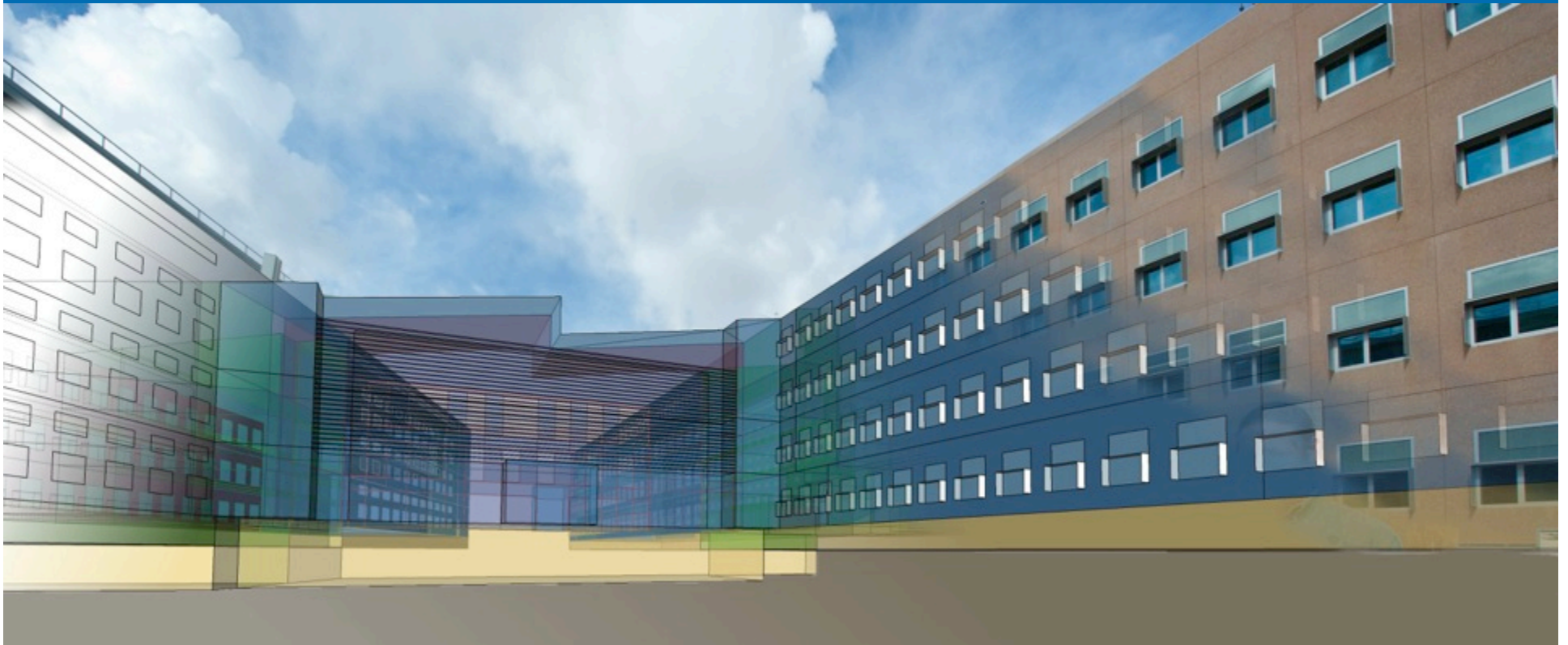




OpenStudio Overview

12th Annual Radiance International Workshop

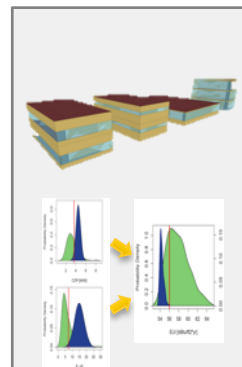


Commercial Buildings Controls and Analysis Tools Team
August 2013

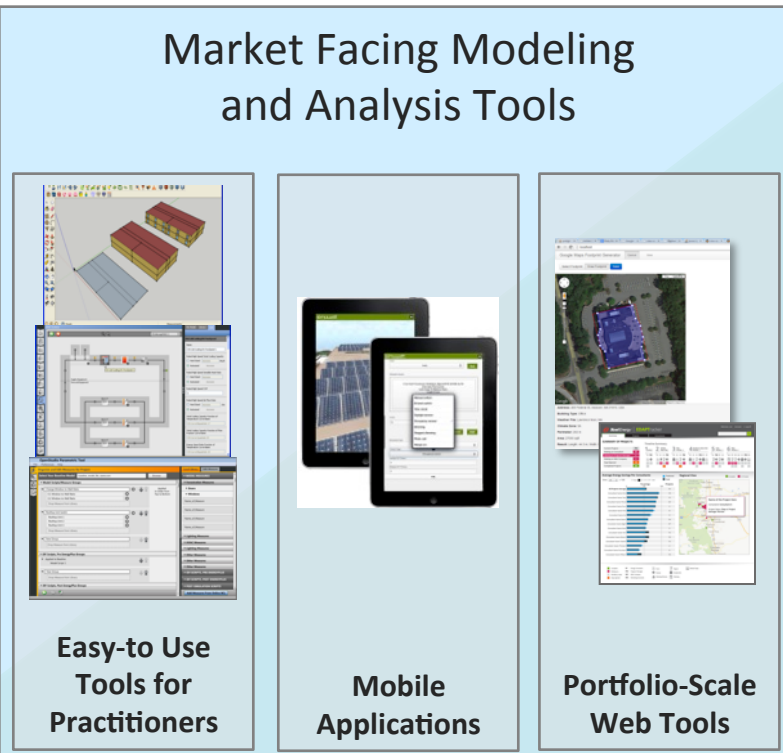
DOE'S Energy Modeling Platform

OpenStudio bridges the gap between capable but complex engines and the easy-to-use applications that drive change.

Sample Applications →



Enabling Analysis for Emerging Technologies



Easy-to Use Tools for Practitioners

Mobile Applications

Portfolio-Scale Web Tools

“Operating System” →

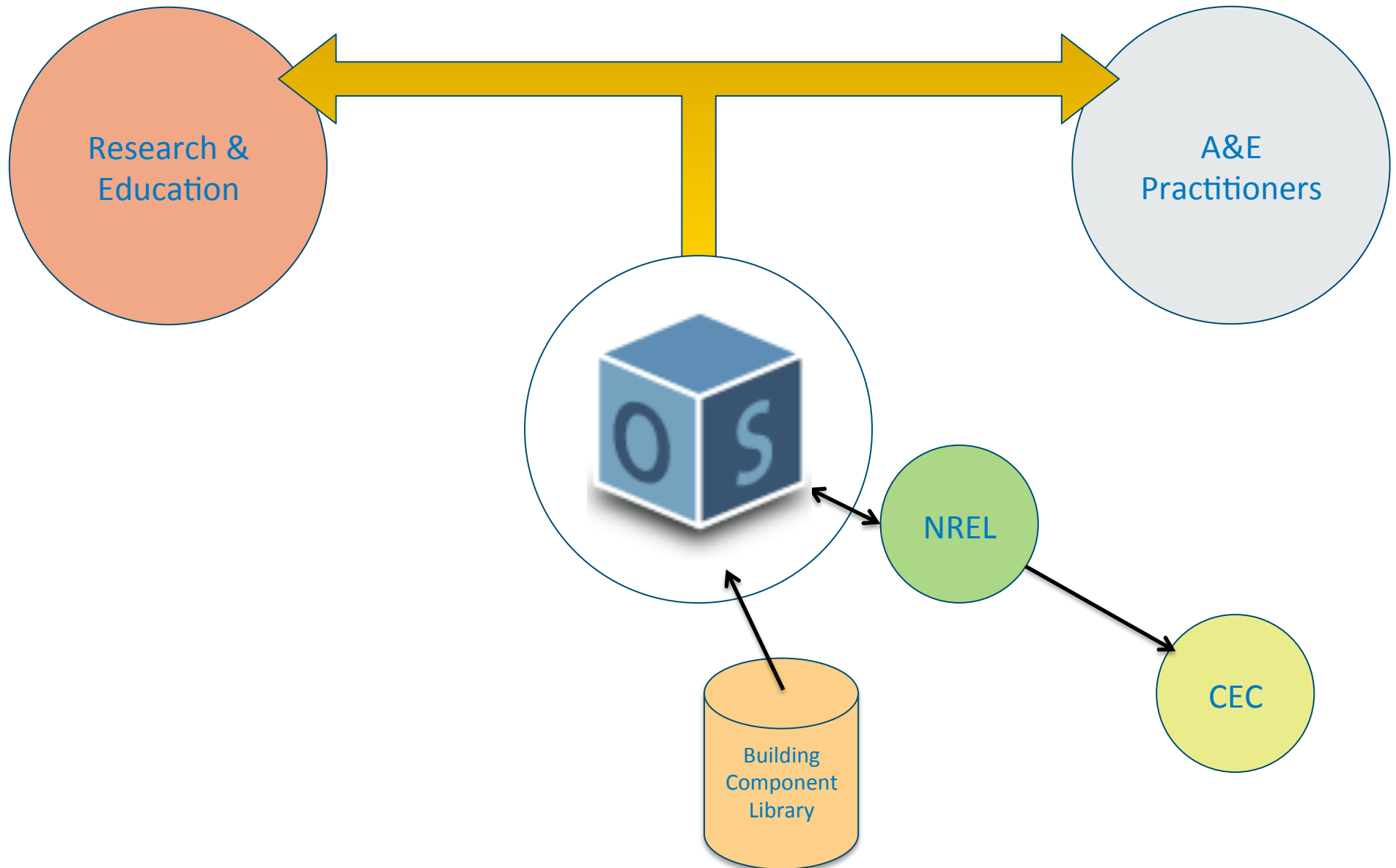
OpenStudio Software Development Kit (SDK)

Modeling Engines (EnergyPlus, Radiance, Others)

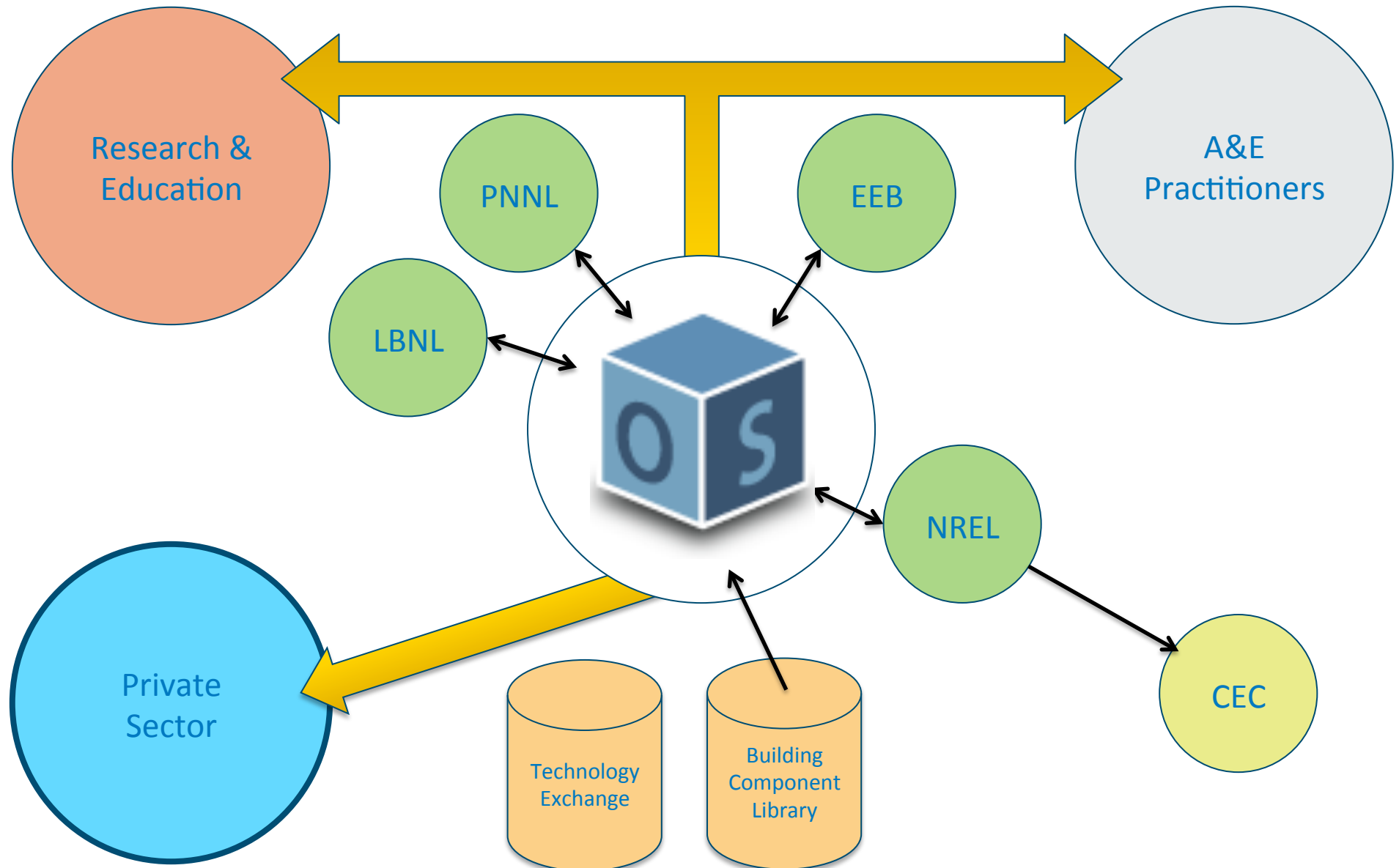
← User Expertise →

↑ Broad Market Penetration

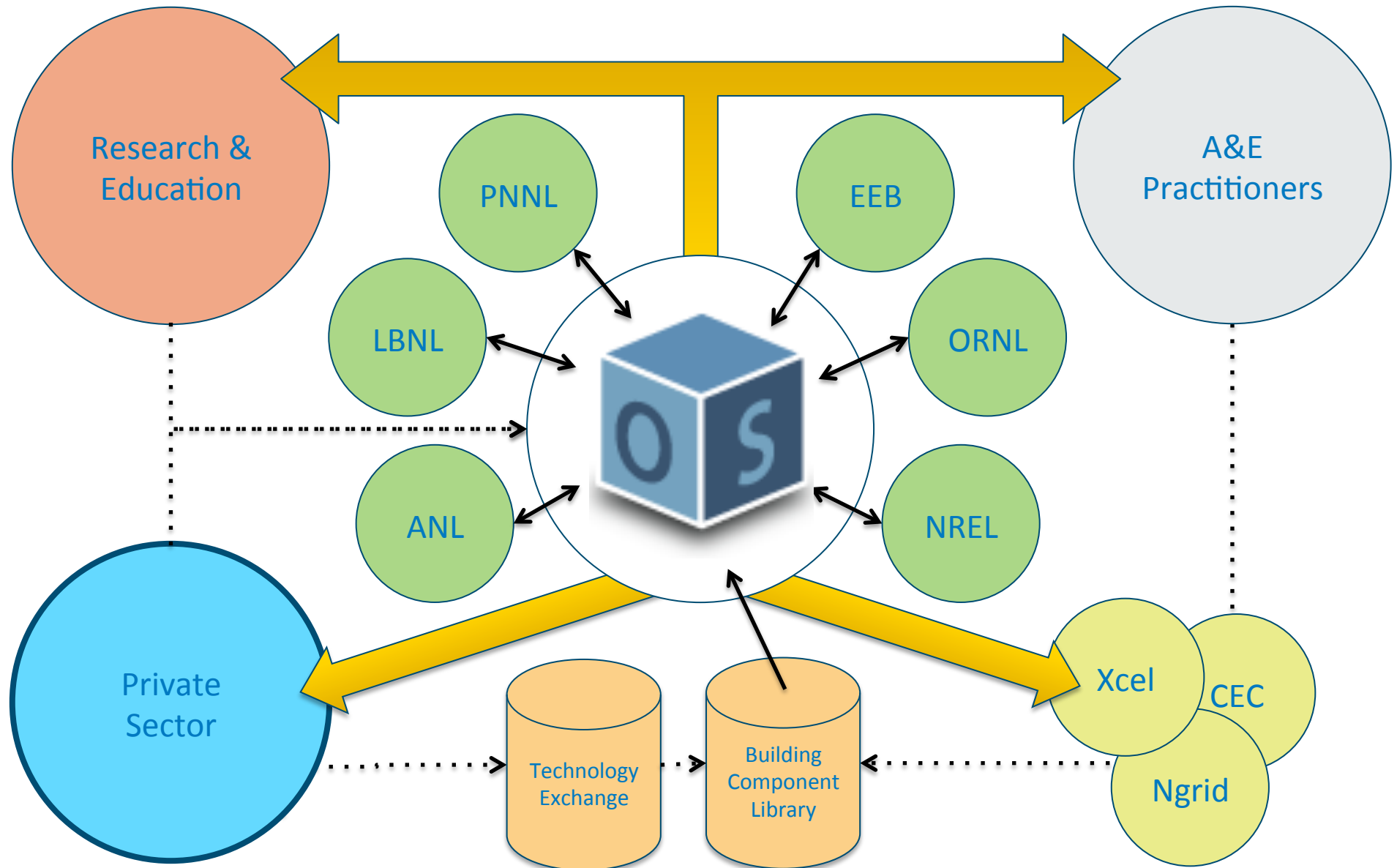
The Emerging OpenStudio Eco System – FY11



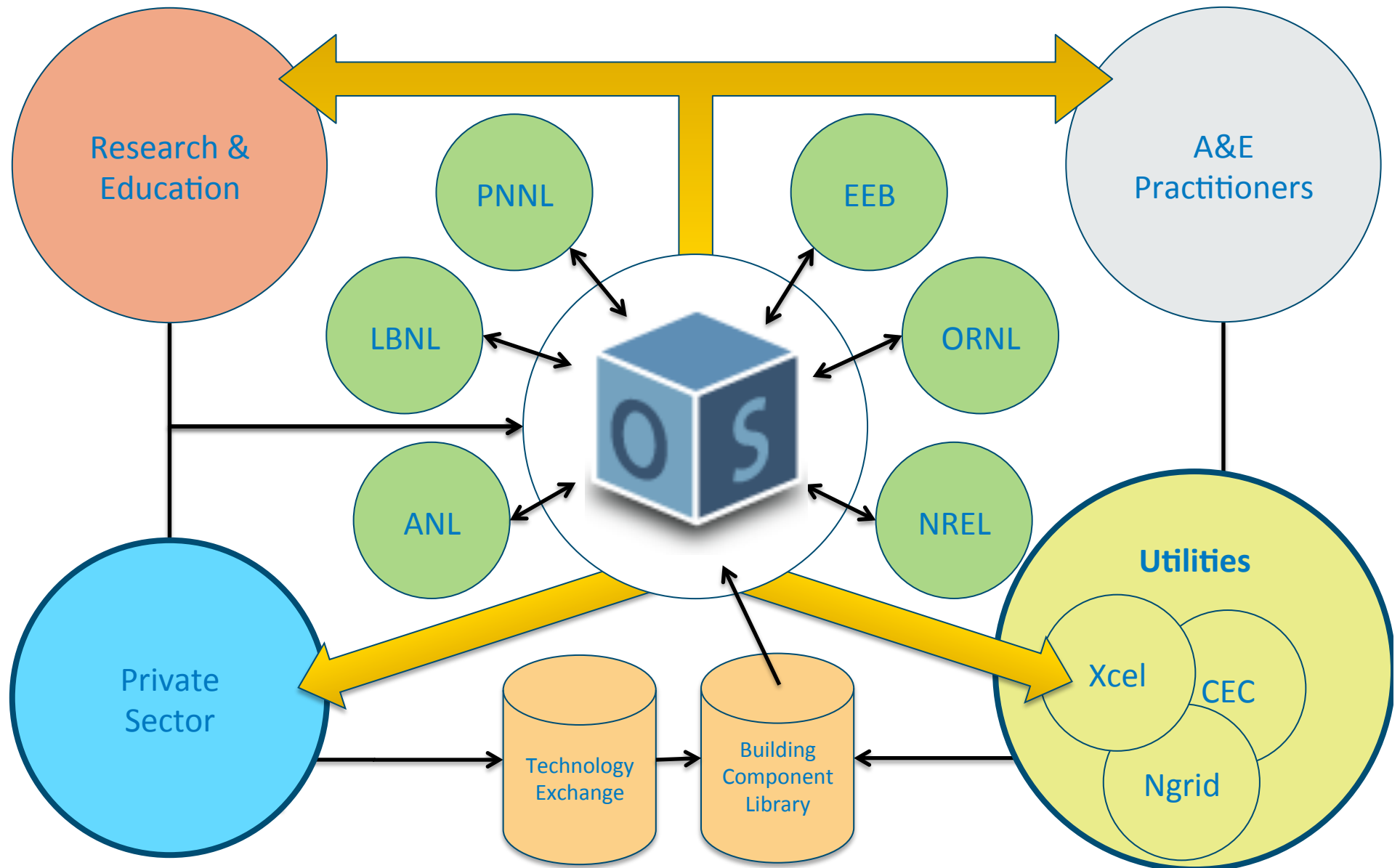
The Emerging OpenStudio Eco System – FY12



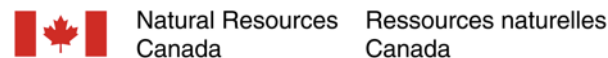
The Emerging OpenStudio Eco System – FY13



The Emerging OpenStudio Ecosystem



OpenStudio Partners (Partial List)



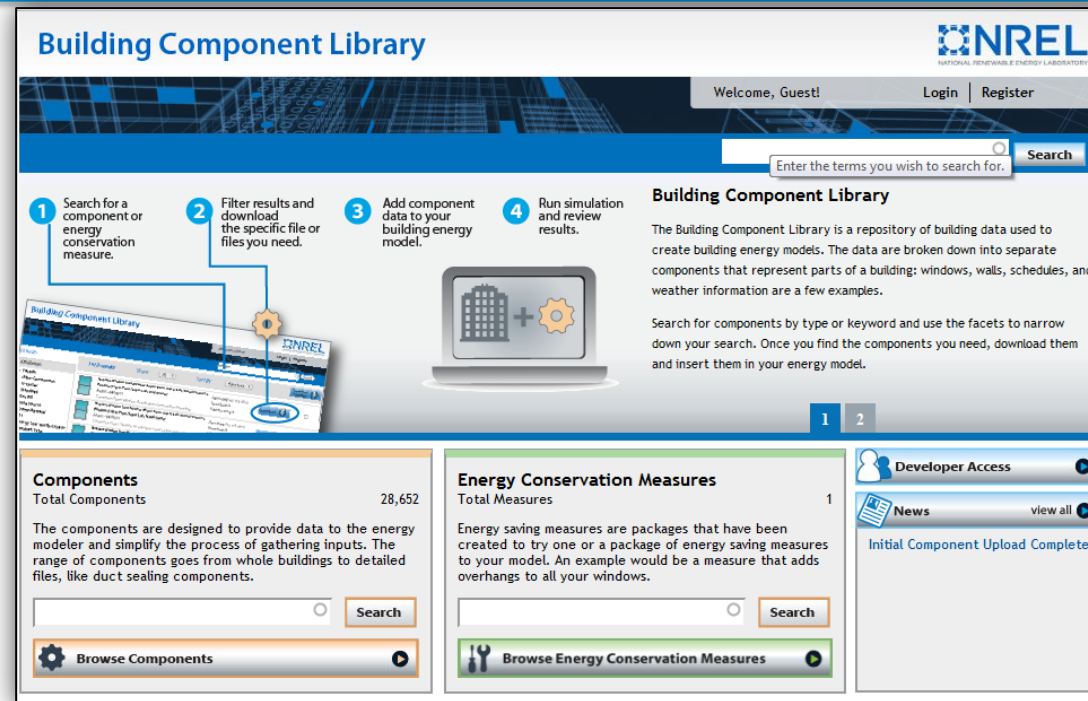
[illegible]

Note: gmail.com, hotmail.com, yahoo.com, and NREL.gov are filtered out of these results

NATIONAL RENEWABLE ENERGY LABORATORY

8

The Building Component Library



- An Internet-connected source of building energy modeling data:
 - Enables drag-and-drop modeling for **quick** technology evaluation
 - Provides **consistent**, detailed inputs to drive decision-making
 - **Searchable** readily available within applications
 - **Crowd sourced** content leverages sector knowledge

The BCL: A Source for Reusable Input Data

Building Component Library

Welcome, Guest! | Login | Register

Enter the terms you wish to search for.

- 1 Search for a component or energy conservation measure.
- 2 Filter results and download the specific file or files you need.
- 3 Add component data to your building energy model.
- 4 Run simulation and review results.

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.

Search for components by type or keyword and use the facets to narrow down your search. Once you find the components you need, download them and insert them in your energy model.

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: 1

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.

Developer Access

News

Initial Component Upload Complete

ASHRAE 90.1 Constructions Exterior Wall Steel-Framed NR

Click to view more images

Fidelity level:

User Rating:

Downloads: 7

Component Types:
Construction Assembly
Wall
Exterior Wall

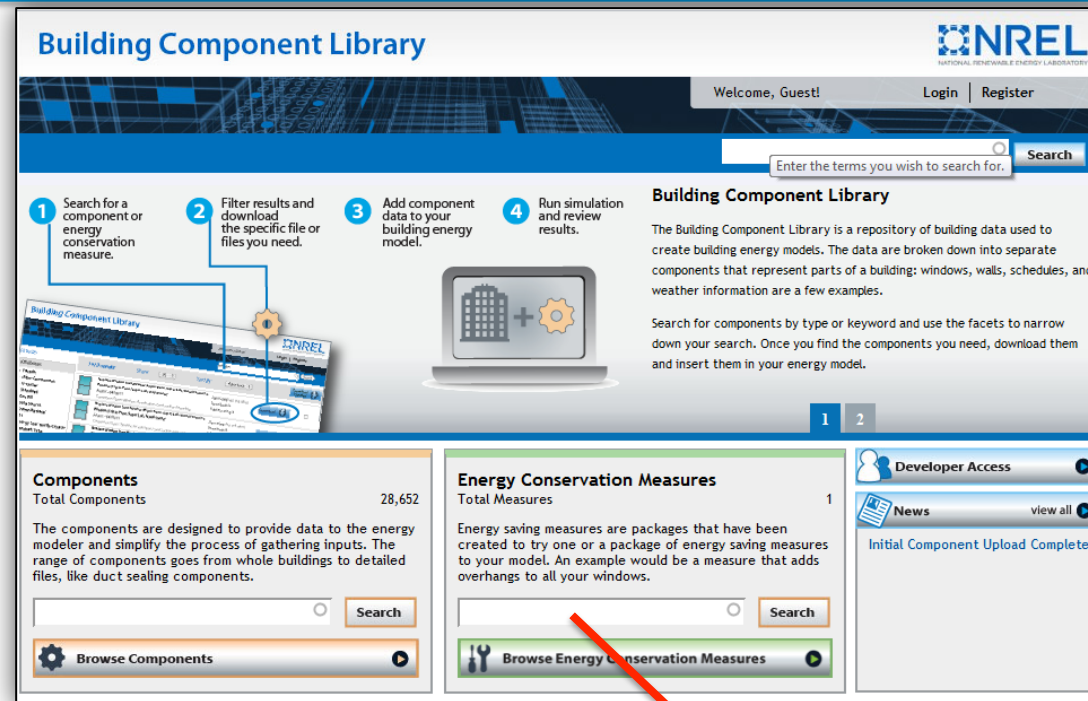
Attributes	
Standard	ASHRAE 90.1 Constructions
Construction	Exterior Wall
Construction type	Steel-Framed
Effective r-value	0.4421 ft ² F h/Btu
Insulation minimum r-value	R ft ² F h/Btu
Film coefficients	false
OpenStudio Type	OS:Construction

Files	
ASHRAE 90.1 Constructions_Exterior Wall_Steel-Framed_NR_v7.0.0.036.idf	EnergyPlus 7.0.0.036
ASHRAE 90.1 Constructions_Exterior Wall_Steel-Framed_NR_v0.7.0.0.osm	OpenStudio 0.7.0
ASHRAE 90.1 Constructions_Exterior Wall_Steel-Framed_NR_v0.7.0.0.osc	OpenStudio 0.7.0

Components:

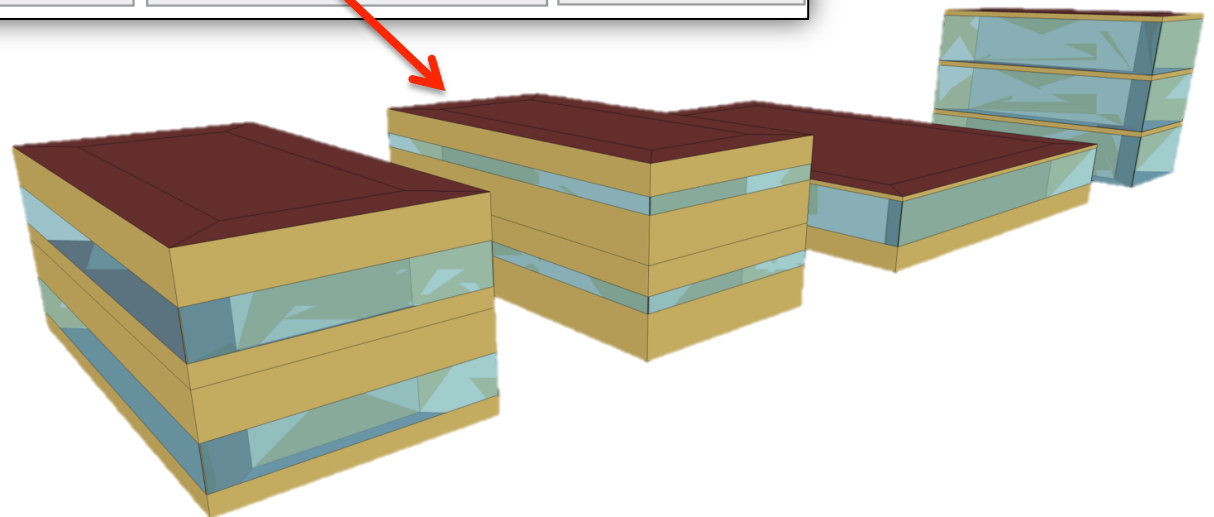
- Assembled to form complete energy models
- Include constructions, lights, schedules, weather data, PV components, and more

The BCL: Fast and Reliable Measure Application



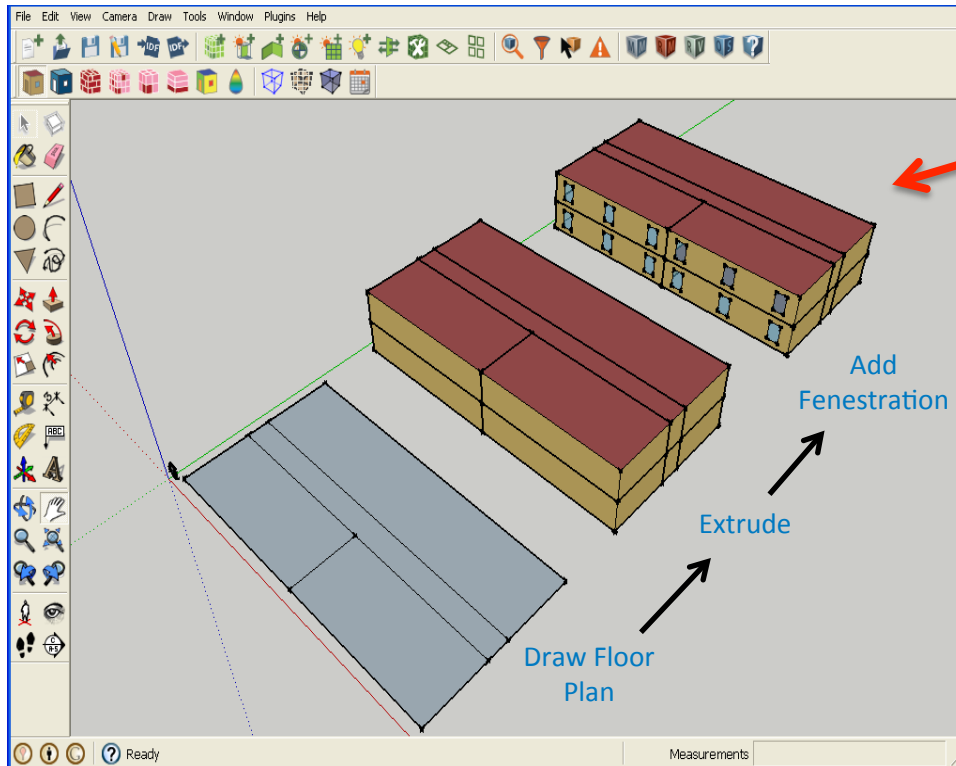
Measures:

- Contain logic needed to transform an energy model easily and consistently
- Can be applied singly or as part of a parametric analysis

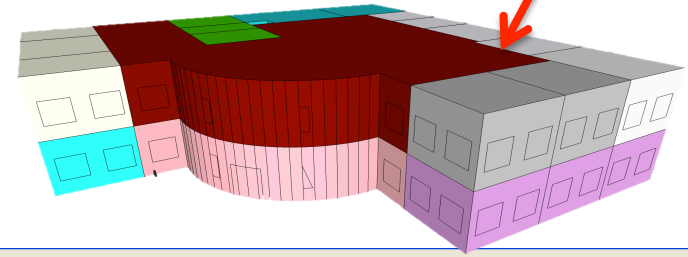


An A&E Practitioner's View

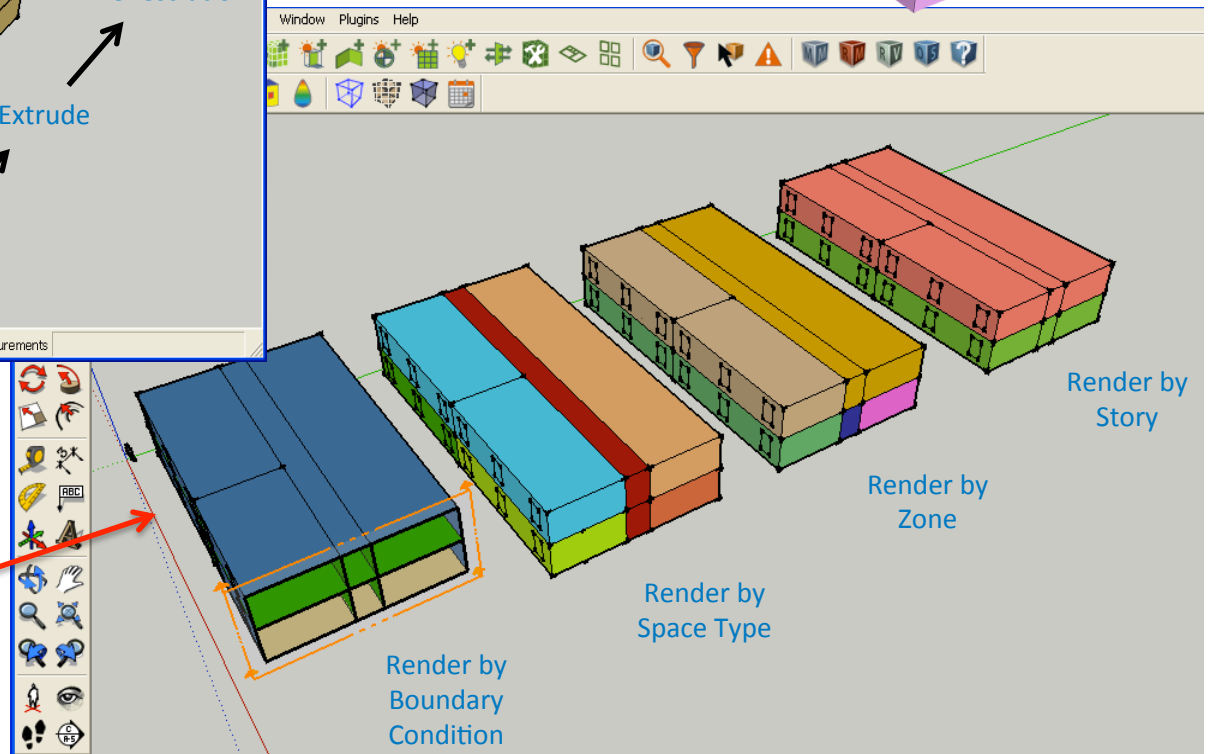
Rapid Geometry and Space Assignment with SketchUp



Draw envelope in minutes using SketchUp, or import from BIM



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



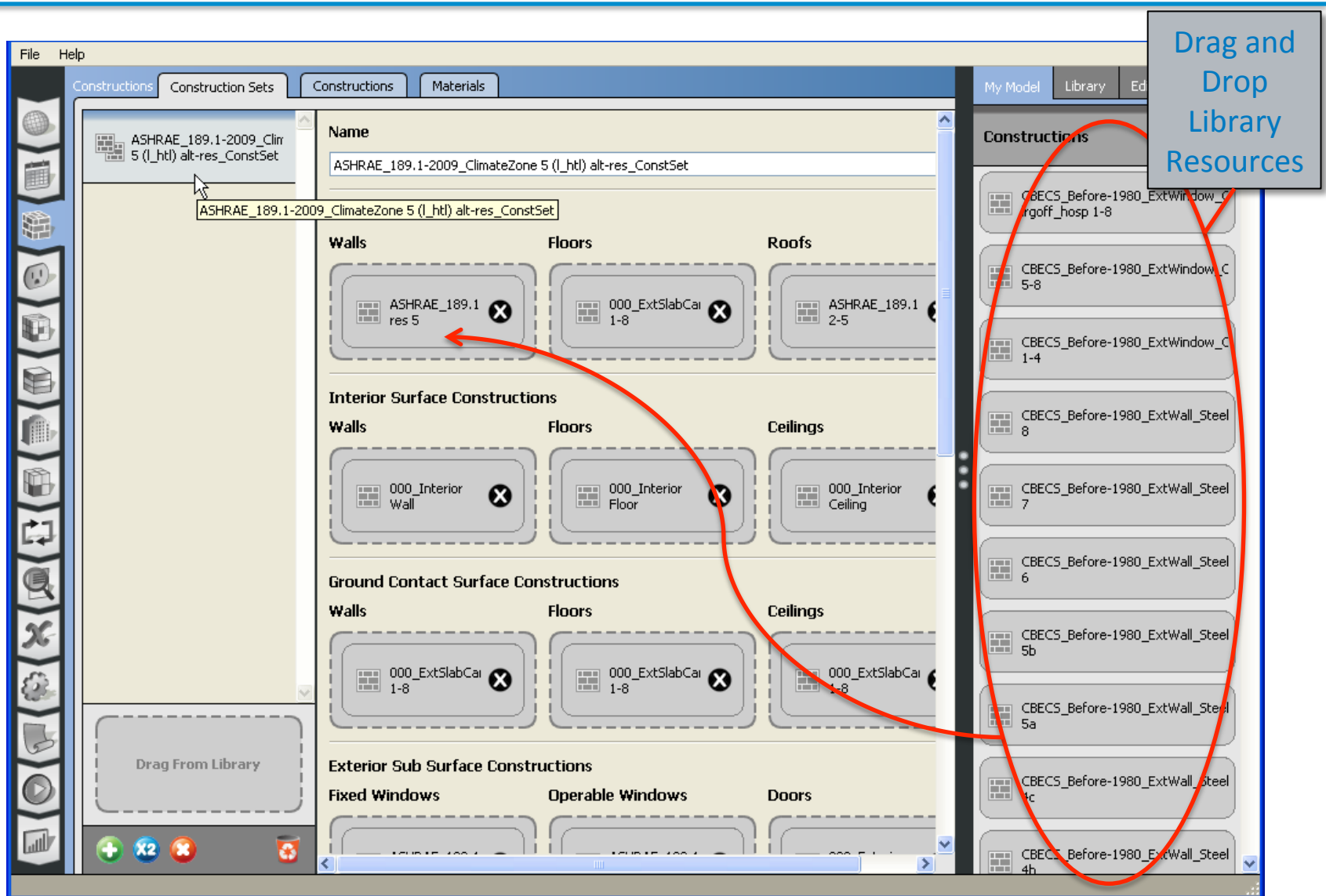
Credit: David Goldwasser / NREL

The OpenStudio Application

Define
Resources

Workflow

Review
Results



Credit: David Goldwasser / NREL

Templated HVAC Systems for Rapid Modeling

The screenshot displays the OpenStudio software interface for modeling HVAC systems. The main window, titled "HVAC Systems", shows a schematic diagram of a system with three packaged rooftop VAV units. A blue box with a red arrow points to the first unit, which is labeled "Packaged DX Rooftop VAV with Reheat". The second unit is labeled "Packaged Rooftop VAV with Parallel Fan Power Boxes and reheat", and the third is labeled "Packaged Rooftop VAV with Reheat". The diagram also shows supply and demand equipment connected to the units. A blue box with the text "1. Pick a System", "2. Add Your Zones", and "3. Done" is overlaid on the left side of the diagram. The right side of the interface shows the "My Model" tab with a list of components. The "OS:Node" component is selected, showing its configuration: Name: OS:Node 13, OS:SetpointManager:SingleZone:Reheat, Minimum Supply Air Temperature: -99 F, Maximum Supply Air Temperature: 99 F, and Control Zone Name: OS:ThermalZone 4.

1. Pick a System
2. Add Your Zones
3. Done

OS:Node
Name
OS:Node 13
OS:SetpointManager:SingleZone:Reheat
Name
OS:SetpointManager:SingleZone:Reheat 1
Minimum Supply Air Temperature
-99 F
Maximum Supply Air Temperature
99 F
Control Zone Name
OS:ThermalZone 4

Credit: David Goldwasser / NREL

Drag and Drop HVAC System Models

The screenshot displays the HVAC Systems software interface, which is designed for creating and customizing HVAC system models through a drag-and-drop workflow.

Interface Components:

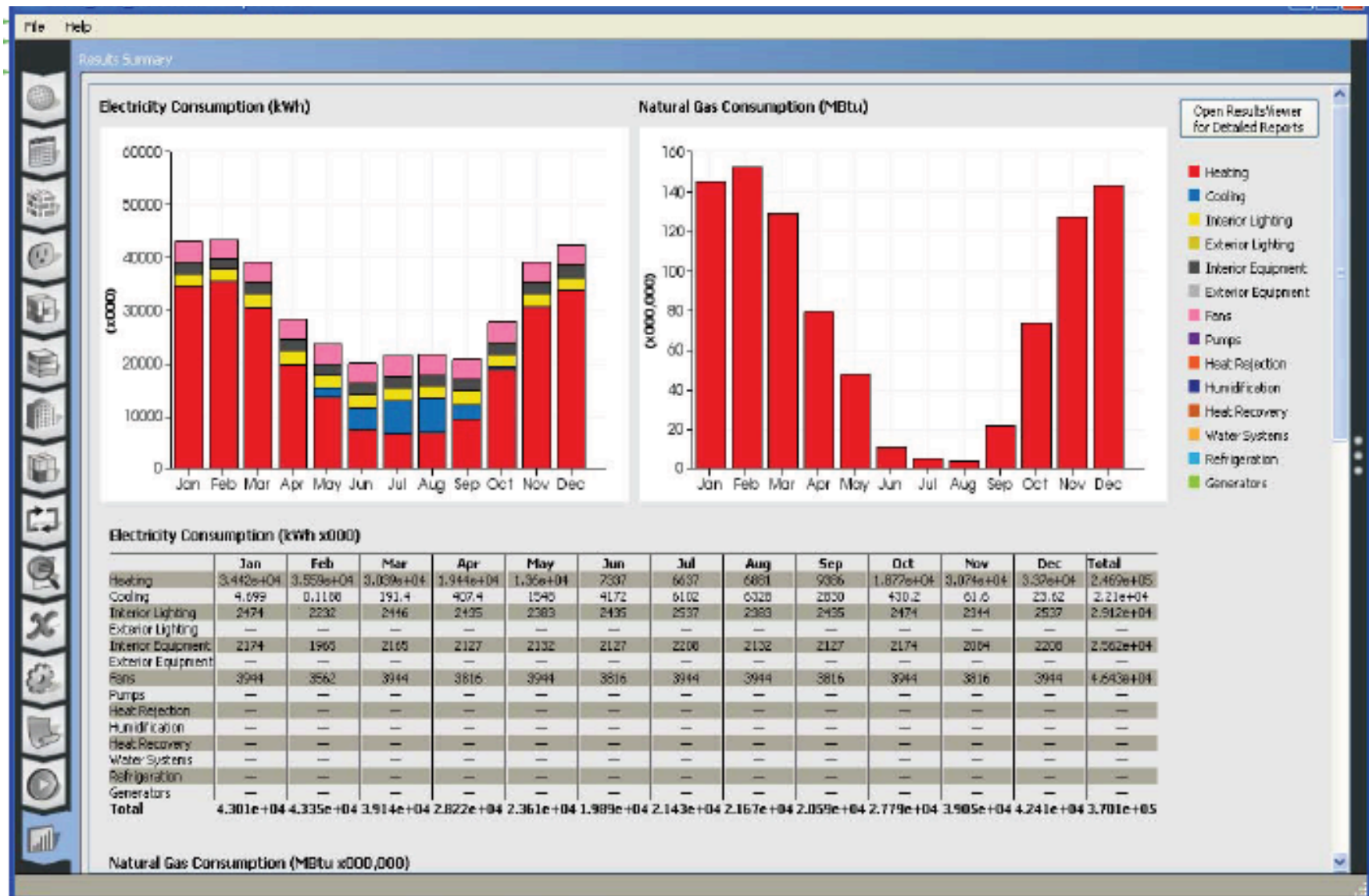
- Top Menu Bar:** Includes "File" and "Help" options.
- Left Toolbar:** A vertical column of icons representing various HVAC components such as pumps, coils, fans, and zones.
- Main Workspace:** The central area where the system schematic is built. It shows a network of components connected by lines representing air and water loops. A callout box with the text "...or customize your own" is present. A specific component is labeled "OS:Coil:Cooling:DX:TwoSpeed 1".
- Right Panel (Properties):** A detailed configuration area for the selected component, titled "OS:Coil:Cooling:DX:TwoSpeed". It includes tabs for "My Model", "Library", and "Edit".

Properties Panel Details:

- Name:** OS:Coil:Cooling:DX:TwoSpeed 1
- Rated High Speed Total Cooling Capacity:** Options for "Hard Sized" (Autosize Btu/h) and "Autosized" (Autosize).
- Rated High Speed Sensible Heat Ratio:** Options for "Hard Sized" (Autosize) and "Autosized" (Autosize).
- Rated High Speed COP:** A text input field with the value "3".
- Rated High Speed Air Flow Rate:** Options for "Hard Sized" (Autosize cfm) and "Autosized" (Autosize).
- Total Cooling Capacity Function of Temperature Curve Name:** OS:Curve:Biquadratic 17
- Total Cooling Capacity Function of Flow Fraction Curve Name:** OS:Curve:Quadratic 23
- Energy Input Ratio Function of Temperature Curve Name:** OS:Curve:Biquadratic 18

Credit: David Goldwasser / NREL

High Level Simulation Summary



Credit: David Goldwasser / NREL

The OpenStudio Parametric Analysis Tool

OpenStudio Parametric Tool

File Preferences Help

Organize and Edit Measures for Project

Select Your Baseline Model

▼ **Model Scripts/Measure Groups**

▼ **Change Window-to-Wall-Ratio**

- 0.1 Window-to-Wall Ratio
- 0.2 Window-to-Wall Ratio
- Drop Measure from Library

▼ **Rooftop Unit Switch**

- Rooftop Unit 1
- Rooftop Unit 2
- Rooftop Unit 3
- Drop Measure from Library

▼ **New Group**

- Drop Measure from Library

► **IDF Scripts, Pre EnergyPlus Groups**

▼ Applied to Baseline

- Model Script 1

▼ **New Group**

- Drop Measure from Library

► **IDF Scripts, Post EnergyPlus Groups**

Local Library Edit Measure

Change Window-to-Wall Ratio

Description

Set the building's window-to-wall ratio to [Window to Wall Ratio] on the (Facade) site of the building.

OpenStudio Parametric Tool

File Preferences Help

Create and View Reports Summary Details

Select Report Type

▼ **OpenStudio High-level Comparison**

Baseline Model

Name	baseline_model_file_name.osm
Annual Total Energy Cost (\$)	\$100,000
Annual Electricity Use (kWh)	500,000 kWh
Annual Electricity Peak Demand (kW)	\$100,000
Annual Natural Gas Usage (Therms)	25,000 Therms
Site EUI (kBtu/ft2*yr)	100 kBtu/ft2*yr

Name	Measures Applied	Annual Energy Cost Reduction (\$)	Annual Electricity Use Reduction (kWh)	Annual Electricity Peak Demand Reduction (kW)	Annual Natural Gas Usage Reduction (Therms)	Site EUI Reduction (kBtu/ft2*yr)
alternative1_file...	M1.2-0.2 WWR on North Facade	\$5,000	5%	\$15,000	3%	9
alternative2_file...	M1.3-0.3 WWR on North Facade	\$4,000	4%	\$10,000	2%	6
alternative3_file...	M1.4-0.4 WWR on North Facade					
alternative3_file...	M1.4-0.4 WWR on North Facade					
alternative3_file...	M2.4-0.4 Other Measure Name					
alternative3_file...	M3.2-0.4 Other Measure Name					
alternative3_file...	M1.4-0.4 WWR on North Facade					
alternative3_file...	M3.2-0.4 Other Measure Name					

► Other Report Name

► Other Report Name

► Other Report Name

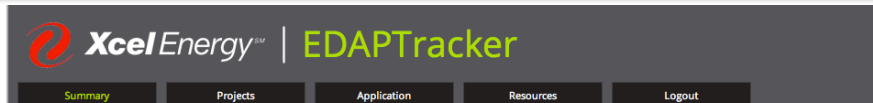
Select measures from BCL and apply them to your baseline model

Inspect measures applied to specific alternative models

Compare energy performance, cost reduction, and paybacks

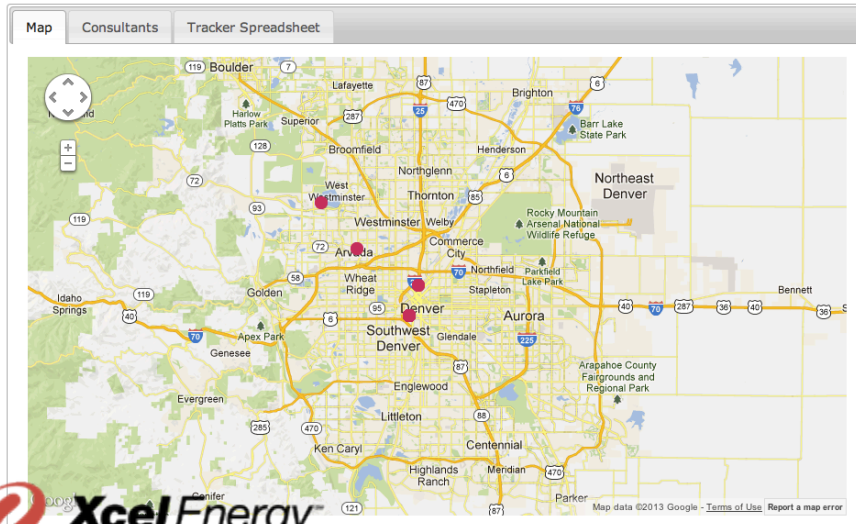
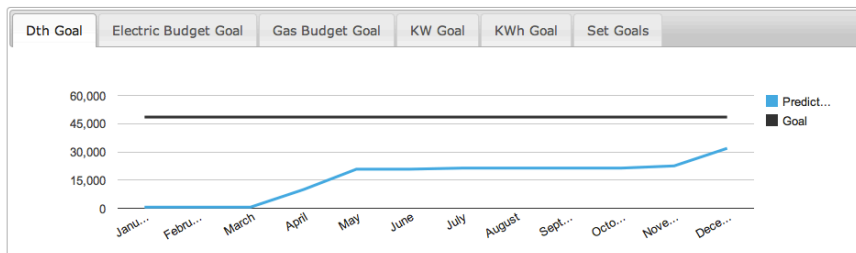
Results may be exported for integration with other applications

Incenting New Construction Efficiency



Summary

Current Projects	31	1 APPLY	2 INTRO	3 PEA	4 FEA	5 CD REVIEW	6 M&V
Waiting on Xcel - PM	12	EC	EC	EC	EC	EC	EC
Waiting on Xcel - MA	0	10	2	10	1	2	1
Waiting on Xcel - EEE	0						
Waiting on Energy Consultant	17						
Waiting on Measurement & Verification Company (MVC)	0						
Waiting on Measurement & Verification Energy Modeler (MVEM)	0						
Completed Projects	2						



• Energy Design Assistance (EDA)

- These programs are a primary tool to influence efficiency beyond code for new construction

• Problems:

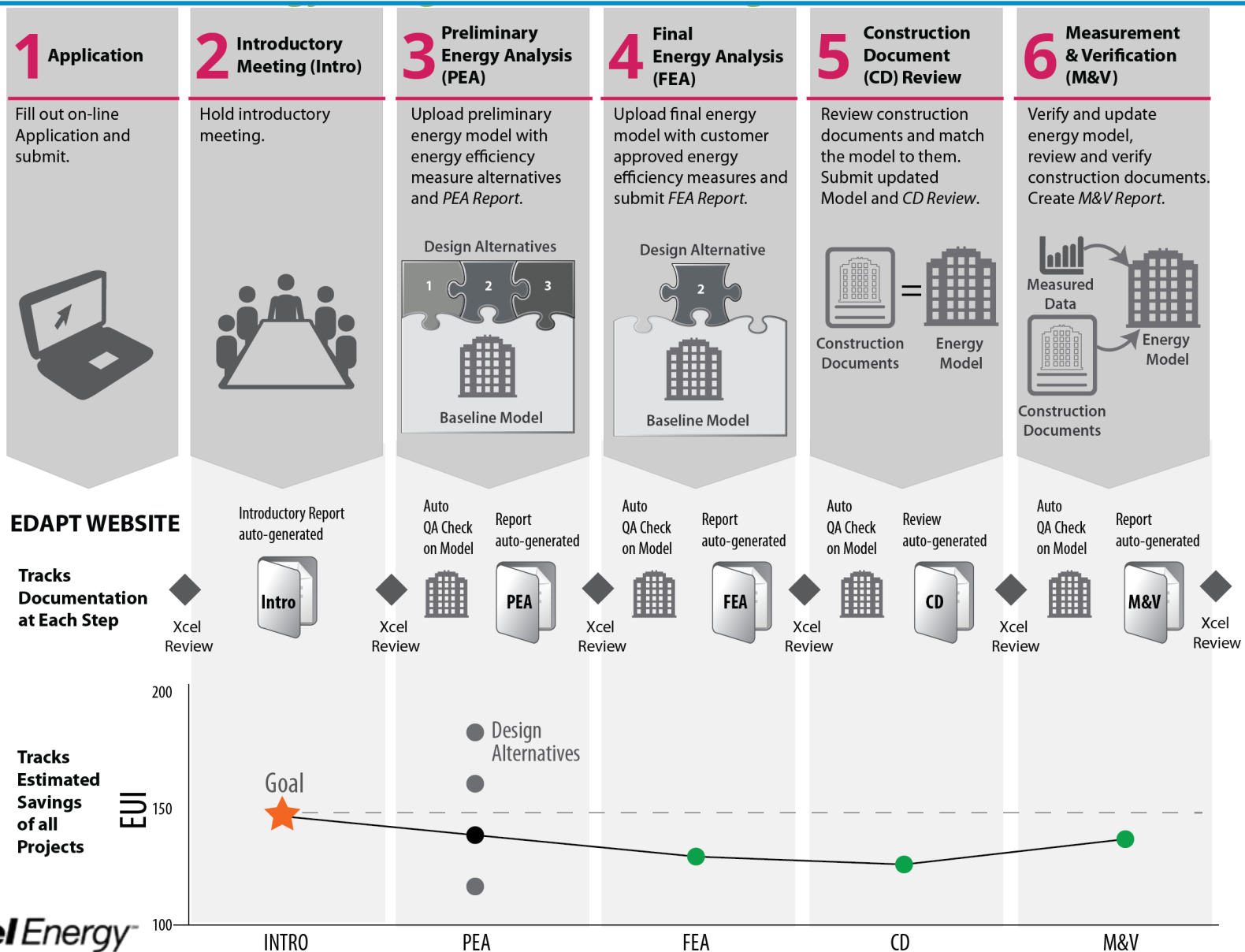
- EDA viability jeopardized as codes become more stringent
- Must reduce admin costs to remain viable
- Must maintain quality

• Solution:

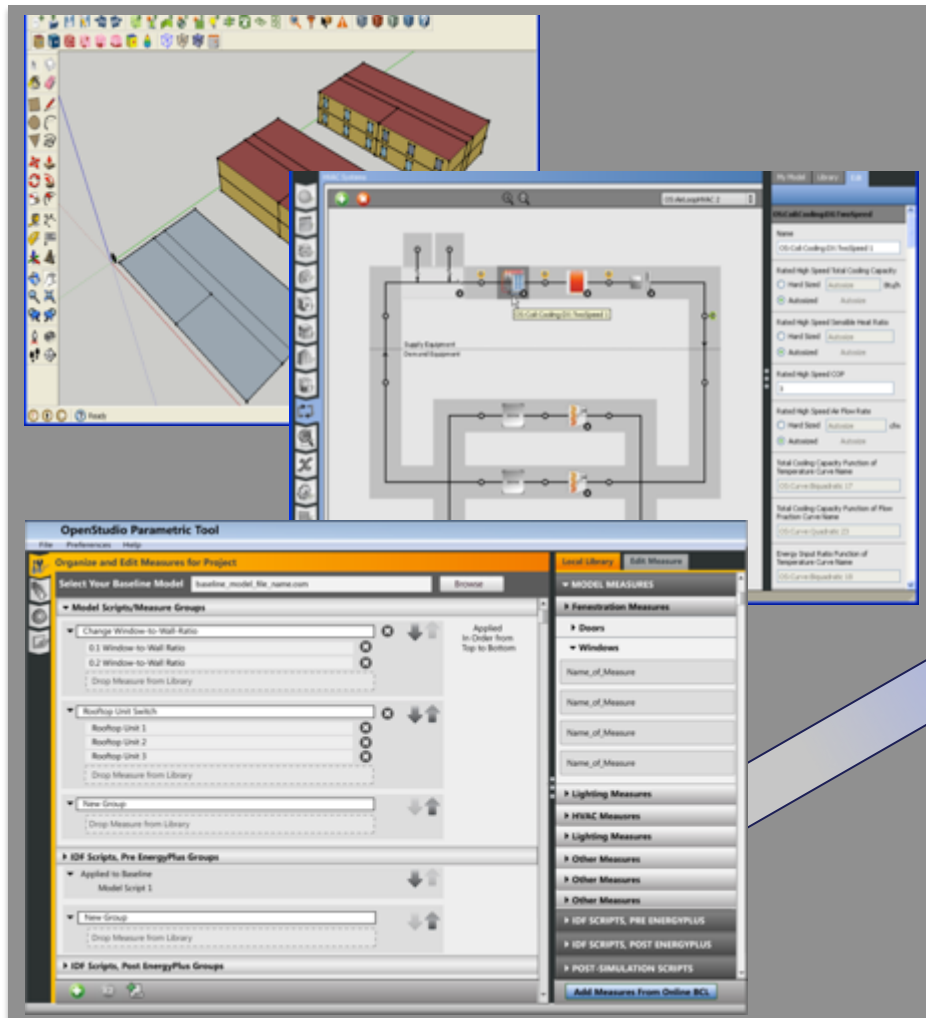
- Web service tracks projects, manages data and communications, and reports program-wide outcomes
- OpenStudio provides automated quality and EDA protocol checking
- EDAPT connects project data with model outcomes to streamline reporting



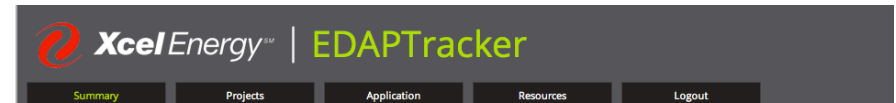
Incenting New Construction Efficiency



OpenStudio-EDAPT Integration

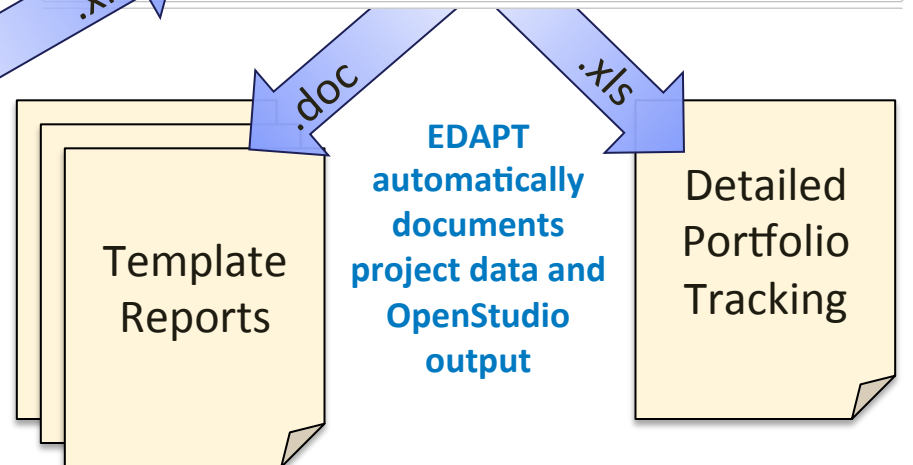
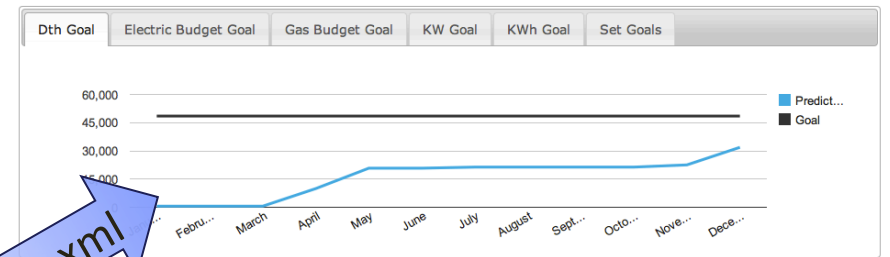


OpenStudio baseline and design alternate models
along with simulation results



Summary

Current Projects	31	1 APPLY	2 INTRO	3 PEA	4 FEA	5 CD REVIEW	6 M&V
Waiting on Xcel - PM	12	EC	EC	EC	EC	MV	MV
Waiting on Xcel - MA	0	10	2	10	1	2	1
Waiting on Xcel - EEE	0						
Waiting on Energy Consultant	17						
Waiting on Measurement & Verification Company (MVC)	0						
Waiting on Measurement & Verification Energy Modeler (MVEM)	0						
Completed Projects	2						



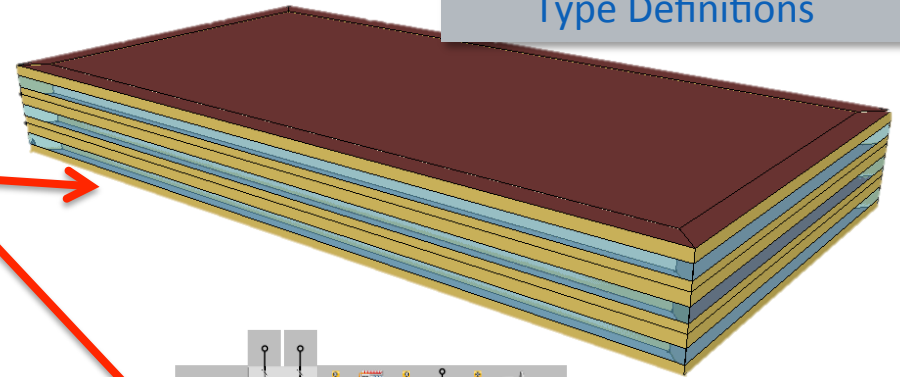
Advanced Applications

OpenStudio Enables Automated Model Generation

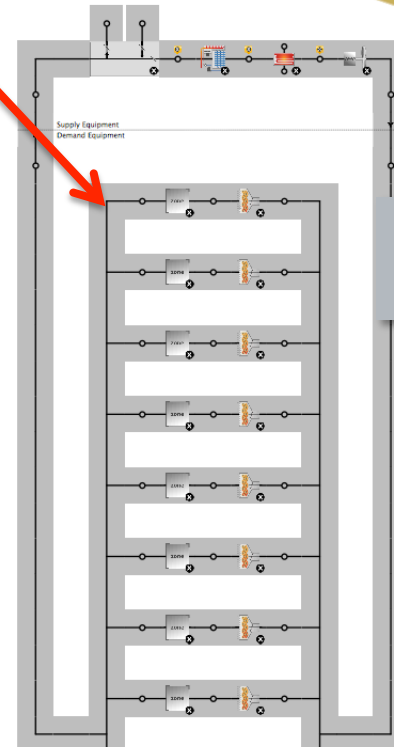
```
VirtualPULSE_run.rb
1 require 'openstudio'
2 require 'VirtualPULSEModel'
3
4 #create a new model
5 model = VirtualPULSEModel.new
6
7 #add geometry (in this case a simple multi-story core/perimeter building)
8 model.add_geometry({"length" => 100,
9                    "width" => 100,
10                   "height" => 10})
11 #add windows at a given window-to-wall ratio
12 model.add_windows({"wtr" => 0.4})
13 #add HVAC - Packaged VAV w/ Reheat - DX Cooling, Hot Water heat and reheat
14 model.add_hvac({"fan_eff" => 0.5,
15               "heating_setpoint" => 24,
16               "cooling_setpoint" => 55})
17 #add thermostats
18 model.add_thermostats({"heating_setpoint" => 24,
19                      "cooling_setpoint" => 55})
20 #assign constructions from a local library to the model (windows/etc. in the model)
21 model.add_constructions({"construction_library_path" => "#{Dir.pwd}/VirtualPULSE_default_constructions.osm"})
22
23 #add space type from a remote library (90.1 to the model)
24 model.add_space_type({"NREL_reference_building_vintage" => "ASHRAE_90.1-2004",
25                    "space_type" => "Office"})
26 #add design days to the model
27 model.add_design_days()
28
29 #save the OpenStudio model (.osm)
30 model.save_openstudio_model({"osm_save_directory" => Dir.pwd})
31 #translate the OpenStudio model (.osm) to an EnergyPlus model (.idf)
32 model.translate_to_energyplus_and_save_idf({"idf_save_directory" => Dir.pwd})
33 #run the EnergyPlus model (.idf)
34 VirtualPULSEModel.run_energyplus_simulation({"idf_directory" => Dir.pwd})
35
```

2 Lines of Ruby Code + Comments

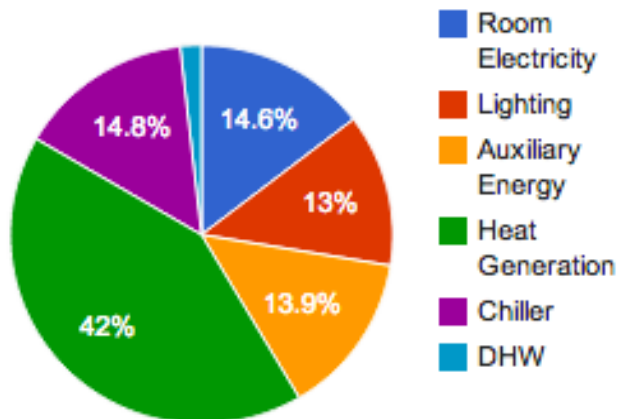
Geometry and Space Type Definitions



Detailed HVAC and Zoning



Equipment Consumption [kBTUx10^6]



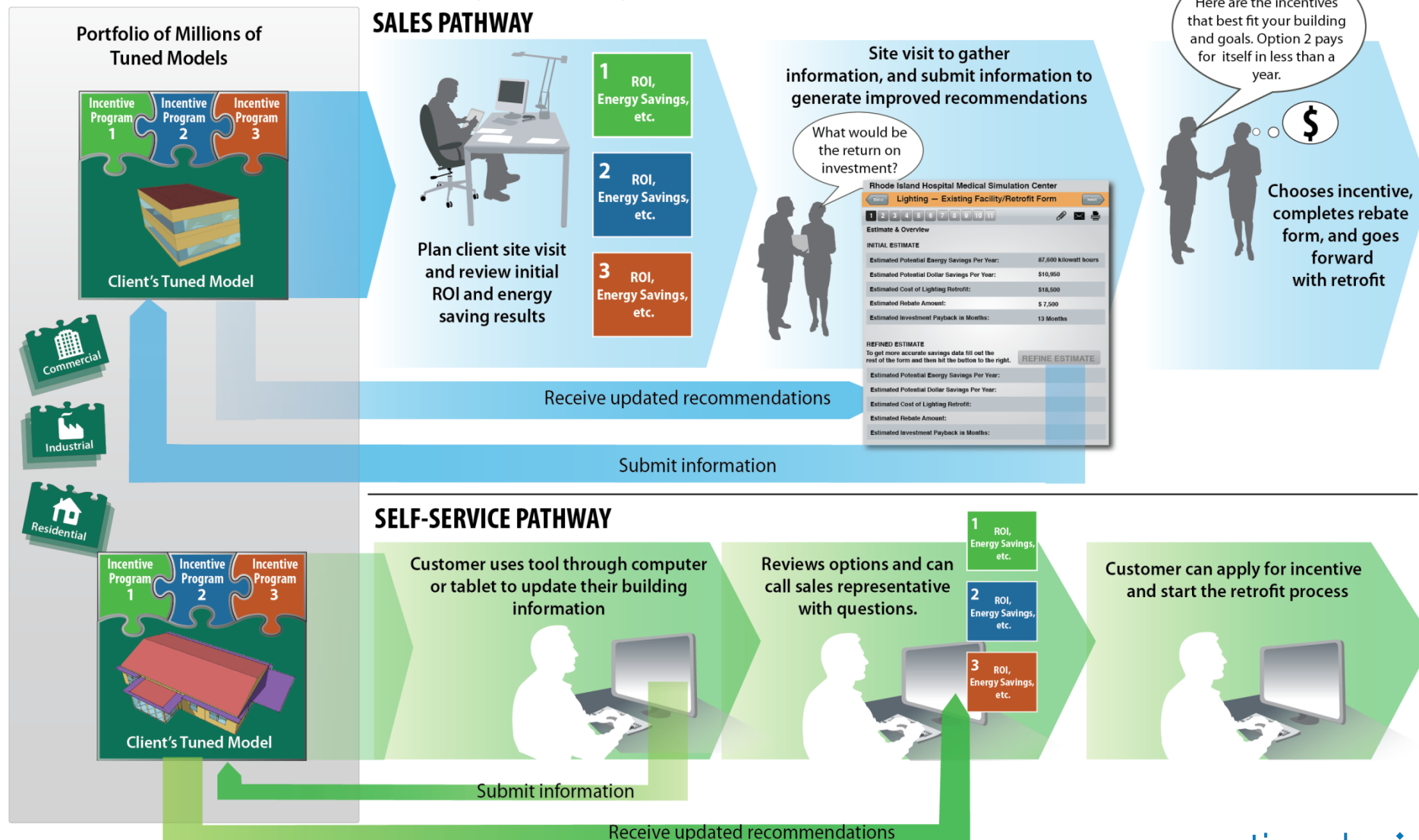
Simulated End Uses

Pacific Northwest
NATIONAL
LABORATORY

eebHUB Energy
Efficient
Buildings
Hub

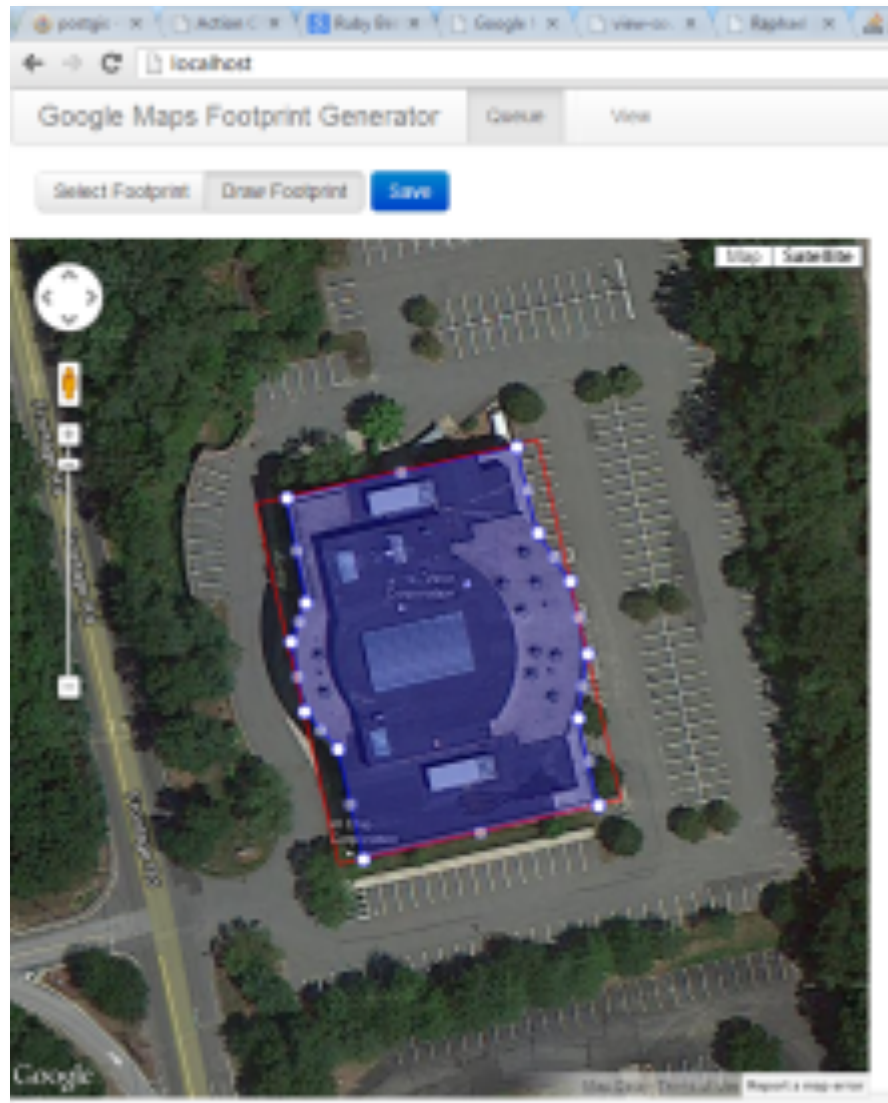
Portfolio-Scale Automated Modeling

Customer Optimization For Energy Efficiency (COFEE)



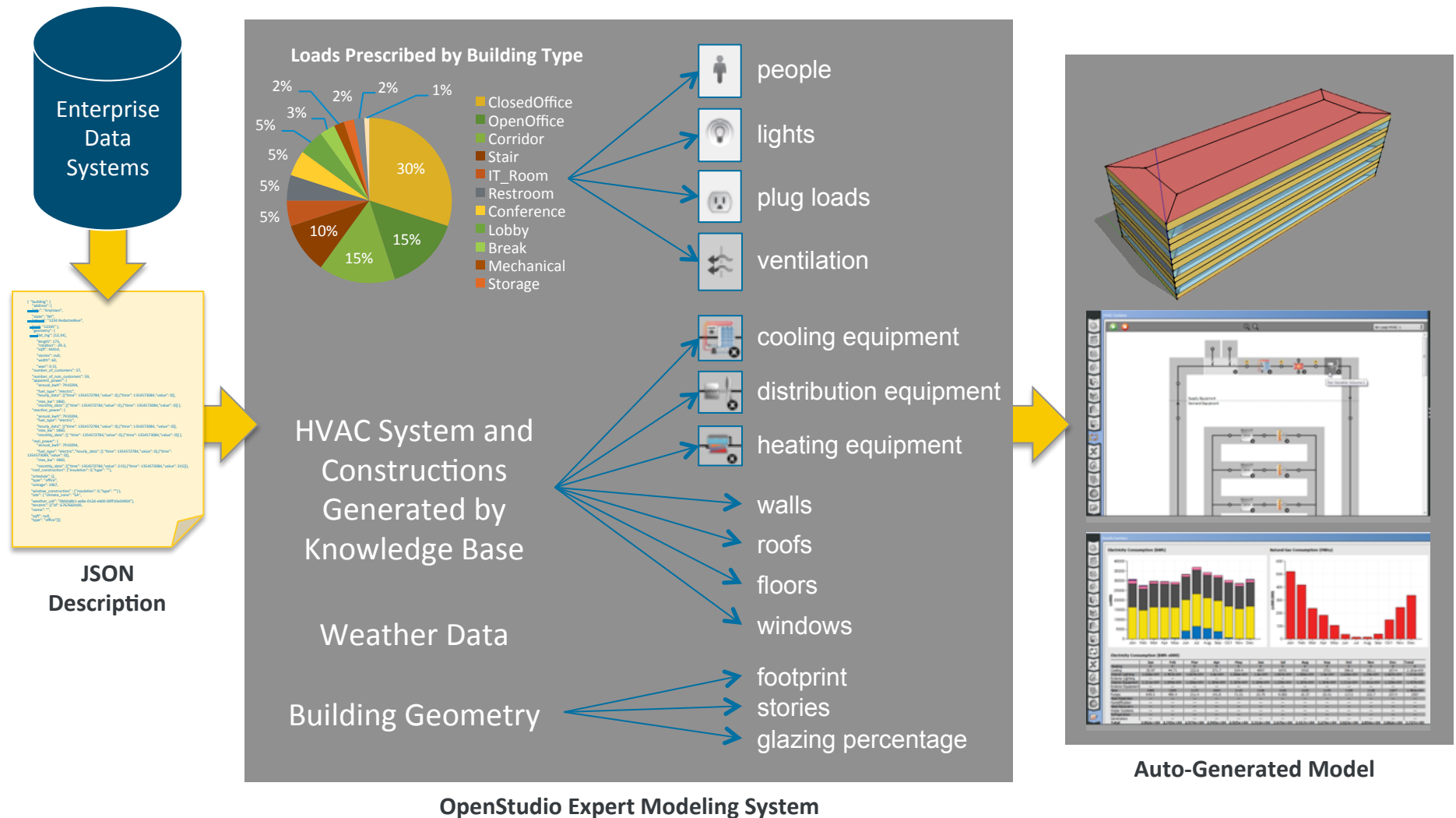
nationalgrid

What High Level Data Are Used to Create Baseline Models?

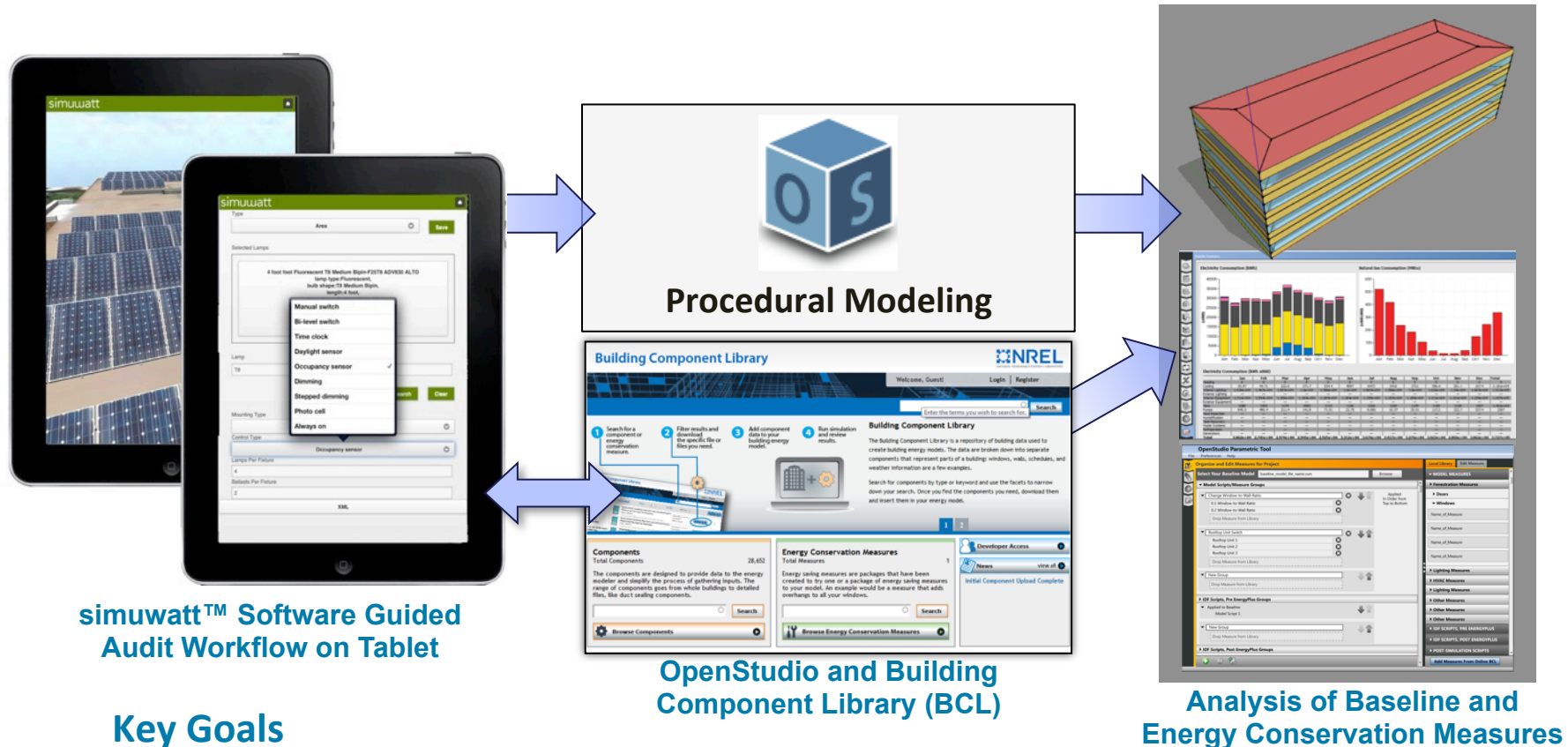


- **Address:** *PII*
- **Size:** 10,000 ft²
- **Number of Floors:** 3
- **Vintage:** 1982
- **Building Type:** Office
- **Web app assists with geometry extraction**

An Expert System to Create Baseline Models



An OpenStudio-Enabled Product for Auditing and PV System Design



Key Goals

- **Reduce cost** of investment-grade, level 3 audits below current cost of level 1 or 2
- Produce **higher quality, more consistent** audits with **greater residual value**
 - Not simply a report that prescribes actions and quantifies savings
 - Data and models aggregate and can be reused for further cost reduction in EISA 2007 compliance, portfolio assessment, etc.

<http://simuwatt.com/rd100.html>

simuwatt

simuwatt Software Guided Workflow

- Comprehensive workflow is modeled after NREL Deployment's proven methodology
- UI design guided with input from industry professionals



Geometry Capture



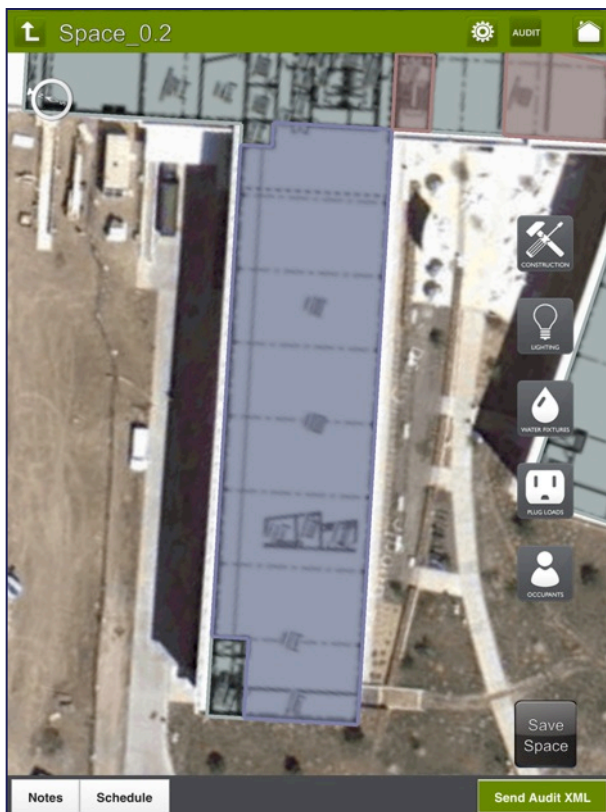
Level Navigation



simuwatt

simuwatt Software Guided Workflow

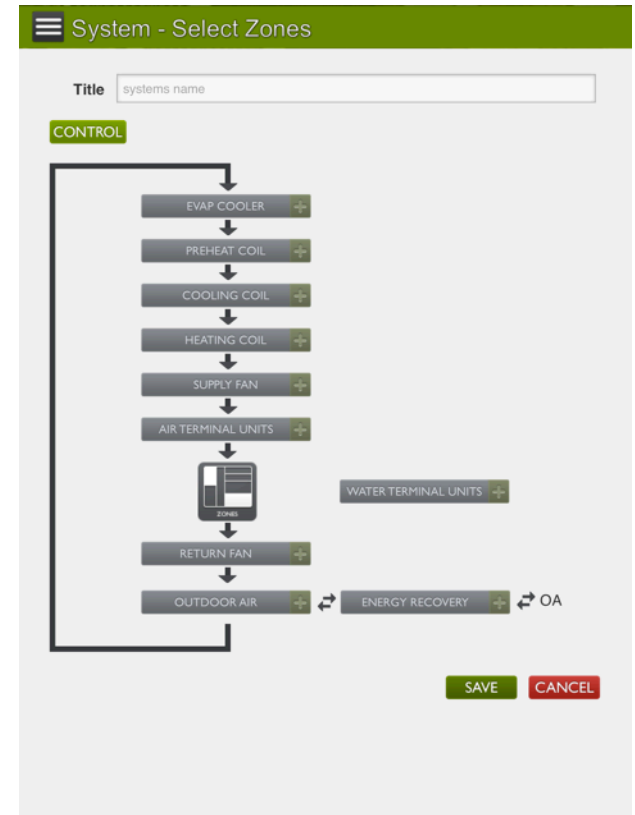
- Workflow includes space-by-space load assignment, scheduling, HVAC system specification, photo logging, note taking, and more
- Component definitions pulled from BCL



Load Allocation to Spaces

Holidays	
New Year's Day	Birthday of Martin Luther King Jr.
Washington's Birthday	Memorial Day
Independence Day	Labor Day
Columbus Day	Veterans Day
Thanksgiving Day	After Thanksgiving Day
Christmas Eve	Christmas Day

Schedule Specification



HVAC System Specification

simuwatt

simuwatt EE™: Using OpenStudio & BCL to Redefine Audits

Automatically
Generated
OpenStudio
Model
Geometry

Simulated
End Uses in
OpenStudio
Application

Component
Data Pulled
From BCL

Highly Efficient
Software Guided
Workflow

simuwatt