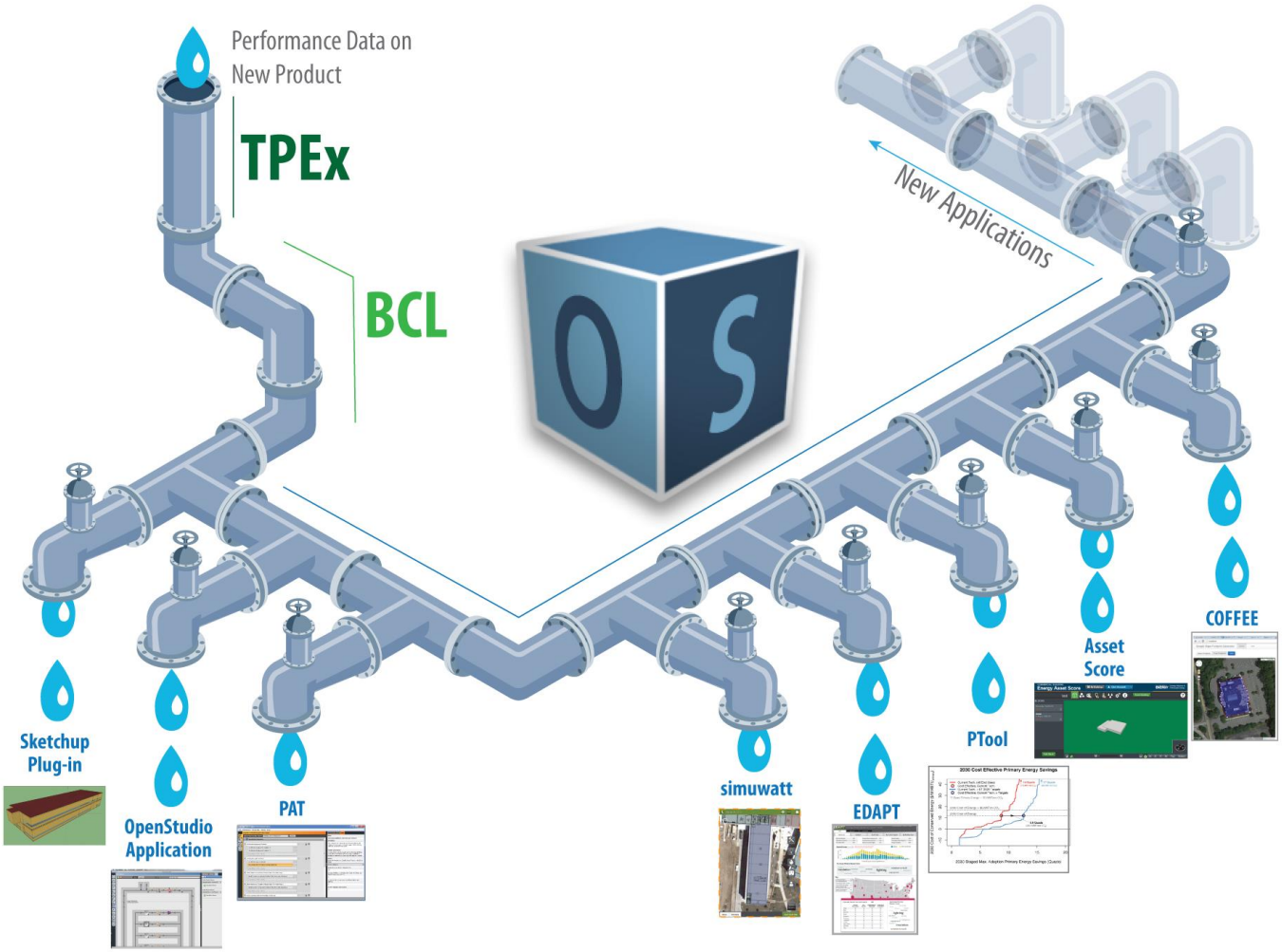
OpenStudio Core

2016 Building Technologies Office Peer Review



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

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National Renewable Energy Laboratory

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:

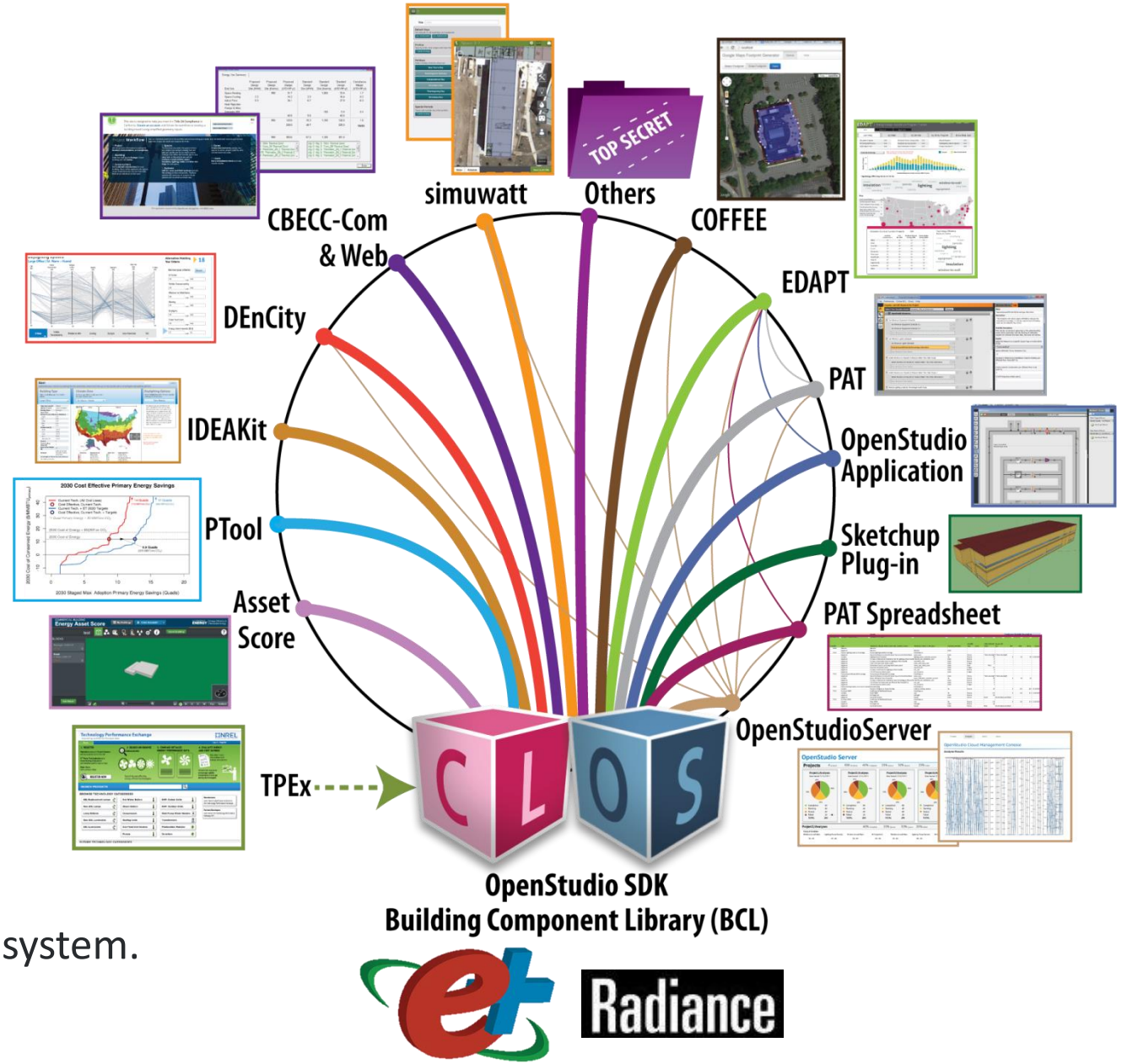
Develop BTO's building energy analysis ecosystem as a best-in-class capability that enables rapid, low-cost development of new market facing tools produced by the National Laboratories, Universities, Private Sector, and other agencies.

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.

*** Includes funding from Asset Score and Prioritization Tool**

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?

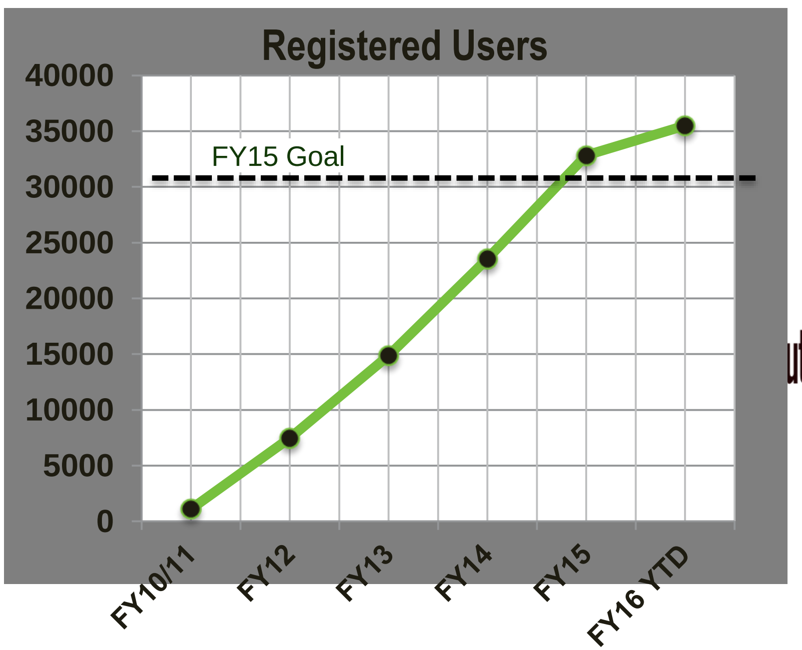


A: DOE's OpenStudio ecosystem.

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.



* This is OpenStudio's biggest growth area

Partial List of Partners

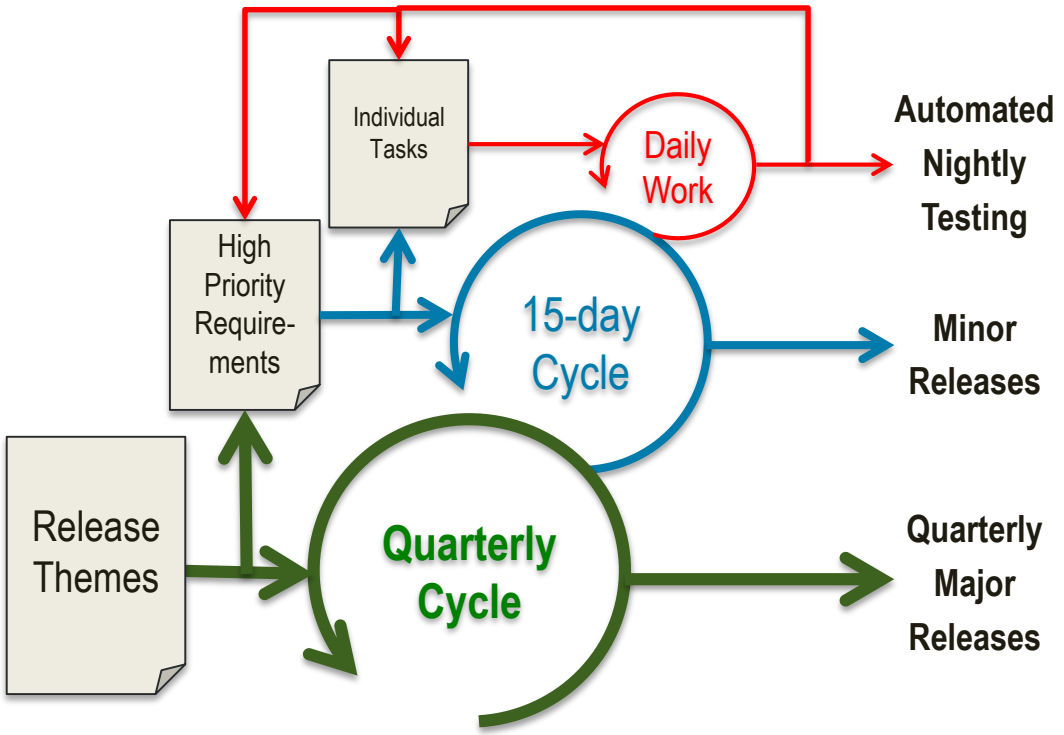
Approach to Development and Deployment

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:

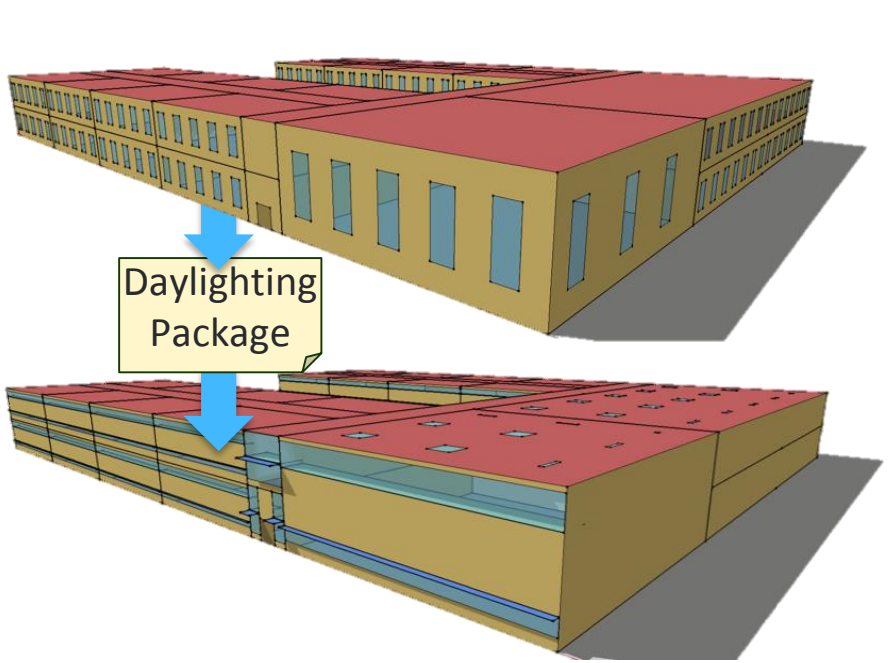
- Flexibility to **quickly** produce new desktop, mobile, and web tools that are easily **integrated** with one another
- **Agile process** allows focus to change as new requirements emerge
- Rigorous approach to creating software for the marketplace - **not a research project**
- **Open**, **collaborative**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

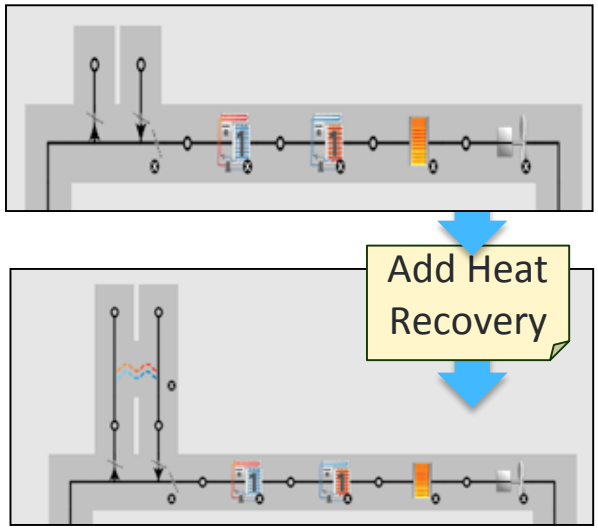


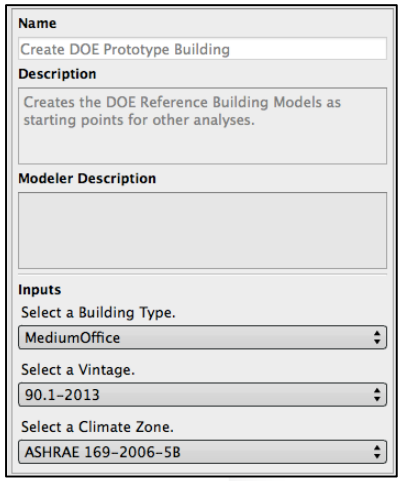
OpenStudio's Killer Feature: Measures

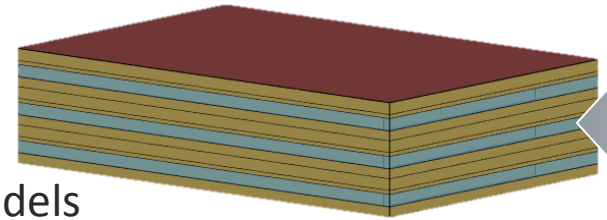
OpenStudio Measures: scripts that operate on models & results

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



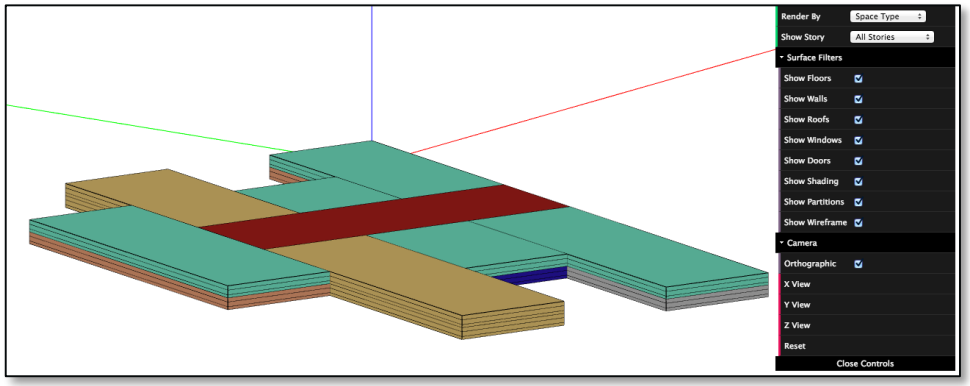


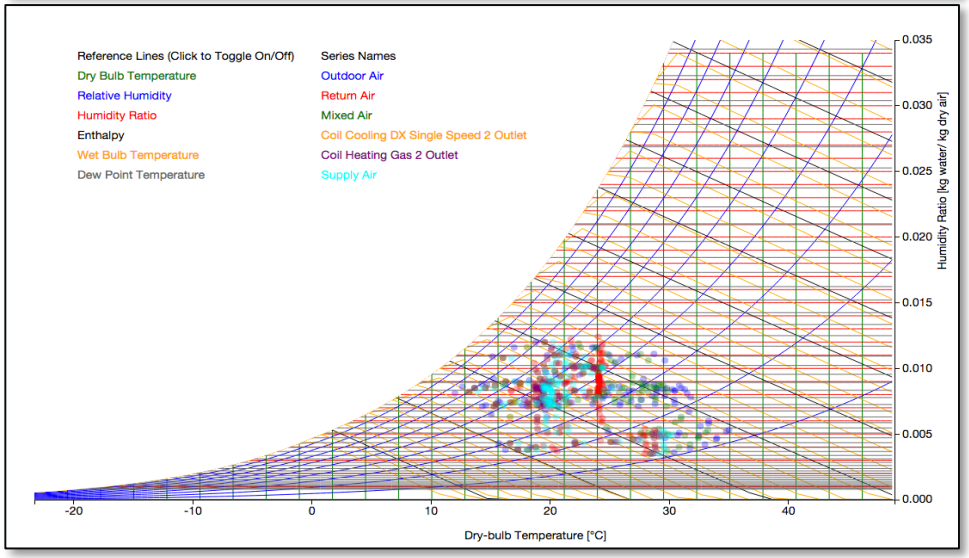


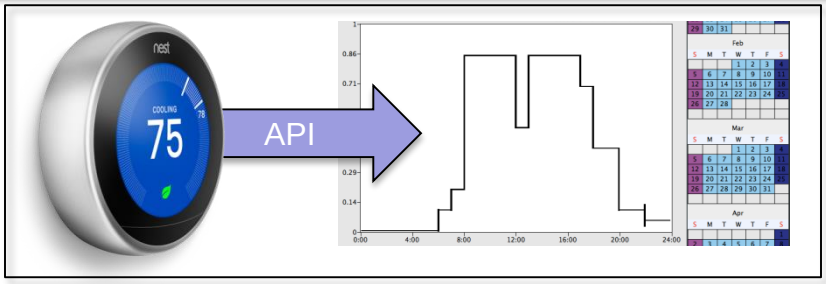


- Measures can be ECMs or create entire models

Workflow Innovations Via OS Measures







Austin Energy EDA Reporting and QAQC

QAQC Check Summary

List of Checks in Measure

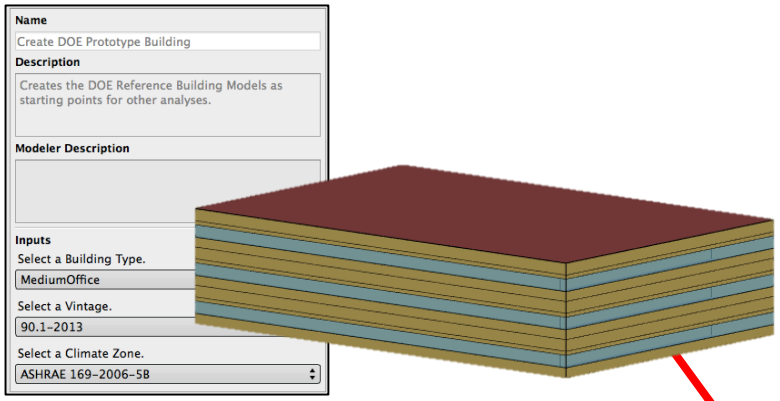
Name	Category	Flags	Description
EUI Reasonableness	General	0	Check EUI for model specific building type against DOE prototype buildings with Austin Energy specific tolerance.
Weather Files	Austin Energy	0	Check weather file, design days, and climate zone against Austin Energy list of allowable options.
End Use by Category	General	2	Check end use by cateogry against DOE prototype buildings with Austin Energy specific tolerance.
Mechanical System Part Load Efficiency	General	0	Check 40% and 80% part load efficency for the following compenent types: ChillerElectricEIR, CoilCoolingDXSingleSpeed, CoilCoolingDXTwoSpeed, 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, CoilCoolingDXTwoSpeed, 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.
Domistic Hot Water	Baseline	1	Rule-of-thumb check per ASHRAE standards.

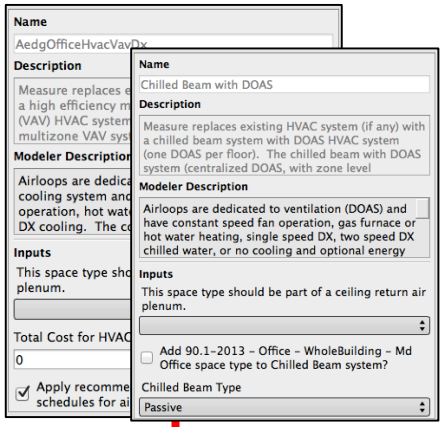
QAQC Flag Details

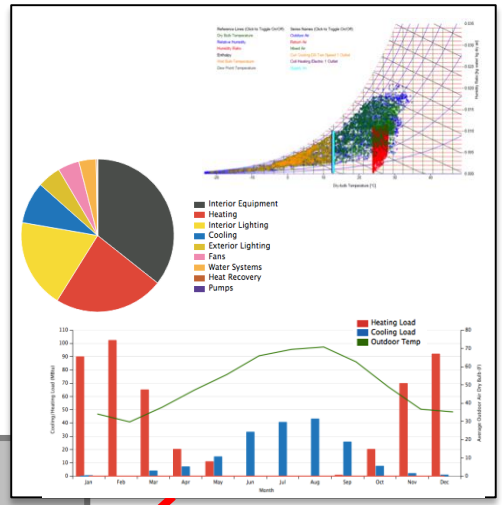
List of Flags Triggered for All Checks in Measure.

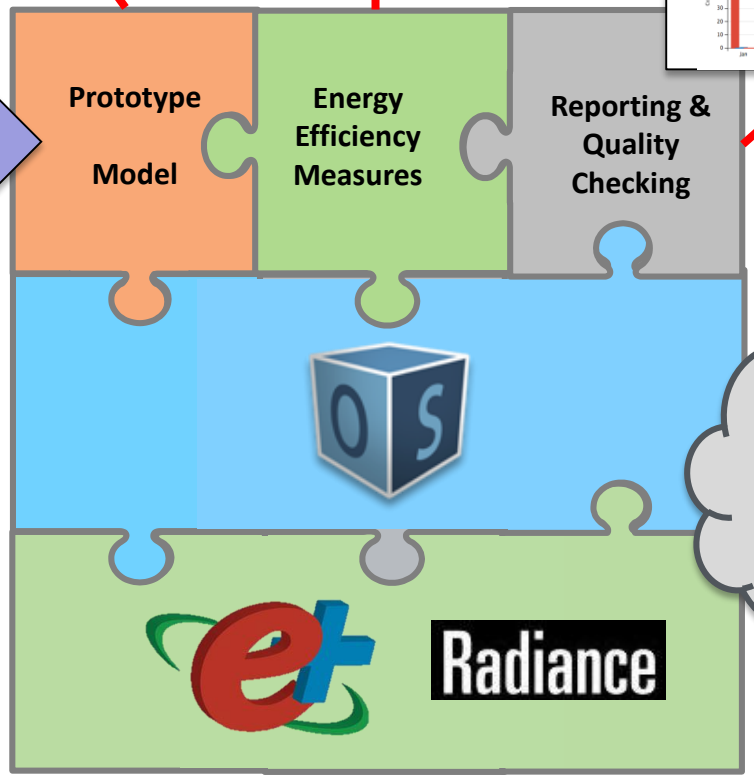
Name	Flag Detail
End Use by Category	Interior Lighting EUI of 7.1 (kBtu/ft^2) is more than 10.0 (%) above the target Interior Lighting EUI of 5.8 (kBtu/ft^2).
End Use by Category	Fans EUI of 1.6 (kBtu/ft^2) is more than 10.0 (%) above the target Fans EUI of 1.4 (kBtu/ft^2).
Envelope R-Value	U value of 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).
Domistic 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



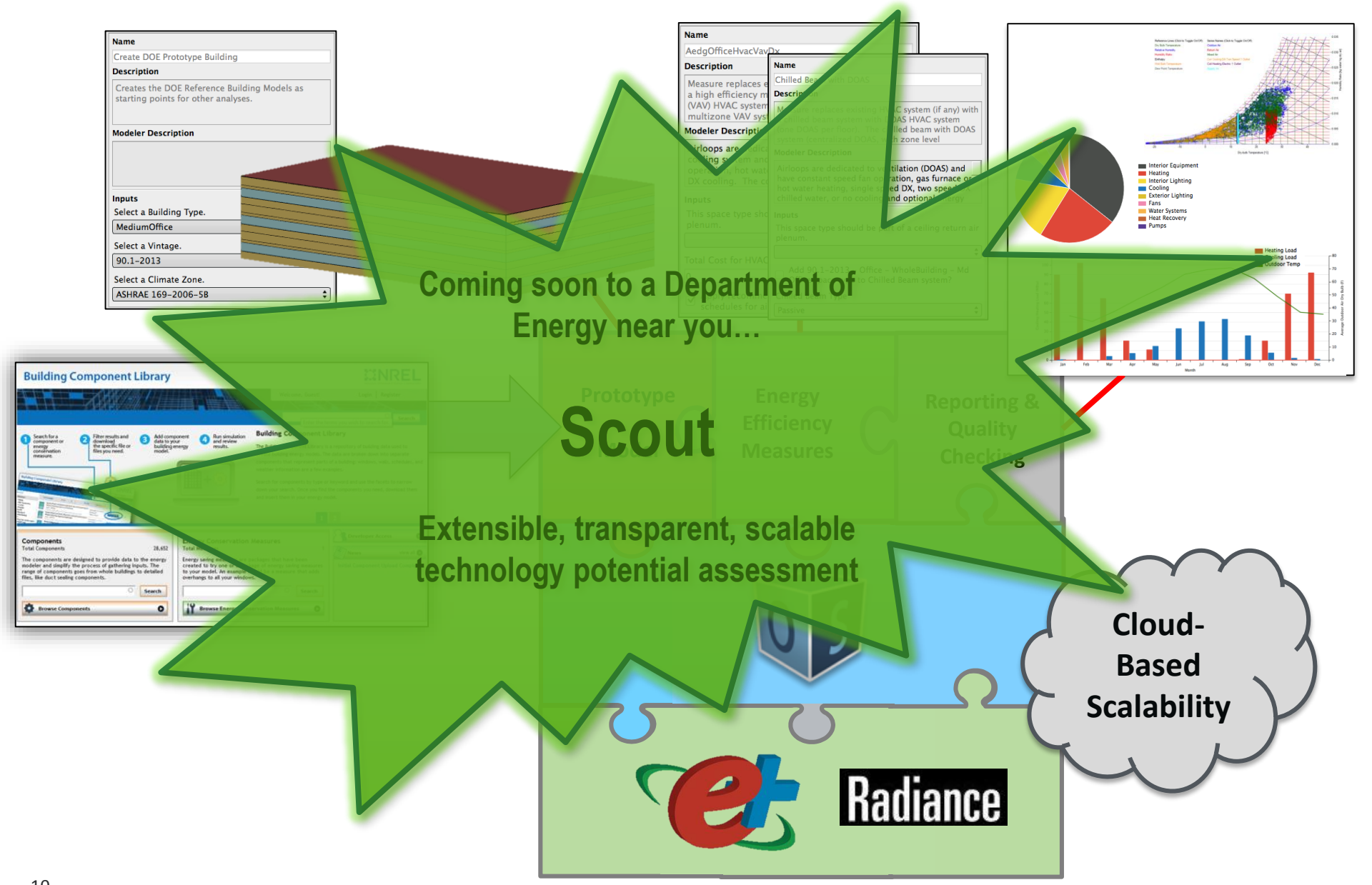






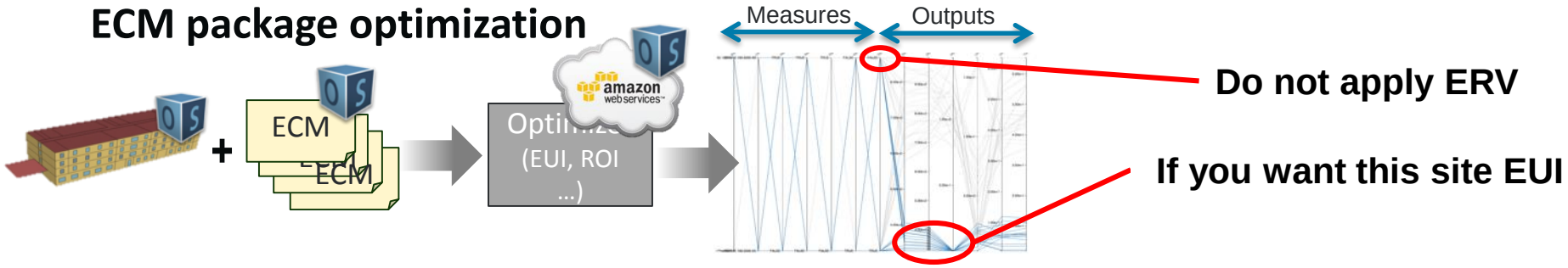
Cloud-Based Scalability

DOE's Prioritization Tool "2.0"

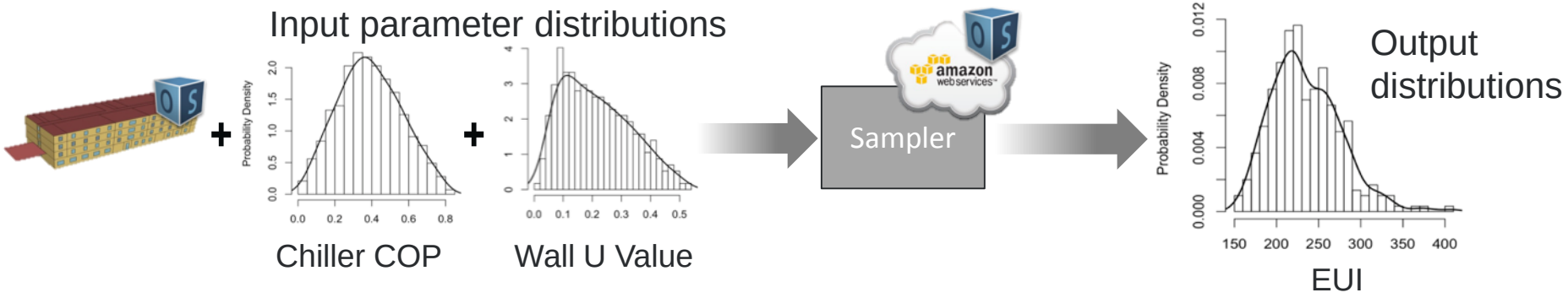


Measures + OpenStudio Server

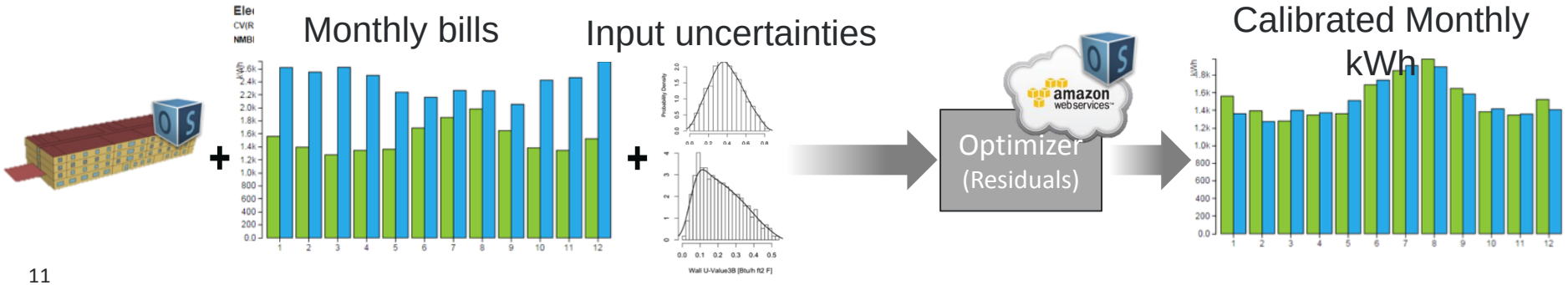
ECM package optimization



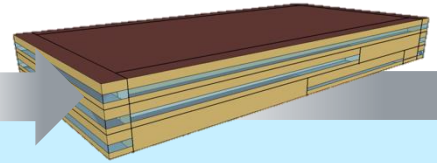
But also uncertainty analysis ➔ ranges instead of point estimates

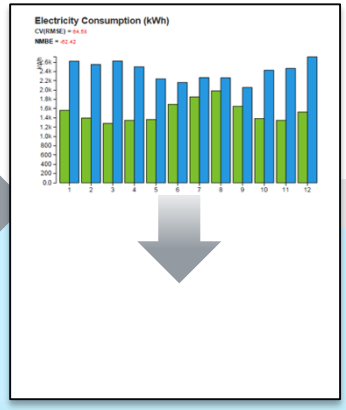


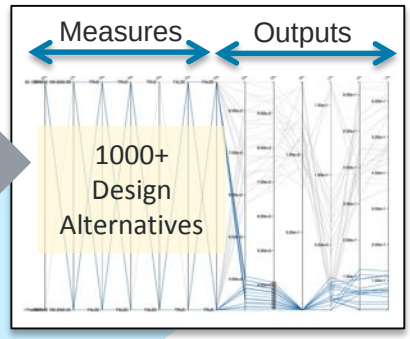
And calibration ➔ Better estimates for existing buildings



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

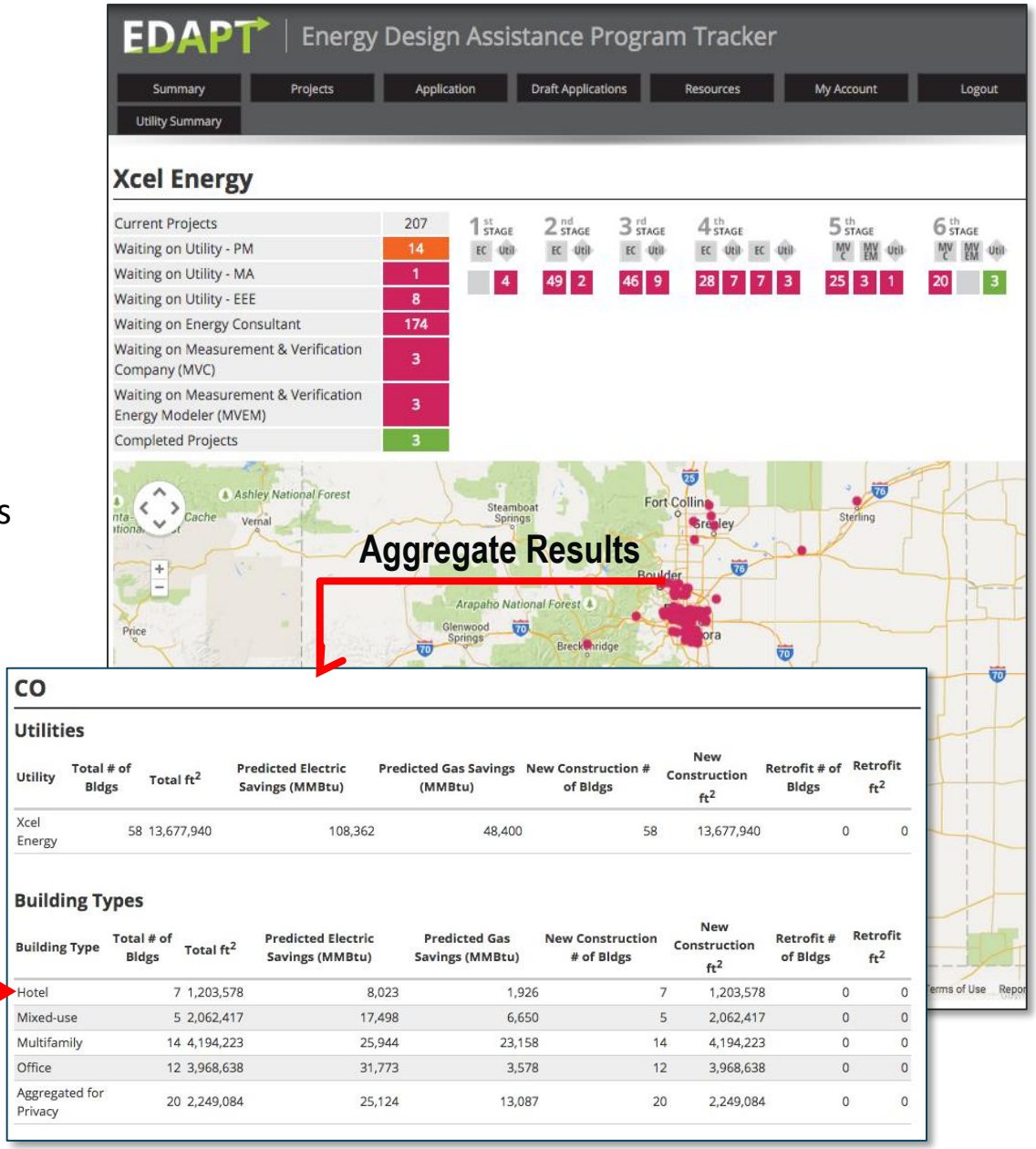
Cloud-Based Retrofit Recommendations For Each Customer

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

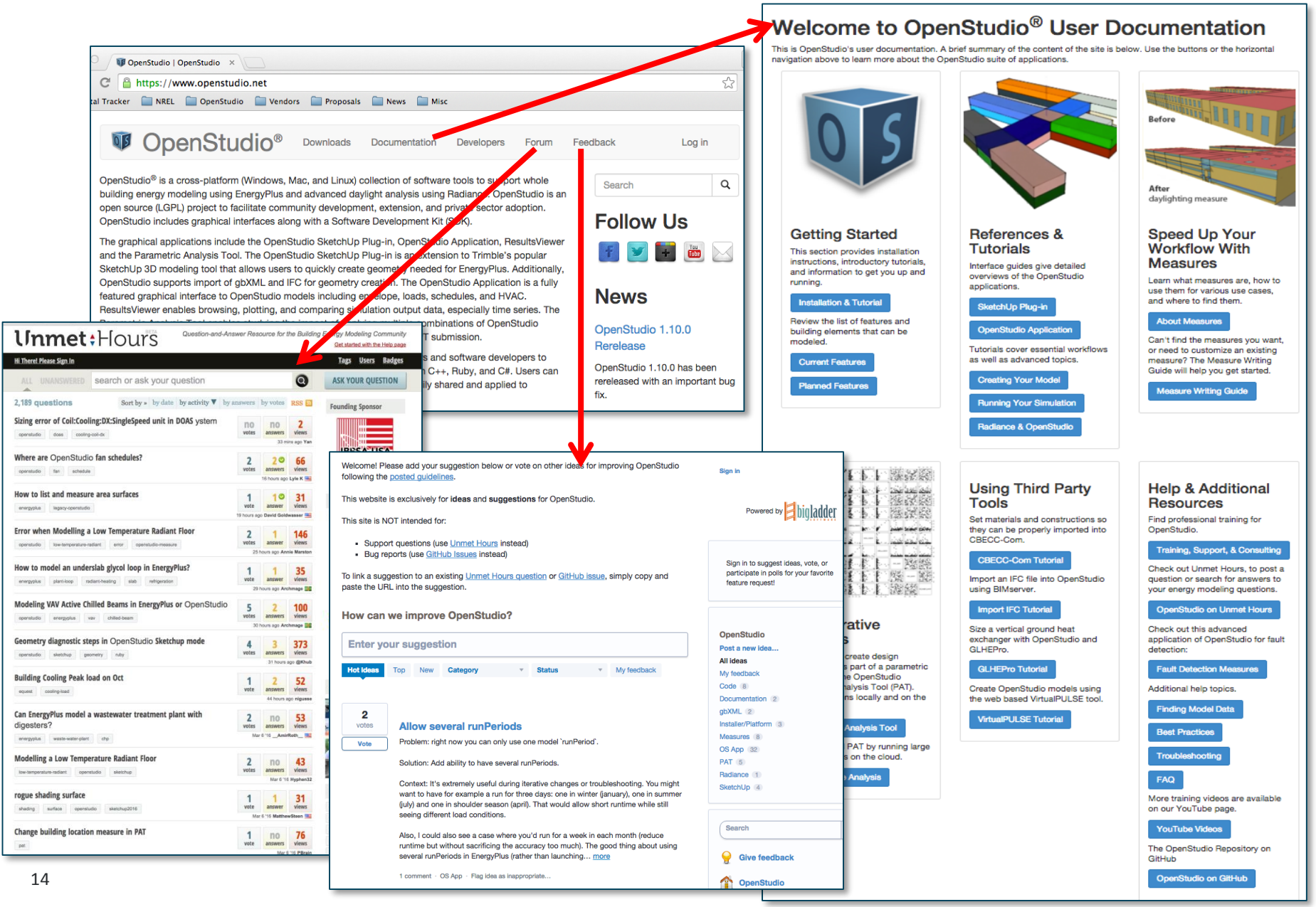
nationalgrid

EDAPT: Transforming Utility Incentive Programs

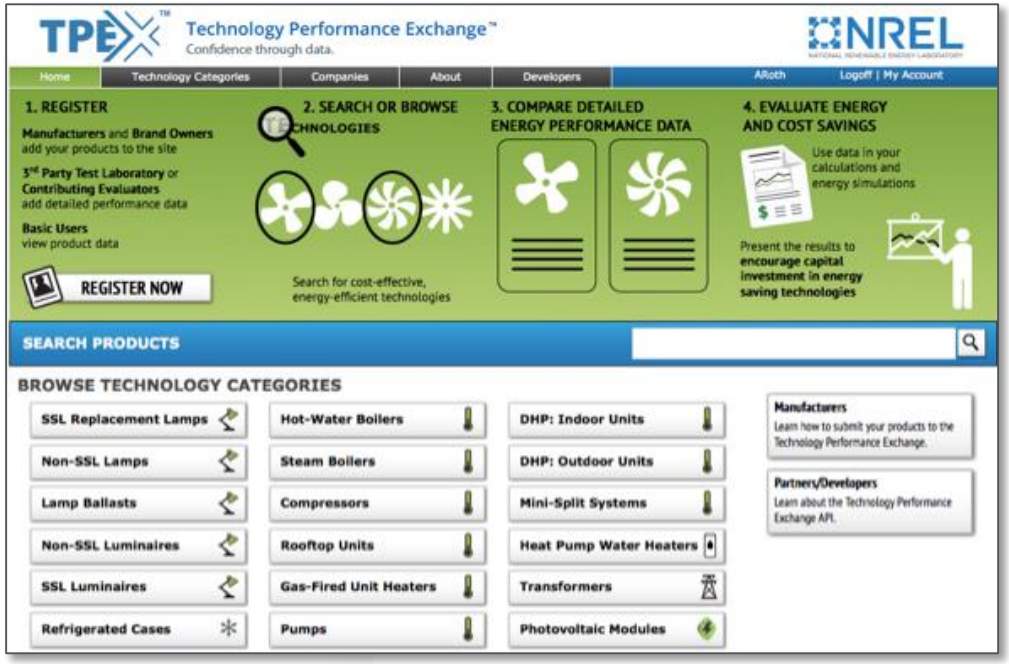
- **Launched in FY14 for new construction incentive programs**
- **Automates:**
  - Notifications
  - Quality checking
  - Reporting
  - Portfolio roll-ups
- **Developed for Xcel Energy**
  - Saved $500k in program admin costs in 1st year of operation
  - Grew from 2 consultants to 10
  - Significant 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**

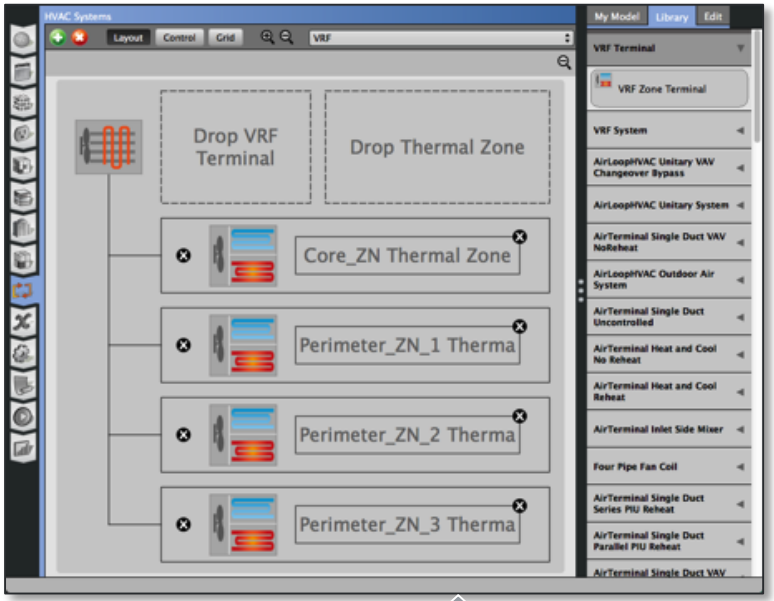


New Resources for a Growing Community



TPEx: Making Product Evaluation Drag-and-Drop Easy



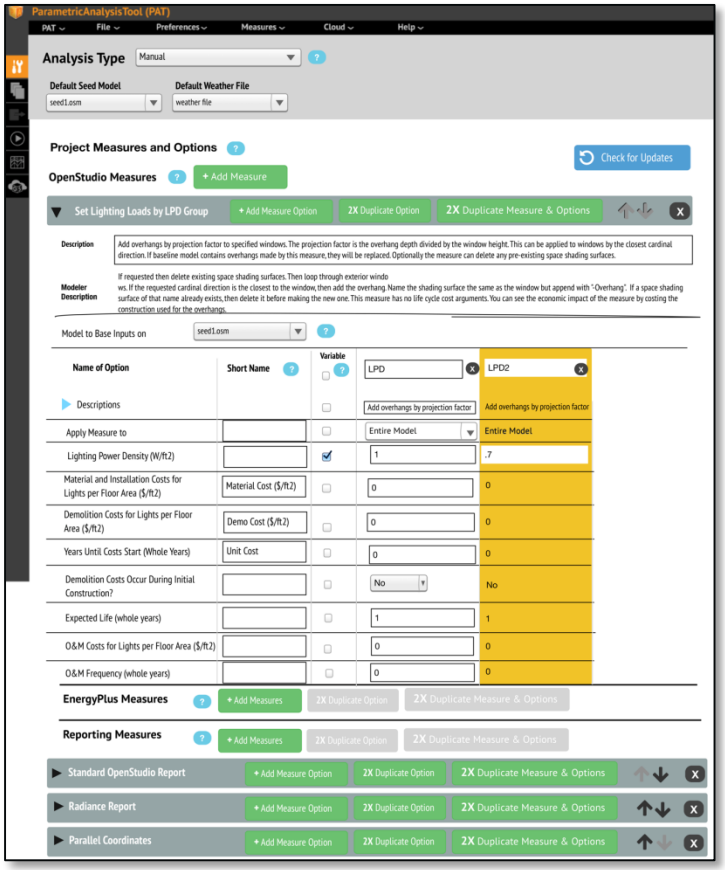


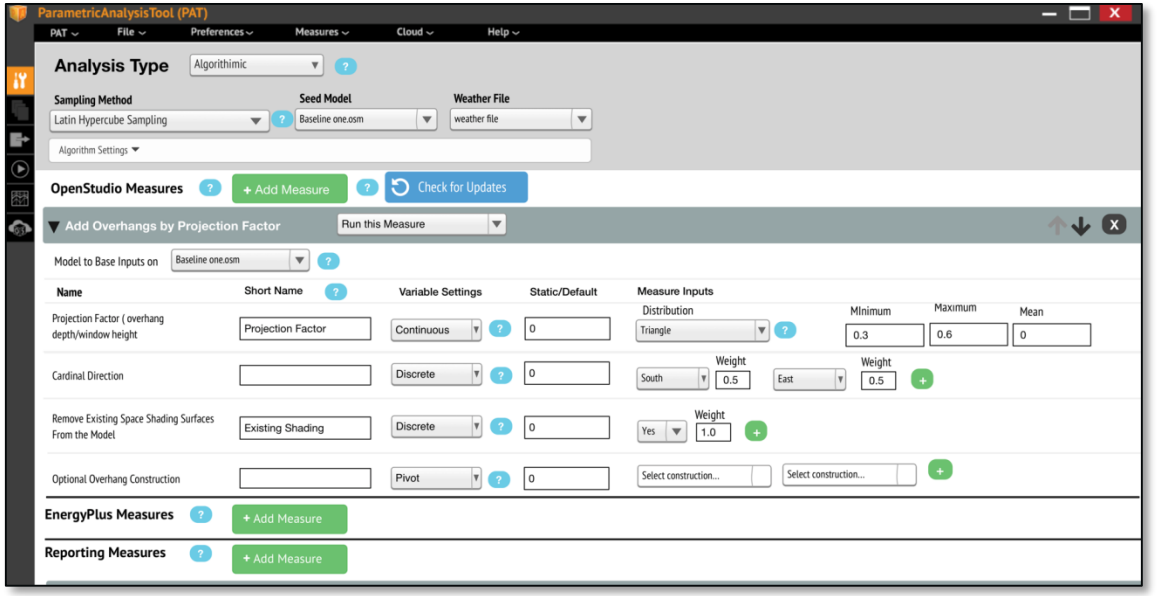
Raw performance data automatically converted into BCL objects

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

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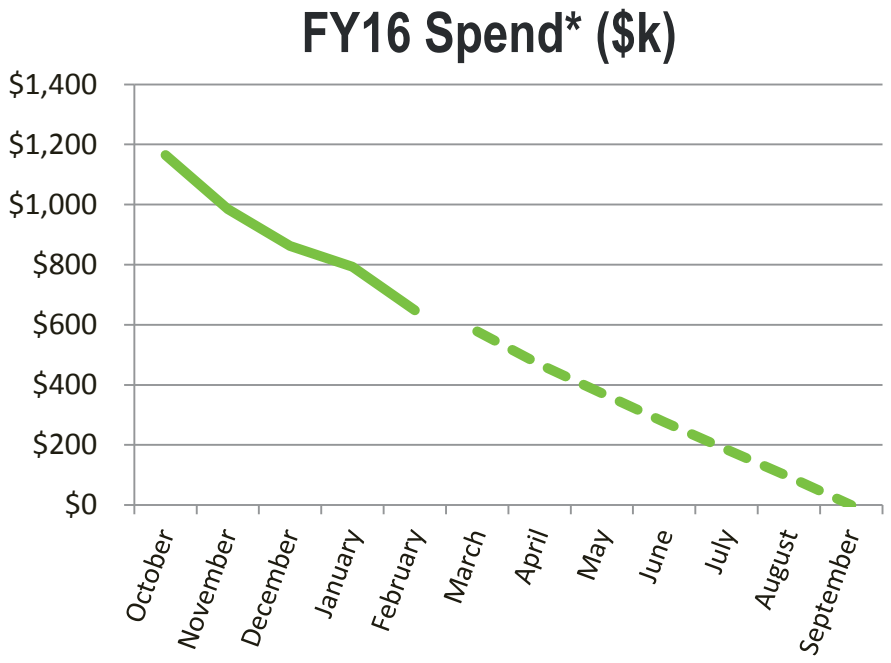
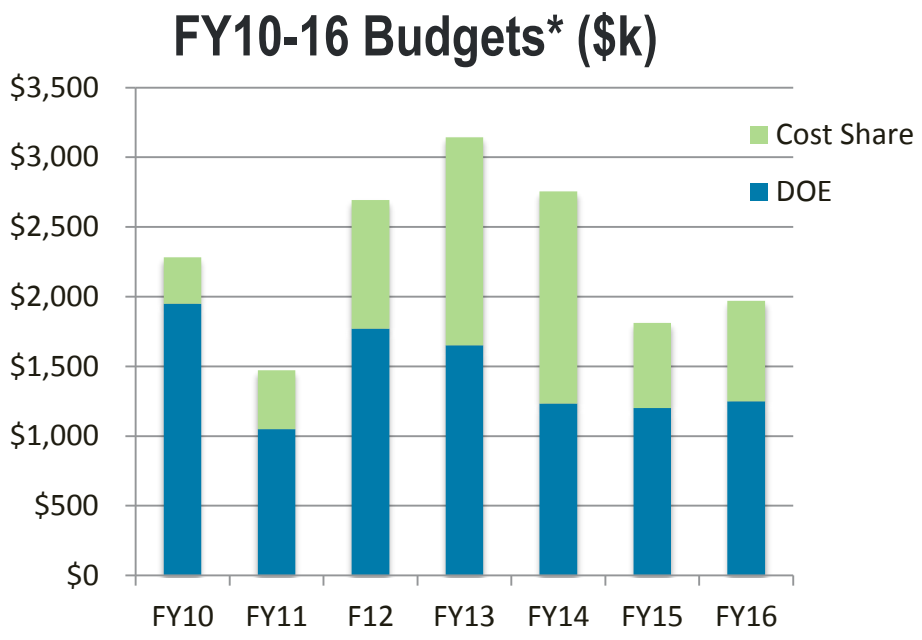
Near-Term Focus Areas

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





Additional Funding Sources:

Xcel Energy

AUSTIN ENERGY

BONNEVILLE POWER ADMINISTRATION

STATE OF CALIFORNIA ENERGY COMMISSION

nationalgrid

NORESCO

NYSERDA

ESTCP

EnergyTrust of Oregon, Inc.

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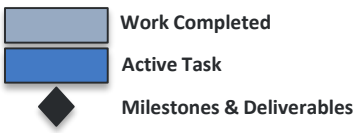
Project Plan and Schedule

Project Initiation Date: Q1/FY10

Planned Completion Date: Ongoing with Frequent Off-Ramping of Components
(e.g. training transitioned to private sector in Q1 FY14)

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



	FY2012				FY2013				FY2014				FY2015				FY2016			
	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Project Name: OpenStudio Core																				
Q1 Milestone: OpenStudio 0.6 Released (Initial BCL Integration with OpenStudio)	◆																			
Q2 Milestone: OpenStudio 0.7 Released (First Version of OpenStudio App with BCL Integration)		◆																		
Q3 Milestone: OpenStudio 0.8 Released (App Suite Workflow Improvements and DEnCity)			◆																	
Q4 Milestone: OpenStudio 0.9 Released (BIM Interop and Initial Support for BCL Measures)				◆																
Q1 Milestone: OpenStudio 0.10 Released (Sim Settings Tab and Backend Work for PAT)					◆															
Q2 Milestone: OpenStudio 0.11 Released (Initial Version of PAT and BCL UGC)						◆														
Q3 Milestone: OpenStudio 1.0 Released (PAT Economics and Measures)							◆													
Q4 Milestone: OpenStudio 1.1 Released (Cloud Support and additional Measures)								◆												
Q1 Milestone: OpenStudio 1.2 Released (Commercial Refrigeration Systems)									◆											
Q2 Milestone: OpenStudio 1.3 Released (HVAC, Refrigeration, and OS Server Improvements)										◆										
Q3 Milestone: OpenStudio 1.4 Released (OS Server Workflow and HVAC Improvements)											◆									
Q4 Milestone: OpenStudio 1.5 Released (HVAC and Performance Improvements, DEnCity Development)												◆								
Q1 Milestone: OpenStudio 1.6 Released (E+ 8.2 and Title 24 Support)													◆							
Q2 Milestone: OpenStudio 1.7 Released (Radiance 3-Phase Support and Usability Improvements)														◆						
Q3 Milestone: OpenStudio 1.8 Released (E+ 8.3 and BIM-Server Support)															◆					
Q4 Milestone: OpenStudio 1.9 Released (Substantial Completion of HVAC Coverage)																◆				
Q1 Milestone: OpenStudio 1.10 Released (E+ 8.4 Support and Performance Improvements)																	◆			
Q2 Milestone: OpenStudio 1.11 Released (E+ 8.5 and Dual Duct Support)																		◆		
Q3 Milestone: OpenStudio 1.12 Released (Code refactor and PAT 2.0 Preview)																			◆	
Q4 Milestone: OpenStudio 2.0 Released (Significant Code Refactor and PAT 2.0)																				◆