Ongoing energy performance: ratings and savings for existing buildings

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Abstract

Energy Design Assistance programs which seek to help utility customers understand savings opportunities in design have helped to realize significant energy savings in the United States for more than 20 years. Utilities are now trying to help their customers find additional savings and opportunities by leveraging the existing relationships and energy models created as part of these programs. *Ongoing Performance* is a process currently being piloted by two utilities and under consideration by others that does just that. This pilot program is being launched at the same time as many state and national organizations are also focusing on the energy use of existing buildings and how to benchmark the usage.

Candidates are initially targeted using some simple benchmarking, so that consulting and incentive dollars are spent first on the buildings with the greatest opportunity for savings. Using utility billing information actual building performance is benchmarked against the expected performance from the design energy models that were created as part of utility sponsored energy efficiency programs. If the meter usage shows 20 % or more energy use than the model, potential exists for cost effective energy savings opportunities in operations.

The original Baseline and Proposed energy models are updated to reflect the current operation of the building. These updates are done using the utility billing information and walkthrough auditing techniques. The updated models account for changes in occupancy, weather and even space usage since the design period. Current savings for the original energy efficiency investment can then be calculated, but the real power lies in using the actualized Proposed Building Model to help the building owner, operator and utilities understand potential energy savings opportunities in the existing building.

Customers have been excited participants in the initial pilots and significant energy savings in both low cost operational adjustments and future capital planning have been found and are being considered for implementation. This paper will detail the process and provide a case study example of a completed project.

Introduction

Utility companies which in the Midwestern United States supply electricity and natural gas to buildings offer *Energy Design Assistance (EDA)* programs to help customers design in energy savings opportunities when building a new building or doing a major renovation. These programs have helped to realize significant energy savings in the United States for over 20 years. As the utilities are being asked to help their customers achieve even greater levels of conservation and as goals such as the Architecture 2030 challenge are developed, utilities are looking for ways to find additional savings. The process discussed in this paper, *Ongoing Performance*, is one opportunity being piloted by a Midwestern utility.

This paper discusses current *EDA* programs and how they relate to building asset ratings as well as how they feed into operational ratings and new *Ongoing Performance* opportunities. The energy models used throughout this continuous process from design through construction and occupancy are defined as the timings of their evolution relative to the design, construction and operation of buildings. Asset and operational ratings for buildings are another way to describe the process. *EDA* operates like an asset rating system in that the building operational characteristics are developed with the utility, refined over the years of the program and held constant between the models. *Ongoing Performance* operates like an operations rating system in that the actual building operations are used in the models and opportunities are studied for improved operations.

This *Ongoing Performance* process examines the energy performance of buildings that participated in *EDA* and assists owners and operators with achieving increased energy savings. The energy use of the building with the actual occupants, equipment and schedules is used to update models and additional strategies are proposed to help reduce the energy use of the building given the current operational needs. Energy models and online tracking tools are used to inform owners through this process. This is a forward looking process, concentrating on reducing the overall energy use of the building in operation. The process involves not only an energy consultant, but also the utility, building owner and operators. A case study is presented to further illustrate the potential savings.

Model Definitions

Energy model simulations are defined below as they relate to both *EDA* and *Ongoing Performance*. Some energy models are developed during design, while others are created, as modified or new models, based on operational findings. Operational models are compared to the actual metered use. These simulations provide consistent reference points for building design and operation as they relate to a baseline minimum standard. The following terms will be used throughout the remainder of this paper.

M1 – EDA BASELINE

The baseline model developed for the *EDA* program uses a standard typical meteorological year (TMY2) weather file. This model follows the State Energy Code in place at the time of design. The model is operated according to criteria in the code and discretionary parameters such as temperature setpoints, equipment loads, and schedules not governed by the code, but determined by the Design Team, Owner and Utility. This model sets the operational parameters and the weather for the remaining EDA Models, M2 and M3 described below.

M2 – EDA SELECTED BUNDLE

Contains the set of energy efficiency strategies selected by the Design Team and Owner during the design and uses a standard TMY2 weather file. This model has the same operating and code parameters as M1. This definition is provided for context but this model is not used in this paper.

M3 – EDA AS-VERIFIED

The as-verified model adjusts for physical design changes (implemented energy efficiency measures), but otherwise uses the same operating and code parameters as M1 and uses a standard TMY2 weather file. The difference between the M1 and M3 models is the projected savings calculated upon construction completion, based on the design phase occupancy and weather expectations.

M4 – ADJUSTED BASELINE MODEL

The adjusted baseline model is the M1 model updated with operational information from the survey and site visit, using actual weather from the meter period. This M4 model uses the State Energy Code in place at the time of design and then is adjusted for the operational parameters and building characteristics found during the operational walkthrough.

M5 – AS-OPERATED MODEL

This model reflects the actual building as it is operating today, given the depth of the operational survey and walkthrough. The model has the same operating parameters and weather as M4, but includes the implemented efficiency measures. The difference between the M4 and M5 models is the updated projected savings from the EDA studied measures.

M6 – OPERATIONAL POTENTIAL MODEL

This model reflects the set of energy efficiency strategies selected by the Owner for savings beyond current operations. These strategies may be operational changes, system updates, or capital improvements. The model has the same operating parameters and weather as M5, but includes the efficiency measures planned for implementation. The difference between the M5 and M6 models is the future projected savings.

METER

The meter represents the actual utility bill for the building. The available meter data from the utilities is monthly billing information, showing the peak demand and total consumption within each month. The meter data reflects the year of operation studied and is represented by the M5 model.

Energy Design Assistance Programs

Energy Design Assistance (EDA) is provided to owners and design teams to evaluate alternative energy efficiency strategies for new and renovated building projects during design. An *EDA* program is frequently one program in a portfolio of programs offered by utilities to encourage energy efficiency and conservation. In some areas, state regulations require utilities to assist customers with energy conservation. Regardless of local regulations, efficiency programs have proven to be cost effective ways to reduce energy loads and delay the need to build new power plants. All utility customers support these programs on their energy bills through cost recovery mechanisms. Building owners participate because they get valuable energy modeling information and there are no further charges to them for program participation. There are also further cash incentives available for implementation of efficiency measures beyond minimum energy use baseline requirements.

During *EDA* participation, Owners and Design Teams select a set of energy efficiency strategies during the design of the building, and the program consultant verifies inclusion of the selected strategies after construction completion. In response to the installed energy efficiency potential, utilities provide cash incentives upon construction completion for the implementation of these strategies to help their customers reduce energy use.

Program participation concludes with the one time payment of the incentive to the building owner and tracking of projected savings based on the design-stage operational attributes. Of course, the building owner retains ongoing operational decisions. As a result, energy consumption and actual savings can migrate from the estimates due to actual occupancy, operations and weather conditions.

The *EDA* program energy models are developed during early stages of design, in order to be timely during key decision-making periods. These early models include the owner and project team's best estimates for how a building that has not yet been built will be used. They also often include default information on certain building characteristics such as outside air and supply air quantities. The State Energy Code is used to develop other baseline information. This is necessary to allow for a common starting point for all projects and also to allow the models to be developed at a time when they can be used to influence the design.

Figure 1 portrays the variables for the energy models in terms of three areas: physical design parameters; operational parameters; and weather parameters. Each set of variables contains preferences or requirements that are either known, discovered during operation or are assumed. Moreover, each of these three sets of variables interacts with each other. The initial models developed during design use TMY2 weather files and the owners' best assumptions for operations. The operational parameters are held constant between the baseline (M1) and as-verified bundle models (M3). The physical design is studied in great detail and the M3 model reflects the physical (as-built) design of the building at the time of construction completion.

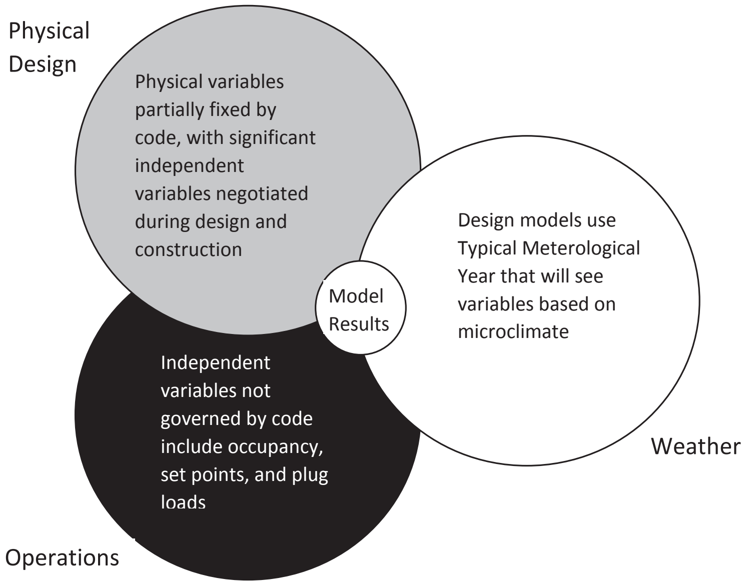

Figure 1. Energy Modeling Variables.

Ongoing Performance in the Context of U.S. Building Rating Systems

Energy Design Assistance is similar to an asset rating, the difference being that *EDA* looks at a number of different options to optimize the asset for that owner and location. The asset rating simply takes the final design and compares it in a standardized way to other buildings. *Ongoing Performance* is similarly like an operational rating taking into account the occupants and their impacts on the building. Both of these work to quantify the performance of the actual building for the owner and operator.

States and municipalities around the United States are beginning to require either public buildings or all commercial buildings to rate and disclose their energy use. Many jurisdictions use ENERGY STAR®, an existing building rating system by the Environmental Protection Agency that compares a building's energy use to a statistical model based on a survey of 4,859 buildings done in 2003. But ENERGY STAR® only covers 15 building types. When exploring benchmarking for public buildings, Minnesota found that it did not cover ¾ of the public buildings in the state because of their mix of uses, hours and other factors.

Building ratings fall into two categories. Operational ratings rate the actual energy consumption of the building, including the effects of a building's physical attributes, operations and maintenance and, occupant behaviour. Asset ratings address only the physical attributes of the building. Asset ratings may be advantageous for real estate transactions where the occupant will be a variable affecting other dynamic variables. Operational ratings may be more informative in helping current and future operators of a building judge how well the building is being or can be operated.

The asset rating of a building and operational rating of a building may differ substantially. A building may have very high energy consumption despite having efficient equipment if that equipment is operated poorly. This could lead to a high asset rating and a low operational rating. Likewise, a building may have very good energy performance despite having less efficient equipment if the users are energy aware and good operators. For instance, occupants who carefully turn off the lights manually whenever there is sufficient daylight would have an impact on the operational rating, but not the asset rating. An automatic dimming daylighting system that was not properly calibrated on the other hand would have a beneficial effect on the asset rating, but may not turn off the lights very frequently and thus have little impact on the operational rating. Comparing the asset and operational ratings can give a building's owner an indication if fine tuning the operations and calibration or upgrading the building systems would have a greater impact.

METHODS OF COMPARISON

Rating systems also can be categorized by their method of comparison. A building can be compared to itself during a previous time period, a population of buildings, or to a purposeful construct such as an energy code. A building compared to itself is the first method.

The second and most direct and easy to understand comparison is to a peer set of buildings. Comparing a building to similar buildings, with similar use, and weather allows you to compare how that building performs compared to the mean of all the buildings, or what percentile it falls into. This requires a sufficiently large number of peer buildings both in terms of use and weather. One way to overcome this challenge is to use statistical regression to allow a building to be compared to peers with a wider set of parameters such as different hours of use, occupancy densities or weather. This is the approach that ENERGY STAR® has used. Their current data set is the 2003 Commercial Building Energy Consumption Survey that looked at 4,859 buildings (CBECs, 2008).

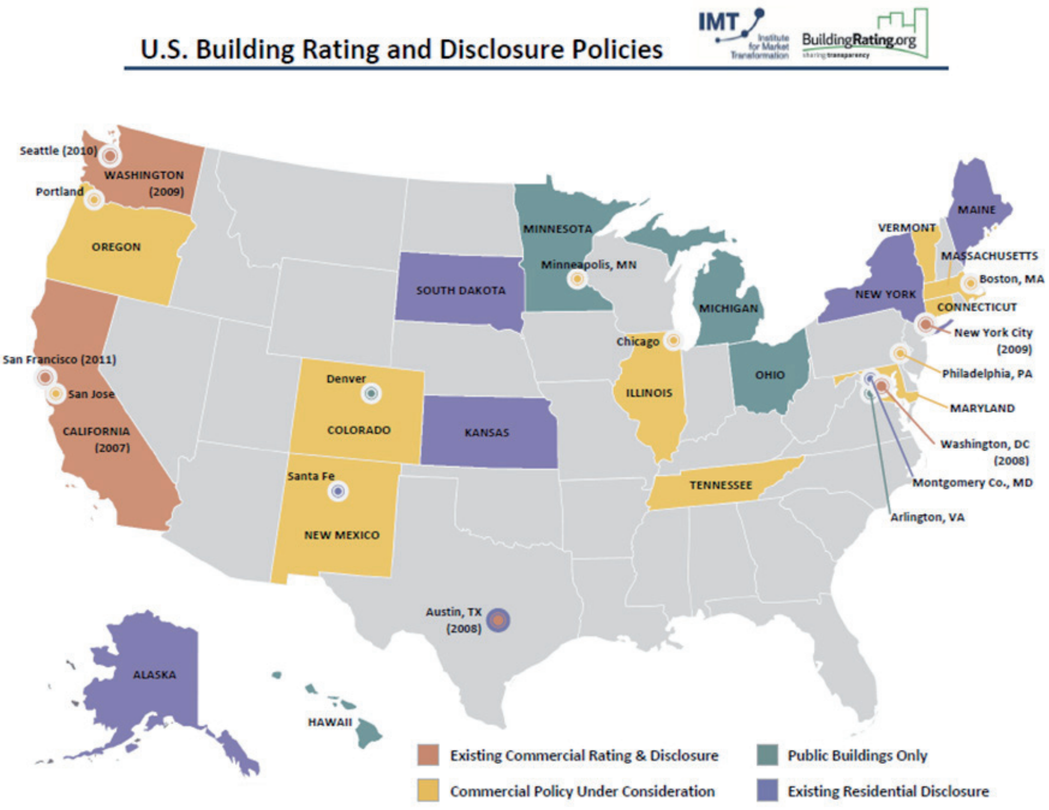

Figure 2. U.S. Building Rating and Disclosure Policies (Keicher, 2012).

A third method for comparing a building is a model based benchmark. A model based benchmark compares the actual or predicted energy use of a building to the modeled energy used for a building with a prescribed set of characteristics. That prescribed set can represent a building built to the current energy code, or it can represent a typical existing building's attributes. This gives the advantage of not requiring a large sample of peer buildings and can be codified as an objective standard.

All three methods provide a useful basis for sorting and rating buildings. With multiple methods for comparing the relative energy performance of dissimilar buildings, owners of multiple buildings of different types can compare and screen for buildings that may be the best candidates for energy efficiency retrofits or simply improved operations.

Asset Models/Rating Systems

The major benefit of asset ratings over operational ratings is that an asset rating will not fluctuate due to a change of occupancy or operational settings. Excluding a retrofit, the asset rating of a building will be the same regardless of the occupant. This allows perspective tenants to compare different spaces without the impact of the existing tenants on the comparison. ASHRAE 90.1 and most other energy codes are essentially asset ratings for buildings during the design phase. In their performance paths they compare the projected energy use of the building to a baseline building's energy use holding occupancy, operations and weather constant between the two. This allows building designers to compare different options to understand trade-offs of first cost and energy efficiency. This is the goal of most current *EDA* programs.

NATIONAL ASSET RATINGS

Several organizations are working on establishing asset ratings that are more appropriate for existing buildings. ASHRAE is developing a joint asset and operation rating called Building Energy Quotient (bEQ). Currently the operational rating portion is publicly available, and the asset rating portion is under development. The operational rating is discussed in that section of this paper (ASHRAE, 2012).

The U.S. Department of Energy piloted an asset rating tool in the fall of 2012. Their web-based asset rating tool allows a building engineer or other professional to enter information about the existing building and receive a rating as well as suggestions of which systems could be improved. The DOE intends to launch this system as a free web-based tool in 2013 for use by the general public (McCabe, 2012).

ONGOING PERFORMANCE ASSET MODELING

The comparison of design models (M3) to metered use is not a good comparison or benchmarking exercise and a very common mistake that leads to undervaluing pre-construction modeling. The comparison of design models (M3) to metered use can only help to illustrate the value of creating updated models based on actual operation. When this comparison is made, the "operational sphere" from Figure 1 is where most of the change occurs since there is no energy code for operational characteristics. However, this is an essential step toward an accurate performance rating and future performance enhancements.

Operations Ratings

Operational ratings compare the actual energy consumption of a building to a benchmark of some type, either statistical, peer buildings, or an energy model.

In the United States ENERGY STAR® is the most commonly used operational rating. Most other operational ratings, including ASHRAE bEQ, Green Globes, and LEED Existing Buildings: Operational and Maintenance use ENERGY STAR® as their basis. To date there are over 20,260 buildings and plants that have received an ENERGY STAR® rating (ENERGY STAR, 2012). The rating is available to buildings that use less energy than 75% of similar buildings from the 2003 CBECs survey. These ratings are available for 15 building types.

Ongoing Performance

Ongoing Performance is a continuation of *EDA*. Through this process, projects which have been modeled during the early design stages under *EDA*, using preliminary forecasts for parameters such as operating schedules, are revisited to further optimize the benefits of concepts identified during design. The process follows a similar consulting proposition to that of the original *EDA* discussions. The consulting uses an online energy tracking and comparison tool to screen projects, track results, and verify savings over time. The process provides information that is otherwise not readily available to either the building owner/operator nor the utility about the current building performance and options for increased energy efficiency. The process efficiently builds upon the already created energy models to achieve additional savings beyond the *EDA* process.

Four main deliverables are produced for each project, in addition to the online information available through the energy tracking and comparison tool.

- Current Building Operation Report, detailing the current operation relative to the expected operation from the *EDA* program and establishes the goal for energy savings.
- Results Report detailing strategies to achieve the energy savings.
- Implementation Report detailing which strategies will be implemented and on what schedule.
- Verification Report showing the implemented strategies and how the building is performing post implementation.

In addition a comparison of the modeled energy performance and the actual utility metered building performance over time is available online, allowing the owner/operator and the utility to see the performance relative to the goal. This reporting method helps ensure that the energy savings are realized and maintained over time. This process in effect becomes an operational rating process for the building, while showing multiple options to understand trade-offs of first cost and energy efficiency.

BACKGROUND

Enrollment in the initial *EDA* program creates two assets for the utility; an energy efficient building and a corresponding energy model. *EDA* helps to achieve buildings in the utility territory that are more energy efficient than the current building code and it provides a sophisticated energy model that contains significant information about the building, including its shape, systems, and intended operation.

Each building, as an asset, has the potential for efficient operation. However, since the building operators are not always part of the discussions during the *EDA* process, the continuity between creating an efficient asset and operating it efficiently can be lost. Energy savings are also possible during building operation through behavioral changes of the building operator and the building users.

The energy model, as an asset, can be used to provide information and analysis to the building owner and operator to identify opportunities for additional energy savings compared to business-as-usual operation.

GOALS

High level goals of the *Ongoing Performance* process are to leverage the original *EDA* energy model to help the customer understand how well their building could perform and to achieve greater energy savings in the ongoing operation of recently completed buildings. Use of the online tools helps to maintain savings over time.

CUSTOMER BENEFITS

The benefits to the customer include: consulting from the utility on their building's current performance and potential strategies for reducing energy consumption; reducing the energy operating cost of the building by implementing strategies with the best return on investment; online tracking of the building performance over time; and one time cash incentives to the building owner from the utility for reducing energy consumption.

UTILITY BENEFITS

The benefits to the utility include: additional energy savings during building operation; online screening to select appropriate projects; online tracking of the building performance over time; ongoing, consistent, customer contact to help ensure program satisfaction and success; and cost-effective continued use of energy model investment from the original *EDA* analysis.

PROCESS

The process includes the following major steps: project selection; building survey and walkthrough; model updates; current operation analysis; strategy modeling; results meeting; bundle modeling; and verification. The overall consulting process is very similar to the successful *EDA* process. Each of these key components is described in more detail below.

Project Selection

Monthly utility bill data is gathered, both electric and natural gas, for a minimum of 1 year. Smart or interval utility meter data has been explored and would provide additional information for the project; however it has not been available on the projects to date. In general projects become candidates for this process a minimum of 2 years after construction completion. The reason for this is that the first year of operation is spent really learning about the building and by the second year, the operation tends to level out, giving at least 1 year of consistent operation to start to compare against the M3 model.

Table 1. Sample Project Screening.

Project Name	As-verified Model (M3) kWh Usage	Metered kWh Usage	kWh Difference	Ratio
Project A	934,370	1,007,709	73,339	1.1
Project B	1,186,461	1,492,288	305,827	1.3
Project C	727,176	1,082,100	354,924	1.5
Project D	1,325,814	1,399.091	73,276	1.1

The monthly utility bill information is compared to a weather-corrected, As-verified model (M3). The comparison is shown online as an annual usage including; total energy cost and energy consumption by fuel stream. Monthly views are also available to help determine if the differences are concentrated in a certain time of the year and how well the monthly shape of the M3 model tracks with the Meter usage. All projects are then shown on a summary screen with a Ratio of the Metered Consumption divided by the M3 Modeled Consumption. Projects with a Ratio of 1.2 or greater are initially targeted as a good candidate for *Ongoing Performance* services.

As shown in Table 1 some projects have Ratios very close to 1 and others are above or could be below. Projects with a Ratio of 1.2 or greater are initially targeted as a good candidate for *Ongoing Performance* services. In the 35 projects screened to data 47 % have a ratio greater than 1.2, 33 % are between 0.9 and 1.1 and the remaining 20 % of projects could not be compared because the meter serves more than the modeled area.

Building Survey and Walkthrough

Once a project is selected a meeting is set up on-site with the building owner and operator to review the process and begin learning about the current buildings usage and operation. The energy consultant completes a short survey with the help of the building operator. This includes details about building operation, hours of use, number of occupants, and temperature set points. This survey gathers information on the operational variables and the baseline building characteristics. Current floor plans, any Commissioning Reports and Test and Air-balance Reports are collected and access to the Building Automation System (BAS) is arranged. A walkthrough is scheduled with the building operator.

The building walkthrough is similar to an ASHRAE Level I audit (ASHRAE, 2011). Information is gathered on the lighting system(s), mechanical system(s) and the plug loads using the *EDA* verification as a starting point. Additionally, some basic building information is reviewed in the Building Automation System (BAS) with the help of the building operator and spot measurements are taken of key energy-using equipment such as fans, pumps, and plug load circuits, with the assistance of an electrician.

Information gathered is collected and recorded for use in creating the M4 and M5 models as well as for publication in the Current Building Operation Report.

Model Updates

Using the utility bill information and the information gathered through the building survey and during the walkthrough, the M4 and M5 models. This is done by modifying the models previously created as part of the *EDA* process. The results of these models are presented to the Owner and Utility in a formal meeting and are also available online.

Current Operation Analysis Meeting

This is the first formal meeting for this process. The meeting includes the building owner, building operator, any architects or engineers currently working with the owner, utility representatives and the energy consultant. The purpose of the meeting is to present the M4 and M5 results, show the relation of M5 to the current operation and set a savings goal for reducing the M5 energy use moving forward. In addition, the team reviews a list of potential strategies with the goal of adding strategies to the list for further analysis.

The strategies may include changes to the baseline assumptions, such as schedule changes, temperature setpoint changes, baseline operating parameters such as economizers, warmest zone control, airflows, etc. that were not previously directly incented under *EDA*. Other strategies may be minimal cost changes, such as fine tuning of occupancy sensors, daylighting controls, variable frequency drives, demand control ventilation, etc. This is re-optimizing the savings of these strategies that were incorporated as part of *EDA*. The final set of strategies is capital improvements. This can be anything that is on the list of strategies from *EDA* that they had not previously implemented or new technologies that were not initially available during the design. Additionally the owner may suggest strategies that either alter the building from the original design or re-optimize or re-engineer the building compared to what has previously occurred.

Strategy Modeling

Each of the strategies captured in the meeting are then modeled in isolation and compared to the current building operation which is represented by the M5 model. The strategies and M5 all use average TMY weather files for this analysis so that decisions are not influenced by the past years' weather. Doing this allows savings and potential incentives to be based on the current building operation, helping to prevent the Utility from counting the same savings twice.

A Results Report is then created along with an interactive tool to be used during the results meeting to understand the impact of different strategy selections on the current building's energy use. Costs for implementing the strategies are either provided by the owner or determined based on historical projects. This allows for the inclusion of simple paybacks when reviewing the results with the Owner.

Results Meeting

This meeting is very similar to the Strategy Results Meeting in the *EDA* process. The participants are the owner, building operator, maintenance person, architect and engineers if in place, utility and energy consultant. The Results Report is reviewed during this meeting that shows the top energy saving strategies and their individual results. The group assembles the strategies into different bundles using the interactive tool and chooses a bundle for implementation in the meeting. Once a bundle has been chosen, it may need to be broken down into a smaller subset of bundles to allow for phased implementation.

Implementation

The owner implements the selected bundle and notifies the utility upon completion.

Verification

A site visit is conducted to re-check the survey information and verify the strategies are in place. The utility bills are checked against a weather-normalized version of the selected bundle model (M6) to verify savings have been achieved. Any available incentive is then paid to the owner. Projects are able to track the savings through the online energy tracking and comparison tool. The tool is available to both the utility and the customer. The online energy tracking and comparison tool allows the owner and building operator to have online access to continue to track building operation into the future to assist with maintaining savings or to facilitate re-optimization at some point in the future as the building use changes.

Case Study

The *Ongoing Performance* process is currently being piloted by MidAmerican Energy and another utility in the MidWestern United States. At the time of this paper one project has completed the entire process and three other projects are in process. The four customers that have been approached to date have been excited about participating in the pilot. They have been interested in both better understanding how their buildings are currently performing and in what opportunities exist for reduced energy use. This section focuses on the project that has completed the entire modeling process.

The case study project is a 43,087 m^2 office building located in Minnesota. The building includes 15,700 m^2 of parking ramp; the remainder of the building is a mix of private office, open office and conference rooms. The main floor includes a conference center and kitchen and dining space. The building has a window to wall area ratio of 44 %. The building uses two large rooftop variable air volume units with evaporative DX cooling and electric heat to provide heating and cooling. Gas boilers are provided at the units for morning warm-up. Humidification is provided by electric steam boilers. The building has parallel fan powered VAV boxes with electric resistance heat for air distribution.

The customer approached the utility as the building was originally a developer building, meaning the building was speculatively built with no upfront knowledge of the tenant. The customer has now leased the entire building and as the sole tenant has taken control of their utilities. They wanted to better understand the original design intent from an energy efficiency stand point and reduce their current energy use.

The utility bills provided were compared to the M3 model. This comparison showed that the building was using 30 % more kWh than originally anticipated. This is further illustrated in Figure 3. Results were presented to the owner and their facility manager. They were not surprised and noted that since construction completion additional make-up air had been added for the kitchen, three of the floors had changed to 24 hour per day and 7 day per week operation and storage space in the lower level had been converted to open office cubicles. A site visit was scheduled to further review changes to the building and to better understand the current operations.

During the site visit time was spent with the building operator reviewing the building automation system in detail. During the walkthrough it was discovered that the building discharge air setpoint was set to a constant 12.7 °C. In discussions with the building operator this was required to condition the data closets located on each floor that were served by the central AHUs. The temperature setpoint was 22 °C regardless of heating or cooling and there were no temperature setbacks. The economizer is controlled by outside air temperature, not enthalpy. Equipment loads were higher, particularly on the 24 hour floors as many individuals had two computers and 3 monitors. However there were no personal fans or space heaters at any of the workstations. The daylighting controls and occupancy sensors were found to be functioning as expected during the visit. The site visit also revealed that a snow melt system with a natural gas boiler had been added.

The M4 and M5 models were then created based on the findings from the site visit. These results are shown below in Figure 3. Note that while the meter is using more energy than the original M3 model, almost similar to the M1 Baseline, there is still significant savings for the original efficiency measures. Also from the graph below, the Meter is comparable to M5, within 10 % on an annual basis. Without the benefit of system level submetering this was deemed acceptable to continue forward to evaluate additional savings opportunities.

Similar information was presented regarding the monthly energy use.

Ultimately the breakdown of the M5 model by end-use was presented and the team used this to focus on savings opportunities moving forward.

A list of 40 strategies was reviewed with the Owner's team including the CFO, building operator, building electrician and maintenance personnel. Each strategy was simulated relative to M5 to show the isolated impact of the change.

Figure 5 shows the highest savings strategies in both annual energy cost (US Dollars) and also electric kWh savings. The top strategies were mostly mechanical, including operational changes and physical changes particularly to the kitchen. Lighting and other strategies were also studied and some were chosen for implementation.

While separating the data closets from the main air-handling units by installing a mini-split system was not one of the top savings strategies it was a key strategy as it allows the top strategies to be implemented. The key strategies chosen for M6 were the separation of the data closets from the main air-handling units, shutting the main air-handling units down at night, change from a constant discharge setpoint to a warmest zone setpoint and increase the heating and cooling temperature setpoints to a 2 °C deadband. Other smaller measures were to switch to an enthalpy controlled economizer, replace CFL can lights with LED lights in the lobby and elevators and adjust the daylighting controls. As shown in Figure 6, the M6 model rep-

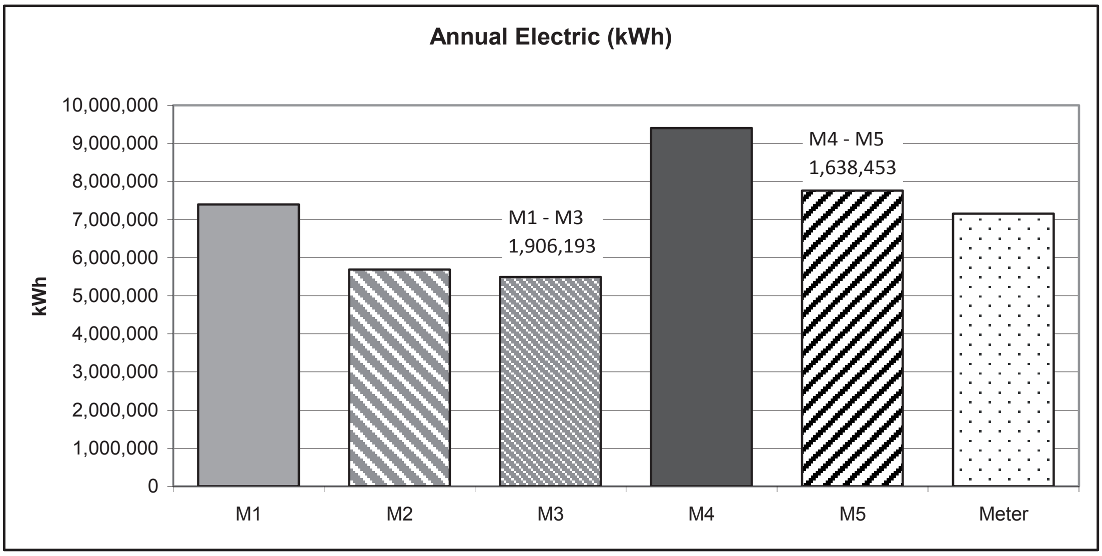

Figure 3. Annual Energy Use kWh.

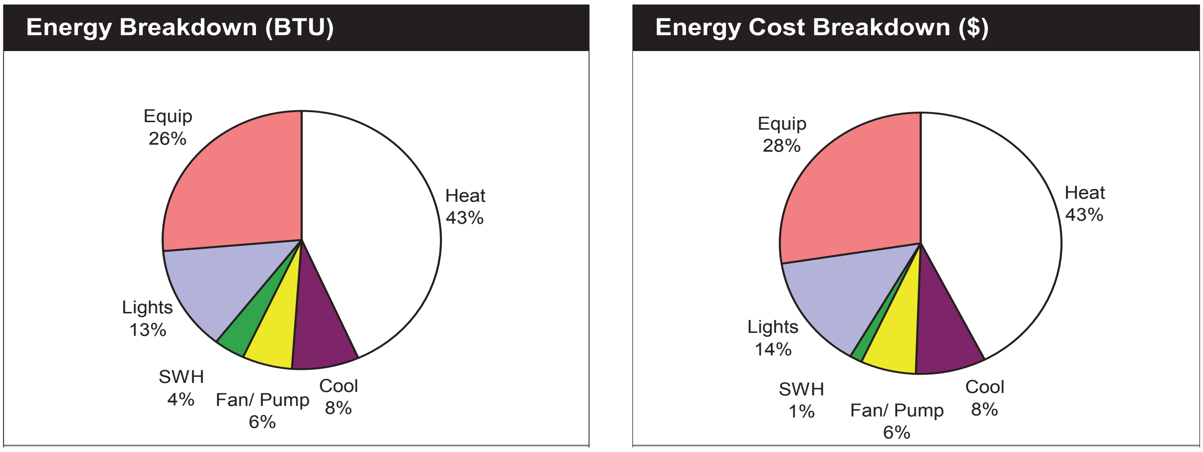

Figure 4. M5 breakdown by end-use.

resenting the bundle of measures selected by the owner reduces the overall energy use below that of the original M3 bundle, resulting in significant savings.

The owner is currently exploring the implementation of these measures over the next 2 years. Some of the measures, particularly the addition of the split systems for the data closets resulted in a capital expense that required budgeting for in the next year. However, by including the Chief Financial Officer, building operator and maintenance personnel in the process, they all understood the strategies and saw the savings associated with them, and made the decision together on what to implement and when.

The predicted monthly energy use of M6 with the implemented measures, but no other changes in operations or physical parameters, are shown relative to the current metered usage. This allows the building operator to track the progress towards the goal and also allows the utility over time to verify the savings. Of course if the building function or use changes, the models would need to be updated to assist the operator with maintaining the savings over time.

Conclusions

A number of variables contribute to an energy model and the physical building and design is only one set of key variables. If changes in weather or operational parameters such as occupancy are not accounted for in the energy models, comparing them to meter data is not a fair comparison and will likely lead to the wrong conclusions.

Overall, when updated to reflect actual weather and operations, the baseline (M4) and as-verified models (M5) provide good estimation of the actual energy savings and metered energy use as determined by industry standard statistical guidelines.

The largest impacts on the models were from the "operational sphere." Once the actualized M5 model is created, this allows for detailed examination of savings opportunities within the existing building. By including the owner, building operator, and maintenance people in the discussion it allows for all ideas and concerns to make it to the table and be evaluated.

A key part of the case study projects success was the involvement of the financial decision makers, building operators and maintenance staff so that all were able to contribute to the strate-

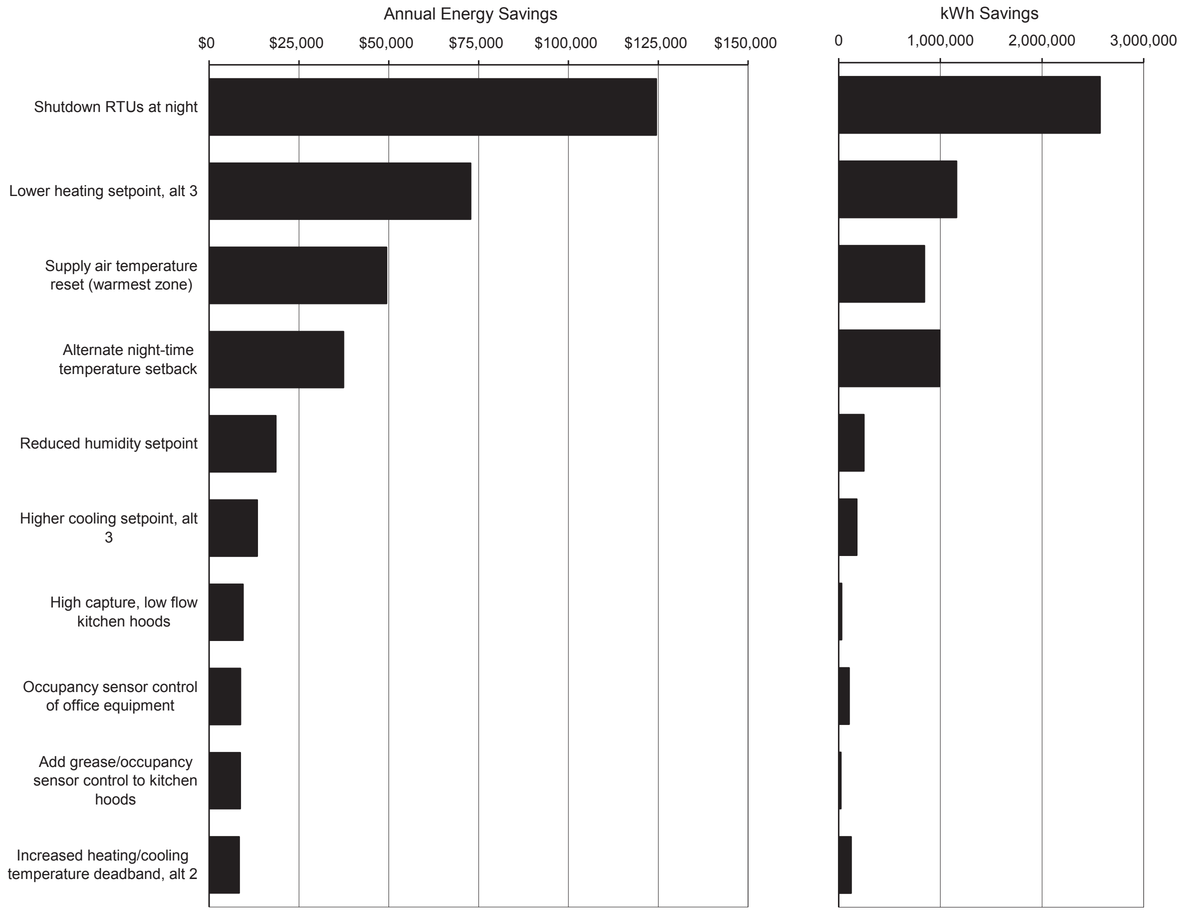

Figure 5. Top Energy Savings Strategies.

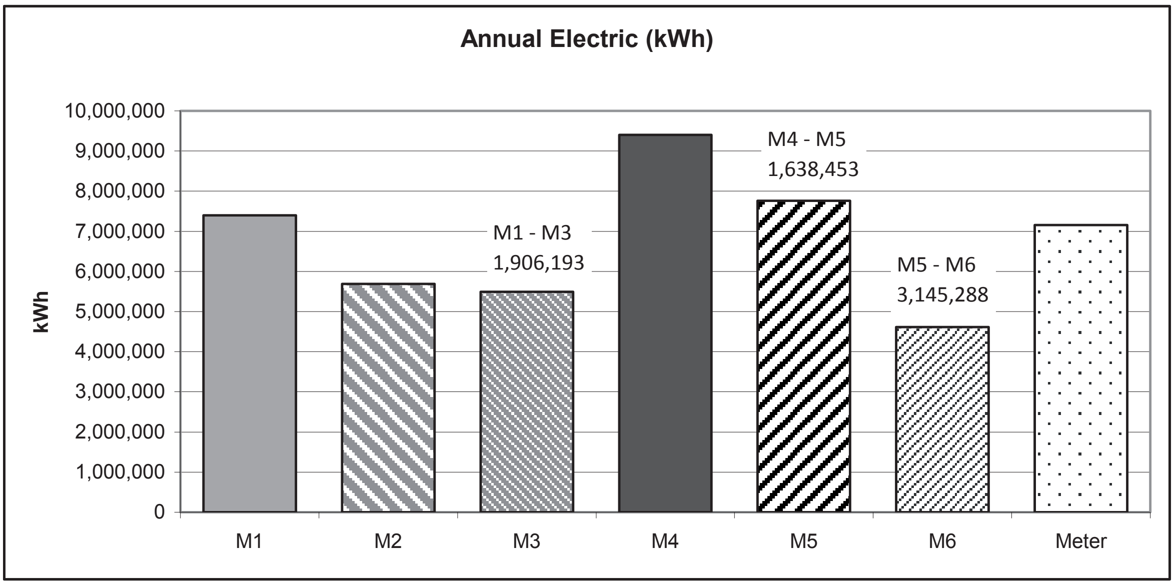

Figure 6. All Models and Meter, kWh.

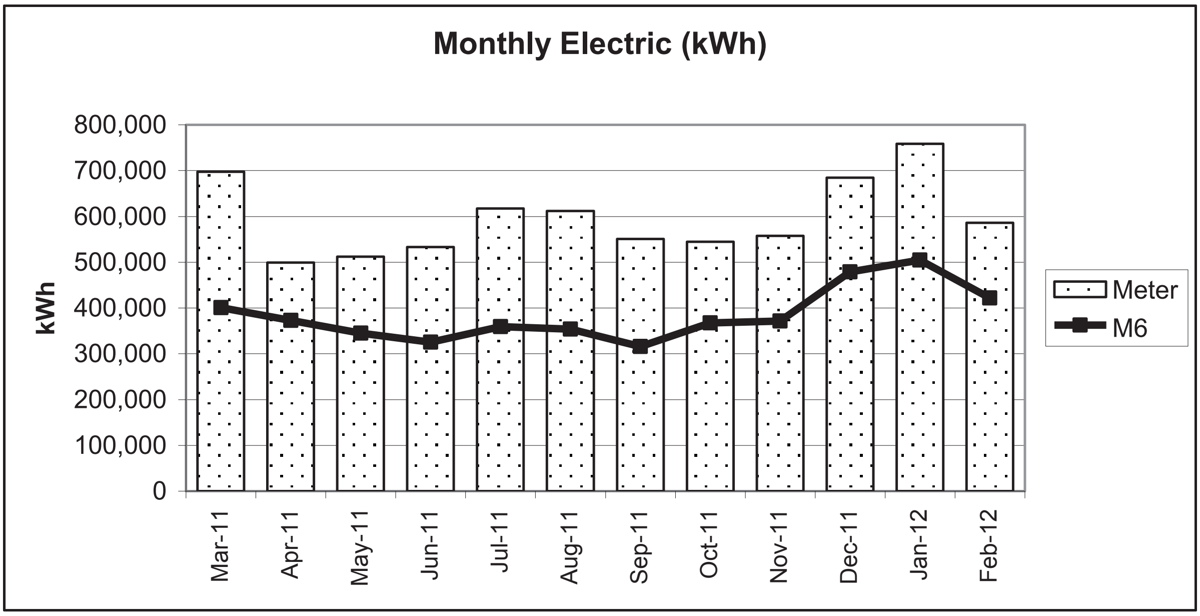

Figure 7. Monthly M6 vs. Current Meter – kWh.

gies and understand the investment and the impacts over time. Throughout the process it is important to recognize that differences from design models to actual building operation are to be expected, it doesn't mean that anything is wrong with either the models or the building, it just means that things have changed.

A key finding from the case study and in projects in process is that often one bundle is not sufficient. Strategies will be implemented over time as budgets allow. Not showing just the end goal upon all implementation, but being able to break this into phases for both the Owner and the Utility is key. The savings most likely will be achieved over time. Tracking the progress towards the goal online with access for both the Owner and the Utility is also key to assisting with the implementation. If you are not measuring to at least the utility bill level you don't know how far you have progressed or strayed from your goals.

If detailed models are created during the design phase using relatively limited metering information, it allows for creating actualized models that accurately reflect a building's true operation. As buildings evolve over time these models may be used to help maintain energy savings and study additional savings opportunities going forward. The detailed models created during the design phase can be useful to assist the owner with energy efficiency design and operational decisions.

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