The ENERGY STAR® Building Label: Building Performance through Benchmarking and Recognition

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ABSTRACT

The proliferation of commercial building energy codes and standards has resulted in measurable energy savings across the United States. However, many commercial buildings are currently realizing energy savings 20% to 50% beyond energy codes and standard by simply making use of cost effective energy efficient technologies and whole-system design concepts. Addressing the energy saving opportunities that exist between nationally codified standards and high performance, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) are developing a voluntary performance-based recognition effort to provide a market incentive for more energy efficient commercial building performance.

As announced by President Clinton on April 20, 1998, the ENERGY STAR® Building label will be used to recognize commercial buildings that are currently the most energy efficient and cost effective in the country. By strategically setting a level of performance high enough to exceed existing commercial building energy codes, while at the same time attainable within current market conditions, the ENERGY STAR® Building label will strive to become *The Mark Of Excellence In Energy Performance* and a force in market transformation. One that is fully associated with profitability, productivity, comfort and better utilization of our natural resources.

This paper will discuss the drivers of energy consumption for commercial office buildings, the cost effectiveness of the performance targets, the assessment tool behind the ENERGY STAR® Building label, and the application process.

Introduction

As more efficient technologies are introduced and design codes made more stringent, today's commercial buildings can and should perform better. Whether the focus is on the design side, as is the case with new buildings, or the operations side, as is the case with existing buildings, there remains a significant opportunity to improve energy efficiency, lower operating costs, and provide more comfort. Current commercial energy codes have primarily served to standardize the application of cost effective, energy efficient technologies in new building design. This design-side focus leaves building performance – the ability to utilize energy efficiently while providing occupant comfort – in the hands of the building operators downstream of construction, several steps removed from the design intent. Many utility demand-side management programs, Federal/state initiatives, and energy services company offerings have routinely demonstrated the economic, environmental, and productivity benefits that energy efficiency has to offer. These efforts have generally had mixed success. What has been missing thus far in the commercial building marketplace is a performance-based metric that both designers and building operators can use as a goal toward which to strive.

To date, building operators concerned with their energy consumption have only been able to benchmark their buildings against themselves; striving to maintain or perhaps reduce their annual consumption relative to years previous. Likewise, architects and engineers, who now routinely meet the prescriptive requirements of commercial energy codes and standards in their new building designs, have no discrete performance target toward which to design. While meeting the prescriptive requirements of energy codes and baselining building energy use are laudable actions, success in achieving a higher performing stock of commercial buildings may require more than a design-focused, mandatory approach. The ENERGY STAR Building label has been developed as a voluntary approach to improve commercial building energy efficiency by focusing on performance.

The objectives of this undertaking are simple. First, compel commercial building owners, designers, and operators, of the need and benefits to benchmark their existing buildings against their peers. Then motivate these players to take economically justified actions based on their benchmark. And finally, shift the energy performance of the entire stock of commercial buildings toward reducing pollution through the better utilization of energy and our natural resources. Through the efforts of the ENERGY STAR Building label, EPA and DOE intend to meet these goals by providing the commercial building market with a national target of energy efficient performance, a tool to measure it, and recognition for achieving it.

Background

Several years ago, in an attempt to mitigate the increased electric load due to the widespread use of personal computers (PCs) and associated peripherals, the EPA created a voluntary partnership with PC manufacturers to produce more energy efficient products. The ENERGY STAR Office Equipment program enabled manufacturer's whose office equipment met the idle mode power consumption criteria to use the ENERGY STAR label on their products, thus allowing consumers to easily identify energy-efficient office equipment. Designed as a market-pull activity, the ENERGY STAR Office Equipment program has achieved much success in the commercial and residential marketplace for personal computers, fax machines, and copiers. In recent years, EPA has teamed with DOE and now collectively use ENERGY STAR label to recognize five additional product lines including HVAC equipment, homes, transformers, exit signs, and TVs/VCRs. While the products achieving and being recognized with the ENERGY STAR label are quite diverse, the guiding tenet – that a product that bears the ENERGY STAR label symbolize energy excellence – is the common bond. Building upon the success and principles of the various ENERGY STAR programs, EPA and DOE now offer the ENERGY STAR label for commercial buildings. Rewarding the achievements of commercial building owners whose buildings meet the performance criteria, EPA and DOE have initiated a new market-pull activity to recognize those buildings as ENERGY STAR Buildings.

Principal Drivers of Building Energy Consumption

Developing the ENERGY STAR Building label began by identifying the principal drivers of energy consumption in existing commercial buildings. In a study conducted and reported by Oak Ridge National Laboratory (Sharp 1996) found statistically significant relations between commercial building energy use intensity (EUI), in energy use per square foot, and several characteristics. The study focused on existing commercial office buildings; relying on the energy consumption, energy expenditure, and energy-related building characteristics contained within the 1992 Commercial Buildings Energy Consumption Survey (CBECS). Using stepwise linear regression modeling in the analysis of 1358 office buildings, six principal drivers of office building energy consumption were identified out of 75 CBECS characteristics. These six drivers of commercial building EUI in order of indicator strength were: occupant density, number of personal computers, operating hours, occupancy type (i.e. owner-occupied), the presence of an economizer, and the presence of a chiller. CBECS data were collected through personal interviews of various building personnel. As such, the accuracy of the data is dependent upon the interview process, the questions asked, and to what extent those interviewed have knowledge of their building. With that said, CBECS is among the largest and most extensive data sets of commercial building energy use and characteristics in existence; having been conducted on five occasions since 1979.

Beyond the inaccuracies inherent to statistical surveys, one of the primary weaknesses in using national average data such as CBECS is that it only reflects average performance for existing buildings rather than energy efficient performance (Komor 1998). Thus, using national average data as a primary source for benchmarking does not necessarily indicate how commercial building energy performance compares to that of an energy efficient building. One solution to this problem is to define the benchmark at some percentage better, that is, at a more efficient level than the national average (Komor 1998). Another primary weakness in using national average data is that in order for the energy benchmarking to be accurate, operational conditions which affect energy use must be accounted for such as climate, operating hours, electrical power density, and occupant density.

Using the 1992 CBECS and 1995 CBECS data sets – representing a combined total of roughly 2,400 office buildings – work is nearing completion to determine target values unique to all major climates in the United States. Once done, these values will be incorporated into an on-line assessment tool – the ENERGY STAR Benchmarking Tool – and evaluated against existing commercial building data from various utility companies, trade associations, and Federal programs. This data will be used to assess the prediction capability of the Benchmarking Tool as well as provide an indication of the relative stringency of the ENERGY STAR targets. To understand how ENERGY STAR relates to commercial building energy codes, the targets will be compared against the simulated energy performance of office buildings designed to be code compliant for various locations across the country. The targets will be compared to Title 24 compliant office buildings in California locations and to ASHRAE/IES Standard 90.1-1989 compliant office buildings elsewhere. Based on the results of these evaluations, the performance targets may be calibrated to better track with current energy performance and construction practice.

The definition of ENERGY STAR was chosen to represent the best 25% of existing commercial buildings – a level high enough to exceed the performance of buildings that are marginally code compliant, while attainable within market conditions. By definition that latter holds true. For the former, analysis underway will reveal any disparities between the ENERGY STAR performance targets and current energy codes. The intent is to motivate all locations as equally as possible. For example, relative to the rest of the country, California has had an energy code more aggressive than ASHRAE/IES Standard 90.1-1989 in place for many years. So, in theory, the as-occupied energy performance of the California stock of commercial buildings should be better than in most other locales throughout the nation. If, upon the results of the analysis underway, the ENERGY STAR target values for the California locations are not sufficiently stringent to recognize the best 25% in the California market, then the targets may be adjusted accordingly for that market. Likewise, as other regional market data becomes available, the ENERGY STAR target values may also be adjusted to be more stringent in other areas of the country.

Cost Effectiveness of ENERGY STAR Performance Targets

There are several simple indicators the ENERGY STAR performance target is cost effective. Probably the most powerful of which is the fact that, by definition, 25% of commercial buildings meet the

ENERGY STAR performance target; a reflection of the commercial building market as it exists. Beyond this, in the case of office buildings, preliminary analysis of the CBECS data indicates that an average office building would need to reduce energy consumption 35% to reach a level corresponding to the best 25% of the office market. This aligns well with EPA's experience with upgrading and measuring the performance of 15 commercial office buildings as part of the Showcase Buildings of the ENERGY STAR Buildings℠ partnership. These existing buildings reduced energy consumption 30% with an average rate of return (IRR) of 19%. In another analysis, a detailed assessment of the 40 existing commercial buildings investigated the costs and benefits of building commissioning. This study concluded that building commissioning alone can result in energy savings of 50% with typical energy savings of 5% to 15% and an average simple payback of 2 years (Gregerson 1997). The implication of these studies is that defining the ENERGY STAR performance target values that represent the best 25% of the commercial office building market appears to be a cost-effective level. Results of comparisons to codes and additional market data sets will determine whether this is, in fact, valid.

The Benchmarking Tool

The Benchmarking Tool is the key to the success of the ENERGY STAR Building label. It is designed to be credible, motivational, and simple. The Benchmarking Tool will be internet-based and freely available to the public to use in obtaining the ENERGY STAR Building label or for any other internal or business uses. While designers may find it useful as a design tool, the Benchmarking Tool has been developed primarily for occupied existing buildings. For those intending to apply for the ENERGY STAR Building label, the audience for the benchmarking tool are Professional Engineers (PEs), however the tool is sufficiently simple to permit anyone with the necessary information to complete it. To determine an ENERGY STAR performance target and to benchmark a building against it, the user need only provide the following:

- Location (or average heating degree-day and cooling degree-day data)
- Area in square feet (sq. ft.)
- Average weekly operating hours
- Average occupant density (people/1000 sq. ft.)
- Plug load power density in watts per sq. ft.
- 12 months of monthly energy consumption

With this information, the Benchmarking Tool calculates an energy performance target based on the market energy performance of the best 25% customized to operating conditions, physical size, and location. Using multi-variant regression modeling, indications are that the analysis will be able to accurately predict building energy consumption based upon the user inputs listed above. The Benchmarking Tool then calculates a customized energy performance target, or EUI, expressed as an annual energy consumption per unit building area in units of kWh_{eq}/sf-yr or kBtu/sf-yr . The subscript "eq" stands for equivalent and is meant to indicate that the Benchmarking Tool converts all site energy consumption to source energy consumption, simply equating all energy uses be they electricity, natural gas, oil, or district heat use intensities to their source of generation.

Based upon the start and end dates of the utility billing cycle, the Benchmarking Tool then accounts for the effects of yearly weather variations and calculates a normalized energy consumption. Weather normalization is accomplished by calling up to an on-line site of average daily temperatures and pulling down the weather file for the location and dates required. The values of average daily temperature are then compared to the typical values for average daily temperature permitting a first order adjustment of the user-inputted utility data. Like the customized ENERGY STAR performance target, the normalized energy consumption will be expressed in source energy terms.

Once the ENERGY STAR performance target and the weather normalized energy consumption have been calculated, the Benchmarking Tool then compares the two values and displays the information numerically, graphically, and as a rating or percentile. A form, the Statement of Energy Performance, is then generated summarizing the pertinent user inputs, utility data, calculated target, and normalized energy consumption.

Process of Obtaining the ENERGY STAR Building Label

Obtaining the ENERGY STAR Building label is straightforward requiring the building owner to complete and submit: 1) an application form; and 2) a Statement of Energy Performance using the Benchmarking Tool validated by a Professional Engineer (PE). The application form contains information about the building such as location, points of contact, and owner/operator along with language regarding the proper use of the ENERGY STAR logo. Along with the customized ENERGY STAR performance target and the normalized energy consumption, the Statement of Energy Performance will also address indoor air quality, thermal comfort, and visual comfort. In short, to be eligible for the ENERGY STAR Building label, regardless of the energy performance level met, a PE must validate that the observed operation of the building indicates that is capable of meeting current industry standards for indoor air quality, thermal comfort, and visual comfort. ASHRAE Standard 62 -1989 for indoor air quality, ASHRAE Standard 55-1992 for thermal comfort, and IES Illuminance selection procedure for visual comfort will be used initially. As these standards are updated, they will be incorporated accordingly.

Thus, to obtain recognition as an ENERGY STAR Building, the ENERGY STAR performance target must be met along with an adequate level of comfort; namely indoor air quality, thermal comfort, and visual comfort. Licensed PEs, because of their established role in assuring that building owners receive unbiased engineering services, will be called upon to validate both the quality and performance information with their stamp and signature. Relying on the high level of professionalism, experience, and expertise should assure building owners that the ENERGY STAR Building label has significant and verified value.

Future

The ENERGY STAR Building label will begin being awarded as soon as the Benchmarking Tool is finalized, which is anticipated to be during the summer of 1998. At that time, applications along with the Statement of Energy Performance will be accepted. Those building owners whose existing buildings achieve the criteria will be provided specifications for the label and be recognized by EPA and DOE as an ENERGY STAR Building.

Initially, the ENERGY STAR Building label will be available for office buildings only. ENERGY STAR performance targets will be included later in 1998 for retail space while other space uses will be added over the following 18 months as sufficient reliable data are obtained and analyzed. Starting in 2001 and every subsequent year ending in a "5" or a "0", the ENERGY STAR Building label criteria will be revisited to determine if it is in need of being made more stringent in light of progress made by the commercial building sector, improvements in energy codes, and the economics of new technologies.

Beyond adding more space uses, over the next couple of years the ENERGY STAR Building label will also look to develop complementary tools and continue to reach out to other efforts. These include independent environmental incentive programs; financing, property appraising and insurance; code compliance software; and commercial building energy simulation software. As a service for the public, two databases will be provided on the ENERGY STAR Building label Web page. One will be a simple listing of those existing buildings that have met the criteria and have been designated as ENERGY STAR Buildings; masking any sensitive owner information. The other database will be tailored toward the research community and contain more detailed information. The purpose of these databases are to verify that the buildings affixed with the ENERGY STAR label are truly among our nation's best in terms of energy efficiency.

Conclusions

The ENERGY STAR Building label will attempt to become a market transformation force toward improving commercial building performance by creating a benchmarking tool, setting performance targets, and providing national recognition to those buildings that meet it. To truly have a significant impact as a market transformation force, the benchmarking tool must be simple yet credible, the performance targets must be stringent tough yet achievable, and the recognition must be motivational and valuable. If successful, taking this performance-based, market-pull approach should result in more cost effective, energy efficient commercial buildings - buildings that are more comfortable, have greater asset value, exemplify environmental leadership.

References

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