

Low-E Storm Windows: A Coming of Age

Emerging Technologies Showcase

December 2, 2015

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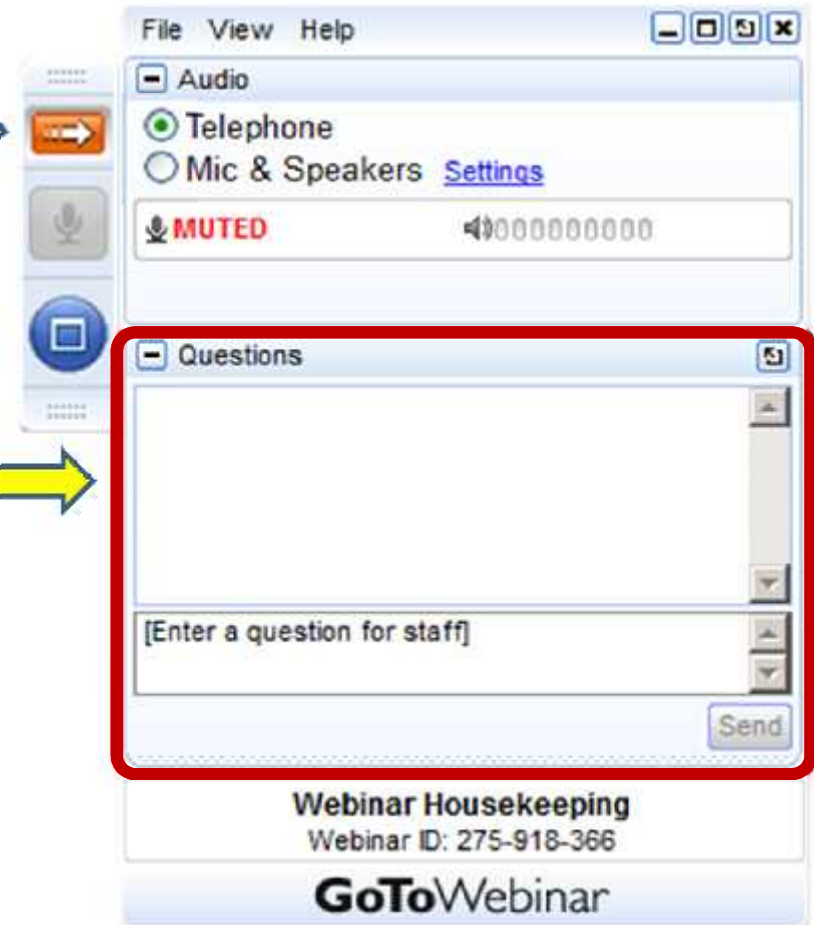
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Presenters:

**Terry Mapes – ACS Professional Staffing
Contractor to BPA**

Sarah F. Moore – BPA Residential Lead



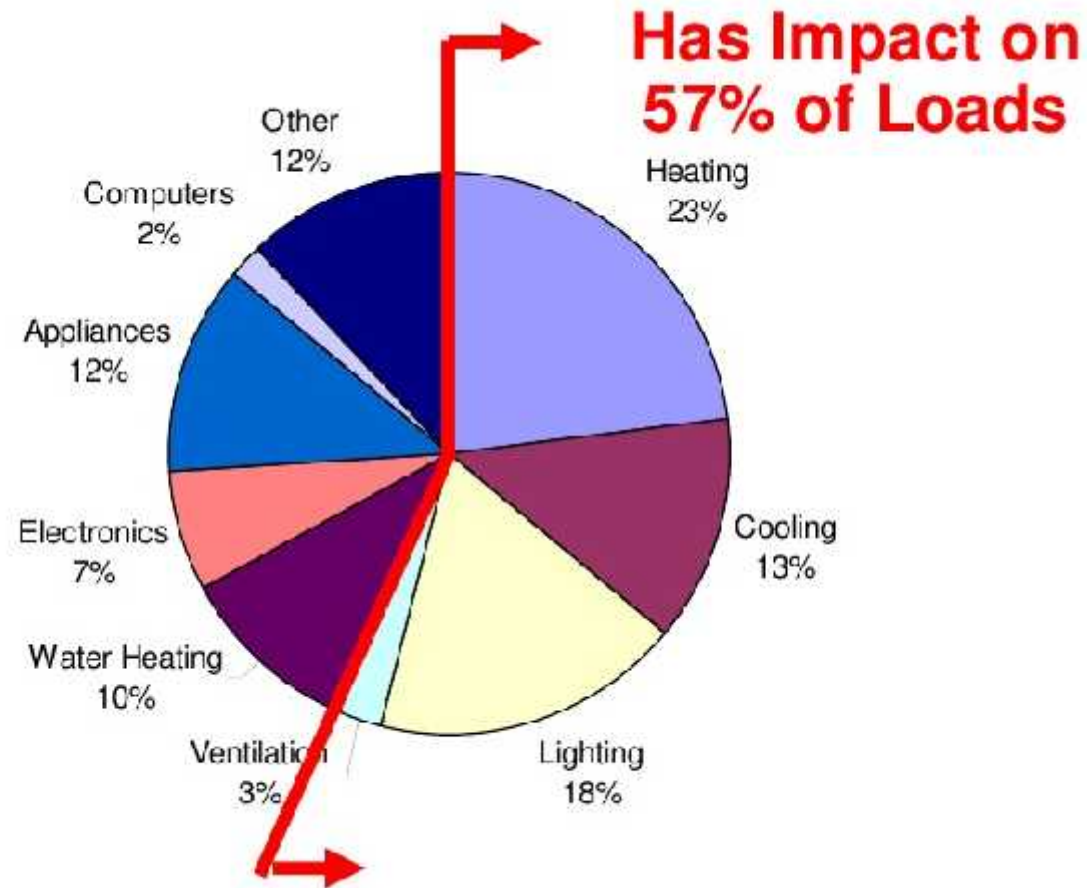
Forty Years - A Coming of Age

- Storm windows originally designed to protect primary windows, not conserve energy
- Greatest barriers to adoption were created shortly after introduction of secondary glazing systems in 1970s
- Energy Conservation increased focus in U.S. in 1990s
- LBNL identified storm windows as having tremendous potential to reduce heat loss in homes (circa 2000)
- Redesign of storm windows as energy saving product in last ten years created opportunity to improve esthetics
- Despite advances, many stigmas from the past remain

Subject Areas

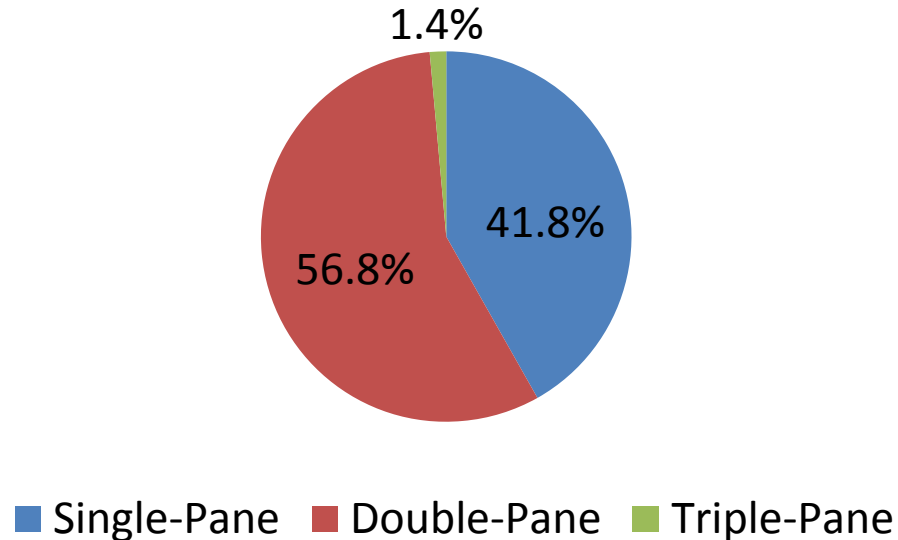
- The need for window improvement technologies
- Performance and price in today's market
- Ratings and incentives available now and tomorrow
- Questions and Answers

Impact of Windows on Typical Building Performance



Existing Potential for Retrofits

Percent of Single Family Homes in the US with Each Window Type

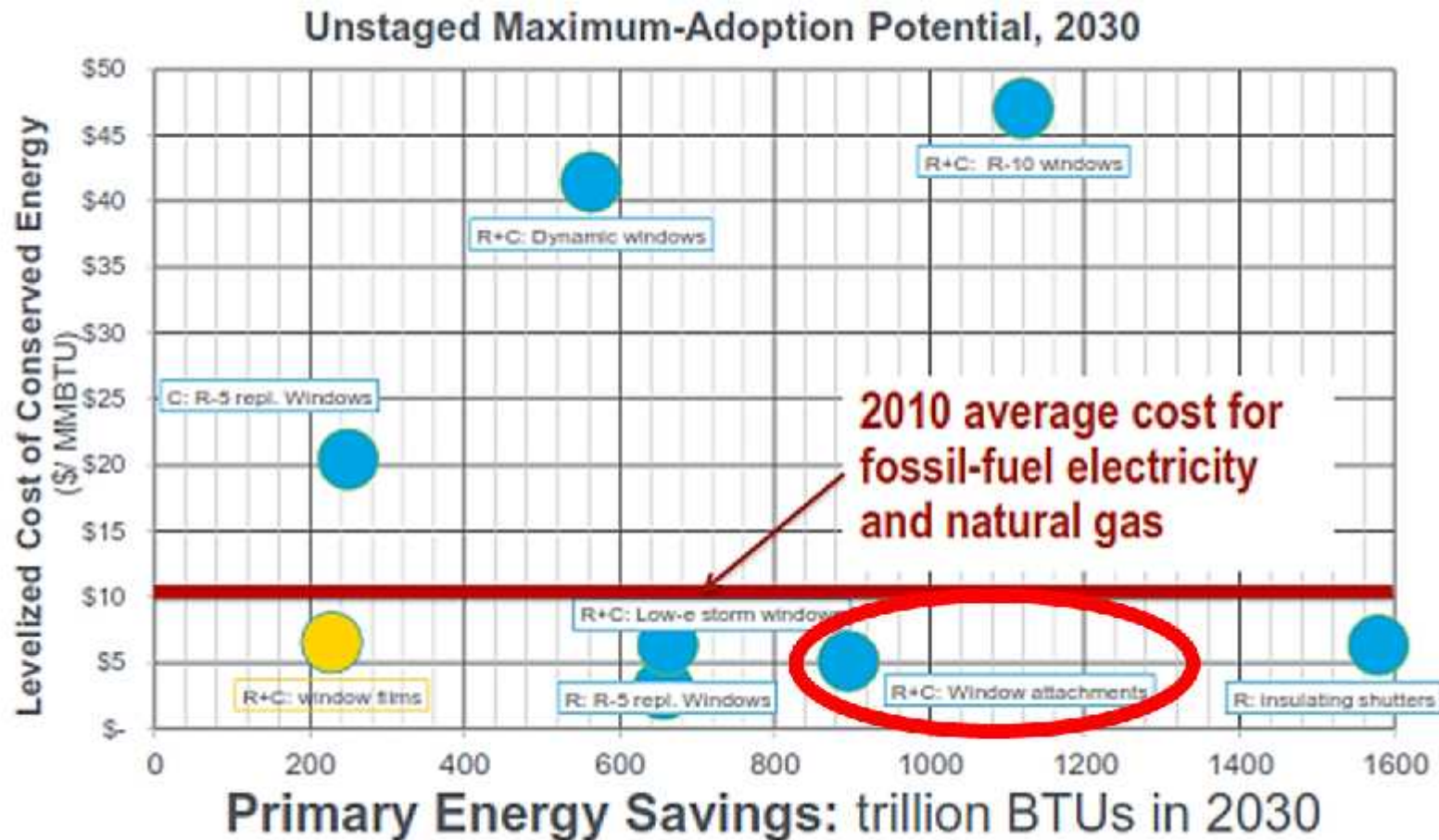


- 19 billion ft² of existing windows, ~42% with single pane glass
- ~47 million homes with single glazing, ~46 million with double pane clear¹

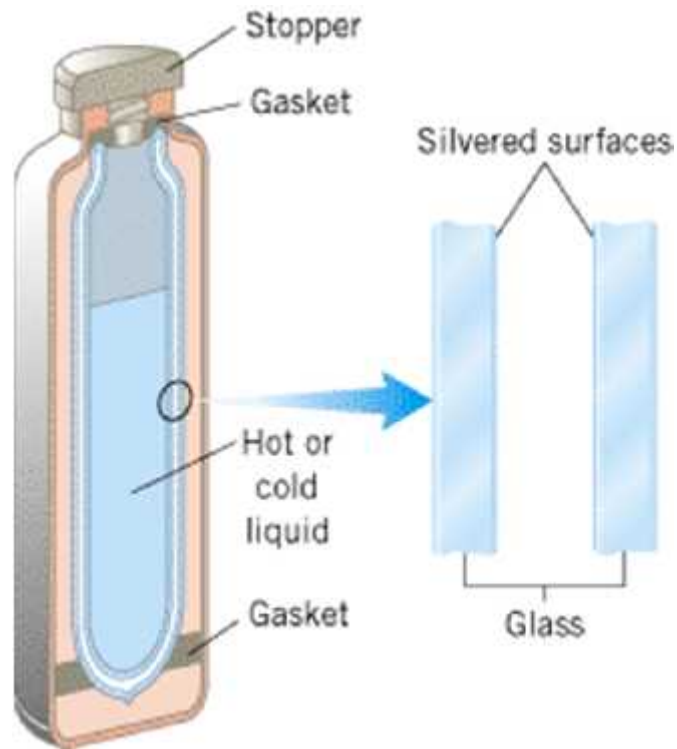
Secondary glazing systems can dramatically impact heat exchange through single pane and double pane windows

¹Cort (2013) and DOE-EIA

DOE Prioritization Tool: Unstaged Potential



Low-E Coating



E = emissivity: the percentage of Incident radiation which passes through

Predecessor to low-E window coatings
In thermos lining

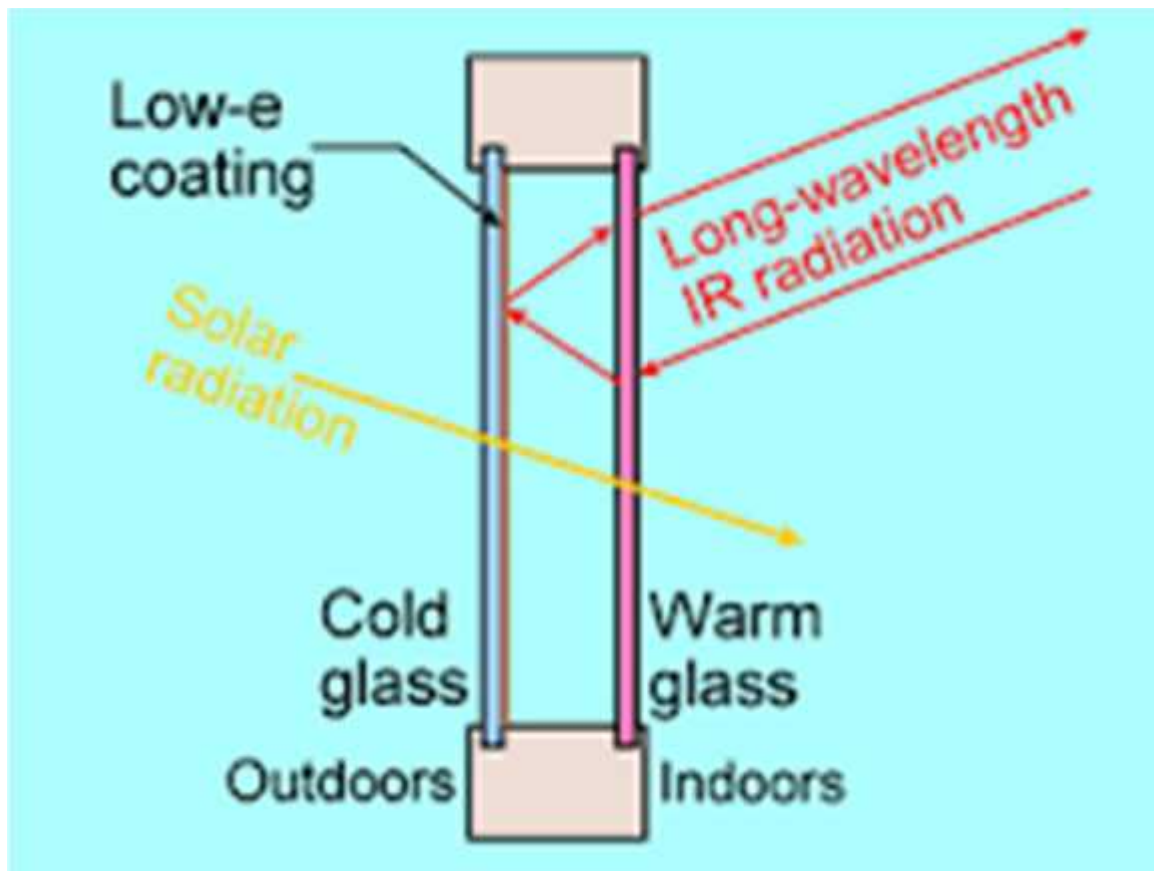
Coating is added to glass in semi-molten state, called 'pyrolytic' or 'hard' coat

Cost is pennies per ft² to manufacturer

Coating should always face the primary window

Image courtesy of
Waldorf HS, Portland, ME

Thermal Conductivity of Air



Material	K*
Aluminum	240
Glass	1.05
Vinyl	0.25
Wool	0.039
Air	0.024
Argon	0.016

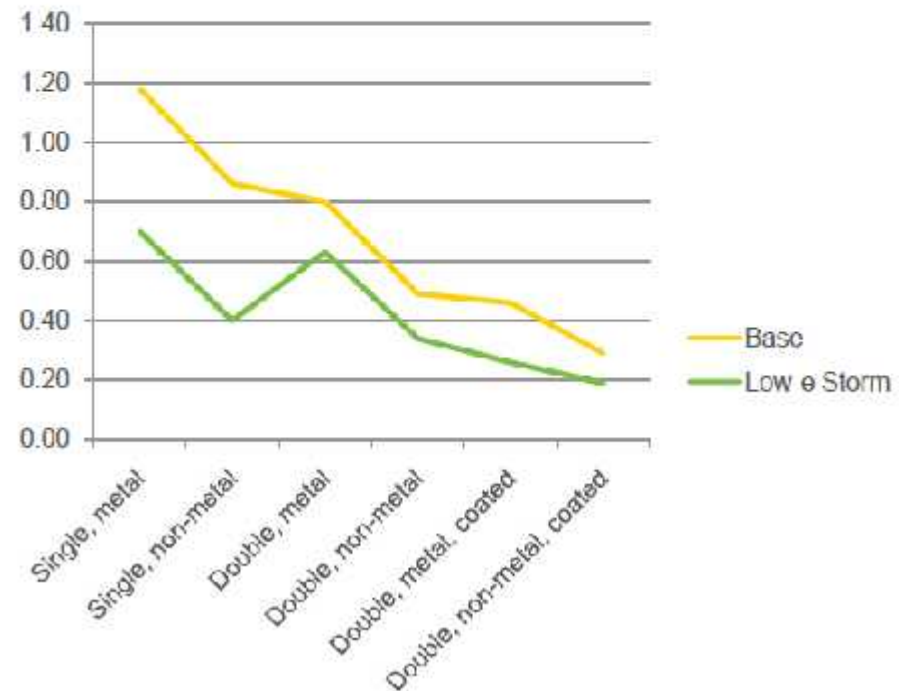
*W / M²·K

Image courtesy of
University of Central Florida

Low-e Storm Window Performance

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



Low-E Storm Windows: Concept

- IR field images show obvious improvement in reduced heat loss:

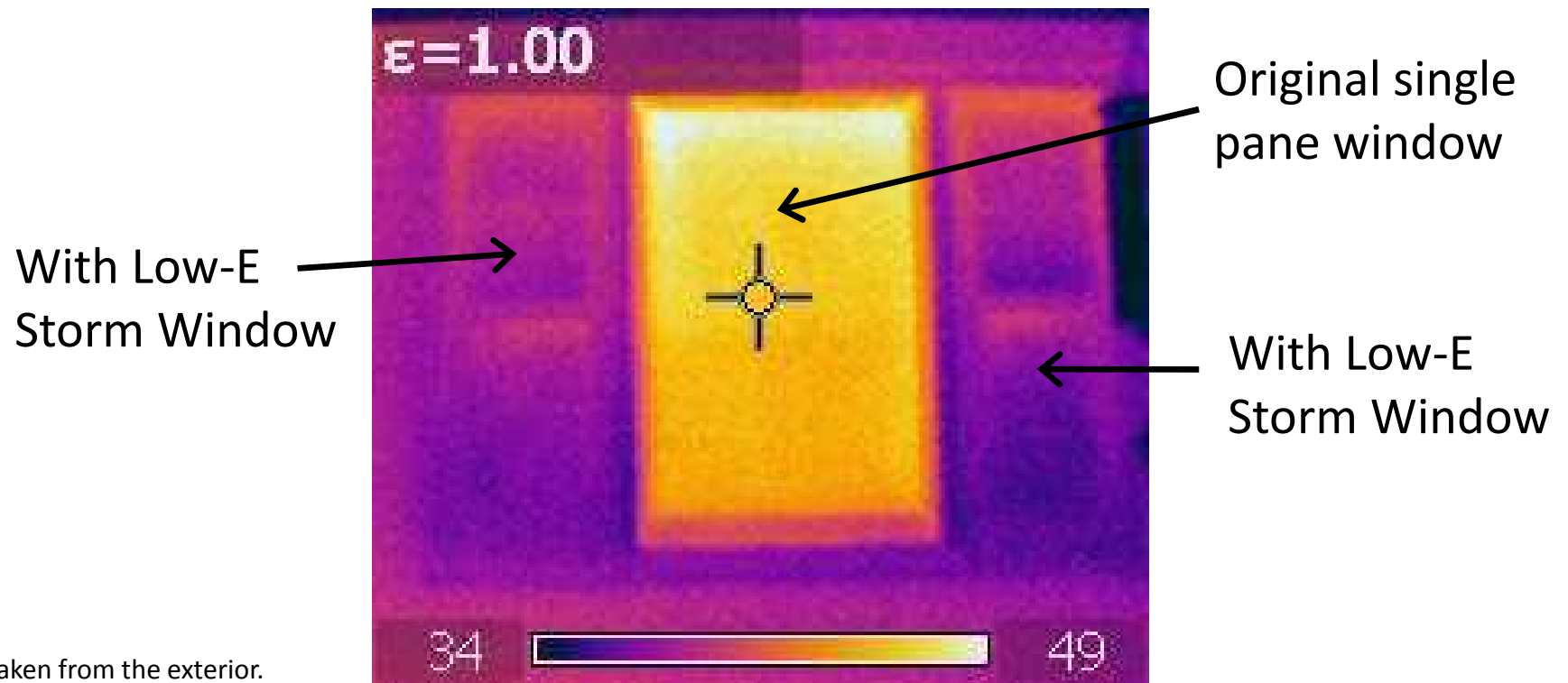


Image taken from the exterior.
Light colors show heat loss.

Advantages of Storm Windows

- Basic low-e storms from name brand manufacturers < \$8/ft²
 - 80% are installed by the homeowner
 - Primary windows: \$15-20/ft² + \$10-15/ft² installation = \$25-35/ft²
 - Distribution channels are well established nationally
 - Payback periods generally 3-4 years
- Superb energy savings by improving insulation and air leakage
 - Results have been verified by several independent sources
- Most mature of all existing window improvement options
- Operable windows and screens eliminate the need to install and remove seasonally
- Protects primary window from wear, damage, forced entry
- Improves comfort level near windows
 - Eliminates hot and cold spots

Homeowner Installation



<http://www.thisoldhouse.com/toh/video/0,,20052892,00.html>

Courtesy of This Old House Ventures, Inc.

The New Look of Low-E Storms: Inside and Out



- Esthetically pleasing
- Operable
- Adds comfort
- Similar energy savings to full window replacement



- Cost is about one quarter of the cost of full window replacement!



Images courtesy of Larson Manufacturing Company and QUANTAPANEL

Demonstration Case Studies

2003-2006 Chicago field study
(DOE, HUD, NAHB Research Center, LBNL)

- Energy monitoring on 6 state weatherization homes with single glazing
- Reduced heating load of the home by 21%
- Simple payback of 4.5 years
- Overall home air infiltration reduced by 6-8% (15 cfm₅₀ reduction per window)



¹ Drumheller, 2007

Demonstration Case Studies

2011-13 Atlanta field study

(NAHB Research Center, Larson Manufacturing, QUANTAPANEL)¹

- 10 older homes with single glazing
- Approx. 15% heating savings, 2-30% cooling savings (large variability)
- Overall home air leakage reduced by 17% (3.7 ACH50)
- Occupants ranked other benefits:
 - improved home appearance
 - reduced drafts
 - improved comfort
 - reduced noise

¹ Culp et al, 2013



Demonstration Case Studies

2012-13 Philadelphia multifamily field study
(NAHB Research Center, QUANTAPANEL, Larson Manufacturing)¹

- Two large 3-story apartment buildings (101 apartments)
- Replaced old clear storm windows over single glazing with new low-E storm windows
- 18-22% reduced heating energy use
- 9% reduced cooling energy use
- Apartment air leakage reduced by 10%



¹ Culp et al, 2013

Whole House Energy Savings

- Average savings from low-E storm windows of 10% annually, compared to 12% for triple-pane primary windows.

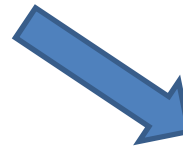
Experimental Period	Operating Scenario	Average Daily Energy Savings	Average Energy Savings (%)
Summer Cooling Season	With Storm Windows in Lab Home B	3,623 ± 349 Wh	8.0 ± 0.5
Winter Heating Season	With Storm Windows in Lab Home B	14,251 ± 2,720 Wh	10.5 ± 1.2
Estimated Annual Results	With Storm Windows in Lab Home B	2,216 ± 31 kWh	10.1 ± 1.4
<i>Estimated Annual R-5 Results³</i>	<i>With R-5 Windows in Lab Home B</i>	<i>1,784 ± 189 kWh</i>	<i>12.2 ± 1.3</i>

³Widder et al, 2012. *Side-by-Side Field Evaluation of Highly Insulating Windows in the PNNL Lab Homes*. PNNL-21678, Pacific Northwest National Laboratory, Richland, WA.

Ratings, Certification & Testing

National Fenestration Rating Council (NFRC)

Only uniform, independent rating and labeling system for energy performance of primary windows. Labels are standard information on most windows sold in U.S. today (see image at right). Information in database and labeling system available to public to compare products and make informed decisions.



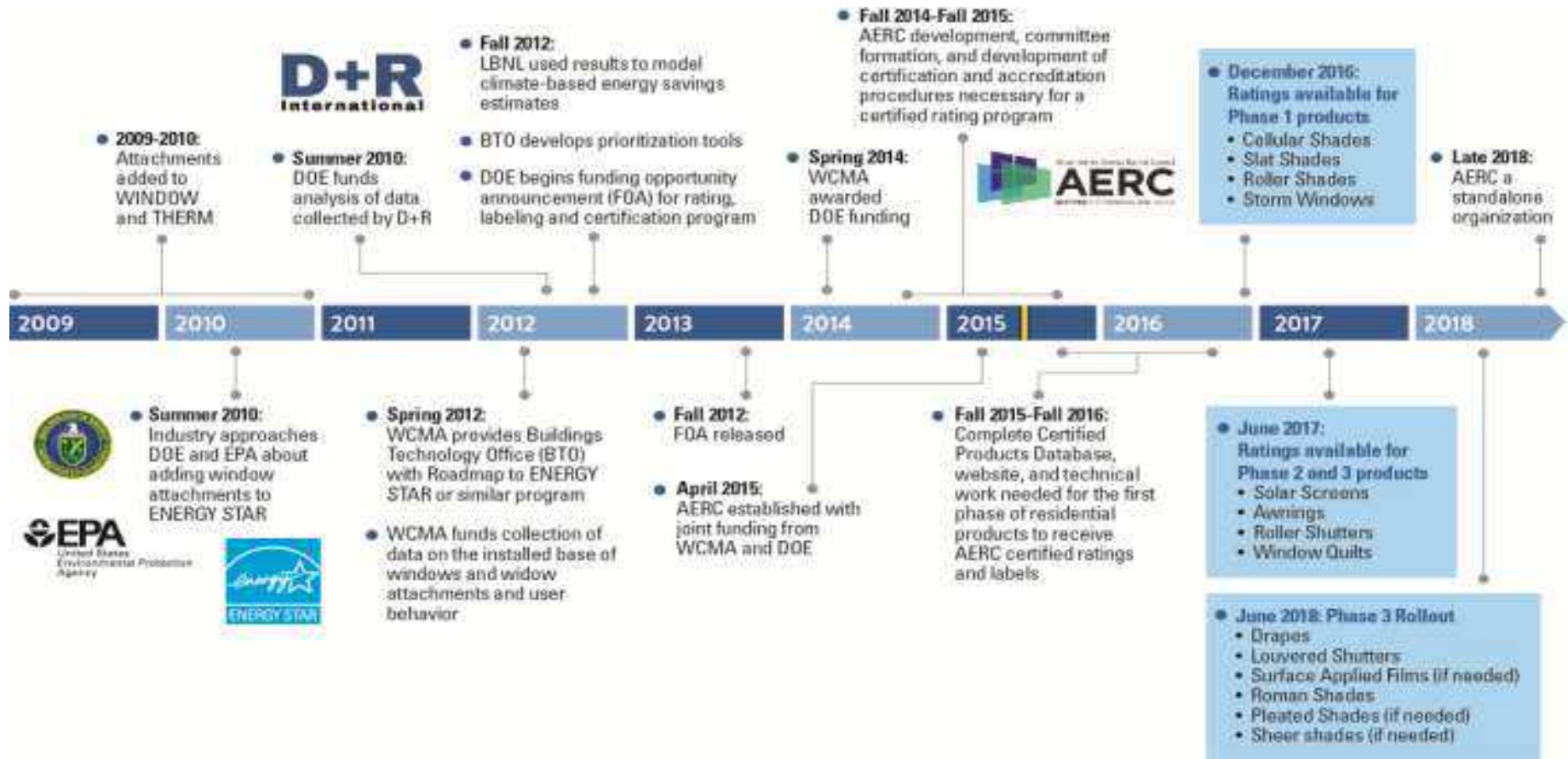
 National Fenestration Rating Council® CERTIFIED	World's Best Window Co. Millennium 2000+ Vinyl-Clad Wood Frame Double Glazing • Argon Fill • Low E Product Type: Vertical Slider
ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P) 0.30	Solar Heat Gain Coefficient 0.30
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance 0.51	Air Leakage (U.S./I-P) 0.2
<small>Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information. www.nfrc.org</small>	

Attachments Energy Rating Council (AERC)

Created with DOE funding in 2014 to make similar information available to public for attachment products, including storm windows.

Three year plan for completion in stages with stage one completion in December 2016

Timeline for Attachments Products



Current Incentives Elsewhere

Many loan programs but few direct rebates

- Wakefield (MA) Municipal Gas & Light Department
 - Rebate up to 25% (\$300 max)
- New Hampshire Electric Co-op
 - Up to \$5,000 in services based on free home audit report
- Randolph (NC) Electric Membership Corporation
 - Discount energy rate to homes meeting minimum conditions

Bonneville Power Administration

BPA's Interest in This Area

- Determine feasibility for a new measure opportunity
- Investigate currently available technologies with greatest potential for energy savings
- Criteria included:
 - Estimated cost
 - Estimated savings (based on U-factor and SHGC)
 - Lifespan compatible with original window
 - Availability around the Pacific Northwest
- Work with Regional Technical Forum (RTF) to establish Unit of Energy Savings (UES) measures

RTF Requirements and Specifications

Single Family Homes

- Emissivity 0.22 or lower
- Solar Transmittance greater than 0.55
- Storm window opening type is same as existing prime window (i.e. single/double hung, casement, slider, etc.)
- Low-E coating installed facing primary window
- Storm window permanently installed
- If metal frame window, storm window frame must not be in direct contact with metal frame

Current status

- ✓ RTF approved UES measures for Single Family Low-E Storm Window only
 - Final Quality Controlled workbook is still pending
- BPA Requirements and Specifications for Implementation Manual
- Qualified Products List?
- RTF UES for Manufactured Homes – April 2016?
- RTF UES for Multifamily – Oct 2016?

BPA - Next Steps

- QC UES workbook for Single Family
- WTP for BPA payment (incentives)
- Finalize BPA Requirements and Specifications
- Develop Qualified Products List?
- Estimate timeline for Manufactured Homes
- Estimate timeline for Multifamily

Summary

- Redesign of storm windows for energy conservation created innovative changes to esthetic barriers of the past
- Low-E storm windows are currently the most cost-effective, market-ready option for improving energy performance of existing windows
- Numerous independent studies have verified the savings potential of these secondary glazing systems
- A ratings program for storm windows and other attachment products will begin to appear late in 2016
- BPA is preparing to release a residential incentive measure for low-E storm windows in April 2016.

For More Information

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Questions and (hopefully) Answers

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Upcoming Showcase Webinars

Multifamily New Construction Technology Roundup

December 17, 2015

Information and registration at www.e3tnw.org/webinars

Join our email list for notification at subscribe-e3tnw@listserv.energy.wsu.edu

More information about emerging technologies:

E3T database: www.e3tnw.org

E3T Program: www.bpa.gov/energy/n/emerging_technology/

Conduit: www.ConduitNW.org

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