



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

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

# **Building Sector – Major Role in Economic Prosperity and Carbon Reduction Opportunity for Envelope Technologies**

## **Global Energy Efficiency Workshop USEA and USAID 9 Marc 2010**

**P Marc LaFrance, CEM**

**Building Technologies Program**

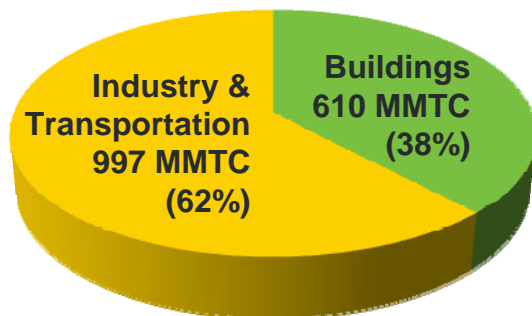
**Office of Energy Efficiency and Renewable Energy**



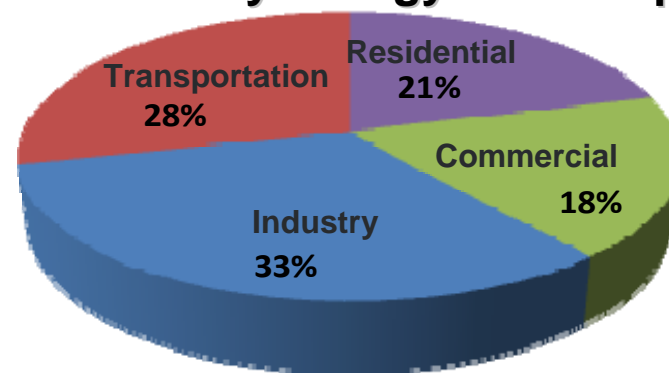


# US Building Energy Use and Carbon Emissions

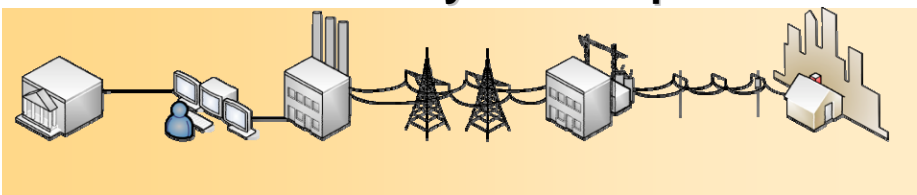
**38% of U.S. Carbon Emissions**



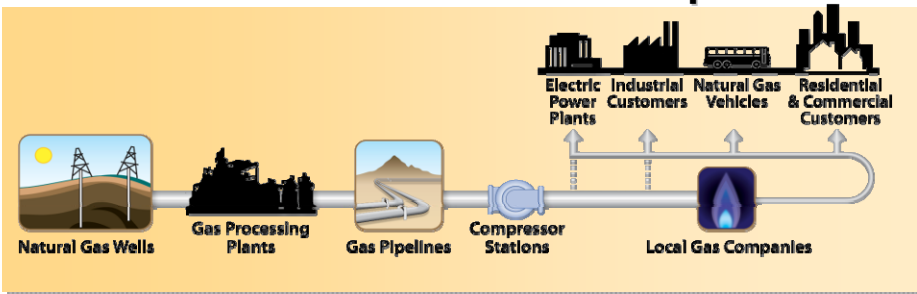
**39% of U.S. Primary Energy Consumption**



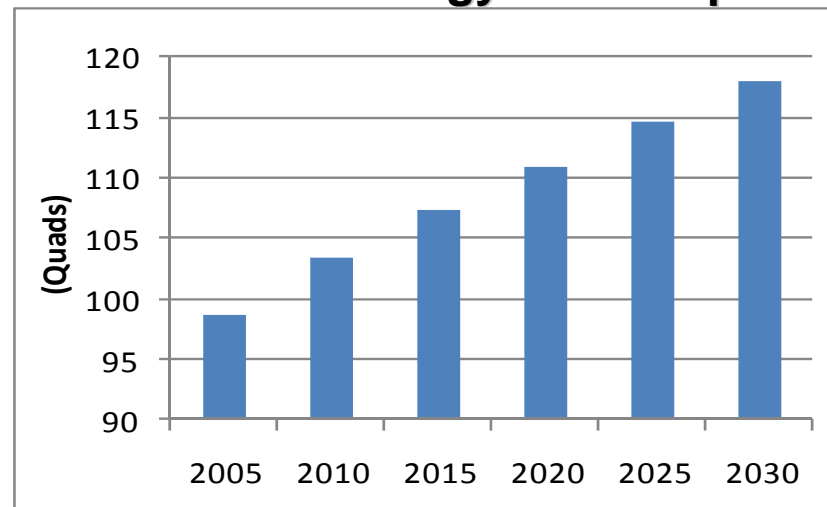
**72% of U.S. Electricity Consumption**



**54% of U.S. Natural Gas Consumption**



**Total U.S. Energy Consumption**

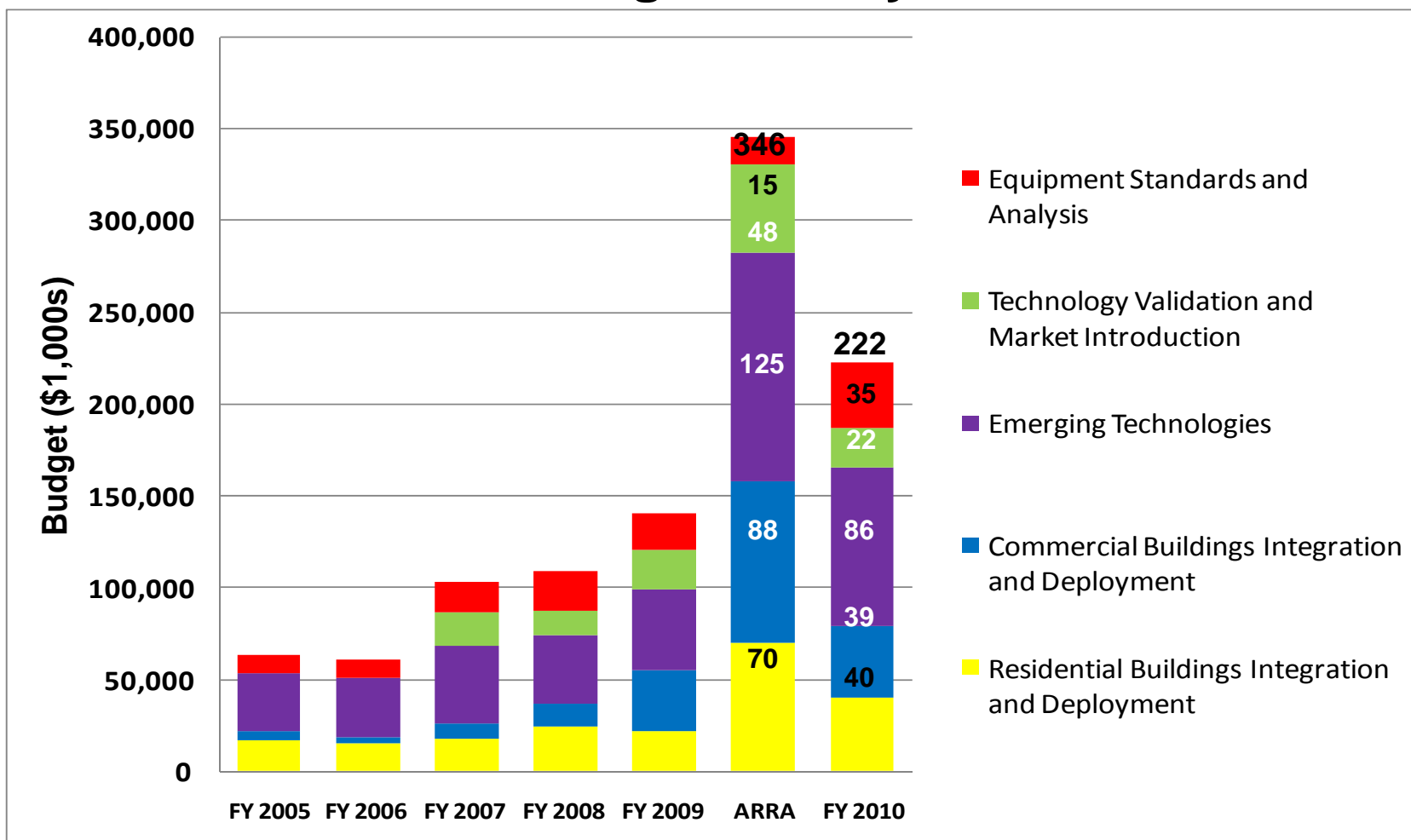


Sources: BED 2009; AEO 2010



BTP's funding has increased dramatically over the past 5 years.

## Budget History

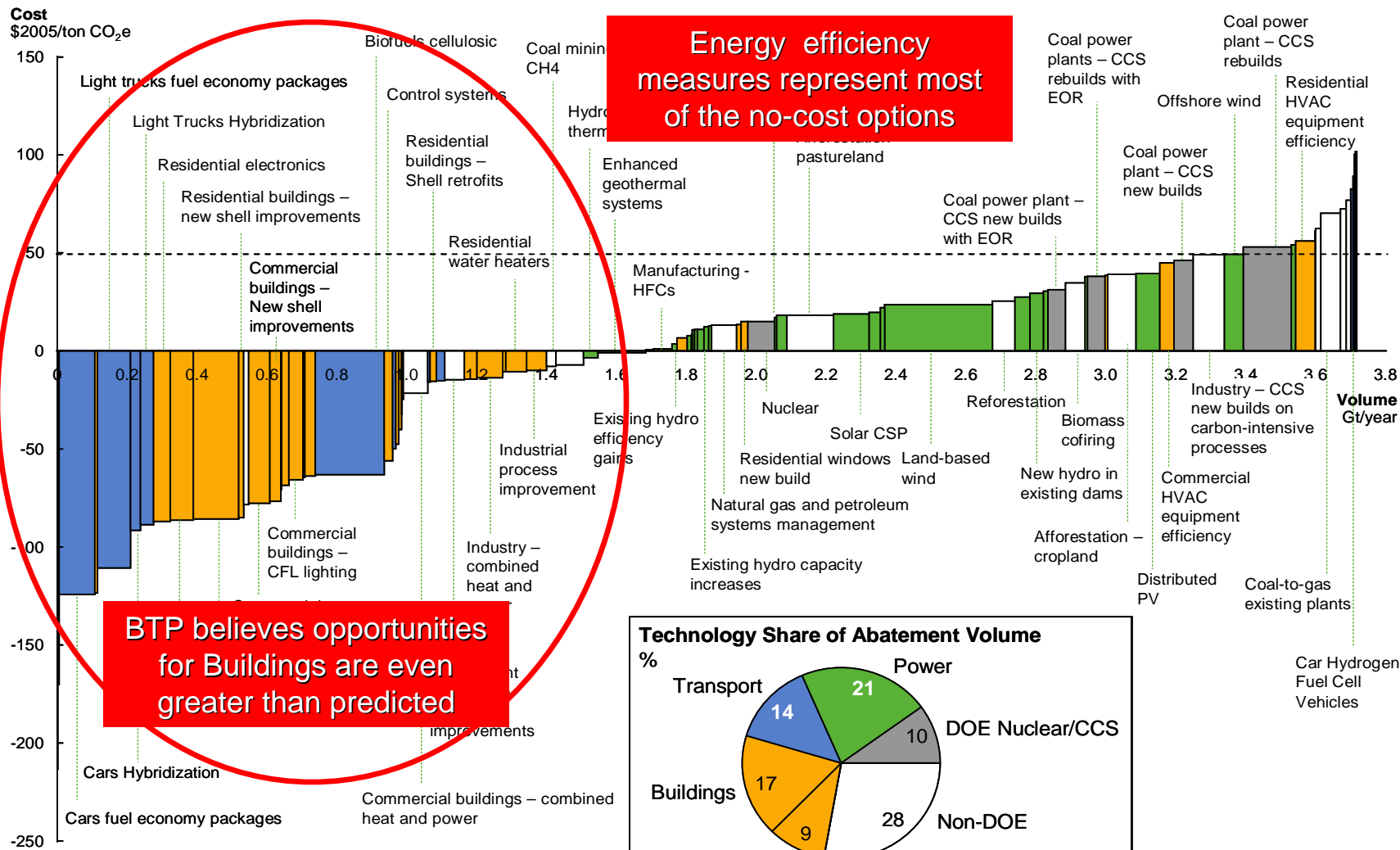


Source: U.S. DOE



# EERE Technologies – Potential Carbon Abatement

■ EERE Power      ■ EERE Energy efficiency  
■ DOE Nuclear/CCS    ■ EERE Transport

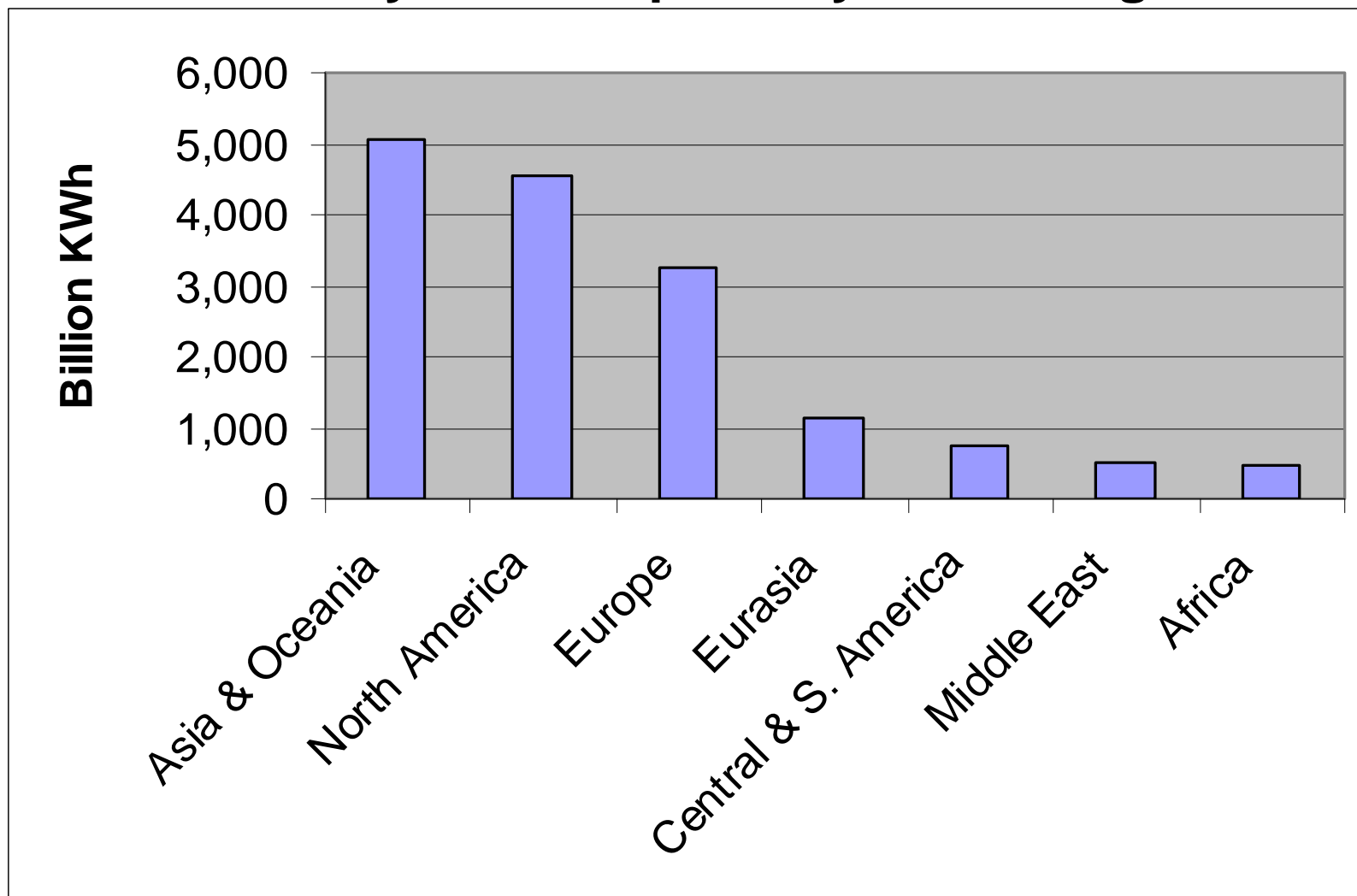


Source: December 2008 analysis conducted by EERE with McKinsey using 2008 DOE technology performance projections; mid-range case

Note: Preliminary analysis, under technical review



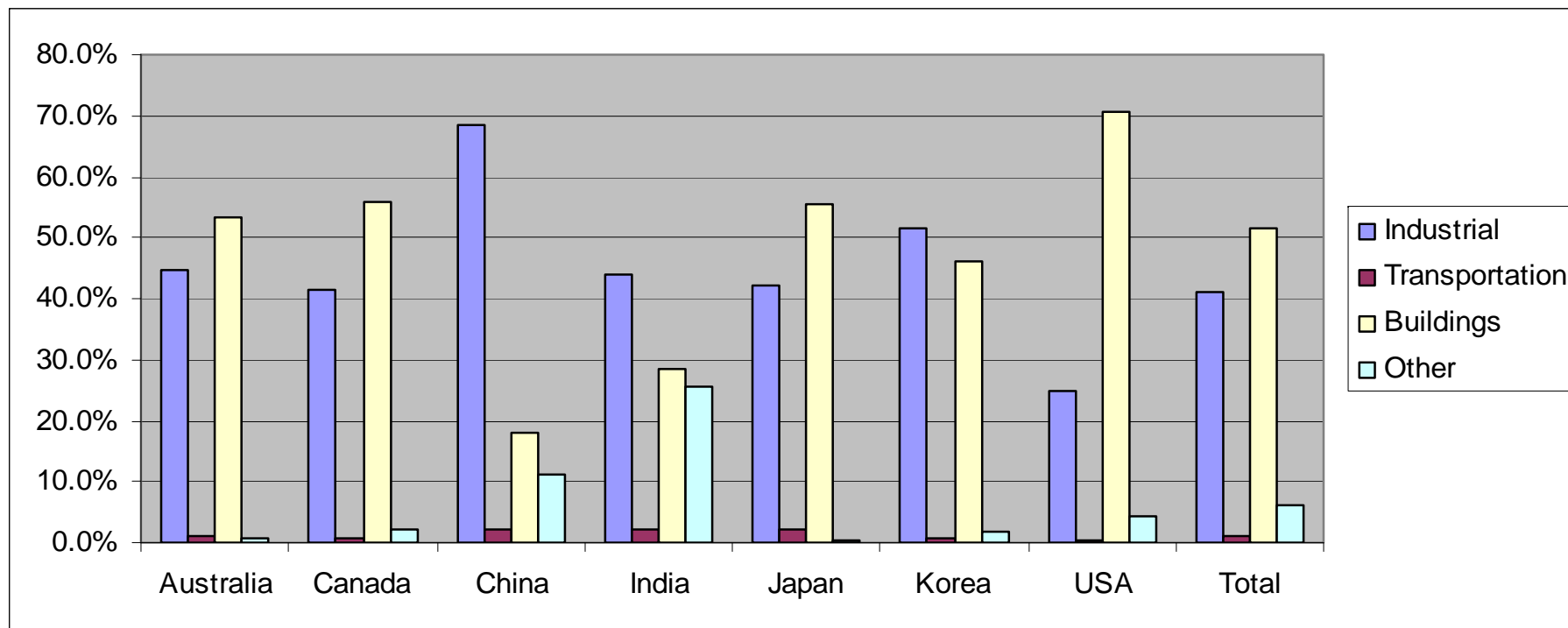
## Electricity Consumption by World Region



Source: IEA 2005



# Electricity Use in Buildings are High



**EU and ASEAN around 55 percent**

**APEC ~ 50 percent**



Net-Zero Energy Buildings by 2025

Net-Zero Energy Homes by 2020

Low incremental cost.





## Major Areas of Building Technologies Program

### Research & Development

- Emerging Technology (Component R&D)
  - Lighting R&D (Solid State Lighting)
  - Envelope R&D (Windows and Thermal Materials)
  - HVAC, Water Heating, and Solar Thermal R&D

### Deployment

- Residential Integration and Deployment
- Commercial Integration and Deployment
  - Retail, Schools, Office Buildings, etc
  - Energy Plus Software
- Technology Validation & Market Introduction
  - ENERGY STAR
  - Building Codes

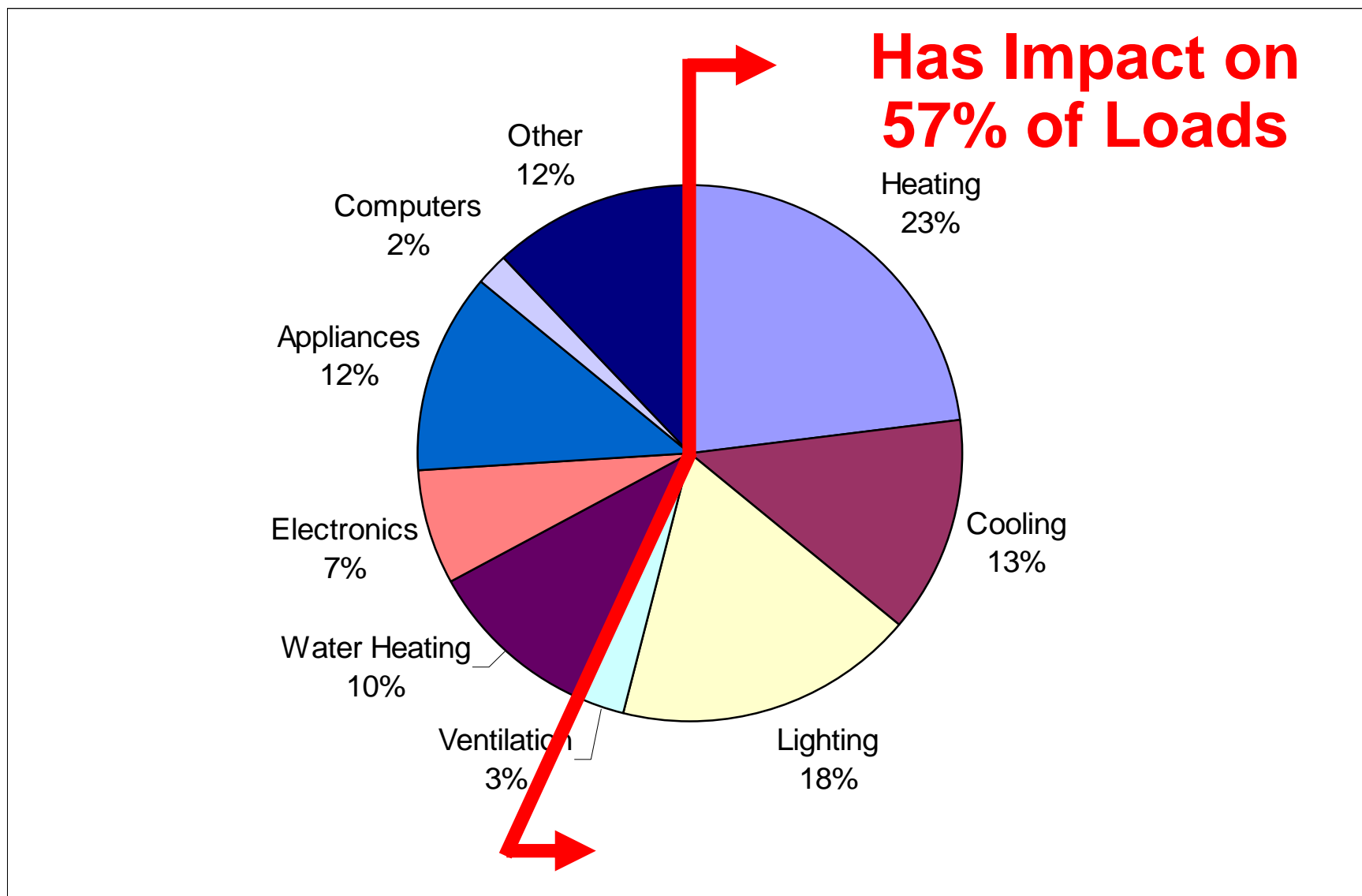
### Regulatory

- Appliance and Equipment Standards





# Building Consumption – Envelope Relationship





# Next Generation of Windows

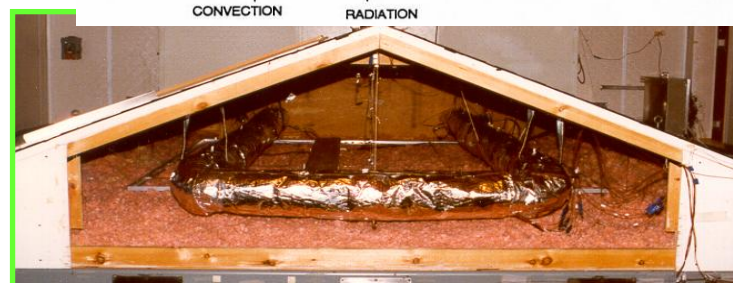
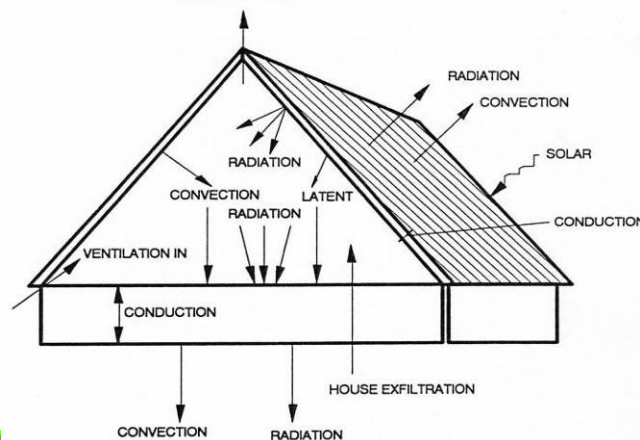
- **Highly Insulating**
  - Goal U value 0.10 (SI U value 0.56)
  - Possible vacuum glazings
- **Dynamic solar control**
  - Passive heating
  - Dramatic peak cooling reduction
  - Market ready, prices will drop with more investment
  - SHGC (0.08 - .53)



**Prototype – Concept Window**  
**(Highly Insulating and Dynamic**  
**U Value 0.18 (SI U value 1.0)**  
**SHGC 0.04 – 0.34)**  
**Low cost unsealed center lite**

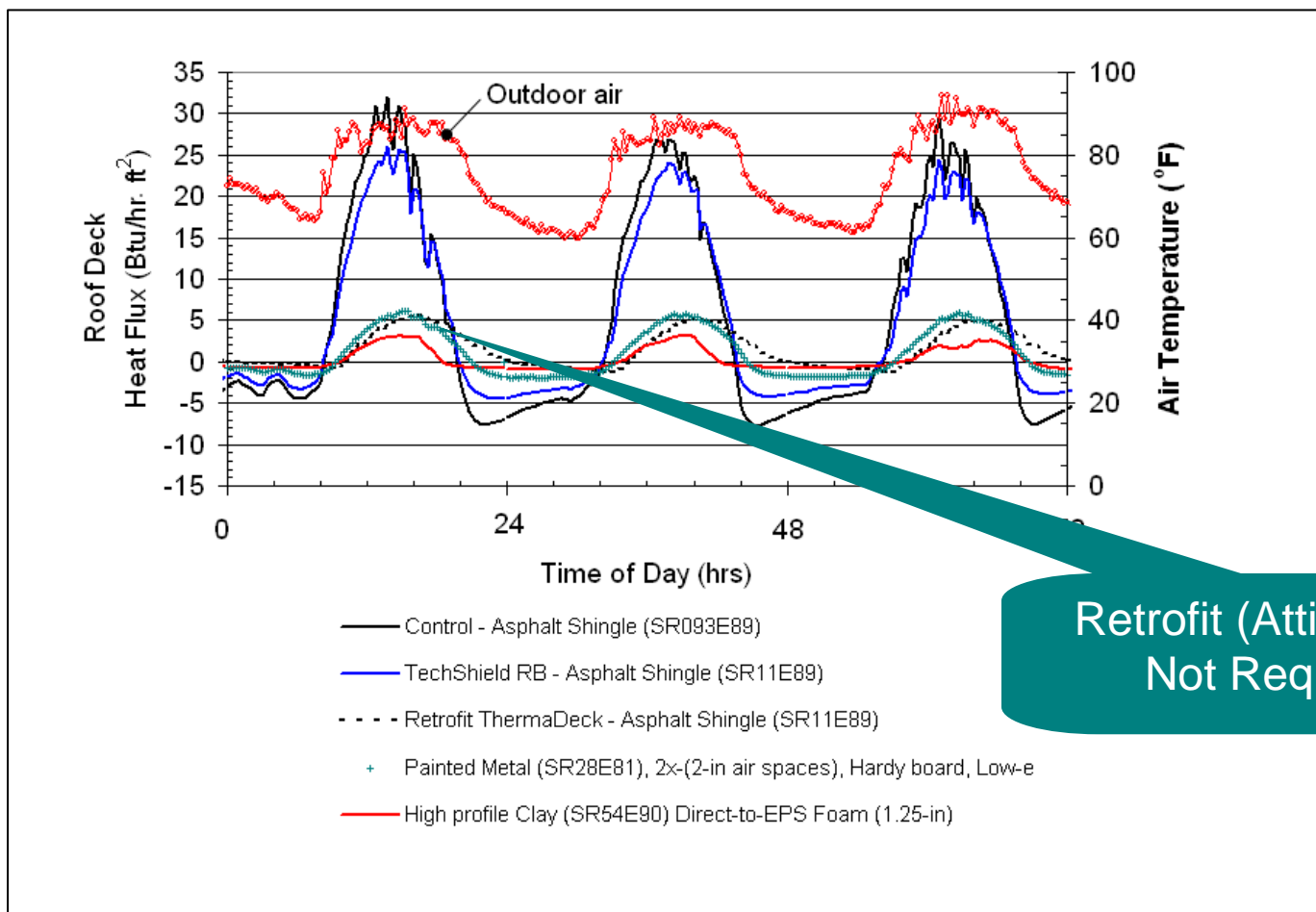


- Advanced walls to reach R20 ( $U = 0.28$  SI) in 3.5" (9cm) cavity, exterior insulation systems, R30 ( $U = 0.19$  SI) total wall
- Next Generation of Attic/Roof System to save 50 Percent Energy
- New Material Development
  - 100 R&D Award in 2009 for phase change material (PCM) insulation
  - Higher performing foams and aerogels
  - Dynamic membranes





# Cost-Effective New \$2/ft<sup>2</sup> Retrofit Roof System for Hot Climate



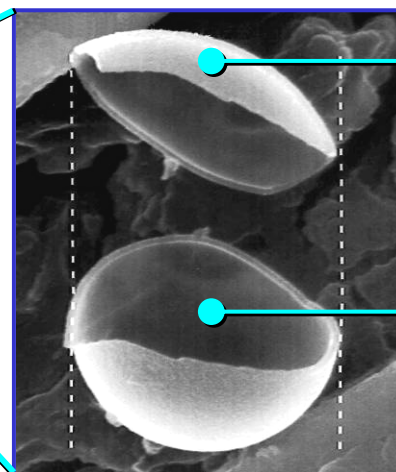
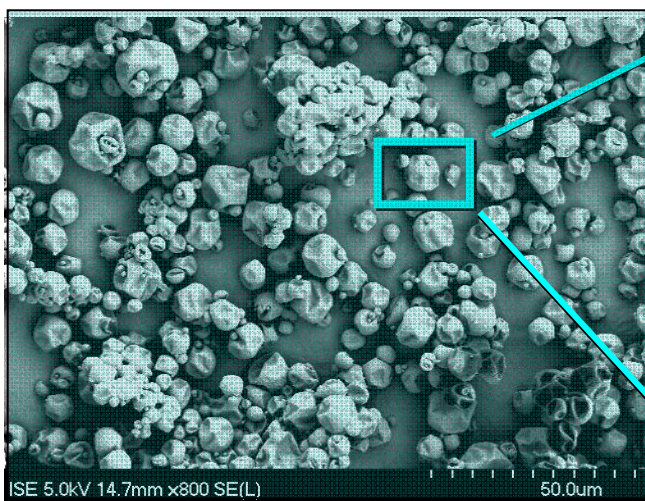
● Continuing Mixed and Cold Climate Research



## Dynamic Insulation - Low-Flammable PCM-Enhanced Cellulose



Recycled Paper Waste



Polymer coating

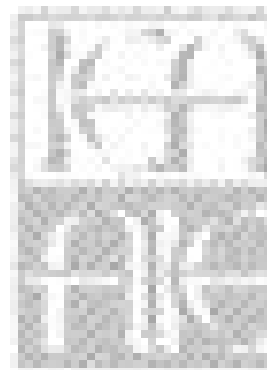
Bio-Based PCM  
Fp: ca. 80F  
 $\Delta H$ : 170 J/g

5 - 25  $\mu\text{m}$



## Conduct Enabling Research

- Test protocols
- Design guidelines
- Modeling tools
- Industry standards
- Education Materials





# Unique facilities and expertise

Tacoma WA



Natural  
Exposure  
Test  
Facilities

U. of Waterloo  
Ontario Canada



Charleston SC



ORNL



# Performance of Interior/Exterior Automated Shading Systems







<http://www.commercialwindows.org>

Commercial Windows

## Windows for High Performance Commercial Buildings

Home | Façade Design Tool | Overview | Case Studies | Tools & Resources | Contact Information

### Façade Design Tool: Compare Performance Options in Boston, Massachusetts

Define Design Conditions to Compare

Scenario	Orientation	Window Area	Daylight Controls	Interior Shades	Exterior Shades	Window
1	South	15%	No Controls	No	None	Double Low-E Clear
2	South	30%	No Controls	Yes	None	Single Clear
3	South	45%	No Controls	No	Deep Overhang	Double Clear
4	South	60%	No Controls	No	Shallow Overhang	Double Bronze Tint

Scenario 1 Scenario 2 Scenario 3 Scenario 4

Run Comparison

#### How to Perform a Comparison

1. Choose the design conditions for each of the 4 scenarios in which to compare.
2. If you need more information regarding the design conditions, [click here](#).
3. Click the Compare Design Conditions button to see the results for annual energy, peak demand, carbon, daylight illuminance, glare, and thermal comfort.
4. Once the results are displayed, you can modify the design conditions to view other comparisons.

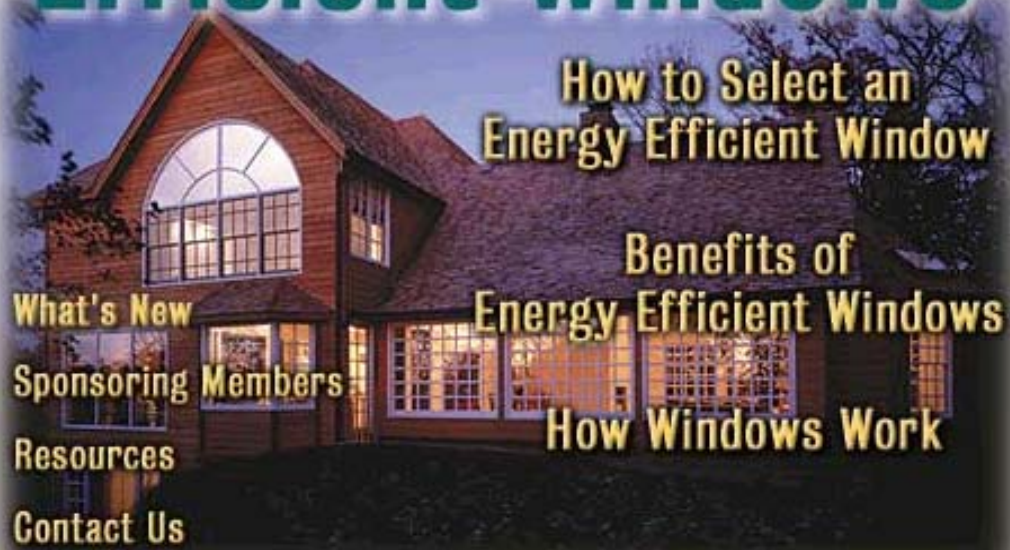


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# Efficient Windows



This web site provides unbiased information on the benefits of energy-efficient windows, descriptions of how they work, and recommendations for their selection and use. EWC members have made a commitment to manufacture and promote energy-efficient windows. Take a look to learn more!

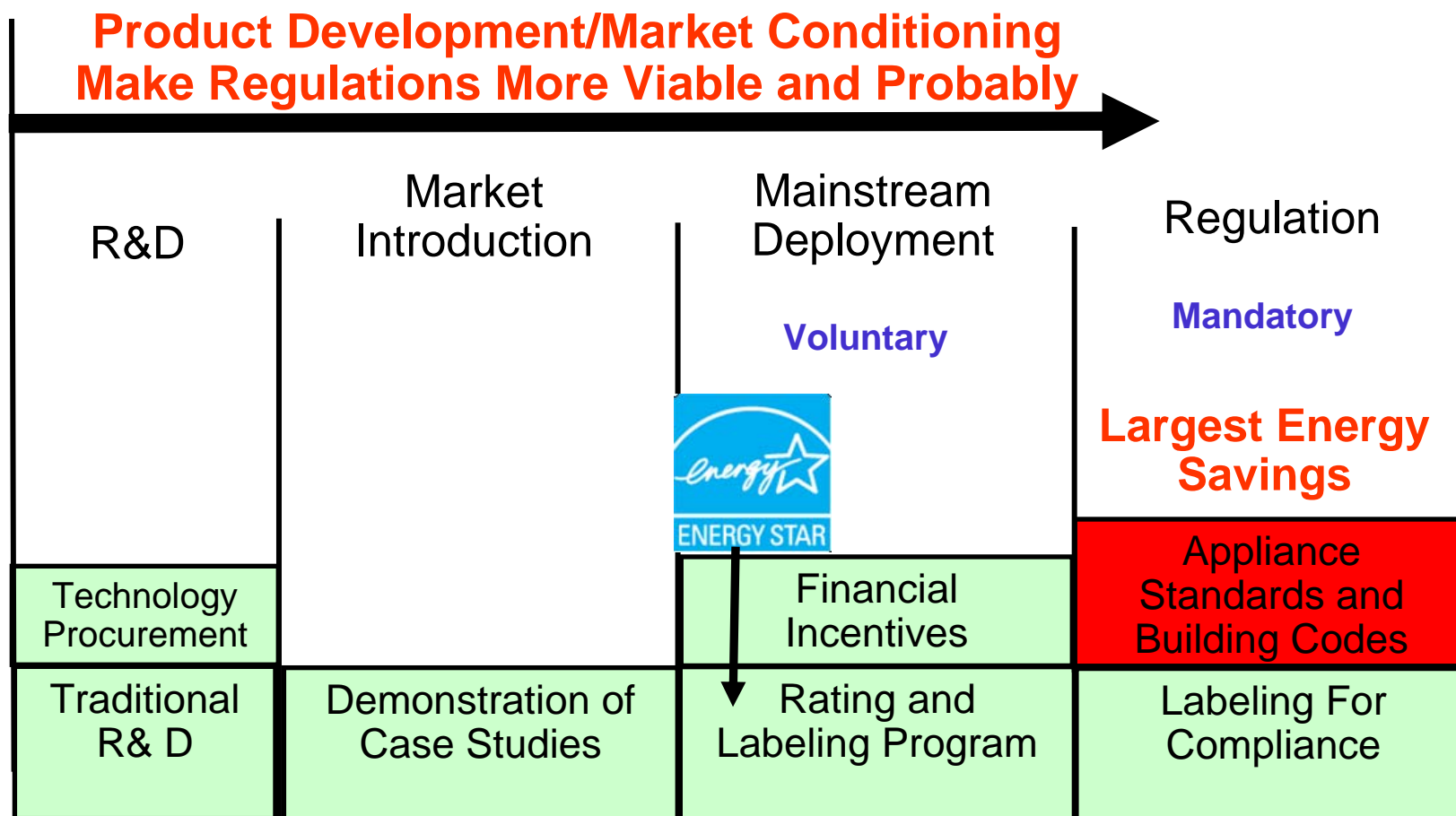
The Efficient Windows web site is sponsored by the Efficient Windows Collaborative (EWC) with support from the U.S. Department of Energy's Windows and Glazings Program and the participation of industry members.

**Over 40,000 users per month**

**[www.efficientwindows.org](http://www.efficientwindows.org)**



# Policies – Commercialization Path



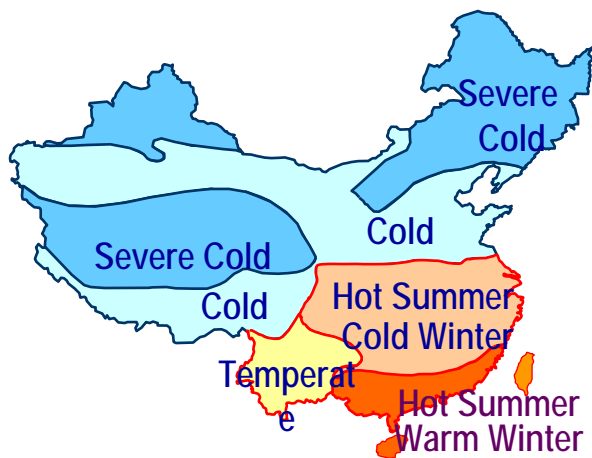
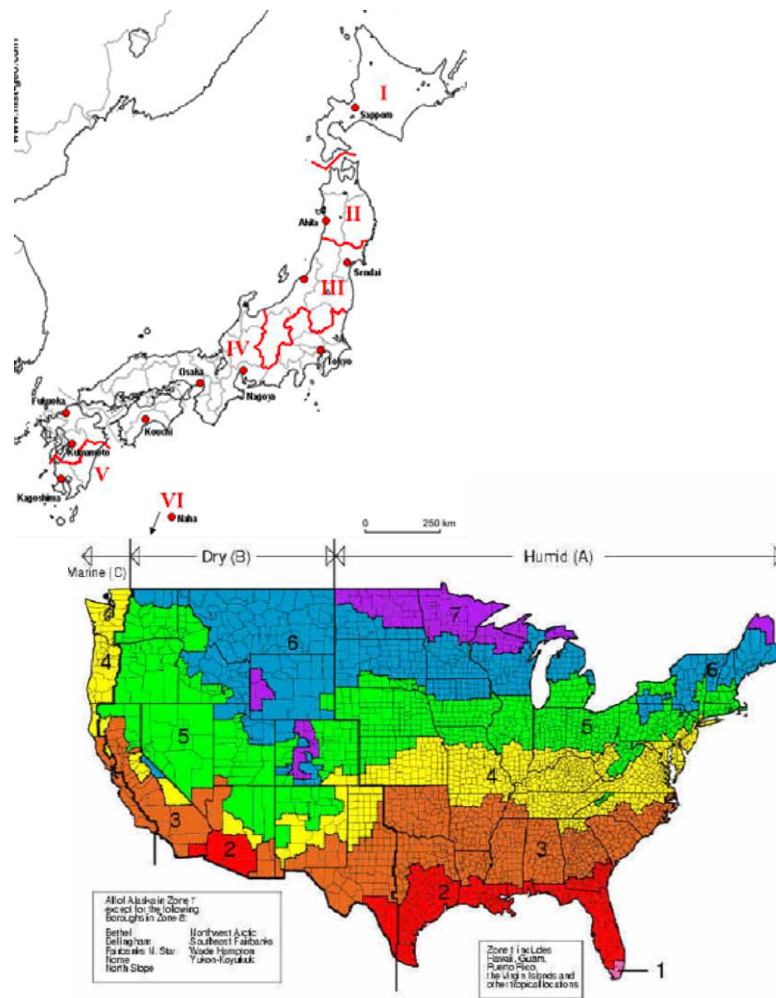
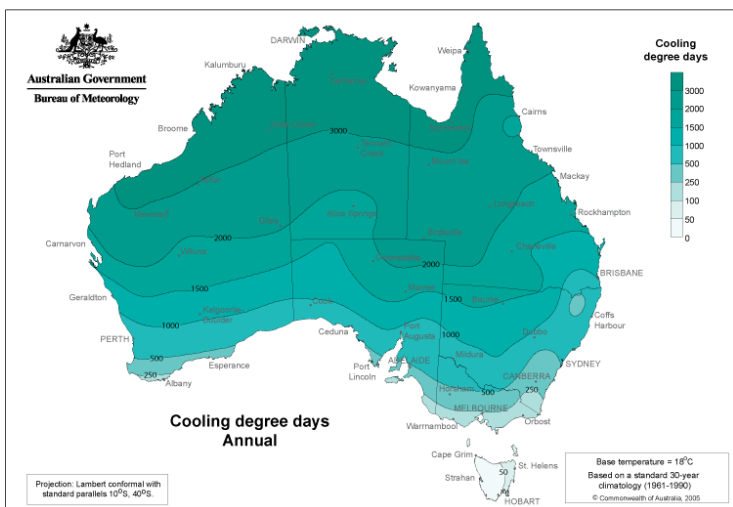


## **Importance of Building Codes**

- Building codes can be highly effective to address a critical area of the economy that consumes a large amount of energy
- Building Codes along with appropriate infrastructure can play a major role in investment of new technologies in all economies, especially in developing economies
- Greater attention on building code implementation with harmonized infrastructure will lead to better building envelopes that reduce energy and peak electricity demand – mitigation of climate change



# Climate is a Major Factor and Challenge when Developing Codes





# Key Elements are Interrelated and Work to Achieve Results

## Code Development

- Sends a strong message to economy
- Sets goals to strive for

## Infrastructure

- Needed to assess key building components
- Likely starting point, but hard to get interest w/o codes

## Enforcement

- Key issue to achieve results, but often not investigated deep enough
- Core problems include lack of product ratings, product availability, lack of knowledge

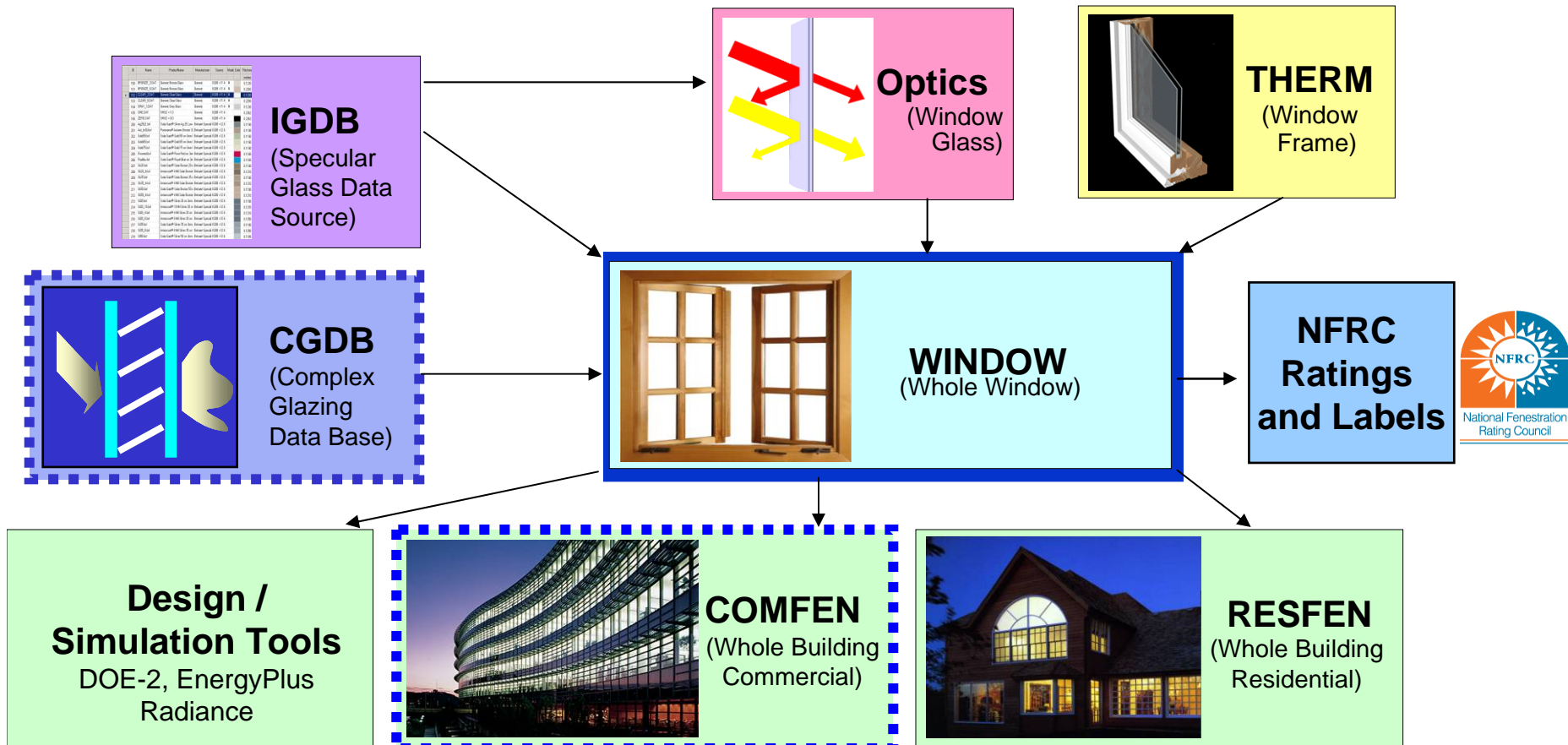


## **Building Code Considerations for Development**

- Prescriptive (set of established measures that are easy to follow) vs performance path is an important consideration – provides greater builder flexibility but allows for old technology to linger in the marketplace
- More stringent codes even if enforcement is a problem lead to better buildings
- Many countries establish building codes from National government perspective even though administered by non-profits, academia, etc
- New codes for developing economies need to be tailored to local economy practices, design conditions and climate, etc
- Just adopting other countries building codes does not work
- Lack of infrastructure is a major problem for effective codes to be implemented



# Window Software to Simulate Performance - Avoid Expensive Prototype Testing



- Design tools for advanced products
- **ISO 15099 Compliant**
- NFRC Ratings

<http://windows.lbl.gov/software>







# Testing Used for Product Certification

## Fenestration:

- Simulation of U-factor, Solar Heat Gain Factor and Visible transmittance - ISO 15099
- U-factor testing - ASTM C 1363, C1199, NFRC 102
- Solar Heat Gain Testing – NFRC 201
- Spectral Optical Property – ASTM E903, NFRC 300, 301
- Air Leakage – ASTM E283, NFRC 400

## Wall Insulation

- ASTM C 518, C 177

## Wall System

- ASTM C1363, ASTM C1155



Hot Box



Solar Calorimeter



Spectrophotometer



Air Leakage



## Well Established Test Methods – “Aged” Values Essential

### Solar Reflectance

- Reflectometer (ASTM C1549)
- Spectrometer (ASTM E903)
- CRRC-1 Test Method 1
- Pyranometer (ASTM E1918 and E1918A)

### Thermal Emittance

- Emittance meter (ASTM 1371)





## Consumer Interest

- Provides performance comparison
- Provides a base line for developments and product improvement
- Promotes energy efficiency
- Help consumer to make informed decision
- Help meet the code requirements
- International Harmonization

## Manufacturer

- Barrier for cheap inferior competition
- Helps push the product through performance in Codes
- Sell more energy efficient products
- Provides means to market products & recognition
- Small number of providers in large market place
- Harmonization helps less duplication of certification and testing

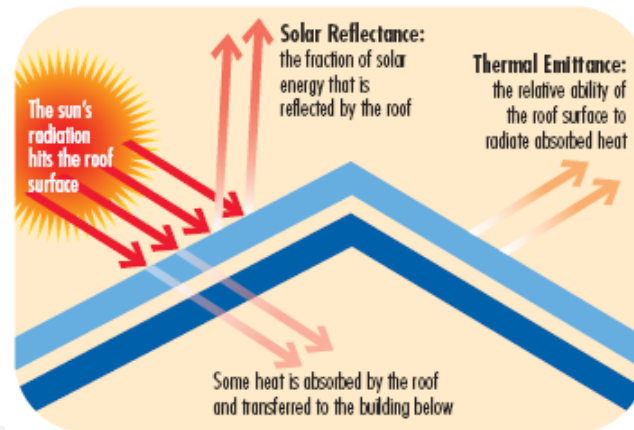


## **Key Envelope Technologies for Developing Countries - mitigate heat gain and loss avoiding need for HVAC**

- Cool Roofs Coatings and Materials
- Cool Wall Coatings
- Radiant Barriers
- Window Film
- Low E Glass
- Insulation
- Exterior Insulation Finishing Systems
- Air Barriers
- Solar thermal for hot water  
(not really envelope but related)



# Cool Roof Example



81°C



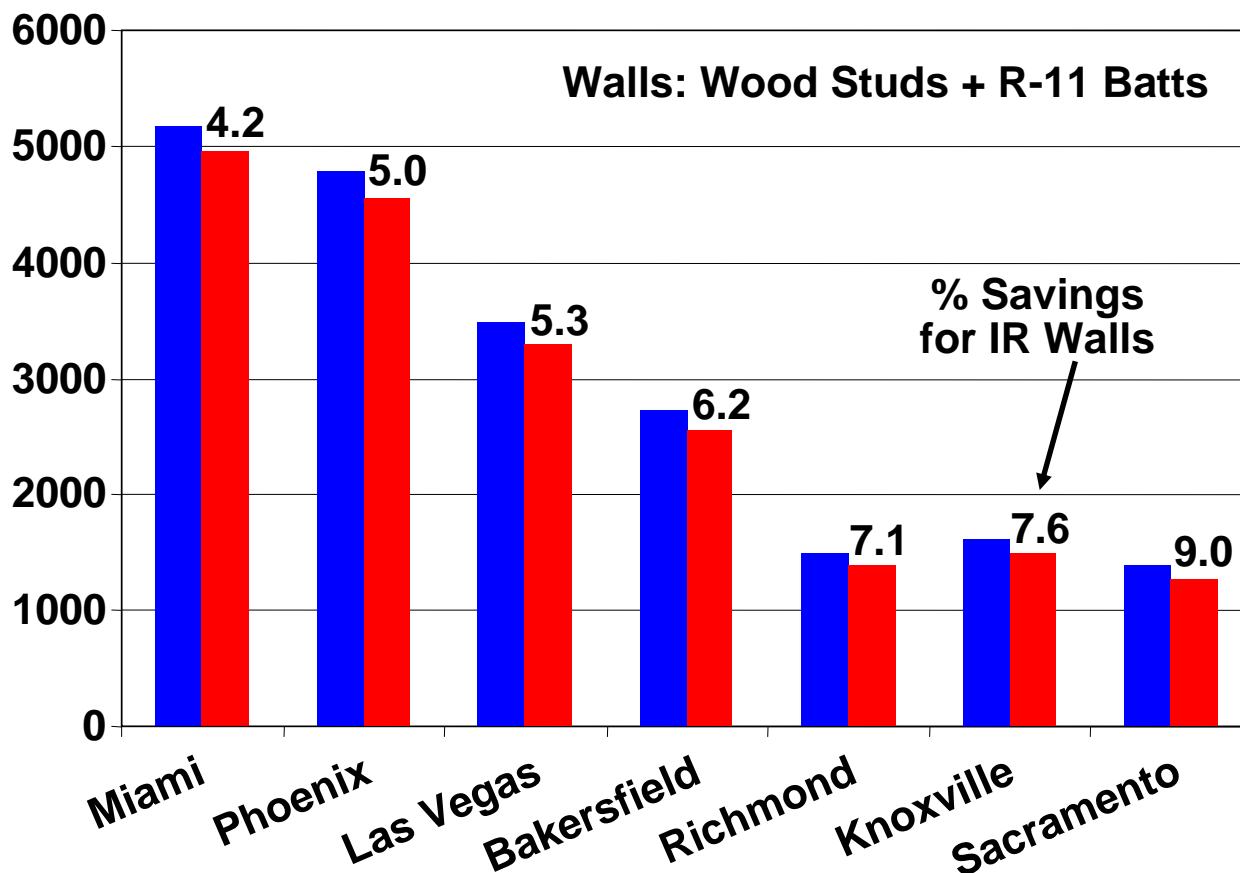
34°C



# Cool Wall Coatings

## Results for Hot Developing Countries with less Insulation will be Greater

- IR reflective coating on conventional walls saves cooling energy. Savings are 4% to 9% compared to non-IR reflecting walls



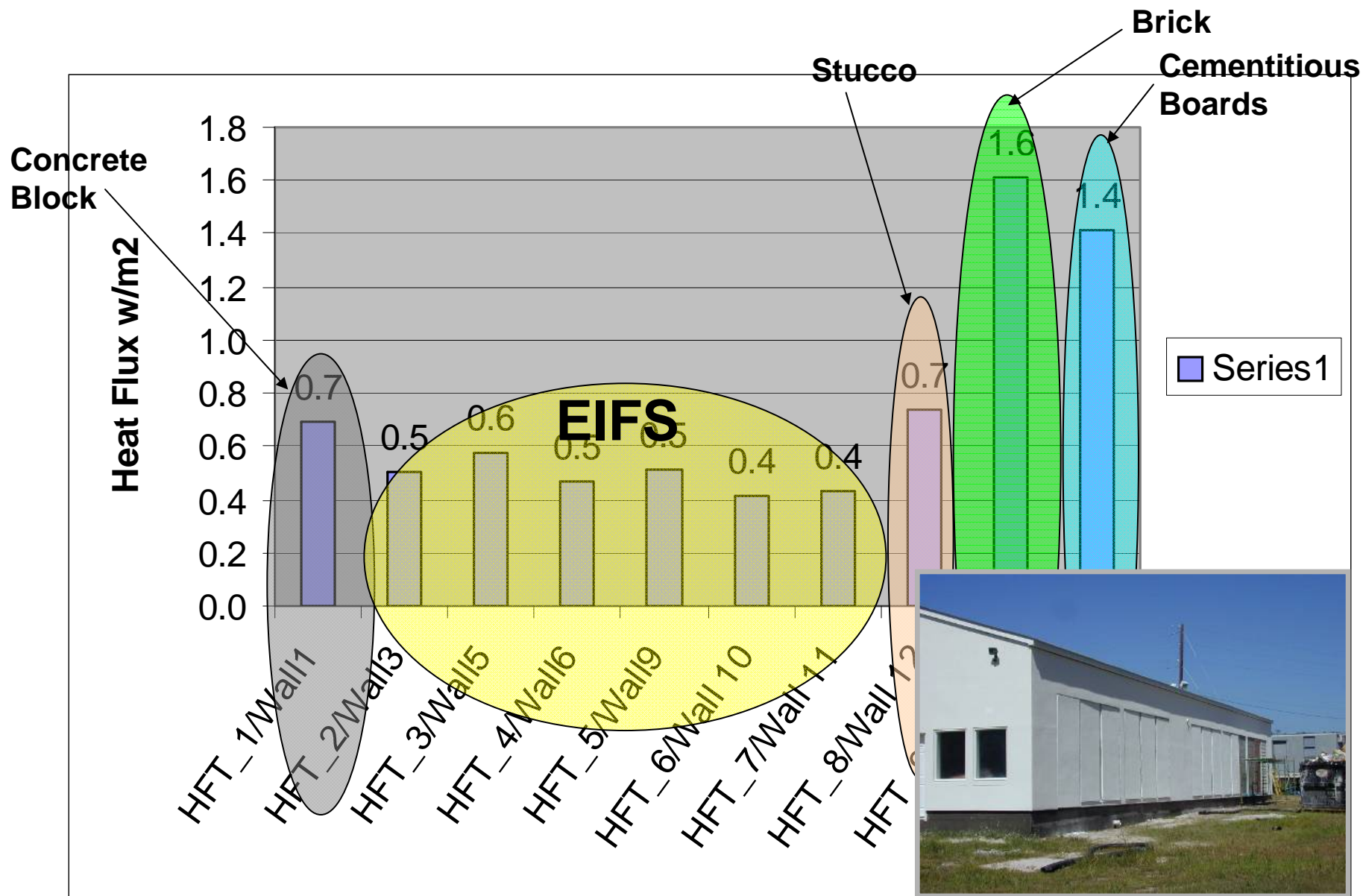
Annual Electricity for Cooling (kWh)

- Non Walls
- IR Walls

- Absolute savings vary from +240 (Phoenix) to +110 (Richmond)



# Exterior Insulation Finishing Systems – Example

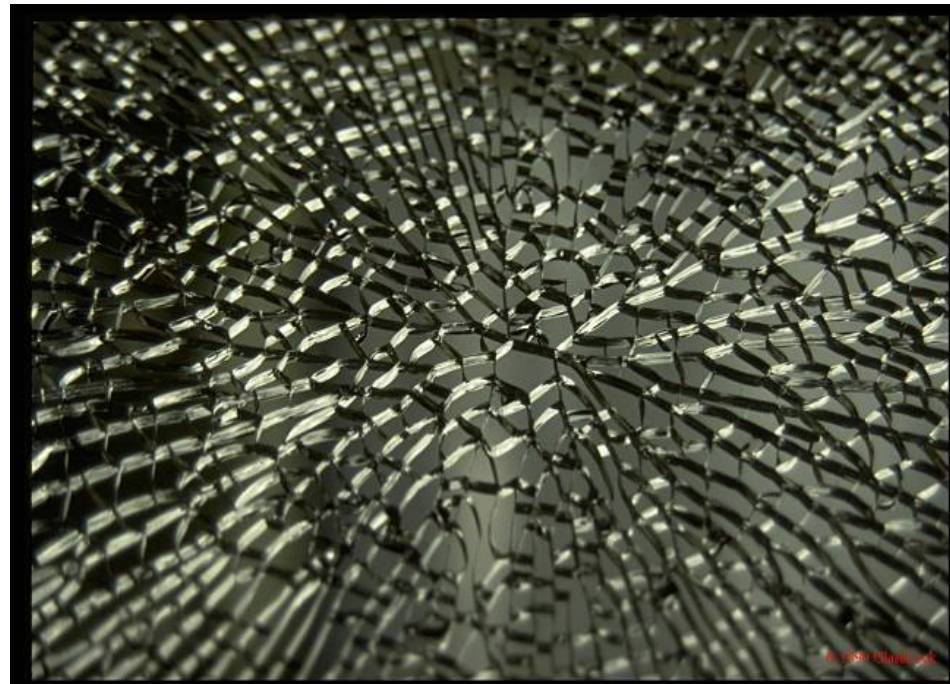




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## **Window Films – Save Energy and Improve Safety ( blast, hurricane, security, etc.)**







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## **Radiant Barrier – Sheet or Liquid Applied Emissivity 0.05 to 0.25 compared to opaque (0.90)**





## Low E Glass

- Significant benefit for hot climates and cold climates
- Reflects near infrared to reduce sun's energy
- Reflects far infrared to stop radiant heat, keep heat in for winter and heat out for summer
- Most effective in a double pane window, but is available in a pyrolytic "hard coat" for exposure to environment



## Final Remarks

- The USA has initiated unprecedented investment in energy efficiency and renewable energy
- New technology will be essential to achieve zero energy buildings – major investment with Stimulus Funding
- Developing building codes with infrastructure for product ratings will foster investment of advanced products in domestic economy
- DOE will have a greater focus for international activities and may be able to provide technical support to assist with development of rating organizations and technical transfer



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## Contact Information

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