BEopt 1.2 Release Guide

May. 9, 2012

1 Purpose 2
2 Attached Walls 2
3 Dehumidifiers (BEoptE+ only) 2
4 Ground Source Heat Pumps 3
4.1 Model Overview 3
4.2 Option Display Variables 3
5 Heat Pump Water Heaters (BEoptE+ only) 3
5.1 Model Overview 3
5.2 Draw Profiles 4
5.3 Option Display Variables 4
6 Condensing Boilers 4
7 Simplified Inputs for Air Conditioner and Heat Pump User Options 5

1 Purpose

This document is designed to give BEopt users guidance on some modeling features new to version 1.2.

2 Attached Walls

BEopt now has the ability to model attached walls (e.g., for duplexes or row houses). This feature is accessed with the checkboxes on the Geometry Screen. BEopt will model all walls on the selected façade(s) as adiabatic. The affected walls are rendered in black. Specifying attached walls may not achieve desired results when non-attached walls face the same direction as attached walls (see Figure 1, house on the right). Remember to select window area options that are compatible with the attached walls. Note that making a wall attached will decrease the home's total window area, because window area is calculated based on exterior wall area.

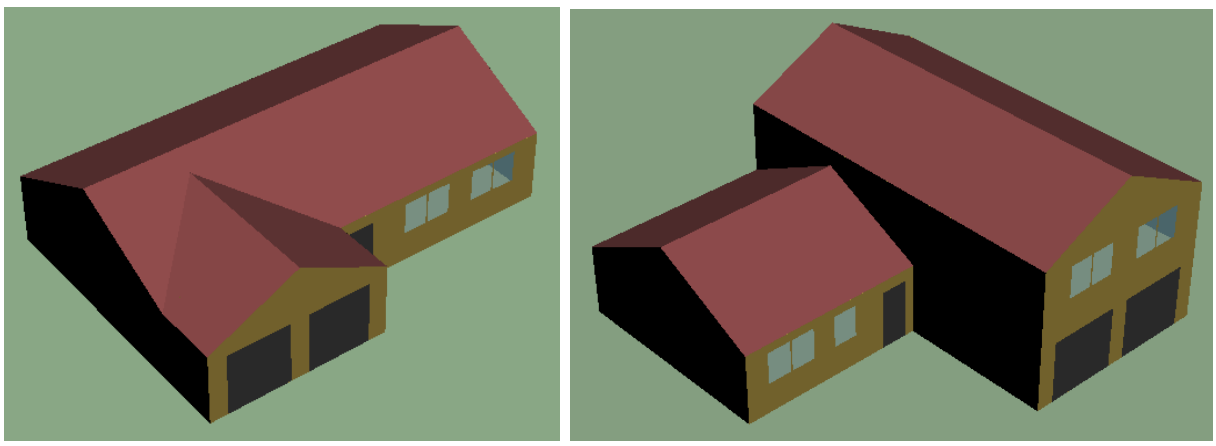

Figure 1. Demonstration of modeling attached walls (rendered in black). May result in undesired results if applied to more complicated geometry (right).

The ability to model more complicated attached homes, as well as multifamily buildings in general, is planned for a future BEopt release.

3 Dehumidifiers (BEoptE+ only)

BEoptE+ models whole-house dehumidification using the EnergyPlus Zone Dehumidifier model and NREL experimental performance data (Winkler et al. 2011). The standard BEopt options span typical capacities and efficiencies found on the market. The distinction between 'Standalone' and 'Ducted' standard options is for costing purposes only, meaning the two technologies are simulated using identical approaches. Rated capacity, energy factor, and airflow rate are required simulation variables; however, all three simulation variables can be automatically determined by BEopt, if requested. If 'Auto' is entered for the capacity, BEopt will use building inputs, climatic information, and a built-in sizing routine to estimate the necessary capacity. If 'Auto' is entered for the energy factor, BEopt will use current ENERGY STAR® requirements and the rated capacity to determine the energy factor. If desired, the rated capacity is also used to determine the rated airflow rate by assuming 2.75 cfm per pint/day of capacity,

which is based on experimental data. Currently, dehumidifier options are only available in the EnergyPlus version of BEopt.

4 Ground Source Heat Pumps

4.1 Model Overview

The BEopt Ground Source HP (GSHP) model is a water-to-air heat pump model with a closed loop vertical bore ground heat exchanger. The modeled options are generic single-stage compressor models with permanent-split capacitor (PSC) supply fans. The ground loop pump is a single-speed pump cycling on and off with the indoor compressor. BEopt GSHP model uses ACCA Manuals J and S sizing results for the heat pump and autosizes the ground heat exchanger in accordance with the IGSHPA (International Ground Source Heat Pump Association) Design and Installation Guide. The bore field sizing is based on local climate design conditions, ground and grout thermal conductivity, heat pump efficiency (EER/COP) and a simplified estimate of annual ground heating and cooling load imbalance. The user can also input some known information such as number of bores , and BEopt can autosize the rest.

4.2 Option Display Variables

EER/COP - ASHRAE ISO 13256-1 rated EER/COP. BEopt auto adjusts the fan and pump power based on rated conditions per ASHRAE ISO 13256-1 calculations, assuming 0.35 inch water column air side internal static pressure drop and 6.0 feet water column ground loop internal coil pressure drop. BEopt calculates the supply fan and ground loop pump energy use separately from heating and cooling energy.

Ground, Grout [Btu/hr-ft-°F] - Ground average thermal conductivity across the bore depth and bore grout thermal conductivity. Using thermally enhanced grout will reduce the bore length based on enhanced heat transfer between the ground and bore pipes.

HX Bore Length [ft/ton] - Estimated ground loop heat exchanger bore length in ft/ton.. The value will vary with climate, system EER/COP and ground and grout thermal conductivity. The effect of annual load imbalance (which depends on simulation) is not included in the displayed value, but it is included in annual energy and cost calculations.

5 Heat Pump Water Heaters (BEoptE+ only)

5.1 Model Overview

The BEoptE+ Heat Pump Water Heater (HPWH) model is based on an NREL laboratory evaluation of five integrated HPWHs available on the U.S. market (Sparn et al. 2011), and validated using HPWH field test data from Building America Teams. The BEopt HPWH model accounts for:

- **Heat pump performance** as a function of environment temperature, humidity, and tank temperature
- **Use of electric resistance elements** triggered by large draws or operational temperature limits
- **Interaction with the surrounding space** including effect on heating and cooling loads of conditioned space

- **Tank standby losses**

The HPWH options in BEopt are generic models illustrating different performance levels possible with HPWH technology. Details of compressor efficiency, control logic, etc. are available via the BEopt Option Editor. Currently, HPWH options are only available in the EnergyPlus version of BEopt.

5.2 Draw Profiles

In order to accurately model auxiliary electric resistance element behavior, HPWH simulations use a draw profile with hourly averaged discrete events (from NREL's DHW Event Schedule Generator tool) as opposed to the smooth continuous profiles from the Building America House Simulation Protocol. Using the hourly averaged discrete event profiles means that DHW use will vary from day to day. This variation should be kept in mind when looking at hourly results.

5.3 Option Display Variables

Energy Factor is not listed for HPWH options since it is not necessarily a good indicator of annual performance for HPWHs.

Tank Volume – This is the *nominal* tank volume listed on the name plate. BEopt assumes actual tank volumes are 10% smaller based on Burch and Erickson 2004

Percent Unmet Showers – This metric is meant to assist users in selecting HPWH options that maintain an acceptable level of hot water delivery. It is an estimate of the percent of annual showering time with water leaving the HPWH below 110°F. The first value is using the Benchmark shower flow rate (2.25 gpm) and the second value is using low-flow showerheads (1.5 gpm). These values are a function of HPWH tank volume, setpoint, climate, and number of bedrooms; and they assume the HPWH is in conditioned space. This metric does not account for the effect that some BEopt options (e.g. demand DHW recirculation pump or Energy Star clothes washer) might have on hot water draw volume or mixed water temperature. The metric is sensitive to the timing of hot water use and thus real world values may vary considerably from one set of occupants to the next. The "Percent Unmet Showers" metric is only available for 50 gallon and 80 gallon HPWHs.

6 Condensing Boilers

Condensing boiler operation differs from the other options in that the boiler efficiency varies with the hot water return temperature (HWRT). The standard options have a design supply water temperature of 150°F, with 20°F loop ΔT to ensure the boiler operates in the condensing mode (HWRT $\leq$ 130°F). Residential boilers are also often equipped with outdoor air temperature (OAT) reset control options. A BEopt example option (denoted with *) demonstrates a condensing boiler with OAT reset. Note: Use caution on condensing boiler with OAT reset when there is a thermostat setback for heating. It can result in large amount of hours of loads not met.

7 Simplified Inputs for Air Conditioner and Heat Pump User Options

In previous versions of BEopt, if users wanted to create custom options in the air conditioner and heat pump categories, they would be required to input many variables including coefficients for eight performance curves. BEopt 1.2 introduces more standard options, reducing the need for users to create custom options.

Additionally, this version, through the use of generalized performance maps, introduces much simpler inputs for custom air conditioner and heat pump options. The reduced set of inputs includes: SEER, EER, C_d (a degradation coefficient indicative of part load performance), sensible heat ratio (SHR), and number of speeds. This method of modeling air conditioner and heat pump performance eliminates the need for the complicated curve coefficient inputs and facilitates the creation of user-defined options.

For users wishing to create their own options, values for most inputs can be found using the AHRI directory. Some values, such as SHR, may need to be sourced from individual manufacturer's data. For two-stage units, it is necessary to enter a C_d value. This input is not widely available; however, C_d values for standard options can be used if the unit-specific C_d is not available.

The capability to model variable speed air conditioners and heat pumps was also introduced in this release. The standard option is representative of variable speed compressors in a split-system with distribution ducts (not mini-splits).