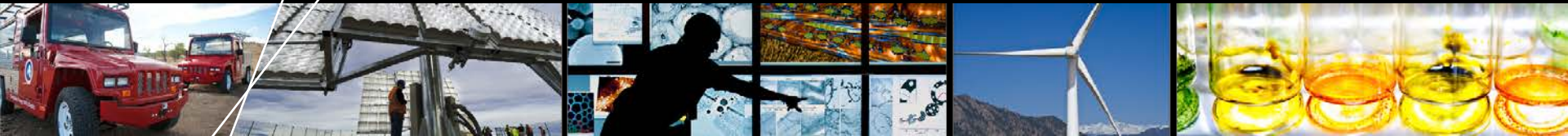


SCRIPTED BUILDING ENERGY MODELING AND ANALYSIS



SimBuild 2012, Madison, WI

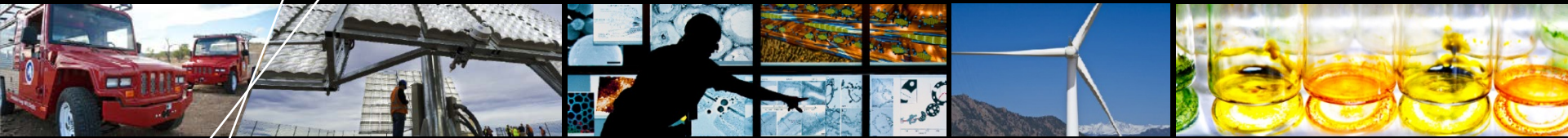
Daniel Macumber, NREL

August 2, 2012

NREL/PR-5500-55863

Outline

- **Problem Statement and Solution**
- **Measures in OpenStudio**
 - What is an OpenStudio Measure?
 - Structured Rulesets
 - Freeform Scripts
- **Use Cases for OpenStudio Measures**
 - Interactive Measure Application
 - Noninteractive Measure Application
 - Composing Parameter Spaces With Measures
- **OpenStudio Measures and the BCL**
- **Conclusions**



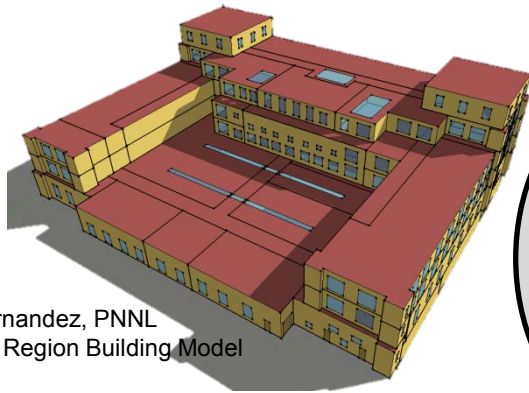
Problem Statement and Solution

Problem Statement and Solutions

- **Building energy analysis is often time-intensive, error-prone, and nonreproducible**
 - GUIs help
 - Libraries of data help
 - Still need to automate tedious workflows
- **Entire energy analyses can be scripted end to end using the OpenStudio Ruby API**
- **Common tasks within an analysis can be automated using OpenStudio Measures**

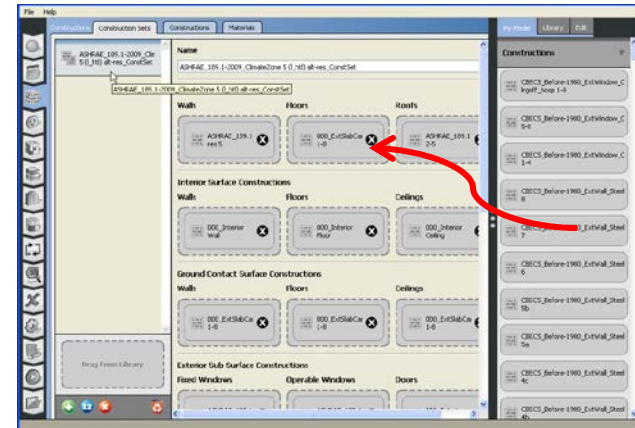
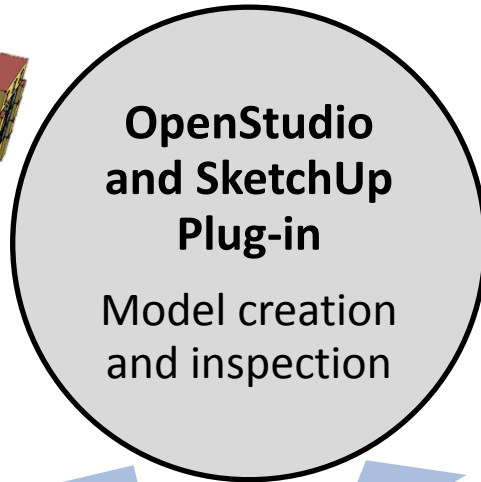
OpenStudio Approach

Credit: David Goldwasser / NREL

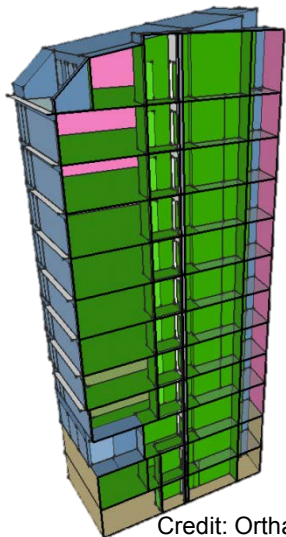


Credit: Nick Fernandez, PNNL
GSA Heartland Region Building Model

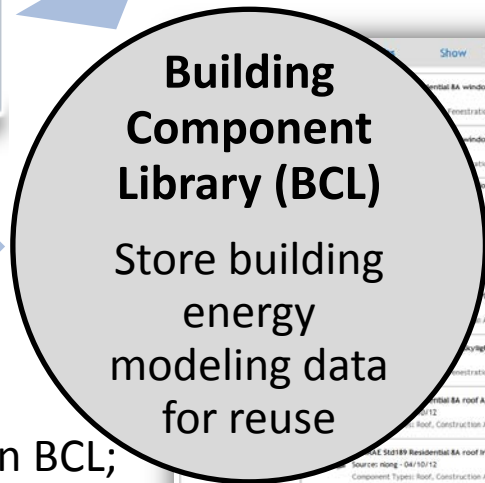
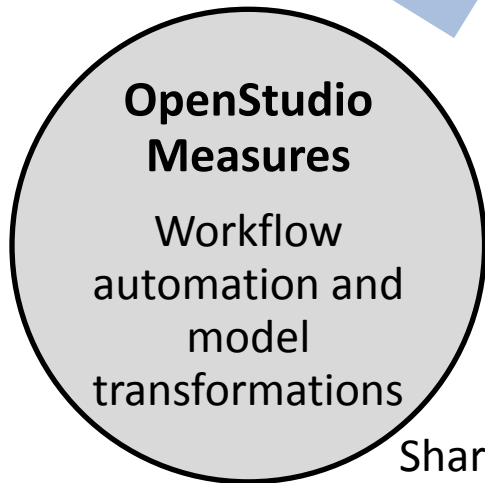
Use measures interactively from GUIs or noninteractively as part of model's simulation workflow



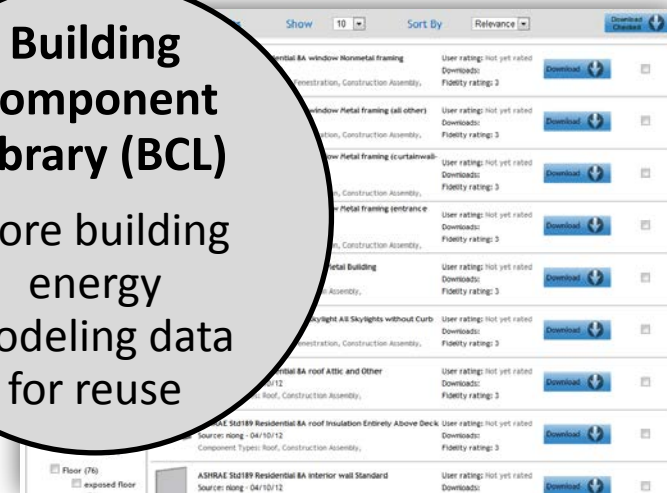
Drag and drop components from BCL into current model



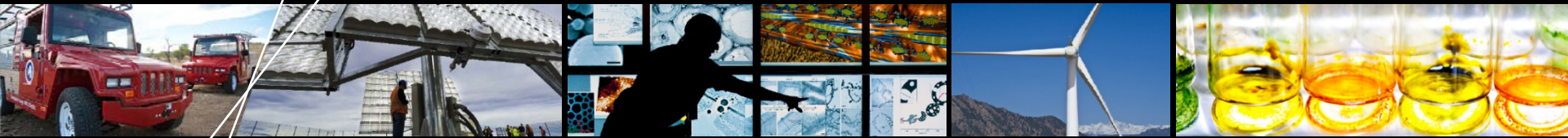
Credit: Orthan Veli Kazanci



Share measures in BCL; measures may refer to BCL data



Credit: David Goldwasser / NREL



Measures in OpenStudio

Measures in OpenStudio

- **What is a “Measure” in OpenStudio?**

- Repeatable transformation of an input building energy model into an output energy model

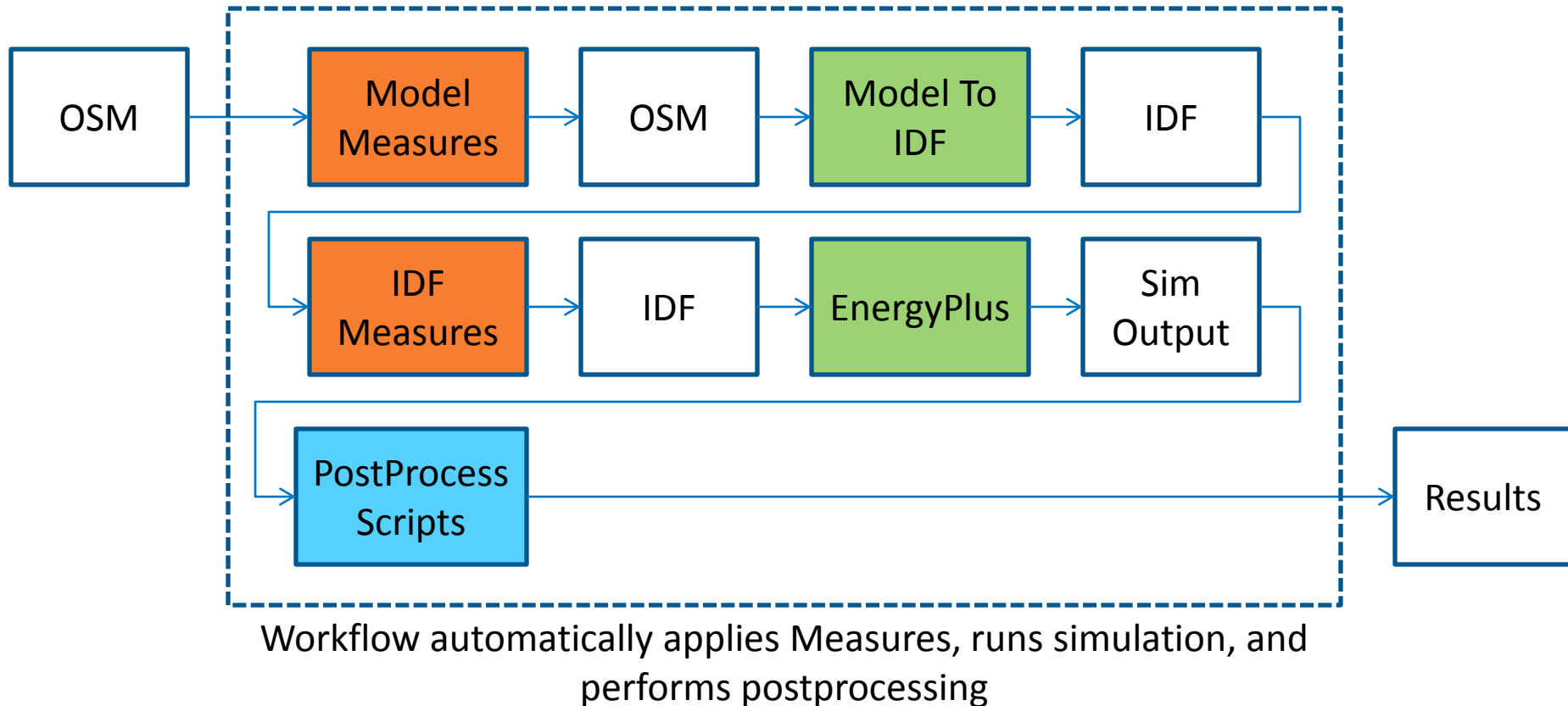


- **Examples of OpenStudio Measures**

- Set window to wall ratio to 40% on all façades
- Replace all T-12 light fixtures with T-5 fixtures
- Improve fan efficiency from 50% to 70%
- Import IDF text snippets and set object names

Measures in OpenStudio

- Users may drag and drop multiple Measures at two points in the OpenStudio simulation workflow



Measures in OpenStudio

- **Measures may be written generically to be reused across many building models or written for a specific building model**
- **Measures may take input parameters**
 - WindowToWallRatio Measure takes arguments 'wwr', 'offset', and 'application_type'
- **Types of OpenStudio Measures**
 - Structured Rulesets
 - Freeform Scripts

Structured Ruleset

- Attributes allow OpenStudio ModelObject methods to be called through a string key at runtime
 - `Surface::windowToWallRatio() == getAttribute("windowToWallRatio")`
- Some attributes are read only, others allow read/write
- A Ruleset is composed of Rules
- A Rule is composed of Filters and Actions (there are many types of filters and actions)
- Attribute filters pass or reject objects based on attribute values
- Attribute actions change objects by calling `setAttribute`
- Structured Ruleset can be serialized to XML format

Example Rule to set WWR on exterior walls:

Filter 1	If type is "OS:Surface"
Filter 2	If getAttribute("surfaceType") is "Wall"
Filter 3	If getAttribute("outsideBoundaryCondition") is "Outdoors"
Action 1	Then setAttribute("windowToWallRatio", 0.4)

Initial Structured Ruleset GUI:

The screenshot shows the 'Edit Rules' window with the following configuration:

- If**: Building is 6, ClimateZone is 6
- And**: Wall, PartitionThermalType is Exterior
- And**: Wall, WallConstructionType is Mass Heavy Wall
- Then rule passes if**: Wall, UFactor LessThanOrEqualTo 3.92 W/m²K

Credit: Elaine Hale/ NREL

Freeform Script

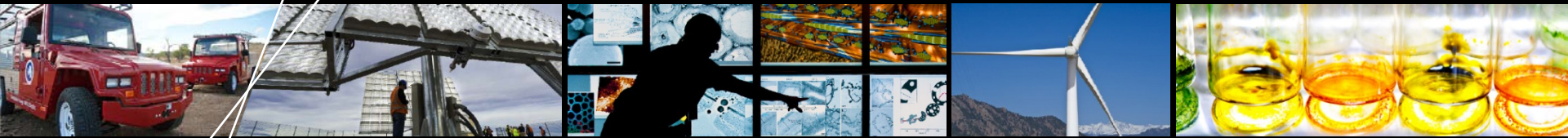
- User defines Ruby class
- Class must have methods 'name', 'arguments', and 'run'
- Run method can use any method exposed in the OpenStudio Ruby API
- Freeform Script serialized as Ruby script (text file)

Example code to set WWR on exterior walls:

```
def run(model, runner, arguments)
  wwr = arguments["wwr"]
  offset = arguments["offset"]
  application_type =
    arguments["application_type"]

  heightOffsetFromFloor = nil
  if (application_type.valueAsString ==
      "Above Floor")
    heightOffsetFromFloor = true
  else
    heightOffsetFromFloor = false
  end

  model.getSurfaces.each do |s|
    next if not runner.inSelection(s)
    next if not (s.outsideBoundaryCondition ==
                 "Outdoors")
    new_window = s.setWindowToWallRatio(
      wwr.valueAsDouble,
      offset.valueAsDouble,
      heightOffsetFromFloor)
  end
end
```

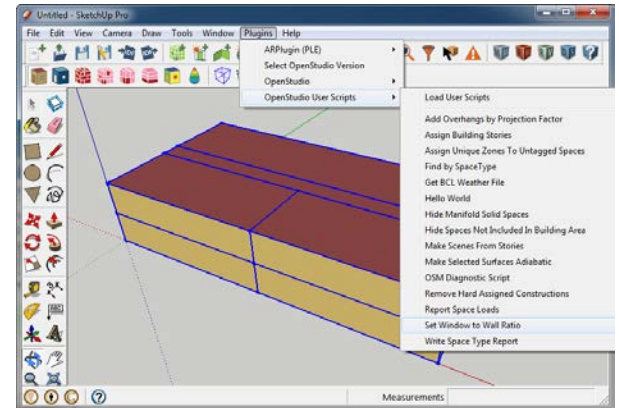


Use Cases for OpenStudio Measures

Interactive Measure Application

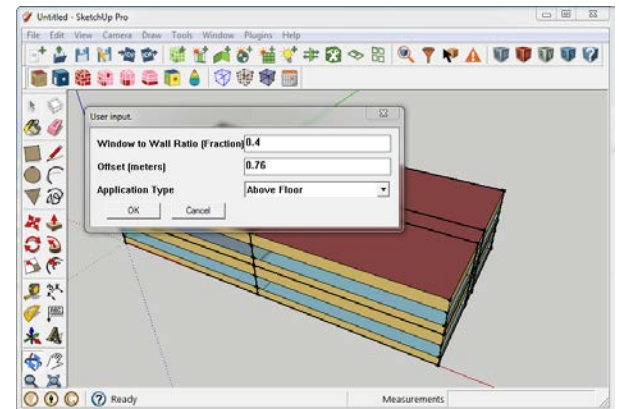
- User can run script at will
- Input arguments are collected at runtime
- User's selection is passed to the script
- Example scripts available in SketchUp plug-in
 - Includes WindowToWallRatio Measure

Before WindowToWallRatio Measure



Credit: David Goldwasser / NREL

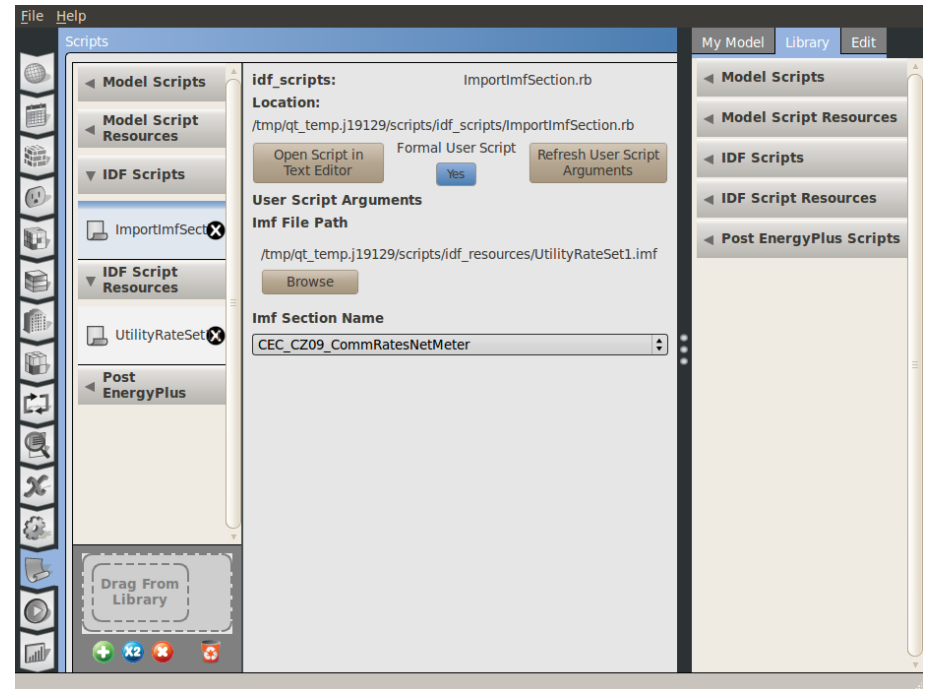
After WindowToWallRatio Measure



Credit: David Goldwasser / NREL

Noninteractive Measure Application

- User must save all input parameters ahead of time
- Script is saved with the model; can be thought of as part of the model
- Script is run every time the model is simulated
- Example scripts available in OpenStudio Application
 - Includes WindowToWallRatio Measure

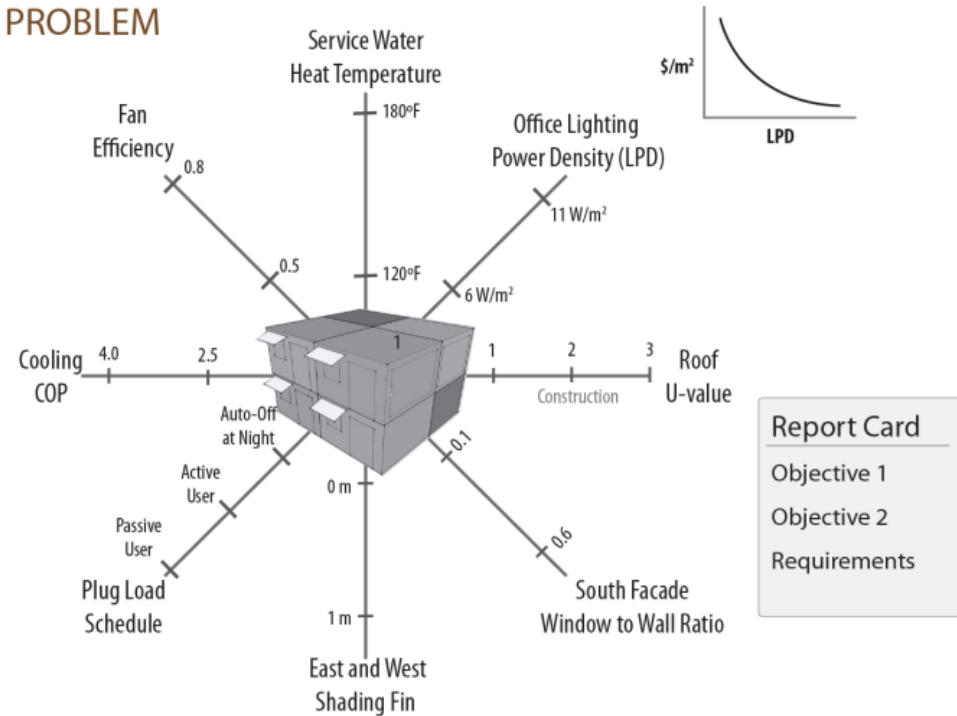


Credit: David Goldwasser / NREL

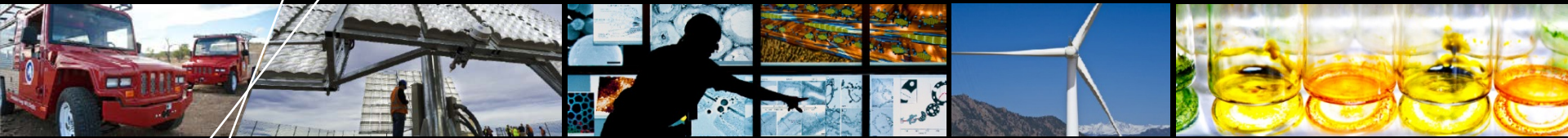
Composing Parameter Spaces with Measures

- Parameter space is composed of several variables
- Measures are used to set a variable to a given value
- Measures are applied as part of the simulation workflow for each model
- Once parameter space is defined, scripted analyses can be run
 - Design of Experiments
 - Optimization
 - Uncertainty Quantification
- Used to generate data for 179D DOE Calculator web tool
 - 250,000 E+ simulations in two weeks
 - Entire analysis rerun in one week after inputs models and measures were revised

PROBLEM



Credit: Marjorie Schott/ NREL



OpenStudio Measures and the BCL

The Building Component Library (BCL)

Building Component Library

Welcome, Guest! | Login | Register

Enter the terms you wish to search for. Search

Building Component Library

The Building Component Library is a repository of building data used to create building energy models. The data are broken down into separate components that represent parts of a building: windows, walls, schedules, and weather information are a few examples.

Components
Total Components: 28,652

The components are designed to provide data to the energy modeler and simplify the process of gathering inputs. The range of components goes from whole buildings to detailed files, like duct sealing components.

Energy Conservation Measures
Total Measures: 23,231

Energy saving measures are packaged to try one or a package to your model. An example would be duct sealing to all your windows.

Filter by
26668 results | Show 10 | Sort By Relevance | Download Checked

Filter by type
 Component (26668)

Component Types

- Location-Dependent Component (23231)
 - Design Day (20620)
 - Weather File (1308)
 - Water Main Temperature (1302)
- Construction Assembly (3077)
 - Wall (904)
 - exterior wall (716)
 - interior wall (188)
 - Fenestration (791)
 - Window (450)
 - Skylight (191)
 - Door (150)
- Floor (76)
 - exposed floor

ASHRAE Std189 Residential 8A window Nonmetal framing
Source: nlong - 04/10/12
Component Types: Window, Fenestration, Construction Assembly,
User rating: Not yet rated
Downloads: 3
Fidelity rating: 3

ASHRAE Std189 Residential 8A window Metal framing (all other)
Source: nlong - 04/10/12
Component Types: Window, Fenestration, Construction Assembly,
User rating: Not yet rated
Downloads: 3
Fidelity rating: 3

ASHRAE Std189 Residential 8A window Metal framing (curtainwall-storefront)
Source: nlong - 04/10/12
Component Types: Window, Fenestration, Construction Assembly,
User rating: Not yet rated
Downloads: 3
Fidelity rating: 3

ASHRAE Std189 Residential 8A window Metal framing (entrance door)
Source: nlong - 04/10/12
Component Types: Window, Fenestration, Construction Assembly,
User rating: Not yet rated
Downloads: 3
Fidelity rating: 3

ASHRAE Std189 Residential 8A roof Metal Building
Source: nlong - 04/10/12
Component Types: Roof, Construction Assembly,
User rating: Not yet rated
Downloads: 3
Fidelity rating: 3

ASHRAE Std189 Residential 8A skylight All Skylights without Curb
Source: nlong - 04/10/12
Component Types: Skylight, Fenestration, Construction Assembly,
User rating: Not yet rated
Downloads: 3
Fidelity rating: 3

ASHRAE Std189 Residential 8A interior wall Standard
Source: nlong - 04/10/12
Component Types: Roof, Construction Assembly,
User rating: Not yet rated
Downloads: 3
Fidelity rating: 3

<http://bcl.nrel.gov>

Create an account to save your components and get access to BCL API

- 1 component or energy conservation measure.
- 2 download the specific file or files you need.
- 3 data to your building energy model.
- 4 and review results.

Components

Total Components

28,652

The components are designed to provide data to the energy modeler and simplify the process of gathering inputs. The range of components goes from whole buildings to detailed files, like duct sealing components.

Search

Browse Components

Energy Conservation Measures

Total Measures

Energy saving measures are packaged to try one or a package to your model. An example would be duct sealing to all your windows.

Browse Energy Conserv

Search for and download BLC components from website, <http://bcl.nrel.gov>

Credit: David Goldwasser/NREL

Credit: David Goldwasser/NREL

OpenStudio and the BCL

The image displays the OpenStudio application interface. A central window titled 'Online BCL' is open, showing a search for 'cec non'. The search results are categorized under 'Constructions' and list 16 items, including 'CEC Title 24-2008 15 Door Non-Swinging' which is checked. The 'Attributes' panel on the right shows details for the selected item, such as 'Standard: CEC Title 24-2008' and 'Climate Zone: CEC 2008:15'. A 'Download' button is visible at the bottom right of the 'Online BCL' window. A green callout box at the top left of the main interface says 'Drag and drop downloaded BCL components into your model'. Another green callout box at the bottom of the 'Online BCL' window says 'Search for and download BCL components within OpenStudio Application'. The main interface also shows various construction categories like 'Tubular Daylight Domes', 'Interior Sub Surface', 'Fixed Windows', 'Other Constructions', 'Space Shading', and 'Interior Partitions', each with a 'Drag From Library' button.

Drag and drop downloaded BCL components into your model

Search for and download BCL components within OpenStudio Application

Credit: Evan Weaver/NREL

Credit: Evan Weaver/NREL


OpenStudio Measures and the BCL

- **BCL allows Measures as well as Components**
 - Measures may refer to Components
 - Components downloaded as needed when Measure runs
 - Measures in BCL still in early stages
- **Future integration with applications planned**
 - Drag and drop Measures into user script libraries, simulation workflow, and parameter spaces

Components

Total Components 27,537


The components are designed to provide data to the energy modeler and simplify the process of gathering inputs. The range of components goes from whole buildings to detailed files, like duct sealing components.

A button with a gear icon on the left, the text "Browse Components" in the center, and a play button icon on the right.

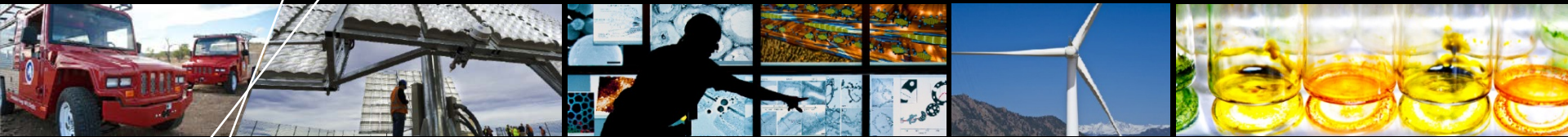
Energy Conservation Measures

Total Measures 7

Energy saving measures are packages that have been created to try one or a package of energy saving measures to your model. An example would be a measure that adds overhangs to all your windows.

A button with a wrench and screwdriver icon on the left, the text "Browse Energy Conservation Measures" in the center, and a play button icon on the right.

Credit: Daniel Macumber/NREL



Conclusions

Conclusions

- **GUIs and component libraries reduce time, decrease errors, and improve repeatability in energy modeling**
- **Entire custom analyses can be scripted end to end using the OpenStudio Ruby API**
- **Common tasks within an analysis can be automated using OpenStudio Measures**
- **Initial integration of Measures with OpenStudio, SketchUp Plug-in, and BCL is complete**
- **Future work will improve integration with GUIs and generate libraries of shareable Measures**

Acknowledgments

Funding Organizations:

- U.S. Department of Energy Building Technologies Program
- California Energy Commission

Coauthors:

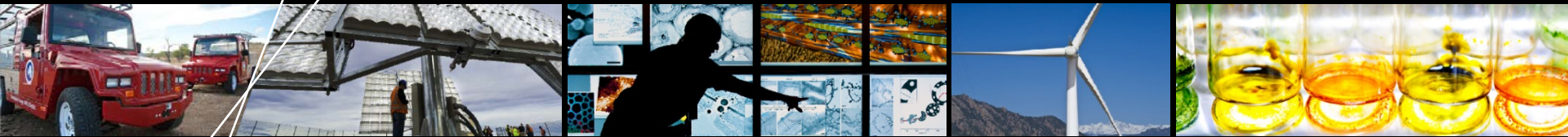
- Elaine Hale, Kyle Benne, and David Goldwasser

OpenStudio Team Members:

- Brian Ball, Larry Brackney, Luigi Gentile Polese, Nick Long, Marjorie Schott, Alex Swindler, Jason Turner, and Evan Weaver

179D Case Study:

- Brent Griffith, Matt Leach, Eric Bonnema, Katherine Fleming, and Michael Deru



Backup Slides

Future Work

- **Parameters for Structured Rulesets**
- **Run Structured Rulesets from OpenStudio and SketchUp Plug-in**
- **Each measure should generate a report on what it did**
- **Check if measure applies to given model (alternatively report says it did nothing)**
- **New measures are added to the BCL over time**
- **User generated components and measures in BCL**