Analysis – Targeting Zero Net Energy

2014 Building Technologies Office Peer Review

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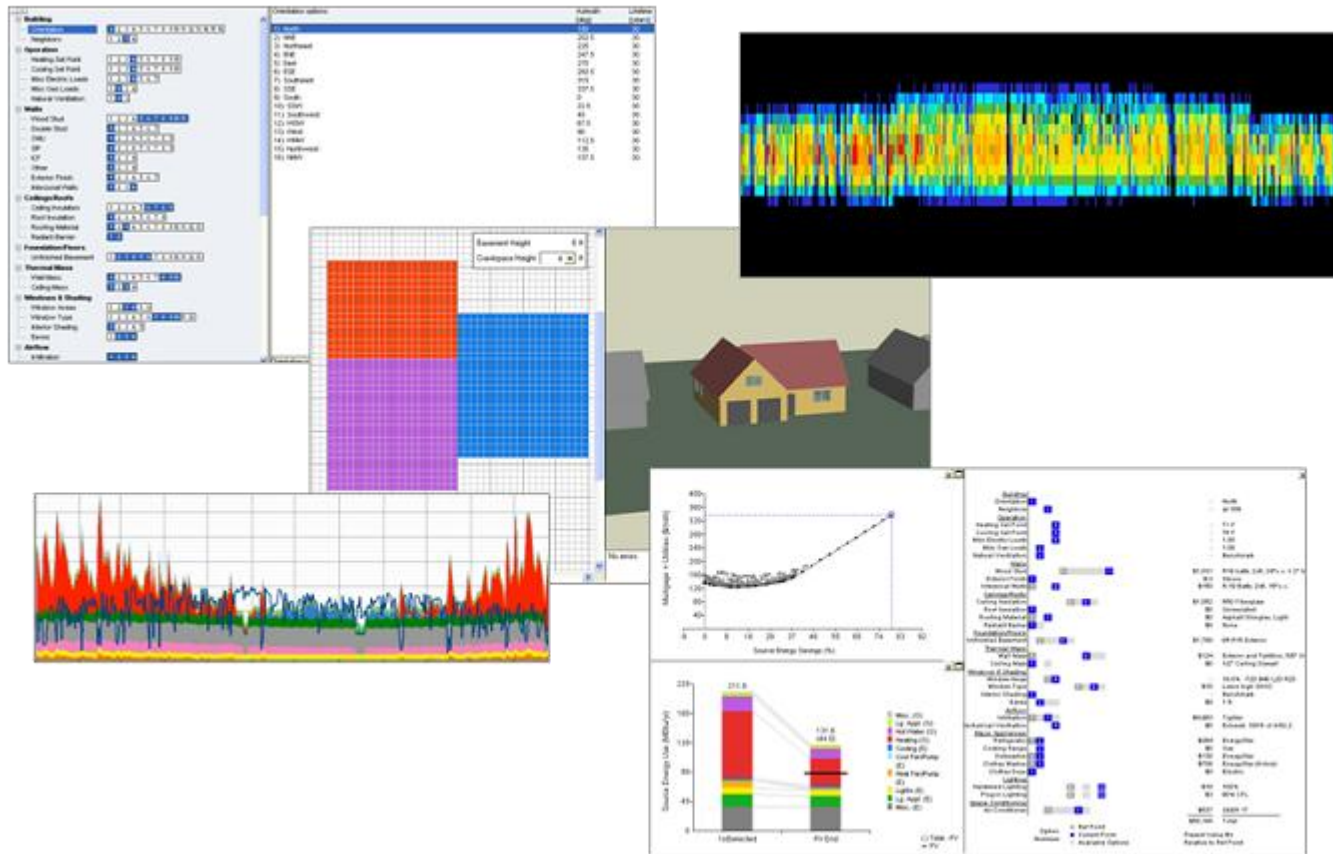
Project Summary

Timeline:

Start date: 2010

Planned end date: ?

Key Milestones

- 2010: BEopt release (v1.0) w/EnergyPlus
- 2012-13: New residential models: HPWH, MSHP, GSHP, Window AC, dehumidifier, etc.
- 2013: BEopt release (v2.0) w/retrofit analysis

Budget:

Total DOE $ to date: $2.5M (includes $600k ARRA)

Total Non-DOE $ to date: $1.3M

Total future DOE $: TBD

Target Market/Audience:

Market: Residential new/existing homes; single family and multifamily

Audience: BA teams, production home builders, home performance practitioners, manufacturers , utilities, researchers, local/state governments

Key Partners:

BA Teams	RESNET
CPUC	BPI
BPA	PG&E
CEC	SMUD
DEG	Univ. of Colorado

Project Goal:

To provide accurate analysis for:

- Building America (BA) program planning
- Emerging technologies
- ZNE packages for new construction and existing homes

by using cost-based optimization and detailed, physics-based EnergyPlus simulations for the residential sector.

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Purpose and Objectives

Problem Statement:
1. Need analysis tools to cost-effectively steer $10M of BA research each year toward gaps in zero net energy solutions for new construction and existing homes
2. Lack of accurate models for residential emerging technologies on the path to BA field demonstrations and broader market deployment

Target Market and Audience:

Market: Residential new construction (1.4 quads/decade) and existing homes (10.2 quads)

Audience: BA teams, production home builders, home performance practitioners, researchers, universities, manufacturers, utilities, state/local government
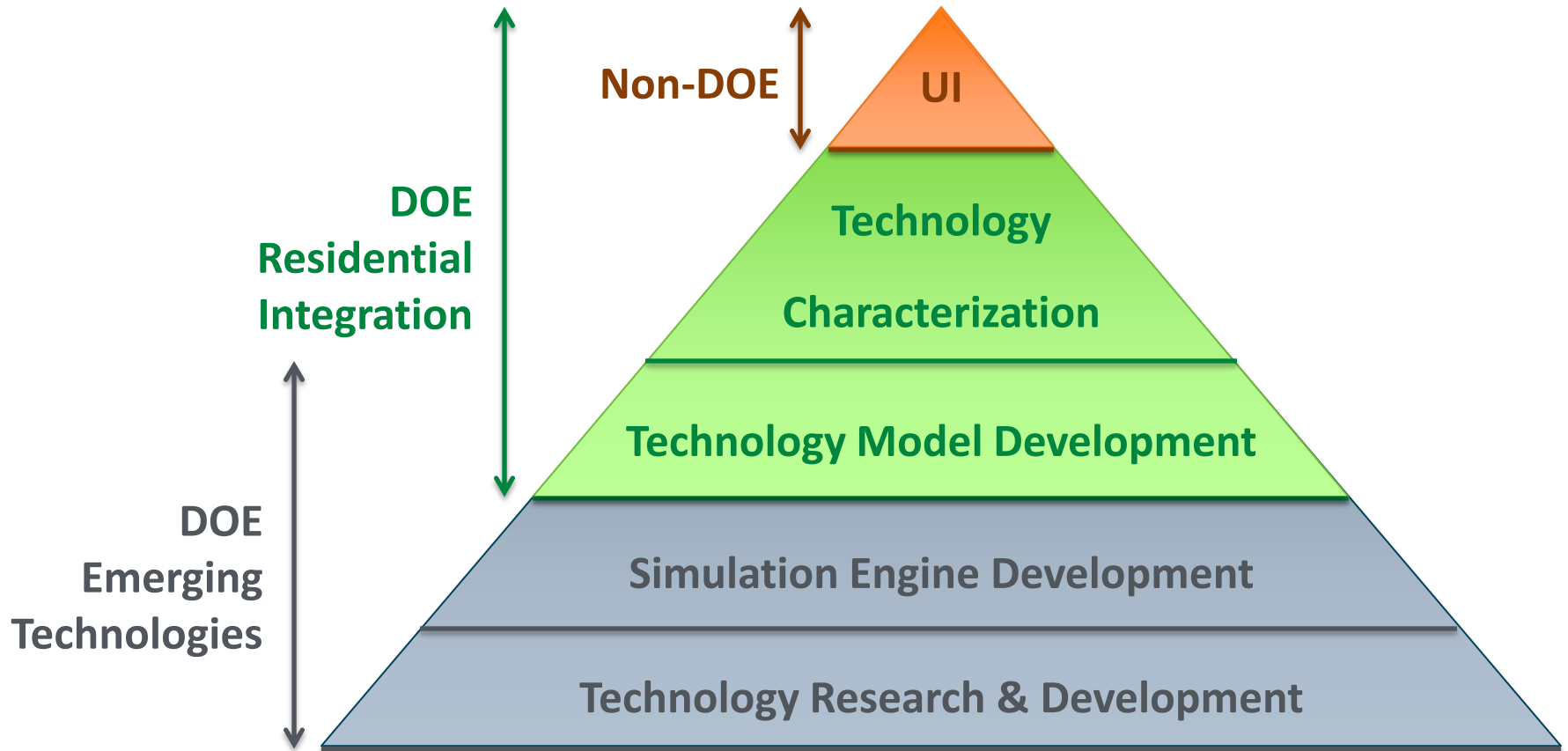
Impact of Project: This project provides:
1. A residential energy analysis tool to identify cost-optimized technology pathways and gaps to zero net energy
2. Whole-building EnergyPlus models for residential emerging technologies

Impact measurements:

Energy saved for new/existing buildings; Number of non-DOE partners; Number of new residential models; Number of tool users, downloads, publications, and analyses

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Purpose and Objectives: Res. Whole-Building Simulation

Non-DOE

DOE Residential Integration

DOE Emerging Technologies

UI

Technology Characterization

Technology Model Development

Simulation Engine Development

Technology Research & Development

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Approach

Approach:
1. Develop new EnergyPlus-based model for residential emerging technology
2. Characterize technology for residential sector to create components with representative properties/costs
3. Test and validate model against field and equipment testing data and/or other simulation engine models
4. Analyze cost-effectiveness of technology in the context of cost-optimized building designs along the path to ZNE for a range of climate zones and energy costs

FY14: Add multifamily capabilities to target ZNE solutions (CPUC cost-share)

Key Issues: NREL development of empirical test method, in collaboration with home performance tool developers, increases consistency/accuracy of energy savings predictions.

Distinctive Characteristics:
- Establishes analytical foundation for BA residential program
- Directs substantial BA program research/funds towards ZNE technology gaps
- Drives large-scale energy savings for production home builders via BA teams
- Leverages numerous other projects: EnergyPlus, NREL Measures Database, BA House Simulation Protocols, BA Field Data Repository, HPXML, OpenEI, etc.

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Approach: Path to Zero Net Energy

Goal: Find minimum-cashflow designs at energy-savings levels up to ZNE
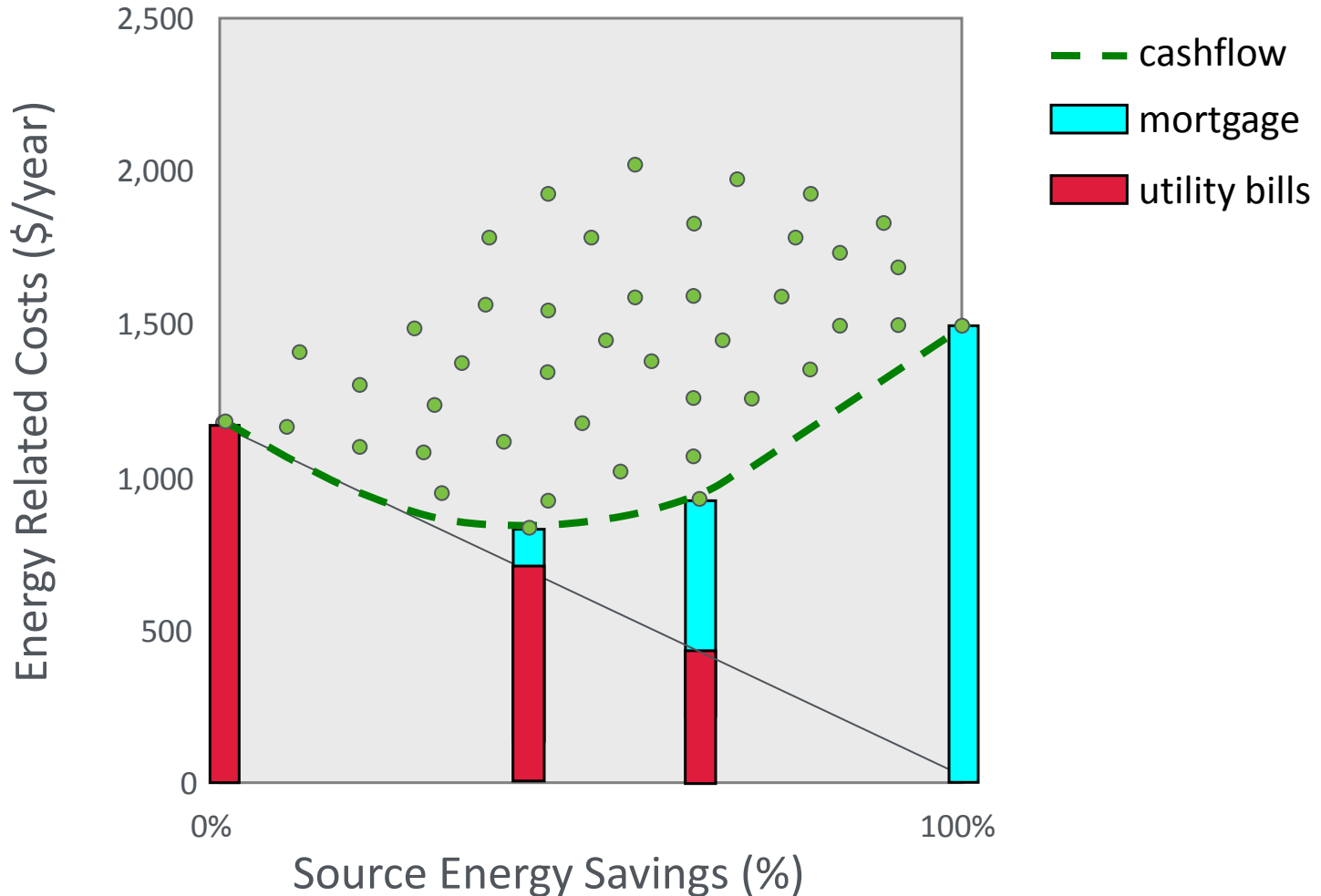
Approach: Optimization Search & Validation

Result: Sequential search finds minimum-cashflow building designs with ~1,000x fewer simulations

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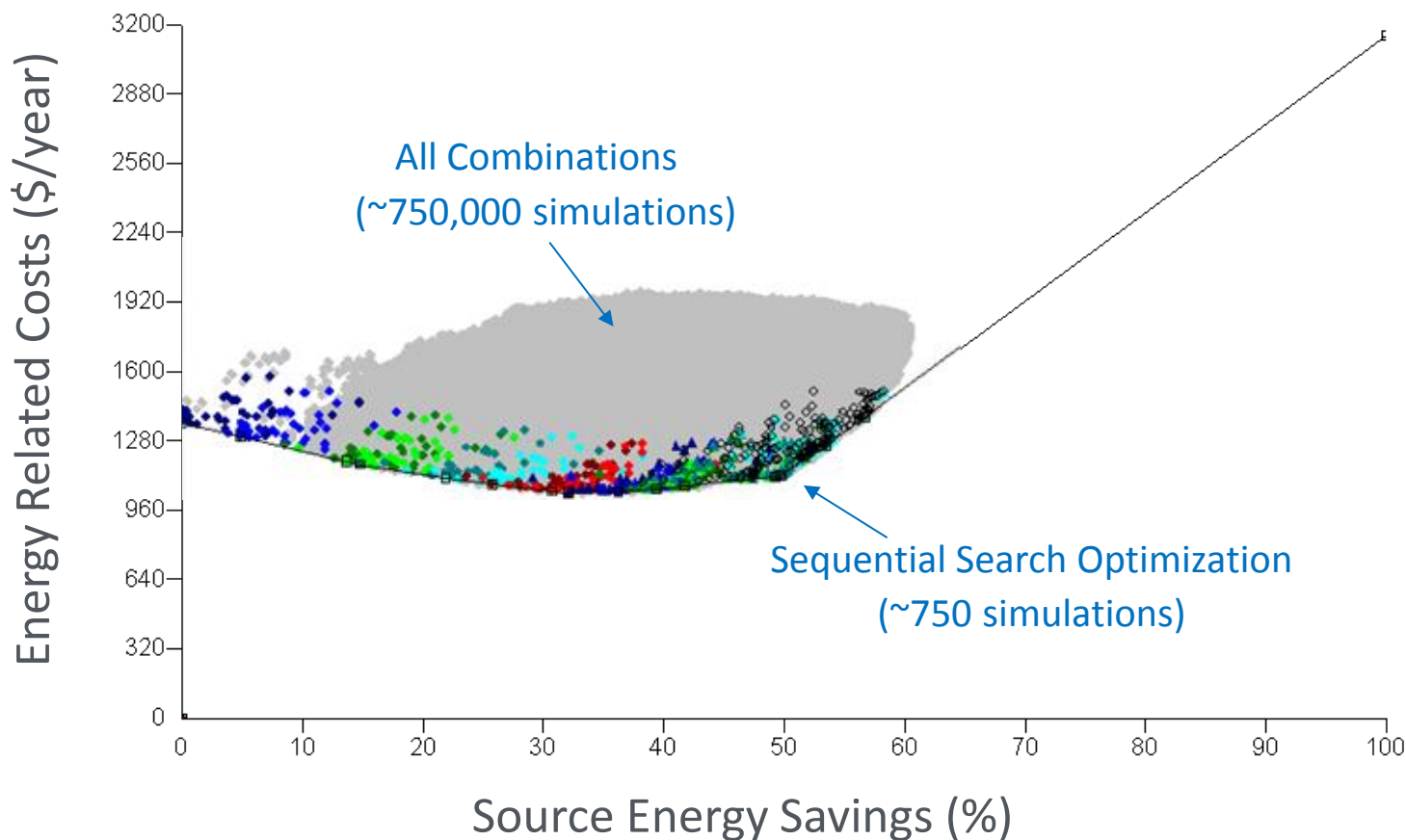
Approach: BEopt Analysis Tool

Plug-and-Play Optimization Software

Heating
Cooling
Lighting
Appliances
Other Efficiency
PV/SHW

EnergyPlus (DOE2) (SEEM) → **BEopt** → Optimal Building Designs

Energy Use
Utility Bills
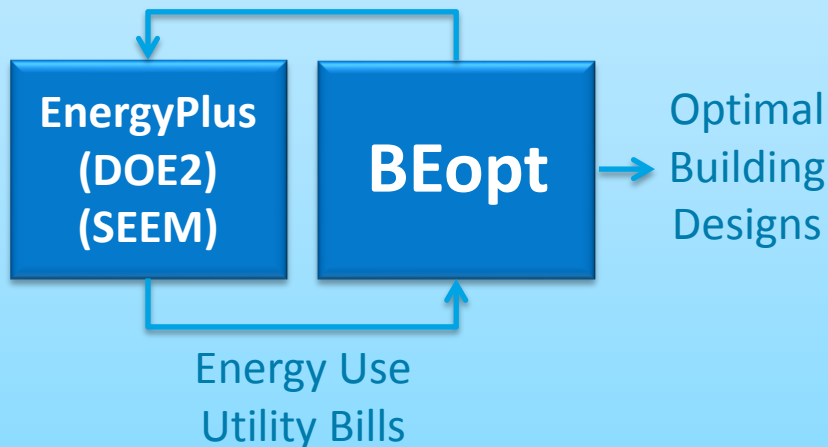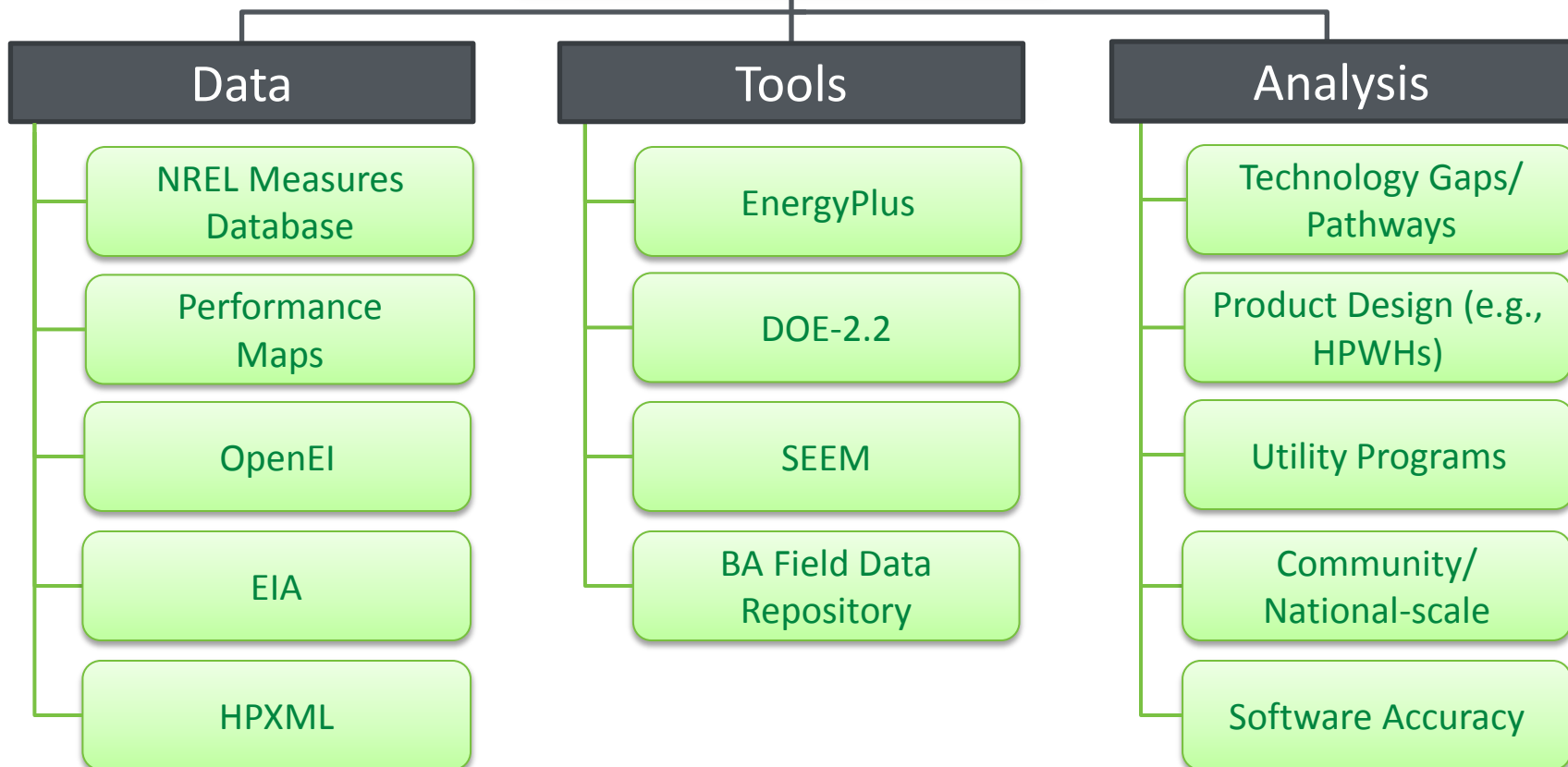
Features:
- Design, parametric, optimization
- New construction and retrofit
- Detailed cost database
- Rapid building drawing tool
- Detailed utility rates (tired, time-of-use, real-time pricing)
- PV compensation (net-metering, feed-in tariffs)
- Utility cost effectiveness tests
- PV/efficiency incentives
- Demand response
- HPXML export
- Schedule wizard
- Output visualization
- Metrics: LCC, NPV, SPP, LCOE, CO_2
- Batch simulations
- Library manager
- …

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Approach: BEopt Integration

Data
- NREL Measures Database
- Performance Maps
- OpenEI
- EIA
- HPXML

Tools
- EnergyPlus
- DOE-2.2
- SEEM
- BA Field Data Repository

Analysis
- Technology Gaps/ Pathways
- Product Design (e.g., HPWHs)
- Utility Programs
- Community/ National-scale
- Software Accuracy

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Progress and Accomplishments

Lessons Learned:

Relative to new construction, existing buildings require a unique analysis approach -- age of equipment, HVAC downsizing limitations, additional technologies (e.g., window ACs), performance of old components (e.g., ACs < SEER 13), etc.

Accomplishments:

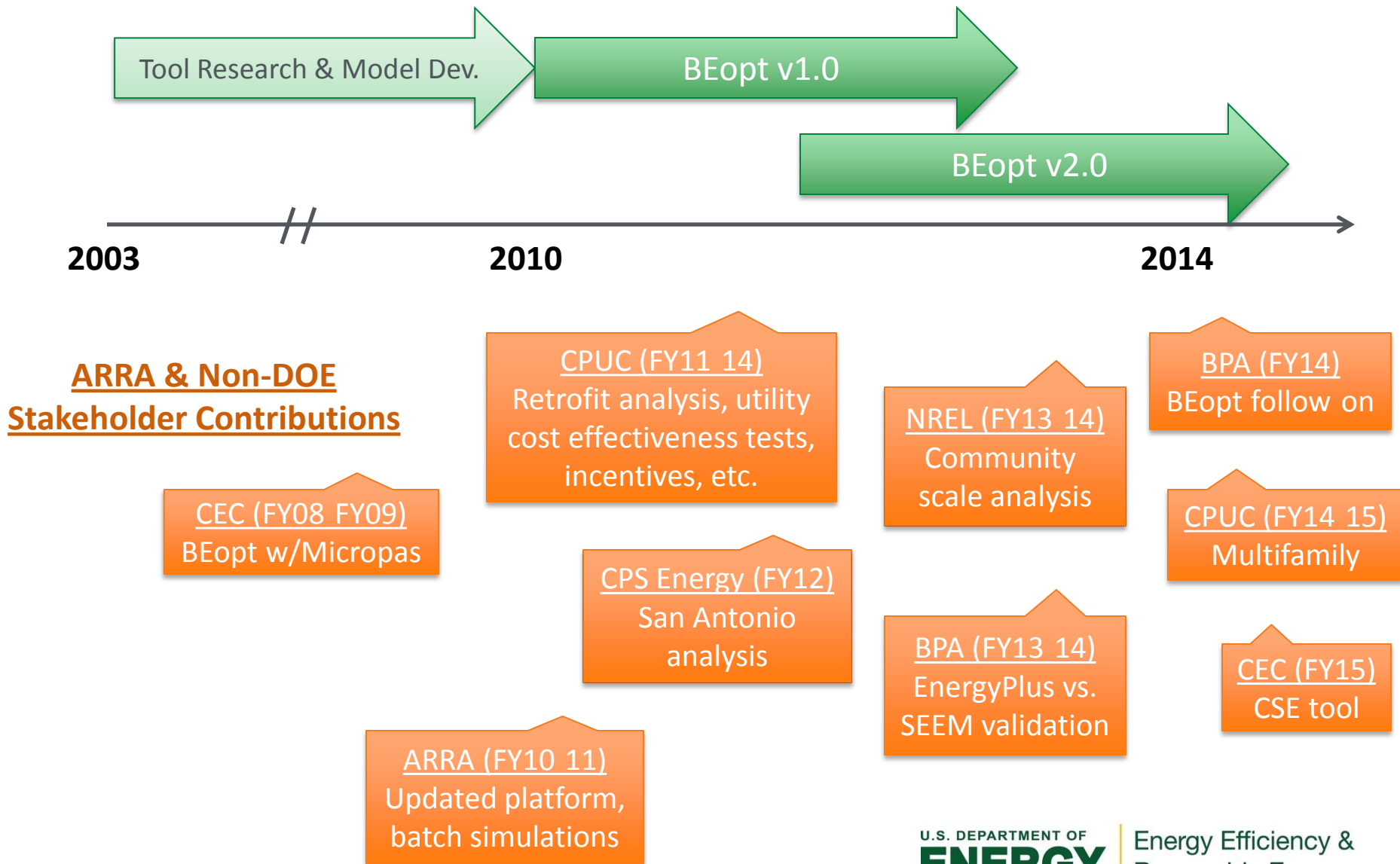2010: Public release of BEopt with EnergyPlus

2012-13: New residential models, including:

• Heat pump water heaters	• Window air conditioners
• Mini-split heat pumps	• Electric baseboard
• Ground-source heat pumps	• Rim joist insulation
• Variable-speed equipment	• Whole slab insulation
• Dehumidifiers	• Duct blaster test results
• Heating recovery ventilators	• Etc.

2013: Empirically-based method of test pilot with home performance industry

2013: BEopt v2.0 (retrofit analysis, NREL Measures Database, HPXML)

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Progress and Accomplishments: Timeline

Tool Research & Model Dev.

BEopt v1.0

BEopt v2.0

2003   2010   2014

ARRA & Non-DOE Stakeholder Contributions

CEC (FY08 FY09)
BEopt w/Micropas

CPUC (FY11 14)
Retrofit analysis, utility cost effectiveness tests, incentives, etc.

CPS Energy (FY12)
San Antonio analysis

ARRA (FY10 11)
Updated platform, batch simulations

NREL (FY13 14)
Community scale analysis

BPA (FY13 14)
EnergyPlus vs. SEEM validation

BPA (FY14)
BEopt follow on

CPUC (FY14 15)
Multifamily

CEC (FY15)
CSE tool

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Progress and Accomplishments: Leveraged Funding

Year-by-Year Funding

Total Funding

Legend:
- Non-DOE*
- ARRA
- DOE AOP
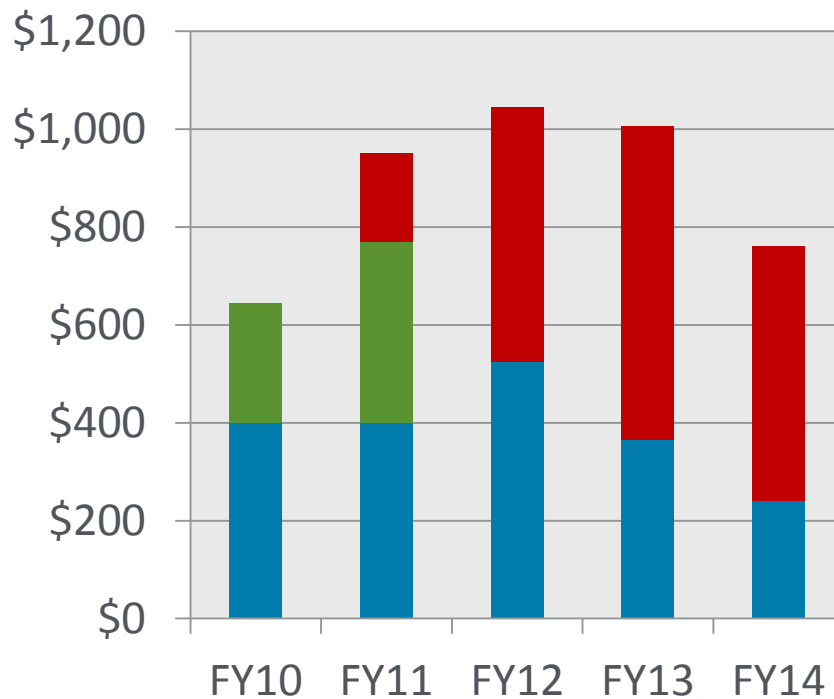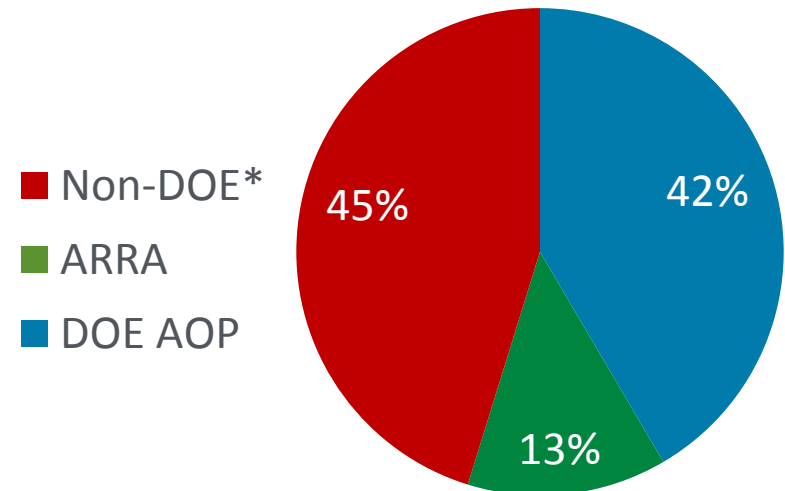
* **Includes non-development funding**

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Progress and Accomplishments

Market Impact:
Public availability of BEopt/EnergyPlus has resulted in:
- Directly impacting over 45,000 (and indirectly over 1.5 million) homes through BA advanced efficiency demonstration projects
- 6,000+ downloads, 140,000+ website views, 100+ publications (~2 years)
- Use by DOE/BA, builders, utilities, states, manufacturers, universities
- National/regional ZNE goals and stronger building codes via BEopt analysis
- Leveraged non-DOE funds: community-scale analysis, simulation engine validation, retrofit analysis, new technologies
- Participation of major res. private-sector tool developers to improve models

Based on recently completed and ongoing projects, future potential to impact:
- California (CPUC/CEC): 11 million homes (675 million Btus)
- Pacific Northwest (BPA): 4 million homes (306 million Btus)

Awards/Recognition:
2012 Building America Top Innovation Hall of Fame

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Progress and Accomplishments: Analysis Applications

DOE Building America program

- R&D technology gaps/pathways
- Innovative prototype buildings
- Energy savings targets
- Production home builder packages

Website Registered Users

Pie chart legend:
- A&E — 37%
- University — 21%
- Personal Use — 16%
- Other — 12%
- Government — 8%
- Non-profit — 6%

DOE Initiatives

- Solar Buildings Initiative
- US Virgin Islands
- Greensburg, KS
- Katrina
- Hawaii

Other

- California Public Utilities Commission
- California Energy Commission
- Bonneville Power Administration
- SMUD, PG&E, CPS Energy
- Manufacturers
- Universities
- Researchers
- Habitat for Humanity

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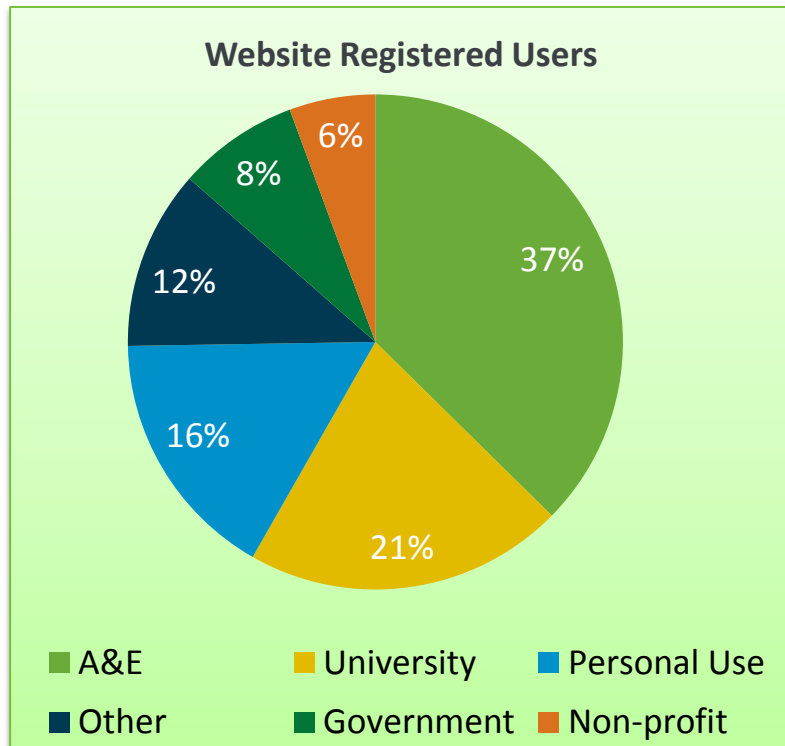
Project Integration and Collaboration

Project Integration:
- BA teams use BEopt to inform production home builders on cost-optimal whole-house efficiency package solutions on the path to zero net energy
- Non-DOE stakeholders use BEopt to validate and improve residential models in other regions (e.g., SEEM in the Pacific Northwest, CSE in California)
- Home performance industry tool developers will use NREL's empirically-based method of test to increase consistency and accuracy of their tools

Partners, Subcontractors, and Collaborators:
- General: BA teams (collaborator), EnergyPlus development team (collaborator), University of Colorado (collaborator), Allegiance (subcontractor)
- Multifamily: CPUC (funder), Davis Energy Group (partner)
- Simulation engine validation: BPA (funder), Ecotope (collaborator)
- Empirically-based method of test: Residential Software Accuracy Working Group (collaborator), Neymark & Associates (subcontractor)

Communications:
2014 RESNET Building Performance Conference, 2013 ACI National Home Performance Conference, Builder Magazine, Energy Design Update, BEopt webinars, website forum, training videos, user documentation

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Next Steps and Future Plans

- BEopt multifamily capabilities
- Residential EnergyPlus models for additional emerging technologies
- Technical support to BA teams and other users
- Accurate analysis to support:
  - BA program goals
  - Utilities/communities
  - State/local governments
  - Home performance industry
  - Building codes
  - Ratings industry
- OpenStudio coordination (FY14 NREL funds to integrate residential modeling data into OpenStudio)
- Leveraging of BEopt capabilities for further collaboration with industry and other relevant stakeholders
  - Currently in discussions with multiple industry partners

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REFERENCE SLIDES

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Project Budget

Project Budget:

- 2010 (BEopt v1.0): $650k
- 2011-13 (BEopt v2.0): $550k/yr + $310k/yr cost-share
- 2014: $240k + $360k cost-share

Variances: FY14 task shifted to develop residential multifamily capabilities (w/CPUC cost-share)

Cost to Date: In FY2014: 25% of DOE, 80% of cost-share

Additional Funding:

- ARRA (FY2010-11)
- CPUC (FY2011-14,15)
- BPA (FY2013-14)
- CEC (FY2015)
- NREL (FY2013-14)

Budget History					
FY2010 – FY2013 (past)		FY2014 (current)		FY2015 – ? (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$2.3M	$0.9M	$240k	$360k	TBD	$240k+

Project Plan and Schedule

- FY2014 plan builds on substantial cross-cutting work from prior years
- E+ vs. empirical data technical report: TDM approved extension due to expanded scope of including additional homes (RBSA dataset)

Project Schedule														
Project Start: 2010				Completed Work										
Projected End: ?				Active Task (in progress work)										
				Milestone/Deliverable (Originally Planned)										
				Milestone/Deliverable (Actual)										

	FY2013				FY2014				FY2015			
Task	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)
Past Work												
Q3 Deliverable: BEopt v2.0 release	▓	▓	▓ ♦									
Q3 Milestone: Draft empirical method of test		▓	▓ ♦	▓ ♦								
Q4 Milestone: E+ improvement recommendations			▓	▓	♦							
Q4 Milestone: E+ vs. empirical data analysis			▓	▓ ♦								
Q1 Deliverable: E+ vs. empirical data technical report					🔴♦	♦						
Q1 Milestone: BEopt v2.1 release					▓	▓ ♦						
Q1 Deliverable: Monthly status reports					▓	▓ ♦						
Q2 Deliverable: Monthly status reports						▓	▓ ♦					
Current/Future Work												
Q3 Milestone: Industry pilot of empirical method of test						▓	▓	♦				
Q4 Deliverable: BEopt release						▓	▓	♦				