Radiance and OpenStudio

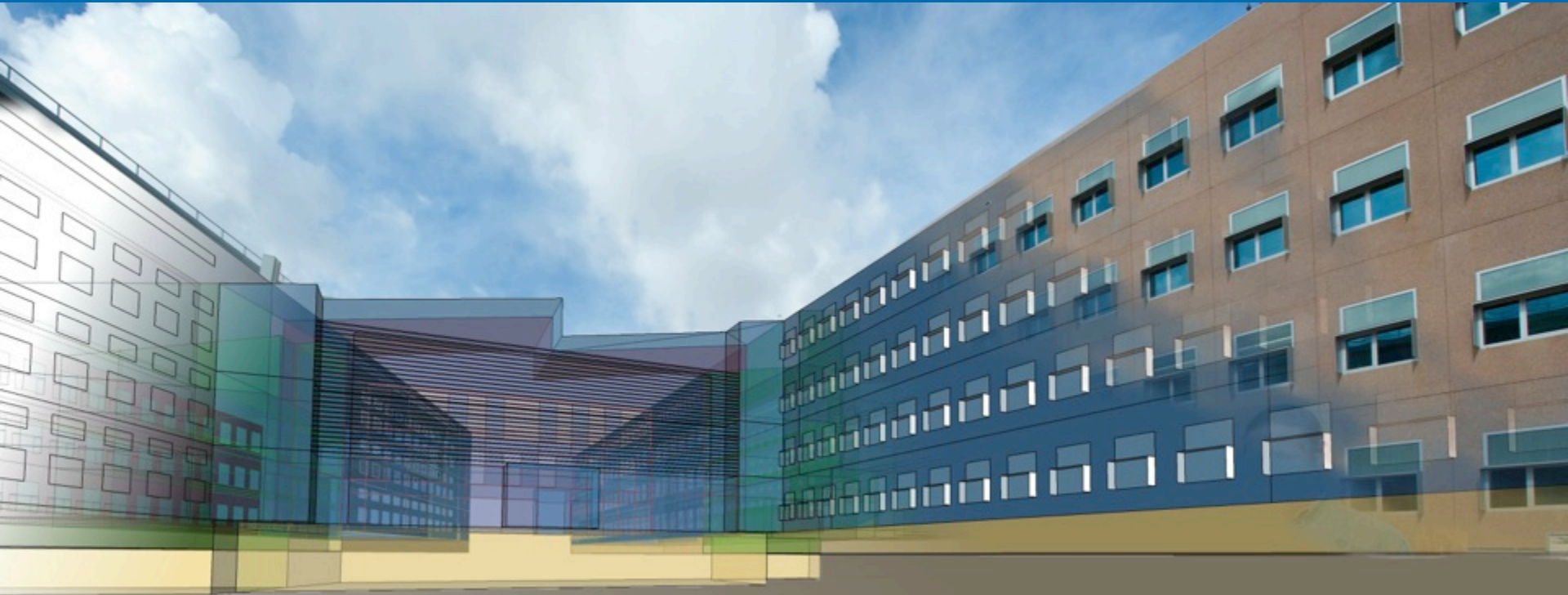**RADIANCE**

Rob Guglielmetti - NREL Commercial Buildings Research

13th Annual Radiance International Workshop
London Metropolitan University/ARUP - September 2, 2014

Inspirational Quotes

"To nature, who gives us marvelous complexity,
All the while making it look easy."
- Greg Ward, "Rendering with Radiance" book dedication
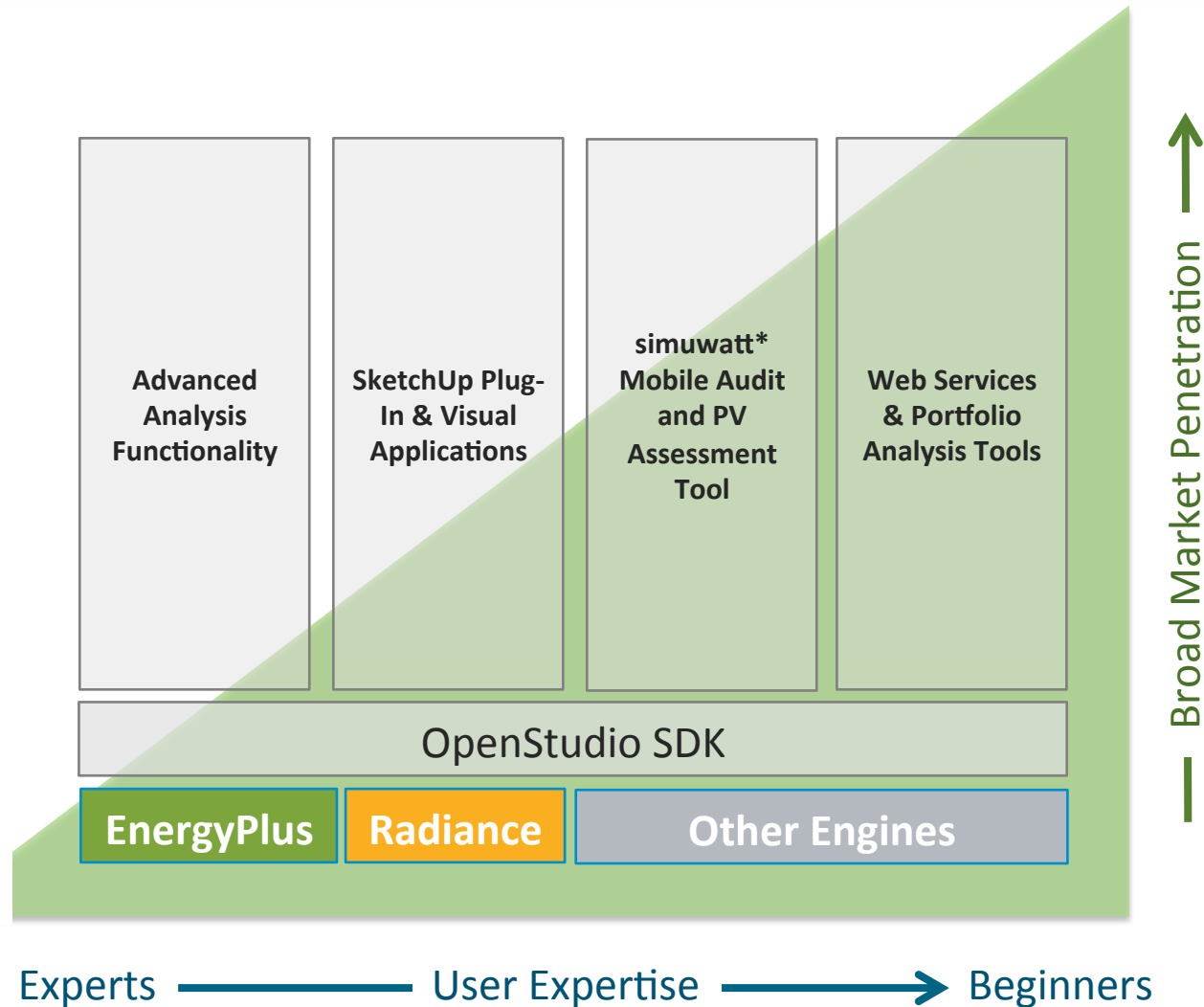
"Without lamps, there'd be no light."
- John Bender, "The Breakfast Club"

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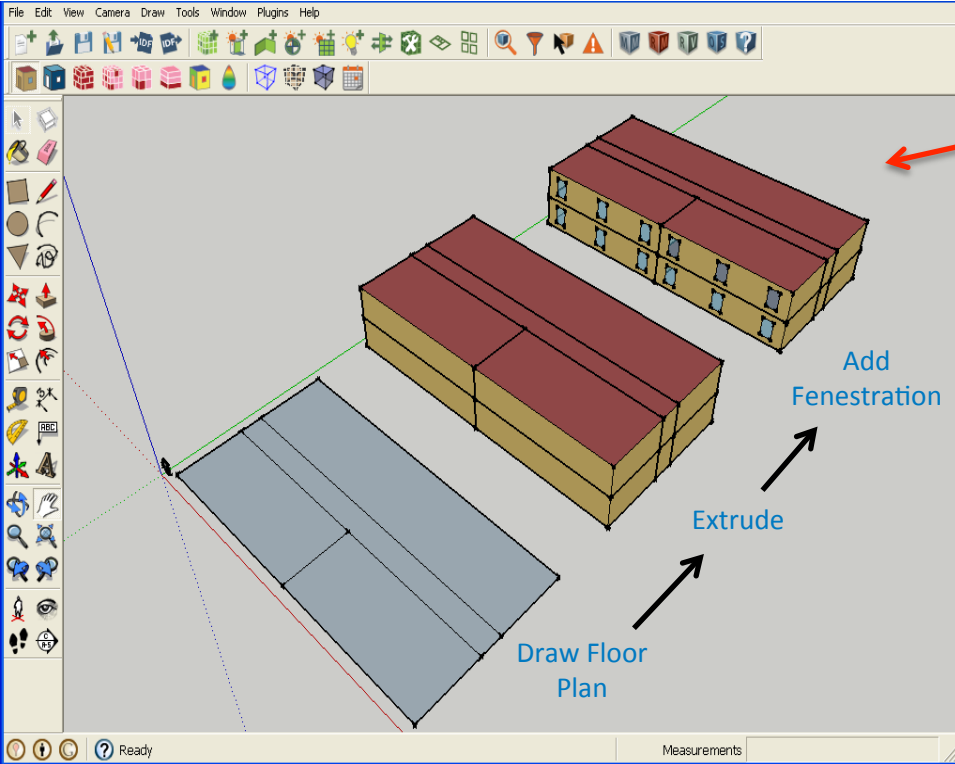'Ministry of War', which showed commendable honesty."
- Stephen Bugnay, "The Most Dangerous Enemy"
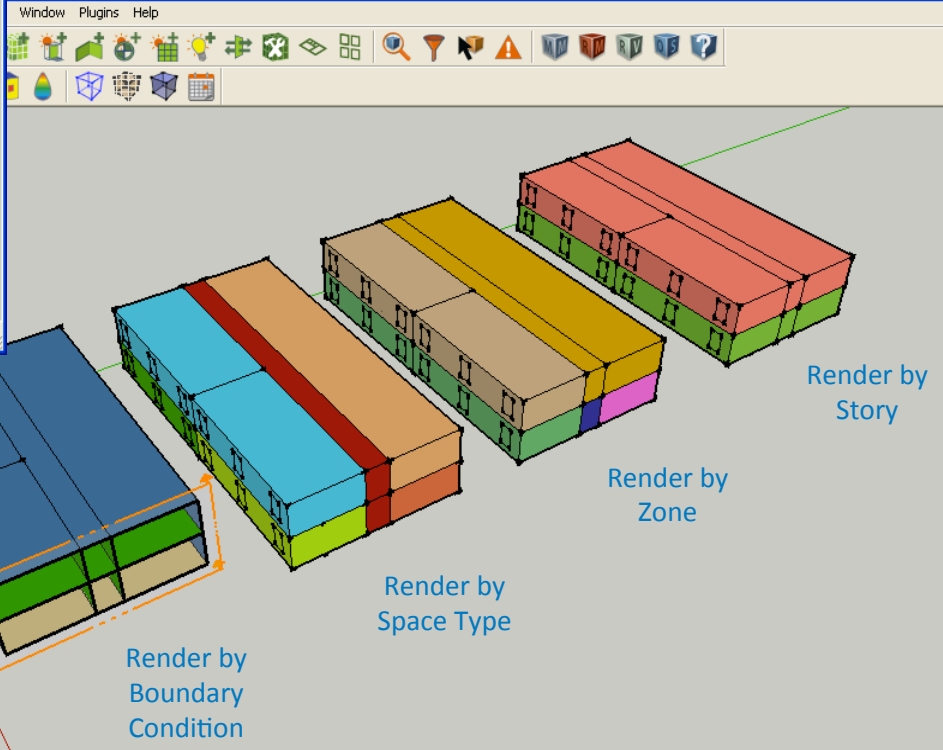
What is OpenStudio?

- 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

| Advanced Analysis Functionality | SketchUp Plug-In & Visual Applications | simuwatt* Mobile Audit and PV Assessment Tool | Web Services & Portfolio Analysis Tools |

OpenStudio SDK

| **EnergyPlus** | **Radiance** | **Other Engines** |

Broad Market Penetration →

Experts ⟶ User Expertise ⟶ Beginners

Geometry Creation and Attribute Assignment with SketchUp...

Draw envelope in minutes

Add Fenestration

Extrude

Draw Floor Plan

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

Render by Story

Render by Zone
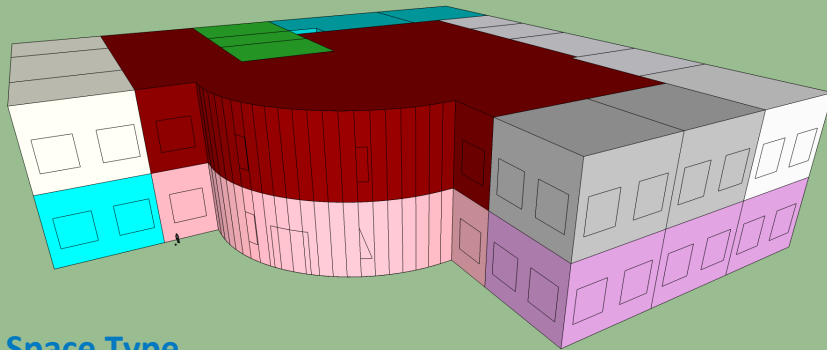
Render by Space Type

Render by Boundary Condition

Credit: David Goldwasser / NREL

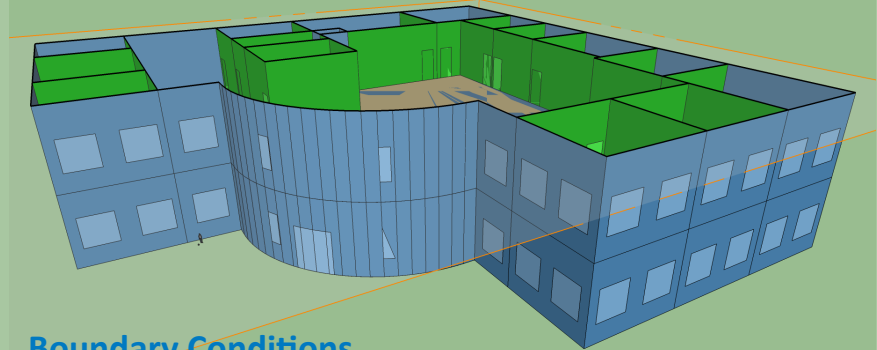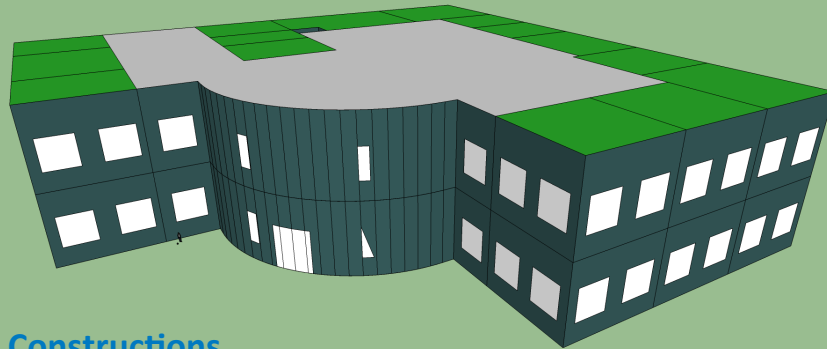# …or import your existing BIM model…

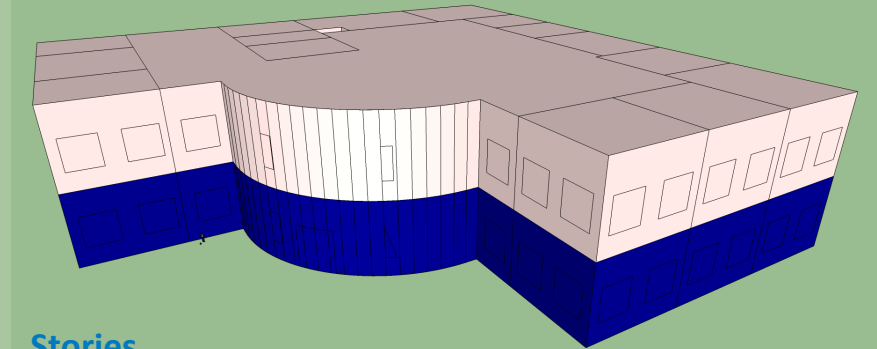gbXML Import from BIM

OpenStudio

Space Type

Boundary Conditions

Constructions

Stories

Credit: Dan Macumber / NREL

gbXML Export from OpenStudio

- BIM/BEM interoperability creates a seamless and efficient workflow for architects and engineers

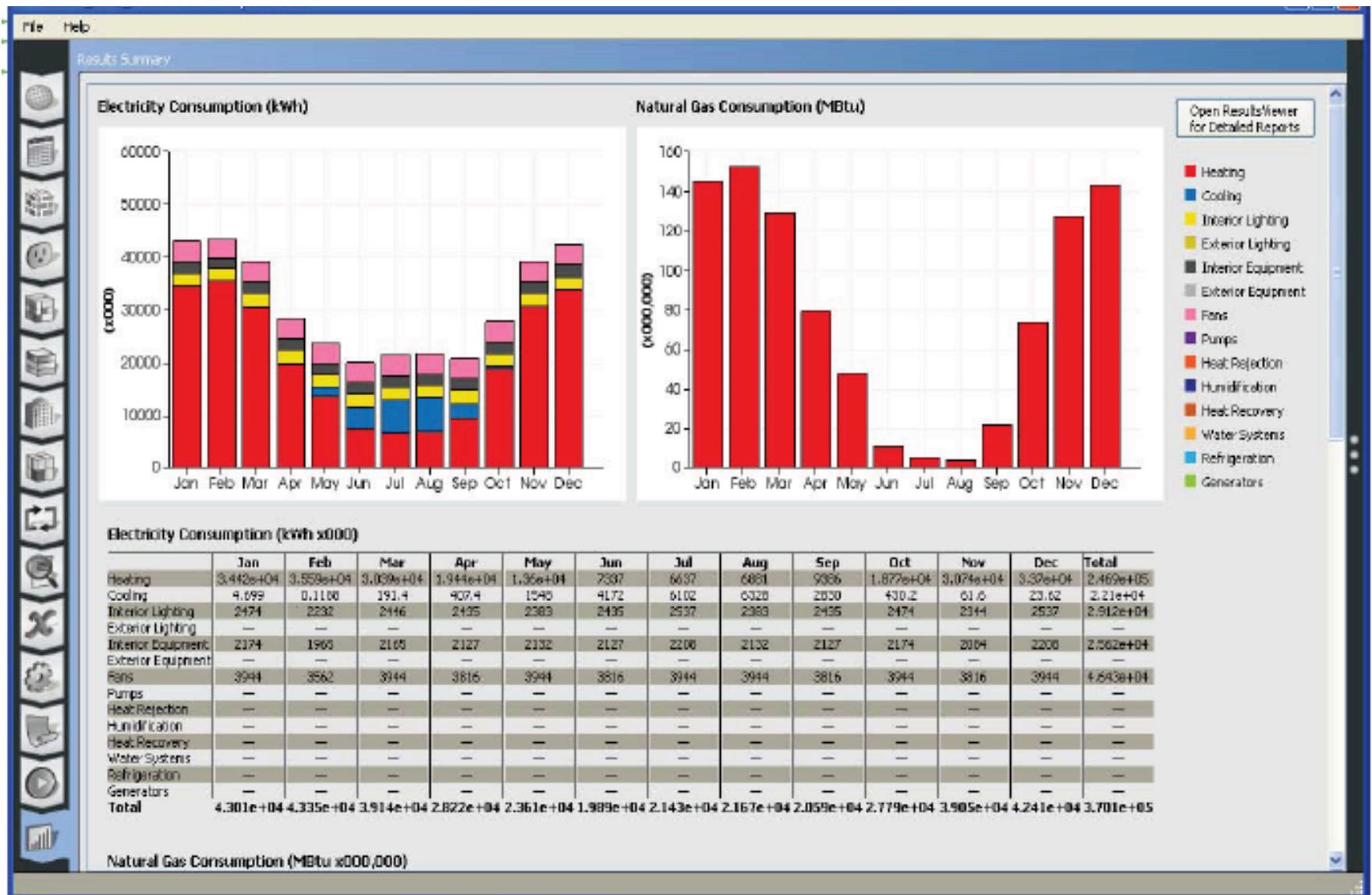- Also supports CEC Title 24 SDD format

The OpenStudio Application

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:** <u>Standardized</u>, <u>versioned</u>, and <u>citable</u> input data and seamlessly link it to modeling and analysis tools

Templates

Usability

Consistent Input

Energy Modeling Outcomes

Fast
Low-Cost
Reliable

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
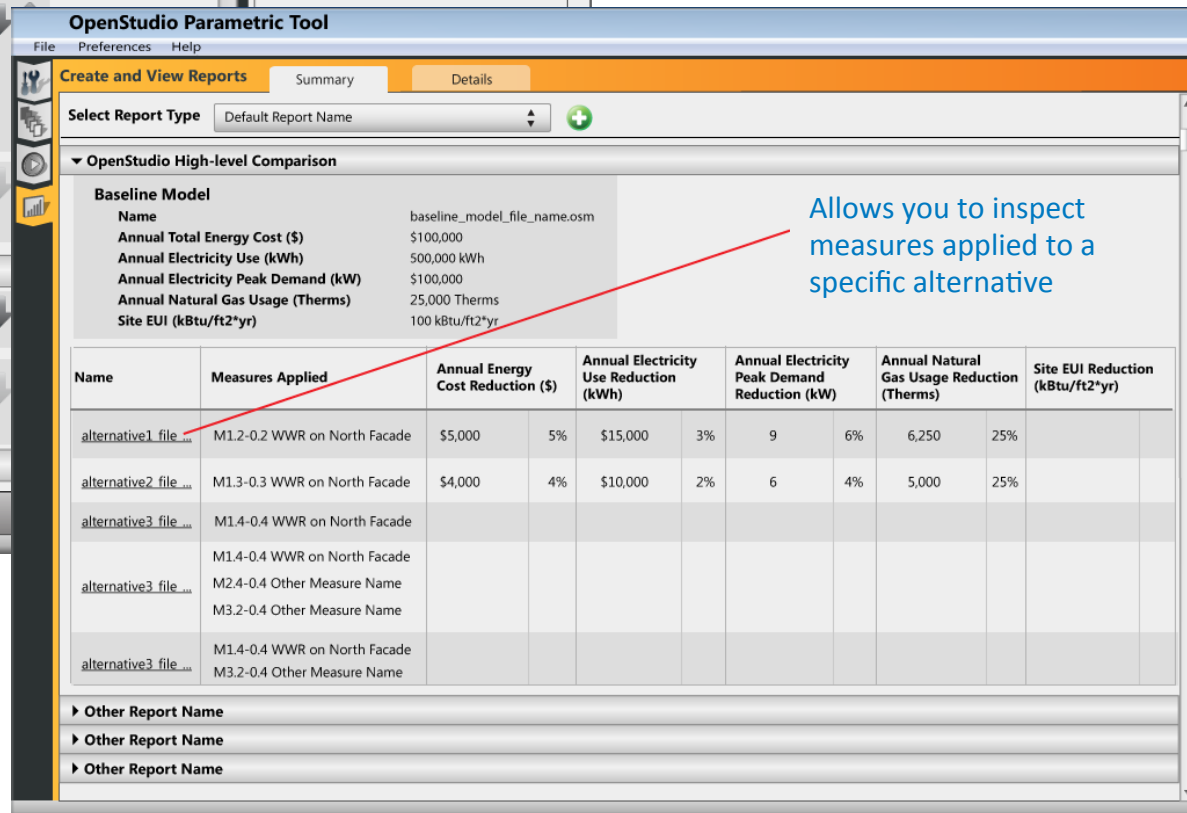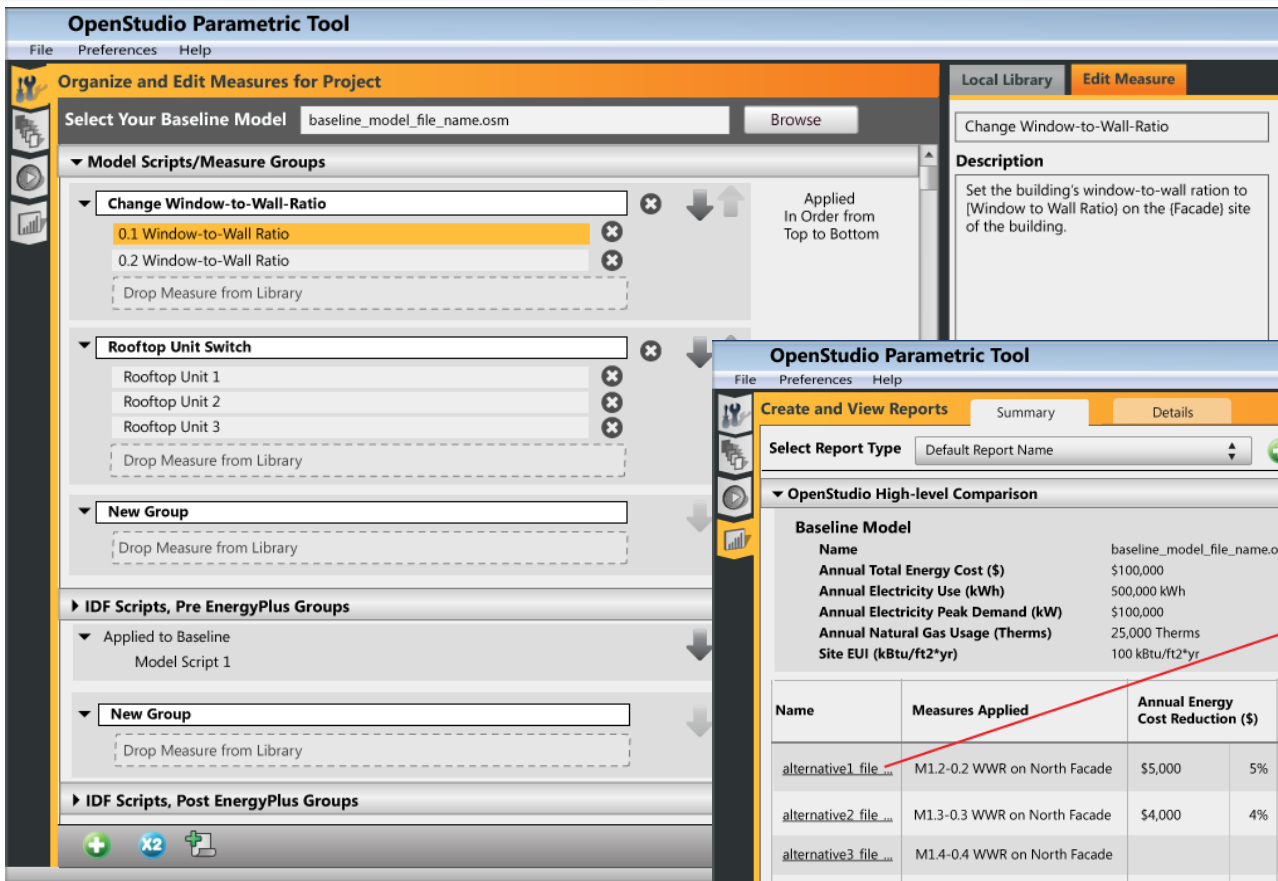
Allows you to inspect measures applied to a specific alternative

Compare energy performance, cost reduction, and paybacks

Credit: Marjorie Schott/ NREL

Radiance For Daylighting Analysis

- The same model can also be used for detailed daylighting analysis with Radiance

- No need to maintain two separate models

OpenStudio Model for EnergyPlus or Radiance

Radiance Output
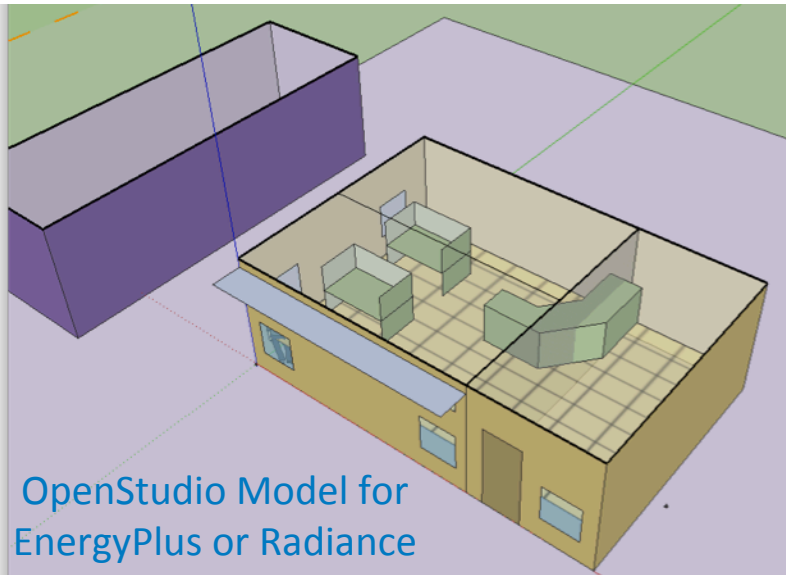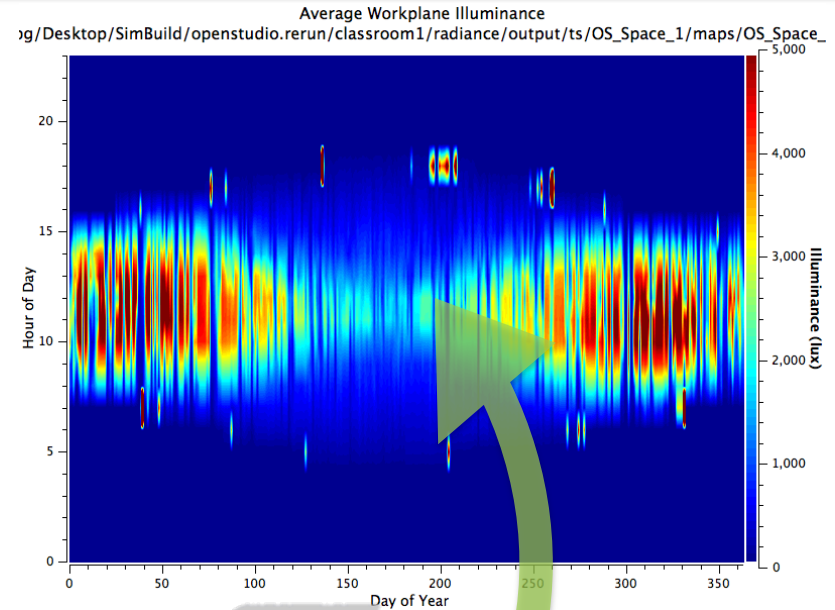
Credit: Rob Guglielmetti / NREL

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
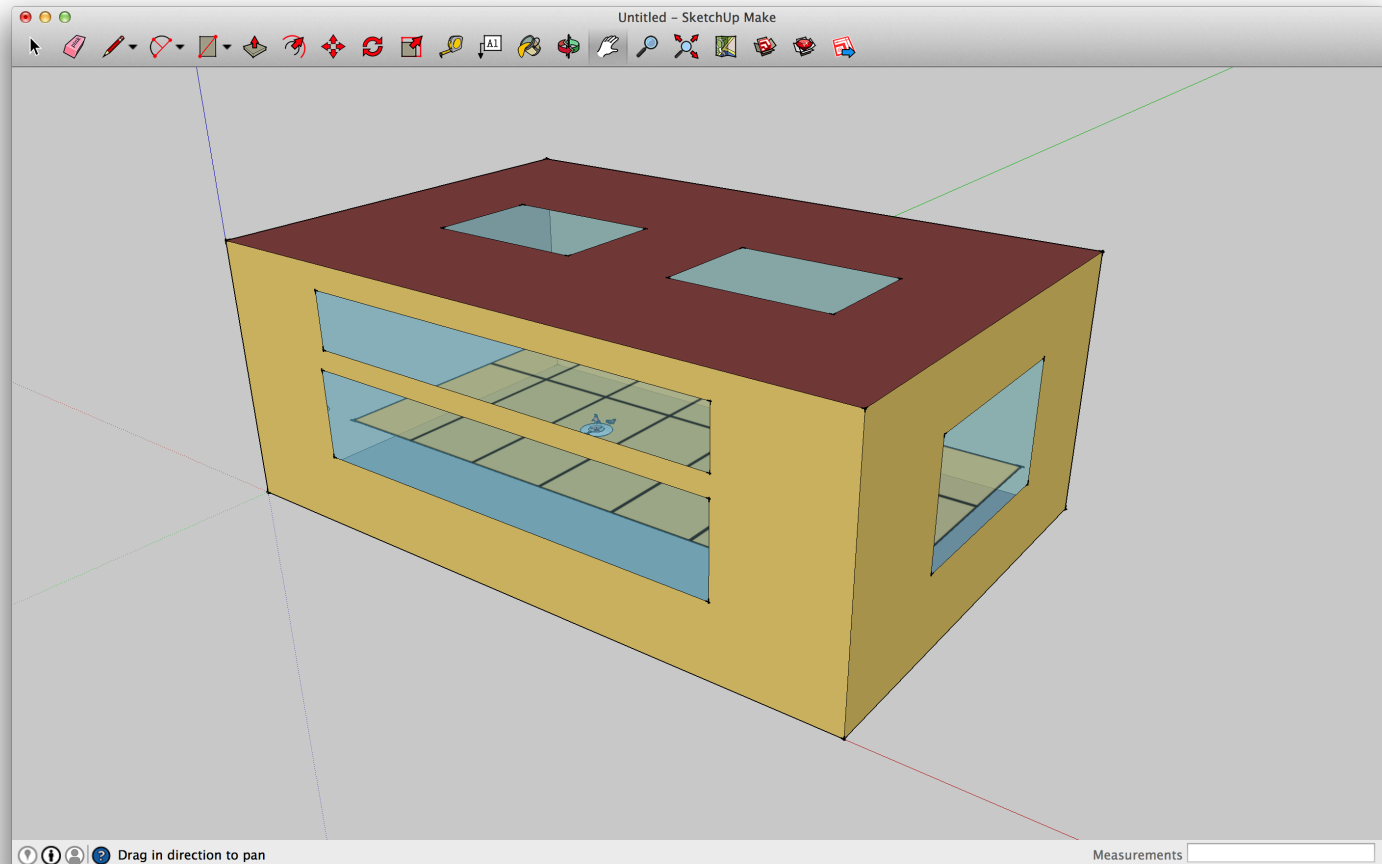
3-Phase Workflow

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
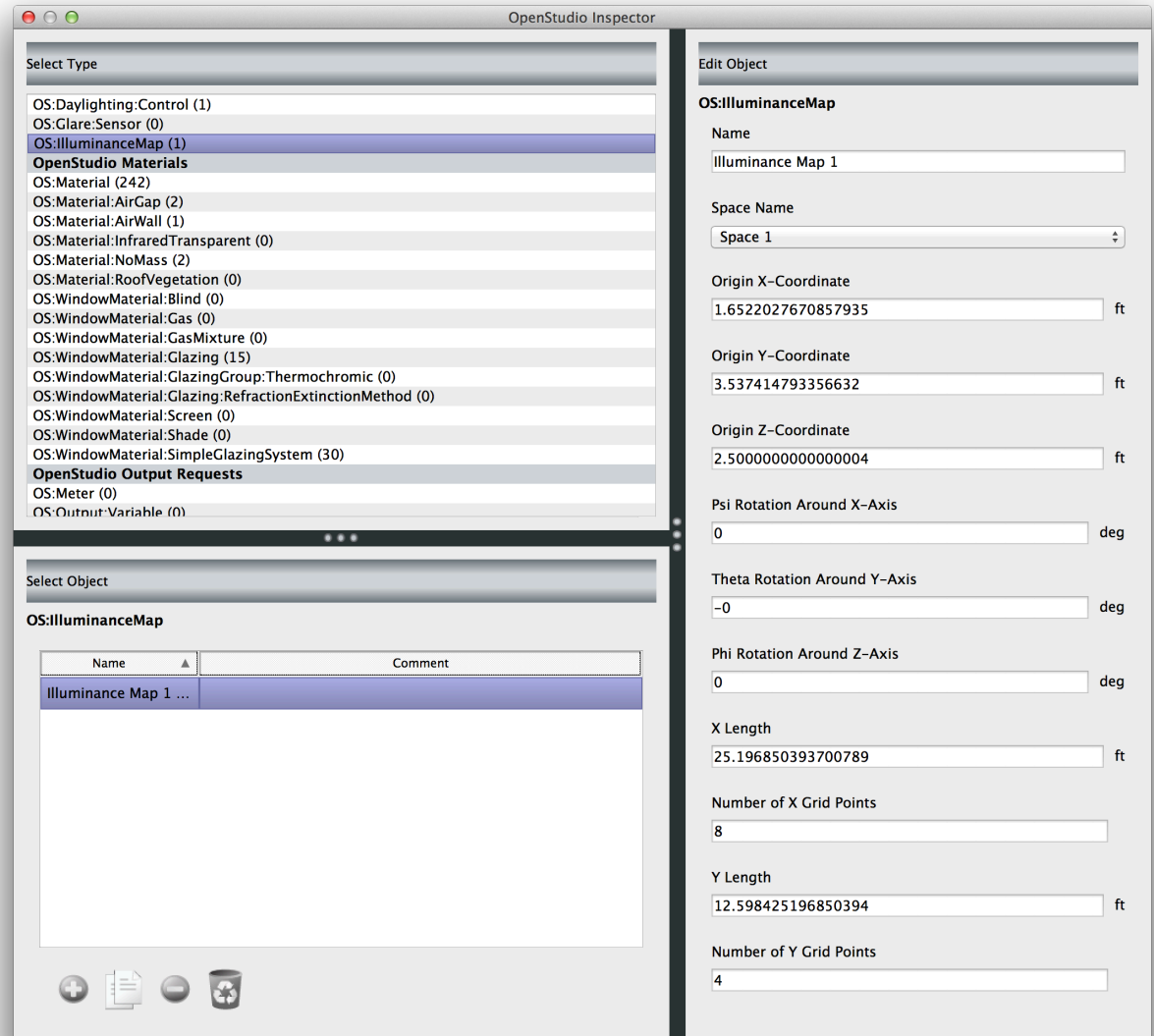
3-Phase Workflow

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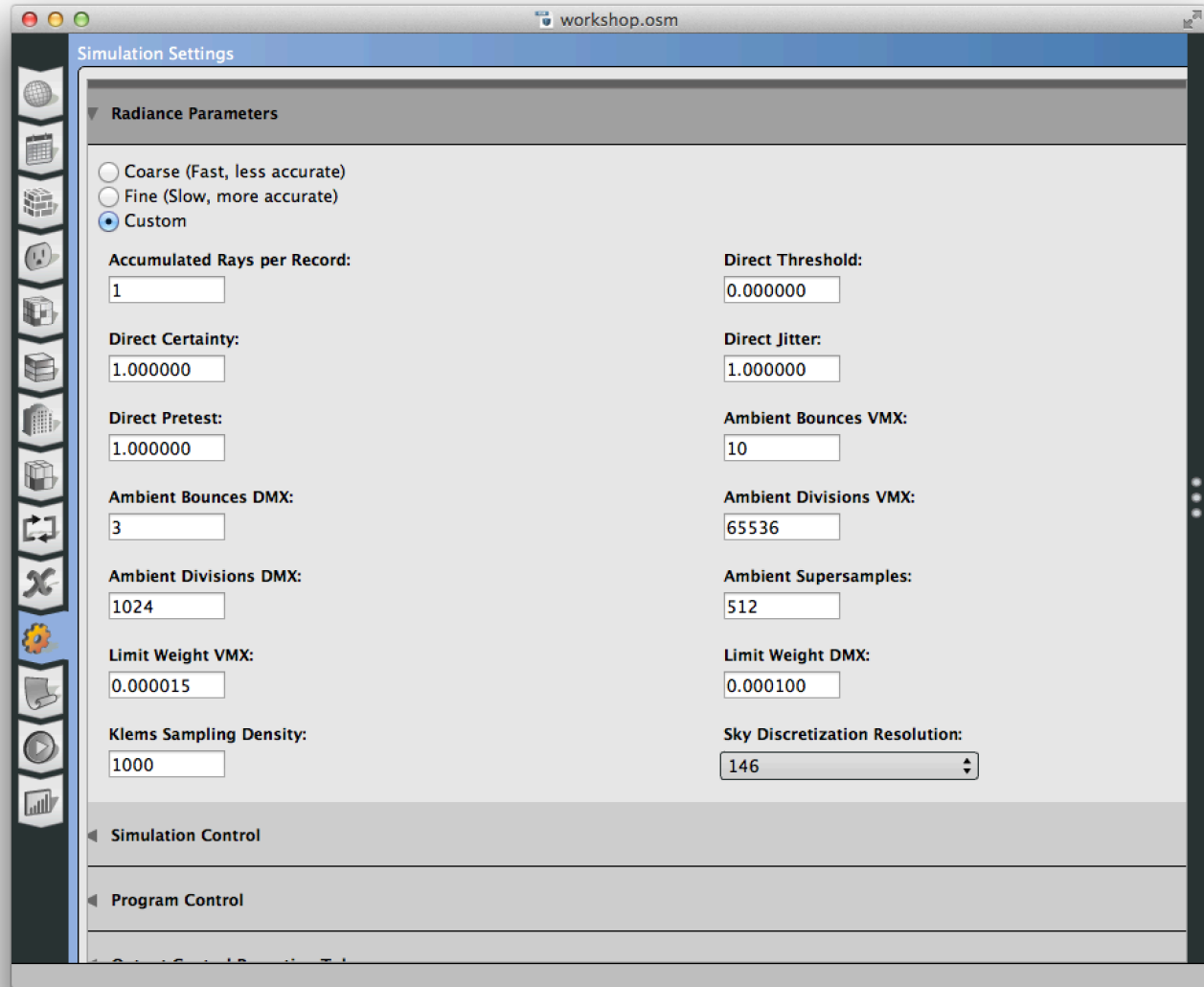
3-Phase Workflow

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

Diffuse skylights and daylight clerestory (WG0)

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

Clear glazing **with blind,** *east-facing* (WG1)
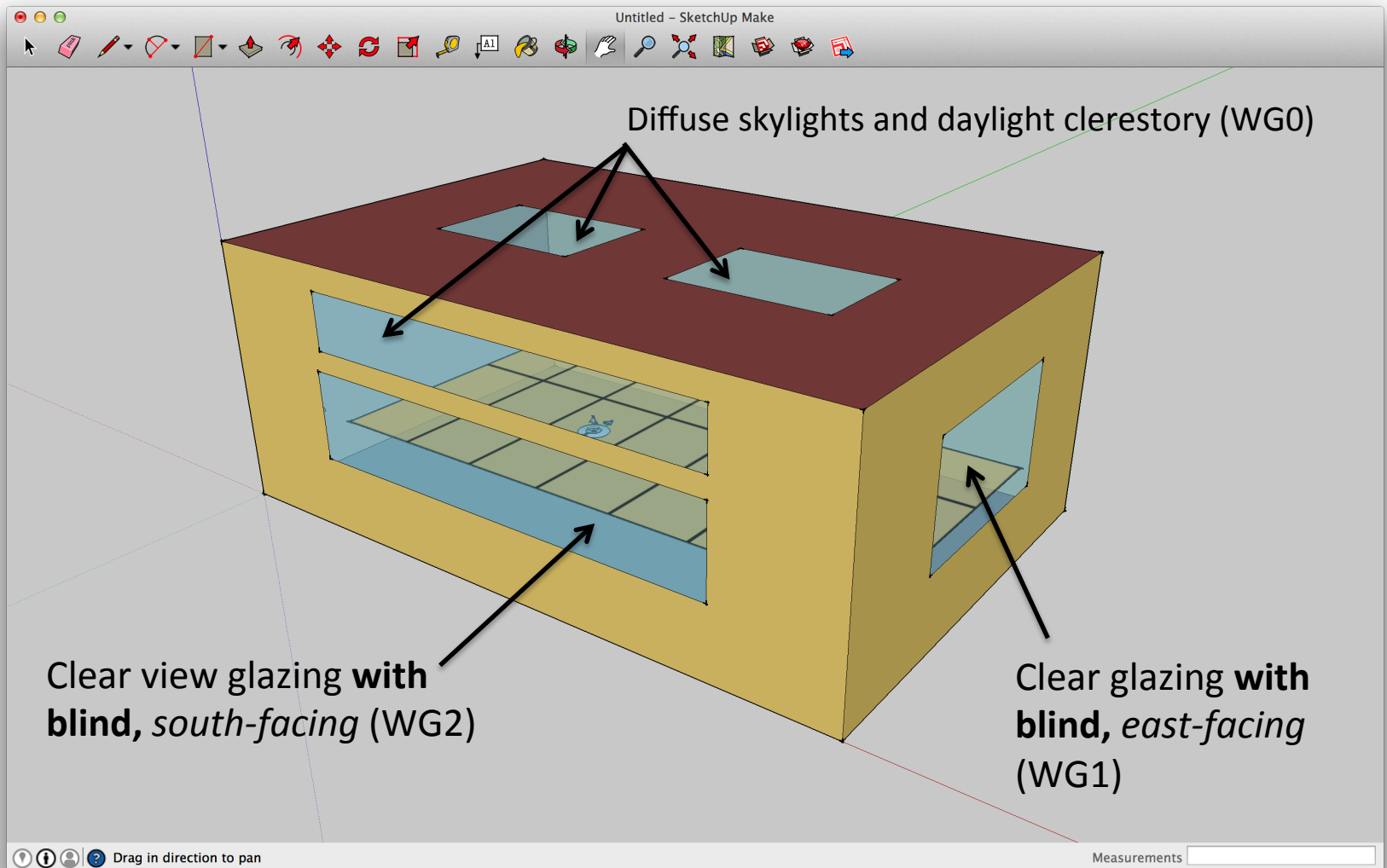
3-Phase Workflow

Run

- Select "Radiance" as daylight simulation engine
- Click the "Run" button
- Impress your friends
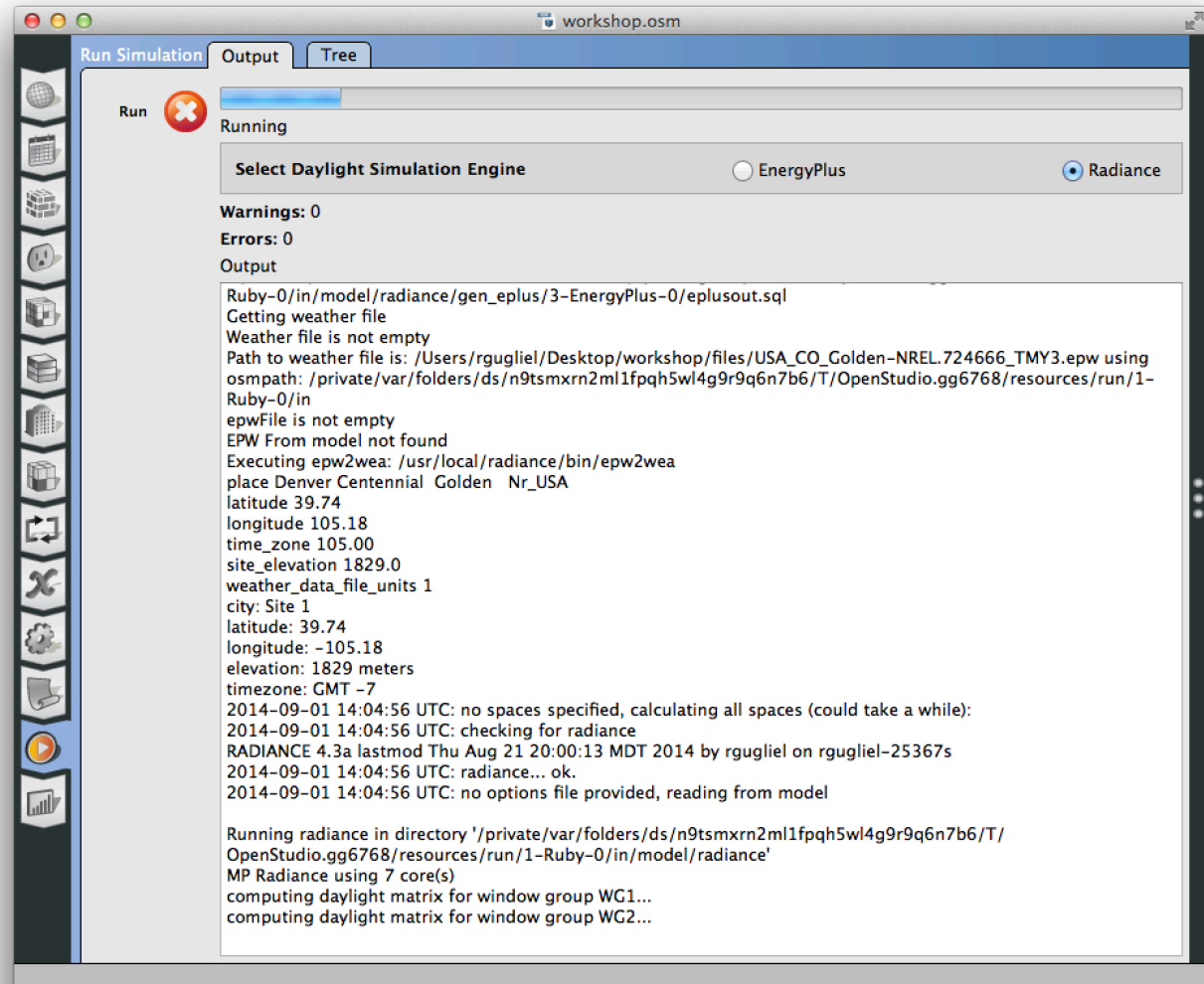
3-Phase Workflow

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

WG0 (uncontrolled)
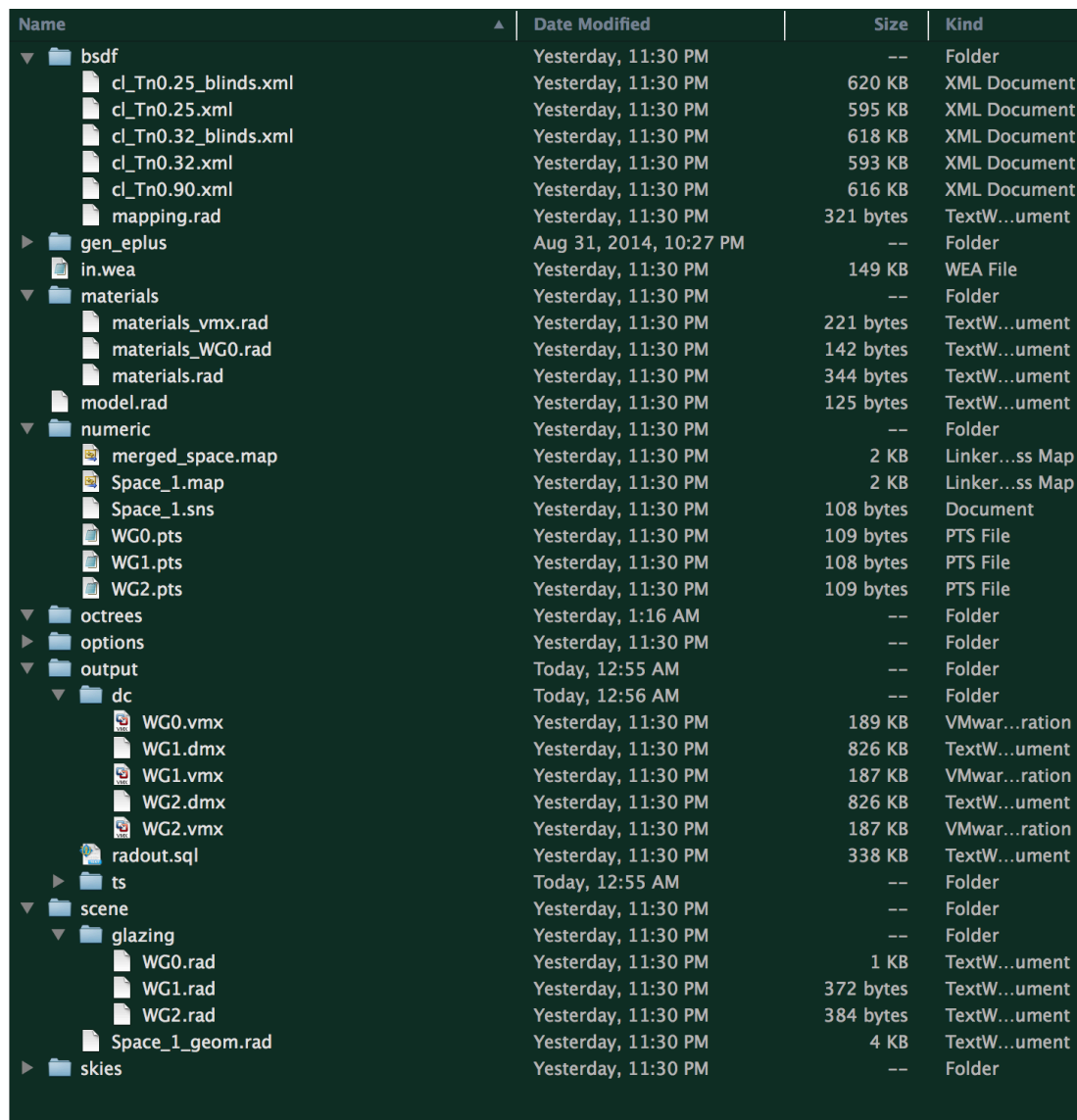
186	198	247	216	245	197	228	153
196	283	396	394	391	352	329	166
269	422	498	441	517	527	368	173
248	315	480	472	473	397	384	190

WG2 (south)

588	1,021	781	468	750	397	287	122
972	1,353	2,175	1,955	2,516	1,944	650	111
269	4,282	5,013	4,337	4,554	4,913	651	119
190	8,239	11,613	9,032	8,730	6,652	1,147	93

44	59	65	65	68	59	51	40
55	67	81	88	88	76	58	41
75	94	128	132	127	122	86	56
69	168	237	259	242	225	133	60

WG1 (east)

27	29	42	62	98	187	371	372
31	30	40	67	118	221	472	1,030
30	31	37	51	95	178	387	754
29	24	31	47	69	105	150	71

2	2	5	7	10	15	20	25
3	3	5	8	11	21	30	50
3	3	4	6	12	19	31	50
2	3	4	6	10	14	19	16

How'd ya do that?

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

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

| Name	Date Modified	Size	Kind
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📄 cl_Tn0.25_blinds.xml	Yesterday, 11:30 PM	620 KB	XML Document
📄 cl_Tn0.25.xml	Yesterday, 11:30 PM	595 KB	XML Document
📄 cl_Tn0.32_blinds.xml	Yesterday, 11:30 PM	618 KB	XML Document
📄 cl_Tn0.32.xml	Yesterday, 11:30 PM	593 KB	XML Document
📄 cl_Tn0.90.xml	Yesterday, 11:30 PM	616 KB	XML Document
📄 mapping.rad	Yesterday, 11:30 PM	321 bytes	TextW...ument
▶ 📁 gen_eplus	Aug 31, 2014, 10:27 PM	--	Folder
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📄 materials.rad	Yesterday, 11:30 PM	344 bytes	TextW...ument
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📄 WG2.pts	Yesterday, 11:30 PM	109 bytes	PTS File
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▶ 📁 options	Yesterday, 11:30 PM	--	Folder
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▶ 📁 skies	Yesterday, 11:30 PM	--	Folder

Rfluxmtx Integration

OS::Radiance::ForwardTranslator

- Adds necessary headers for rfluxmtx
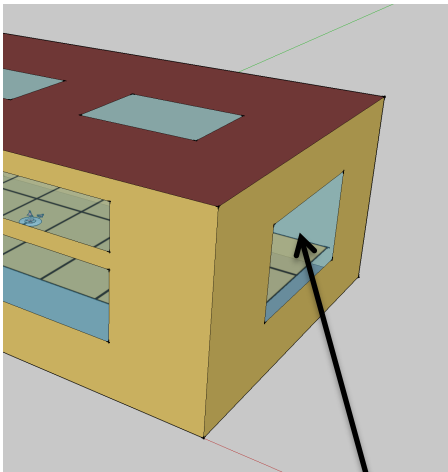
Clear glazing **with blind,** *east-facing* (WG1)

```
# 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
```

rfluxmtx integration

OS::Radiance::ForwardTranslator
- Materials files

```
# 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 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 0
void plastic WG2
0
0
5
0 0 0 0 0
```

Next Steps

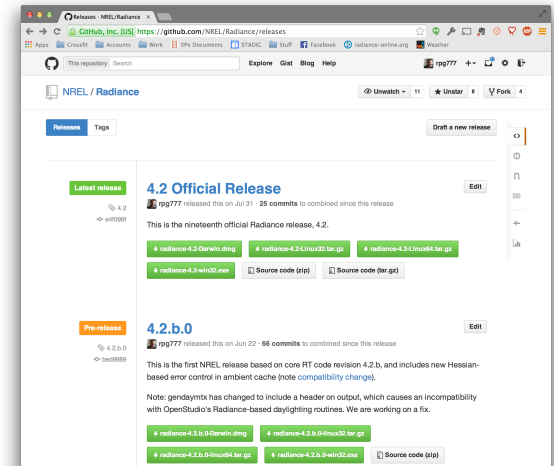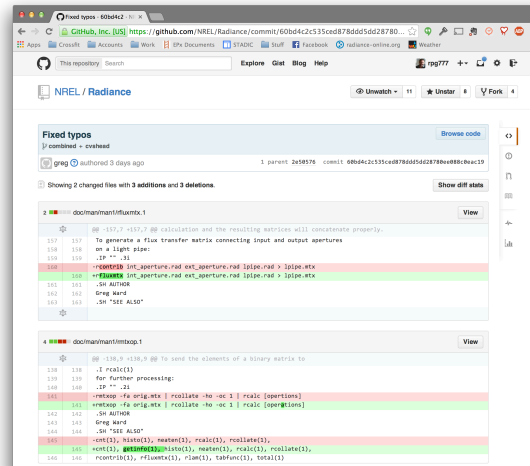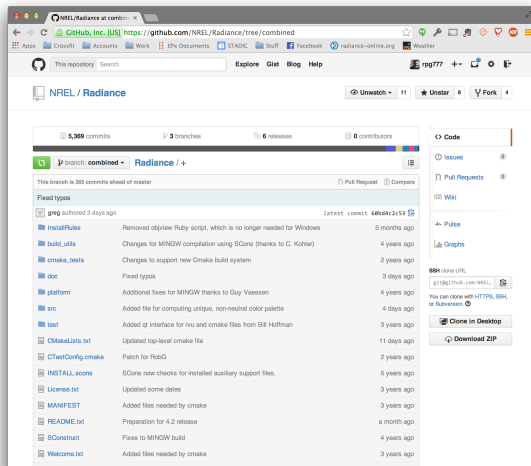**For Version 1.5.0, due out end of September 2014**
- Generate space-level lighting load schedules, based on "on if high solar" shade control algorithm
- More reliance on new Radiance utilities such as rmtxop for more efficient matrix processing
- Integrate 3-phase results with EnergyPlus
- Validation
- 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.)