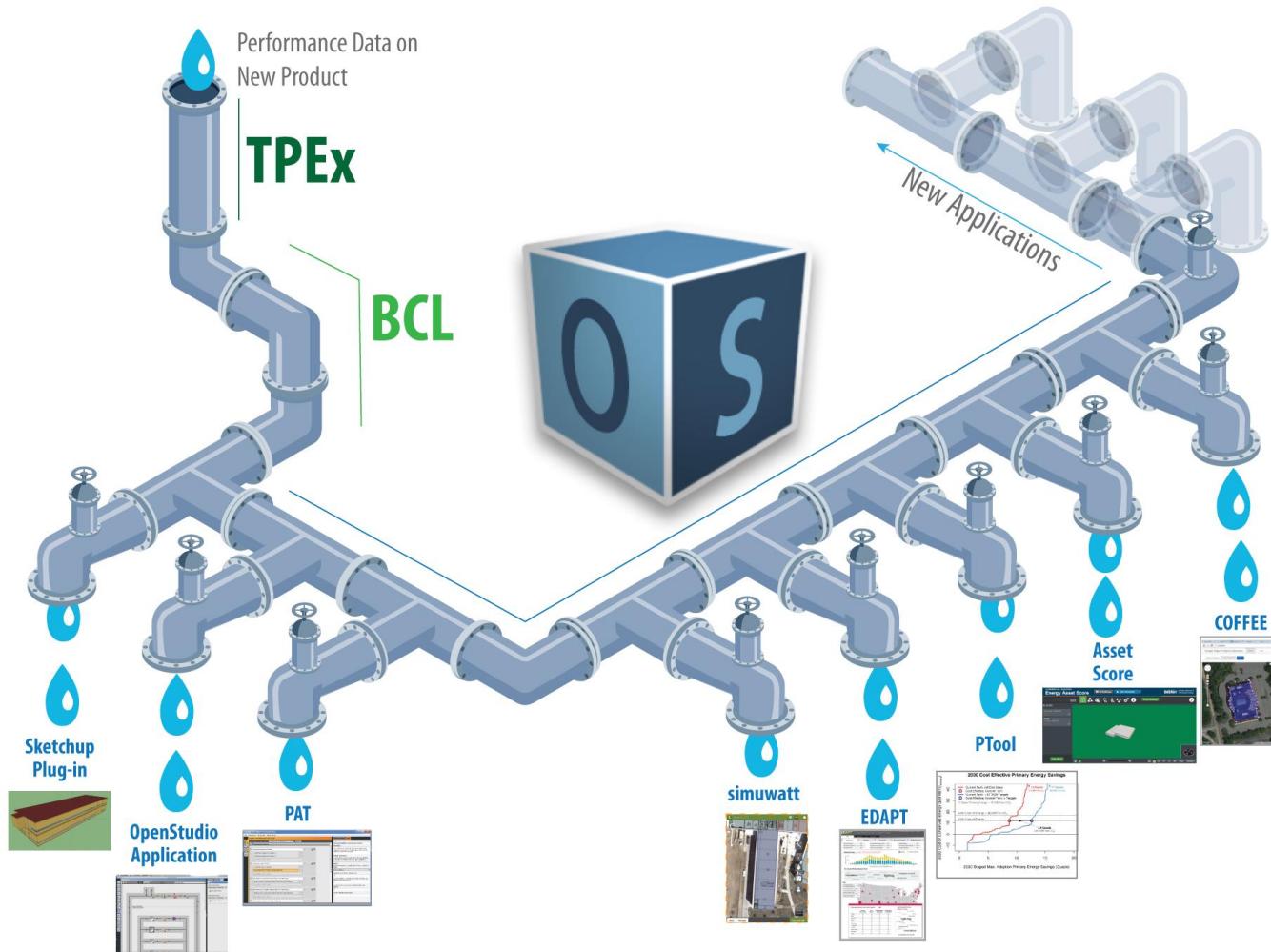


# OpenStudio Core

2016 Building Technologies Office Peer Review



# Project Summary

## Timeline:

Start date: **Q1 FY10**

Planned end date: **Ongoing w/  
Frequent Off-Ramping of Components**

## Key Milestones:

1. Quarterly Major Releases
2. V2.0 (Extensive refactor with new patterns) – 9/30/2016

## Budget:

Total DOE \$ to date: **\$10,106,000\***

Total Cost Share to date: **\$5,786,000**

Total future DOE \$: **\$3,500,000**

## Target Market/Audience:

**Tool Developers, A&E Practitioners,  
Utilities, Researchers, and Students**

## Key Partners:

|               |                                  |
|---------------|----------------------------------|
| All BTO Labs  | NRCan/NRC                        |
| CEC           | PSD Consulting                   |
| BPA           | NYSERDA                          |
| Xcel Energy   | Multiple Universities            |
| National Grid | Several Private Sector Companies |

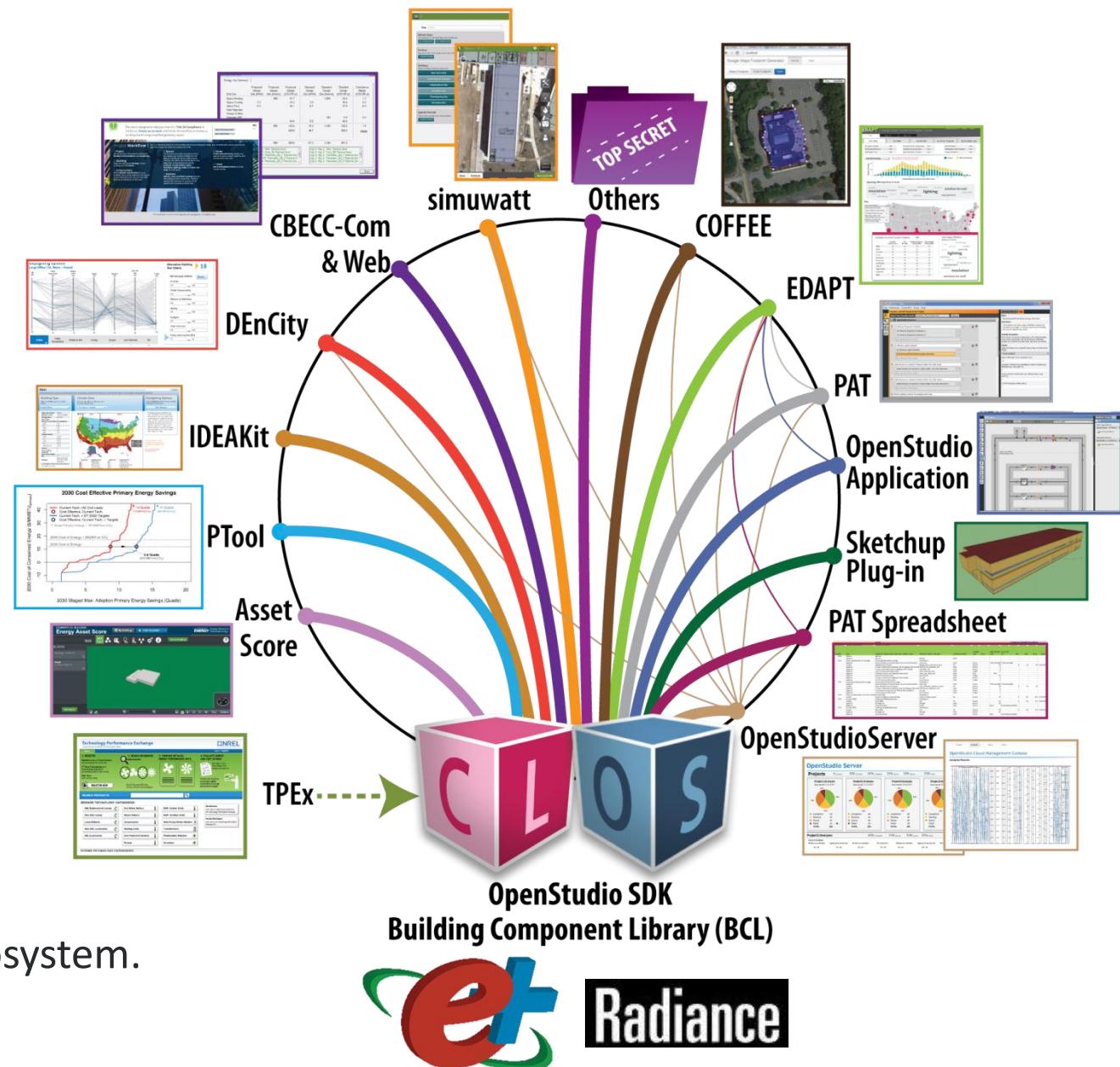
## Project Outcome:

Develop BTO's building energy analysis ecosystem as a best-in-class capability that enables rapid, low-cost development of new market facing tools produced by the National Laboratories, Universities, Private Sector, and other agencies.

Facilitate successful deployment of the software development kit across BTO performers, utilities, and private sector developers to drive real energy savings in new construction and retrofit projects.

# Problem Statement

Q: What collection of software technologies will make energy modeling less costly, more accessible, increasingly reliable, and ubiquitous for the broad range of stakeholders who rely on analysis to make real business decisions for their new construction and retrofit portfolios?

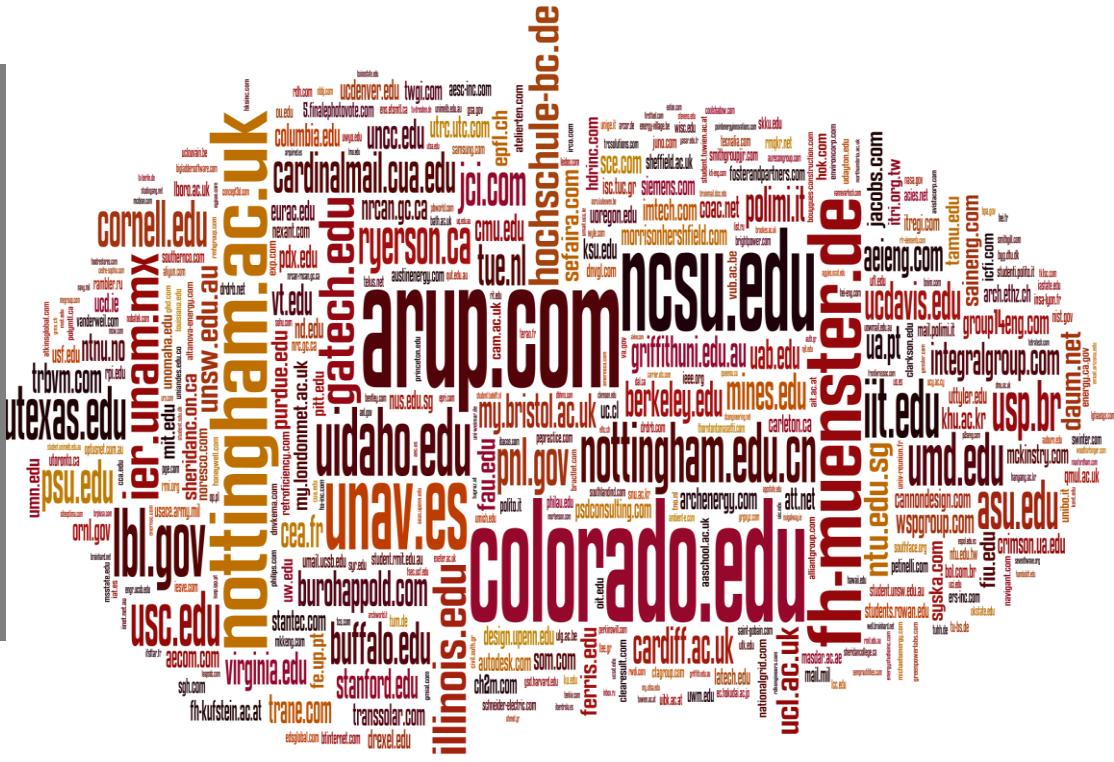
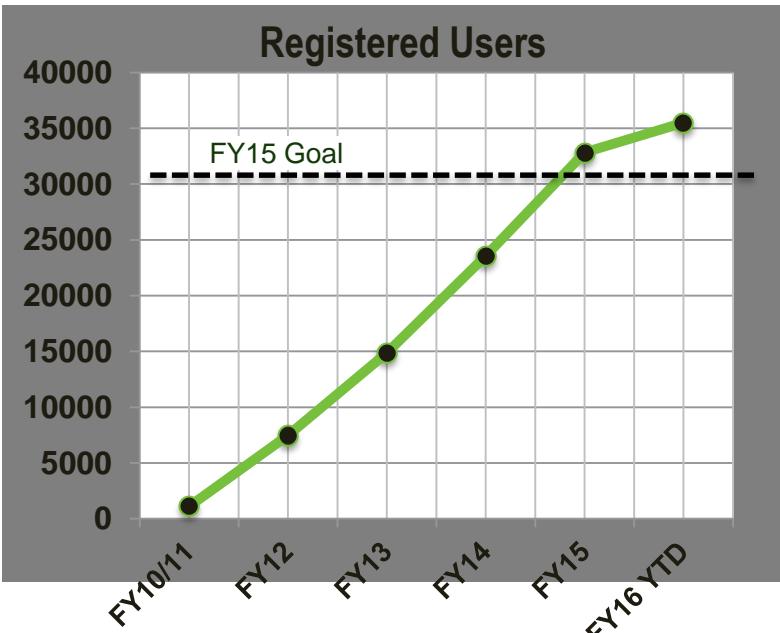


A: DOE's OpenStudio ecosystem.

# Target Market and Audience

The market for OpenStudio is diverse and includes:

- Tool developers\* that are able to quickly and cost-effectively bring new software innovations to market;
- A&E practitioners that use the example applications to reduce energy consumption for new construction and retrofit projects;
- Utilities that are trying to reduce the cost of incenting EE, realize greater EE savings, and assess technology potentials;
- Researchers who are trying to design and assess new technologies; and
- Students who are the next generation of building designers.



# Partial List of Partners



**Xcel Energy<sup>SM</sup>**



**nationalgrid**

**Group 14  
ENGINEERING**

**PERFORMANCE SYSTEMS  
DEVELOPMENT**



**EnergyTrust  
of Oregon, Inc.**



**SketchUp**

**concept3D  
Location. Web. 3D.**



**Johnson  
Controls**



**CONSORTIUM for  
BUILDING ENERGY  
INNOVATION**



**United Technologies  
Research Center**



**Pacific  
Northwest**



**Nexant**

**MITSUBISHI  
ELECTRIC**

**NIST**



**OAK  
RIDGE**

**Argonne  
NATIONAL LABORATORY**



**Natural Resources  
Canada**

**GENABILITY**

**GARDAnalytics**

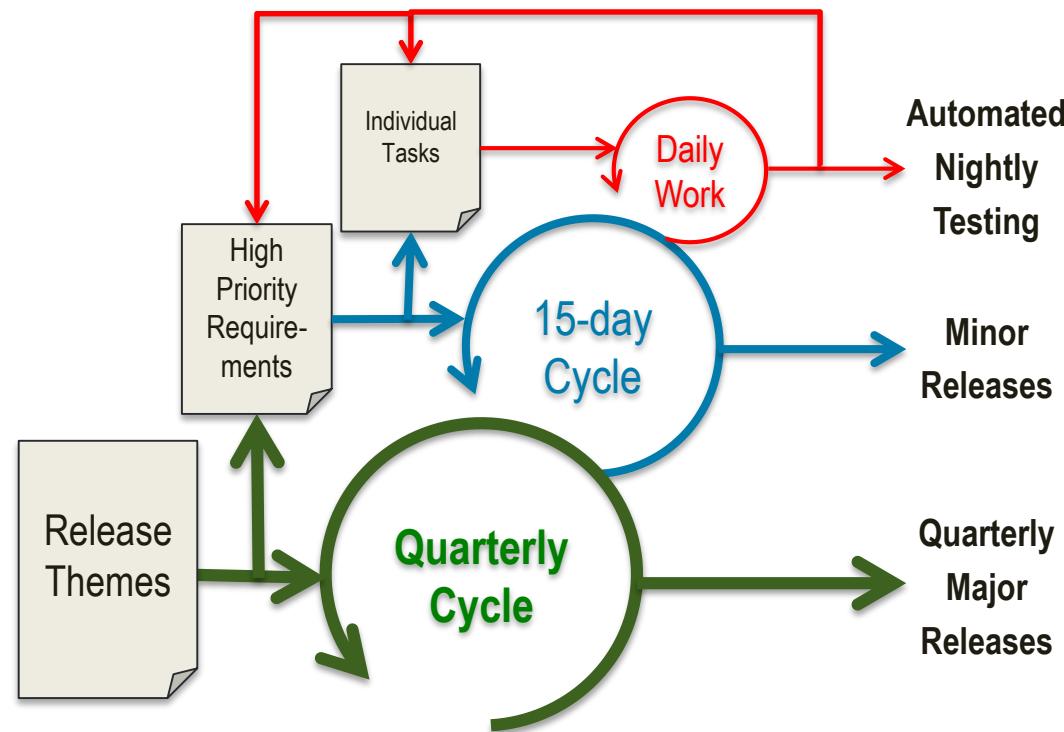
# Approach to Development and Deployment

## 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:

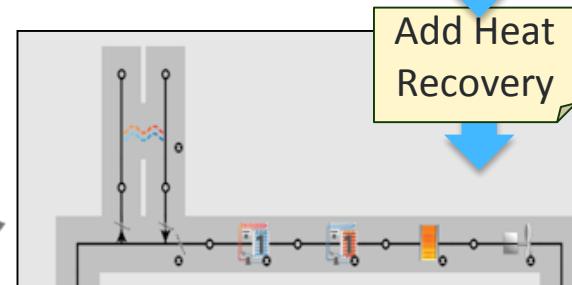
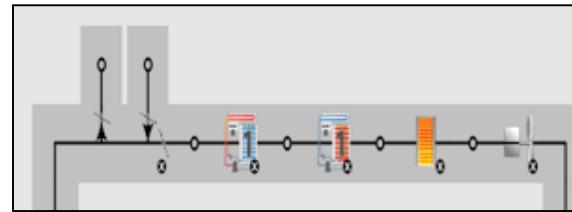
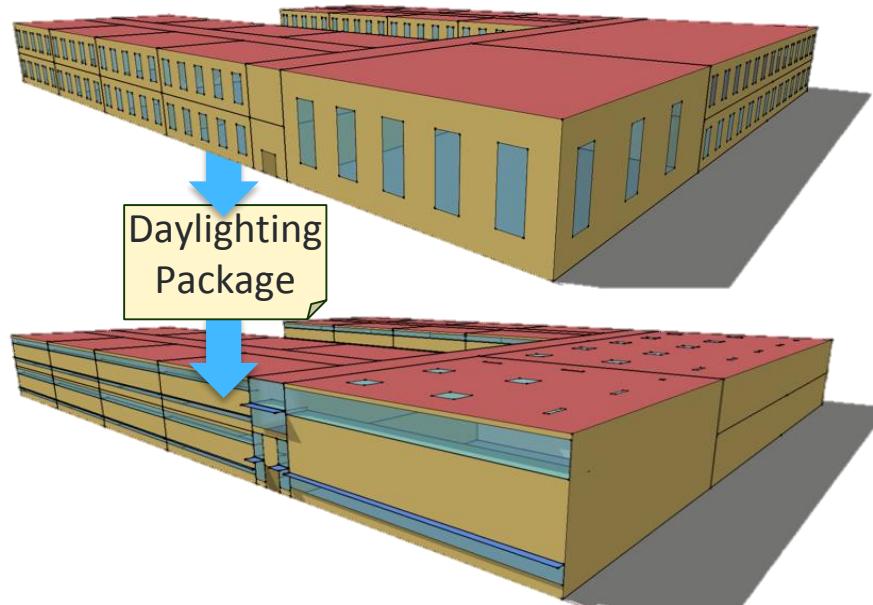
- Flexibility to **quickly** produce new desktop, mobile, and web tools that are easily **integrated** with one another
- **Agile process** allows focus to change as new requirements emerge
- Rigorous approach to creating software for the marketplace - **not a research project**
- **Open, collaborative**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



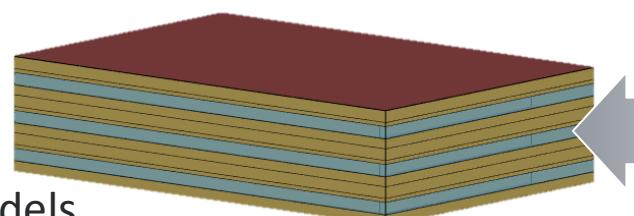
# OpenStudio's Killer Feature: Measures

## OpenStudio Measures: scripts that operate on models & results

- Transform model e.g., replace constructions, daylighting package, etc.
- Means for standardized modeling – fast, cheap, and consistent

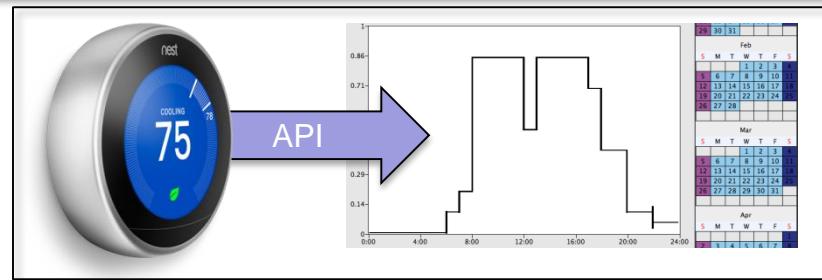
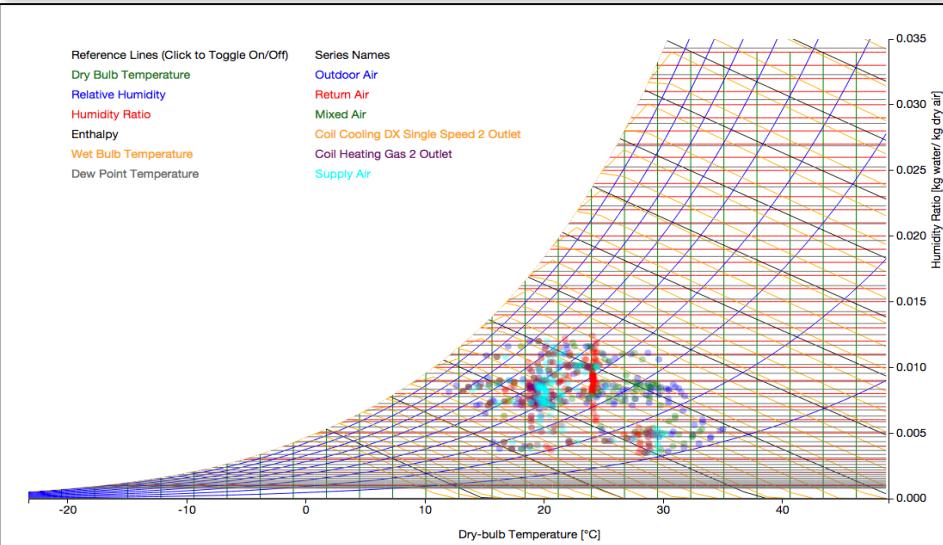
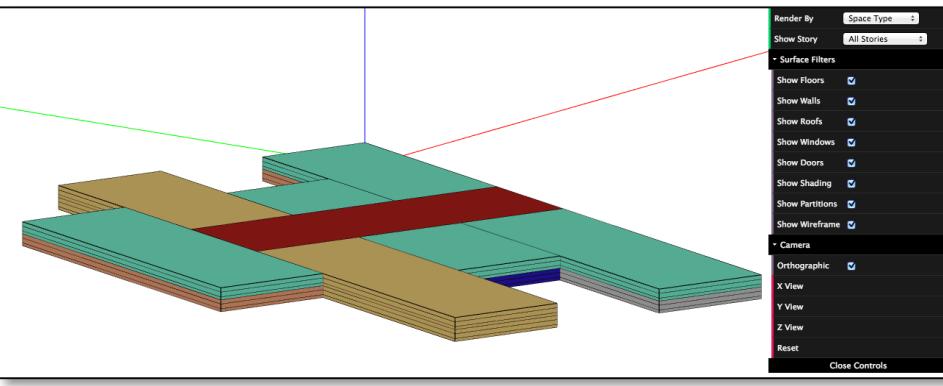


Name  
Create DOE Prototype Building  
Description  
Creates the DOE Reference Building Models as starting points for other analyses.  
Modeler Description  
Inputs  
Select a Building Type.  
MediumOffice  
Select a Vintage.  
90.1-2013  
Select a Climate Zone.  
ASHRAE 169-2006-5B



- Measures can be ECMs or create entire models

# Workflow Innovations Via OS Measures



## Austin Energy EDA Reporting and QAQC

### QAQC Check Summary

#### List of Checks in Measure

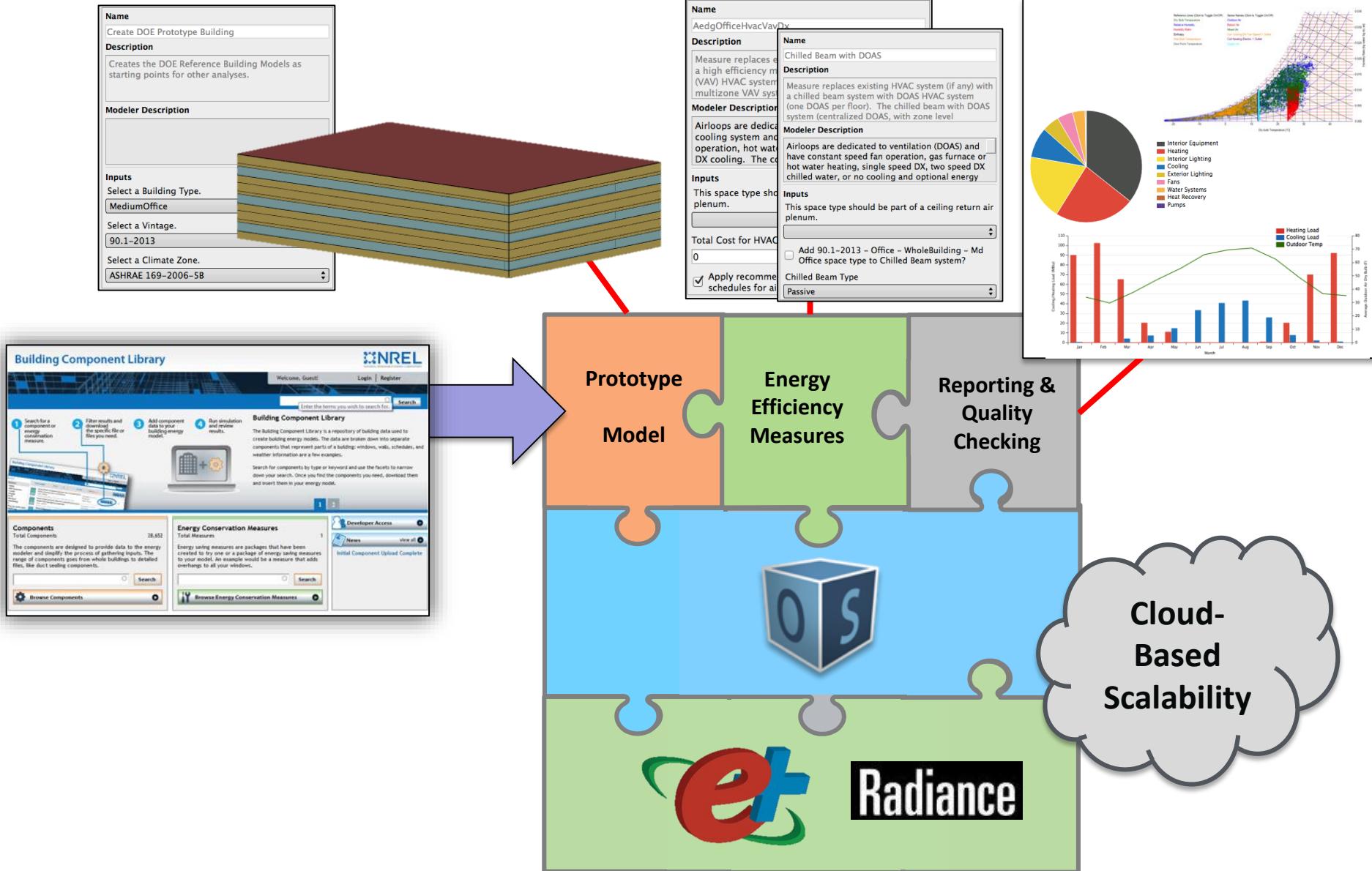
| Name                                   | Category      | Flags | Description  |
|--|---------------|-------|--|
| EUI Reasonableness                     | General       | 0     | Check EUI for model specific building type against DOE prototype buildings with Austin Energy specific tolerance.  |
| Weather Files                          | Austin Energy | 0     | Check weather file, design days, and climate zone against Austin Energy list of allowable options.   |
| End Use by Category                    | General       | 2     | Check end use by category against DOE prototype buildings with Austin Energy specific tolerance.   |
| Mechanical System Part Load Efficiency | General       | 0     | Check 40% and 80% part load efficiency for the following component types: ChillerElectricEIR, CoilCoolingDXSingleSpeed, CoilCoolingDTxTwoSpeed, CoilHeatingDXSingleSpeed. Checking EIR Function of Part Load Ratio curve for chiller and EIR Function of Flow Fraction for DX coils. |
| Internal Loads                         | Baseline      | 0     | Check Space-by-space load checks for LPD, ventilation rates, occupant density, plug loads, and equipment loads against ASHRAE standards and DOE Prototype buildings.   |
| Schedules                              | Baseline      | 0     | Check schedules for lighting, ventilation, occupant density, plug loads, and equipment based on DOE reference building schedules in terms of full load hours per year.   |
| Mechanical System Efficiency           | Baseline      | 0     | Check per 90.1 Tables 6.8.1 A-K. The following component types are checked: ChillerElectricEIR, CoilCoolingDXSingleSpeed, CoilCoolingDTxTwoSpeed, CoilHeatingDXSingleSpeed, BoilerHotWater, FanConstantVolume, FanVariableVolume, PumpConstantSpeed, PumpVariableSpeed               |
| Envelope R-Value                       | Baseline      | 1     | Check per ASHRAE 90.1 Table 5.5.-2 per Table G2.1.5 b,c,d,e (with reflectance = 0.55), Section 5.5.3.1.1a.   |
| Domestic Hot Water                     | Baseline      | 1     | Rule-of-thumb check per ASHRAE standards.  |

### QAQC Flag Details

#### List of Flags Triggered for All Checks in Measure.

| Name                | Flag Detail  |
|---------------------|--|
| End Use by Category | Interior Lighting EUI of 7.1 (kBtu/ft^2) is more than 10.0 (%) above the target Interior Lighting EUI of 5.8 (kBtu/ft^2).  |
| End Use by Category | Fans EUI of 1.6 (kBtu/ft^2) is more than 10.0 (%) above the target Fans EUI of 1.4 (kBtu/ft^2).  |
| Envelope R-Value    | U value of 0.62 (Btu/ft^2*h*R) for U 0.60 SHGC 0.25 Dbl 2.5mm air in 90.1-2013 - Office - WholeBuilding - Md Office is more than 10.0 (%) below the target value of 0.83 (Btu/ft^2*h*R). |
| Domestic Hot Water  | Annual average of 201 gallons per day of hot water is more than 5.0 % below the target value of 268 gallons per day.   |

# Measures: Basis for Large-Scale Analysis



# DOE's Prioritization Tool “2.0”

**Name**  
Create DOE Prototype Building  
**Description**  
Creates the DOE Reference Building Models as starting points for other analyses.  
**Modeler Description**  
**Inputs**  
Select a Building Type.  
MediumOffice  
Select a Vintage.  
90.1-2013  
Select a Climate Zone.  
ASHRAE 169-2006-5B



**Name**  
AedOfficeHvacVavDx  
**Description**  
Measure replaces a high efficiency multi-zone VAV HVAC system with DOAS system  
**Modeler Description**  
Loop is dedicated to cooling system and consists of hot water, DX cooling. The cooling coil is located at the zone level.  
**Inputs**  
This space type should be part of a ceiling return air plenum.  
**Total Cost for HVAC**  
Total cost for HVAC includes all costs for HVAC equipment, ductwork, piping, and controls. This includes all costs for HVAC equipment, ductwork, piping, and controls. This includes all costs for HVAC equipment, ductwork, piping, and controls.

Modeler Description

Airloops are dedicated to ventilation (DOAS) and have constant speed fan operation, gas furnace or hot water heating, single speed DX, two speed chilled water, or no cooling and optional heat recovery.

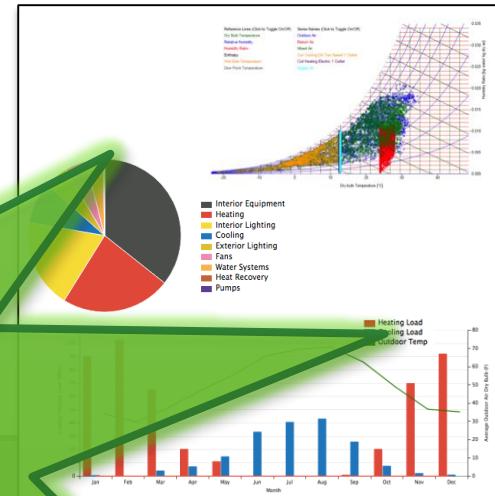
Inputs

This space type should be part of a ceiling return air plenum.

Total Cost for HVAC includes all costs for HVAC equipment, ductwork, piping, and controls. This includes all costs for HVAC equipment, ductwork, piping, and controls.

Add 90.1-2013 Office - WholeBuilding - Md to Chilled Beam system?

Passive



Coming soon to a Department of Energy near you...

Prototype  
**Scout**

Energy Efficiency Measures

Reporting & Quality Checking

Extensible, transparent, scalable technology potential assessment

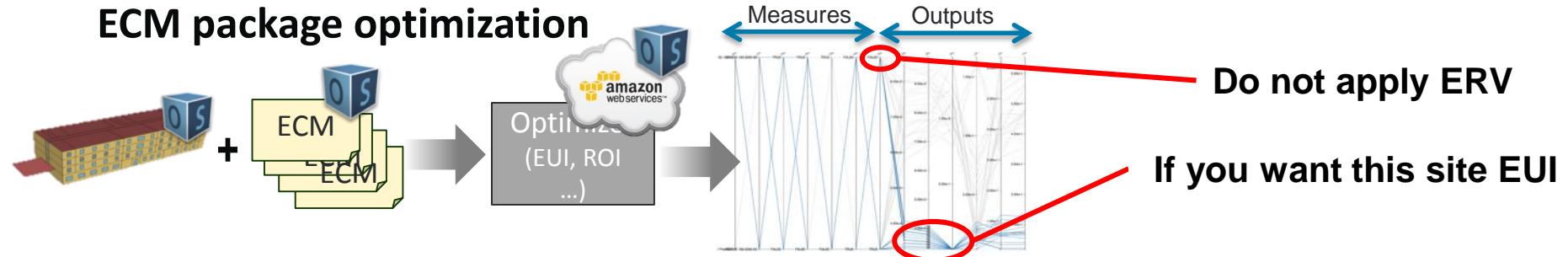
Cloud-Based Scalability



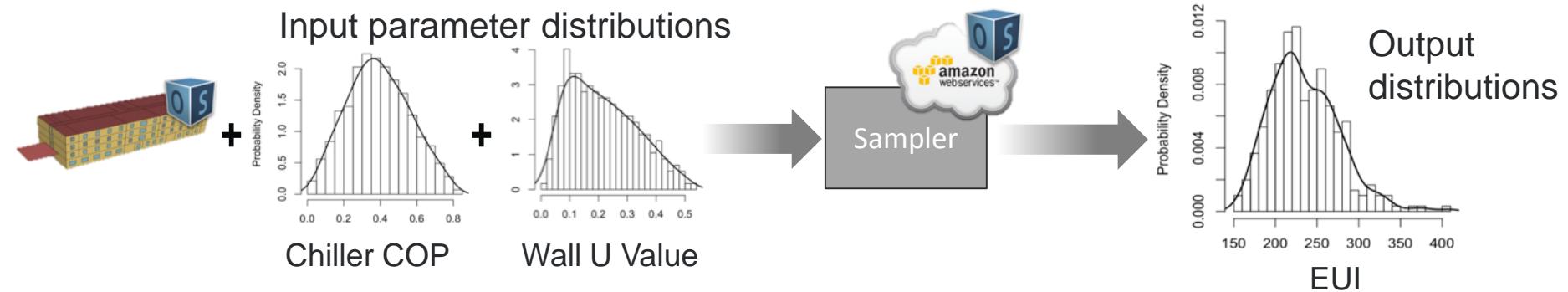
Radiance

# Measures + OpenStudio Server

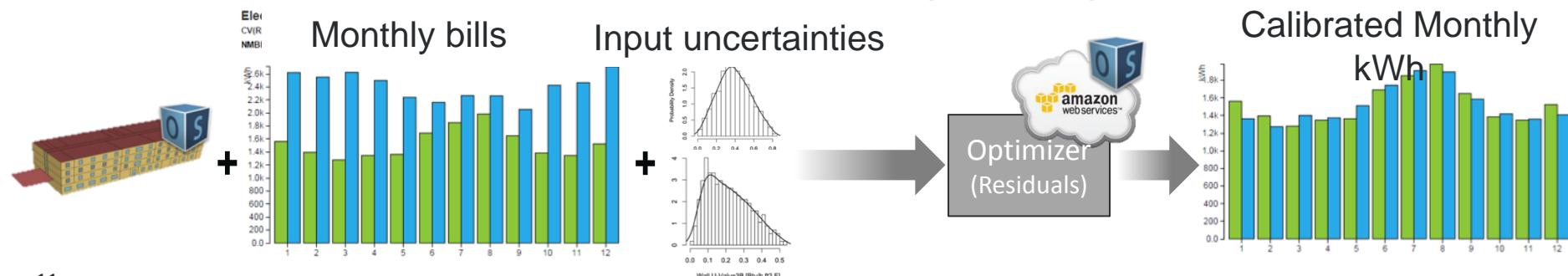
## ECM package optimization



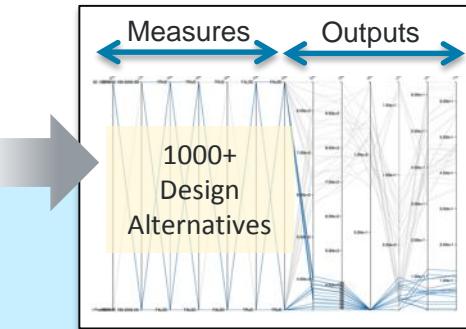
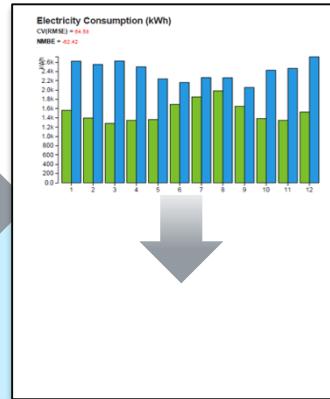
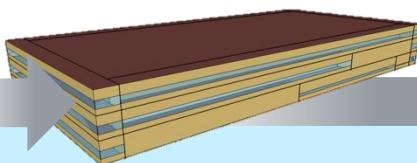
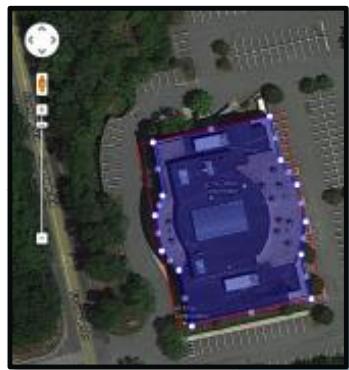
But also uncertainty analysis → ranges instead of point estimates



And calibration → Better estimates for existing buildings



# Customer Optimization For Furthering Energy Efficiency (COFFEE)



High level data  
from public and  
utility records

Automated  
Model  
Generation

Automated  
Model  
Calibration

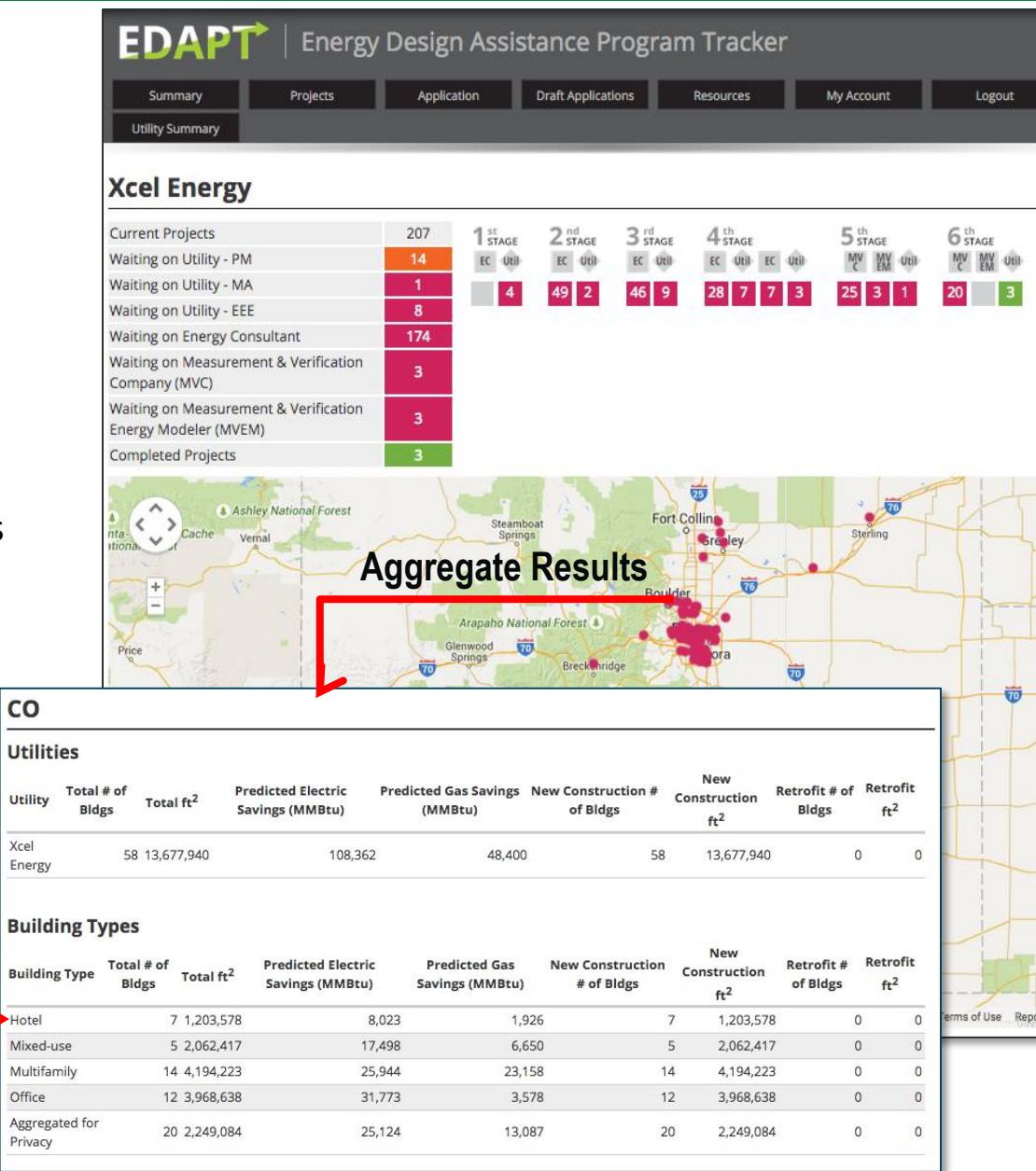
Cost/Performance  
Comparison of  
Available Measures

Cloud-Based Retrofit  
Recommendations  
For Each Customer

≈ 3,600 Buildings in MA  
\$10-20 Per Building

# EDAPT: Transforming Utility Incentive Programs

- Launched in FY14 for new construction incentive programs
- Automates:
  - Notifications
  - Quality checking
  - Reporting
  - Portfolio roll-ups
- Developed for Xcel Energy
  - Saved \$500k in program admin costs in 1<sup>st</sup> year of operation
  - Grew from 2 consultants to 10
  - Significant increase in number of projects processed annually
- Now available to other utilities
  - Austin Energy
  - Energy Trust of Oregon
  - RFQ for Implementers in Process
- DOE dashboard quantifies real project impacts for OpenStudio



# New Resources for a Growing Community

The screenshot shows the OpenStudio website. A red arrow points from the top right towards the "Documentation" section of the navigation bar. Another red arrow points down to a specific forum post about "Allow several runPeriods".

**OpenStudio®** is a cross-platform (Windows, Mac, and Linux) collection of software tools to support whole building energy modeling using EnergyPlus and advanced daylight analysis using Radiance. OpenStudio is an open source (LGPL) project to facilitate community development, extension, and private sector adoption. OpenStudio includes graphical interfaces along with a Software Development Kit (SDK).

The graphical applications include the OpenStudio SketchUp Plug-in, OpenStudio Application, ResultsViewer and the Parametric Analysis Tool. The OpenStudio SketchUp Plug-in is an extension to Trimble's popular SketchUp 3D modeling tool that allows users to quickly create geometry needed for EnergyPlus. Additionally, OpenStudio supports import of gbXML and IFC for geometry creation. The OpenStudio Application is a fully featured graphical interface to OpenStudio models including envelope, loads, schedules, and HVAC. ResultsViewer enables browsing, plotting, and comparing simulation output data, especially time series. The combinations of OpenStudio T submission.

Tags Users Badges

ASK YOUR QUESTION

Founding Sponsor

OpenStudio 1.10.0 Rerelease

OpenStudio 1.10.0 has been rereleased with an important bug fix.

**Welcome to OpenStudio® User Documentation**

This is OpenStudio's user documentation. A brief summary of the content of the site is below. Use the buttons or the horizontal navigation above to learn more about the OpenStudio suite of applications.

**Getting Started**

This section provides installation instructions, introductory tutorials, and information to get you up and running.

**Installation & Tutorial**

Review the list of features and building elements that can be modeled.

**Current Features**

**Planned Features**

**References & Tutorials**

Interface guides give detailed overviews of the OpenStudio applications.

**SketchUp Plug-in**

**OpenStudio Application**

Tutorials cover essential workflows as well as advanced topics.

**About Measures**

Can't find the measures you want, or need to customize an existing measure? The Measure Writing Guide will help you get started.

**Measure Writing Guide**

**Using Third Party Tools**

Set materials and constructions so they can be properly imported into CBECC-Com.

**CBECC-Com Tutorial**

Import an IFC file into OpenStudio using BIMserver.

**Import IFC Tutorial**

Size a vertical ground heat exchanger with OpenStudio and GLHEPro.

**GLHEPro Tutorial**

Create OpenStudio models using the web based VirtualPULSE tool.

**VirtualPULSE Tutorial**

**Help & Additional Resources**

Find professional training for OpenStudio.

**Training, Support, & Consulting**

Check out Unmet Hours, to post a question or search for answers to your energy modeling questions.

**OpenStudio on Unmet Hours**

Check out this advanced application of OpenStudio for fault detection:

**Fault Detection Measures**

Additional help topics.

**Finding Model Data**

**Best Practices**

**Troubleshooting**

**FAQ**

More training videos are available on our YouTube page.

**YouTube Videos**

The OpenStudio Repository on GitHub

**OpenStudio on GitHub**

**OpenStudio**

# TPEx: Making Product Evaluation Drag-and-Drop Easy

The screenshot shows the TPEx homepage with a navigation bar at the top. Below it, four main steps are outlined:

1. REGISTER: Manufacturers and Brand Owners add their products to the site.
2. SEARCH OR BROWSE TECHNOLOGIES: Search for cost-effective, energy-efficient technologies.
3. COMPARE DETAILED ENERGY PERFORMANCE DATA: Use data in your calculations and energy simulations.
4. EVALUATE ENERGY AND COST SAVINGS: Present the results to encourage capital investment in energy saving technologies.

Below these steps, there's a search bar labeled "SEARCH PRODUCTS" and a section titled "BROWSE TECHNOLOGY CATEGORIES" with various product categories like SSL Replacement Lamps, Hot-Water Boilers, and DHP: Indoor Units.

This screenshot shows a HVAC system model in an OpenStudio application. A "VRF Terminal" is connected via lines to several "Thermal Zone" components, which are labeled "Core\_ZN Thermal Zone", "Perimeter\_ZN\_1 Therma", "Perimeter\_ZN\_2 Therma", and "Perimeter\_ZN\_3 Therma". On the right side, a sidebar lists various HVAC components and systems, such as "VRF System", "AirLoopHVAC Unitary VAV", and "AirTerminal Single Duct VAV".

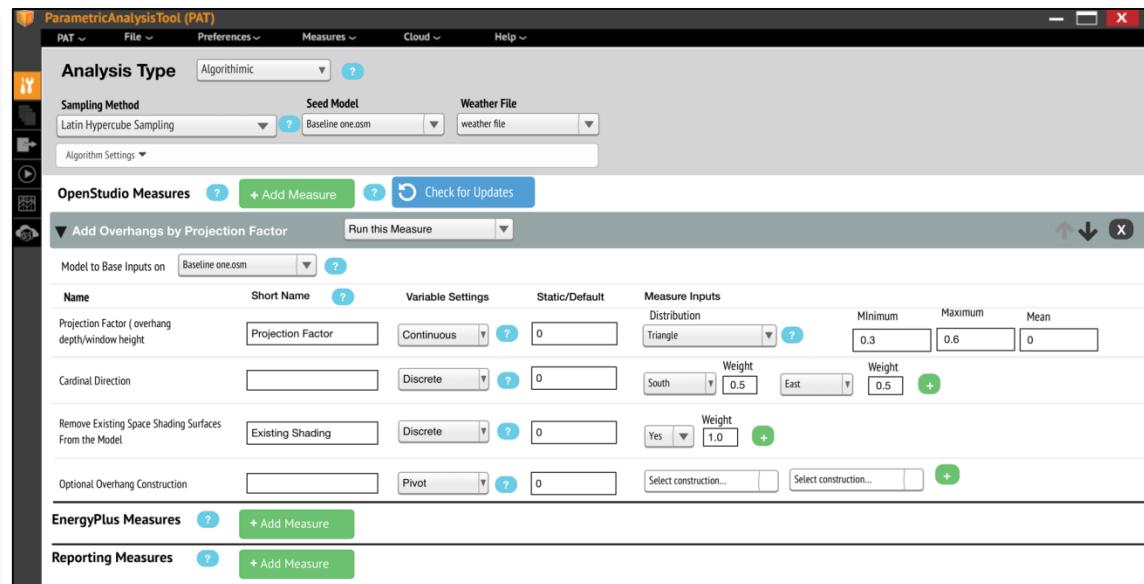
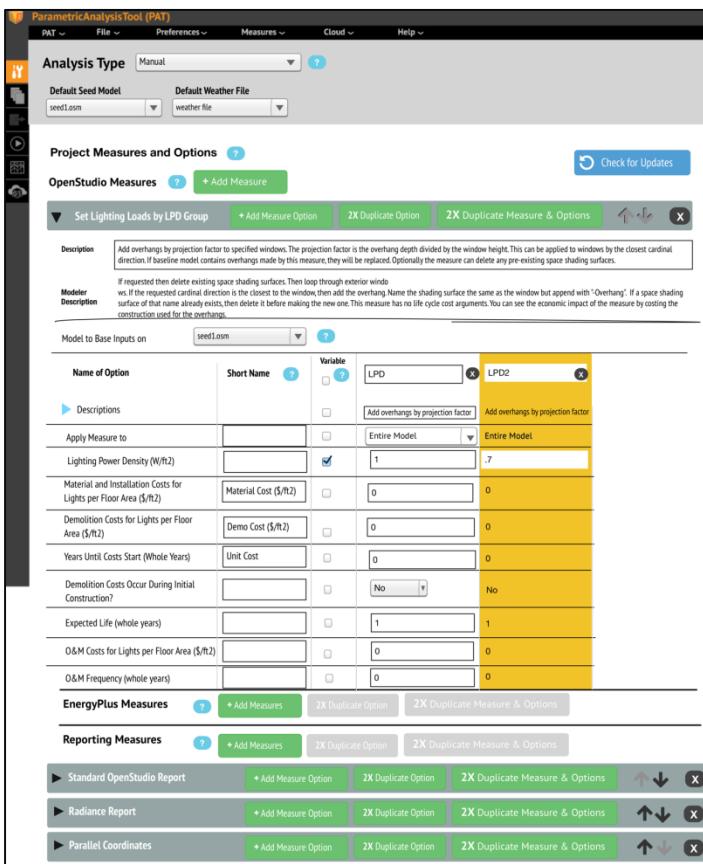
This screenshot shows the Building Component Library (BCL) interface. It includes sections for "Any User", "Register and Join a Group", "Start a New Group", "Components", "Measures", and "Groups". The "Components" section shows a count of 47900 total components. The "Measures" section shows a count of 190 total measures. The "Groups" section provides links to "About the BCL" and "Developer Resources".

Raw performance data automatically converted into BCL objects

Apply product to model using any OpenStudio app

# Near-Term Focus Areas

- Extensive code refactor → OS 2.0
  - Dependency & SDK code reduction
  - Command Line Interface (CLI)
  - Alignment of PAT and OS Server code/functionality



- App integrates “OS Spreadsheet” functions into PAT
- New development pattern leverages web tech to facilitate developer and SAAS adoption

# Near-Term Focus Areas

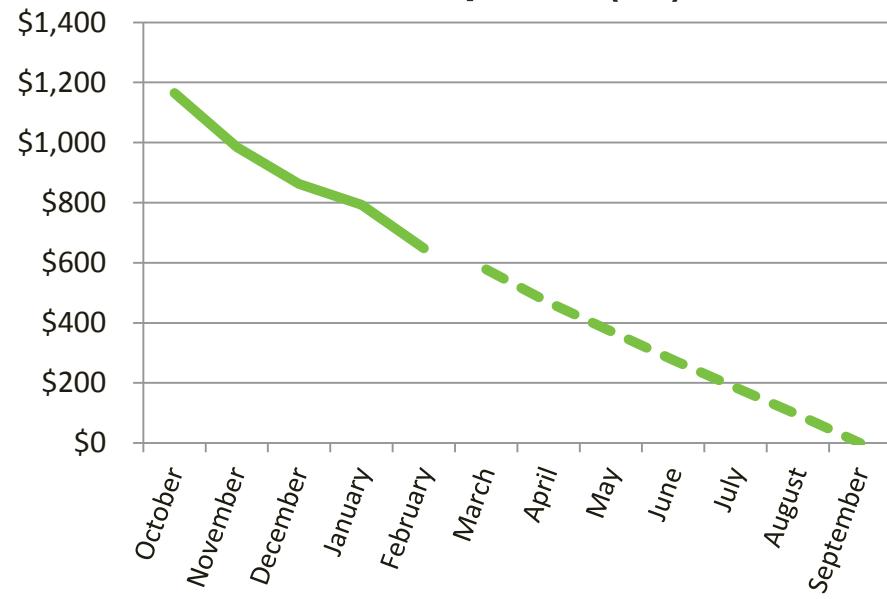
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- Extensive code refactor → OS 2.0
  - Dependency & SDK code reduction
  - Command Line Interface (CLI)
  - Alignment of PAT and OS Server code/functionality
- OS Measure work
  - Additional content (ECMs, QAQC, etc.)
  - Release of building prototype measure
  - Automated baseline generation measure
  - Code cleanup and automated testing framework
- Adoption support
  - Tool vendors (e.g. Carrier)
  - CPUC, BPA, etc.
- Community-Scale Modeling – *Internal Research*
- Demand-Response Analysis – *Internal Research*
- OS support for EMS (Controls) Objects - *NYSERDA*

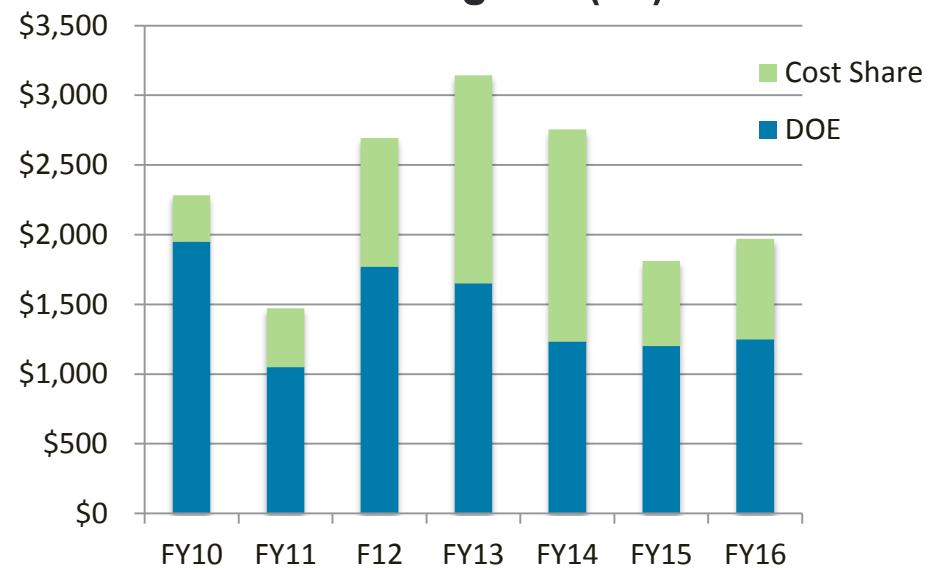
# REFERENCE SLIDES

# Project Budget

FY16 Spend\* (\$k)



FY10-16 Budgets\* (\$k)



## Additional Funding Sources:



nationalgrid



EnergyTrust  
of Oregon, Inc.



NYSERDA



U.S. DEPARTMENT OF  
ENERGY

Energy Efficiency &  
Renewable Energy

