Residential Building Energy Modeling & Data Analytics

National Renewable Energy Laboratory
Scott Horowitz, Senior Engineer
scott.horowitz@nrel.gov
Project Summary

**Timeline:**

- Start date: 10/1/15
- Planned end date: TBD

**Key Milestones**

2. Residential OS Measures [7/31/17]
3. OS/E+ ERI Beta Workflow [STRETCH 8/31/17]
4. GEB Component Model Roadmap [3/31/18]

**Budget:**

**Total Project $ to Date:**

- DOE RBI: $2,800k
- DOE Non-RBI: $1,150k
- Cost Share: $830k

**Total Project $:**

- DOE RBI: $3,020k
- DOE Non-RBI: $1,685k
- Cost Share: $1,732k

**Key Partners:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>DOE ET/EPSA/WIP/OSP/OE</td>
<td>Tendril</td>
</tr>
<tr>
<td>HERS Software Vendors</td>
<td>NEEA</td>
</tr>
<tr>
<td>NASEO</td>
<td>EPA</td>
</tr>
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<td>LADWP</td>
<td>City of Boulder</td>
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<tr>
<td>BPA</td>
<td>Many Others</td>
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</tbody>
</table>

**Project Outcome:**

Foundational open-source energy modeling capabilities using BTO’s flagship building simulation ecosystem (OpenStudio & EnergyPlus) and HPXML, that is leveraged by research programs and industry software tools to advance state-of-the-art residential efficient buildings and technologies.
Team

NREL Residential Buildings Tools & Analysis team

Scott Horowitz, Senior Engineer, PI
Expertise: Software development, energy modeling, optimization, stock analysis

Craig Christensen, Principal Engineer
Expertise: Energy modeling, stock analysis, optimization, active/passive solar

Anthony Fontanini, Research Engineer
Expertise: Energy modeling, computational fluid dynamics, high performance computing

Chioke Harris, Research Engineer
Expertise: Stock analysis, envelope technologies, energy storage, Scout

Jeff Maguire, Research Engineer
Expertise: Energy modeling, hot water systems, model validation

Noel Merket, Research Engineer
Expertise: Software development, HPXML, stock analysis, Home Energy Score

Maharshi Pathak, Research Engineer
Expertise: Energy modeling, stock analysis, HPXML, data analytics

Ben Polly, Senior Engineer
Expertise: Grid interactive efficient buildings, model validation/calibration, urban modeling

Dave Roberts, Group Manager
Expertise: Building science, energy modeling, software development

Joe Robertson, Research Engineer
Expertise: Software development, data analytics, stock analysis, model calibration

Eric Wilson, Research Engineer
Expertise: Stock analysis, energy modeling, HVAC and hot water systems

Jon Winkler, Senior Engineer
Expertise: Energy modeling, HVAC design & testing, comfort solutions
Team

Key Stakeholders

- U.S. Department of Energy
- Bonneville Power Administration
- EPA
- NEEA
- EERE Building Technologies Office
- EERE Office of Strategic Programs
- EERE Weatherization and Intergovernmental Programs Office
- Office of Energy Policy and Systems Analysis
- Office of Electricity
- Los Angeles Department of Water & Power
- TEN-DRIL
- ICF
- NYSERDA
- RESNET
- Mayor’s Office of Sustainability
- National Association of State Energy Officials
- City of Boulder
- RESCO
- ekotrope
- Wrightsoft
- PIVOTAL Energy Solutions
Challenge

RBI Goal: By 2030, reduce EUI in residential buildings by 40%.

Research Challenge: BTO invests substantial R&D funding into new and emerging building technologies. How do we steer these investments toward the best opportunities to reduce energy consumption at least cost?

Industry Challenge: Industry increasingly demands modeling tools to quantify energy savings for hundreds of thousands of buildings each year. How do we ensure these tools rapidly incorporate new building technologies and provide fair and consistent results?
1. Research community uses **energy modeling** to identify technology areas and housing segments with highest savings potential.

2. Manufacturers and national laboratories use **energy modeling** to test, develop, and validate new building technologies.

3. Industry uses **energy modeling** software tools to credit building technologies through ratings/scores, codes, utility programs, etc.
Challenge

Market Barriers & Inefficiencies

<table>
<thead>
<tr>
<th>Simulation Engine</th>
<th>Interface(s)</th>
<th>Primary Sector(s)</th>
<th>General Purpose?</th>
<th>Capability</th>
<th>Active Development</th>
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<tbody>
<tr>
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</table>

**Capability**
- Slow to add/credit new technologies
- Lack “utility grade” calculations

**Consistency**
- Generate inconsistent results
- “Race to the lowest HERS Index”

**Transparency**
- Black-box, proprietary calculations
- Cannot leverage outside contributions

**Cost**
- Redundant software implementations
- High industry-wide costs incurred
Approach

A common, open-source residential energy modeling platform, built on DOE’s flagship OpenStudio/EnergyPlus (OS/E+) ecosystem, that is suitable for both research & industry.

1. Leverage BTO and industry investments in OS/E+/HPXML
2. Supplement OS/E+ with missing, prioritized residential technologies
3. Expand HPXML developer capabilities, support, and use
4. Develop open-source workflows to support industry calculations/metrics
5. Engage with private-sector software developers and other stakeholders
**Approach**

**Benefits**
- Accelerates new technologies into software tools
- Increases consistency across DOE/industry programs
- Reduces developer effort to use EnergyPlus
- Lowers industry-wide costs of maintaining multiple engines
- Allows private-sector competition around innovations for user interface, business support, etc.
RESStock

Highly granular modeling of the U.S. housing stock

**Approach**

**PROBLEM**

Prototype-based analysis can lead to incorrect all-or-nothing results.

**APPROACH**

Granular analysis can lead to targeted opportunities within the housing stock.

**SOLUTION**

1000s of statistically representative models

5 million homes in housing segments with average payback less than 5 years
Approach

Grid-interactive Efficient Buildings (GEB) Roadmap

- Valuation of building efficiency and load flexibility strategies versus PV/battery solutions
- Component-level residential GEB models
- Discrete event-based occupancy models
- Whole-building analysis and optimization techniques
Impact

Energy modeling software is used **pervasively and at scale** to drive efficient buildings and technologies.

BTO’s energy modeling capabilities are targeting **the largest programs**.

<table>
<thead>
<tr>
<th>Program</th>
<th>Impact Description</th>
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</thead>
<tbody>
<tr>
<td>Building America</td>
<td>45,000+ new homes (and over 1.5 million indirectly)</td>
</tr>
<tr>
<td>HERS Industry</td>
<td>225,000+ new homes/year (2 million homes to date)</td>
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<tr>
<td>Home Energy Score</td>
<td>85,000+ existing homes to date</td>
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<tr>
<td>Weatherization Assistant</td>
<td>35,000+ existing homes/year</td>
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<tr>
<td>ENERGY STAR Certified Homes</td>
<td>100,000+ new homes/year (1.9 million homes to date)</td>
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<tr>
<td>Zero Energy Ready Homes</td>
<td>14,000+ new homes to date</td>
</tr>
<tr>
<td>Utility Programs</td>
<td>$2 billion/year spent on residential efficiency programs</td>
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</tbody>
</table>
Highly granular modeling of the U.S. housing stock

Quadrennial Energy Review 1.2

EPSA State Fact Sheets

EPA/EPSA Low-Income Potential

City of Boulder EE Market Engagement
Progress

**BEopt technology models available**

**ResStock workflow available**

**Proof-of-concept HERS workflow**

**GEB Roadmap**

**EnergyPlus Models**

- New foundation model, multiple/partial HVAC, duct radiation, new PV model, etc.

- HPWHS, enhanced moisture buffer model, etc.

**OpenStudio**

- 2016
- 2017
- 2018
- Today

**BEopt**
Stakeholder Engagement

Conferences/Forums
- RESNET Conference & Board Meeting
- ASHRAE/IBPSA Building Simulation Conference
- ACEEE Summer Study on Buildings
- ACEEE Hot Water Forum
- National Home Performance Conference
- CEE Industry Partners Meeting
- National Energy Codes Conference
- Better Buildings Summit

Working Groups/Committees
- RESNET Standards Development Committee
- RESNET Common Schema Subcommittee
- RESNET Collaborative Modeling Subcommittee
- RESNET Subject Matters Expert Committee
- NASEO Harmonization Working Group
- NASEO EMPRESS project
- HPXML Working Group
Stakeholder Engagement

Other Communications
• Journal articles
• Conference papers
• Building America webinars
• ASHRAE Journal
• Home Energy magazine
• Energy Design Update magazine

Collaborators/Subcontractors
• OpenStudio & EnergyPlus development teams
• HERS software vendors
  – NORESCO, Wrightsoft, Pivotal, Ekotrope, etc.
• Research laboratories
  – ORNL, PNNL, LBNL, FSEC, Fraunhofer, etc.
• Big Ladder Software
Remaining Project Work

Near Term
• Implement technology models for new/emerging technologies
• Complete build-out of residential (HERS/HEScore/WAP) workflow
• Complete multifamily capabilities for ResStock
• Tackle short-term needs outlined in residential GEB Roadmap

Longer Term
• Implement technology models for new/emerging technologies
• Incorporate research-grade models into industry software as appropriate
• Expand third-party use of ResStock by consultants/organizations
• Implement capabilities needed for GEB analysis/optimization
Thank You

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REFERENCE SLIDES
Project Budget: Substantial increase of non-RBI funding starting in first half of FY17 and continuing into FY18 as we promote the residential OS/E+ capabilities and demonstrate value.

Variances: N/A

Cost to Date: In FY18: 100% of DOE RBI, 40% of DOE Non-RBI

Additional Funding: BPA (FY16-17), EPA (FY16-17), DOE EPSA/OSP/ET/CBI/WIP (FY16-18), Tendril (FY16-18), LADWP (FY18), Misc (FY16-18)

### Budget History

<table>
<thead>
<tr>
<th></th>
<th>FY 2016 – FY 2017 (past)</th>
<th>FY 2018 (current)</th>
<th>FY 2019 – TBD (planned)</th>
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<td>DOE RBI</td>
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<td>DOE Non-RBI</td>
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<td>$778k</td>
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<td>Cost-share</td>
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TBD: To Be Determined
Project Plan and Schedule

Project initiation date: FY16
Project completion date: Ongoing; specific tasks sunset as appropriate

- Substantial completion of core residential capabilities implemented in OS/E+
- Continued work on 1) residential OS/E+ models, 2) build out of common HEScore/HERS/WIP workflow, 3) ResStock capabilities & analysis, and 4) GEB component models
- Most significant milestones shown below

<table>
<thead>
<tr>
<th>Task</th>
<th>FY2016</th>
<th>FY2017</th>
<th>FY2018</th>
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</thead>
<tbody>
<tr>
<td>Past Work</td>
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<tr>
<td>FY16 Q1 Milestone: Paper on ResStock Value for Use Cases</td>
<td>✧</td>
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<tr>
<td>FY16 Q2 Milestone: Release of HPXML Data Validator Tool &amp; API</td>
<td>✓</td>
<td>✧</td>
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<tr>
<td>FY16 Q3 Milestone: ResStock Analysis Results to DOE/EPSA</td>
<td>✓</td>
<td>✧</td>
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<td>FY16 Q4 Milestones: Releases of EnergyPlus/OpenStudio with Res. Models</td>
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<td>✧</td>
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<td>FY17 Q2 Milestone: Demo of ResStock OpenStudio Workflow</td>
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<tr>
<td>FY17 Q4 Milestone: Release of ResStock Web Interface</td>
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<tr>
<td>FY17 Q4 Milestone: Release of Res. OpenStudio Measures</td>
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<tr>
<td>FY17 Q4 STRETCH Milestone: Release of HERS Index Workflow in OpenStudio</td>
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<td>Current/Future Work</td>
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<td>FY18 Q1 Milestones: Releases of EnergyPlus/OpenStudio with Res. Models</td>
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<td>FY18 Q1 Milestone: Release of SEED HPXML Importer</td>
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<tr>
<td>FY18 Q2 Milestone: Roadmap for Residential GEB component models</td>
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<tr>
<td>FY18 Q3 Go/No-Go: Significant Progress &amp; Value to Stakeholders</td>
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<tr>
<td>FY18 Q3 Milestone: Technical Presentation Update on ResStock</td>
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<td>FY18 Q4 Milestones: Releases of EnergyPlus/OpenStudio with Res. Models</td>
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<td>✧</td>
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</table>