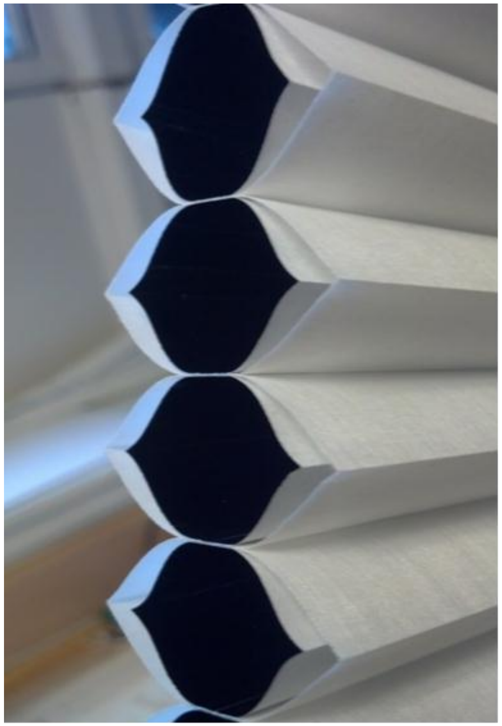
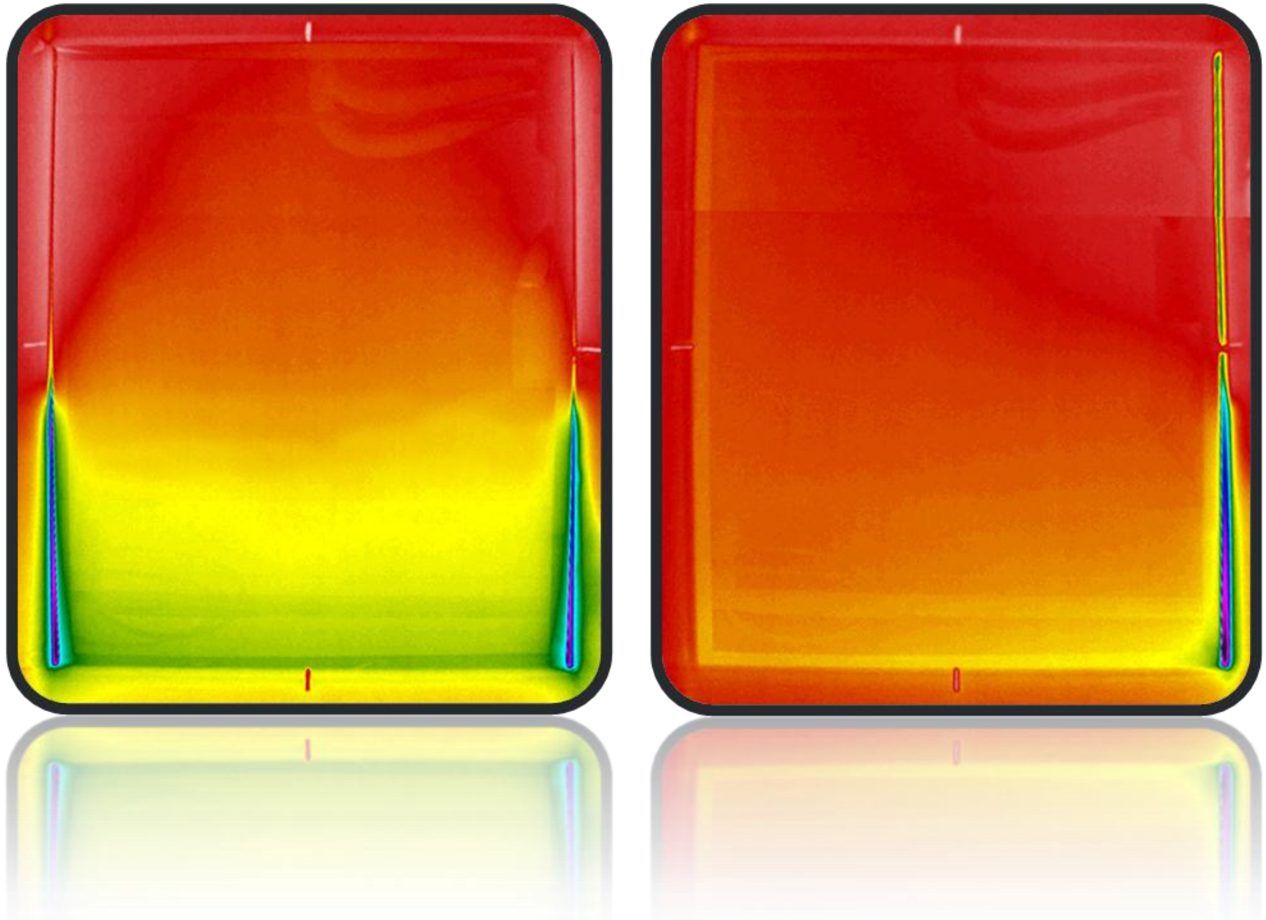
Window Attachments

2015 Building Technologies Office Peer Review





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Project Summary

Timeline:

Start date: 10/1/2013

Planned end date: 9/30/2018

Key Milestones:

1. CGDB Releases (2); 3/31; 9/30/2015
2. Validated simulation methods for priority window attachments; 9/30/2015

Budget:

Total DOE $ to date: $1,100k

Total future DOE $: $2,100k [estimated]

Target Market/Audience:

AERC, NFRC, window attachments manufacturers, researchers, component and systems modeling professionals, academia

Key Partners:

AERC	PAMA
Hunter-Douglas	ESSA
Levelor	NEEA
Rollease	
ES-SO	

Project Goal:

Develop validated simulation models and procedures for characterizing wide range of window attachments. Implement improvements in existing simulation models and newly developed ones in WINDOW and THERM software tools, so that AERC have sound infrastructure on which to base its ratings and certification program.

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Purpose and Objectives

Problem Statement: Window attachments have the economic potential to save nearly 800 TBtus in cooling and heating energy by 2030. However, there are currently no performance rating mechanisms for assessing energy performance of fenestration attachments. As a result, available energy savings cannot be realized because consumers are unable to identify fenestration attachment products that have the potential to save energy.

Target Market and Audience: AERC, NFRC, window attachment and integral window shading manufacturers. Windows are responsible for 4 quads of energy with one additional quad that can be saved through effective daylighting. Window attachments and integral shading have an opportunity to affect large portion of this energy, with credible rating and certification providing impetus to improve products.

Impact of Project: This project provides technical backbone for the DOE supported and funded AERC organization. Algorithms developed during this project and their validation provide necessary credibility for simulation tools that will be used for rating and certification. The project is divided up in 3 phases; Phase 1 includes 6 classes of products and is scheduled to be completed at the end of FY16, while remaining two phases are planned to extend through FY18.

Approach

Approach: Develop and validate simulation methods to model thermal, optical and energy performance of fenestration attachments. Develop associated test methods and lead the effort to incorporate standardized measurement procedures in ASTM and ISO standards. Validate simulation methods and algorithms to achieve full credibility of simulation methods and associated software tools, which will be used in the rating and certification. Assist AERC in the development and establishment of technical documents and rating procedures.

Key Issues:

- Enable cost-effective rating/certification of window attachments and integral shading systems
- Reduce the cost of energy efficient window attachment and shading products development
- Enable rapid development of new window attachment and window shading technologies

Distinctive Characteristics:

- Credible simulation methods and algorithms that will provide technical foundation for software tools used in AERC rating and certification
- Standardized and internationally harmonized simulation and testing methods

Window Attachment Product Classes

Window shading & attachments for Residential and Commercial Buildings.
New construction and retrofit

Exterior attachments


Low-e Storm Window


Fixed Awning


Dynamic Awning


Roller Shutter - Window


Roller shade


Solar screen

Interior attachments

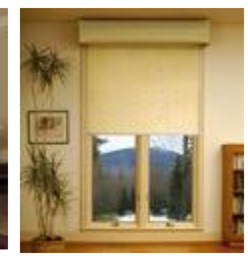

Drapes


Louvered blinds


Roller shades


Surface applied film


Cellular shade

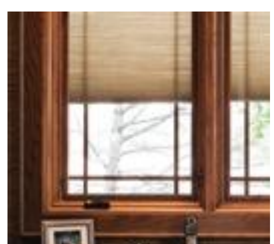

Window quilt


Seasonal film kit

Between glass attachments (applies to non-sealed glazing systems only – applied as a retrofit option)


Louvered blinds


Roller shades

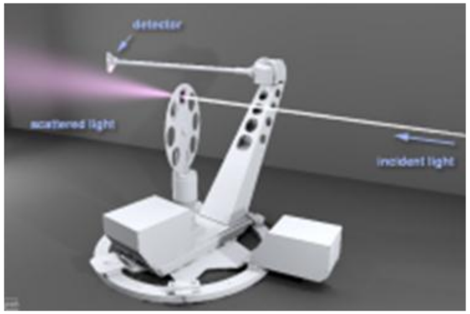

Cellular shades

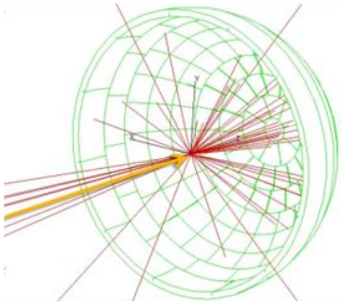
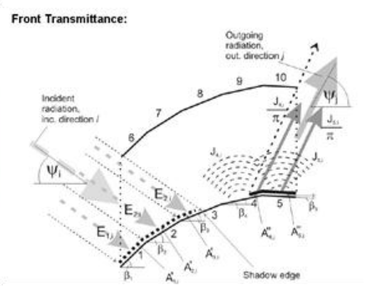

Solar screens


Surface applied films

Workflow For Credible Product Characterization



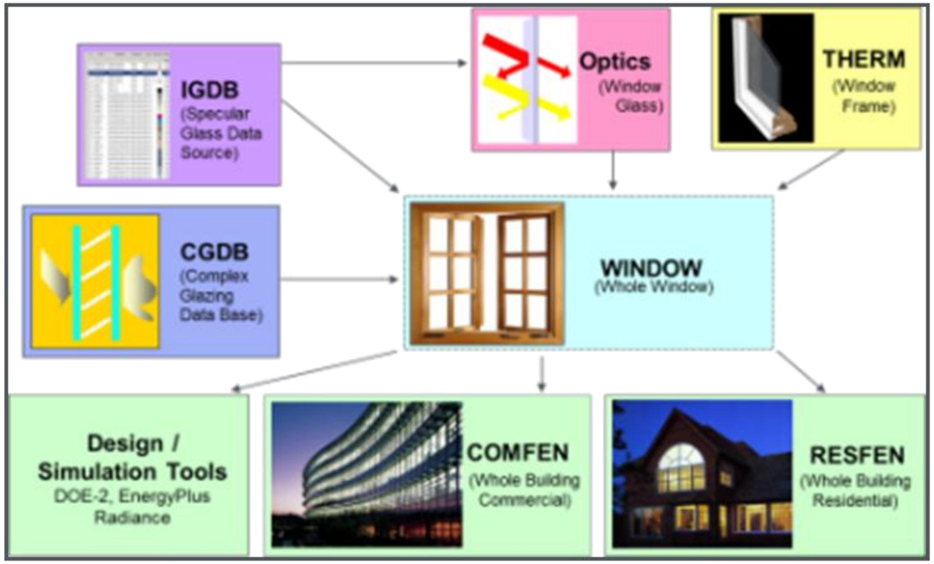


Window Characterization Facilities



Product Design



Ratings / Deployment


Tools, Standards, Product Data

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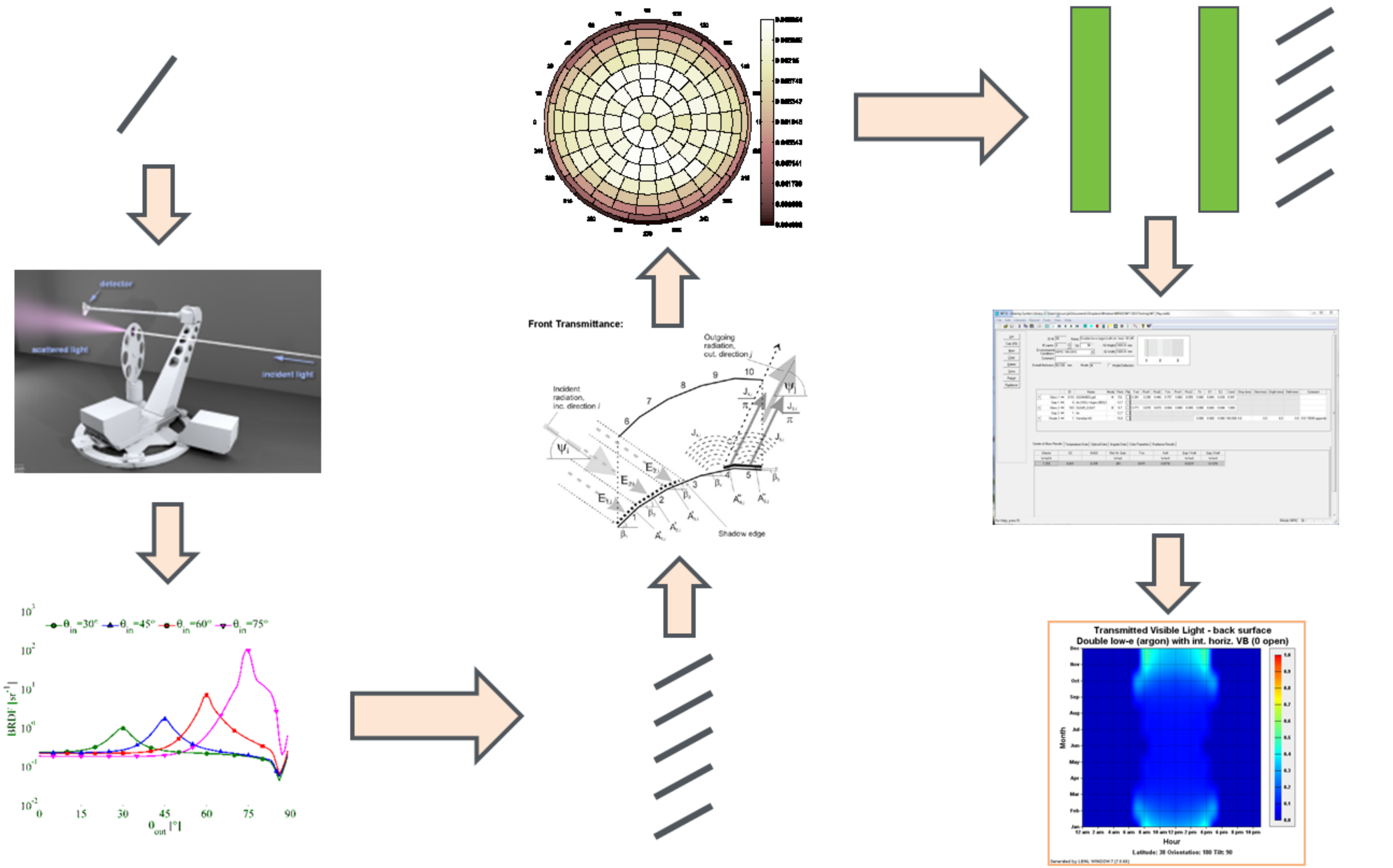
Modeling – From Components To Systems



Material Layer System

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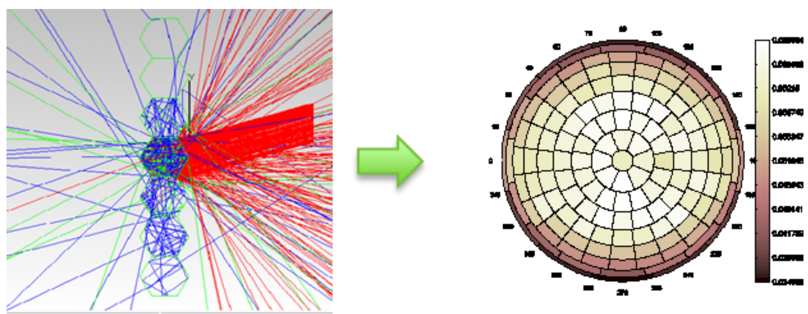
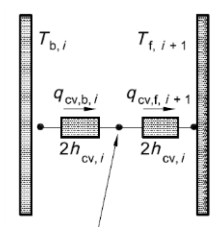
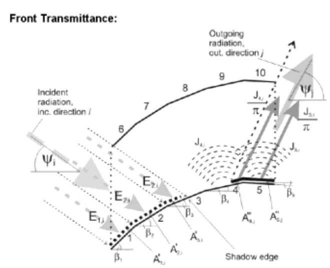
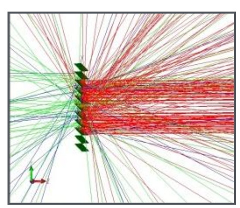
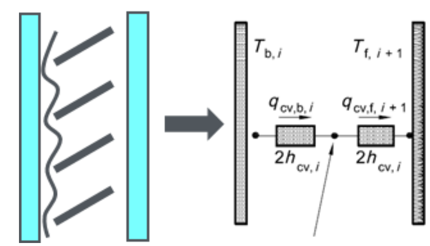
Cellular (Honeycomb) Shades

Device Type	Optical Characterization & Calculation	Thermal Calculation
Material types: • Polymer Optical types: • Opaque base material • Translucent base material Geometry types: • Single cell • Cell-in-cell • Multiple cell-in-cell • Double cell • Triple and multiple cell 	Material Characterization • Spectroscopic measurements of fabric coupons Layer Characterization • Raytracing of actual geometry from fabric properties – resulting BSDF  Software Implementation • Implemented for all types	Conduction Heat Transfer: • Conductivity of the material – generic (from literature) Convection Heat Transfer: • Extension of ISO 15099 model • Validation of models in process  Software Implementation • Implemented

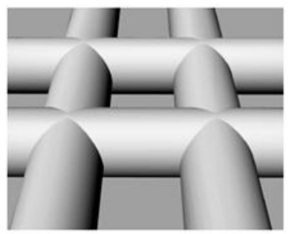
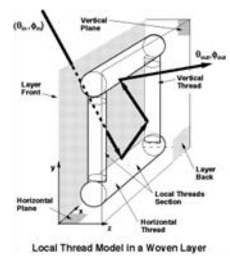
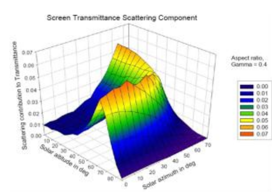
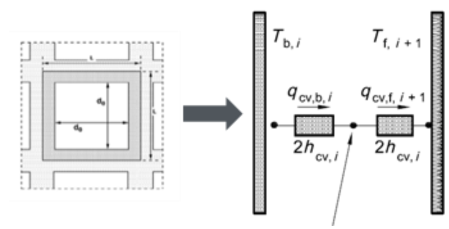
Louvered (Slat) Products

<table>
<tr><th>Device Type</th><th>Optical Characterization & Calculation</th><th>Thermal Calculation</th></tr>
<tr>
<td>
<u>Material types:</u>
Polymer
Metal
Wood
<u>Optical types:</u>
Specular
Diffuse
Transparent
<u>Geometry types:</u>
Single slat
Double slat
Curvature
Horizontal/Vertical

</td>
<td>
<u>Material Characterization</u>
Spectroscopic specular and diffuse optical measurements of material coupons
<u>Layer Characterization</u>
Analytical model


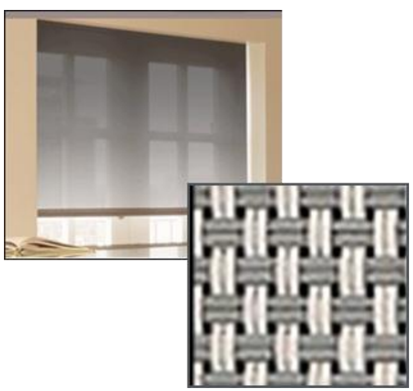
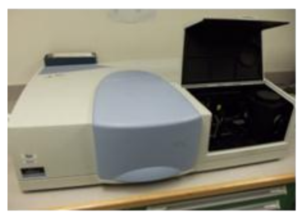
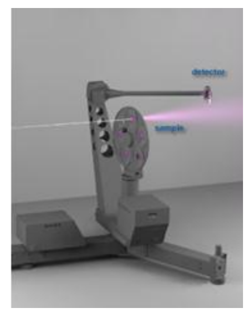
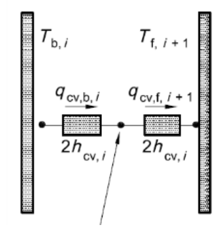
Raytracing from base material properties and knowledge of surface features geometry

<u>Software Implementation</u>
Analytical model implemented
Planned implementation of real-time raytracing
</td>
<td>
<u>Conduction Heat Transfer:</u>
Conductivity of the material – generic in literature
<u>Convection Heat Transfer:</u>
ISO 15099 model
Validation of models in process

<u>Software Implementation</u>
Implemented
</td>
</tr>
</table>

Square Weave Products

Device Type	Optical Characterization & Calculation	Thermal Calculation
Material types: • Polymer • Metal Optical types: • Opaque threads • Translucent threads Geometry types: • No variation 	Material Characterization • Spectroscopic measurements of thread material coupons Layer Characterization • Analytical model   • Real-time raytracing from base material properties and geometry  Software Implementation • Analytical model implemented • Planned implementation of real-time raytracing	Conduction Heat Transfer: • Conductivity of the material – generic in literature Convection Heat Transfer: • Extension of ISO 15099 model • Validation of models in process  Software Implementation • Implemented

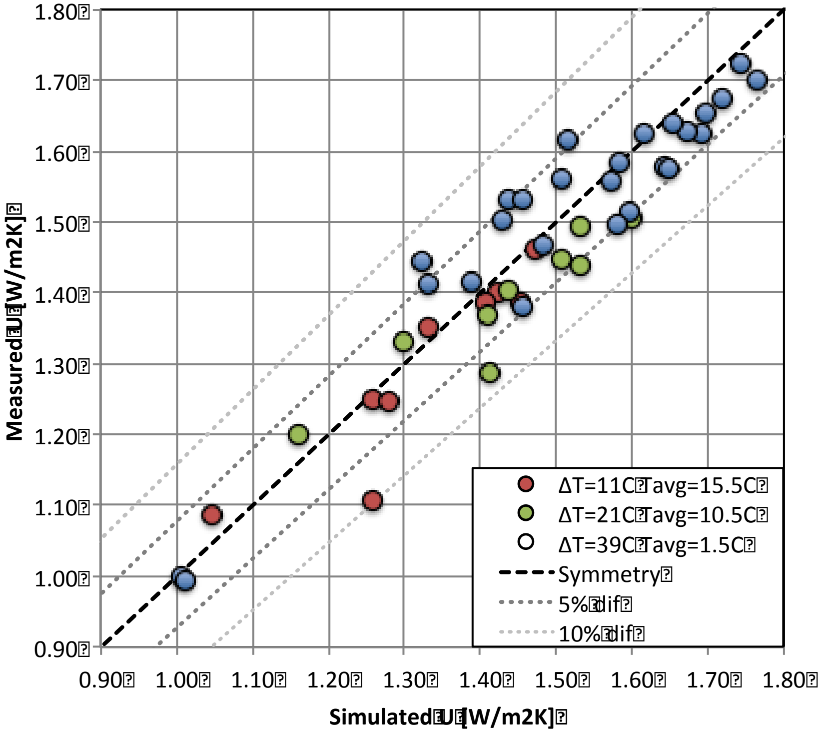
Woven, Non-Uniform Fabrics

Device Type	Optical Characterization & Calculation	Thermal Calculation

Material types:
• Polymer
• Metal (rarely)
Optical types:
• Opaque threads
• Translucent threads
• Bi-color
Geometry types:
• No variation

	Material Characterization
	• Spectroscopic measurements of thread material coupons
	Layer Characterization
	• Spectroscopic measurement of layer coupon
	  • Normal incidence + angular correlations
	  • Angular tubes
	  • Gonioradiometer
	 
	
	• Raytracing of approximate (average) geometry from base material properties – resulting BSDF
	Software Implementation
	• Implemented for BSDF data
	• Planned implementation of real-time raytracing
		Conduction Heat Transfer:
		• Conductivity of the material – generic (from literature)
		Convection Heat Transfer:
		• Extension of ISO 15099 model
		• Validation of models in process
		
		
		Software Implementation
		• Implemented

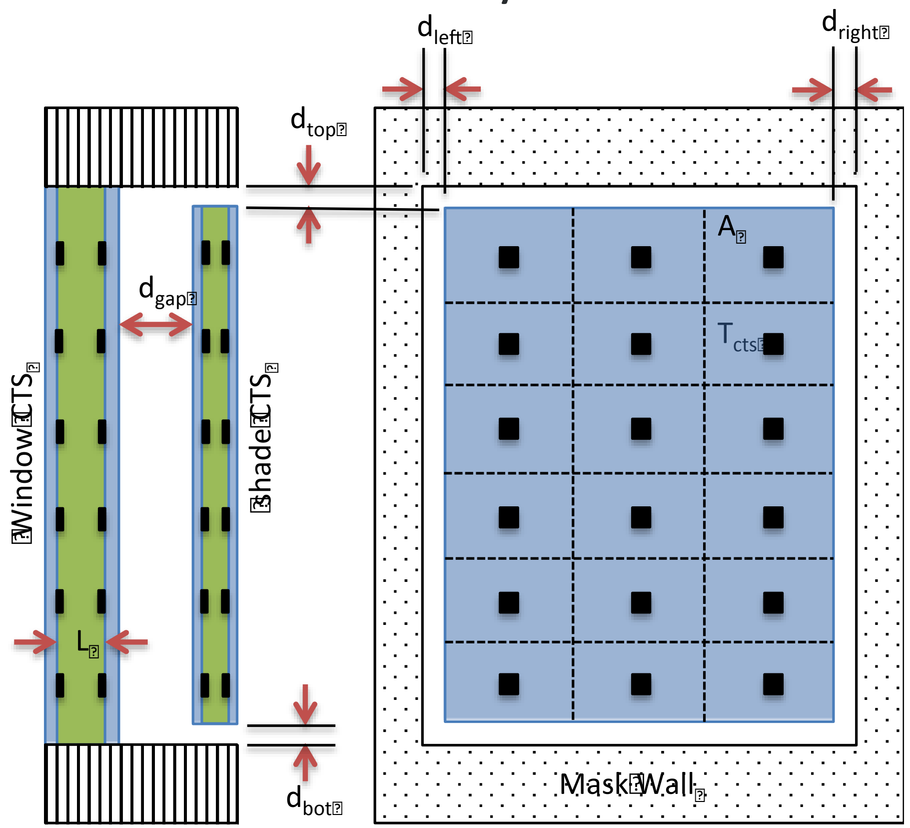
Ventilated Gaps Modeling

- Ventilated gaps:
  - Top
  - Bottom
  - Sides
  - Perforated
- Over 40 configurations tested
- Simulations correlate well with measurements
- Accommodation coefficients being determined to reduce systematic differences between measurement and simulation



CTS measurement technique

- CTS – Calibration Transfer Standard
- New technique for measuring attachment system heat flow
- Validated to < 1 W/m^2 with non-venting systems
- Method may be expanded for highly insulating glazing systems that are traditionally difficult to measure with hotbox method.



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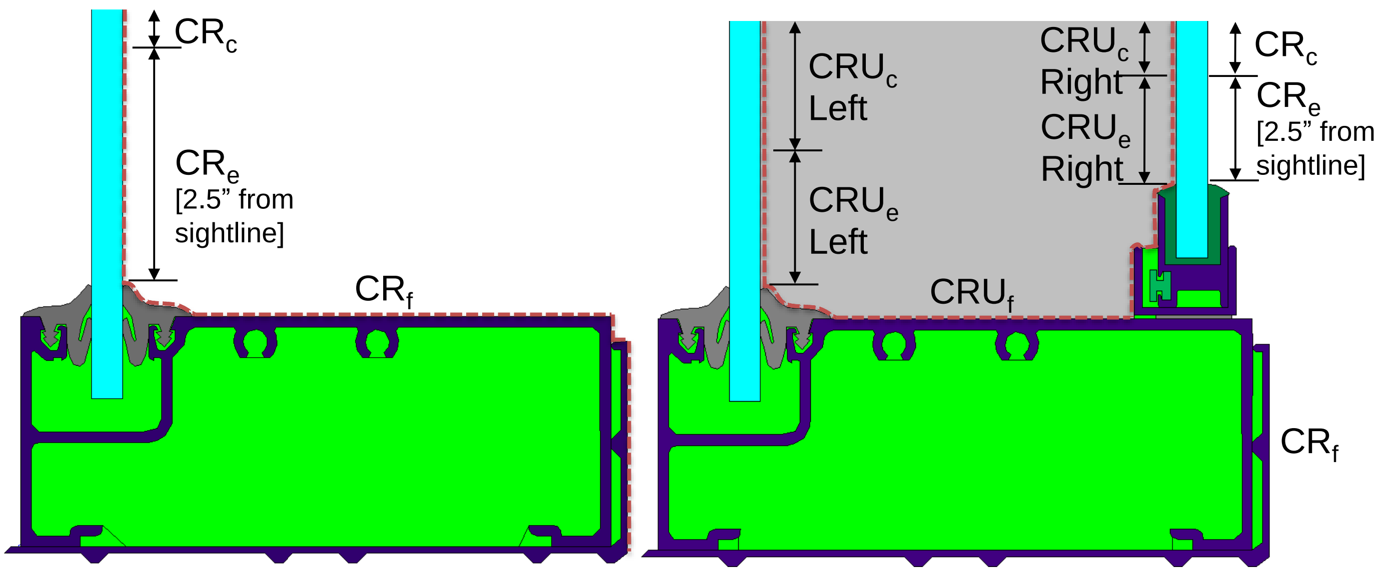
Condensation Resistance (CR) Unventilated Cavities

- Characterize CR between glass
- Valid for storm windows and interior window panels
- Functionality added to software tools
- Primarily funded by NEEA. Helps augment DOE funding for AERC



Progress and Accomplishments

Lessons Learned:

- Close working with industry leads to consensus energy rating system
- International harmonization is within reach

Accomplishments:

- Completion of new simulation models (thermal and optical):
  - Cellular shades
  - Pleated shades
  - Vertical louvered blinds
  - Perforated screens
  - Optical modeling of arbitrary shading geometry
- Validated ventilated cavities for top and bottom gaps.
- Developed CTS measurement technique for attachments systems
- Developed and validated CR model for vented cavities

Market Impact:

- AERC adopted developed simulation methods and LBNL software tools in rating and certification
- Shading system manufacturers working closely with LBNL and providing products and systems for validation measurements

Project Integration and Collaboration

Project Integration:

- Rating and certification organizations:
  - NFRC – adopted new models for integral shading systems
  - AERC – working closely with newly established organization to provide credible simulation and testing methods and software tools
  - Collaborate with industry to quantify the scope of attachment product variances including: fabrics, installations, gaps, etc.
  - All test samples are provided by industry partners

Partners, Subcontractors, and Collaborators:

- AERC, NFRC
- Hunter-Douglas
- Levelor-Rubbermaid
- Spring Fashions
- Rollease

Communications: AERC and NFRC technical committee and membership meetings.

Next Steps and Future Plans

Next Steps and Future Plans:

Technical:

- Start development of optical and thermal models for Phase 2 products
- Complete measurements and modeling work to validate edge gap air flow and heat transfer
- Perform validation of air flow through permeable shading systems
- Validation of current horizontal blind (venetian blind) model
- Development of improved model for horizontal blinds that can handle specular blind slat materials
- Preparation of models for their inclusion in software tools

Organizational:

- Support for NFRC efforts to rate and certify integrated shades
- Support for AERC efforts to develop rating and certification system for window attachments, from technical to rating issues
- Work with industry to further develop EfficientWindowCoverings web site for the promotion of energy efficient products.

REFERENCE SLIDES

Project Budget

Project Budget: So far $1,100k for two years. Estimated $2,100k over the next three years
Variances: None
Cost to Date: 65%
Additional Funding: NEEA

Budget History					
10/1/2014 – FY2014 (past)		FY2015 (current)		FY2016 – FY18 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$550k	None	$550k	$110k	$2,100k	TBD

Project Plan and Schedule