Adhesive and Sealant Council

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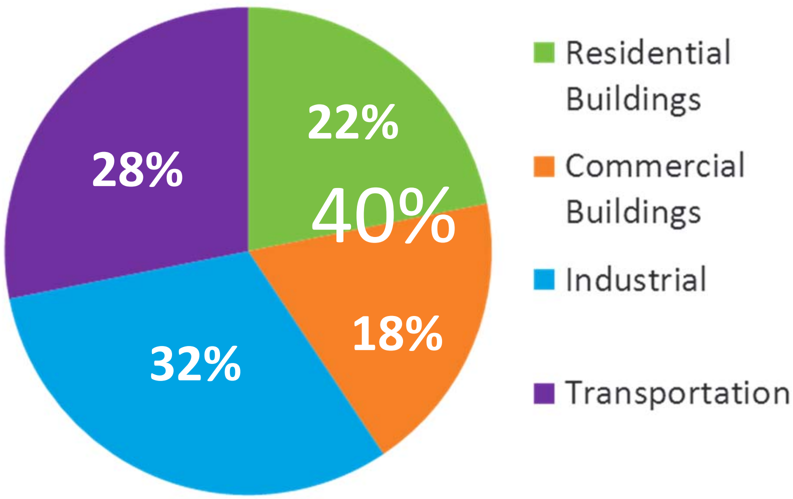
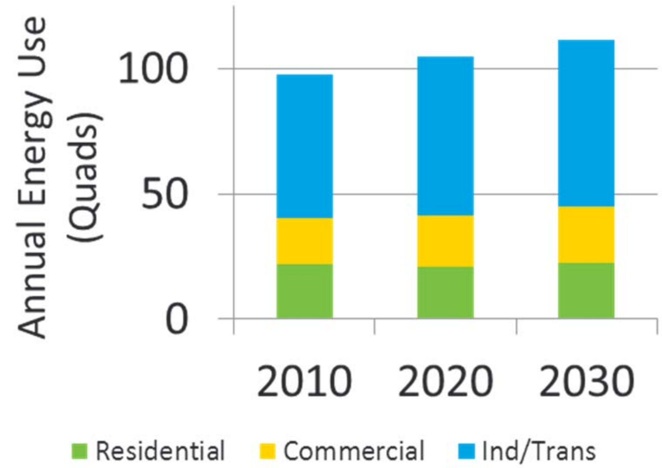
US DOE Building Envelope R&D Activity and Opportunities for the Adhesive and Sealant Industry

Marc LaFrance
US DOE
17 April 2012

U.S. Primary Energy Consumption

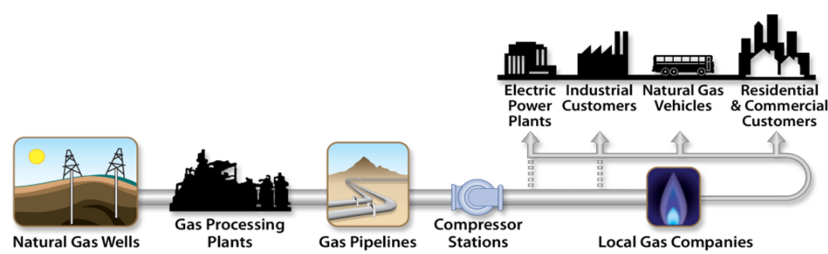


Total U.S. Energy Consumption



73% of U.S. Electricity Consumption

55% of U.S. Natural Gas Consumption



Building Consumption – Envelope Relationship

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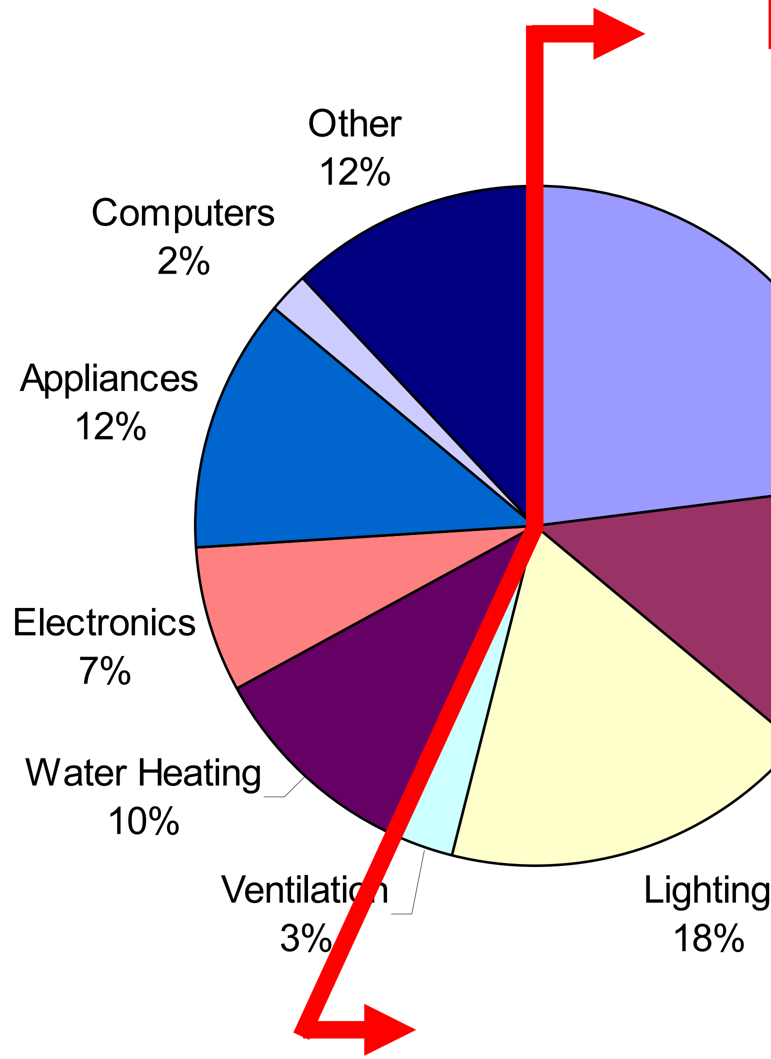

1/7 US Economy

- 133 Billion $/yr
- 13.9% US Energy
- 3.5% Global Energy

Buildings Energy Efficiency: Large % of CO_2 Savings Potential

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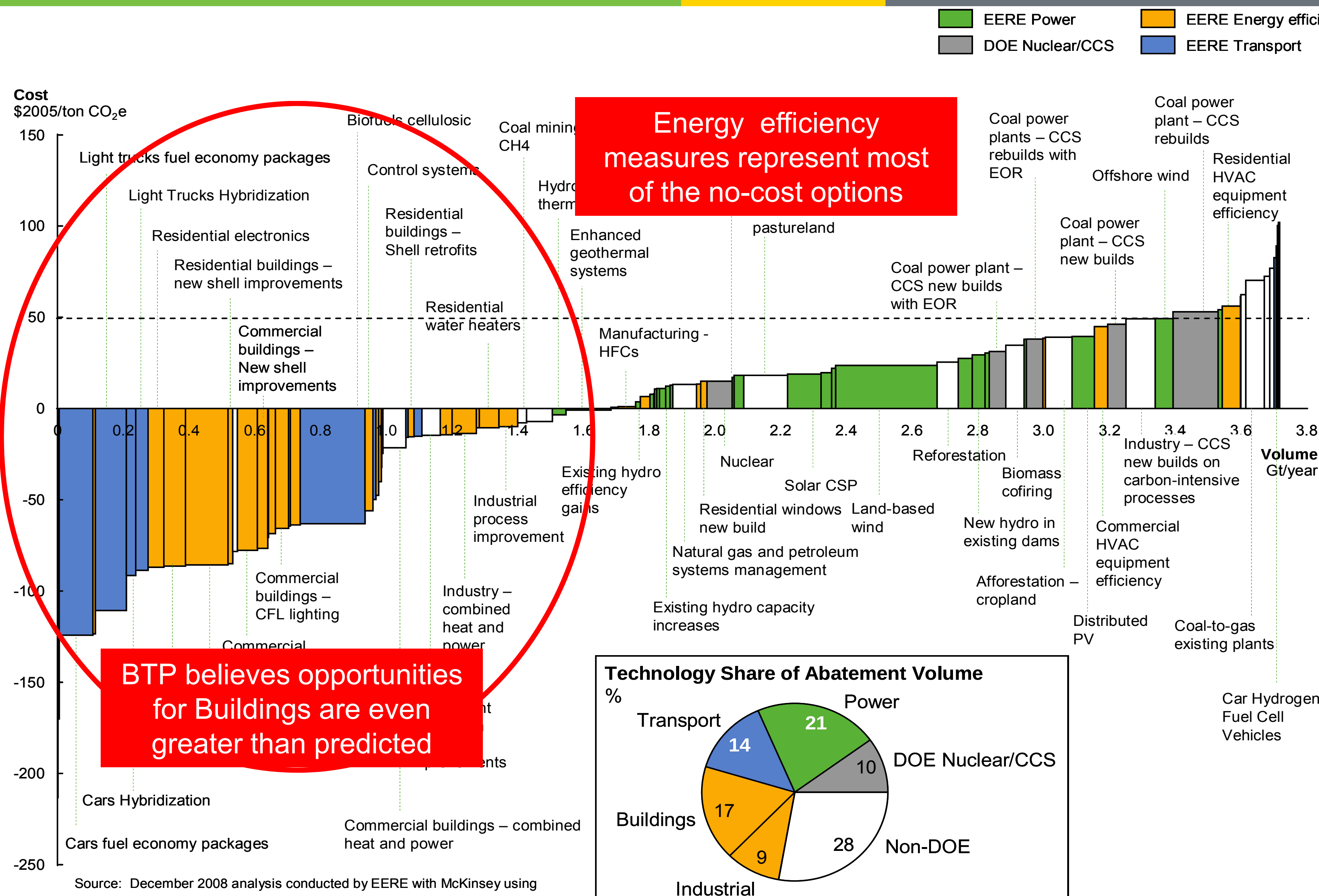

Source: December 2008 analysis conducted by EERE with McKinsey using 2008 DOE technology performance projections; mid-range case

Window Pathway

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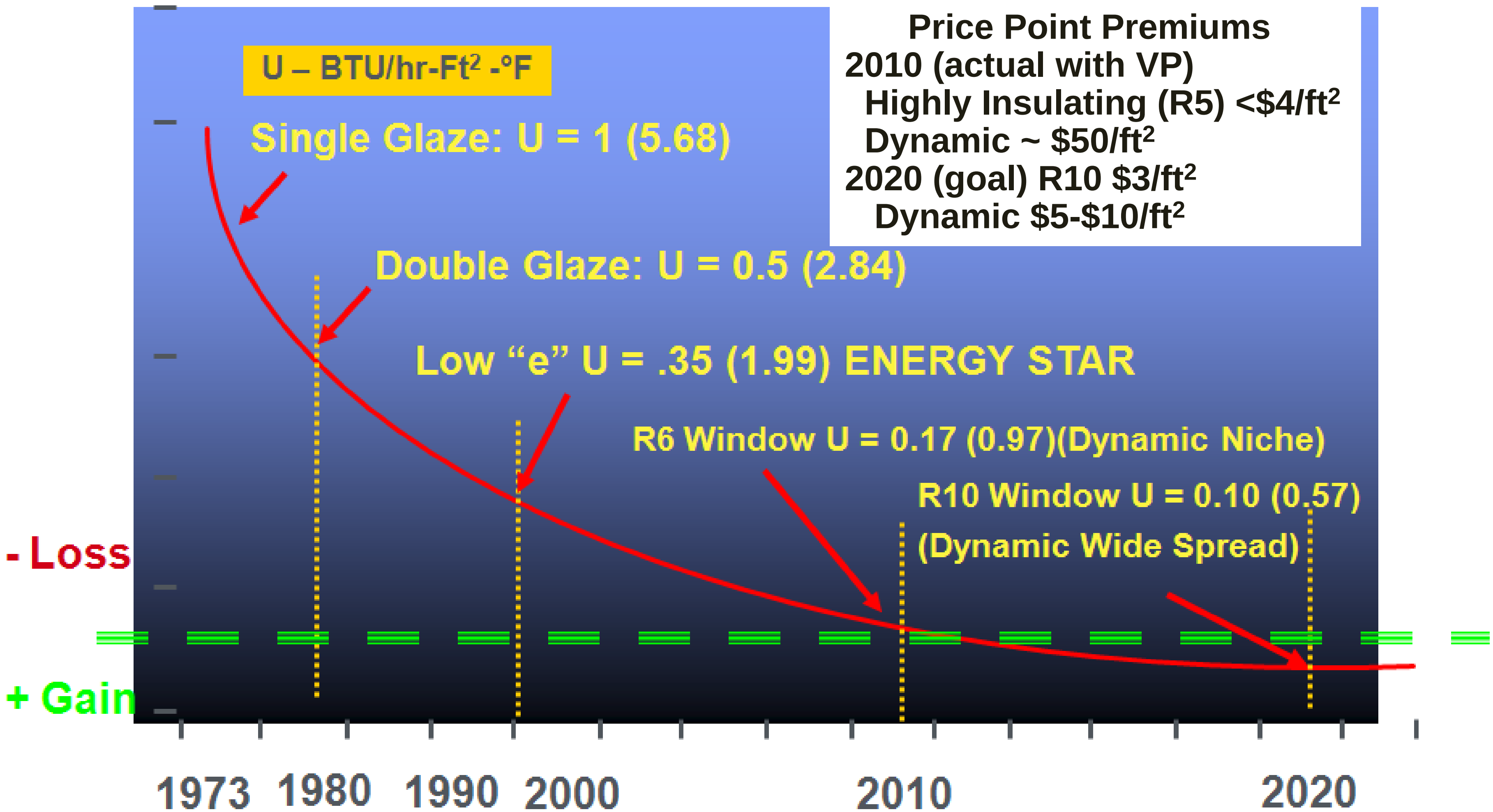
Advanced Windows Can Become Energy Producers

(US Mixed and Northern Climates)



Next Generation of Windows

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- 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 – 0.09

  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

Commercialization of Highly Insulating Dynamic Window in 2010

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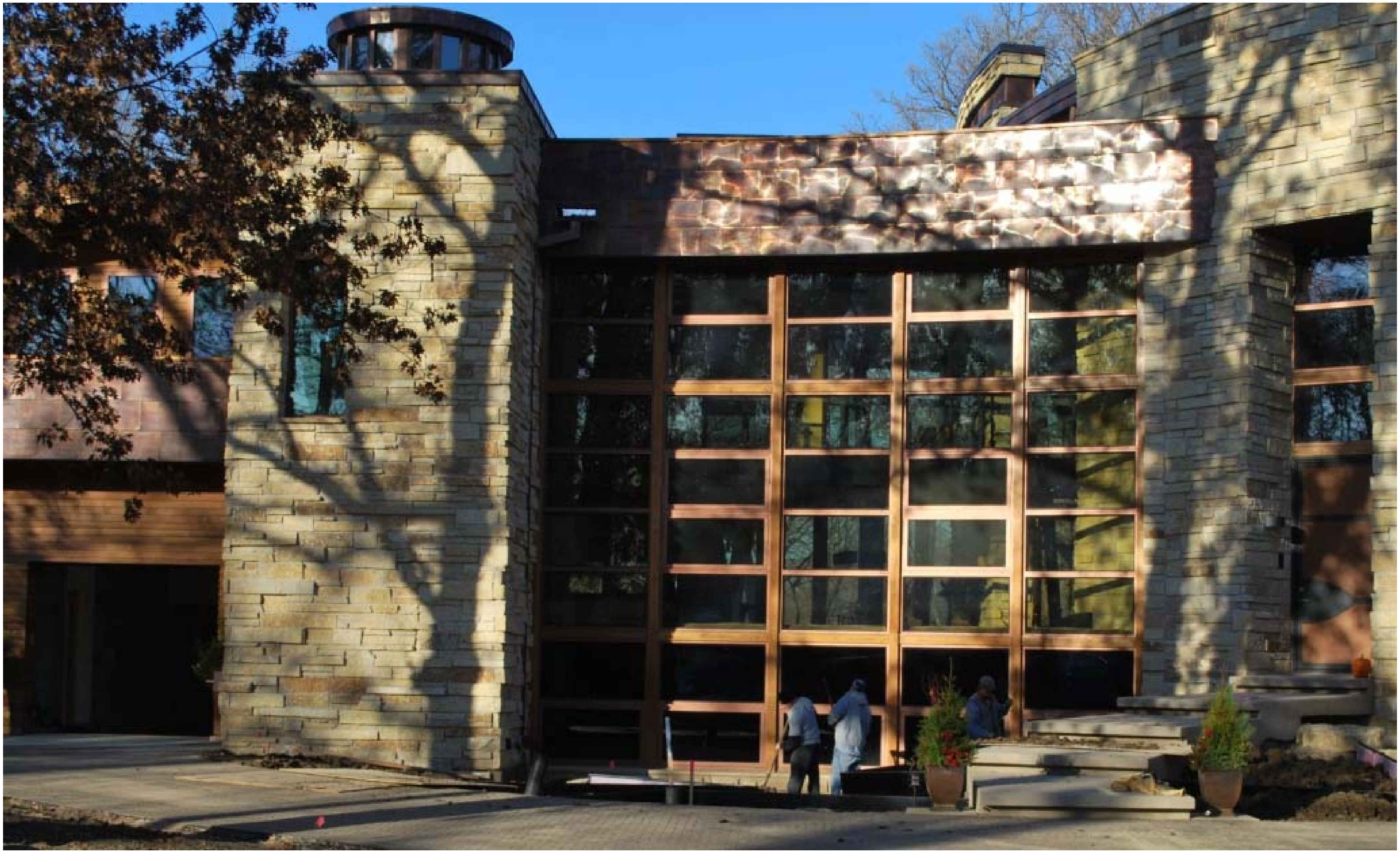

South facing large residential home in MN – Courtesy Sage Electrochromics

Window Installation

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- ASTM 2112 establishes standards for proper installation
- Major companies pursuing Installation Masters certification
- New proposed ENERGY STAR criteria will require guidance on installation
- Significant infiltration reduction can be realized from window replacement but currently not considered in policy formulation or by programs to determine window cost effectiveness
- DOE is interested in working with industry to pursue a way to properly assess benefits – high variability will be a challenge for adoption by promotional programs

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

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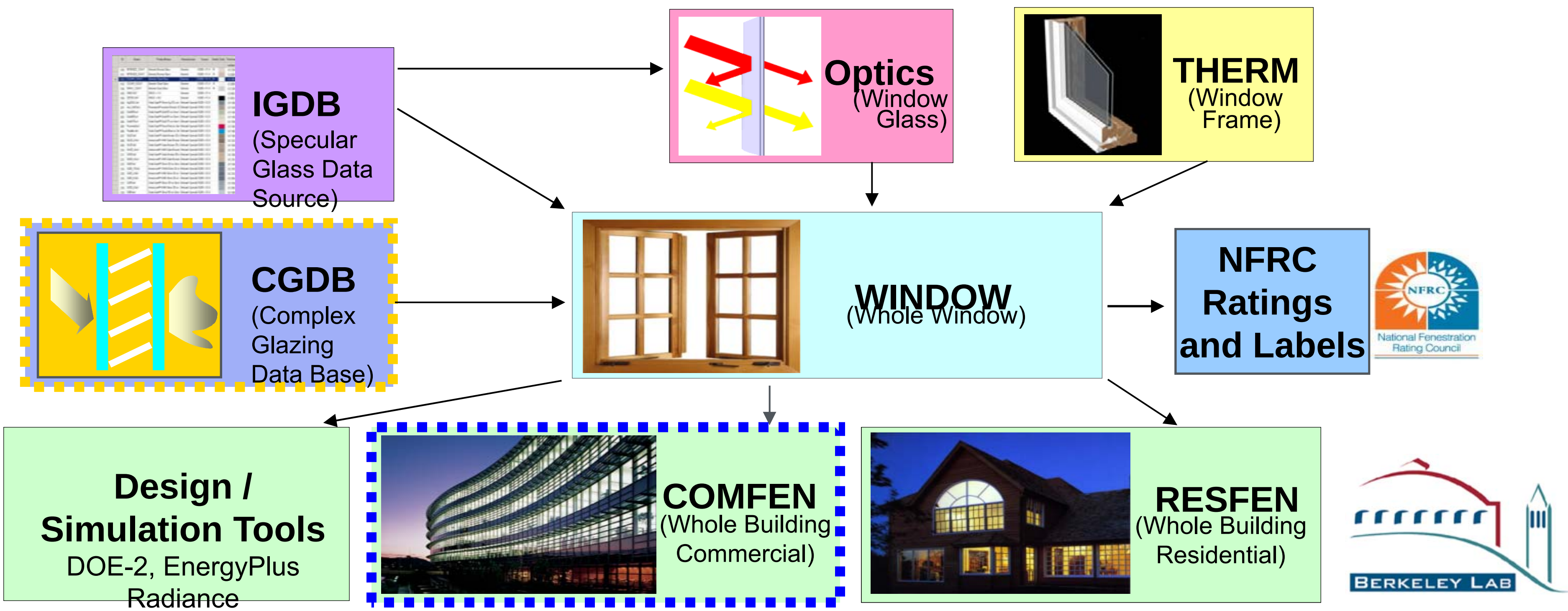
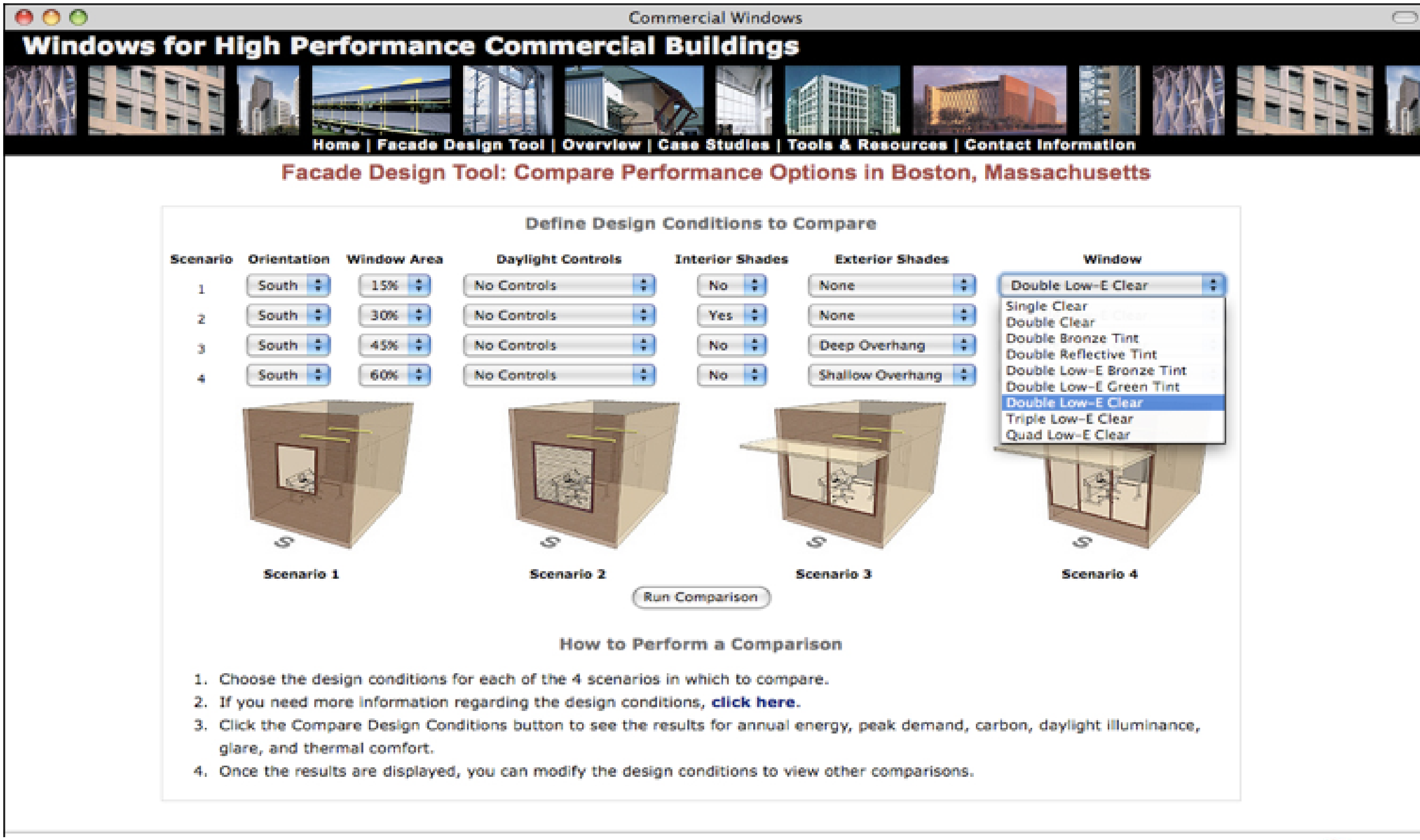
- **Design tools for advanced products to optimize energy efficiency and cost**
- **ISO 15099 Compliant**
- **Basis for certified NFRC product ratings**
- **Performance tools used to design façade e.g. eliminate perimeter heating**



http://windows.lbl.gov/software

Façade Design Tool

http://www.commercialwindows.org



Knowledge Base for Stakeholders

National Fenestration Rating Council

www.nfrc.org

Efficient Windows Collaborative

www.efficientwindows.org

Windows for High Performance Commercial Buildings

www.commercialwindows.org/

High Performance Volume Purchase Program

www.windowsvolumepurchase.org

Window Attachments

www.windowattachments.org/

www.eereblogs.energy.gov/buildingenvelope

High Quality Performance Impacts of Innovative Products

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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

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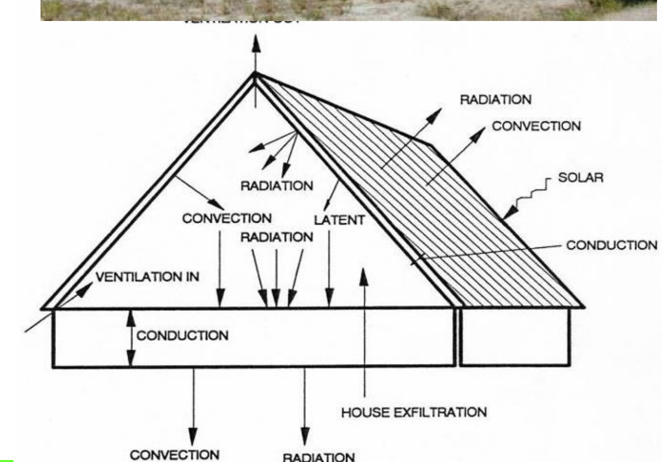
- Next Generation of Attic/Roof System to save 50 Percent Energy
- Advanced walls to reach R20 (U = 0.28 SI) in 3.5” (9cm) cavity, exterior insulation systems, R30 (U = 0.19 SI) total wall exterior insulation systems
- New Material Development
  - 100 R&D Award in 2009 for phase change insulation
  -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



Next Generation of Attic/Roof Systems – Sloped Roofs

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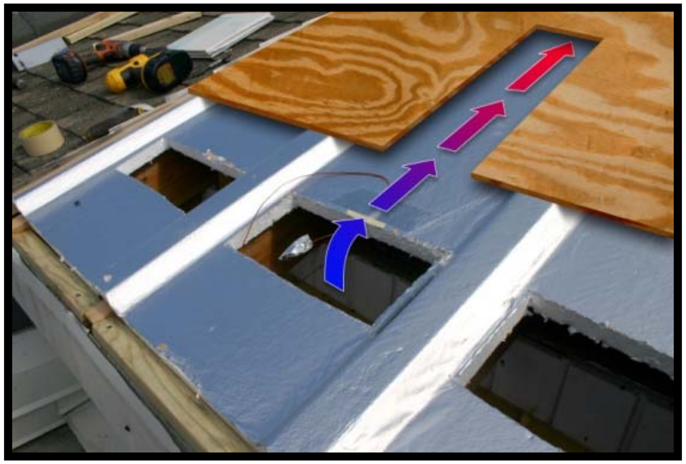
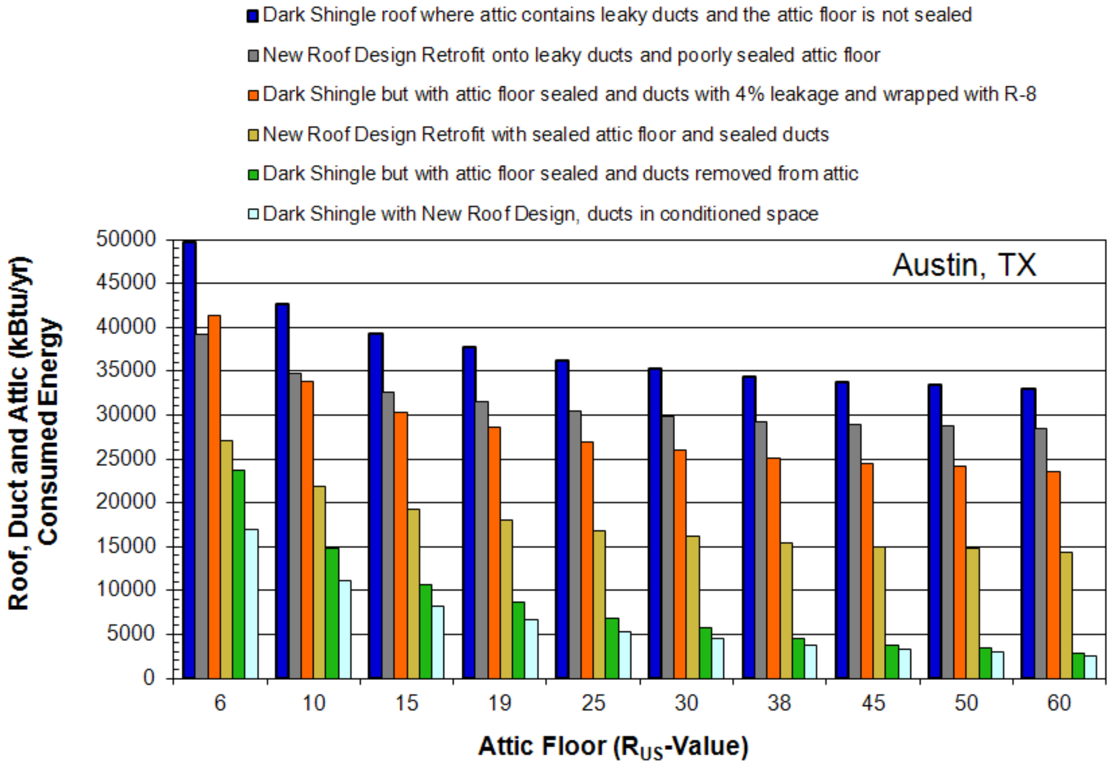
- Demonstrated 90 percent peak loading reduction
- > 35% cost effective energy savings
- Working with 3M and other partners to improve marketability
- Mostly residential, ~ 20 percent commercial market share





Dow CRADA Develops Improved Commercial Cool Roofs

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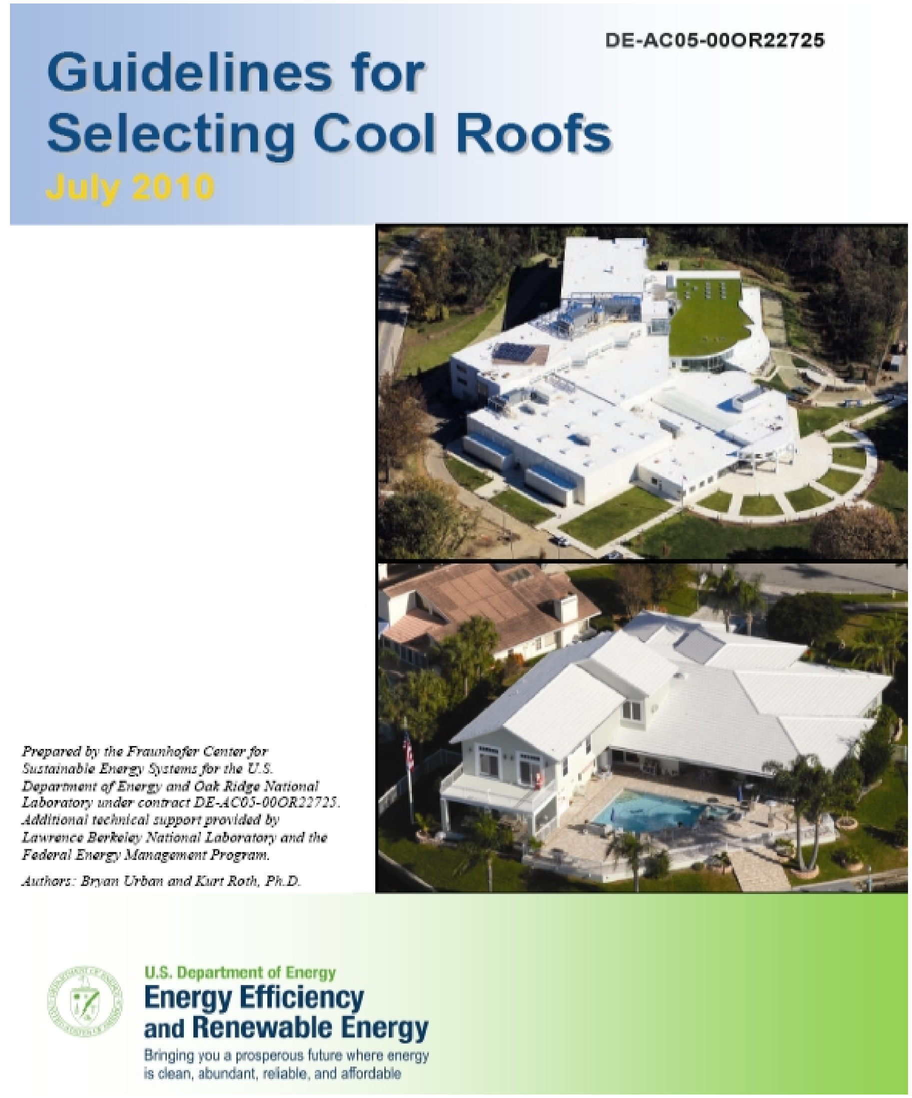
CRADA Goals:

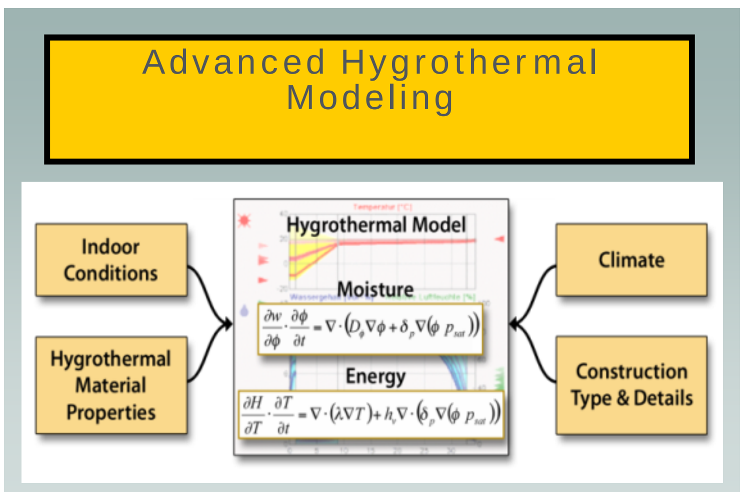
- Improve aged solar reflectance (SR) to 75%
- Develop a accelerated aging protocol
- Develop self-cleaning materials
- Evaluate de-soiling and anti-soiling additives/functionalities

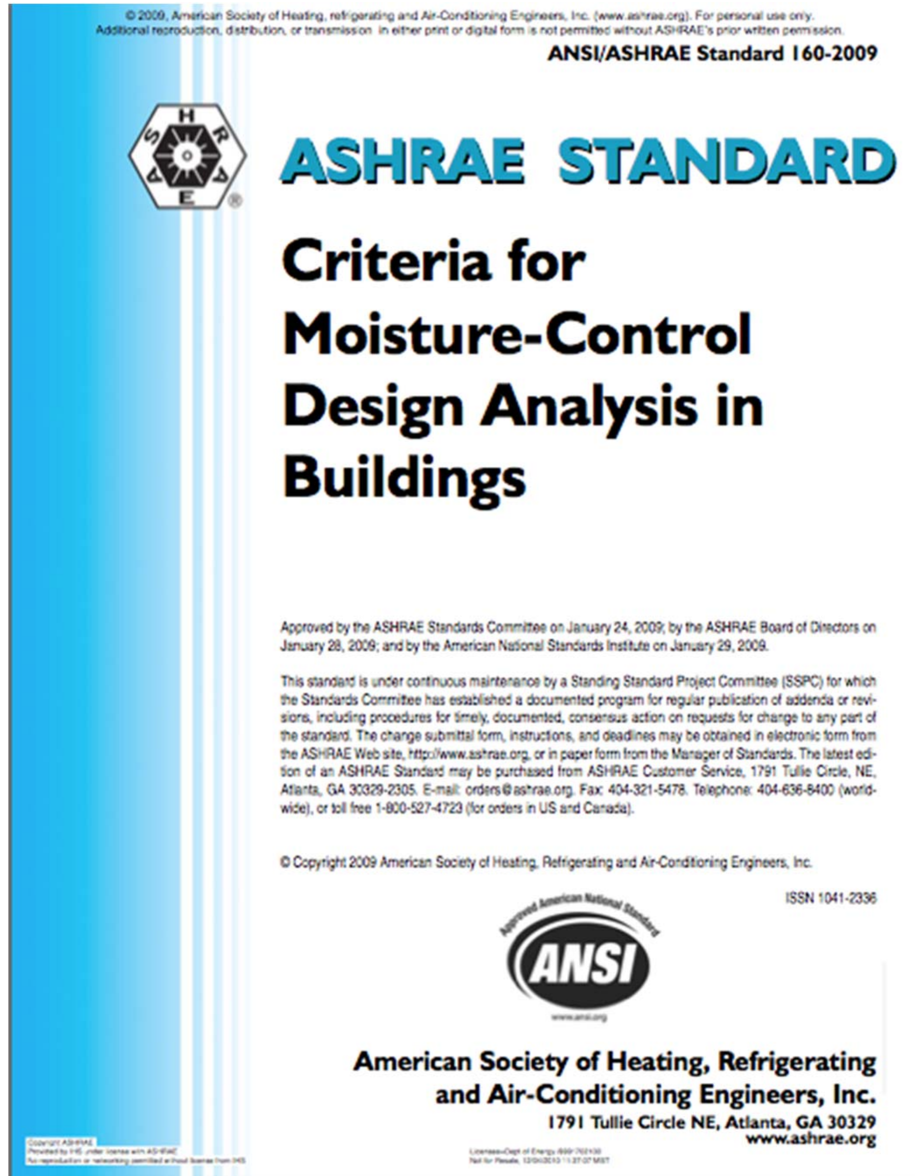


http://www1.eere.energy.gov/femp/pdfs/coolroofguide.pdf

- 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)





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 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

ISSN 1041-2336

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

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

Air Barriers for Residential and Commercial Buildings

- Objectives
  - Quantify energy benefits from air barriers with field data
  - Study the effect of air barriers on material durability
  - Characterize properties of air barriers
  - Use field data and material properties to benchmark simulation tools
  - Identify major sources of air leakage
  - Evaluate sealing mechanisms


Interior

Spray-applied foam


Mechanically fastened


Non-insulating board stock


Insulating board stock


Sealers w/ backup structure


Self-adhered


Fluid-applied non-foaming

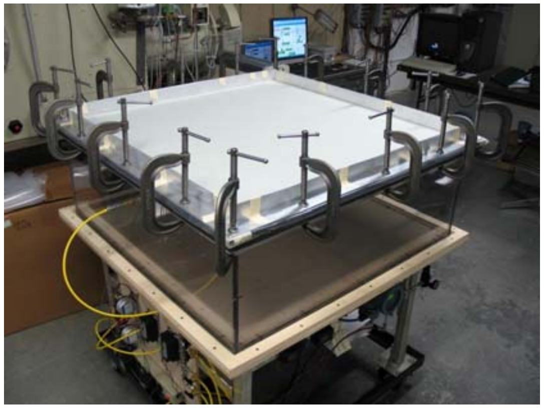
Research Partners

New York State
Energy Research and Development Authority

Syracuse University

Material Characterization

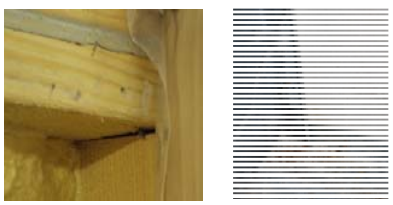
- Air permeance (ASTM E 2178 – 03)
- Water vapor permeance (ASTM E 96 – 10)
- Sorption isotherms (ASTM C 1498 – 04a)
- Liquid uptake



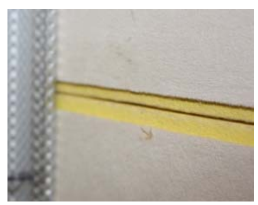
Phase 1 at Syracuse Natural Exposure Testing Facility

- Test facility
  - Conditioned indoor environment
  - Weather station
  - Pressurization setup for building and panels

- Identified air leakage paths and installation problems



Stud/plate interface



Exterior sheathing joint

Unsealed perimeter of penetrations

Detached membrane

Void in spray foam

Unsealed electrical outlet

Spray foam pullout

Phase 2 at Syracuse Natural Exposure Testing Facility

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Evaluation of 8 air barrier types

Interior

Spray-applied foam

Mechanically fastened

Non-insulating board stock

Insulating board stock

Sealers w/ backup structure

Self-adhered

Fluid-applied non-foaming

Phase 2 at Syracuse Natural Exposure Testing Facility

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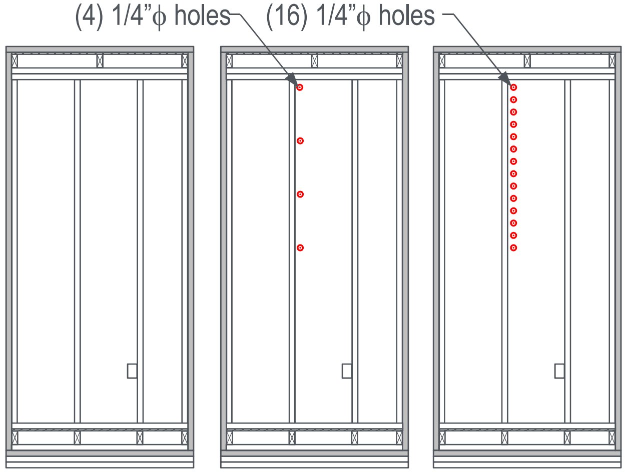
- 3 panels per air barrier type
  - Level 1 < 0.02 L/(s.m^2) (material)
  - Level 2 ~ 0.2 L/(s.m^2) (assembly)
  - Level 3 ~ 1 L/(s.m^2) (enclosures)

  ΔP = 75 Pa

- Simulated imperfections

Simulated imperfection
OSB joint at stud



Phase 2: Preliminary Results at ΔP = 12.6 Pa

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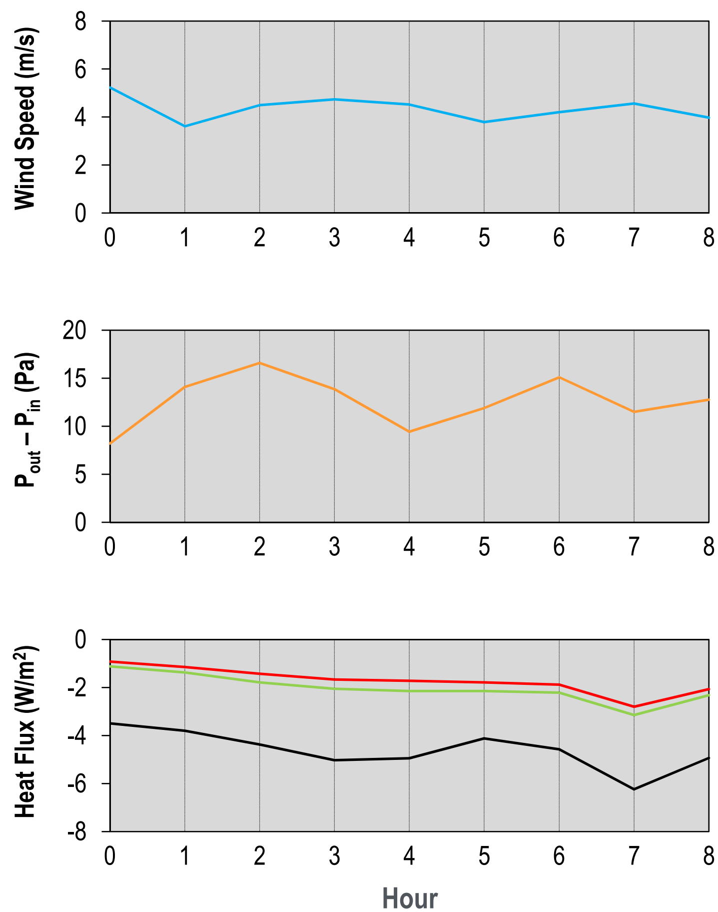
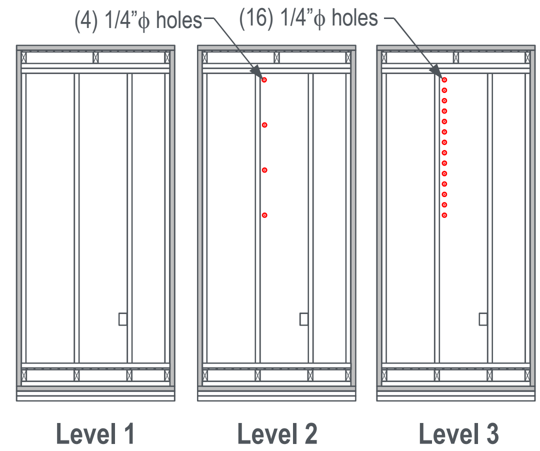
November 3, 2011

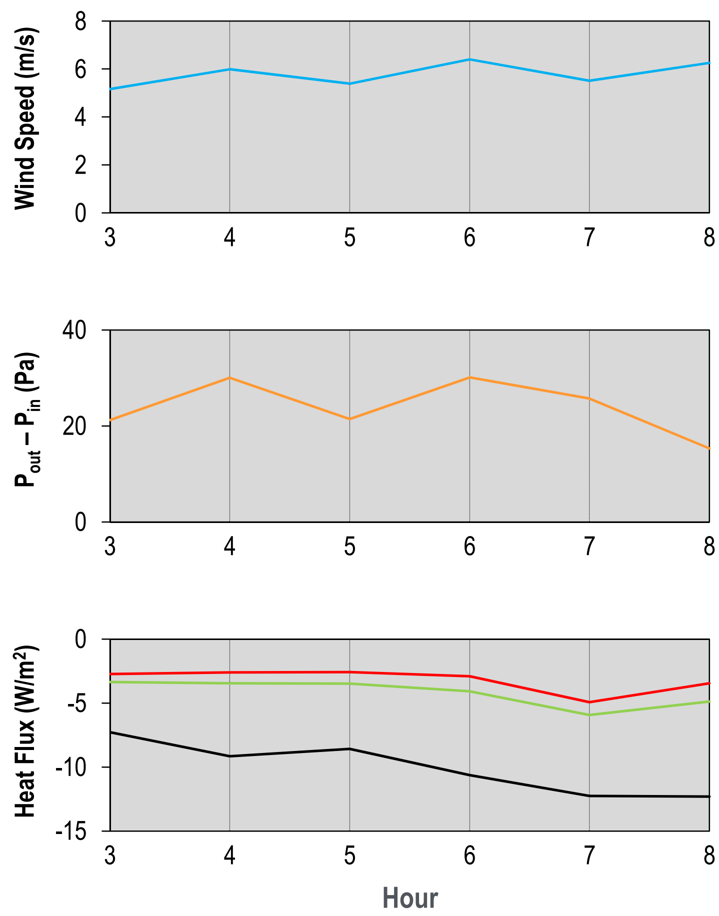


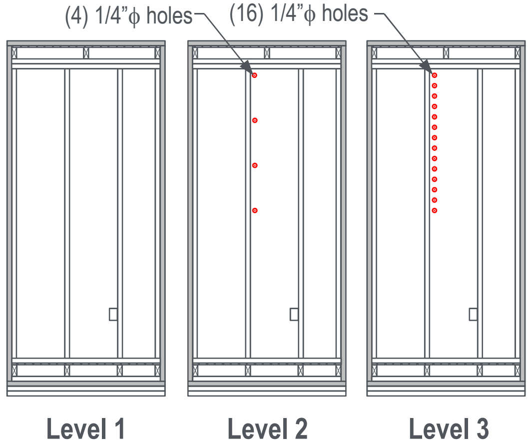


	Air Leakage [L/(s.m²)] at ΔP = 12.6 Pa	Avg Heat Flux (W/m²)
Level 1	< 0.02	-1.7
Level 2	~ 0.08	-2.0
Level 3	~ 0.23	-4.6

Phase 2: Preliminary Results at ΔP = 21.3 Pa

November 6, 2011

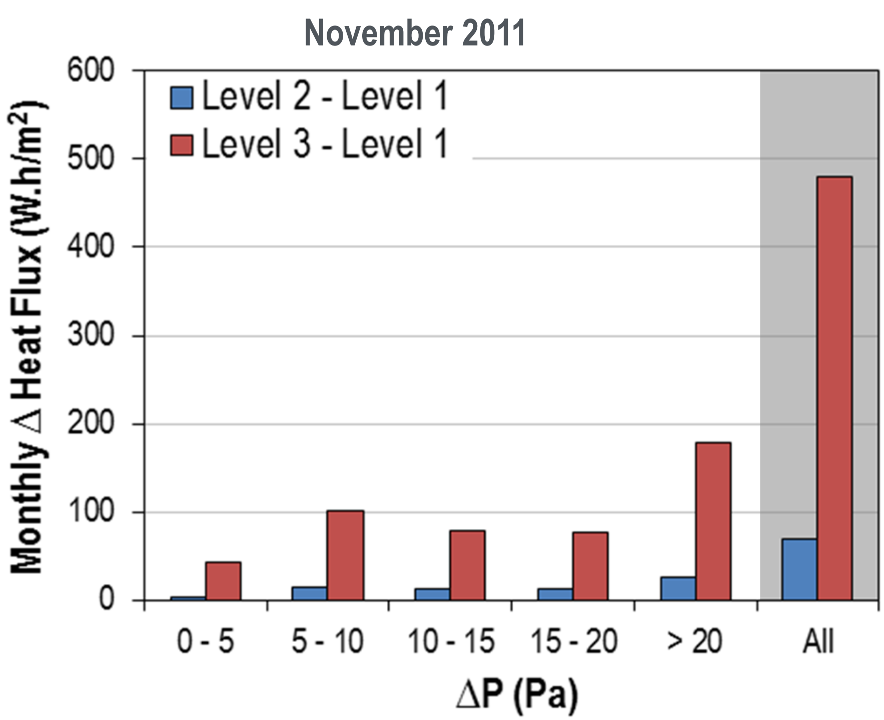


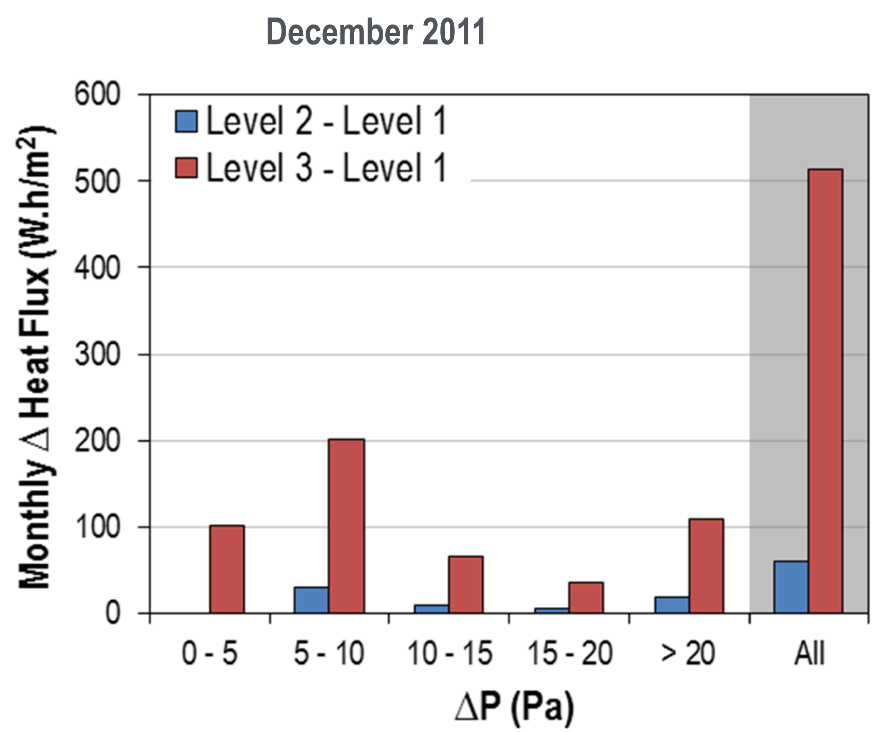


	Air Leakage [L/(s.m²)] at ΔP = 21.3 Pa	Avg Heat Flux (W/m²)
Level 1	< 0.02	-3.2
Level 2	~ 0.11	-4.2
Level 3	~ 0.33	-10

Phase 2: Preliminary Monthly Results

Quantify energy benefits from air barriers with field data





Reference Tests

Level 1 < 0.02 L/(s.m^2) Level 2 ~ 0.21 L/(s.m^2) Level 3 ~ 0.72 L/(s.m^2) at ΔP = 75 Pa

Phase 2: Predict Air Barrier Benefits

Material properties

+

Field data

→

Validate simulation tools

Future Assessments

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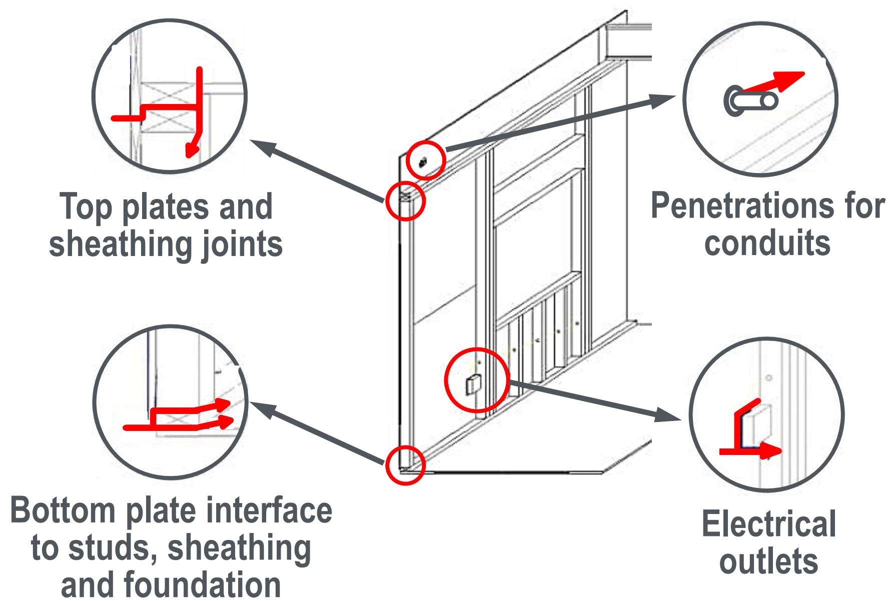
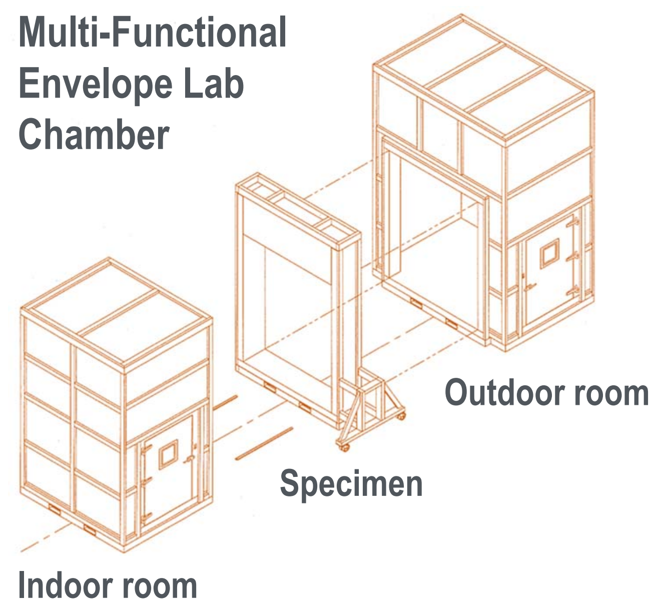
- Characterize typical air leakage paths in walls
  - Based on literature and input from manufacturers
- Identify major sources of air leakage
- Evaluate methods to seal significant sources of leakage





Can we Develop New Solutions to Reduce Labor, Increase Rate of Implementations

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New Guidelines with DOE Support

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BUILDING TECHNOLOGIES PROGRAM

Measure Guideline: Sealing and Insulating Ducts in Existing Homes

R. Aldrich and S. Puttagunta
Consortium for Advanced Residential Buildings (CARB)

December 2011

Building America
U.S. Department of Energy

GUIDE TO ATTIC AIR SEALING

IDENTIFYING AND BLOCKING AIR LEAKAGE PATHWAYS PROVIDING AIRTIGHT CLOSURE

Attics should be air sealed prior to adding insulation. Adding insulation alone does not save much energy and can lead to health and durability problems. The intent of this guide is to provide information for the preparation work necessary prior to adding attic insulation.

Inspect the House	Inspect the work area, check for combustion appliances, controlled ventilation, and required attic ventilation. Develop the work plan. See page 3 and Appendix A.
Do Not Proceed If:	▪ The house attic has active knob and tube wiring ▪ The house attic has vermiculite insulation ▪ The house attic has bathroom fans vented into the attic ▪ The house has a leaking roof ▪ The house has an unvented kerosene heater or gas fireplace
1. Combustion Safety	Combustion air is required. If you have gas or oil-fired furnaces or gas or oil-fired water heaters or boilers that have natural draft chimneys combustion air supplied directly from the outside is required. Test for backdrafting. The best approach is to replace natural draft appliances with sealed combustion, induced draft or power-vented furnaces, boilers and water heaters. Install carbon monoxide detectors. See page 5.
2. Ventilation for Indoor Air Quality	Controlled ventilation is required. As a minimum, houses require an exhaust, supply or balanced controlled mechanical ventilation system. See page 10.
3. Attic Ventilation for Durability	Attic Ventilation is required. All roofs must be vented according to the applicable building code. See page 12.
Air Seal the Attic	Follow the details provided in this Guide. See page 15.
5. Then Insulate	Install according to manufacturer's instructions, including all safety, performance and quality assurance requirements.

bsc Building Science Corporation

IECC: Airtightness in Commercial Buildings – Future for Testing

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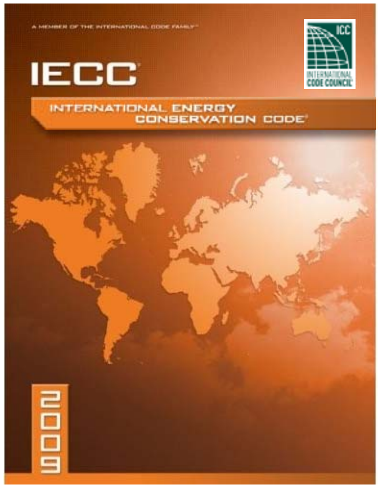
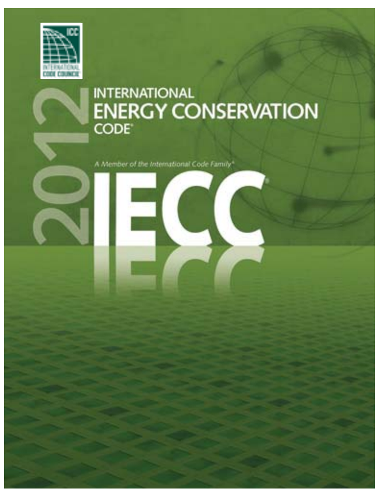


502.4.3 Sealing of building envelope. Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location.



C402.4.1 Air barriers. A continuous air barrier shall be provided throughout the building thermal envelope. Exception: Not required in Climate Zones 1, 2 and 3.

C402.4.1.2 Air barrier compliance options. A continuous air barrier for the opaque building envelope shall comply with C402.4.2.1, C402.4.2.2 or C402.4.2.3.

- **C402.4.2.1 Materials**. Materials with an air permeability no greater than 0.02L/s.m^2 at 75 Pa when tested in accordance with ASTM E 2178 shall comply with this section.
- **C402.4.2.2 Assemblies.** Assemblies of materials and components with an average air leakage not to exceed 0.2 L/s.m^2 at 75 Pa when tested in accordance with ASTM E 2357, ASTM E 1677 or ASTM E283 shall comply with this section.
- **C402.4.2.3 Building test.** The completed building shall be tested and the air leakage rate of the building envelope shall not exceed 2.0 L/s.m^2 at 75 Pa.

Energy Impact of Infiltration

- Rough estimate for infiltration impact
  - Residential approximately 2.2 quads
  - Commercial approximately 0.60 quads
- Ventilation impact in commercial buildings approximately 2.2 quads
- Large opportunity for commercial is optimization of infiltration and ventilation control

Residential Cost Effectiveness – NREL Database (Cost/Each % Improvement)

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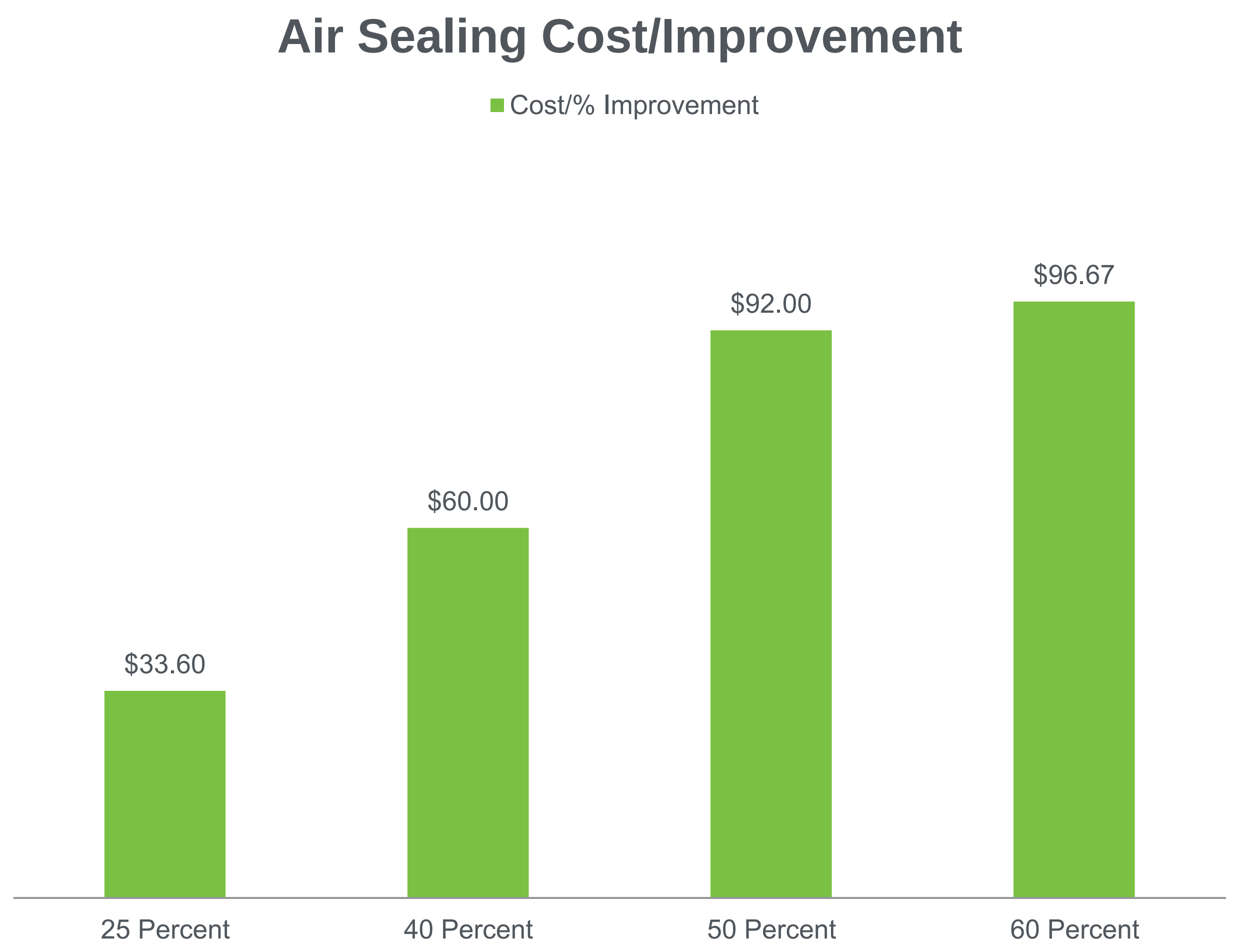

Final Remarks

- Reduced infiltration is a major area for energy efficiency
- Solutions exist but greater effort is needed to implement
- Can technological solutions reduce labor cost and increase market adoption
- How can we move from research and advanced housing to mainstream implementation
- Is industry interested in working with DOE to properly assess reduced infiltration attributed to window replacements

Contact Information

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www.eereblogs.energy.gov/buildingenvelope