LBNL – P. Haves, F. Buhl, M. Wetter, T. Hong, T. Nouidui, S. Vidanovic, G. Sawaya
NREL – B. Griffith, E. Bonnema, P. Tabares
ORNL – J. New, B. Fricke, B. Shen, M. Bhandari
PNNL – K. Gowri, W. Wang, D. Kang
FSEC – L. Gu, R. Raustad, B. Nigusse, C. Sharma
GARD Analytics – M. Witte, J. Glazer, R. Henninger
DHL Consulting – L. Lawrie
UIUC – R. Strand
OSU – D. Fisher, E. Lee
DOE – A. Roth

EnergyPlus

Brent T. Griffith
NREL
Brent.Griffith@nrel.gov 303-384-7395
April 2, 2013

Project Budget

Project Budget: FY2013 budget $2,500,000 (entire team)

Variances: None

Cost to Date: On schedule

Additional Funding: Collaborative developers contribute source code. Trane company on development team.

Budget History					
FY2010		FY2011		FY2012	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$4,027,000		$3,420.000		$2,900,000	

Purpose & Objectives

Problem Statement: Fair and accurate assessment of different energy efficiency measures for all types of buildings projects requires a general analysis framework based on physics and systems integration modeling.

Impact: EnergyPlus is enabling energy savings in broad ways:

- **R&D** – prioritizes technologies, quantifies whole-building savings, promotes technical collaboration with market performers
- **Market Stimulation** – delivers integrated design tools, supports product sales, quantifies value of efficiency measures, supports analysis for design guides, education
- **Codes and Standards** – offers analysis for prescriptive levels, performance path compliance, quantifies progress across revisions

EnergyPlus is a comprehensive, continuously updated and maintained, fully supported and documented, free, and open-source solution!

Purpose & Objectives

Project Focus: Maintain EnergyPlus as BTO's best-in-class product for whole-building energy performance modeling, by incrementally improving its capabilities and accuracy, and by supporting users and application developers.

Enable broad use cases for BTO including:

- Integrated design for energy-efficient new buildings and retrofits
- Analysis to support codes and standards (90.1, 189.1)
- Analysis to support design guides (AEDG, AERG)
- Building performance rating (LEED, Asset Score)
- Packaged analyses for fast deployment (179D DOE Calculator)
- Evaluation of component (emerging) technologies
- Policy-scale technology assessments
- Building science education

Approach

Key Issues:

- Empirical validation—high-resolution, high-fidelity test data required
- Execution speed increases
- Accommodating new equipment, systems, and controls
- Training and support

Distinctive Characteristics:

- DOE-branded production software that is the basis for both standards and commercial tools
- State-of-the-art detailed physics, other engines well behind
- Significant recent adoption by states, vendors, and research organizations
- Successful, multi-lab/contractor/university collaboration
- R&D 100 award (2003)

Project Integration, Collaboration & Market Impact

Third-party software based on EnergyPlus

- **US:** AECOsim Energy Simulator (Bentley), Simergy (DOE, CEC, Trane, H-Q, NEEA), OpenStudio (NREL), MLE+(UPenn), N++(ExpertApp), CleanUrbanEnergy (CUE)
- **International:** SMART ENERGY (India), DesignBuilder (UK), JEPlus (UK), GreenSpaceLive (UK), VisualEPlus (China)

Organizations switching to EnergyPlus

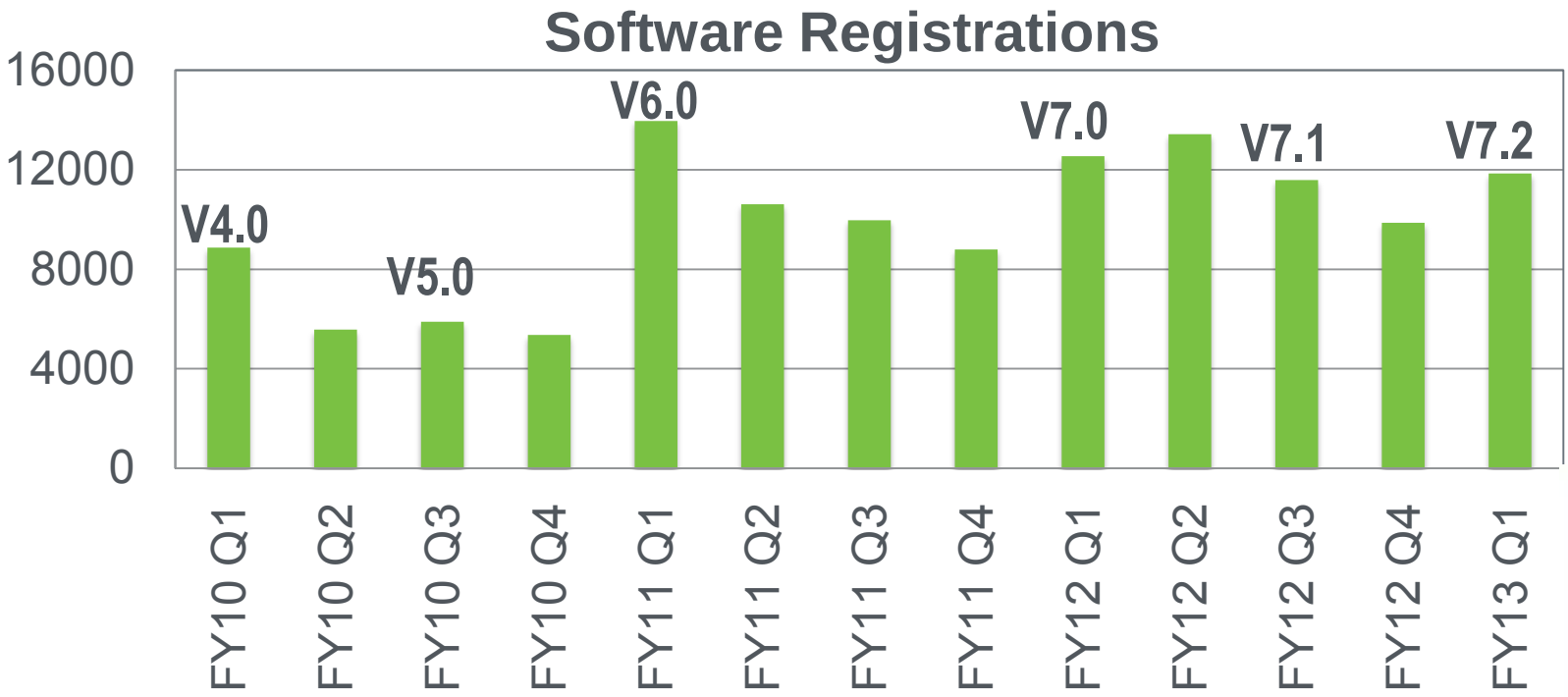
- California Energy Commission – Title 24
- Trane Company – TRACE 800, development
- Natural Resources Canada – research, development
- National Research Council Canada – research
- FSEC – EnergyGauge software for FL energy code
- Xcel – utility design assistance program software
- National Grid – utility design assistance market research
- PNNL – COMcheck for IECC and ASHRAE Standard 90.1
- Others under NDAs

Project Integration, Collaboration & Market Impact

EnergyPlus Website Metrics

1,968,039 hits in 2012, 56% from USA, 49% returning

Third highest traffic across all of EERE's distinct websites



Approach

EnergyPlus is large production software branded by DOE

- 604,600 lines of code (Fortran2003, some C++)
- 689 input objects (e.g., Fan), 55,143 fields
- Runtime programming language
- 3,490 output variables, 89 summary tables
- 4,259 pages of documentation, 775 pages of validation reports
- Online helpdesk, support for 3rd-party interface developers

Approach

Development process: 6-month release cycle

- Collaborative effort—broad expertise base (HVAC, airflow, numerics)
- Distributed team—biweekly calls, annual physical planning meeting
- Programming standard
- New feature proposal review and approval process
- New projects selected from list of requests (370 items)
  - BTO guides priorities
  - Development team estimates effort
  - Consensus-based selections during planning meeting
- Bugs from helpdesk tracked, prioritized, fixed and 2nd party verification
- Regression testing, timing checks
- Validation test suite (Standard 140, others)

Accomplishments and Progress

Version 7.0 (Released November 2011)

- Plant system major renovation
- Ground heat transfer model with buried pipes
- Refrigerated warehouse air chiller
- Shadowing model improvements

Version 7.1 (Released April 2012)

- ASHRAE Standard 62.1 based calculations and reports
- Variable speed water-to-air coils
- Commercial refrigeration: transcritical CO2, two-stage
- Functional Mock-up Unit interface for co-simulation
- Generic user-defined components for EMS

Accomplishments and Progress

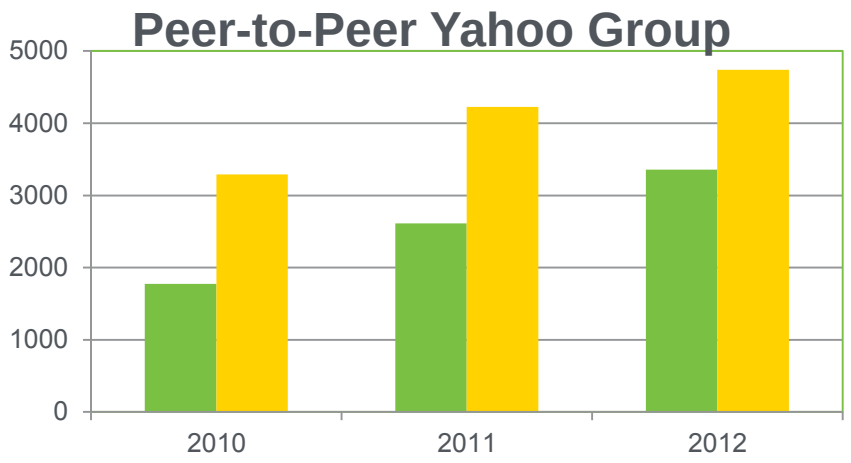
Version 7.2 (Released October 2012)

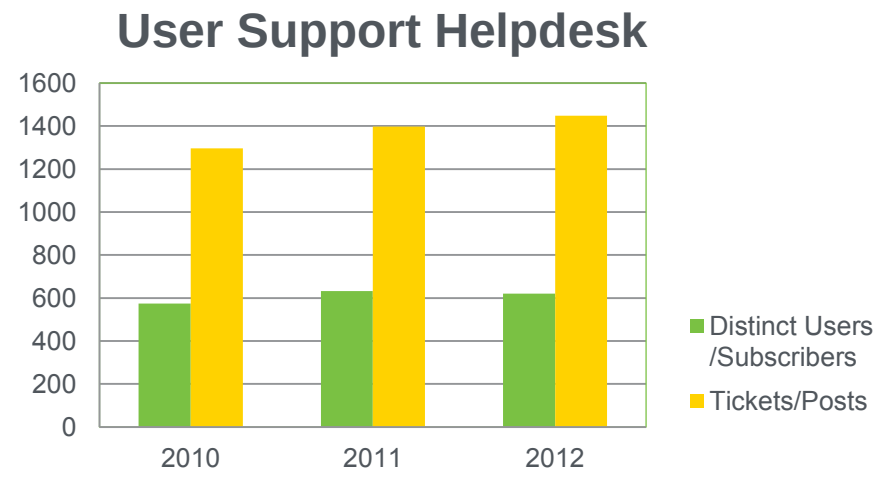
- Simultaneous Variable Refrigerant Flow (VRF)
- Complex windows (BSDF)
- Variable speed DX air-to-air coils
- Zone equipment availability managers

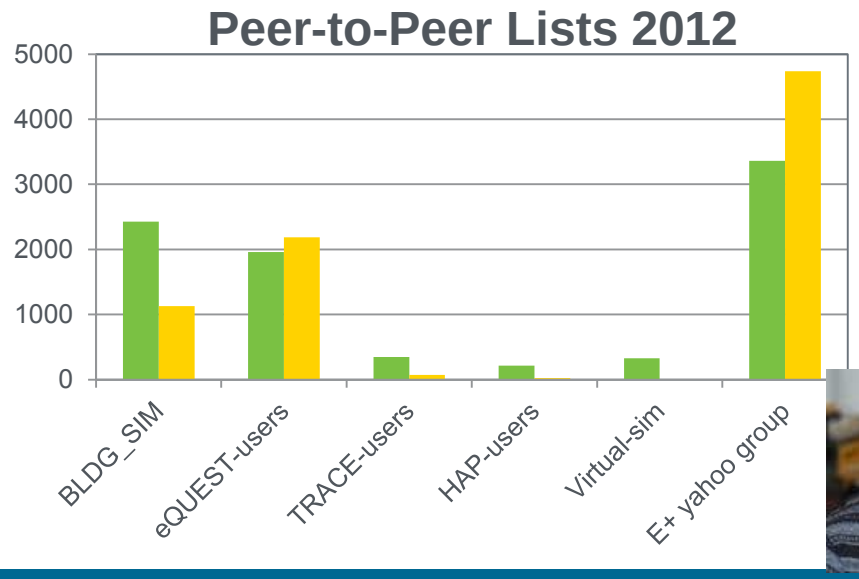
Version 8.0 (Planned April 2013)

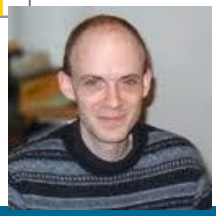
- Overhaul of output: variable names, zone load components, LEED summary, XML style (required major version change)
- High SEER multispeed AC furnace
- Plant heat exchanger for multiple secondary loops
- Central chiller heater system

Accomplishments Large, growing, and global user base









Project Plan & Schedule

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

EnergyPlus development is organized around a revolving 6-month software release.

- Months 1- 4: new features and planned enhancements
- Month 5: bug fixes, clean up, robustness testing
- Month 6: critical bug fixes, packaging, distribution testing
- Month 7: post release validation testing and reports

Summary	
WBS Number or Agreement Number (NREL and subcontractors)	#8006
Project Number (NREL and subcontractors)	ET-MOD-NREL-FY13-01
Agreement Number (NREL and subcontractors)	#8006

Legend	
	Work completed
	Active Task
	Milestones & Deliverables (Original Pla
	Milestones & Deliverables (Actual)

Task / Event	FY2012				FY2013				FY2014			
	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)
Project Name: EnergyPlus												
Fall 2011 Release Version 7.0 (November 2011)												
Spring 2012 Release Version 7.1 (April 2012)												
Fall 2012 Release Version 7.2 (October 2012)												
Spring 2013 Release Version 8.0 (target April 2013)												
Fall 2013 Release (target October 2013)												
Spring 2014 Release (target April 2014)												

Next Steps and Future Plans

Continue 6-month release cycle

- Codes and standards requirements—e.g., 62.1, 205
- Interface developer requests—e.g., documentation database
- User feedback and requests—e.g., VRF
- Manufacturer requests—e.g., Daikin-McQuay “Rebel” RTU (V8.1)

Technical priorities

- Execution speed—multi-threading, vectors, caching, new algos
- Empirical validation—requires high-res data sets (e.g., FLEXlab)
- Co-simulation—with other engines
- Support for operations—controls, fault models, Modelica

Major rewrite coming?

- C++/Modelica, multi-core enabled, GPU-enabled?