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
Model Predictive Control
M&V
Code Compliance

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BEM – The Ultimate (Meta) ECM

BEM in design

- Payback << 1 year and sometimes instantaenous

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

Source: HOK

HVAC and control design

Architectural Design

Asset Rating

Code Compliance

LEED

Model Predictive Control

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2030 Savings Potential

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

<table>
<thead>
<tr>
<th>Program Outputs</th>
<th>Market Outcomes</th>
<th>Uber Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOTA capabilities: EnergyPlus, Spawn, Radiance</td>
<td>Improved developer &amp; user productivity</td>
<td>Industry &amp; market are confident in BEM &amp; regularly use it to design &amp; operate energy efficient buildings</td>
</tr>
<tr>
<td>Automation &amp; productivity: OpenStudio</td>
<td>3rd-party apps &amp; services</td>
<td></td>
</tr>
<tr>
<td>Applications &amp; Services: BTO, FOAs, SBIR</td>
<td>More professionals</td>
<td></td>
</tr>
<tr>
<td>Resources &amp; partnerships: IBPSA, ASHRAE, AIA</td>
<td>More consistent, higher-quality deliverables</td>
<td></td>
</tr>
<tr>
<td>Accuracy &amp; Uncertainty: ASHRAE 140, Validation</td>
<td>Increased confidence</td>
<td></td>
</tr>
<tr>
<td>EE evaluation capabilities</td>
<td>Increased adoption</td>
<td></td>
</tr>
<tr>
<td>Applications &amp; services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professionals &amp; productivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Awareness &amp; confidence</td>
<td></td>
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</tr>
</tbody>
</table>

Activities (roughly) map to contributing factors

EE evaluation capabilities \( \times \) Applications & services \( \times \) Professionals & productivity \( \times \) Awareness & confidence = % GSF designed and/or operated
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

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

High-value package for vendors, utilities, etc.
- Supports BTO/National Lab analysis projects

OpenStudio ([openstudio.net](http://openstudio.net))
- SDK/bindings, CLI/Meta-CLI, Measures, Standards “gem”, Server
- Graphical Application?

EnergyPlus ([energyplus.net](http://energyplus.net)) & Spawn (stealth-mode)

Radiance/THERM/WinCalc
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)
Since Last Peer Review

Some milestones
- Trane TRACE 3D Plus ([.../buildings/articles/trane-switches-engines-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)
Also Since Last Peer Review

41-33

#FLIIEaglesFLII
openstudio-standards “gem” ([rubygems.org/gems/openstudio-standards](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
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

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?
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](http://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**
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)