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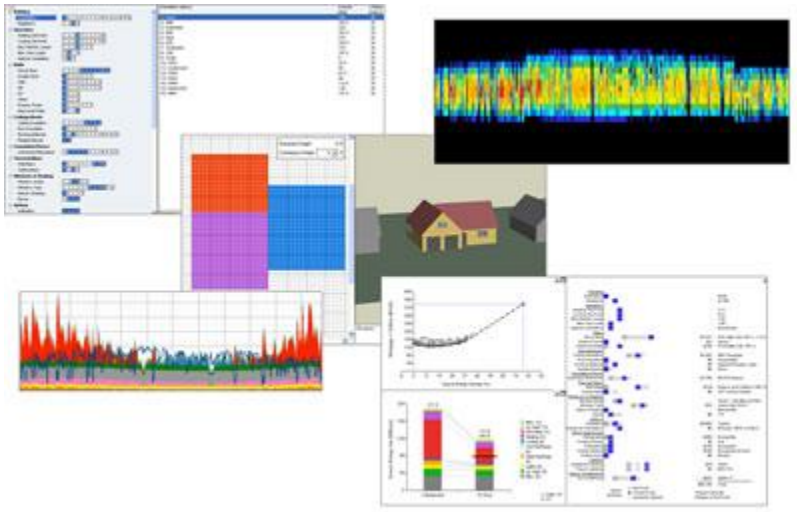
BEopt Version 2.7: New Features



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
U.S. Department of Energy

Summary

A new release of BEopt, version 2.7, is now available. To install, please visit https://beopt.nrel.gov.

New features include:

- Enhanced mini-split heat pump model & options, particularly for colder climates
- Flue/chimney inputs for air leakage
- Updated costs/lifetimes for several measures
- Updated to EnergyPlus v8.6

See the Changelog for a detailed list of changes.

The BEopt software provides capabilities to evaluate residential building designs and identify cost-optimal efficiency packages at various levels of whole-building 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, location, and utility rates. Discrete envelope and equipment options, reflecting realistic construction materials and practices, are evaluated. Simulation assumptions are based on the Building America Housing Simulation Protocols.

Note: BEopt v2.7 now comes bundled with a version of the EnergyPlus simulation engine. With the increasing range of modeling capabilities now available in the EnergyPlus-based BEopt, but not available in the DOE2-based version, BEopt 2.7 no longer supports use of the DOE-2.2 simulation engine.

In the coming years we'll be transitioning BEopt's residential analysis capabilities to OpenStudio, a cross-platform, open-source project that facilitates software development and community contributions around EnergyPlus building modeling.

Acknowledgments

The U.S. Department of Energy (DOE) Energy Efficiency and Renewable Energy, Building Technologies Program in conjunction with the Building America program has provided multi-year BEopt funding. Two California Solar Initiative (CSI) research projects (Solicitation 1, Solicitation 5) have provided funding support for several BEopt v2 features as well as multi-family analysis capabilities. Bonneville Power Administration (BPA) also provided funding for some multi-family analysis capabilities for the Pacific Northwest as well as software packaging for the Energy Rating Index (ERI) capability.

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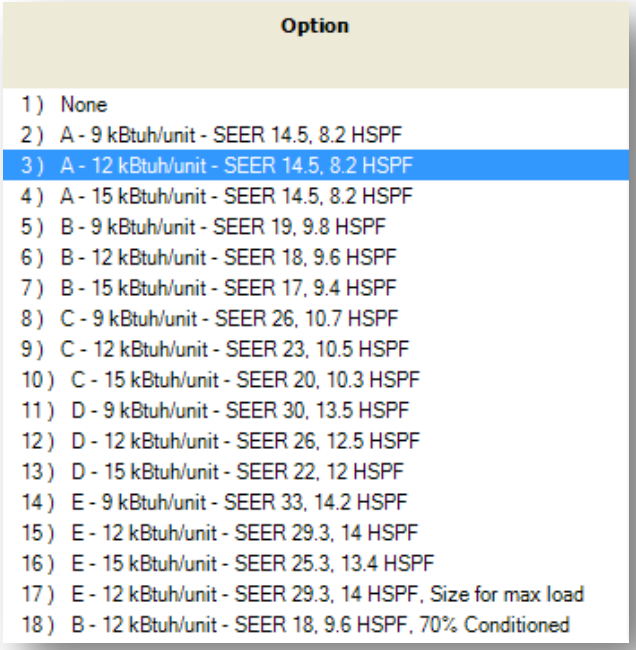
Enhanced Mini-Split Heat Pump Model

BEopt v2.7 now uses a new EnergyPlus Variable Refrigerant Flow (VRF) model for mini-split heat pump (MSHP) technologies. This new model allows for more accurate modeling of MSHP performance part load conditions and performance at low temperatures with better representation of capacity retention at low temperatures and the impact of pan heaters on performance. The new model also allows for separate MSHPs to be modeled in different zones in the house.



New Options

Taking advantage of the new model, BEopt v2.7 ships with a new set of options more representative of the range of performances seen in the market, including models intended to operate in colder climates. The Cold Climate Air Source Heat Pump Specification Listing provided by the Northeast Energy Efficiency Partnerships (NEEP 2016) was used to develop the representative options.

Note that efficiency and retention of heating capacity at colder temperatures is highly related to system size; therefore, the system size (nominal cooling capacity) is included in each option name. Letters prefixing each option name include units in the same manufacturer series.

New Inputs

- **Heating Capacity Retention Fraction** – This is the maximum heating capacity at X degrees F divided by the maximum heating capacity at 47 degrees F. The value for X is the Heating Capacity Retention Temperature input. Can be derived from NEEP's Cold Climate Air-Source Heat Pump Specification Listing spreadsheet. BEopt uses a linear relationship between this point and the rating point to determine maximum heating capacity as a function of outdoor temperature.
- **Heating Capacity Retention Temperature** – This is the outdoor drybulb temperature at which the heating capacity retention fraction is defined.
- **Pan Heater** – MSHPs designed for use in cold climates often include a pan heater in the outdoor unit as an optional or integrated accessory, to prevent ice buildup from damaging the coil. This field specifies the power of the pan heater included in each outdoor unit. Pan heaters are assumed to operate when the compressor is running and the outdoor drybulb is less than 32 degrees F. Note that the pan heater typically reduces the Rated HSPF by 0.1–1.0 points; units with integrated pan heaters should use the Rated HSPF input of an equivalent unit without a

pan heater. This input is available in NEEP's Cold Climate Air-Source Heat Pump Specification Listing spreadsheet.

- **Size For Max Load** – If set to True, the BEopt autosizing algorithm will use the maximum of the heating and cooling loads to set the heat pump capacity, based on the heating/cooling capacities under design conditions. If set to False, the regular BEopt autosizing algorithm will be used, which uses the cooling load to set the heat pump capacity, with up to 1.3x oversizing allowed for variable-speed equipment in colder climates when the heating load exceeds the cooling load (per ACCA Manual S). Replaces the "Is Cold Climate" input.

Flue/Chimney Inputs for Air Leakage

BEopt has been using the Alberta Air Infiltration Model (AIM-2) (Walker and Wilson 1990) to model stack-induced and wind-induced infiltration. This model is alternatively known as the "Enhanced" ASHRAE infiltration model. The model is widely considered state-of-the-art, having undergone numerous validation studies by Lawrence Berkeley National Laboratory (Walker and Wilson 1998).

Compared to simpler models, the AIM-2 model gives improved estimates for total building ventilation rates of single-zone houses with flues/chimneys. The improvement is obtained by treating the flue/chimney as a separate leakage site with its own wind shelter, locating the flue outlet above the house rather than grouping the flue leakage with the other building leaks.

BEopt v2.7 now includes user inputs regarding flues/chimneys for furnaces, boilers, water heaters, and fireplaces. When a flue or chimney is present in a house, the stack-induced and wind-induced building leakage, per the AIM-2 model, is appropriately modified. Buildings modeled in BEopt v2.7 without a flue/chimney will obtain air leakage rates identical to previous versions of BEopt, while buildings modeled with a flue/chimney will see increased air leakage rates.

Updated Measure Costs/Lifetimes

BEopt v2.7 includes updated costs/lifetimes for a variety of technologies. These include:

- Mini-split heat pump – Updated costs based on data from actual installations of over 50 units in the Pacific Northwest and retail product costs.
- PV – Updated costs based on the latest available residential product and installation costs
- LEDs – Updated lifetimes based on LED retail product costs as well as updated lifetimes for all options
- HPWHs – Updated material and installation costs, including ducting costs, based on actual installation data from the Pacific Northwest
- Attic Insulation – Updated installation costs based on additional national installation data

EnergyPlus Version 8.6

EnergyPlus is the Department of Energy's flagship whole building energy simulation engine that is shipped with BEopt and used under the hood. BEopt v2.7 has been updated to use EnergyPlus v8.6, released on September 27th, 2016.

EnergyPlus v8.6 includes a significant number of bug fixes, performance improvements, and new technology models. More information can be found on the EnergyPlus website.

References

ASHRAE. (2013). 2013 *ASHRAE Handbook of Fundamentals*. Atlanta, GA.

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