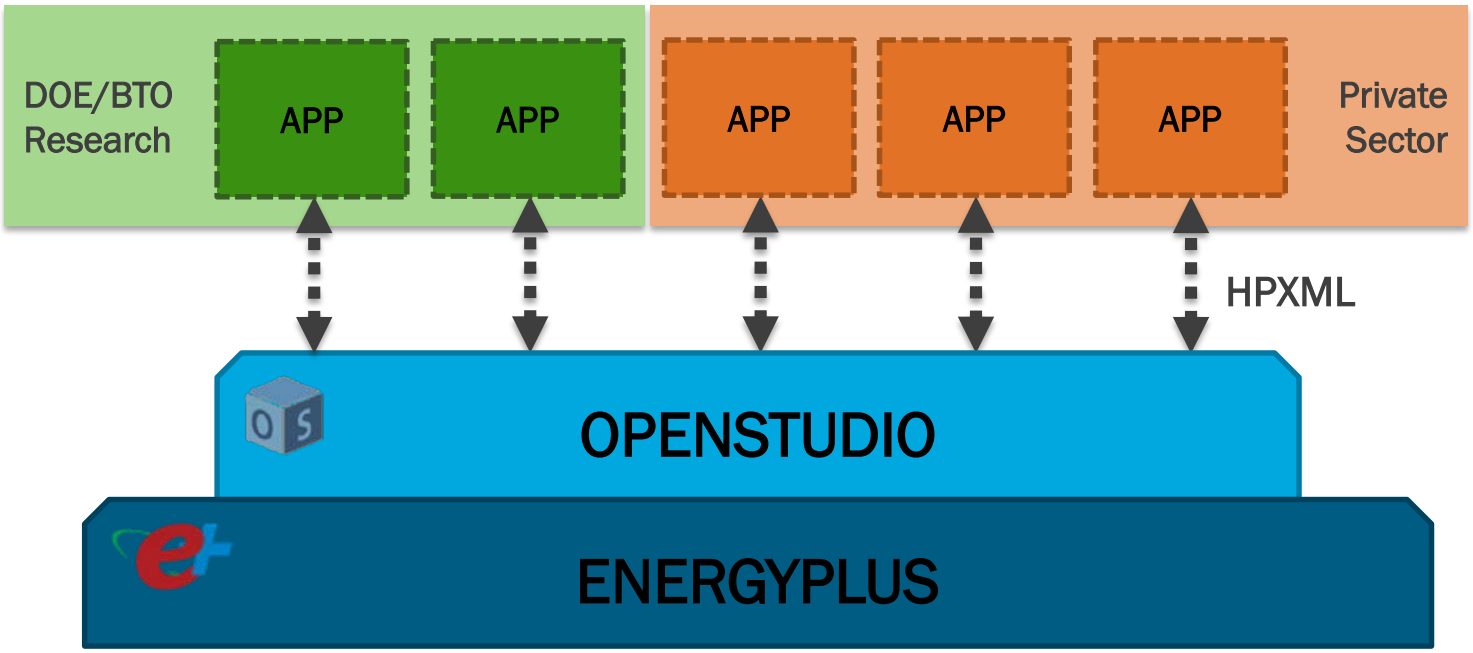
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

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/EPSA/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

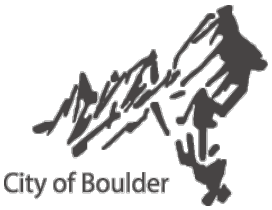
Eric Wilson, Research Engineer
Expertise: Stock analysis, energy modeling, HVAC and hot water systems

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

Team

Key Stakeholders

EERE Building Technologies Office
EERE Office of Strategic Programs
EERE Weatherization and Intergovernmental Programs Offic
Office of Energy Policy and Systems Analysis
Office of Electricity



Challenge

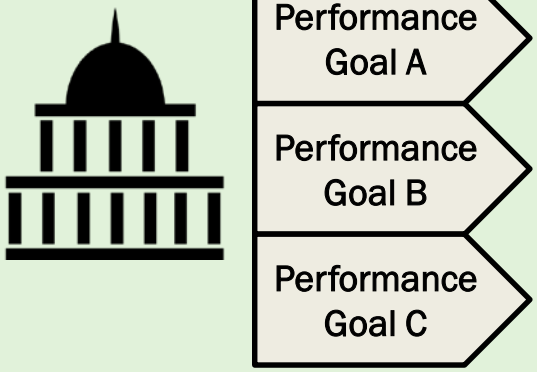
RBI Goal: By 2030, reduce EUI in residential buildings by 40%.

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?

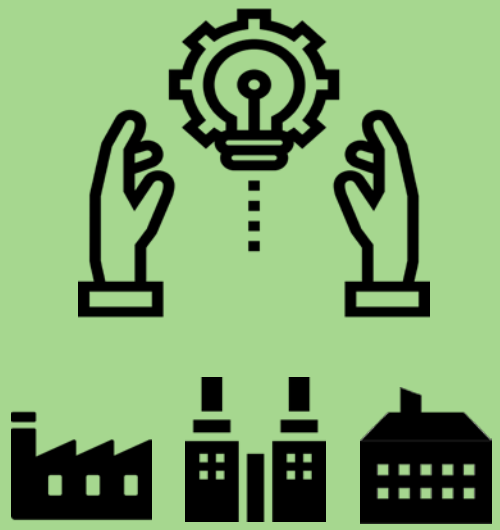
Industry Challenge: Industry increasingly demands modeling tools to quantify energy savings for hundreds of thousands of buildings each year. How do we ensure these tools rapidly incorporate new building technologies and provide fair and consistent results?

Challenge

Technologies: Research-to-Market via Energy Modeling



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

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, e			+++++	+++++
ESP-r		/Com	Yes	+++++	++
HEED		Res		++	+
HOT	00	Res		++	++
	iser, Snugg	Res/Com		++	+
P	PHPP	Res		++	++
RE 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

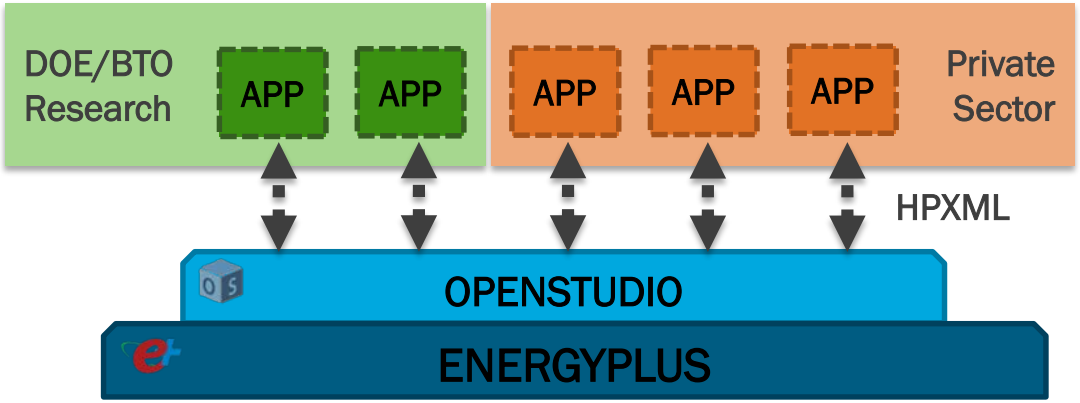
Consistency
- Generate inconsistent results
- “Race to the lowest HERS Index”

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

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

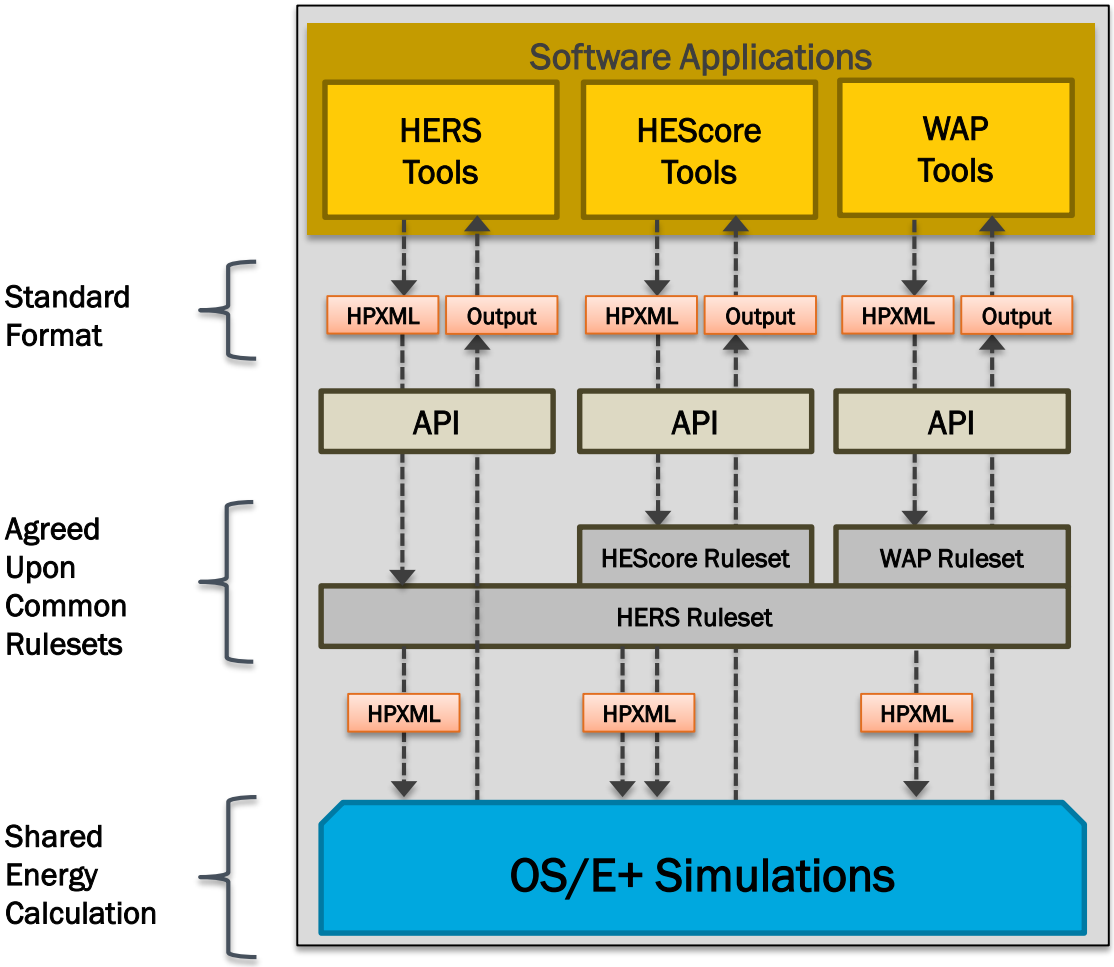
Approach

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



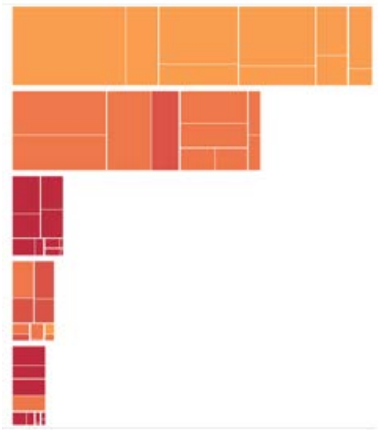
Benefits

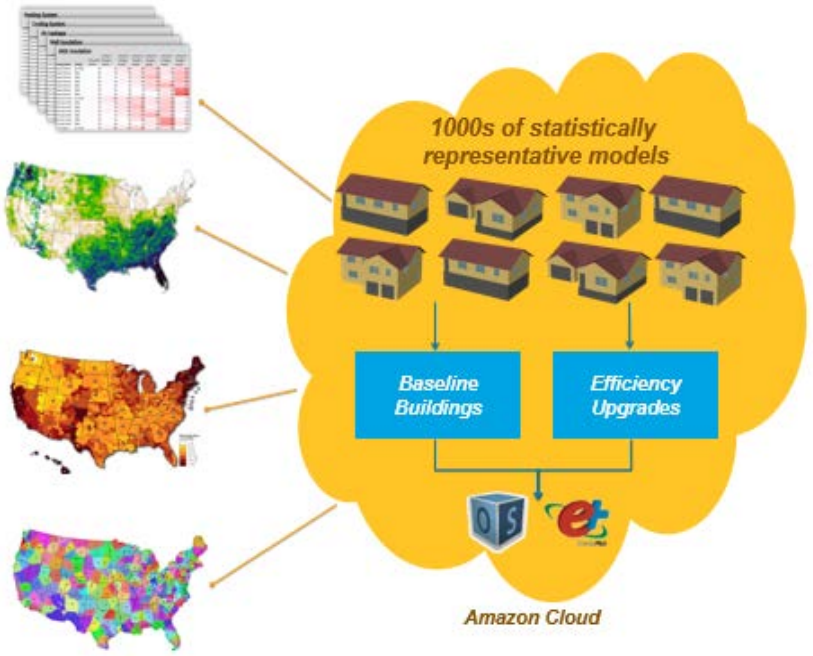
- ✓ **Accelerates new technologies** into software tools
- ✓ **Increases consistency** across DOE/industry programs
- ✓ **Reduces developer effort** to use EnergyPlus
- ✓ **Lowers industry-wide costs** of maintaining multiple engines
- ✓ **Allows private-sector competition** around innovations for user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

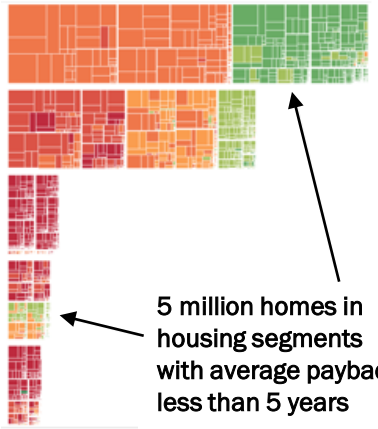
Approach

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

PROBLEM	APPROACH	SOLUTION







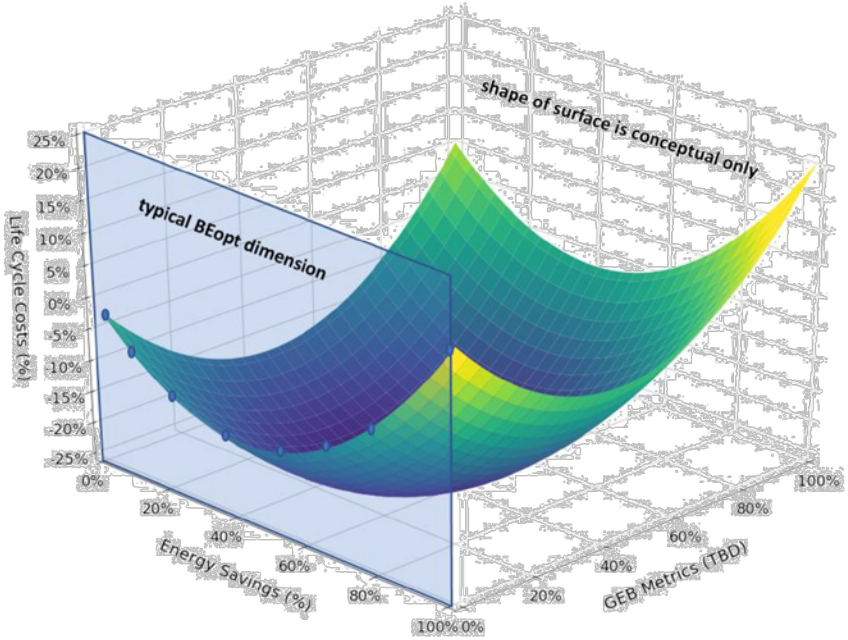
Prototype-based analysis can lead to **incorrect all-or-nothing** results.

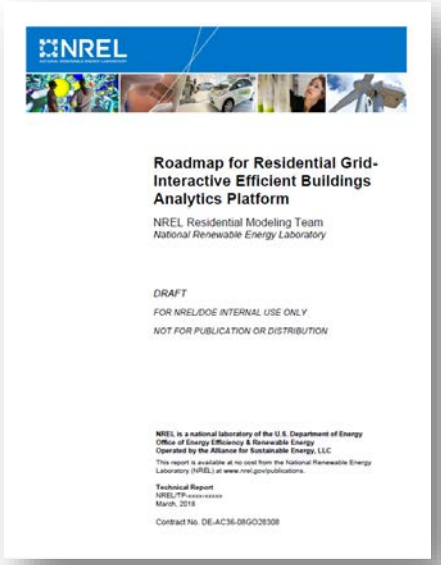
Granular analysis can lead to **targeted opportunities** within the housing stock.

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




NREL

Roadmap for Residential Grid-Interactive Efficient Buildings Analytics Platform

NREL Residential Modeling Team
National Renewable Energy Laboratory

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Office of Energy Efficiency & Renewable Energy
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Technical Report
NREL/TP-
March, 2018

Contract No. DE-AC36-08GO28308

Impact

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

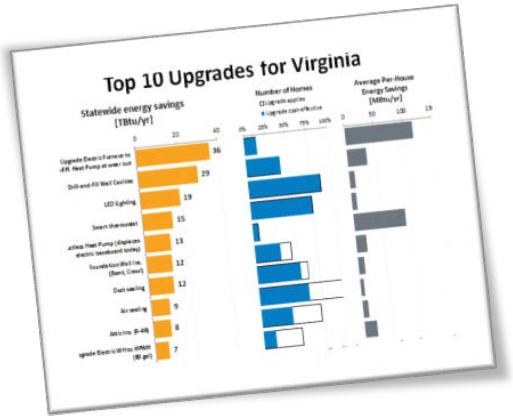
BTO's energy modeling capabilities are targeting **the largest programs.**

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	**85,000+ existing homes** to date
Weatherization Assistant	**35,000+ existing homes**/year
ENERGY STAR Certified Homes	**100,000+ new homes**/year (1.9 million homes to date)
Zero Energy Ready Homes	**14,000+ new homes** to date
Utility Programs	**$2 billion**/year spent on residential efficiency programs

Impact

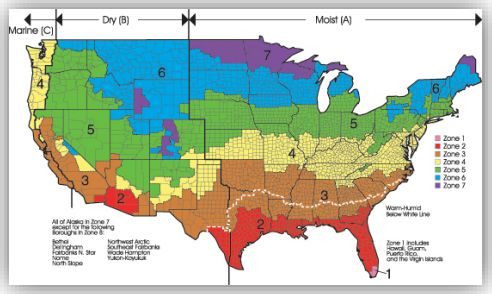
ResStock

Highly granular modeling of the U.S. housing stock



EPSA State Fact Sheets

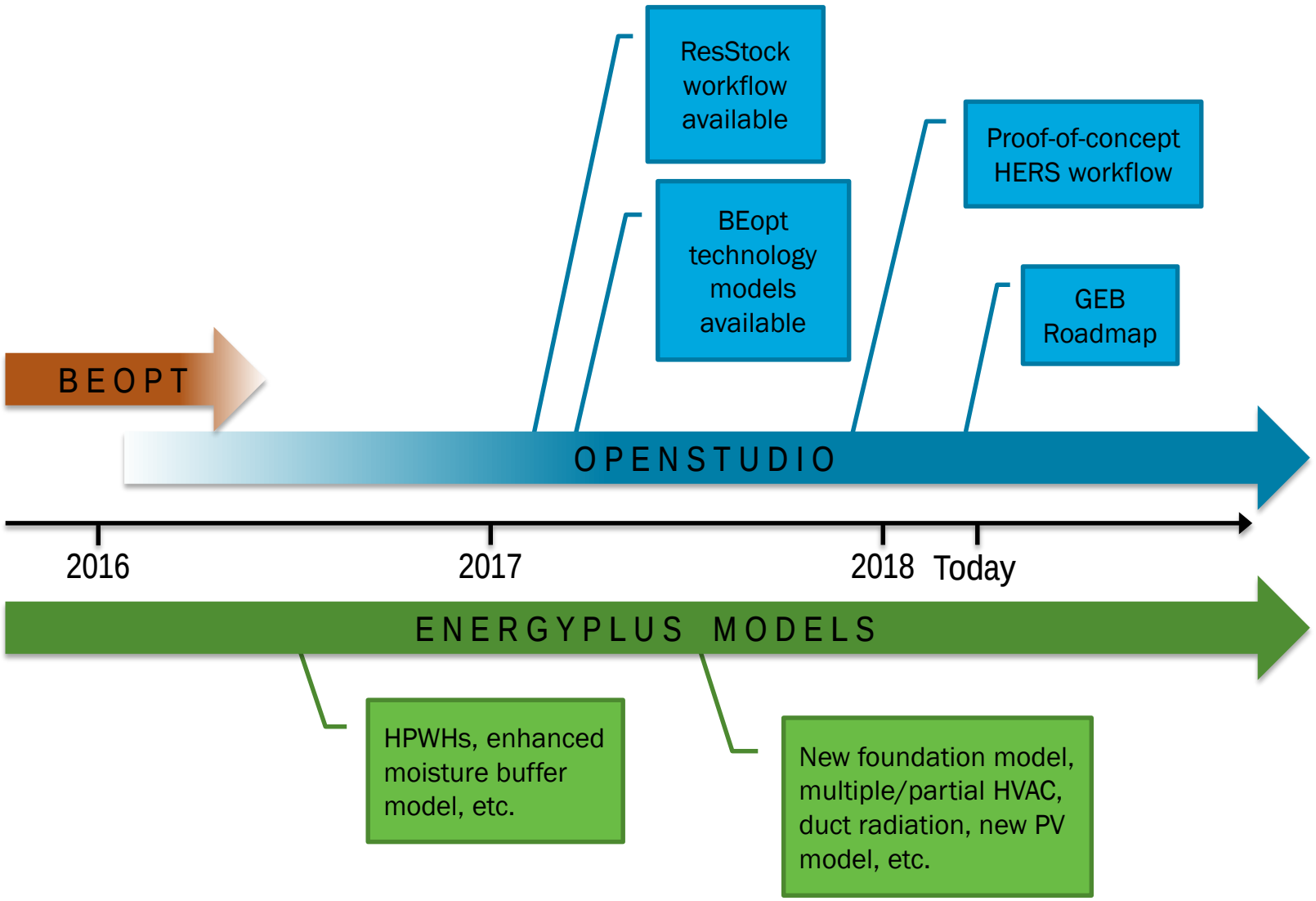
Quadrennial Energy Review 1.2



EPA/EPSA Low-Income Potential

City of Boulder
EE Market Engagement

Progress


ResStock workflow available
BEopt technology models available
Proof-of-concept HERS workflow
GEB Roadmap
BEOPT
OPENSTUDIO
2016
2017
2018
Today
ENERGYPLUS MODELS
HPWHs, enhanced moisture buffer model, etc.
New foundation model, multiple/partial HVAC, duct radiation, new PV model, etc.

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

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