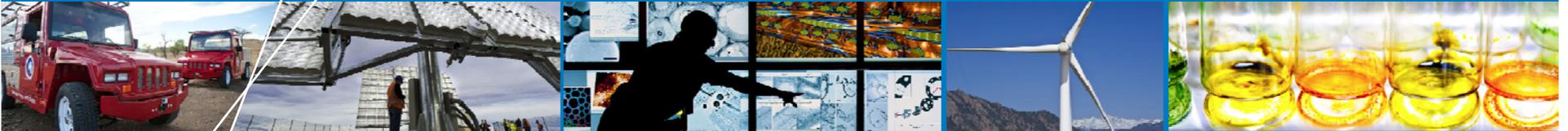




BEopt-CA (Ex) : A Tool for Optimal Integration of EE, DR and PV New Capabilities in BEopt Software



David Springer
Davis Energy Group

Craig Christensen, Scott Horowitz
National Renewable Energy Laboratory

CSI RD&D Final Project Webinar
March 5, 2014

Acknowledgements

- The California Public Utility Commission provided funding under CSI RD&D Solicitation #1
- Itron provided program management
- Pacific Gas and Electric Company provided cost match funding



Agenda

- **Background**

- Objectives, Team, Roles
- What Is BEopt?
- Validation, Simulation Engines

-----Q&A-----

- **New Capabilities**

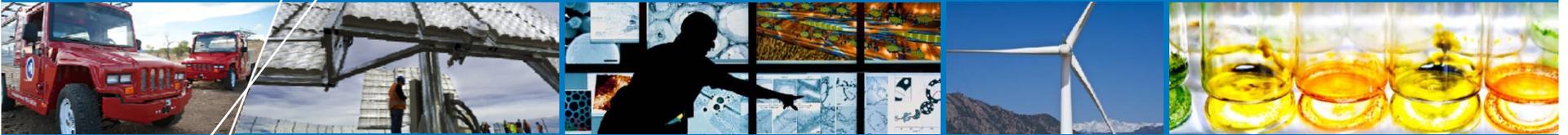
- Retrofit Analysis, Measures and Costs
- Incentives
- Demand Response

-----Q&A-----

- Utility Tariffs
- Utility Cost Effectiveness Tests
- Example Analysis

- **Conclusions**

-----Q&A-----

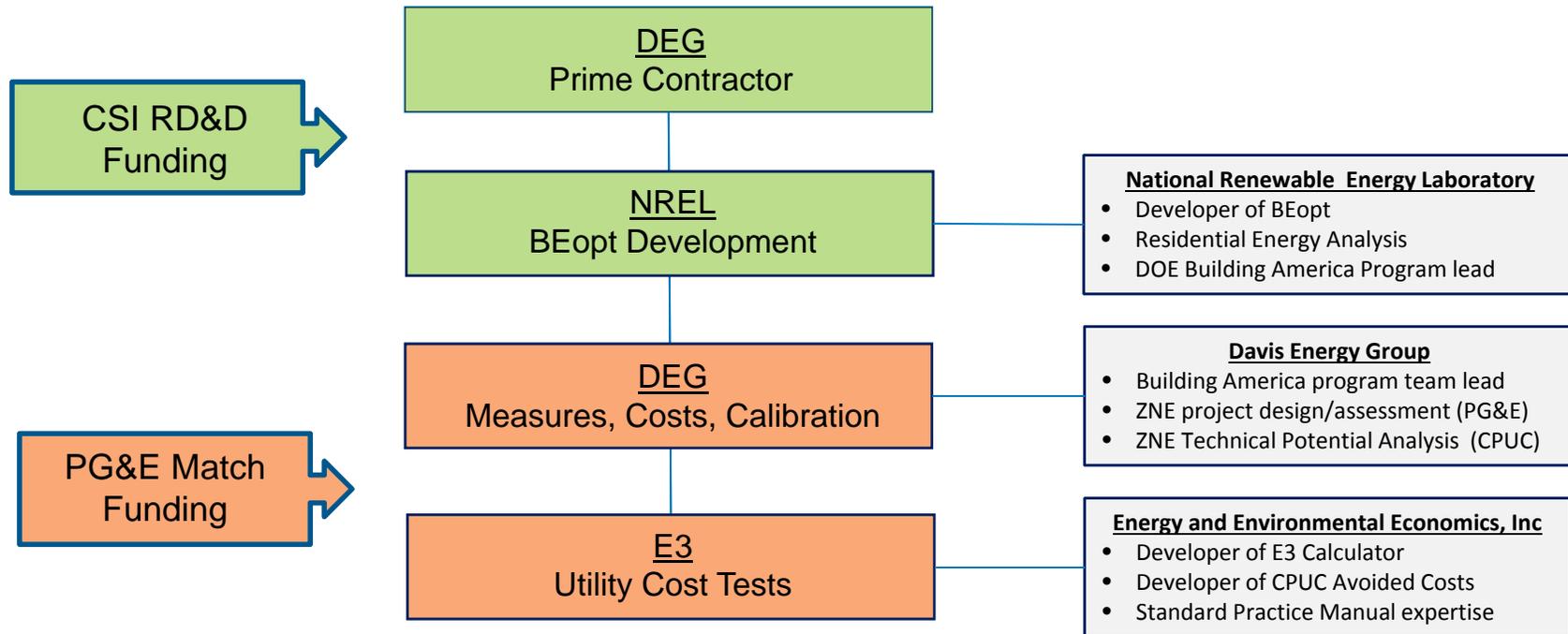


Background

Objective

Develop a software tool to provide utility planners, program managers, consultants, architects and engineers in California with a means of balancing and integrating energy efficiency (EE), demand Response (DR) and photovoltaics (PV) in existing [and new] homes on the path to ZNE.

Team/Roles



BEopt Versions

BEopt-CA (Ex) New Capabilities



BEopt-dev 2.2.0.0

BEopt

*Building Energy Optimization
with Hour-by-Hour Simulations*



National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
www.nrel.gov

Project type:

Standard

Building America

California Metrics

Do not ask again

Application type:

New Construction

Retrofit

OK

Final Deliverables

BEopt v2.2

Posted on the BEopt website (beopt.nrel.gov)



Final Report

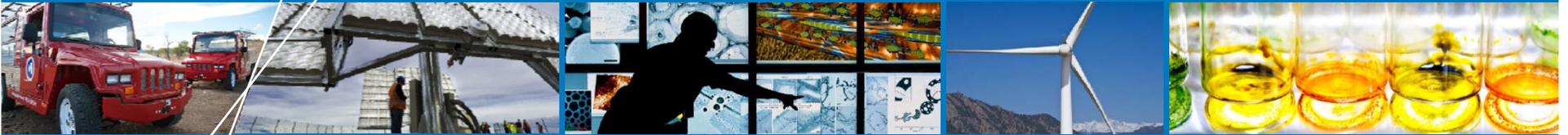
To be posted on the CSI-RD&D website soon

BEopt-CA (Ex): **A Tool for Optimal Integration of EE, DR and PV in Existing California Homes**

Craig Christensen and Scott Horowitz, Jeff Maguire, and Paulo Tabares Velasco
National Renewable Energy Laboratory

David Springer, Peter Coates and Christy Bell
Davis Energy Group

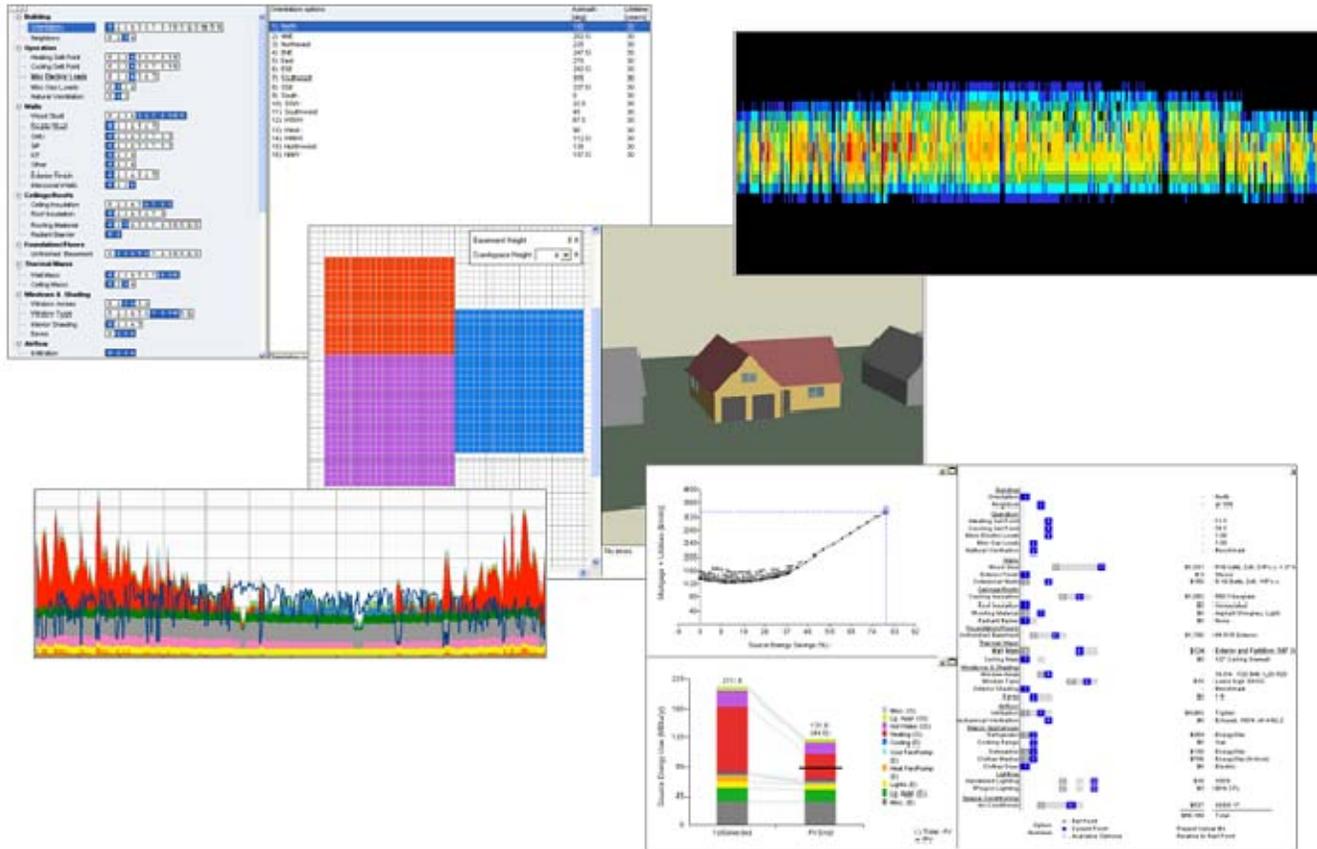
Snuller Price, Priya Sreedharan, and Katie Pickrell
Energy + Environmental Economics



What Is BEopt?

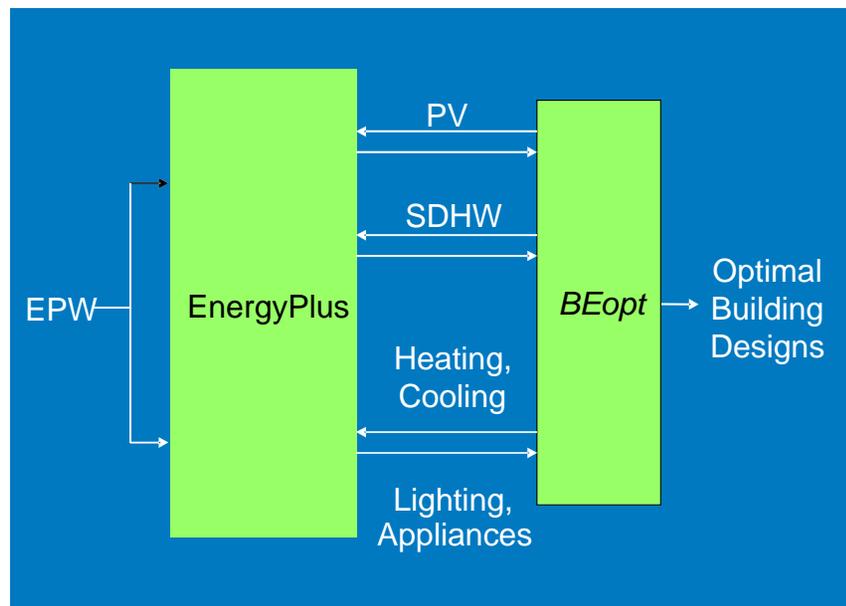
BEopt Building Energy Optimization Based on Hour-by-Hour Simulations

beopt.nrel.gov



BEopt

BEopt (EnergyPlus)

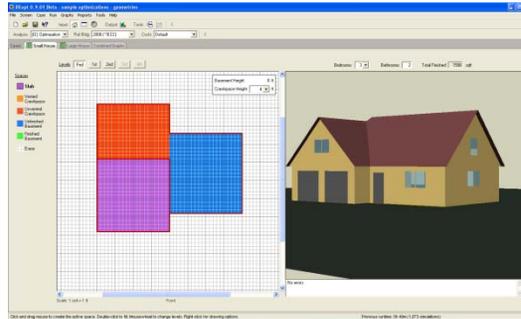


- Runs detailed hour-by-hour simulations
- Accurately accounts for interactions (e.g., glass type and HVAC)
- Evaluates realistic (discrete) options
- Finds optimal designs from base case to zero net energy
- Identifies near-optimal alternative designs
- Building America occupancy/operating assumptions and climate-specific reference buildings

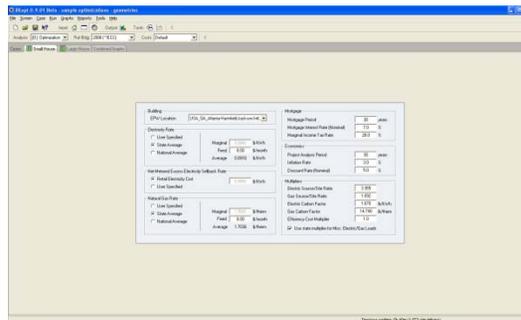
BEopt

Input

Geometry



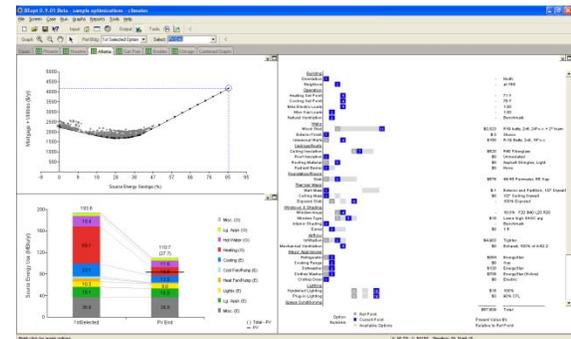
Site



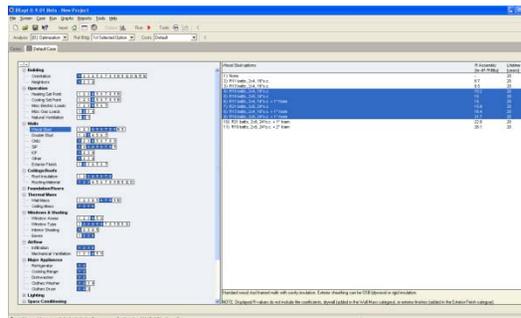
Run



Output



Options



BEopt Input

Drawing Tool – quick/accurate input of detailed building geometry

The screenshot displays the BEopt Drawing Tool interface. On the left, a 2D grid shows a building footprint composed of several colored regions: a purple slab, an orange crawlspace, a blue unfinished basement, and a green finished basement. The drawing is overlaid on a grid with a scale of 1 cell = 1 ft. The interface includes a 'Levels' menu with options for 'Fnd', '1st', '2nd', '3rd', '4th', and 'Roof'. A 'Spaces' legend on the left identifies the colors: Slab (purple), Crawlspace (orange), Unfinished Basement (blue), Finished Basement (green), and Erase (grid icon). Below the legend, 'Attached Walls' options are listed: Left-Facing, Right-Facing, and Back-Facing. On the right side, a 3D perspective view shows a yellow house with a brown roof, corresponding to the drawing on the left. The 3D view includes a 'No errors.' status message and navigation icons. At the top right, summary statistics are displayed: 'Beds 3', 'Baths 2', and 'Total Finished 2680 sqft'. A control panel at the top right also includes 'Crawlspace Height' (4 ft) and 'Basement Height' (8 ft) input fields.

BEopt Input

Site Inputs – weather, financing, utility rates, incentives, etc.

Building EPW Location: CZ01RV2.epw Terrain: Suburban	Payment Type: <input checked="" type="radio"/> Tax Deductible Loan <input type="radio"/> Loan <input type="radio"/> Cash Cash Payment: 0.0 % Loan Interest Rate: 6.5 % Loan Period: 5 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response: <input type="checkbox"/> Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> PG&E
Electricity Natural Gas Oil Propane	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff Annual Excess Sellback Rate: <input type="radio"/> Retail Electricity Cost: 0.04396 \$/kWh <input checked="" type="radio"/> User Specified
Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed IOUs only <input checked="" type="checkbox"/> <input checked="" type="radio"/> OpenEI: Pacific Gas & Electric Co <input type="radio"/> User Specified: Sample Tiered Rate Fuel Escalation (Real): 0.00 %/year	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

BEopt Input

Options – operation, envelope, equipment

Category

Options

Option	R-Assembly [h-ft ² -R/Btu]	Framing Factor [frac]	Install Gr
2) Uninsulated, 2x4, 16 in o.c.	3.6	0.25	
3) Uninsulated, 2x6, 24 in o.c.	3.7	0.22	
4) R-7 Fiberglass Batt, Gr-3, 2x4, 16 in o.c.	8.3	0.25	
5) R-7 Fiberglass Batt, Gr-2, 2x4, 16 in o.c.	8.7	0.25	
6) R-7 Fiberglass Batt, Gr-1, 2x4, 16 in o.c.	8.9	0.25	
7) R-11 Fiberglass Batt, Gr-3, 2x4, 16 in o.c.	9.6	0.25	
8) R-11 Fiberglass Batt, Gr-2, 2x4, 16 in o.c.	10.1	0.25	
9) R-11 Fiberglass Batt, Gr-1, 2x4, 16 in o.c.	10.5	0.25	
10) R-13 Fiberglass Batt, Gr-3, 2x4, 16 in o.c.	10.3	0.25	
11) R-13 Fiberglass Batt, Gr-2, 2x4, 16 in o.c.	10.9	0.25	
12) R-13 Fiberglass Batt, Gr-1, 2x4, 16 in o.c.	11.4	0.25	
13) R-15 Fiberglass Batt, Gr-3, 2x6, 24 in o.c.	10.9	0.25	
14) R-15 Fiberglass Batt, Gr-2, 2x4, 16 in o.c.	11.7	0.25	
15) R-15 Fiberglass Batt, Gr-1, 2x4, 16 in o.c.	12.2	0.25	
16) R-19 Fiberglass Batt, Gr-3, 2x6, 24 in o.c.	14.6	0.22	
17) R-19 Fiberglass Batt, Gr-2, 2x6, 24 in o.c.	14.6	0.22	
18) R-19 Fiberglass Batt, Gr-1, 2x6, 24 in o.c.	15.5	0.22	
19) R-21 Fiberglass Batt, Gr-3, 2x6, 24 in o.c.	14.6	0.22	
20) R-21 Fiberglass Batt, Gr-2, 2x6, 24 in o.c.	16.1	0.22	
21) R-21 Fiberglass Batt, Gr-1, 2x6, 24 in o.c.	17.2	0.22	
22) R-13 Cellulose, Gr-3, 2x4, 16 in o.c.	10.3	0.25	
23) R-13 Cellulose, Gr-2, 2x4, 16 in o.c.	10.9	0.25	

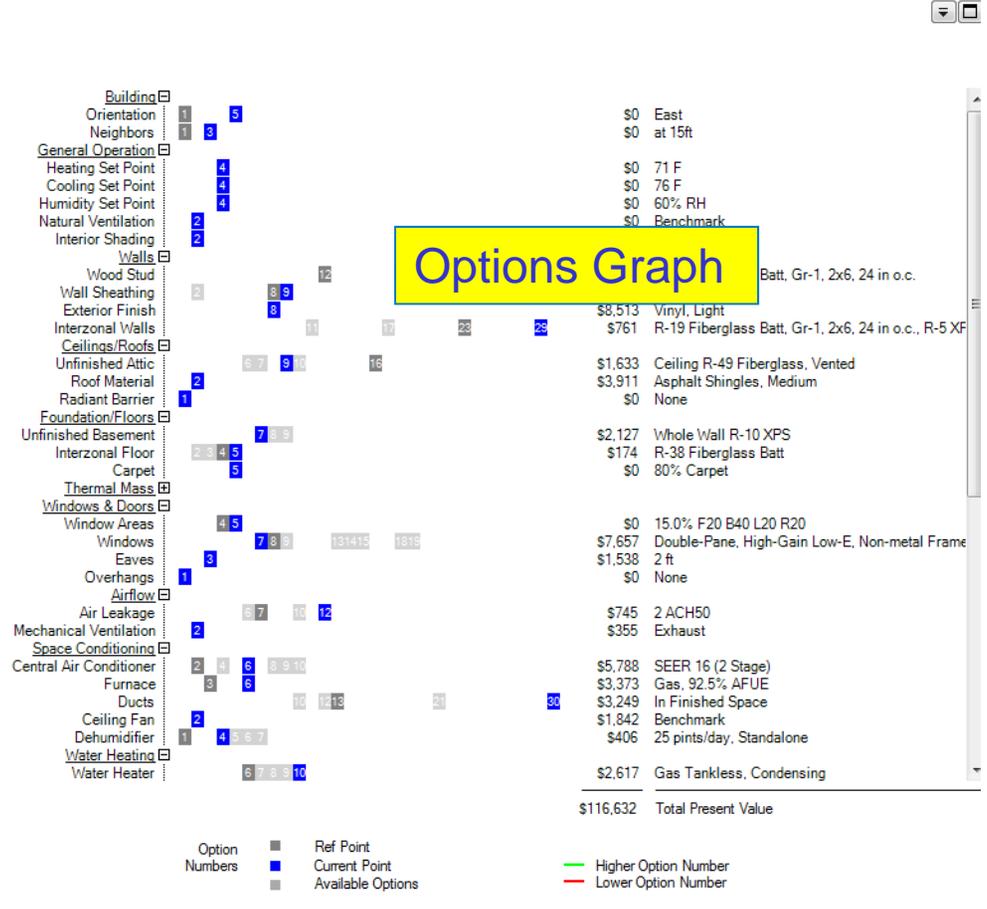
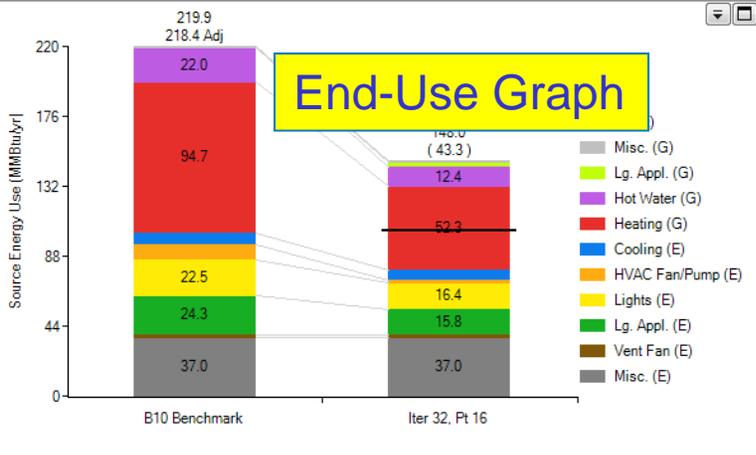
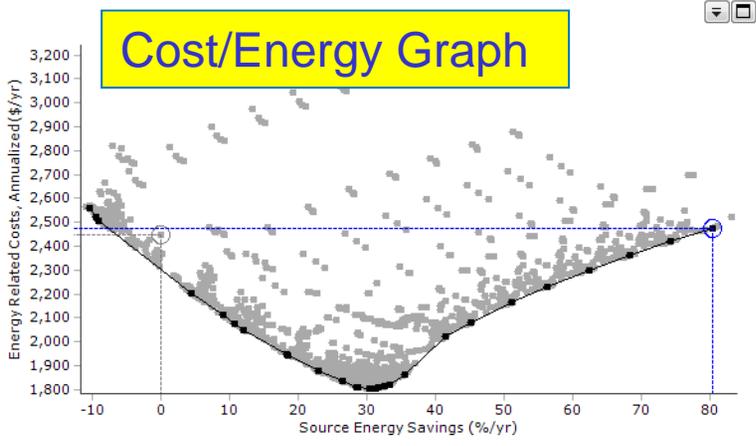
Wood stud walls are standard wood stud framed walls with cavity insulation.
When batt insulation must be compressed to fit within the cavity (e.g. R19 in a 5.5' 2x6 cavity), R-values reflect this effect.

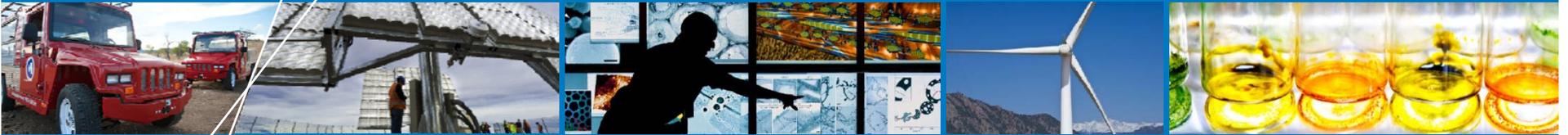
Gr = Grade of batt installation quality (1, 2, or 3) as described in RESNET's "2006 Mortgage Industry National Home Energy Rating Systems Standards."

~1000 options (in ~100 categories)

BEopt Output

Results – multiple designs, selected individual designs

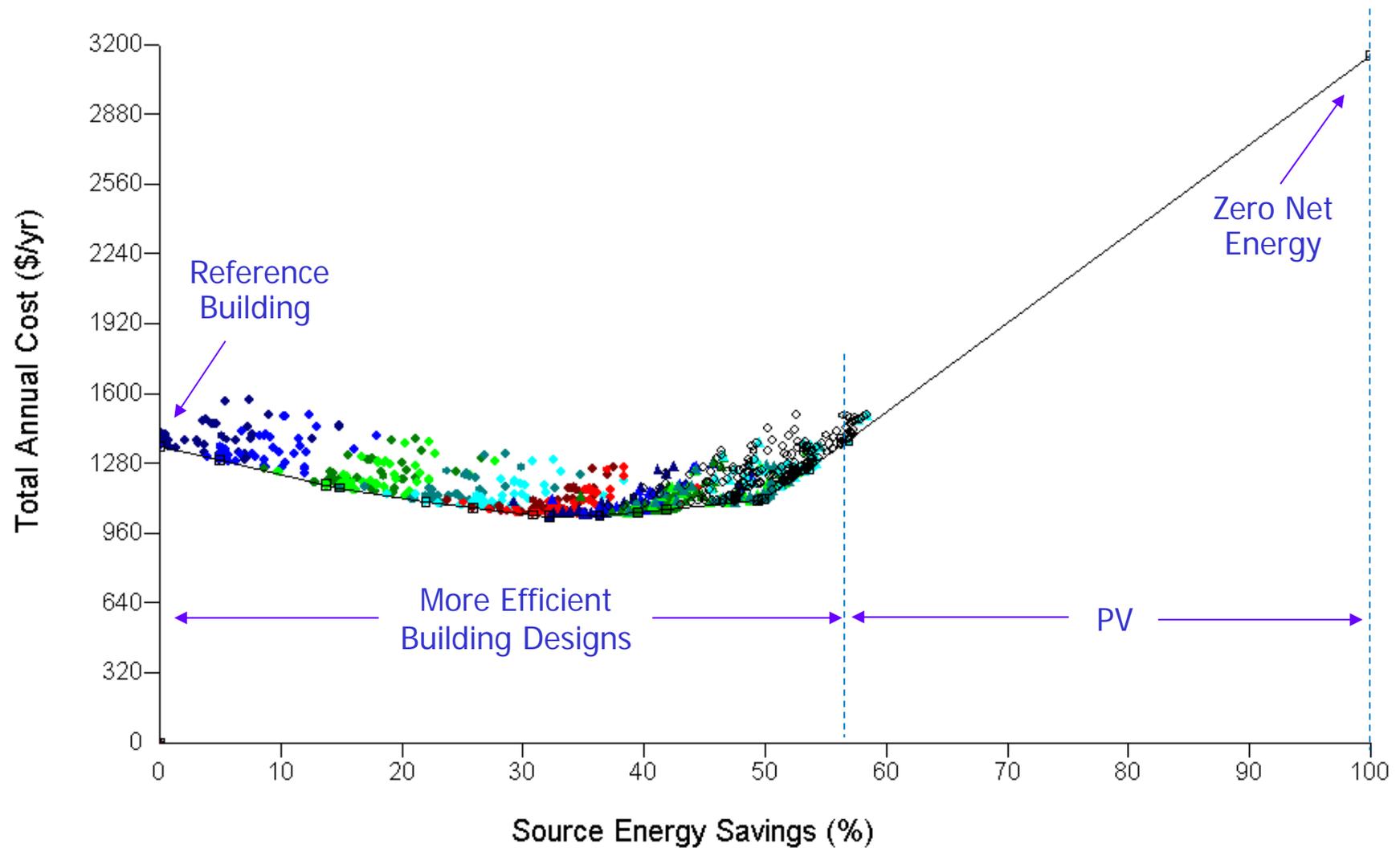




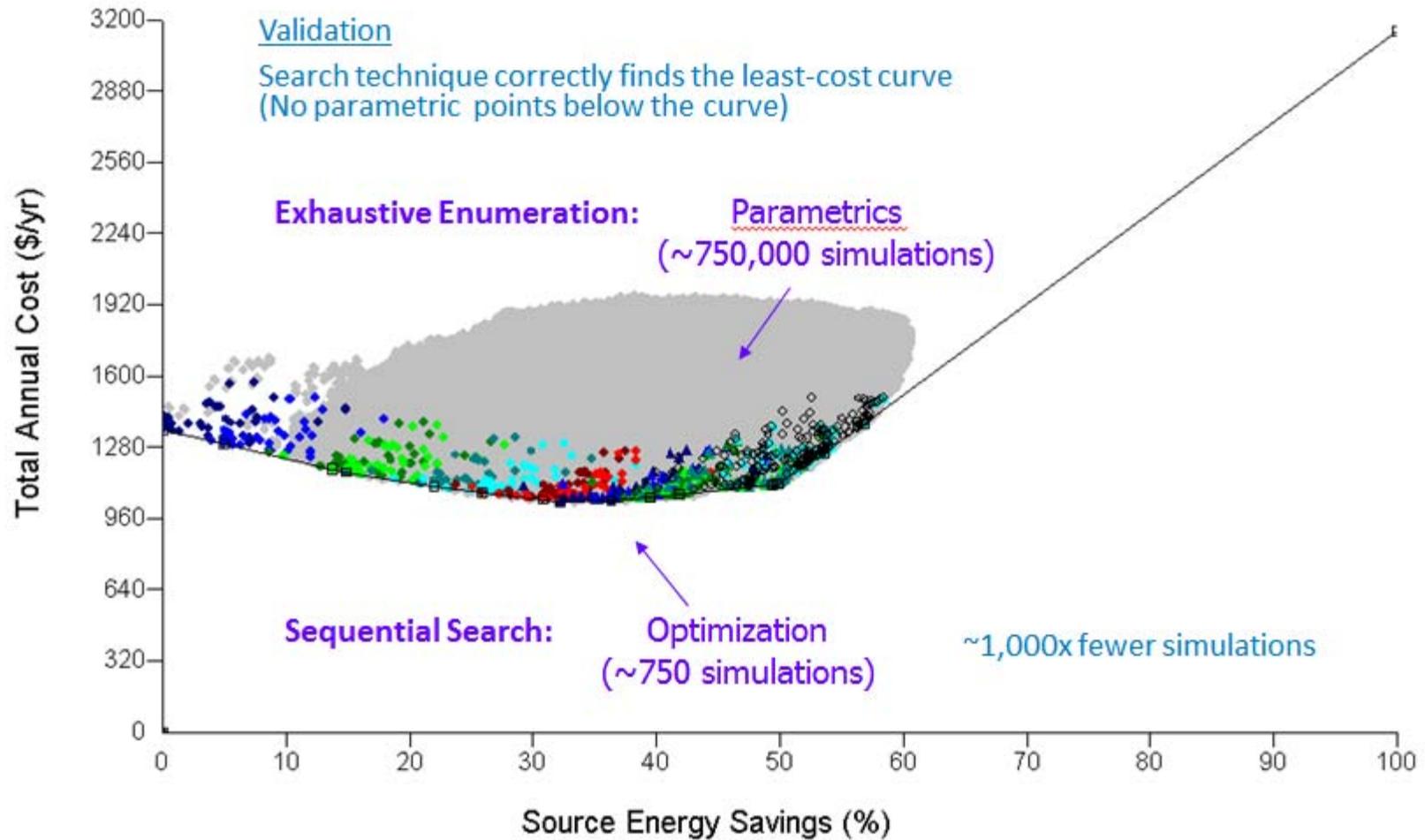
Validation, Simulation Engines

BEopt Output

Cost/Energy Graph

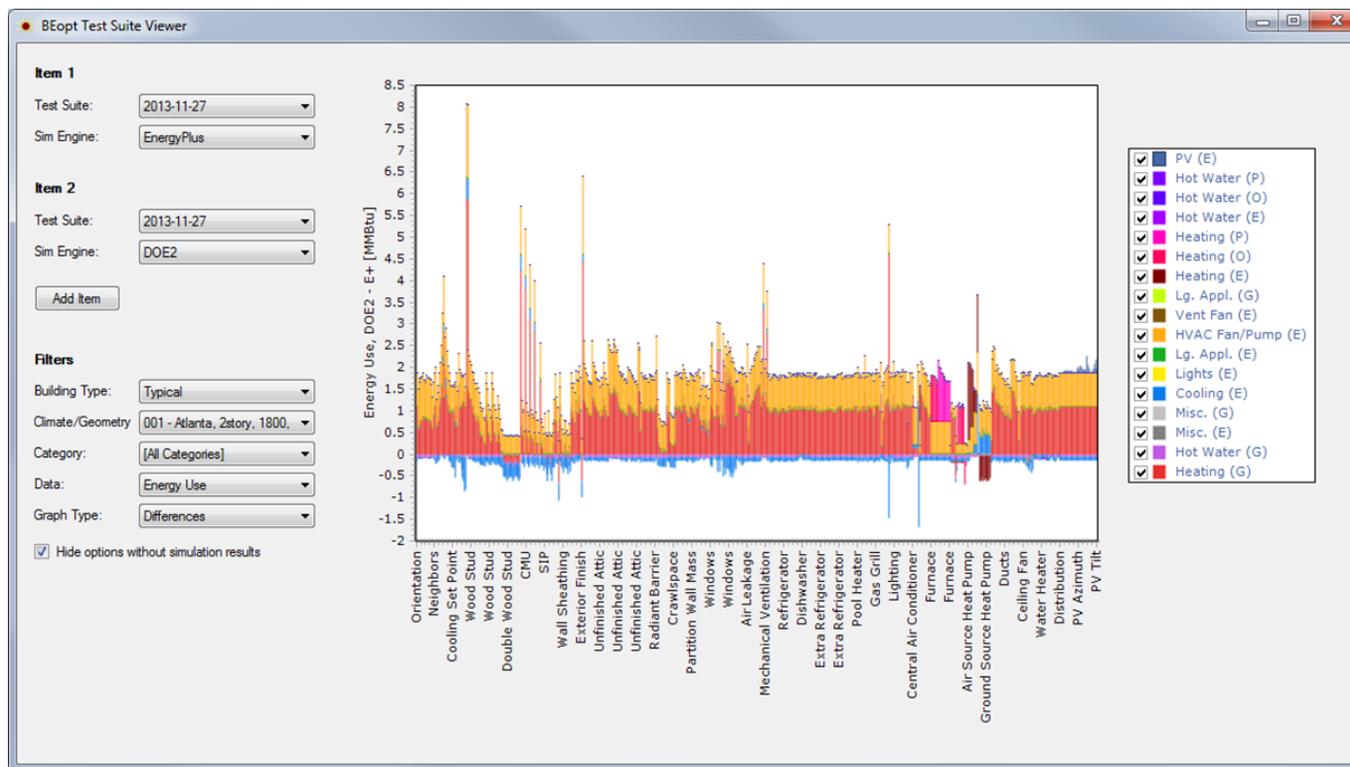


Validation

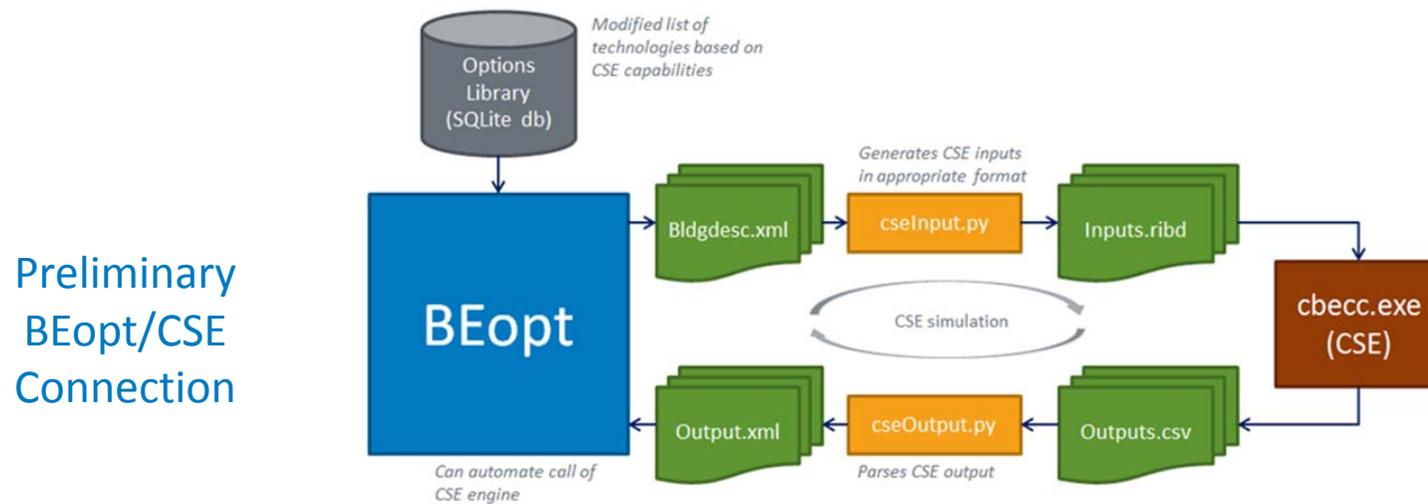


BEopt Test Suite

- Systematically sweeps through technology options for each BEopt category (tens of thousands of building simulations)
- Test suite results are stored in a database; differences can be quickly visualized and filtered



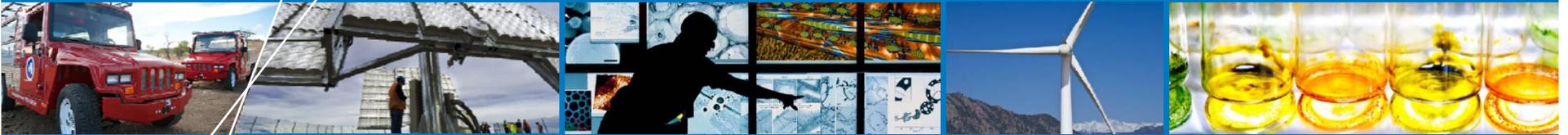
California Simulation Engine (CSE)



Potential applications for BEopt (CSE):

- (1) compare CSE to EnergyPlus via the BEopt Test Suite
- (2) parametric (and optimization) capabilities for CSE that could be used in Title 24 development
- (3) potential front end for a CSE-based Title 24 user tool

Q & A



Retrofit Analysis, Measures and Costs

Retrofit Analysis



Retrofit Analysis

Retrofit Application Type

- **Options Screen**
 - Existing building tab
 - Options/costs tailored for existing building
 - Age of existing equipment
 - Equipment replacement choices
 - Today, Wear Out, or Either
 - HVAC replacement capacity choice
 - Same as Existing, Autosize, or Fixed Size
 - Default reference: “Existing (w/ Min Replace)”
- **Site Screen**
 - Payment types: tax deductible loan, loan, or cash

Retrofit Analysis

File Screen Case Run Reports Tools Help

Input: Output: Run:

Analysis: Optimization Reference: Existing (w/ Min Replace) Cost Group: Default Sim Engine: DOE2

Existing Reference Start Optimization

Building
General Operation
Walls
Ceilings/Roofs
Foundation/Floors
Thermal Mass
Windows & Doors
Airflow
Space Conditioning
Central Air Conditioner
Furnace
Electric Baseboard
Boiler
Ducts
Air Source Heat Pump
Ground Source Heat Pump
Ceiling Fan
Water Heating

Cooling Output Capacity Autosize

Option	Age [Years]	Compressor	Cycling [frac]	Lifetime [Years]
1) None				
2) SEER 8	8	1 Stage	0.20	16
3) SEER 10	12	1 Stage	0.20	16
4) SEER 13	8	1 Stage	0.07	16
5) SEER 14	8	1 Stage	0.07	16
6) SEER 15	8	1 Stage	0.07	16
7) SEER 16	8	1 Stage	0.07	16
8) SEER 16 (2 Stage)	8	2 Stage	0.11	16
9) SEER 17	8	2 Stage	0.11	16
10) SEER 18	8	2 Stage	0.11	16
11) SEER 21	8	2 Stage	0.11	16
12) SEER 24.5	8	Var. Speed	0.25	16

Retrofit Analysis

File Screen Case Run Reports Tools Help

Input: Output: Run:

Analysis: Optimization Reference: Existing (w/ Min Replace) Cost Group: Default Sim Engine: DOE2

Existing Reference Start Optimization

Cooling Output Capacity: Same As Existing

Option	Replace	Compressor	Cycling [frac]	Lifetime [Years]
1) None	Today			
2) SEER 13	Wear Out	1 Stage	0.07	16
3) SEER 14	Today	1 Stage	0.07	16
4) SEER 15	Today	1 Stage	0.07	16
5) SEER 16	Today	1 Stage	0.07	16
6) SEER 16 (2 Stage)	Today	2 Stage	0.11	16
7) SEER 17	Today	2 Stage	0.11	16
8) SEER 18	Today	2 Stage	0.11	16
9) SEER 21	Today	2 Stage	0.11	16
10) SEER 24.5	Today	Var. Speed	0.25	16

Building

- General Operation
- Walls
- Ceilings/Roofs
- Foundation/Floors
- Thermal Mass
- Windows & Doors
- Airflow
- Space Conditioning
 - Central Air Conditioner
 - Furnace
 - Electric Baseboard
 - Boiler
 - Ducts
 - Air Source Heat Pump
 - Ground Source Heat Pump
 - Ceiling Fan
- Water Heating

Retrofit Analysis

File Screen Case Run Reports Tools Help

Input: Output: Run:

Analysis: Optimization Reference: Existing (w/ Min Replace) Cost Group: Default Sim Engine: DOE2

Existing Reference Start Optimization

Building
 General Operation
 Walls
 Ceilings/Roofs
 Foundation/Floors
 Thermal Mass
 Windows & Doors
 Airflow
 Space Conditioning
 Central Air Conditioner
 Furnace
 Electric Baseboard
 Boiler
 Ducts
 Air Source Heat Pump
 Ground Source Heat Pump
 Ceiling Fan
 Water Heating

Cooling Output Capacity Autosize

Option	Replace	Compressor	Cycling [frac]	Lifetime [Years]
1) None	Today			
2) SEER 13	Wear Out	1 Stage	0.07	16
3) SEER 14	Wear Out	1 Stage	0.07	16
4) SEER 15	Either	1 Stage	0.07	16
5) SEER 16	Either	1 Stage	0.07	16
6) SEER 16 (2 Stage)	Either	2 Stage	0.11	16
7) SEER 17	Today	2 Stage	0.11	16
8) SEER 18	Today	2 Stage	0.11	16
9) SEER 21	Today	2 Stage	0.11	16
10) SEER 24.5	Today	Var. Speed	0.25	16

Retrofit Analysis

Building
EPW Location: CZ01RV2.epw
Terrain: Suburban

Economics
Project Analysis Period: 30 years
Inflation Rate: 2.4 %
Discount Rate (Real): 3.0 %
Material Cost Multiplier: 1.00
Labor Cost Multiplier: 1.00

California Metrics
Net-to-Gross Ratio: 90.0 %
Program Cost (Present Value): 100 \$/home

Payment
Type: Tax Deductible Loan Loan Cash
Cash Payment: 0.0 %
Loan Interest Rate: 6.5 %
Loan Period: 5 years
Marginal Income Tax Rate, Federal: 28.0 %
Marginal Income Tax Rate, State: 9.3 %

Other
Incentives: PV Efficiency
Demand Response: Signals

CA Climate Zone
Utility: PG&E

Electricity | Natural Gas | Oil | Propane

Utility Rates
 Simple Detailed
IOUs only
 OpenEI: Pacific Gas & Electric Co
 User Specified: Sample Tiered Rate
Fuel Escalation (Real): 0.00 %/year

PV Compensation
 Net Metering Feed-in Tariff
Annual Excess Sellback Rate:
 Retail Electricity Cost: 0.04396 \$/kWh
 User Specified

Energy Factors
Source/Site Ratio: 3.150
Carbon Factor: 1.530 lb/kWh

Retrofit Analysis

Retrofit Measures and Costs

- Include measures that are most likely to be used in standard California retrofits
 - Older equipment (Inefficient ACs, Furnaces, Appliances)
 - Older envelope components (uninsulated walls/ceilings/floors, single glazed windows)
 - Non-central space conditioning systems (Window ACs, Mini-Split Heat Pumps)
- Retrofit specific labor costs include details not included in other cost data
- Compliments NREL's National Residential Efficiency Measure Database (www.nrel.gov/ap/retrofits/)

Retrofit Analysis

National Residential Efficiency Measures Database



About the Database

All Measures

- Airflow
- Ceilings/Roofs
- Foundation/Floors
- Lighting
- Major Appliances
- Miscellaneous
- Space Conditioning
- Walls
- Water Heating
- Windows & Doors

Application Developer Tools

- Change Log
- Data Dictionary
- XML File Download
- Simulation Protocols

Glossary

Help

Submit Comments

Submit Data

The National Residential Efficiency Measures Database is a publicly available, centralized resource of residential building retrofit measures and costs for the U.S. building industry.

With support from the U.S. Department of Energy, NREL developed this tool to help users determine the most cost-effective retrofit measures for improving energy efficiency of existing homes. Learn more [about the database](#).

By accessing the database, the user agrees to the [terms and conditions of use](#).

[View Data Now](#)

Supporting Resources

The following resources provide more information about the data and allow you to download the data.

- [Data dictionary](#)
- [XML file download](#)
- [Simulation Protocols](#)
- [Glossary](#)
- [Guide for Application Developers](#) 
- [Development Document](#) 

Version: [v3.0.0](#)

[Webmaster](#) | [Security & Privacy](#) | [Disclaimer](#) | [NREL Home](#)

Retrofit Analysis

National Residential Efficiency Measures Database



↳ Retrofits Home

About the Database

All Measures

Airflow

Ceilings/Roofs

Foundation/Floors

Lighting

Major Appliances

Miscellaneous

Space Conditioning

Walls

-Exterior Finish

-Wall Sheathing

-Wood Stud

Water Heating

Windows & Doors

Application Developer Tools

Change Log

Data Dictionary

XML File Download

Simulation Protocols

Glossary

Help

Submit Comments

Submit Data

[Submit Questions/Comments](#)

Retrofit Measures for Wood Stud

Here you will find the data for Wood Stud measures available in the National Residential Efficiency Measures Database. Each measure consists of a before-component, an after-component, and the estimated cost to implement the measure. The measures are listed alphabetically based upon the name of the before-component. Where multiple costs are indicated they must be combined to obtain total measure cost (e.g., fixed (\$) and normalized (\$/sf) costs).

Filter on Before-Component:

Filter on After-Component:

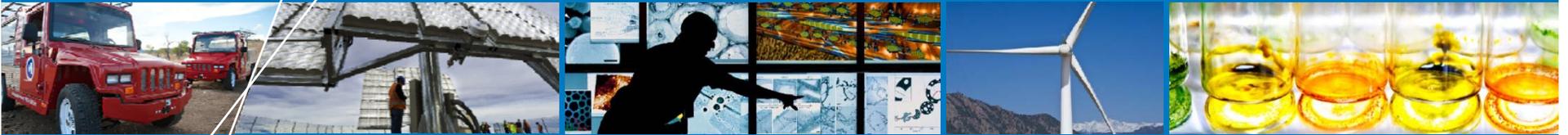
Viewing 18 Wood Stud Measure(s) of 90

Insulate with Loose Fill through Exterior (Non-Brick):

Before-Component	After-Component	Cost						
<p>Uninsulated, 2x4, 16 in o.c.</p> <p>Properties:</p> <ul style="list-style-type: none"> Cavity Depth: 3.5 in Cavity Insulation Nominal R-value: h-ft²-R/Btu Cavity Insulation Type: Framing Factor: 0.25 frac Install Grade: Stud Size: 2x4 in x in Stud Spacing: 16.0 in <p>Lifetime:</p> <ul style="list-style-type: none"> 999 Years 	<p>R-13 Cellulose, Gr-1, 2x4, 16 in o.c.</p> <p>Properties:</p> <ul style="list-style-type: none"> Cavity Depth: 3.5 in Cavity Insulation Nominal R-value: 13.0 h-ft²-R/Btu Cavity Insulation Type: cellulose Framing Factor: 0.25 frac Install Grade: 1 Stud Size: 2x4 in x in Stud Spacing: 16.0 in <p>Performance Standards:</p> <ul style="list-style-type: none"> Meets IECC 2009 (1A, 1B, 1C, 2A, 2B, 2C, 3A, 3B, 3C, 4A, 4B) Meets IECC 2012 (1A, 1B, 1C, 2A, 2B, 2C) <p>Lifetime:</p> <ul style="list-style-type: none"> 999 Years 	<p>Measure Cost</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 33%;">Units</th> <th style="width: 33%;">Range</th> <th style="width: 34%;">Average</th> </tr> </thead> <tbody> <tr> <td>\$/ft² Exterior Wall</td> <td>1.5 - 3.1</td> <td>2.4</td> </tr> </tbody> </table>	Units	Range	Average	\$/ft ² Exterior Wall	1.5 - 3.1	2.4
Units	Range	Average						
\$/ft ² Exterior Wall	1.5 - 3.1	2.4						

Insulate with Loose Fill through Exterior (Brick):

Before-Component	After-Component	Cost						
<p>Uninsulated, 2x4, 16 in o.c.</p> <p>Properties:</p> <ul style="list-style-type: none"> Cavity Depth: 3.5 in Cavity Insulation Nominal R-value: h-ft²-R/Btu Cavity Insulation Type: Framing Factor: 0.25 frac Install Grade: Stud Size: 2x4 in x in Stud Spacing: 16.0 in 	<p>R-13 Cellulose, Gr-1, 2x4, 16 in o.c.</p> <p>Properties:</p> <ul style="list-style-type: none"> Cavity Depth: 3.5 in Cavity Insulation Nominal R-value: 13.0 h-ft²-R/Btu Cavity Insulation Type: cellulose Framing Factor: 0.25 frac Install Grade: 1 Stud Size: 2x4 in x in Stud Spacing: 16.0 in 	<p>Measure Cost</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 33%;">Units</th> <th style="width: 33%;">Range</th> <th style="width: 34%;">Average</th> </tr> </thead> <tbody> <tr> <td>\$/ft² Exterior Wall</td> <td>2 - 4.1</td> <td>3.2</td> </tr> </tbody> </table>	Units	Range	Average	\$/ft ² Exterior Wall	2 - 4.1	3.2
Units	Range	Average						
\$/ft ² Exterior Wall	2 - 4.1	3.2						



Incentives

Incentives

Building EPW Location: CZ01RV2.epw Terrain: Suburban	Payment Type: <input checked="" type="radio"/> Tax Deductible Loan <input type="radio"/> Loan <input type="radio"/> Cash Cash Payment: 0.0 % Loan Interest Rate: 6.5 % Loan Period: 5 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response: Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> PG&E
Electricity Natural Gas Oil Propane	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff Annual Excess Sellback Rate: <input type="radio"/> Retail Electricity Cost: 0.04396 \$/kWh <input checked="" type="radio"/> User Specified
Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed IOUs only <input checked="" type="checkbox"/> <input checked="" type="radio"/> OpenEI: Pacific Gas & Electric Co <input type="radio"/> User Specified: Sample Tiered Rate Fuel Escalation (Real): 0.00 %/year	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

Incentives

PV Incentives

Tax credits and rebates can be defined below for photovoltaics.

Tax Credits | **Rebates**

Federal

<input type="checkbox"/> Amount	<input type="text" value="0.00"/>	\$	<input type="button" value="Define Tiers"/>
<input type="checkbox"/> Percent of Capital Cost	<input type="text" value="30.00"/>	%	<input type="button" value="Define Tiers"/>
<input type="checkbox"/> Capacity	<input type="text" value="0.000"/>	\$/W DC	<input type="button" value="Define Tiers"/>
<small>Note: If converting from \$/W AC to \$/W DC, a derate factor of 0.77 is recommended. For example, the CSI program is \$0.20/W AC x 0.77 = \$0.154/W DC.</small>			
<input type="checkbox"/> Simulated Performance	<input type="text" value="0.000"/>	\$/kWh	<input type="button" value="Define Tiers"/>
	Incentive Term	<input type="text" value="10"/>	years
	Escalation (Nominal)	<input type="text" value="0.0"/>	%/year

Max Amount \$

Max Percent of Capital Cost %

Apply incentive to reference

Incentives

PV Incentives [X]

Tax credits and rebates can be defined below for photovoltaics.

Tax Credits Rebates

Federal

Amount \$

Percent of Capital Cost %

Capacity \$/W DC

Note: If converting from \$/W AC to \$/W DC, a derate factor of 0.77 is recommended.
For example, the CSI program is $\$0.20/\text{W AC} \times 0.77 = \$0.154/\text{W DC}$.

Simulated Performance \$/kWh

Incentive Term years

Escalation (Nominal) %/year

Max Amount \$

Max Percent of Capital Cost %

Apply incentive to reference

Incentives

PV Incentives

Tax credits and rebates can be defined below for photovoltaics.

Tax Credits Rebates

State

Amount \$

Percent of Capital Cost %

Capacity \$/W DC
Note: If converting from \$/W AC to \$/W DC, a derate factor of 0.77 is recommended.
For example, the CSI program is \$0.20/W AC x 0.77 = \$0.154/W DC.

Simulated Performance \$/kWh
Incentive Term years
Escalation (Nominal) %/year

Max Amount \$
Max Percent of Capital Cost %
 Apply incentive to reference

Help Close

Incentives

PV Incentives

Tax credits and rebates can be defined below for photovoltaics.

Tax Credits Rebates

State

<input type="checkbox"/> Amount	0.00	\$	Define Tiers
<input type="checkbox"/> Percent of Capital Cost	0.00	%	Define Tiers
<input type="checkbox"/> Capacity	0.154	\$/W DC	Define Tiers

Note: If converting from \$/W AC to \$/W DC, a derate factor of 0.77 is recommended.
For example, the CSI program is $\$0.20/\text{W AC} \times 0.77 = \$0.154/\text{W DC}$.

<input checked="" type="checkbox"/> Simulated Performance	0.030	\$/kWh	Define Tiers
Incentive Term	5	years	
Escalation (Nominal)	0.0	%/year	

Max Amount \$

Max Percent of Capital Cost %

Apply incentive to reference

Help Close

Incentives

Whole-House Efficiency Incentives

Tax credits and rebates can be defined below for while-house efficiency packages.

Tax Credits | Rebates

Federal, Electricity

<input type="checkbox"/> Amount	0.00	\$	Define Tiers
<input type="checkbox"/> Percent of Capital Cost	0.00	%	Define Tiers
<input type="checkbox"/> Simulated Performance	0.000	\$/kWh	Define Tiers

Max Amount: 4,000 \$

Max Percent of Capital Cost: %

Apply incentive to reference

Help | Close

Incentives

Whole-House Efficiency Incentives

Tax credits and rebates can be defined below for whole-house efficiency packages.

Tax Credits Rebates

State, Electricity

Amount \$

Percent of Capital Cost %

Simulated Performance

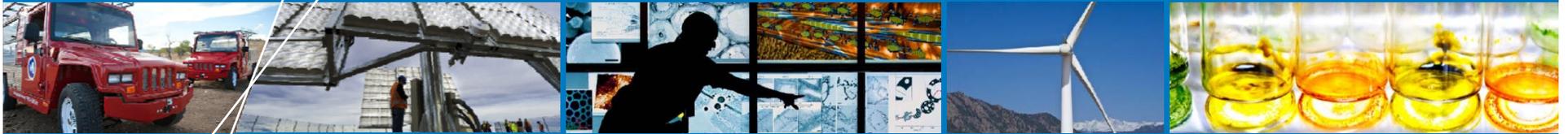
Tier #	Min Elec. Savings [%]	\$/kWh	To Next Tier
1	10	0.1	Ramp
2	30	.30	Flat

Max Amount \$

Max Percent of Capital Cost %

Apply incentive to reference

Help

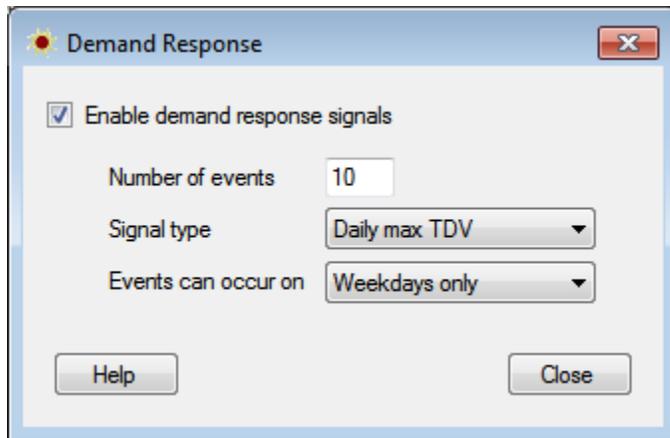


Demand Response

Demand Response

Building EPW Location: CZ01RV2.epw Terrain: Suburban	Payment Type: <input checked="" type="radio"/> Tax Deductible Loan <input type="radio"/> Loan <input type="radio"/> Cash Cash Payment: 0.0 % Loan Interest Rate: 6.5 % Loan Period: 5 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response <input type="checkbox"/> Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> PG&E
Electricity Natural Gas Oil Propane	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff Annual Excess Sellback Rate: <input type="radio"/> Retail Electricity Cost: 0.04396 \$/kWh <input checked="" type="radio"/> User Specified
Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed IOUs only <input checked="" type="checkbox"/> <input checked="" type="radio"/> OpenEI: Pacific Gas & Electric Co <input type="radio"/> User Specified: Sample Tiered Rate Fuel Escalation (Real): 0.00 %/year	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

Demand Response



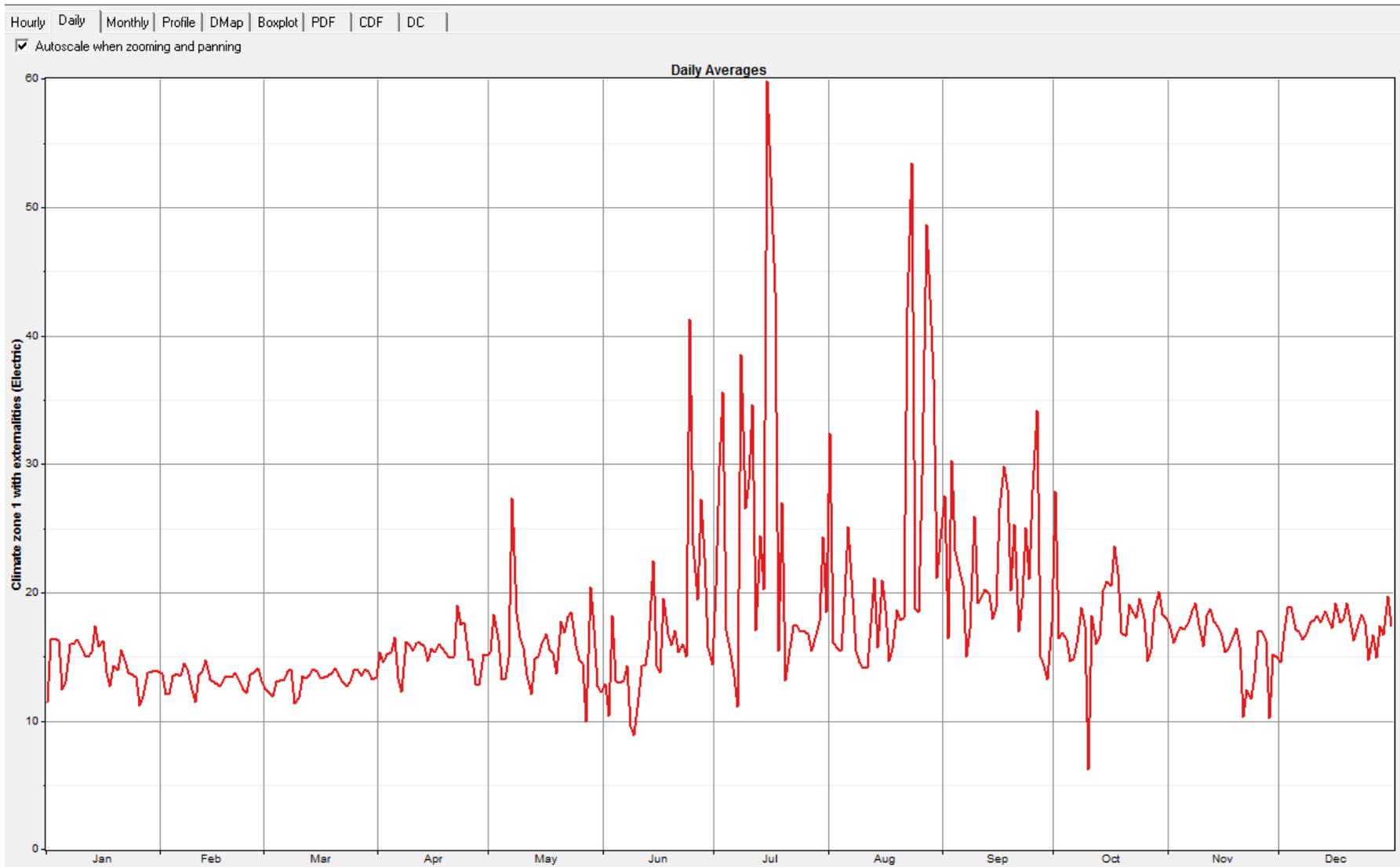
Signal type:

- Daily avg TDV
- Daily max TDV
- Daily avg temperature
- Daily max temperature

Events can occur on:

- All days
- Weekdays only
- Weekends only

Demand Response



Demand Response

Old

Major Appliances	
... Refrigerator	1 2 3 4 5 6
... Cooking Range	1 2 3 4 5 6
... Dishwasher	1 2 3 4 5 6
... Clothes Washer	1 2 3 4 5 6
... Clothes Dryer	1 2 3 4 5 6



New

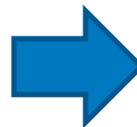
Major Appliances	
... Refrigerator	1 2 3 4 5 6
... Cooking Range	1 2 3 4 5 6
... Dishwasher	1 2 3 4 5 6
... Clothes Washer	1 2 3 4 5 6
... Clothes Dryer	1 2 3 4 5 6

Major Appliances Operation	
... Refrigerator Schedule	1 2
... Cooking Range Schedule	1
... Dishwasher Schedule	1 2 3 4
... Clothes Washer Schedule	1 2 3 4
... Clothes Dryer Schedule	1 2 3 4

Demand Response

Old

Operation	
... Heating Set Point	1 2 3 4 5 6 7 8 9 10
... Cooling Set Point	1 2 3 4 5 6 7 8 9 10
... Misc Electric Loads	1 2 3 4 5 6 7 8
... Misc Gas Loads	1 2 3 4
... Misc Hot Water Loads	1 2 3 4
... Natural Ventilation	1 2 3 4
... Interior Shading	1 2 3 4 5 6



New

Miscellaneous	
... Extra Refrigerator	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
... Freezer	1 2 3 4 5 6 7 8 9
... Pool Heater	1 2 3 4
... Pool Pump	1 2 3 4
... Hot Tub/Spa Heater	1 2 3 4
... Hot Tub/Spa Pump	1 2 3
... Well Pump	1 2 3 4 5
... Gas Fireplace	1 2 3
... Gas Grill	1 2 3
... Gas Lighting	1 2 3
... Other Electric Loads	1 2 3 4 5 6 7 8
... Other Hot Water Loads	1 2 3 4
Miscellaneous Operation	
... Extra Refrigerator Schedule	1 2
... Freezer Schedule	1 2
... Pool Heater Schedule	1
... Pool Pump Schedule	1 2
... Hot Tub/Spa Heater Schedule	1 2
... Hot Tub/Spa Pump Schedule	1 2
... Well Pump Schedule	1 2
... Gas Fireplace Schedule	1
... Gas Grill Schedule	1
... Gas Lighting Schedule	1
... Other Electric Loads Schedule	1 2
... Other Hot Water Loads Schedule	1

Demand Response

Major Appliances

Refrigerator	1 2 3 4
Cooking Range	1 2 3 4
Dishwasher	1 2 3 4
Clothes Washer	1 2 3 4
Clothes Dryer	1 2 3 4

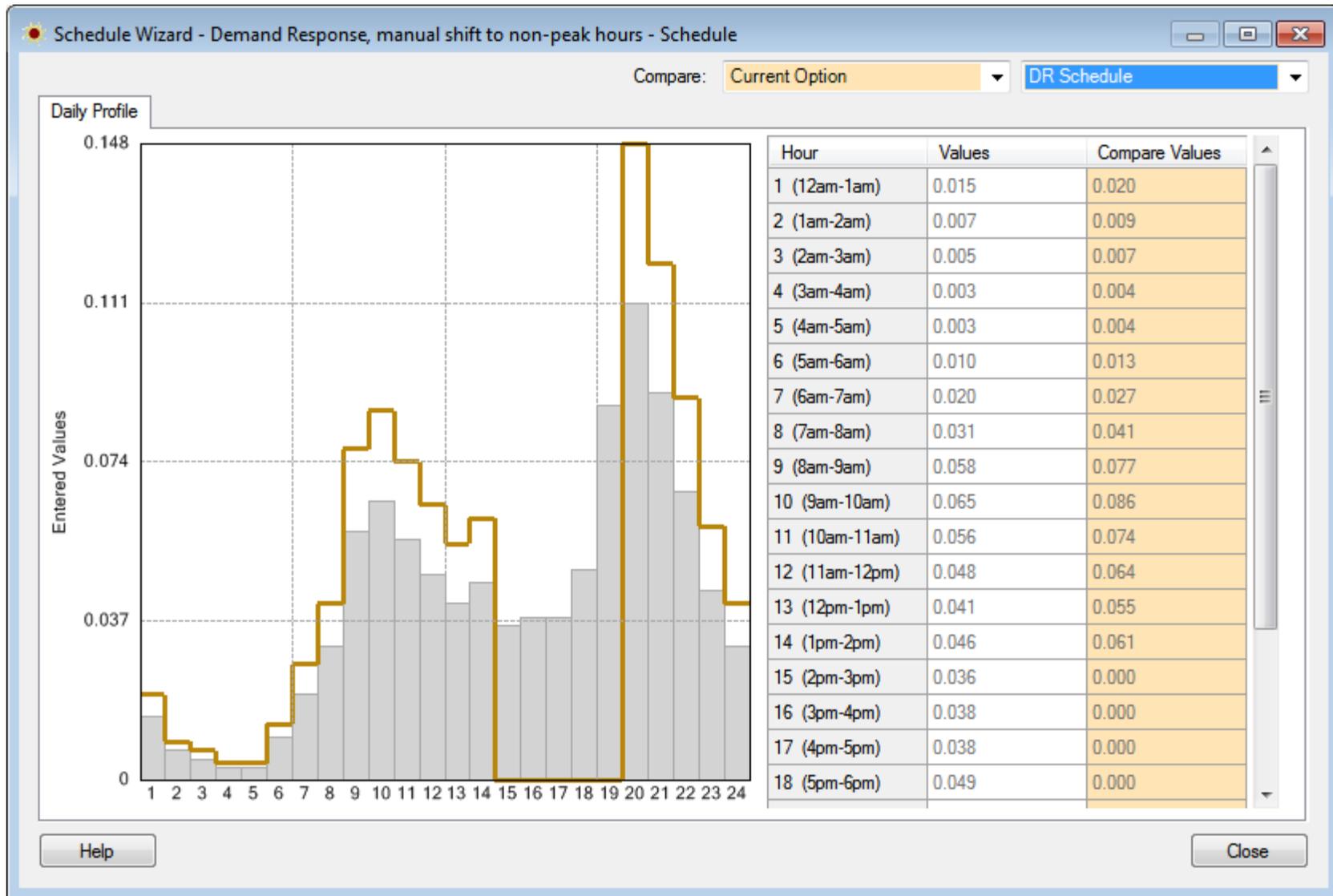
Option	Annual kWh [kWh/year]	DR Automatic Control	Cost [\$]
1) None			
2) Benchmark		False	\$879.00
3) 0.8 x Benchmark		False	\$959.00
4) 318 Annual kWh	318.0	False	\$879.00
5) 290 Annual kWh	290.0	False	\$959.00
6) 290 Annual kWh, DR control	290.0	True	\$1,159.00

Major Appliances Operation

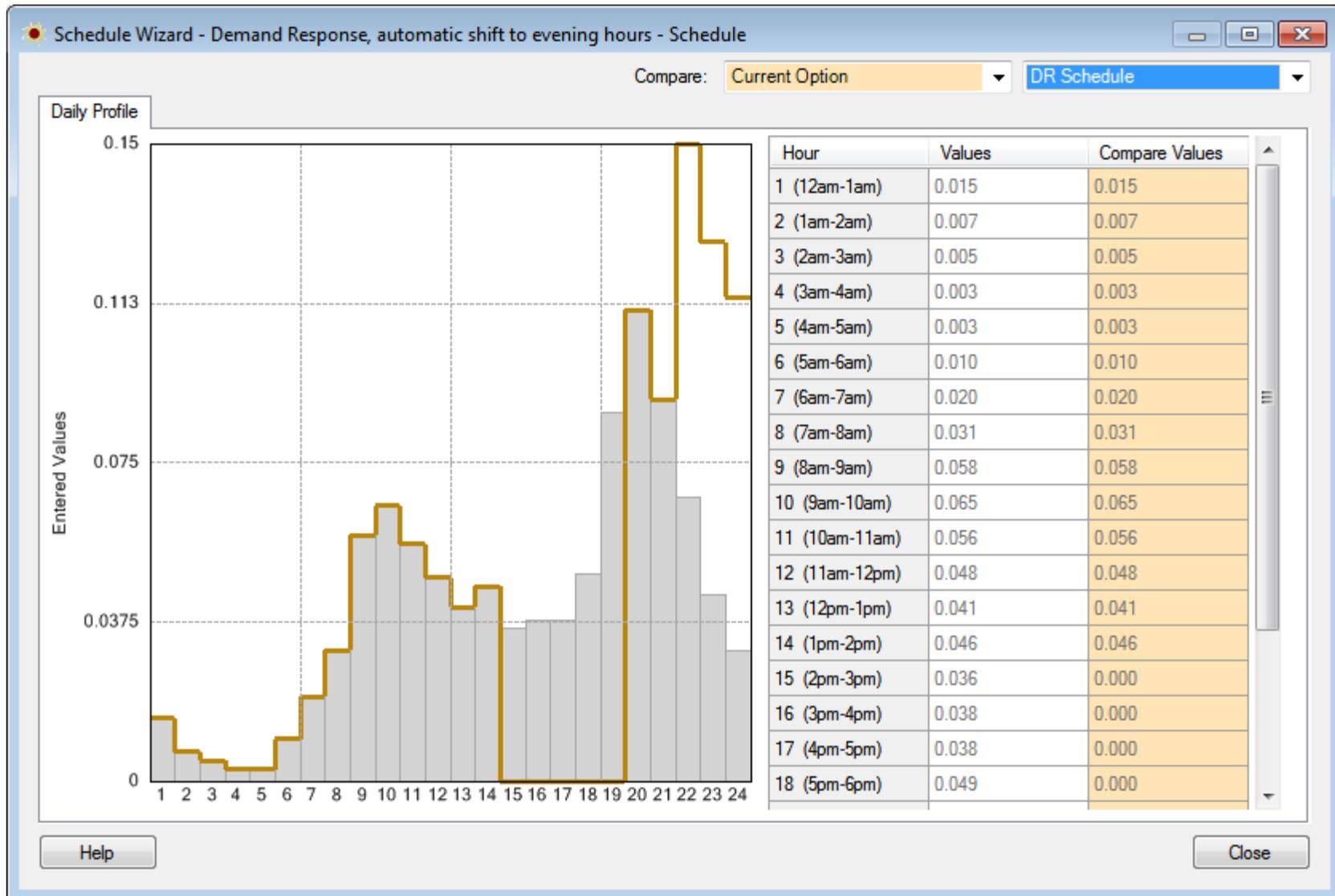
Refrigerator Schedule	1 2
Cooking Range Schedule	1
Dishwasher Schedule	1 2 3 4
Clothes Washer Schedule	1 2 3 4
Clothes Dryer Schedule	1 2 3 4

Option	Schedule	DR Schedule	DR Control
1) Standard	View		
2) Demand Response, manual shift to non-peak hours	View	View	manual
3) Demand Response, manual shift to evening hours	View	View	manual
4) Demand Response, automatic shift to evening hours	View	View	automatic

Demand Response



Demand Response



Demand Response

Major Appliances Operation

Refrigerator Schedule	1 2
Cooking Range Schedule	1
Dishwasher Schedule	1 2 3 4
Clothes Washer Schedule	1 2 3 4
Clothes Dryer Schedule	1 2 3 4

Option	Schedule	DR Schedule	DR Penetration Rate	DR Control
1) Standard	View			
2) Demand Response, manual shift to non-peak hours	View	View	1.0	manual
3) Demand Response, manual shift to evening hours	View	View	1.0	manual
4) Demand Response, automatic shift to evening hours	View	View	1.0	automatic
5) Demand Response, automatic shift to evening hours, 30%	View	View	.3	automatic

Q & A

Project Types



Project Types

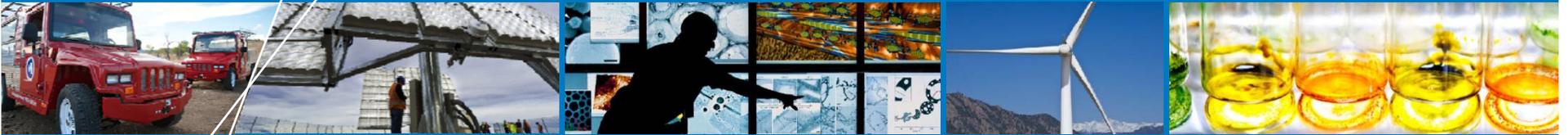
California Metrics Project Type

- **Site Screen**

- CA climate zone weather files
- Net-to-gross ratio and program cost inputs (utility cost tests)
- CA climate zone utility and region inputs (avoided costs)
- Default marginal state income tax
- Default net-metered annual excess sellback rates
- CSI PV rebate program specified/enabled by default

- **Optimization/Output Screen**

- Utility cost test metrics
 - TRC, PCT, RIM, or PAC
 - Net Present Value (NPV) or Benefit-Cost Ratio (BCR)
- TDV energy metric



Utility Tariff Capabilities

Utility Tariff Capabilities

Building EPW Location: CZ03RV2.epw Terrain: Suburban Natural Gas Hookup: <input checked="" type="checkbox"/>	Mortgage Down Payment: 0.0 % Mortgage Interest Rate: 4.0 % Mortgage Period: 30 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response: <input type="checkbox"/> Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> PG&E Region: <input checked="" type="radio"/> Peninsula <input type="radio"/> East Bay
Electricity Natural Gas Oil Propane	
Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed <input checked="" type="radio"/> OpenEI: Pacific Gas & Electric Co <input type="radio"/> User Specified: CPUC ED TOU PG&E Fuel Escalation (Real): 0.00 %/year	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff Annual Excess Sellback Rate: <input type="radio"/> Retail Electricity Cost: 0.04396 \$/kWh <input checked="" type="radio"/> User Specified
	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

Utility Tariff Capabilities

Building EPW Location: CZ03RV2.epw Terrain: Suburban Natural Gas Hookup: <input checked="" type="checkbox"/>	Mortgage Down Payment: 0.0 % Mortgage Interest Rate: 4.0 % Mortgage Period: 30 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response: <input type="checkbox"/> Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> PG&E Region: <input checked="" type="radio"/> Peninsula <input type="radio"/> East Bay
Electricity Natural Gas Oil Propane	
Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed <input checked="" type="radio"/> OpenEI Pacific Gas & Electric Co <input type="radio"/> User Specified CPUC ED TOU PG&E Fuel Escalation (Real): 0.00 %/year	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff Annual Excess Sellback Rate: <input type="radio"/> Retail Electricity Cost 0.04396 \$/kWh <input checked="" type="radio"/> User Specified
	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

Utility Tariff Capabilities

Utility Rate Wizard ✕

This rate is provided by OpenEI. Values can't be changed.

Rate Name: Description: This schedule is applicable to single-phase and polyphase residential service in single-family dwellings and in flats and apartments separately metered by PG&E; to single-phase and polyphase service in common areas in a multifamily complex; and to all single-phase and polyphase farm service on the premises operated by the person whose residence is supplied through the same meter.

Utility Name:

Fixed Charge: \$/month

Minimum Charge: \$/month

Reference: http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHS_E-1.pdf

Energy Charges

Periods

1	7
2	8
3	9
4	10
5	11
6	12

Weekday

	Morning											Afternoon												
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
Jan	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Feb	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mar	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Apr	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jul	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Aug	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sep	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oct	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nov	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Dec	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Weekend

	Morning											Afternoon												
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
Jan	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Feb	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mar	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Apr	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jul	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Aug	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sep	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oct	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nov	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Dec	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

	Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8		Period 9		Period 10		Period 11		Period 12	
	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh	Max kWh	\$/kWh
Tier 1	15.3	0.1323	12	0.1323																				
Tier 2	19.8	0.1504	15.6	0.1504																				
Tier 3	30.6	0.32377	24	0.32377																				
Tier 4	45.9	0.36377	36	0.36377																				
Tier 5		0.36377		0.36377																				
Tier 6																								

Utility Tariff Capabilities

Building EPW Location: CZ10RV2.epw Terrain: Suburban Natural Gas Hookup: <input checked="" type="checkbox"/>	Mortgage Down Payment: 0.0 % Mortgage Interest Rate: 4.0 % Mortgage Period: 30 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response: <input type="checkbox"/> Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> SCE <input type="radio"/> SDG&E
Electricity Natural Gas Oil Propane	
Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed <input type="radio"/> OpenEI Southern California Edison <input checked="" type="radio"/> User Specified CPUC ED TOU PG&E Fuel Escalation (Real): 0.00 %/year	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff <u>Annual Excess Sellback Rate</u> <input type="radio"/> Retail Electricity Cost 0.14187 \$/kWh <input checked="" type="radio"/> User Specified
	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

Utility Tariff Capabilities

Utility Rate Wizard

Rate Name: CPUC ED TOU SCE (2) Description:
 Utility Name: SCE Region 9 URL: <http://en.openei.org/wiki/Data:E1e71f1745c9-4fb4-a611-8e6f5984b548>
 Fixed Charge: 0 \$/month
 Minimum Charge: 5 \$/month
 Rate Type: Time-of-Use and/or Tiered
 Energy Charges: Time-of-Use and/or Tiered (highlighted)
 Real-Time Pricing (8760)

Periods	Weekday												Weekend																																	
	Morning						Afternoon						Morning						Afternoon																											
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11										
1	7	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	8	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	9	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	10	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	11	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	12	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12
	Max kWh	Max \$/kWh	Max kWh	Max \$/kWh								
Tier 1		0.14		0.21		0.162				0.406		
Tier 2												
Tier 3												
Tier 4												
Tier 5												
Tier 6												

Buttons: Help, Save, Cancel

Utility Tariff Capabilities

Utility Rate Wizard

Rate Name: Sample Real-Time Pricing Rate (2) Description: Sample file defined by BEopt.

Utility Name: Sample Utility

Fixed Charge: 9 \$/month

Minimum Charge: 0 \$/month

Rate Type: Real-Time Pricing (8760)

Energy Charges: Time-of-Use and/or Tiered
Real-Time Pricing (8760)

Hour	Value
1	0.04625
2	0.0444
3	0.03885
4	0.0407
5	0.0296
6	0.03885
7	0.0407
8	0.0407
9	0.0407
10	0.0444
11	0.04995
12	0.0518
13	0.0518
14	0.0481
15	0.04625
16	0.04625
17	0.0518
18	0.05735
19	0.0555
20	0.0592
21	0.05735

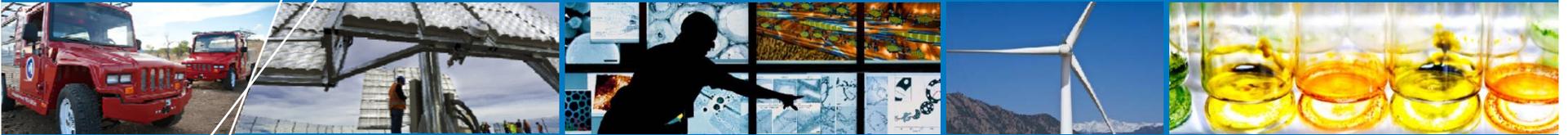
Buttons: Help, Save, Cancel

Utility Tariff Capabilities

Building EPW Location: CZ03RV2.epw Terrain: Suburban Natural Gas Hookup: <input checked="" type="checkbox"/>	Mortgage Down Payment: 0.0 % Mortgage Interest Rate: 4.0 % Mortgage Period: 30 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response: <input type="checkbox"/> Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> PG&E Region: <input checked="" type="radio"/> Peninsula <input type="radio"/> East Bay
Electricity Natural Gas Oil Propane	
Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed <input checked="" type="radio"/> OpenEI: Pacific Gas & Electric Co <input type="radio"/> User Specified: CPUC ED TOU PG&E Fuel Escalation (Real): 0.00 %/year	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff Annual Excess Sellback Rate: <input type="radio"/> Retail Electricity Cost <input checked="" type="radio"/> User Specified: 0.04396 \$/kWh Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

Utility Tariff Capabilities

Building EPW Location: CZ03RV2.epw Terrain: Suburban Natural Gas Hookup: <input checked="" type="checkbox"/>	Mortgage Down Payment: 0.0 % Mortgage Interest Rate: 4.0 % Mortgage Period: 30 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response: <input type="checkbox"/> Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> PG&E Region: <input checked="" type="radio"/> Peninsula <input type="radio"/> East Bay
Electricity Natural Gas Oil Propane	
Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed <input type="radio"/> OpenEI <input type="text" value="Pacific Gas & Electric Co"/> <input checked="" type="radio"/> User Specified <input type="text" value="CPUC ED TOU PG&E"/> Fuel Escalation (Real): 0.00 %/year	PV Compensation <input type="radio"/> Net Metering <input checked="" type="radio"/> Feed-in Tariff Hourly Value: 0.12000 \$/kWh Escalation (Real): 0.00 %/year Note: Applies to full (not excess) PV production.
	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh



Utility Cost Effectiveness Tests

Utility Cost Effectiveness Tests

Test	Acronym	Key Question Answered	Summary Approach
Participant cost test	PCT	Will the participants benefit over the measure life?	Comparison of costs and benefits of the customer installing the measure
Program administrator cost test	PACT	Will utility bills increase?	Comparison of program administrator costs to supply-side resource costs
Ratepayer impact measure	RIM	Will utility rates increase?	Comparison of administrator costs and utility bill reductions to supply-side resource costs
Total resource cost test	TRC	Will the total costs of energy in the utility service territory decrease?	Comparison of program administrator and customer costs to utility resource savings
Societal cost test	SCT	Is the utility, state, or nation better off as a whole?	Comparison of society's costs of energy efficiency to resource savings and non-cash costs and benefits

Source: Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects.

Utility Cost Effectiveness Tests

Component	TRC	PCT	PAC	RIM
Energy and capacity	Benefit	-	Benefit	Benefit
Additional resource savings	Benefit	-	-	-
Non-monetized benefits		-	-	-
Equipment and install costs	Cost	Cost	-	-
Program overhead costs	Cost	-	Cost	Cost
Incentive payments	-	Benefit	Cost	Cost
Bill Savings	-	Benefit		Cost

Utility Cost Effectiveness Tests

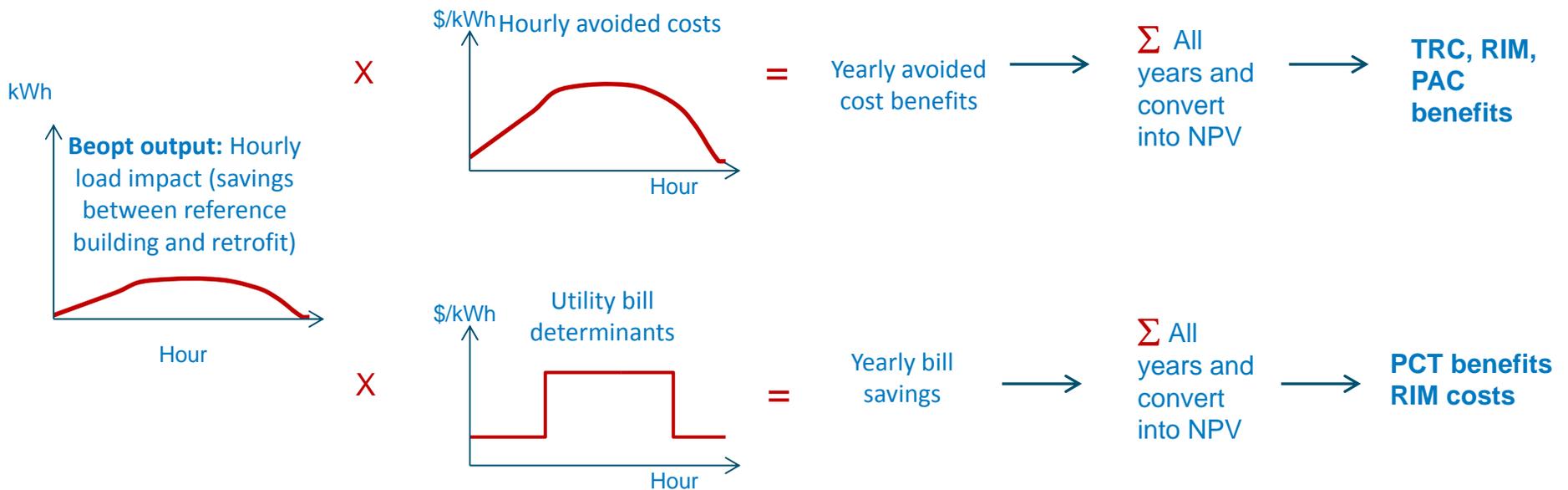
Two Approaches:

1. Integrated approach: Integrating the cost-effectiveness assessment into BEopt so that it can optimize across measures to maximize criteria such as TRC
2. External calculator approach: Values from BEopt are exported to a version of the E3 Calculator to calculate cost test values, treating the retrofit as a single measure

We implemented both approaches to provide full flexibility to users and to facilitate reporting through the CPUC process

Utility Cost Effectiveness Tests

BEOPT provides hourly energy savings information about the proposed retrofit that is used to calculate avoided cost benefits & bill impacts



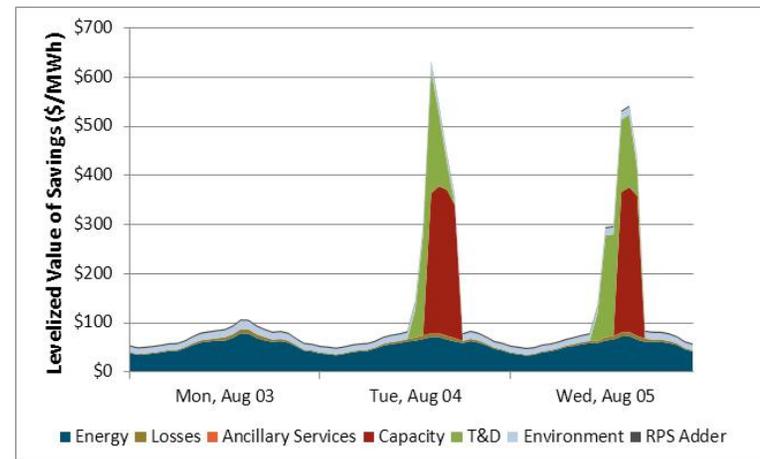
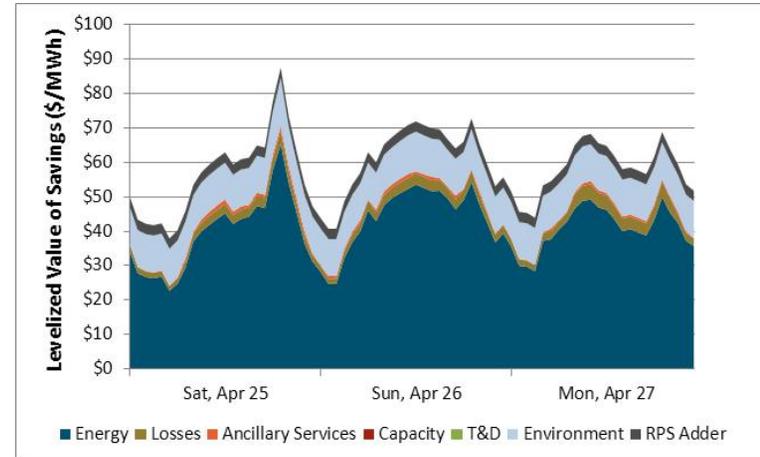
Measure cost and program information feed into the cost side of the tests.

Utility Cost Effectiveness Tests

+ Avoided Cost Components

- + Energy purchases or generation cost
- + Generation Capacity
- + T&D Capacity
- + Ancillary Services Procurement
- + GHG Emissions
- + Losses
- Reduced RPS procurement

Three-Day Avoided Cost Snapshots



Utility Cost Effectiveness Tests

Building EPW Location: CZ10RV2.epw Terrain: Suburban Natural Gas Hookup: <input checked="" type="checkbox"/>	Mortgage Down Payment: 0.0 % Mortgage Interest Rate: 4.0 % Mortgage Period: 30 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response: <input type="checkbox"/> Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> SCE <input type="radio"/> SDG&E
Electricity Natural Gas Oil Propane	
Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed <input type="radio"/> OpenEI: Southern California Edison <input checked="" type="radio"/> User Specified: CPUC ED TOU PG&E Fuel Escalation (Real): 0.00 %/year	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff <u>Annual Excess Sellback Rate</u> <input type="radio"/> Retail Electricity Cost: 0.14187 \$/kWh <input checked="" type="radio"/> User Specified
	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

Utility Cost Effectiveness Tests

Building EPW Location: CZ03RV2.epw Terrain: Suburban Natural Gas Hookup: <input checked="" type="checkbox"/>	Mortgage Down Payment: 0.0 % Mortgage Interest Rate: 4.0 % Mortgage Period: 30 years Marginal Income Tax Rate, Federal: 28.0 % Marginal Income Tax Rate, State: 9.3 %
Economics Project Analysis Period: 30 years Inflation Rate: 2.4 % Discount Rate (Real): 3.0 % Material Cost Multiplier: 1.00 Labor Cost Multiplier: 1.00	Other Incentives: <input checked="" type="checkbox"/> PV <input type="checkbox"/> Efficiency Demand Response: <input type="checkbox"/> Signals
California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> PG&E Region: <input checked="" type="radio"/> Peninsula <input type="radio"/> East Bay
Electricity Natural Gas Oil Propane Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed <input checked="" type="radio"/> OpenEI: Pacific Gas & Electric Co <input type="radio"/> User Specified: Sample Tiered Rate Fuel Escalation (Real): 0.00 %/year	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff Annual Excess Sellback Rate <input type="radio"/> Retail Electricity Cost: 0.14187 \$/kWh <input checked="" type="radio"/> User Specified
	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

Utility Cost Effectiveness Tests

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California Metrics Net-to-Gross Ratio: 90.0 % Program Cost (Present Value): 100 \$/home	CA Climate Zone Utility: <input checked="" type="radio"/> PG&E Region: <input checked="" type="radio"/> Peninsula <input type="radio"/> East Bay
Electricity Natural Gas Oil Propane Utility Rates <input type="radio"/> Simple <input checked="" type="radio"/> Detailed <input checked="" type="radio"/> OpenEI: Pacific Gas & Electric Co <input type="radio"/> User Specified: Sample Tiered Rate Fuel Escalation (Real): 0.00 %/year	PV Compensation <input checked="" type="radio"/> Net Metering <input type="radio"/> Feed-in Tariff Annual Excess Sellback Rate <input type="radio"/> Retail Electricity Cost: 0.14187 \$/kWh <input checked="" type="radio"/> User Specified
	Energy Factors Source/Site Ratio: 3.150 Carbon Factor: 1.530 lb/kWh

Utility Cost Effectiveness Tests

The screenshot shows the 'Run Simulations' dialog box with the following configuration:

Case Name	Type	DView	Y-Axis Metric	X-Axis Metric	Stop at
<input checked="" type="checkbox"/> My Case (2)	Optimization		Total Resource Cost (1)	TDV Energy Savings ('	Zero Net Energy

The Y-Axis Metric dropdown menu is open, showing the following options:

- Energy Related Costs (\$/yr)
- Participant Cost Test (PCT) (\$)
- Program Administrator Cost (PAC) Test (\$)
- Ratepayer Impact Measure (RIM) Test (\$)
- Total Resource Cost (TRC) Test (\$)

Buttons: Help, Run, Cancel. A '<< Less' link is also present.

The screenshot shows the 'Run Simulations' dialog box with the following configuration:

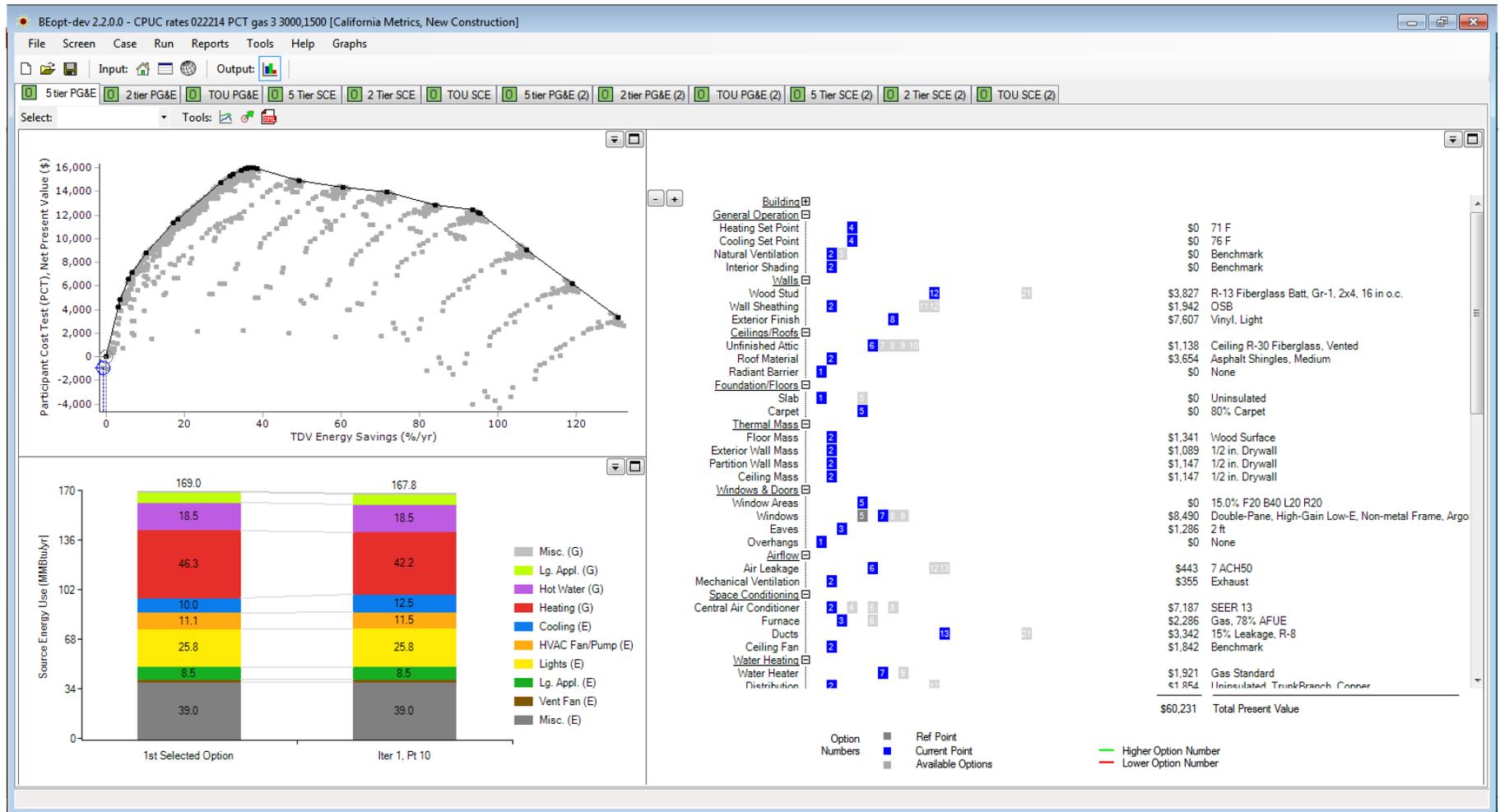
Case Name	Type	DView	Y-Axis Metric	X-Axis Metric	Stop at
<input checked="" type="checkbox"/> My Case (2)	Optimization		Total Resource Cost (1)	TDV Energy Savings ('	Zero Net Energy

The X-Axis Metric dropdown menu is open, showing the following options:

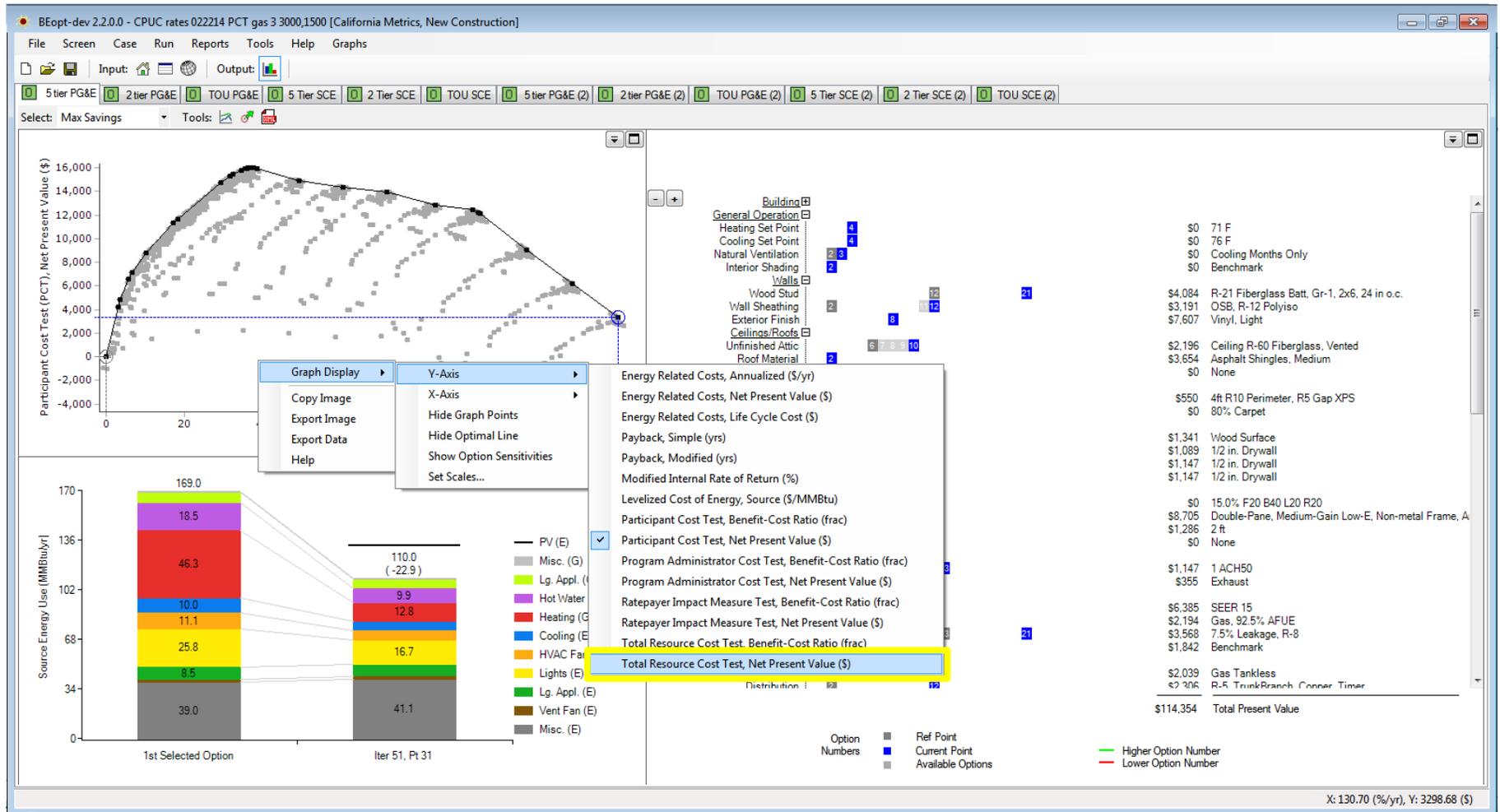
- CO2 Savings (%/yr)
- Site Energy Savings (%/yr)
- Source Energy Savings (%/yr)
- TDV Energy Savings (%/yr)

Buttons: Help, Run, Cancel. A '<< Less' link is also present.

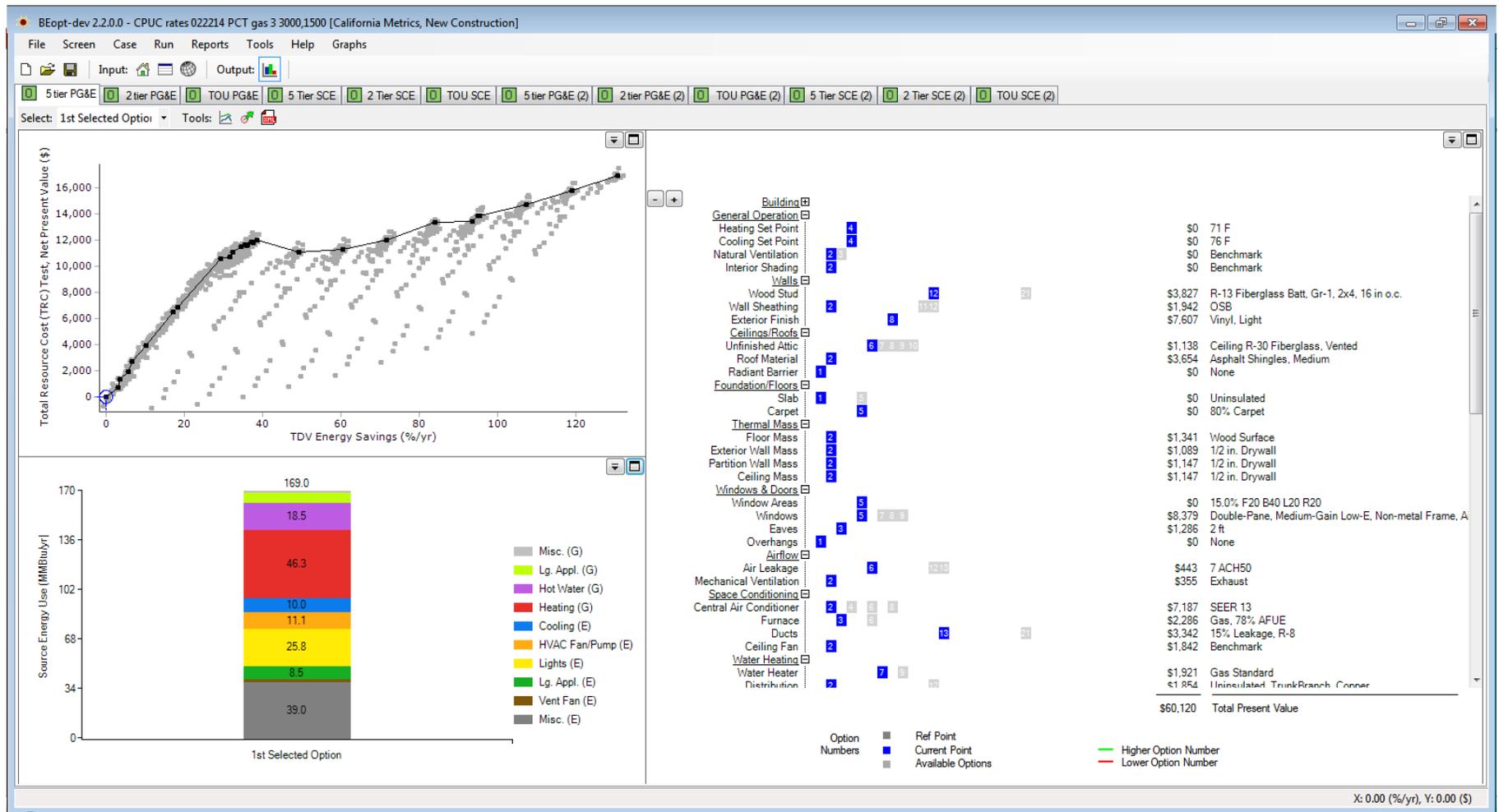
Utility Cost Effectiveness Tests



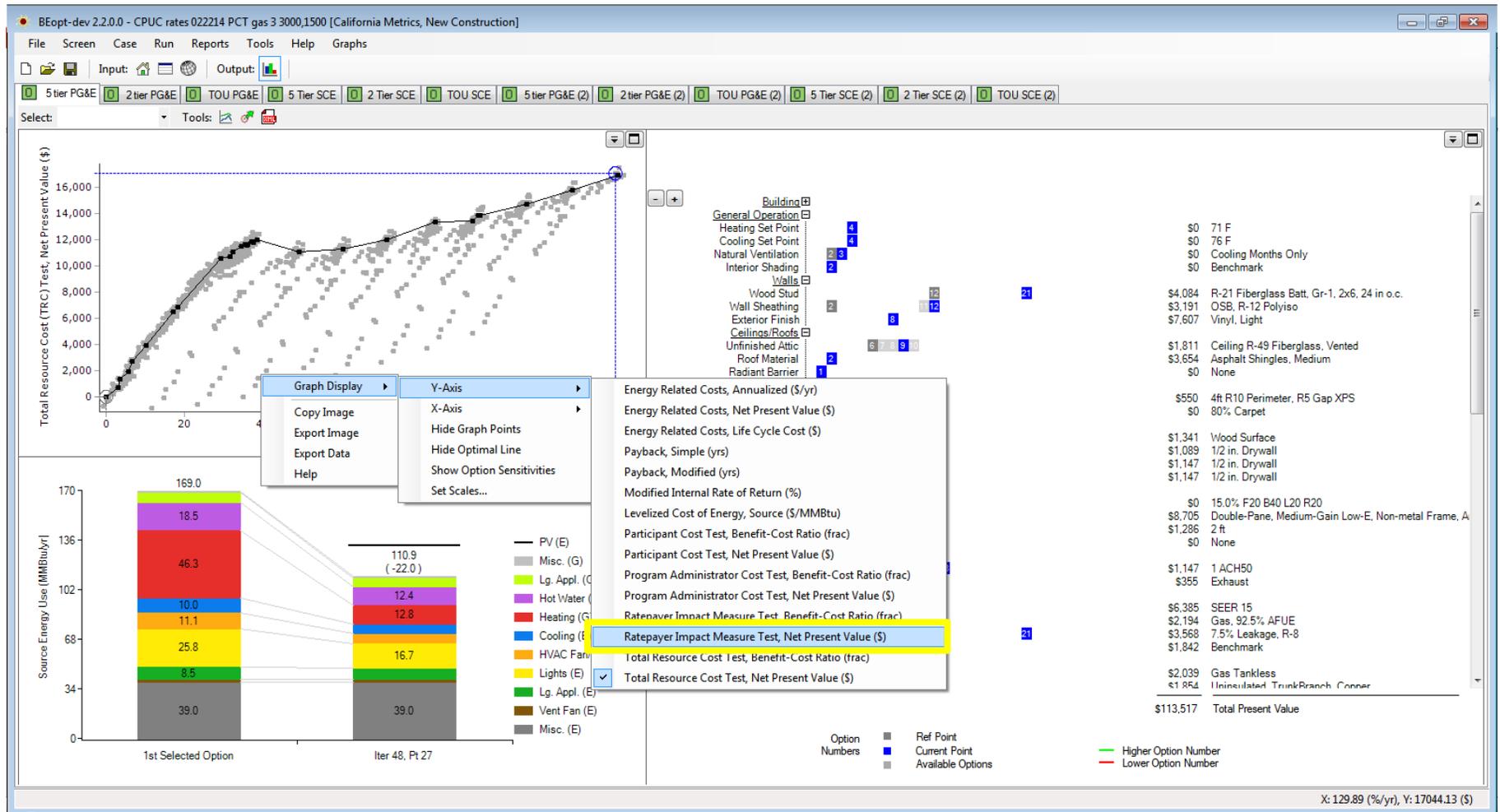
Utility Cost Effectiveness Tests



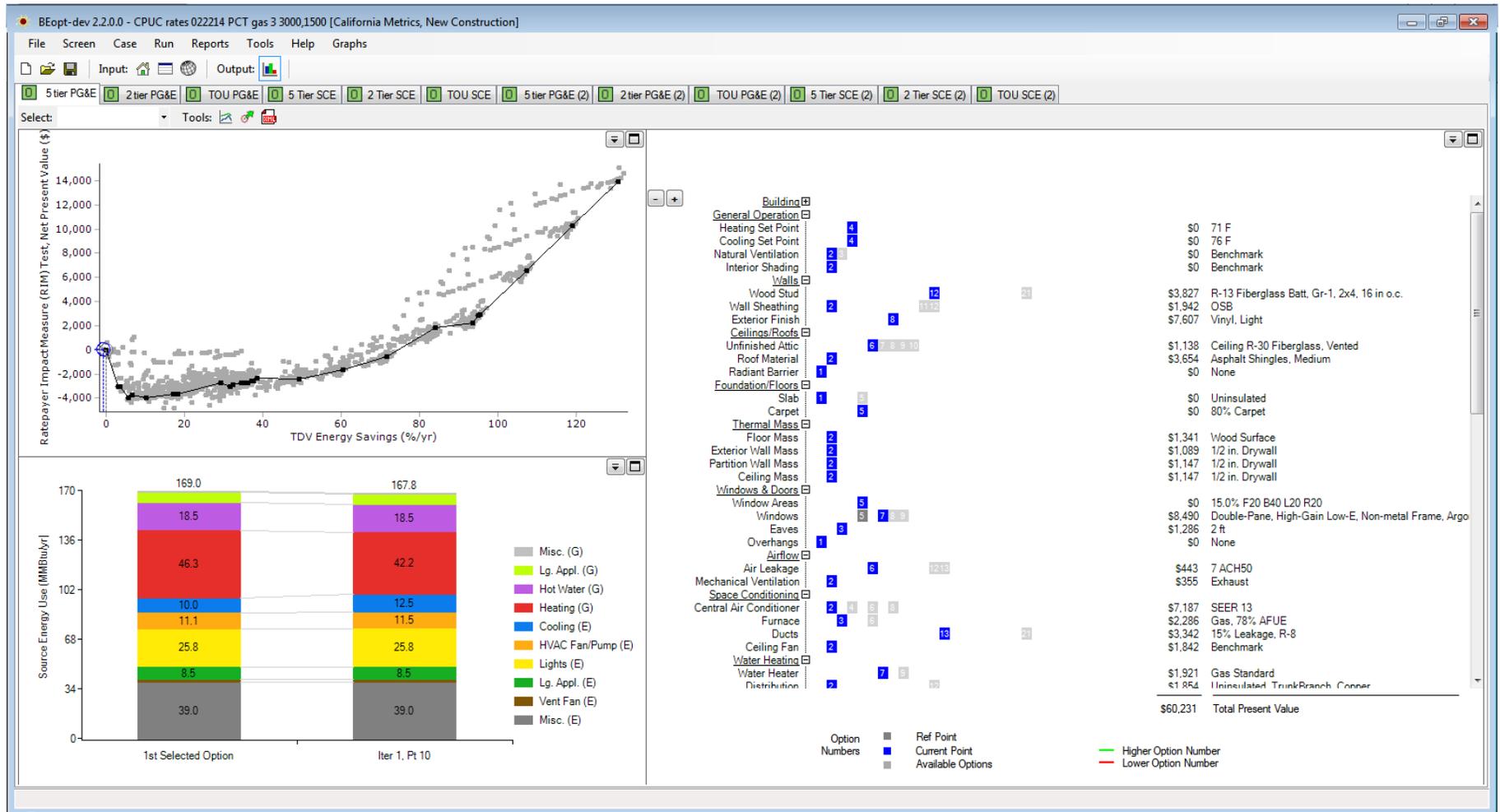
Utility Cost Effectiveness Tests

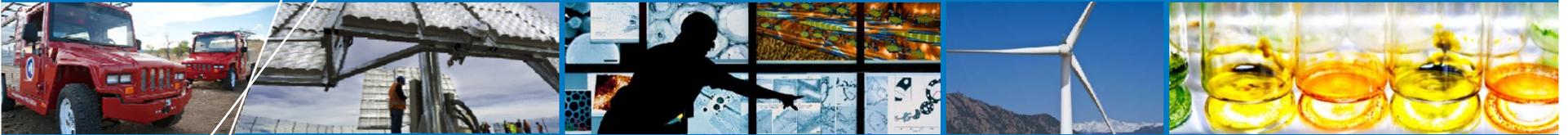


Utility Cost Effectiveness Tests



Utility Cost Effectiveness Tests





Example Analysis

Example Analysis

Table 3. PG&E Rates

Energy Division and Party Proposed Rate Designs - PG&E Non-CARE	Tiered Rate Structure (c/kWh)				TOU Rate Structure (c/kWh)					Baseline & Off-Peak Credit, On-Peak Surcharge, Average Rate (c/kWh), Demand & Customer Charge, Minimum Bill (\$/mo.)						
	T1	T2	T3	T4	Sum On-Peak	Sum Mid-Peak	Sum Off-Peak	Win Mid-Peak	Win Off-Peak	Baseline Credit	TOU On-Peak Surcharge	TOU Part-Peak Surcharge	TOU Off-Peak Credit	Ave. Rate ¹	Cust. Charge	Min. Bill
PG&E Rates (May 2013)	13.2	15.0	31.1	35.1										18.9		4.5
ED ¹ Transitional Default 3-Tier	14.1	21.2	30.6											18.1		5.0
ED End-State Default TOU					36.8	22.0	14.7	17.6	14.7					17.9		5.0
ED End-State Optional 2-Tier	17.0	20.4												18.0		5.0

Typical →

Illustrative →

Table 4. SCE Rates

Energy Division and Party Proposed Rate Designs - SCE Non-CARE	Tiered Rate Structure (c/kWh)				TOU Rate Structure (c/kWh)					Baseline & Off-Peak Credit, On-Peak Surcharge, Average Rate (c/kWh), Customer Charge, Minimum Bill (\$/mo.)					
	T1	T2	T3	T4	Sum On-Peak	Sum Mid-Peak	Sum Off-Peak	Win Mid-Peak	Win Off-Peak	Baseline Credit	TOU On-Peak Surcharge	TOU Off-Peak Credit	Ave. Rate ¹	Customer Charge	Minimum Bill
SCE Rates (April 2013)	12.8	16.0	27.1	31.1									N/A	0.9	
ED Transitional Default 3-Tier	14.9	22.4	29.3										19.8	0.9	5.0
ED End-State Default TOU					40.6	24.3	16.2	21.0	14.0				19.4	0.9	5.0
ED End-State Optional 2-Tier	17.9	21.5											19.8	0.9	5.0

Typical →

Illustrative →

Example Analysis

Example analysis results are shown to demonstrate new BEopt capabilities. The results are not intended as policy analysis; in fact, they are sensitive to a number of assumptions and could change significantly over a range of plausible inputs.

Table 1. Climates

Climates	Climate Zone	Utility
Sacramento	12	PG&E
Riverside	9	SCE

Table 2. Energy Use Levels

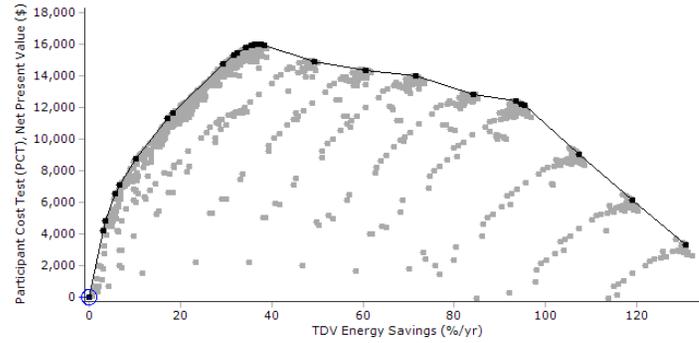
Use Level	House Size (ft ²)	Misc. Electrical Use (% BEopt default ¹)
High	3000	100
Low	1500	50



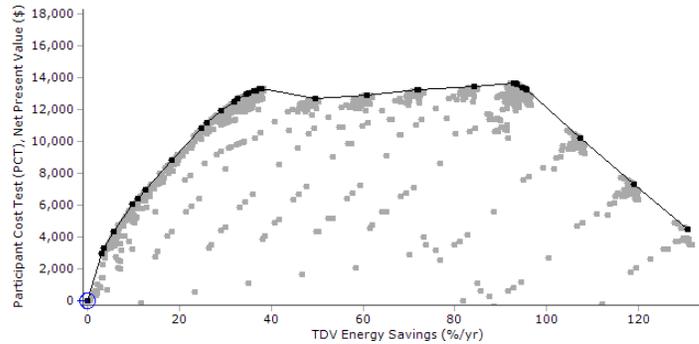
High-use Sacramento

Example Analysis

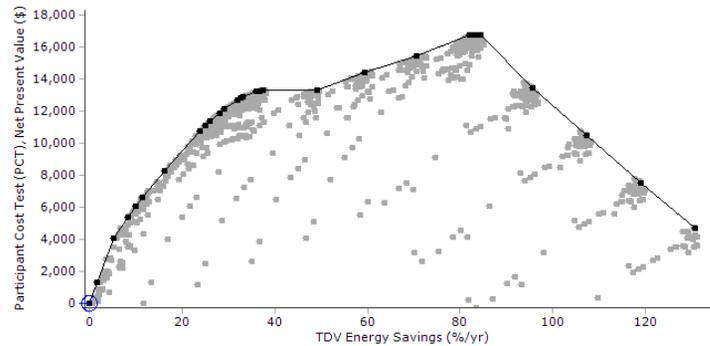
4-Tier Rate



2-Tier Rate

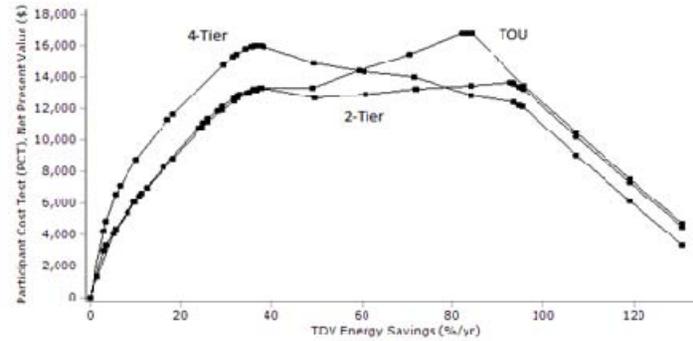


TOU Rate

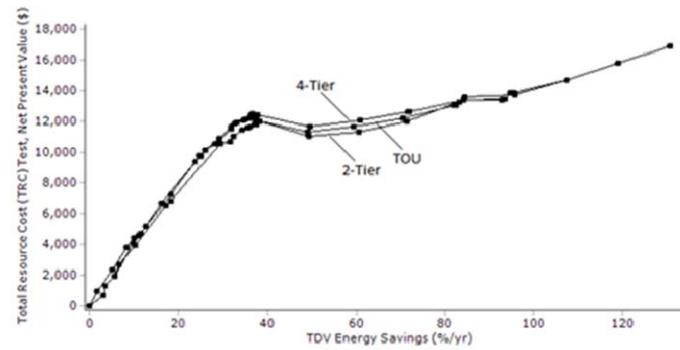


Example Analysis

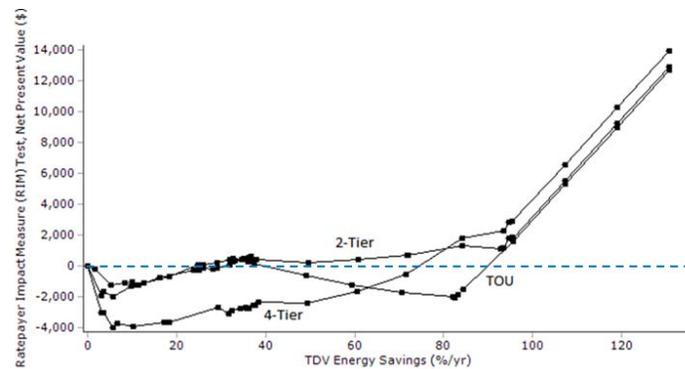
PCT



TRC



RIM



Example Analysis

Table 3. PG&E Rates

Energy Division and Party Proposed Rate Designs - PG&E Non-CARE	Tiered Rate Structure (c/kWh)				TOU Rate Structure (c/kWh)					Baseline & Off-Peak Credit, On-Peak Surcharge, Average Rate (c/kWh), Demand & Customer Charge, Minimum Bill (\$/mo.)						
	T1	T2	T3	T4	Sum On-Peak	Sum Mid-Peak	Sum Off-Peak	Win Mid-Peak	Win Off-Peak	Baseline Credit	TOU On-Peak Surcharge	TOU Part-Peak Surcharge	TOU Off-Peak Credit	Ave. Rate ¹	Cust. Charge	Min. Bill
PG&E Rates (May 2013)	13.2	15.0	31.1	35.1										18.9		4.5
ED ¹ Transitional Default 3-Tier	14.1	21.2	30.6											18.1		5.0
ED End-State Default TOU					36.8	22.0	14.7	17.6	14.7					17.9		5.0
ED End-State Optional 2-Tier	17.0	20.4												18.0		5.0

Typical →

Illustrative →

Table 4. SCE Rates

Energy Division and Party Proposed Rate Designs - SCE Non-CARE	Tiered Rate Structure (c/kWh)				TOU Rate Structure (c/kWh)					Baseline & Off-Peak Credit, On-Peak Surcharge, Average Rate (c/kWh), Customer Charge, Minimum Bill (\$/mo.)					
	T1	T2	T3	T4	Sum On-Peak	Sum Mid-Peak	Sum Off-Peak	Win Mid-Peak	Win Off-Peak	Baseline Credit	TOU On-Peak Surcharge	TOU Off-Peak Credit	Ave. Rate ¹	Customer Charge	Minimum Bill
SCE Rates (April 2013)	12.8	16.0	27.1	31.1									N/A	0.9	
ED Transitional Default 3-Tier	14.9	22.4	29.3										19.8	0.9	5.0
ED End-State Default TOU					40.6	24.3	16.2	21.0	14.0				19.4	0.9	5.0
ED End-State Optional 2-Tier	17.9	21.5											19.8	0.9	5.0

Typical →

Illustrative →

Example Analysis

Example analysis results are shown to demonstrate new BEopt capabilities. The results are not intended as policy analysis; in fact, they are sensitive to a number of assumptions and could change significantly over a range of plausible inputs.

Table 1. Climates

Climates	Climate Zone	Utility
Sacramento	12	PG&E
Riverside	9	SCE

Table 2. Energy Use Levels

Use Level	House Size (ft ²)	Misc. Electrical Use (% BEopt default ¹)
High	3000	100
Low	1500	50



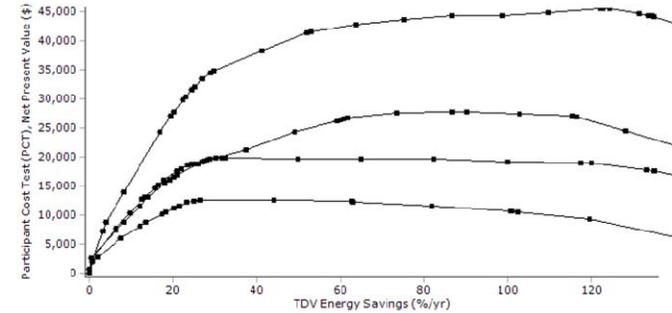
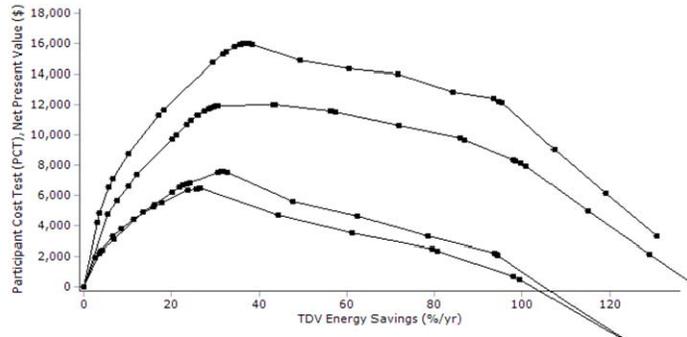
High-use Sacramento
High-use Riverside
Low-use Sacramento
Low-use Riverside

Example Analysis

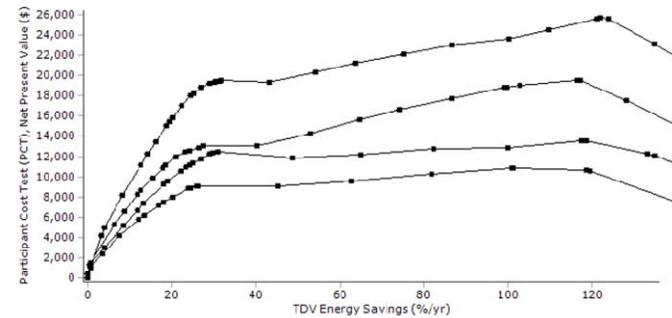
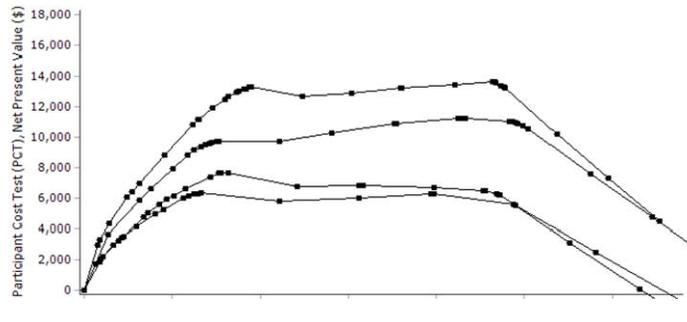
PCT, Gas/Electric

PCT, All-Electric

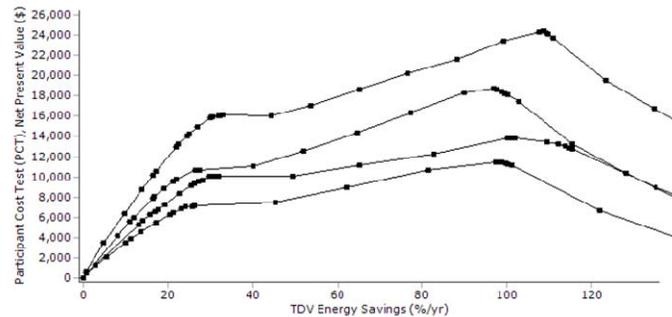
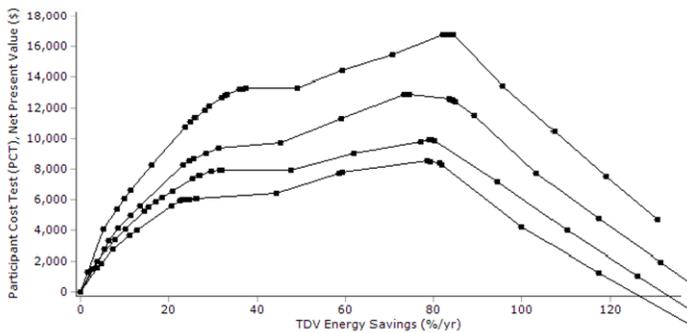
4-Tier



2-Tier

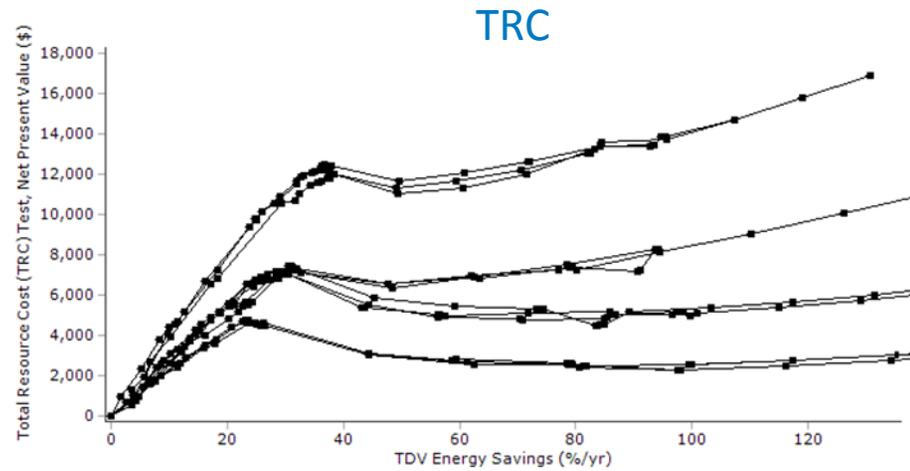


TOU

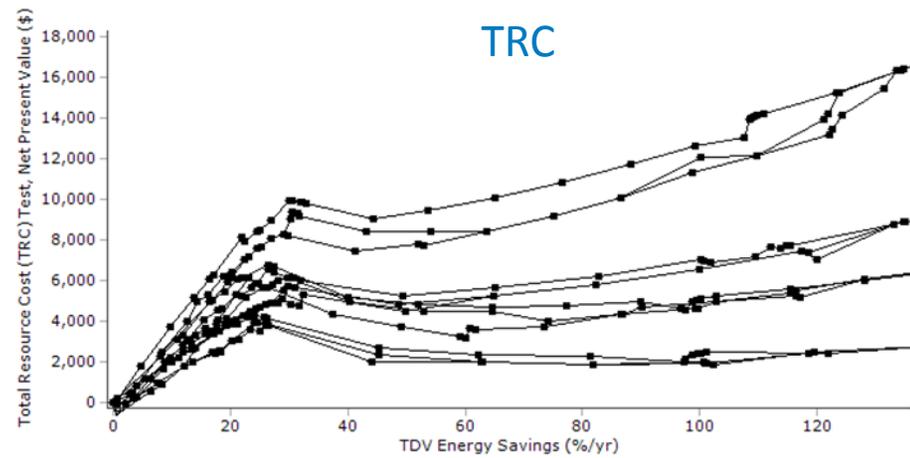


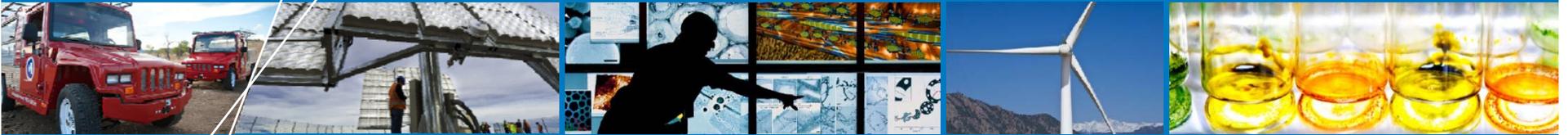
Example Analysis

Gas/Electric



All-Electric





Conclusions

New Capabilities for BEopt

Retrofit Analysis

- Retrofit Costs, Equipment Sizing, Remaining Life, Standards, Retrofit Timing

Incentives (rebates, tax credits)

- Whole-House Efficiency
- Rooftop Solar PV

Demand Response

- Demand Response Schedules
- Peak-Day Signals
- Uncommon Miscellaneous Electric Loads

Detailed Utility Tariffs

- Tiered, Time-of-Use, Real-Time-Pricing
- NEM and FIT

Utility Cost/Benefit Tests

- Participant (PCT), Total Resource (TRC), Ratepayer (RIM), Utility (PAC)

Potential applications of BEopt

- **New construction applications:**
 - ZNE goals analysis *
 - ZNE building design *
 - Title 24 development ***
 - Title 24 compliance ***
- **Retrofit applications:**
 - Energy efficiency program design
 - Energy efficiency program implementation **
 - Demand response program design
 - Integrated demand side management

* BEopt used in the ZNE Technology Potential analysis and in the utility ZNE programs

** BEopt used for package development in the CEC large scale retrofit program

*** If BEopt integrated with the California Simulation Engine (CSE)

BEopt is a public tool, available for free download from the NREL website

ZNE building design

- **Supports integrated design for architects, developers and engineers**
- **Key features make BEopt an ideal tool for ZNE building design**
 - The integrated assessment of solar and energy efficiency
 - Optimization features allow for very efficient analysis of many different building configurations
 - Relatively simple user interface and effort required to get a building modeled
- **BEopt is currently being used by consultants in the ZNE new construction utility programs**

Note: BEopt can be used in 'non-optimization' mode to simply evaluate the performance of a particular building design

Support ZNE program design

- **Utilities can use BEopt to design their residential new construction programs towards ZNE**
- **BEopt provides an integrated assessment of solar and energy efficiency from an engineering and cost-effectiveness perspective**
- **BEopt can analyze optimal new construction configurations to meet ZNE based on costs**
 - Multiple ZNE metrics can be evaluated: Source or site energy savings, TDV
 - BEopt was used by DEG in the recently completed ZNE Technology Potential analysis

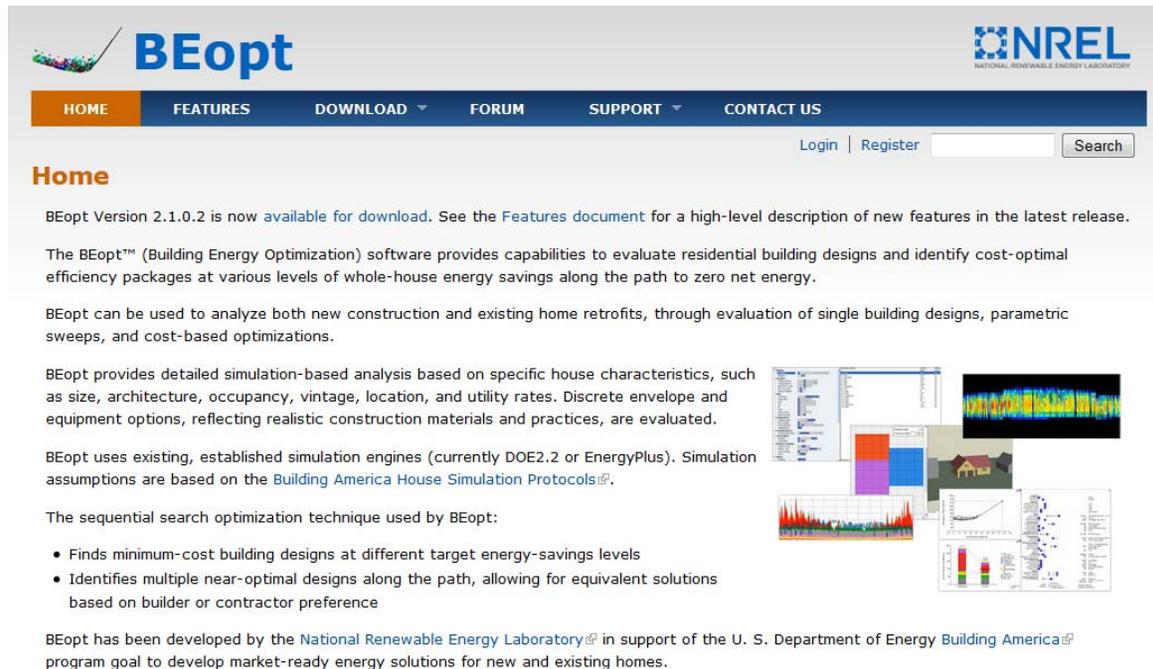
Future Work

BEopt Multifamily Modeling Capabilities

- CSI-RD&D Solicitation 5
- US DOE cost match

For More Information

beopt.nrel.gov



The screenshot shows the BEopt website homepage. At the top left is the BEopt logo, and at the top right is the NREL logo. A navigation bar contains links for HOME, FEATURES, DOWNLOAD, FORUM, SUPPORT, and CONTACT US. Below the navigation bar are links for Login, Register, and a search box. The main content area is titled "Home" and contains several paragraphs of text. The first paragraph states that BEopt Version 2.1.0.2 is available for download. The second paragraph describes the software's capabilities. The third paragraph explains the types of buildings it can analyze. The fourth paragraph details the simulation-based analysis. The fifth paragraph mentions the simulation engines used. The sixth paragraph describes the optimization technique. Below this is a bulleted list of features. The seventh paragraph mentions the software's development by NREL. To the right of the text is a collage of various charts and graphs, including bar charts, line graphs, and a heatmap.

BEopt Version 2.1.0.2 is now available for download. See the [Features](#) document for a high-level description of new features in the latest release.

The BEopt™ (Building Energy Optimization) software provides capabilities to evaluate residential building designs and identify cost-optimal efficiency packages at various levels of whole-house energy savings along the path to zero net energy.

BEopt can be used to analyze both new construction and existing home retrofits, through evaluation of single building designs, parametric sweeps, and cost-based optimizations.

BEopt provides detailed simulation-based analysis based on specific house characteristics, such as size, architecture, vintage, location, and utility rates. Discrete envelope and equipment options, reflecting realistic construction materials and practices, are evaluated.

BEopt uses existing, established simulation engines (currently DOE2.2 or EnergyPlus). Simulation assumptions are based on the [Building America House Simulation Protocols](#).

The sequential search optimization technique used by BEopt:

- Finds minimum-cost building designs at different target energy-savings levels
- Identifies multiple near-optimal designs along the path, allowing for equivalent solutions based on builder or contractor preference

BEopt has been developed by the [National Renewable Energy Laboratory](#) in support of the U. S. Department of Energy [Building America](#) program goal to develop market-ready energy solutions for new and existing homes.

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Q & A