Radiance and OpenStudio

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Inspirational Quotes

“To nature, who gives us marvelous complexity,
All the while making it look easy.”
- Greg Ward, “Rendering with Radiance” book dedication

“Without lamps, there’d be no light.”
- John Bender, “The Breakfast Club”

“In 1935, Germany renamed their ‘Ministry of Defense’ to ‘Ministry of War’, which showed commendable honesty.”
- Stephen Bugnay, “The Most Dangerous Enemy”
What is OpenStudio?

- An application suite software development kit (SDK)
- Intended to increase adoption of advanced simulation tools (Radiance, EnergyPlus)
- Enable reliable and integrated building energy modeling
- Free, open source
- Windows, MacOS, Linux

OpenStudio SDK

EnergyPlus  Radiance  Other Engines

Experts  User Expertise  Beginners

* simuwatt is a commercial product being developed using the SDK by concept3D

http://openstudio.nrel.gov
Geometry Creation and Attribute Assignment with SketchUp...

Quickly assign constructions, loads, and schedules via templates and specify zones.

Credit: David Goldwasser / NREL
...or import your existing BIM model...

- BIM/BEM interoperability creates a seamless and efficient workflow for architects and engineers
- Also supports CEC Title 24 SDD format

Credit: Dan Macumber / NREL
The OpenStudio Application

Define Resources

Workflow

Review Results

Credit: David Goldwasser / NREL
High Level Simulation Summary

Credit: David Goldwasser / NREL
Addressing Reliability Barriers

- What about reliability and repeatability?
  - Input data remains a serious issue for modelers
  - Garbage In = Garbage Out → Quality In = Quality Out

- **Solution:** Standardized, versioned, and citable input data and seamlessly link it to modeling and analysis tools
The Building Component Library (BCL)

**Components:**
- Assembled to form complete energy models
- Include constructions, lights, schedules, weather data, PV components, and more

**Measures:**
- Contain logic needed to transform an energy model easily and consistently
- Can be applied singly or as part of a parametric analysis
Parametric Analysis Capability

Select measures from BCL and apply them to your baseline model

Allows you to inspect measures applied to a specific alternative

Compare energy performance, cost reduction, and paybacks
Radiance For Daylighting Analysis

• The same model can also be used for detailed daylighting analysis with Radiance
• No need to maintain two separate models
What’s New with OpenStudio/Radiance

Completely new 3-phase Support, using rfluxmtx

- OpenStudio Radiance ForwardTranslator updated
- Annual simulations use rfluxmtx
- Generic BSDFs for the NREL Building Component Library (BCL)
- Focus on numbers, not images (although data can render beautiful and informative images!)

GitHub mirror of Radiance source repository

- Release tags
- Revision history
- Installers

OpenStudio (main) -- http://openstudio.nrel.gov
OpenStudio (GitHub) - https://github.com/NREL/OpenStudio
Building Component Library -- https://bcl.nrel.gov/
Radiance Git Mirror -- https://github.com/NREL/Radiance
3-Phase Workflow

Create (or import) model:
  • geometry, spaces, thermal zones
3-Phase Workflow

Assign Materials
- Room surface reflectances
- Glazing
  - VLT
  - clear/diffuse
- Can get from BCL

Assign Schedules
- People (occupancy)
- Plug loads
- Lighting
- Window Shading

HVAC
- Templates, GUI editor
3-Phase Workflow

Add daylighting analysis objects

- Illuminance Maps (analysis grids)
- Daylighting Control Points (photosensors)
- Glare Sensors
3-Phase Workflow

Set simulation parameters
- Radiance
- EnergyPlus
- General (weather/site, etc)
3-Phase Workflow

OpenStudio -> Radiance “Forward Translator”
- Handles conversion of model from OpenStudio format to Radiance “project”
  - Geometry
  - Materials
  - Analysis objects
  - Weather
  - Schedules

- Uncontrolled windows are placed together:
  - Glass/trans materials are used
  - WG0

- Controlled windows are logically grouped by:
  - Space/Orientation/VLT/Distribution/Schedule

- Generic BSDFs are used
  - Clear glass, Clear glass w/ venetian blind
  - Pulled from BCL
  - WG1, WG2, etc...
3-Phase Workflow

Clear view glazing with blind, south-facing (WG2)

Clear glazing with blind, east-facing (WG1)

Diffuse skylights and daylight clerestory (WG0)
3-Phase Workflow

Run

• Select “Radiance” as daylight simulation engine
• Click the “Run” button
• Impress your friends
# 3-Phase Workflow

## Review Results

OpenStudio produces annual illuminance schedules for each window group and shade combination.

Visualization and WG combination routines are being developed for the Fall ‘14 Release (v1.5, end of September 2014).

Space-level lighting schedules are generated and embedded in OpenStudio model, for use in EnergyPlus building energy simulations.

### Table

<table>
<thead>
<tr>
<th>WG0 (uncontrolled)</th>
<th>WG2 (south)</th>
<th>WG1 (east)</th>
</tr>
</thead>
<tbody>
<tr>
<td>186 198 247 216 245 197 228 153</td>
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<td>69 168 237 259 242 225 133 60</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
How’d ya do that?

- **OpenStudio SDK**
  - Forward Translator
  - DaylightSim.rb

- **New utilities in Radiance**
  - rfluxmtx, rmtxop
Rfluxmtx Integration

**OS::Radiance::ForwardTranslator**
- Adds necessary headers for rfluxmtx

```plaintext
# OpenStudio Window Group: WG1
#@rfluxmtx h=kf u=Z o=output/dc/WG1.vmx

# SubSurface = East_Window
# Tvis = 0.25 (tn = 0.27)
WG1 polygon East_Window
0
0
12
8.561387500000031 4.110043965327130 2.504345203724800
8.561387500000031 4.110043965327130 0.973995203724805
8.561387500000031 1.633885650643690 0.973995203724805
8.561387500000031 1.633885650643690 2.504345203724800
```

Clear glazing **with blind**, *east-facing* (WG1)
rfluxmtx integration

**OS::Radiance::ForwardTranslator**

- Materials files

```plaintext
# OpenStudio Materials File
void glass WG1
0
0
3
0.274 0.274 0.274
void glass WG2
0
0
3
0.349 0.349 0.349
void plastic refl_0.400
0
0
5
0.400 0.400 0.400 0 0
void trans glaz_trans_tn-0.978
0
0
7
0.052 0.052 0.052 0.050 0.000 0.950 0.00

# OpenStudio "vmx" Materials File
# controlled windows:
# material="light", black out all
# others.

void plastic WG0
0
0
5
0 0 0 0
void alias glaz_trans_tn-0.978 WG0

void light WG1
0
0
3
1 1 1
void light WG2
0
0
3
1 1 1

# OpenStudio "WG0" Materials File
# black out all controlled window groups
void plastic WG1
0
0
5
0 0 0 0
void plastic WG2
0
0
5
0 0 0 0
```
Next Steps

For Version 1.5.0, due out end of September 2014

- Generate space-level lighting load schedules, based on “on if high solar” shade control algorithm
- More reliance on new Radiance utilities such as rmtxop for more efficient matrix processing
- Integrate 3-phase results with EnergyPlus
- Validation
- Simple results visualization tools

For FY2015 (begins October, 2014)

- More validation =)
- GUI support:
  - user-assigned BSDFs
  - shade schedule creation, assignment
- Non-simple visualization
- Collaboration/support to CBEI (Formerly EEBHub)
  - Daysim fork for detailed lighting control placement and control optimization
  - Penn State University – Dr. Rick Mistrick, Craig Casey
  - http://cbei.psu.edu/
Radiance on GitHub

- Mirror of Radiance CVS source code repository
- Refreshed every 15 minutes
- Full revision history
- Use “combined” branch for latest history!
- NREL installers (Windows, Mac, Unix)
- Release snapshots
- Thanks/fist-bumps to Nick Long (NREL), Zack Galbreath (Kitware), and US Department of Energy for this resource!
Thank You! (woof.)