

Building Technologies Program

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



Window and Envelope Solutions for
Today and Tomorrow

**Buildings America Meeting
Atlanta**

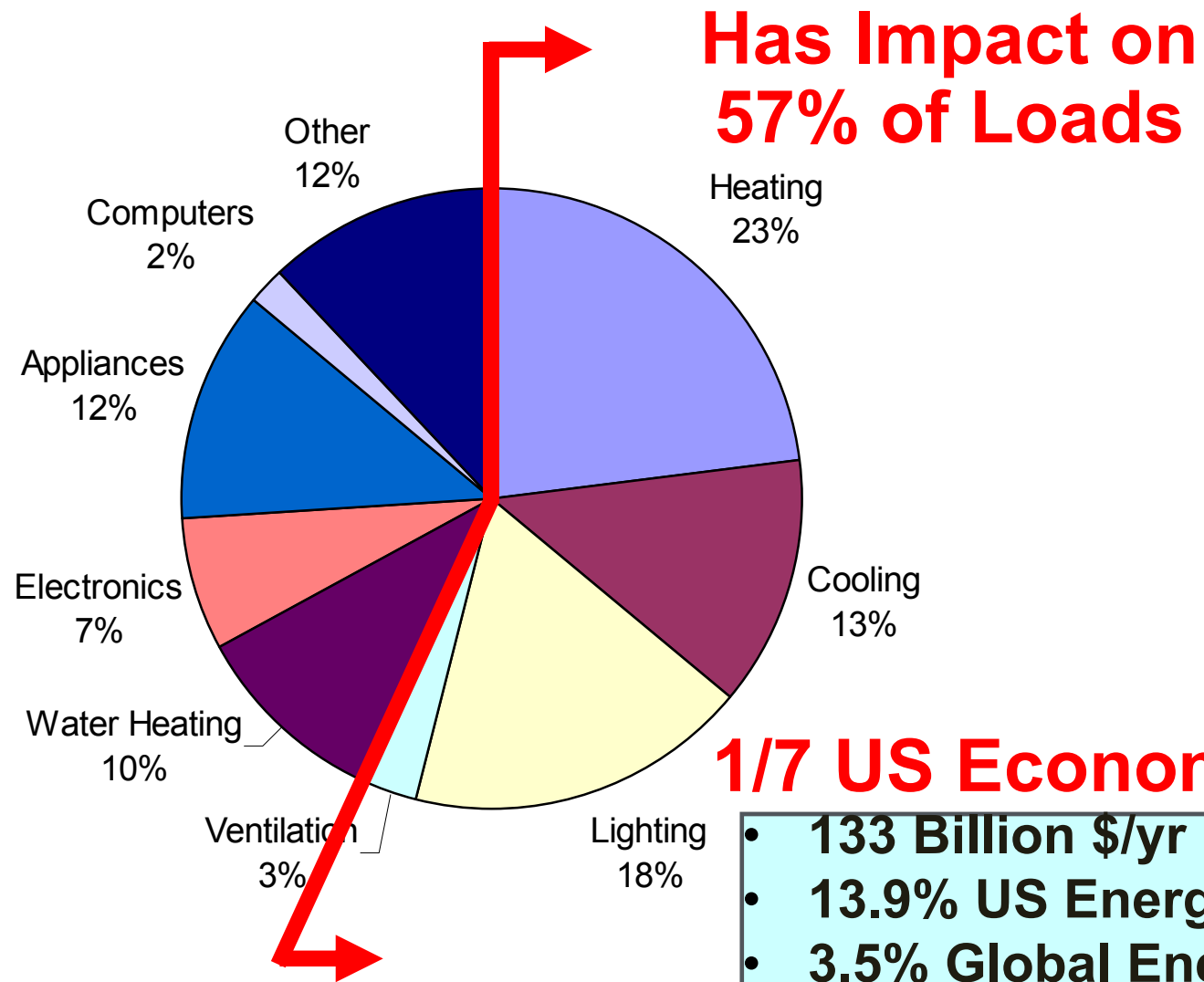
March 16, 2010

Marc LaFrance

Building Consumption – Envelope Relationship

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Total Building Envelope and Window R&D Budget

	Administration Budget Request	Enacted Appropriations
FY05	5.0M Windows 0 Envelope	5.8M Windows 2.8M Envelope
FY06	5.0M Windows 0 Envelope	*3.8M Windows (*earmarks) 2.9M Envelope
FY07 & FY08	4.7M Windows 2.4M Envelopes	4.7M Windows 2.4M Envelope
FY09	5.2M Windows 3.4M Envelopes	5.5 Windows 4.5 Envelope
FY 10	10.5M Windows 5.5M Envelope	Core 10.5M Windows 5.5M Envelope
FY 11	10.5M Windows 8.5M Envelope	TBD – Not expected to exceed FY10 CR
FY 12	25 M (9M BIPV)	TBD

ARRA

25M

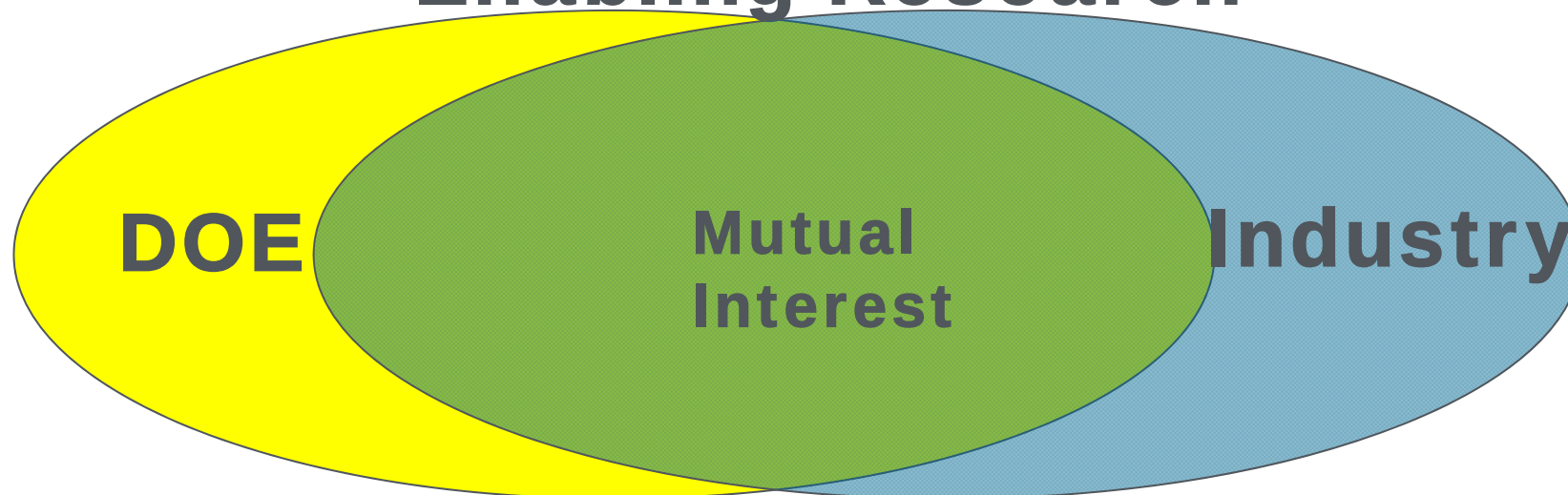
Roadmap with Stakeholders

(Historical Perspective Based on Many Events)

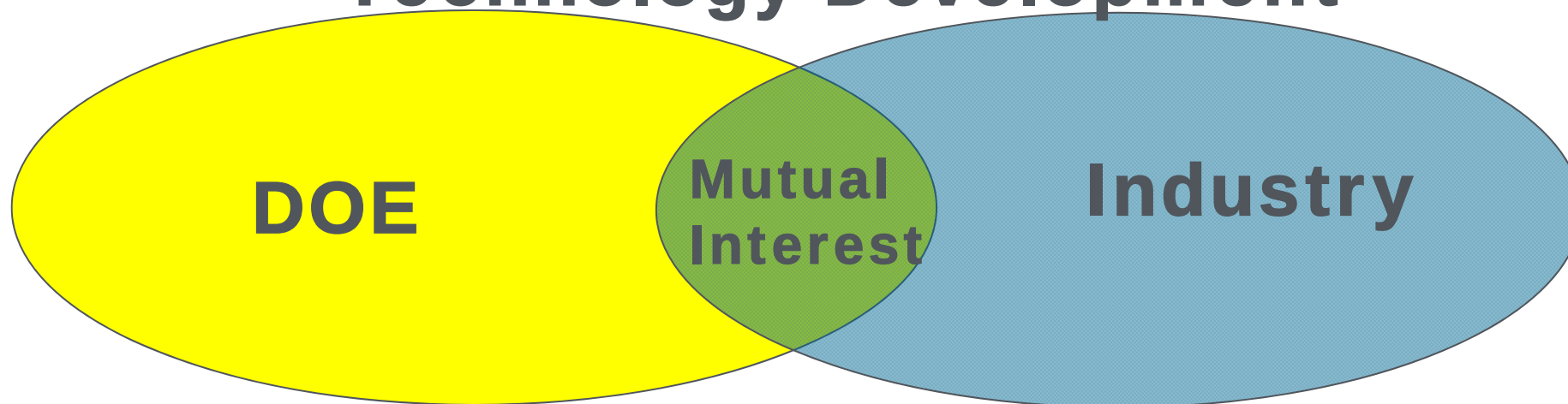
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Enabling Research

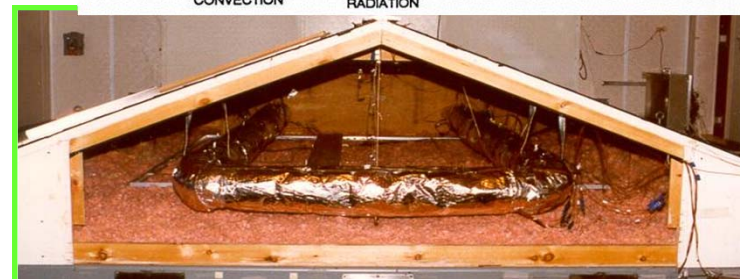
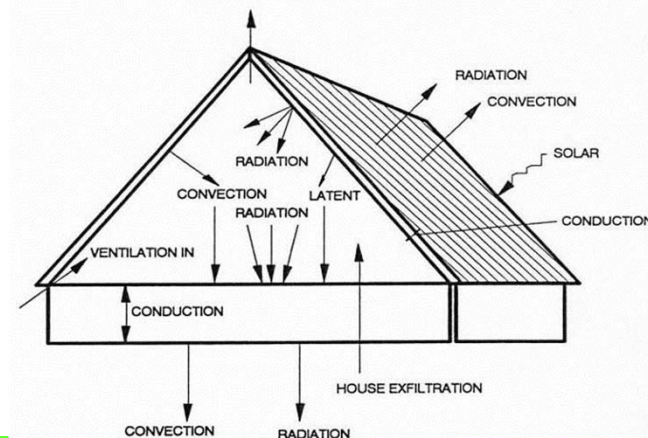


Technology Development

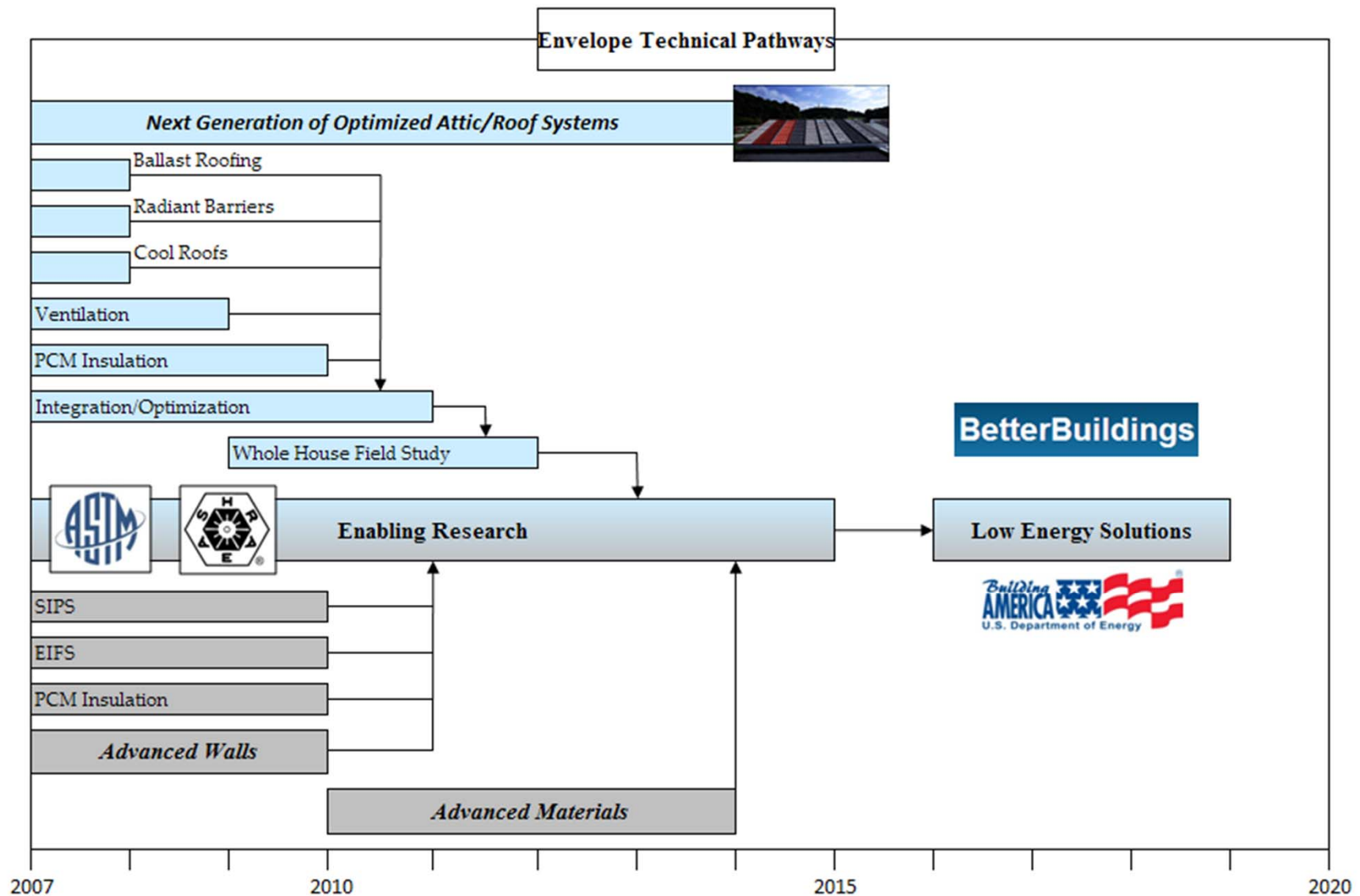


Thermal Envelope R&D

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

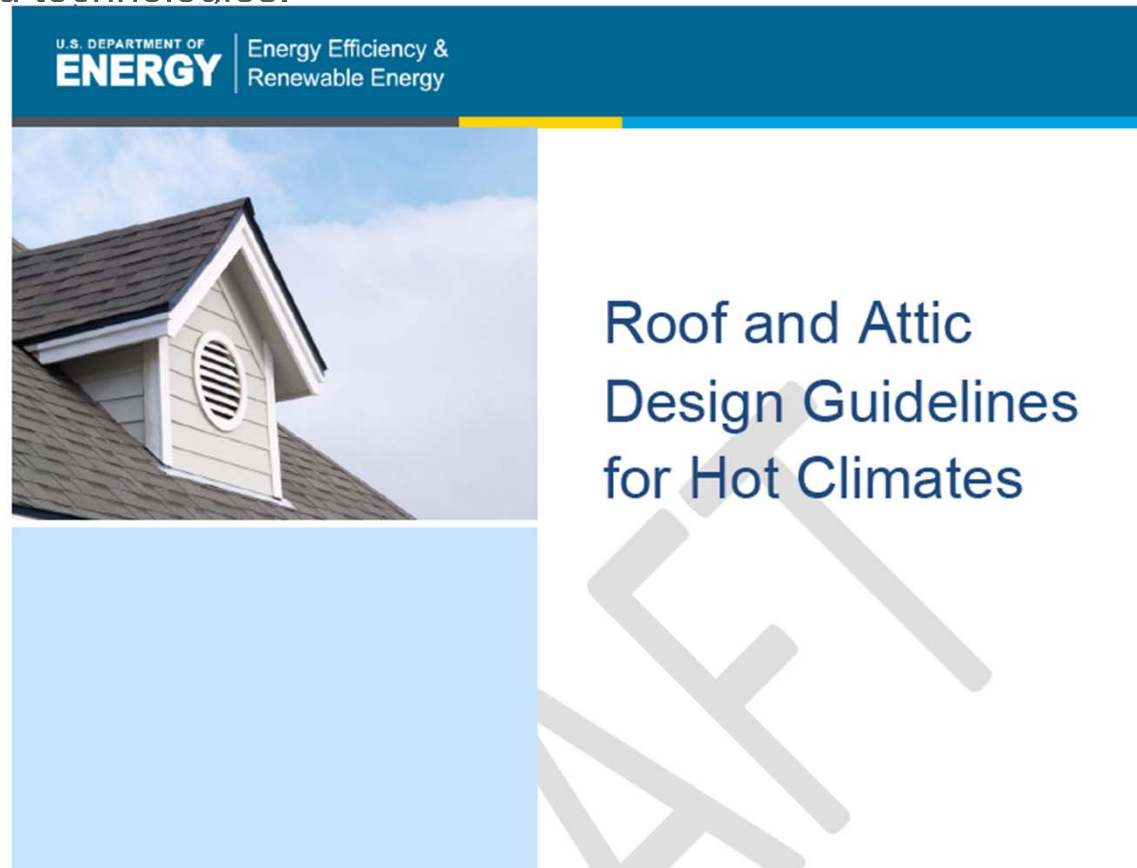


Envelope Pathway



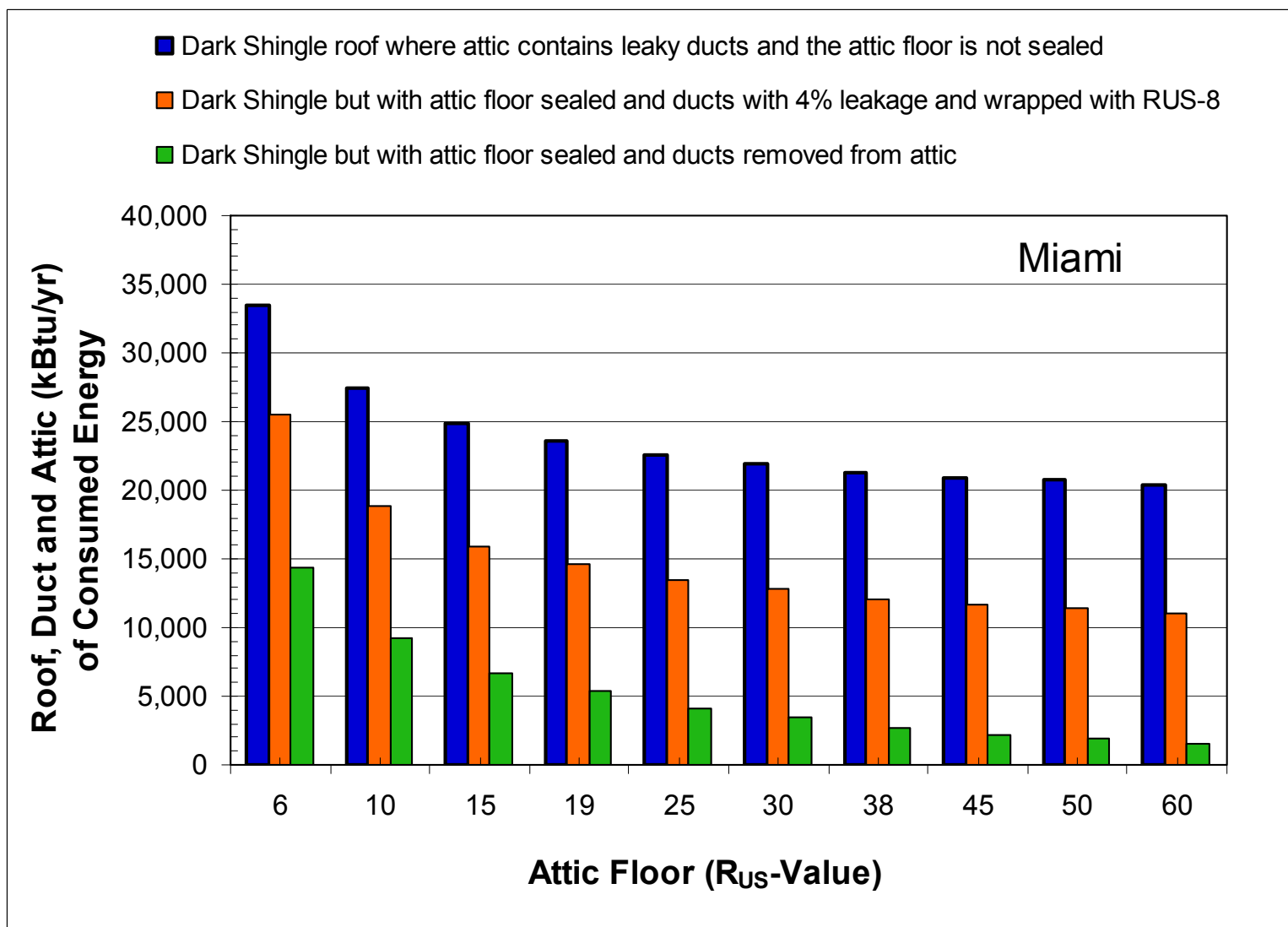
Roofs and Attics

- Goal: Develop advanced attic technologies that reduce the space conditioning attributable to attics by 50% compared to Building America regional benchmarks by 2015. Provide tools to enable adoption of advanced technologies.



www.eereblogs.energy.gov/buildingenvelope

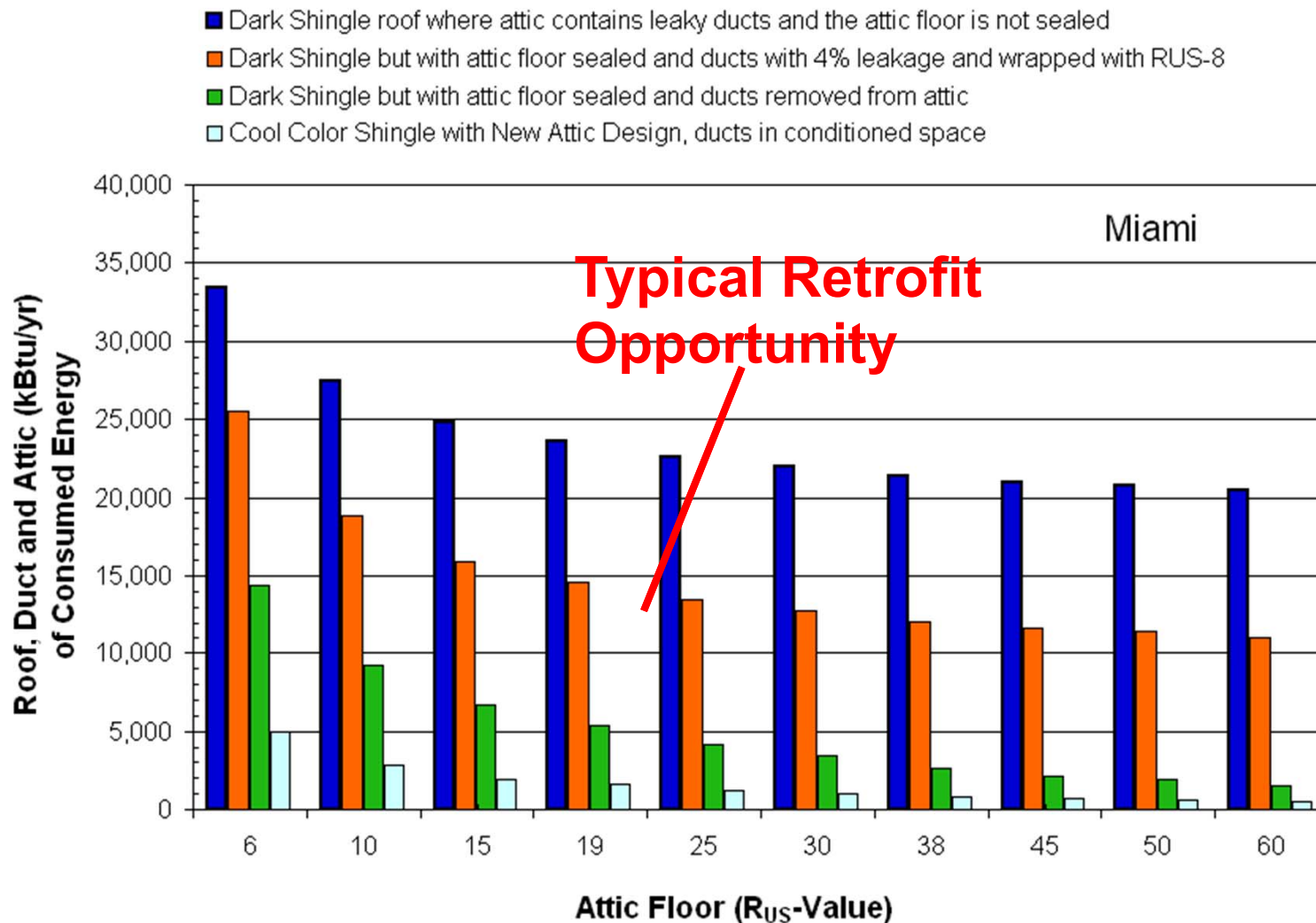
Next Generation of Attic/Roof Systems – Hot Climate



Outperforms Ducts in Conditioned Space – Retrofit Most Viable

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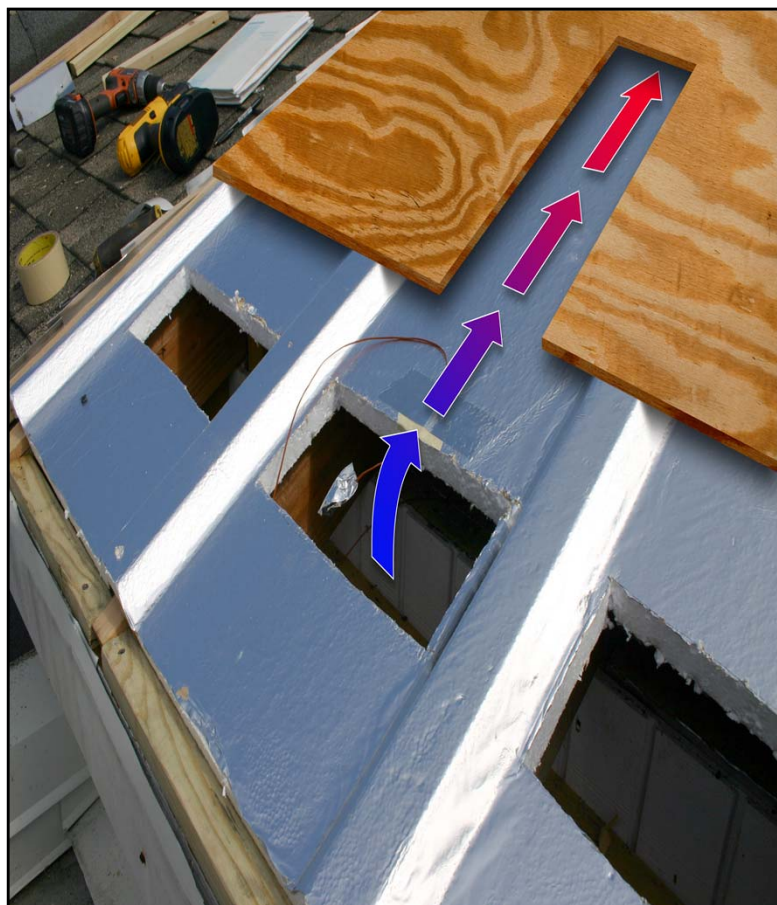


Above Deck Insulation and Ventilation

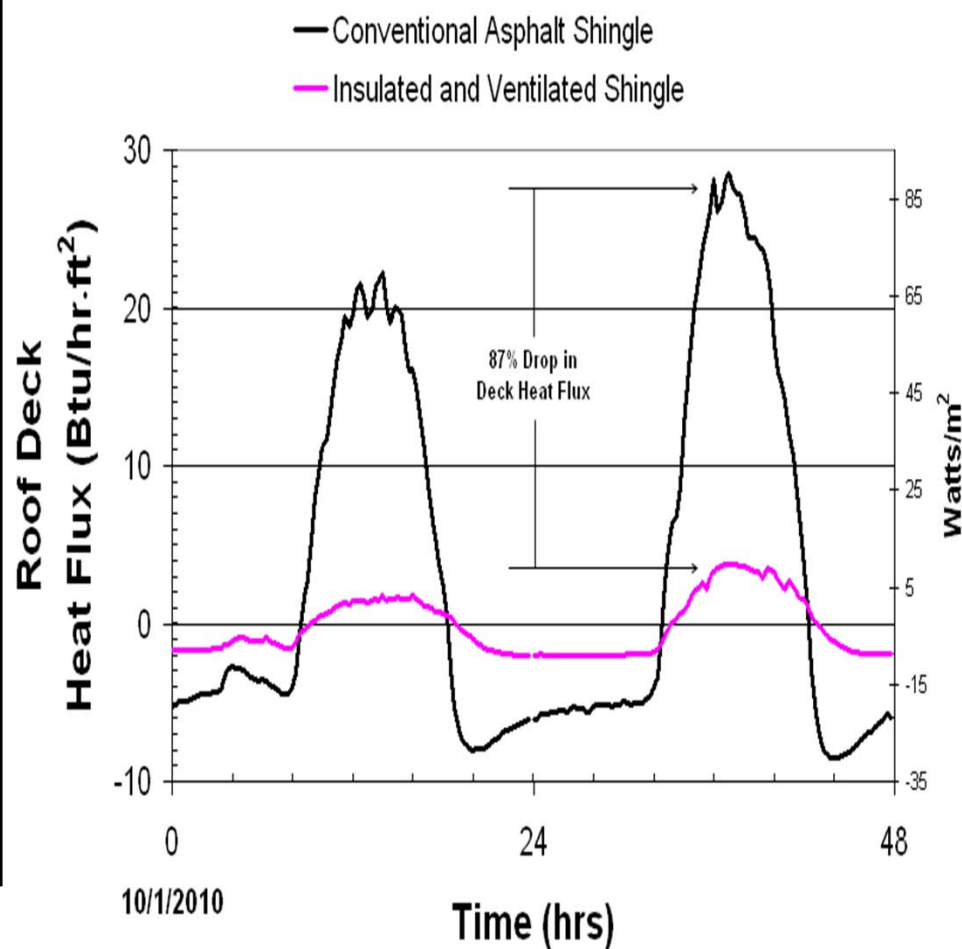
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Retrofit: Incremental cost \$1 per square ft; Payback ≤ 15 years



Convection, radiation and
conduction controls



Cool Roof Roadmap



- Research Plan
 - Buildings level
 - Urban Level
 - Global Level
 - International Activities
- Draft Roadmap is available for stakeholder review

www.eereblogs.energy.gov/buildingenvelope

Cool Roof Selection Guide

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DE-AC05-00OR22725

Guidelines for Selecting Cool Roofs

July 2010



Prepared by the Fraunhofer Center for Sustainable Energy Systems for the U.S. Department of Energy and Oak Ridge National Laboratory under contract DE-AC05-00OR22725. Additional technical support provided by Lawrence Berkeley National Laboratory and the Federal Energy Management Program.

Authors: Bryan Urban and Kurt Roth, Ph.D.



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

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

A low-sloped roof (pitch less than or equal to 2:12) must be designed and installed with a minimum 3-year aged solar reflectance of 0.55 and a minimum 3-year aged thermal emittance of 0.75 in accordance with the Cool Roof Rating Council program, or with a minimum 3-year aged solar reflectance index (SRI) of 64 in accordance with ASTM Standard E1980-01. Steep-sloped roofs (pitch exceeding 2:12) must have a 3-year aged SRI of 29 or higher.

Requires R30 insulation

Is required unless determined to be uneconomical by life cycle cost analysis

Roof Savings Calculator

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- Collaboration by ORNL and LBNL with funding from DOE and CEC and supported by EPA
- Provides cool roof assessments and advanced roof options
- Runs full simulations
- See RoofCalc.com

Roof Savings Calculator (RSC)

Beta Release v0.7

Oak Ridge National Laboratory
Lawrence Berkeley National Laboratory

Introduction

The Roof Savings Calculator was developed as an industry-consensus roof savings calculator for commercial and residential buildings using whole-building energy simulations. It is built upon the DOE-2.1E engine for fast energy simulation and integrates AtticSim for advanced modeling of modern attic and cool roofing technologies. An annual simulation of hour-by-hour performance is calculated for the building properties provided based on weather data for the selected location. Annual energy savings reported are based upon heating and cooling loads and thus this calculator is only relevant to buildings with a heating and/or cooling unit.

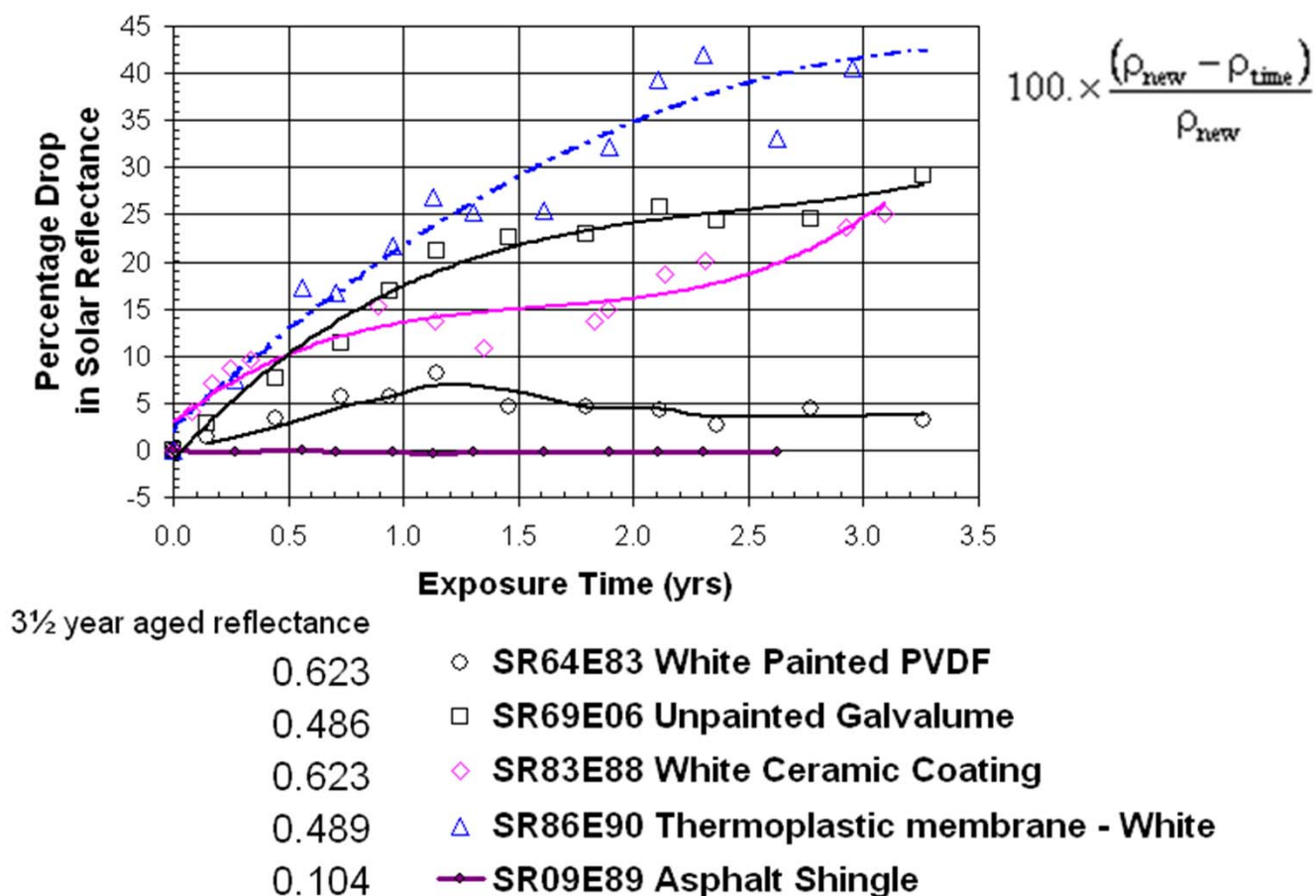
Roof Savings Calculator

To begin, please select from the following options:



Accelerated 3-year aged ratings

A major effort is to develop accelerated “aged” rating protocol to get results in six months rather than three years

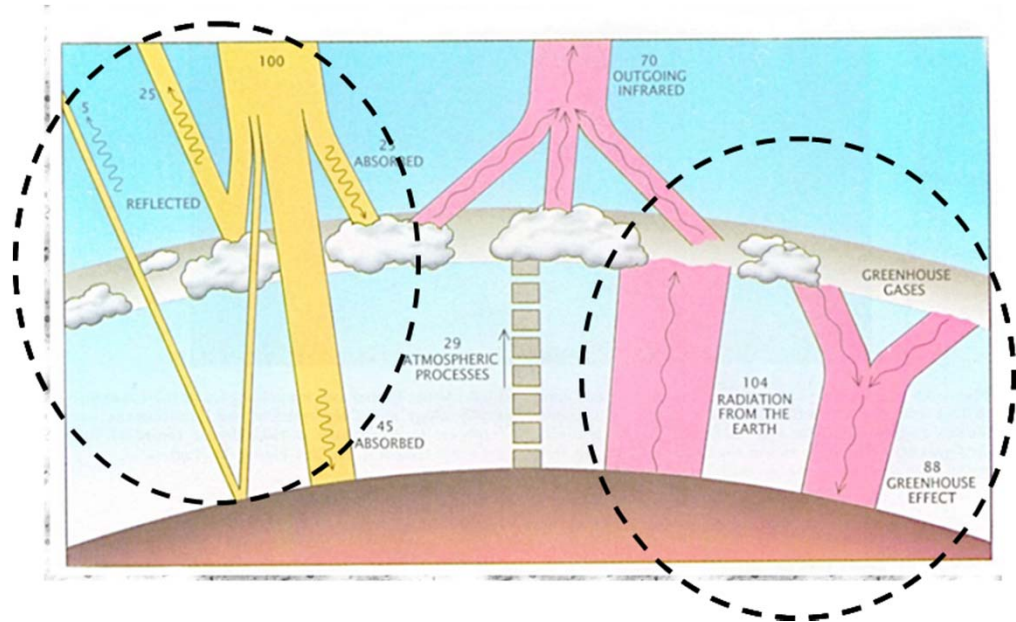


Develop next generation products:

- Affordable cool asphalt shingles
- Higher performing coatings
- Evaluate de-soiling and anti-soiling additives/functionalities
- Develop self-cleaning materials
- Develop thermochromic intellegent roof coating
- Explore cool pavements

- Review of over 240 research papers, articles, and presentations
- Key Findings:
 - The scale of UHI phenomena is large and increasing. The cost incurred is considerable.
 - Countermeasures (including white and vegetative roofs) are an effective way to reduce urban temperature and its effects.
 - The few macro scale assessments suggest countermeasures would improve urban environments and lead to both direct and indirect CO2 savings.

- Key Accomplishments:
 - Peer Review Panel
- Key Upcoming Work
 - Validation of Global cooling models
 - India Project



Source: IPCC

Total emitted CO₂ offset for cool roofs and cool pavements = 44 GT CO₂

BTP BIPV FY12 Plans (9.3M)

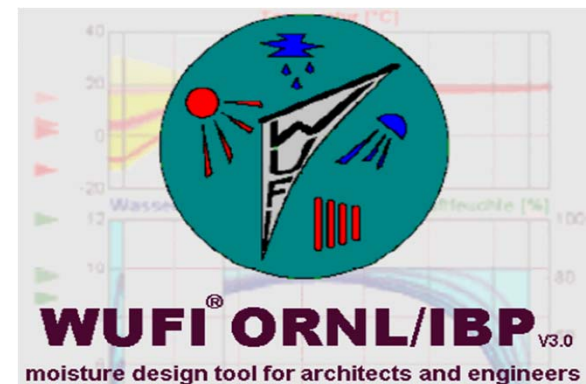
- Joint RFP with solar program to develop optimized systems that reduce roof thermal loads and increase PV output at lower cost (75% of funds)
- Demonstration of optimized BIPV to document performance improvements
- Development of guidelines and design tools for façade and roof systems to encourage optimized, durable, integrated designs



Sample advanced roof design applied to BIPV to be evaluated (50% reduction of roof thermal load)

Conduct Enabling Research

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



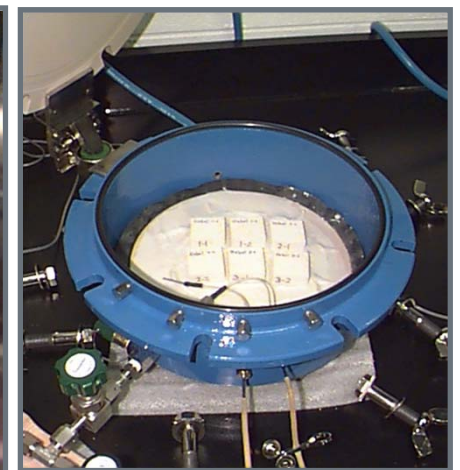
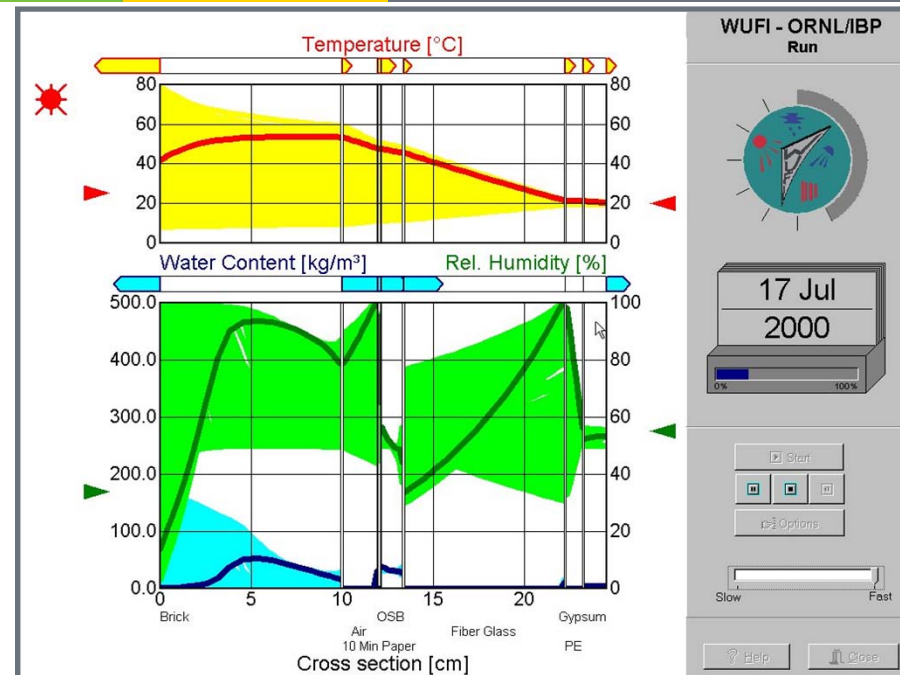
High Performance Envelopes Need to be Designed for Moisture Consideration

Moisture and Durability paramount in enabling tighter buildings

- Powerful models require material properties
- No commercial labs cover the range of needed tests
 - Some test methods developed, others expanded

WUFI – Moisture Design Tool
(German/USA Collaboration)

www.ornl.gov/sci/btc/moisture



Moisture Research

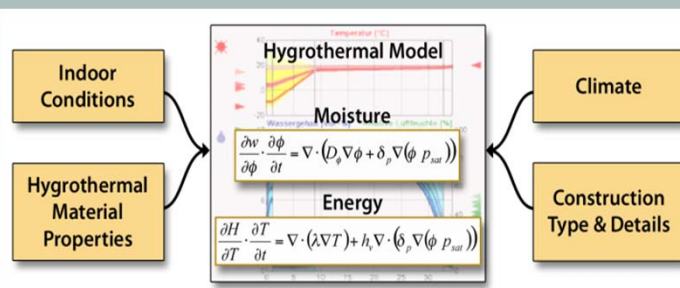
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- DOE-supported moisture engineering led to passage of ASHRAE Standard 160
- Continue WUFI cooperative development with Fraunhofer
- WUFI training outreach

**Wärme Und Feuchte
Instationär (WUFI)**

Advanced Hygrothermal Modeling



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ANSI/ASHRAE Standard 160-2009



ASHRAE STANDARD

Criteria for Moisture-Control Design Analysis in Buildings

Approved by the ASHRAE Standards Committee on January 24, 2009; by the ASHRAE Board of Directors on January 28, 2009; and by the American National Standards Institute on January 29, 2009.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, <http://www.ashrae.org>, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (world-wide), or toll free 1-800-527-4723 (for orders in US and Canada).

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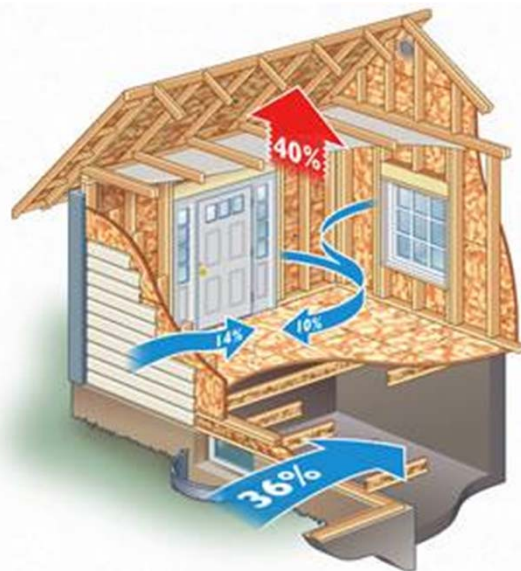


**American Society of Heating, Refrigerating
and Air-Conditioning Engineers, Inc.**

1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

DOE/ORNL Conducting In-depth Air Barrier Research

- Sophisticated energy performance measurements
- Supports real world performance and code activity
- 20 wall panels with 13 manufacturing supplier partners and Syracuse Univ.
- Needed to support higher code levels leading to low energy buildings



Air Barrier Research Plan

Air Barrier Type	Number of Specimens							
	Material Tests					Assembly Tests		
	Laboratory					Laboratory	Field	
	New				Weathered		BEST Facility	
	ASTM E96	ASTM C1498	Liquid Uptake	ASTM E2178	ASTM E2178		Phase 1	Phase 2
Fluid applied non-foaming liquid	8	8	8	8	7		7	3
Insulative boardstock	1	1	1	1	1		1	3
Non-insulative boardstock	2	2	2	2	2		2	3
Interior air barrier	-	-	-	-	-		2	3
Mechanically fastened membrane	4	4	4	4	4		4	3
Self-adhered membrane	2	2	2	2	2		1	3
Spray-applied foam	4	4	4	4	-		4	3
Controls	-	-	-	-	-		4	1
TOTAL	21	21	21	21	16		25	22

Material Level

ASTM E 96: Water vapor transmission

ASTM C 1498: Hygroscopic sorption isotherms

ASTM E 2178: Air permeance

 To be determined

 Tentative

Assembly Level

ASTM E 2357: Determining air leakage of air barrier assemblies

Exterior Insulation Finishing Systems (EIFS)



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- **Joint industry/DOE study – R30 Wall Solutions**
- **Experimental data used to validate advanced hygrothermal models and simulation tools – validation expanded to other climates**
- **Completed comprehensive studies to verify moisture-tolerant and energy-efficient EIFS drainage plane wall systems**

Data Acquisition



Test Walls



Facility



2009 R&D 100 Award Dynamic Insulation

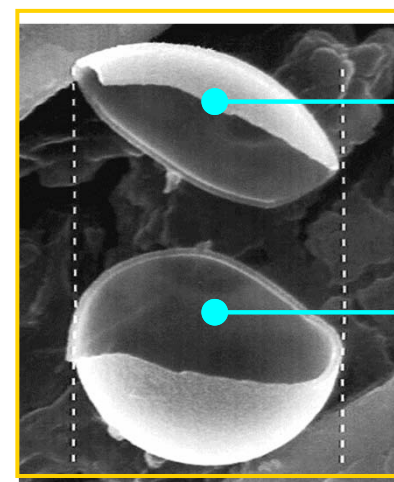
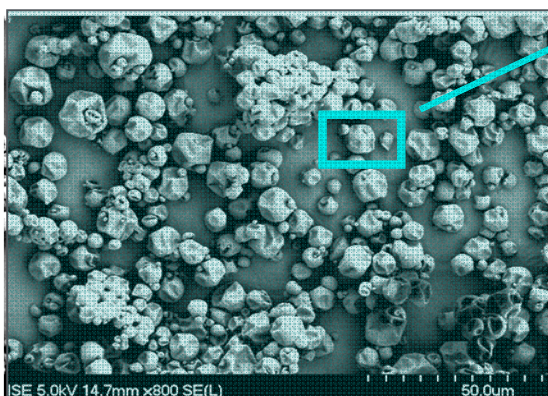
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Low-Flammable PCM-Enhanced Cellulose Insulation



Recycled Paper Waste



**Polymer
coating**

Bio-Based PCM
Fp: ca. 80F
 ΔH : 170 J/g



- In-depth development of test performance metrics leading to a consumer friendly marketable metric
- Collaboration with international partners, especially Fraunhofer and ZAE Bayern, leading to ASTM and ISO standards
- Comprehensive modeling to fully optimize pcm placement, melt temperature and melting range
- Field testing in multiple climate zones to validate performance and to correlate models

Next Generation of Windows

- **Highly Insulating**
 - Goal U value 0.10 (SI U value 0.56)
 - Possible vacuum glazings
- **Dynamic solar control**
 - Passive heating and dramatic peak cooling reduction, SHGC 0.53 – 0.09
 - Market ready, prices will drop with more investment
 - Many new projects underway, competitive market in 2012 - 2014

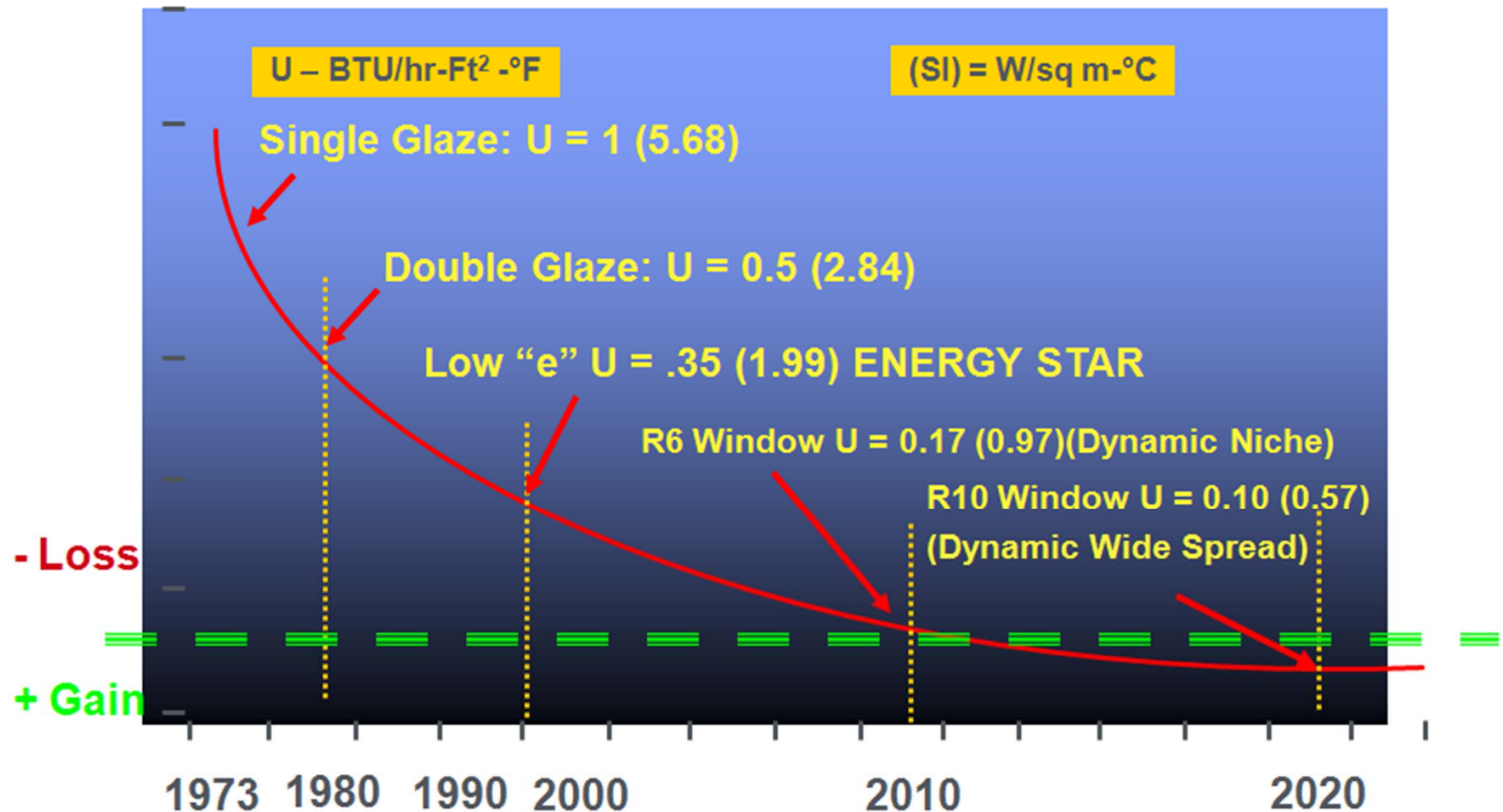


Prototype – Concept Window
(Highly Insulating and Dynamic
U Value 0.18 (SI U value 1.0)
SHGC 0.04 – 0.34)
Low cost unsealed center lite

Window Pathway

Advanced Windows Can Become Energy Producers

(US Mixed and Northern Climates)



Dynamic Windows – Cost Neutral within 5 Years (No blinds < HVAC)

DeHority Hall, Ball State University **Muncie, IN**



Courtesy of Sage – DO NOT USE WITHOUT SAGE PERMISSION

Commercialization of Highly Insulating Dynamic Window in FY10

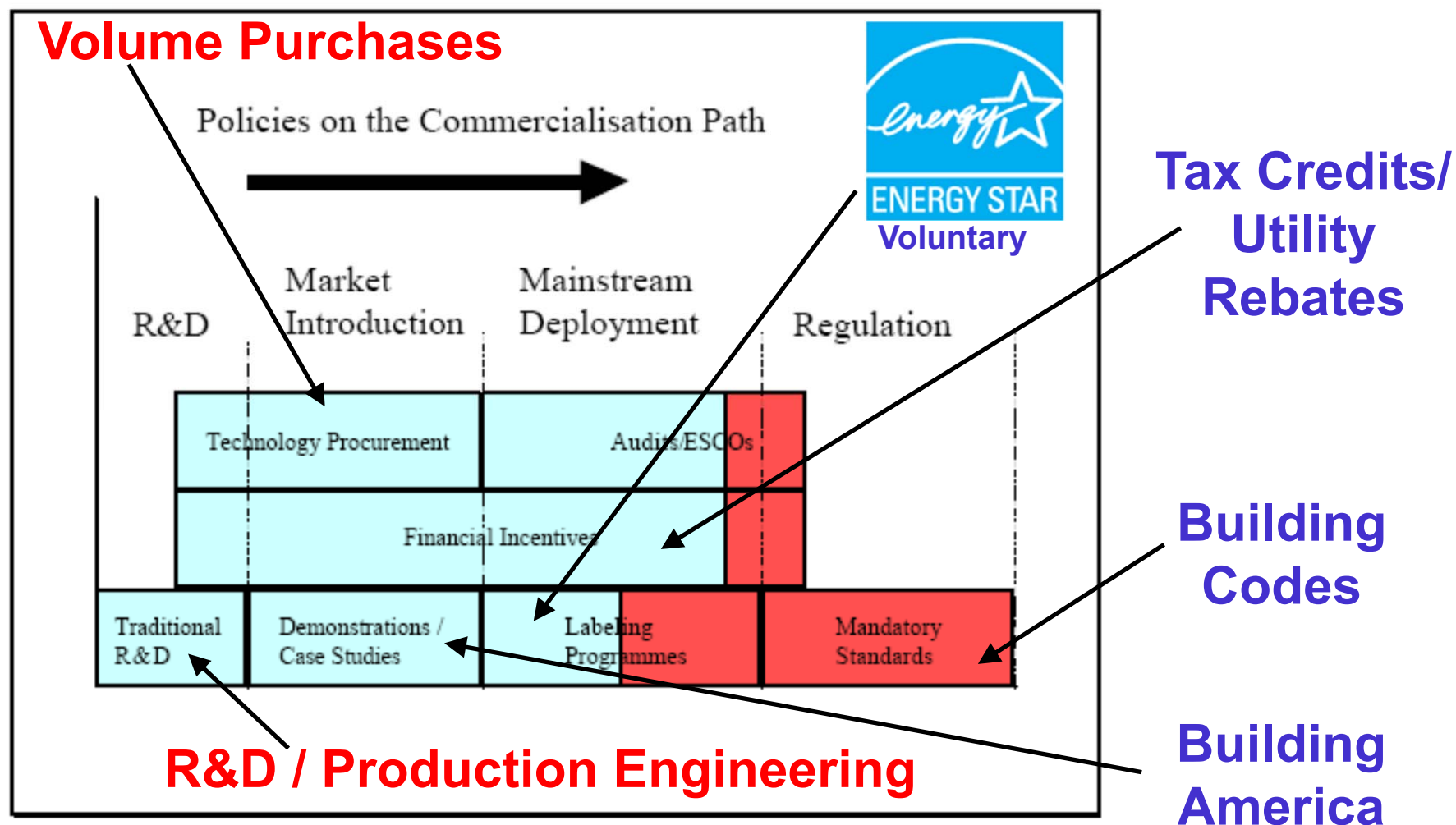
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South facing large residential home in MN – Courtesy Sage Electrochromics

Efficiency Policies for Windows



Integrated Programs to Reduce Price of Highly Insulating Windows



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Building America demonstrations/ production housing

High-performance specs in LEED for Homes & NGBS

**Production Engineering RFP – 50%
Cost Share**

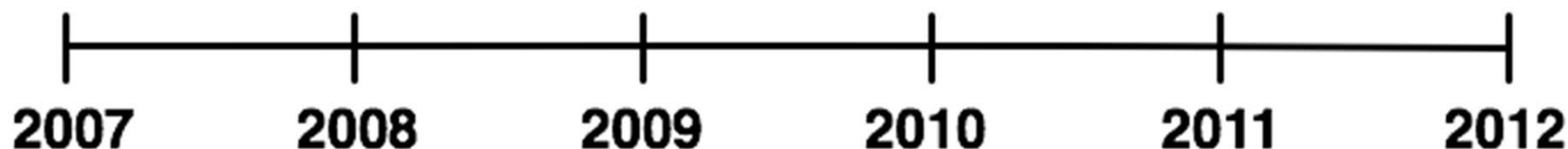
**Technology Procurement/Volume Purchases
– Multifamily/Public Housing/Condo, Builders, etc**

**Develop
advanced utility
program specs**

**Utility programs for advanced
windows**

ENERGY STAR spec revision

**New ENERGY STAR /
Phase II**



Windows Volume Purchase Phase I R-5 ($U=0.2-0.22$) and Low-E Storm

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**Educate Buyer Groups
March 2009 – continuing**



**Develop Draft Solicitation
Specifications with Buyers and
Industry
July – November 2009**



Issue Solicitation – Dec 2009



Responses Due – Feb 2010



**Finalize Agreements with
Qualified Vendors April – 2010**



**Promote Qualified Products
June 2010 – continuing**

**40 Certified
Suppliers
(9 of 16 top window
companies by sales)**



Volume Purchase Program Specifications

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Final Windows and Low-E Storm Windows Specifications and Certifications

High Performance Windows

- U-factor: [0.20-0.22](#)
- Air leakage: ≤ 0.30 cfm/ft²
- Certifications: [NFRC/NAFS](#)
- Warranty (yr): [20 glass/10 non-glass](#)
- NFRC label required
- NAFS 05: Performance Grade R25



Low-e Storm Windows

- Emissivity: [<0.22](#)
- Structural test: [ANSI/AAMA 1002.10-93](#)
- Registry: [IGDB \(LBNL database\)](#)
- Warranty (yr): [10 glass/non-glass](#)



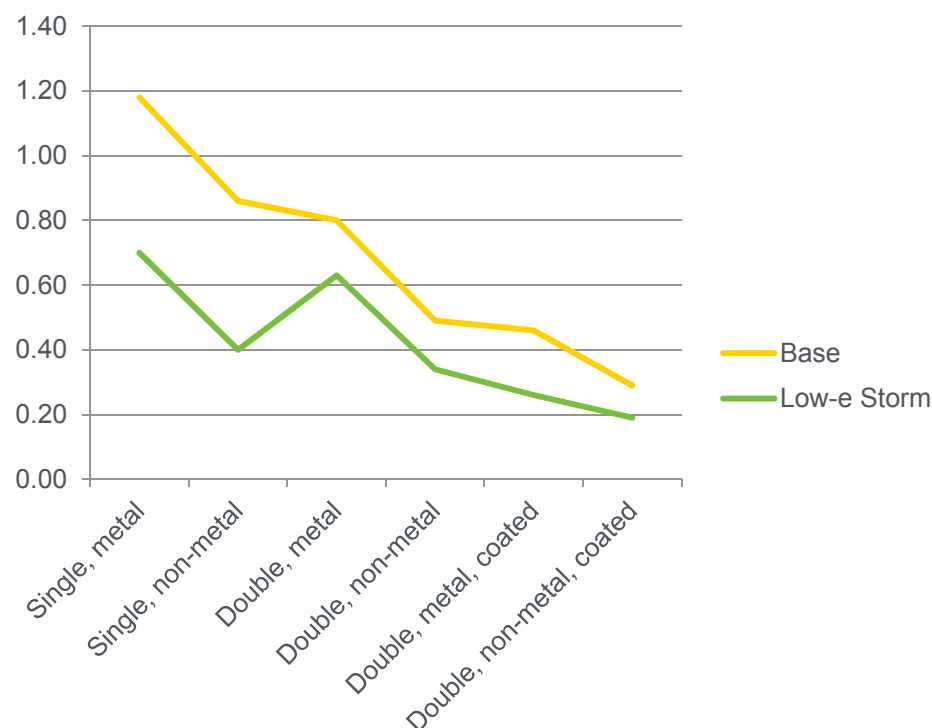
Low-E Storm Window Performance Improvement



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Existing Window	Base		With low-E Storm	
	U-factor	SHGC	U-factor	SHGC
Single pane, metal frame (eg aluminum)	1.18	0.78	0.70	0.61
Single pane, non-metal frame (eg wood or vinyl)	0.86	0.68	0.40	0.52
Double pane, metal frame, no coating	0.8	0.7	0.63	0.57
Double pane, non-metal frame, no coating	0.49	0.6	0.34	0.48
Double pane, metal frame, low-e coating	0.46	0.6	0.26	0.48
Double pane, non-metal frame, low-e coating	0.29	0.5	0.19	0.38

Effects of adding Low-e storm windows to existing windows



www.windowsvolumepurchase.org

- Cost effective residential R5 (U value 0.2) windows (~ \$2 to \$4 / sq ft price premiums), many < \$250 per 15 sq ft double hung
- Cost effective, low e storm windows (~\$7 to \$9 / sq ft)
- Minimum orders of 15/20
- Phase I – price range on web, not all vendors have effective web pages, improvements expected in phase II

The screenshot shows the homepage of the Windows Volume Purchase website. At the top, a blue banner reads "High Performance R-5* Windows & Low-E Storm Windows Volume Purchase Products". Below this is a navigation bar with links: "Frequently Asked Questions", "Complete Vendor Listing", "Utility Incentives", and "Learn more about Windows Volume Purchase". The main content area is divided into two columns. The left column, titled "Order Windows", lists four product categories with icons: "Optional Open Bid Request", "New Construction R-5 Windows (Minimum order: 20)", "Retrofit Construction R-5 Windows (Minimum order: 15)", "R-5 Patio Doors (No minimum order)", and "Low-E Storm Windows (Minimum order: 20)". The right column, titled "High Performance Windows: Advancing Technology. Saving Energy.", contains an "About this Website" section with text about the program, a "Site Updates" section with dates and links, and a "Learn More..." section with a link to a "Midwest Regional Workshop".

High Performance R-5* Windows & Low-E Storm Windows Volume Purchase Products

Frequently Asked Questions Complete Vendor Listing Utility Incentives Learn more about Windows Volume Purchase

Order Windows

- Optional Open Bid Request
- New Construction R-5 Windows (Minimum order: 20)
- Retrofit Construction R-5 Windows (Minimum order: 15)
- R-5 Patio Doors (No minimum order)
- Low-E Storm Windows (Minimum order: 20)

High Performance Windows: Advancing Technology. Saving Energy.

About this Website

You have accessed this website because you are interested in purchasing high performance windows or low-e storm windows that are available through a U.S. Department of Energy (DOE) volume purchase program.

High performance (R-5*/U-factor 0.22 or less) windows and low-e storm windows are available for purchase through this website from a number of vendors who have qualified to participate in the volume purchase program.

Each qualified vendor of windows products on this site has met the minimum specifications established by DOE. The qualified vendors have agreed to sell window products to customers that meet the minimum purchase quantities shown.

Customers should be aware that not all vendors offer all window types nor do all vendors sell to all parts of North America. This website will assist purchasers to identify windows products and vendors for their particular location and application. Please be aware that the prices shown for the window products are 'base' prices bid into the program and do not include delivery, installation, and other features such as grids. Vendors may also offer high performance (R-5/U-0.22) windows with other frame materials and/or colors, and the price for those windows may be different than the price offered through this program

Site Updates

- 09.2010 - Optional Open Bid Request Form
- 08.2010 - High Performance Windows Utility Incentives
- 07.2010 - Frequently Asked Questions

Learn More...

Windows Volume Purchase Midwest Regional Workshop September 22-23, 2010 Chicago, Illinois

R-5 Window Example - Need Building America Case Study Data



Energy Efficiency & Renewable Energy

**A highly-insulating building envelope not only saves substantial energy...
but can allow for up-front savings in HVAC system costs.**

- High-performance windows are a critical link in the Building Envelope

Windows Area: 300 ft²
**Incremental Cost
for R-5 Windows:** *\$5/ft²
Total Cost: \$1500

Cost: \$1500

Savings: \$1000

Total: \$500

6-12 yr simple payback

*Consumer price premiums are
\$2-\$4 per sq ft, but wholesale base
cost to builders may be lower



**Reduced Duct
Savings:** \$450

**Reduced HVAC
Savings:** \$550

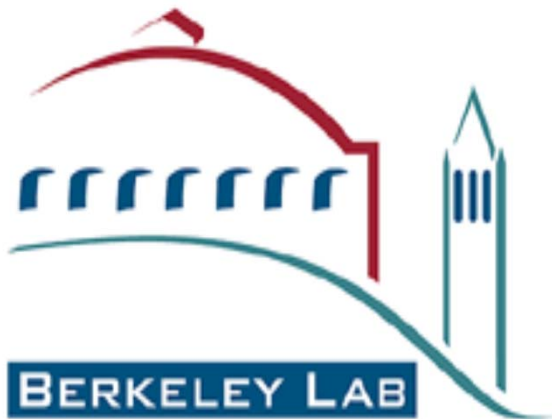
2000 ft² Home

Major Changes

- Commercial-grade products added
- Vendor's base bid prices to be shown
- Website to be redesigned including:
 - Searchable database
 - Descriptor box with distinctive features of products
- Optional pricing of smaller and larger quantities (20-49 is required bid quantity).

- January 24: Phase II solicitation released
- March 18: Priority deadline
 - Responses received after deadline will be processed in order received after bids meeting priority deadline have been processed.
- May 3: Phase II launch
- September 18: Deadline for entry into program.
- May 2012: End of Phase II

DOE Assists with Technical Support Activities



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



www.nfrc.org

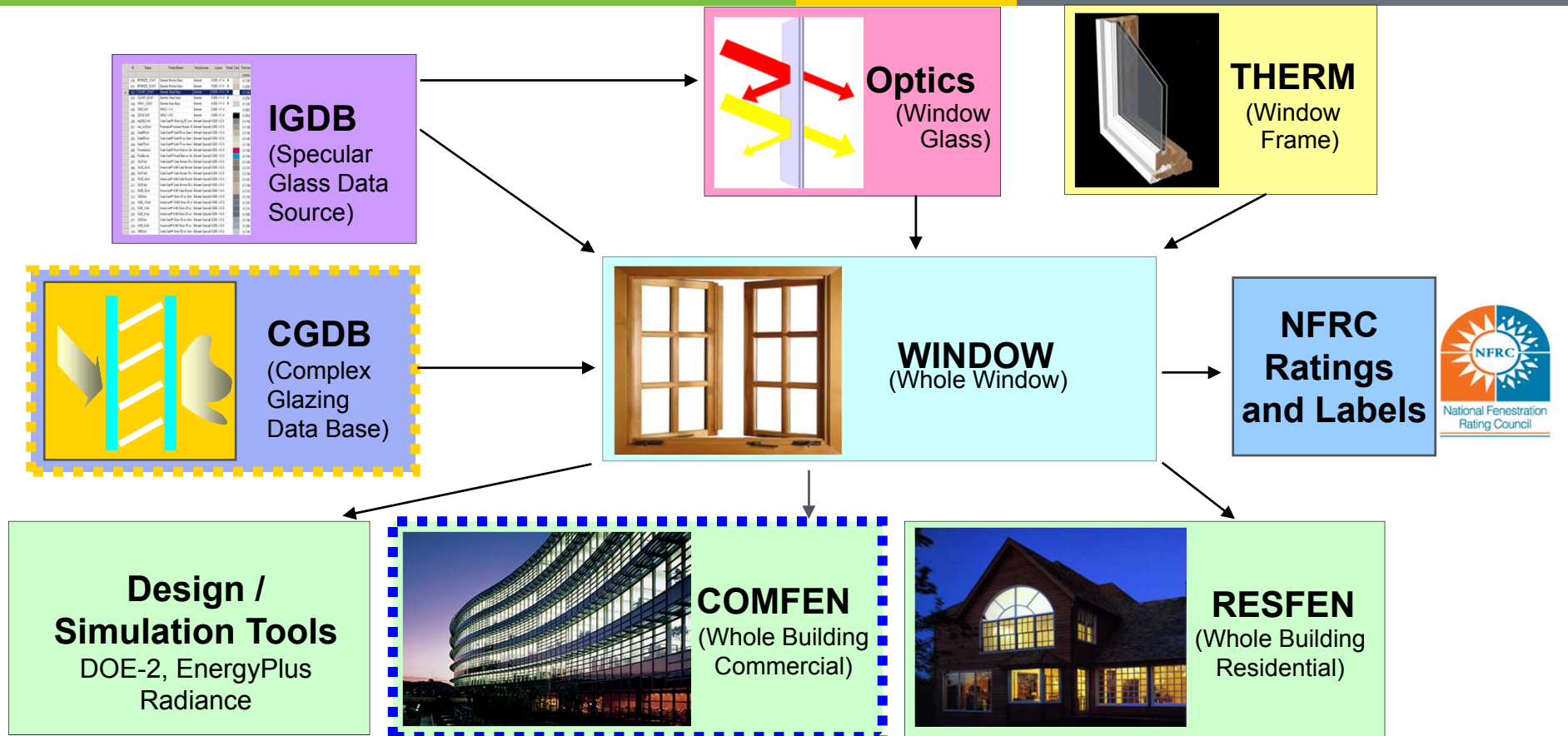


www.efficientwindows.org

- Full range of software support tools, education materials and expansion to new product categories
- Continued financial support to assist industry in rating and promoting efficient products

WINDOW6 Software Suite

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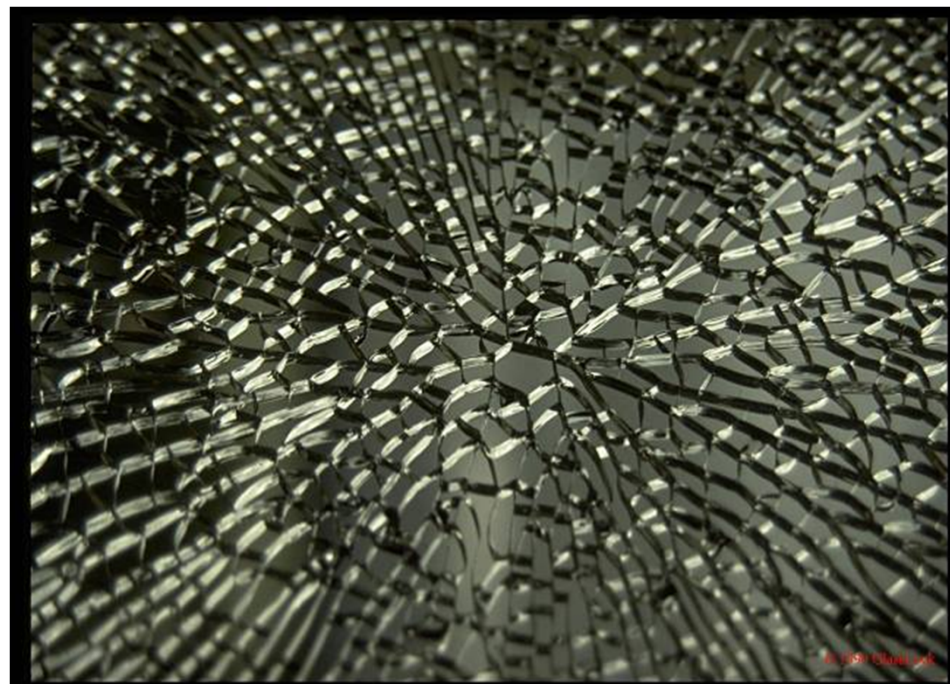
- Design tools for advanced products
- **ISO 15099 Compliant**
- NFRC Ratings

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



Window Film Retrofit Applications - energy, blast, hurricane, etc.

Look for new NFRC ratings



ARRA Major Effort Over the Next Two Years

- 23M for BTP1 and 4M for SBIR, total value with cost share is approximately 44M
- Major areas of new projects
 - Dynamic Windows
 - R10 Highly Insulating Windows
 - New Daylighting and lower emissivity window films
 - R5 commercial window production engineering
 - Demonstration of thermochromic windows and low e storm windows in commercial and hotter climates
 - High Performance Insulation and Wall Systems
 - Innovative Cool Roof static and dynamic new materials
 - Lower cost phase change materials

Window and Daylighting Technology Development

- **Soladigm, Inc.:** Low-Cost, High-Energy Savings, Solid State Dynamic Windows
- **Southwall Technologies, Inc.:** Low-Cost R10/High SHGC Heat Mirror® Window Development
- **Applied Materials, Inc.:** Technology for Low-Cost Electrochromic Dynamic Windows
- **EverSealed Windows, Inc.:** High Reliability R10 Using High Windows Using Vacuum Insulating Glass Units
- **SAGE Electrochromics, Inc.:** Electrochromic Glazing Technology: Improved Performance, Lower Price
- **Quanta Technologies, Inc.:** Low-E Retrofit Demonstration and Educational Program
- **Traco Delaware, Inc.:** Production Engineering for R5 and Higher Windows
- **3M:** Polymeric Multilayer Infrared Reflecting Mirrors
- **Pleotint LLC:** Demonstration with energy and daylighting assessment of Sunlight Responsive Thermochromic (SRTTM) Window Systems
- **CPFilms, Inc.:** Low-Emissivity Energy-Control Retrofit Window Film

- **Dow Chemical:** Advanced Insulation for High-Performance, Cost-Effective Wall, Roof and Foundation Systems
- **Dow Corning:** Contributing to Net-Zero Building: High Energy Efficient EIFS Wall Systems
- **Syntroleum:** Development of Low-Cost Bio-Based Phase Change Material
- **Industrial Science & Technology Network, Inc.:** Advanced Building Insulation by CO2 Foaming Process
- **United Environment & Energy LLC:** Bio-Based Thermochromic Intelligent Roof Coating
- **Technova Corporation:** Shape-Stable and Highly Conductive Nano-Phase Change Materials
- **Nanotrons Corporation:** Nano-Enabled TiO2 UV Protective Layer for Cool-Color Roofing Application

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Thursday, December 09, 2010

Draft Roof and Attic Design Guide now Available for Review

Posted by Eric Jones on 1. December 2010 16:55

NOW ACCEPTING COMMENTS: A draft of our New Roof and Attic Design Guide for Hot Climates is now available for review. These guidelines give homeowners and builders the tools to make informed decisions on the most economical and best practices for renovating a home's roof and attic. The guide includes information on new designs and conventional strategies for saving money by improv... [\[More\]](#)

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DOE Building Envelopes Roadmap Workshop at Buildings XI

Posted by Walter Zalis on 18. November 2010 17:51

Workshop Alert! Please join members of the Building Envelope R&D Program as Oak Ridge National Laboratory hosts the 11th International Conference on Thermal Performance of the Exterior Envelopes of Whole Buildings on December 5-9, 2010 in Clearwater Beach, Florida. This conference focuses on both the research principles and practical applications of building technologies. DOE's envelope... [\[More\]](#)

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Draft Cool Roof Roadmap Now Available for Review!

Posted by Walter Zalis on 18. November 2010 13:25

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Major Accomplishments

FY10 Major Accomplishment	
Major Contribution to DOE Wide Cool Roof Policy	Commercialization of Cost Effective R5 Windows
Cool Roof Selection Guidelines	Commercialization of Cost Effective Low E Storms
New Integrated Cool Roof Calculator	Implementation of PA Priority List for Windows
New Attic/Roofs Designs for Hot Climates	Commercialization of High R Dynamic Windows
Initiation of Whole House PCM Studies	Opening of India Window Rating and Test Center

Envelope and Windows Major Program Accomplishments (2002 – 2009)	
New Moisture Modeling Capability	Commercialized Dynamic Windows
Vapor Barrier Code Requirements	NFRC Labels for Window Film & Dynamic Windows
Aged & Reduced ASTM Insulation Values	Window Design Tools (Used by 80% of Industry)
Developed Sealed Crawl Space Designs	Developed Major Commercial Glazing and Daylight Tools
In-depth Cool Roof Case Studies	Comprehensive Dynamic Window/Daylight Demos
R30 Wall Solutions (EIFS Validation)	Extensive Studies – Driving Policy for High SHGC in North
Commercialized Dynamic Insulation	New Commercial Façade NFRC Rating Program
ASHRAE 160 Moisture Design Standard	Showcase Highly Insulating Dynamic Window Prototypes

- Need triple pane (R5, U value 0.22 or lower) window case studies for energy savings, systems net costs, etc
- Opportunity for next generation attic/roof system demonstrations for new and retrofit roof systems in hot climates (late FY11 and FY12)
- PCM demonstration is needed for FY12
- Two key requirements from our December 2010 Roadmap Workshop
 - Below grade moisture modeling (consistent with BA requests)
 - Thermal shorts 3D modeling effects (mostly for commercial)
- Need more formal consolidated process for BA “needs areas” to be provided to Envelope R&D

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