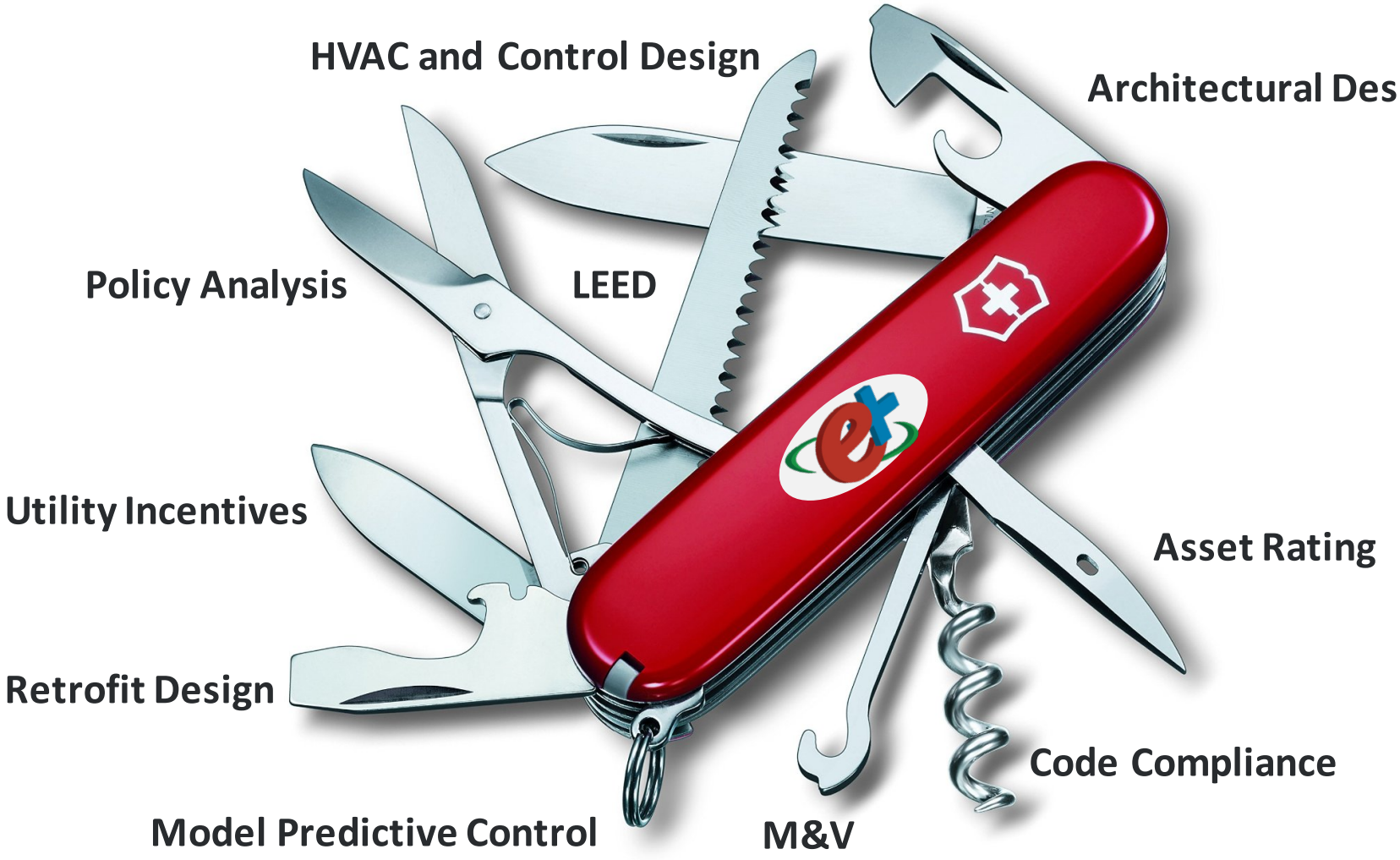
BTO's Building Energy Modeling Program Overview

BTO Peer Review 2017



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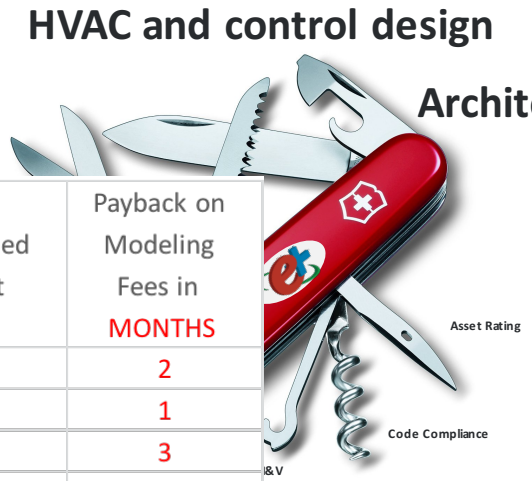
BEM – The Ultimate (Meta) ECM



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

- Potential to save 0.7 quad/year by 2030
- Payback << 1 year and sometimes instantaenous
- https://energy.gov/eere/buildings/articles/shockingly-short-payback-energy-modeling

Logic Model, MYPP, and Goals

Program Outputs	Market Outcomes	Uber Outcome
State-of-the-art open-source platform: EnergyPlus SOEP Radiance, THERM OpenStudio	Improved developer & user productivity	Industry & market are confident in BEM & regularly use it to design & operate energy efficient buildings
Characterized accuracy: ASHRAE 140	3rd-party apps & services	
Resources & partnerships: IBPSA, ASHRAE, AIA	More professionals	
	More consistent, higher-quality deliverables	
	Increased confidence	
	Increased adoption	

Design & operation EUI reduction **x** App # & productivity **x** Professional # & productivity **x** Industry confidence **=** % GSF designed and/or operated

2020 goals

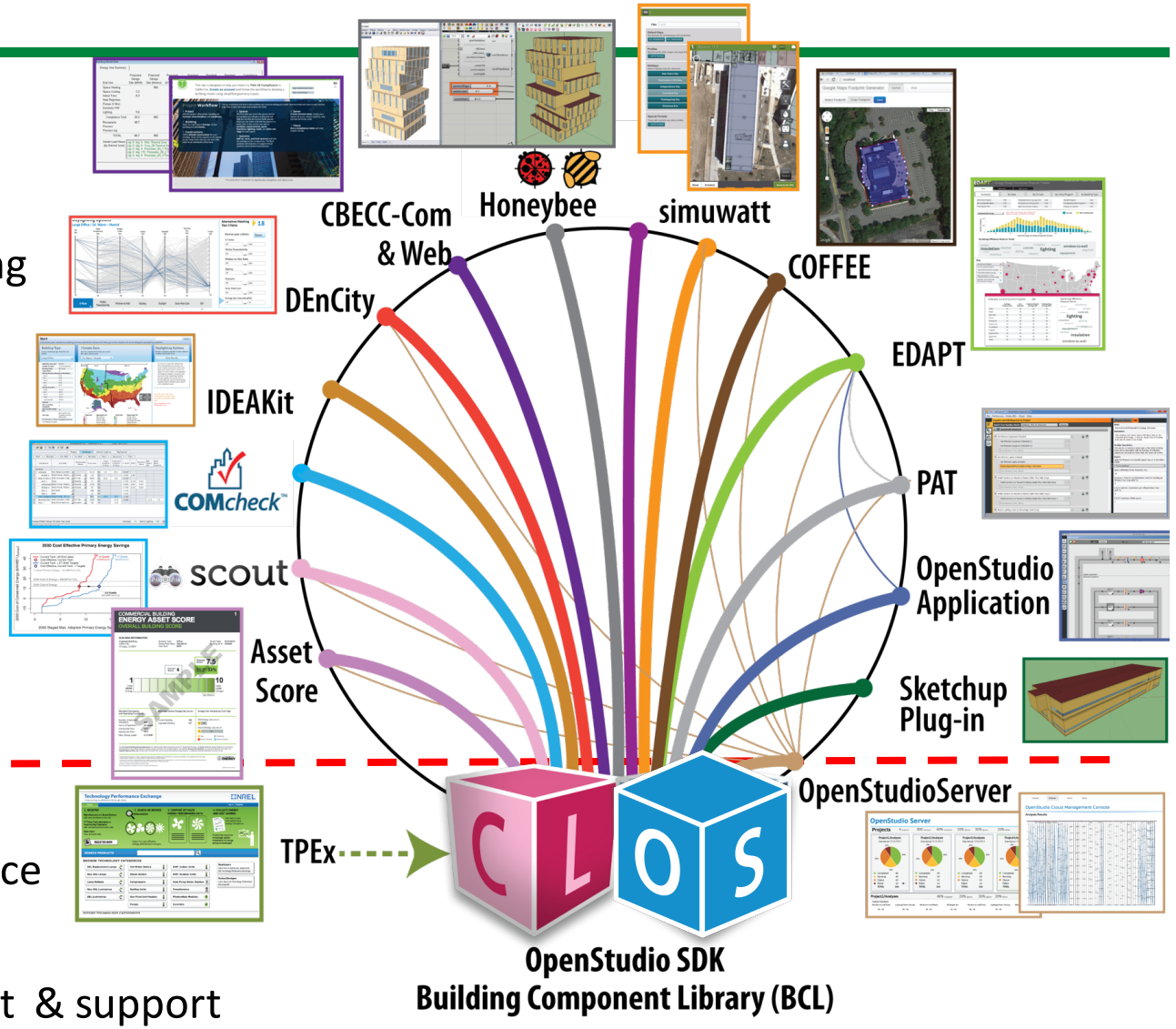
- BEM for new construction GSF: 70% (now: 76%), EnergyPlus: 5% (7%)
- Savings over code: EnergyPlus: 20% (20%)
- 3rd-party EnergyPlus tools: 12 (8)

The Dream-catcher

Apps: use-case specific

- Open-source or proprietary
- Public, private, or mixed 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

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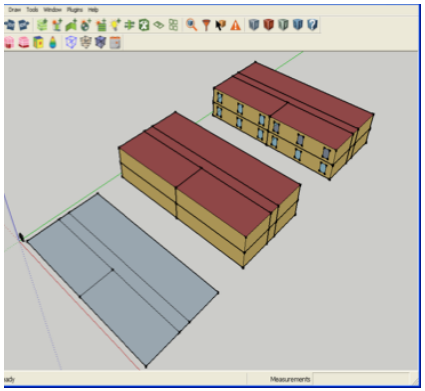
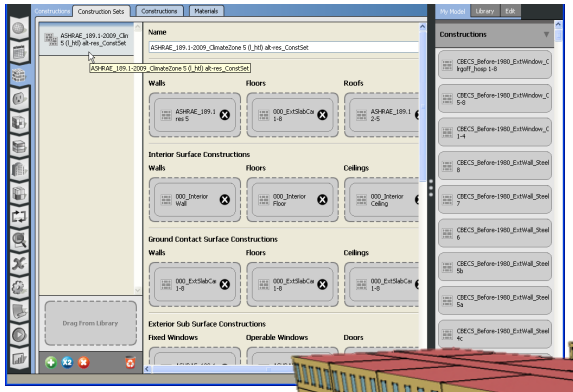
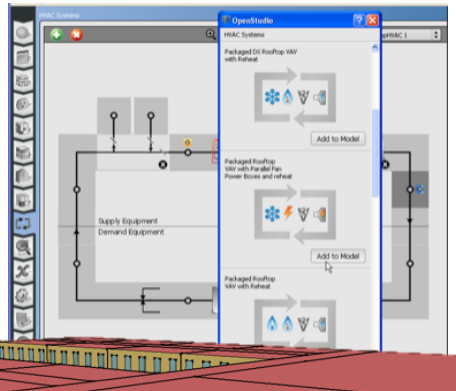
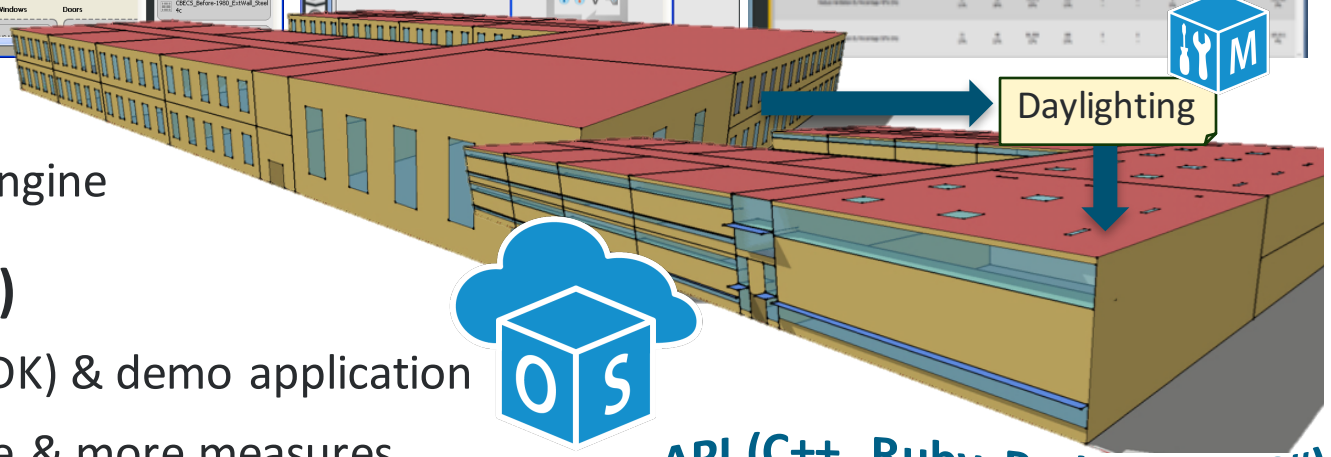
The Platform: EnergyPlus & OpenStudio

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









EnergyPlus (energyplus.net)

- Industry leading simulation engine

OpenStudio (openstudio.net)

- Software development kit (SDK) & demo application
- Measures, Amazon EC2 image & more measures

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

High-value package

- Great offering to market partners (vendors, utilities, etc.)
- Helps streamline BTO's own BEM work
- Serves as template for other BTO BEM projects

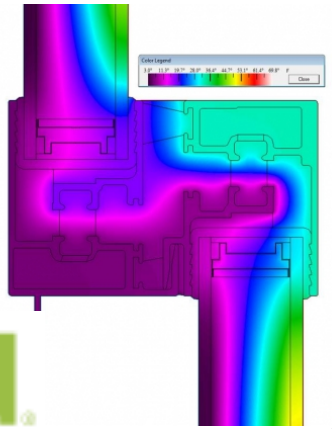
Today's Agenda

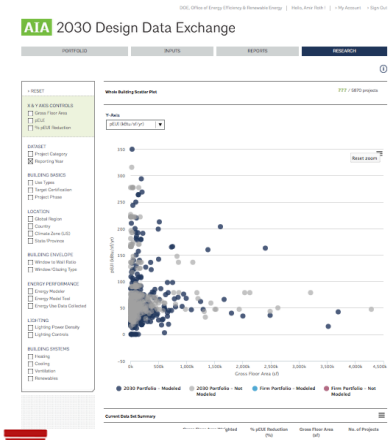
Program updates (me)

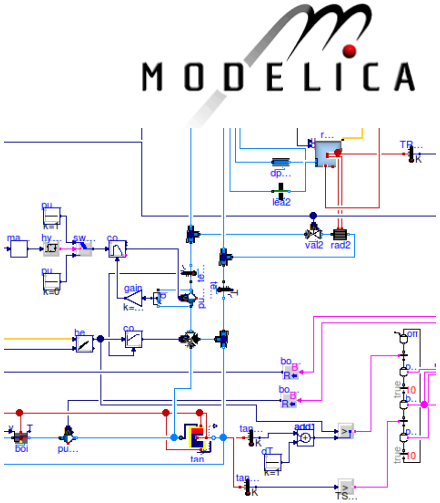
- EnergyPlus and OpenStudio updates – not being reviewed this year
- Program accomplishments & future directions

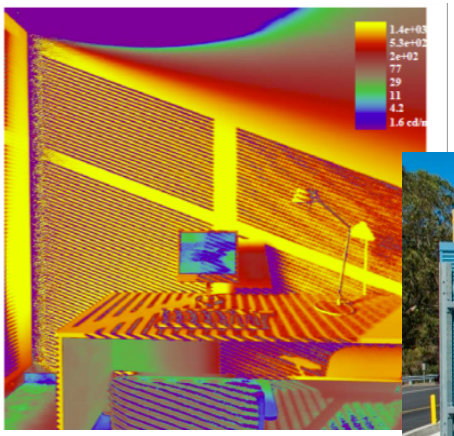
Reviews of other projects in portfolio (PIs)

- AIA 2030 DDx – benchmark and tracking BEM in design
- Spawn-of-EnergyPlus (SOEP) – next-generation simulation/controls product
- Validation & Uncertainty Characterization – ground truth
- Fenestration: THERM – thermal characterization of facades
- More fenestration: Radiance – detailed lighting simulation
- NRG & Lucid – helping small businesses develop new capabilities









lucid

NRGsim

Energy Systems Simulation

AIA

EnergyPlus Updates

Data Center

- ITE, CRAC, controls

Residential

- Ground-coupling, integrated heat-pumps, multiple air-systems per zone, duct radiation
- V8.7 (March 2017) will be MVP (minimum viable product) for residential modeling

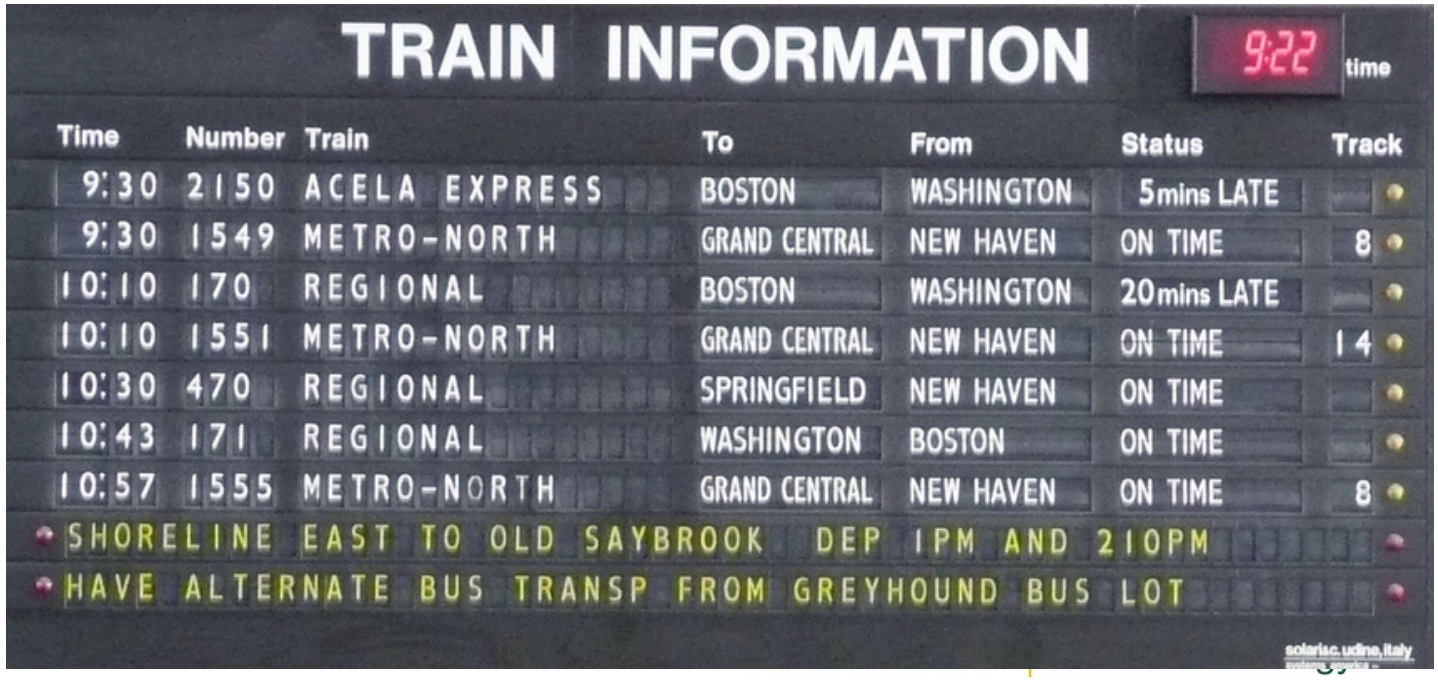
JSON input

- First step in modernizing input, output & error handling

DOAS configurations

Shading speedups

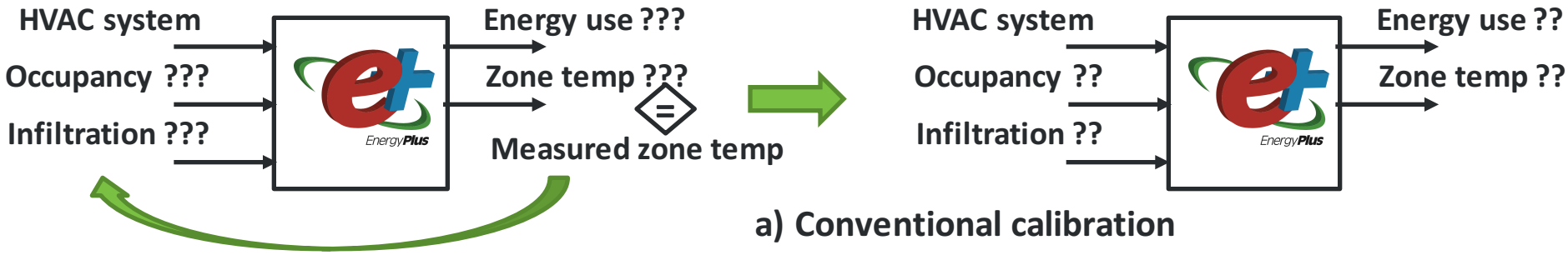
Hybrid Modeling!

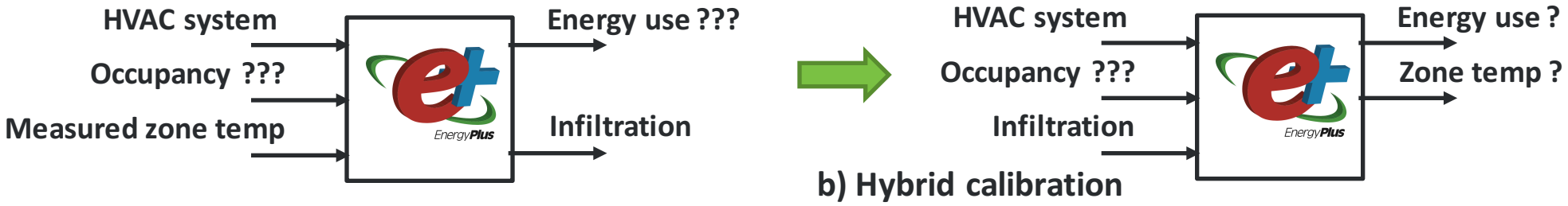


EnergyPlus Updates – "Hybrid Modeling"

Better Name: "Selective Inverse Modeling" or "Hybrid Calibration"

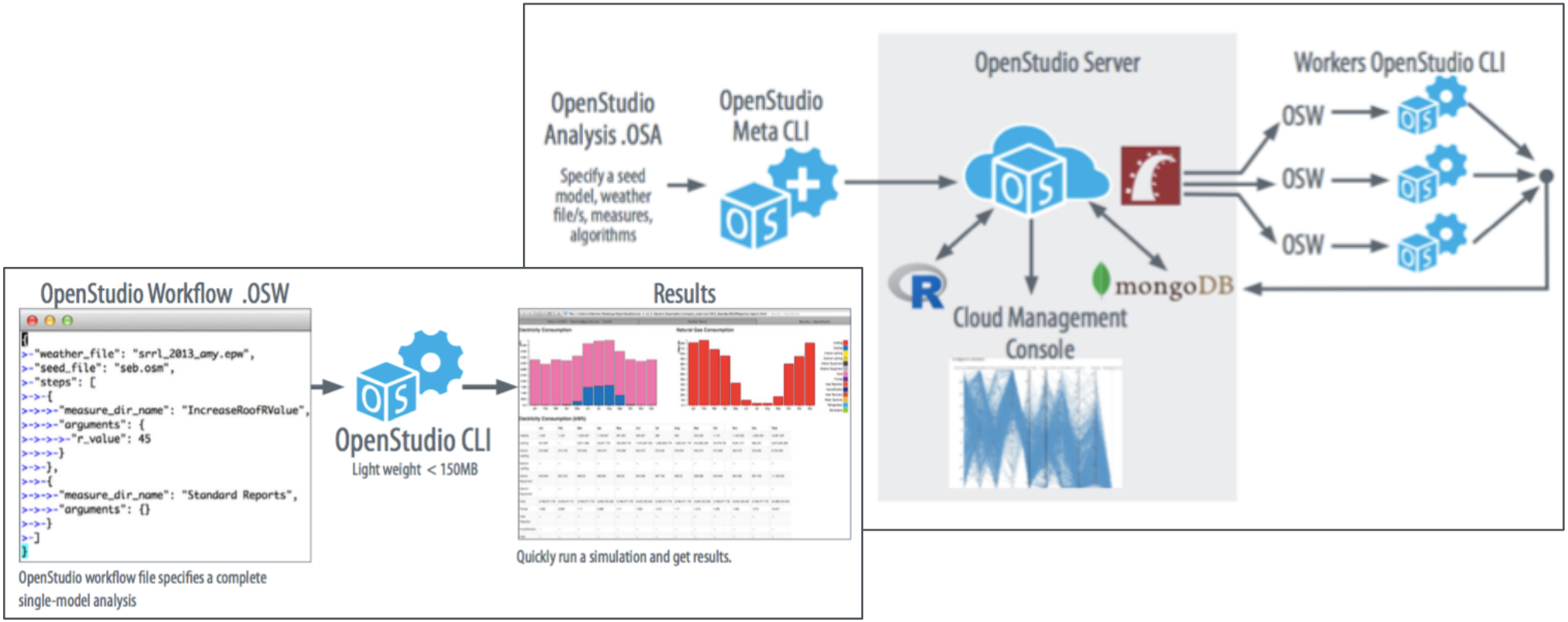
- Conventional heat-balance (HB) equation calculates zone temperature time series
- Zone temperature time series easy to obtain from BAS & smart thermostats
- Invert HB to take temperature as input … and calculate one traditional input as output
- Useful when said input is harder to obtain than zone temperature, e.g., infiltration





- More accurate than conventional calibration … and can be combined with it!
- S-H. Lee & T. Hong, "Hybrid Modeling", Building Simulation 2017.

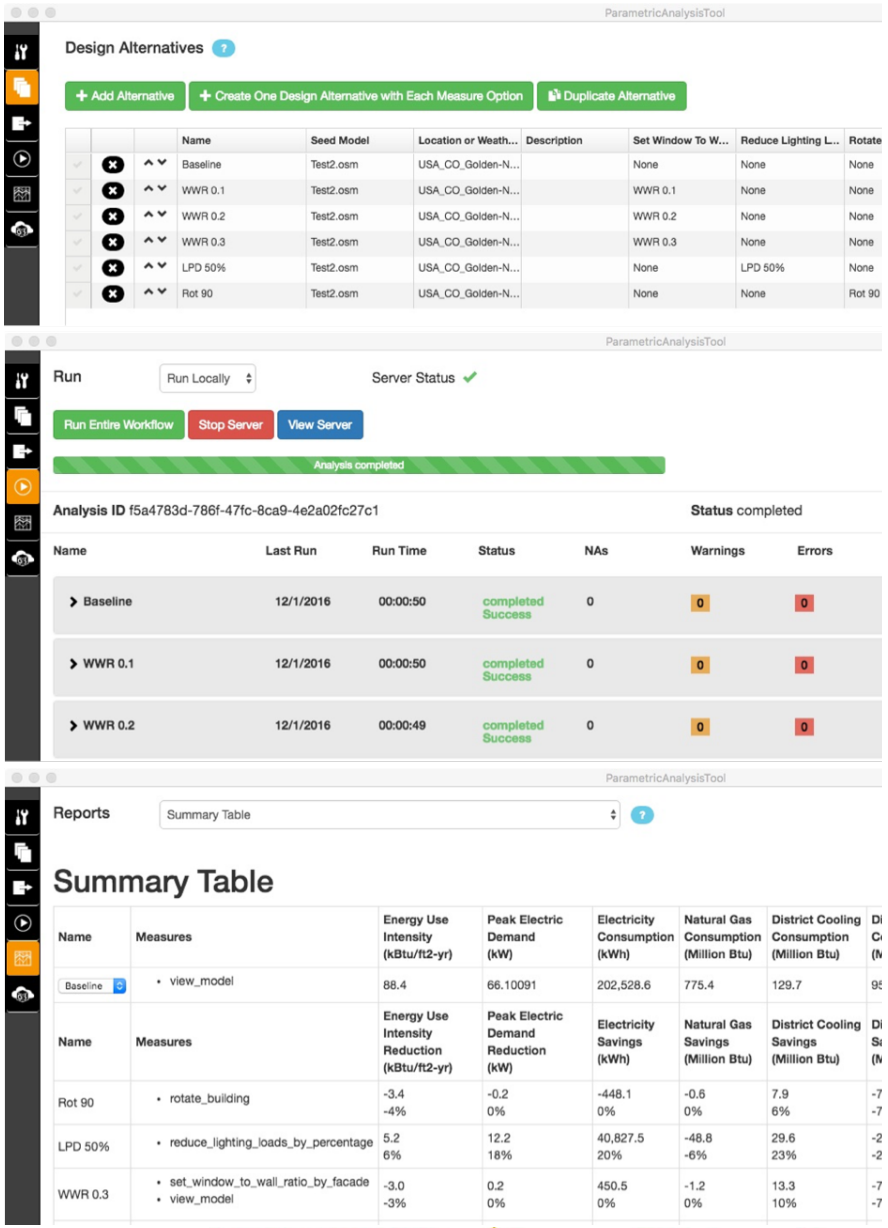
OpenStudio Updates – OpenStudio 2.0



Developer-centric re-factor of OpenStudio 1.X

- Two new file formats: OSW (single model workflows), OSA (large scale analysis)
- Command Line Interface (CLI) – 150 MB self-contained OSW execution machine
- Meta-CLI – OSA ➔ (many) OSW translation machine
- Server 2.0 — elastic, multi-cloud image, runs locally also
- Modular installer – install only the pieces you want
- …/articles/finally-major-update-openstudio

OpenStudio Updates – PAT 2.0



New front-end

- Qt ➔ electron.io (JavaScript in browser)
- Local or web applications
- No dependences (every system has a browser)
- How we will do UI from now on

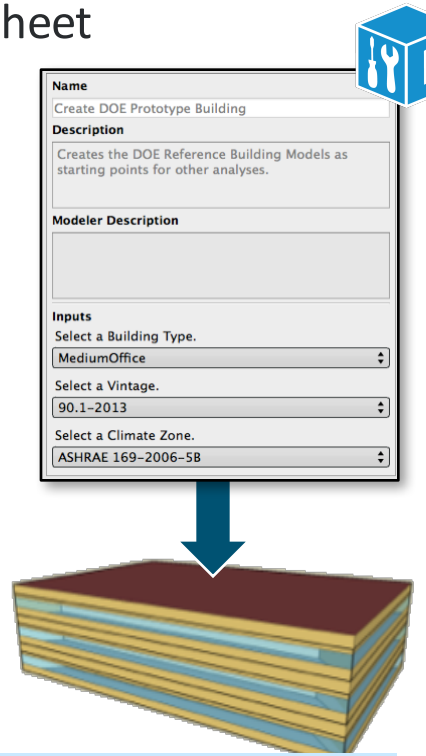
OpenStudio Updates – OpenStudio-Standards

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

- Functions for creating & applying ASHRAE 90.1 constructions, schedules, systems, etc.
- Data (insulation levels, equipment efficiencies, etc.) in Excel Spreadsheet

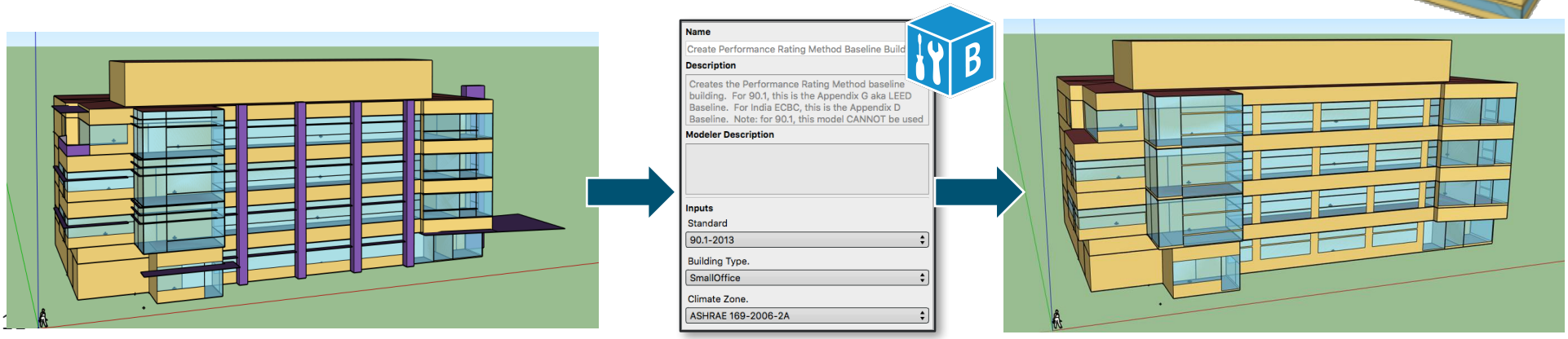
1) Create DOE Prototype Building

- { Type, CZ, Code-Version } ➔ Prototype-Model



2) Create Performance Rating Method Baseline Building

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



Program Summary & Plans

Core funding

- ET: $4,600k – EnergyPlus, SOEP, ASHRAE 140, Empirical Validation, Fenestration Tools
- CBI: $1,500k – OpenStudio
- CC: $500k – AIA 2030, Scout, "Decision Science"

Starts and stops

- Two BENEFIT projects ending: grey-box RTU models, selective inverse modeling
- Three BENEFIT projects starting: MOISTHERM, OpenBuildingControl, Data Center Toolkit
- Two CBI FOA projects starting: OpenEfficiency, BayREN BRICR

Forward Emphasis

- Control/operations applications ➔ EnergyPlus-to-SOEP resource shift
- Connectivity with (BTO) data ecosystem
- Connectivity with fenestration/envelope modeling ecosystem
- District- and urban-scale (LDRD) ➔ better communities alliance (BCA)
- More, smaller competitive awards
- Leveraging external resources

Additional Reading & Writing

Since last peer review

- EnergyPlus & OpenStudio exceeding 35,000 downloads per version
- New annual-simulation products from Autodesk & Sefaira
- Re-launch of simuwatt energy auditor
- Launch of NEEA/BetterBricks SPARK
- California utility eTRM moving to EnergyPlus/OpenStudio
- Scout alpha & beta
- New fellow, Janet Reyna (janet.reyna@ee.doe.gov): large-scale modeling, data-ecosystem

Resources

- Website: …/building-energy-modeling/ (updated content including "BEM 101" series)
- Blog: …/end-use-breakdown-building-energy-modeling-blog
- MYPP: .../downloads/multi-year-program-plan (updates in progress)
- Revised RD&D Roadmap: coming soon-ish
- Email: amir.roth@ee.doe.gov