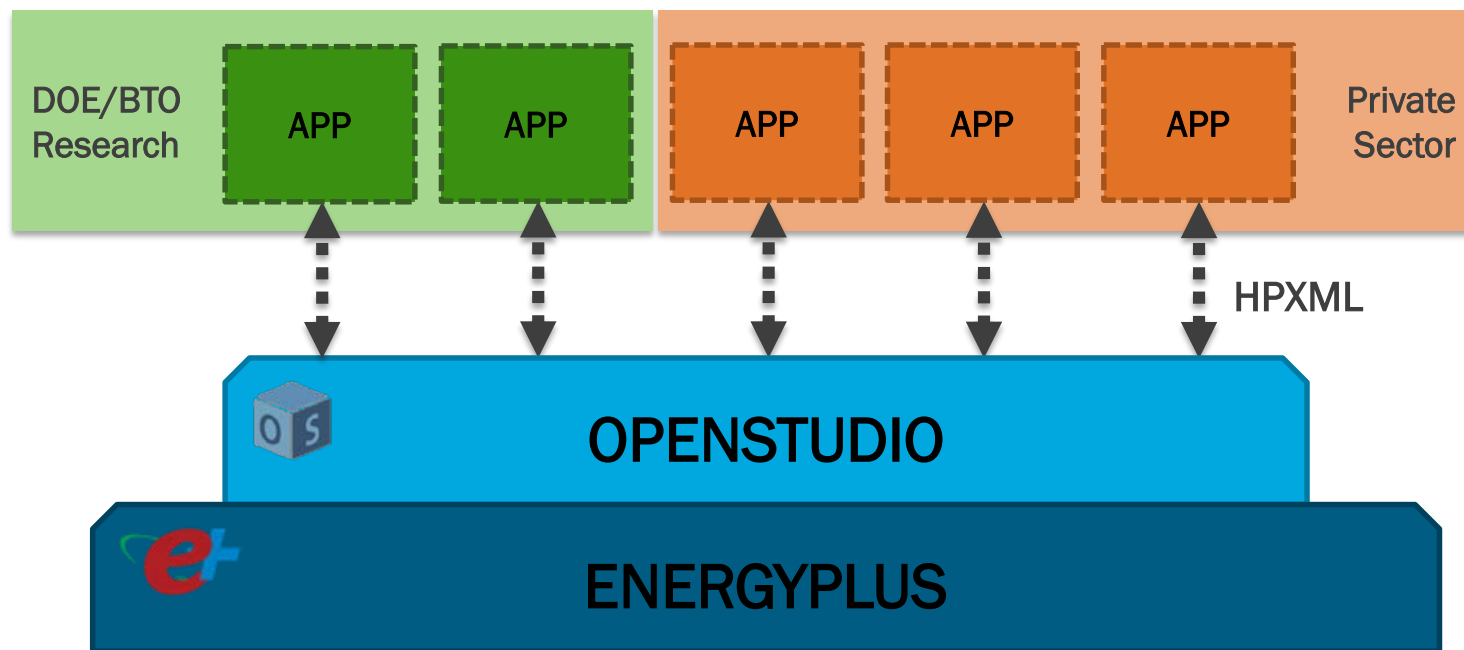


Residential Building Energy Modeling & Data Analytics



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

1. ResStock/OS Demonstration [3/15/17]
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:

DOE ET/EPISA/WIP/OSP/OE	Tendril
HERS Software Vendors	NEEA
NASEO	EPA
LADWP	City of Boulder
BPA	Many Others

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

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

Bonneville
POWER ADMINISTRATION



Los Angeles
Department of
Water & Power

TEN-DRIL®

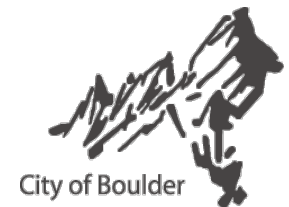


NYSERDA



NYC
Mayor's Office
of Sustainability

NASEO
National Association of
State Energy Officials



NORESCO



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?

Challenge

Technologies: Research-to-Market via Energy Modeling



Performance
Goal A

Performance
Goal B

Performance
Goal C

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.



SCORE			
			✓
			x

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

Challenge

Market Barriers & Inefficiencies

Simulation Engine	Interface(s)	Primary Sector(s)	General Purpose?	Capability	Active Development
CSE	CBECC-Res, Right-Energy	Res	Yes	+++	++
DOE-2.1e	Home Energy Score, EnergyGauge, Beacon	Res/Com	Yes	+++	—
DOE-2.2	eQUEST	Res/Com	Yes	—	—
Ekotrope	Ekotrope	Res	—	—	++
Energy-10	Energy-10	Res/Com	—	—	—
EnergyPlus	DesignBuilder, BEopt, Autodesk, TRACE, CBECC Com, eQUEST	Res/Com	Yes	+++++	+++++
ESP-r	ESP-r	Res/Com	Yes	+++++	++
HEED	HEED	Res	—	++	+
HOT2000	HOT2000	Res	—	++	++
ThermTrak	ThermTrak, Snugg	Res/Com	—	++	+
PHPP	PHPP	Res	—	++	++
REM/Rate	REM/Rate	Res	—	+	+
SEEM	SEEM	Res	—	++	+
SIMPLE	CakeSystems	Res	—	+	+
SUNREL	TREAT	Res	Yes	++	—
TRNSYS	TRNSYS	Com	Yes	+++++	++
TrueHome	TrueHome	Res.	—	+	+

Current state of the market

Capability

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

Consistency

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

Transparency

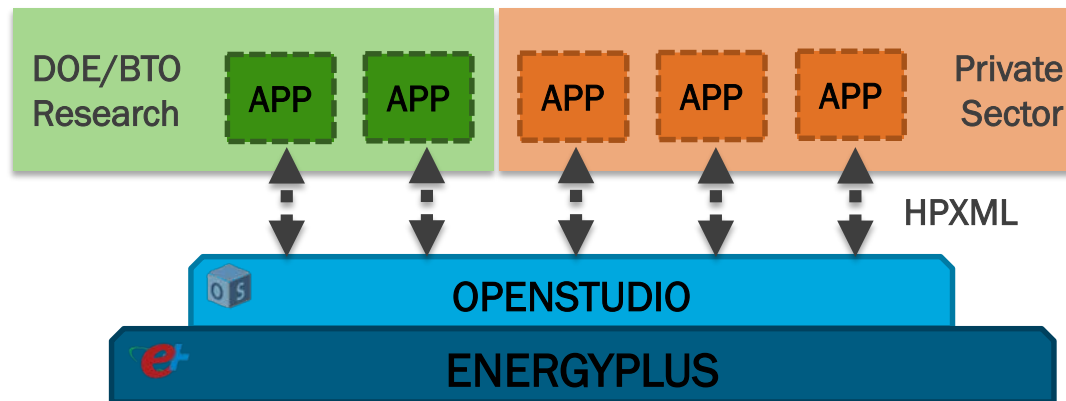
- Black-box, proprietary calculations
- Cannot leverage outside contributions

Cost

- Redundant software implementations
- High industry-wide costs incurred

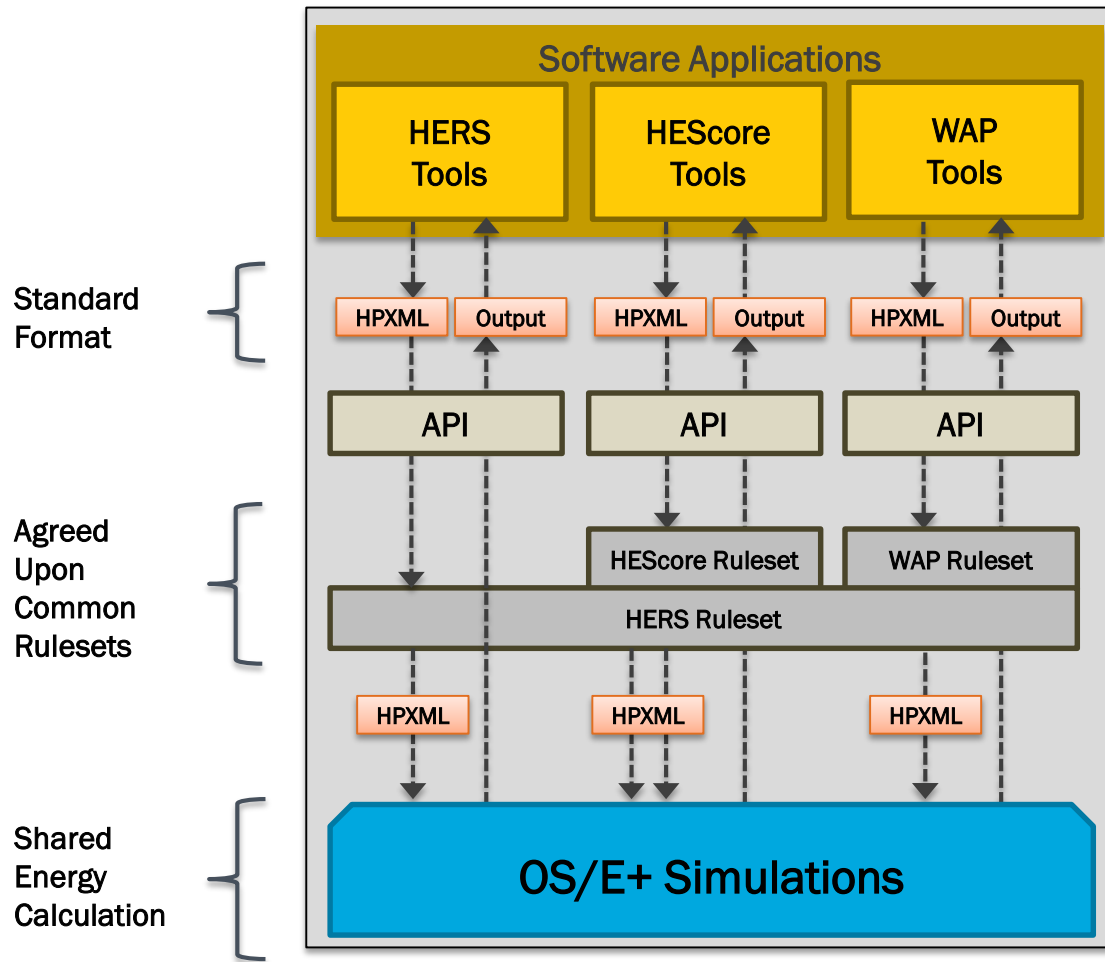
Approach

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.

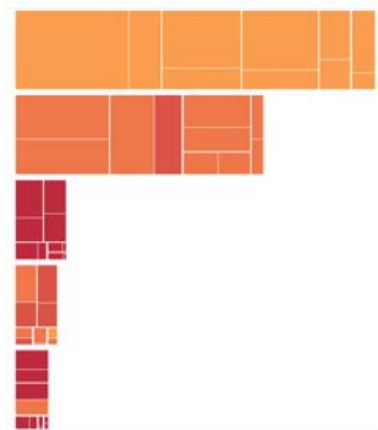
Approach

 **ResStock** Highly granular modeling of the U.S. housing stock

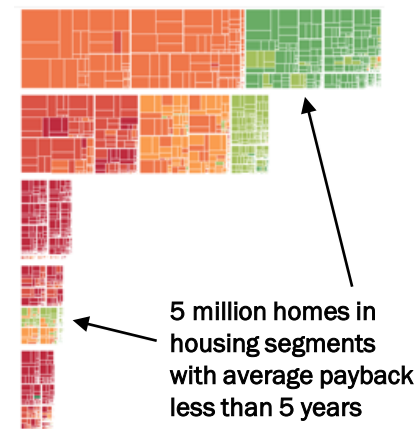
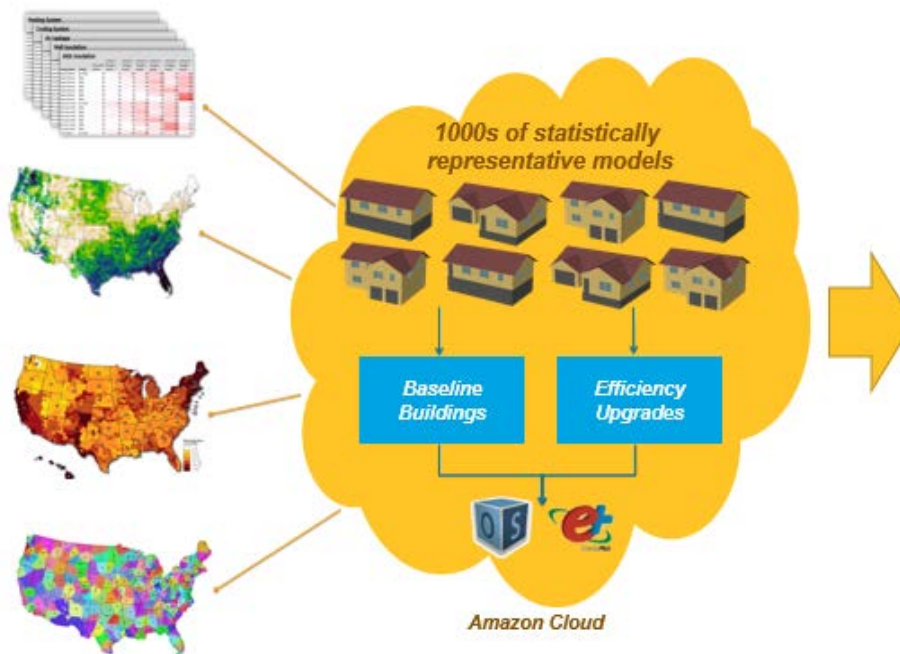
PROBLEM

APPROACH

SOLUTION



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

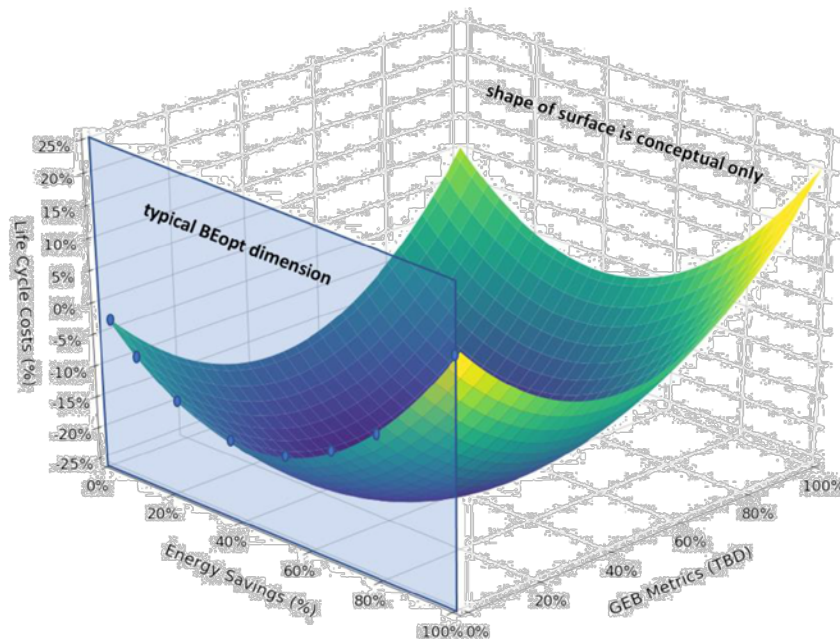


Granular analysis can lead to **targeted opportunities** within the housing stock.

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.

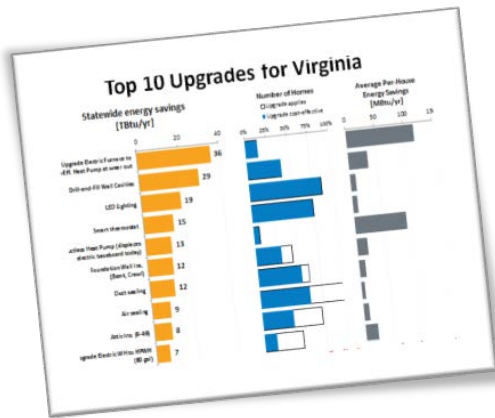
BTO's energy modeling capabilities are targeting **the largest programs**.



Building America	45,000 new homes (and over 1.5 million indirectly)
HERS Industry	225,000 new homes/year (2 million homes to date)
Home Energy Score	75,000 existing homes to date
Weatherization Assistant	35,000 existing homes/year
ENERGY STAR Certified Homes	70,000 new homes to date
Zero Energy Ready Homes	14,000 new homes to date
Utility Programs	\$2 billion/year spent on residential efficiency programs

Impact

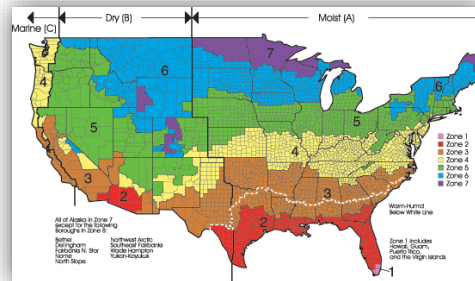
Highly granular modeling of the U.S. housing stock



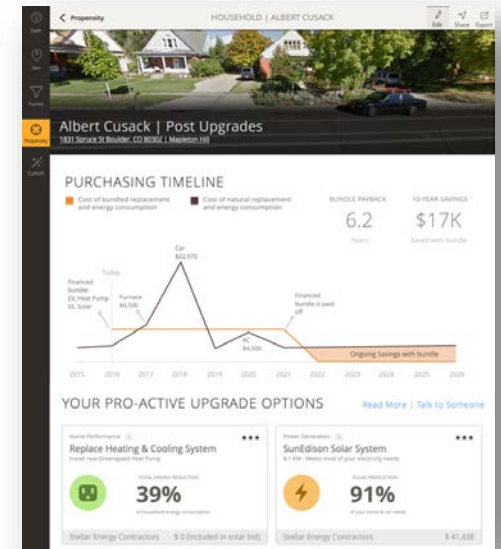
EPSA State Fact Sheets



Quadrennial Energy Review 1.2

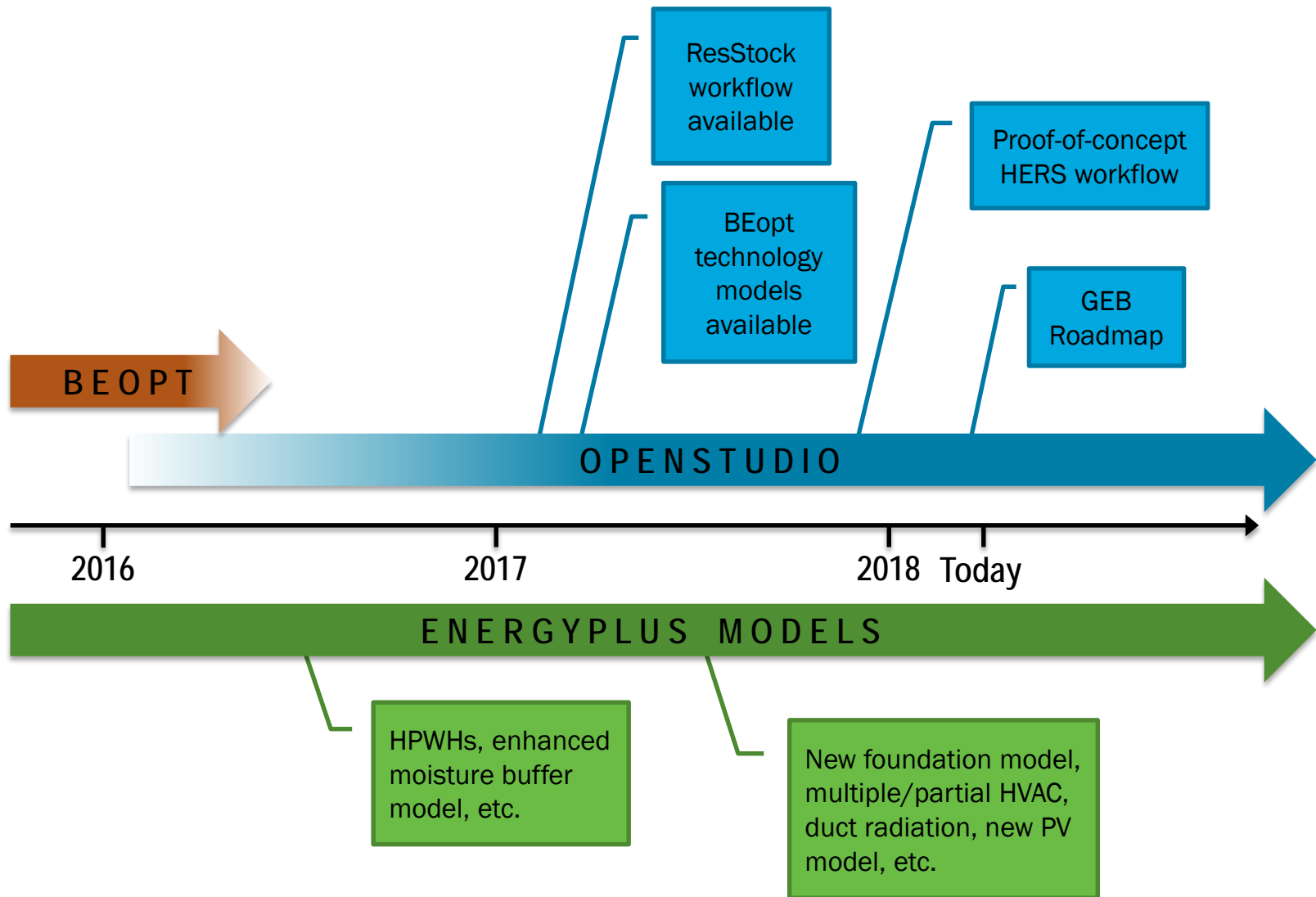


EPA/EPSE Low-Income Potential



City of Boulder
EE Market Engagement

Progress



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

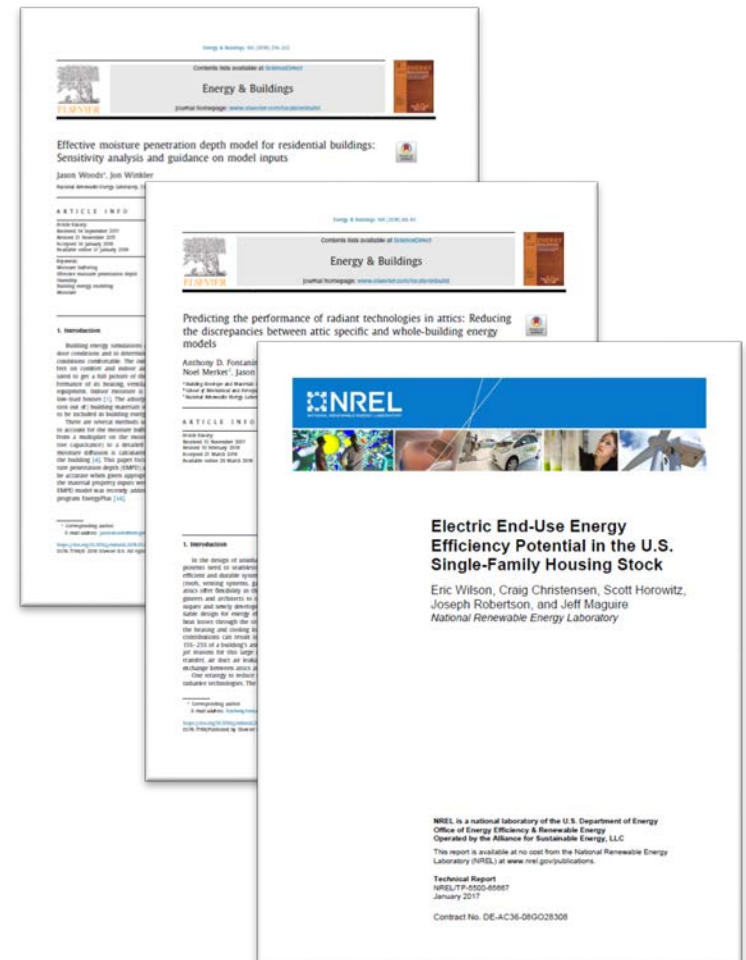
Stakeholder Engagement

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
 - NORESO, 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

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

REFERENCE SLIDES

Project Budget

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

FY 2016 – FY 2017 (past)			FY 2018 (current)			FY 2019 – TBD (planned)		
DOE RBI	DOE Non-RBI	Cost- share	DOE RBI	DOE Non-RBI	Cost- share	DOE RBI	DOE Non-RBI	Cost- share
\$2495k	\$605k	\$832k	\$277k	\$778k	\$300	TBD	TBD	TBD

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

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