Building America: Leading the Way to Zero Energy Homes

Ren Anderson
National Renewable Energy Laboratory
RESNET Conference
March 1, 2006

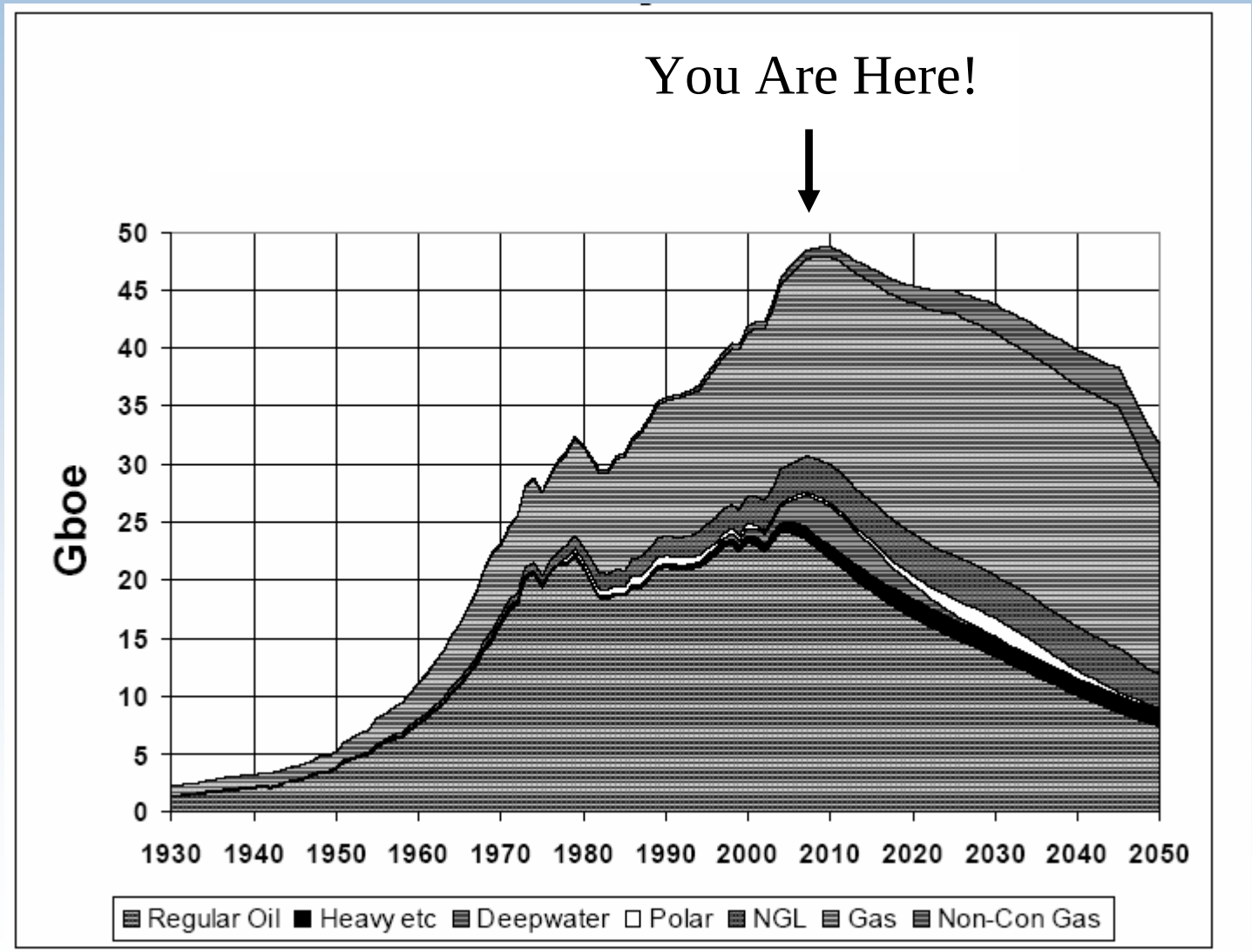
NREL Research Funded in Part by USDOE

NREL is operated by Midwest Research Institute • Battelle

Why is DOE Interested in ZEH?

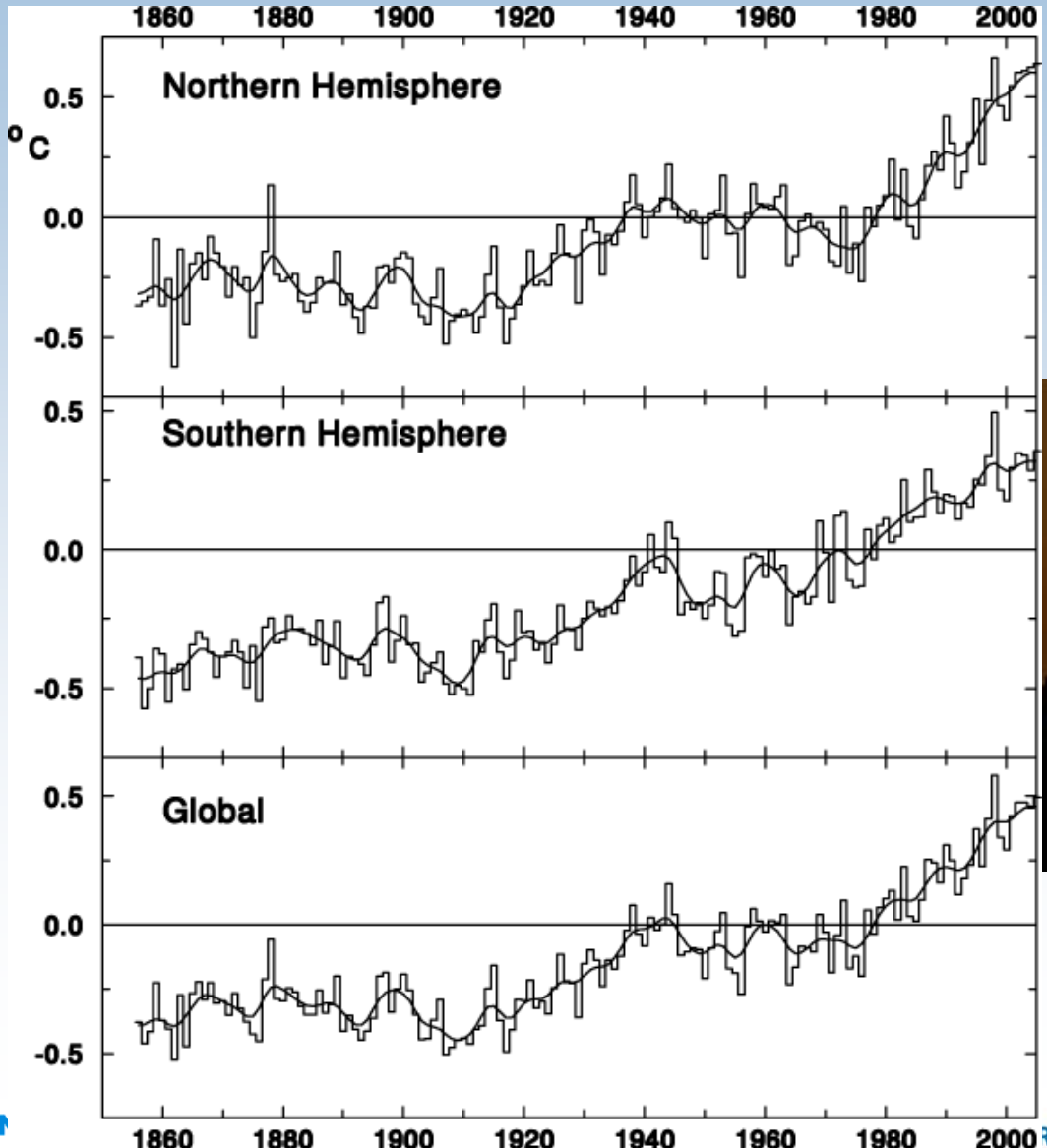
Development of cost effective Zero Energy Homes (ZEH) is the long term (2020) research goal for the Building America Program, as part of ongoing efforts to increase the efficiency of US energy use.

How Long Will Fossil Fuels Last?



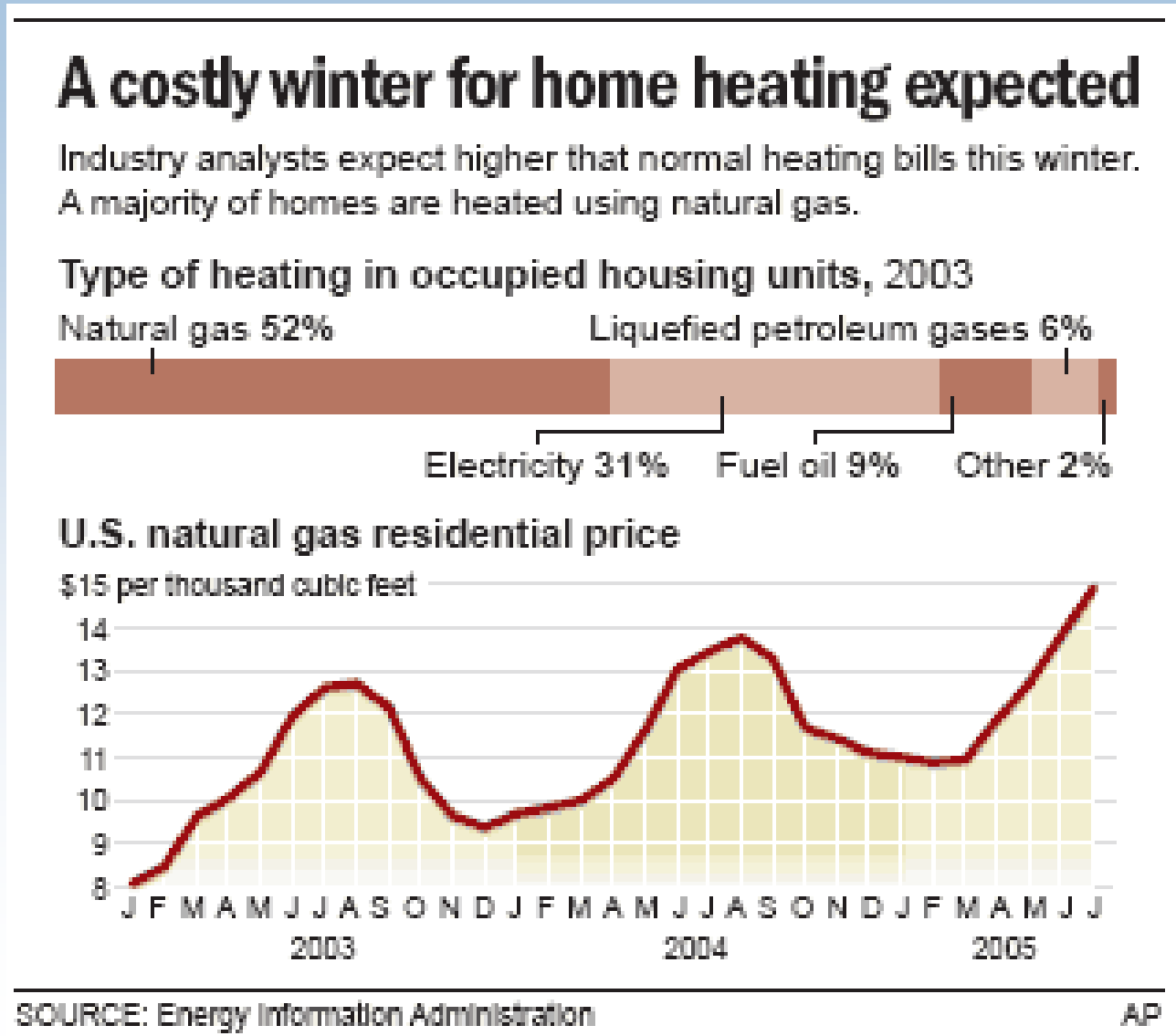
The Association for the Study of Peak Oil and Gas, October 2005 Newsletter, www.peakoil.ie

How Hot Will It Get?



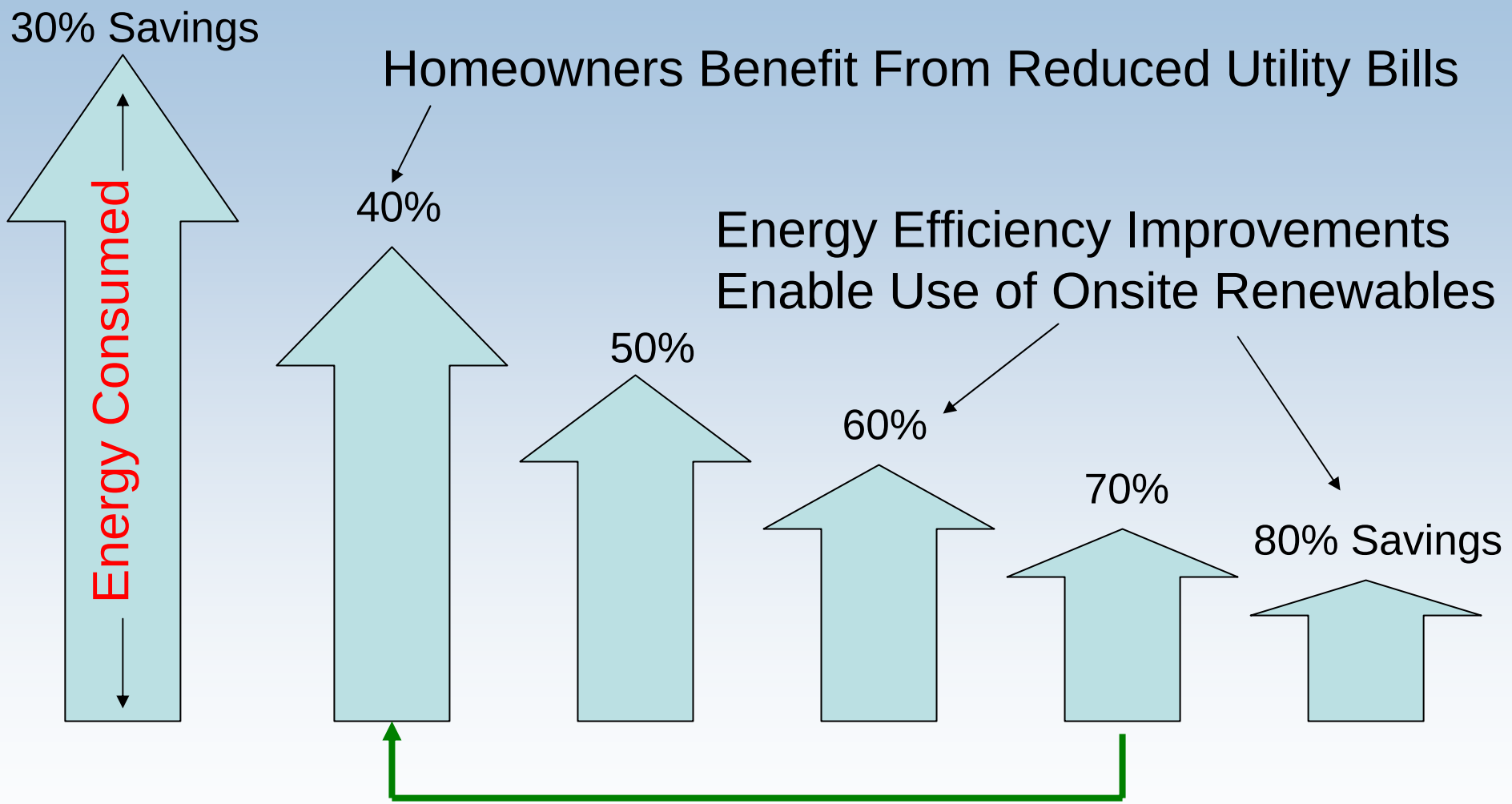
"World temperatures keep rising. Climate data show 2005 on track to be hottest on record."

How High Will Utility Bills Go?



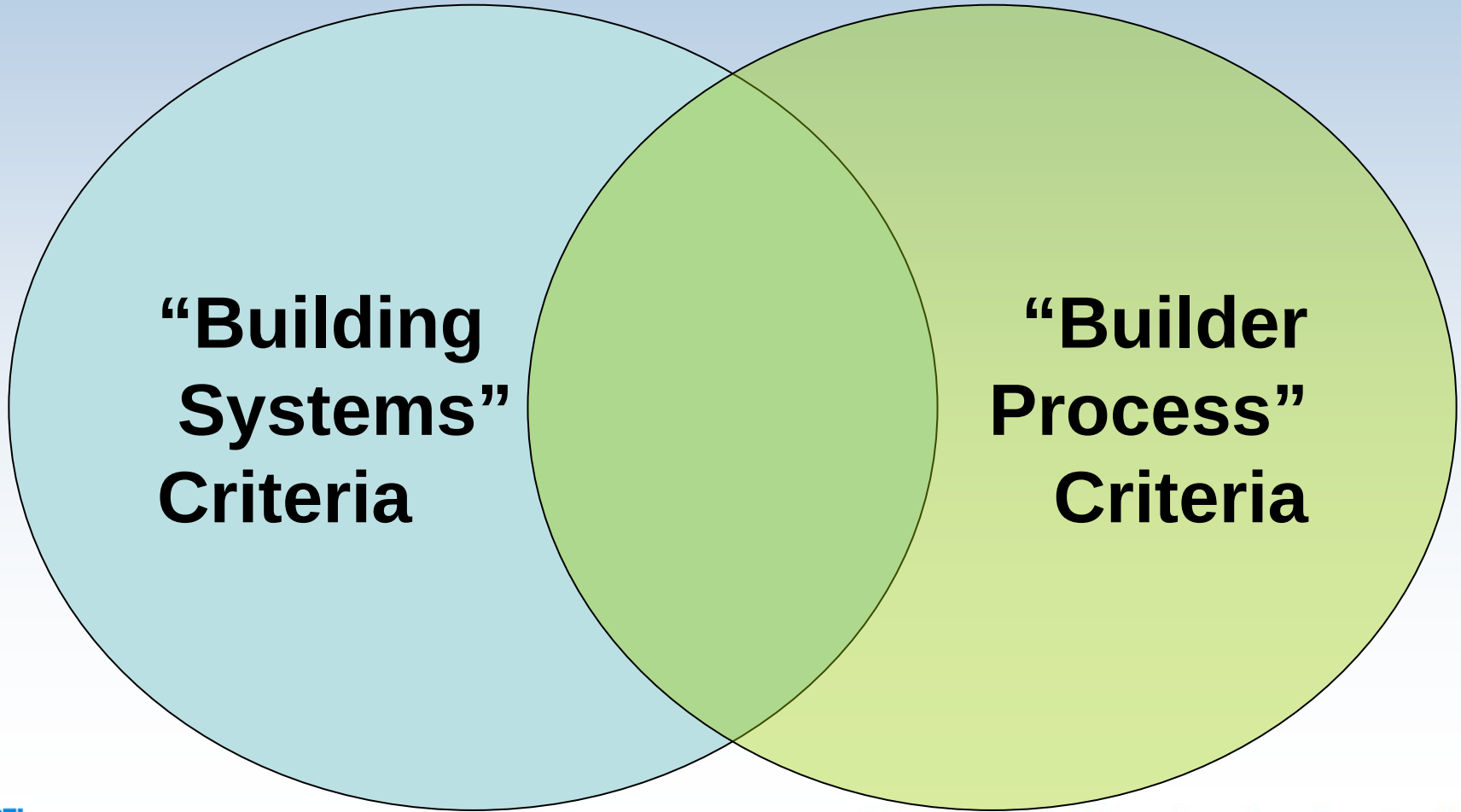
Developing Zero Energy Homes Requires a Comprehensive Research Strategy

Parallel Goals Ensure Rapid Progress And Immediate Market Adoption

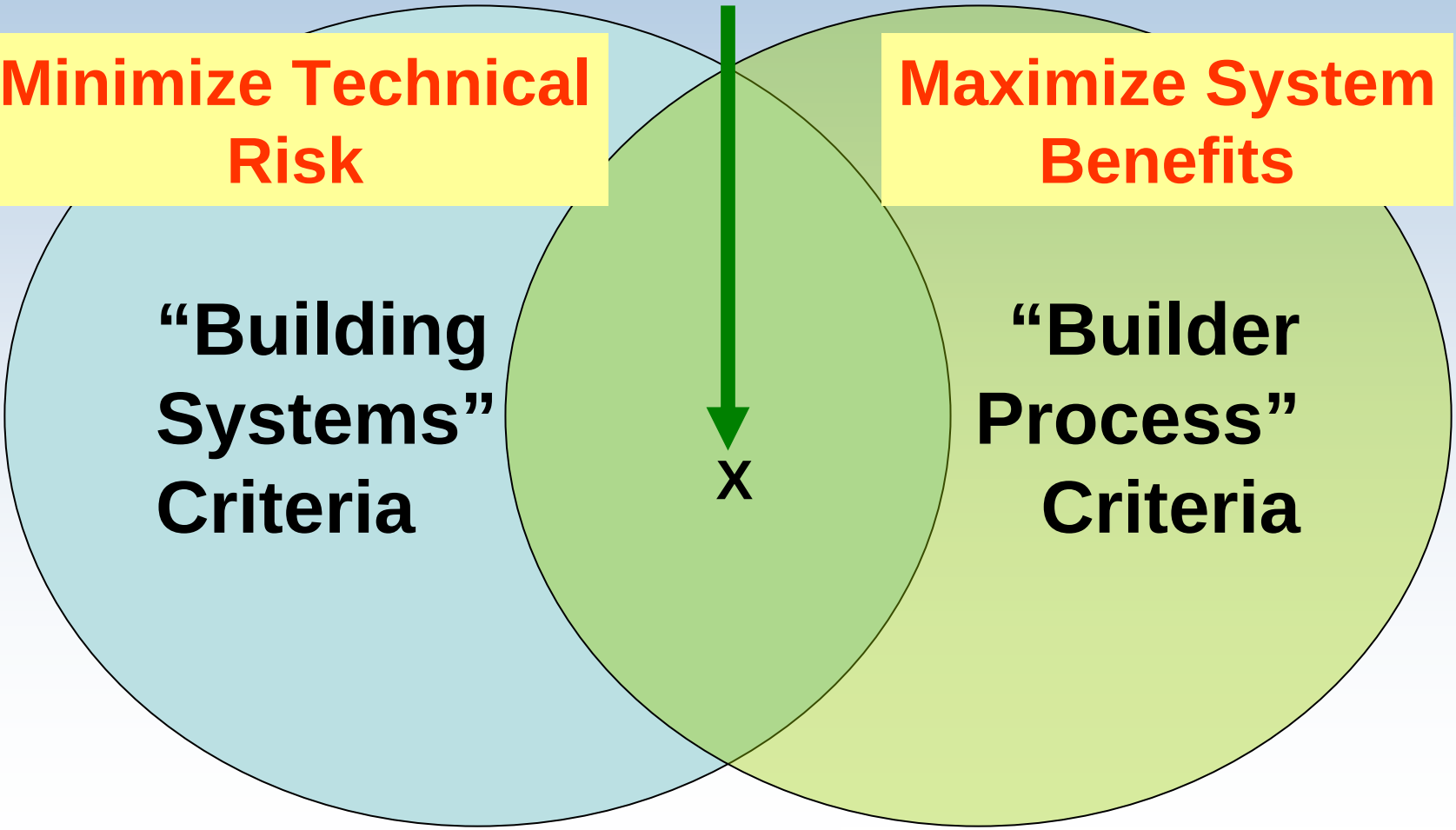


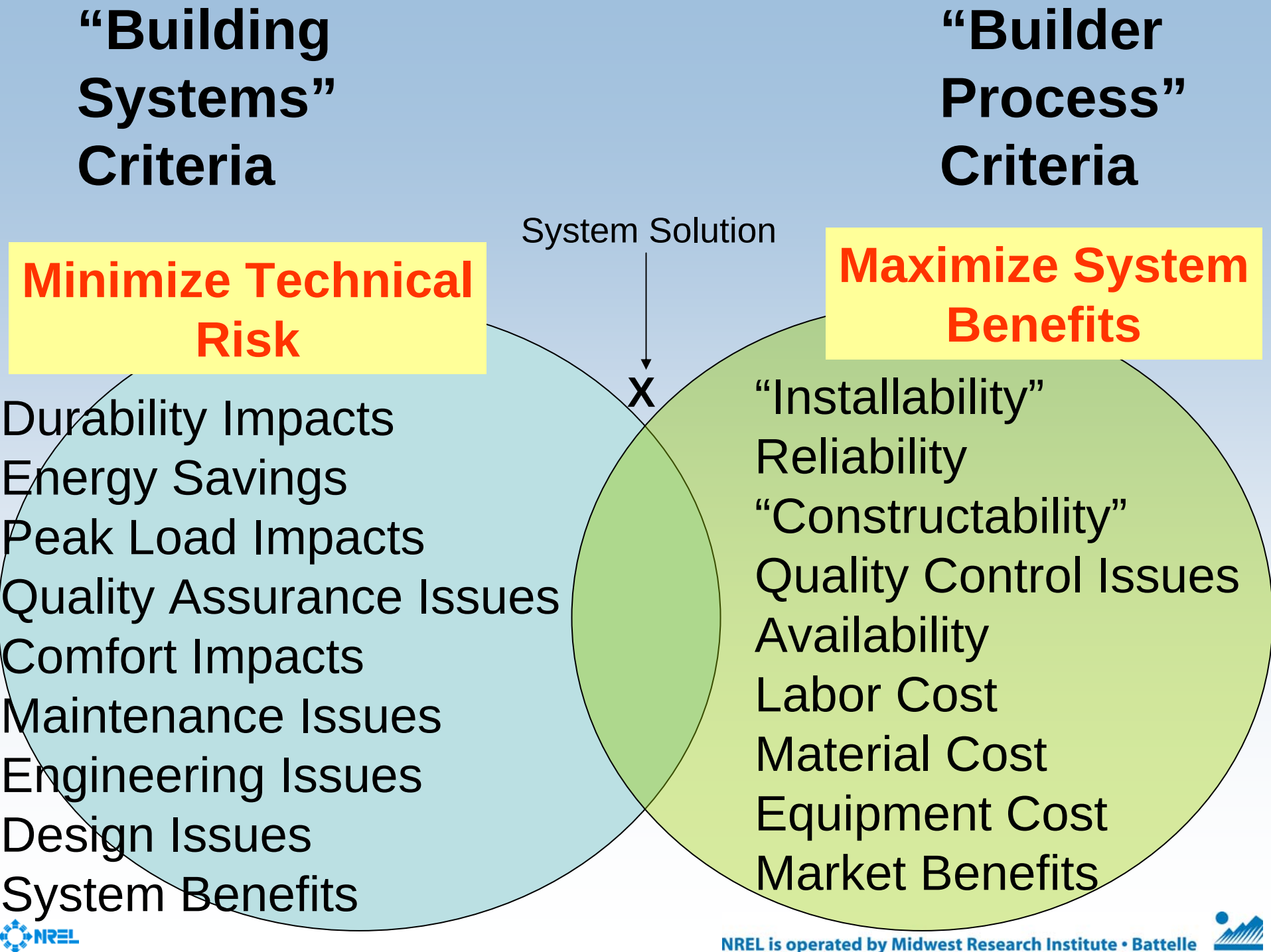
Solutions from “market leaders” are used to inform and accelerate adoption by other market sectors

BA Research Go/No Go Decisions are based on the ability to Satisfy Two Sets of Criteria



These Criteria are Used to Evaluate System Options to Ensure that they Meet minimum Requirements to be used Successfully in Production Homes




"Building Systems" Criteria
"Builder Process" Criteria
System Solution
Minimize Technical Risk
Maximize System Benefits
X
Durability Impacts
Energy Savings
Peak Load Impacts
Quality Assurance Issues
Comfort Impacts
Maintenance Issues
Engineering Issues
Design Issues
System Benefits
"Installability"
Reliability
"Constructability"
Quality Control Issues
Availability
Labor Cost
Material Cost
Equipment Cost
Market Benefits

Minimize Technical Risk

Durability Impacts
Energy Savings
Peak Load Impacts
Quality Assurance Issues
Comfort Impacts
Maintenance Issues
Engineering Issues
Design Issues
System Benefits

x

Maximize System Benefits

"Installability"
Reliability
"Constructability"
Quality Control Issues
Availability
Labor Cost
Material Cost
Equipment Cost
Market Benefits

BA Residential Research Experience:
Successful system innovations often require a change in technical systems and a change in business and construction practices.

Key Questions Answered By BA Research

1. Have Critical System Performance Specifications Been Clearly Identified?

Unvented Conditioned Crawlspaces

barrier and thermal envelope—are resolved. In other words, it is possible to satisfy BSC Building America performance targets if the crawlspace is unvented and conditioned.

Lesson Learned

There are actually two lessons in this work. The first one is — always start with the larger question. In this case, why do you really want a crawlspace? BA has worked with builders on substituting slab-on-grade construction for crawlspaces in many areas of the country where the real reasons for utilizing crawlspace foundations are perceived mechanical needs or market demand that may, in fact, not hold true.

The second lesson has to do with accomplishing change in the building industry. A large part of working with the building community is working with the local building officials. Bringing building science into the building industry means educating builders and local building departments.

A little more than one-sixth of new homes in the United States are built on crawlspace foundations. Typical crawlspace construction calls for passive venting to the outside with cavity insulation for the first floor. No one is sure how this situation came about, but it certainly is

BSC also conducted work under Building America on structural sub-basement crawlspaces typical of the Metro Denver area, where the combination of expansive clay soil conditions and full basements have led to moisture and performance problems. Applying

Moving Ducts/Equipment into Conditioned Space

Lesson Learned

It often takes "outside-the-box" thinking on the part of several members of a building team to accomplish the desired result: systems engineering, systems design, systems installation, or field work. It's only when all team members "get the picture" and "build the vision" that the most elegant solutions rise to the top.

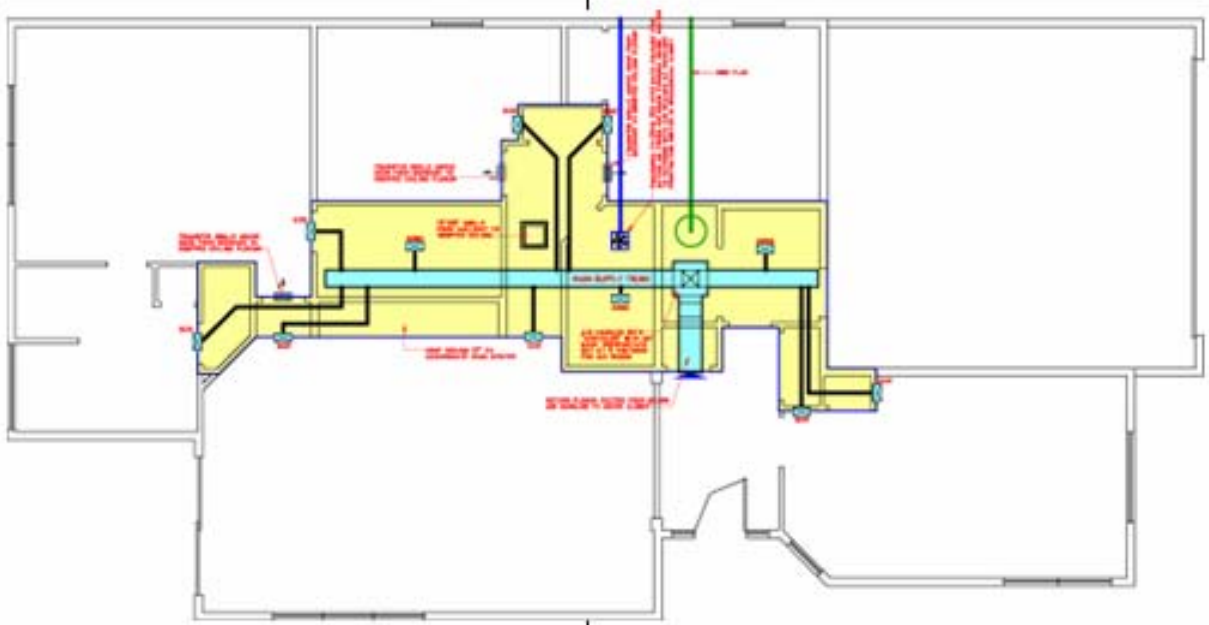
building assemblies. On the other hand, fitting the duct system within conditioned space presents design and engineering challenges. But herein lies the beauty of the Building America approach—when you combine a high-performance envelope with an innovative framing system, the engineer and the architect are freed from key constraints of conventional construction and the resulting simplified duct distribution system (see below) makes it much easier to move ducts and equipment into the conditioned space.

Artistic Homes took the Building America systems-thinking approach one step further in the field. They were having trouble getting the desired duct air sealing on the trunk duct tucked into the main hallway soffit. So, they decided the only way to keep this duct in conditioned space and seal it tight all the way around (the top side is nearly impossible to get to) was to assemble and mastic the trunk duct at ground level and then install it in the soffit. They accomplished this by getting the framer to build—but not install—the two 7-foot end-of-hallway partitions. After the trunk duct has

Simplified Duct Distribution Systems

Lesson Learned

Good duct design and engineering often lead to a system that is simpler, less expensive, and of higher performance.



One of the most common callback complaints experienced by production builders has been comfort.

A key part of the design is the 12- to 18-inch horizontal off-set, with two 90-degree changes in direction, which

Advanced Framing Systems and Packages

Advanced framing is a pillar of the Building America systems engineering approach. Rarely are changes in design and construction so universally compelling as advanced framing. Benefits include the following:

Lesson Learned

Originally developed by NAHBRC, advanced framing has been around for over 25 year. By demonstrating key cost performance tradeoffs including reduced labor, job site waste, and increased consumer value, Building America has succeeded in making advanced framing a standard approach in many US markets.

- Improved thermal performance
- Reduced call-backs (particularly drywall cracking)
- Reduced materials costs (less material in the framing package)
- Reduced labor costs
- Easier accommodation of mechanicals (particularly HVAC ducting in floor assemblies)
- Reduced waste disposal costs.

BSC is proud of the fact that approximately half of BSC builders and their developments embrace advanced framing systems, but it's difficult to reconcile its absence in the other half. Despite the professional technical assistance offered to every

Load Bearing Wall

BSC Building America builder, there are more than a few that choose to stick with conventional framing. Each of the obstacles below is more an issue of perception or interpretation than an issue of substance:

- Resistance from the framing contractor – Although the inability to make the change (crews that either do not understand or cannot read detailed framing plans) is not uncommon, more frequently it is unwillingness rather than inability to employ advanced framing.
- Resistance from the sales staff/homebuyer – "Wood is good; therefore, more wood must be better," makes it difficult to convince the consumer of the benefits of advanced framing, particularly on interior walls, where there is no quantifiable energy benefit.
- Resistance from local building inspectors – Despite

2. What is the net benefit to a builder?

Example Cost Summary
Cold Climate

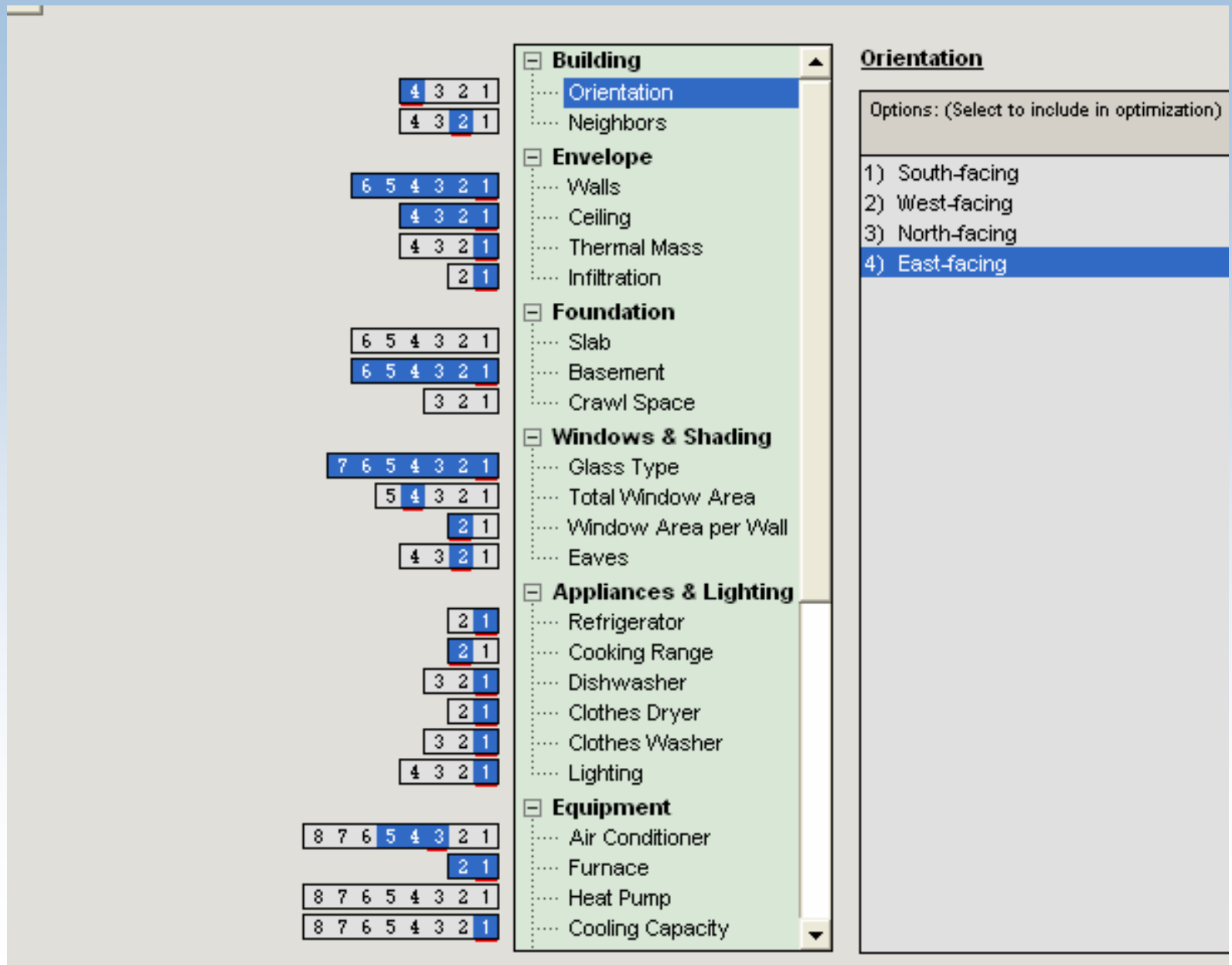
Advanced Framing	- $250
High performance windows	+ $250
Controlled ventilation system	+ $150
Power vented gas water heater	+ $300
Simplified duct distribution	- $250
Downsize air conditioner by 1 ton	- $350
Net Benefit	- $150

3. What is the net benefit to a homeowner?

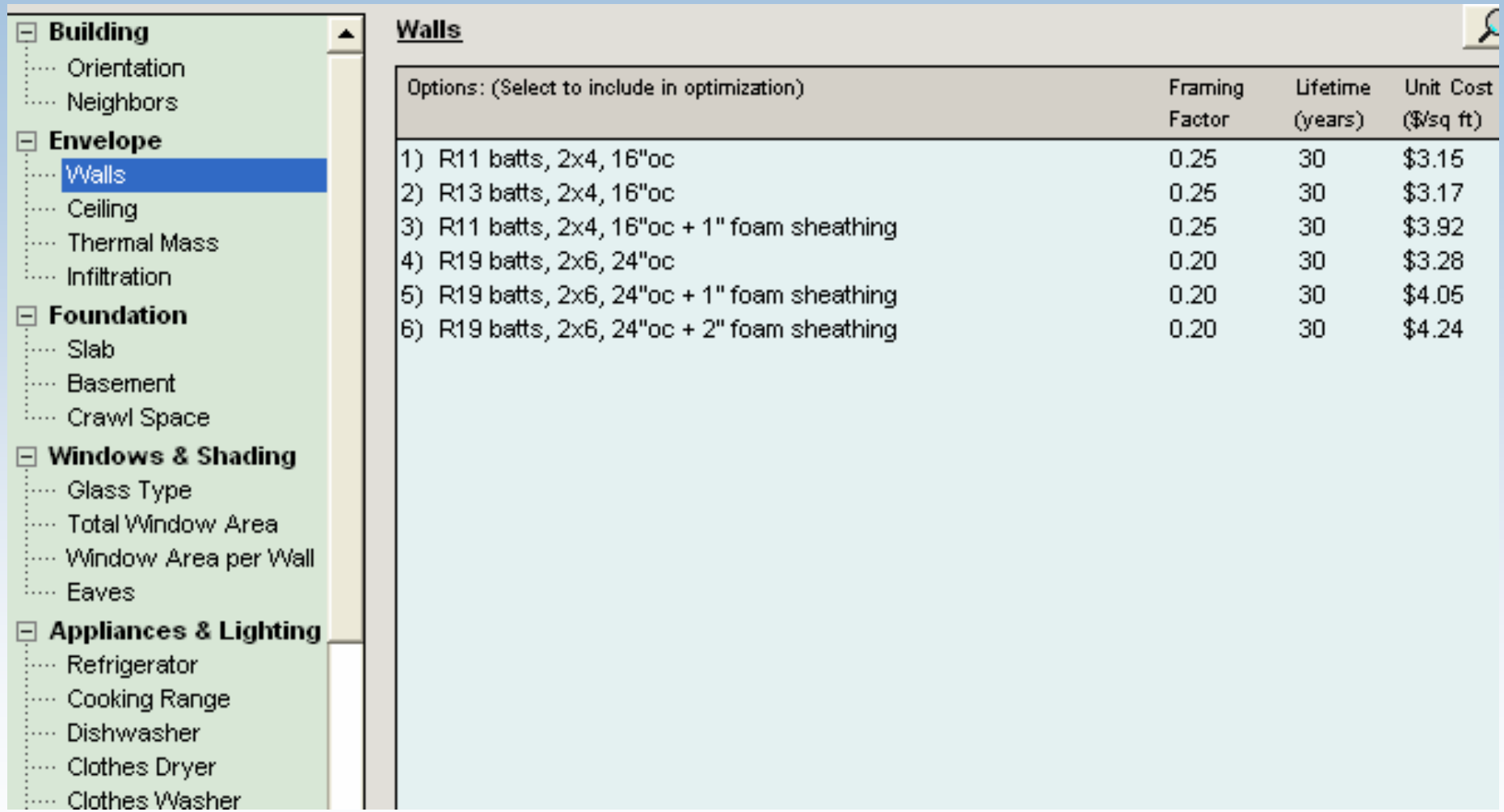
What are the Long Term Market Benefits of BA System Research Results?



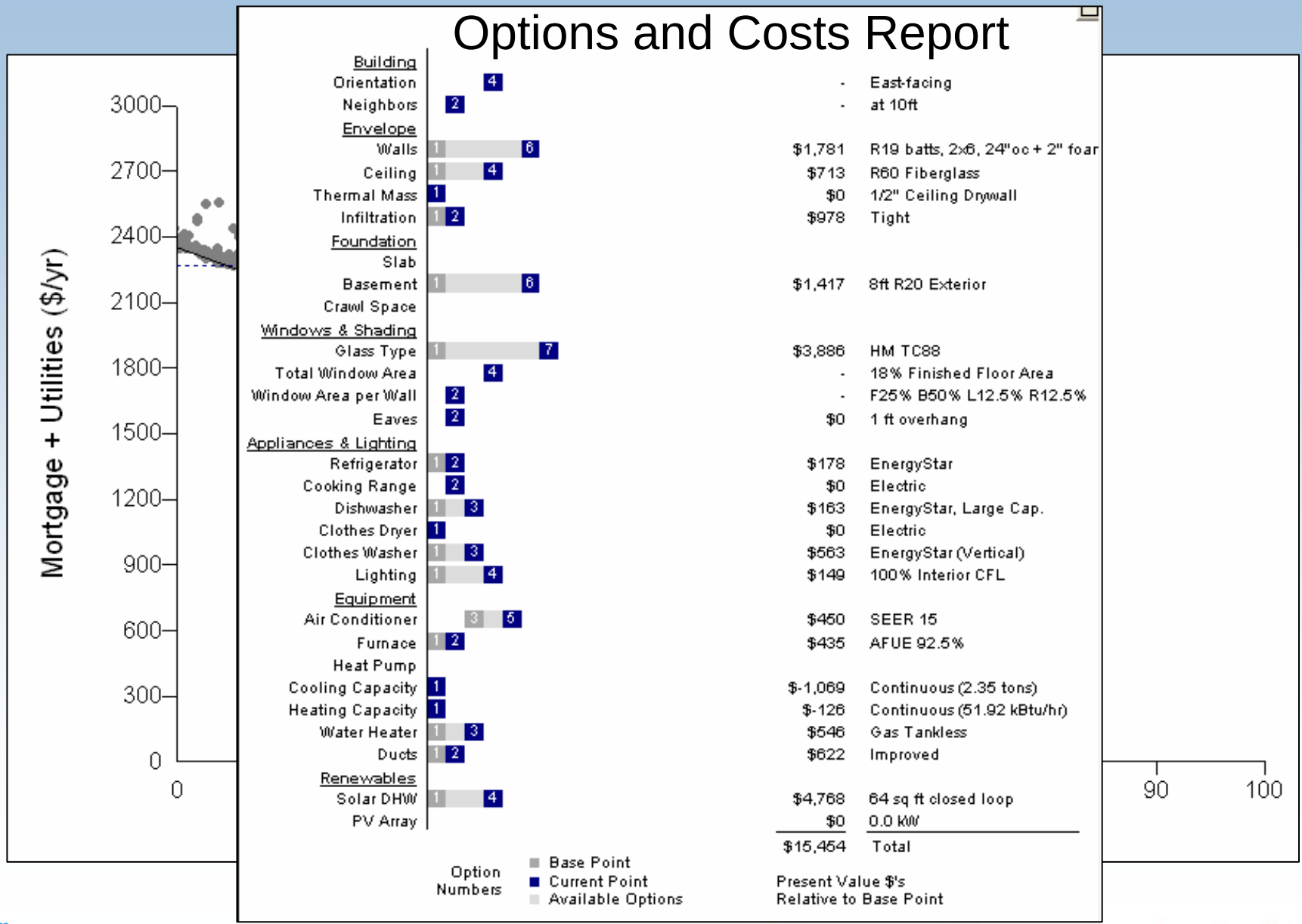

Residential Energy Saving Options



Residential Energy Saving Options



Determining Incremental Costs and Benefits for Energy Efficient Homes



Options and Costs Report

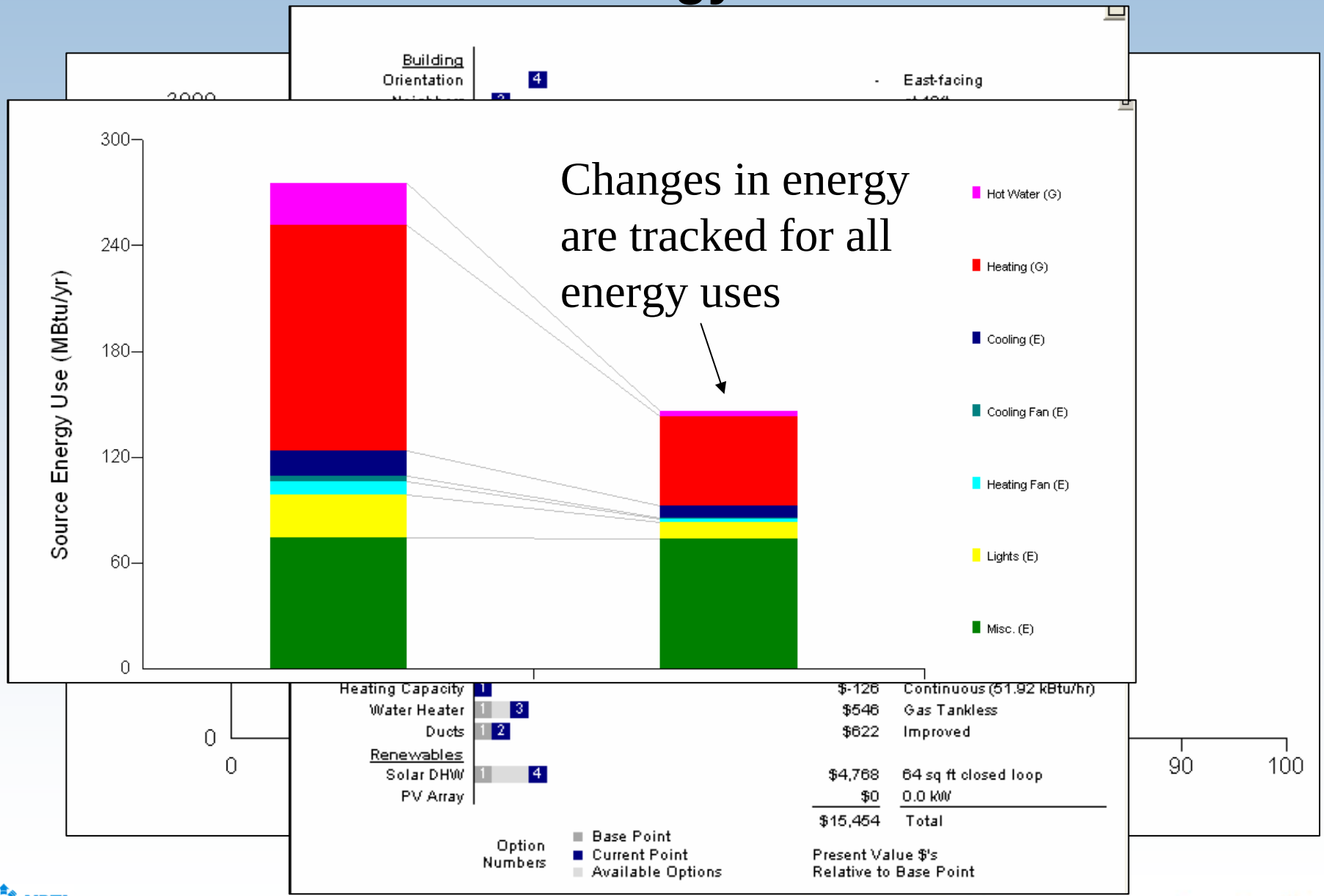
Building			
Orientation	4	-	East-facing
Neighbors	2	-	at 10ft
Envelope			
Walls	1 6	$1,781	R19 batts, 2x6, 24"oc + 2" foar
Ceiling	1 4	$713	R60 Fiberglass
Thermal Mass	1	$0	1/2" Ceiling Drywall
Infiltration	1 2	$978	Tight
Foundation			
Slab			
Basement	1 6	$1,417	8ft R20 Exterior
Crawl Space			
Windows & Shading			
Glass Type	1 7	$3,886	HM TC88
Total Window Area	4	-	18% Finished Floor Area
Window Area per Wall	2	-	F25% B50% L12.5% R12.5%
Eaves	2	$0	1 ft overhang
Appliances & Lighting			
Refrigerator	1 2	$178	EnergyStar
Cooking Range	2	$0	Electric
Dishwasher	1 3	$163	EnergyStar, Large Cap.
Clothes Dryer	1	$0	Electric
Clothes Washer	1 3	$563	EnergyStar (Vertical)
Lighting	1 4	$149	100% Interior CFL
Equipment			
Air Conditioner	3 5	$450	SEER 15
Furnace	1 2	$435	AFUE 92.5%
Heat Pump			
Cooling Capacity	1	$-1,069	Continuous (2.35 tons)
Heating Capacity	1	$-126	Continuous (51.92 kBtu/hr)
Water Heater	1 3	$546	Gas Tankless
Ducts	1 2	$622	Improved
Renewables			
Solar DHW	1 4	$4,768	64 sq ft closed loop
PV Array		$0	0.0 kW
		$15,454	Total

Option Numbers

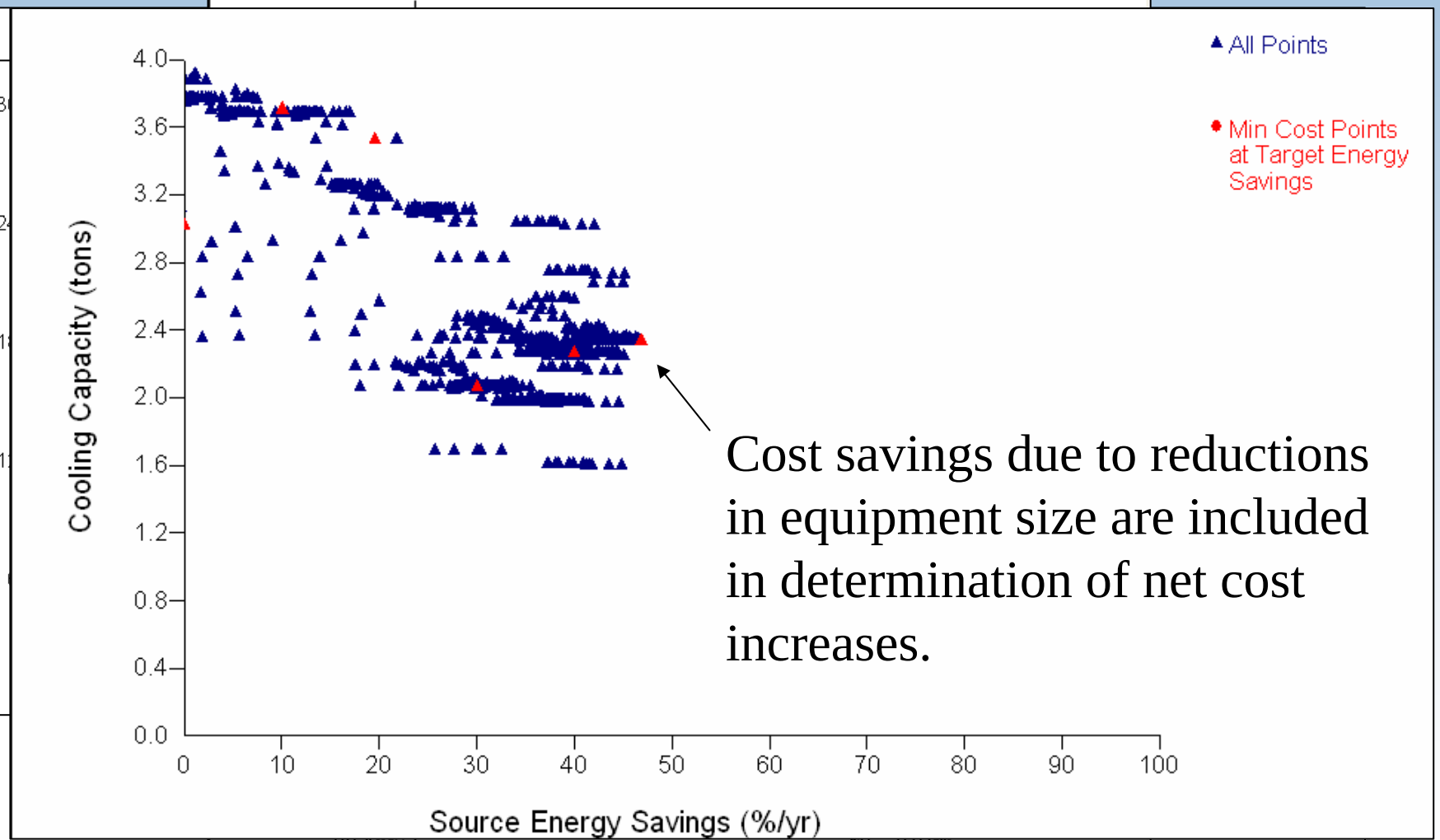
Base Point
Current Point
Available Options

Present Value $'s
Relative to Base Point

Determining Incremental Costs and Benefits for Energy Efficient Homes

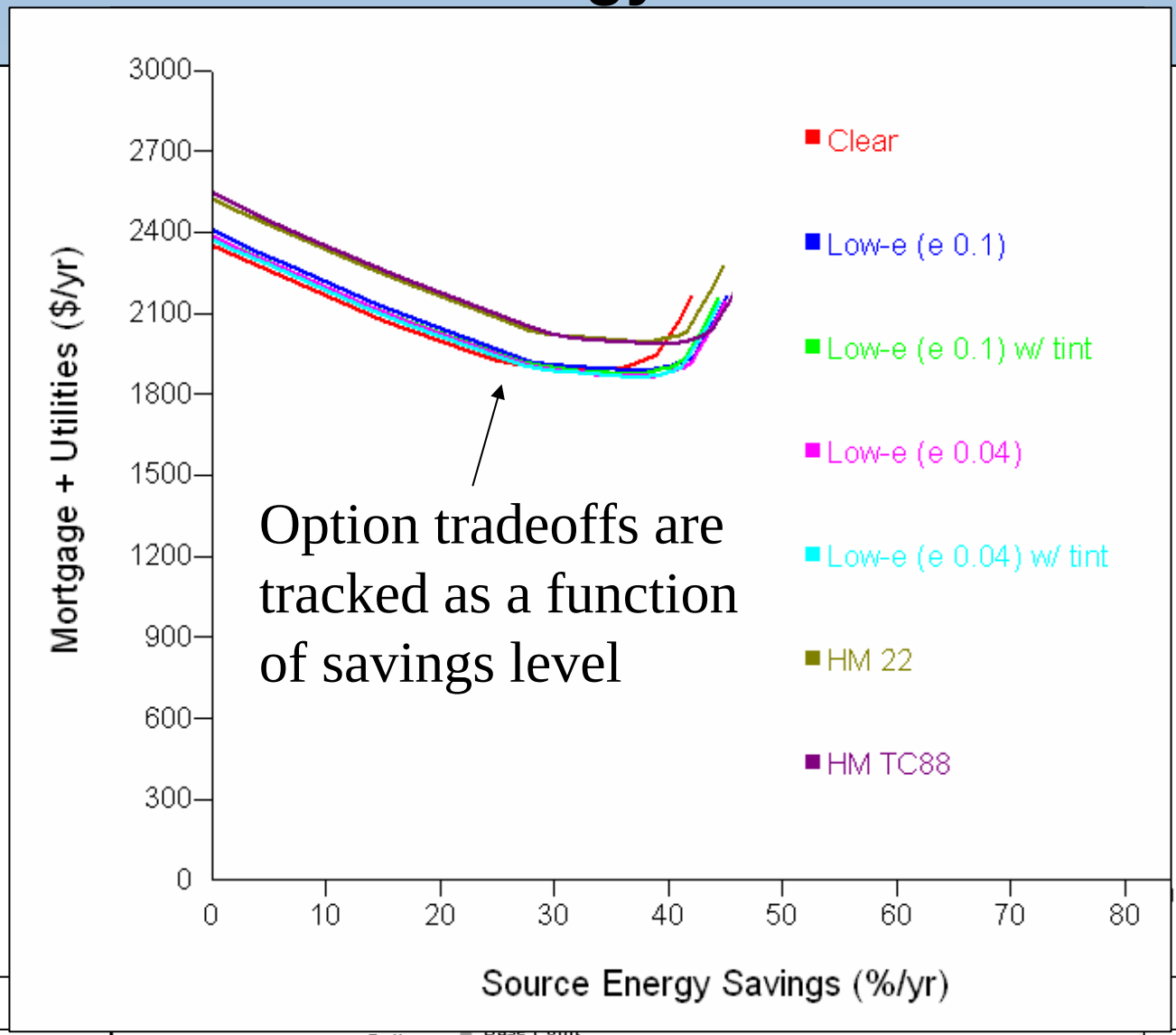


Determining Incremental Costs and Benefits for Energy Efficient Homes

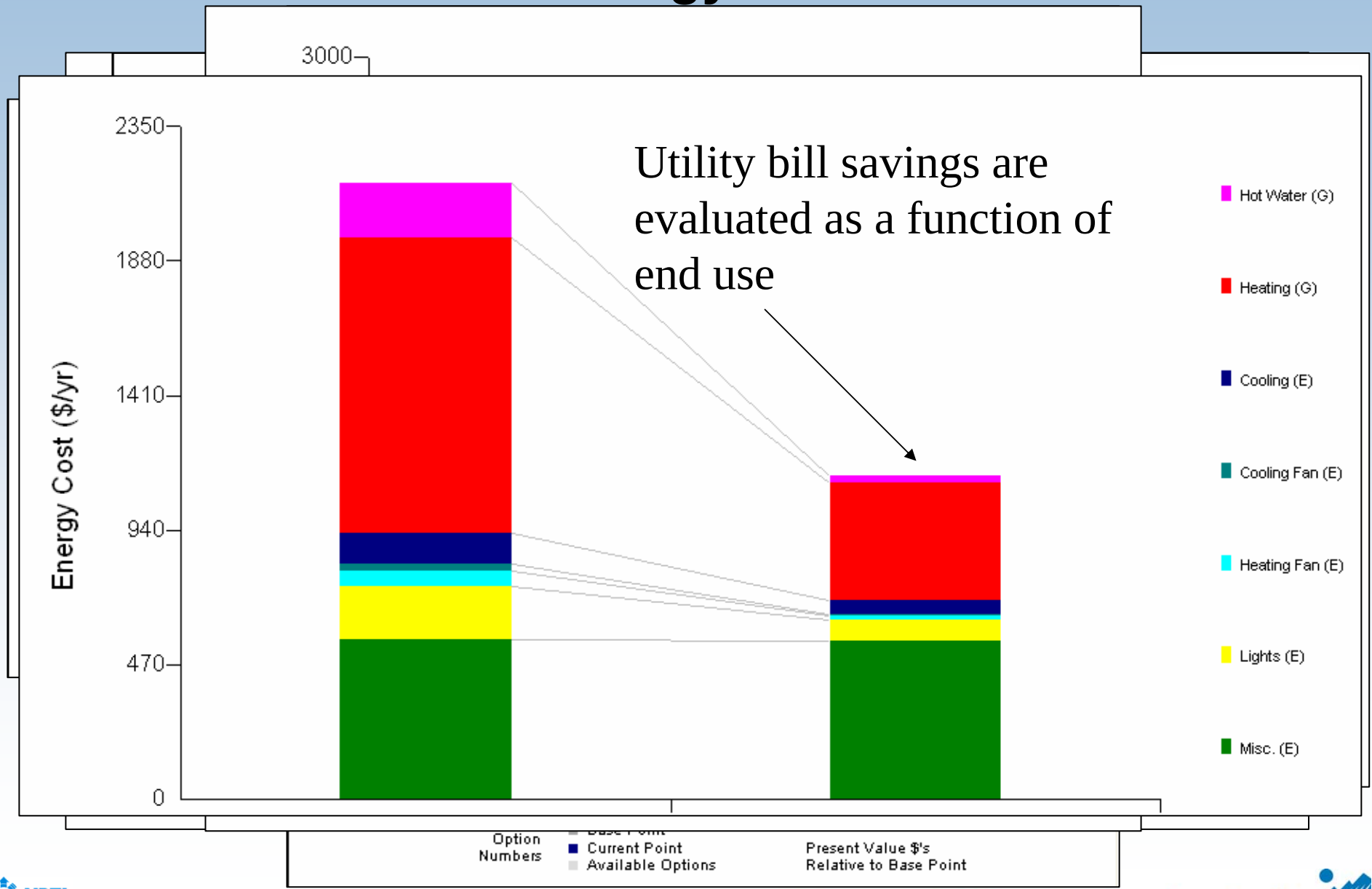


Cost savings due to reductions in equipment size are included in determination of net cost increases.

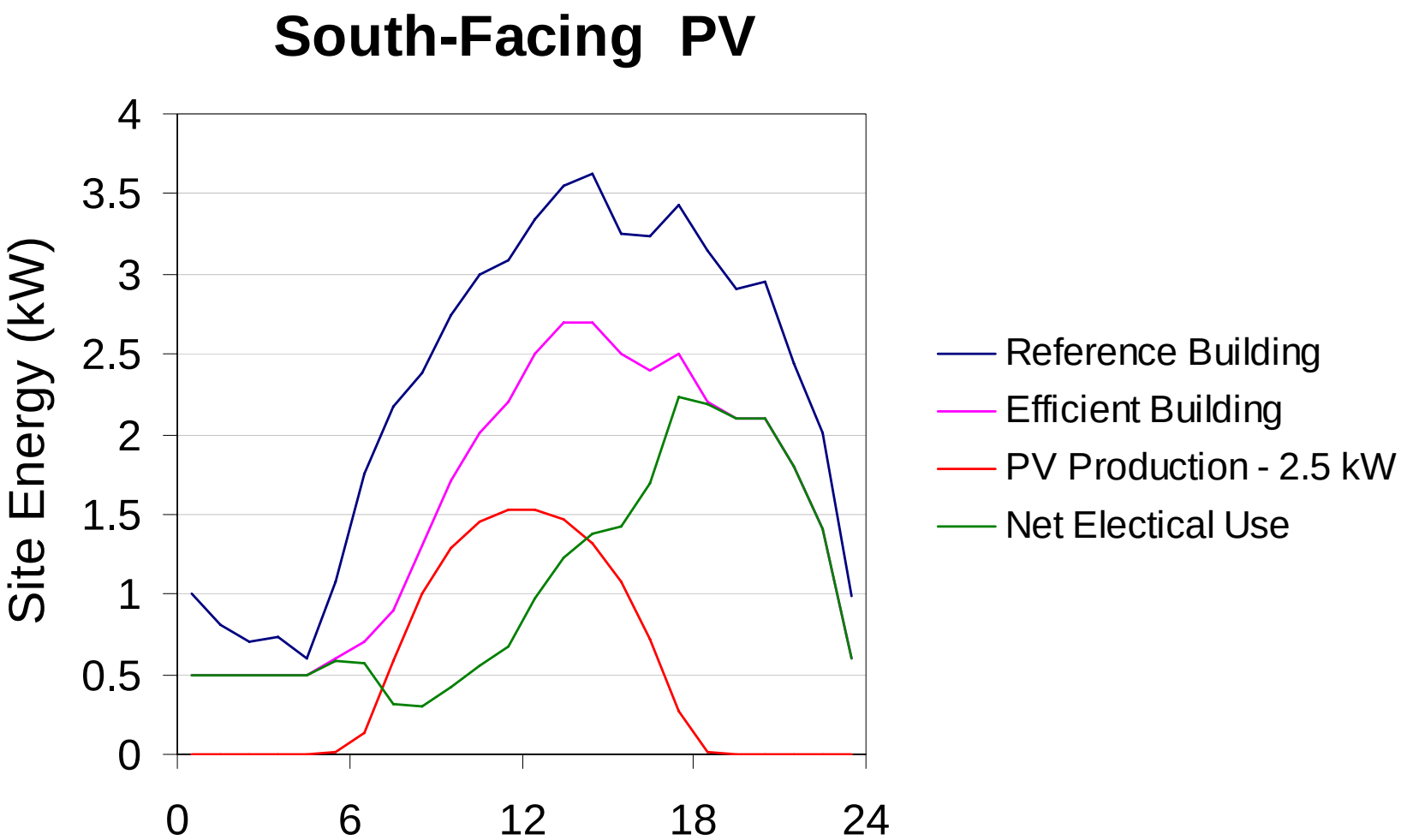
Determining Incremental Costs and Benefits for Energy Efficient Homes



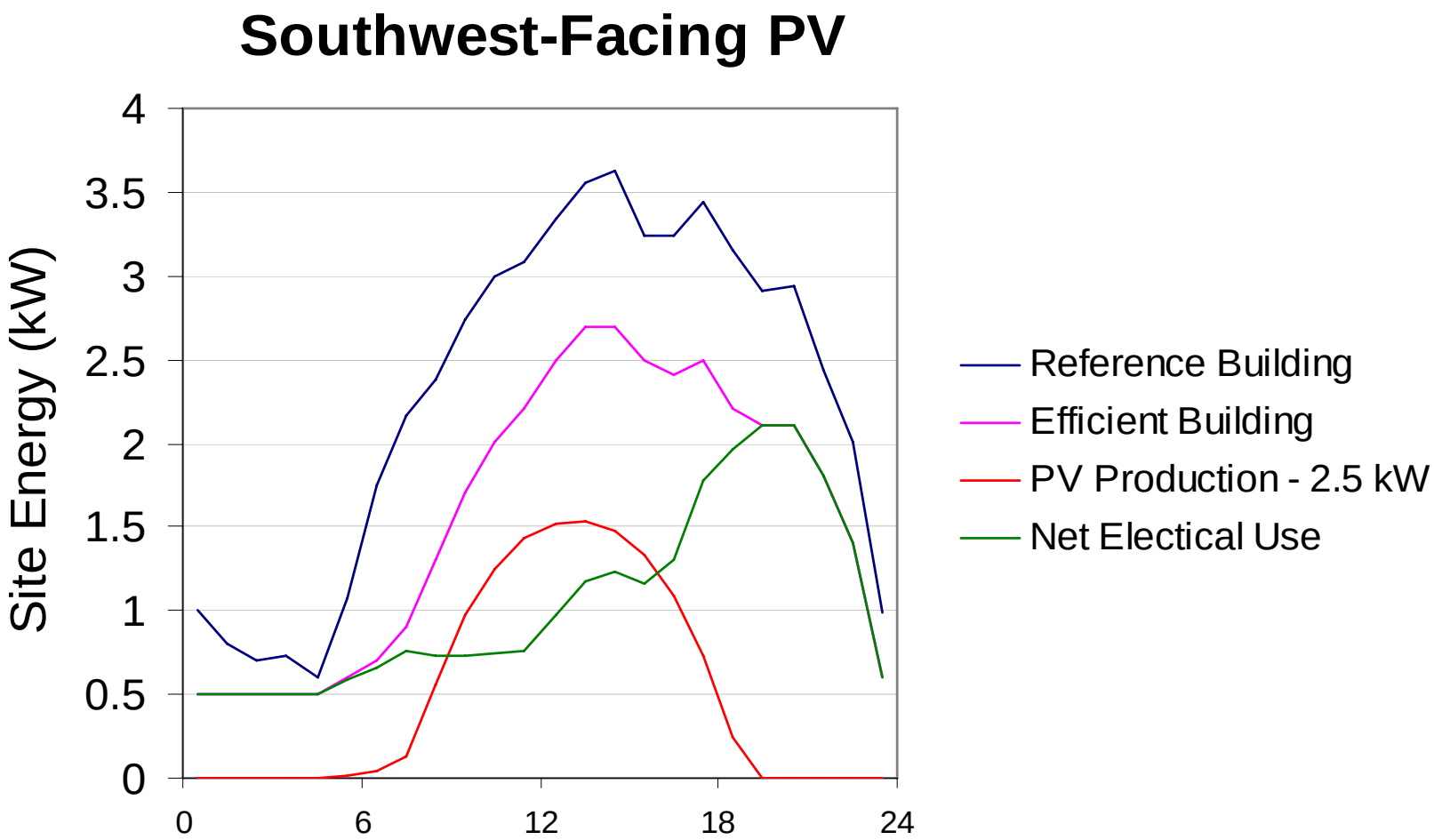
Determining Incremental Costs and Benefits for Energy Efficient Homes



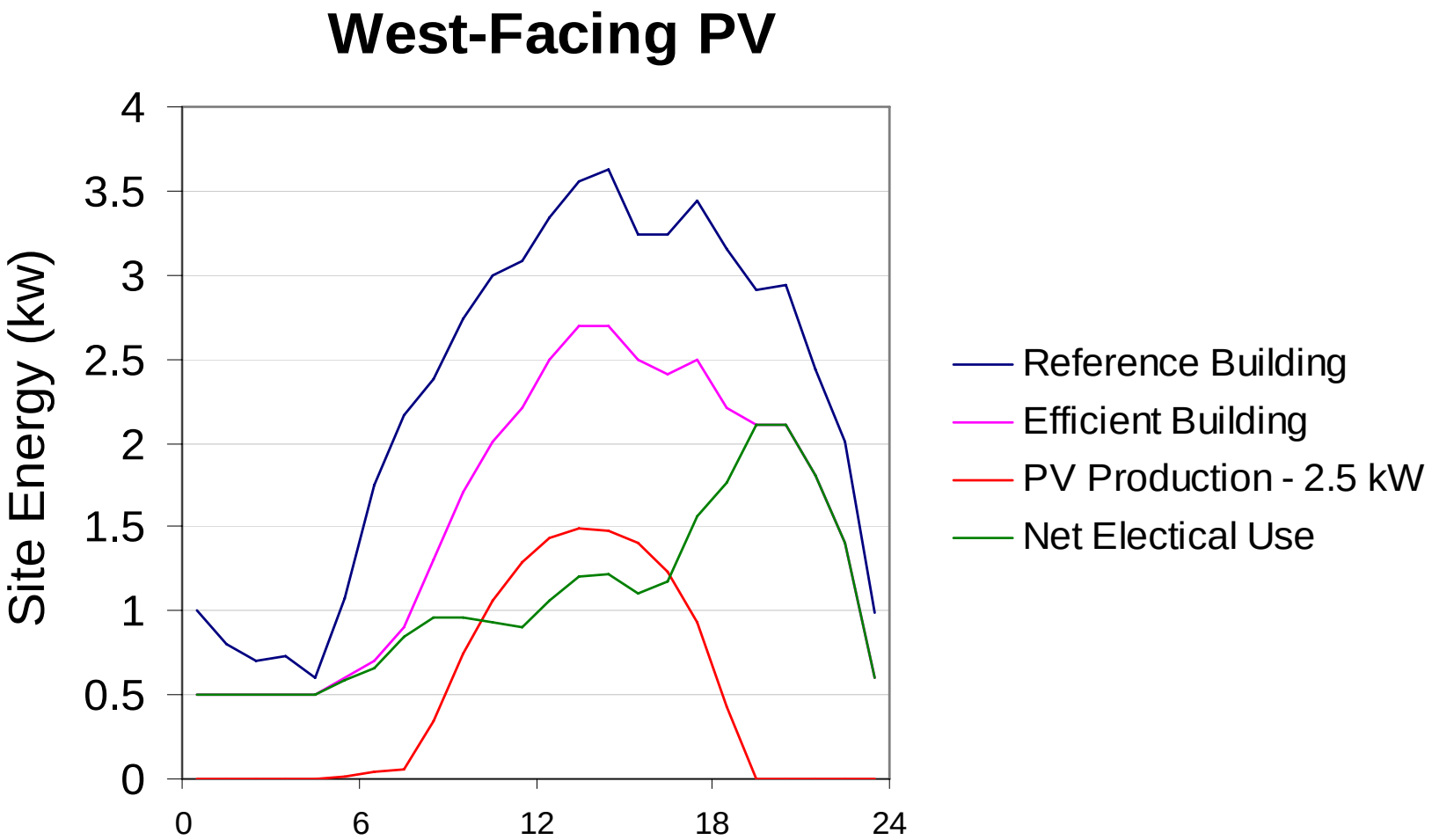
Determining Incremental Costs and Benefits for Energy Efficient Homes



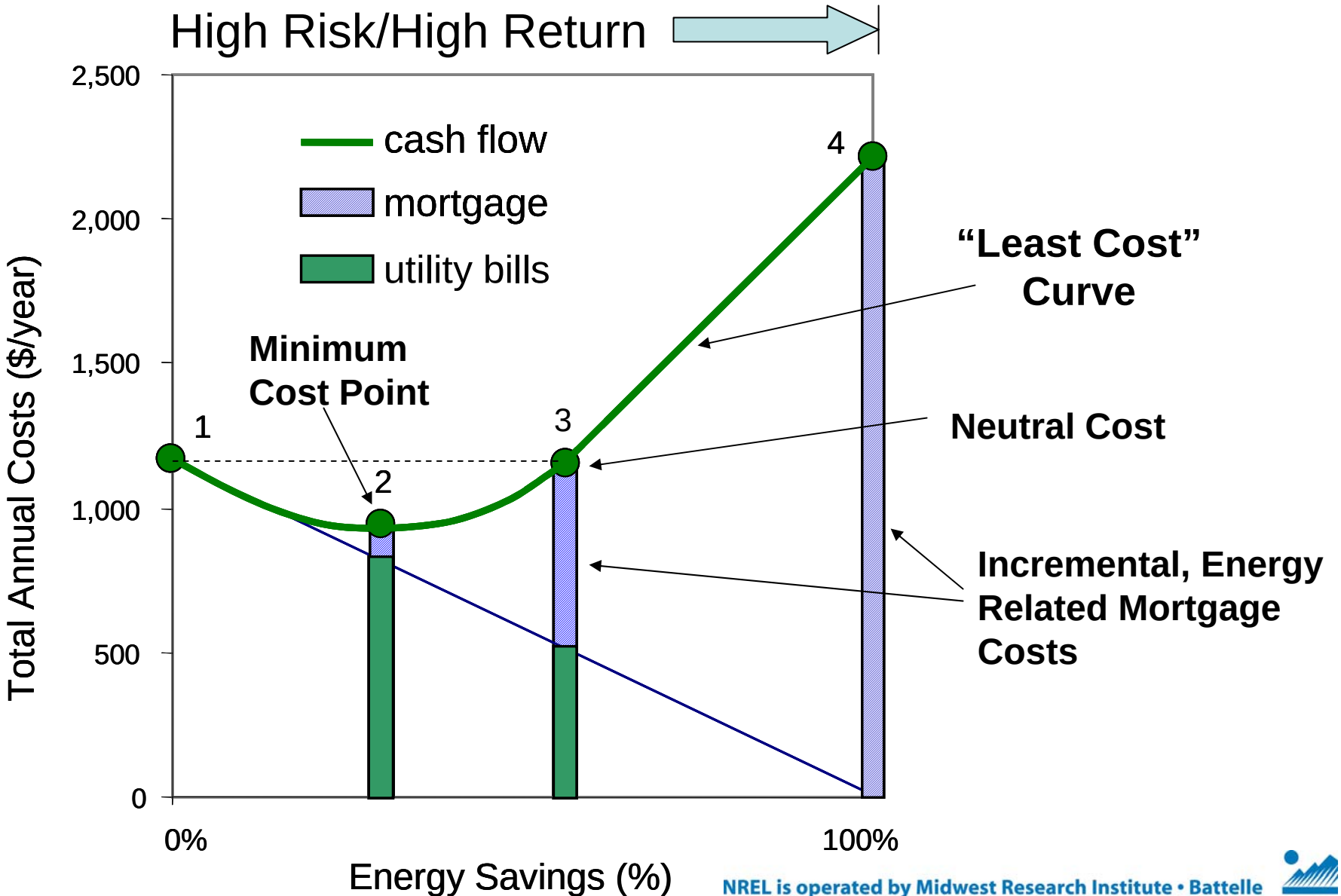
Determining Incremental Costs and Benefits for Energy Efficient Homes



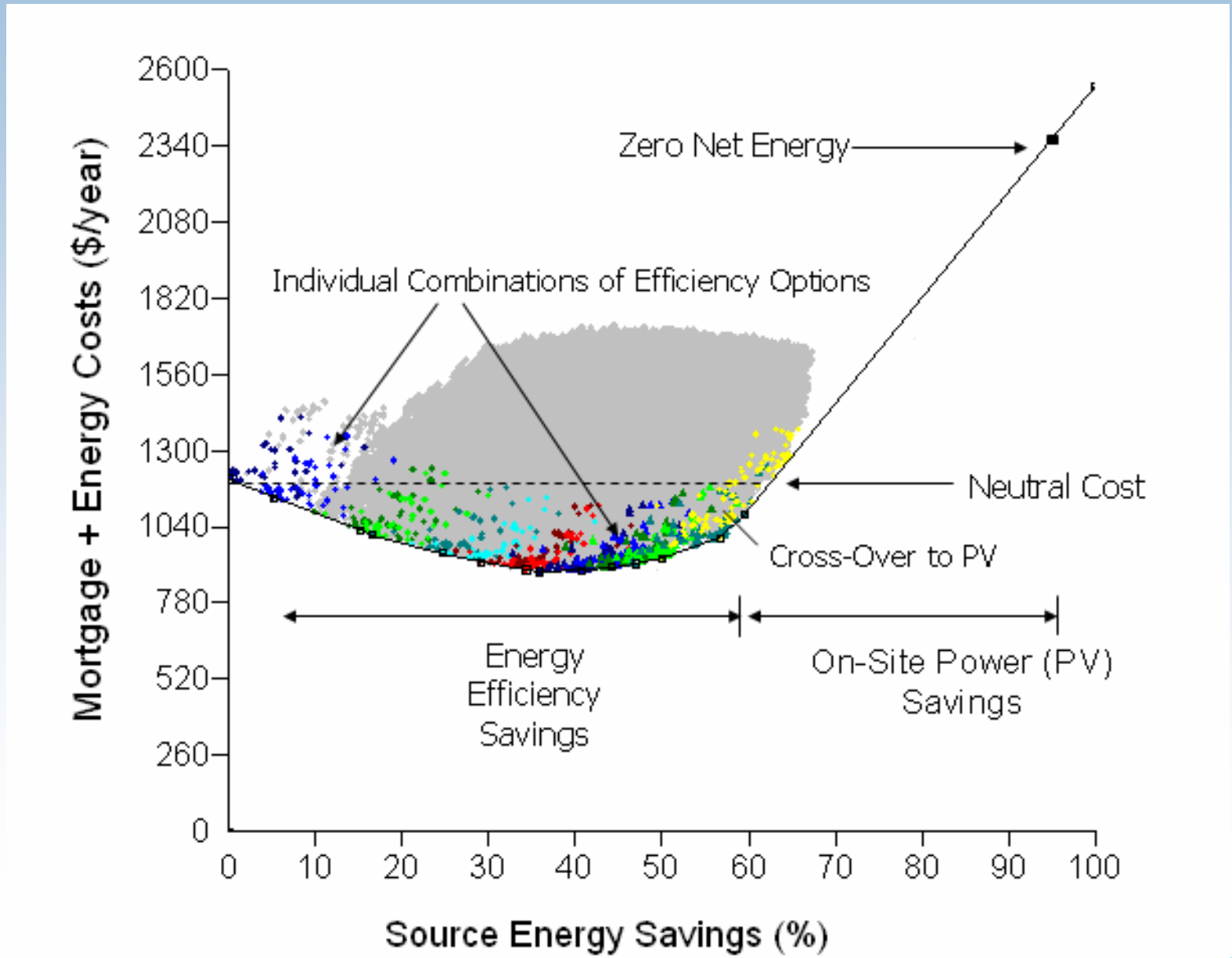
Determining Incremental Costs and Benefits for Energy Efficient Homes



Determining Incremental Costs and Benefits for Energy Efficient Homes



Determining Incremental Costs and Benefits for Energy Efficient Homes



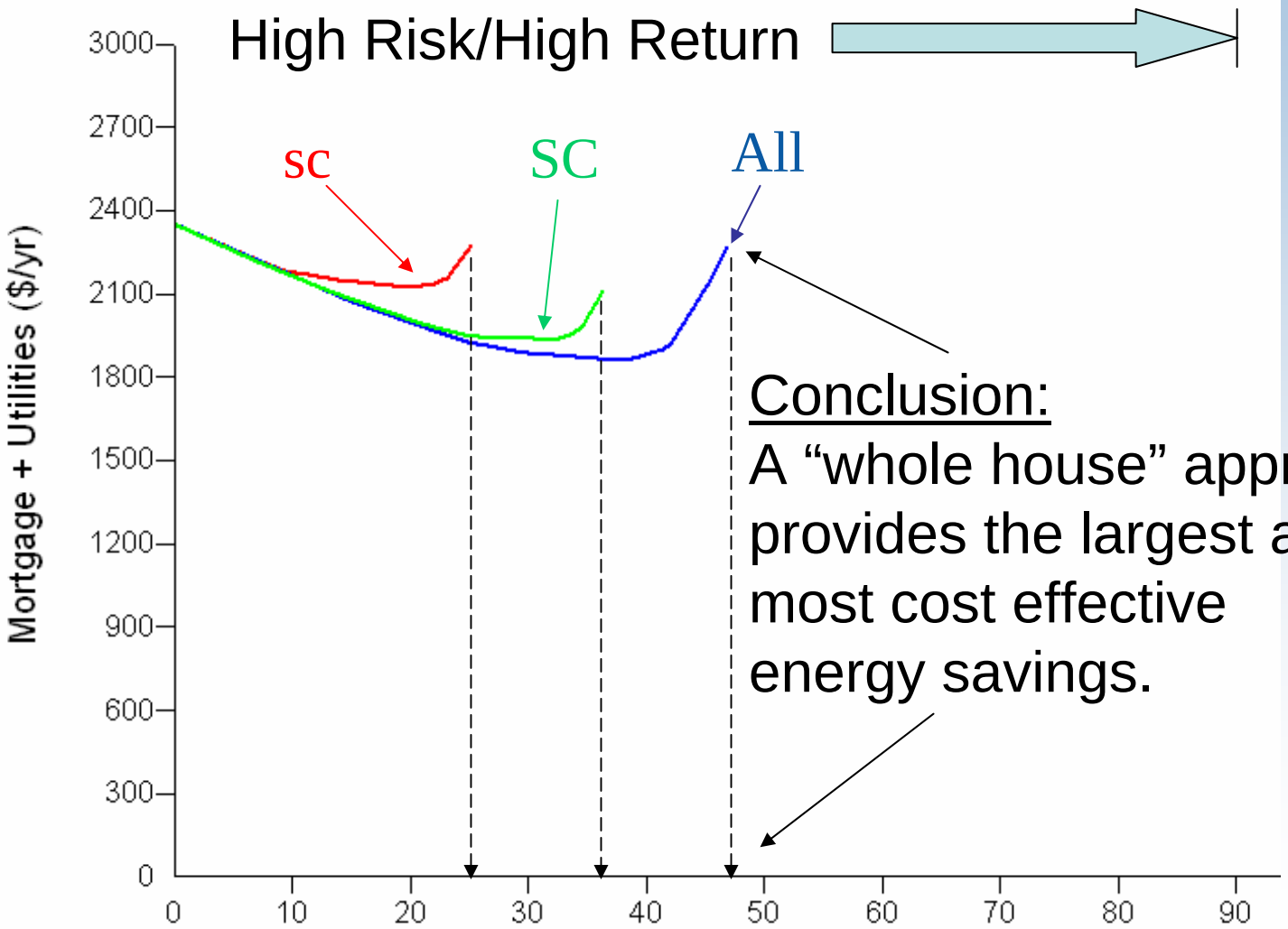
Consumer Benefits from Energy Efficient Homes are Much Broader than Reductions in Utility Bills

- In addition to providing the highest immediate cash flow back to a homeowner, a comprehensive approach increases delivery of other market drivers including increased durability, reduced maintenance, increased comfort, ….

Comparison of Energy Saving Strategies From the Perspective of A Homeowner

"sc"=Equipment, Windows and Insulation Options Only

"SC"=sc + Duct and Infiltration Measures

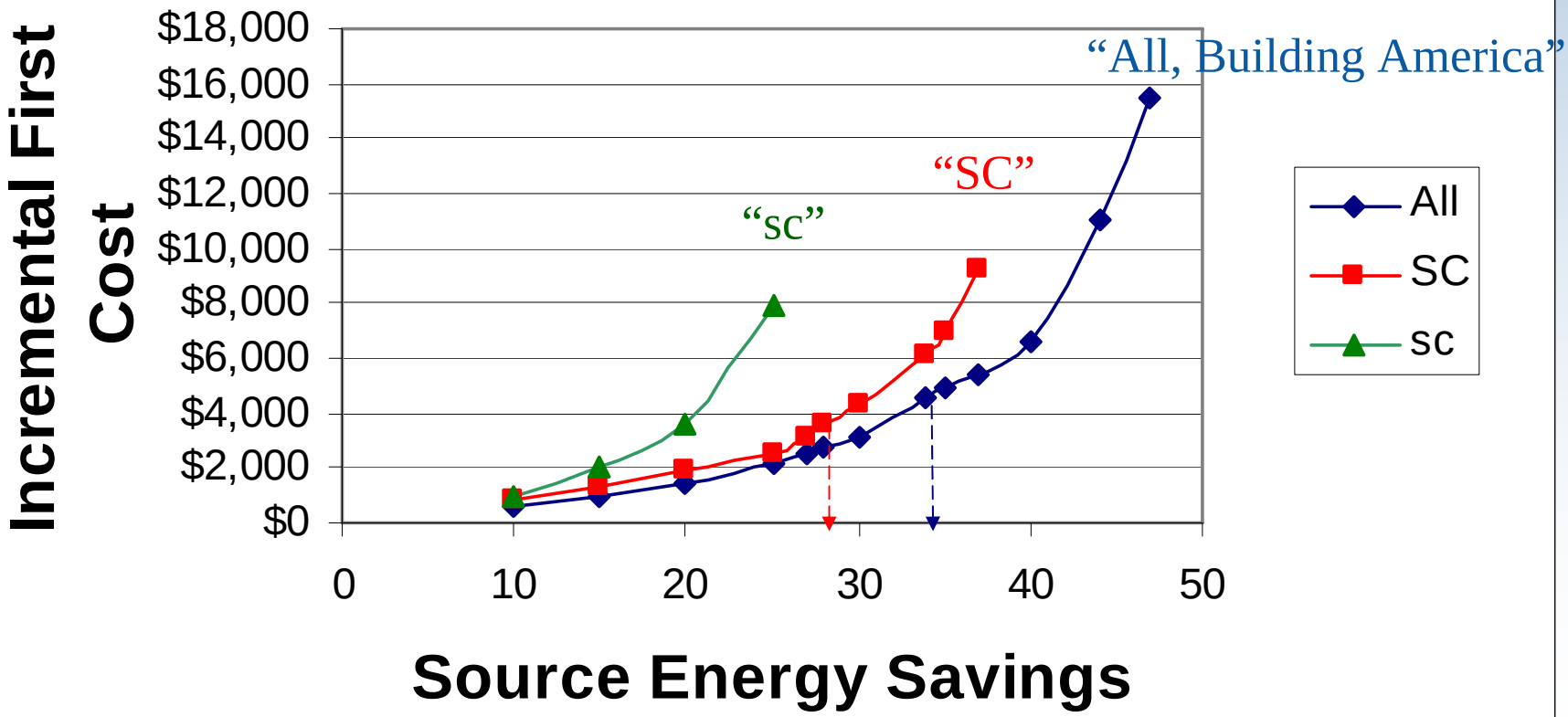


Conclusion:

A "whole house" approach provides the largest and most cost effective energy savings.

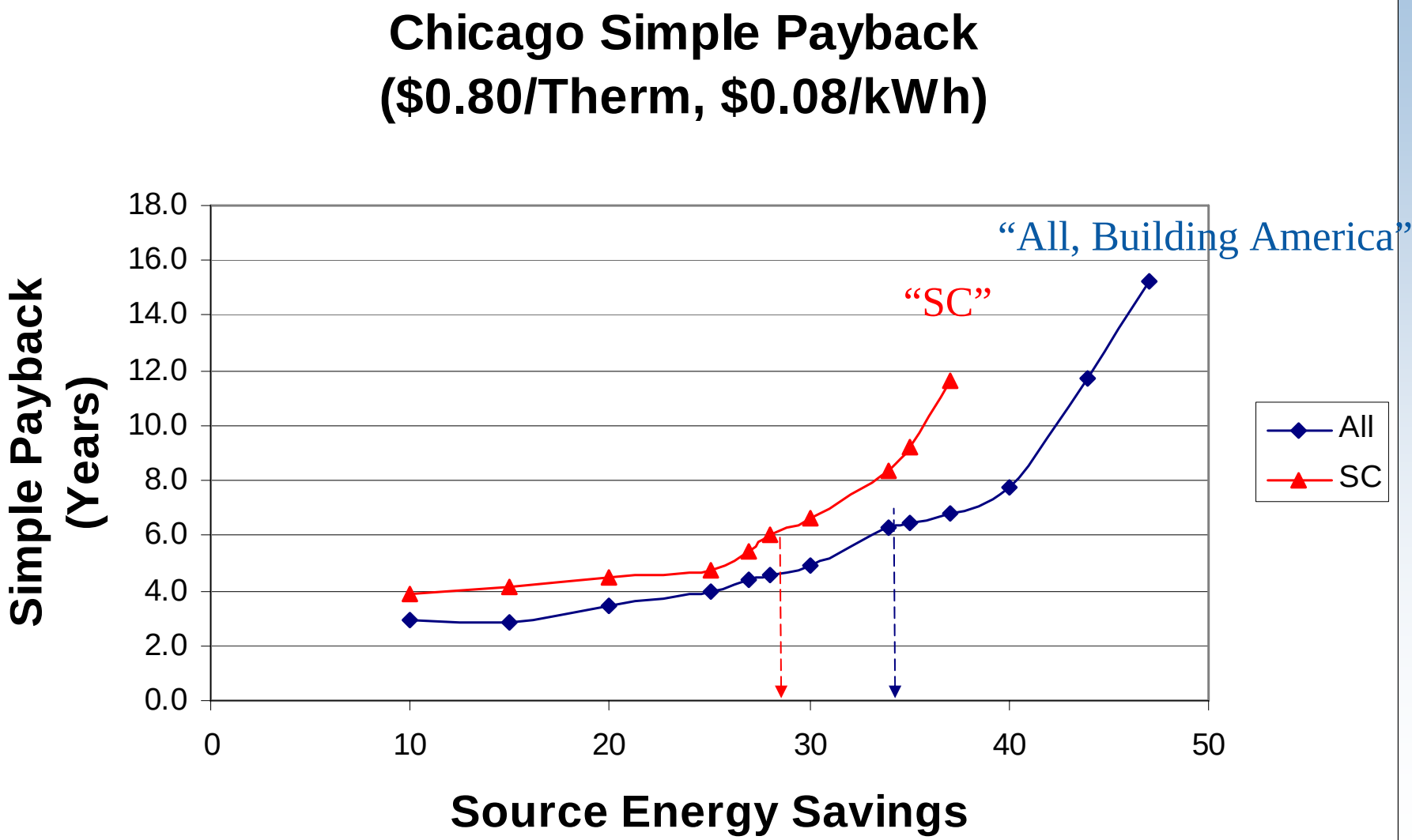
Comparison of Energy Saving Strategies: First Cost

Chicago First Cost Comparison

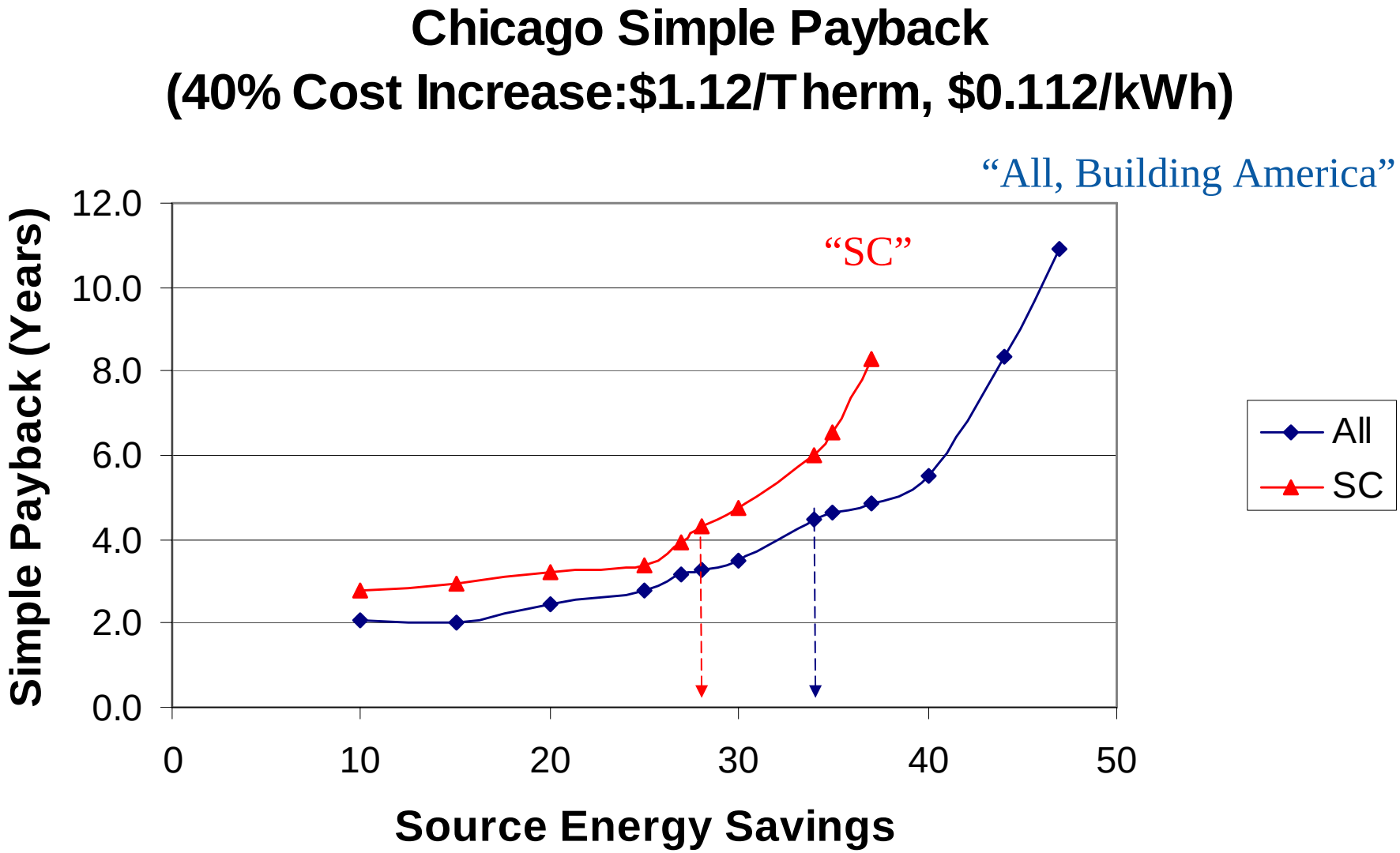


2600 ft2, 2 Story, basement

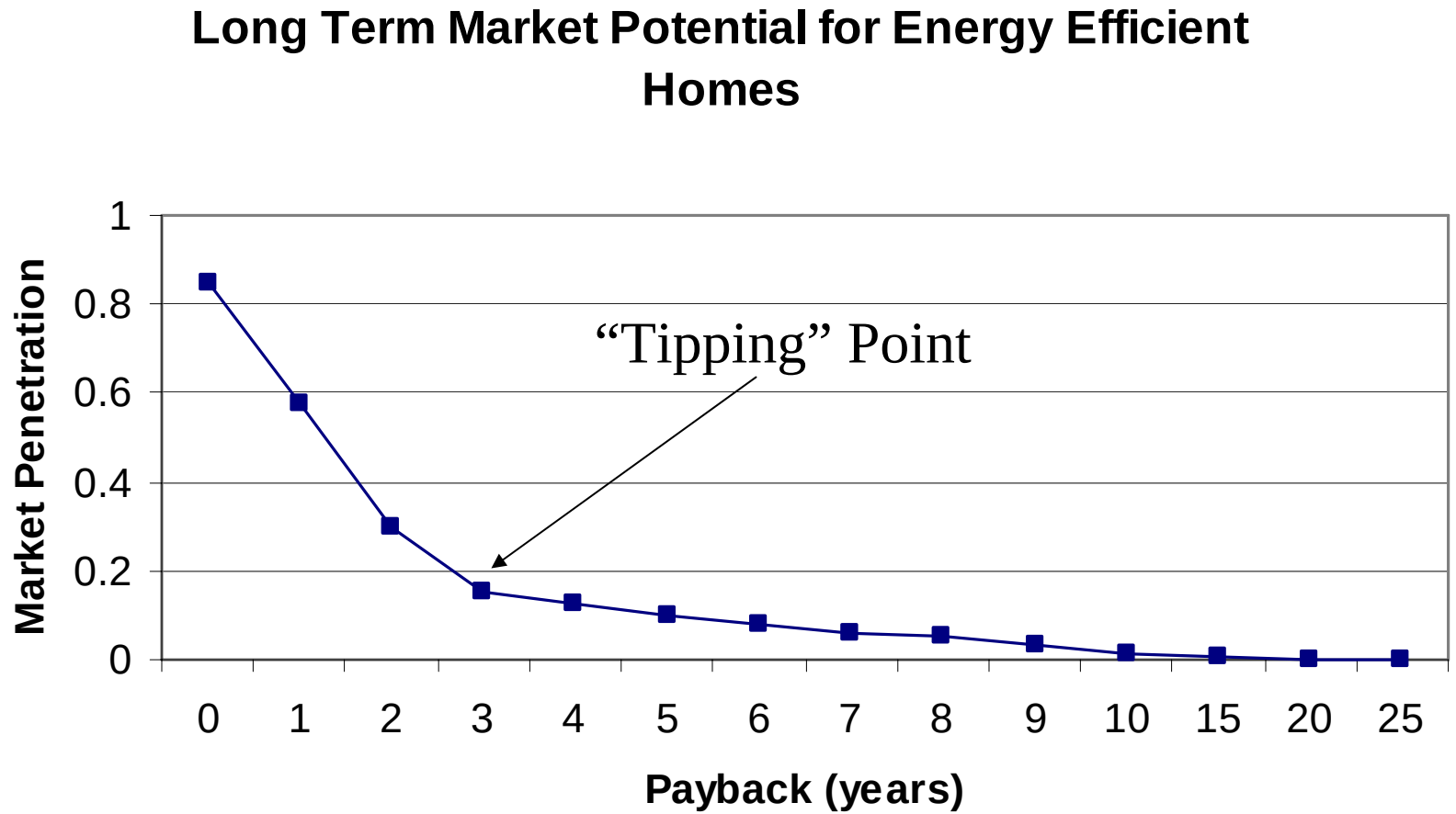
Comparison of Energy Saving Strategies: Simple Payback



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

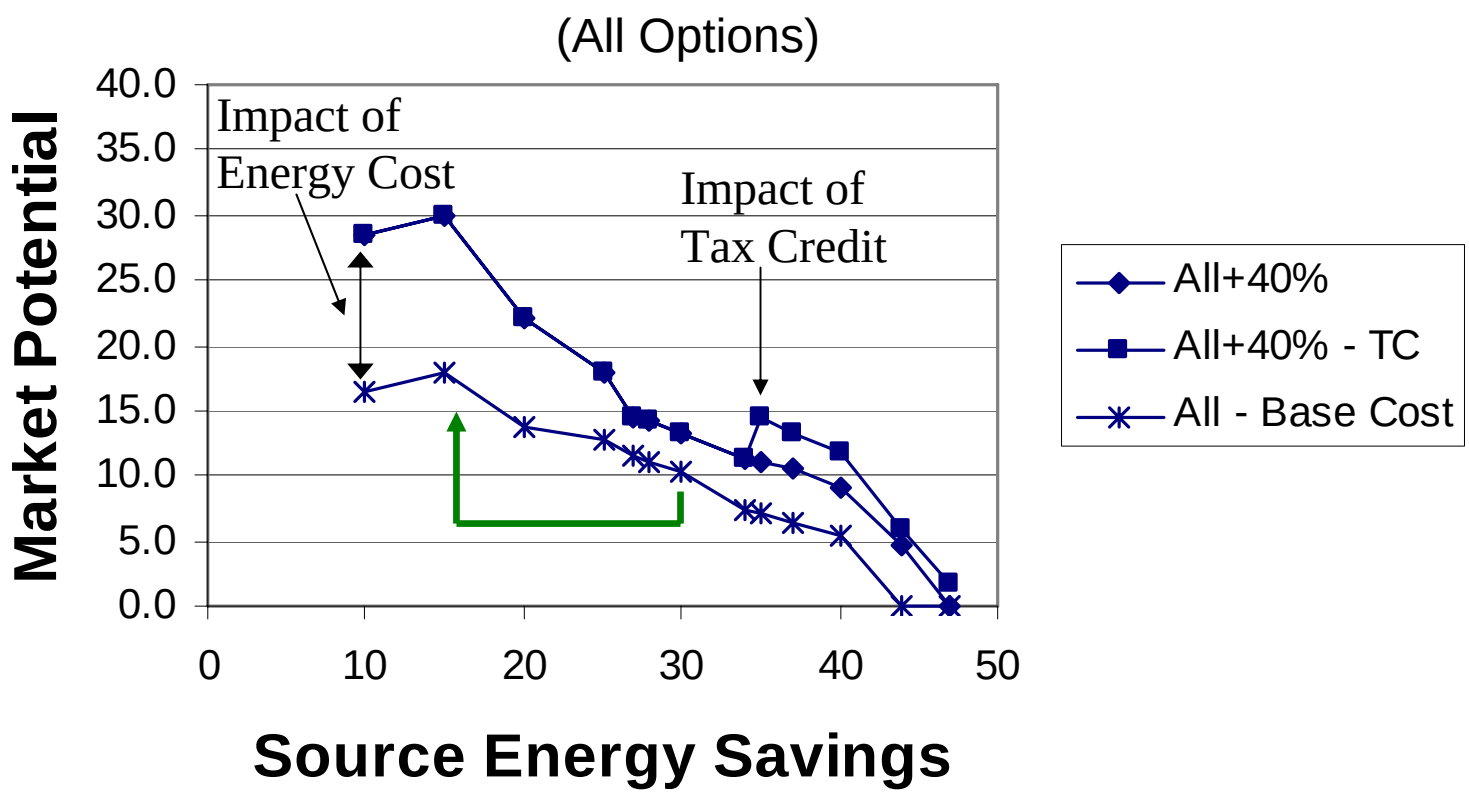


Estimated Impacts of Energy Savings on Long Term Market Potential

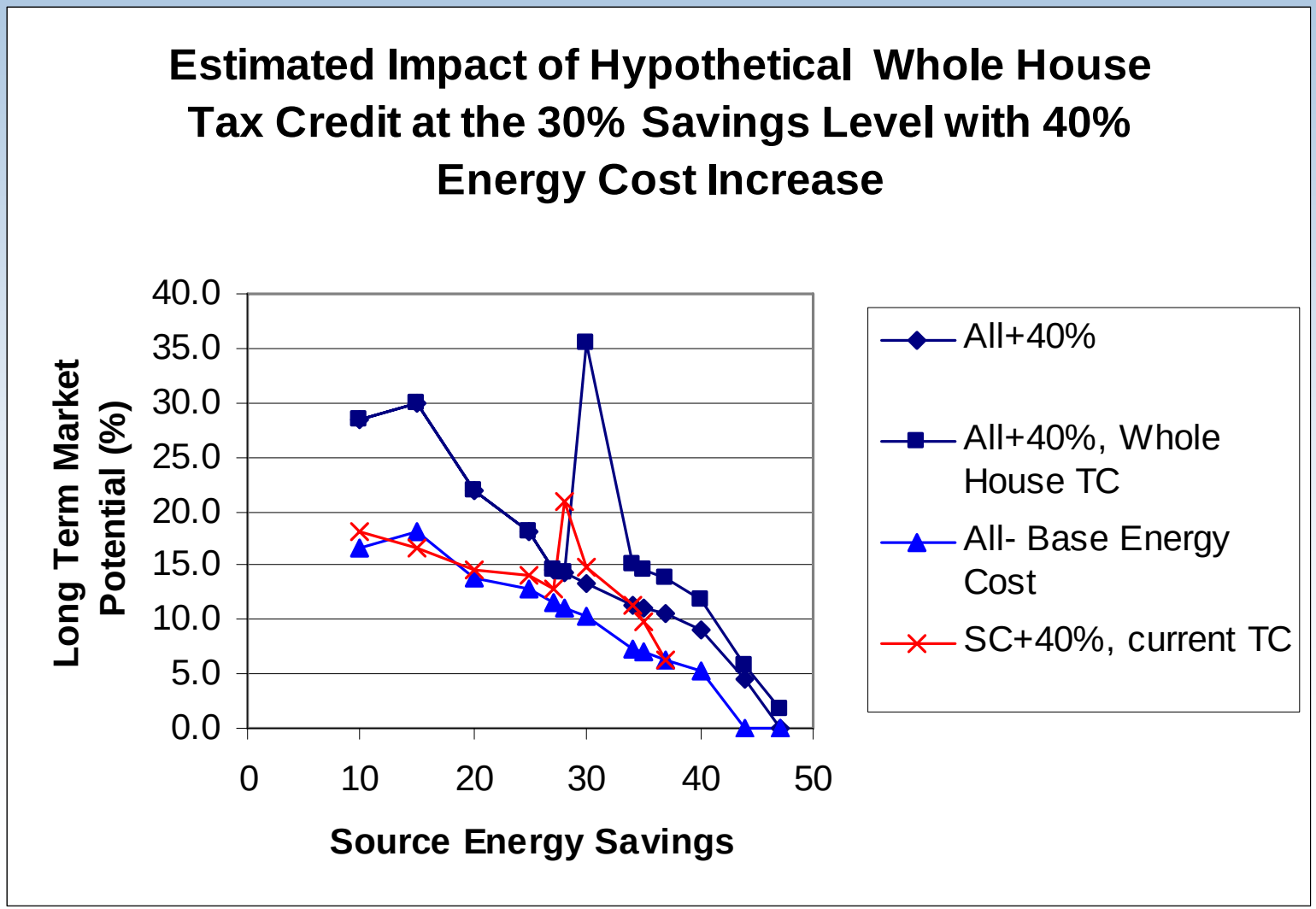


"Fuel Cells for Building Cogeneration Applications – Cost/Performance Requirements and Markets"; prepared for the Building Equipment Division, Office of Building Technologies, U.S. Department of Energy; prepared by Arthur D. Little, Cambridge, MA; Arthur D. Little, Reference Number 42526; Figure 6.1.2, January 1995.

Estimated Impacts of Energy Savings on Long Term Market Potential



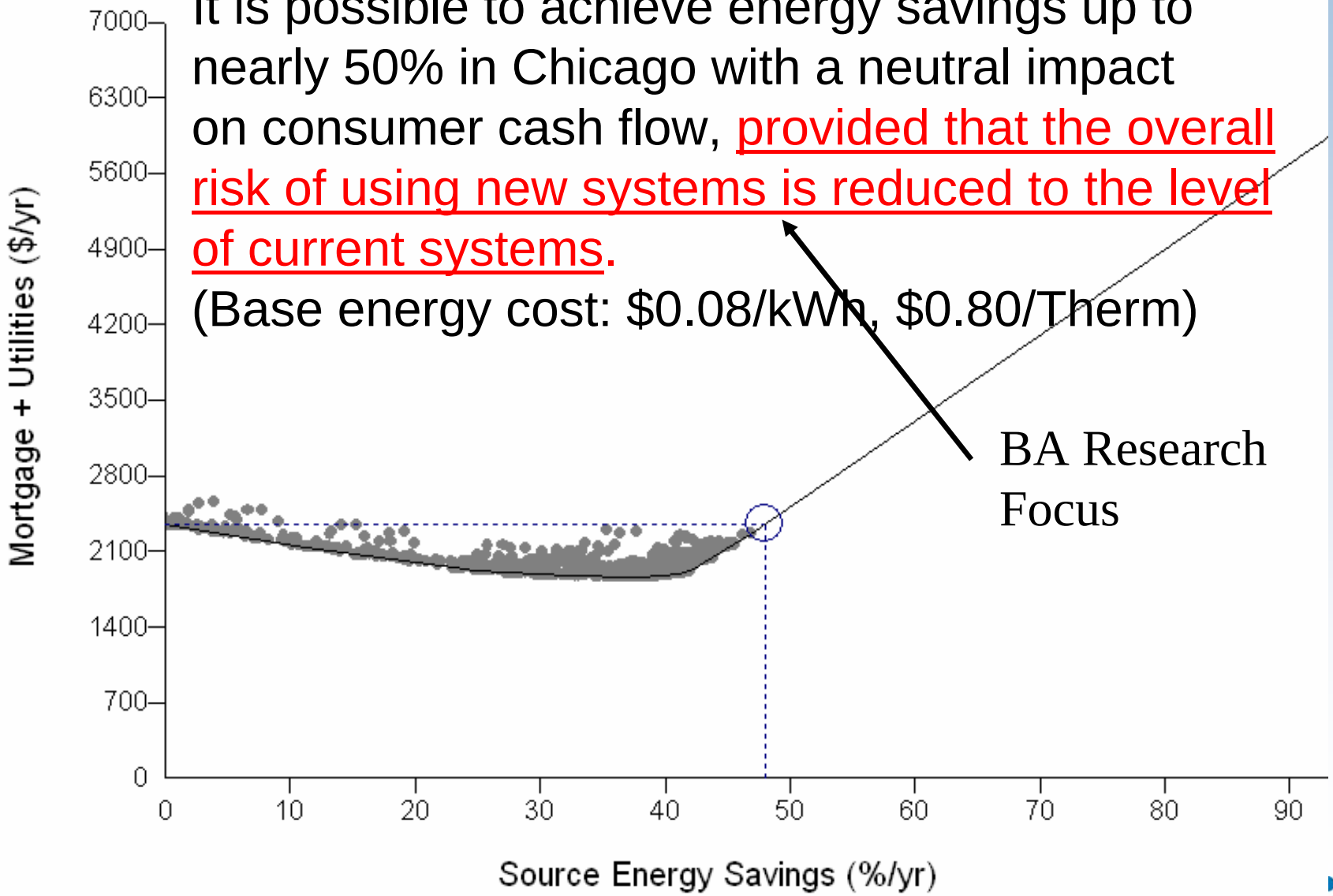
Estimated Impacts of Hypothetical "Whole House" Tax Credit On Market for Energy Efficient Homes



Conclusions

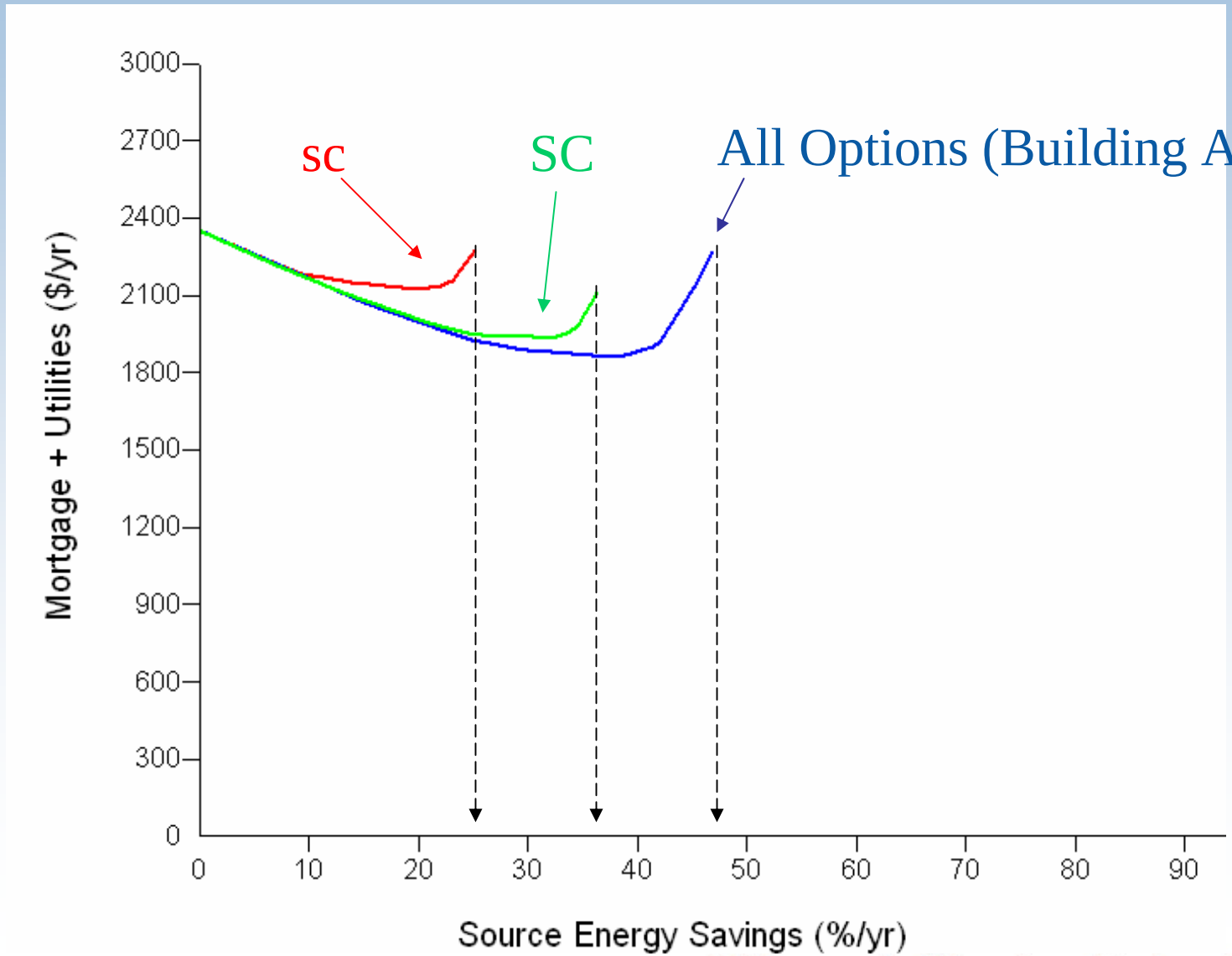
It is possible to achieve energy savings up to nearly 50% in Chicago with a neutral impact on consumer cash flow, provided that the overall risk of using new systems is reduced to the level of current systems.

(Base energy cost: $0.08/kWh, $0.80/Therm)



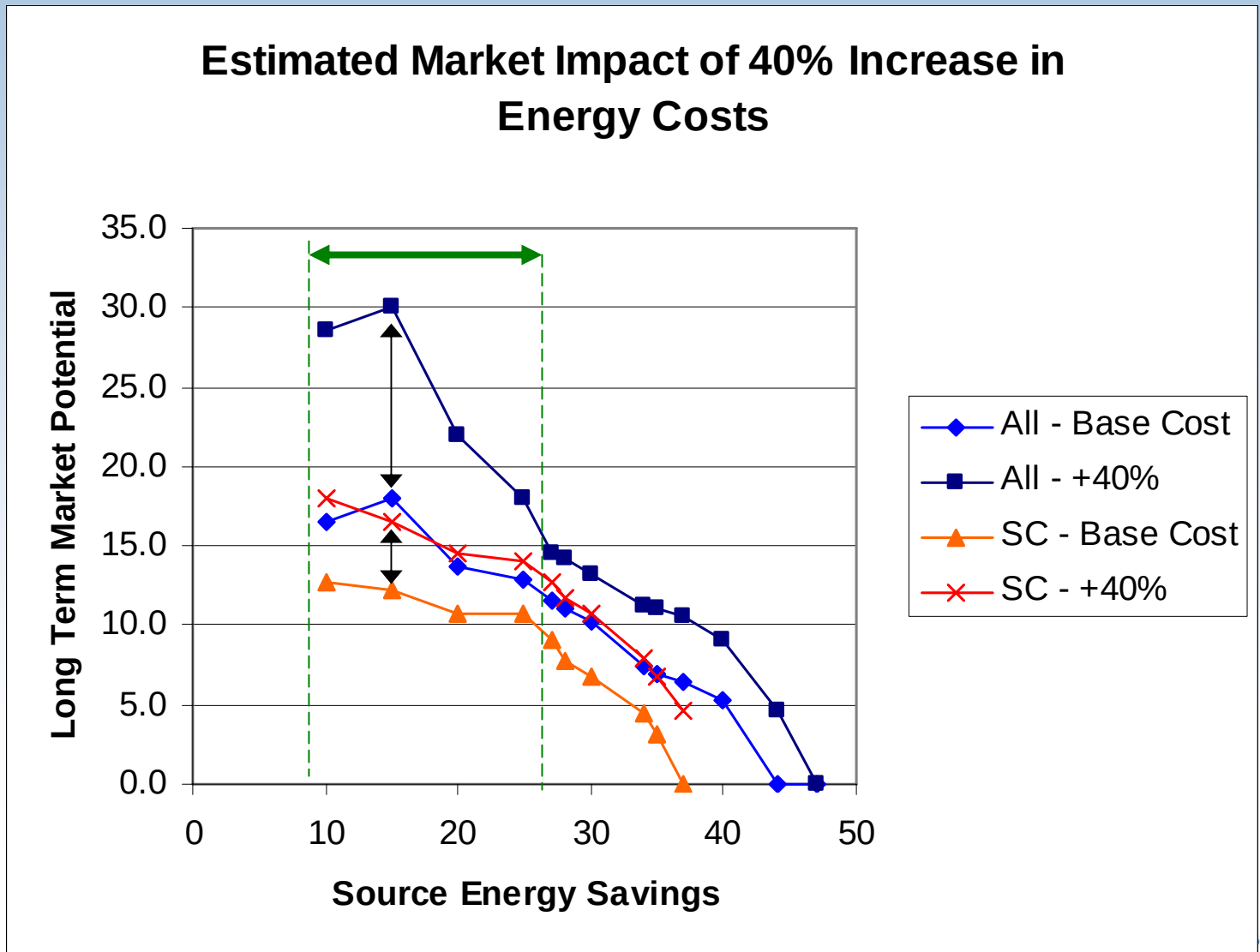
Conclusions

A “whole house” approach provides the largest and most cost effective energy savings.



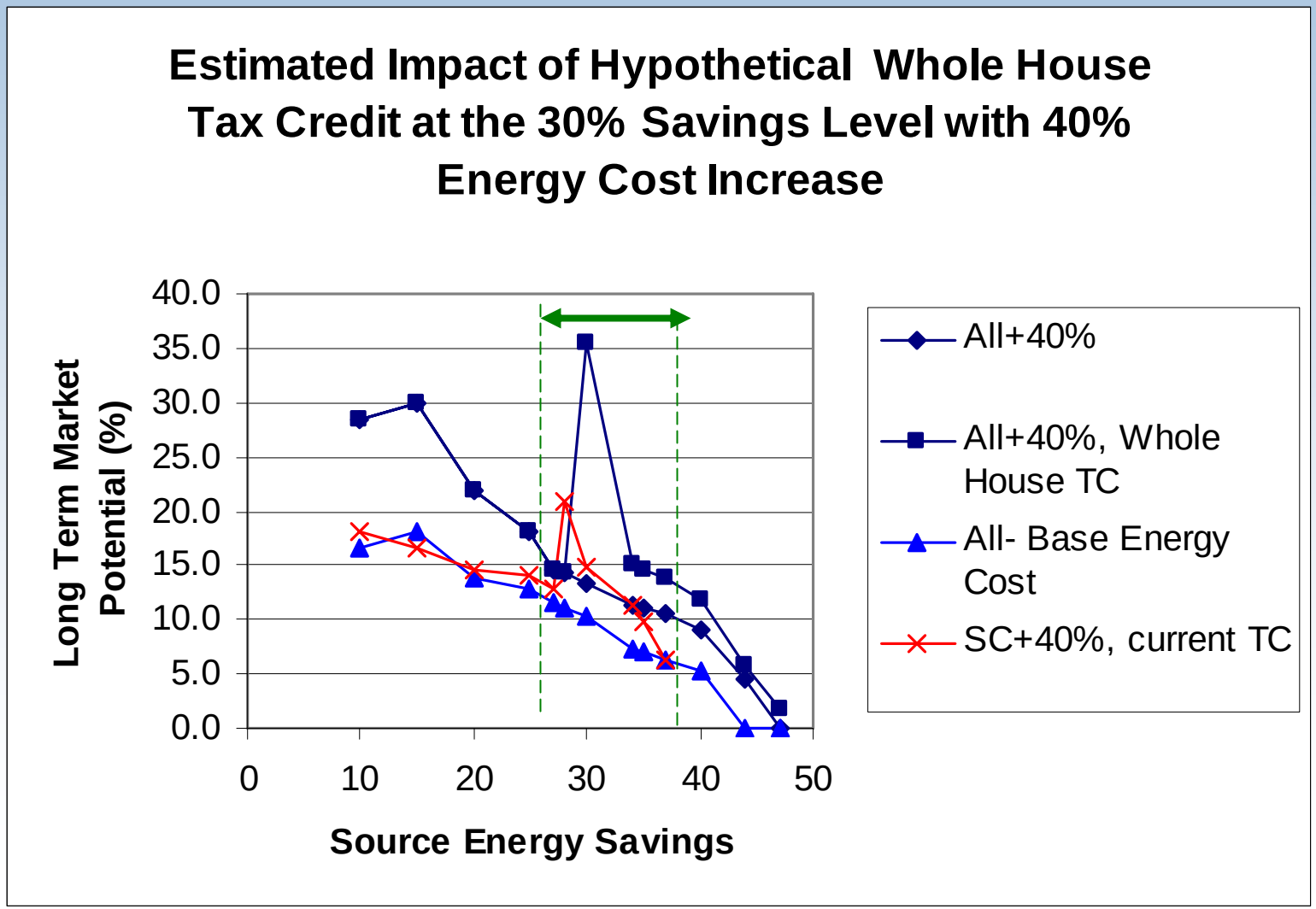
Conclusions

Current increases in energy costs are expected to create a significant increase in the long term demand for houses in the 10-25% savings range.

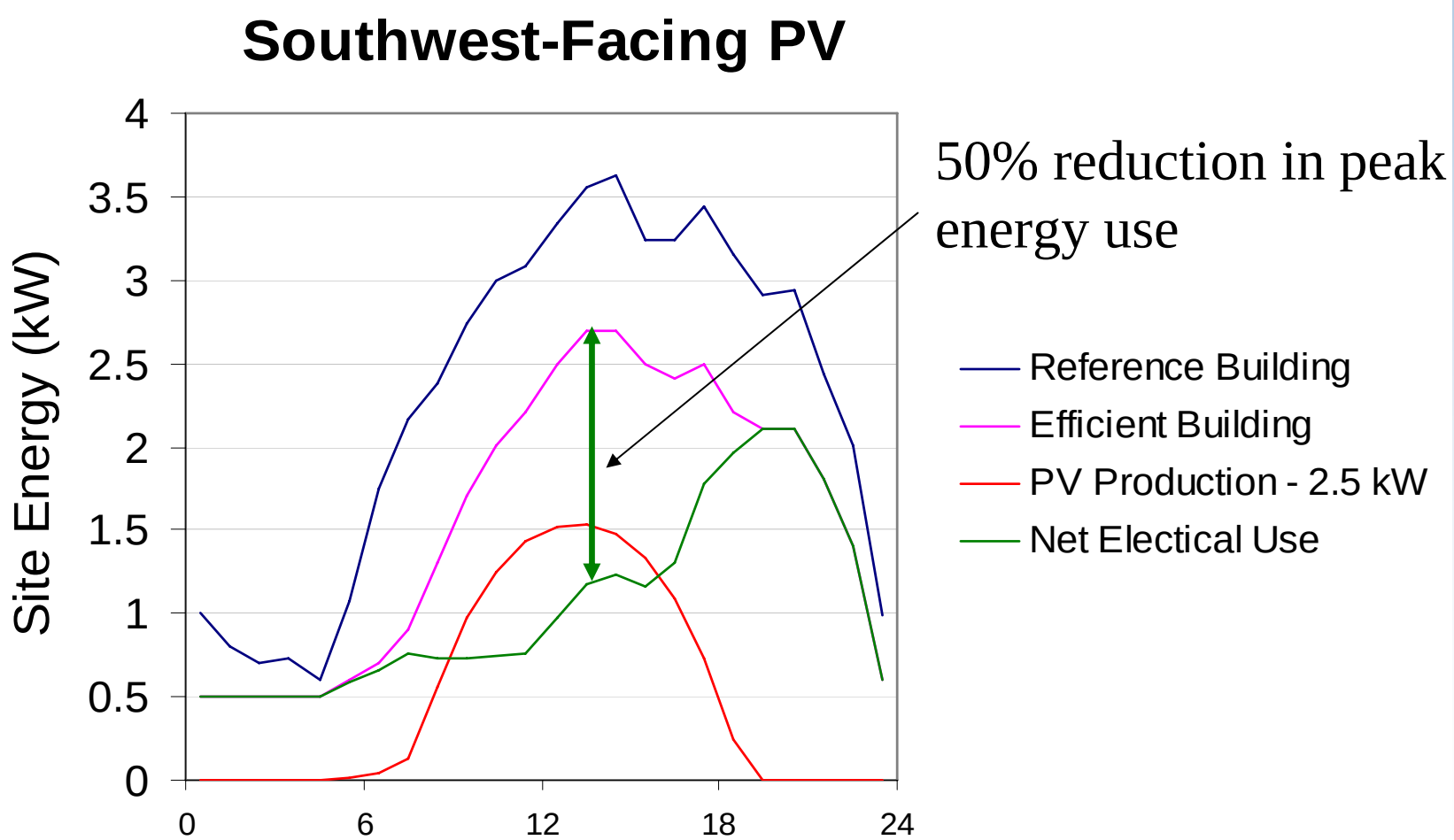


Conclusions

A "whole house" energy tax credit could provide 2-3 times the impact of the current space conditioning tax credit.



Future Opportunity for Zero Energy Homes: Capture Value of Peak Energy Savings



Questions?

Ren_Anderson@nrel.gov
NREL
1617 Cole Blvd
Golden, Colorado
80401