BTO's Building Energy Modeling Program Overview

BTO Peer Review 2017

HVAC and Control Design

Architectural Design

Policy Analysis

LEED

Utility Incentives

Asset Rating

Retrofit Design

Code Compliance

Model Predictive Control

M&V

Amir Roth, Ph.D.
amir.roth@ee.doe.gov

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

BEM – The Ultimate (Meta) ECM

HVAC and control design

Architectural Design

Asset Rating

Code Compliance

M&V

Project Name	% Modeling Fees vs Gross Fees	Annual Modeled Energy Cost Savings	Payback on Modeling Fees in MONTHS
Office Building	0.7%	$122,876	2
Office Building	0.5%	$306,692	1
Justice Center	0.8%	$350,000	3
Convention Hotel	0.6%	$233,791	1
Regional Hospital	2.4%	$3,300,000	1
Government Office Building	3.3%	$186,000	4
Government Building 20	1.1%	$224,276	2
Cancer & Critical Care Tower	0.6%	$853,013	3
Institutional Research Center	0.6%	$340,000	3
Energy Institute	2.5%	$169,432	7
Institutional Research Facility	1.0%	$302,169	1
Science Teaching and Research Facility	0.8%	$419,599	1
Corporate Headquarters	1.0%	$239,835	4

Source: HOK

BEM in design

- Payback << 1 year and sometimes instantaenous
- https://energy.gov/eere/buildings/articles/shockingly-short-payback-energy-modeling

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

2030 Savings Potential

scout
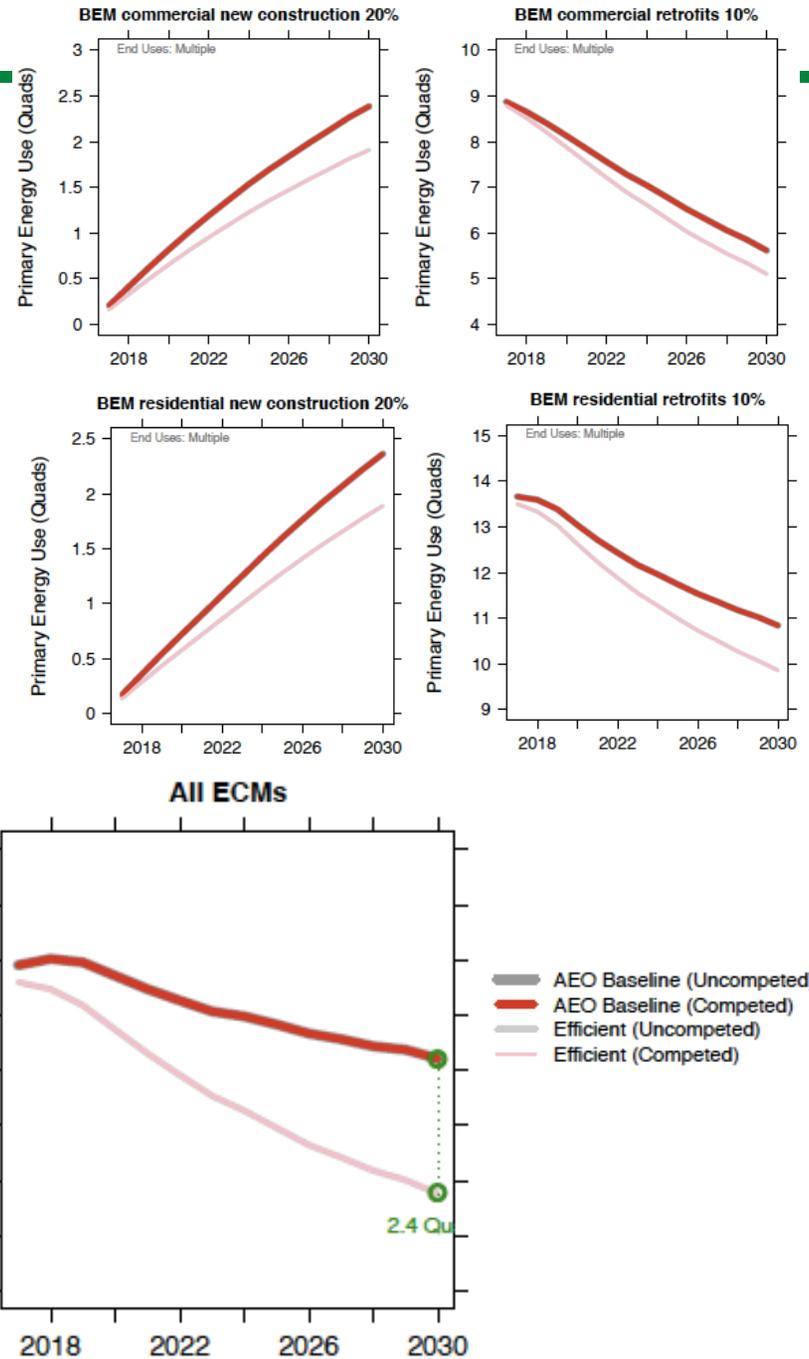### U.S. DEPARTMENT OF ENERGY

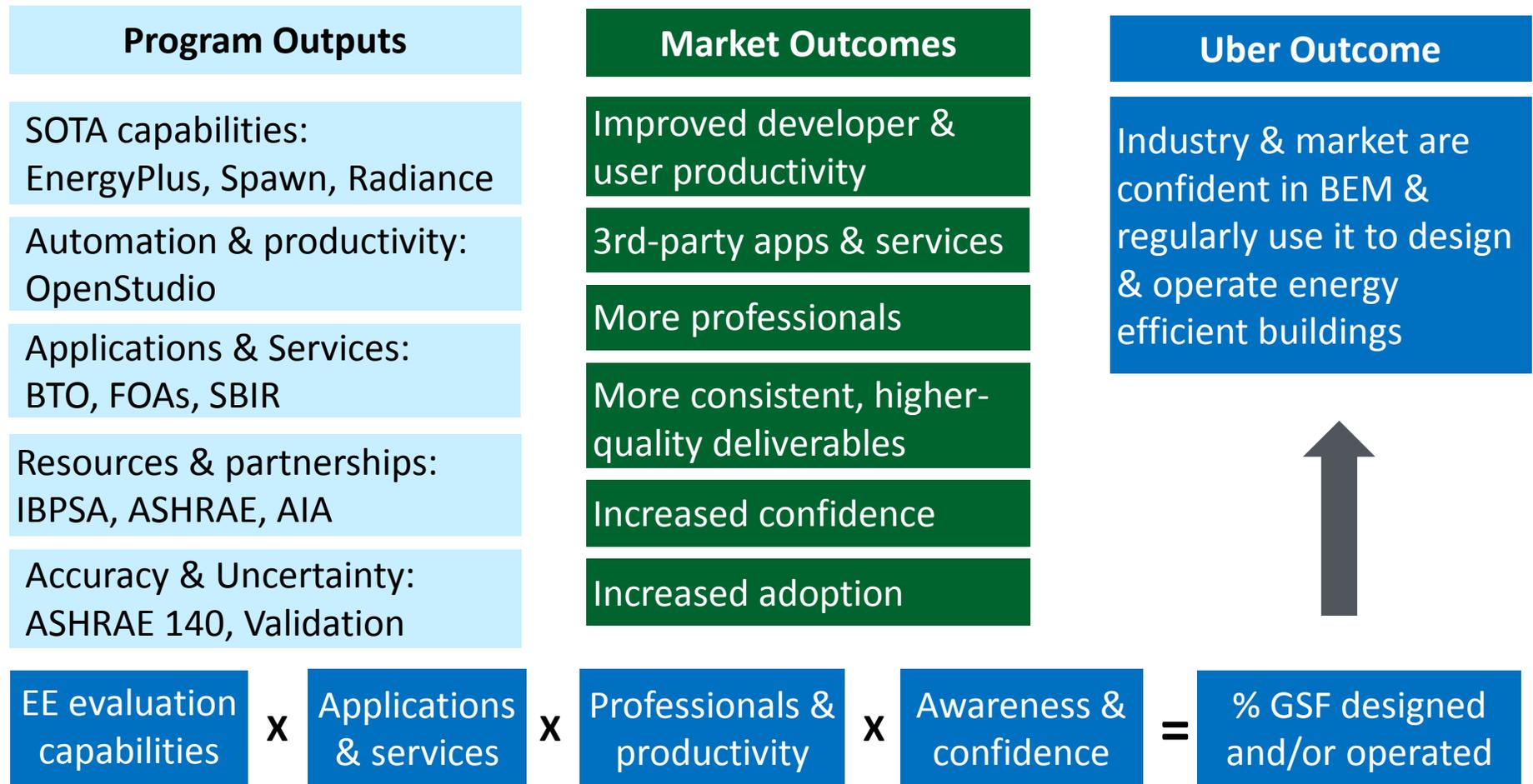**BEM in design – assumptions**

- 20% savings for new construction
- 10% savings for retrofit
- 1.5% GSF new construction/yr
- 1.5% GSF retrofit/yr
- "Max Adoption Potential" scenario
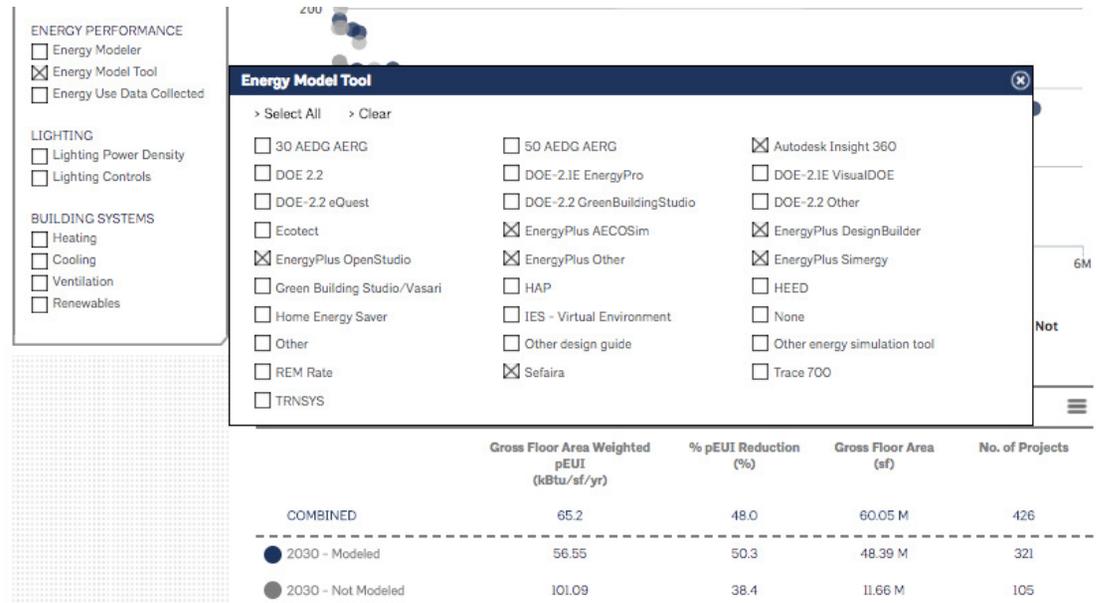
2.4 Quads!

What about other use cases?

Logic Model

Program Outputs

SOTA capabilities:
EnergyPlus, Spawn, Radiance

Automation & productivity:
OpenStudio

Applications & Services:
BTO, FOAs, SBIR

Resources & partnerships:
IBPSA, ASHRAE, AIA

Accuracy & Uncertainty:
ASHRAE 140, Validation

Market Outcomes

Improved developer & user productivity

3rd-party apps & services

More professionals

More consistent, higher-quality deliverables

Increased confidence

Increased adoption

Uber Outcome

Industry & market are confident in BEM & regularly use it to design & operate energy efficient buildings

EE evaluation capabilities **X** Applications & services **X** Professionals & productivity **X** Awareness & confidence **=** % GSF designed and/or operated

Activities (roughly) map to contributing factors

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

MYPP & BEM Goals

2020 goals

- BEM for new construction GSF: 70% (now: 51%*), EnergyPlus: 5% (7%**)
- Savings over code: EnergyPlus: 20% (13%***)
- 3rd-party EnergyPlus applications & services: 12 (10)

Useful goals need data ← AIA 2030 Commitment (https://2030ddx.aia.org/)

- *Going down ← 2030 is growing "from the bottom"
- ** Going up ← Sefaira
- ***Going down ← codes becoming more stringent

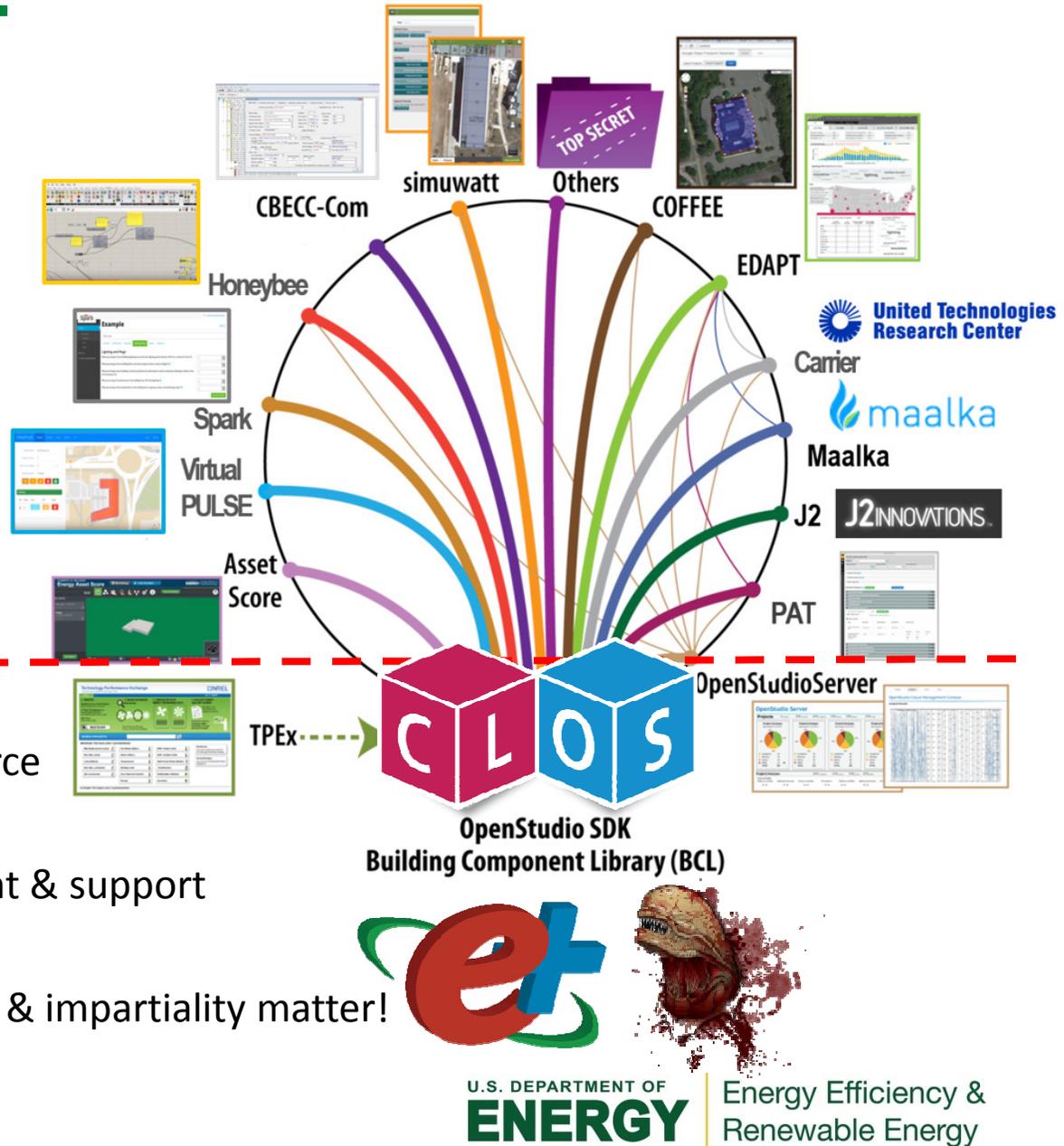**Want additional goals (for other use cases) but data is hard to come by!**

The Dream-catcher

Apps: use-case specific

- Open-source or proprietary
- Public or private funding

BEM industry adapting to (& adopting) open-source!

Platform: general

- Commercial-friendly open-source
- State-of-the-art capabilities
- Commercial-grade development & support
- Long-term commitment
- Public funding ← transparency & impartiality matter!
- Focus BTO resources here

The Platform

Envelope → Constructions, loads schedules, etc. → HVAC templates or custom systems → Run, compare, report, QAQC, & parametric analysis

Daylighting
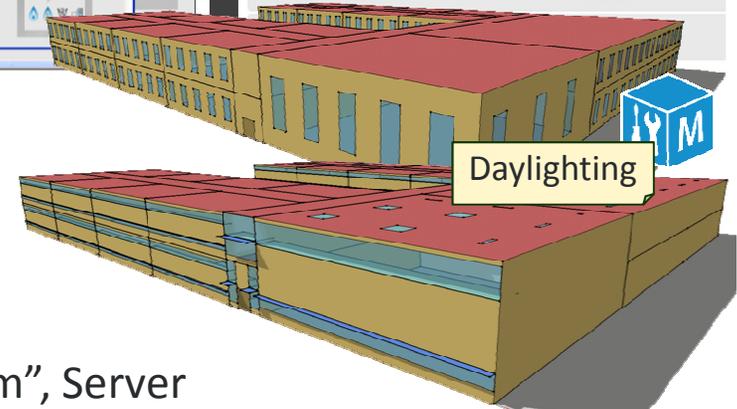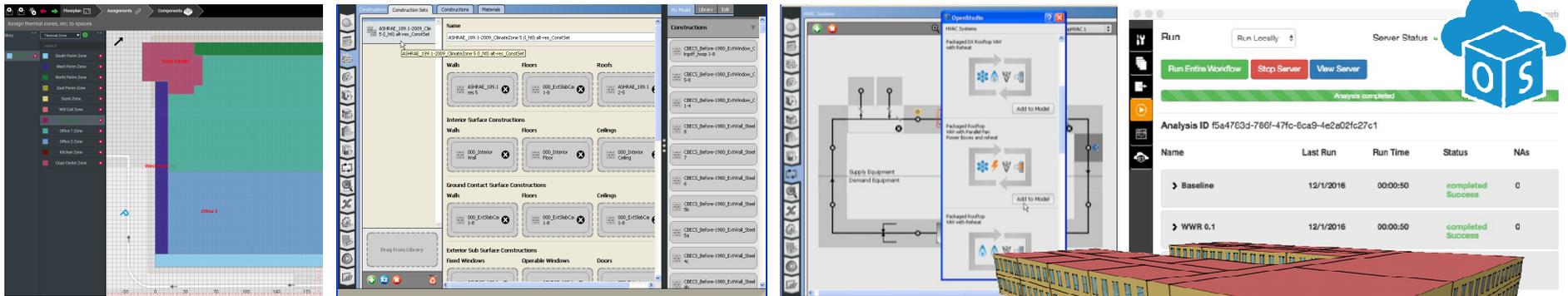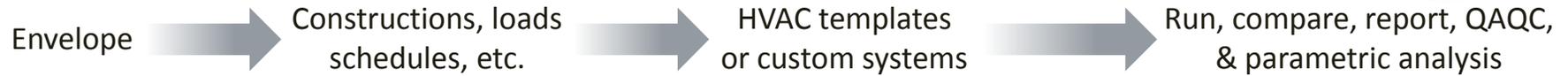
High-value package for vendors, utilities, etc.

- Supports BTO/National Lab analysis projects

OpenStudio (openstudio.net)

- SDK/bindings, CLI/Meta-CLI, Measures, Standards "gem", Server
- Graphical Application?

EnergyPlus (energyplus.net) & Spawn (stealth-mode)

Radiance/THERM/WinCalc

API (C++, Ruby, Python, JS, C#)

Today's Agenda

Program updates (me)

- Program accomplishments & future directions

Reviews of other projects in portfolio (PIs)

- BayREN BRICR – data & modeling workflows for EE program implementers
- WÜRM – integrated heat & moisture modeling for envelopes
- Data-Center Toolkit – (design and) operation tools
- Commercial Building Energy Saver/Lucid BuildingOS – technology commercialization
- Validation & Uncertainty Characterization – ground truth
- EnergyPlus, Spawn, and OpenStudio
- Virtual EPB – data & modeling workflows for utilities (not reviewed, but stick around)
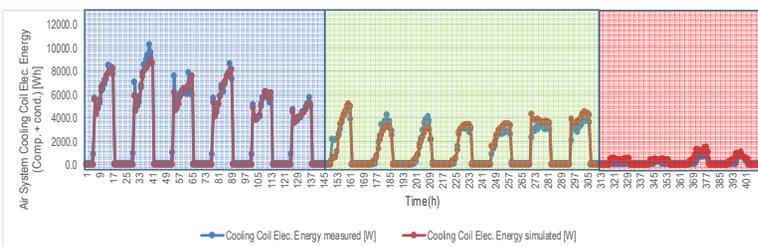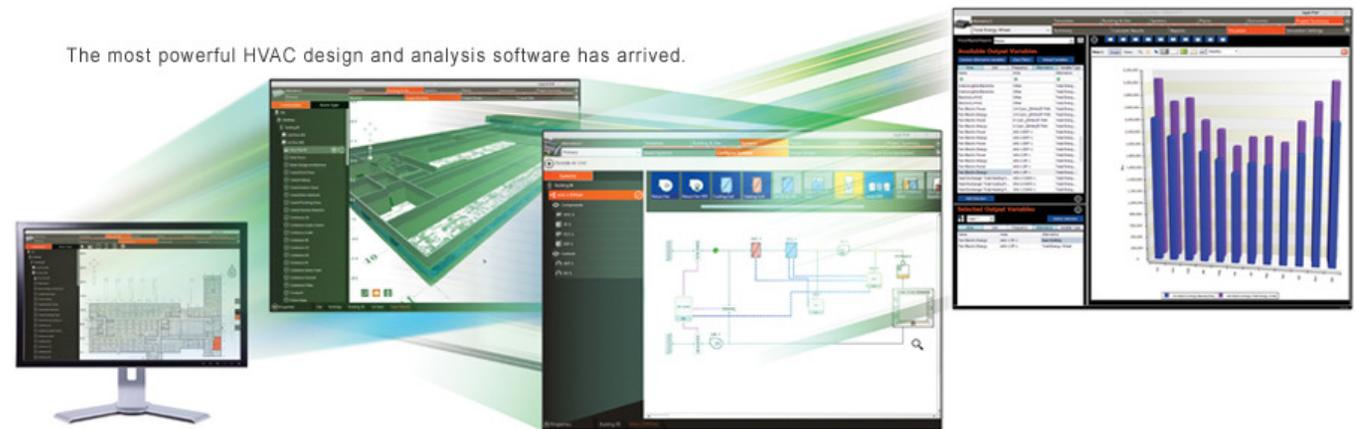
18:35

Since Last Peer Review

The most powerful HVAC design and analysis software has arrived.
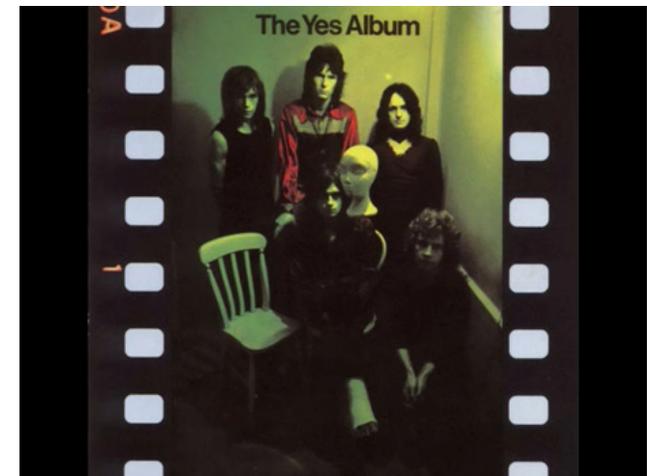
Some milestones

- Trane TRACE 3D Plus (…/buildings/articles/trane-switches-engines-trace-3d-plus)
- EnergyPlus/OpenStudio exceed 40,000 downloads per version
- Scout 1.0
- Spawn lives!

Starts, stops, and continuations

- One ending lab-call project: Empirical Validation & Uncertainty Characterization.
- Two ending BENEFIT/BUILD projects: Selective inverse modeling, Black-box RTU models
- Three in-flight BENEFIT projects: THERMM, OpenBuildingControl, Data Center Toolkit
- Two in-flight CBI FOA projects: OpenEfficiency, BayREN BRICR
- Up to eight (!!!!!!!!) new SBIR projects (announcement soon-ish)

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

Also Since Last Peer Review

41-33

#FLIIEaglesFLII

ENERGY | Energy Efficiency & Renewable Energy

OpenStudio-Standards

openstudio-standards "gem" (rubygems.org/gems/openstudio-standards)

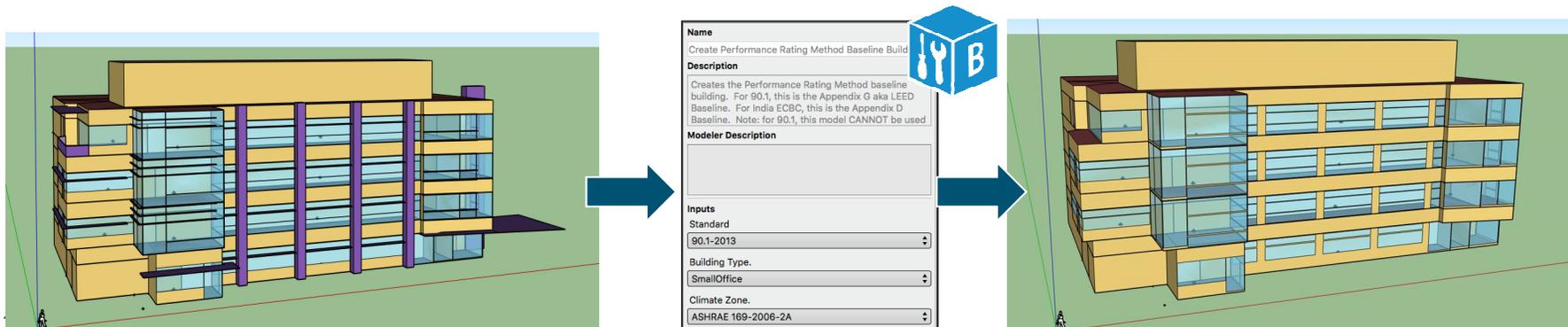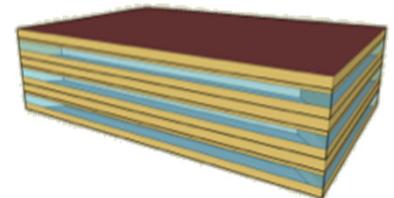- Data (insulation levels, equipment efficiencies, etc.) in Excel Spreadsheets

Measure #1. Create DOE Prototype Building

- { Type, CZ, Code-Version } ➜ Prototype
- Refining existing & adding new (supermarket, courthouse, data-center)
- CA DEER prototypes

Measure #2. Create Performance Rating Method Baseline Building

- { Type, CZ, Code-Version, Model } ➜ "Appendix G" Baseline
- Reduces tedium, confusion, inconsistency, and "cheating"
- Canada NECB, India ECBC, Title 24?
- …/articles/new-openstudio-standards-gem-delivers-one-two-punch

We've Gone Residential

What's the difference between commercial & residential BEM?

- Unify (DOE) BEM portfolio around EnergyPlus/OpenStudio

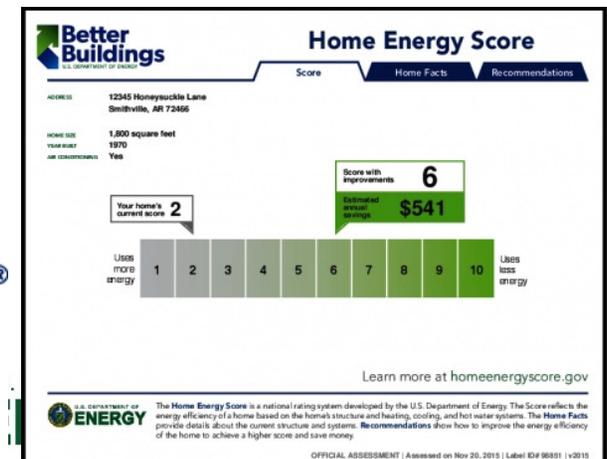**Residential-focused EnergyPlus enhancements**

- Attic/duct
- Moisture transfer
- Residential HVAC/water-heating equipment
- Ground heat transfer

Transition Home Energy Score to EnergyPlus/OpenStudio

Develop EnergyPlus/OpenStudio/HPXML HERS/ERI calculations

- Align HERS/Home Energy Score assumptions/calculations
- Collaboration with NASEO/RESNET

Innovator's Dilemma

Innovator's Dilemma – Support the present … while preparing for the future

Spawn alpha is here! – What is the plan for it & EnergyPlus?

Long term (5 years? 10 years?) → Just Spawn
- OpenStudio Platform front

Short term (3 years) → Both EnergyPlus and Spawn
- Keep supporting EnergyPlus, its users & client vendors
- Build up Spawn use & user base (controls, district systems, etc.)
- Rationalize shared EnergyPlus/Spawn components
- Improve Spawn execution speed
- Expand traditional capabilities (e.g., sizing)
- Add OpenStudio support
- Socialize → many more public announcements

Medium term → Re-evaluate on a yearly basis
- **#TrustTheProcess**

Unnamed Dilemmas → Dilambdas

OpenStudio is about productivity & automation: SDK/Measures/Server/Standards

OpenStudio Platform targets vendors

- Multiple public/private/in-house applications & services

OpenStudio Application targets users, provides access to these features

- Has played a significant role in EnergyPlus uptake
- 40k+ downloads/version
- AIA2030: 1. eQuest, 2. IES, 3. EnergyPlus (a. Sefaira, b. DesignBuilder, c. OpenStudio)

Diλ #1 – Time to get out of the OpenStudio Application business?

- Benefit in staying in … including to some vendors (ones that don't expose details)
- Greater benefit in getting out? More collaboration with vendors in similar space?
- In dialogue with vendors & other stakeholders via IBPSA

Diλ #2 – how to ramp up Spawn uptake without OpenStudio Application?

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

Jailbreak

## Investigate spinning off OpenStudio Application

- Physically separate App from OpenStudio (repository, build, test, installer)
- Recruit non-DOE/NREL caretaker(s)

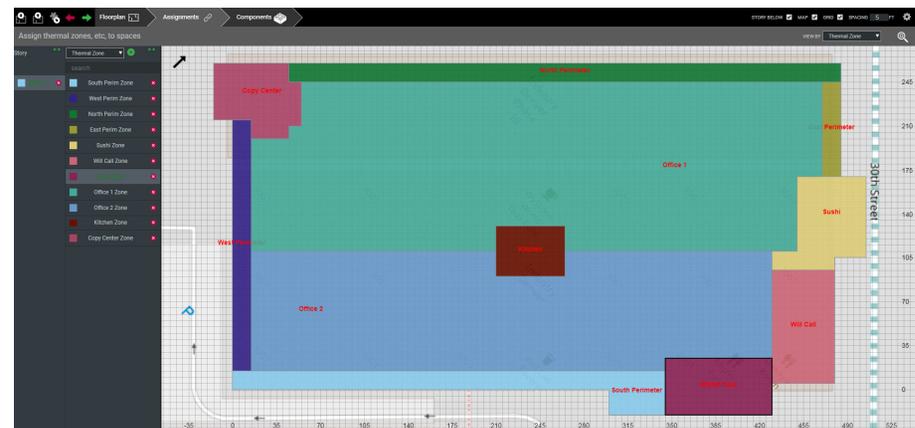## Avoid developing new graphical components unless necessary

- Sometimes really really really really really incredibly necessary!

Schema (not OpenStudio API)-based web widgets

- More portable & usable
- Less OpenStudio SDK maintenance/testing burden
- Floorspace.JS ← 2D "replacement" for SketchUp plug-in (nrel.github.io/floorspace.js/)
- λ.JS ← Spawn HVAC/controls editor
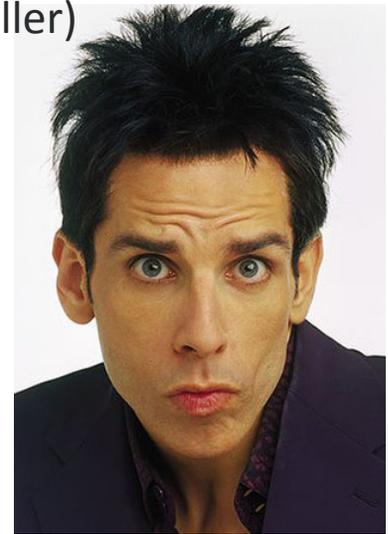
Forward Emphasis

BEM/controls nexus

- Spawn, OpenBuildingControl, EnergyPlus Python EMS
- Alfalfa/BOPTEST – BEM-driven Haystack-based controls/FDD sandbox/benchmark suite
- BENEFIT FOA topic (eere-exchange.energy.gov)
- Blockchain

Connectivity with (BTO) data ecosystem

- SEED, BuildingSync, HPXML, TPEx

Connectivity with envelope model ecosystem

- THERMM, WinCalc, AERCalc, I/CGDB

District-/urban-scale Data/BEM → better communities alliance (BCA)

- CityGML/EnergyADE, EnergyPlus/Spawn/OpenStudio SDK support

More, smaller competitive awards

Leveraging external resources & partnerships

More blockchain

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

More Reading & Writing

Core program

- Entire AOP (lab portfolio) up for 3-year Merit Review this year
- EnergyPlus, Spawn & OpenStudio → tomorrow

Resources

- Website: …/building-energy-modeling/
- Blog: …/end-use-breakdown-building-energy-modeling-blog
- MYPP: …/downloads/multi-year-program-plan
- Email: amir.roth@ee.doe.gov
- Something "special": https://www.youtube.com/watch?v=qW1xbhW2PEE (8:00)

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