CBEI - Enhancing OpenStudio for Airflow and Daylight Modeling

2015 Building Technologies Office Peer Review
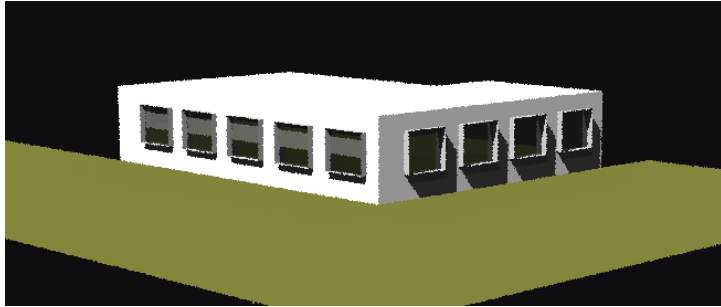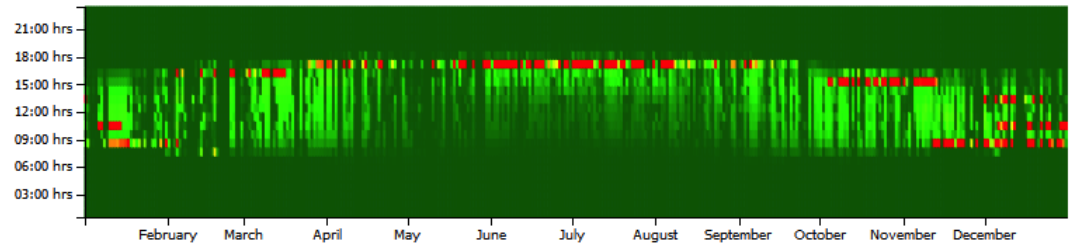

John Messner, jmessner@engr.psu.edu
Charles and Elinor Matts Professor of Architectural Engineering
CBEI - The Pennsylvania State University
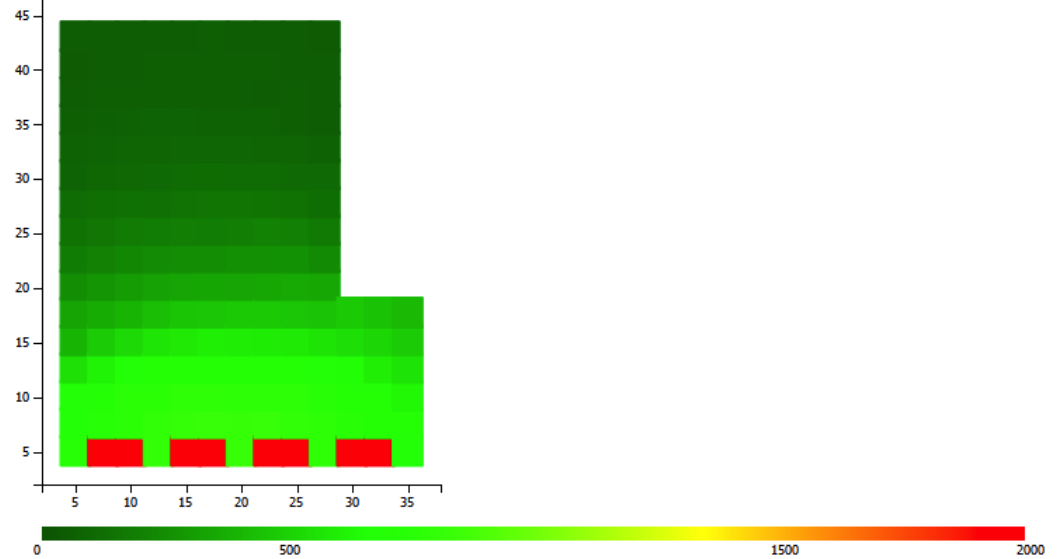
Project Summary

Timeline:

Start date: February 1, 2013

Planned end date: April 30, 2016

Key Milestones:

1. Create OpenStudio code to support enhanced daylighting analysis, improved airflow network analysis and fundamental IFC integration (Apr. 30, 2015)

2. Improved lighting and IFC integration with OpenStudio (Apr. 30, 2016)

Budget:

Total DOE $ to date: $ 1.313 M

Total future DOE $: $ 0.472 M

Target Market/Audience:

Building tool developers who support the profession by creating tools for design professionals with a specific focus on the analysis of energy retrofit and high performing building projects.

Key Partners:

CBEI - Penn State

NREL

LBNL

TNO (The Netherlands)

Project Goal:

The goal is to enhance the functionality of OpenStudio to support retrofit projects, and enable project teams to easily integrate energy, daylight and airflow modeling into their design workflows.

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CBEI
CONSORTIUM for BUILDING ENERGY INNOVATION

Vision:
By 2030, deep energy retrofits that reduce energy use by 50% in existing SMSCB, which are less than 250,000 sq ft

Mission:
Develop, demonstrate and deploy technology systems and market pathways that permit early progress (20-30% energy use reductions) in Small and Medium Sized Commercial Buildings

Our Goals:

- **Enable deep energy retrofits** in small to medium sized commercial buildings

- **Demonstrate energy efficient systems** tailored for SMSCBs in occupied buildings – living labs

- **Develop effective market pathways** for energy efficiency with utilities and other commercial stakeholders: brokers, finance, service providers.

- **Provide analytical tools** to link state and local policies with utility efficiency programs

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CBEI Partners

Industry
- Bayer MaterialScience
- United Technologies Research Center

Economic Development Organizations
- DVIRC
- PIDC — Driving growth to every corner of Philadelphia
- Ben Franklin Technology PArtners

Universities
- PENNSTATE 1855
- Penn — UNIVERSITY of PENNSYLVANIA
- VirginiaTech — Invent the Future — 1872
- PURDUE UNIVERSITY
- NJIT
- Drexel UNIVERSITY
- MORGAN STATE UNIVERSITY — GATEWAY TO OPPORTUNITY, STAIRWAY TO EXCELLENCE
- Carnegie Mellon University
- RUTGERS

DOE'S Energy Modeling Ecosystem: A BTO Priority

OpenStudio SDK is an open source platform that bridges the gap between capable but complex engines and the easy-to-use applications that drive energy savings.

The Technology Performance Exchange (TPEx) and Building Component Library (BCL) provide the raw data that powers the ecosystem.

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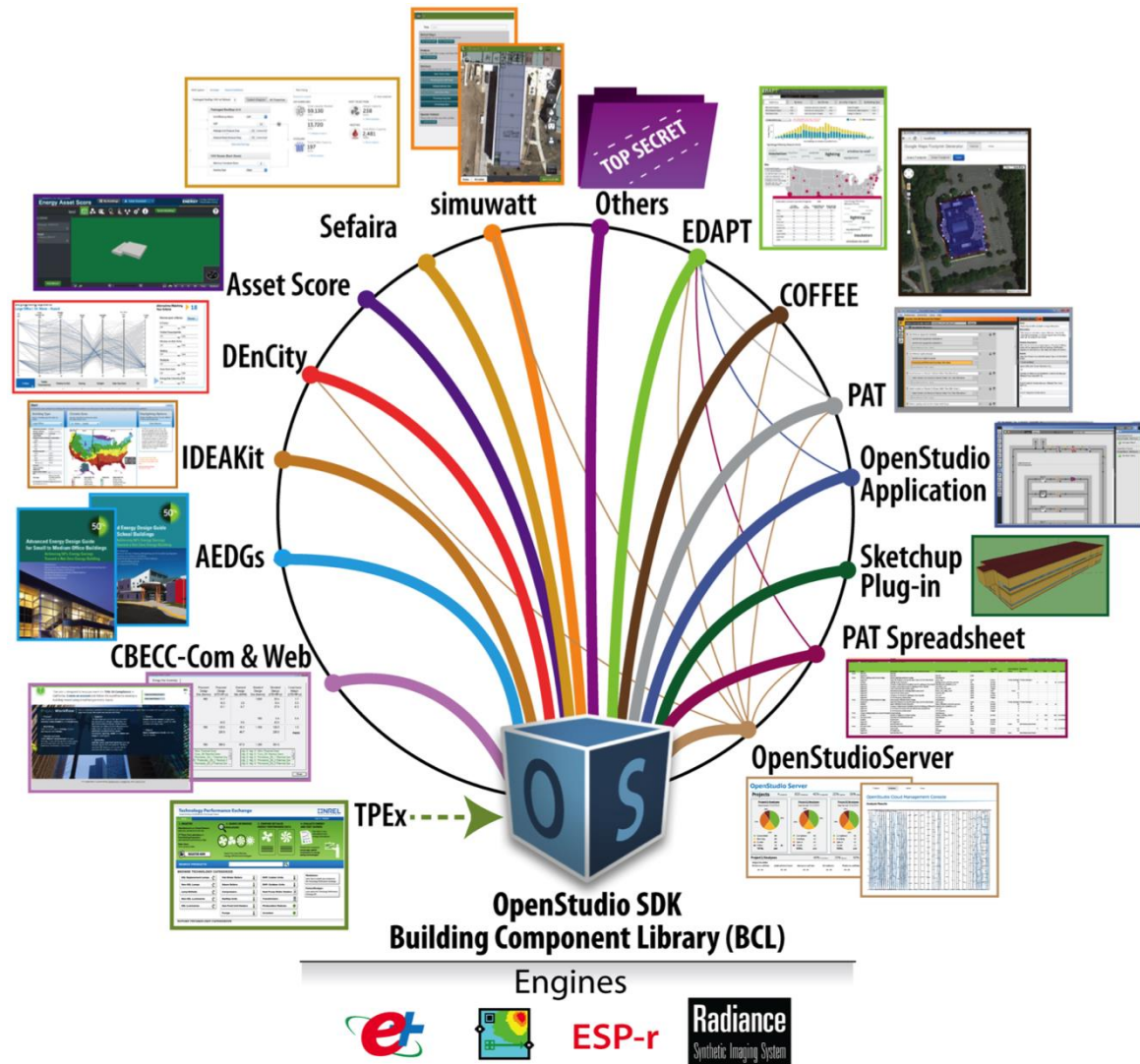
The Challenge

Problem Statement:

Energy modeling is inconsistently applied in the retrofit of Small and Medium Size Commercial Buildings (SMSCB), in part because:

1) it is difficult to develop high quality energy models, and
2) it is time consuming to recreate model content due to poor interoperability with retrofit design tools.

Target Market and Audience:

Building tool developers and building design professionals who service the SMSCB market.

Impact of Project:

Through the enhancements to the OpenStudio SDK as well as Radiance, application developers and design professionals will be able to develop more accurate energy models with a significant time reduction in model development. The improvements will encourage greater adoption of modeling in SMSCB projects, which will yield improved designs that consume less energy. In five years, our goal is to enable these enhancements to be leveraged on a daily basis by design teams through the functional enhancements embedded into software applications that they use.

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Overall Project Approach

Approach: The project focuses on enhancing OpenStudio to enable the integration of airflow and daylighting analysis into energy models, along with improving interoperability between design applications and the OpenStudio platform.

Key Issues: The project team is closely collaborating with the OpenStudio team at NREL, the Radiance team at LBNL, and the BIMserver team at TNO.
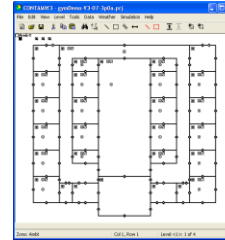
Distinctive Characteristics: The team at Penn State is composed of specialists in lighting analysis, mechanical analysis, and information science and technology. The team also works closely with building design professions in industry.
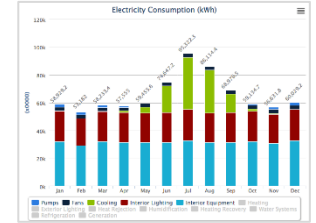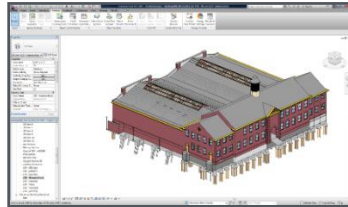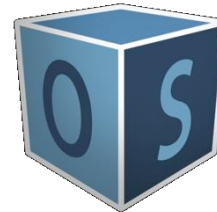
Our Approach

ENHANCE
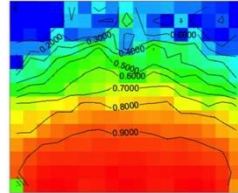
Daylighting

Airflow Modeling

Energy Model

INTEGRATE

Design Tools

OpenStudio

EnergyPlus

Radiance
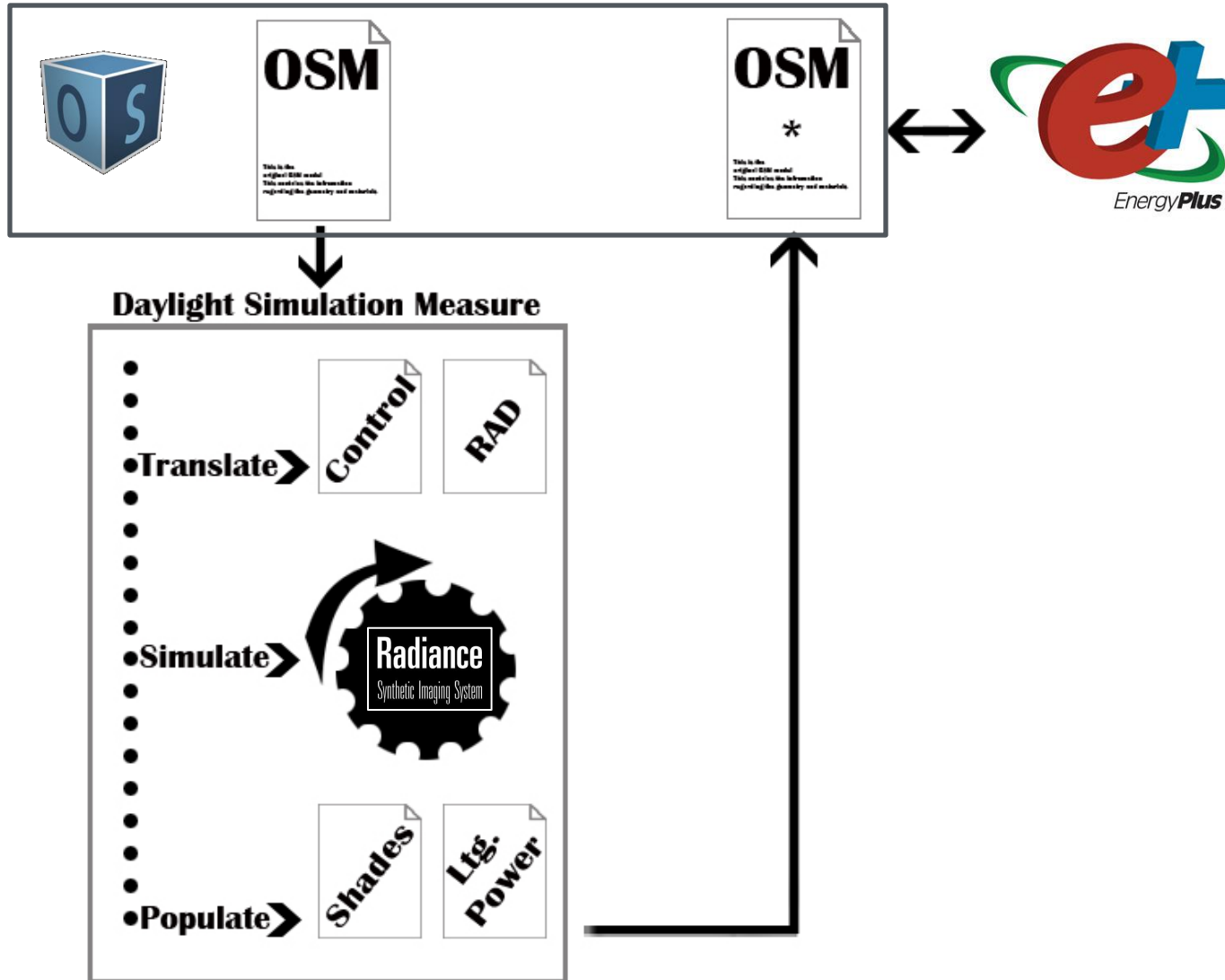
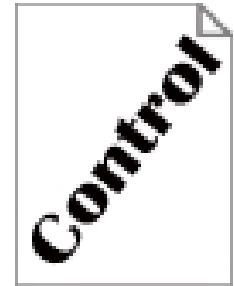U.S. DEPARTMENT OF **ENERGY** | Energy Efficiency & Renewable Energy

Integrating OpenStudio and Radiance

New Radiance Control File for Daylight Modeling

Developed in collaboration with NREL for full-building Radiance daylight simulations

Physical Model Details

> » Space geometry and materials
>
> » Exterior Objects
>
> » Operable Shading Devices
>
> » Site Weather Data
>
> » Occupancy Data
>
> » Lighting Power

Simulation Details

> » Radiance analysis settings
>
> » Lighting control
>
> » Shade control
>
> » Requested performance metrics

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New Radiance Programs for Developers and End Users

Pre-simulation: Create analysis grids, test for leaks, and combine spaces into fully enclosed models.
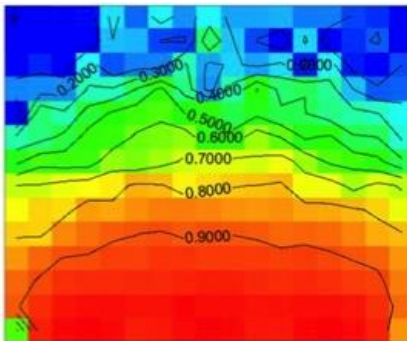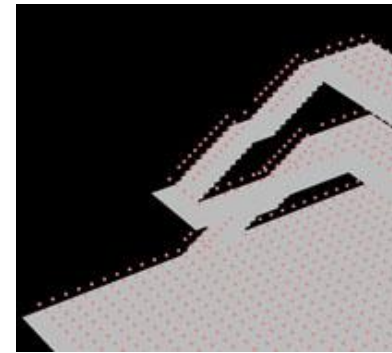
Simulation: Compute daylight illuminance at grid points and shade sensors, then combine data into final annual illuminance files based on shade settings.

Analysis: Process annual space and full-building daylight metrics, shade and lighting schedules, and other design performance analyses.
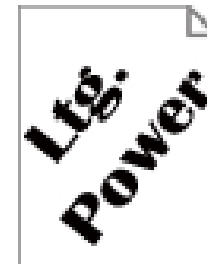
Airflow Enhancements to OpenStudio

Developed objects in OpenStudio for airflow zones, paths, airflow elements, other essential elements, along with a translator object
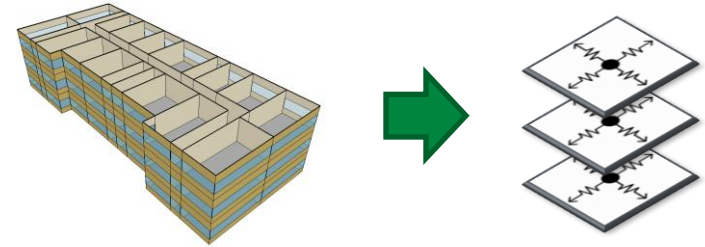
Developed proof-of-concept translator for AirflowNetwork (AFN) by leveraging CONTAM effort for E+ internal solver

Fully integrated AFN into OpenStudio by developing element objects and extending the translator object
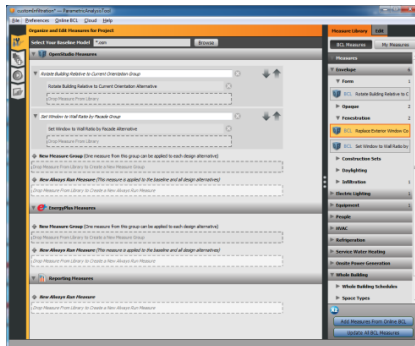
Developed PAT-based scripts for Indoor Air Quality and ventilation measures

BIMserver: Enabling Interoperability with Design Tools
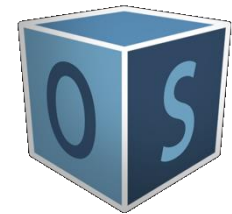
Design Tools   **BIMserver**   **OpenStudio**

IFC Format

OSM Stream

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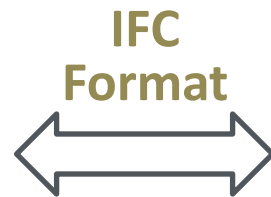
IFC Import Function Supported Elements

Roof	
IfcRoof	OS:Surface

Wall	
IfcWall	OS: Surface

Door	
IfcDoor	OS:SubSurface
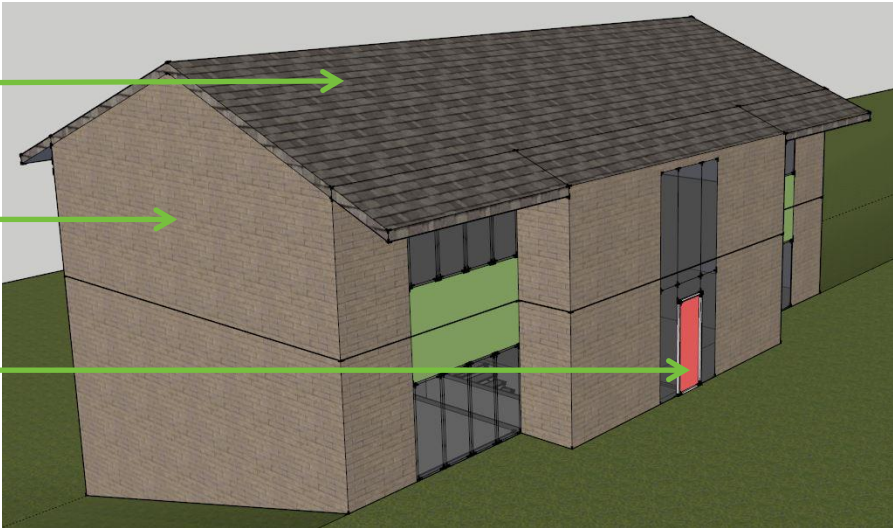
Ceiling	
IfcRoof	OS:Surface

Floor	
IfcSlab	OS:Surface

Window	
IfcWindow	OS:SubSurface

Space

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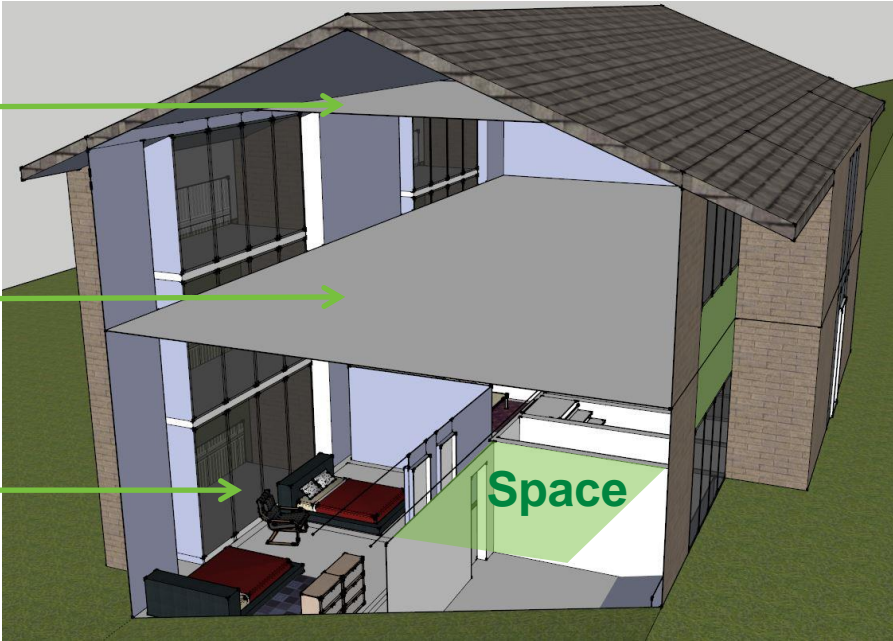
Accomplishments and Deliverables

OpenStudio
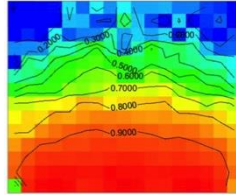
**OpenStudio
Radiance Integration**
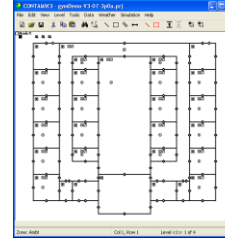
**OpenStudio
Airflow Network Integration**
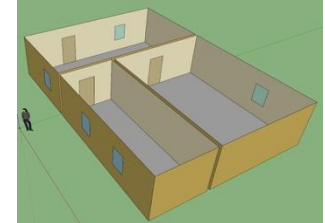
**OpenStudio
BIMserver Integration**

**Open Source
Code**

Radiance
Synthetic Imaging System

BiMserver ™
Open source Building Information Modelserver

**Radiance
Software**

**OSM Serializer
For BIMserver**

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Project Integration and Collaboration

Project Integration:
- Hosting the International Radiance Workshop in Aug. 2015 at CBEI
- Hosting webinar on Whole Building Daylight Simulation

Collaborators:
- Close collaboration with NREL and LBNL

Communications:
- ASCE Computing Conferences
- Building Simulation Conference
- IES Annual Conferences
- Building Energy Information Summits

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Impact

- Model development time significantly improved through IFC integration

- Daylight integration into energy models improved through automated reference point selection, complex space modeling, and shading schedule generation

- Airflow integration into energy models improved through automated schedule generation

- Daylighting support for whole building daylight analysis, including the calculation of spatial daylight autonomy and annual sunlight exposure (LEED 4.0 daylight credit option)

These improvements enable the development of more accurate energy simulations at earlier stages within a project.

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Who will use this functionality?

- Application developers using OpenStudio and/or Radiance

- Daylighting consultants

- Lighting control and shading manufacturers

- Whole building energy modelers

- EDAPT-based utility incentive programs

- Energy researchers at the national labs, private companies, and academia

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Next Steps & Future Plans

Our focus for the next 12 months:

- Modeling of physically based lighting layouts and systems including daylight integrated photocontrol to allow for the modeling of actual project lighting system data

- Space-level lighting control system analysis and optimization to include studies of control zone layout and photosensor placement

- Increase data interoperability with BIM applications with a focus on extending beyond the geometric information for energy modeling to enable more analyses related to lighting and energy

- Webinars to support application developers and users

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Acknowledgements

- DOE BTO

- NREL

- LBNL

- TNO, and the rest of the BIMserver community

- CBEI colleagues

- And all the design professionals that have worked with us.

REFERENCE SLIDES

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Project Budget

Project Budget: The project is funded through The Penn State Consortium for Building Energy Innovation. CBEI is a 5 year initiative. The current budget period is Budget Period 4 (BP4) which is from May 1, 2014 to April 30, 2015. BP5 is scheduled to start on May 1, 2015.

Variances: None

Cost to Date: Approximately 90% of the current BP4 funds have been expended.

Additional Funding: Cost-share funds from the Consortium for Building Energy Innovation (CBEI).

Budget History					
CBEI BP3 (past) 2/1/2013 – 4/30/2014		CBEI BP4 (current) 5/1/2014 – 4/30/2015		CBEI BP5 (planned) 5/1/2015 – 4/30/2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$743,738	$182,020	$570,000	$116,244	$472,480	$159,202

CBEI – Consortium for Building Energy Innovation (formerly EEB Hub)

BP – Budget Period

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Project Plan and Schedule

Project Schedule												
Project Start: February 1, 2013	◼ Completed Work											
Projected End: April 30, 2016	◼ Active Task (in progress work)											
	◆ Milestone/Deliverable (Originally Planned)											
	◆ Milestone/Deliverable (Actual)											
	BP3 (2013-14)				BP4 (2014-15)				CBEI BP5 (2015-16)			
Task	Q1 (Feb-Apr)	Q2 (May-Jul)	Q3 (Aug-Oct)	Q4 (Nov-Apr)	Q1 (May-Jul)	Q2 (Aug-Oct)	Q3 (Nov-Jan)	Q4 (Feb-Apr)	Q1 (May-Jul)	Q2 (Aug-Oct)	Q3 (Nov-Jan)	Q4 (Feb-Apr)
Past Work												
Initial OpenStudio Enhancements (Contam, Radiance & BIMserver Query Functionality)	◼	◼	◼	◼	◆							
Create Specifications (Airflow Network, Daylight, BIMserver)					◼	◼						
G/NG: Develop OpenStudio Contribution Proposal						◼	◆					
Object implementation in OpenStudio					◼	◼						
Development of Documentation & Demonstration Content							◼	◼	◆			
Current/Future Work												
Contribution Proposal Development & Submission									◼			
Develop initial implementations of necessary features both inside and outside of OpenStudio										◼	◼	

BP – Budget Period for Consortium for Building Energy Innovation (formerly EEB Hub)