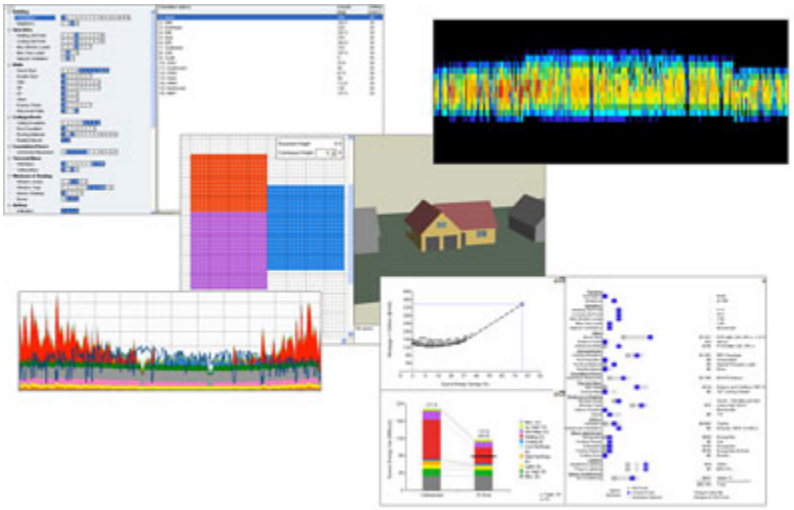
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

BEopt Version 2.0: New Features



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.

Building AMERICA SM
U.S. Department of Energy

Abstract

BEopt Version 2.0 is now available and contains major new features such as improved retrofit analysis capabilities, integration with the National Residential Efficiency Measures Database, photovoltaic (PV), and whole-house efficiency incentives, and HPXML export.

The BEopt 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, occupancy, 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.

Acknowledgments

The U.S. Department of Energy (DOE) Energy Efficiency and Renewable Energy, Building Technologies Office, in conjunction with the Building America program, has provided multiyear funding for BEopt. A California Solar Initiative (CSI) research project has provided funding support for several BEopt features, including retrofit analysis, California utility cost tests, photovoltaic (PV), and whole house efficiency incentives, and OpenEI utility tariffs.

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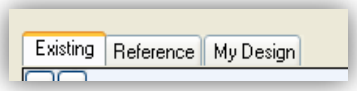
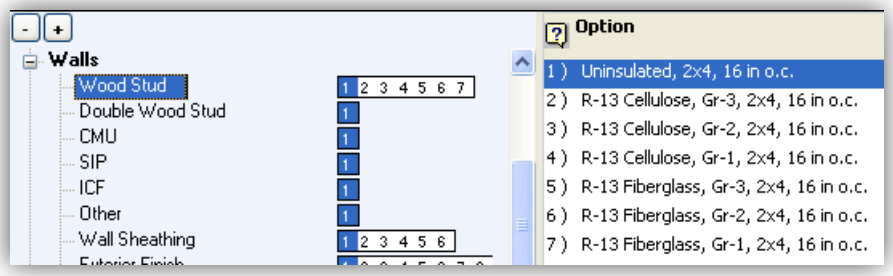
Retrofit (Existing Homes) Analysis

BEopt 2.0 has been completely redesigned to better accommodate the particulars of retrofit analysis.

An Existing tab is now displayed where the user can select the options that describe the existing building. Options include envelope components with no or little insulation, old equipment and appliances, etc.

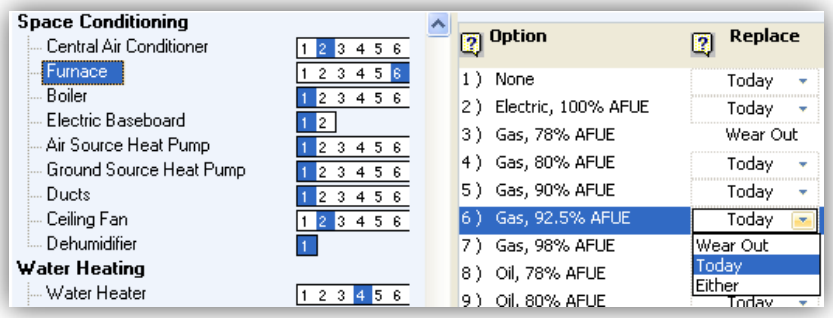


Retrofit options available to the user are tailored to the characteristics of the existing building. For example, if the existing building has an uninsulated 2x4 wall, BEopt will filter out 2x6 wall options from the display. Likewise, options that reduce the efficiency of the building, don't meet any applicable



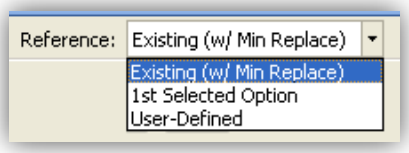
federal standards, or cannot be purchased on the market are also filtered from the display.

Costs are also now tailored to the situation. The cost to insulate an attic from R-10 to R-30 is greater than the cost of insulating from R-20 to R-30. The cost to replace a conventional tank water heater with a tankless water heater is greater than the cost of replacing an existing tankless water heater with another tankless water heater.



BEopt 2.0 simplifies the process of evaluating measures at "wear-out", that is, when the existing component wears out based on its age and expected lifetime. For example, users can compare the cost effectiveness of upgrading an old furnace today versus upgrading the furnace when the existing one wears out. If replace at "wear out" is selected, the option for the existing tab is combined with the upgrade option to calculate energy and costs over the analysis period.

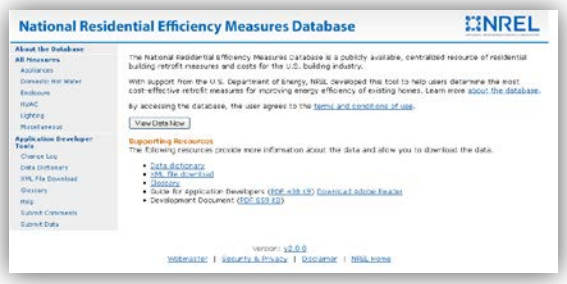
For calculation of energy savings and cost, BEopt 2.0 introduces a new automated reference called "Existing (w/ Min Replace)" that is intended to represent the "do-nothing" baseline. In general, this reference matches the options of the existing building; however, in categories where we know that the



existing building's option does not meet code or cannot be purchased on the market (e.g. SEER 8 air conditioner), the reference includes the minimum replace option (SEER 13) at wear out. By defining such a reference, we ensure that energy savings for an upgraded air conditioner (e.g. SEER 15) is calculated fairly given the most typical baseline scenario for the analysis period (as opposed to using the SEER 8 air conditioner's energy use for the entire analysis period).

National Residential Efficiency Measures Database

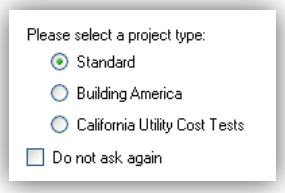
BEopt 2.0 is fully integrated with the National Residential Efficiency Measures Database (NREMDB) [4]. This public database developed by NREL provides a centralized source of residential building measures and costs.



By coordinating with this database, BEopt is able to bring additional accuracy and standardization to its data, in terms of costs, component properties, appropriate retrofit measures, etc. The database also includes disaggregated labor and material costs, which enables BEopt to adjust option costs to various retrofit situations.

Building America Switch

When creating new projects in BEopt 2.0, the user can choose the Building America project type. Choosing this option results in a streamlined interface for this type of analysis – for example, defaulting to the Building America energy savings metric and specifying the B10 Benchmark as the reference for new construction.



California Utility Cost Tests Switch

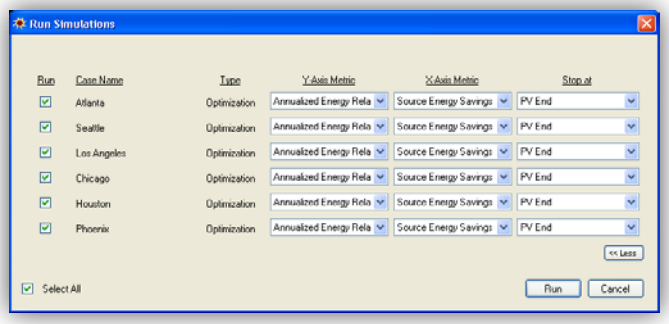
When creating new projects in BEopt 2.0, the user can also choose the California Utility Cost Tests project type. This project type allows the use of four new California utility cost test metrics in BEopt that represent different perspectives: the Total Resource Cost (TRC) Test, Participant Cost Test (PCT), Ratepayer Impact Measure (RIM) Cost Test, and Program Administrator Cost (PAC) Test. These four tests measure the cost-effectiveness of utility-sponsored energy efficiency programs, per the California Standard Practice Manual [6]. The project type also defaults the interface in various ways, such as defining the California Solar Initiative (CSI) PV rebate.

HPXML Export

The Home Performance Extensible Markup Language (HPXML) [5] is an open, standardized XML schema that provides a framework for the exchange of information about home efficiency among various software applications, such as building energy simulation models and field test databases. BEopt 2.0 provides a preliminary capability to generate HPXML files for any new construction or retrofit building design. The ability to export HPXML files will ultimately facilitate storing measured/audited building data, improving simulation accuracy, and automating energy analysis workflows.

Optimization Metrics

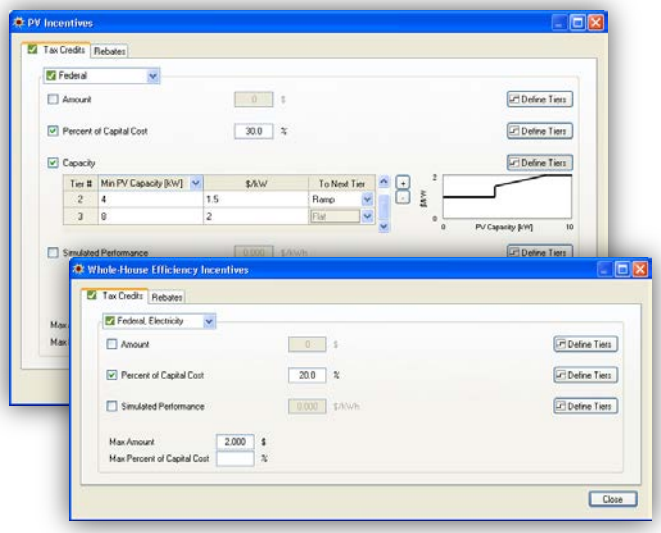
BEopt 2.0 provides the ability for the user to specify which x- and y-axis metrics to optimize over for each case through the BEopt run dialog box. For example, the user can choose to optimize over site energy instead of source energy. Or, if performing analysis for California, the user can choose to optimize from the homeowner perspective (Participant Cost Test metric) or the societal perspective (Total Resource Cost Test metric). As with previous versions of BEopt, the user can also choose optimization stopping criteria, specific to the selected metrics, in order to decrease optimization runtime.



Also, on the output screen, the user is now able to select various metrics for plotting by right-clicking on the Cost/Energy graph and choosing their x- and y-axis metrics of interest, regardless of the metrics that were selected for optimization.

PV & Whole-House Efficiency Incentives

BEopt 2.0 now includes the ability to specify PV and whole-house efficiency incentive programs. The interface allows tax credits and/or rebates to be specified for one of a number of different entities (e.g. federal/state governments, utilities, etc.). Federal tax credits of 30% for PV are enabled by default.



The interface can accommodate fairly elaborate incentive programs, including:

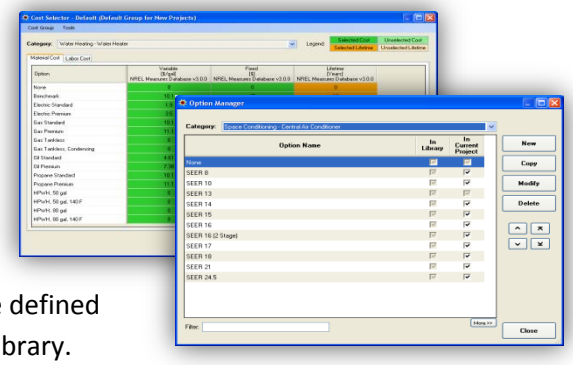
- Programs where incentives are defined as a fixed amount, percent of capital cost, capacity-based (for PV), and/or based on simulated performance

- Programs where incentives include maximum limits, either defined as a fixed amount or percent of capital cost
- Programs that define tiered incentives (e.g. $1/kW for <= 4kW PV systems and $0.75/kW for larger PV systems)
- PV incentive programs whose rebates are linked to energy efficiency savings.

Note: We recognize many energy efficiency incentive programs are defined on a measure-by-measure basis rather than a whole-house approach. We hope to include capabilities to accommodate these types of programs in the future.

Library & Project File Management

BEopt 2.0 provides a new library and project file management system to better facilitate storing, displaying, and sharing option and cost data.



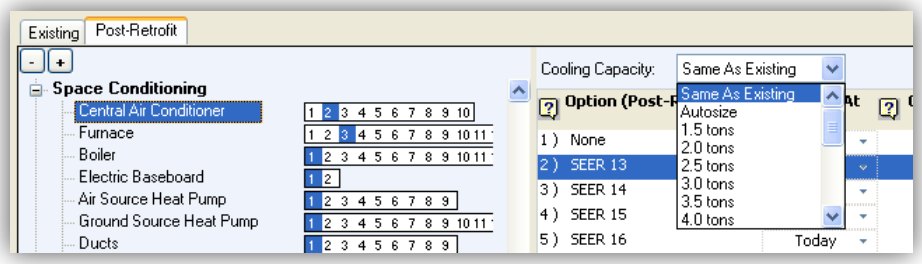
The library can now accommodate an unlimited number of both standard and user-defined options within each category. For convenience, a subset of the options in the library may be made available for a given project analysis. Also, temporary options may be defined for use in a given project without adding them to main library.

In addition, all the data associated with a project, including any user-specified options and costs, are now saved in its project file. Thus, anyone who opens a project file you provided will see all the same information you used in your analysis. There is no need to separately export/import any library data. Also, data found in any project file can be easily added to one's library for future use.

For power users, BEopt 2.0 provides additional flexibility. Users can specify the default options that show up in a new project, the default new construction and retrofit selections for each category, as well as all the default costs and lifetimes that are used.

HVAC Sizing

In BEopt 2.0, additional flexibility is allowed related to HVAC sizing. For both new construction and retrofit analysis, users can now specify either autosizing consistent with ACCA Manual J or user-specified fixed sizes. This allows, for example, evaluating retrofits where the HVAC system can be downsized due to load reductions from energy efficiency improvements.

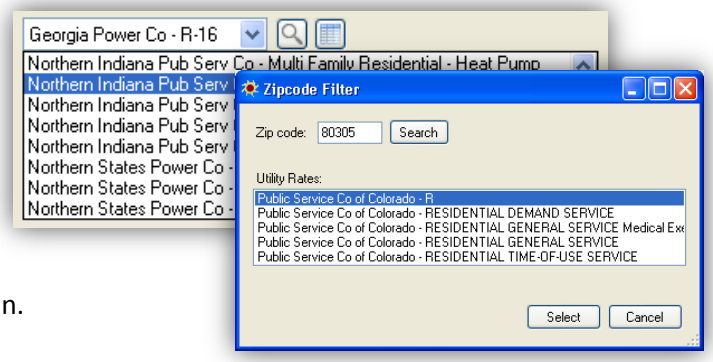


For retrofit analysis, the previous BEopt approach is also still

available, where HVAC replacements are of the same capacity as the pre-retrofit HVAC system. In the HVAC sizing dropdowns, this option is called “Same as Existing”.

OpenEI Utility Tariffs

BEopt 2.0 now accommodates the Open Energy Information (OpenEI) [7] website’s framework to make thousands of residential utility tariffs available directly in the BEopt user interface. The tariffs can include time-of-use rates, tiered rates, and demand charges.



To quickly find OpenEI utility tariffs, users can enter a zip code and quickly bring up the available tariffs in their location.

The ability to choose OpenEI utility tariffs is in addition to the existing utility rate choices found in BEopt: user-specified and EIA state/national average.

Building America Benchmark

The Building America Benchmark is an automated new construction reference described in the Building America House Simulation Protocols [8] intended to track progress towards energy savings goals. In BEopt 2.0, we have made the Benchmark reference more transparent by building it up from a series of options with associated costs. This means users can view all the options, properties, and costs that comprise the Benchmark reference, and see how the Benchmark changes with climate zone or other variables. Users may also choose to use some parts of the Benchmark while overriding others (this can be done by selecting the B10 Benchmark from the Reference dropdown and then changing it to User-Defined).

In addition, the Benchmark reference is undergoing a process of simplification. By simplifying the definition of the Benchmark, BEopt is becoming more flexible by allowing dissimilar technologies to be compared. For example, users can now compare two new construction building designs that use different heating fuel types or evaluate basement insulation at the ceiling vs. the walls.

Simulation Engines

In order to facilitate running simulations across multiple simulation engines, we now have a single BEopt 2.0 package that works with both the DOE2 and EnergyPlus simulation engines. If both are enabled, the simulation engine can be specified for each case – the user can easily switch from one engine to another at any point. Note that some categories/options may disappear when switching simulation engines if those modeling capabilities are not available for that engine.

We have also eliminated the use of TRNSYS for hot water and PV modeling in our DOE2 simulation path; we now run the building completely with the DOE2 simulation engine. This means that fully specified DOE2 input files are available from BEopt, and also results in some additional simulation speed.

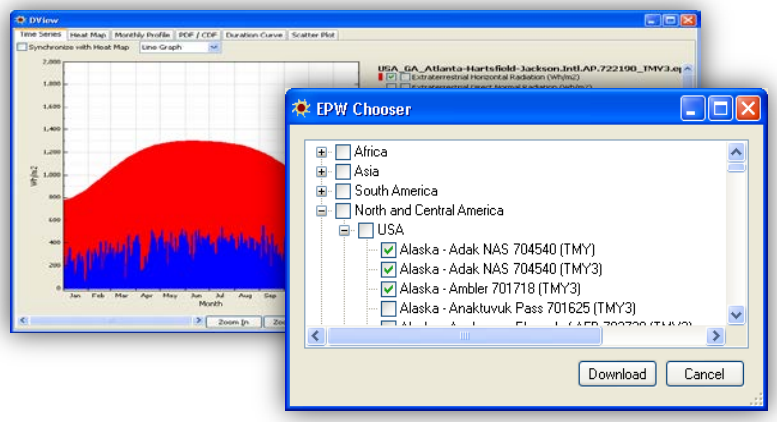
Simulation Speed

BEopt 2.0 can automatically make use of computers with multiple processors when running EnergyPlus and DOE2 simulations. BEopt defaults to using one less than the total number of processors on the machine; alternatively, users can override this default and specify the number of processors to use under the Tools > Options menu. If you happen to have a 12-core workstation idling in your closet, now is the time to dust it off!

In addition, the DOE2 simulation path in BEopt 2.0 is faster than before, as a result of eliminating the use of TRNSYS for hot water and PV modeling, and now running the building completely with the DOE2 simulation engine.

Weather Files

BEopt 2.0 simplifies the process of downloading and using weather files that are not shipped in the software. You can quickly download one (or batches) of weather files, organized geographically, directly from the interface. You no longer have to navigate the EnergyPlus website and figure out what files BEopt needs to perform a simulation. Visualization capabilities are also available directly from the input screen.



Modeling Framework (Batch Simulations)

The open-architecture modeling framework in BEopt 2.0 has been completely revamped. Simulation input files are now generated (and output files are parsed) via the open-source Python [9] scripting language. This language provides a rich set of capabilities that can be leveraged for many purposes.

Most significantly, the new BEopt modeling framework allows for batch simulation – that is, buildings can be easily defined and automatically simulated through either DOE2 or EnergyPlus without using the BEopt interface. This allows power users to automate and integrate the BEopt modeling framework into their own analysis workflow. For example, one could automate the process of simulating buildings for a database of existing buildings in order to compare simulation results against utility bills.

The modeling framework includes capabilities for generating DOE2 and EnergyPlus input files, performing HVAC sizing calculations consistent with ACCA Manual J, generating HPXML files, obtaining data from weather files, etc. For more details, see the Modeling Framework section in the BEopt Help file.

References

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