

EnergyPlus



*Energy***Plus**

An NREL-led project with collaboration from LBNL and ORNL
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Presenter: Edwin Lee, NREL (Edwin.lee@nrel.gov)

Project Summary

Timeline:

Start date: 1996, Current Period: FY16-FY18
(Next DOE Lab Call FY19-FY21)

Key Milestones

1. Annual Releases, 3/31/XX & 9/30/XX
2. Residential MVP (3/17)
3. JSON Input Structure (3/18)

Budget:

Total Project \$ to Date:

- DOE: \$77,500k (PoP ~2,500k/yr)
- Cost Share: \$0 (in kind)

Total Project \$:

- DOE: \$86,190k
- Cost Share: \$0 (in kind)

Key Partners:

LBNL	Objexx Engineering
ORNL	EmptyCrate
GARD Analytics	Big Ladder
FSEC	
OSU	

Project Outcome:

The outcome of this project is to support the Department of Energy's goals through increased adoption of EnergyPlus. This is achieved through focusing on an open, collaborative development process, and continued enhancements to EnergyPlus for new capabilities, runtime performance and code structure.

Team

National Labs



- Luigi Gentile Polese
- Edwin Lee
- Jason Degraw
- Kyle Benne
- Scott Horowitz
- Noel Merket



- Tianzhen Hong
- Rongpeng Zhang
- Xuan Luo



- Joshua New
- Mark Adams

Subcontractors

GARD Analytics

Building Energy Software, Modeling, and Standards



In-kind Partners



- Bi-weekly web-meetings
- Annual in-person planning meeting

Challenge

Goals

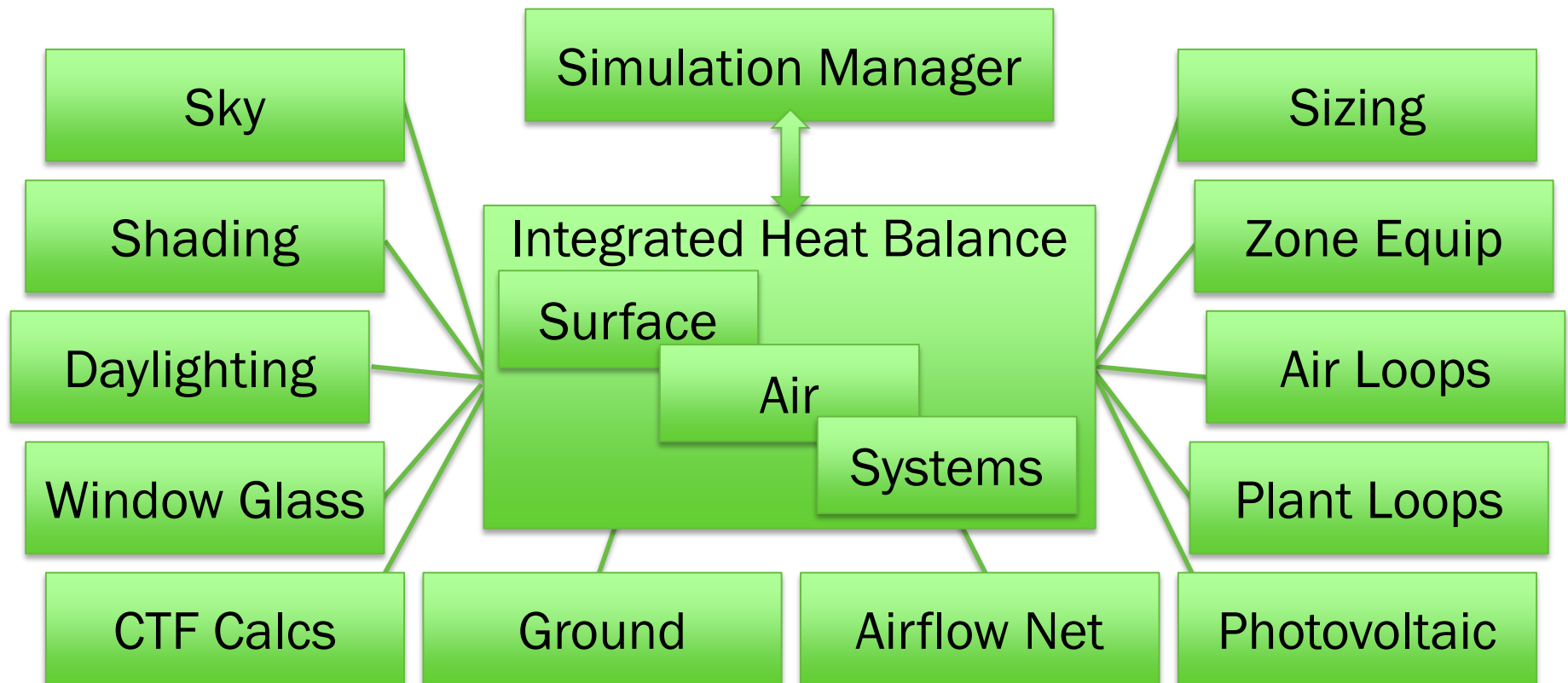
- Powerful, up-to-date engine that keeps up with new building and computing technologies
- Robust enough to support private sector applications and services for design, code-compliance, LEED, etc.
- Transparent to support vendor-neutrality and regulatory/financial applications.
- Flexible enough to support early-stage R&D and component & system performance analysis (workhorse for BTO's mission)

EnergyPlus meets these goals, recently focusing on:

- Robustness and testability
- Execution performance
- New features driven by users and vendors

What is EnergyPlus?

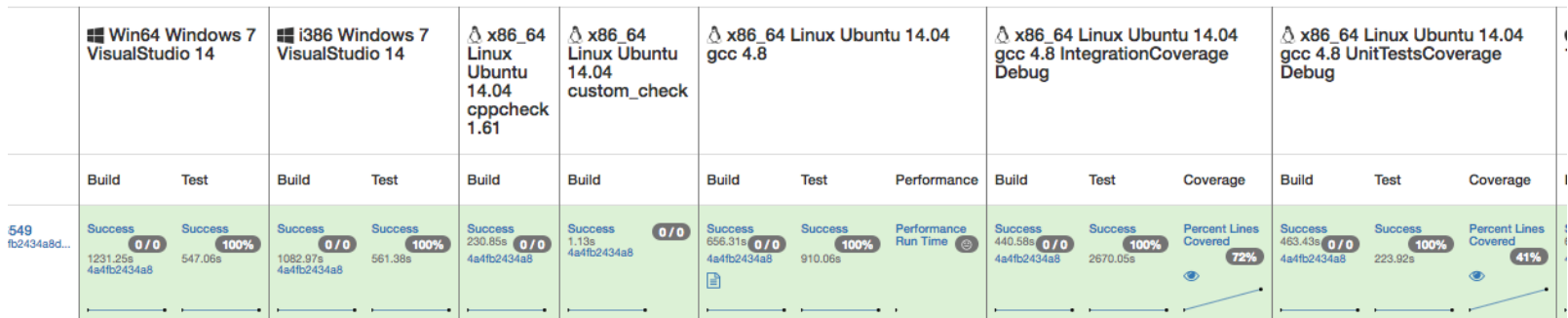
- Whole-building energy simulation engine
- Annual energy simulation + zone & equipment “sizing”
- Building science + computer science



Approach

Development

- Open-source BSD-3 license / C++ (since 2013)
- Public GitHub repository (<https://github.com/NREL/EnergyPlus/>)
 - That doesn't mean anyone can modify, GitHub doesn't work that way
- Cross-platform builds (CMake): MS-Windows, MAC OS, Linux
- gTest unit testing + regression suite with continuous integration (CI)



- Performance test suite

Version	5ZoneAirCooled	Ref: Large Office	Ref: Large Hotel
8.2.0	9.0s	42.0s	75.0s
8.8.0	7.4s	38.7s	58.8s

Approach

Documentation

- Engineering + Input/Output ref
- LaTeX PDF and HTML

Training

- Third-party providers

Support

- Peer-to-peer site (<http://unmethours.com/>)
- Helpdesk for sensitive questions (<http://helpserve.energyplus.com/>)

User feedback

- User feedback/voting used to select features for 8.5 on
- Transitioning from UserVoice to Github issue tracker

Unmet Hours BETA Question-and-Answer Resource for the Building

Hi There! Please Sign In

ALL UNANSWERED [energyplus] X 🔍

2141 questions Sort by » relevance date activity ▼ answers votes RSS

LEED Baseline G3.1.2.1: EER and COP with fan energy
energyplus performance-data leed appendix-g 3 votes 1 answer 46 views Mar 20 '18 dradair

Indirectly heated water heater with a backup electric heater - IndirectHeatAlternateSetpoint
energyplus service-hot-water storage-tank 2 votes 1 answer 28 views Mar 20 '18 Julien Marrec

What's the best way to add thermal bridges in OpenStudio?
openstudio thermal-bridge energyplus 2 votes 1 answer 120 views Mar 19 '18 mdahlhausen

LEED Baseline Building: G3.1.2.9
energyplus leed appendix-g design-air-flow-rate vav 3 votes 1 answer 48 views Mar 16 '18 dradair

What does the EnergyPlus warning "Inside surface heat balance did not converge" mean?
energyplus error convergence heat-balance 1 vote 1 answer 44 views Mar 16 '18 Molly Curtz



Progress: Features

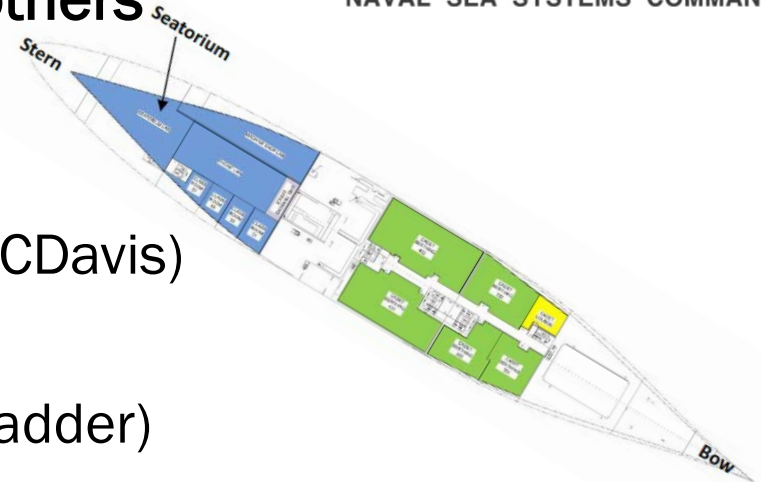
Features added in most recent two versions

- Enhanced urban context simulation
- Integrated PVWatts calculations
- JSON input structure
- Integrated WinCalc engine
- Simple command-line interface (CLI)



Features added in collaboration with others

- Ship simulation (NAVSEA)
- Phase change materials (NRGSim)
- Performance-map driven hybrid RTU (UCDavis)
- Attic duct model (Fraunhofer CSE)
- Kiva ground heat transfer model (Big Ladder)

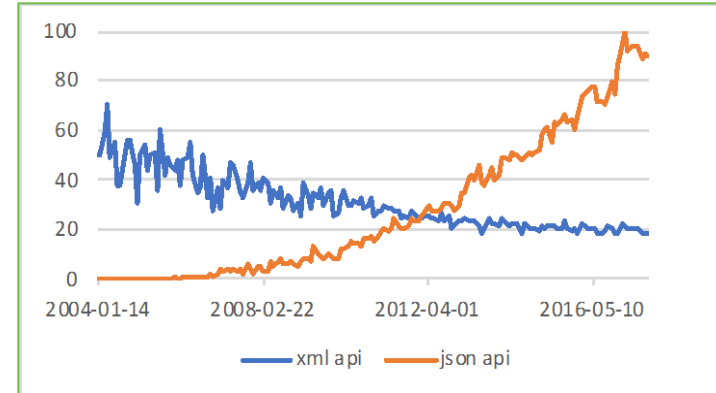


Progress: Feature Deep Dive



Transition from IDF to JSON Input Structure

- User requested feature
- IDF: Custom EnergyPlus input format
- JSON: Industry standard format (the new XML)
- Key-value structure simplifies maintainability
- Reduces runtime
- Supported by many editors and libraries
- Available in 8.9, Primary in 9.0
- IDF removed in future version



JSON's scaled popularity with XML as reference (Google Trend)

```
Site:Location,  
  Denver Centennial,    !- Name  
  39.74,                 !- Latitude {deg}  
  -105.18,              !- Longitude {deg}  
  -7.00,                !- Time Zone {hr}  
  1829.00;              !- Elevation {m}
```



```
"Site:Location": {  
  "Denver Centennial": {  
    "elevation": 1829.0,  
    "latitude": 39.74,  
    "longitude": -105.18,  
    "time_zone": -7.0  
  }  
},
```

Progress: Other

Bug fixes (big focus for last several years)

- Versions 8.7-8.9: 171 defects repaired (77 in 8.8 alone!)

Re-factoring and object-orientation to take advantage of C++

- Recent effort to object-orient plant component models
- Current effort to unify/refactor DX cooling coil models

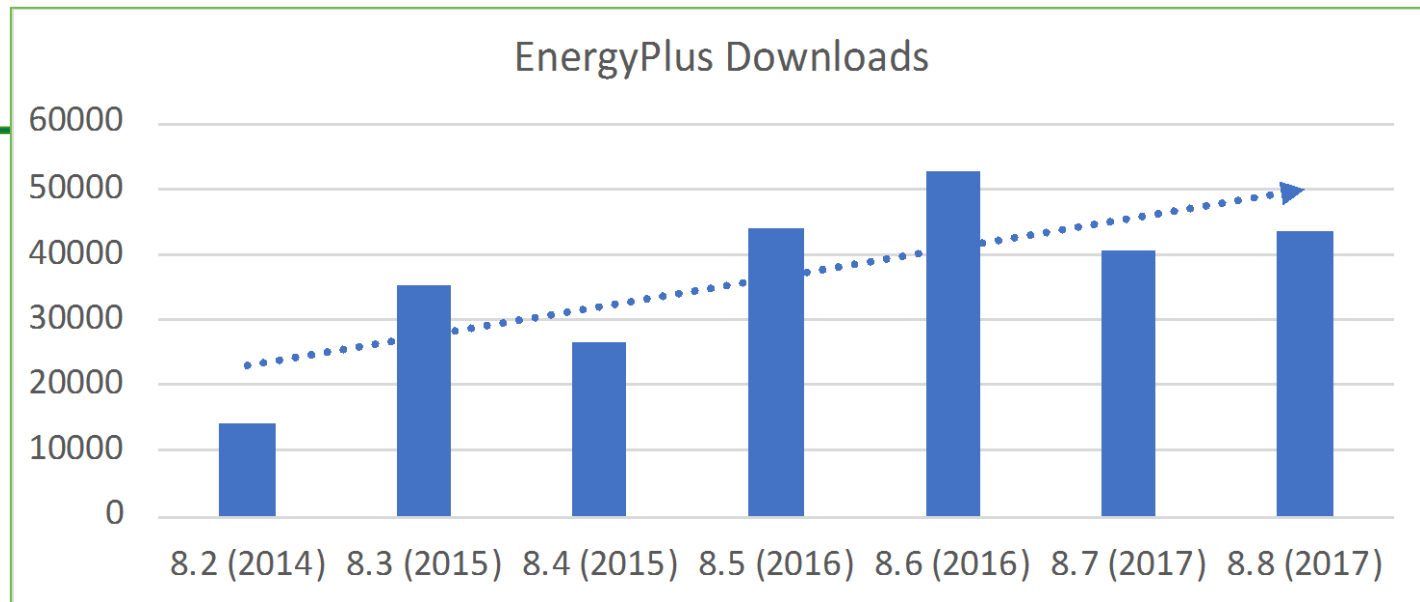
Re-factoring to share code with Spawn

- Creating modular components also improves testability

Testing

- Automated ASHRAE Standard 140 testing and report generation

Impact



New products and services

- Trane TRACE 3D Plus, Autodesk Insight, Lucid buildingOS, Simuwatt 2.0

AIA 2030 reporting – 2017

- Used in 322 of 2385 (13.5%) of modeled



TRACE 3D Plus

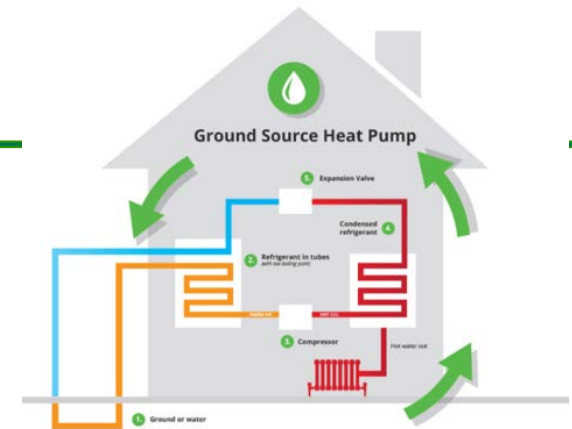
Research

- 15,300 Google Scholar hits since 2014
- Most widely used engine (by far) for (published) research

Remaining Project Work

FY18

- A September 30, 2018 release
- EIR formulated water-to-water heat pump
- Improved modeling of refrigerated open vertical display cases
- Enhanced ground source heat pump sizing and simulation



Beyond FY18

- Continued support of users and evolving standards and technology
- Python-based EMS (user defined components and controls)
- An API layer to support interfaces and workflows
- Convergence with Spawn (Modelica-based HVAC modeling)



Thank You

NREL, LBNL, ORNL, and Subcontractors

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Presenter: Edwin Lee, Engineer, NREL, Edwin.lee@nrel.gov

REFERENCE SLIDES

Project Budget

Project Budget: Estimated from 1996-FY13: \$65000k, FY14-FY18: \$2500k/yr

Variances: Project budget was not significantly modified during this period

Cost to Date: PoP (FY16-FY18): ~\$6000k of \$7500k; Total-to-date: ~\$76000k

Additional Funding: Contributions to EnergyPlus have come from DOE SBV, society grants, direct contributions from industry partners, and more

Budget History

1996 – FY 2017 (past)		FY 2018 (current)		FY 2019 – FY 2021 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$76000k		\$1250k		\$8690k	

Project Plan and Schedule

- EnergyPlus project started in 1996
- Current period of performance FY16-FY18
- Primary milestones: biannual releases – all on time
- No remaining go/no-go decision points for this period of performance

	FY16	FY17	FY18
8.5.0	◆		
8.6.0		◆	
8.7.0		◆	
8.8.0			◆
8.9.0			◆
9.0.0			★