

EnergyPlus Development

2016 Building Technologies Office Peer Review



*Energy***Plus**

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

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Project Summary

Timeline

- Official start: 1996
- Current Merit Review cycle: FY16-FY18

Key Milestones

- Two annual releases: Mar. & Sep.

Budget

- \$2,500k / yr
- \$1,250k labs
 - NREL, LBNL, ORNL
- \$1,250k competitively solicited contractors
 - GARD, FSEC, Objexx, Fraunhofer-CSE
 - OSU, UIUC, Big Ladder Software
 - EnergyArchmage, Empty Crate Software
 - Solicitation follows 3-year Merit cycle

Key Partners

- Trane
- Carrier
- Autodesk

Project Outcome

- Software engine that is capable and robust enough to support codes & ratings as well as commercial products

Purpose & Objectives

Mission Statement: “Develop, maintain, and support a BEM engine for fair and accurate assessment of different energy efficiency measures for all types of buildings projects.”

Target Applications & Audiences:

- New construction & retrofit design, HVAC selection & sizing, energy-efficiency code development & compliance, asset ratings & labels, policy analysis, commissioning, fault-detection, demand-response & model-predictive control, control design, product design, research & education
- Architects, mechanical engineers, energy consultants, utility program administrators, ESCOs, software vendors, control engineers, control vendors, researchers, educators

Impact:

- Hard to calculate & easy to underestimate
- ~700 TBTU/yr for design use case [P-Tool]

Approach, Issues & Characteristics

Approach:

- Develop engine, work with vendors to embed into end-user use-case specific apps
 - OpenStudio really helps here (more in next presentation)
- Focus on speed, robustness & high-leverage features that vendors (and users) want
- Modern, rigorous development, documentation & testing processes & tools
- Annual in-person team planning & training meeting, bi-weekly iteration web-meetings

Key Issues:

- Stability & bugs
- Future-proofing & new use-cases
- Empirical validation
- Usability

Distinctive Characteristics:

- Long-running project
- Multi-lab collaboration
- DOE as a successful *direct* market actor



Progress & Accomplishments (since April 2015)

Direct downloads: V8.2 (Sep. 2014) → V8.3 (Mar. 2015) → V8.4 (Sep. 2015)

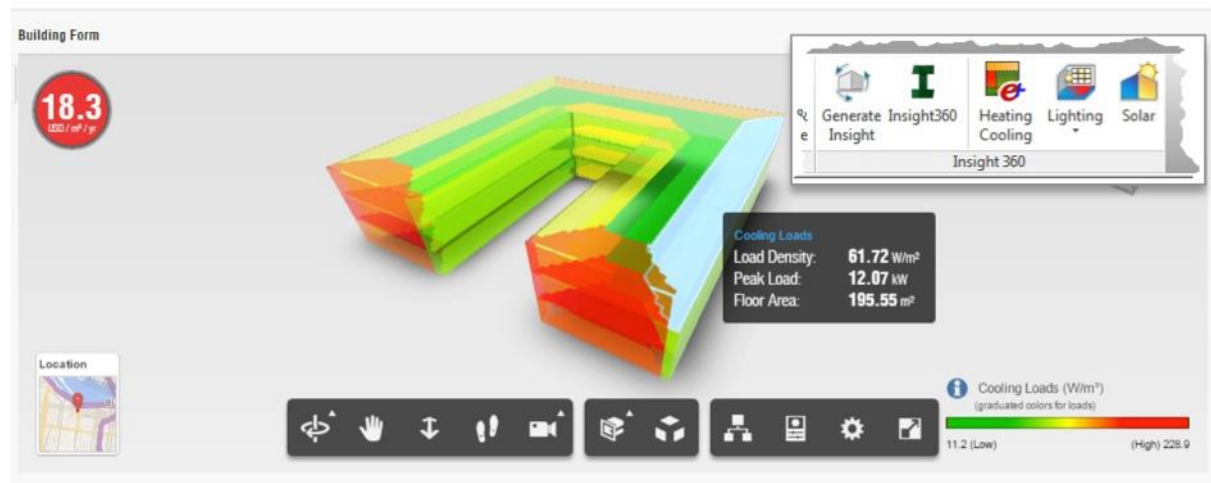
- 19,365 → 33,968 → 35,050!!

AIA 2030 Commitment Reporting Stats: 2013 → 2014 → 2015* (ends 3/31/2016)

- Projects: 65 (6%) → 76 (4%) → 2 (1%)
- GSF: 63M (13%) → 84M (14%) → 0.7M (3%)

New Products:

- Autodesk releases EnergyPlus-based Insight360 for Revit & FormIt
- Sefaira-cum-Trimble releases EnergyPlus-based Sefaira-cum-Trimble Architecture
- Trane releases beta of EnergyPlus-based TRACE (most frequently used BEM tool)
- RESNET votes to adopt EnergyPlus-based single implementation of HERS rating



Progress & Accomplishments (since April 2015)

Technical milestones:

- V8.4: <https://github.com/NREL/EnergyPlus/releases/tag/v8.4.0-Update1>
- V8.5: <https://github.com/NREL/EnergyPlus/releases/tag/v8.5.0>
- New residential features: improved heat pump water heater
- New commercial features: 90.1 single-zone VAV control & economizer DX integration
- New daylighting feature “Octree” for significant speed improvements on large models
- New usability features: sizing, HVAC configurations & thermal storage controls
- New ground temperature models: foundation heat loss & ground heat exchangers
- New unit-testing framework
- New performance testing framework: quantify improvements & catch slowdowns
- Initial object-oriented restructuring: supports code evolution & unit testing
- Over 160 “defects” addressed: bug fixes & minor enhancements

Other improvements:

- Simplified (standard) open-source license (BSD-3) & contributor agreement
 - OpenStudio, WINDOW & THERM all moving to same license
- New documentation platform (LaTeX)
- New website (energyplus.net) ...

New Feature Request Portal (energyplus.uservoice.com)!

Planned for several years, launched Aug. 2015 in response to BEM roadmap input

- Available under Feedback tab from energyplus.net (single sign-on)
- Currently tracking & refining 64 feature requests

The screenshot shows the EnergyPlus website's Feedback section. The navigation bar includes links for EnergyPlus, Downloads, Documentation, Support & Training, Licensing, Extras, Weather, and Feedback. A user profile for Amir Roth is visible, with options to stay signed in, view settings, or sign out. The main content area features a feature request titled "Replace IDF with a standardized data format (e.g., JSON, XML, etc.)" which has 10 votes and a "Voted!" button. The request details include a problem statement, a solution, and three bullet points. A user named nealkruis is credited with sharing the idea on July 31, 2015. A "IN DISCUSSION" badge is also present. On the right, a "Powered by bigladder" logo is shown above a section titled "What should we add next?" containing two suggestions: "Add ability to model ice rinks" and "Add Coolerado type evaporative cooling capability".

EnergyPlus Downloads Documentation Support & Training Licensing Extras Weather Feedback

Amir Roth (Stay signed in)
Settings · Sign out

10 votes
Voted!

Replace IDF with a standardized data format (e.g., JSON, XML, etc.)

Problem: IDF is non-standard, non-extensible, and positionally dependent.

Solution: Moving to a key-value pair style input (instead of positional) means:

- * Better handling of defaulting fields (no explicit blanks).
- * Long lists can be infinitely extensible (the schema doesn't need to specify fields for items 1-N, like the IDD does).
- * Transitions between versions of objects is handled more simply.

nealkruis shared this idea · July 31, 2015 · [Flag idea as inappropriate...](#)

IN DISCUSSION · July 31, 2015

Powered by bigladder

What should we add next?

- Add ability to model ice rinks >
- Add Coolerado type evaporative cooling capability >

New Feature – JSON Input Scheme

```
BuildingSurface:Detailed,  
  Bath_ZN_1_FLR_1_Floor,    !- Name  
  Floor,                    !- Surface Type  
  Insulated Carpet 6in Slab,!- Construction  
  Bath_ZN_1_FLR_1_ZN,      !- Zone  
  Ground,                   !- Outside Boundary Condition  
  ,                          !- Outside Boundary Object  
  NoSun,                    !- Sun Exposure  
  NoWind,                   !- Wind Exposure  
  ,                          !- View Factor to Ground  
  ,                          !- Number of Vertices  
  19, 10, 0,                !- X,Y,Z Vertex 1 {m}  
  19, 0, 0,                 !- X,Y,Z Vertex 2 {m}  
  0, 0, 0,                  !- X,Y,Z Vertex 3 {m}  
  0, 10, 0;                 !- X,Y,Z Vertex 4 {m}
```

IDF

```
"BuildingSurface:Detailed" : {  
  "Name" : "Bath_ZN_1_FLR_1_Floor",  
  "Surface Type" : "Floor",  
  "Construction" : "Insulated Carpet 6in Slab",  
  "Zone" : "Bath_ZN_1_FLR_1_ZN",  
  "Outside Boundary Condition" : "Ground",  
  "Sun Exposure" : "NoSun",  
  "Wind Exposure" : "NoWind",  
  "Vertices" : [{"X":19, "Y":10, "Z":0},  
                {"X":19, "Y":0, "Z":0},  
                {"X":0, "Y":0, "Z":0},  
                {"X":0, "Y":10, "Z":0}]  
}
```

JSON

Internally translate IDF (current) to JSON (new), expose JSON as option

- Target release is Sep. 2016

What does this buy us?

- More succinct (no need to represent empty elements)
- Easier handling of extensible objects & lists
- Easier schema evolution & version migration (no need to keep things in same positions)
- Many tools & libraries for dealing with JSON, IDF is EnergyPlus specific
- Vendors have been asking for this

Spawn-of-EnergyPlus

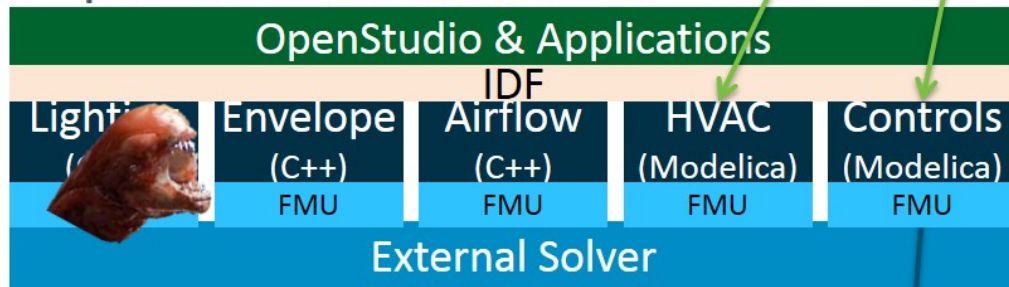
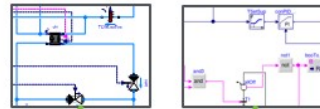


EnergyPlus

- Monolithic
- No component reuse channels



HVAC & control models from public or manufacturer libraries



Control models run on physical controllers (e.g., Tridium)



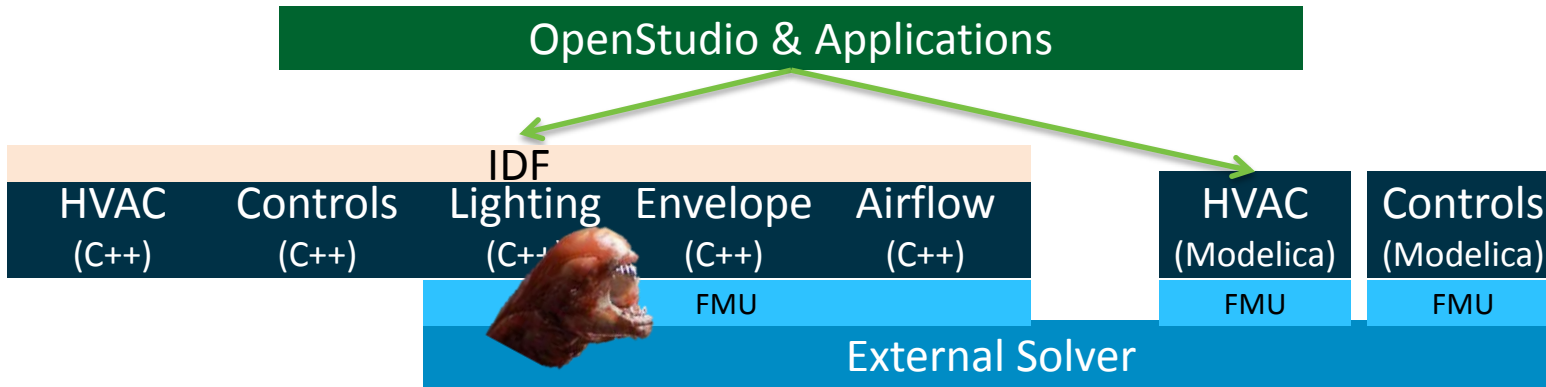
Spawn-of-EnergyPlus

- Modular
- Uses model libraries
- Inter-operable with control workflows

Internal initiative, intended to carry EnergyPlus forward for 20 years

- Rapid (even third-party) component development & reuse
- Component-specific time-steps & parallelization for high performance
- Unified simulation & control workflows
- How? Standard simulation interfaces (FMI), languages (Modelica) & external solvers

New Feature – Spawn-of-EnergyPlus Join Point



What is happening this year?

- Spawn compatible “wrapper” for existing lighting-envelope-airflow modules
 - Reformulated zone-heat-balance module acts as “join point”
 - Shared by EnergyPlus and Spawn going forward (EnergyPlus not going away soon)
- Minimal OpenStudio translator
 - Alternate engine from OpenStudio, not a drop-in replacement for EnergyPlus yet
- Continued coordinated development of Modelica libraries via IEA Annex 60

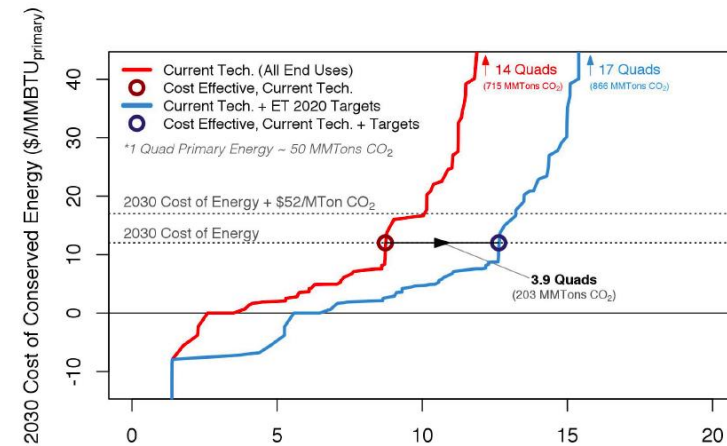
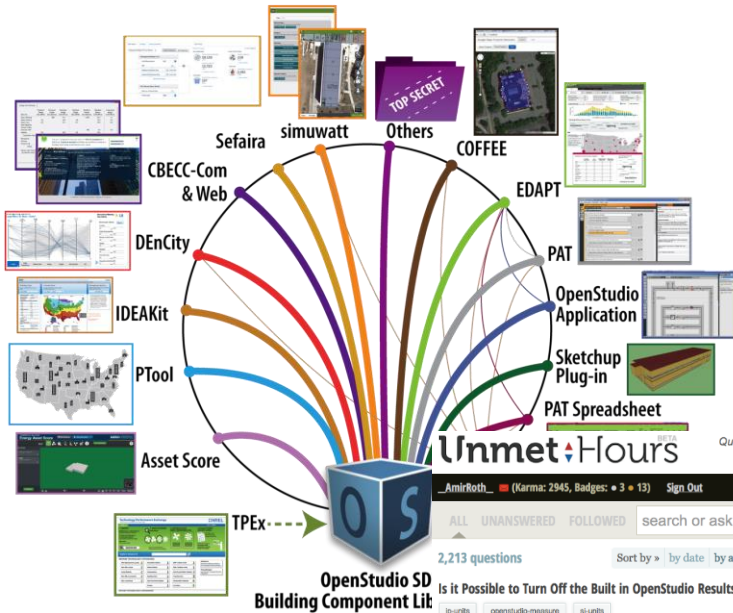
Next year?

- Initial support in OpenStudio application (GUI)
- Continued coordinated development of Modelica libraries via IBPSA-World

Project Integration & Collaboration

Integration:

- Work closely with OpenStudio (CBI) & BeOpt (RBI) project teams
- Supports: 90.1 & COMcheck (Codes), Asset Score (CBI) & Scout (cross-cutting)
- Supported by: ASHRAE140 & Validation (ET), UnmetHours (CBI), Hybrid Modeling (FOA)



Communications & Publications

Communications:

- [.../buildings/listings/end-use-breakdown-building-energy-modeling-blog](#)
 - [.../buildings/articles/energyplus-logo-debuts-revit-toolbar](#)
 - [.../buildings/articles/sefaira-serves-double-helping-energyplus-collaboration-top](#)
 - [.../buildings/articles/doe-releases-updated-versions-energyplus-and-openstudio](#)

Publications:

- A. Andelovic & M. Dakic, “Experimental Validation of an EnergyPlus Model: Application of a Multi-Storey Naturally Ventilated Double Skin Façade”, Energy and Buildings, Jan. 2016.
- M. Wetter, T. Noudui, D. Lorenzetti, E. Lee & A. Roth, “Prototyping the Next Generation EnergyPlus Simulation Engine”, Proceedings of 14th IBPSA World Conference, Dec. 2015.
- T. Hong, K. Sun, R. Zhang, R. Hinokuma, S. Kasahara & Y. Yura, “Development and Validation of a New Variable Refrigerant Flow System Model in EnergyPlus”, Energy and Buildings, Sep. 2015.
- A. Rempel & S. Remington, “Optimization of Passive Cooling Control Thresholds with GenOpt and EnergyPlus”, Simulation for Architecture & Urban Design, 2015.
- M. Martin, A. Afshari, P. Armstrong, L. Norford, “Estimation of urban temperature and humidity using a lumped parameter model coupled with an EnergyPlus model”, Energy and Buildings, Jun. 2015.

Communications & Publications

Publications cont'd:

- J. Zhao, K. Lam, B. Ydstie & O. Karaguzel, “EnergyPlus model-based predictive control within design–build–operate energy information modeling infrastructure”, Journal of Building Performance Simulation, Jun. 2015.
- F. Favonio, Y. Cascone, L. Bianco, F. Goia, M. Zinzi, M. Overend, V. Serra & M. Perrino, “Simulating Switchable Glazing with EnergyPlus: An Empirical Validation and Calibration of a Thermotropic Glazing Model”, Journal of Building Performance Simulation, Jun. 2015.
- L. Lan & Y. Tan, “Advanced Building Energy Monitoring Using Wireless Sensor Integrated EnergyPlus Platform for Personal Climate Control”, Power Electronics & Drive Systems, 2015.
- C. Peng & J. Yang, “The Effect of Photovoltaic Panels on Rooftop Temperature in the EnergyPlus Simulation Environment”, Journal of Photoenergy, 2016.
- U. Manandhar, A. Ukil & D. Wang, “Building HVAC Load Profiling Using EnergyPlus”, SmartGrid Technologies-Asia, 2016.

Many many many other publications in many venues!

Google Scholar: 3,160 mentions of EnergyPlus since beginning of 2015!

Next Steps & Future Plans

Process

- Continue focus on object-orientation & unit testing
- Continue integration of pre-processing utilities

Features

- Refine residential modeling features including basement & attic modeling
- Continue focus on performance for large “BIM” models
- Additional support for JSON input ... including JSON output?
- Additional support for Spawn-of-EnergyPlus
- Continue focus on addressing defects & improving usability
- High-leverage new features that are important for users & vendors

EnergyPlus is a “reactive” project that tracks & responds to technology developments & user & vendor needs

Thank You



REFERENCE SLIDES

Project Budget

Project Budget:

FY16: \$2,500K

FY17: \$2,500K

FY18: \$2,500K

Variances: Not Applicable

Cost to Date:

FY16: 80% (subcontract execution)

Additional Funding: NA

Budget History

Oct 2014 – FY 2015 (past)		FY 2016 (current)		FY 2017 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$5,000K	\$0k	\$2,500K	\$0k	\$2,500	\$0k

Project Plan and Schedule

Current FY16-18 Merit Review Cycle

Project Schedule												
Project Start: 10/1/2015	Completed Work											
Projected End: 9/30/2018	Active Task (in progress work)											
	◆ Milestone/Deliverable (Originally Planned)											
	◆ Milestone/Deliverable (Actual)											
	FY2016				FY2017				FY2018			
Task	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)
Past Work												
Release 8.5	◆											
Current/Future Work												
Release 9.0 (JSON)			◆									
Release 9.1 (Spawn Alpha)					◆							
Release 9.2							◆					
Release 9.3 (Spawn Beta)									◆			
Release 9.4											◆	