

# Building Technologies Program

U.S. DEPARTMENT OF  
**ENERGY** | Energy Efficiency &  
Renewable Energy

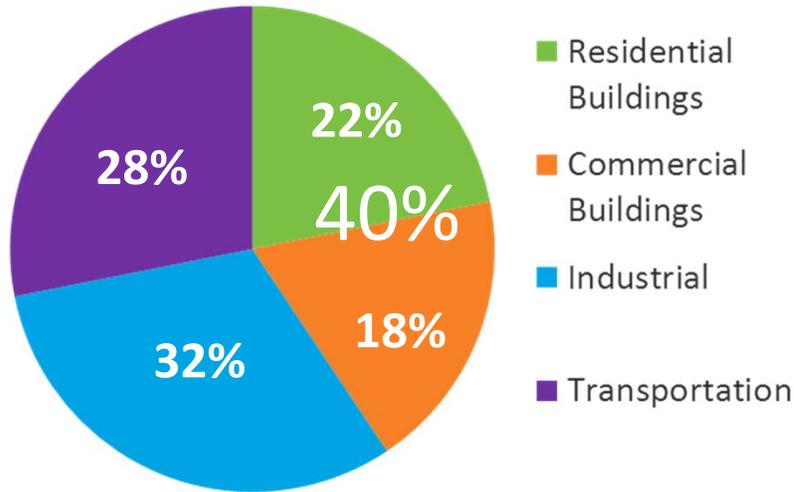


Building Envelope and Windows Update  
FEMP ESPC Working Group

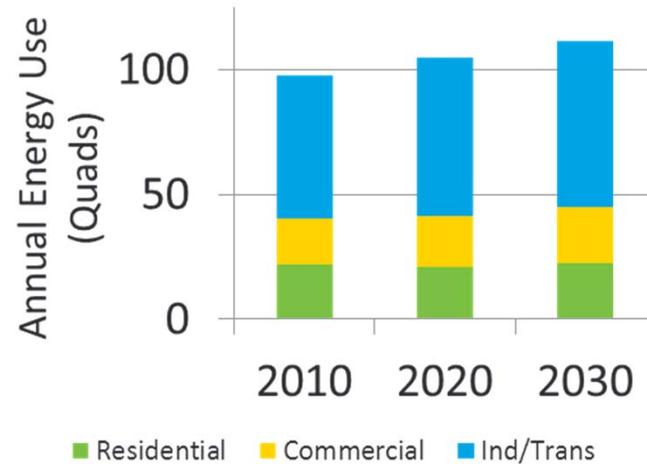
Marc LaFrance  
US DOE  
8 February 2012

# The U.S. Energy Big Picture...

## U.S. Primary Energy Consumption



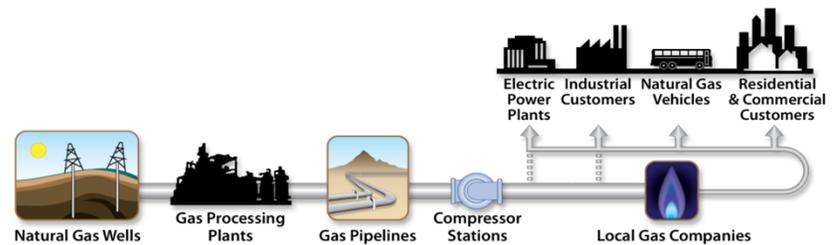
## Total U.S. Energy Consumption



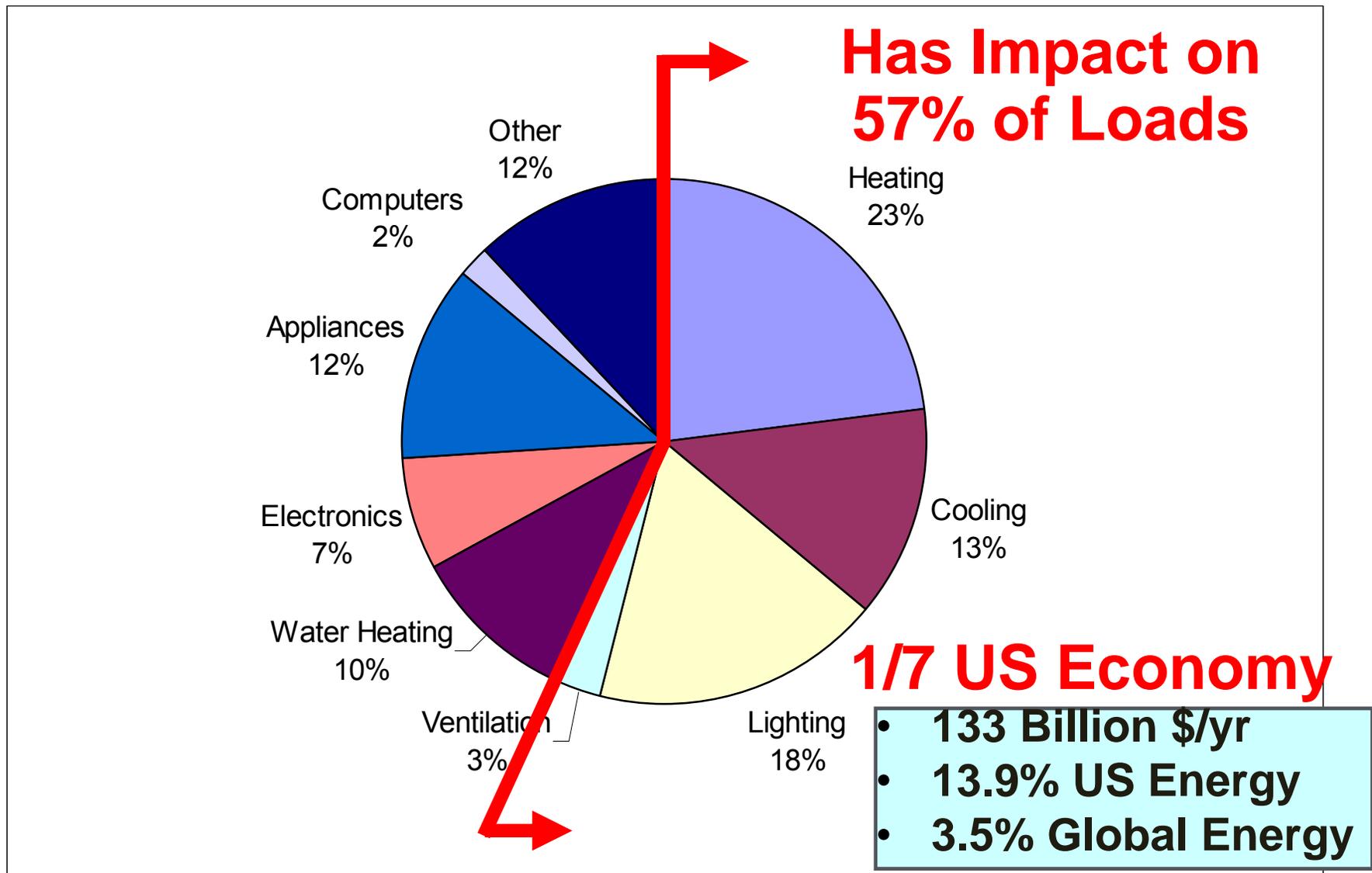
## 73% of U.S. Electricity Consumption



## 55% of U.S. Natural Gas Consumption

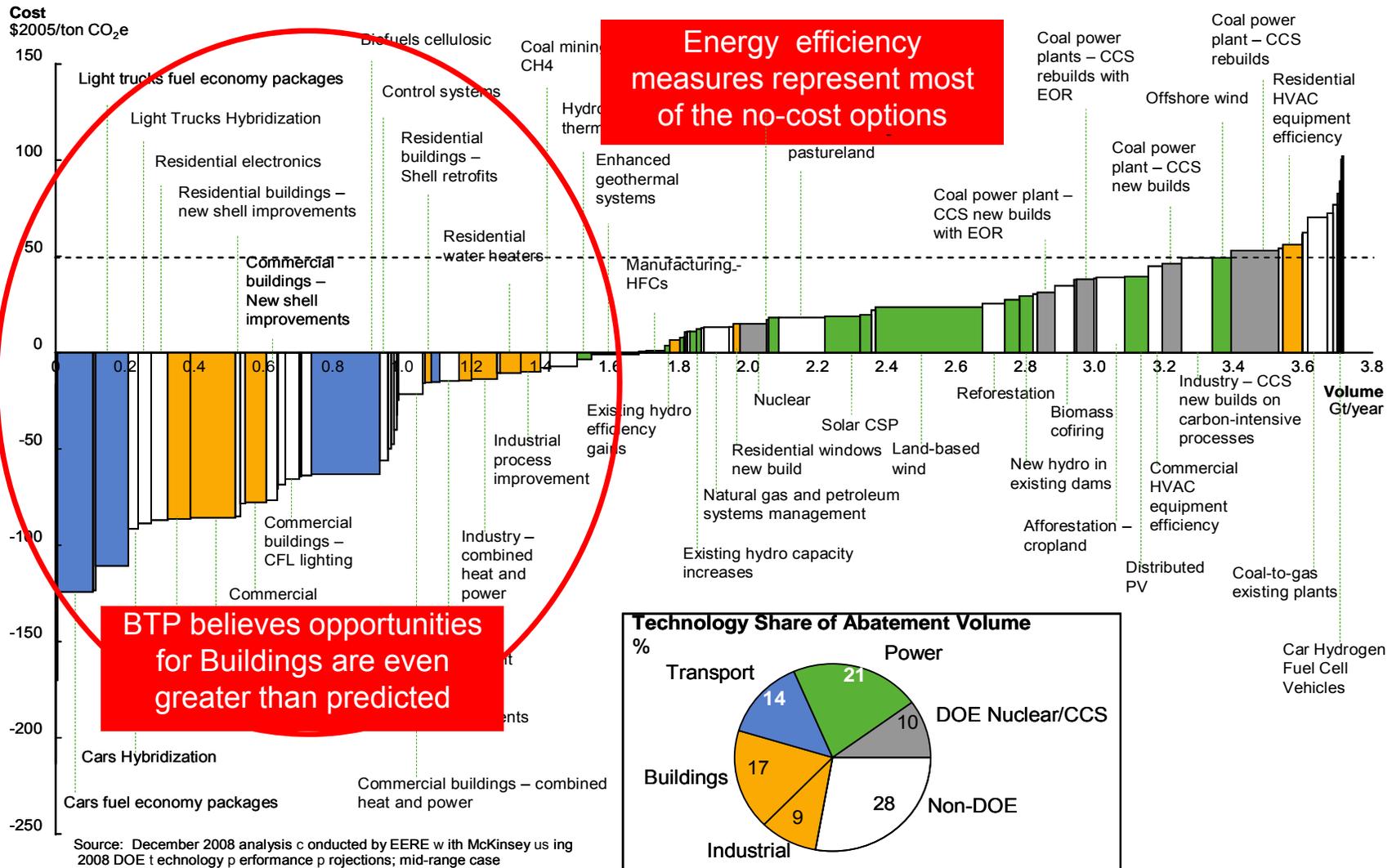


# Building Consumption – Envelope Relationship



# Buildings Energy Efficiency: % of CO<sub>2</sub> Savings Potential Large

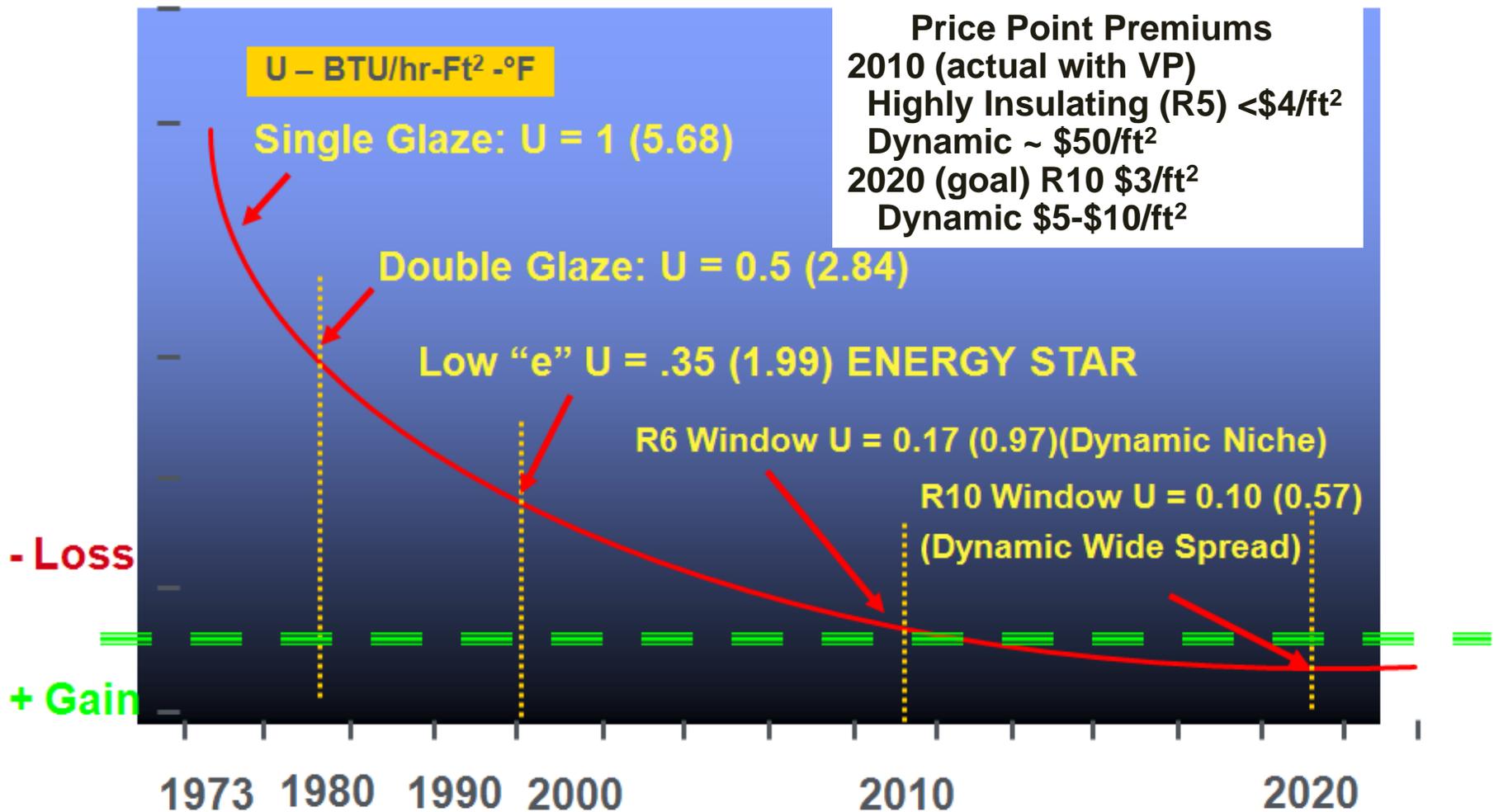
■ EERE Power  
■ EERE Energy efficiency  
■ DOE Nuclear/CCS  
■ EERE Transport



# Window Pathway

## Advanced Windows Can Become Energy Producers

(US Mixed and Northern Climates)



# Next Generation of Windows

- **Highly Insulating**
  - Goal U value 0.10 (SI U value 0.56)Vacuum glazing have the greatest potential for high light transmission
- **Dynamic solar control**
  - Passive heating and dramatic peak cooling reduction, SHGC 0.53 – 0.09Market ready, prices will drop with more investment
  - Many new projects underway, competitive market in 2012 - 2014

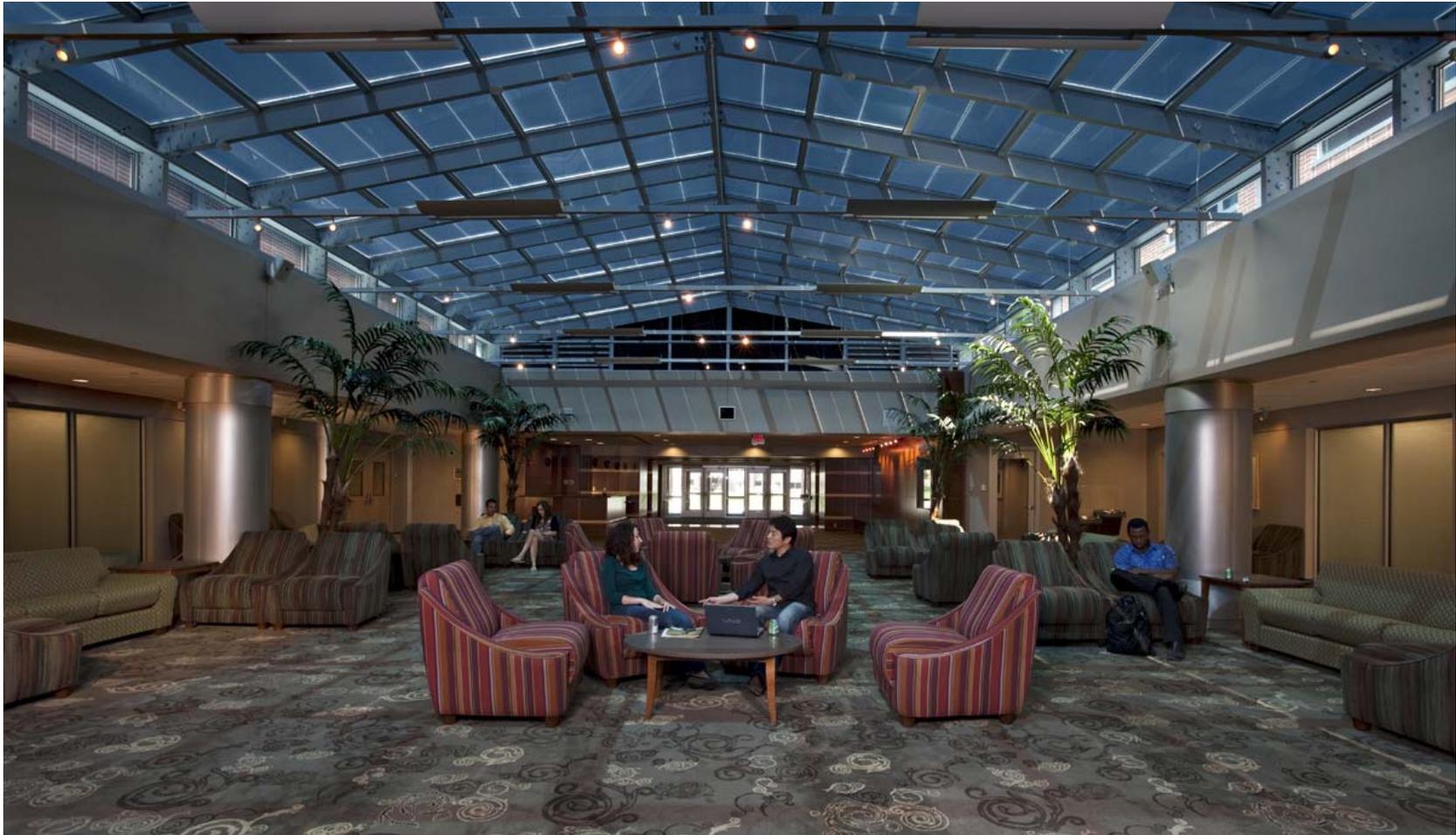


**Prototype – Concept Window  
(Highly Insulating and Dynamic  
U Value 0.18 (SI U value 1.0)  
SHGC 0.04 – 0.34)  
Low cost unsealed center lite**



# Dynamic Windows – Cost Neutral by 2020 (No blinds < HVAC)

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

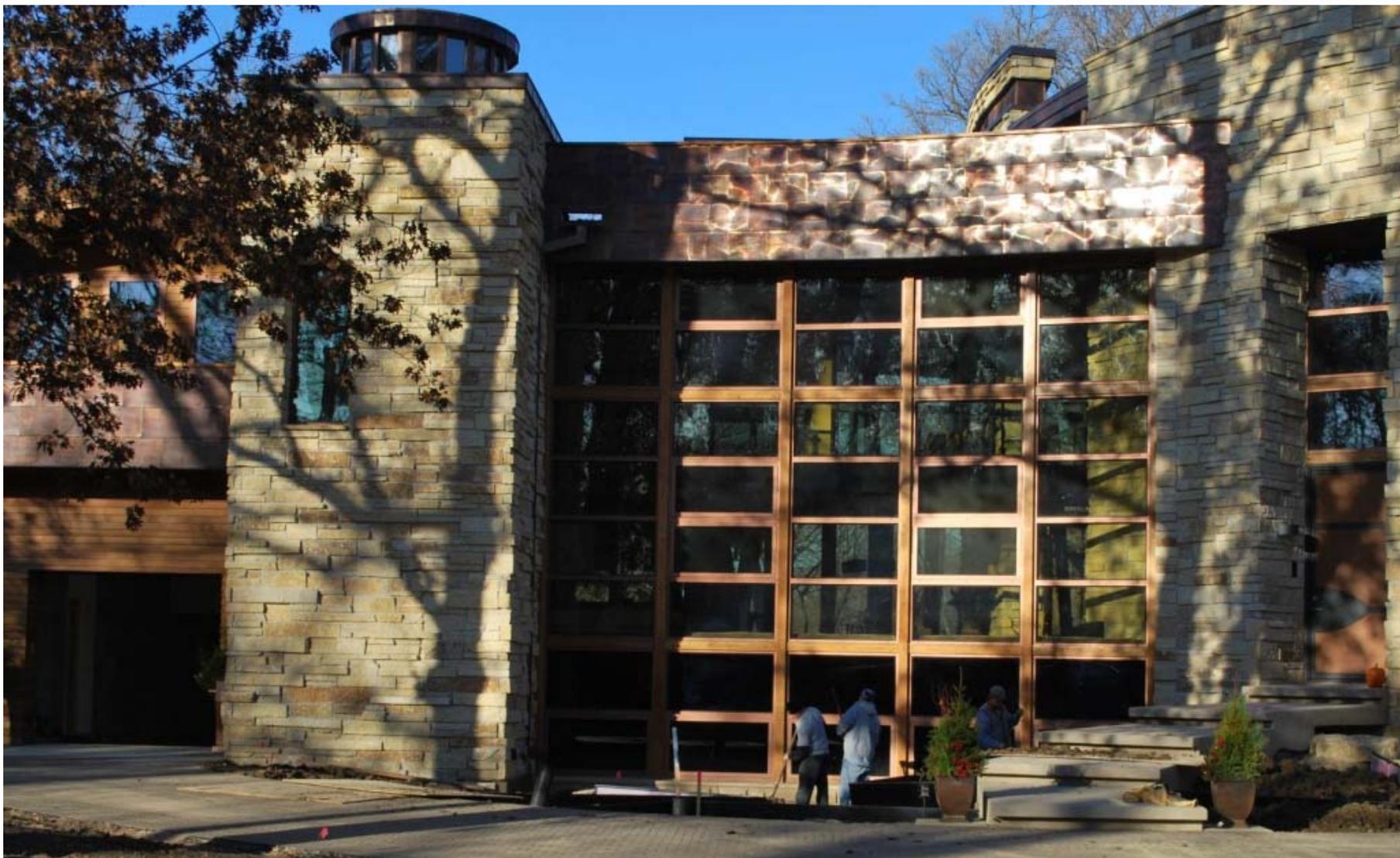


Courtesy of Sage

# Commercialization of Highly Insulating Dynamic Window in 2010

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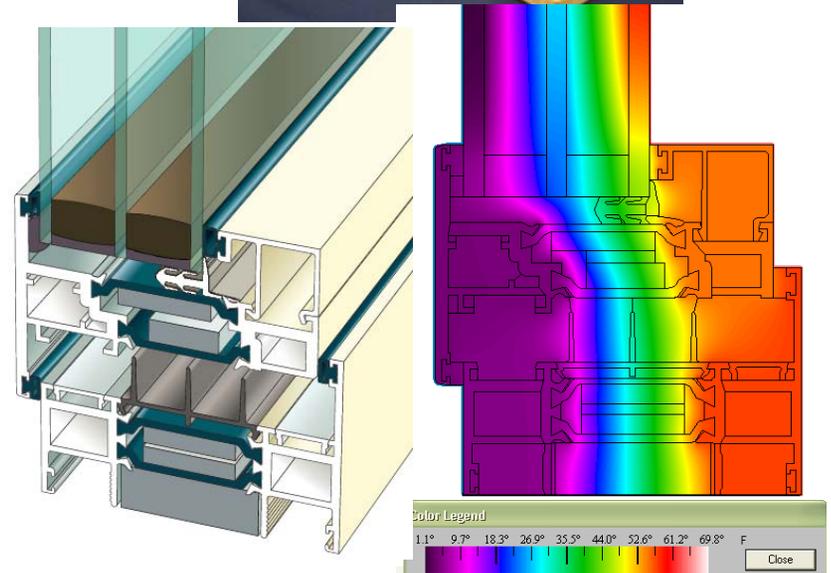
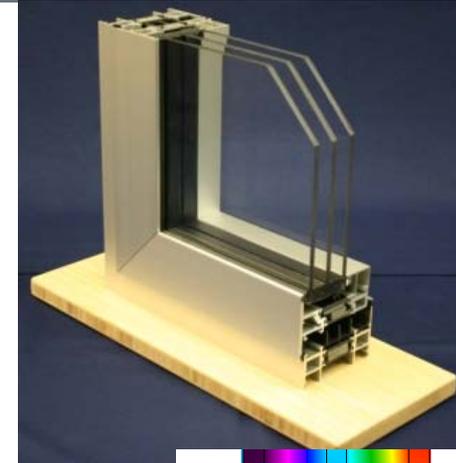
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**South facing large residential home in MN – Courtesy Sage Electrochromics**

# High Structural R5 Highly Insulating Commercial Windows - ARRA

- U-Factor of 0.17- 0.22 (~R5) **and** Architectural structural rating (AW)
  - 30% better thermal performance compared to current high-structural windows
  - 1<sup>st</sup> Aluminum window to achieve R5 thermal performance
  - Exceptional condensation resistance (CR>72, CRF>78)
- Cost efficient product design and manufacturing engineering
  - Reduce the cost of R5 windows → increase market penetration
  - High volume-automated IGU line; R10 capable
- Phase I – Casement/Projected → **commercialized** in Q4-2011
- Phase II & III – Sliding windows → planned for Q3-2012



# Automated Tri-Lite Assembly System (ATLAS)

Produces Triple IGUs in Unprecedented 20 Second Cycle Times

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ATLAS's 'no-touch' Bernoulli technology glass lifting system ensures contamination-free placement and alignment of triple IGUs.

High-Volume, Low Material and Labor Cost Effective Automated System that Results in a High Performance R-5 Highly Insulated Window systems

- ARRA partner, first system being installed with major glass partner, 1<sup>st</sup> qtr 2012
- Enables industry to provide homeowners with affordable, highly efficient residential windows at a minimal cost
- Adaptive to unique insulated glass (IG) unit combinations (*both duals and triples.*) *6 dual IG units/minute or 3 triple IG units/minute in any combination*
- Machine-controlled consistency ensures uniform, high-quality IG units at higher production rate. Simplifies IG assembly through GED's WIN IG-5 software and the "no touch" Vortex vacuum lift technologies
- Vacuum lift mechanisms lift and suspend the lite in mid-air without contact to the lite surface; Touchless assembly minimizes chance of glass breakage, damage and worker injuries

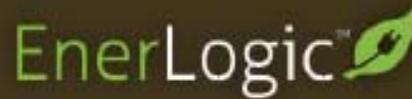


ATLAS



**GED**  
Integrated Solutions

# New Very Low Emissivity Window Films - ARRA



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## • EnerLogic 35\*

- 42% improvement in single-pane glass insulating performance
- Improves “annual-average U-value” of single-pane to that of dual-pane (dual -> triple)
- Payback 2.75 years (Large Office Bldgs, National Average)
- Year-round energy savings 2-3x that of same VLT, non-low-e films

## • EnerLogic 70\*

- 41% improvement in single-pane glass insulating performance
- Industry’s ONLY high-VLT, spectrally-selective, low-e window film
- Residential installations:
  - 3x the year-round energy savings of high-VLT, non-low-e films
  - Up to \$3,500 in energy savings over life of the film
  - Save up to 10% on heating bills
  - Annual savings equal to replacing all lights in a home with CFLs
  - 10-30% greater cooling savings over other high-VLT, non-low-e films



	SHGC	Winter U-Value	Emissivity	Visible Light Transmission	Light to Solar Gain Ratio	Visible Reflectance Interior
Single Clear Glass	0.86	1.04	0.84	0.90	1.05	8%
With EnerLogic 35	0.24	0.60	0.07	0.33	1.38	30%
With EnerLogic 70	0.51	0.61	0.09	0.70	1.37	4%

\* CP Films analysis, significant thermal improvement, possible greater condensation in colder climates

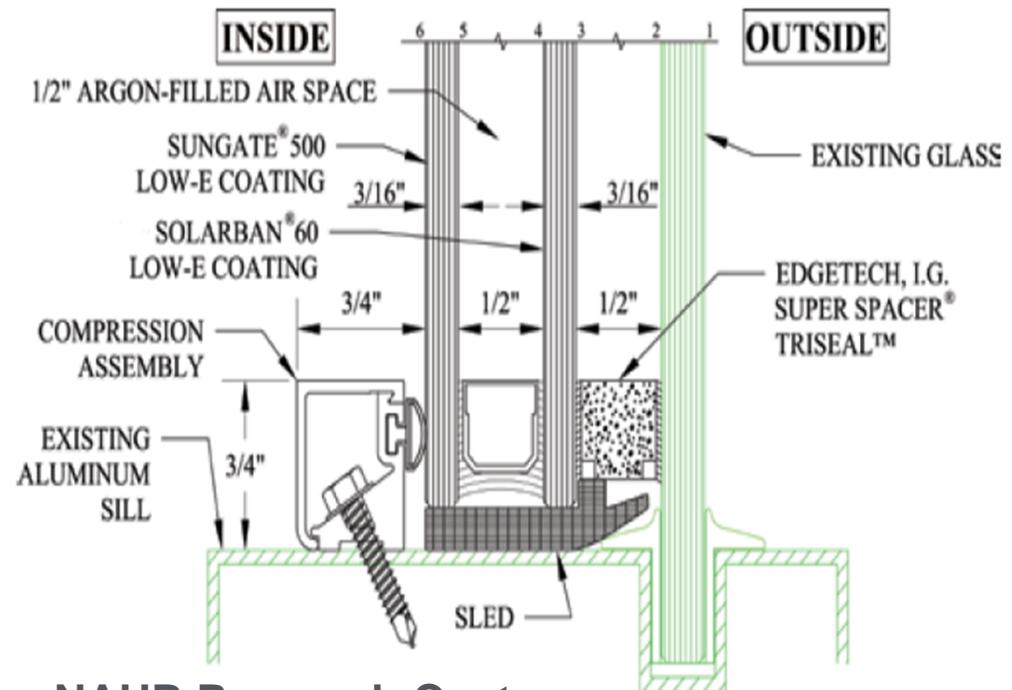


# Commercial Low-E Storm Window Retrofit System

Ongoing case study in Philadelphia 12 story office building – retrofit 18,000 ft<sup>2</sup> glazing



- ARRA partner, field evaluation w/ 50% cost share
- Converts existing single glazing to triple low-e glazing
- 12 month energy consumption comparison
- Detailed monitoring in two pairs of side-by side offices (north, east)



J.E. Berkowitz, Quanta Technologies, NAHB Research Center

# SAGE Electrochromics

- In production, revenue stream
- New factory to open early 2013
- Large scale, 500' sputtering coater process
- First EC company to pass ASTM durability standards
- ARRA and CRADA partner



**HVAC Ductless Common Area**



**Sage New Factory Under Construction**

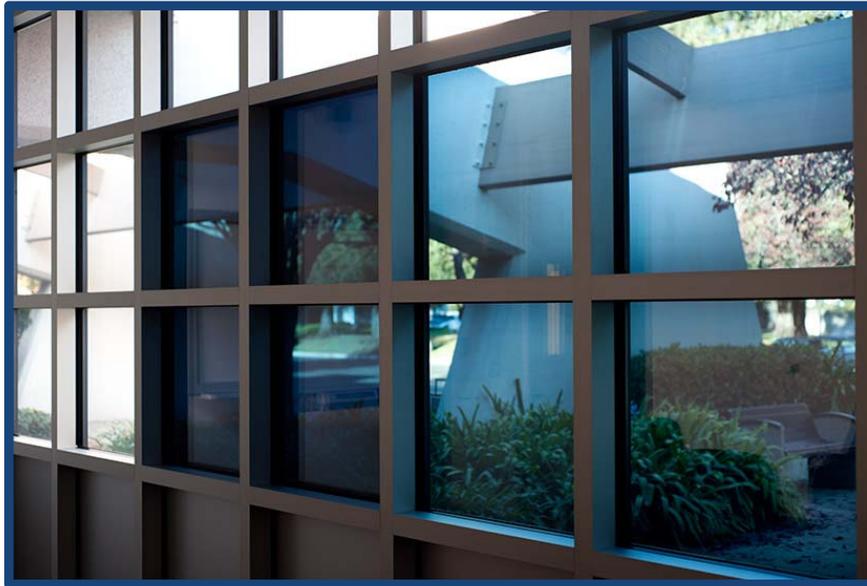


**Siemens 5000 ft<sup>2</sup> Curtain Wall**

# Soladigm Dynamic Glass

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## Dynamic Glass

- Electronically tintable glass based on electrochromic technology
- Surpasses ASTM 2141 durability
- Unobstructed glare control
- Increased natural daylighting
- HVAC energy savings
- ARRA and CRADA partner

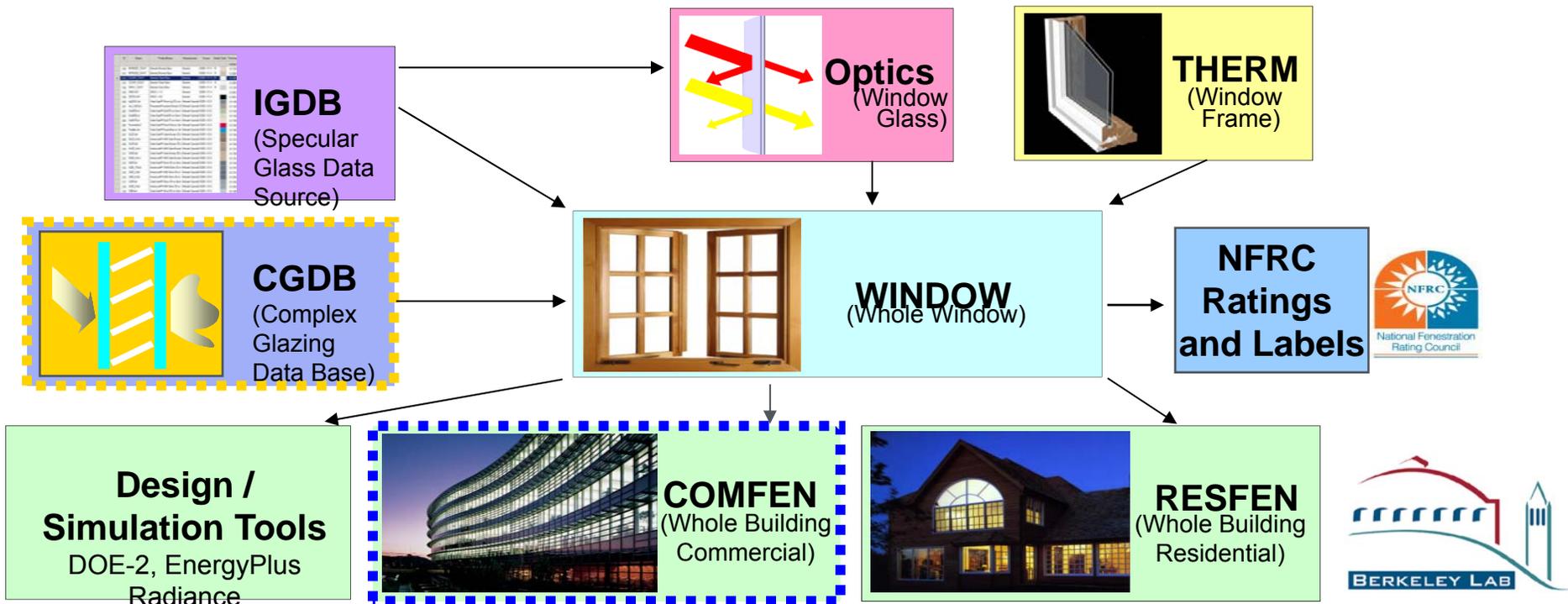


## High Volume Production

- State-of-the-art manufacturing facility
- Up to 5x10 foot Insulating Glass Units
- Production starting in Summer 2012

# Product Design and Building Impact Tools – Used by 80% of Industry

- Design tools for advanced products to optimize energy efficiency and cost
- ISO 15099 Compliant
- Basis for certified NFRC product ratings
- Performance tools used to design façade e.g. eliminate perimeter heating



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

<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

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.



National Fenestration  
Rating Council

[www.nfrc.org](http://www.nfrc.org)



Efficient Windows *Collaborative*

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

*Windows for High Performance  
Commercial Buildings*

[www.commercialwindows.org/](http://www.commercialwindows.org/)

*High Performance Volume  
Purchase Program*

[www.windowsvolumepurchase.org](http://www.windowsvolumepurchase.org)

*Window Attachments*

[www.windowattachments.org/](http://www.windowattachments.org/)

[www.eereblogs.energy.gov/buildingenvelope](http://www.eereblogs.energy.gov/buildingenvelope)

# High Quality Performance Impacts of Innovative Products

## Measurement of Interior and Exterior Blinds at LBNL



## NY Times Building Automatic Blinds and Lighting



## Exterior Insulation Finishing Systems (EIFS)

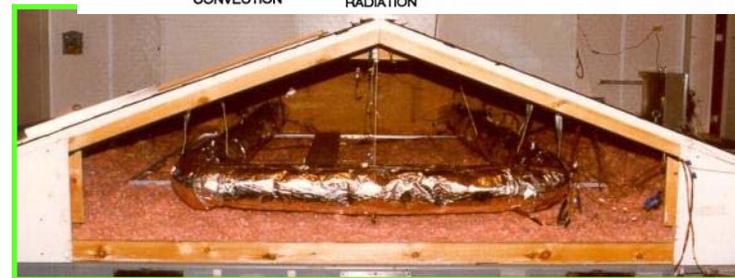
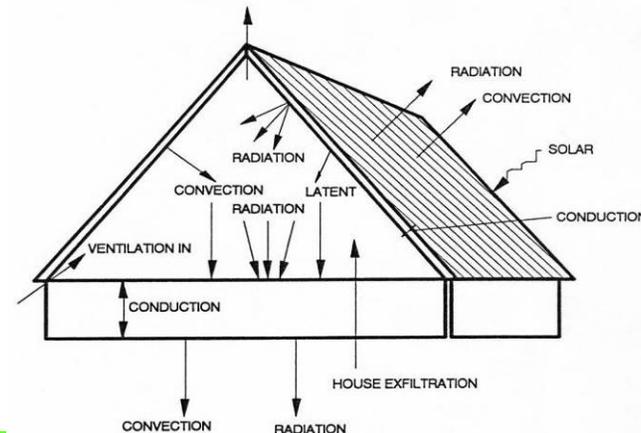


## Air Barriers at Syracuse University



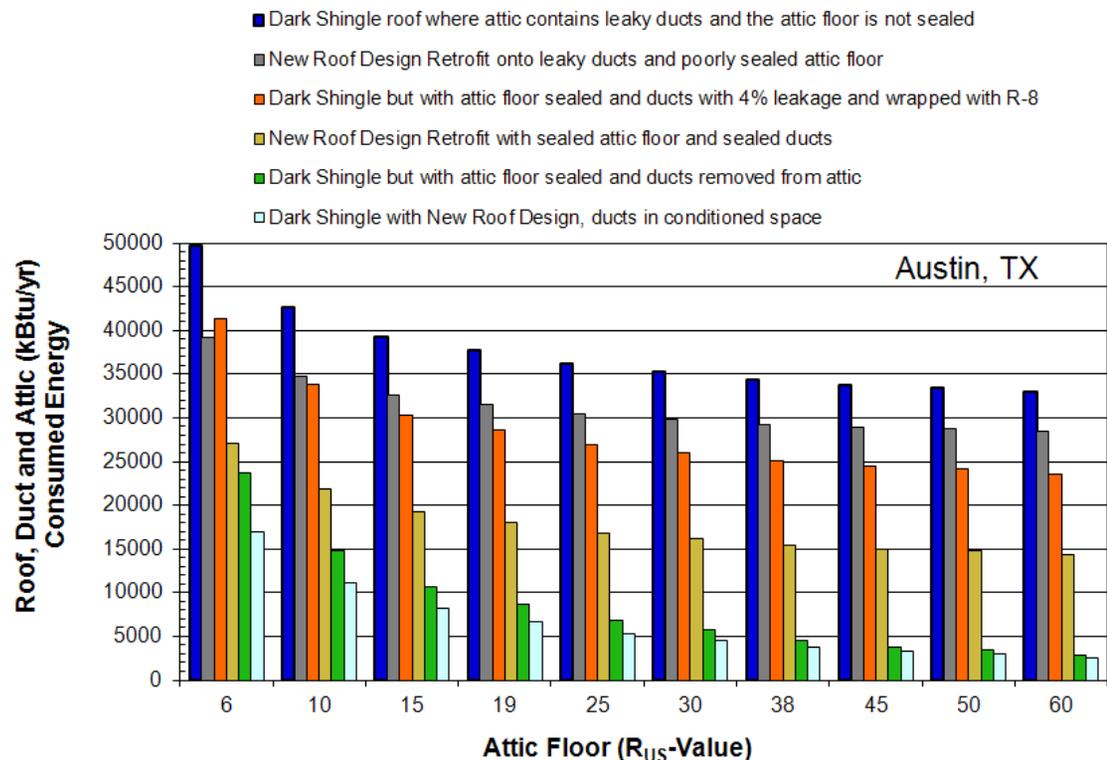
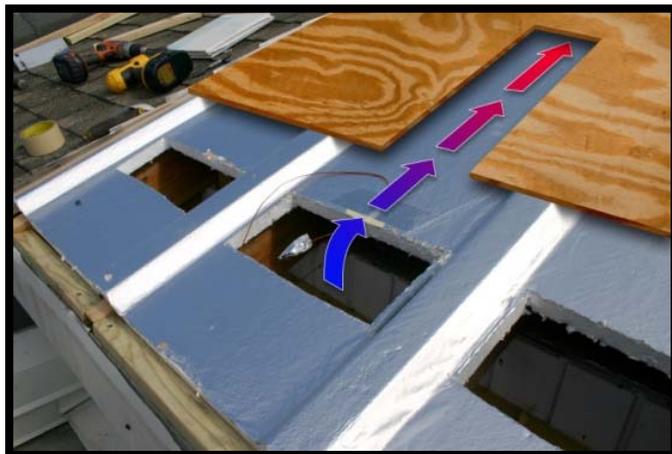
# Thermal Envelope R&D

- 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



# Next Generation of Attic/Roof Systems – Sloped Roofs

- Demonstrated 90 percent peak loading reduction
- > 35% cost effective energy savings
- Working with 3M and other partners to improve marketability
- Mostly residential, ~ 20 percent commercial market share



# Dow CRADA Develops Improved Commercial Cool Roofs

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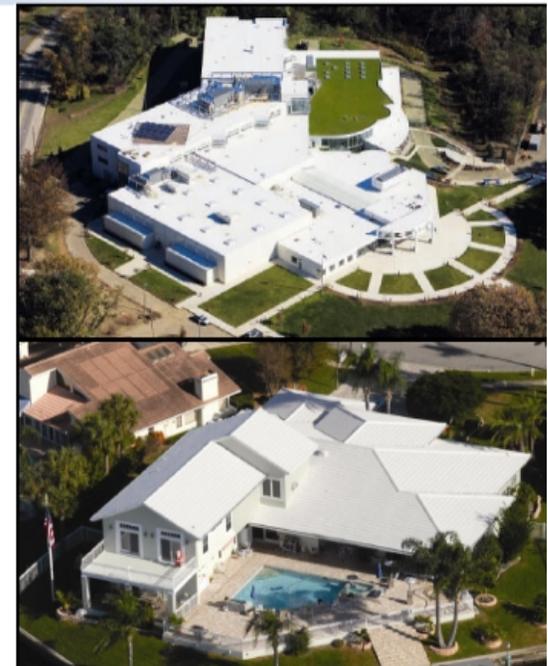
## CRADA Goals:

- Improve aged solar reflectance (SR) to 75%
- Develop an accelerated aging protocol
- Develop self-cleaning materials
- Evaluate de-soiling and anti-soiling additives/functionalities

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

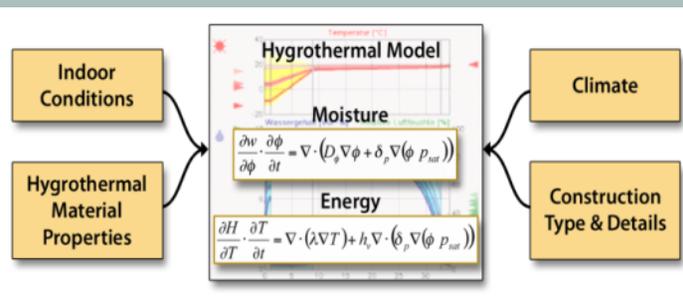
<http://www1.eere.energy.gov/femp/pdfs/coolroofguide.pdf>

# Moisture Research

- DOE-supported moisture engineering led to passage of ASHRAE Standard 160
- Continue WUFI cooperative development with Fraunhofer
- New foundation research

## 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](mailto: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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# 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	ASTM E2357	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
<b>TOTAL</b>	<b>21</b>	<b>21</b>	<b>21</b>	<b>21</b>	<b>16</b>		<b>25</b>	<b>22</b>

## Material Level

ASTM E 96: Water vapor transmission

ASTM C 1498: Hygroscopic sorption isotherms

ASTM E 2178: Air permeance

## Assembly Level

ASTM E 2357: Determining air leakage of air barrier assemblies

 To be determined

 Tentative

# Exterior Insulation Finishing Systems (EIFS)

- **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



- With increasing Executive Order directives, agency funding, and ESCO financing, opportunities for innovative measures should be greater
- Advanced cutting edge technology being developed
- New lower cost products (low e storms and low e window film)
- Support tools available to help assess envelope and façade opportunities
- Possible increased demonstrations with agencies and DOE

## Contact Information

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[www.eere.doe.gov](http://www.eere.doe.gov)

[www.eereblogs.energy.gov/buildingenvelope](http://www.eereblogs.energy.gov/buildingenvelope)