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Is What They Want What They Get?

Examining Field Evidence for Links between Design Intent and As-built Energy Performance of Commercial Buildings

Final Report – EPA Cooperative Agreement Number X – 82905201 – 0

Volume 1 -- Revised July 14, 2003

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Acknowledgements

The New Buildings Institute (Institute) produced this report with the support of US Environmental Protection Agency (EPA) Cooperative Agreement Number X – 82905201 – 0. Karen Butler is the EPA Grant Administrator for this agreement.

The New Buildings Institute's Jeff Johnson managed this project.

Subcontractors on this project were:

Architectural Energy Consultants

Pete Jacobs
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The Institute would like to acknowledge the following individuals for their contributions to the project:

- Pat Heatherly, Maggie Johnson, Cathy Higgins, New Buildings Institute
- Thomas Hicks, Robert Rose, Doug Gatlin, Bill VonNida, US Environmental Protection Agency
- John House, Iowa Energy Center
- Mary Ann Piette, Alan Meier, Lawrence Berkeley Lab
- Ed Smyth, RLW Analytics
- Darryl Mills, Bill Pennington, John Wilson, Art Rosenfeld, California Energy Commission
- David Goldstein, Natural Resources Defense Council
- Lauren Castenini, Jennifer Smead, Janis Erickson, Aleisha Kahn, D&R International
- Ian Graham, Steven Winter Associates
- Chip Fox, San Diego Gas and Electric Co.
- Abdullah Ahmed, Southern California Gas Co.
- Pat Eilert, Misti Bruceri, Ken Gillespie, Alyssa Newman, Pacific Gas and Electric Co.
- Gregg Ander, Southern California Edison Company.
- Adam Hinge, Dave Abrey, Northeast Energy Efficiency Partnerships, Inc.
- Fran Boucher, Michael McAteer, National Grid, USA
- Peter Schwartz and Mark Williams, formerly with New Buildings Institute

1. Introduction

Voluntary market-based efforts such as the ENERGY STAR programs rely on cooperation and good will between the private sector and government, but to succeed they must result in measurable economic, energy and environmental benefits. All parties must agree upon reasonable measures and verifiable outcomes. This project compared the energy performance of typical newly constructed commercial buildings in California with the original design intent for such buildings. Specifically, the objectives of this work were to:

- Compare the ENERGY STAR buildings rating system against pertinent field data.
- Answer questions and issues raised by two critical audiences (those prospective ENERGY STAR decision-makers who so far have declined to participate in the program, and, building science researchers and architectural energy practitioners who challenge the technical approach of the rating system).
- Create a dialogue within each community to discuss these issues and present credible and useful information about building energy performance.
- Recommend means of improving, refining or promoting the ENERGY STAR rating system.

In addition, the Institute invited organizations that are active in these regions to actively participate in this project and to consider enhancing the scope of work through co-funding or in-kind contributions of expertise.

ENERGY STAR has three components to its Energy Performance Rating Scale:

1. ENERGY STAR Energy Performance Rating Scale – a simulation tool that compares the performance of buildings to a national in-place stock using a 1 to 100 scale. The Energy Performance Rating Scale defines the lowest energy performing buildings (most energy use per unit metric) as a 1 and the highest energy performing buildings a 100.
2. ENERGY STAR Target Finder – a tool that is used during new design phase to compare predicted performance (kWh/Therms) to the Energy Performance Rating Scale, and
3. ENERGY STAR Energy Star Building Label – a program that rewards the highest performing buildings (top quartile) with a plaque. The buildings must score a 75 or better using the Energy Performance Rating Scale and receive a professional engineers certification that indoor conditions, including lighting and indoor air quality, exceed IESNA and ASHRAE guidelines.

2. Background

An effective means of increasing participation in voluntary programs is to develop a wide-based consensus to help to build support among both building science experts and the peer-sensitive building owner and developer community.

The commercial building energy efficiency community is a sophisticated collection of engineers, policy analysts and marketing representatives. This group has a diverse view of the commercial buildings market and how to affect change in that market. These views range from the need for specific technical analysis to predict energy savings on a specific job, to marketing the non-energy benefits of high performance buildings. The Energy Performance Rating Scale has a number of features that the commercial building efficiency community can use in their efforts. These features include:

- The tool's ease of use,
- ENERGY STAR brand recognition,
- Ability for building owners, developers and property managers to quickly grasp the energy performance-rating concept.

There are specific areas in the US that are taking a hard look at their commercial building programs (Johnson 2001). They include:

- California –Commercial building rating is not yet included in the proposed program offerings in California. There is significant opportunity to work with program planners in California to develop mid- to long-range programs that incorporate the Energy Performance Rating Scale.
- Northwest – The Northwest Energy Efficiency Alliance (Alliance) is working on a new commercial buildings program. The relationship between codes, new buildings and existing buildings is evolving in this program design. The Energy Performance Rating Scale can play a role in this new program, provided the Alliance is able to translate the benefits of rating commercial buildings to the real estate community.
- Northeast -- The Northeast Energy Efficiency Partnerships, Inc. is currently evaluating the role of rating buildings within a utility program framework. The relationship between codes, utility new construction programs and the Rating Scale is a part of this effort.
- Midwest – The Midwest Energy Efficiency Alliance is in the early planning stages for commercial programs. There is an opportunity to provide information on the Rating Scale and how it might be used as an element of their commercial new construction programs in the mid-west region.

The activities in all of these regions present an enormous opportunity for promoting a stronger link between design-intent and as-built energy performance of newly constructed buildings.

3. Methodology

The methodology for this study focused on eliciting the most critical voices within various building communities, articulating their concerns and their requests for persuasive evidence, and then testing hypotheses using appropriate sets of data from buildings in California. It relied on four primary elements:

- Surveying utility program managers, architects, engineers and building owners from around the United States to identify current practices related to setting energy performance targets, tracking energy performance and their use of benchmarking tools,
- Soliciting input from a working group of individuals that are familiar with building science issues related to benchmarking to help inform the analysis of datasets to see how actual building performance tracks design intent,
- Analyzing datasets to address issues raised by building scientists, and

- Publishing the results of this effort to allow the energy efficiency community, building owners and the design community to become aware of the role of goal setting and tracking in assuring buildings actually deliver their intended performance.

4. Research Hypothesis

It was anticipated that the two audiences (pre-construction and post-construction) would have divergent concerns and the two audiences would have a vested interest in each other's expertise and opinions. Therefore, facilitating their interaction and consensus would have a synergistic result, supportive of the improving commercial new construction energy efficiency programs.

On a technical level, it was anticipated that the Energy Performance Rating Scale would give a reasonable approximation of various energy measures in office buildings.

Finally, a meta-analysis of this type would reveal some ways to offer guidance to designers, so that their intent to save energy can be more readily fulfilled when the buildings are occupied and operated.

5. Stakeholder Input

The ENERGY STAR Program has a number of features that the commercial building efficiency community[1] is evaluating for use in their efforts. This project will focus on working with that community to better understand the building label, and how it can help them achieve their energy efficiency goals.

The Institute assessed this communities needs by:

- Contacting building science and building industry professionals via telephone and electronic mail and compiled a list of their concerns, issues and questions regarding building benchmarking and the ENERGY STAR Program We also identified the type and rigor of the evidence necessary to positively assess the ENERGY STAR Energy Performance Rating Scale system, and
- Convening a working session of ten to fifteen experts who generated hypotheses that would address the discrepancy between design intent and as-built energy performance.

5.1. Survey Results

A survey of 115 building science and building industry professionals was conducted via telephone and electronic mail. The list of persons to be surveyed was compiled from utility program directories, association directories, and random selection from regional and national directories of architects and engineers. The survey was not intended to be statistically representative of each of these professions but a random sampling of practices to identify potential trends in practices.

[1] This refers to entities charged with designing and implementing ratepayer funded energy efficiency programs including utilities, state and local governments, and non-profit market transformation organizations

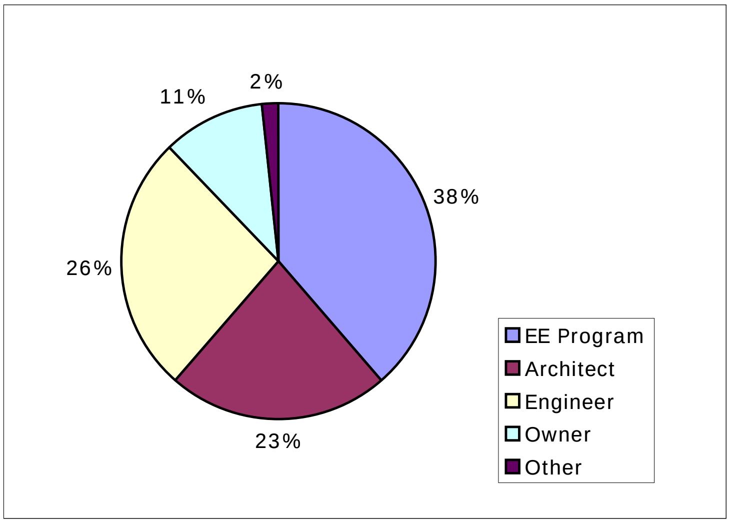
The survey is useful in identifying baseline practices for these audiences and helping to understand why these two audiences have a different view of setting performance targets and tracking building energy performance.

Of the 115 persons contacted, 57 were involved in commercial new construction programs. The remaining discussion is a summation of the 57 respondents.

The surveyed professionals reported that they were involved in influencing over 170 million square feet of new construction projects. Building owners, including property managers and developers, were most likely to decline to be surveyed. Many of the owners contacted were not involved in commercial construction efficiency programs and only managed previously built properties (not in the scope of our study).

Figure 1 shows the range of professions that were contacted. The majority of persons that we contacted were energy efficiency program managers. Owners represented the smallest category of survey respondents.

Figure 1. Professions Contacted (n=57)



The three groups; energy efficiency program managers, designers (architects and engineers) and owners reported divergent practices related to pre-construction energy efficiency target setting and post-construction energy benchmarking. Table 1 shows the practices of each group.

Table 1. Practices of Surveyed Professionals

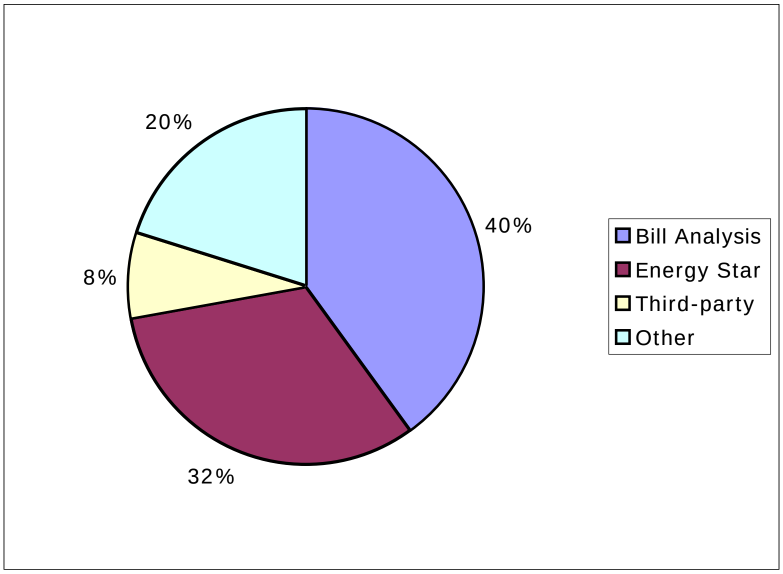
Profession	Target Only	Track Only	Target/Track	Do Nothing
EE Program Manager	59%	0%	27%	14%
Design	24%	10%	41%	21%
Owners	17%	33%	0%	50%

The practices of the professionals in the survey showed that the energy efficiency program managers primarily set targets for new designs while the majority of owners involved in new construction either did nothing or tracked energy use. Designers reported they were involved in both setting targets for new designs and reportedly tracked energy use after construction.

A total of 68% of the respondents indicated they set energy targets during the design phase. The majority of those who set energy targets used DOE 2 computer simulations or the Trane TRACE program as their primary tool.

Forty-four percent of the survey respondents indicated they tracked building energy performance after the building was constructed. Figure 2 shows the primary tools that survey respondent's use.

Figure 2. Energy Tracking Tool Practices (n=25)



Respondents indicated they performed bill analysis to track the energy performance of their buildings. The ENERGY STAR Energy Performance Rating Scale was the second-most used method of tracking building performance. Other responses included using third parties to do the tracking, spreadsheets and DOE 2 simulation. Building owners were the primary respondents who performed bill analysis while energy efficiency program managers were the primary respondent to use the Energy Performance Rating Scale.

The results of the survey support our hypothesis that these groups of professionals have divergent concerns. The energy efficiency program managers were concerned with designing and delivering improvements in targeted energy savings on new construction projects. The design community was interested in using targets to meet or exceed building codes and, when asked, assist their clients in understanding how their buildings performed. Owners that were involved in energy efficiency programs were most interested in the bottom line energy use of their buildings.

5.2. Working Group Discussion

A group of thirteen building science experts was convened to discuss the proposed analysis methodology and to identify the key questions that should be answered. The group raised the following issues in the meeting.

5.2.1. Development of design decisions

Design teams use a wide range of approaches to develop design decisions. This range of approaches needs to be understood in order to interpret the results. In particular, the analysis needs to understand how the design teams set energy targets for each building that is analyzed. For example, did the design team us a manual or automated approach to setting the baseline energy use in order to establish their energy target.

5.2.2. How the buildings were simulated

Discussion of the issues related to how the simulation results accounted for non-regulated loads. Non-regulated loads are plug loads, process loads, outdoor lighting, etc. that fall outside the scope of most building energy codes and utility new construction programs. It was suggested that the analysis properly track and account for these loads when developing a percent above or below baseline.

5.2.3. Datasets used

There was concern about the ability to gather datasets that include both predicted performance and utility bill information. While this data was readily available for buildings in California, data for buildings outside California would have to be obtained on a case-by-case basis.

5.2.4. Dataset analysis

The analysis to account for the following issues:

- The baseline will vary by region but the benchmarking tool is national in scope. The results should be segmented by baseline to best reflect any comparison between design-intent and as-built performance.
- Quality control and assurance must be rigorous. End-uses, schedules, etc. can greatly affect the predictions.
- The time after construction is critical. Buildings usually take a year to “settle down” before utility billing data accurately reflects as-built performance.
- The analysis must go beyond the simple comparison and be able to explain the range of results. For example, was there a rigorous commissioning procedure done on a particular building? What are the ranges of O& M practices

6. Analysis Methodology and Results

The overall goal of the data analysis is to identify the relationship (if any) between the design intent and the energy performance of the building. This can be translated into two key elements:

- Design intent typically focuses on the efficiency of the building as compared to baseline. In this analysis, the baseline is defined as the percent above or below California’s Nonresidential Standards.
- Energy performance typically focuses on the energy intensity of the building. In this analysis, the energy intensity is based on the Energy Performance Rating Scale (Hicks 2000).

The basic objective of the analysis is to compare energy savings (as a percentage of baseline) with the Energy Performance Rating Scale. The overall steps in the data analysis process were as follows:

- The predicted kWh and Therm values for 157 office buildings in California constructed between 1992 and 1998 were developed from calibrated DOE2 for three conditions: as-constructed, minimum code (Title 24) and as-operated.
- The kWh and Therm values were provided to EPA for analysis using the Energy Performance Rating Scale.
- Regression analysis was used to examine the strength of the relationship between the expected energy savings and the Energy Performance Rating score.
- The percent above code versus Energy Performance Rating score comparison results were examined, and explanations for the results were developed.

The Energy Performance Rating Scale adjusts the energy consumption of a building by factors that were determined by EPA to be the most significant variables in normalizing energy use across US buildings. The key factors used in the analysis of newly constructed office buildings in California compared to the 1995 Commercial Energy Building Energy Consumption Survey (CBECS) (EIA 1998) are summarized in Table 2:

Table 2. Key Factors in Analysis of Office Buildings

Value	New CA Offices	CBECS
Occupant Density (people/1,000 sf)	4.03	2.52
Personal Computer Density (PC's/1,000 sf)	2.41	2.17
Operating Hours/Week	58.5	70
Site End Use Index (kBtu/sf/yr)	89.3	104.3
Average Energy Performance Rating Score	64	50

A scatter plot representing data for each building in the study was prepared. Figure 3 shows the results of an analysis comparing the as-constructed of 157 office buildings in California to the Energy Performance Rating Scale.

Figure 3. Office Electric "as-constructed" Savings vs. Rating Scale Score

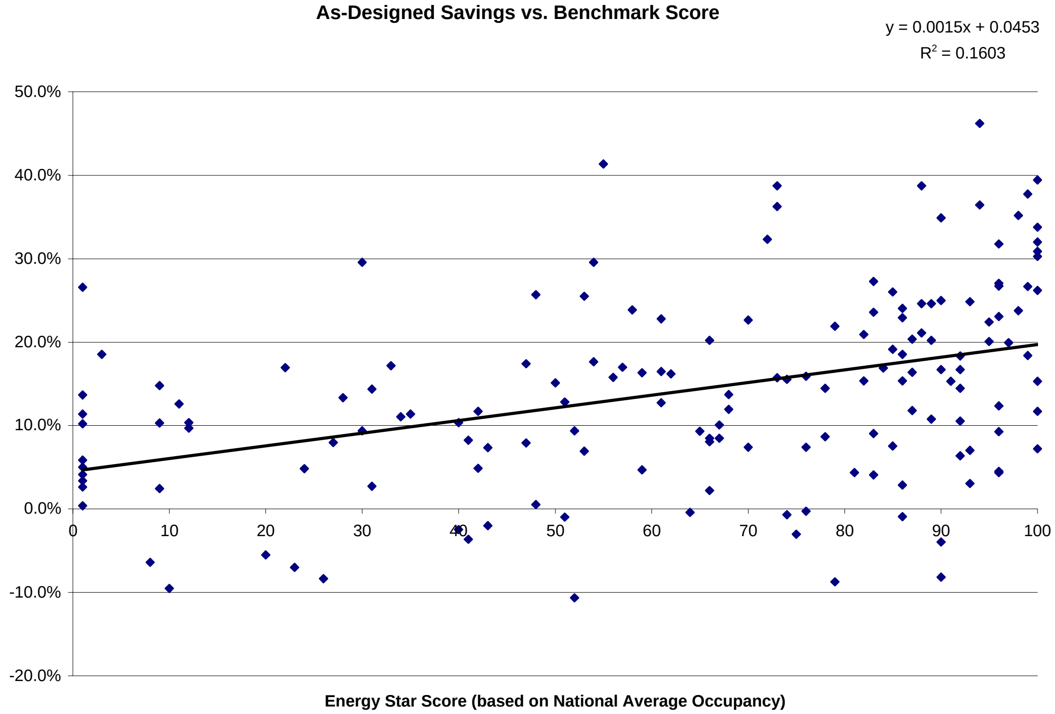


Figure 3 uses the "as-constructed" data to compare to the benchmark score. The as-constructed data is a simulation of the building with efficiency measures installation verified by a site visit. The schedule for building operation was not calibrated to energy bills. The as-designed data set did not account for natural gas use but for commercial office buildings in California, consumption is too low to significantly affect the score.

The as-constructed data was the most available data for use in this study because the original building simulations, when done, were not available in the dataset. The Pacific Gas and Electric Company, through their interaction with the Institute, has initiated a study to gather design intent on a subset of California buildings.

Figure 3 shows that low energy consumption (as shown on the x-axis with 1 being the highest consumption and 100 being the lowest) does not correlate well with energy efficiency (shown on the y-axis with 0 equal to minimum code).

The differences are likely due to assumptions about building operation, thermal massing and non-regulated energy consumption (plug loads, etc.). These assumptions can greatly affect the total energy bill, even if energy efficient lighting, windows and HVAC systems are present.

Figure 4. As-Operated vs. Rating Scale Score

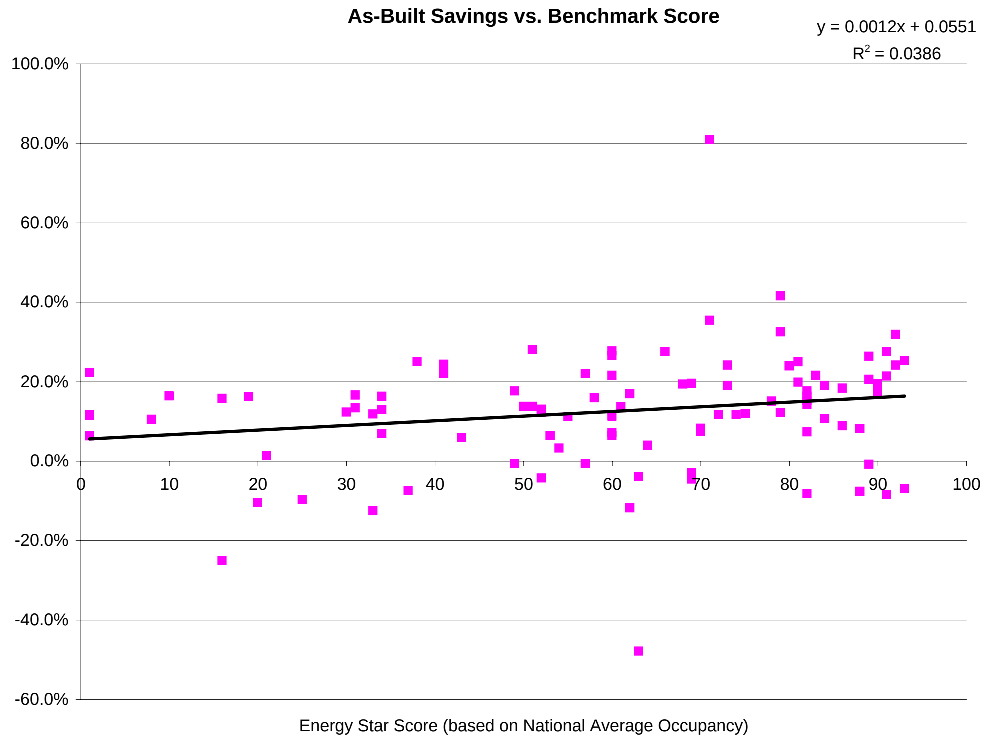


Figure 4 uses the "as-operated" data to compare to the Energy Performance Rating System score. The as-operated data is the result of a calibrated simulation of the building with efficiency measures installed. The building simulation data was calibrated to twelve months of gas and electricity energy bills.

The reason that calibrated simulation results were used is to be able to make an accurate comparison between what would have been required by minimum code (Title 24) versus how the building actually performed. The "as-operated" simulation results are, in effect, the same as entering 12 months of utility bill data.

Even correcting for building operations, the data shows a similar discrepancy between building energy efficiency and performance. It also shows fewer outlying buildings (i.e. buildings with very high or very low scales compared to Title 24) suggesting that new office buildings in California are performing closer to their design intent (as defined by Title 24).

Figure 5. Energy Performance Rating Score Comparison

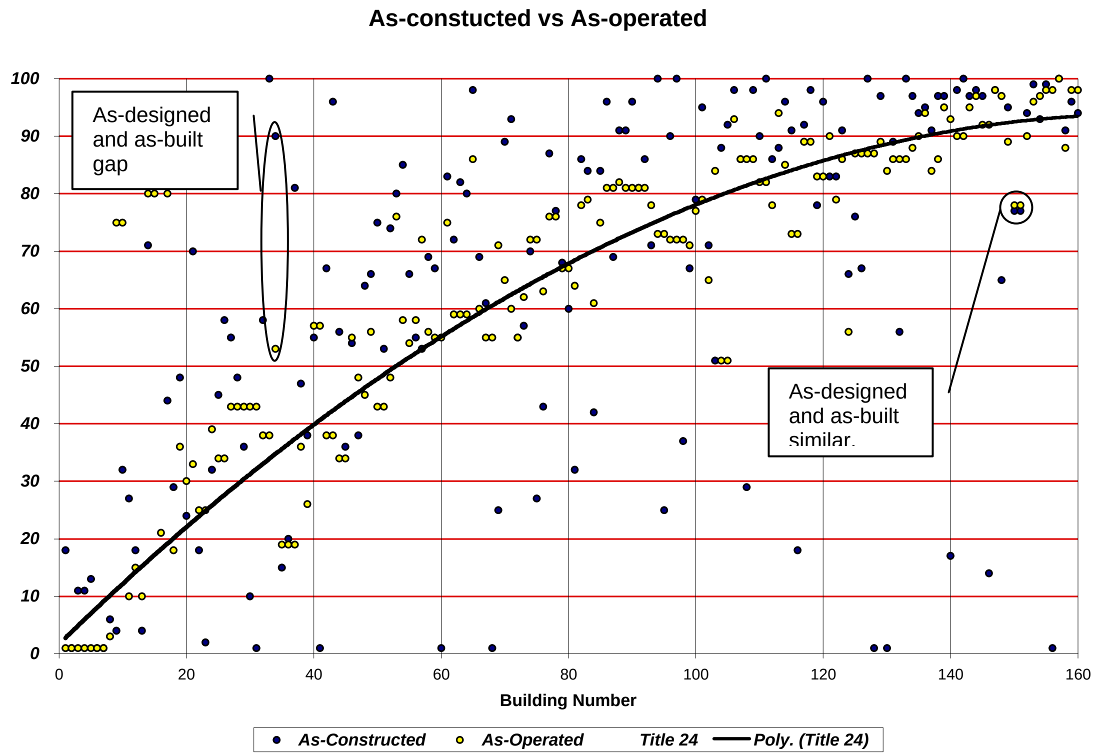


Figure 5 show a comparison of buildings with as-constructed, as-operated and Title 24 Energy Performance Rating scores. The data shows a much stronger correlation between as-built and Title 24. This suggests a strong correlation between predicted energy efficiency using Title 24 and actual building energy use. In addition, office buildings are an average of 4% more energy efficient than required by Title 24.

This data also confirms the challenge of predicting building performance using design intent. The as-designed data points for each building. In most cases, the Energy Performance Rating score dropped from design intent to as-built performance. This drop is most likely related to operational assumptions made in the design process that failed to occur once the building was constructed and operated.

7. Discussion of Results

The results of this analysis raise some interesting questions about new California office buildings. This discussion will provide some insight into the results:

Do California office buildings perform better than average?

In both the as-designed and as-built buildings, California offices scored an average Energy Performance Rating score of 64. The national average score estimated by using CBECS for similar new buildings constructed since 1980 is 55[2]. This shows new California office buildings performing on average 9 points higher than national average newer office buildings.

Why is there little correlation between energy efficiency and energy performance?

Energy efficiency is defined in this study as the presence or absence of measures in a building when compared to Title 24 using a calibrated computer simulation. Performance is evaluated using the Energy Performance Rating Scale. The results support previous studies (Hicks 2000) that the presence or absence of energy efficiency measures alone does not define building energy performance. The corollary is also true; a high Energy Performance Rating Scale score does not constitute an energy efficient building. From the perspective of overall greenhouse gas emissions, a higher Energy Performance Rating Scale score means the building, on a per square foot basis, releases fewer greenhouse gas emissions than it's peers.

Does this mean that building codes and public benefit programs are rewarding poor performance?

Figure 6 shows the relationship between Energy Performance Rating Scale and simulation results. This relationship was developed by looking at the DIFFERENCES (rather than absolute results) of scores for two cases: as-operated and Title 24. This figure shows that when the as-operated building simulation has energy efficiency measures replaced with measures that exactly meet Title 24 (e.g. lighting power levels, equipment efficiency levels, envelope characteristics), the difference in Energy Performance Rating Scale score somewhat correlates with the percentage savings from Title 24 derived from calibrated simulations.

This result suggests that the Energy Performance Rating Scale generally responds to the presence or absence of efficiency measures in a similar manner to the simulation results. If this is the case, then it may be possible that while the public benefit programs are rewarding achieved efficiency results, they may also be missing another dimension of potential savings – building performance. The fact that a comparison of the absolute score shows a poor correlation but the difference in scores is dramatically better points to the need to further study. To be useful to public benefit programs, a causal relationship between potential policy actions and building performance improvements needs to be established. If this relationship can be established, it would open a new range of program opportunities for public benefit programs.

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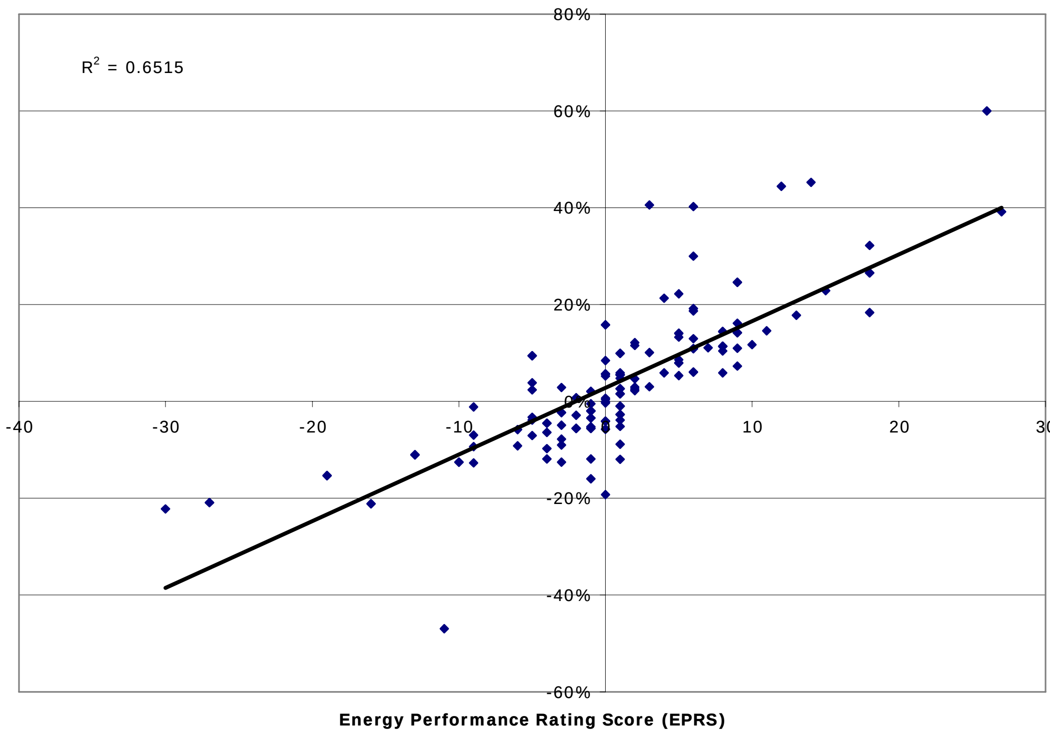
[2] Correspondence with Thomas Hicks, US Environmental Protection Agency May 2, 2002.

Figure 6. Relationship Between As-operated Score and Title 24 Score



Is there a difference between simulated design intent and as-built performance?

The answer is yes, if you are evaluating building performance using the Energy Performance Rating Scale. The predicted energy consumption based on simulation results did not correlate with actual energy performance.

But if you are interested in the energy efficiency of a building, design intent and as-built performance track considerably well. This means that buildings with energy efficiency measures installed performed better than that same building without the measures.

The issue of building performance (low energy consumption) vs. energy efficiency vs. simulation results is a challenge to new construction program design and the Energy Performance Rating Scale. Building performance takes into account a variety of factors including the efficiency of the building, design parameters not accounted for in the analysis but that contribute to the overall building performance (orientation, shading, etc.), and the intensity of the business operations within the building.

For example, a designer that has the flexibility to re-orient a building to take advantage of climatic conditions may produce a building design that has lower overall energy use but may not get credit for that component of their design as an "efficiency measure" in the new construction program. If the new construction program tries to give a credit to those features, then a building site that doesn't have the flexibility to work with the climate (urban development) may not qualify for new construction program benefits regardless of the level of efficiency incorporated into the design.

The policy question comes down to the purpose of the new construction program. If the purpose is to require a consistent level of technical efficiency measures in every building, then measuring the energy efficiency (percent above code) of a building in a new construction program achieves that goal, but allows a wide variation in actual energy usage depending on the intensity of building use, its hours of operation, its level of maintenance of energy-related controls, and its site constraints.

If the purpose of the new construction program is to ration energy, then a metric based on total energy use (such as the Energy Performance Rating Scale) best achieves that goal. This goal is achieved at the expense of requiring vastly different levels of investment in efficiency measures or design changes in order to meet the new construction program goals —levels that depend on all the factors listed above, and more. Experience suggests that the political cost of a rationing approach is too high for minimum code requirements but may be practical through voluntary programs.

For the reasons stated above, it is important to make the distinction between building energy efficiency and building performance. The analysis shows that the Energy Performance Rating Scale is a poor indication of the energy efficiency potential of a building. For example, an identical building with identical tenants and operations will perform better with higher efficiency equipment, regardless of the tenants operating profile. The corollary is that an energy efficient building may not perform as well as a less efficient building given different tenants and operating profiles.

Is there an explanation for these differences?

A number of hypothesis have been raised regarding these differences. They include:

- Factors that relate to the Energy Performance Rating Scale dataset and algorithms,
- Factors that relate to the operations and maintenance of the facility, including control system operations, and
- Factors that relate to design flaws in the mechanical systems that result in-efficient operation.

Issues about the dataset and algorithms used to develop the Energy Performance Rating Scale have been discussed amongst the energy efficiency community (Hinge 2002, Brown 2002, Piette 2002). Special features of certain buildings or climate locations that are unique to their particular buildings or properties (and not accounted for in the Energy Performance Rating Scale) are the principle issues raised. Further investigation many times leads to other conclusions such as operating or design characteristics that led to the apparently low Energy Performance Rating score.

The operations and maintenance has been identified as the reason for an apparently lower Energy Performance Ratings Scale (Hinge 2002) in some buildings. Evidence shows that maintenance practices can be tracked using the Energy Performance Rating Scale. The analysis done for this study accounted for maintenance practices and doesn't explain the differences identified in the study.

Design characteristics (beyond individual measure efficiency) are being investigated by a number of groups including the Iowa Energy Center and California Energy Commission (through their Public Interest Energy Research (PIER) Program). In addition, benchmarking individual loads was shown to be valuable in the design process (Brown 2002). These investigations are focusing on the building control system and design problems that introduce large long-term inefficiencies in mechanical systems. In all cases, these inefficiencies may be built into the building and are very difficult if not impossible to correct without major renovation. Examples include improper duct design, chilled water plant sizing and control, or improper air-side and water-side design parameters.

There is no direct evidence that any one of these factors is the reason for the differences. The current hypothesis of the building science community is that these differences are the result of design inefficiencies not typically recognized by code or new construction programs and unique functions that the building occupant is demanding from the building but is not accounted for in the Energy Performance Rating Scale algorithms.

8. Implications for New Construction Programs

The challenge in using the Energy Performance Rating Scale in new buildings is that they must be "existing" buildings (i.e. operated for at least two years) before a meaningful score can be generated. In addition, design targets based on Energy Performance Rating Scale scores are difficult to interpret. Variables including maintenance, operations, tenant demands and design flaws not accounted for in simulation programs can greatly affect the final score. Finally, typical new construction policies promote energy efficiency (building energy codes and new construction programs). The results of this paper suggest a poor correlation between these two approaches.

Even with these challenges, creating targets for the design process is an important step in producing buildings that reduce greenhouse gas emissions. The Energy Performance Rating Scale can enhance new construction programs by incorporating steps 2 and 3 into the traditional design process (shown as step 1).

1. A performance-based efficiency target is met based on codes or standards, the local utility new construction program, national tax credit or other criteria.
2. Target Finder is used to establish a score based on results of the energy performance analysis of the proposed design (from step 1).
3. The Benchmarking Tool is used to assess if the Target Finder score was realized by the building after one year of reliable energy bills are available.

This new steps can easily be incorporated into new construction programs (code and beyond-code) to provide a simple means of verifying the intent of a design is realized in building operation. It fits well with existing processes as target setting typically occurs at the beginning of a project while building owners are more likely to track performance using energy bills.

For example, a 60,000 square foot office building is modeled to exceed an energy code by 15%. The building uses national average occupant and personal computer densities. Using ENERGY STAR Target Finder, the building scores a 53 on the ENERGY STAR Rating Score scale. Once the building is constructed, the building operations team enters the actual building occupancy data, hours of operation and personal computer density, along with 12 months gas and electric bills into the ENERGY STAR Benchmarking Tool. If the building score is less than 53, the building operations team should investigate operating practices because the building is not performing to its design intent. If the building scores better than a 53, the design intent was realized but there may be additional opportunities to improve the overall performance of the building.

As noted earlier in this report, a building that went through a thorough design process, has efficiency measures installed and operates them correctly will likely meet or exceed the initial design target and in many cases, fall into the top 30% of energy performing buildings.

9. Conclusion

Commercial new construction energy efficiency programs do not consistently deliver low-energy buildings as defined by the Energy Performance Rating Scale. While the goals of new construction programs go beyond low energy bills, the correlation between design intent and building performance suggests a larger structural issue within the process of predicting building performance and benchmarking energy use. There are two key elements of this structural gap:

- Design intent is determined using simulation tools that automatically generate baselines based on the overall minimum efficiency allowed by an energy code. The variation from this baseline (efficiency) is the basis for many new construction program designs (Johnson 2000). This process rewards the efficiency of a building but may not fully account for the energy performance of the building.
- The Energy Performance Rating Scale does not attempt to address every aspect that a building must meet to be a productive asset. Some aspects may include satisfied occupants, meeting all organizational goals of the company, and being an asset to the community (Heerwagen 1998). This means that certain classes of buildings may use more energy to improve their overall productivity as a capital asset. The use of average building performance as defined by the Commercial Building Energy Consumption Survey (CBECS) makes it difficult to demonstrate if the building is a poor performing building or that it is an energy-efficient performer given the building's particular class.
- The gap between simulated efficiency and actual performance needs further investigation to better understand how to affect building performance in the design and construction process. Further investigation of the California data set may help identify the magnitude of this gap and what design factors directly contribute to poor building performance. This investigation needs to be coordinated with PIER and other research looking at design contributions to building performance.

This study suggests a new strategy is needed to better capture the lost opportunities in new construction and deliver built environments that benefit future generations. This new strategy should focus on using the Energy Performance Rating Scale to provide:

- The *building design team* with marketing resources to support the sale of value added services to building owners through the ENERGY STAR brand and to establish a target using the Energy Performance Rating Scale based on the simulated performance of the building design. It also provides them an energy intensity target to evaluate the performance of the entire design, not just individual components. This verifiable target then becomes a key part of the quality assurance process by the building operations team.
- The *building operations* team can utilize the Energy Performance Rating Scale to provide the building owner with assurances that the energy targets established in the design process were implemented and are delivering the intended performance.

Incorporating this strategy into new construction programs will help ensure that all of the benefits of energy efficient design are realized by the building operating team.

10. Recommendations

- *ENERGY STAR Needs to Differentiate Performance from Simulated Efficiency*

One is a potential to save and the other how the building energy efficiency measures PLUS organizational needs PLUS the design perform relative to energy use. This needs to be a clear part of the Energy Star message (similar to other EPA products including homes, automobiles and appliances).

- *Promote Efficiency AND Performance*

Promote methods that link all aspects of the design, construction and start-up/operations with good energy efficiency advice to promote the delivery of high-performance new buildings. This not only includes evaluating performance but providing references on how to improve efficiency and performance.

- *Compare the Energy Performance Rating Scale to itself within bounds*

Use the Energy Performance Rating Scale to evaluate how a building does before and after construction and/or commissioning to assess improvements rather than comparing only to a national database. This could also be done for existing buildings to evaluate the impact of installing new energy efficiency measures. The Energy Performance Rating Scale seems better suited to self-comparison (as is done in building simulation). This approach needs to specify a lower limit if used in new construction, as on average, new buildings are performing better than average.

- *Follow-up Research – Disaggregated Scores and Organizational Role*

Select a subset of the California buildings and look at the role of the organization in overall building performance. This could include hours of operation, type of work, etc. to disaggregate the Energy Performance Rating Scale scores and develop a better understanding of what elements of a disaggregated score may be contributing to an energy efficient building appearing to have lower overall performance. This research should be done in conjunction with major sponsors in the NE, NW and CA to help them better understand the impacts of efficiency programs on overall building performance.

- *Follow-up Research – Disaggregated Scores and Design Role*

Select a subset of the California buildings and look at the role the design played in overall building performance. This could include building orientation, chilled water plant sizing, air-side system design, control performance, etc., to disaggregate the Energy Performance Rating Scale scores and develop a better understanding of what elements of the score related to building system design components.

11. References

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