Department of Energy & Climate Change

Appendix F – Checking the accuracy of your baseline(s)

Electricity Demand Reduction pilot

M&V manual

URN 14D/279

Any enquiries regarding this publication should be sent to us at edr-project@decc.gsi.gov.uk

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Checking the Accuracy of Your Baseline(s)

1. Overview

There will be some level of uncertainty in any measurement process resulting from errors in metering, sampling or the calculation of adjustments. The measurement method in the M&V Plan should aim to minimise errors as far as possible, so there is enough certainty that the change in demand has been caused by the equipment installed rather than another source, for example weather, building occupancy, or production volumes.

You should quantify the accuracy by comparing the expected savings to the “standard error” of the proposed baseline and this section of the M&V Plan will provide guidance on how to do this for the different measurement methods described baseline section of the M&V manual. The excel spreadsheet templates for average demand readings and for regression analysis have in-built equations to calculate the standard error for each of these measurement techniques.

Standard Error

This is a measure of the statistical accuracy of an estimate and can be calculated for a set of readings from which an average is taken, or for a baseline derived from a regression analysis. The key test for statistical significance is that the level of expected savings should be twice the standard error of the estimate.

There are two methods for calculating baselines – either using average demand readings or regression analysis to calculate adjustments. Worked examples are available as appendices to the manual, including examples where the text below refers to functions available in standard spreadsheet software.

Full definitions of statistical terms used in the manual are included in the FAQs section.

2. Average Demand Readings

If you have chosen Partial Measurement approach as your chosen M&V approach, you will establish the baseline by taking measurements of the equipment’s present level of demand. It is also suitable to do this for Full Measurement (Submetering and Whole Building) methods if the demand within the measurement boundary is constant enough during the baseline period. You can assess this using the template spreadsheet for demand readings, which has the calculations for accuracy built in. The section below describes what is calculated to evaluate the accuracy of a set of readings.

Where a set of measurements is taken to record the present level of equipment demand, the level of savings should be compared to the standard deviation of the sample. Common spreadsheet software has in-built functions to allow you to calculate the sample standard deviation for a dataset of readings, which can be compared to the expected saving. If the sample standard deviation is greater than twice the expected demand saving, then the baseline can be considered statistically valid.

An example baseline with calculations for standard error derived from a set of readings is appended. This can be used as a template for your own readings, where the number of readings you take can be calculated by following the guidance in appendix G.

3. Regression Analysis

The baseline section of the M&V manual refers to "independent variables" and their use in working out routine adjustments to the baseline. These may be required if you have chosen one of the Full Measurement (Submetering or Whole Building) approaches where the demand within the measurement boundary is variable.

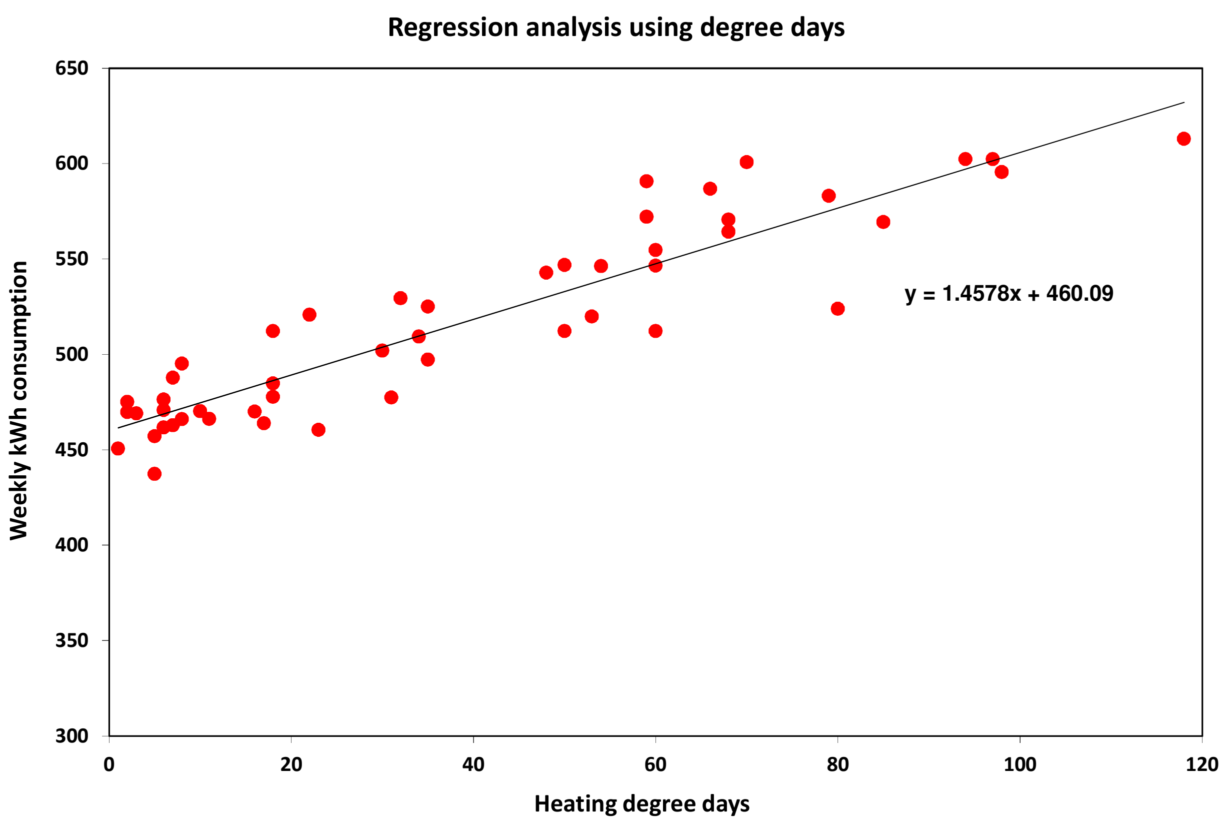
The process of finding a mathematical relationship between a dependent variable (in this case electricity demand) and independent variables is known as "regression analysis".

Regression Analysis

This is a statistical approach to estimating relationships between a dependent and independent variables. In this context, the dependent variable is energy (kWh) or demand (kW) and the aim of regression analysis is to determine how the dependent variable will change when the independent variable(s) change.

The following chart illustrates a regression analysis graphically – it shows a plot of a building's average peak kW demand against the associated total for heating degree days for the same time period.

In this case, the half hourly kWh data recorded between 4 and 8pm on weekdays has been converted into an average peak demand value.



In this case we can see from the trend of the data that as the value of heating degree days increases (i.e. as external temperature decreases), the building uses more electricity. The trend line can be added using inbuilt functions of common spreadsheet software and quantifies the relationship between energy consumption and heating degree days for this building. It tells us that there is a fixed component of energy consumption, plus a variable component depending on the independent variable, in this case:

Expected weekly consumption = 1.4578 kW per heating degree days + 460.09 kW

This equation provides a baseline for comparison once the new equipment has been installed – all we need to know is the post-installation values for degree days and the expected value can be calculated. The values of the fixed and variables components of the equation can also be determined using standard functions of common spreadsheet software for a given dataset (e.g. for the underlying data shown in the chart).

4. Standard Error

In addition to the baseline equation, spreadsheet software can be used to establish the standard error of the estimate, which should be compared to the expected savings. The standard error should be at least twice the expected saving in order for the model to be considered statistically valid, i.e. accurate enough to measure savings at the expected level.

Note that the savings should be compared at the same resolution as the data used for the regression model, e.g. if weekly totals are used, then the average weekly savings should be compared. For the data in the previous chart, the standard error is 19.93 kW; as the regression analysis has been carried out for weekly data, the expected weekly savings would need to be greater than 39.86 kW in order to meet this criterion.

Please see FAQs for hints and tips on improving the accuracy of regression analyses.

5. Statistical significance: p-values

You should also consider whether the independent variables you have used do actually have some effect on energy consumption. By inspection, the plot above indicates that this is likely to be the case because the trend of the data is clear – the data points approximate to a straight line going diagonally upwards.

However, this can be established statistically using “p-values”.

p-values

In statistical significance testing, a p-value quantifies the probability that the variable you have tested has no influence on demand or energy consumption. A common threshold for p-values is 0.05 or lower, i.e. the probability that the independent variable actually has no effect is less than 5%.

For the data in the previous chart, the p-value is equal to 1.39 x 10-20 i.e. a very small number; this indicates that the probability that heating degree days are significant is very high as the threshold of 0.05 has easily been met.

The worked example for regression analysis includes calculations of the standard error of the model and p-value for the independent variable. The example can be used as a template for your own data when entered in the same format, providing a simple way of checking whether your own data meets the criteria for accuracy.

6. Multiple Regression

It is possible for some buildings that there is more than one significant independent variable, leading to more than one routine adjustment. These can also be determined using regression analysis, but it is important to establish which variables are relevant by calculating p-values for each variable and including these in the M&V Plan. Where the calculation of routine adjustments is not straightforward, you should contact DECC to discuss the format of your M&V Plan edr-project@decc.gsi.gov.uk

Department of Energy & Climate Change
3 Whitehall Place
London SW1A 2AW
www.gov.uk/decc
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