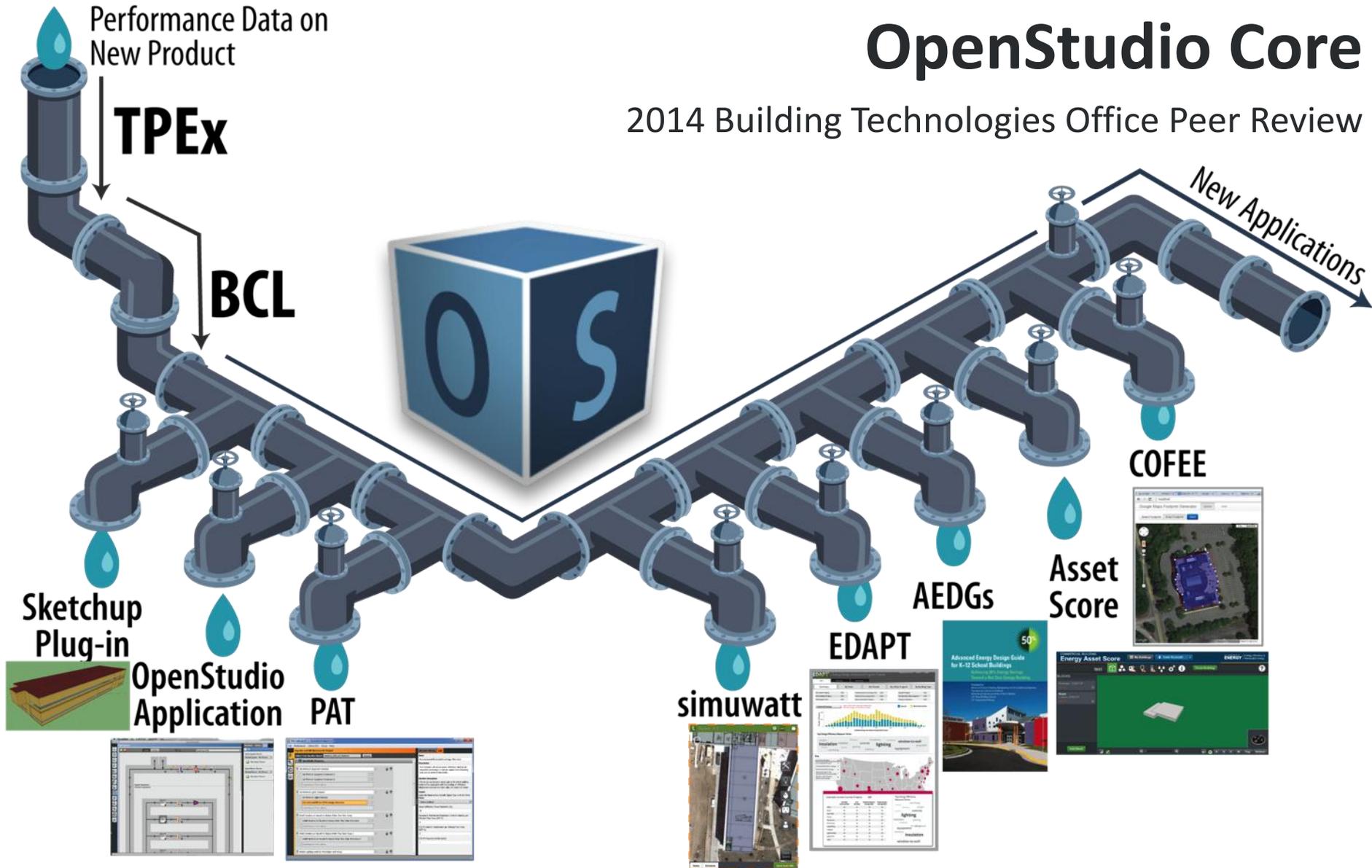


OpenStudio Core

2014 Building Technologies Office Peer Review



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Dr. Larry Brackney, larry.brackney@nrel.gov
National Renewable Energy Laboratory
Oliver Davis, oliver@concept3d.com

concept3D Inc.

Project Summary

Timeline:

Start date: **Q1 FY10**

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

Key Milestones:

1. V1.1 (Cloud) – 9/27/2013
2. V1.2 (Refrigeration) – 12/20/2013
3. V1.3 (HVAC/Refrigeration) – 3/28/2014

Budget:

Total DOE \$ to date: **\$7,655,000***

Total Cost Share to date: **\$4,691,000***

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	concept3D Inc.
BPA	PSD Consulting
Xcel Energy	Multiple Universities
National Grid	Other Private Sector Companies

Project Goal:

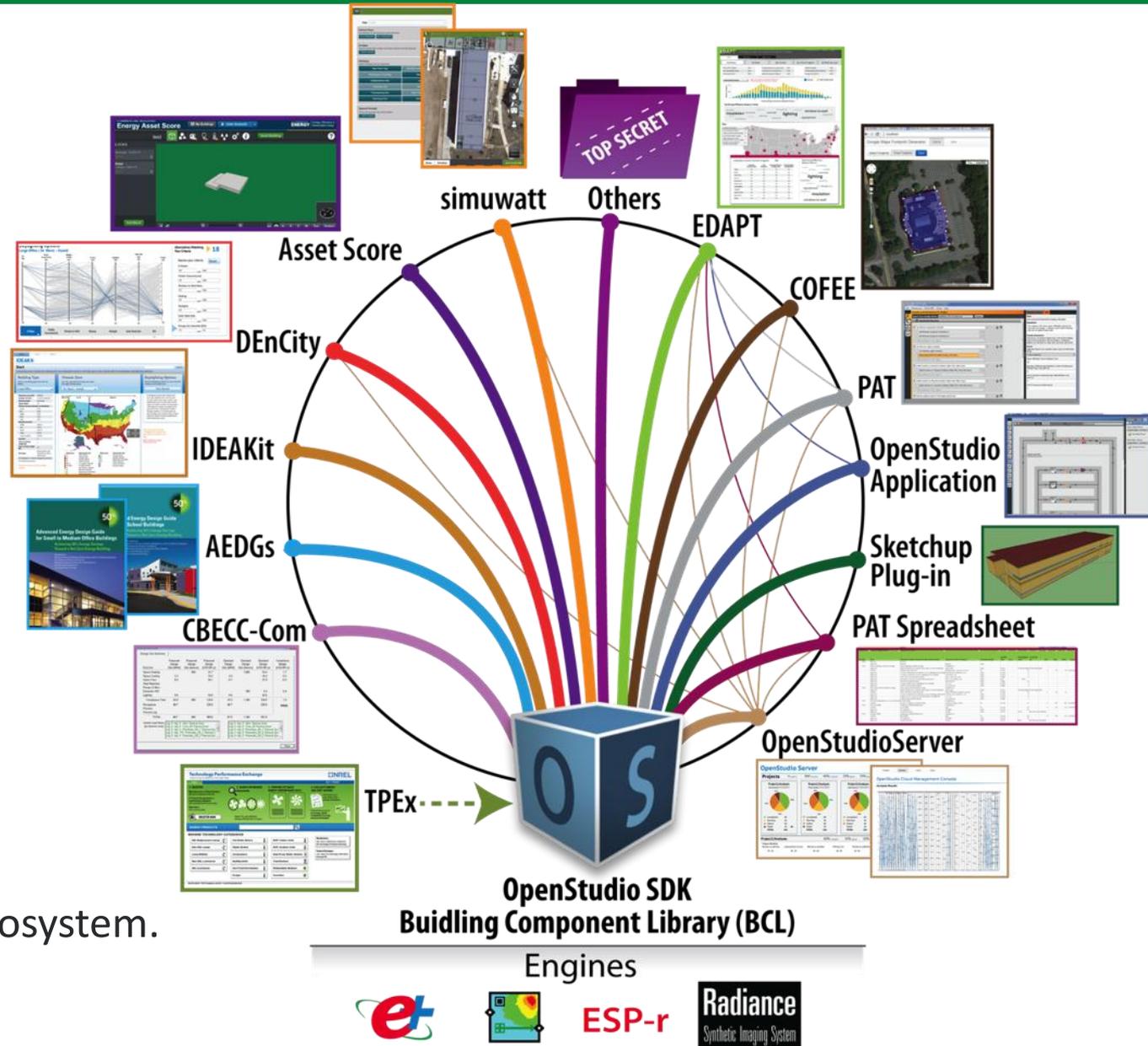
Develop BTO's best-in-class building energy analysis ecosystem to enable rapid, low-cost development of new market facing tools produced by the National Laboratories, Universities, Private Sector, and other agencies.

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 business decisions for their new construction and retrofit portfolios?

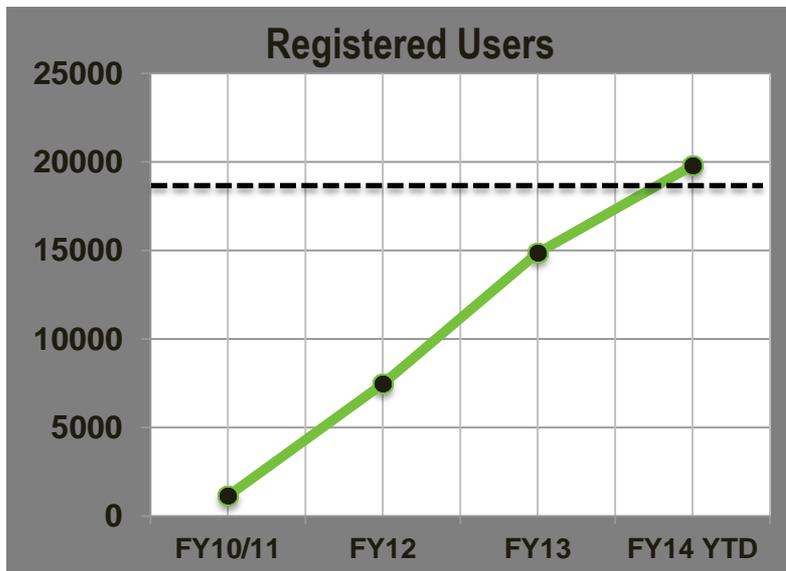
A: DOE's OpenStudio ecosystem.



Target Market and Audience

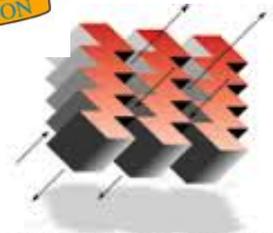
The market for OpenStudio is diverse and includes:

- 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 in FY13/14

Partial List of Partners



Pacific Northwest



Natural Resources Canada / Ressources naturelles Canada

GENABILITY



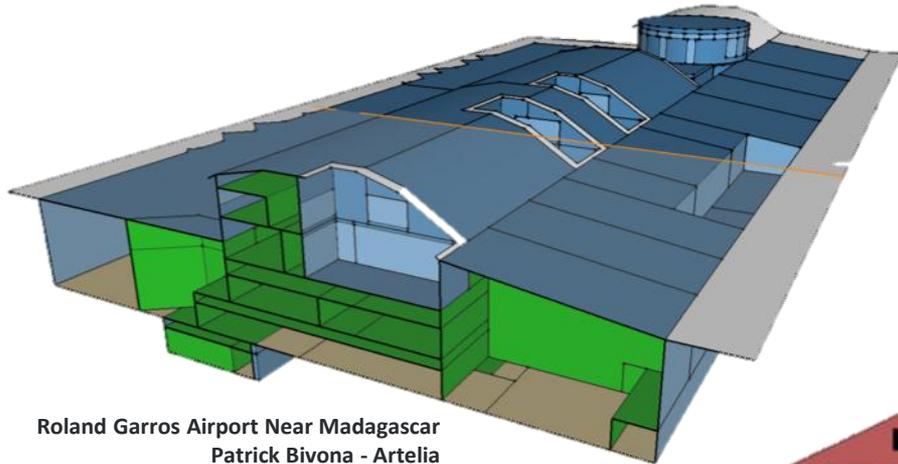
Canada

SPARC

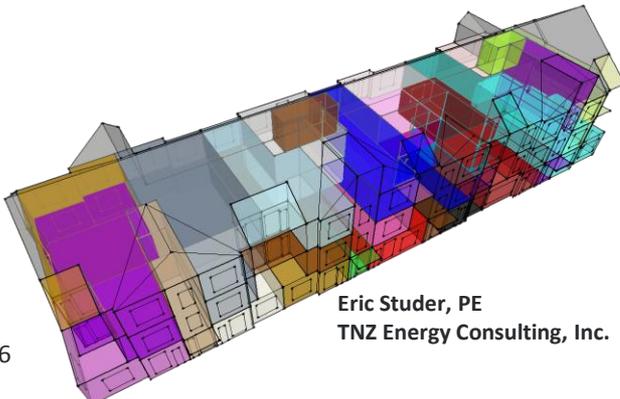


Real Market Adoption = Real Impact

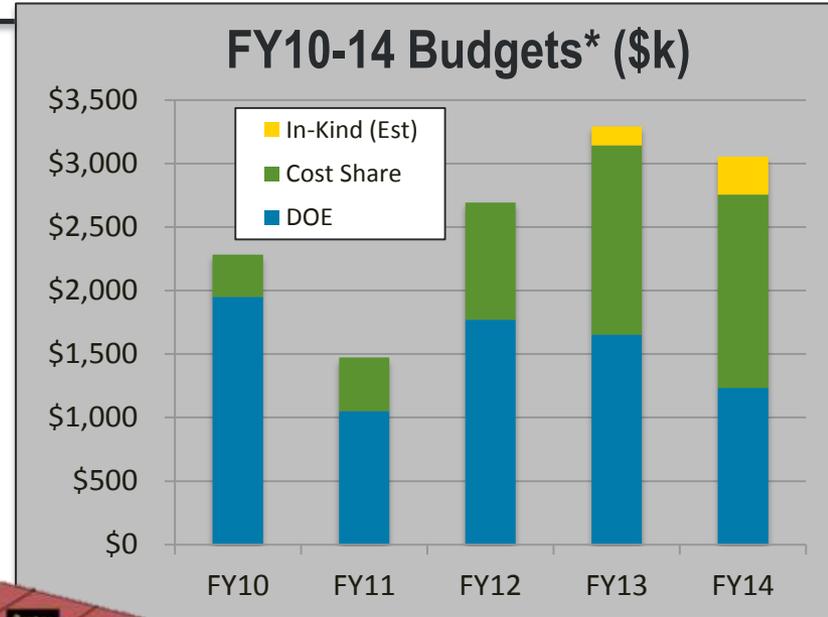
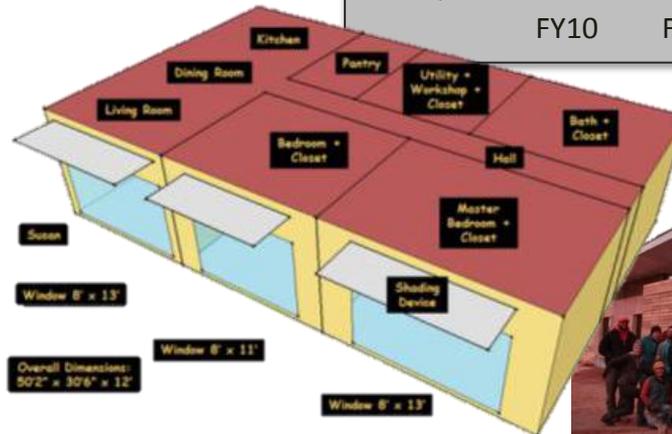
- For Xcel Energy's new construction program OpenStudio is directly contributing to its program savings goal of 40 GWH (up from 30 in 2013)
- Increasing cost-share from private sector
- Example models from practitioners:



Roland Garros Airport Near Madagascar
Patrick Bivona - Artelia



Eric Studer, PE
TNZ Energy Consulting, Inc.



DesignBuildBluff
Southern Utah University and University of Colorado, Denver

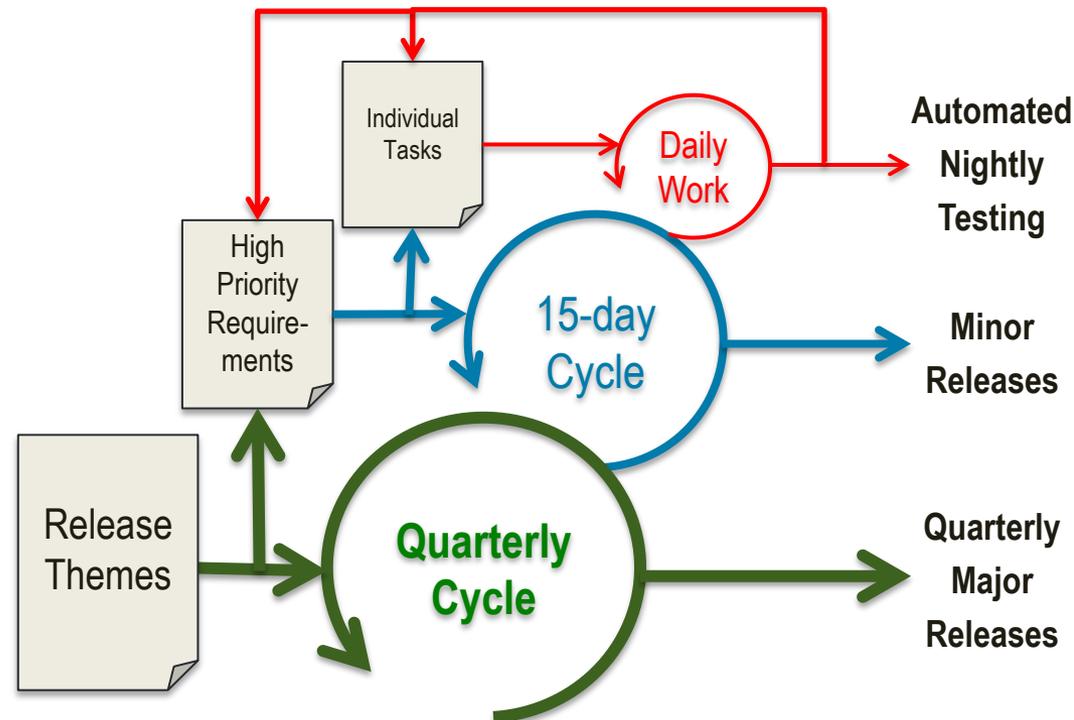
Approach to Development and Deployment

Approach:

- Development team uses an “agile” software development process
 - Formal task and bug tracking systems
 - Automated nightly software build, test, and dashboard 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**



Adapting to Changing Needs



Increased Focus on Collaboration:

- Inclusion of non-NREL developers drove more process formalism
- New processes for better code sharing -> Canary in the coalmine for EnergyPlus
- Greater transparency of development plans on website
 - Key features
 - HVAC roadmap
 - Measures roadmap

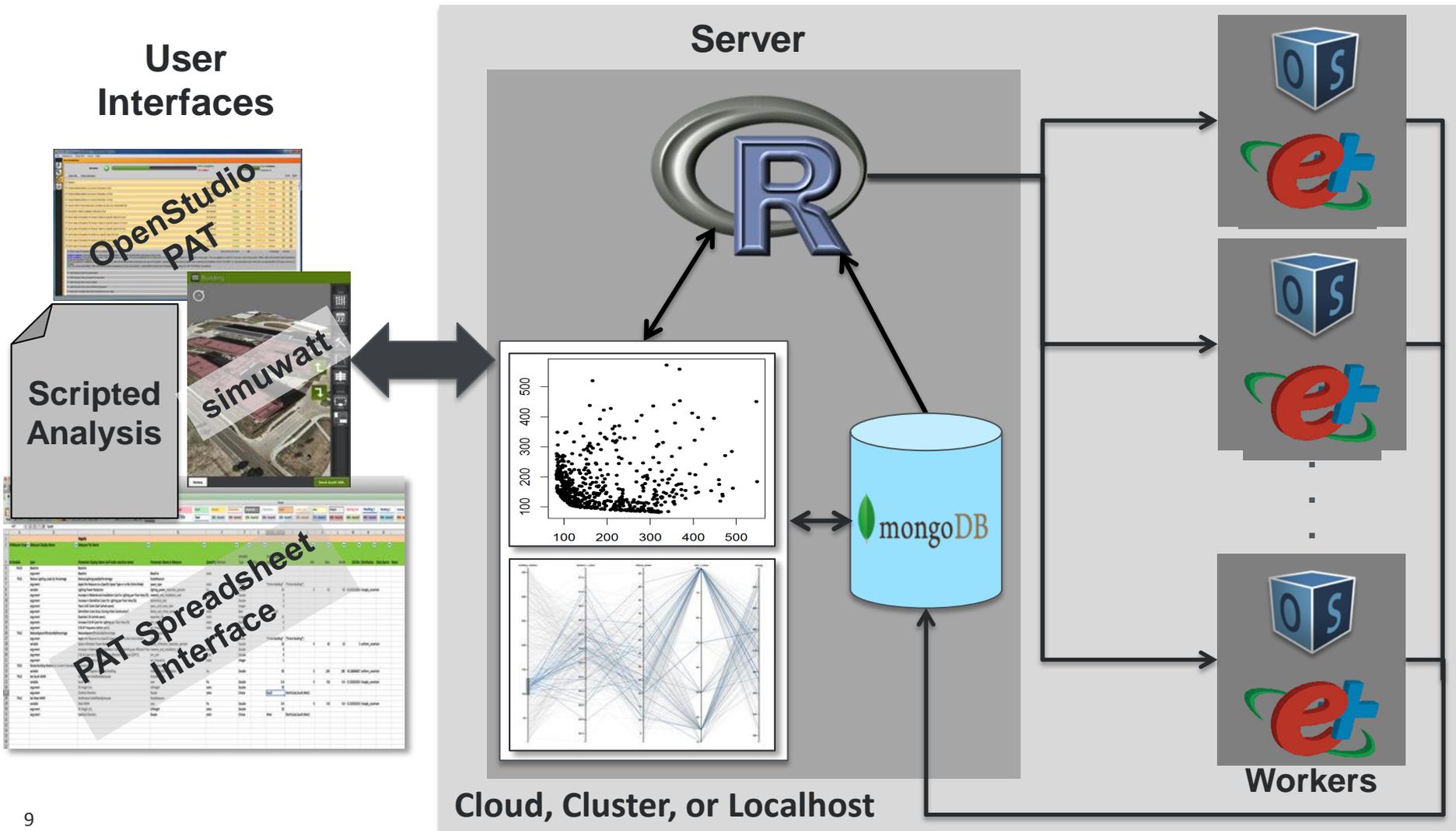
Embracing Agile:

- HVAC coverage initiatives driven by CEC, Xcel, and other market actors
- New software technologies have enabled a more extensible, scalable OpenStudio analysis framework that works well in the cloud
- Solution is enabling us to deliver optimization capability along with our AOP objectives for parametric uncertainty analysis

Master OpenStudio HVAC Roadmap						
Last Updated 4/1/14			Note:			
151 objects are currently visible.			When Adding an object make sure it has a unique ID in column A			
Status						
ID	HVAC SYSTEMS AND EQUIPMENT	OpenStudio Back End Support	OpenStudio GUI support	Planned Release	Priority	OpenStudio approach - E+
129	Inter-Zone Air Transfer	IP - NREL	IP - NREL	1.4 Jun 2014	1	ZoneMixing
153	Unitary HVAC Equipment	No	No	1.4 Jun 2014	1	AirloopHVAC:UnitarySystem
22	Unit Ventilator - Makeup Air Unit	No	No	1.4 Jun 2014	1	ZoneHVAC:OutdoorAirUnit
7	Series Fan Power Boxes	No	No	1.4 Jun 2014	1	AirTerminal:SingleDuct:Series
24	Evaporative Cooler Systems - Indirect	No	No	1.4 Jun 2014	1	EvaporativeCooler:Indirect
150	OA Pre-treat Setpoint Manager	No	No	1.5 Sep 2014	1	SetpointManager:OutdoorAir
90	Water-side economizer	No	No	1.5 Sep 2014	1	HeatExchanger:FluidToFluid
151	Setpoint Manager Scheduled Dual Setpoint	No	No	1.5 Sep 2014	1	SetpointManagerScheduled
147	Duct Heat Loss	No	No		1	How do we do this in E+?
132	Indoor and Outdoor Pipes (for modeling steam and hw losses)	No	No		1	Pipe:Indoor and Pipe:Outdoor
152	Air System Bypass (For modeling CAV AHU with VAV terminals)	No	No		1	Duct (E+ analog for pipe ad
110	Air Distribution System - Underfloor air distribution	No	No		1	DesignSpecification:ZoneAir
116	Chilled water loop - Primary and secondary	No	No		1	Need Water-to-Water Heat
125	HVAC Controls - AHU Static Pressure Reset	No	No		1	SetpointManager:Warmest
130	Heat Pipe (wraparound heat pipe coil)	No	No		1	How do we do this in E+?
131	Packaged Water-cooled DX coupled with Zone hw heating coil	No	No		1	How do we do this in E+?
12	Dual Duct Sytems	No	No		2	
140	Solar Thermal	No	No		2	Look at SolarCollectorFlatPl
30	Adiabatic humidification	No	No		2	
59	Ground Source Heat Pump - Horizontal Loops (straight tube/slinky tube)	No	No		2	
69	Thermal Storage - Chilled Water Storage	No	No		2	
71	Thermal Storage - Ice Storage	No	No		2	Very common in NE in schoo
112	Air Distribution System - Displacement ventilation	No	No		2	ZoneVentilation:DesignFlow
118	Condenser Heat Recovery	No	No		2	
133	Wastewater heat reclaim	No	No		2	How do we do this in E+?
134	Duct Leakage	No	No		2	ZoneHVAC:AirDistributionU
135	Induction air systems - high pressure airloop w/ induction terminals	No	No		2	How do we do this in E+?
136	Water-cooled server racks	No	No		2	How do we do this in E+?
137	Hot water tank heated by a heat exchanger from another HW loop	No	No		2	Is this already in the backen
141	Runaround loop heat recovery	No	No		2	Commonly used for retrofit
29	Dessicant Cooling - Solid Dessicant Dehumidification	No	No		3	
47	Chiller - Electric Centrifugal with heat recovery	No	No		3	Duplicate of row up further
48	Chiller - Absorption Chiller with water-cooled condensor (single stage/two st	No	No		3	PSD thinks that steam-fired
91	Natural Ventilation	No	No		3	Perhaps add simple ventilat

Major Accomplishment – Cloud Support

Significance: Practitioners now have access to scalable computing resources on par with National Laboratories allowing them to consider more measures in less time.

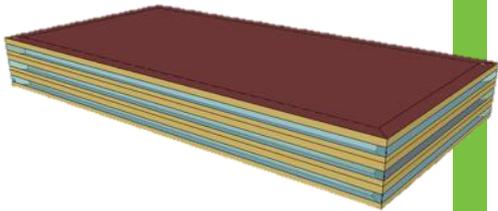


Major Accomplishment – Sensitivity Analysis for Asset Score

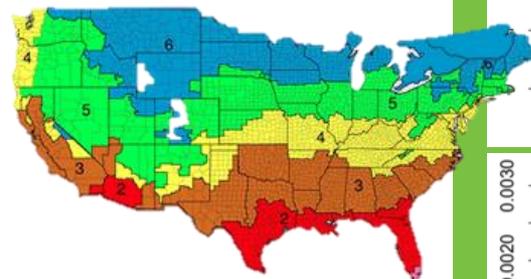
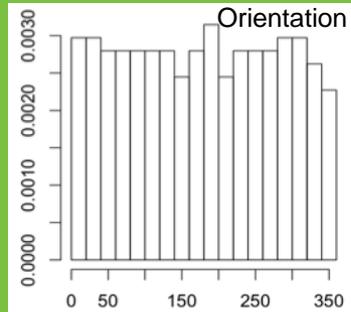
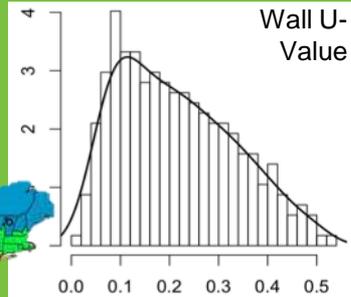
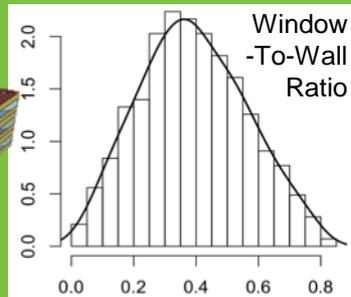
Significance: Practitioners and researchers can now easily assess the impact of uncertainty on energy efficiency for a broad range of parameters.



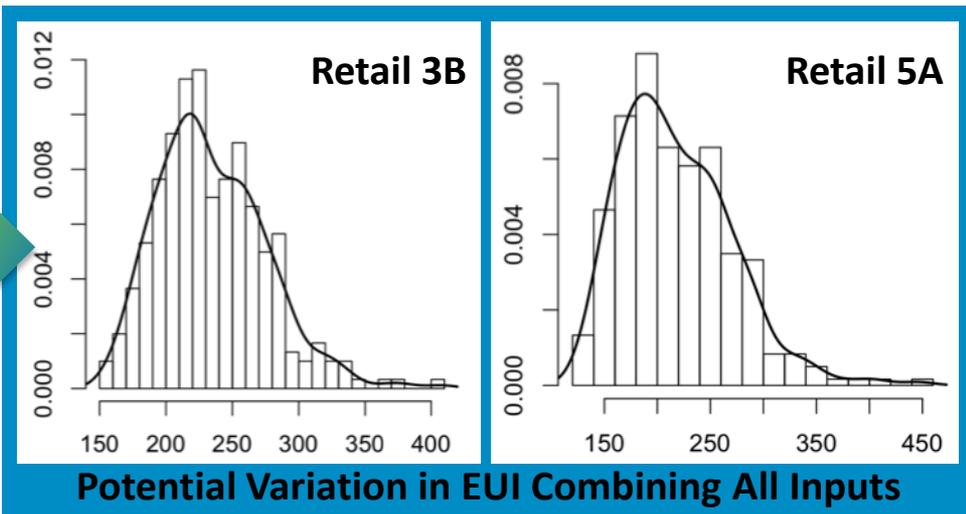
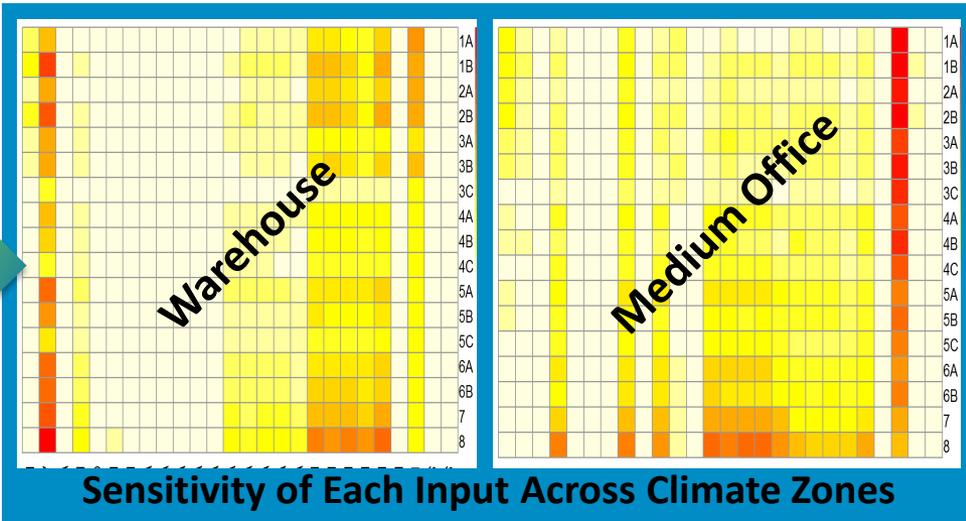
Baseline Models for Major Building Types



OpenStudio Measures for Major Sources of Variation



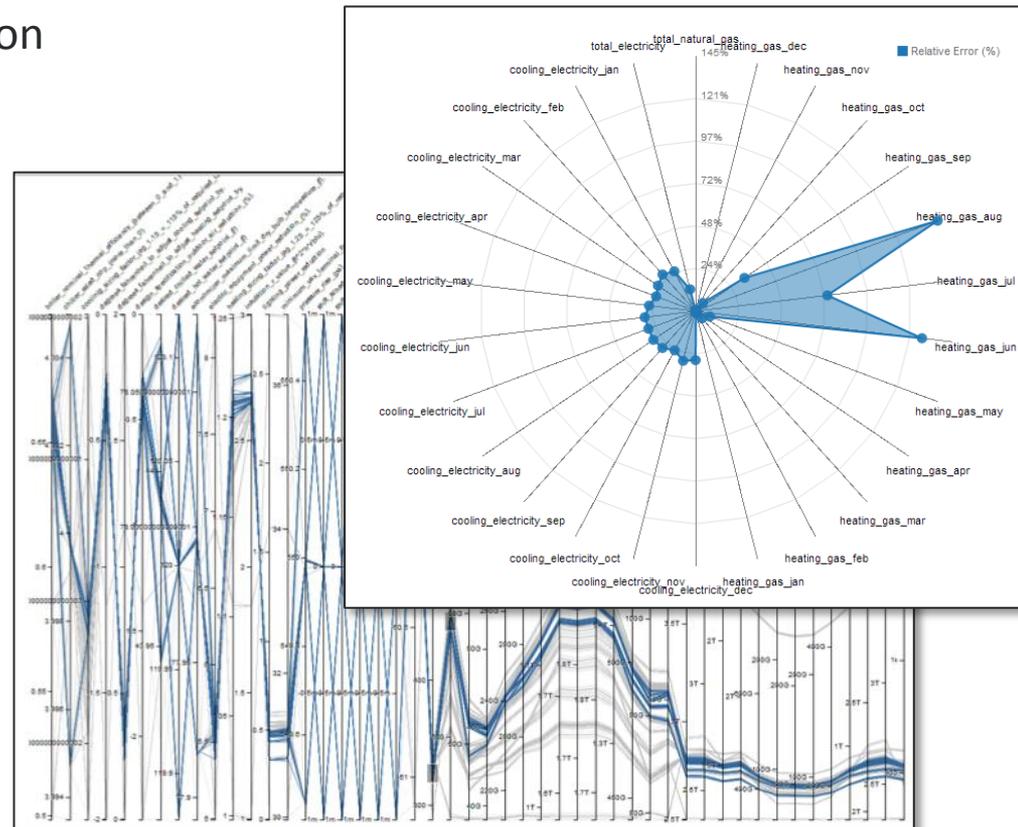
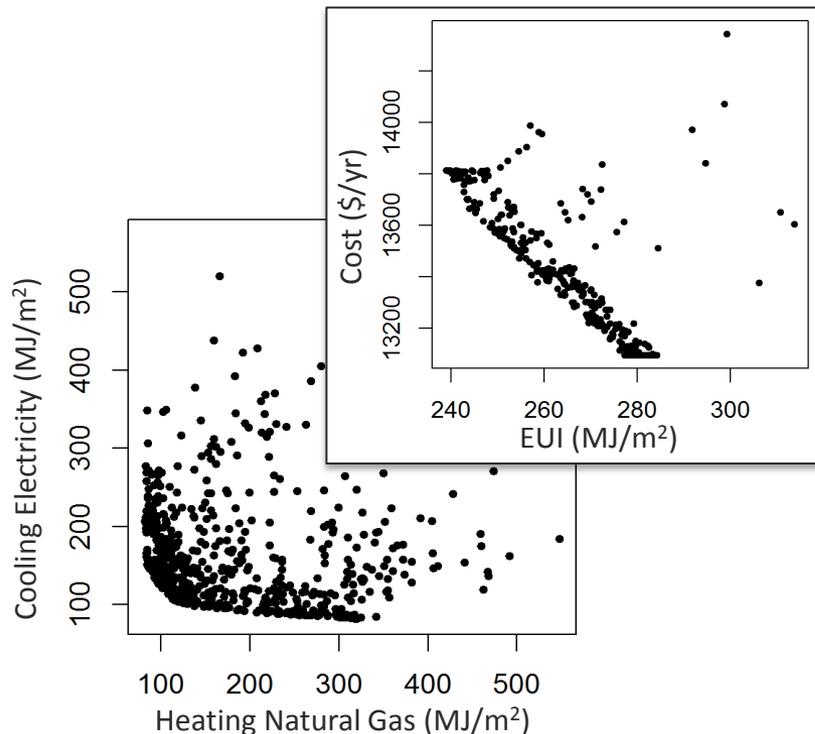
Climate Zones



Major Accomplishment – Optimization*

Significance: Practitioners and researchers can now easily optimize measures and associated parameters for design or to calibrate models.

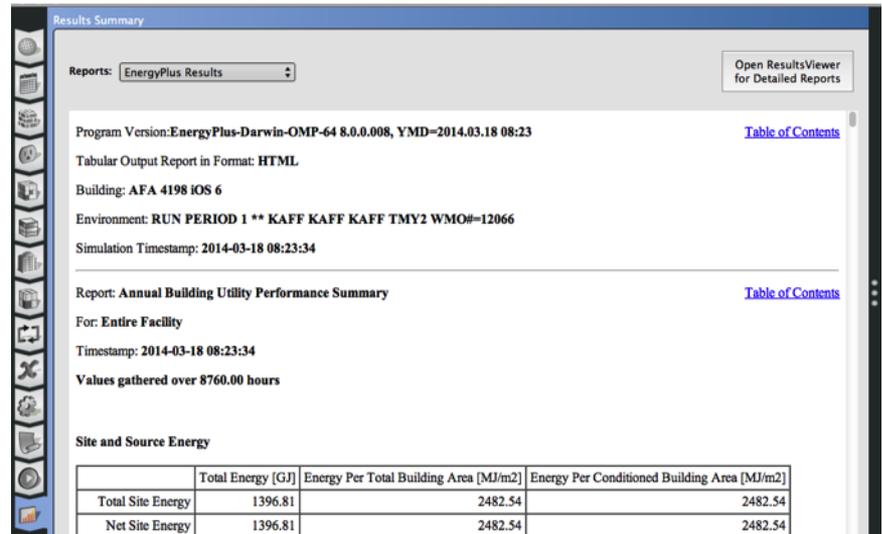
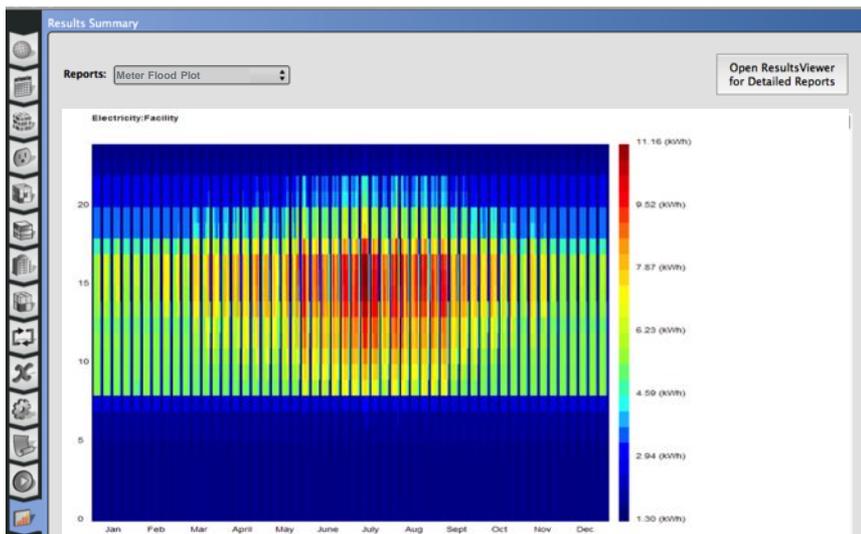
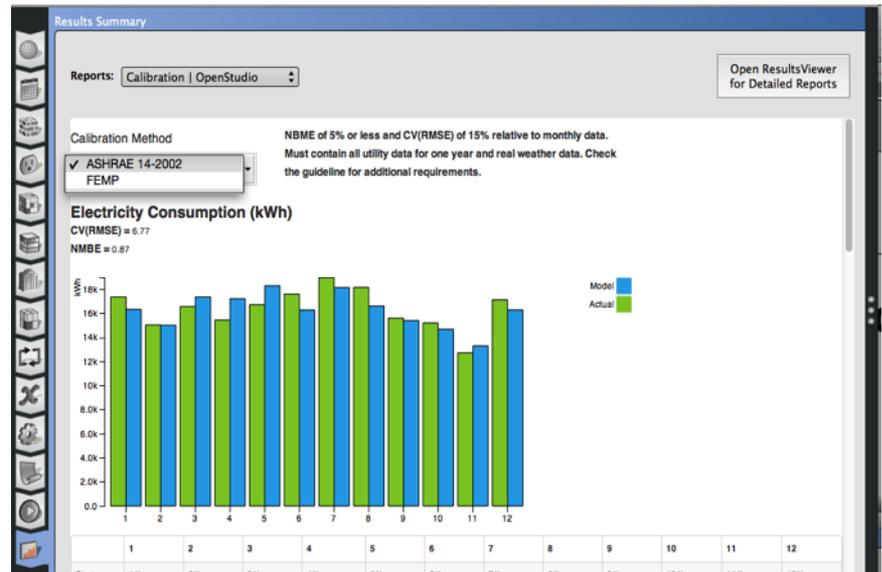
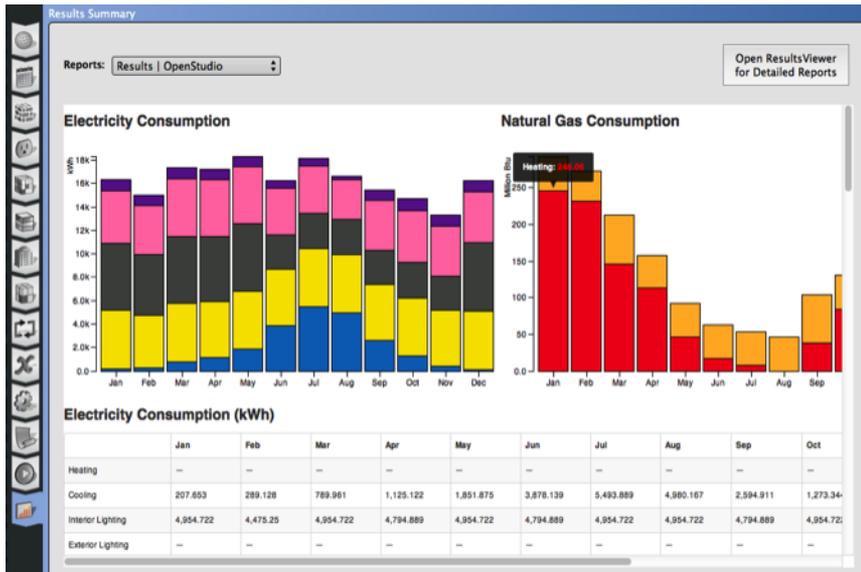
- Multiple algorithms (easily extended via R)
- Supports discrete and continuous variables
- Customizable multi-objective optimization
- Interactive visualization tools built into OS Server help explore large solutions spaces



* Not an AOP deliverable, but something the new analysis framework allowed us to deliver with little additional effort.

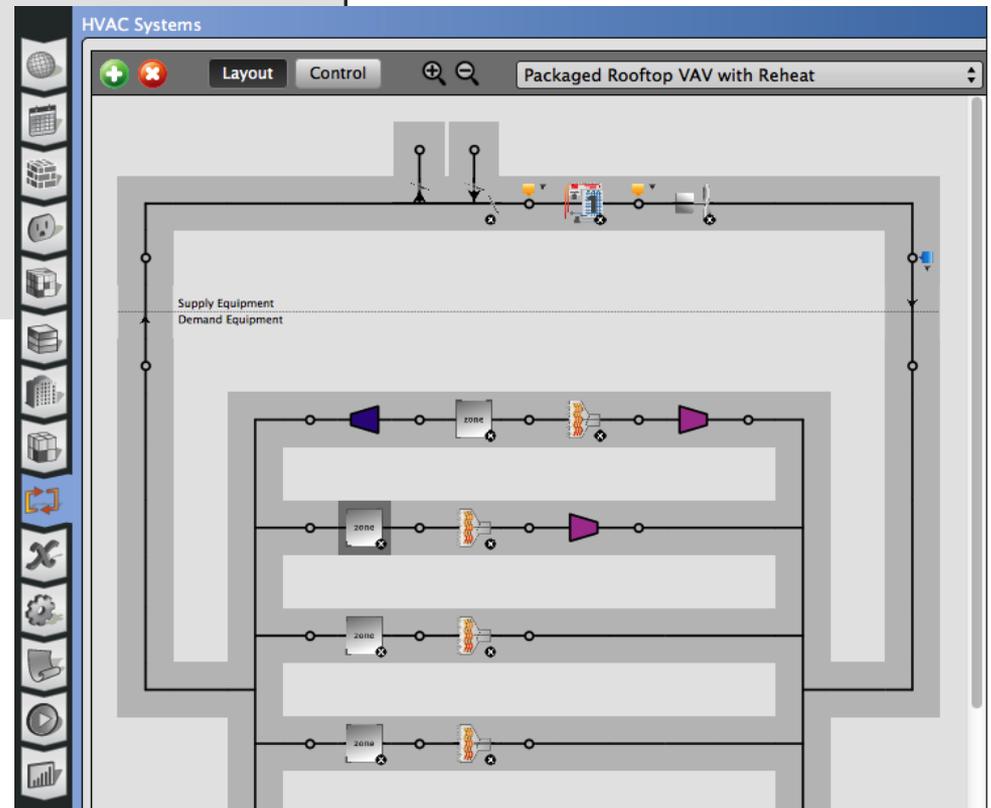
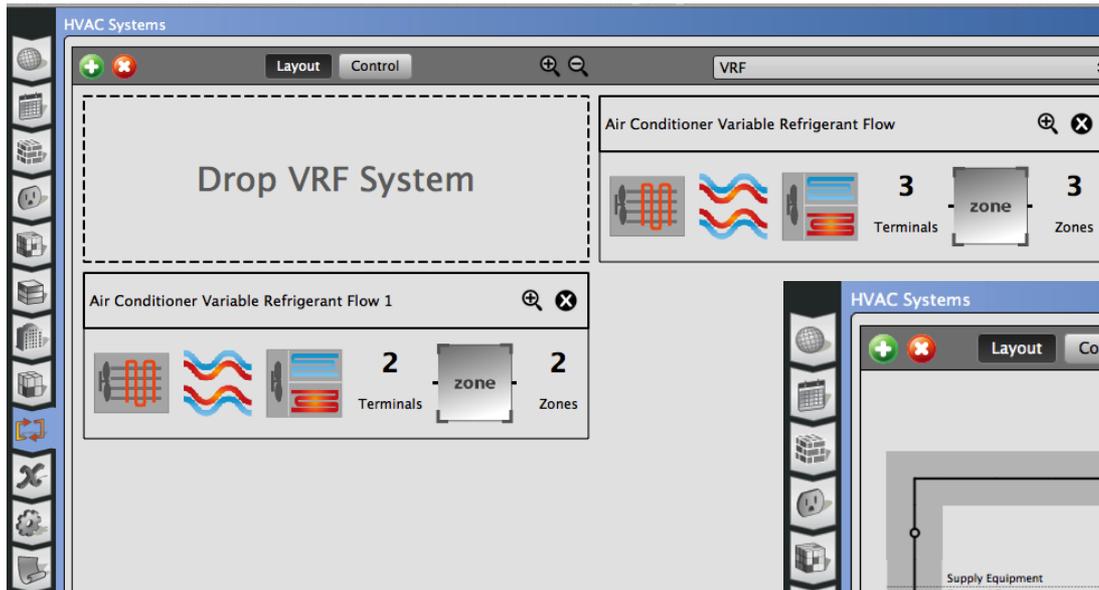
Major Accomplishment – Extensible Results Reporting

Significance: Practitioners can now easily extend the OpenStudio application with their own custom reports via reporting measures.



Major Accomplishment – Additional HVAC Systems

Significance: Much progress made on exposing the breadth of EnergyPlus' HVAC modeling capabilities as prioritized by project needs.



New systems include:

- Variable Refrigerant Flow
- Plenums
- Ground Source Heat Pumps (Vertical Well)
- Chilled Beams
- Exhaust Fans
- Radiant Slabs
- Baseboard Heating
- Demand Control Ventilation
- Many more complete or in process

Major Accomplishment – Commercial Refrigeration

Significance: Commercial refrigeration modeling is now “drag-and-drop” easy.



The screenshot displays the HVAC Systems software interface. The main window shows a schematic diagram of a refrigeration system with components like a compressor, condenser, evaporator, and piping. A sidebar on the right lists various components for selection, including Fan Constant Volume, Fan Variable Volume, Heat Exchanger Air To Air Sensible and Latent, Pipes, Pump Variable Speed, Pump Constant Speed, Refrigeration Case, Refrigeration Condenser Air Cooled, Refrigeration Condenser Evaporative Cooled, Refrigeration Condenser Water Cooled, Refrigeration Condenser Cascade, Refrigeration Compressor, Refrigeration Subcooler Liquid Suction, Refrigeration Subcooler Mechanical, Refrigeration System, and Refrigeration Walkin.

The bottom panel shows the configuration for a 'Refrigeration Case'. The 'Display Cases' section includes a table with the following data:

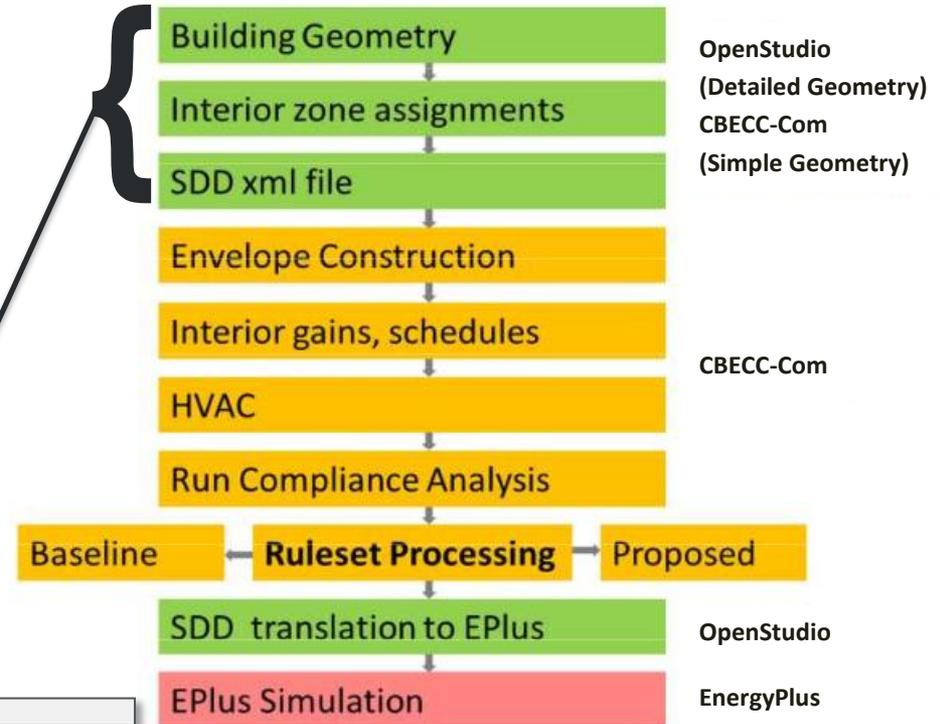
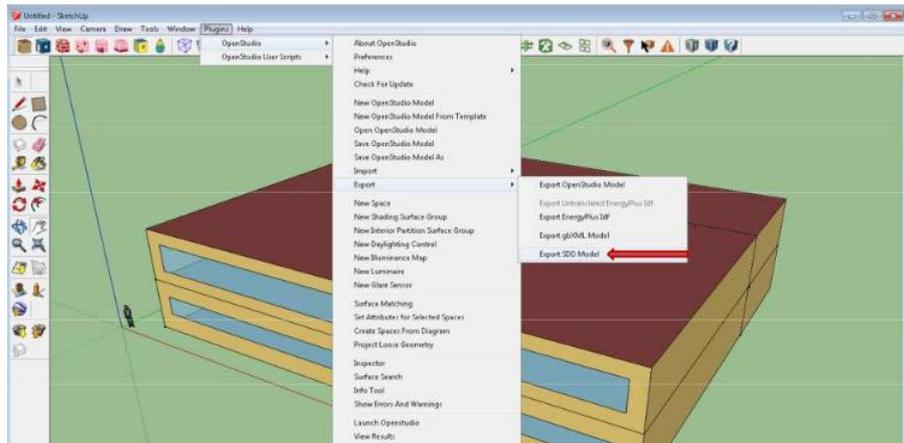
Name	Case Anti Sweat Heater Power per Unit Length	Anti Sweat Heater Control Type	Minimum Anti Sweat Heater Power per Unit Length	Humidity at Zero Anti Sweat Heater Energy	Fraction of Anti Sweat Heater Energy to Case
Refrigeration Case	0.000000 W/m	None	0.000000 W/m	-10.000000	1.000000
Refrigeration Case 1	0.000000 W/m	None	0.000000 W/m	-10.000000	1.000000
Refrigeration Case 2	0.000000 W/m	None	0.000000 W/m	-10.000000	1.000000
Refrigeration Case 3	0.000000 W/m	None	0.000000 W/m	-10.000000	1.000000
Refrigeration Case 4	0.000000 W/m	None	0.000000 W/m	-10.000000	1.000000
Refrigeration Case 5	0.000000 W/m	None	0.000000 W/m	-10.000000	1.000000
Refrigeration Case 6	0.000000 W/m	None	0.000000 W/m	-10.000000	1.000000

The 'Walk Ins' section below the table includes a table for configuring walk-in units:

Name	Rack	Thermal Zone
Refrigeration Walk In	Refrigeration System 1	
Refrigeration Walk In 1	Refrigeration System 1	

Major Accomplishment – CEC Title 24 Compliance Tool

- Version 1 of CBECC-Com certified 9/2013
- Certification for version 2 expected 4/2014

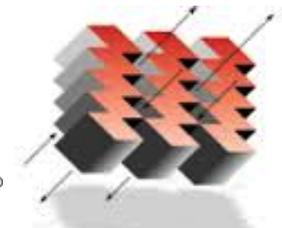


End Use	Proposed Design Site (MWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft ² -yr)	Standard Design Site (MWh)	Standard Design Site (therms)	Standard Design (kTDV/ft ² -yr)	Compliance Margin (kTDV/ft ² -yr)
Space Heating		292	10.0		292	10.0	
Space Cooling	9.9		71.6	9.9		71.7	0.1
Indoor Fans	19.6		81.0	19.6		81.0	
Heat Rejection Pumps & Misc.							
Domestic HW		169	5.0		169	5.0	
Lighting	7.9		35.8	7.9		35.8	
Compliance Total	37.4	461	203.5	37.4	461	203.6	0.2
Receptacle Process	23.6		109.8	23.6		109.8	
Process Ltg							
TOTAL	60.9	461	313.3	61.0	461	313.4	

Unmet Load Hours: (by thermal zone)

clg: 0 htg: 0 'Attic Thermal Zone'	clg: 0 htg: 0 'Attic Thermal Zone'
clg: 0 htg: 0 'Core_ZN Thermal Zone'	clg: 0 htg: 0 'Core_ZN Thermal Zone'
clg: 0 htg: 0 'Perimeter_ZN_1 Thermal Zone'	clg: 0 htg: 0 'Perimeter_ZN_1 Thermal Zone'
clg: 0 htg: 0 'Perimeter_ZN_2 Thermal Zone'	clg: 0 htg: 0 'Perimeter_ZN_2 Thermal Zone'
clg: 0 htg: 0 'Perimeter_ZN_3 Thermal Zone'	clg: 0 htg: 0 'Perimeter_ZN_3 Thermal Zone'

Result: **PASS**

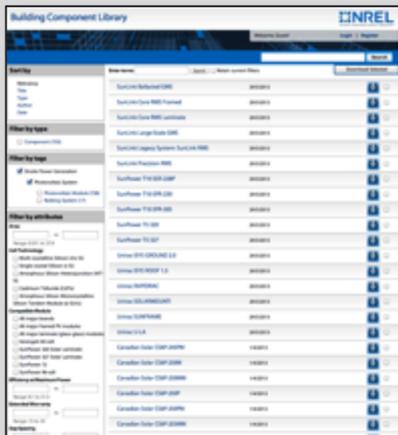


Energy Efficiency & Renewable Energy

concept3D Inc. and simuwatt Energy Auditor



Building Component
Library (BCL)



CRADA

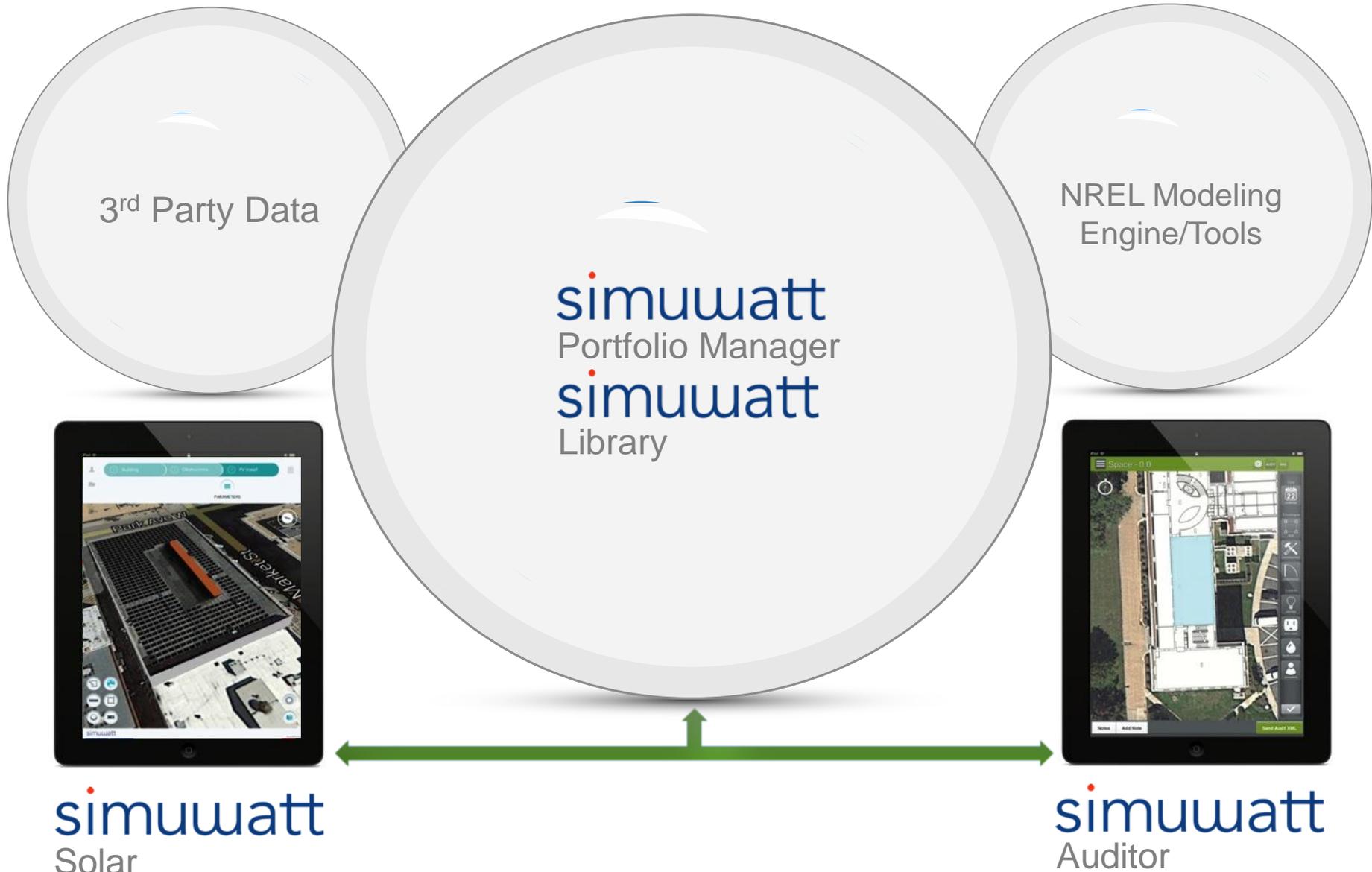


Go to Market Summer 2014

Benefits

- Streamlined, high quality commercial energy audits (Level II, III)
- Lower the cost of energy audits by 35-75%
- Consistent, standardized and reusable data format
- Access data from the cloud and share projects
- Custom reporting and output
- Asset tracking and building lifecycle tracking
- Opportunity for benchmarking and portfolio tracking

simuwatt Cloud and Applications



simuwatt Energy Auditor Workflow Overview

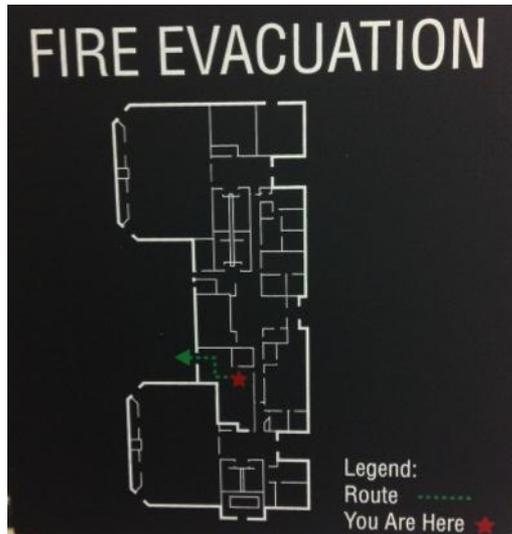
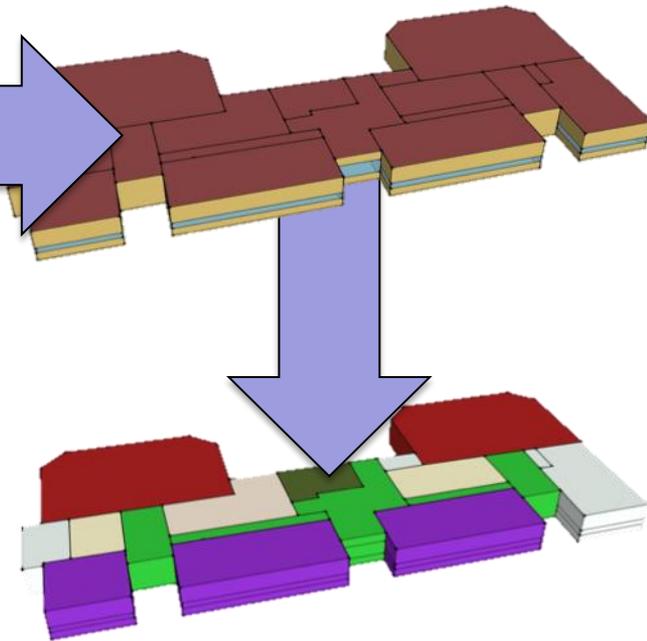


Photo of on-site evacuation plan



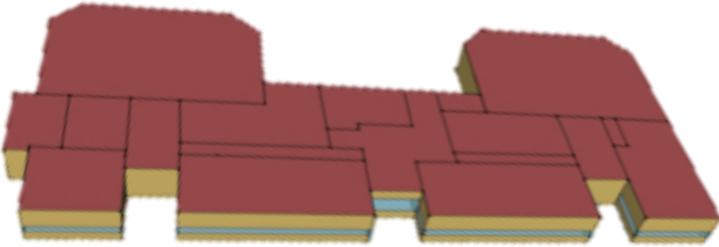
Google Maps satellite imagery



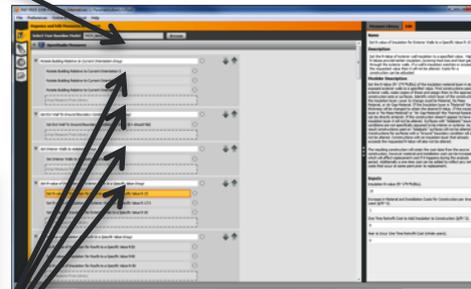
- **OpenStudio automatically generates a detailed energy model ready for simulation**



simuwatt Energy Auditor Workflow Overview

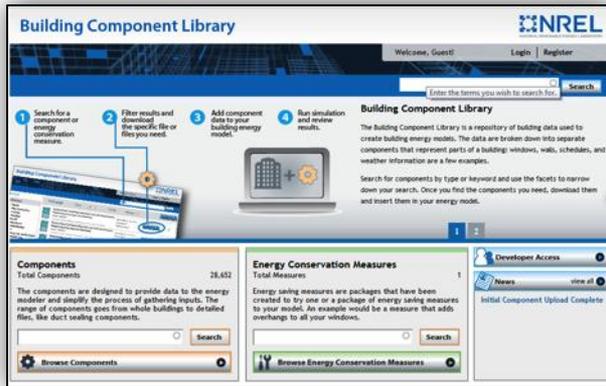
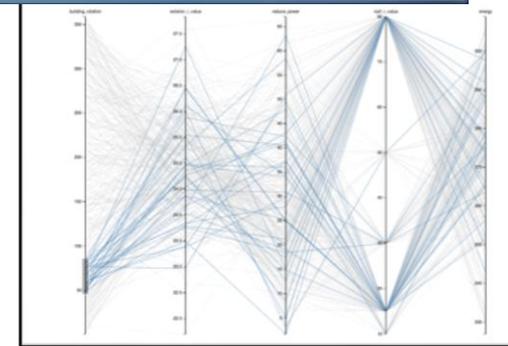


Baseline Model



OpenStudio Parametric Analysis Tool (PAT)

Measure	Energy Use Intensity (kBtu/ft ² ·yr)	Peak Electric Demand (kW)	Electricity Consumption (kBtu/ft ² ·yr)	Natural Gas Consumption (kBtu/ft ² ·yr)	District Cooling Consumption (kBtu/ft ² ·yr)	District Heating Consumption (kBtu/ft ² ·yr)	Peak Year Capital Cost (\$)	Annual Energy Cost (\$)	Annual Energy Cost (\$/ft ²)	Total LCC (\$)
Baseline	111	122	893,000	1,800	0	0	1,800,000	18,000	18,000	1,818,000
Energy Star Resource Reduction (R50)	28	22	174,000	211	0	0	1,700	1,700	1,700	180,000
Energy Star Resource Reduction (R50) + R50	8	20	18,750	21	0	0	1,700	1,700	1,700	18,000
Energy Star Resource Reduction (R50) + R50 + R50	4	20	18,750	21	0	0	1,700	1,700	1,700	18,000
Energy Star Resource Reduction (R50) + R50 + R50 + R50	22	20	18,000	117	0	0	1,800	1,800	1,800	18,000
Energy Star Resource Reduction (R50) + R50 + R50 + R50 + R50	14	20	18,750	110	0	0	1,700	1,700	1,700	18,000
Energy Star Resource Reduction (R50) + R50 + R50 + R50 + R50 + R50	22	20	18,750	110	0	0	1,800	1,800	1,800	18,000



Building Component Library: Online Database of Measures

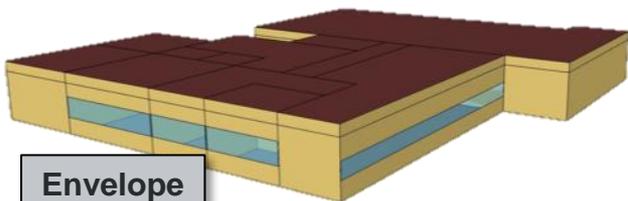
- Life cycle analysis identifies most cost-effective measures



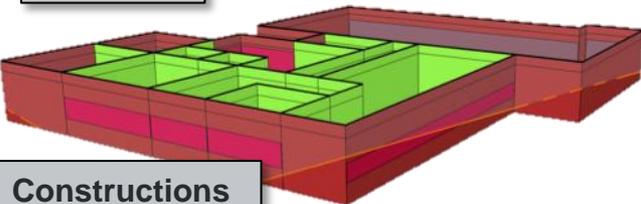
Ft. Jackson Bldg 10400

simuwatt Energy Auditor Case Study

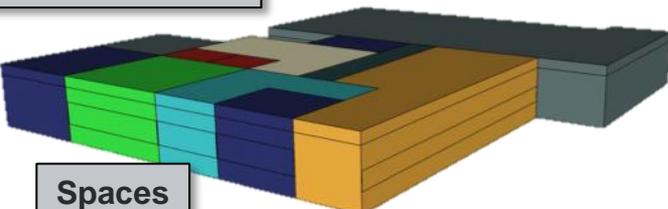
Envelope



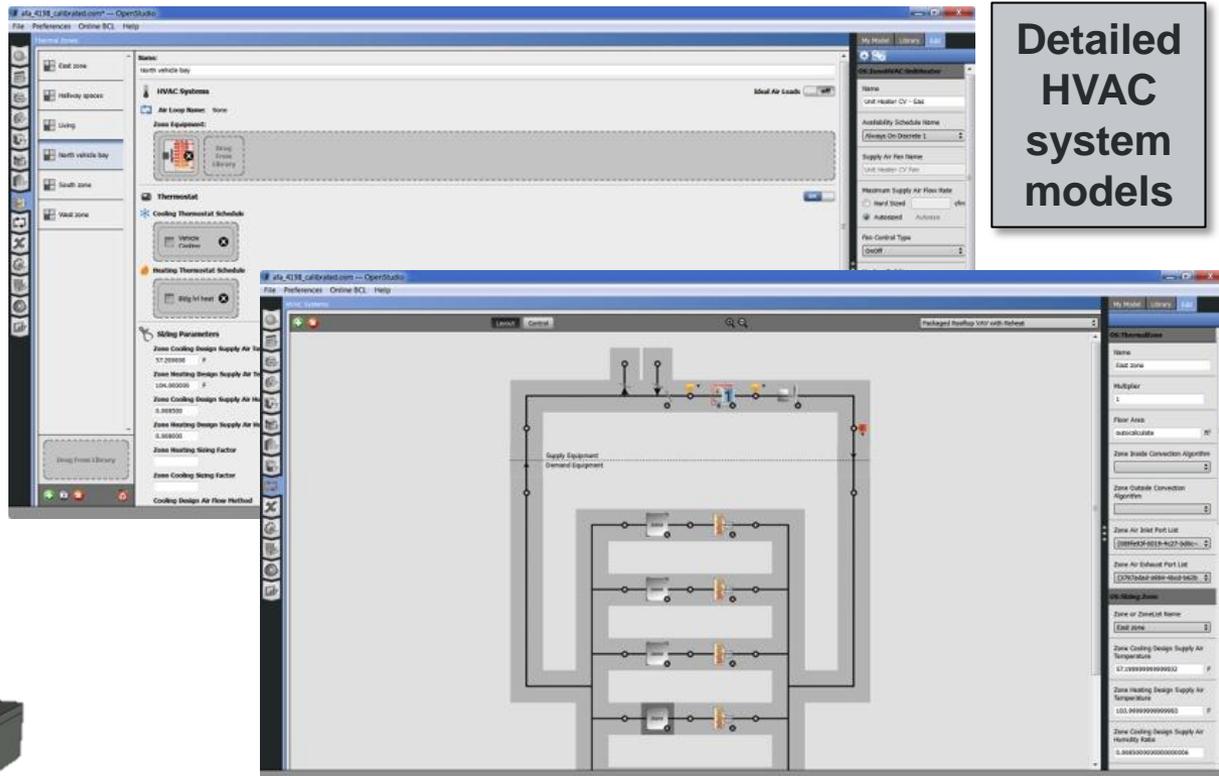
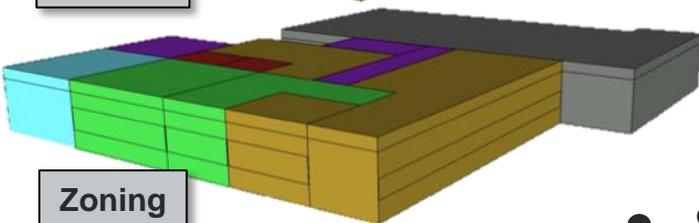
Constructions



Spaces



Zoning



Detailed
HVAC
system
models

- simuwatt and OpenStudio produce the complete model needed for rigorous energy analysis



AFA Bldg 4198

simuwatt Energy Auditor Case Study

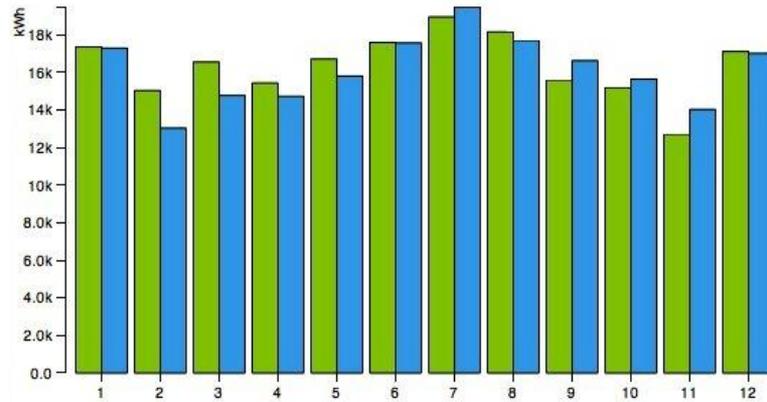
Calibration Method

ASHRAE 14-2002

NBME of 5% or less and CV(RMSE) of 15% relative to monthly data.
Must contain all utility data for one year and real weather data. Check the guideline for additional requirements.

Electricity Consumption (kWh)

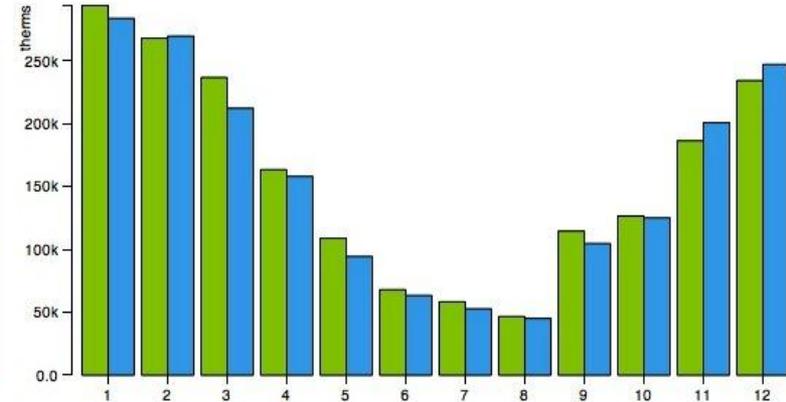
CV(RMSE) = 6.37
NMBE = 1.53



Natural Gas Consumption (therms)

CV(RMSE) = 7.28
NMBE = 2.79

Model ■
Actual ■



	1	2	3	4	5	6	7	8	9	10	11	12
Start	1/1	2/1	3/1	4/1	5/1	6/1	7/1	8/1	9/1	10/1	11/1	12/1
End	1/31	2/28	3/31	4/30	5/31	6/30	7/31	8/31	9/30	10/31	11/30	12/31
Actual	17,360	15,040	16,560	15,440	16,720	17,600	18,960	18,160	15,600	15,200	12,720	17,120
Model	17,297	13,041	14,778	14,730	15,810	17,572	19,471	17,705	16,631	15,645	14,033	17,019
NMBE	-0.36%	-13.29%	-10.76%	-4.6%	-5.44%	-0.16%	2.7%	-2.51%	6.61%	2.93%	10.33%	-0.59%

- OpenStudio assists with rapid model calibration



AFA Bldg 4198

simuwatt Energy Auditor Case Study

Create and View Reports

View:

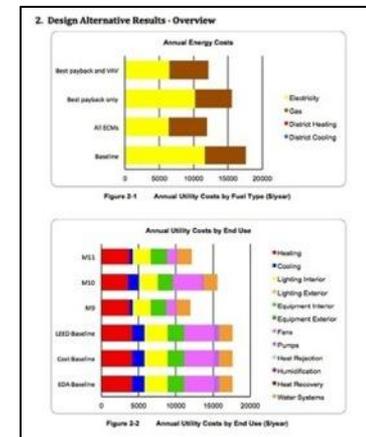
Design Alternative Name	Energy Use Intensity (kBtu/ft2-yr)	Peak Electric Demand (kW)	Electricity Consumption (kWh)	Natural Gas Consumption (Million Btu)	District Cooling Consumption (Million Btu)	District Heating Consumption (Million Btu)	First Year Capital Cost (\$)	Annual Utility Cost (\$)	Total LCC (\$)
Baseline	263	36	193,678	1,913	0	0	0	17,627	311,140

Design Alternative Name	Energy Use Intensity Reduction (kBtu/ft2-yr)	Peak Electric Demand Reduction (kW)	Electricity Savings (kWh)	Natural Gas Savings (Million Btu)	District Cooling Savings (Million Btu)	District Heating Savings (Million Btu)	First Year Capital Cost Increase (\$)	Annual Utility Cost Savings (\$)	Simple Payback (years)	Total LCC Savings (\$)
Implement setbacks at night Only	24 9%	0 0%	3,097 2%	227 12%	0 --	0 --	120 --	897 5%	0	16,008 5%
High efficiency motors in AHU Only	0 0%	0 0%	0 0%	0 0%	0 --	0 --	1,116 --	0 0%	--	(1,084) (0%)
Install cogged v-belts Only	0 0%	0 0%	0 0%	0 0%	0 --	0 --	240 --	0 0%	--	(233) (0%)
CAV with Reheat to VAV with Reheat Air Handler Only	17 6%	11 32%	64,439 33%	(56) (3%)	0 --	0 --	70,944 --	3,692 21%	19	(4,709) (2%)
Constant Speed to Variable Speed Pump Alternative Only	0 0%	0 1%	6,467 3%	(18) (1%)	0 --	0 --	400 --	332 2%	1	5,350 2%
							4,650 --	709 4%	7	7,764 2%
							31,500 --	171 1%	185	(27,620) (9%)



AFA Bldg 4198

- **Simulation results compare:**
 - EUI and peak demand savings
 - Gas and district heating/cooling impacts if appropriate
 - Capital cost increases
 - Annual utility cost savings
 - Simple payback
 - Total life cycle cost savings
- **Auto-generated report creates standard plots, text, etc. to save even more time**



High Demand Across Products – 300+

Energy Services/ Construction/Real Estate

Johnson Controls

NRESO

Honeywell

TRANE

AMERESCO
Green • Clean • Sustainable

SIEMENS

McKinstry
For The Life Of Your Building

Mortenson
construction

JONES LANG
LASALLE

WYNDHAM
Hotels and Resorts

Solar

SolarCity

CIVICSOLAR

STANDARD
SOLAR

UMCpower
Simplifying Energy

Johnson Controls

Honeywell

Chevron
Energy Solutions

REC
SOLAR

Utilities

Xcel Energy

nationalgrid

SOUTHERN CALIFORNIA
EDISON
An EDISON INTERNATIONAL Company

EPRI
Electric Power Research Institute

ComEd
An Exelon Company

State/Local/Feder al/non-profit

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

PUBLIC UTILITIES COMMISSION
EUREKA
STATE OF CALIFORNIA

ROCKY
MOUNTAIN
INSTITUTE

SF Environment
Our home. Our city. Our planet.

Project Integration and Collaboration

Project Integration: OpenStudio platform directly enables the development of other National Laboratory products and private sector applications identified on previous slides. OpenStudio is also a critical component for CEC, NRCAN, and multiple utility initiatives.

Communications:

- Active communication via:
 - <http://openstudio.nrel.gov> website and forums
 - OpenStudio YouTube channel with over 100 tutorial videos
- Multiple training opportunities offered by private sector performers
- Presentations at Fall eSource Forum and follow up scheduled for June
- Upcoming workshop at eSim in Ottawa Canada
- Papers presented at IBPSA SimBuild 2013
- Upcoming publications at:
 - eSim in Ottawa Canada
 - ACEEE Summer Study
 - IBPSA SimBuild 2014

Next Steps and Future Plans

1. Increased alignment (process and technology) with EnergyPlus 8.2
2. Ensure successful development, deployment, and adoption of platform-based tools
3. Expanded capability for rapid baseline modeling
4. Improve linkages between TPEX and BCL and the modeling ecosystem to enable assessment and adoption of ET
5. Leverage distributed analysis framework to support creation of large pre-computed simulation database (DEnCity)
6. Expand available measures (ECM, reporting, QA/QC) in BCL to further drive down the cost of modeling
7. Continue to increase cost-share and off ramp as value propositions expand for other agencies and utilities

Thank You!



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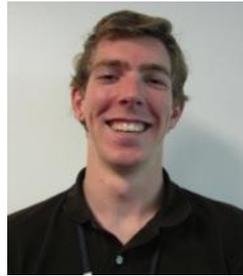
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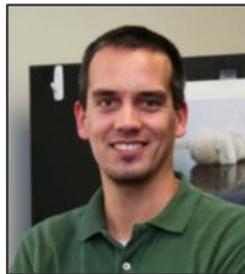
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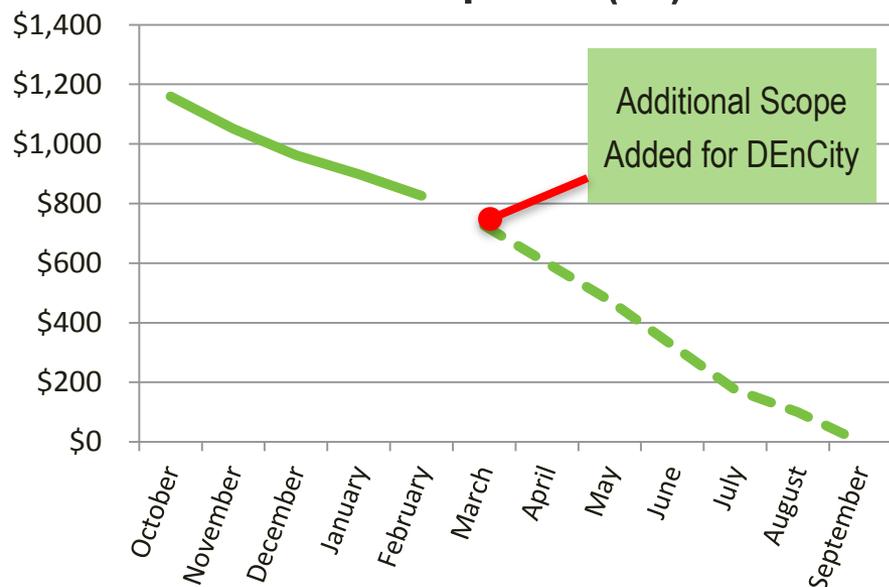


Phylroy Lopez
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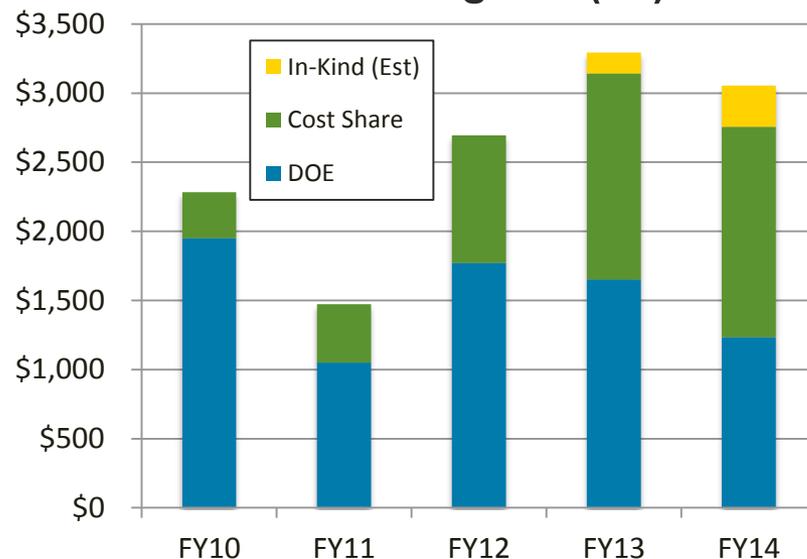
REFERENCE SLIDES

Project Budget

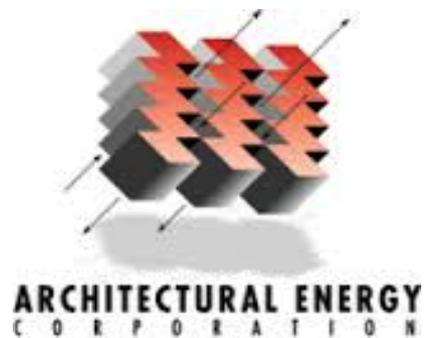
FY14 Spend* (\$k)



FY10-14 Budgets* (\$k)



Additional Funding Sources:



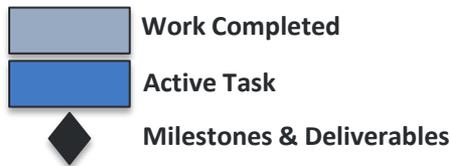
* FY14 Spend and Budget Includes OpenStudio Core, Refrigeration GUI, and Asset Score CBI Budgets

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			
	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 EnCity)				◆								
Q4 Milestone: OpenStudio 0.9 Released (BIM Interop and Initial Support for BCL Measures)					◆							
Q1 Milestone: OpenStudio 1.0 Released (Sim Settings Tab and Backend Work for PAT)						◆						
Q2 Milestone: OpenStudio 1.1 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, EnCity Development)												◆