Tracking Energy Savings

Introduction

Energy conservation that results from behavioral changes, efficiency upgrades, and control strategy enhancements is often identified and documented via Energy Conservation Measures (ECM's). These collective conservation measures are first quantified by engineering calculations of "before" and "after" estimates of consumption and cost savings. If the results are promising then execution of the ECM's will require specific measurement and verification (M & V) procedures[1] to confirm the justification basis was valid and that the savings are being achieved. This M & V process can be accomplished by the strategic location of metering instrumentation or often by using the utility metering already in place. The method to follow uses the basic utility metering data to verify that the calculated savings correlates strongly with the monthly metered consumption after being adjusted for weather influence.

Measurement & Verification

The referenced procedures above are formally presented at the Efficiency Valuation Organization (EVO) website www.evo-world.org/index.php?option=com_docman&task=doc_download&gid=1066 and are excellent for understanding the processes for measuring and verifying energy conservation applications. In our case: The "before" is designated the "**baseyear**" and the "after" is designated the "**post- retrofit**" and is represented by"

(Baseyear) (Post - Retrofit)

Energy Saved = Before ECM's — After ECM's ± Adjustments (weather, occupancy, schedule, etc.)

Normally, the single largest energy consumption influence for a building, not being used for manufacturing of a product, is the weather. In order to see the energy savings after implementing several ECM's, the influences of weather on the HVAC equipment must be adjusted and normalized.

Correction for Weather — Baseyear

The National Oceanic and Atmospheric Administration (NOAA) tracks climatic conditions around the world and provide this data for anyone's use that would have an interest. Their website: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ is a listing by city, monthly values of Cooling Degree Days (CDD) and Heating Degree Days (HDD). The monthly accumulative total of CDD for the months of April through October represents the period when cooling is being used and the months of November through March are predominately the heating months of winter. During these monthly periods it is necessary to retrieve the energy used: primarily electricity - kilowatt-hours for the cooling period and a combination of electricity and natural gas - therms, fuel oil - gallons, propane - gallons for the heating period of winter.

Baseyear/Post-Retrofit Correlation

(Knowing the Adjustments)

The best comparison between baseyear and post-retrofit year utility data occurs when the monthly consumption is not being influenced by other energy disturbances other than the ECM's. The stable and repeatable energy usage allows for the isolation of the energy conservation changes and to readily correlate the uncontrollable influence, such as the weather. Good correlation of the ECM's energy savings with expected results occurs when:

- Building has a consistent schedule - 9 to 5 pm, 7 to 4 pm, 5 days/week, holidays, year in and year out repeatable.
- Building occupancy fairly stable
- Equipment changes have not occurred or at least any changes can be quantified
- Production throughput is same year to year or at least is not energy influential or if it is it can be quantified for normalization
- ECM change to total monthly energy is recognizable by the metered account (s). ECM's/ Total Energy Use ≥ 10%
- Weather is accounted for in the analysis
- The building insulation envelope is up to standards
- No one time energy use crisis event occurs that can not be accounted for

Days of Meter Service Correction

After obtaining the energy (kWh) per month consumed from the utility billings it is necessary to correct the meter reading to the days of the month, for example: April 2006 meter reading is 299,227 kWh with the meter read after 35 days of service (DOS). Corrected to the days of the month the kWh would be 299,227 x 30/35 = 256,480 kWh for the 30 days of April. All meter readings should be corrected to the days of the month for the average consumption for that month.

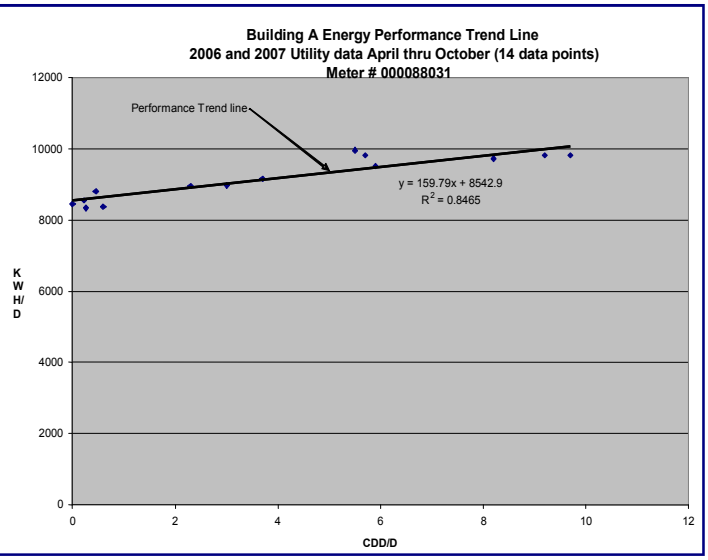
Development of the Baseyear Reference

It is possible to develop a trend line that shows the relationship between kWh consumed in the baseyear and the influence of weather conditions by knowing the cooling degree days for the selected period. From the NOAA website the CDD for the location city is obtained for the two years of kWh readings obtained from the utility. In the "blue" column CDD has been divided by the days of the month and kWh has been corrected for days of service and then divided by the days of the month.

Cooling Degree Days and Electric Meter Data for Office Building A

CDD from NOAA Referenced Website, kWh from Meter # 88031, Corrected to Days of the month

2006/2007 Cooling	CDD	CDD/D	kWh	KWh/day
Apr. 2006	7	0.23	256,480	8549
May	93	3	278,160	8973
Jun	171	5.7	294,910	9830
Jul	253	8.2	301,680	9732
Aug	182	5.9	295,200	9523
Sept	68	2.3	268,900	8963
Oct	8	0.26	258,570	8341
Apr. 2007	0	0	253,770	8459
May	14	0.45	273,180	8812
Jun	164	5.5	298,810	9960
Jul	299	9.7	304,600	9826
Aug	284	9.2	304,650	9827
Sept	111	3.7	275,080	9169
Oct	19	0.6	259,860	8383



These two columns when developed in MS Excel format can now be plotted as shown to the right. The steps are as follows:

Excel Plotting CDD/D and Average kWh/Day

Step 0 After "highlighting" both columns - Select Chart Wizard
Step 1 Under Standard Types Select XY Scatter
Step 2 Chart Sub-type - Select Top Chart "dots" – no lines as shown
Step 3 Insert Title, Legend, X-Y Axis Names CDD/D & KWH/D
Step 4 Select as New Sheet
Step 5 "Right Click" on any data point Select "Add Trend Line"
Step 6 Select Linear Regression Type
Step 7 Options - Check Display Equation on Chart and Display R – Squared Value on Chart
Step 8 Finish

The trend line shows the relationship between kilowatt-hours consumed each day as the cooling load increases through the summer months and then decreases as the summer goes into fall. This represents the increased loading (weather influence, higher temperatures of the day) of the air conditioning/ventilation systems and the electric power consumed by the equipment (chillers, fans, pumps, etc.) as the temperature changes daily. The equation for a line is given by y = mx + b where "m" = 159.8 represents the slope and "b" = 8542.9. The R^2 is the coefficient of determination and is a measure of the degree of goodness of the fit in the regression equation. It has a range of values between 0 and 1, the higher the number the better the fit. Obviously, the more data available, the better correlation between trend line placement and data points, This is why 36 months of data would be better for achieving a better correlation. Another way of saying what R^2 = 0.85 means is that weather is a 85% cause in the variation of kilowatt-hours of the building during the summer months when the outside temperature varies beyond the set interior temperature. R, the square root of R^2, ranges between –1 and + 1 and is a measure of the degree of correlation between y and x or in our case-kilowatt hours and weather, the higher the value of R, the greater the correlation. R= 0.92 is fairly high for this case. The **baseline energy** equation for weather influence is given by:

Y = m * x + b

(kWh) = 159.8 kWh/CDD x N_{CDD} + 8542.9 kWh/day x N_{Days}

Remember that baseline consumption is the amount of energy the building would have used given today's conditions based upon 2 years of data and a high correlation (R= 0.90 or higher) between y and x.

So Building "A" energy gains/losses are represented by:

Energy Conservation = Baseline (Y) – Actual Meter Reading for the Month (Corrected for Days of Service)

Now it is possible to compare kWh used after the ECM's have been applied to the previous year baseline reference that is corrected for the weather. The baseyear equation is entered for the (N_{CDD}) for the month and the number of days (N_{Days}) of the month. Then this baseline kWh can be compared to the actual kWh to the month of question so that savings of ECM's implemented can be estimated for positive net energy saving gains. Good correlation will occur when prior conditions are satisfied.

Revised by Waste Reduction Partners– 04/2010

References: 1. International Performance Measurement and Verification Protocol website: www.evo-world.org/index.php?option=com_docman&task=doc_download&gid=1066

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