Better Buildings CHALLENGE
U.S. DEPARTMENT OF ENERGY

INDUSTRIAL PARTNER

SCHNEIDER ELECTRIC

Implementation Model: Uniform Methodology to Measure Energy Efficiency Improvement

ORGANIZATION TYPE
Electrical equipment and appliance manufacturing

BARRIER
Managing energy across multiple facilities

SOLUTION
An energy model to normalize baseline energy use and track energy savings resulting from improvement projects

OUTCOME
A uniform methodology to measure and verify energy efficiency improvement at the facility and corporate level to help inform business decisions

Overview

Schneider Electric

Schneider Electric developed a robust methodology for measuring energy use at its facilities in support of its corporate-wide energy savings targets. The methodology relies on a predictive modeling technique that adjusts baseline energy use to control for factors that impact energy consumption such as production and weather changes. As a result, Schneider is able to develop more accurate metrics to track progress against its goals. To date, the company estimates cumulative energy savings exceeding 30% throughout North America against a 2004 baseline for the sites in the program. Under DOE's Better Plants Challenge, Schneider has achieved a 16% improvement from a 2008 baseline.

Schneider Electric's Playbook

Policies

Like many large companies, managing energy activities across Schneider Electric's multiple plants and sites proved challenging. There are several barriers involved, most notably large swings in energy data. The metrics barrier was particularly difficult to overcome as Schneider energy managers noticed large swings in raw energy data as production levels and weather changed from month-to-month and year-to-year. These "swings," in many cases, were larger than the impact of energy-saving efforts. It was obvious that some kind of normalizing was necessary. Through the process, Schneider's leadership now understands the importance of energy efficiency as an operations tool, much like safety, quality, and customer service.

Schneider Electric first set formal energy efficiency targets in 2004, when it asked its facilities to reduce energy use per employee by 10% over a three-year period. To drive the needed energy improvements, Schneider's top management transformed an existing network of Facilities Managers into Energy Champions and challenged them with the objective of developing action plans to meet the targets. A few Facilities Managers received energy management training and began to share this knowledge throughout the company, resulting in broader internal subject matter expertise. Within one year, this network of Energy Champions worked with Schneider Electric's internal experts to develop the predictive energy model for analyzing and tracking energy improvement projects and results. Four years later the team established best practices shared within the company. People who are passionate and willing to standardize and proliferate the processes are essential.

To help disseminate the energy model and best practices, the company centralized the Energy Managers (EM- formerly referred to as Energy Champions) of North America into one common reporting structure. This allowed the EM group to create energy-saving objectives for each direct report. Through the process, the group accepted the measurement and verification methods. The company developed a regression analysis tool (the energy model) to find the best correlating factors for each site that explained the variation in energy usage. The group also focused on increasing the energy project list to ensure that there were projects underway to meet objectives, and verifying that the expected savings aligned with modeled results after completion.

Implementing the energy model did require overcoming some challenges, such as educating plant management staff on energy-conserving principles and modeling methodologies. Another challenge was fine-tuning the results for variables too complex to include in the model, such as added shifts or overtime to accommodate short-term production increases. Change management is never easy. It is important to have education in place and consistent methodologies.

Process

To support and monitor progress towards Schneider Electric's energy goals, the Facilities Team tracks electric and natural gas consumption at facilities using a predictive modeling technique. This technique

adjusts baseline energy use to changes in factors that correlate with energy usage, such as weather or production levels.

Schneider Electric developed a standard six-step approach to normalize energy data at each site and determine energy savings:

1. Raw Data Quality

Each bill is entered by Schneider Electric's Energy & Sustainability Services (a supply-side Schneider Electric business), cross-checked and run through algorithms to determine if the numbers deviate significantly from historical averages.

2. Perform Calendarization

The utility data is converted from billing months to calendar months (calendarization) using the read dates on the billing invoices. Calendarization is important, because while many larger electric and gas accounts will be billed on a calendar-month basis, most accounts are billed at various times during the month. As a result, the number of days in any billing cycle can vary. A previous study by Schneider of its North American dataset showed that billing months may vary from 19 to 48 days and usage may have an average of 4% difference between the calendar month and the billing month. This is a large discrepancy especially considering that the efficiency improvements Schneider is attempting to estimate also fall in the 4% range. The calendarization process is not always straightforward, as in any one month a prorated share of up to three billing months may be required. For example, a January bill with service dates from January 2nd through the 29th would be composed of the January bill (28 days) and prorated shares of the December bill (one day) and the February bill (two days).

3. Account for Weather Data

Daily average temperatures are accumulated for each site. In some cases, the daily high and low temperatures are averaged if a weighted average is not available. Heating and cooling degree days for most sites are calculated at base 50°F. If the daily average temperature (DAT) is greater than 50, then DAT minus 50 is the number of cooling degree days (CDD). If the DAT is less than 50, the difference is the number of heating degree days (HDD). Consideration was given to the base used, as the normal standard is a 65°F base. However, most Schneider Electric sites in North America see electric usage decline at 50°F and gas usage increase starting at 50°F. While most sites use the 50°F base, some do require a different base temperature in order to determine the optimum correlation with energy usage.

4. Account for Production Data

Some measure of production at a facility is useful in modeling to determine the impact of changes that may affect energy consumption. Schneider Electric tracks and records a variety of production measures such as shipments, hours worked, overtime, etc. These were developed as a measure of production efficiency, resource allocations, etc. None of the current indices was developed specifically to correlate with energy consumption. Therefore, the results for purposes of predicting energy consumption are varied. To show the impact of production, facilities use a variety of data, with many sites finding correlation with hours worked in the facility. Other correlating production measures include painted surface area, parts produced, and hours worked in a specific area of the facility.

5. Apply Multivariable Regression Model

The model developed for this application is a Multivariable Regression Model. It has the basic form of:

$$kWh = (b + c1 * MNF + c2 * HDD + c3 * HDD^2 + c4 * CDD + c5 * CDD^2)$$

Where:

MNF = manufacturing index (may be parts produced, hours, etc.)
HDD = heating degree days
CDD = cooling degree days

Each site uses a different combination of factors, depending on the factor's correlation with the site's energy use. This correlation is determined by a statistical measure called p-value, which is the probability that the variable's correlation represents a random correlation.

Each model must target (in priority order):

- a p-value of less than 0.10 for each variable used
- an F-test of less than 0.10
- R-squared greater than 0.70

If multiple combinations of variables meet the above requirements, the combination that meets the list of targets and minimizes monthly standard deviation should be used. A site undergoing major changes during the baseline period may use building energy simulation software (for example, eQuest, DOE-2, or Trane Trace 700) to generate the baseline data. The regression can be built from this simulated data. If no variables correlate, the site may choose to use raw energy data as the baseline, provided that the site's energy-consuming systems were stable during the baseline period.

The statistical checks Schneider employs to test for model validity are roughly consistent with what is required under DOE's Superior Energy Performance Program (SEP).

6. Evaluate Model Results

The result of the model is the predicted consumption for each facility based on the actual correlating factors. This is compared to the actual consumption and the difference is considered the underlying reduction (or increase) due to energy conservation efforts.

Tools and Resources

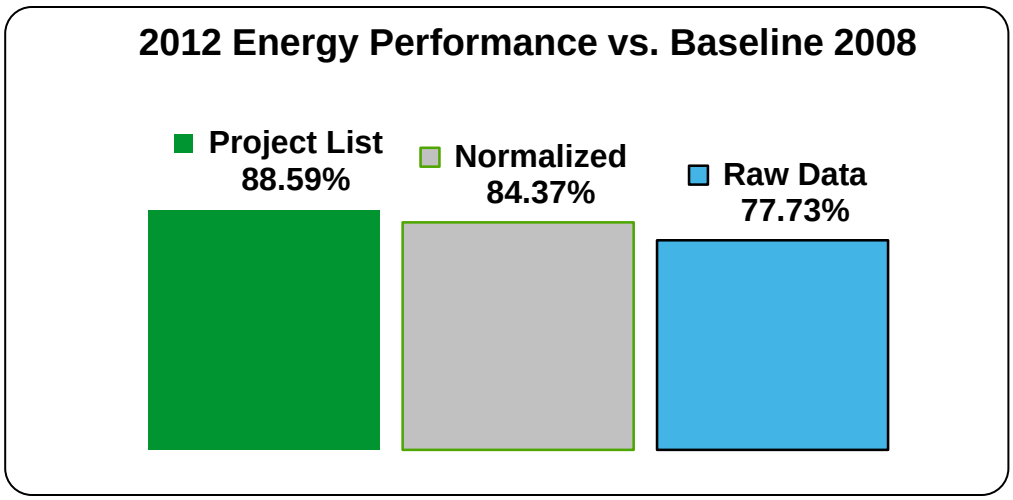
Schneider Electric now uses the Department of Energy's EnPI multi-variable regression tool to normalize energy data and accurately measure and verify the value of energy savings from energy actions. The tool allows each site to be modeled individually in order to accurately depict and model energy data based on variables relevant to each site.

Most sites showed a strong correlation between heating degree days (HDDs) and gas consumption. Many sites showed a good correlation between cooling degree days (CDDs) and electricity consumption. Some manufacturing sites with significant painting processes may show a strong correlation to pounds of steel processed. In some cases, quadratic equations were used to account for non-linear relationships. Many variables were considered to identify those most statistically relevant. Statistical indicators such as p-value, R-squared, T-statistic, and standard deviation were used to analyze each variable. Schneider's experience indicates that selecting the best model for a facility and the most relevant variables is often an iterative process.

Outcomes

Savings for the sites in the program have exceeded 30% compared to 2004. The company estimates that the average payback of energy projects is less than three years. Use of the energy model has been central to achieving these savings. The model is updated monthly and is a basis for monthly conference calls to review model results, track progress towards goals, and adjust planning for the next 12 months. These monthly discussions, based around the model, guide decisions on energy projects.

Measuring Success

Results from Schneider Electric's energy model are analyzed in monthly meetings held by energy managers to ensure accuracy. The results are compared to expected savings associated with energy projects and actual energy consumption as a validity check. The meetings also help focus and drive actions toward meeting annual energy goals and are used to educate staff on how to leverage best practices. This doesn't happen in a silo. To truly be successful, the Schneider Electric community must continue to share across the enterprise and evolve to ensure continuous improvement. The energy program puts the same rigor into the process as is used to approach the award-winning safety program and other imperatives.

The chart below shows cumulative energy performance improvement since 2008 measured three different ways across the 34 U.S. facilities Schneider has enrolled in the Better Plants Challenge. The baseline period equals 100%, so the 84.37% shown under "normalized" data equates to about a 16% improvement in energy performance. This is the data Schneider reports publically through the Better Plants Challenge and other sources. For validation purposes, it also compares the normalized figure to a bottom up calculation (referred to below as "project list") that sums the estimated savings from all the energy saving projects implemented across the company. Additionally, it checks a third data point, which is the "raw," or absolute energy consumption at all sites. These checks are useful in providing additional confidence in the normalized results. Schneider is looking for the numbers to be in general agreement with one another—it does not expect them to be identical. If the metrics are not all moving in the same direction—for example, if the normalized data is showing an energy performance improvement while the raw data is showing an increase in energy consumption—Schneider takes that as a cue to investigate the data further. So far, Schneider has found that the numbers generally align with one another, and the metrics show greater convergence over time.