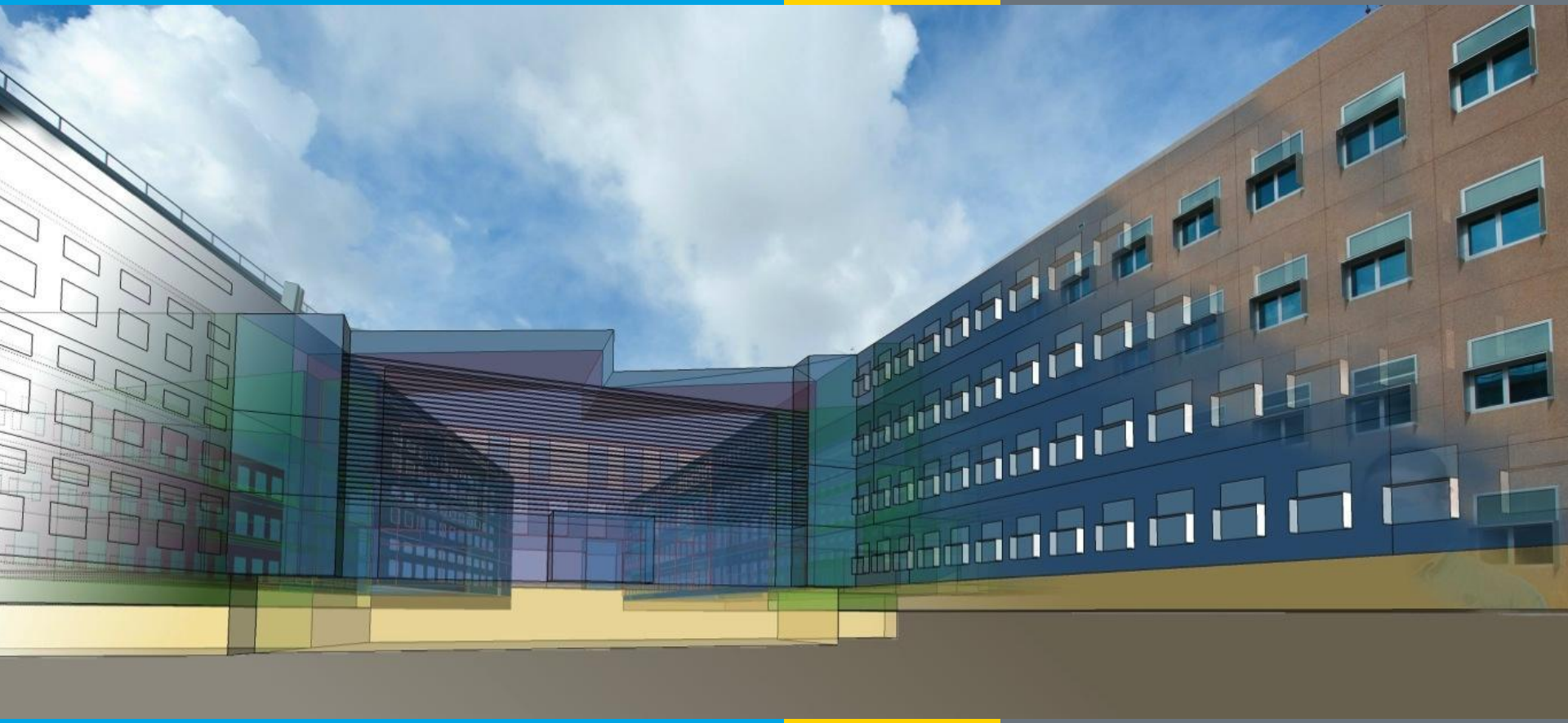
BTO Program Peer Review

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



OpenStudio

TDM – Amir Roth (OpenStudio/BCL Core)

TDM – Joan Glickman (Asset Score Tool)

Larry Brackney

National Renewable Energy Laboratory

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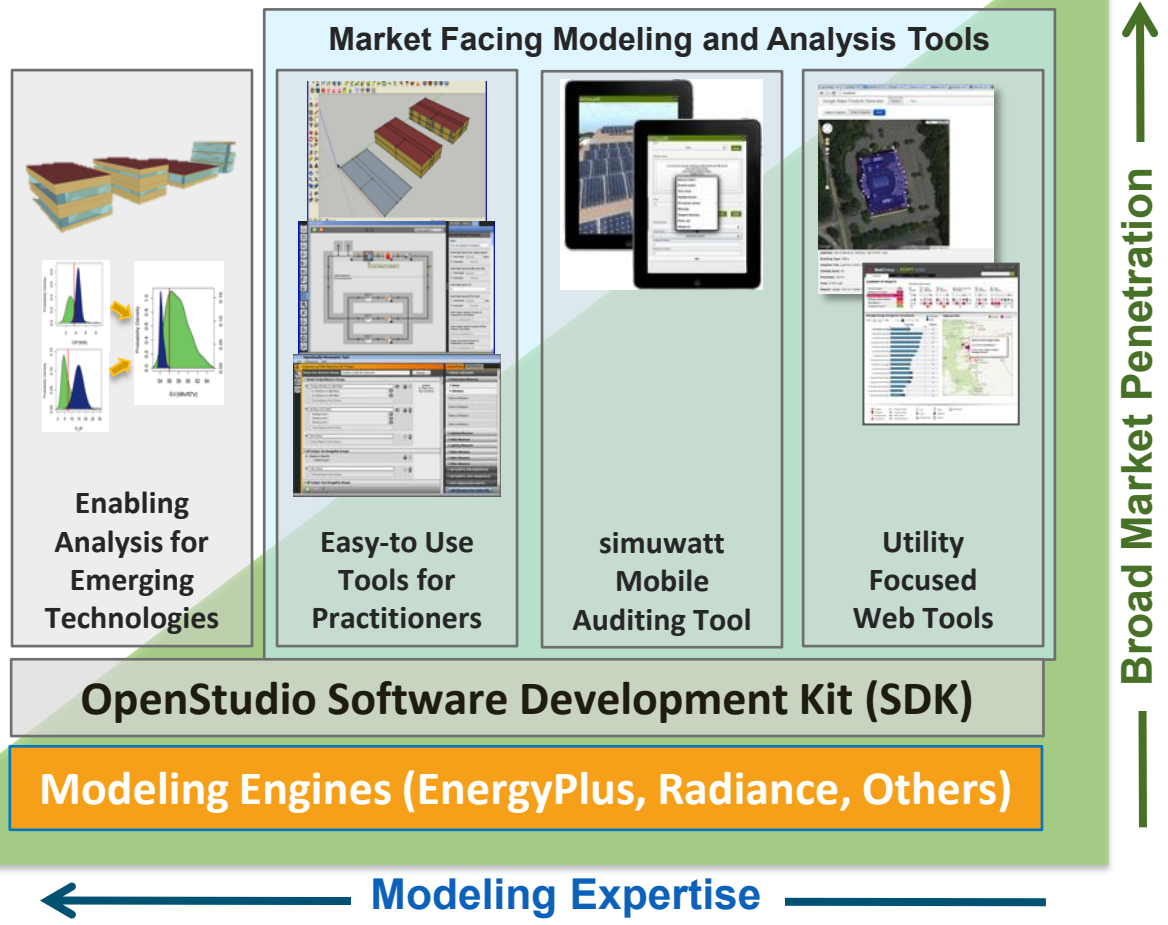
April 2nd 2013

Purpose & Objectives

Problem: Building energy analysis has historically been costly and produces uncertain results depending upon practitioner skill and available input data. New tools are expensive to produce and aren't well integrated.

Impacts: OpenStudio is DOE's platform for rapid, collaborative development of energy analysis applications. It is being used by the labs, EEB, the private sector, and others to create market facing tools.

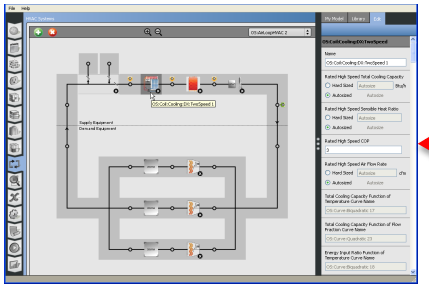
Project Focus: The project cross cuts ET and CBI to spur adoption of new and existing EE technologies by making tools available to a wide range of decision makers.



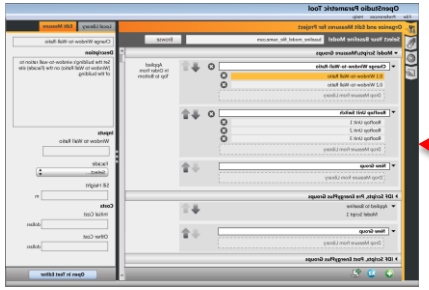
Software Technology

Approach:

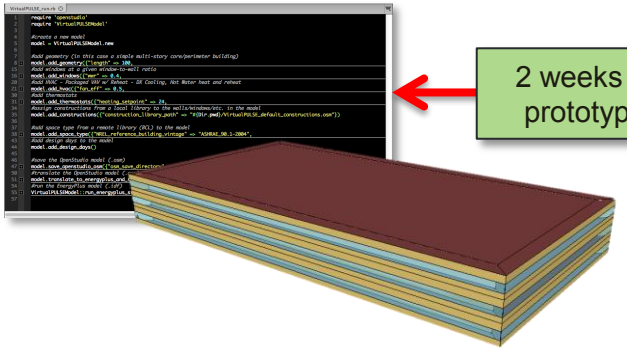
- **Rapid application development:**
  - Cross platform, multi-language support
  - Easy to write web apps for energy modeling
  - Maximum code reuse for low cost
  - Highly efficient, automated model construction
- **Open Source:**
  - Why reinvent the wheel?
  - Remove barriers for adoption
  - OpenStudio is creating a community
- **Interoperability:**
  - Multiple simulation engines
  - BIM (gbXML, IFC)
  - Title 24 compliance engine (SDD)
  - Sandia's DAKOTA Library for analysis



3 months to develop



2 months to develop



2 weeks to prototype

Key Issues:

- Full coverage of all EnergyPlus objects still in progress – a moving target
- Need modularized build process for lighter apps that don't require everything in OpenStudio
- Heavy adoption is putting additional pressure on team for user and developer support

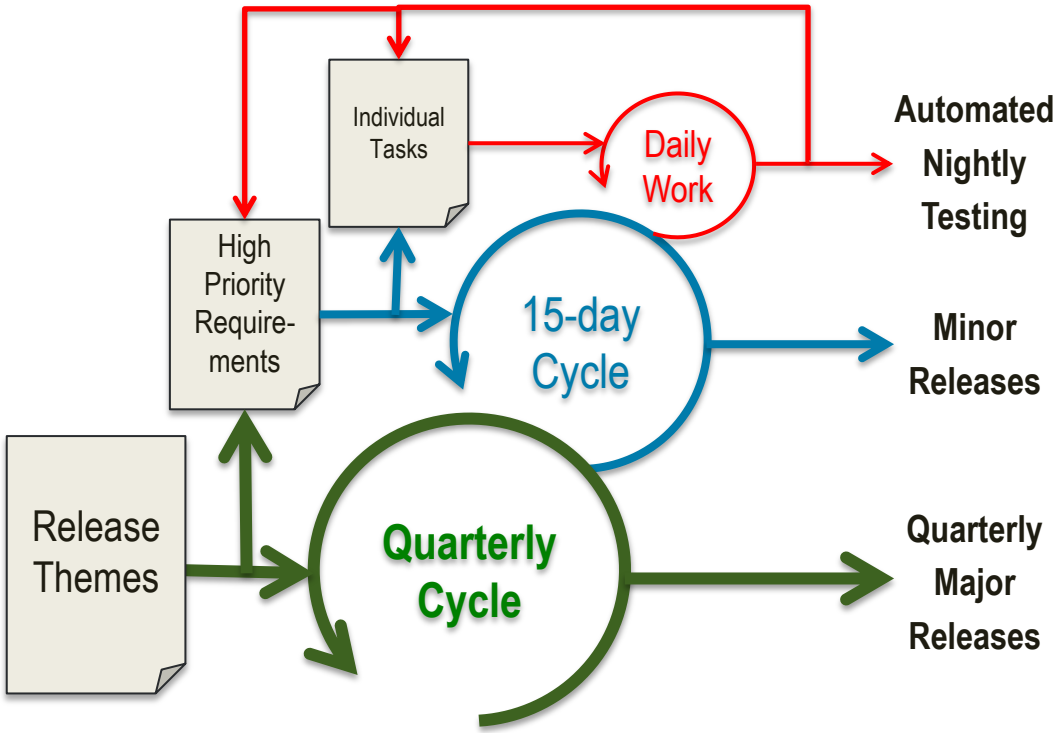
Software Development

Approach:

- **Development team uses an "agile" software development process**
  - Formal task and bug tracking systems
  - Automated nightly software build, test, and dashboarding system
  - Formal processes for design document and code reviews
- **Frequent vetting of UI concepts and workflows with external stakeholders**

Distinctive Characteristics:

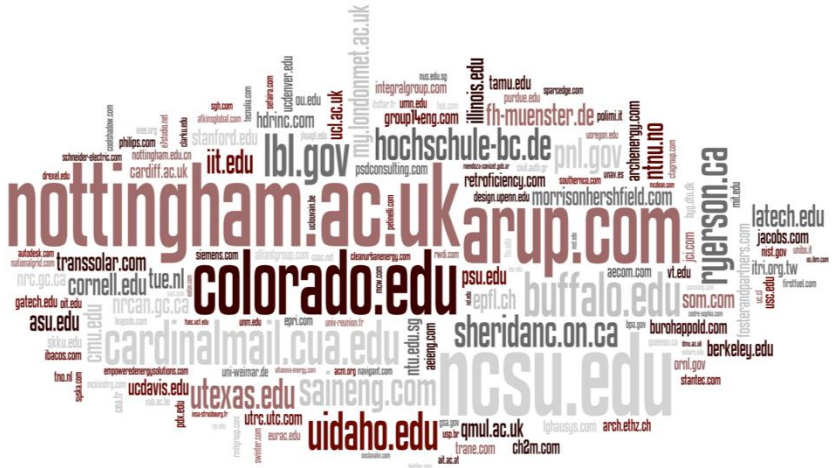
- Flexibility to **quickly** produce new desktop, mobile, and web tools that are easily **integrated** with one another
- **Agile process** allows focus to change as new requirements emerge
- Rigorous approach to creating software for the marketplace - **not a research project**
- **Open**, **collaborative** approach to software development that welcomes partners from other labs, institutions, and the private sector.



Accomplishments and Progress

Accomplishments:

- **Substantial adoption of OpenStudio**
  - Practitioners
  - Researchers
  - Software developers
  - Utilities



- **Significant new capability for:**
  - Rapid desktop, mobile or web application development
  - Efficient automated model generation (Short script ➔1000s of .idf lines)
  - Extensive tool, model, and data interoperability
  - Parametric analysis and extensible measures formalism

Progress on Goals:

- **Continued to meet aggressive quarterly release schedule**
- **On-track to meet key deliverables related to**
  - OpenStudio-based parametric analysis
  - User generated (crowd-sourced) content for Building Component Library (BCL)
  - Private sector stakeholders

OpenStudio Partners (Partial List)

CRADAs

Xcel Energy℠

nationalgrid

concept3D
Location. Web. 3D.

STATE OF CALIFORNIA ENERGY COMMISSION

TITLE 24 COMPLIANT

wrightsoft®

ARCHITECTURAL ENERGY CORPORATION

Group 14 ENGINEERING

SketchUp

Pacific Northwest NATIONAL LABORATORY

eebHUB Energy Efficient Buildings Hub

BERKELEY LAB

Natural Resources Canada | Ressources naturelles Canada

Canada

SPARC
IGNITE THE POSSIBILITIES

OAK RIDGE National Laboratory

Argonne NATIONAL LABORATORY

GARD Analytics
Energy, Economic and Environmental Research

The OpenStudio Tool Suite – An OpenStudio SDK Sample Application

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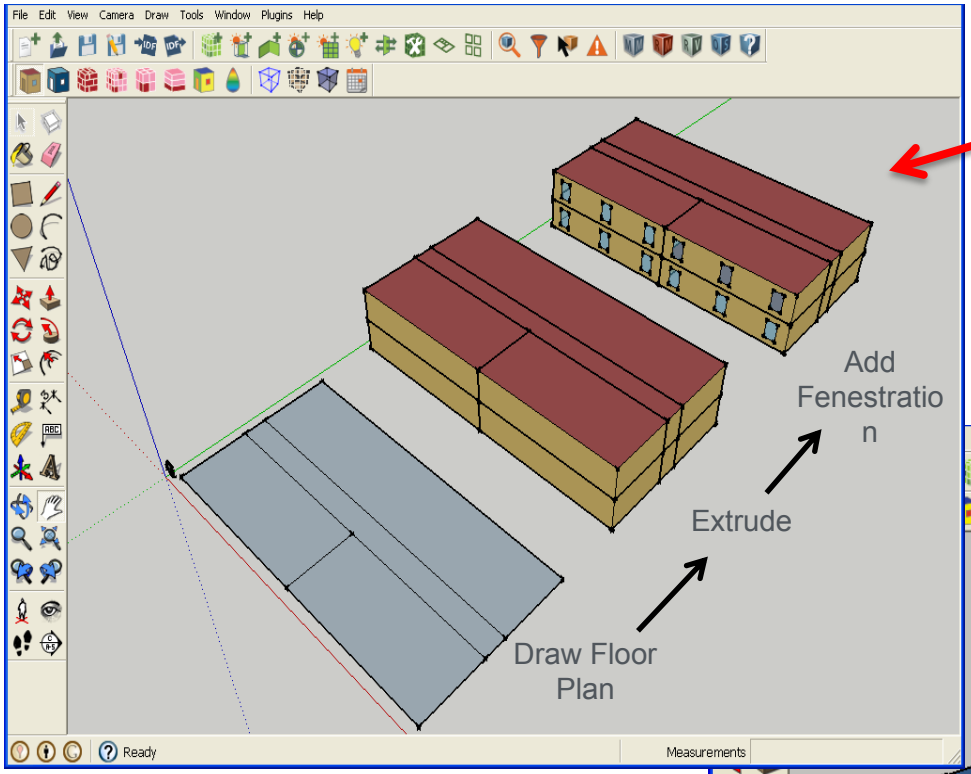
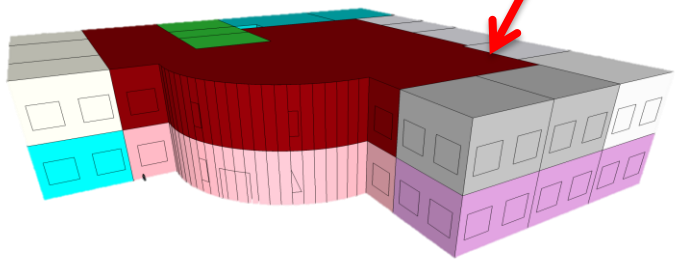
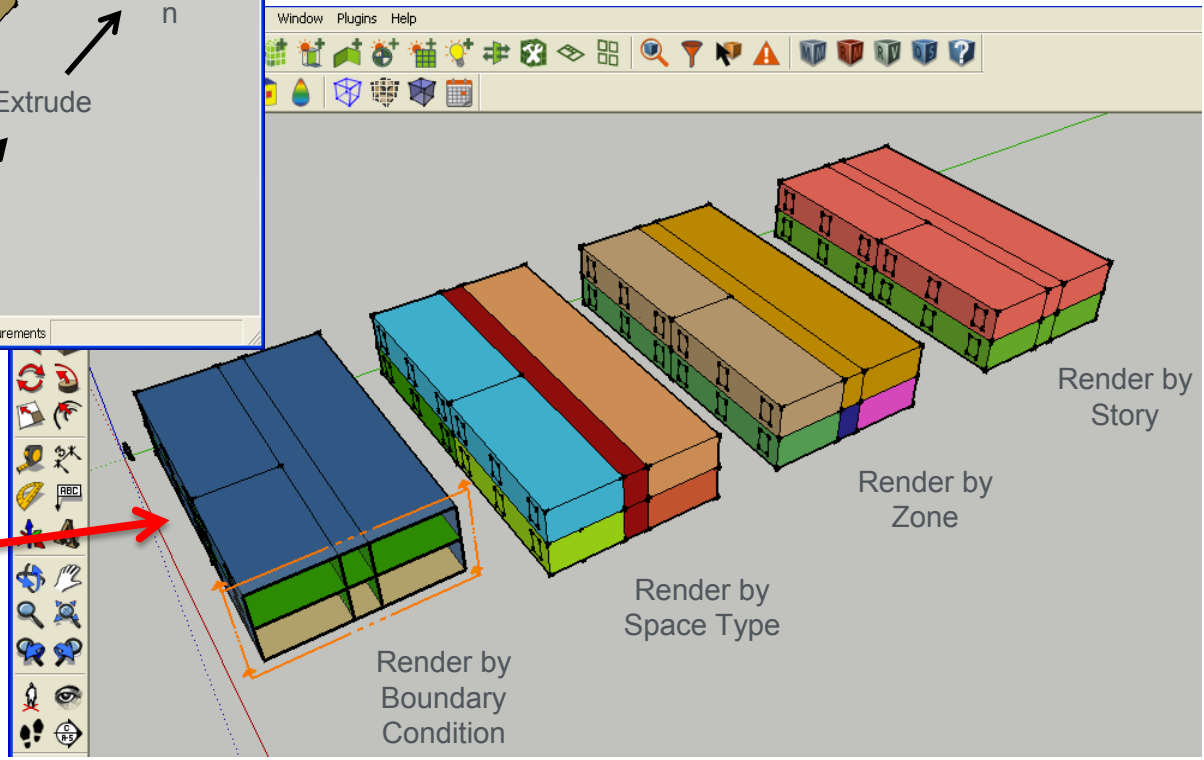


Draw envelope in minutes using SketchUp, or import from BIM





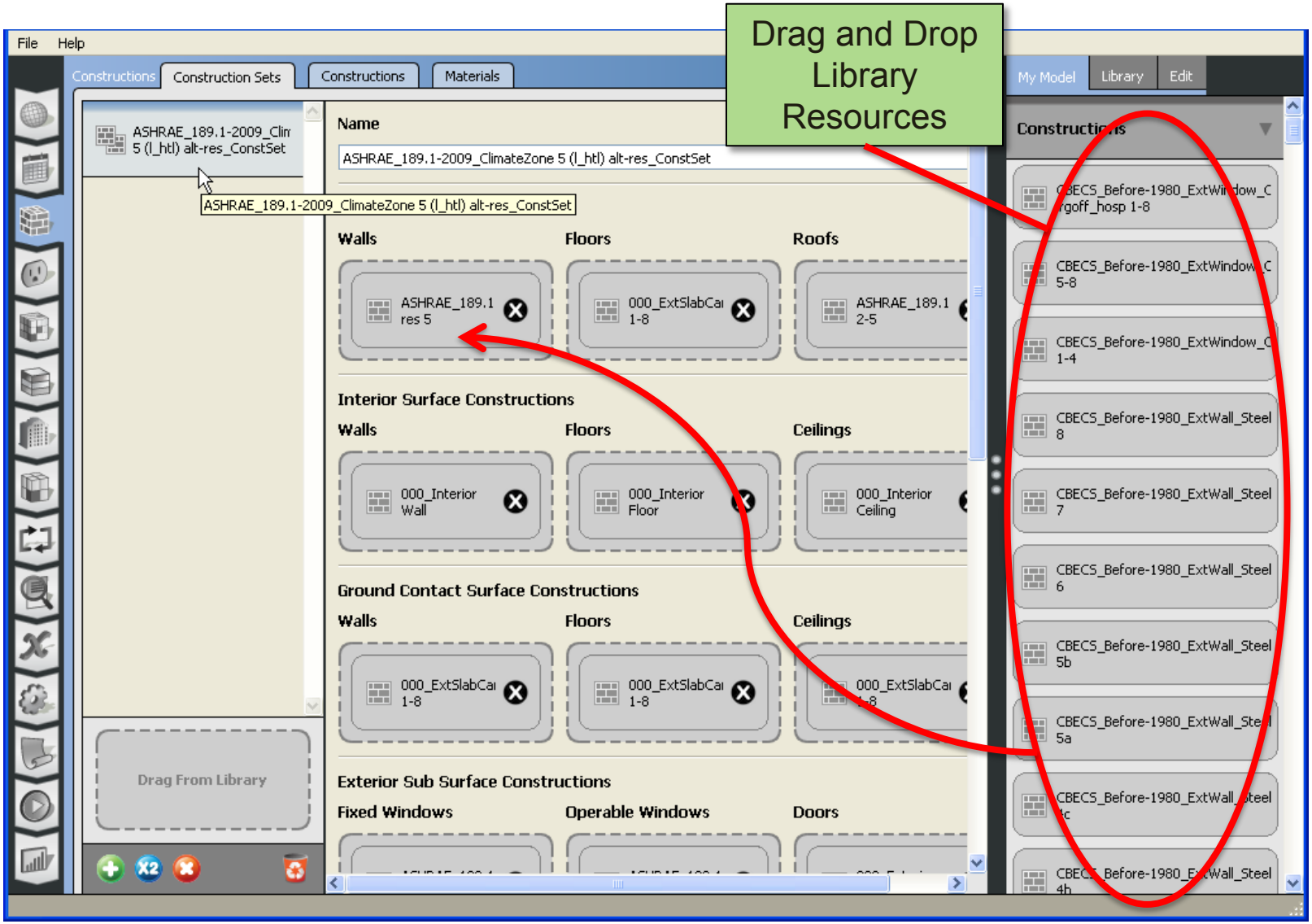
Quickly assign constructions, loads, and schedules via templates and specify zones

Simple Workflows and Modern Software Paradigms with the OpenStudio Suite

Define Resources

Workflow

Review Results



Selecting Templated HVAC Systems with the OpenStudio Suite

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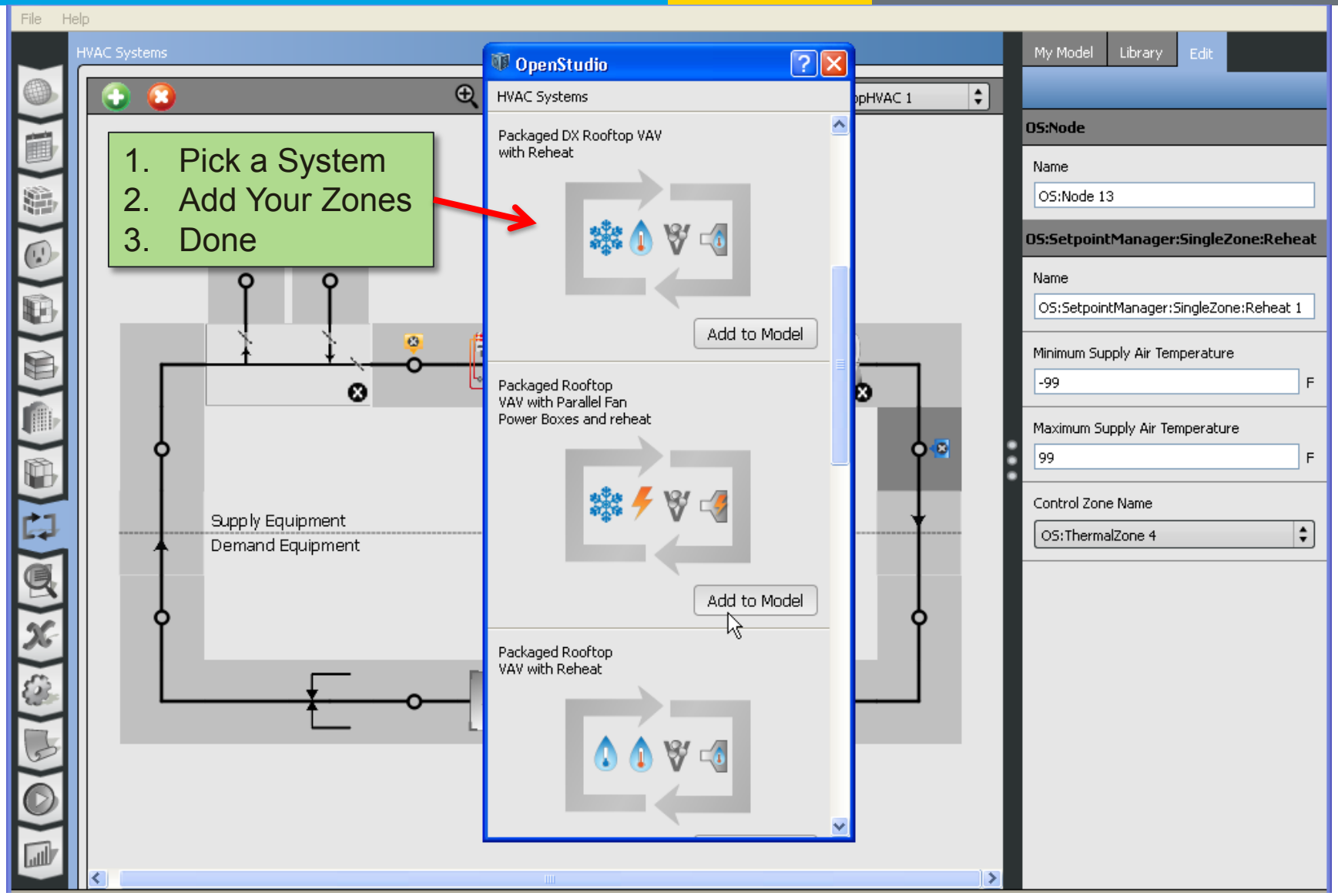

Drag and Drop HVAC Systems for Advanced Users

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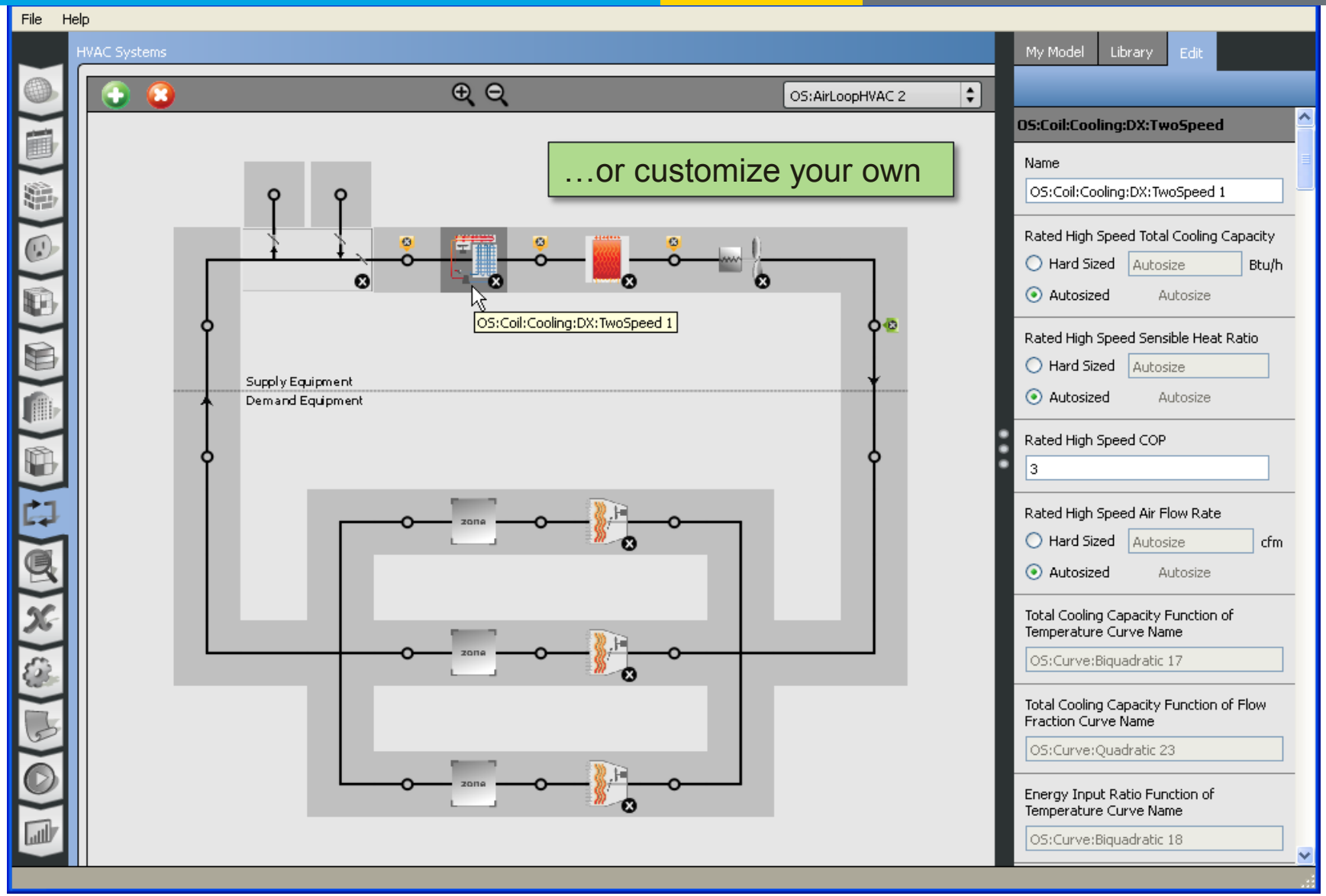
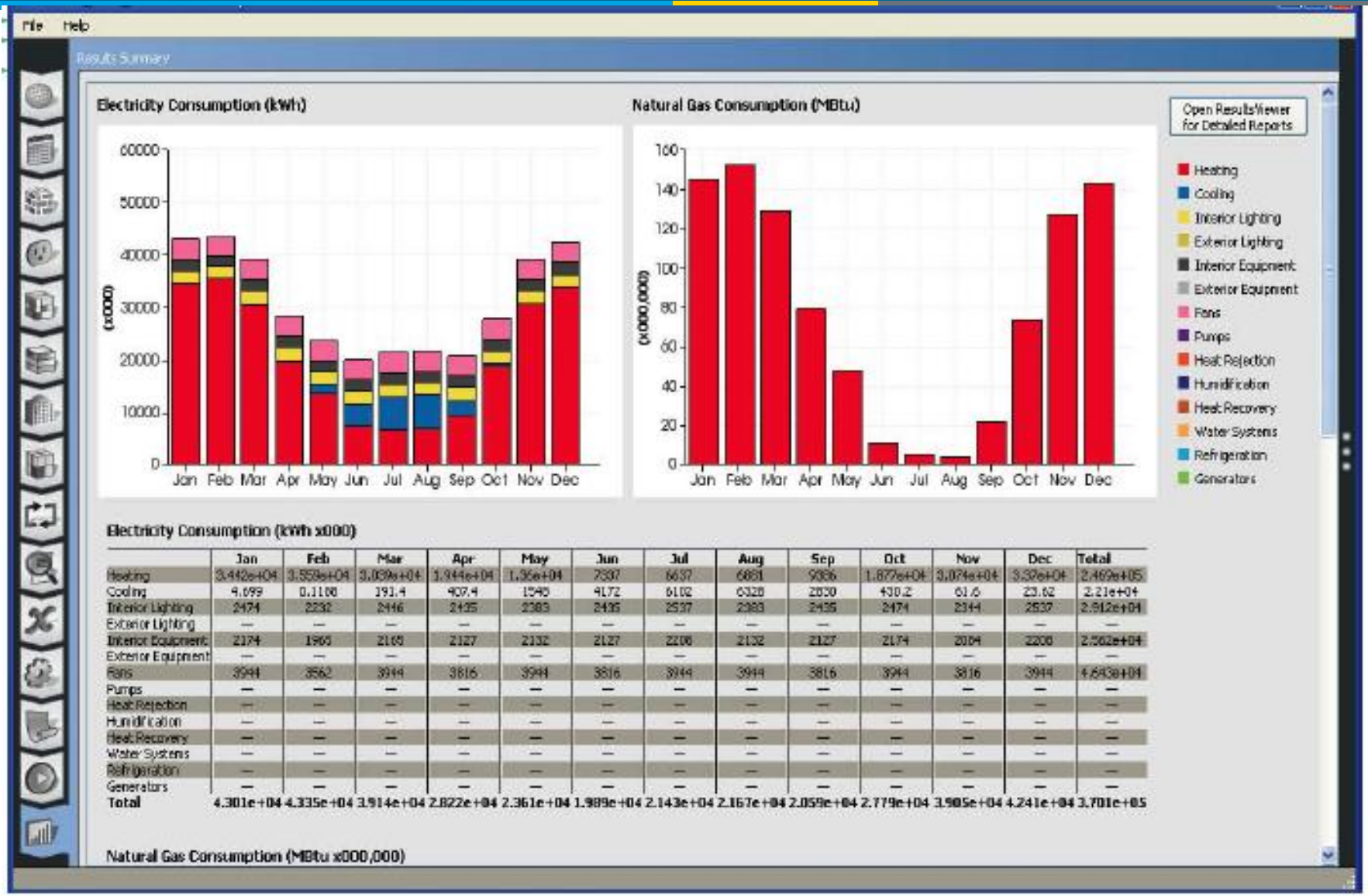


High Level Simulation Results Summaries with the OpenStudio Suite



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Heating	3.442e+04	3.559e+04	3.039e+04	1.944e+04	1.36e+04	7307	6637	6851	9386	1.877e+04	3.074e+04	3.32e+04	2.469e+05
Cooling	4.699	0.1108	191.4	407.4	1540	4172	6102	6328	2830	430.2	61.6	23.62	2.21e+04
Interior Lighting	2474	2232	2446	2435	2383	2435	2537	2383	2435	2474	2344	2537	2.912e+04
Exterior Lighting	—	—	—	—	—	—	—	—	—	—	—	—	—
Interior Equipment	2174	1965	2165	2127	2132	2127	2206	2132	2127	2174	2084	2206	2.562e+04
Exterior Equipment	—	—	—	—	—	—	—	—	—	—	—	—	—
Fans	3944	3562	3944	3816	3944	3816	3944	3944	3816	3944	3816	3944	4.643e+04
Pumps	—	—	—	—	—	—	—	—	—	—	—	—	—
Heat Rejection	—	—	—	—	—	—	—	—	—	—	—	—	—
Humidification	—	—	—	—	—	—	—	—	—	—	—	—	—
Heat Recovery	—	—	—	—	—	—	—	—	—	—	—	—	—
Water Systems	—	—	—	—	—	—	—	—	—	—	—	—	—
Refrigeration	—	—	—	—	—	—	—	—	—	—	—	—	—
Generators	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	4.301e+04	4.335e+04	3.914e+04	2.822e+04	2.361e+04	1.989e+04	2.143e+04	2.167e+04	2.059e+04	2.779e+04	3.985e+04	4.241e+04	3.701e+05

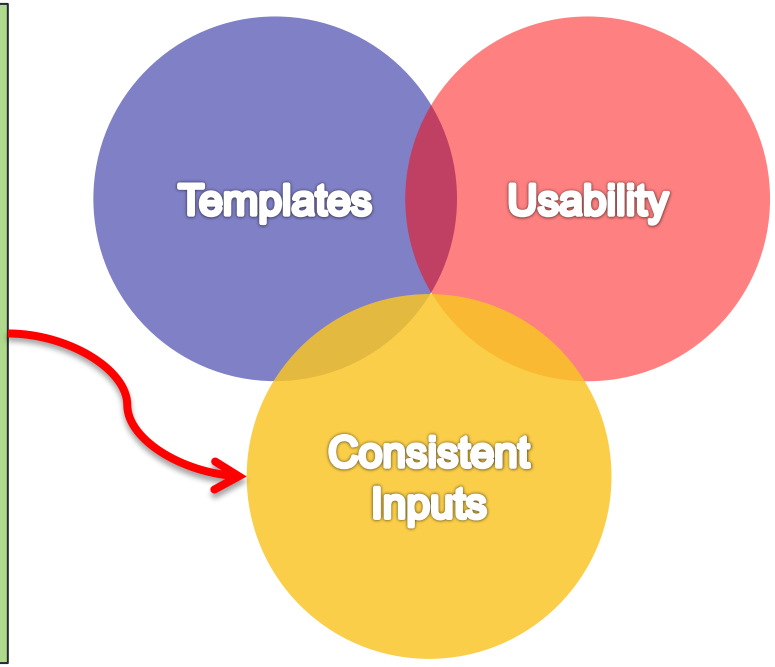
Credit: David Goldwasser / NREL

How Do We Improve Input Data Quality for OpenStudio-Based Tools?

- Input data remains a serious issue for modelers
- Garbage In = Garbage Out ➔ Quality In = Quality Out
- **Solution:** Standardize input data and seamlessly link to OpenStudio-based tools

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



Fast, Low-Cost, Reliable Energy Modeling Outcomes

The Building Component Library (BCL)

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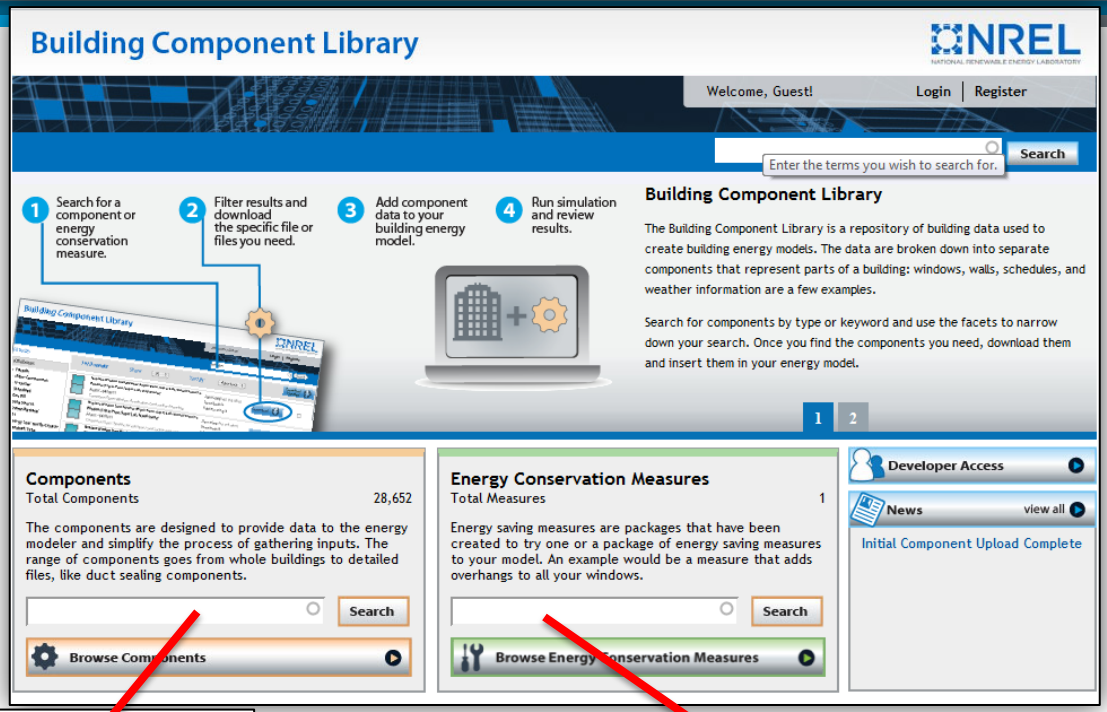
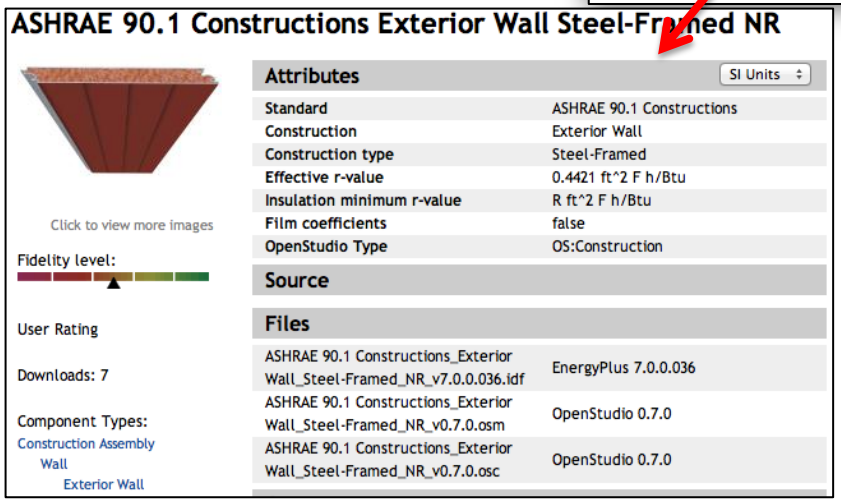
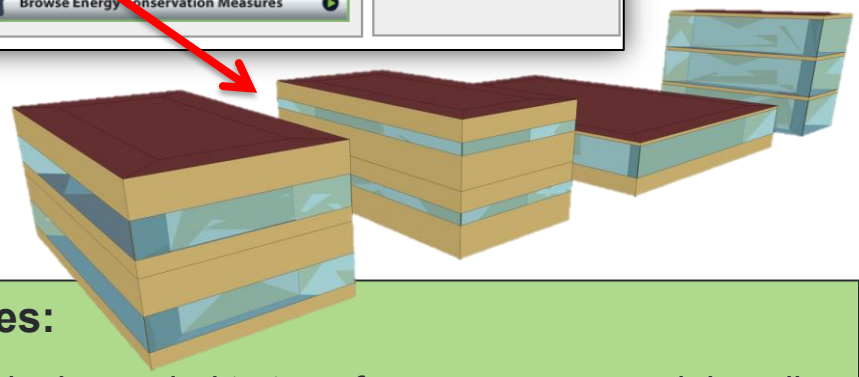
- **Components:**
  - Assembled to form complete energy models
  - Include constructions, lights, schedules, weather data, PV modules, and more
  - Supports faceted searching from web site or API

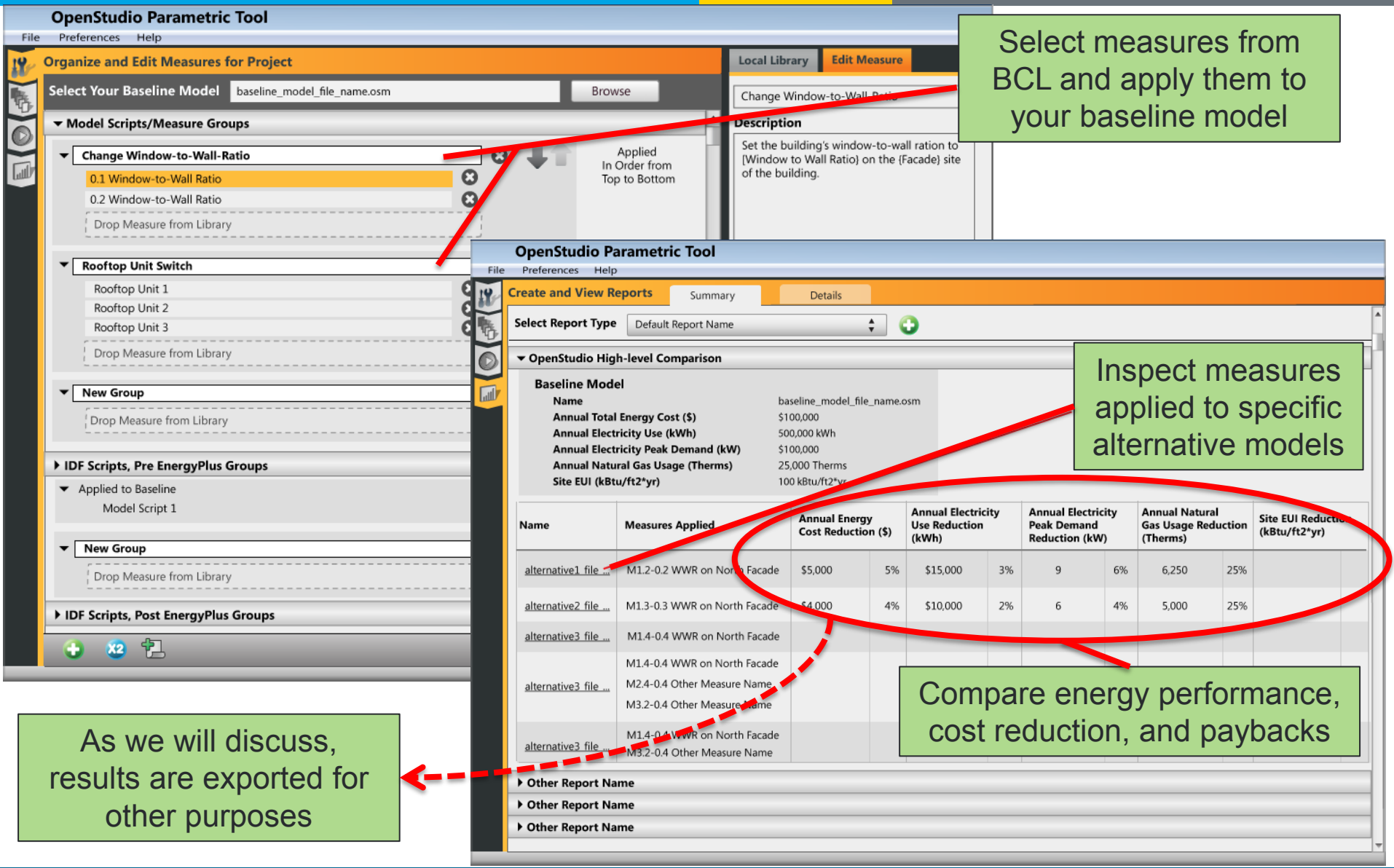






- **Measures:**
  - Contain logic needed to transform an energy model easily and consistently
  - Can be applied singly or as part of a parametric analysis

The New OpenStudio Parametric Analysis Tool



EEB and the DOE Asset Score Tool Use OpenStudio Scripted Models for Web Apps

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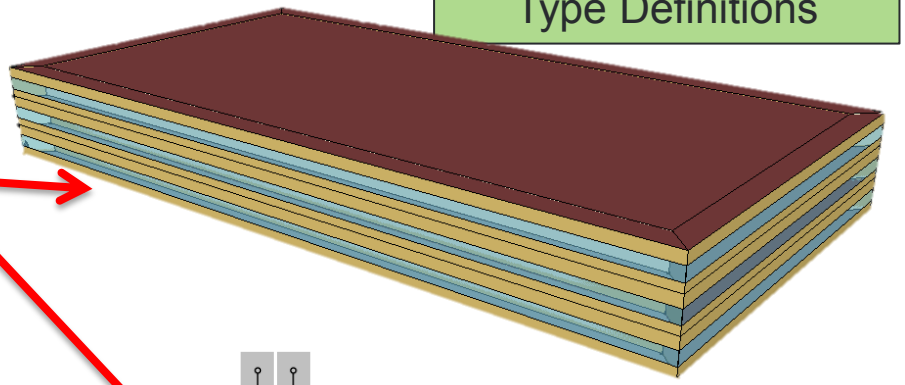
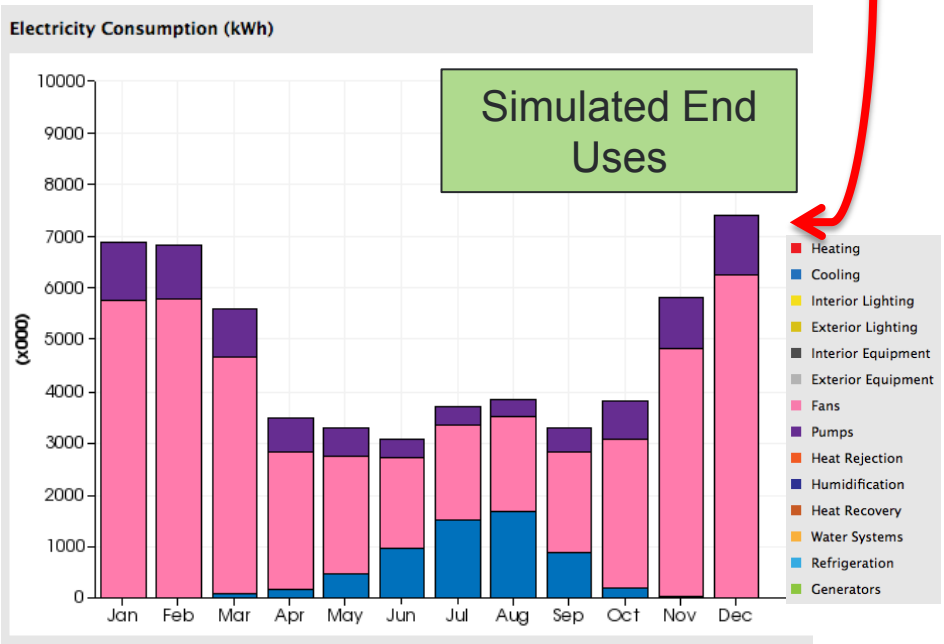
```ruby
require 'openstudio'
require 'VirtualPULSEModel'

#create a new model
model = VirtualPULSEModel.new

#add geometry (in this case a simple multi-story core/perimeter building)
model.add_geometry({"length" => 100,
#add windows at a given window-to-wall ratio
model.add_windows({"wwr" => 0.4,
#add HVAC - Packaged VAV w/ Reheat - DX Cooling, Hot Water heat and reheat
model.add_hvac({"fan_eff" => 0.5,
#add thermostats
model.add_thermostats({"heating_setpoint" => 24,
#assign constructions from a local library to the walls/windows/etc. in the model
model.add_constructions({"construction_library_path" => "#{Dir.pwd}/VirtualPULSE_default_constructions.osm"})

#add space type from a remote library to the model
model.add_space_type({"NREL_reference_building_vintage" => "ASHRAE_90.1-2004",
#add design days to the model (Chicago)
model.add_design_days()

#save the OpenStudio model (.osm)
model.save_openstudio_osm({"osm_save_directory" => Dir.pwd,
#translate the OpenStudio model (.osm) to an EnergyPlus model (.idf)
model.translate_to_energyplus_and_save_idf({"idf_save_directory" => Dir.pwd,
#run the EnergyPlus model (.idf)
VirtualPULSEModel::run_energyplus_simulation({"idf_directory" => Dir.pwd,
```

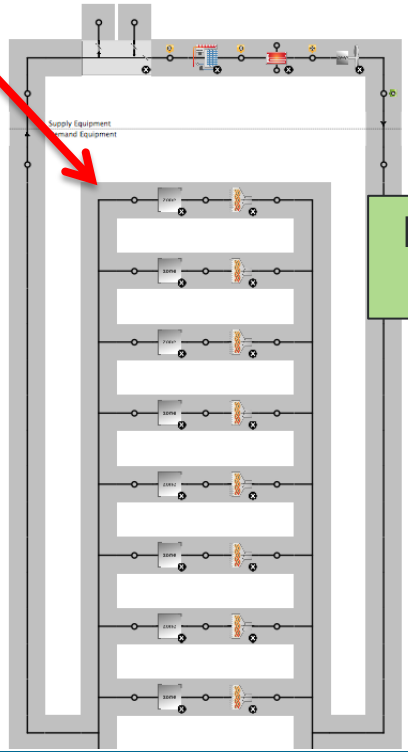
13 Lines of Ruby Code + Comments

Geometry and Space Type Definitions





Simulated End Uses

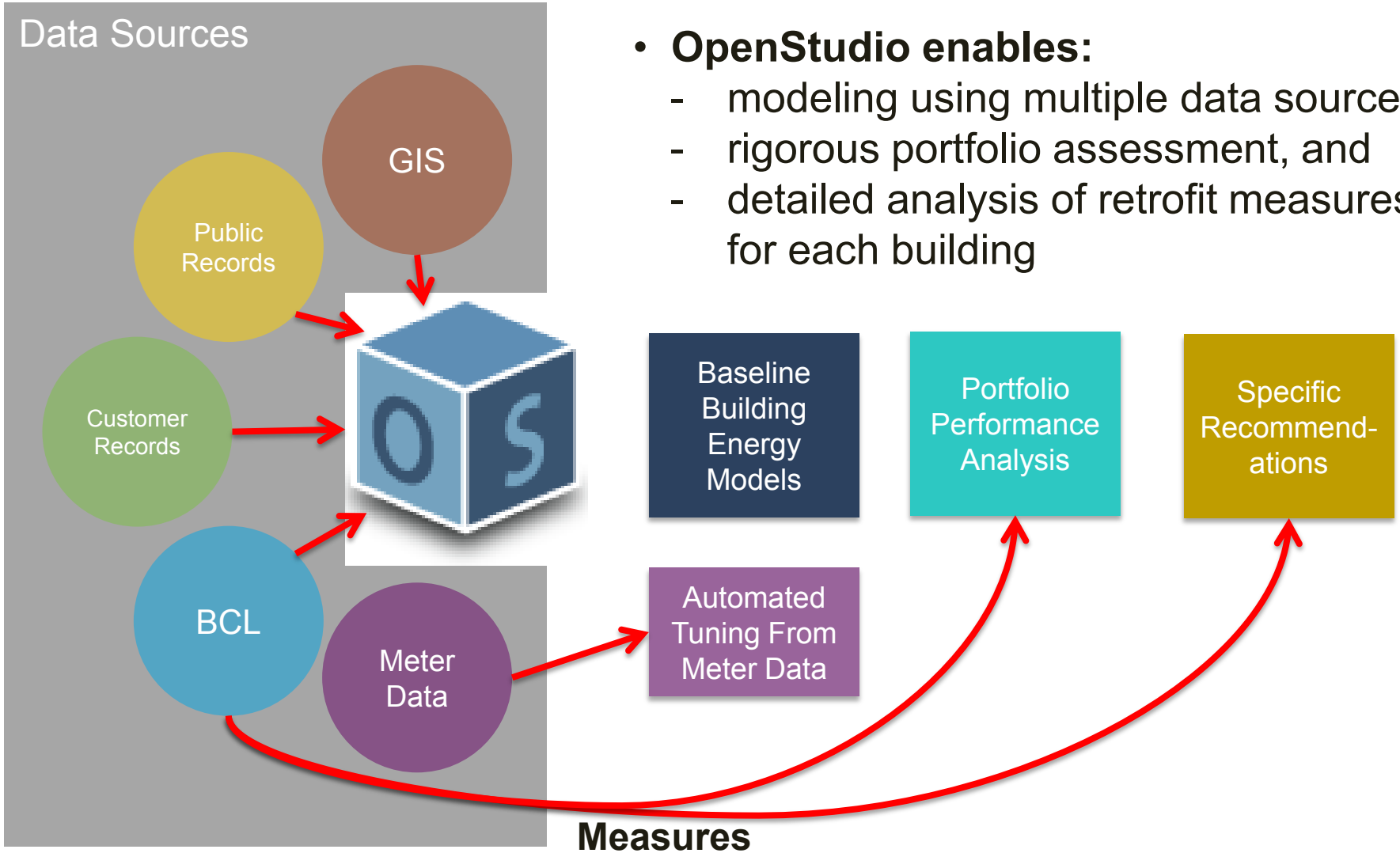


Detailed HVAC and Zoning

Pacific Northwest NATIONAL LABORATORY

eebHUB Energy Efficient Buildings Hub

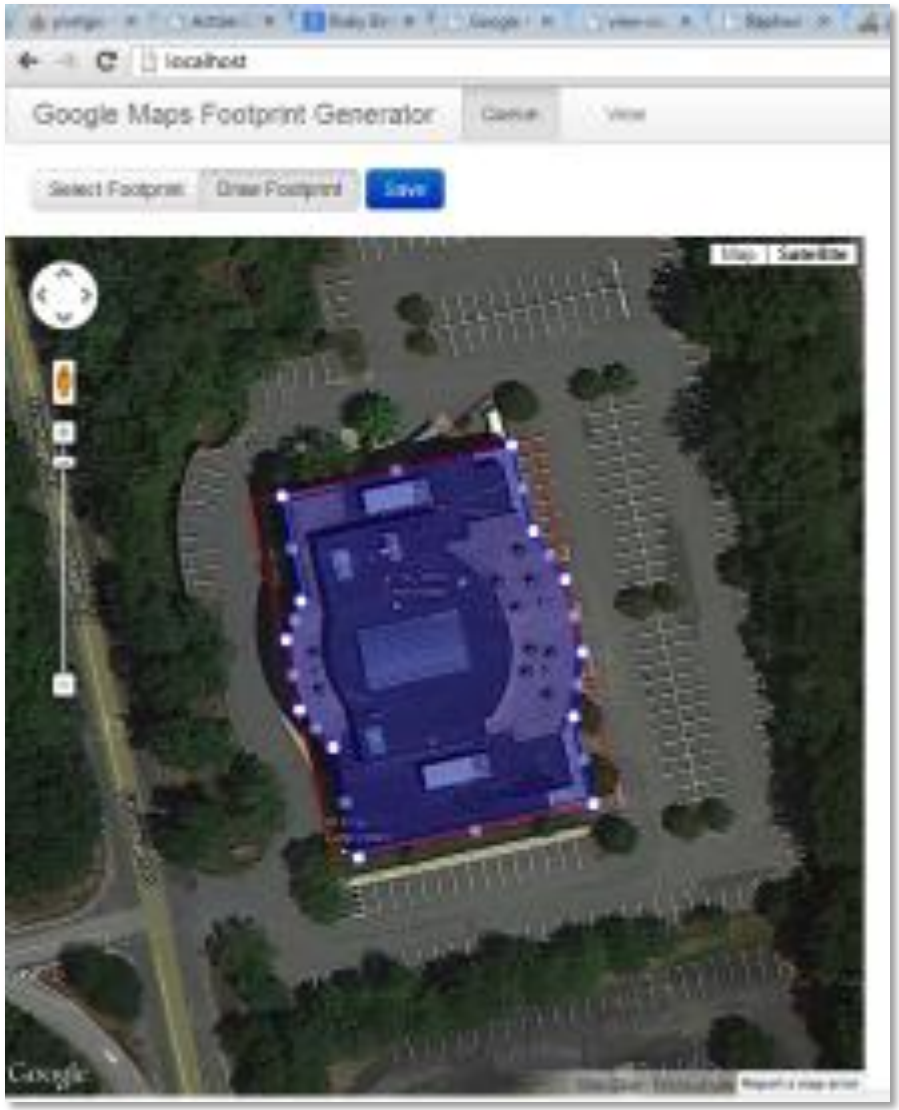
National Grid is Using OpenStudio to Automate Modeling from Mined Data



- **OpenStudio enables:**
  - modeling using multiple data sources,
  - rigorous portfolio assessment, and
  - detailed analysis of retrofit measures for each building

nationalgrid

What High Level Data Are Used to Create NGrid's Baseline Models?



- **Address:** *PII*
- **Size:** 10,000 ft^2
- **Number of Floors:** 3
- **Vintage:** 1982
- **Building Type:** Office
- **Web app assists with geometry extraction**

nationalgrid

An OpenStudio-Enabled Expert System to Create Baseline Models for NGrid

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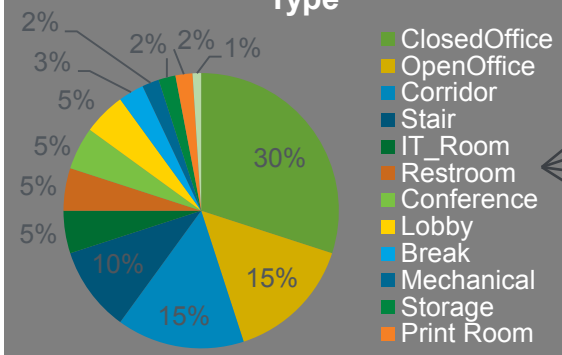
Loads Prescribed by Building Type



HVAC System and Constructions Generated by Knowledge Base

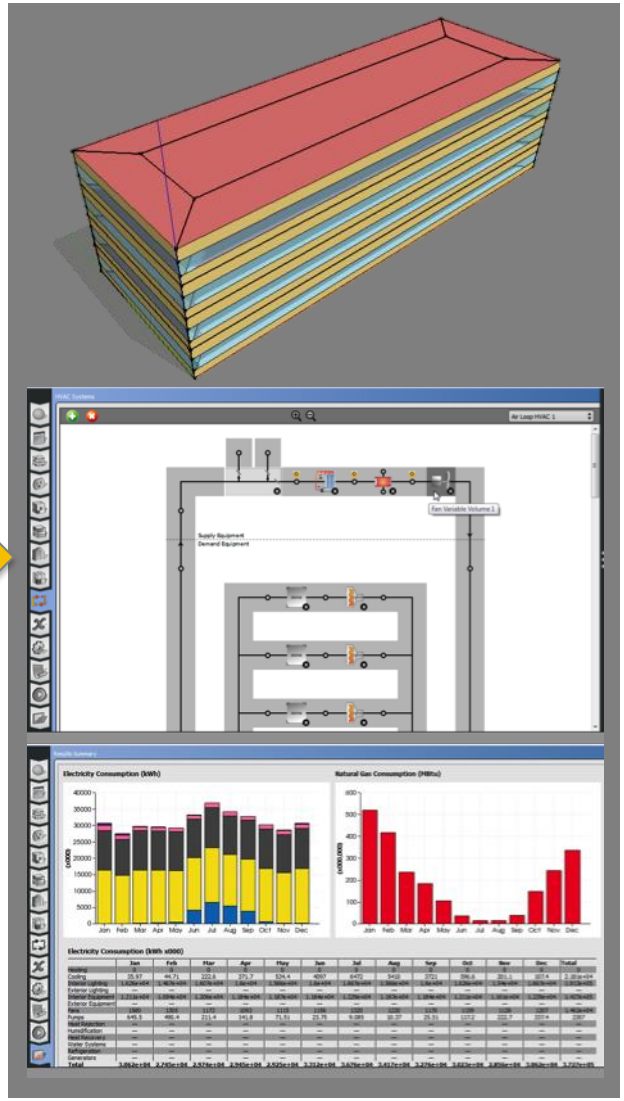
- people
- lights
- plug loads
- ventilation
- cooling equipment
- distribution equipment
- heating equipment
- walls
- roofs
- floors
- windows

Building Geometry

- footprint
- stories
- glazing percentage

Weather Data

OpenStudio Measures Generate Model



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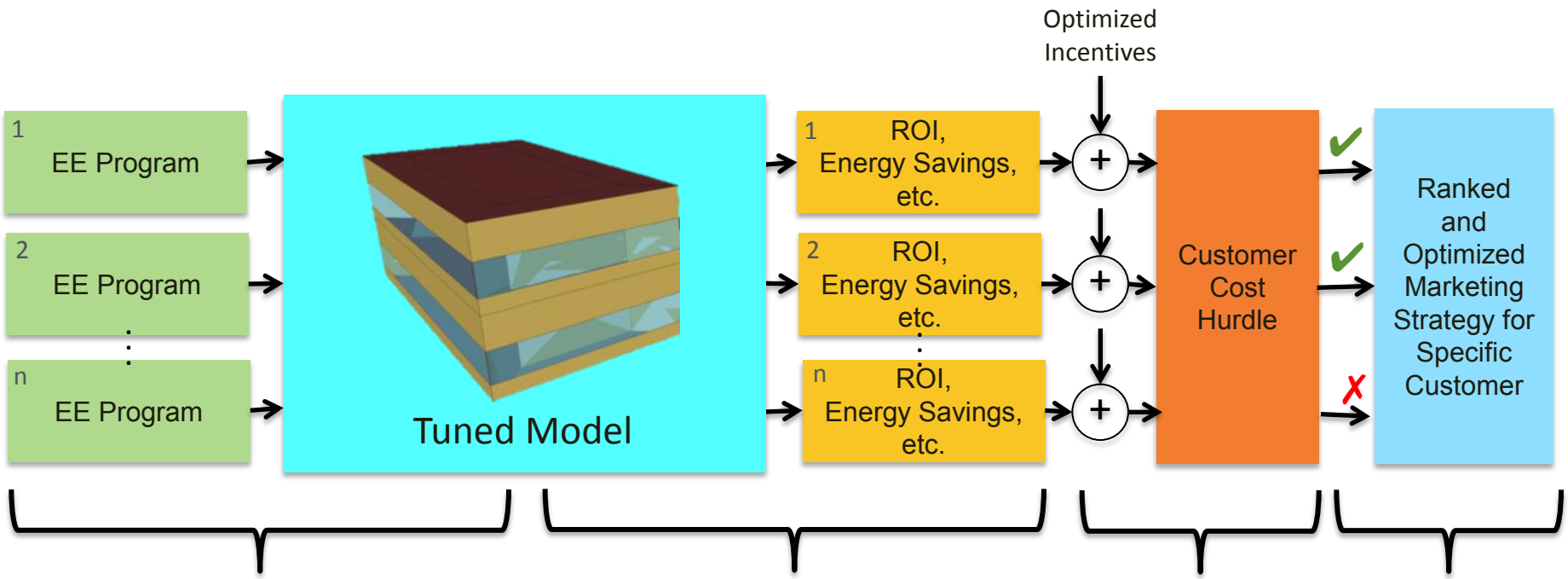
NGrid's Approach to Incentive Program Design – The Long Term Goal



Program measures are applied to tuned model of a customer building

Energy savings, simple payback, and more are calculated from an energy simulation

Calculate incentive required to overcome individual customer hurdle rate

Ranked, customer-specific marketing strategy

Repeat Across Portfolio

nationalgrid

Xcel Energy's Energy Design Assistance Program Tracker (EDAPT)

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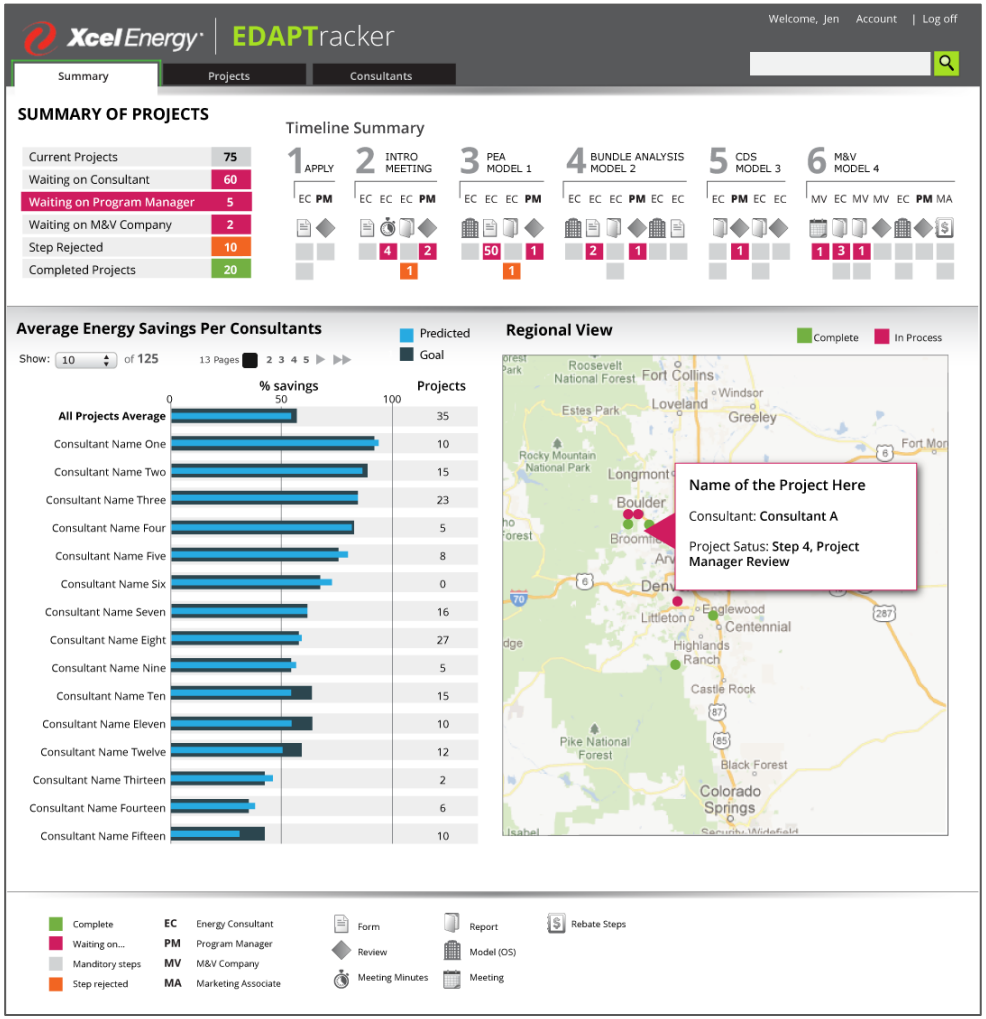
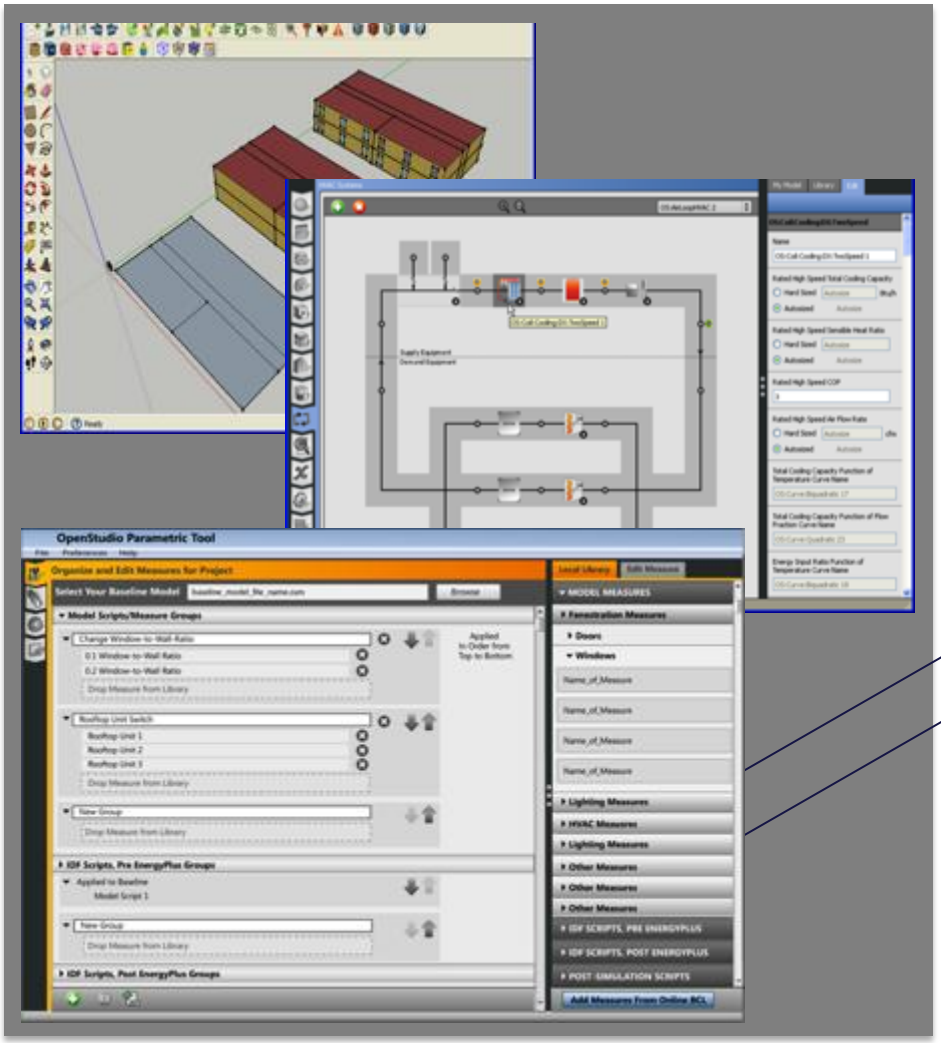
- **Problem:** Reduce cost of Xcel's EDA program, while maintaining quality as additional energy consultants are engaged
- **Solution:**
  - EDAPT web service tracks projects, manages data and communications, and reports program-wide outcomes
  - OpenStudio and BCL are expanded to include automated quality and EDA protocol checking
  - EDAPT connects high level project data with model outcomes to streamline reporting
- **Launching in June 2013**

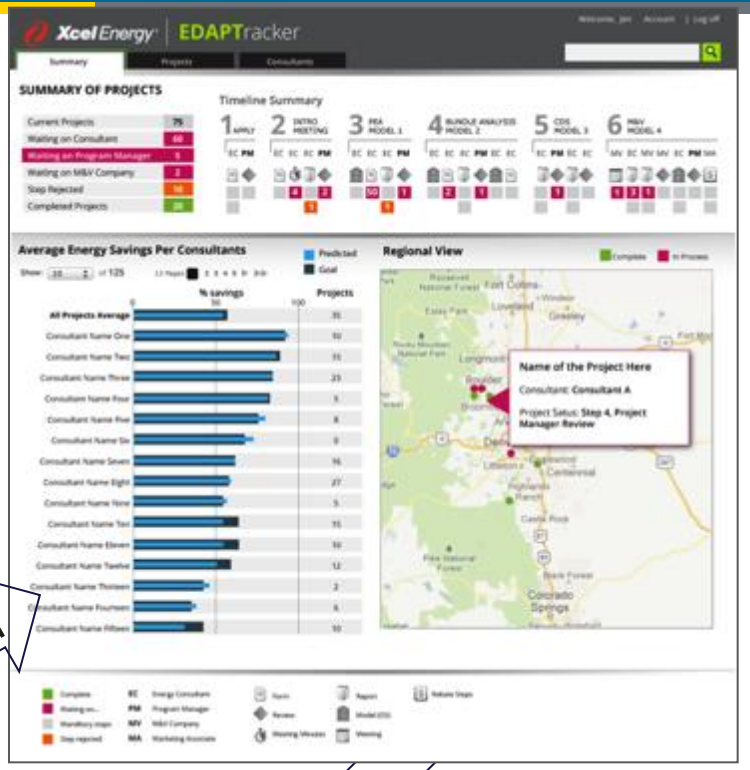


OpenStudio-EDAPT Integration



OpenStudio baseline and design alternate models along with simulation results

.xml



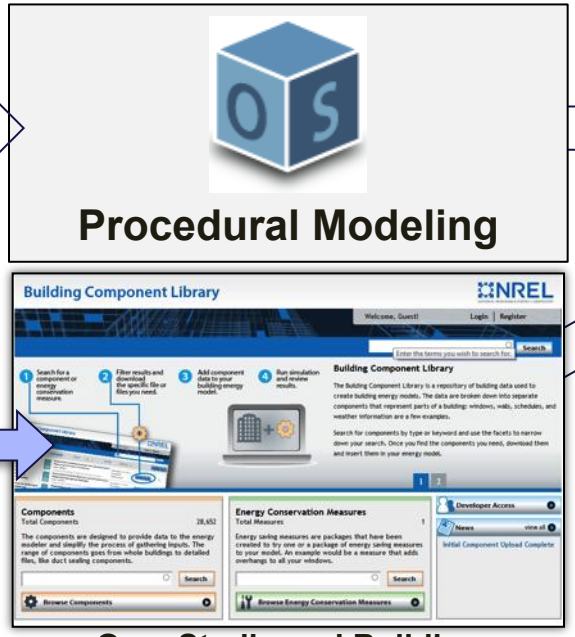
.doc

EDAPT web portal automatically generates report templates from project data and OpenStudio output

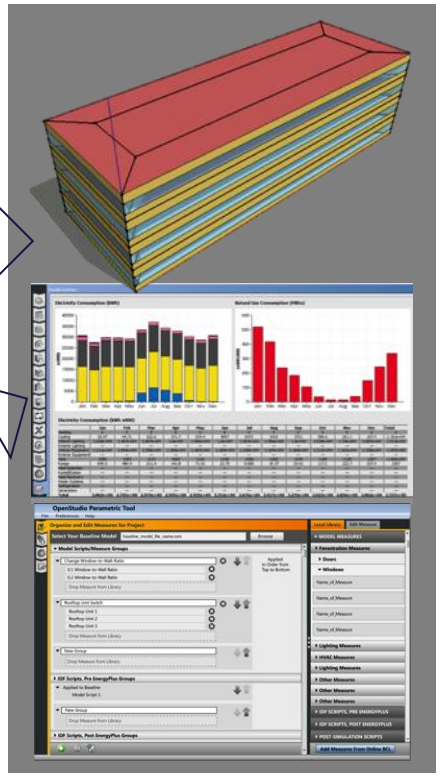
Xcel Energy

An OpenStudio-Enabled Product for Auditing and PV System Design

simuwatt™ Software Guided Audit Workflow on Tablet



OpenStudio and Building Component Library (BCL)



Analysis of Baseline and Energy Conservation Measures

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

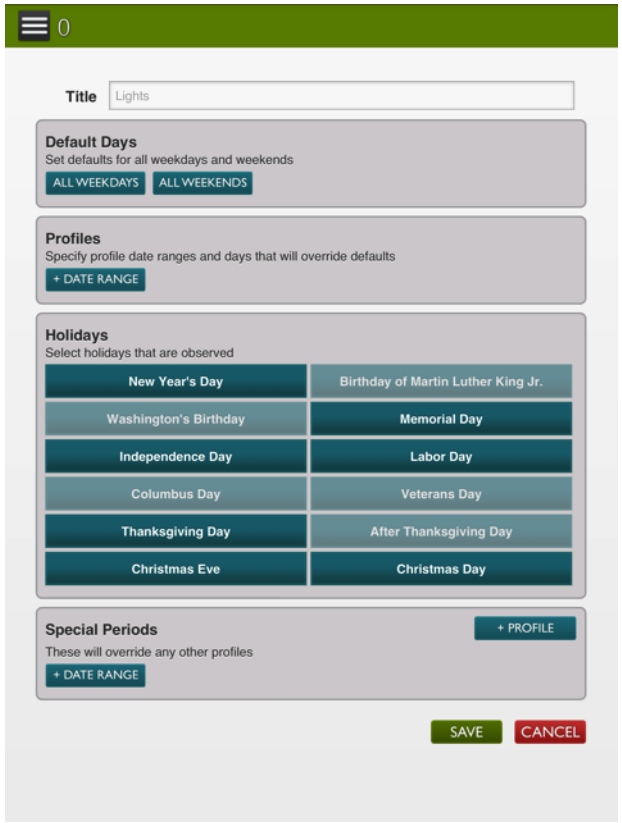
Level Navigation

simuwatt

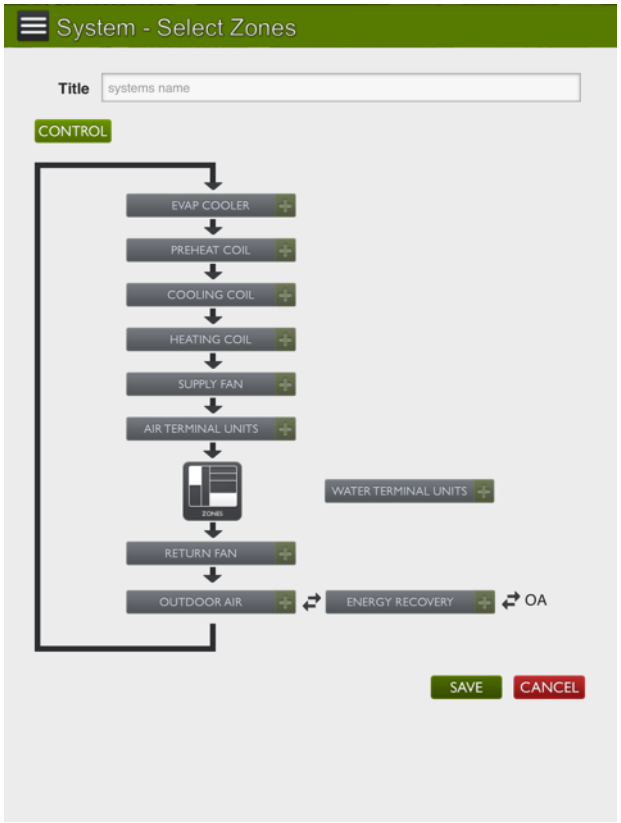
simuwatt Software Guided Workflow

- 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



Schedule Specification



HVAC System Specification

simuwatt

Data Seamlessly Converted to Baseline

Automatically Generated OpenStudio Model Geometry

Simulated End Uses in OpenStudio Application

simuwatt

Project Plan & Schedule

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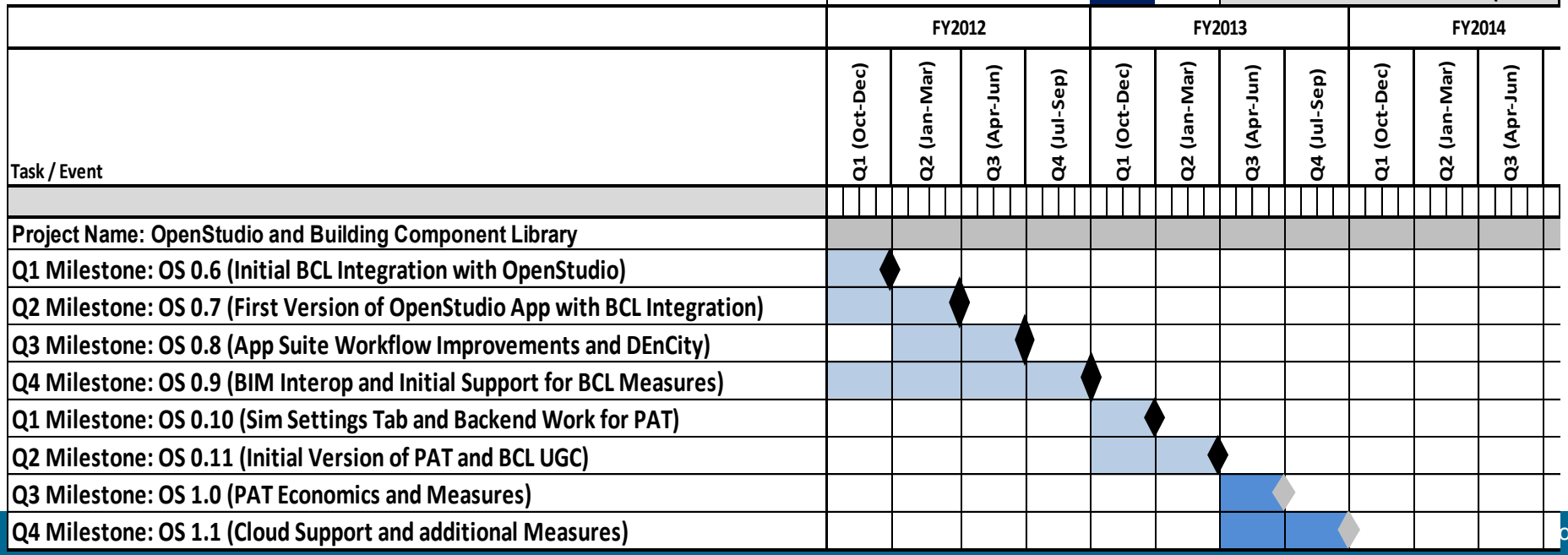
Project Initiation Date: Q1/FY10

Planned Completion Date: Ongoing with Frequent Off-Ramping of Components (e.g. BCL transitioned to private sector by Q4/FY13)

Release Schedule: Bi-weekly (Agile) Minor Releases
Quarterly Major Releases with DOE-Prescribed Focus Areas

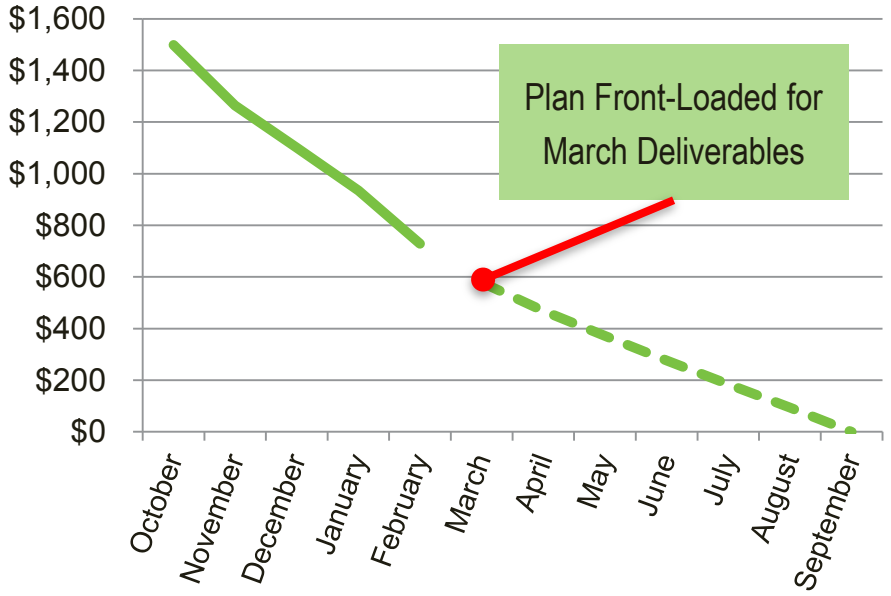
Summary	
Agreement Number	19987
Project Number	NREL-FY13-14 & NREL-

Legend: Work completed; Active Task; Milestones & Deliverables (Origin; Milestones & Deliverables (Actua

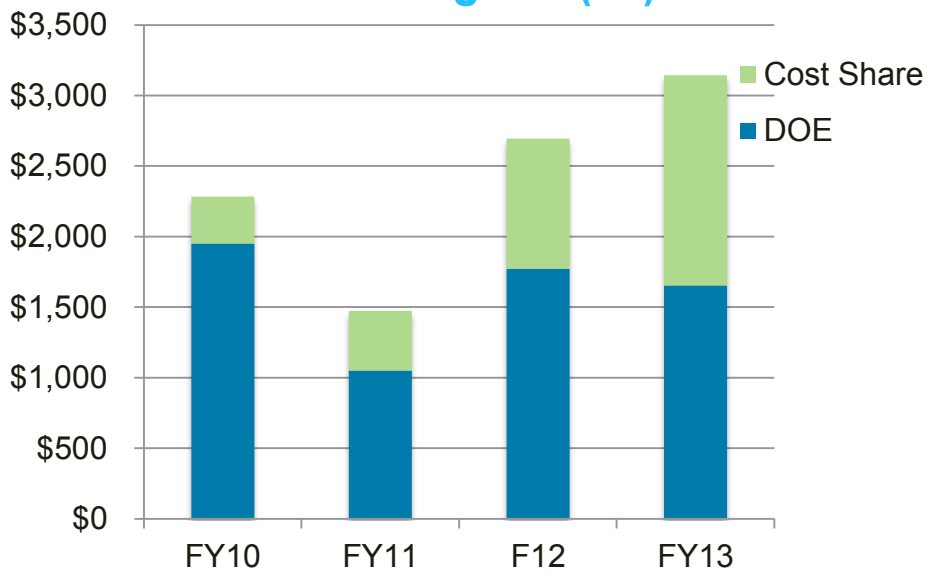


Project Budget

FY13 Spend* ($k)



FY10-13 Budgets* ($k)



Additional Funding Sources:

BONNEVILLE POWER ADMINISTRATION

Xcel Energy

ESTCP

nationalgrid

STATE OF CALIFORNIA ENERGY COMMISSION

*** FY13 Spend and Budget Includes both OpenStudio/BCL and Asset Score CBI Budgets**

Project Integration, Collaboration & Market Impact

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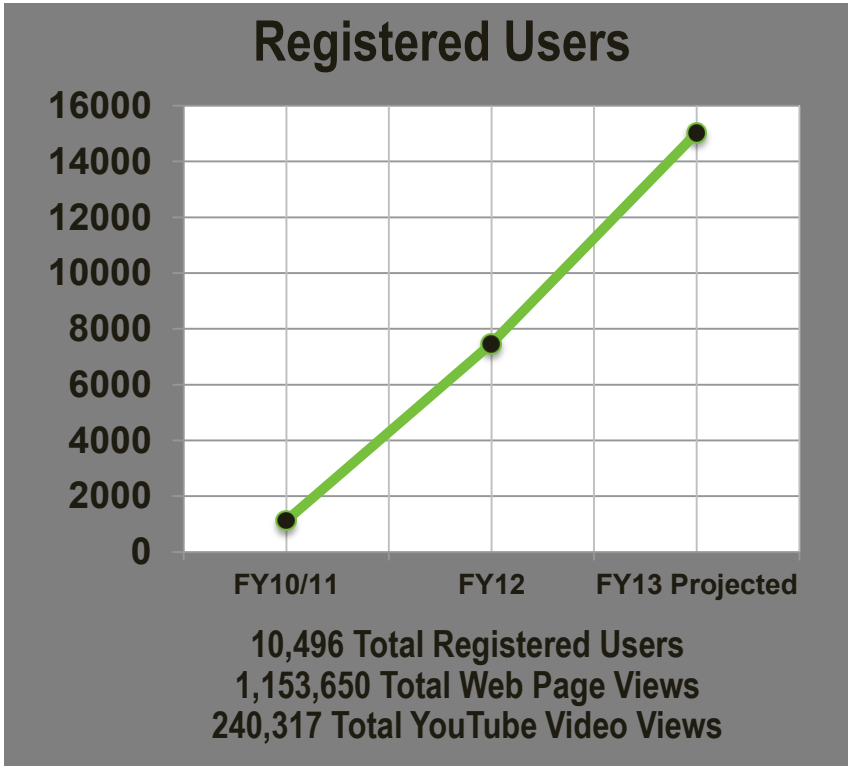
Partners, Subcontractors, and Collaborators:

- Many - spanning other national laboratories, EEB, universities, and the private sector
- RFP for training and user support partners released in February (Train the trainers)

Technology Transfer, Deployment, Market Impact:

- Adoption metrics encompass diverse user base from academia and private sector
- Some noteworthy private sector uptake examples were presented in earlier slides - many more in process
- CEC and utilities are using OpenStudio as a means of shifting the market to EnergyPlus



Communications:

- Multiple training workshops (NREL, AIA, IBPSA, BPA, International, and others)
- Online training at http://openstudio.nrel.gov and on YouTube (Over 100 videos)
- Online discussion and user support forums
- Publications through IBPSA, ACEEE, WREF, etc.
- Frequent webinars
- Multiple universities teaching with OpenStudio

Next Steps and Future Plans

- **Continue making quarterly releases of SDK**
- **Near-term Capability**
  - Add more components and measures to BCL
  - Provide OpenStudio Cloud Support for Practitioners
  - Additional HVAC Systems, Commercial Refrigeration
  - Add additional Quality Checking (QC) automation
  - Extensible Results Visualizations
  - Build System Improvements
- **Utility App Replication**
  - Xcel and National Grid Technology Exchange
  - ComEd
  - Others?
- **Off-Ramping**
  - BCL – In Process
  - Training and User Support – In Process
  - Tool Suite – Seeking Partner
- **Greater interoperability**
  - Additional engines – CONTAM integration at EEB
  - Data sources – e.g. TPEx, OpenEI, DSIRE, etc.
- **Support SDK Adoption for New Products and Applications**

Thank you!

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