

Implementation of the Building America Program Benchmark in the EnergyValue™ Housing Award Program

*Joe Wiehagen, Tom Kenney, and Kevin Mo, NAHB Research Center
Ali Jalalzadeh-Azar, National Renewable Energy Laboratory
Matthew Shaeffer, Boston University (student)*

ABSTRACT

The EnergyValue™ Housing Award (EVHA) program recognizes the achievements of home builders in the design, construction, and marketing of exemplary energy-efficient homes. Many builders have increased the sophistication of their energy efficiency practices by adopting a “systems approach” where all aspects of the home design are valued.

The Building America Program (BAP) supports home builders to implement construction features that increase the energy performance of homes, based on climate and builder experience, and often including materials or methods that may be new to the builder. These construction improvements are designed to systematically improve performance to achieve energy savings of at least 30 percent based on goals outlined by the BAP.

To this point, no consistent metric has been available to evaluate the relative performance of the EVHA designs, nor to estimate progress toward the BAP energy efficiency goals. Adopting the latest BAP Benchmark as a metric to achieve these objectives, the EVHA program can now provide a consistent reference for comparison of the source energy savings of various residential building designs. This paper presents the first benchmark analysis of the 16¹ 2005 gold and silver EVHA winners and provides energy performance estimates within different climate zones as well as a comparison with the current 2005 BAP energy efficiency goals. This analysis illustrates the progress to improve the efficiency of mainstream housing leading to net-Zero Energy Homes.

Introduction

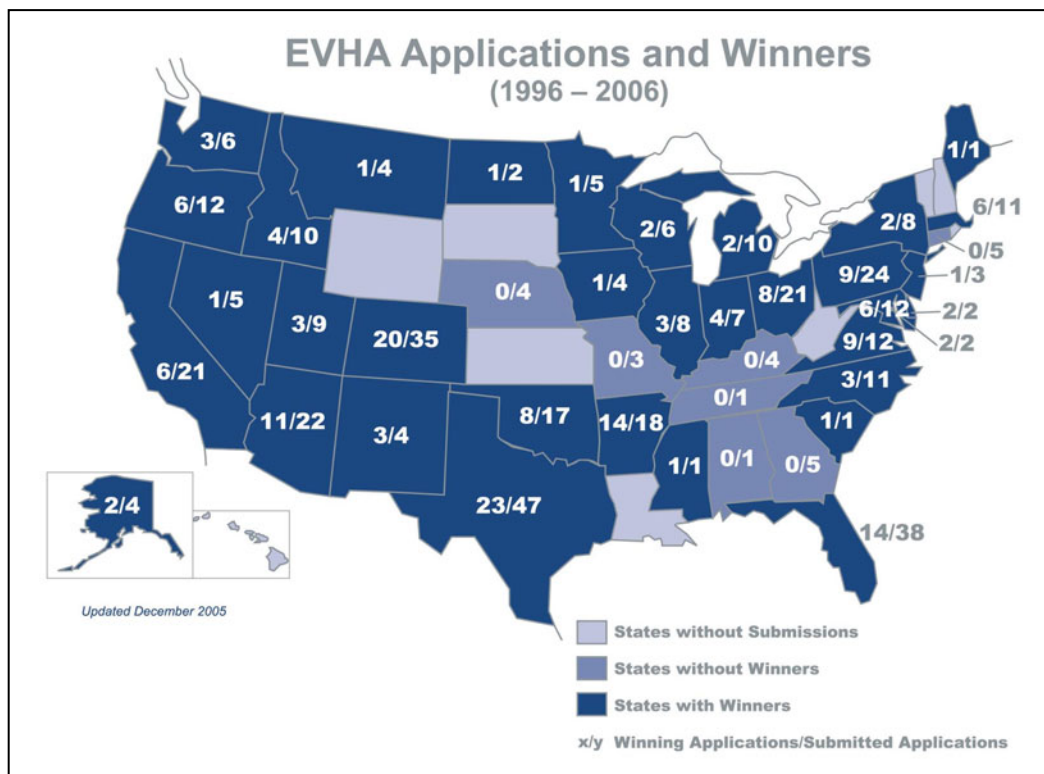
The NAHB Research Center’s EVHA program (EnergyValue™) has, for more than 11 years, evaluated and recognized the superior energy performance of new homes constructed by builders of all types. The evaluation process considers many aspects of energy-efficient home design and construction, marketing, and performance. However, an important aspect missing from the evaluation to date is a quantifiable comparison of the estimated energy performance of the builder’s design with a fixed reference home. This paper describes and demonstrates the use of the BAP Benchmark Analysis (NREL) as a tool to estimate the energy savings of EVHA-winning home designs and offers comparisons of the level of energy savings across different climates and house designs.



¹ For the 2005 cycle, 17 awards were presented; one home was submitted for and won an award in two categories.

Background

The EVHA program is supported through private sector sponsors and the Department of Energy's Building America Program. The goal of the EVHA is to provide an opportunity for home builders to be recognized for their efforts towards energy-efficient construction practices. By winning an EVHA, home builders who have refined and tested the practices and experience of energy-efficient construction can gain national exposure in trade and mainstream shelter publications. This not only benefits the winners, but also provides educational benefits for fellow builders and consumers. The builders who submit EVHA applications typically have incorporated aspects of energy efficiency into their entire construction process, including energy value, design, construction processes, marketing and customer relations, and participation in energy programs. EVHA applications are reviewed by a six-member judging panel, which includes a mix of new and returning judges in the fields of engineering, construction, design, and marketing. Summary assessments from the judges are provided to all applicants with suggested areas for improvement.



The EVHA is open to all builders across the country and the program has received applications from builders in more than 40 states since it began in 1996. Evaluating applications based on climate region allows them to be compared among similar general construction practices typical for the climate. Applications are submitted according to five broad residential construction categories—Affordable, Custom, Factory-Built, Production, and Multifamily (3-stories or less). Applicants complete a detailed description of a home and submit that along with information on various aspects of their companies' energy-efficient practices including marketing, consumer education, and participation in efficiency programs. The judges score the

application criteria according to a predetermined weighting system for the construction category and within one of three general climate regions, for which the application is submitted (EVHA). Specific performance measures, such as a rating for assessing predicted energy savings, are not currently required on the application. Energy performance assessment is generally left to the judges' discretion, although the NAHB Research Center has provided energy analysis summaries when requested by the judges.

As part of the EVHA judging procedure, applicants are evaluated against the program criteria rather than against each other, therefore multiple (or no) awards are possible in any climate and builder type categories.

Purpose of the Benchmark Procedure

The purpose of the benchmarking process is to enable tracking of energy efficiency levels from a common baseline. Providing the benchmark analysis for every award cycle will quantify the levels of energy efficiency, as well as show the details of where the efficiency improvements are being achieved. While evaluation of EVHA-winning homes is comprehensive, a missing feature of the evaluation has been a comparison between the home's predicted energy performance relative to a baseline "standard home." While many applicants submit HERS scores, it is not a requirement for the application. An energy analysis metric can be used to analyze the predicted energy performance of the award-winning homes, as well as to catalog the progression towards the ultimate goal of "near-zero energy homes." The BAP Benchmark can provide consistency to the energy evaluation of the applications, as well as a baseline from which energy performance can be tracked in subsequent program cycles.

In addition, use of the benchmark procedure can provide builders with a clear goal of energy performance to strive for and document. Furthermore, when combined with economic analyses, application of the benchmark procedure can also help builders identify cost-effective, energy-saving measures, although a specific energy efficiency cost analysis is not part of the current EVHA evaluation criteria.

The Building America Benchmarking Analysis Tool

The Building America Program has developed a benchmark process that allows the comparison of a prototype home (in this analysis, an EVHA-winning home) with the corresponding reference home, which is generally consistent with standard homes of the mid to late 1990s (the "benchmark home"). The comparison provides a metric to evaluate energy savings of an EVHA-winning home design.

While the footprint of the benchmark and EVHA-winning homes is identical, other features of the benchmark home such as windows, insulation, and building equipment are determined based on an established set of guidelines (Hendron et al. 2004). For example, the EVHA-winning home can have more or less window area than the benchmark home and include such other aspects as orientation, U-value, and enhanced shading features. The BAP Benchmark allows for an evaluation of all aspects of energy use including heating and cooling, water heating, lighting, and plug and appliance loads.² Heating and cooling duct sizes, duct losses,

² The benchmark procedures include references to Energy Information Administration's Residential Energy Consumption data among other sources. The miscellaneous energy use is more consistent with early 2000.

infiltration rates, and heating and cooling system operation periods are specified for the benchmark home. In addition, the BAP Benchmark specifies an hourly energy use profile for various plug and appliance loads. By establishing a reference for all energy use, the BAP Benchmark makes it possible to compare overall energy savings of an EVHA-winning home to its benchmark home.

Benchmark Analysis Summary of the 2005 EVHA Gold and Silver Winners

For each EVHA winner, the benchmarking process involves a detailed review of each EVHA application including house plans, equipment specification, and implementation of the benchmark reference procedures. Once the benchmark procedures are established, the data is entered into an hourly energy simulation program. The benchmark home simulations are run four times to gather results in all four cardinal orientations and are then averaged to provide an estimate of the energy use for the benchmark home. The EVHA-winning house design is then entered and simulated using information submitted in the EVHA application process.

The total energy use of the benchmark home is compared with the EVHA-winning home. Energy savings for heating, cooling, water heating, lighting, and other loads are calculated for the metered energy at the home as well as for the equivalent source energy. Source energy is calculated based on one standard common conversion for all regions to determine the energy at the gas storage facility (or well head) or at a central generation facility. For electricity, the conversion ratio is 3.16 and for natural gas the conversion ratio is 1.02, as specified by the BAP Benchmark.

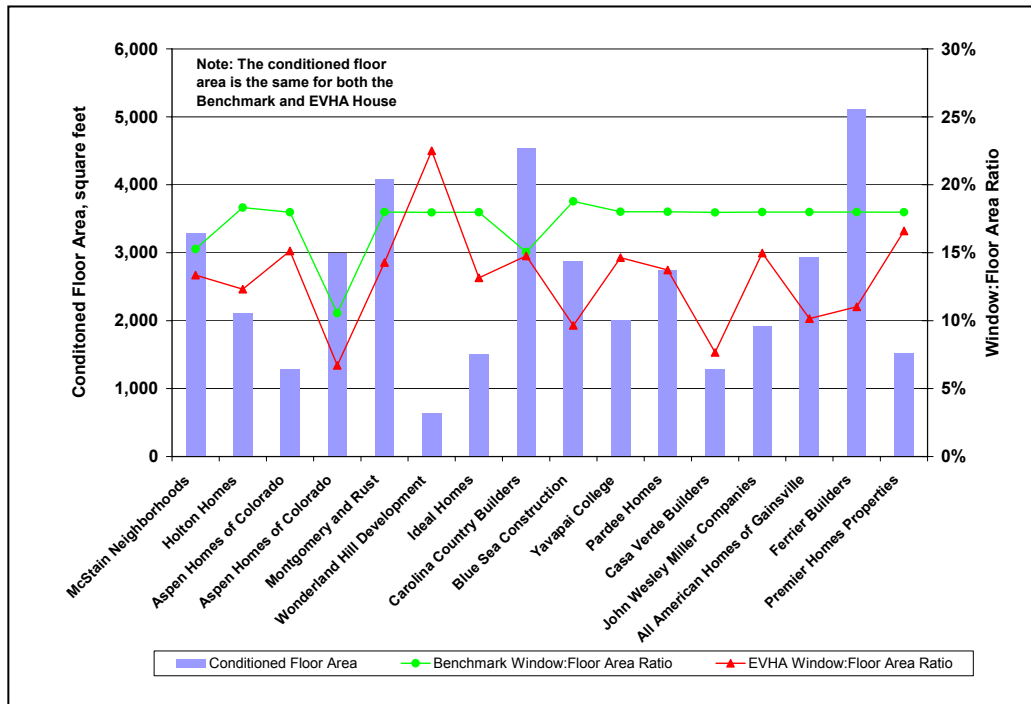
Comparing source energy savings allows a direct comparison of energy savings if fuels other than electricity are used in the home and provides an overall assessment of the magnitude of the energy savings.

A brief overview of the 2005 EVHA Gold and Silver Winners' house sizes is shown in Figure 1. The conditioned floor area includes basements in some houses. The floor area for the benchmark home is the same as for the EVHA home. However, the window area for the benchmark home is established based on procedures specified by the benchmarking process. For comparison, the EVHA house window area is shown with the benchmark window area.

As indicated in Figure 1, all but one EVHA-winning homes have less glazing area than "typical" homes,³ and in some cases much less. Only one house has more glazing area than the benchmark home. Also, the floor area range for the EVHA homes varies significantly representing a wide range of house types in the EVHA program. The average conditioned area for the 2005 winners was 2,557 square feet. While the benchmark is standardized to 18 percent window-to-floor area, the window area calculation presented in Figure 1 is based on conditioned floor area.

³ The BAP Benchmark specifies 18 percent glazing area for a "typical" home based on the total square footage of the house. In Figure 1; houses with basements include a factor based on the wall area ratio for above grade walls to the total wall area including the foundation walls.

Figure 1. Basic EVHA House Size and Window Area Statistics



The following table and figures provide a summary of the benchmarked energy savings of the 2005 EVHA-winning homes over benchmark homes using mid-1990s construction practices. Table 1 provides an overall summary of the 16 different winning homes and the average performance, along with the maximum and minimum range.⁴ The energy savings for heating and cooling alone averages over 50 percent. When considering the whole house performance, the average savings is about one-third over the benchmark home for the 2005

Table 1. Energy Performance of 2005 EVHA-Winning House Designs Compared to Benchmark Homes (Source Energy)

2005 EVHA Gold and Silver Winners	
Average Heating and Cooling Savings	52%
Average Whole House Savings (not including PV supply)	33%
Average Whole House Savings (including PV supply)	37%
Average Whole House Savings (of four PV houses)	53%
Average PV System Supply, kWh (of four houses with PV)	2,660
Average PV System Size, Watts	2,295
Maximum Whole-House Energy Savings (with PV)	57%
Minimum Whole-House Energy Savings	15%

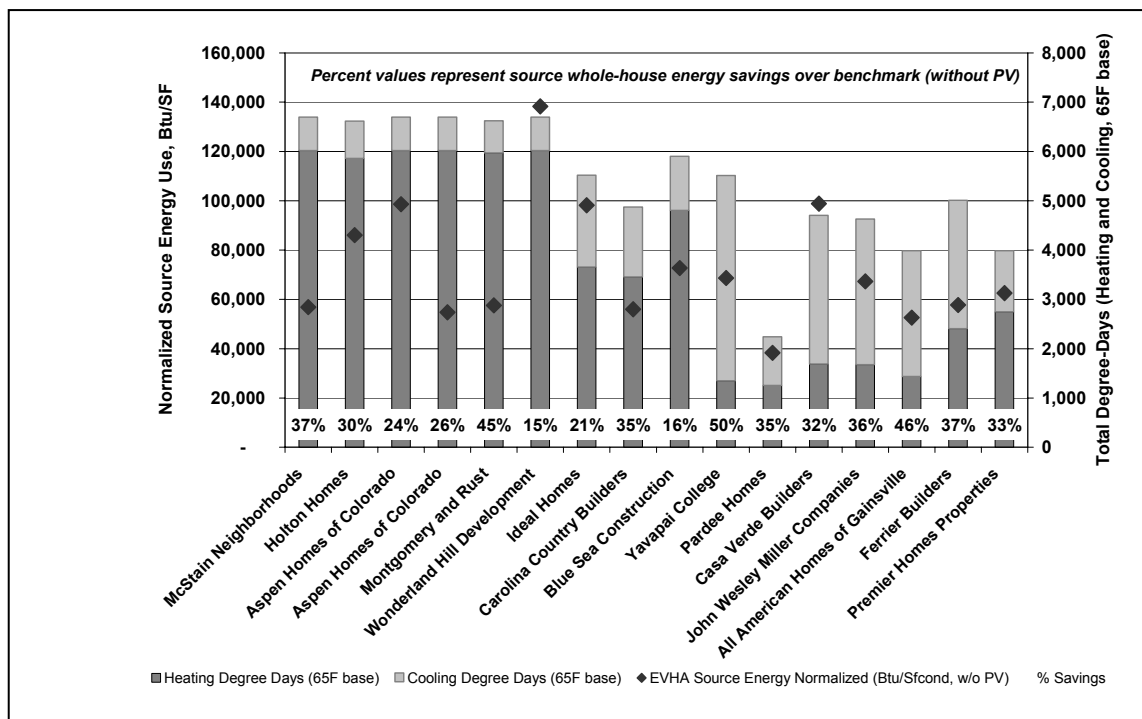
EVHA Gold and Silver winners. Winning homes that score lower percentage savings demonstrate that other judging criteria, such as consumer education or affordability, may have played a more important role in the selection of award winners.

⁴ A deviation from the benchmark procedures is the use of a heating set-point of 68°F and cooling set-point of 78°F.

Source energy is calculated using the BAP Benchmark procedures for converting to source energy from the house metered energy. The energy savings is first evaluated for homes not including the photovoltaic (PV) systems and then again to include the PV system output.

A general comparison of the energy performance of the EVHA-winning homes is shown in Figures 2 and 3 indicating that, in some cases, large gains have been made in reducing the source energy used in the home. The general climate data, heating, and cooling degree-days provides an estimate of the historical severity of the climate.⁵

Figure 2. Normalized Energy Performance of the EVHA-Winning Homes Without PV

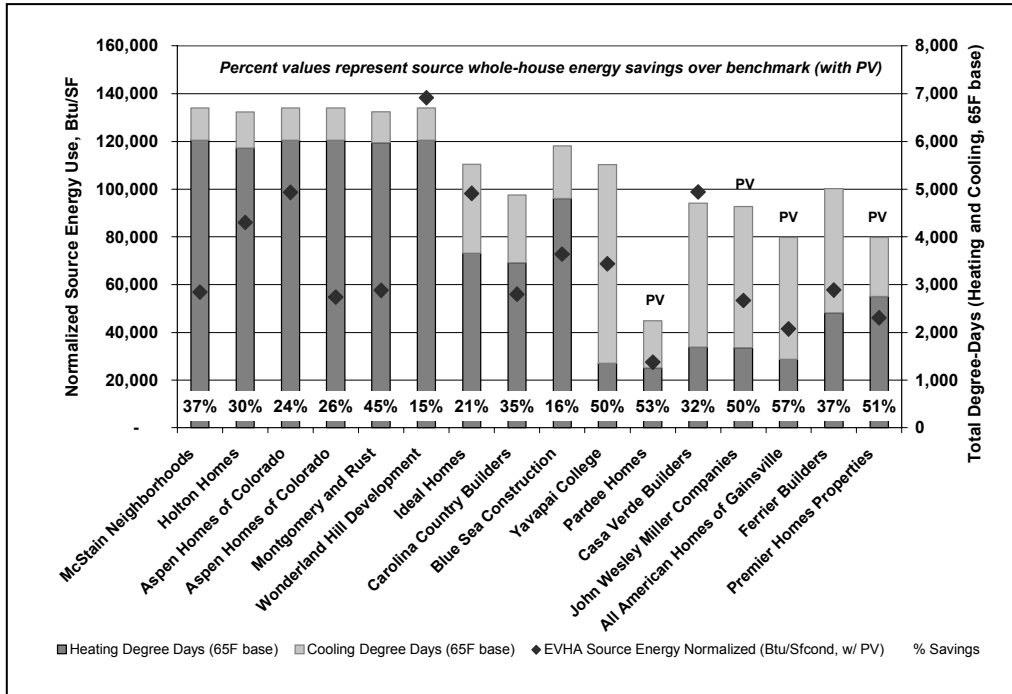


The source energy use is normalized to a square-foot basis. When considered together, the total energy savings varies, in part due to the range of construction types included in the EVHA program (Affordable, Custom, Factory-Built, Production, and Multifamily Homes).

Figure 3 shows the same normalized data but with the PV supply to the house included in the energy use and savings. The four EVHA-winning houses with PV systems are built by Pardee Homes, John Wesley Miller Companies, All American Homes of Gainesville, and Premier Homes Properties.

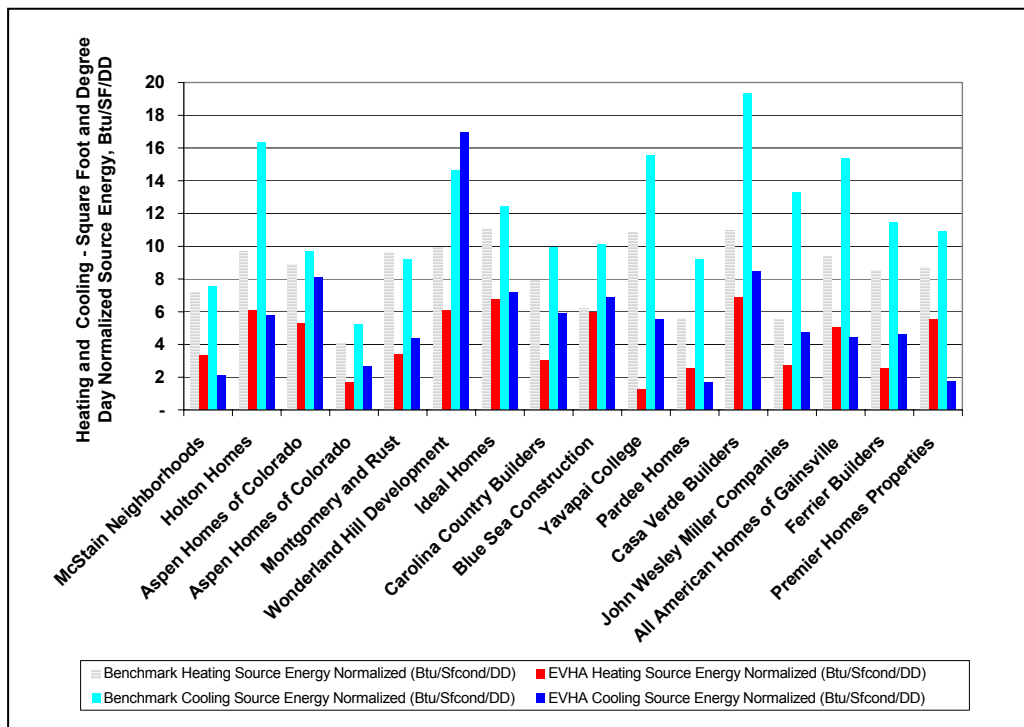
⁵ While it is uncommon to combine heating and cooling degree-days, climate severity is represented on the chart as the sum of heating and cooling degree-days (65°F base).

Figure 3. Normalized Energy Performance of the EVHA-Winning Homes With PV



Another analytical tool to compare the performance of the homes across climate zones is to normalize the heating and cooling energy to the size of the home and the heating and cooling degree-days. Figure 4 shows this comparison for the EVHA house energy use for the heating and cooling systems compared with the benchmark.

Figure 4. Square Foot and Degree-Day Normalized Heating and Cooling Energy Use



While the range of normalized energy use is fairly broad, the evidence of significant savings over the reference home is clear.

Further detail of estimated energy savings can be provided from the benchmark procedures (Hendron et al. 2004) if desired. A comparison of the individual energy use from various loads is shown in Figures 5 and 6. This type of comparison, which is only available from the benchmark process, can help builders identify progressive areas for improvement. Builders can use this information to help show prospective homeowners the innovative design features of their new homes, as well as areas where they can control energy consumption.

Figure 5. Example One of Estimated Loads from the Benchmark Analysis

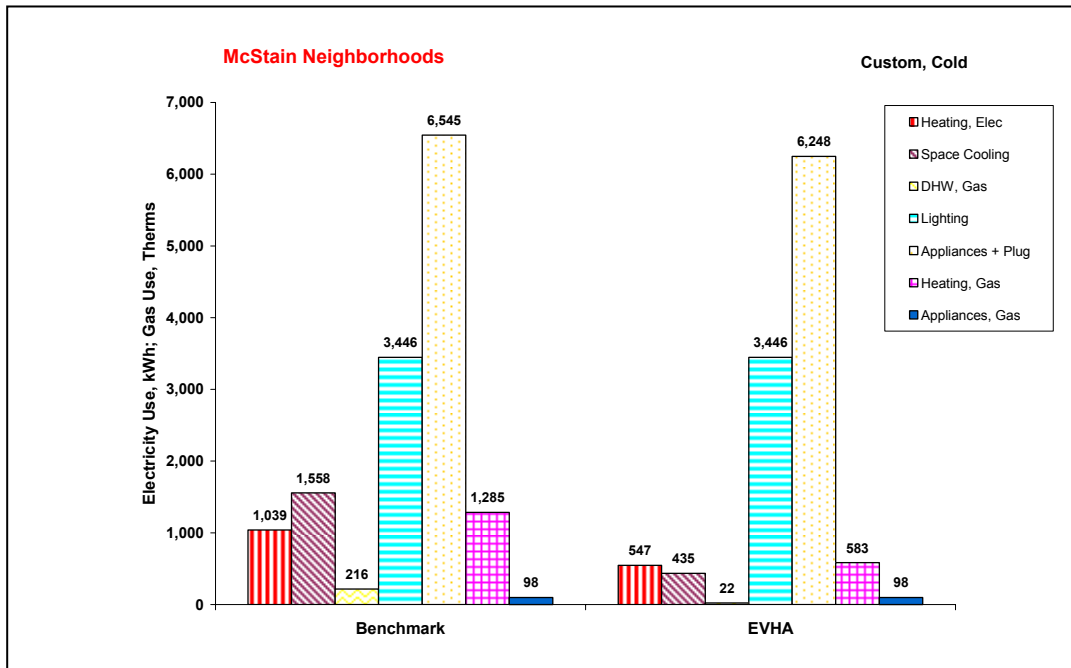
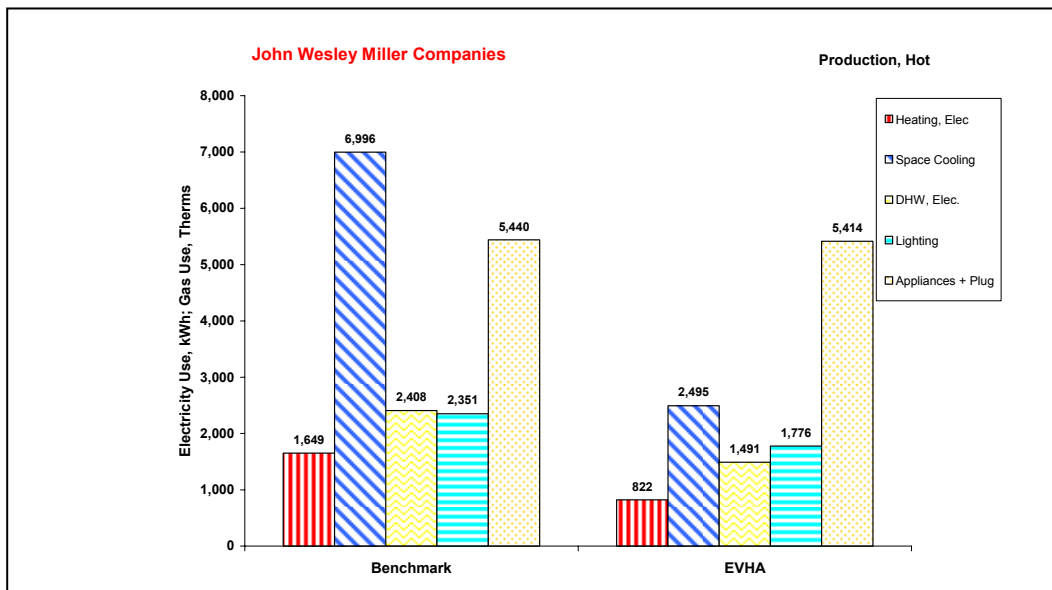


Figure 6. Example Two of Estimated Loads from the Benchmark Analysis



Summary Conclusions

Implementation of the BAP Benchmark procedures to the EVHA winners demonstrates how it can be used to quantify energy performance of the EVHA program over a multiple-year timeframe, providing a clear progression of energy performance from a firm reference point. The benchmarking analysis also allows for a comparison between applicant candidates indicating the range of energy performance and the major component areas where energy savings has been achieved. For this set of EVHA winners, implementation of the BAP Benchmark procedures has shown that EVHA-winning builders have successfully achieved average heating and cooling energy savings of over 50 percent above the benchmark home. These EVHA homes also have taken a large step in reducing the estimated total source energy use with an average of about one-third less total source energy used in the EVHA homes than the typical homes of the mid-1990s. The maximum total energy savings achieved in the 2005 EVHA home was over 57 percent above the benchmark including the PV system output.

Future implementation of the benchmarking procedures could also include providing the judges with a relative energy performance indicator prior to the final judging. While EVHA judges are selected based on their expertise in the field of residential energy efficiency, they occasionally require the aid of energy simulations or ratings to enhance their understanding of the energy performance of the applicant. In those rare instances, energy consumption simulations have been provided and/or HERS ratings are referenced to assist the judges with their deliberations. With the advent of the new HERS indexing system and refinements to the BAP Benchmark, there are more descriptive and meaningful methods to aid in the judging process. The 2006 EVHA judges indicated there would be value with having energy analyses in advance of the judging event and that the data would be influential with scoring the energy component of the evaluation criteria since it represents a significant fraction of the overall score. To the extent practicable, BAP Benchmarking may be conducted for the 2007 EVHA applicants on a trial basis to assess value added from the judges' perspective.

References

[BAP] The Building America Program. Washington, D.C.: U.S. Department of Energy. http://www.eere.energy.gov/buildings/building_america/.

[EVHA] EnergyValue™. Housing Award, Application: <http://www.nahbrc.org/evha/apply.html>.

_____. Housing Award, Program Information: <http://www.nahbrc.org/evha/index.asp>.

Hendron, Bob, et al. 2004. *Building America Performance Analysis Procedures, Revision 1*. NREL/TP-550-35567, June. Golden, Colo.: U.S. Department of Energy, National Renewable Energy Laboratory.

[NREL] National Renewable Energy Laboratory. 2004. *Building America Research Benchmark Definition*. Golden, Colo.: U.S. Department of Energy, National Renewable Energy Laboratory.