What Is Lowest Household Energy Use?

by John F. Robbins CEM / CSDP

It is common to refer to statistics to assess and compare our personal performance or status in sports, investments or health. When assessing or rating casual performance, we compare to averages. But when wanting to know how our performance compares to best, we compare to what has been actually demonstrated to be best. When our own performance is slightly lower than average, statistics may show we need only minor improvement to become average. When our own performance is much lower than average, or much lower than best if we aspire to be best, statistics sometimes show us we need major improvement.

For example, an aspiring young baseball player can easily learn about best hitting and pitching averages by checking statistics for Major League Baseball (MLB) players. The best batters achieve batting averages of 0.300 or higher, meaning they average 3 or more hits for every 10 appearances as a batter. Best pitchers allow only around 2 earned runs per 9 innings. These statistics inform a young player what performance is needed to become a major league player.

2013 MLB National League Leading Batters By Batting Averages

1. Michael Cuddyer, COL, 0.331 average hitting percentage
2. Chris Johnson, ATL, 0.321 average hitting percentage
3. Freddie Freeman, ATL, 0.319 average hitting percentage

2013 MLB National League Leading Pitchers By Earned Run Average

1. Clayton Kershaw, LAD, 1.83 average earned runs per 9 innings
2. Jose Fernandez, MIA, 2.19 average earned runs per 9 innings
3. Matt Harvey, NYM, 2.27 average earned runs per 9 innings

Similarly, an aspiring young football player can easily learn about best rushing and passing averages by consulting player statistics in the National Football League (NFL). Leading rushers run for over 1500 yards per year and leading quarterbacks pass for 5000 yards per year.

2012 NFL Leading Players By Rushing Yardage

1. Adrian Peterson, MIN, 2097 yards
2. Alfred Morris, WSH, 1613 yards
3. Marshawn Lynch, SEA, 1590 yards

2012 NFL Leading Quarterbacks By Passing Yardage

1. Drew Brees, NO, 63% completion rate, 5177 total yards, 7.73 average yards per pass
2. Matthew Stafford, DET, 60% completion rate, 4967 total yards, 6.83 average yards per pass
3. Tony Romo, DAL, 66% completion rate, 4903 total yards, 7.57 average yards per pass

Aspiring investors can easily learn how their personal investments compare to the performance of other stocks and mutual funds by checking statistics in several investment publications which regularly track and publish such data. We also have easy access to a huge amount of health-related statistics, allowing us to compare our own body conditions to the averages and recommendations for most healthy body weight, blood cholesterol, calories of daily food intake, daily exercise, blood pressure, breathing and heartbeat rates, and many other health-related indices.

Knowing how our own performance compares to demonstrated averages and bests around us helps us to know if or how much we need to improve. When our performance is better than average or near demonstrated bests, we can continue as we are, knowing we are likely as good as we can be. But when our performance is nowhere near best or is worse than average, it’s time to consider improvements. Statistics about demonstrated averages and bests give us targets to aim for.

What about home energy performance?

If a homeowner, home designer or homebuilder wants to achieve best or very low home energy use, where are the regional records of historical home energy usage? What home energy statistics are tracked? Unfortunately, actual home energy usage data are often not tracked or published by region. Home energy usage is so seldom discussed, compared or rated that no common language or process has evolved for describing and presenting it.

To describe home energy performance, most consumers and professionals simply report energy bills, energy-related certifications or labels, or installed energy features like R-values, airtightness, windows, heating and cooling equipment, lightbulbs and solar panels. But none of these are descriptions or ratings of actual energy performance. Comparing energy bills only works if comparing similar local households buying from the same energy suppliers. This is because energy use varies according to house design style, type of construction and occupancy as well as climate severity. Energy content per purchase dollar also varies rather substantially between suppliers and different energy types. Most energy-related certifications and labels are based on estimates of energy use during a home's design or how a house is built and outfitted during its construction. Even specifications like R-values and equipment efficiencies do not answer questions like:

What is the actual yearly energy usage?

How much is the yearly energy usage per sf of floor area?

What is the yearly energy usage per person?

How does usage in one household compare to other households?

What is best performance?

An energy consultant and home designer trying to lead customers to achieve very low energy usage, I began conducting free household energy surveys in 2001 to track and compare energy performance among households in my new and remodeled homes in and around the Ohio Valley (mostly Southwest Ohio, Southeast Indiana and Northern Kentucky). My surveys gradually expanded to include mostly non-customers. As of July 2013, 94 households had supplied 252 annual energy data samples for the years 2001 to 2012. While some participants did report average and higher-than-average energy use, a large majority of survey participants reported lower-than-average energy use, whether or not they were my customers. So my survey findings should be interpreted as describing what seems best or better-than-average for energy performance among Ohio Valley households.

Participants were asked to provide information about all amounts, types and costs of conventional energy acquired for their home over a calendar year, including free conventional energy like firewood. Participants were also asked to estimate their home's conditioned floor area in square feet (sf) as well as the number of home occupants. They were asked to state the county and state where their home is. And they were asked to select from a list all the energy efficiency and renewable energy features in the home or used by the household. Robbins seldom questioned submitted data unless there are obvious errors or omissions. When such were noticed, a participant was alerted to recheck and resubmit. Only a few submittals were rejected, almost always because there was no response to a recheck request.

All acquired conventional energy was then converted to equivalent BTUs according to the following conversion rates. This allows comparability between energy sources of different energy content.

Energy Type	**BTU Content**
Electricity	**3413 per kilowatt-hour (kWh)**
Heating Oil	**139,000 per gallon**
Kerosene	**137,000 per gallon**
Liquid Propane (LP)	**91,600 per gallon**
Natural Gas	**102,900 per hundred cubic feet (ccf)**
Pellets	**8000 per pound**
Firewood	**25,000,000 per cord**

Energy Use Per Square Foot (SF)

Total annual energy in BTUs was then divided by each home's conditioned floor area to produce what energy consultants call the "energy usage index" (EUI), the annual BTUs per sf of conditioned floor area. EUI is usually expressed in thousands of BTUs, so kBTU/sf is the actual index. According to the United States Energy Information Agency (EIA), average household EUI in USA in 2001 was 46.7 kBTU/sf.

The following graphic (Figure 1) tracks high, average and low EUI by year 2001-2009. Surveys 2010-2012 were not included in several of the following graphics because those surveys were incomplete, still in-progress. Average EUI in earlier surveys tracked relatively close to EIA's national average for 2001 but became lower in later years, likely because fewer average and high energy users were participating in the survey. Best EUI ranged from 14.0 to 16.7 kBTU/sf.

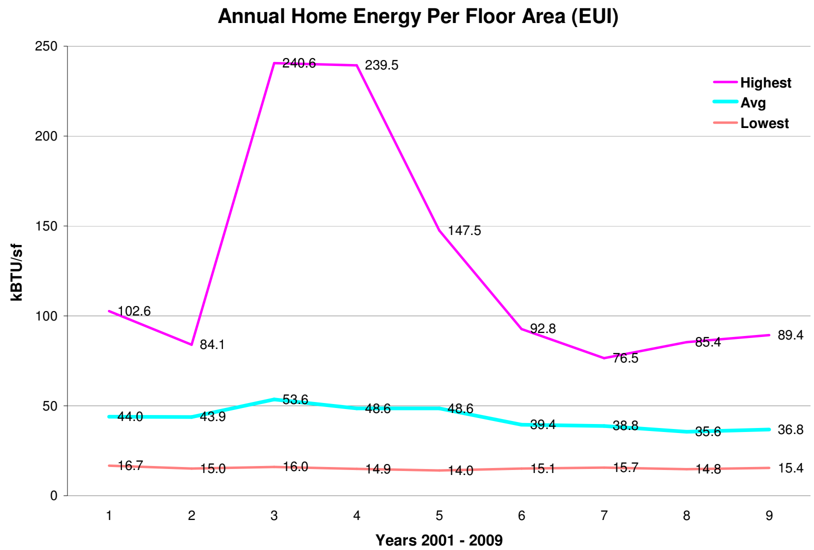

Figure 1

EUI tends to decrease naturally as house size increases. This is because larger homes tend to have less exterior surface areas per floor area than smaller homes. This is important since exterior surface areas are where heating and cooling losses most occur from thermal conduction and air leakage. The tendency of EUI to drop as floor area increases is obvious in this next graphic (Figure 2) showing all 252 EUIs over 12 years compared to each EUI's conditioned floor area.

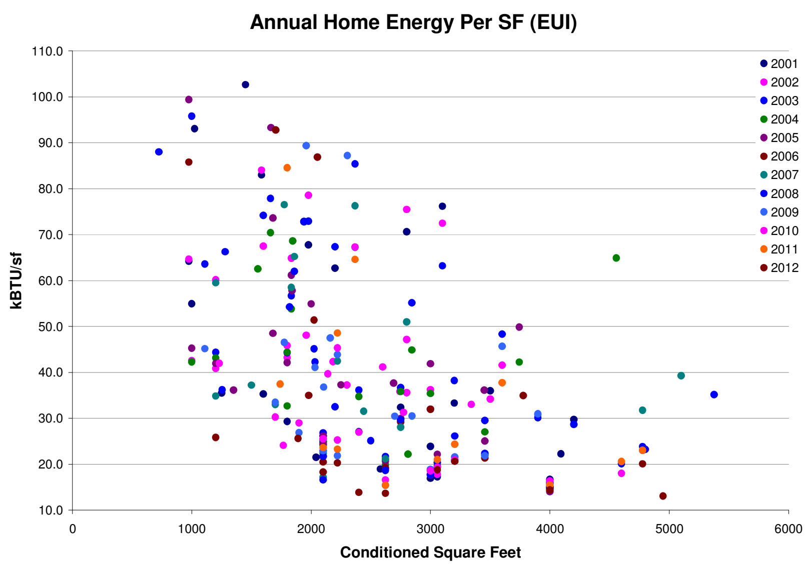

Figure 2

EUI also varies significantly with year-to-year outdoor climate. Ohio Valley homes use a large amount of their annual energy for heating and cooling since there are relatively cold heating seasons and hot humid cooling seasons. Cincinnati OH averaged 4907 heating degree-days (HDD) per year 2001-2010, varying from 4400 in 2006 to 5184 in 2003. Cincinnati averaged 1180 cooling degree-days (CDD) per year 2001-2010, varying from 848 in 2003 to 1637 in 2007. Heating and cooling degree-days measure the accumulated differences between average daily outdoor temperatures and typical indoor temperature, assuming no heating energy is needed if outdoor temperature averages at least 65F, no cooling energy is needed if outdoor temperature average is not over 65F. Heating energy usage rises with higher HDDs. Cooling energy usage rises with higher CDDs.

So to allow better comparability of energy performance between different years, locations and climates, each household's annual EUI was divided by the sum of each year's HDDs and CDDs to produce a climate-sensitive version of EUI. The resulting index is BTU/sf-dd. This next graphic (Figure 3) shows high, average and low BTU/sf-dd 2001-2009. Best values ranged from 2.1 to 2.9 BTU/sf-dd.

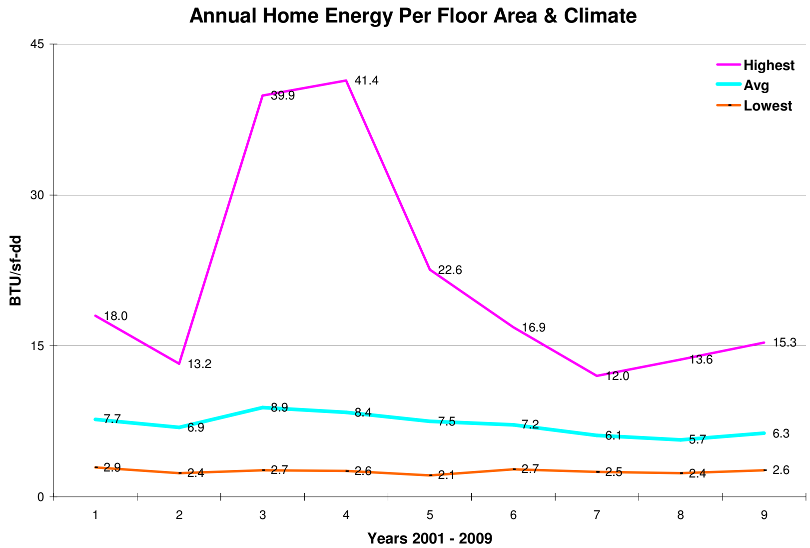

Figure 3

Energy Use Per Person

Truly superior household energy performance should demonstrate low energy use per-sf and per-person. Since it is typical for heating and cooling energy per sf to drop as house size increases and for per-person energy to increase as floor area per person increases, it is possible for energy use per sf to drop while use per person rises. Indeed, it has not been uncommon in my surveys for households in thermally efficient homes with greater floor area per person to score substantially better in energy per sf than energy per person. Figure 4 shows clearly how per-person energy use in my survey rises as floor area per person increases.

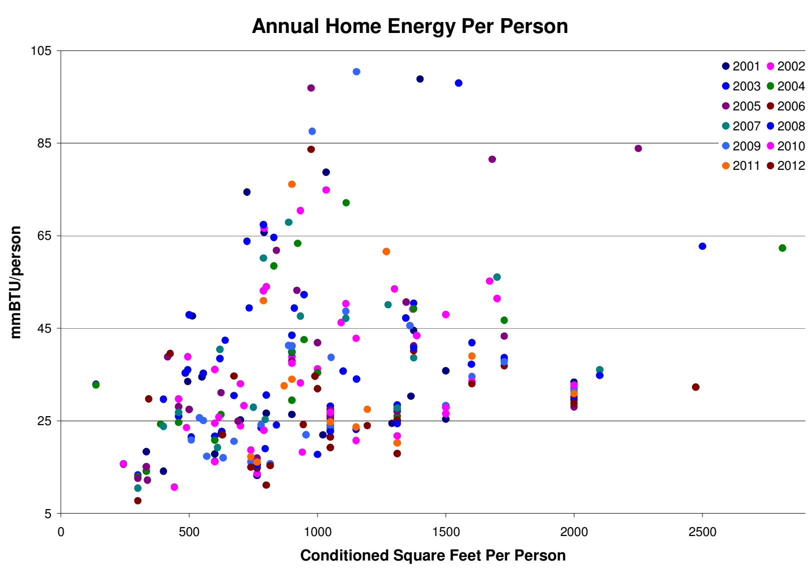

Figure 4

To measure conventional energy per-person, each household's total annual BTUs was divided by the number of home occupants. The answer is in the millions, so the index is mmBTU/person. According to US EIA, household energy usage in USA in 2001 averaged 36.0 mmBTU per person. The next graphic (Figure 5) describes high, average and low per-person energy in my surveys 2001-2009. Best household energy per person per year ranged from 7.7 to 15.7 mmBTU.

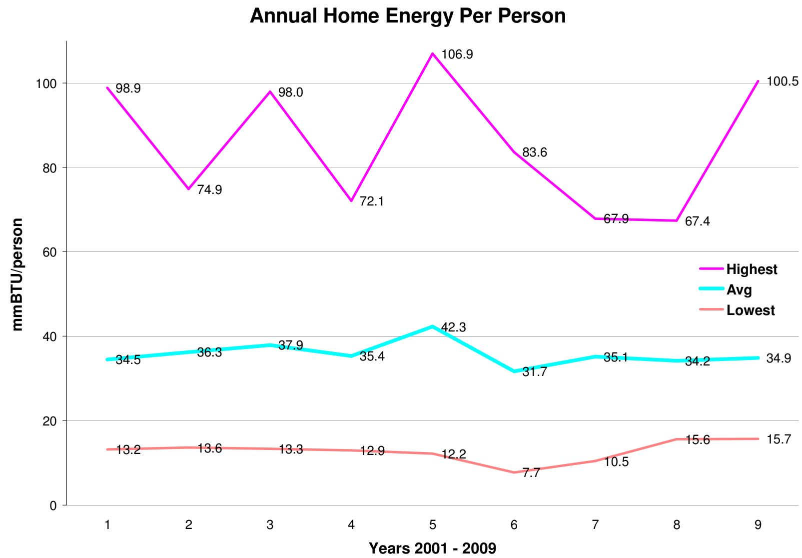

Figure 5

As with per-sf evaluation, per-person energy also fluctuates with outdoor climate. So to improve comparability between different years and/or locations, per-person energy was divided by the sum of each year's heating and cooling degree-days to produce a climate-referenced per-person energy index, similar to what was done with energy per sf. This climate-sensitive per-person energy index is in the thousands, so the actual index is kBTU/person-dd. The next graphic (Figure 6) shows the high, average and low per-person energy per degree-day 2001-2009. The best scores ranged from 1.4 to 2.7 kBTU/person-dd.

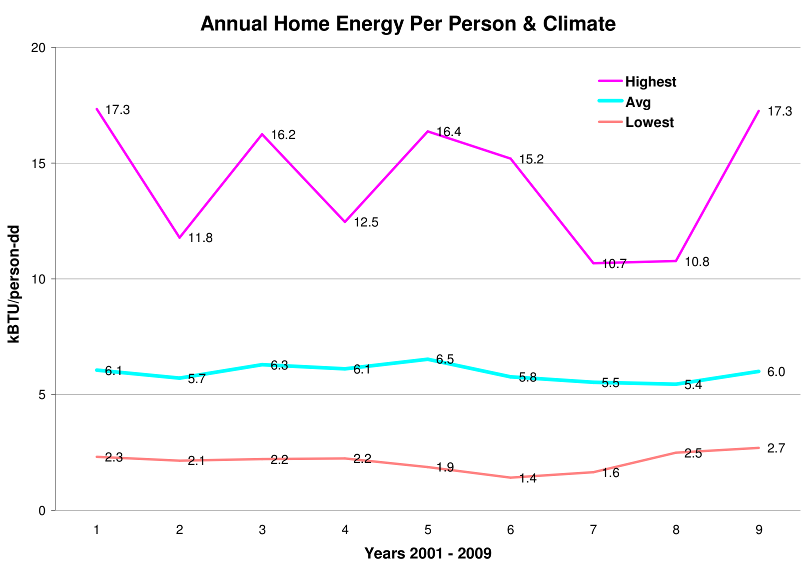

Figure 6

So what is best home energy performance?

Based on my energy evaluation and design experiences since 1983, I developed the following "Ratings Gauge" to describe usual best-to-worst ranges for climate-referenced home energy performance in the Ohio Valley. It describes "super" energy performance as not more than 4 BTU/sf-dd and not more than 3 kBTU/person-dd.

Ratings Gauge

	Best	Super	Better	Average	Poor	Worst
BTU/sf-degree-day	<= 2	2.01 - 4	4.01 - 8	8.01 - 12	12.01 - 16	16.01 =>
kBTU/person-deg-day	<= 2	2.01 - 3	3.01 - 6	6.01 - 9	9.01 - 12	12.01 =>

Through June 2013 in my surveys, achieving the "Super" energy performance both per-sf and per-person has happened only 20 times by only 6 households. Only 2 households have achieved it more than once.

An Ohio household with 4 occupants in a relatively new 3058 sf home designed by me achieved it in each of the 12 years of the survey. This household not only cited many efficiency and renewable energy features (superior insulation values, airtightness and windows, passive solar design, some bermed living spaces [a finished insulated basement], efficient HVAC system, lights and appliances), but also only 765 sf of floor area per person, very close to the national average floor area of 760 sf per occupant in the 2001 EIA report.

A household with 3 occupants in a 2220 sf house in central Kentucky achieved the "Super" energy performance both per-sf and per-person all 4 times it participated in the survey. This household cited many energy features (superior airtightness, some bermed living space, efficient HVAC, efficient lights and appliances) and also had only 740 sf of floor area per person.

In the 20 times a dual "Super" rating was achieved, 19 households reported having at least some bermed living spaces, meaning at least some conditioned living space below outside grades. 19 also reported having efficient lights and appliances. 18 claimed having efficient HVAC systems. 17 claimed superior airtightness. 14 claimed superior insulation levels. 13 reported having passive solar features in their home. 11 claimed superior windows. Only 1 reported having only 1 efficiency feature: efficient lighting. Only 1 reported active solar heating. None reported having solar electricity.

Conclusion

When asked by a customer or student "What is best household energy performance" in the Ohio Valley, I usually show my energy ratings gauge and say "not more than 4 BTU/sf-dd and not more than 3 kBTU/person-dd." But it is certainly not unusual for households to perform significantly better in either per-person or per-sf, while not so well in the other category.

Below are the ranges I have seen as best home energy performance in both categories for the Ohio Valley, as so far documented in my household energy surveys 2001 - 2012. Whether we are homeowners, home designers, homebuilders or residential energy consultants, they can be used as benchmarks for what seems the lowest energy usage already being demonstrated by existing households in the Ohio Valley. When our own households or our customers' usage is far higher, these data inform us how much we need to improve to become among the best. When our own households or our customers' usage is close to these ranges, then we know we are already doing well and are already among the best.

Annual Home Energy Use Per SF, aka "EUI": 14.0 - 16.7 kBTU/sf

Climate-Adjusted Energy Use Per SF: 2.1 - 2.9 BTU/sf-dd

Annual Home Energy Use Per Person: 7.7 - 15.7 mmBTU/person

Climate-Adjusted Energy Use Per-Person: 1.4 - 2.5 kBTU/person-dd

Author

John F Robbins is a home designer, professional energy instructor and energy consultant since the mid-1980s, working for home and small business owners mostly in Ohio, Kentucky and Indiana to achieve lower energy usage, utility bills and environmental impacts. A specialty is designing superinsulated passive solar homes and small buildings, but projects often have solar water heating and solar electricity too. Robbins also consults on stand-alone solar electricity projects like the PV and batteries electric system powering his own office since 2001. He is current residential chair for the Association of Energy Engineers (AEE) SW Ohio Chapter. Robbins has been an AEE-certified energy manager (CEM) since 1990. For more information, contact him at ***859.363.0376*** or ***john@johnfrobbins.com***, or visit his website: ***www.johnfrobbins.com***. A full report on his household energy surveys is also available: ***www.johnfrobbins.com/SurveyReportOct2013.pdf***