

## High Performance Window Attachments

**D. Charlie Curcija**

Lawrence Berkeley National Laboratory

[dccurcija@lbl.gov](mailto:dccurcija@lbl.gov)

510-495-2602

April 4, 2013

## Problem Statement:

- A wide range of residential window attachments are available, but they have widely unknown impacts on energy use. Energy ratings would allow products to be differentiated.
- Utilize experience and lessons learned from research and software tools development for prime windows.
- The best window attachments have the potential to provide large energy savings and achieve NZE buildings goal.

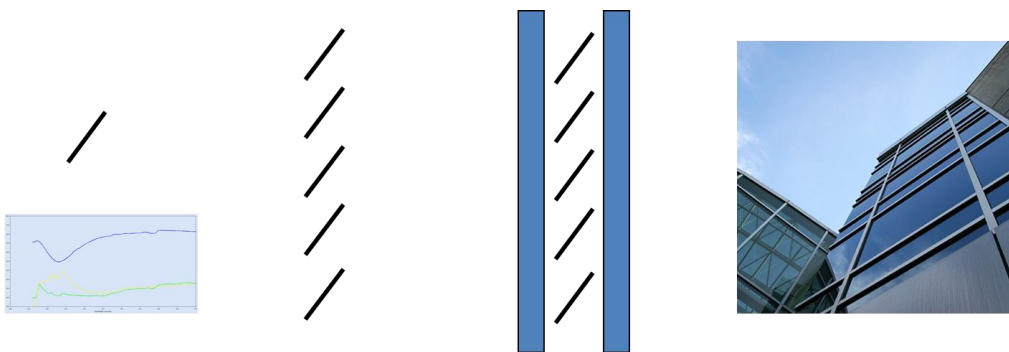
## Impact of Project:

- Motivate manufacturers to make improvements in Window systems U-Factors, SHGC and daylighting utilization
- Increase awareness of benefits from energy efficient window attachments

## Project Focus:

- Develop low-cost technologies applicable for window attachments
- Increase adoption of energy efficient window attachments through the development of the web selection tool, fact sheets and regional guides
- Standardize field and laboratory testing protocols and methods to ensure level playing field
- Develop energy ratings framework and criteria for the development of EnergyStar program for attachments
- Extend residential aspect of this project to commercial window attachments. Both areas build on underlying tools and measurement facilities.

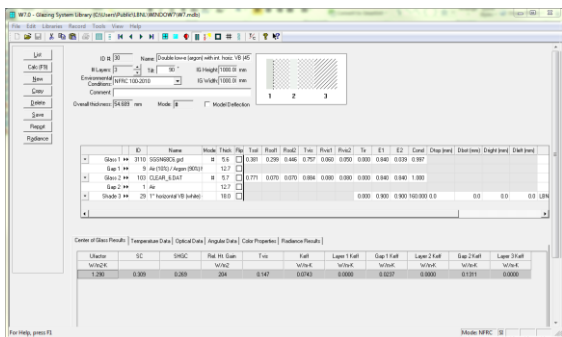
## From components to systems



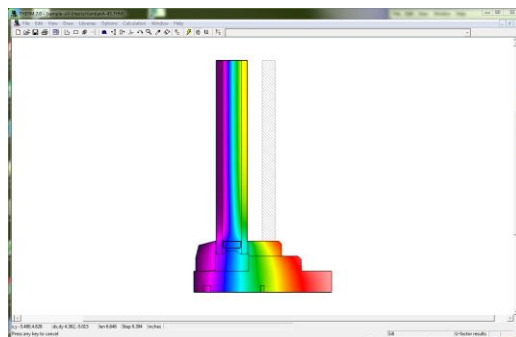
Material Layer System Building

We take this modular approach since there are millions of variants and billions of window/attachment combinations

## WINDOW 7



## THERM 7



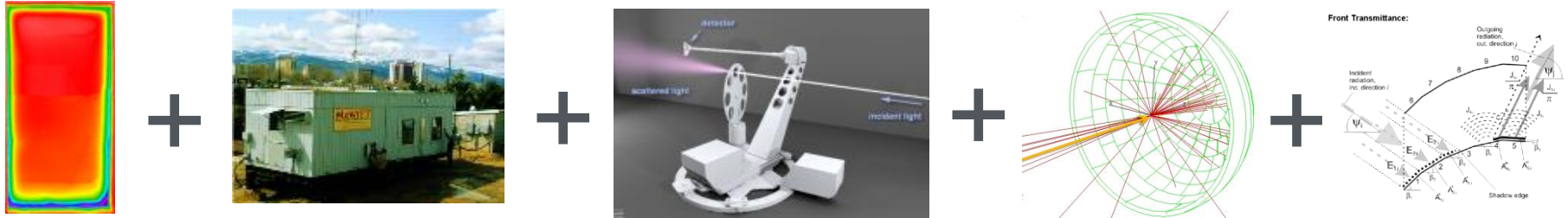
## Infrastructure:

- Portfolio of models that cover major products

Product Type	Test Procedure						Simulation Method						
	IN		OUT		BG		IN		OUT		BG		
	T	O	T	O	T	O	T	O	T	O	T	O	
Cellular Shade													
Window Quilts													
Slat Shade													
Sheer Shade													
Louvered Shutter													
Roller Shutter													
Pleated Shade													
Solar Screen													
Roller Shade													
Roman Shade													
Drape													
Flat panel													
Surface applied Films													
Awnings													

- Procedure to submit measured material and product data (CGDB)
- Updated and reliable software tools (WINDOW, OPTICS, THERM)
- Logistics for data review and approval, software support
- Development of missing algorithms and software upgrades

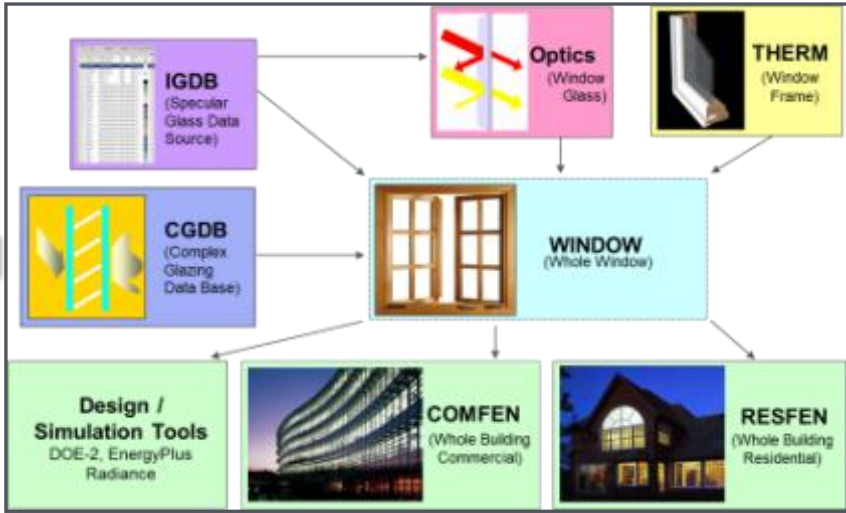
# Approach – Workflow For Credible Product Simulation



Building Science Infrastructure



Product Design



Ratings / Deployment

Tools, Standards, Product Data



## Web site tool and guides

The screenshot shows the 'WINDOW COVERINGS' website. At the top right, there are links for 'Home' and 'About This Site'. The main header features the 'WINDOW COVERINGS' logo and the tagline: 'Intelligent and unbiased guidance on the best window covering for your climate, your needs, your windows.' Below the header is a navigation bar with buttons for 'Help Me Choose', 'Compare Coverings', 'Understanding Window Coverings', and 'Purchasing'. A 'Glossary' button is also visible. The main content area has a blue background and features a photograph of a house with a window awning. To the right of the photo, the text reads: 'What should I do with my windows? So many choices: applied films, awnings, blinds, cellular shades, quilts, shades, shutters, storm windows... So many issues: privacy, glare, thermal performance, shading, security, egress...'. Below this text, it says 'Find the best match for your window covering needs.' and provides two large orange buttons: 'Help Me Choose' and 'Compare Coverings', separated by the word 'or'. At the bottom of the page, there are logos for 'MIRKELLY LAB Lawrence Berkeley National Laboratory', 'BuildingGreen', and 'U.S. DEPARTMENT OF ENERGY'.

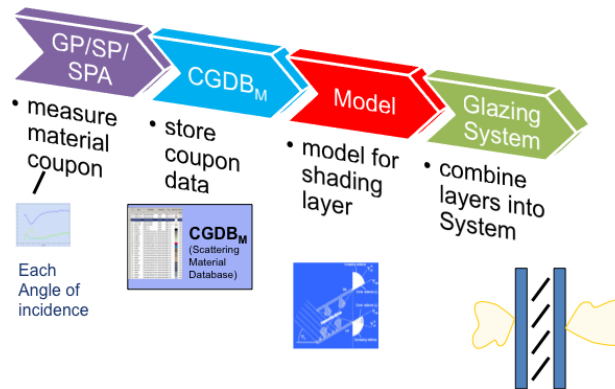
## Pathways:

- Qualitative web selection tool with energy and non-energy qualifiers
- Fact sheets for each class of window attachments
- Regional guides, based on climate and best practices factors
- Quantitative selection tool with energy-related selection based on EnergyPlus simulations and non energy based on qualifiers
- Establish collaborative with stakeholders (DOE, attachment industry, media, research and academic organizations, non-profits, utilities, code officials)
- Disseminate information through conferences, selected media, magazine articles, utilities, DOE web site, etc.)
- Utilize current BuildingGreen media presence and credibility to reach out.

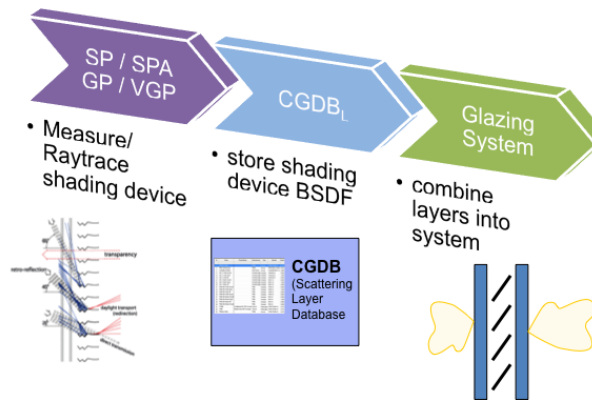
## Complex Glazing and Shading Products Database (CGDB)

### Two paths to CGDB:

Analytical models available  
Measurements of material coupons required

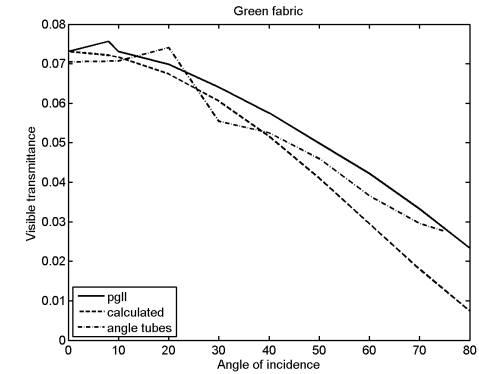
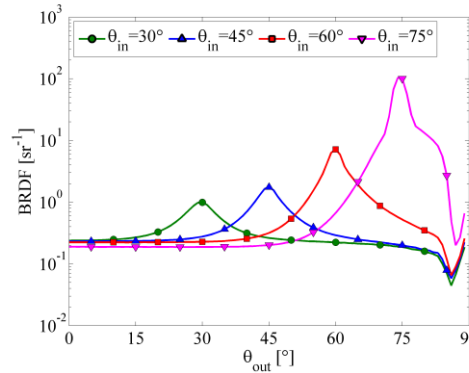


No analytical models available  
Direct shading device measurement required



- Current release 2.0
- Full implementation in WINDOW 7
- Currently 200+ products
- Procedure to accept outside data under development
- Logistics for peer review and regular CGDB publishing (e.g., 2x/year initially) being developed
- Initially, most of the data will be measured at LBNL until standard developed and published
- XML file format for CGDB

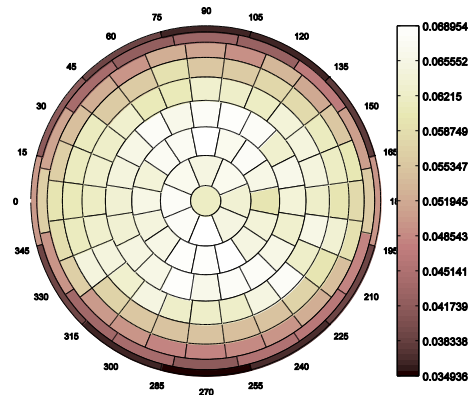
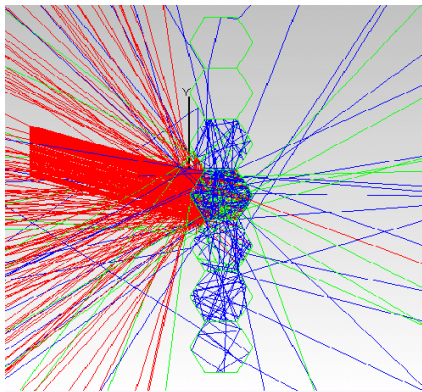
## Cellular Shade Optical Model Development:



Measure Coupon of Fabric



Construct Material Properties File



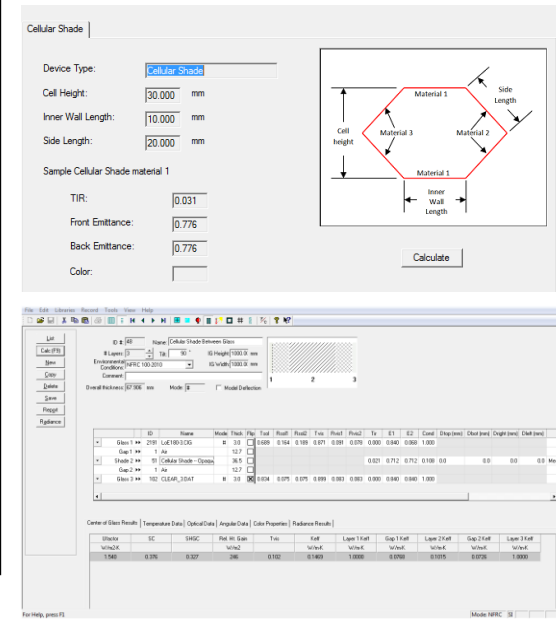
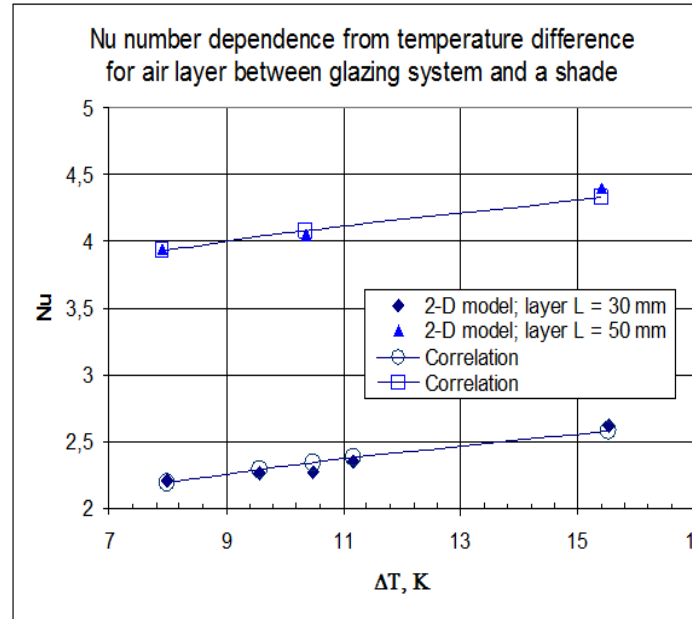
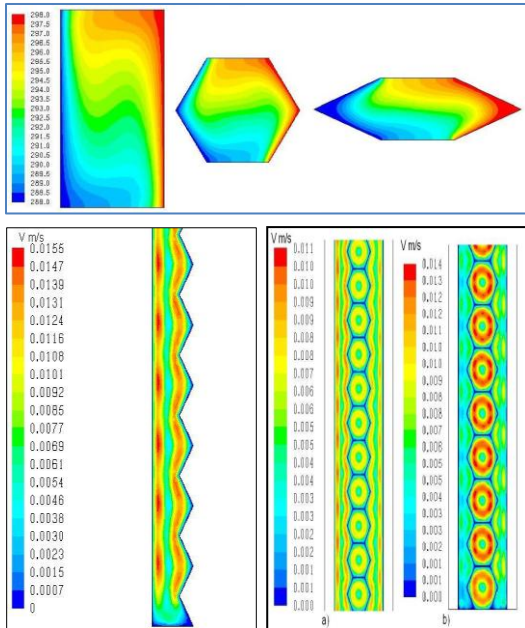
Using Fabric Properties Perform Ray-Tracing in WINDOW and Construct Cellular Shade BSDF

## Cellular Shade Thermal Model Development:

### FLUENT Modeling

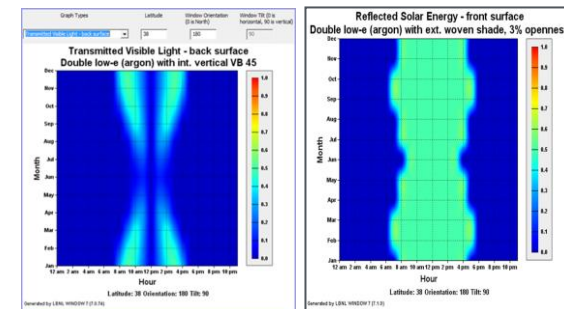
### Heat Transfer Correlations

### WINDOW 7 Cellular Shade GUI



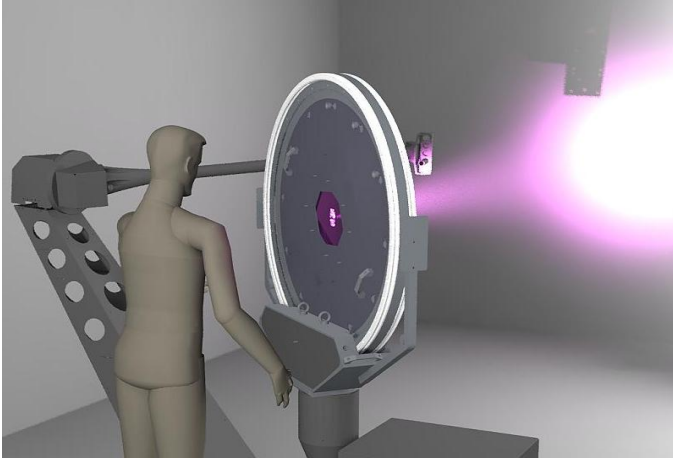
## Major new functionalities for cellular shade simulation:

- Calls THERM 2-D simulation engine in real time to calculate effective conductivity of cellular shades
- Calls RADIANCE/GenBSDF in real time to calculate optical properties of cellular shade based on geometry and materials of cellular shade walls.





## Gonioradiometer Upgrade:



- Optical characterization of scattering glazing and shading products.
- Angle-resolved scattering over the full outgoing sphere to obtain BSDF of a material.
- Automates measurements of anisotropic samples
- Provides better accuracy in angular resolution
- Recent upgrade: Large circular sample holder with automated angle resolution, software and controls upgrade

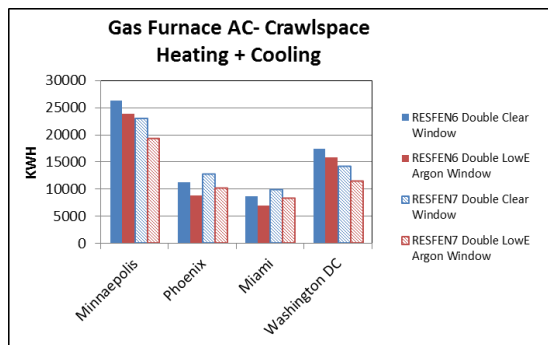
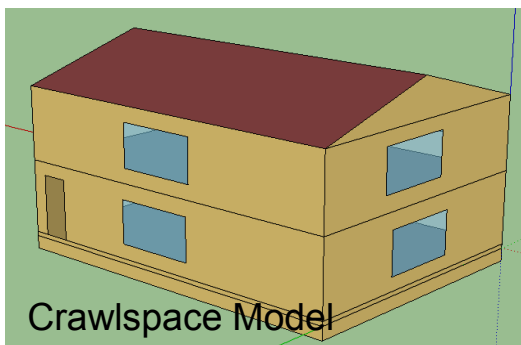
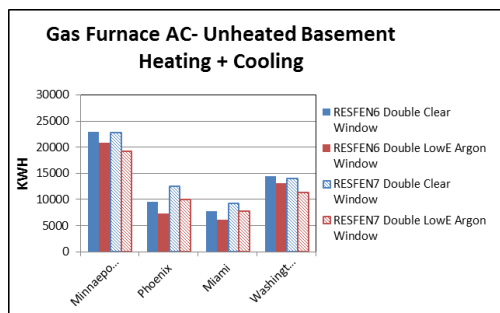
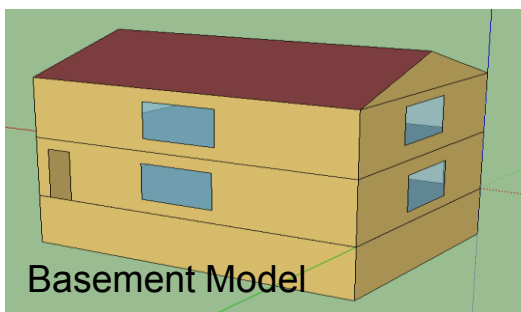
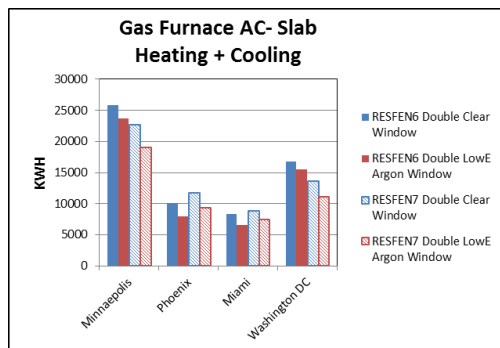
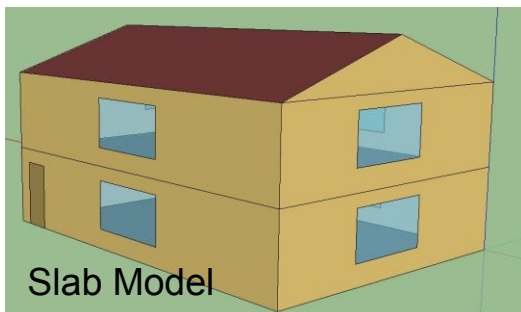
## MoWiTT Refurbishment:



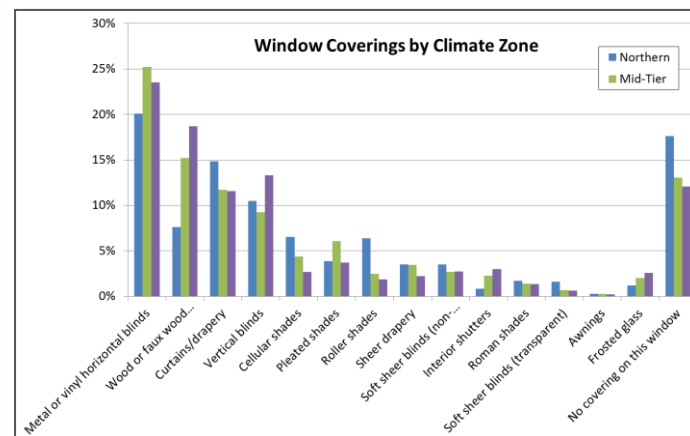
- Built in 1983 and operated for 20 years continuously. Past 10 years mothballed
- Enables research level measurement of U, SHGC
- Replacement of several sensors and logic boards
- New computer system and networking infrastructure
- New LabView software replaces old DOS based data acquisition and control
- Exterior fixes: painting, roof replacement, mask wall repair)
- Interior fixes: painting, cabling, layout, broken sensors

# Accomplishments and Progress – Energy Savings Potential

## RESFEN upgrade to IECC2012 package and EnergyPlus (E+) simulation engine:



- Upgraded DOE2 simulation engine to E+ for better accuracy and ability to model wide range of window coverings
- Performed window coverings behavioral study to determine typical operation. 2800 data points.



- Added comprehensive complex fenestration systems (CFS) model to E+
- Run parametric simulation of a range of window coverings with the range of baseline window to get energy savings potential
- Prepare recommendations for EPA EnergyStar program

## Efficient Window Coverings Web Site:

**WINDOW COVERINGS** Intelligent and unbiased guidance on the best window covering for your climate, your needs, your windows.

Help Me Choose | Compare Coverings | Understanding Window Coverings | Purchasing | Glossary

Compare (choose up to 5)

Interior panel, Interior roller screen, Cellular shade, Covered blind, Drapes/Curtain, Pleated shade, Surface film, Exterior storm, Exterior roller shade, Retractable awning, Sheer shade, Roman shade, Exterior roller screen, Fixed awning, Roller shutter, Exterior covered shutter.

Show what's best for my windows using: **These 3 Coverings**

Interior panel, Surface film, Seasonal film, Interior roller screen, Interior roller shade, View Details, View Details, View Details, View Details, View Details, Purchase, Purchase, Purchase, Purchase, Purchase, Purchase.

**WINDOW COVERINGS** Intelligent and unbiased guidance on the best window covering for your climate, your needs, your windows.

Help Me Choose | Compare Coverings | Understanding Window Coverings | Purchasing | Glossary

Understanding Window Coverings

Fact Sheets

Interior Window Coverings

Exterior Window Coverings

Automation

Overview - Deciding What to Do With Existing Windows

Interior Window Coverings

Cellular Shade

Drapes & Curtains

I live in: **Select closest city**

You live in Energy Star Zone please select

My windows are:

Single Pane Clear

Double Pane Clear

Double Pane with Low-e

Don't Know

Continue

Do your windows already have (or will they have) coverings?

Yes No

These are important to me

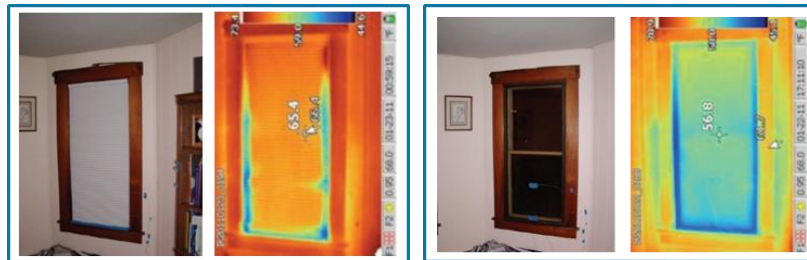
If it's really important, select "critical".

Suggested considerations based on where you live:

Thermal: Insulation, Air-tightness, Solar Heat Control, Water Comfort, Summer Comfort, Condensation Resistance, Ventilation.

Functional: Visible Transmittance (VT), Daylighting, Glare Control, Privacy, Durability, Durability - Service Life, OTF Installation, Pre-Installation.

- 2<sup>nd</sup> iteration of the web site
- Scheduled to be released in April, 2013
- Advisory board consisting of 15 members from industry, government, non-profits, research institutions
- Comprehensive glossary
- Different paths:
  - Help me Choose
  - Compare Coverings
  - Understanding Window Coverings
  - Purchasing
- Guidelines on field testing and use of thermal IR images for comparison purposes



## Fact Sheets:

- 9 fact sheets developed so far
- 3 fact sheets under development

**ENERGY** Energy Efficiency & Renewable Energy

**Window Retrofit Option Interior Blinds, Shades, and Drapes**

Description

Curtains and Drapes are the simplest, most common window treatments and are most associated with interior aesthetics. They are often interior attachments that are either used to fit the window (partially) or to reach all the way to the floor (drapes). Usually installed for privacy, convenience and drapes also offer some energy and comfort benefits.

Roller Shades

Roller shades (often called roller shades or roller blinds) make the window using just the window well and are available in a wide variety of fabrics and weaves. The least expensive and easiest are typically opaque and are usually installed in bedrooms and provide full privacy. Roller shades offer much more energy benefits by providing a small amount of insulation.

Low-eed (Insulated) Blinds

Low-eed blinds are specialized window blinds that enable a greater degree of light and have control than any other conventional interior window treatments. These more beautiful are insulated glass and roller pane. Insulated blinds or screens are typically connected with dark tape or cord running through a clear over the end of each slit. These are commonly called "insulated blinds".

**RETROFIT OPTIONS SUMMARY TABLE**

RETROFIT OPTION	Thermal	Visual	Economics	Other
LEGEND	Thermal	Visual	Economics	Other
● "Excellent benefit"	● Excellent	● Excellent	● Excellent	● Excellent
○ "Moderate benefit"	○ Good	○ Good	○ Good	○ Good
○ "Neutral or average"	○ Fair	○ Fair	○ Fair	○ Fair
○ "Marginal benefit or weak point"	○ Poor	○ Poor	○ Poor	○ Poor
<b>Exterior Attachments</b>				
Low e storm windows	●	○	○	○
Awnings	○	○	○	○
Roller shades	○	○	○	○
Roller shades	○	○	○	○
<b>Interior Attachments</b>				
Conventional roller shades	○	○	○	○
Conventional drapes	○	○	○	○
Low-eed blinds	○	○	○	○
Insulated roller shades	○	○	○	○
Window quilts	○	○	○	○
Surface applied films	○	○	○	○
<b>Other</b>				
Building window seals	○	○	○	○
Storm windows	○	○	○	○
Secondary glazing film	○	○	○	○

Notes:

1. All of the above data is based on the large algorithm. Information is provided for each of the most common retrofits.
2. Some retrofits are not available in all climates.
3. Some retrofits are not available in all climates.
4. Some retrofits are not available in all climates.
5. Some retrofits are not available in all climates.
6. Some retrofits are not available in all climates.
7. Some retrofits are not available in all climates.
8. Some retrofits are not available in all climates.
9. Some retrofits are not available in all climates.
10. Some retrofits are not available in all climates.

U.S. DEPARTMENT OF ENERGY  
EERE Information Center  
1-877-EERE-INFO (1-877-338-6634)  
www.eere.energy.gov/windowcoverings

# Project Plan & Schedule

Project original initiation date: 10/1/2011

Project planned completion date: 9/30/2015

Note: Validated version of RESFEN with EnergyPlus engine and low-cost/high-return technologies were delayed in FY12, with carryover funds used in FY13 to complete those tasks.

Summary					Legend							
WBS Number or Agreement Number					Work completed							
Project Number					Active Task							
Agreement Number					Milestones & Deliverables (Original Plan)							
					Milestones & Deliverables (Actual)							
Task / Event	FY2012				FY2013				FY2014			
	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
<b>Project Name: Residential Window Retrofit/Attachment Solutions</b>												
Q4 Milestone: Validated version of RESFEN with Energy Plus engine												
Q4 Milestone: Milestone: List of candidate products and optimized target performance												
Q2 Milestone: Publish fact sheets and regional guides												
<b>Current work and future research</b>												
Q4 Milestone: Develop draft lab and field test protocol												
Q3 Milestone: Develop framework for implementing a rating system												
Q3 Milestone: Report on overall feasibility of Energy Star Attachments program												
Q3 Milestone: Release new version of software tools												
Q4 Milestone: Release new version of RESFEN GUI												
Q1 Milestone: Publish quantitative web selection tool and updated guides												

## Project Budget: FY13 \$1,160k

- Task 1: Technical needs for testing and simulation (\$390k)
- Task 2: Energy savings potential for residential attachments (\$300k)
- Task 3: Develop prototypes of high impact products (\$100k)
- Task 4: Web-based retrofit evaluation tool (\$160k)
- Task 5: Rating and Certification (\$100k)
- Task 6: Window Covering Behavioral Study (\$60k)
- Task 7: Lab and field testing protocol (\$50k)

**Variations:** None

**Cost to Date:** \$690k

**Additional Funding:** None

Budget History					
FY2010		FY2011		FY2012	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$0K	\$0K	\$285K	\$0K	\$1,225K	\$0K

## Partners, Subcontractors, and Collaborators:

- BuildingGreen (Web selection tool and regional guides)
- D&R International (behavioral study)
- WinBuild (ratings framework)

## Technology Transfer, Deployment, Market Impact:

- Published 9 fact sheets. Distributed to stakeholders for display at trade shows. Posted on DOE EERE web site.
- Released new web site [www.efficientwindowcoverings.org](http://www.efficientwindowcoverings.org)
- Software downloads: 40,000+ unique downloads, 200,000+ software starts

## Communications:

- Conferences: Better Buildings Better Business ECW, Chicago and Wisconsin Dells; NESEA, Boston; Affordable Comfort, Baltimore; IFAI – PAMA, Boston; Energy and Environmental Building Association conference, Las Vegas.
- Webinars: Center for Sustainable Energy California; Energy Center of Wisconsin
- Blogs: BuildingGreen “Getting the Most from Old Windows: A Tale of Attachments”; Several blogs by Alex Wilson in Energy Solutions Weekly, GreenBuildingAdvisor blog, “4 Affordable Ways to Improve the Energy Efficiency of Old Windows”

## Next Steps and Future Plans:

- Develop algorithms and models for products for which there are no models currently
- Finalize measurement (test) procedures and standards that compliments computer modeling
- Participate and help establish rating and certification organization for window attachments
- If EPA establishes EnergyStar program for window attachments, perform national savings and energy impact study to determine metrics for EnergyStar
- Expand the efficient window coverings web site with quantitative selection tool and expanded information, including additional fact sheets
- Develop prototypes of low-cost high-impact window attachment technologies
- Complete the development of software tools and establish production quality complex product database (CGDB), similar to IGDB.