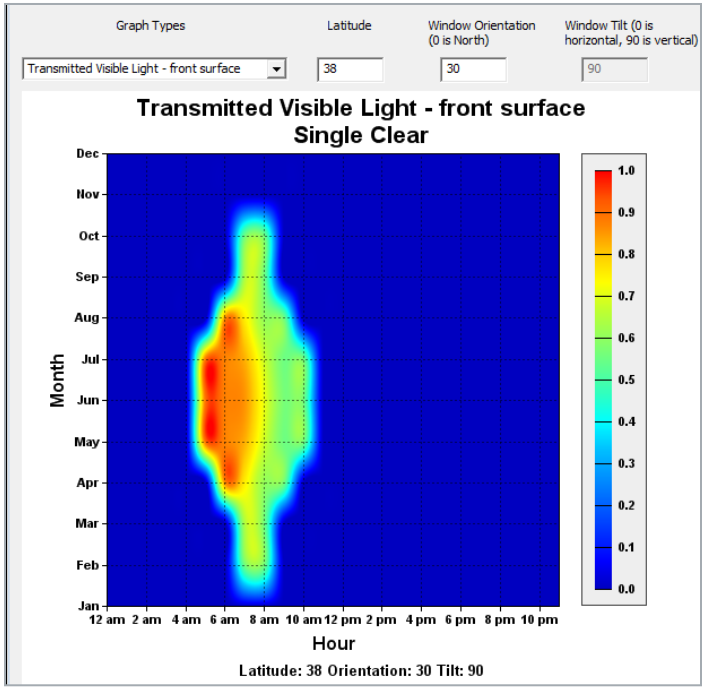
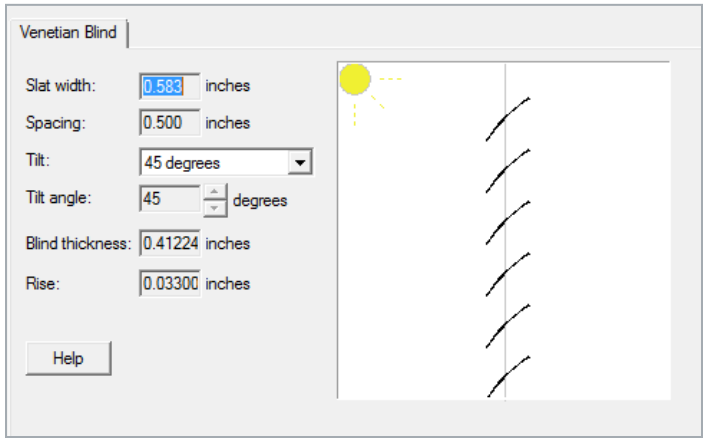
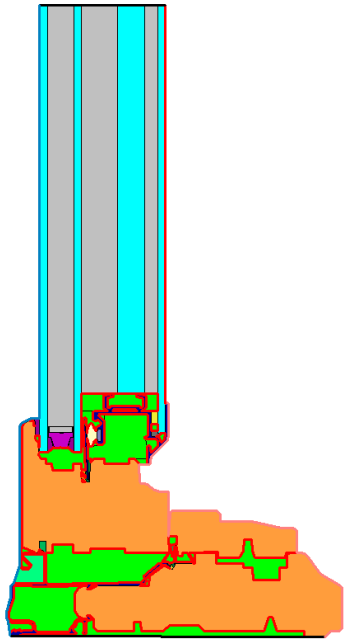
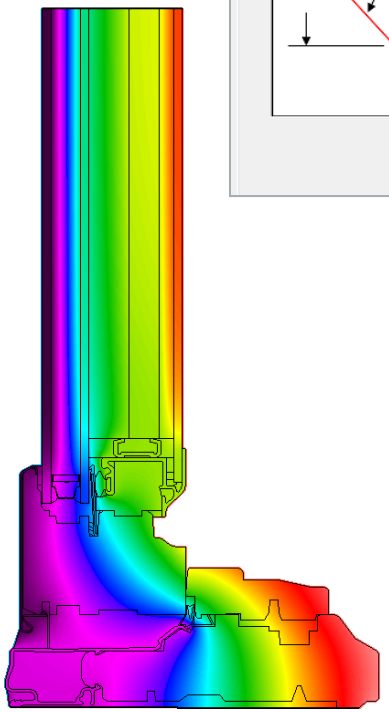
Fenestration Software Tools

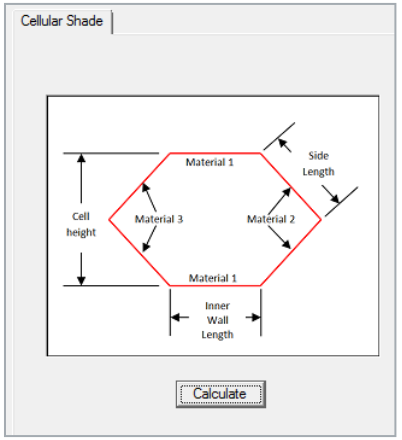
2014 Building Technologies Office Peer Review











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Project Summary

Timeline:

Start date: 10/1/2013 (longer term effort through different projects in the past)

Planned end date: 9/30/2018

Key Milestones

1. Released version of the next generation of fenestration software tools
2. Addition of full set of models for cellular shades and pleated shades

Budget:

Total DOE $ to date: $265k

Total future DOE $: $2,000k

Target Market/Audience:

Fenestration product manufacturers, Fenestration attachment product manufacturers, Rating and Certification Organizations, AEC Firms, Universities, International Partners

Key Partners:

NFRC - National Fenestration Rating Council	Guardian
CRAFT – Certification & Rating of Attachment Fenestration Technology	Pilkington NA
CBERD – Joint US/India Energy Research Center	PPG
Alcoa	SAGE, View
Pella, Jeld-Wen, Marvin, Andersen, Milgard	International partners: Australia, Brazil, South Africa, India, China, EU

Project Goal:

Develop suite of interconnected tools capable of accurately modeling prime fenestration systems, integrated shading systems and window attachments and coverings

Purpose and Objectives

Problem Statement: Advanced tools are intended to move the window industry toward a 21st century paradigm of virtual, rapid product design and product development.

Target Market and Audience: Manufacturers need rapid access to these accurate, user friendly and independently verified computer tools and associated measurement facilities to accelerate design-to-market delivery of new energy efficient window technologies and products. Foundation for rating fenestration products through NFRC and CRAFT (under establishment).

Impact of Project: LBNL's fenestration software tools are widely recognized throughout the world, forming the basis of the building energy codes for fenestration in the US, as well as helping national fenestration manufacturers innovate and sell their products globally using universally accepted and trusted product performance simulation. They contribute to carbon emission reduction through free access to these world class modeling tools. Technical potential for energy savings by 2030 from windows is 2 quads (commercial and residential) and an additional 0.17 quad for daylighting.

Approach

Develop suite of interconnected tools capable of accurately modeling prime fenestration systems, integrated shading systems and window attachments/coverings.

- Support new Organization for rating and certification of window attachments (CRAFT) through added modeling capabilities for fenestration attachments.
- Release expanded complex glazing and shading database (CGDB) with additional complex products and new complex product classes. *Share cost with industry.*
- Expand the International Glazing Database (IGDB) and maintain credible, peer-reviewed database. *Share cost with industry*.
- Build on existing software infrastructure and extend capabilities while improving software tools robustness and accuracy.
- Strengthen open software model by expanding existing APIs.
- Integration of THERM and WINDOW with RADIANCE and COMFEN through API. Integration with third party software tools (e.g., NFRC CMAST, AutoDesk tools)
- Establish software forum, for more effective support of expanding user base.
- Extend knowledge base (KB) and frequently asked questions (FAQ) web pages for better communication with users and release updated documentation.

Key Issues and Distinctive Characteristics

Key Issues:

- Enable rapid development of new technologies, such as vacuum glazing, window attachments & shades, chromogenic glazing, PV integration, Hi-R windows, automated operation, etc.
- Enable cost-effective rating/certification of prime windows with or without integrated shades (NFRC) and window attachments/coverings (CRAFT)
- Reduce the cost of energy efficient product development, by providing a credible modeling platform for product development and improvement of energy efficiency of fenestration and shading systems
- Provide wider access to software tools by building and related industries beyond fenestration. Examples are PassivHaus, opaque envelope modeling, appliance industry.

Distinctive Characteristics:

- High quality, technically accurate, user friendly, free software tools that serve broad audience in building industry.
- Use in rating & certification as a primary software tools for generating rating indices. Referenced by almost all codes across the country and many codes internationally.
- International acceptance and use of fenestration software tools, enabling effective collaboration on mitigating global climate change effects.

Workflow For Credible Product Simulation


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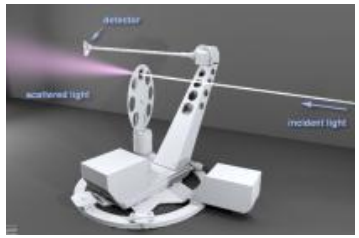
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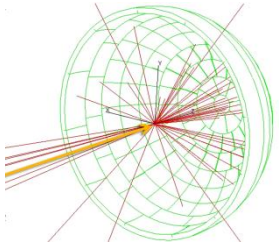
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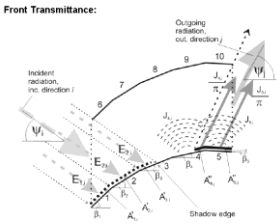
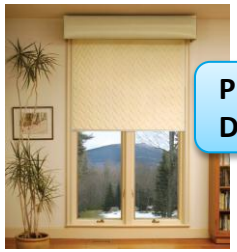
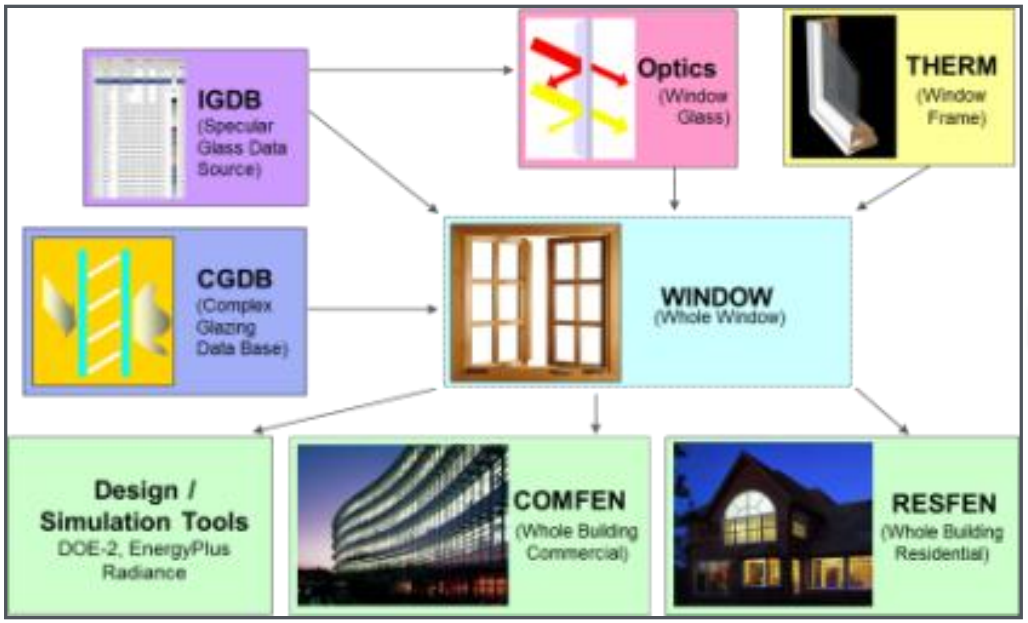


Building Science Infrastructure



Product Design

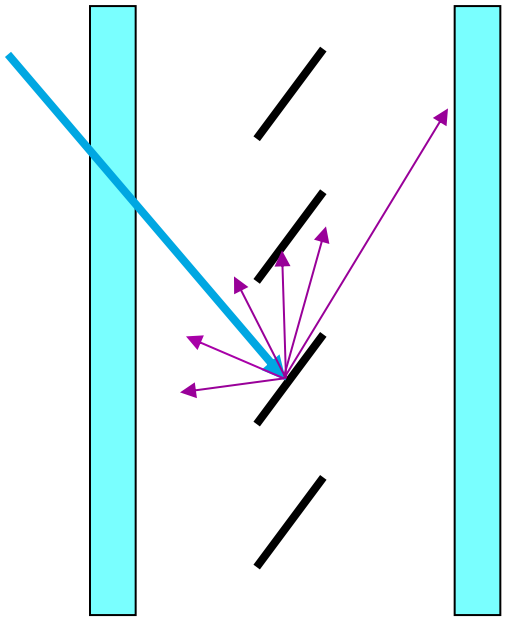


Ratings / Deployment

Tools, Standards, Product Data

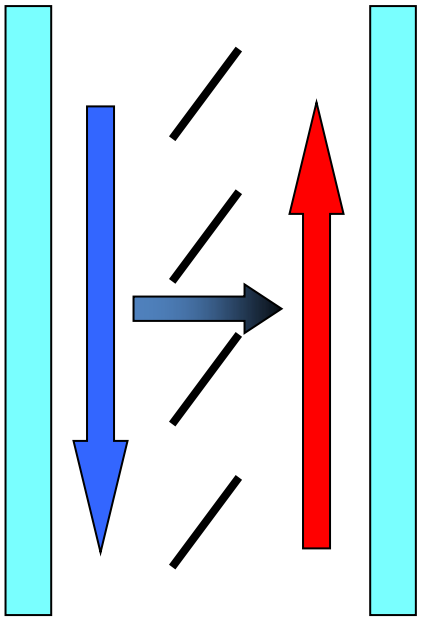
Modeling of Complex (Scattering) Products

Optical



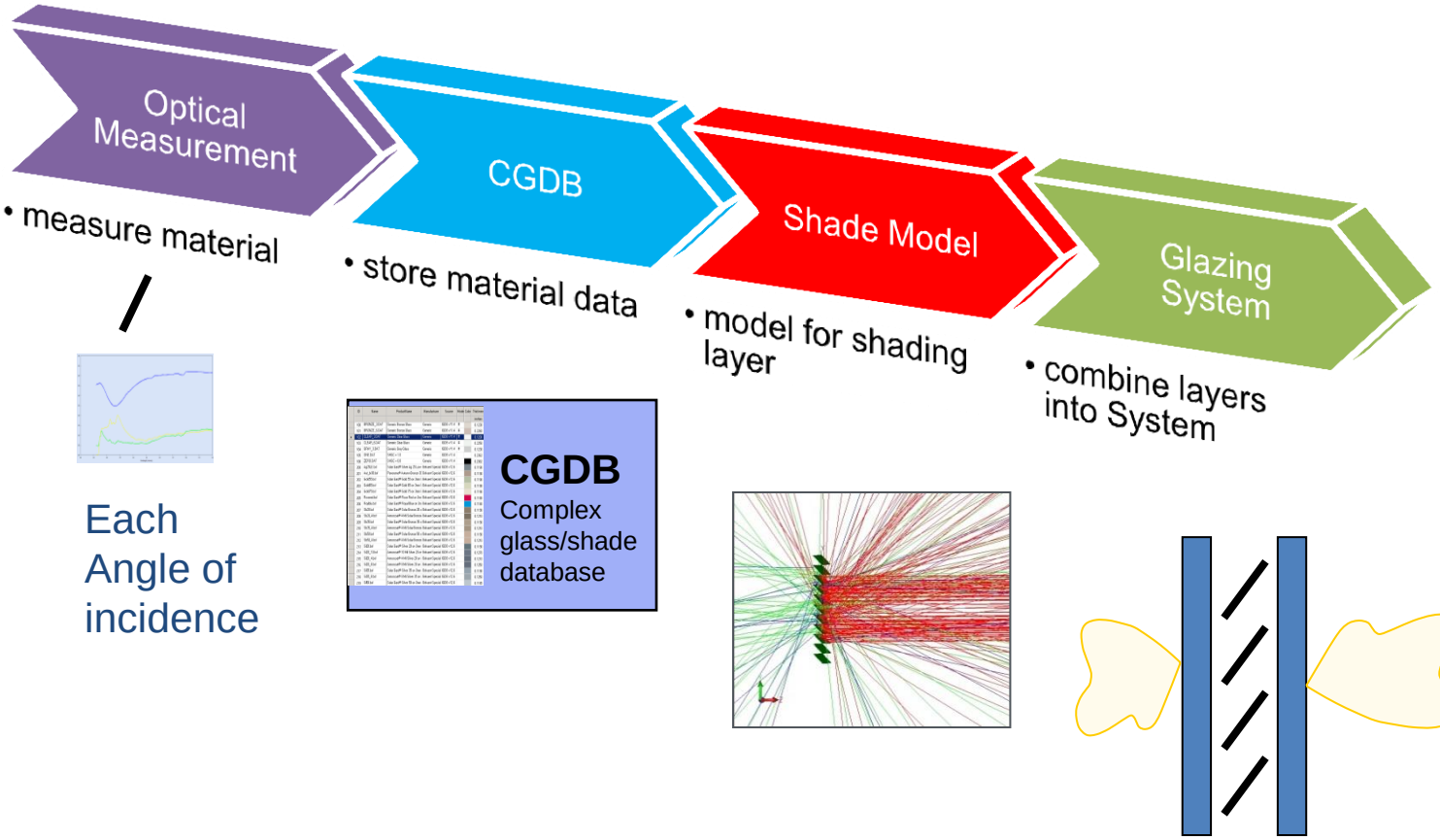
- Visible & Solar: T_f, T_b, R_f, R_b
- Far Infrared: T_{IR}, ε_f, ε_b

Thermal

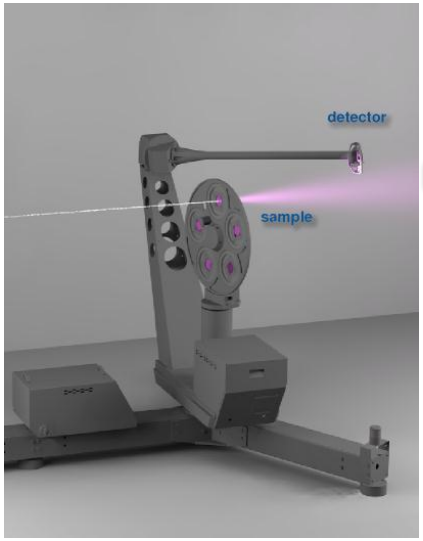


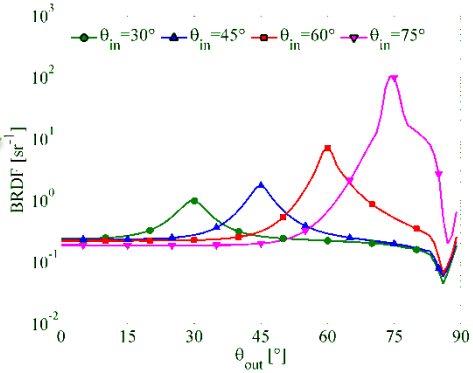
- Conduction
- Convection
- Radiation

From Material Coupon to Whole Product Model

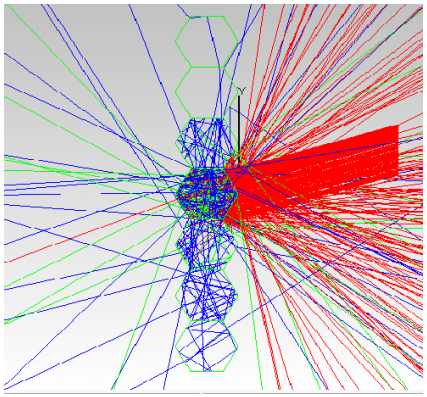


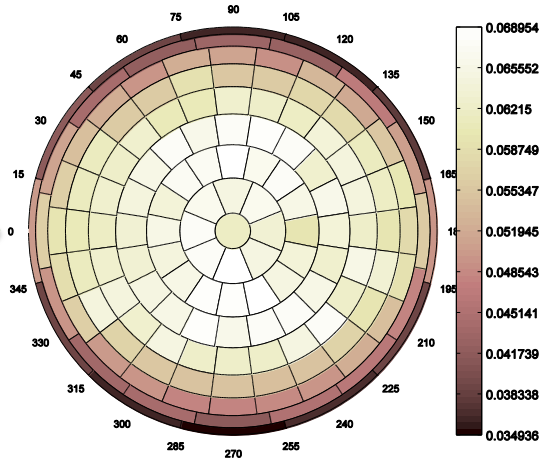
Example of Cellular (Honeycomb) Shade Modeling

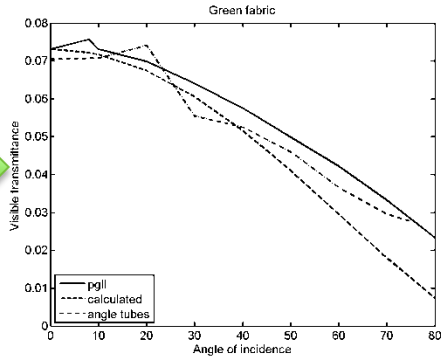




Measure material properties to generate accurate input data for CGDB and perform real-time ray-tracing in WINDOW (genHoney module) to generate BSDF of Cellular Shade

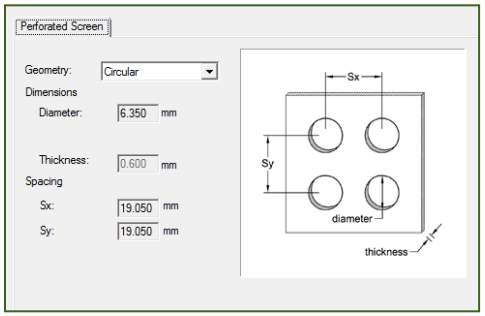




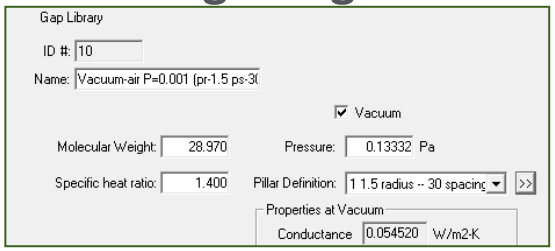


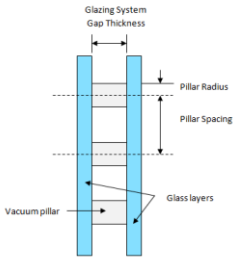
WINDOW and THERM Advancements

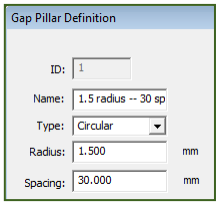
Perforated screens



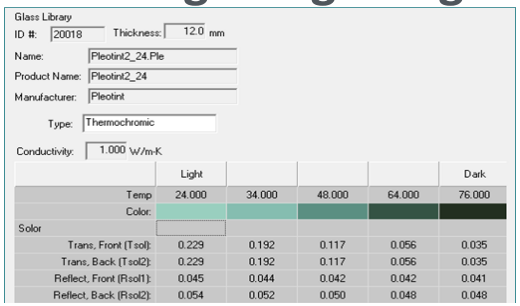
Vacuum glazing



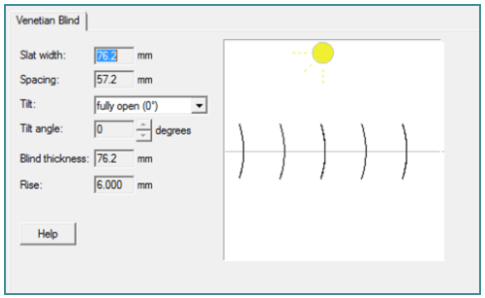




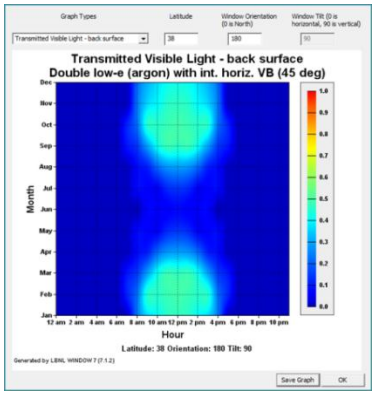
Chromogenic glazing



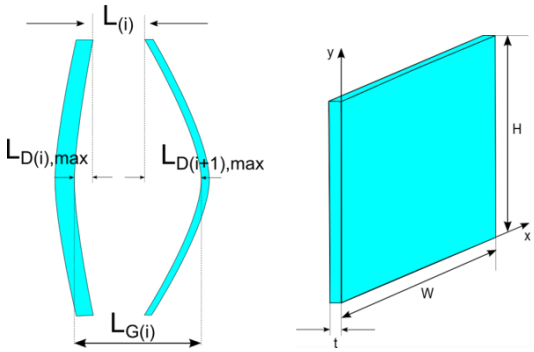
Vertical Louvers



Angular data

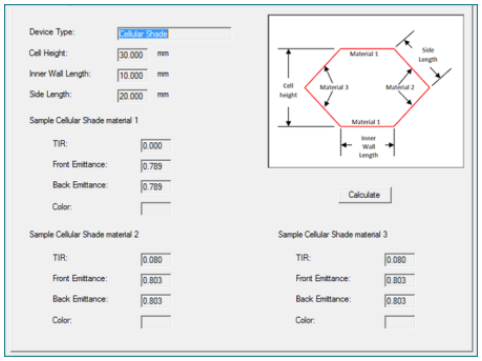


Glazing deflection

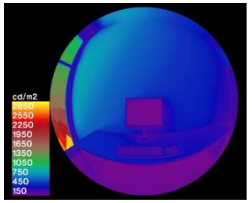


Ufactor	SC	SHGC	Rel. Ht. Gain	Tvis	Keff	Gap 1 Keff
W/m2-K			W/m2		W/m-K	W/m-K
1.667	0.422	0.367	278	0.691	0.0304	0.0304
1.870	0.425	0.369	282	0.691	0.0359	0.0304

Cellular shades



Radiance renderings



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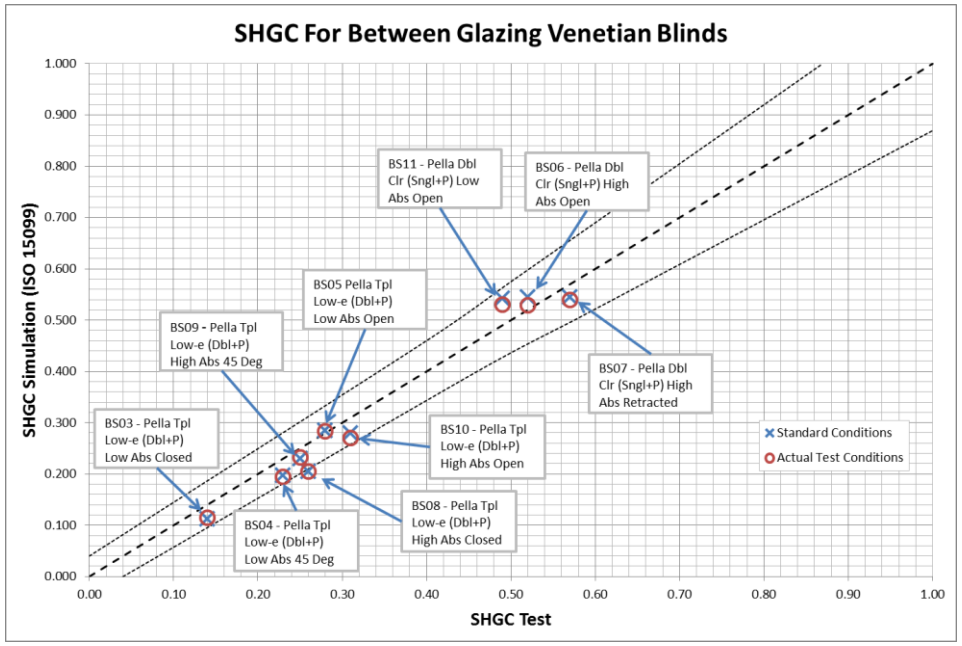
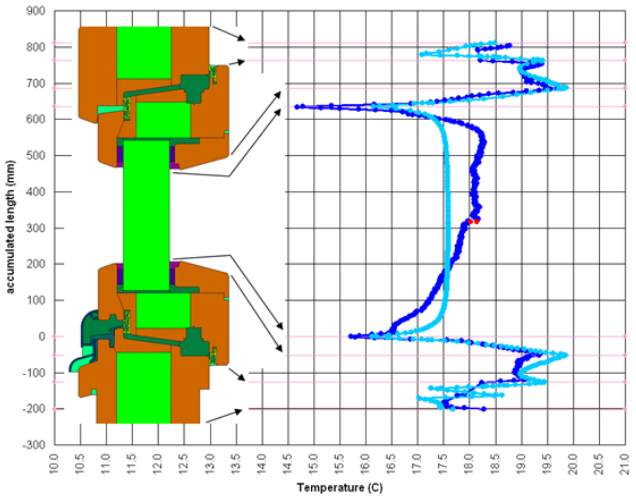
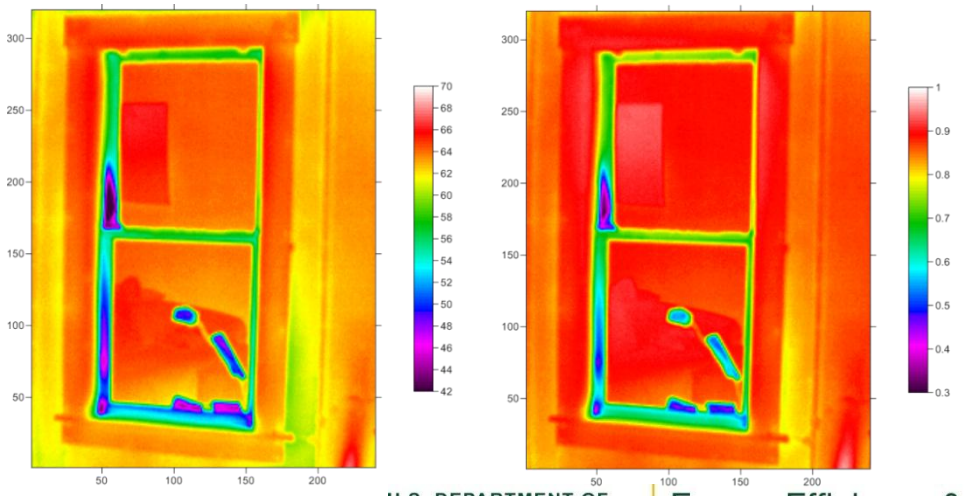
Experimental Validation of Software Tools



Validation is performed in multiple ways:

- Hot box and solar calorimeter measurements of U, SHGC
- MoWiTT measurements of U, SHGC, temperatures
- Measurements of temperatures, air flow and local surface heat fluxes in IR Thermography apparatus.





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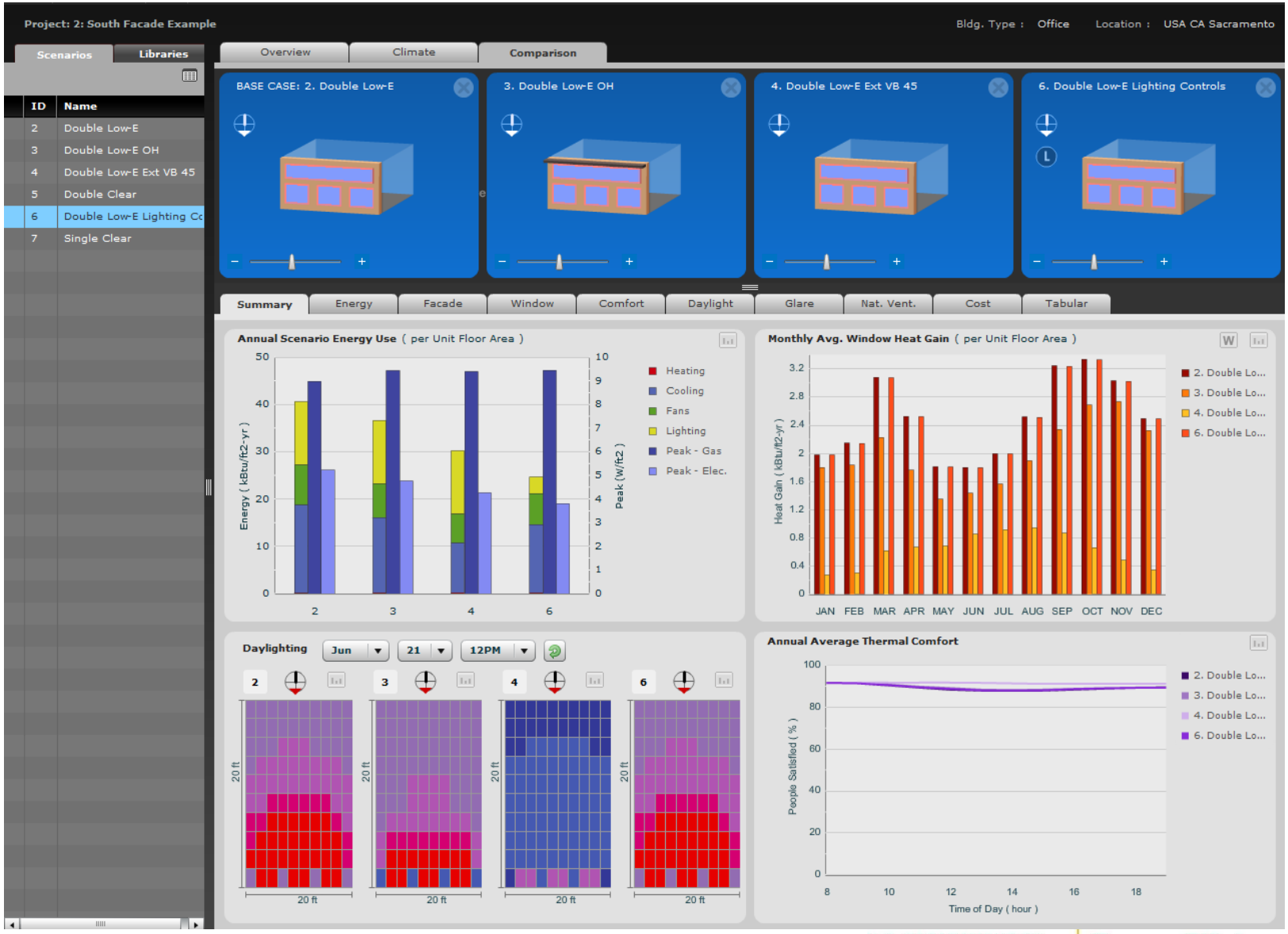
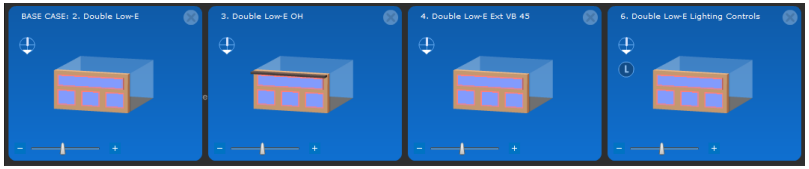
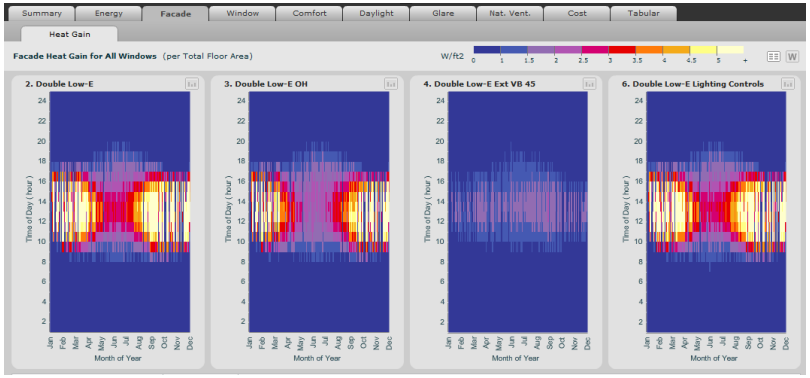
COMFEN: Energy Use From Windows & Façade Systems



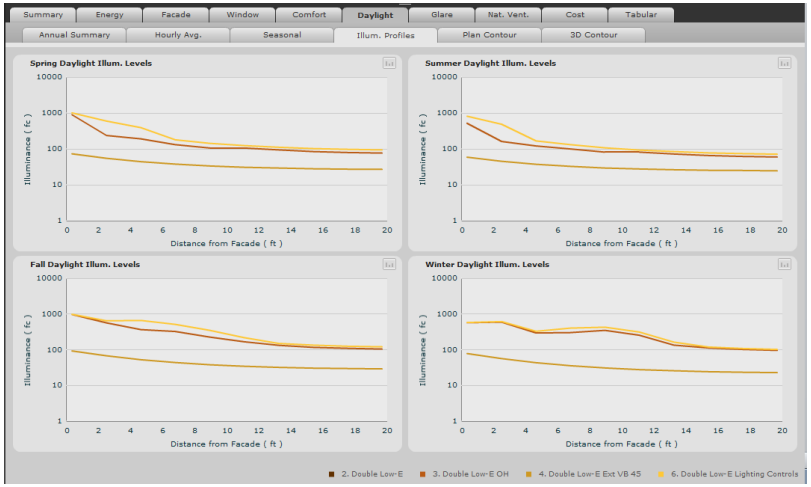
COMFEN: Rapid Model Generation & Visually Compelling Reports



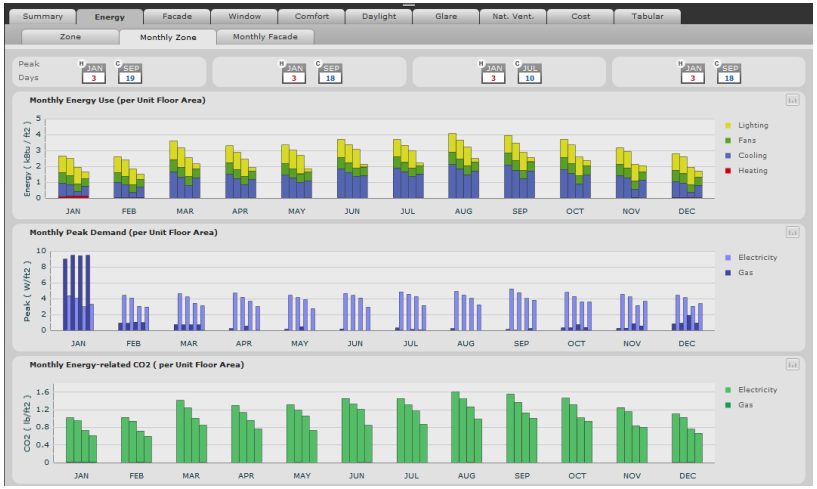
Façade Heat Gain Map



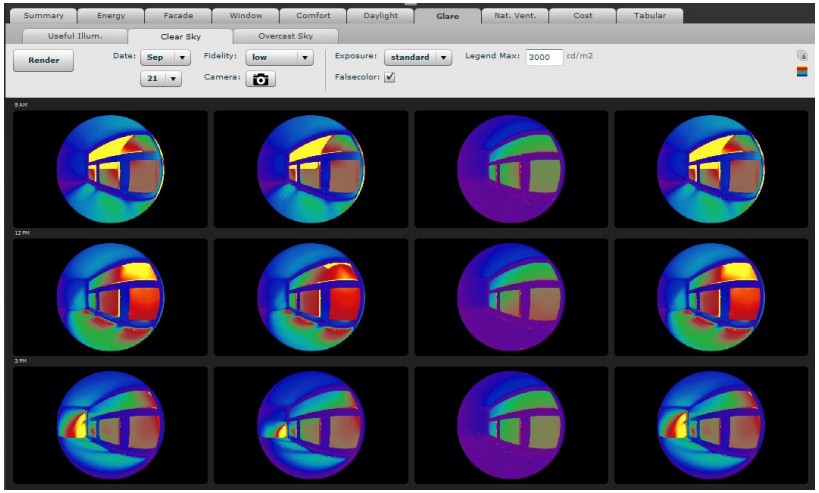
Daylight Illuminance Levels



Monthly Energy Use



Radiance Glare Renderings



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Progress and Accomplishments

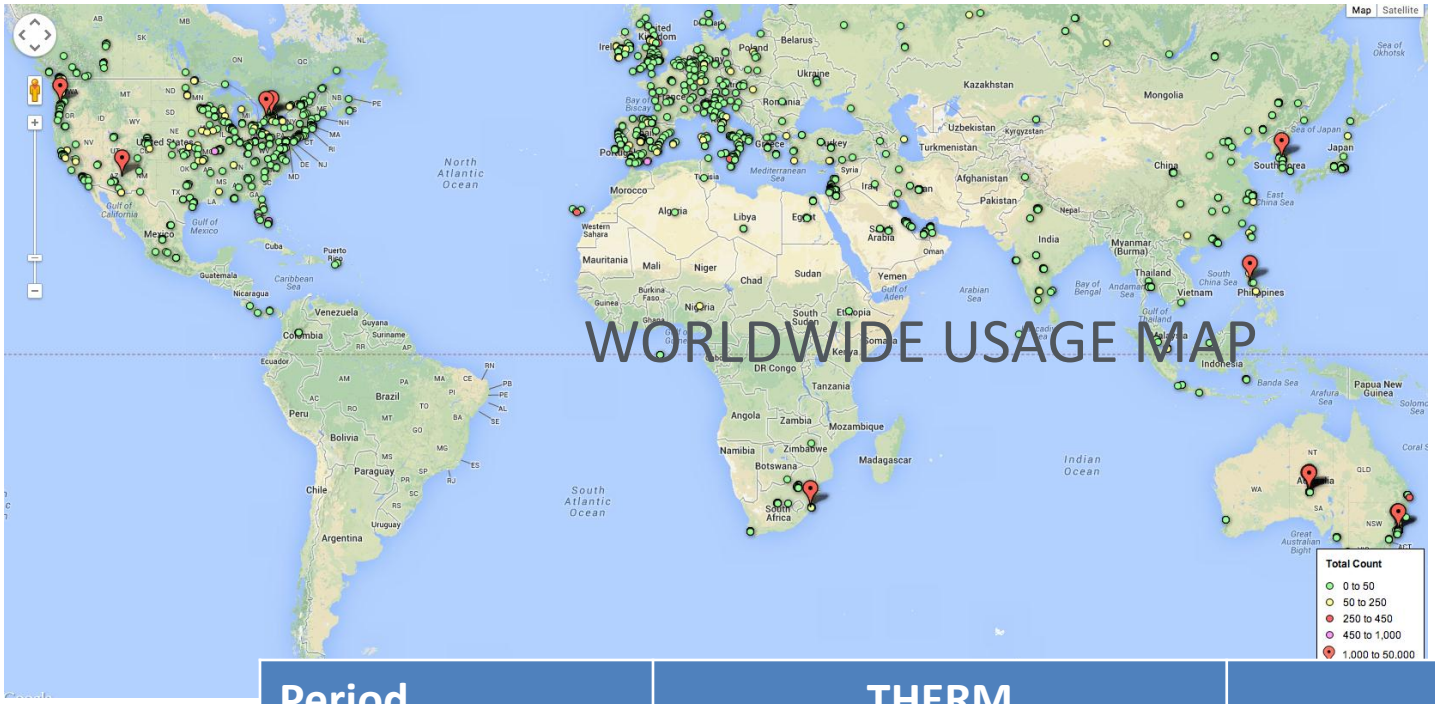
Accomplishments:

- Release of the new generation of fenestration software tools with improved accuracy and robustness
- Implementation of automated updates and notification about available updates
- Completion of new modeling capabilities:
  - Cellular shades
  - Vertical louvered blinds
  - Perforated screens
  - Chromogenics (Thermochromic and Electrochromic glazing)
  - Vacuum insulated glazing, also known as evacuated glazing units (VIG or EGU)
  - Deflection for insulated glazing units (IGUs)
- Release of the new version of CGDB, bi-monthly releases of IGDB
- Improved visualization of optical performance of glazing with scattering layers (i.e., shades, complex glazing)
- Radiance rendering of light distribution in building space
- COMFEN – BSDF modeling, Chromogenics, Improved Radiance visualization.

Market Impact:

- Tools used by all major fenestration manufacturers
- Compliance with standards, codes, & above code programs
- Global user base

Market Impact – Global User Base



Period	THERM		WINDOW	
	Launches	Users	Launches	Users
Since Dec 2011	677k	37k	283k	21k
This FY	181k	15kk	71k	8k
Last 30 days	41k	5.0k	18k	3.1k

Project Integration and Collaboration

Project Integration:

- Rating and certification organizations:
  - NFRC collaboration with monthly conference calls
  - Coordination for supporting future window attachments organization (CRAFT)
- User support and education
- CRADA and non-CRADA collaboration with manufacturers
- Standards development (ISO 15099, NFRC, ASHRAE)

Partners, Subcontractors, and Collaborators:

- Rating organizations: NFRC
- Industry: Pella, Marvin, Andersen, Jeld-Wen, Alcoa, Cardinal, Guardian, Sage, View, Pilkington NA, PPG
- AEC companies: Arup, HOK
- Media companies: BuildingGreen
- Architects, engineers, consultants, building owners
- Trade associations: WCMA, ESSA, AAMA, WDMA, IGMA
- International partners: Brazil, Mexico, South Africa, India, China, Australia, UK, Thailand, ES-SA (European Solar-Shading Association)
- Subcontractors: Maurya McClintock and Daniel McQuillen

Communications: e-mail/phone user support, web-based software support forum, conferences (Façade Tectonics, GANA, IGMA), and webinars.

Next Steps and Future Plans

This FY:

- Extension of cellular shade models to highly insulated, multi-walled products
- Development of optical and thermal model for pleated shades
- Development of optical and thermal model for window quilts and drapes (stretch milestone, pending availability of funds)
- Implementation of improved algorithms for modeling air flow around window shading devices (effects of edge gaps, shade porosity/openness)
- Support for NFRC efforts to rate and certify integrated shades
- Support for the new rating and certification organization for window attachments (CRAFT)

Out Years:

- Development of additional functionalities to model full set of window attachments and shades
- Improvement of CGDB in support of NFRC and CRAFT as well as rapid product development
- Development of models for Fenestration-integrated PV (FIPV)
- Extension of APIs and additional connectivity to other modeling software
- Exploration of open source development model
- Residential model in COMFEN

REFERENCE SLIDES

Project Budget

Project Budget: Newly defined project in FY14 planned to continue until FY18. Long history of fenestration software tools over the past 30 years.
Variances: N/A.
Cost to Date: 205k.
Additional Funding: $100k from California Energy Commission for COMFEN.

Budget History					
FY2013 (past)		FY2014 (current)		FY2015 –FY18 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
N/A*	N/A*	$265k	$100k	$2,000k	TBD

* Fenestration software tools have been developed at LBNL for the past 30 years as integral part of different projects, many being focused on technology development. In FY14, development of fenestration software tools was identified as a separate project, which is reflected in above dollar numbers. However, some of the accomplishments are rooted in prior year investments.

Project Plan and Schedule