!

Please see our website at:
www.buildingamerica.gov



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