NREL – B. Griffith, E. Bonnema, P. Tabares
ORNL – J. New, B. Fricke, B. Shen, M. Bhandari
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: 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.

<table>
<thead>
<tr>
<th></th>
<th>FY2010</th>
<th>FY2011</th>
<th>FY2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOE</td>
<td>$4,027,000</td>
<td>$3,420,000</td>
<td>$2,900,000</td>
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<tr>
<td>Cost-share</td>
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</table>
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!*
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)
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
EnergyPlus Website Metrics

1,968,039 hits in 2012, 56% from USA, 49% returning
Third highest traffic across all of EERE’s distinct websites
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 and Progress

Accomplishments Large, growing, and global user base

Peer-to-Peer Yahoo Group

Peer-to-Peer Lists 2012

User Support Helpdesk
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

<table>
<thead>
<tr>
<th>Task / Event</th>
<th>Project Name: EnergyPlus</th>
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<tbody>
<tr>
<td></td>
<td>Fall 2011 Release Version 7.0 (November 2011)</td>
</tr>
<tr>
<td></td>
<td>Fall 2012 Release Version 7.2 (October 2012)</td>
</tr>
<tr>
<td></td>
<td>Spring 2013 Release Version 8.0 (target April 2013)</td>
</tr>
<tr>
<td></td>
<td>Fall 2013 Release (target October 2013)</td>
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<tr>
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<td>Spring 2014 Release (target April 2014)</td>
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</table>
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?