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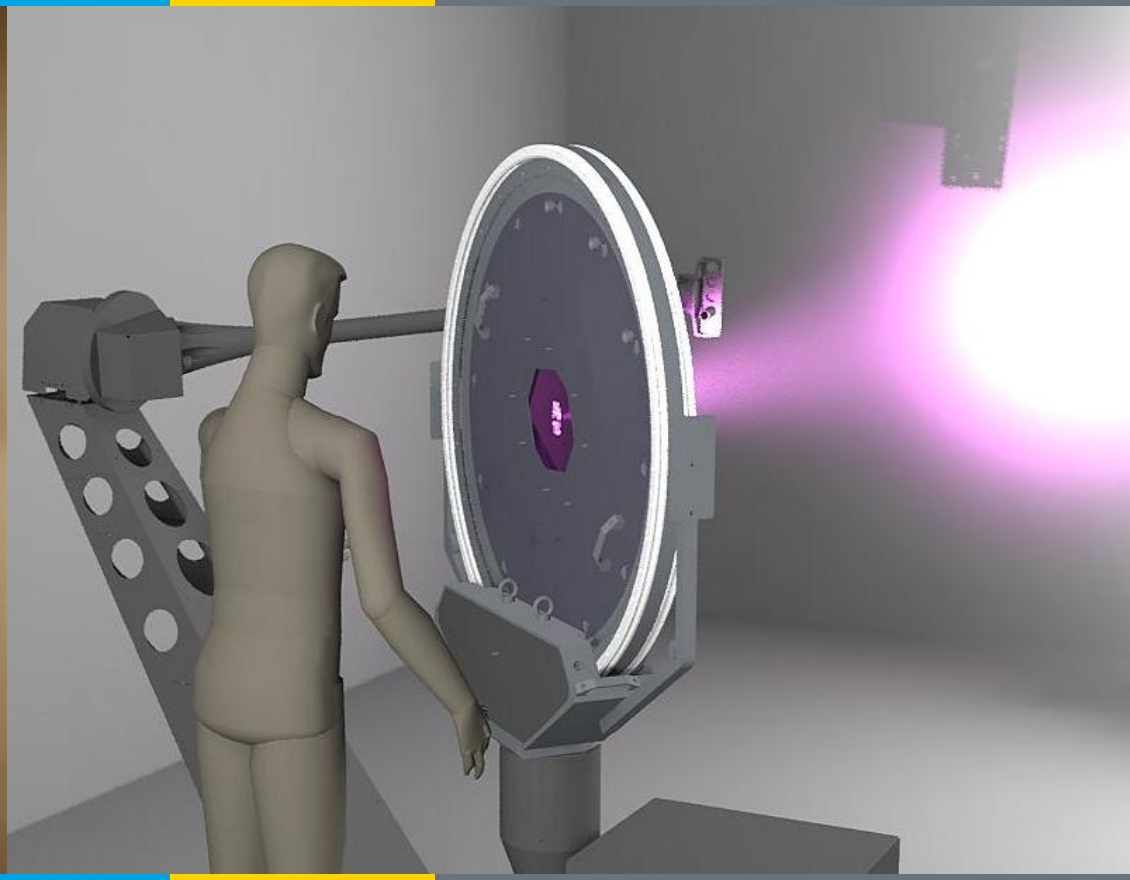

# High Performance Window Attachments

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April 4, 2013

# Purpose & Objectives



## 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.

# Approach – Performance Assessment Through Computer Modeling

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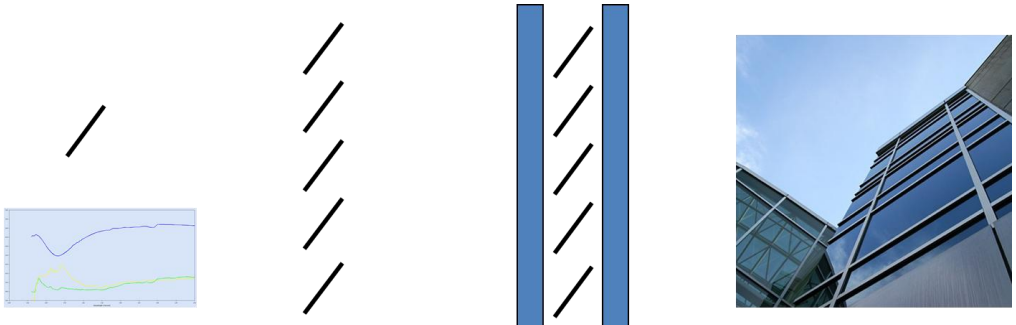
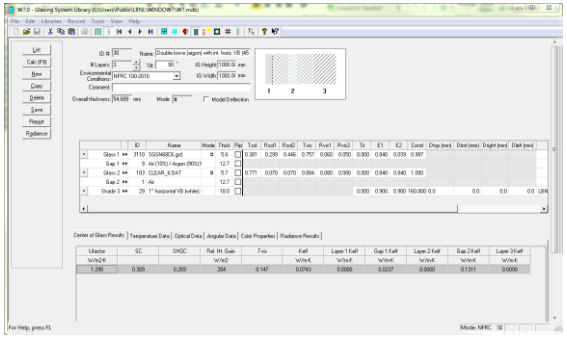
## From components to systems



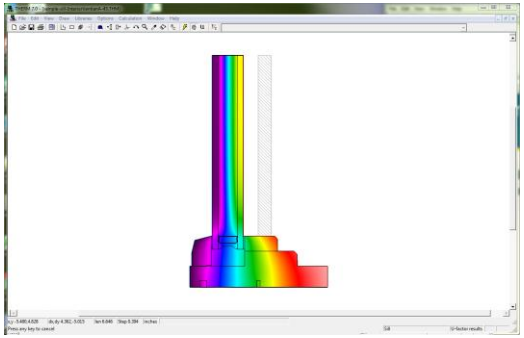
Material Layer System Building

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

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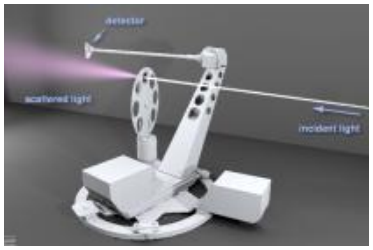

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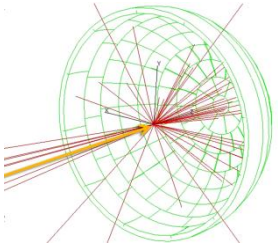
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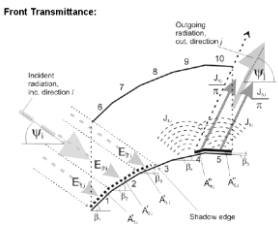
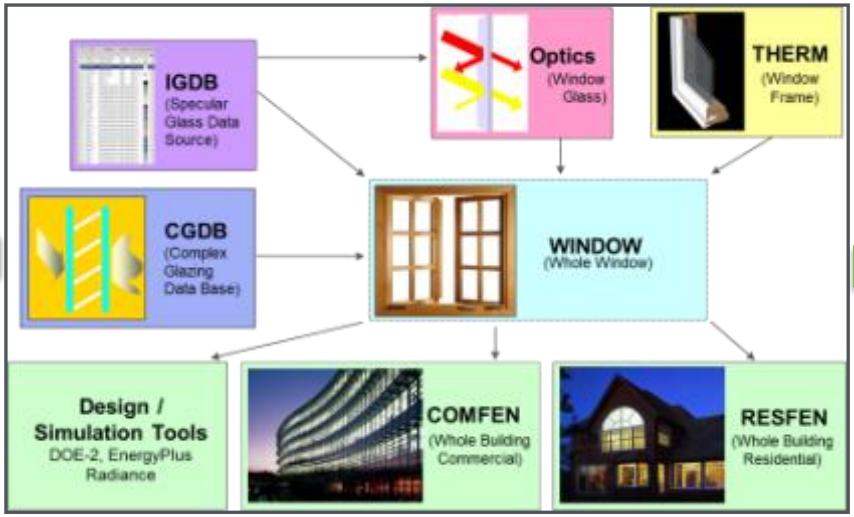



**Building Science Infrastructure**

**Product Design**



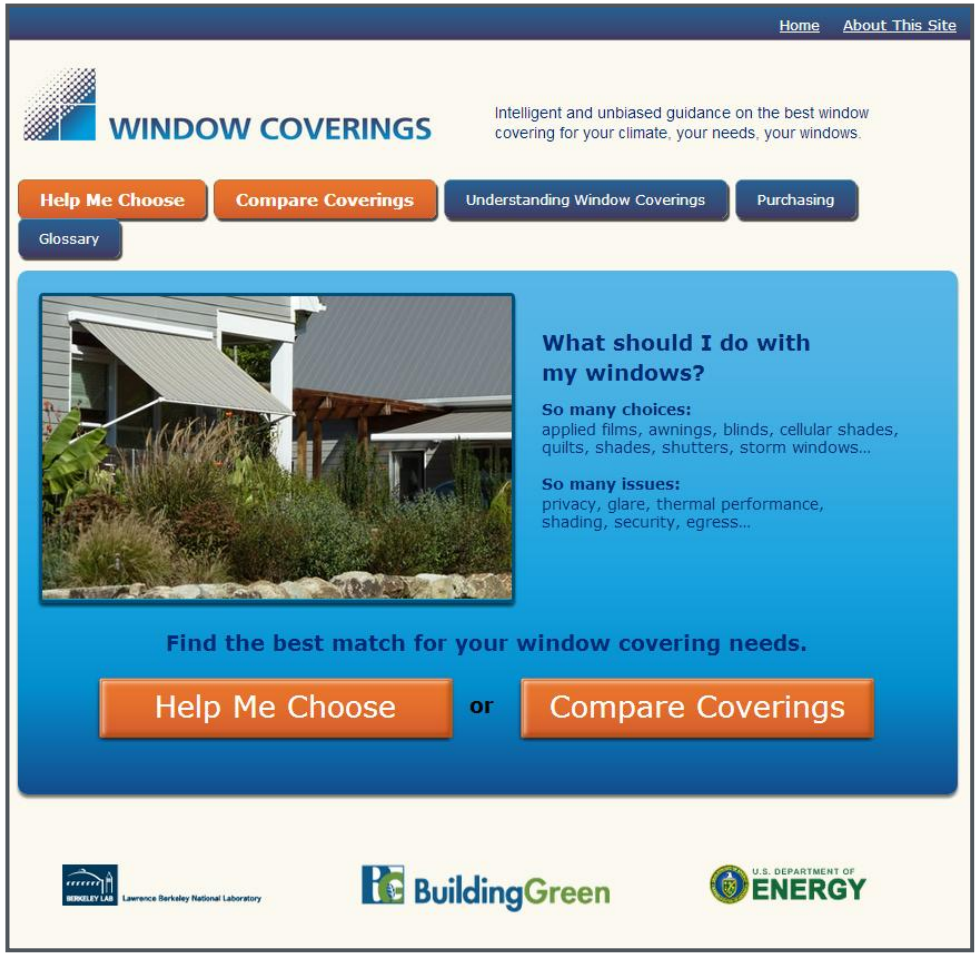

**Ratings / Deployment**

**Tools, Standards, Product Data**

# Approach – Outreach/Deployment



## Web site tool and guides




## Pathways:

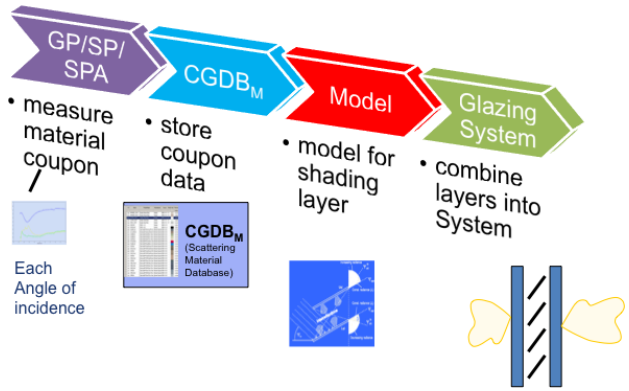
- Qualitative web selection tool with energy and non-energy qualifiers
- Fact sheets for each class of window attachments
- Regional guides, based on climate and best practices factors
- Quantitative selection tool with energy-related selection based on EnergyPlus simulations and non energy based on 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:**

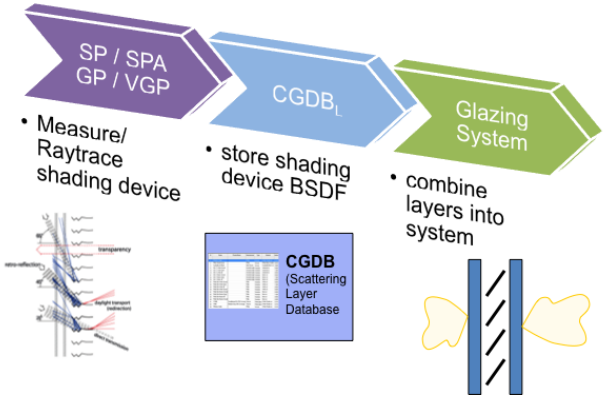
**Analytical models available**

**Measurements of material coupons required**




**No analytical models available**

**Direct shading device measurement required**

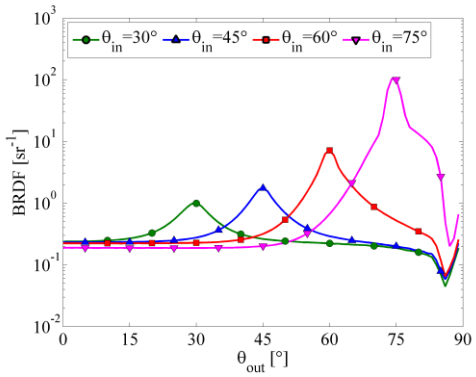


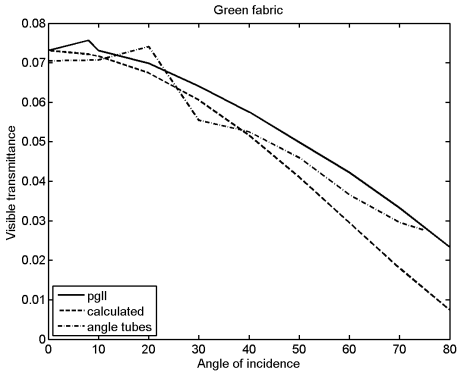

- Current release 2.0
- Full implementation in WINDOW 7
- Currently 200+ products
- Procedure to accept outside data under development
- Logistics for peer review and regular CGDB publishing (e.g., 2x/year initially) being developed
- Initially, most of the data will be measured at LBNL until standard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

# Accomplishments and Progress – Models and Software Implementation

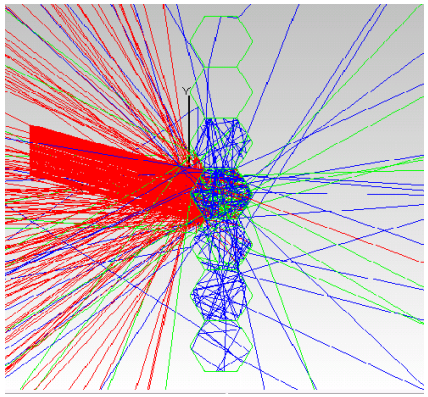


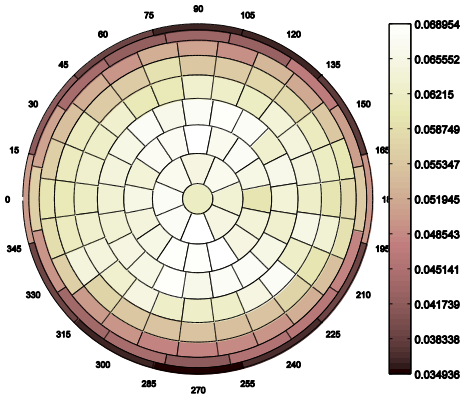
## Cellular Shade Optical Model Development:




Measure Coupon of Fabric → Construct Material Properties File





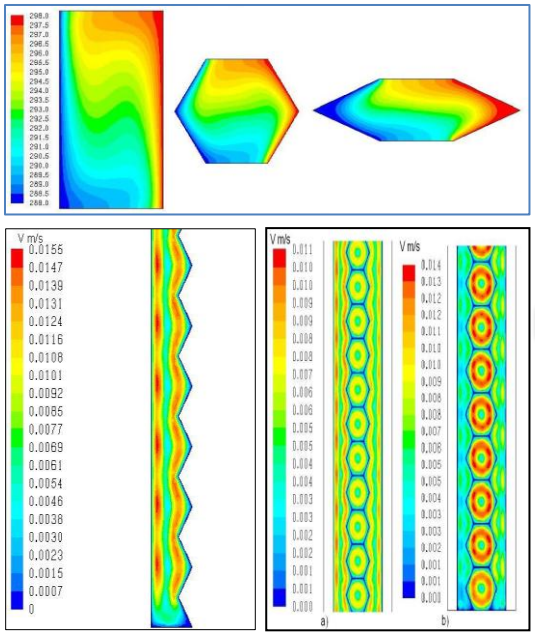
Using Fabric Properties Perform Ray-Tracing in WINDOW and Construct Cellular Shade BSDF

# Accomplishments and Progress – Models and Software Implementation

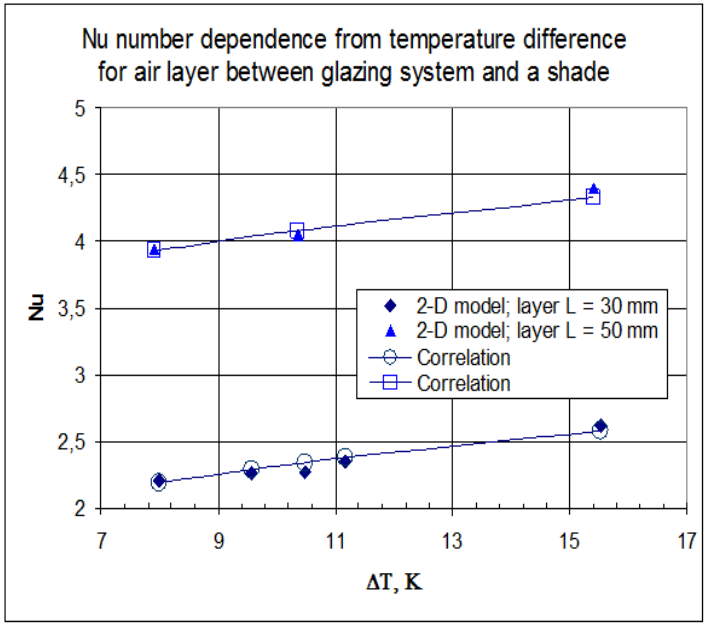


## Cellular Shade Thermal Model Development:

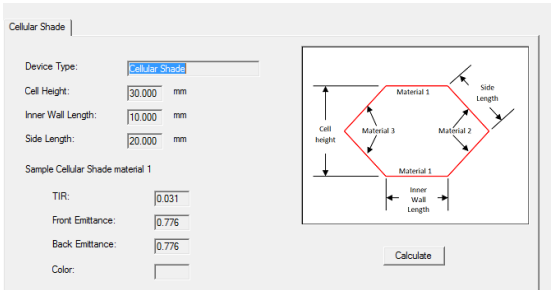
FLUENT Modeling

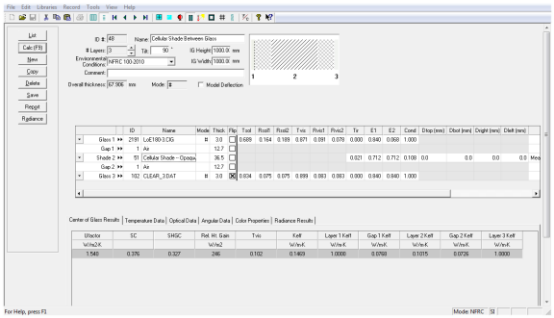


Heat Transfer Correlations



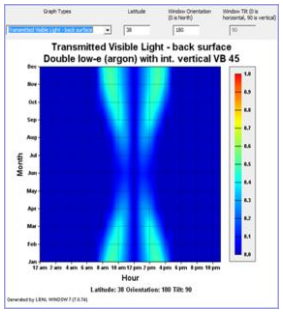

WINDOW 7 Cellular Shade GUI

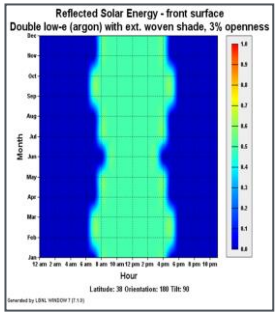


## Major new functionalities for cellular shade simulation:

- 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.

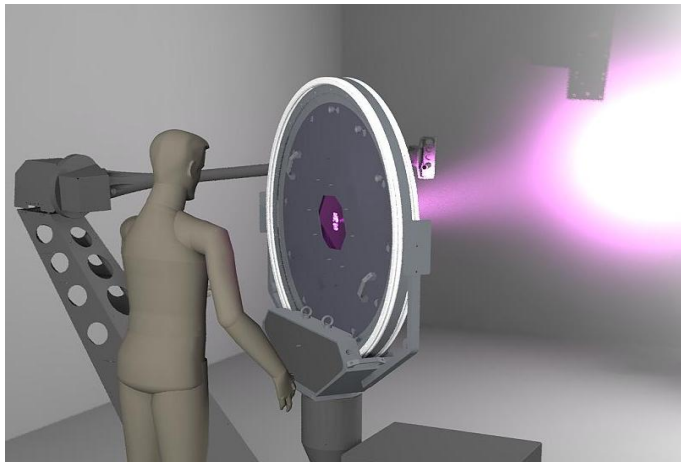


# Accomplishments and Progress – Test Facilities Upgrades



## 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

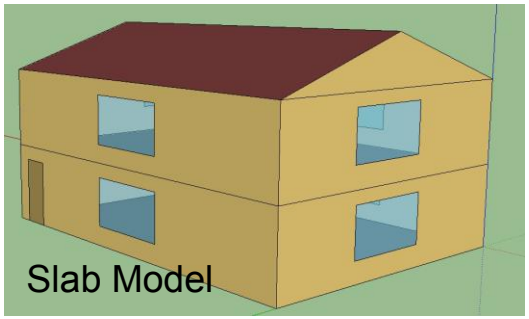
## MoWiTT Refurbishment:

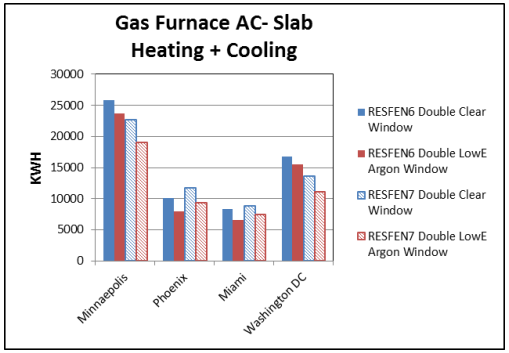

- Built in 1983 and operated for 20 years continuously. Past 10 years mothballed
- Enables research level measurement of U, SHGC
- Replacement of several sensors and logic boards
- New computer system and networking infrastructure
- New LabView software replaces old DOS based data acquisition and control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

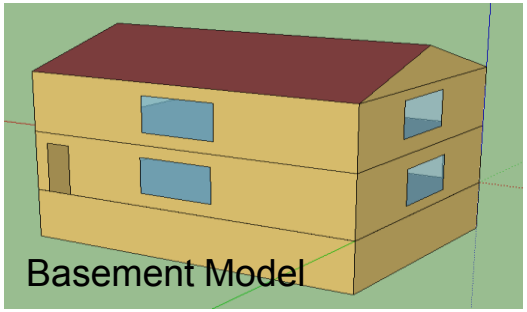
# Accomplishments and Progress – Energy Savings Potential

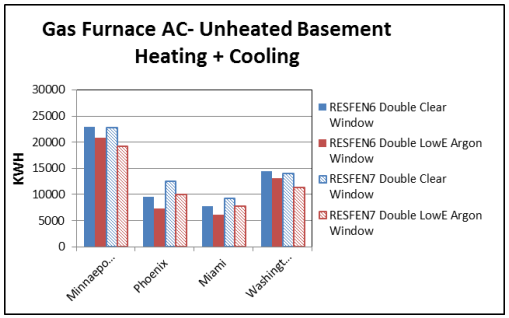


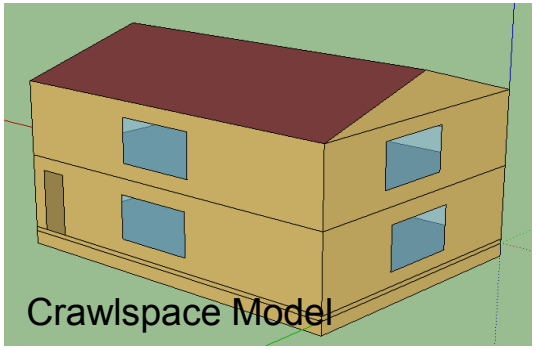
**RESFEN upgrade to IECC2012 package and EnergyPlus (E+) simulation engine:**

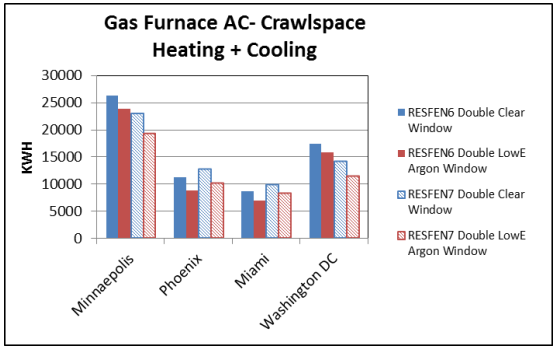


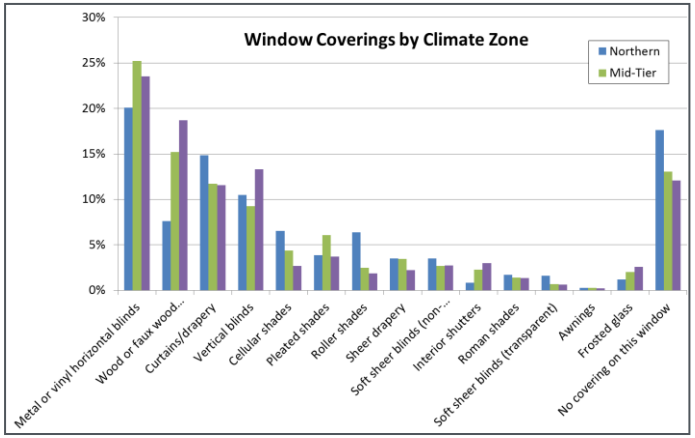




- Upgraded DOE2 simulation engine to E+ for better accuracy and ability to model wide range of window coverings
- Performed window coverings behavioral study to determine typical operation. 2800 data points.




- 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

# Accomplishments and Progress – Web-based Selection Tool and Guides

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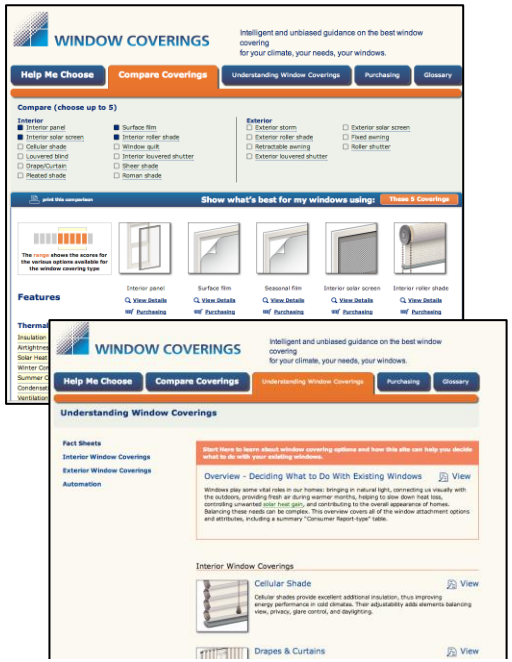
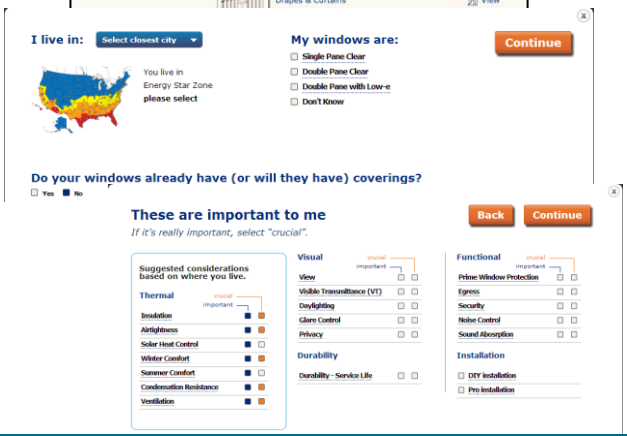
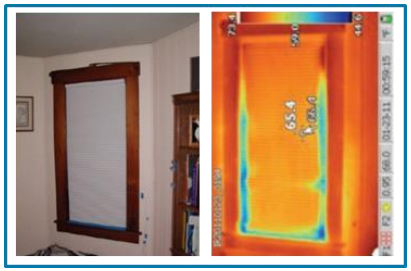
## Efficient Window Coverings Web Site:



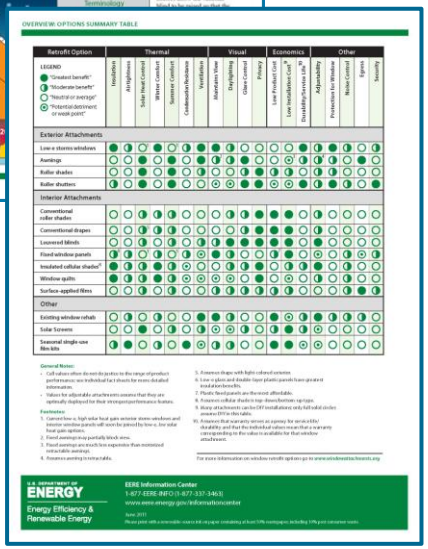




- 2nd iteration of the web site
- Scheduled to be released in April, 2013
- Advisory board consisting of 15 members from industry, government, non-profits, research institutions
- Comprehensive glossary
- Different paths:
  - Help me Chose
  - Compare Coverings
  - Understanding Window Coverings
  - 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

# Project Plan & Schedule

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## 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 | |
|---|---|
| WBS Number or Agreement Number | |
| Project Number | |
| Agreement Number | |
| | |

| Legend | |
|---|---|
| | Work completed |
| | Active Task |
| | Milestones & Deliverables (Original Plan) |
| | Milestones & Deliverables (Actual) |

| | FY2012 | | | | FY2013 | | | | FY2014 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task / Event | Q1 (Oct-Dec) | Q2 (Jan-Mar) | Q3 (Apr-Jun) | Q4 (Jul-Sep) | Q1 (Oct-Dec) | Q2 (Jan-Mar) | Q3 (Apr-Jun) | Q4 (Jul-Sep) | Q1 (Oct-Dec) | Q2 (Jan-Mar) | Q3 (Apr-Jun) | Q4 (Jul-Sep) |
| **Project Name: Residential Window Retrofit/Attachment Solutions** | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | |
| **Current work and future research** | | | | | | | | | | | | |
| 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



## 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)

**Variances:** 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 |

# Project Integration, Collaboration & Market Impact

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## 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
- 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



## 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, inncluding 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.