Quick Start Guide to Energy Monitoring & Targeting (M&T)

Energy Monitoring & Targeting is an approach to energy management based on energy information. It builds on the **"you can't manage what you don't measure**" principle. For this guide we will look at a single site, although the principles and techniques apply to multi-site operations as well.

The traditional approach to M&T is based on defining energy accountable areas and installing suitable metering for those areas. However, if we want a quick start we can't wait for new meters. Every site will have utility meters so let's use what we have got! *(Doing site level M&T could be called "macro" M&T – whilst looking at individual processes or costs centres could be called "micro" M&T.)*

What do you need?

- Energy invoices (or meter readings) for the past 12 to 24 months
- If a manufacturing site, production data for the same period
- If a non-manufacturing site degree day data* for weather correcting your consumption data – available from The Carbon Trust's web site (see "Environmental Business Support Organisations" in the LINKS section of www.oursouthwest.com).
- A PC with a spreadsheet – for example Excel or Lotus 123
- Knowledge of your site and its processes
- Some time

**Degree days are a measure of the variation of outside temperature and enable building designers and users to determine how the energy consumption of a building is related to the weather. They quantify how far, and for how long, the external temperature has fallen below set base temperatures (normally 15.5^{o} C for heating applications). The daily data can then be totalled for any required period - a week, month or year etc and compared directly with energy data. See the Carbon Trust's website at www.thecarbontrust.co.uk for further advice on Degree Days.*

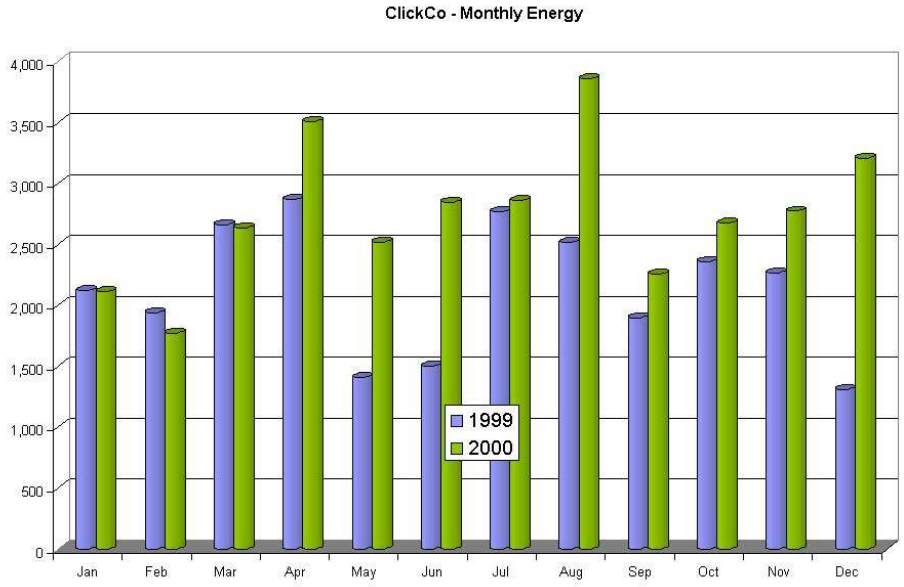
To assist us we are going to look at a fictitious company, ***ClickCo,*** that manufactures "clicks" for use on the Internet! For simplicity ***ClickCo*** has only one energy supply – electricity.

Note: If you want to use this M&T guide for a non-manufacturing site you should replace production volumes with degree days for buildings and mileage for transport operations.

The starting point is to collect and collate 24 months of energy invoices. Every organisation should have access to this data, as they need to keep 6-7 years of invoices to satisfy Inland Revenue requirements. You will also need production data for the same 24 month period.

The energy data is then entered into a spreadsheet. It is hard to envisage what is happening from plain data, so you need to produce charts. Probably the most common chart used in energy management is one showing the energy per month for this year and last year – however, it does not tell us a lot about what is happening. See chart 1.

Chart 1



But is there a trend? Having more than twelve months of data we can plot a moving annual total. For this chart, each point represents the sum of the previous twelve months of data. In this way each point has a full range of the seasons, holidays, etc. See chart 2.

This technique also smoothes out errors in the timing of meter readings. If we just plot energy we are only seeing part of the story – so we plot both energy and production on the same chart – most likely using two y-axes. Looking at this chart both energy and production seem to be "tracking" each other – this suggests there is no major cause for concern. But you will need to watch for a deviation of the energy line to pick up early warning of waste or to confirm that energy efficiency measures are making an effect.

A critical feature of M&T is understanding what drives energy consumption. Is it production, hours of operation, weather? Knowing this you can then start to analyse the data to see how good your energy management is.

For ***ClickCo*** we know that energy should directly relate to the number of clicks produced. Knowing this we could now calculate Specific Energy Consumption (SEC). For ***ClickCo*** the figure is kWh per million clicks. We also know that the level of production may have an effect on the specific consumption. So we now plot a chart of SEC. See chart 3.

At this point it is worth noting that the quality of your M&T system will only be as good as the quality of your data – both energy and production. The chart shows some variation – an all time low in December 99 followed by a rising trend in SEC.

Chart 2

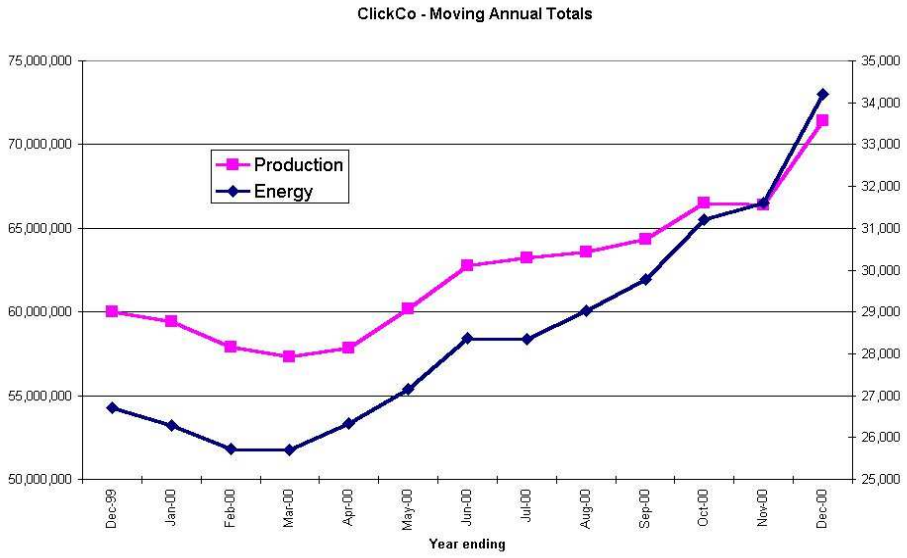
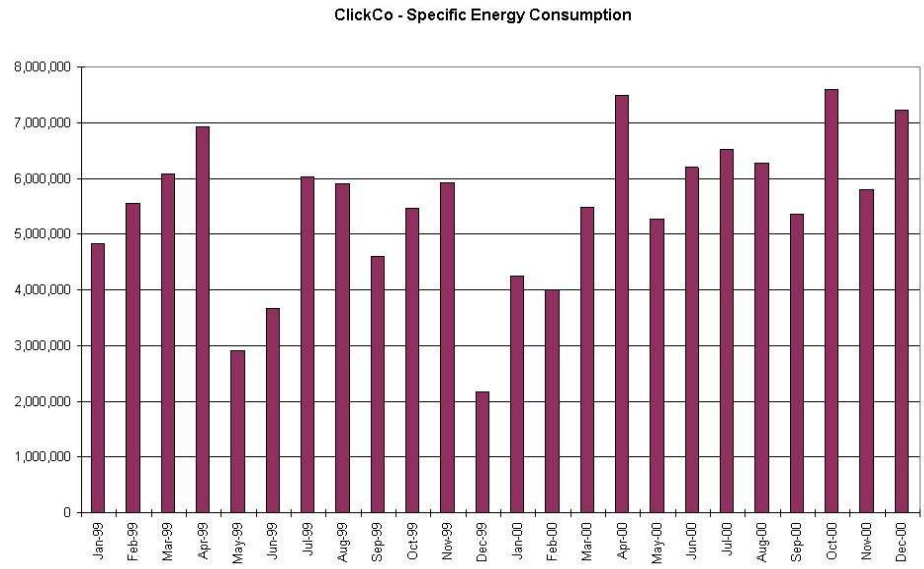


Chart 3



If we add the production levels to the SEC chart it helps to explain some of the features. See chart 4. For example, the very low SEC occurred when there was a record level of production. This indicates that there might be fixed energy consumption – i.e. consumption that occurs regardless of production levels.

The next step is to gain more understanding of the relationship of energy and production, and to provide us with some basis for performance measurement. To do this we plot energy against production – for Excel this is an XY chart option. We then add a trend line to the data set on the chart - see chart 5 (in practice what we have done is carried out a single variable regression analysis!).

The chart (chart 5) shown is based on the data for 1999. We can use it to derive a "standard" for the next year's consumption. This chart shows a low degree of scatter indicative of a good fit. Don't worry if your data fit is not as good. If it is poor, but you know there should be a relationship, it indicates a poor level of control and hence a potential for energy savings.

In producing the production/energy relationship chart we have also derived a formula relating production and energy consumption.

Chart 4

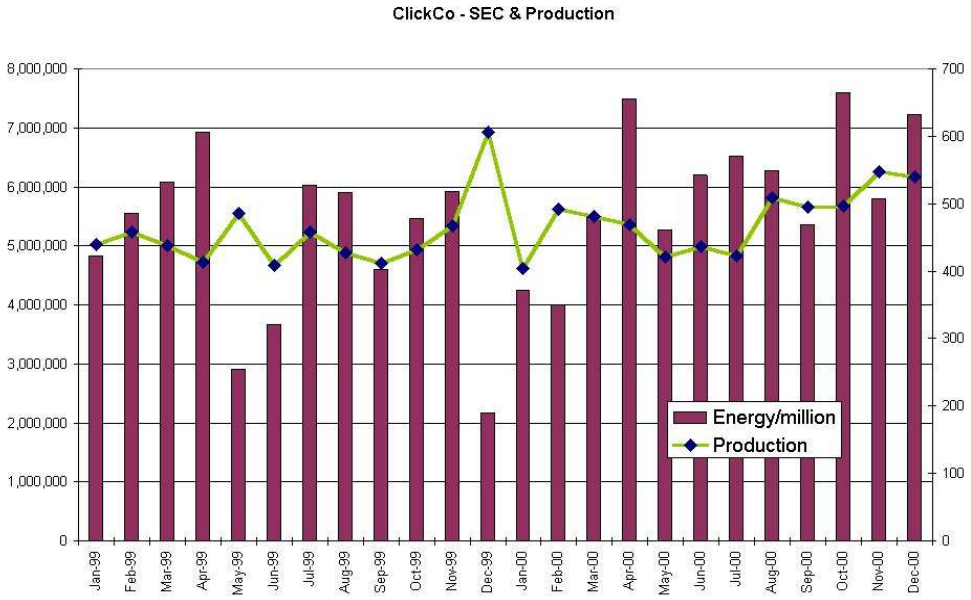
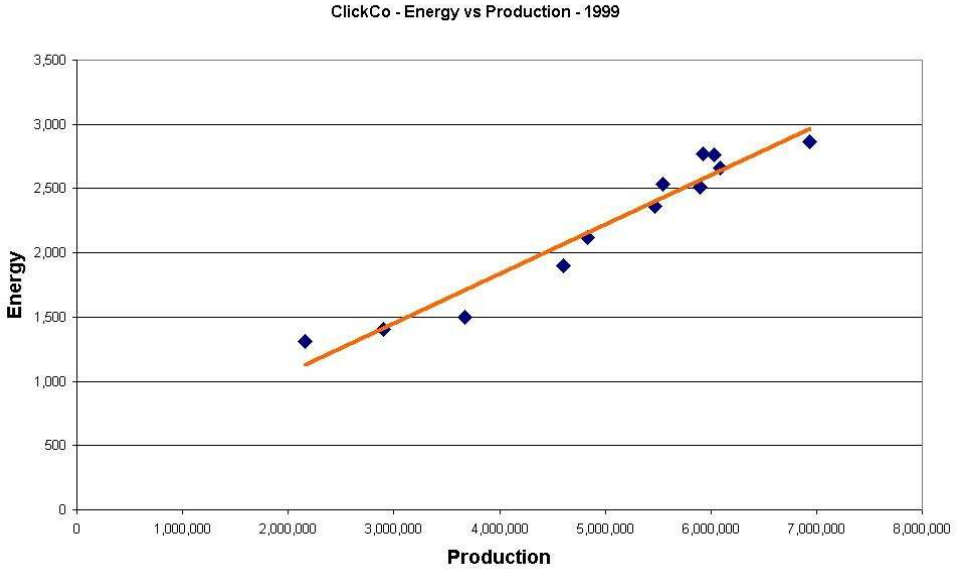


Chart 5



This is in the form:

(Energy consumed for the period) = (M x Production for same period) + C

Where M is the energy consumption directly related to production (variable) and C is the "fixed" energy consumption (i.e. energy consumed such as lighting, heating and general ancillary services that is not affected by production levels). Using this we can calculate the expected or "standard" energy consumption for any level of production within the range of the data set.

We now have the basis for implementing a factory level M&T system. We can predict standard consumption, we can also set targets – for example, standard less 5%. A more sophisticated approach might be applying different reductions to the fixed and variable. Although we have looked at this at a factory level, with sub-metering this approach can be used on individual processes**. In the case of a non-industrial site this technique would be used to assess the heating system by relating heating energy to degree days.**

At a simplistic level you could use chart 5 and plot each new month's point to see where it lies. Above the line, poor energy efficiency, below the line, improved energy efficiency.

The next technique to apply is **Cusum** (Cumulative Sum). This technique not only provides a trend line, it calculates savings/losses to date and shows when the performance changes. Cusum represents the **difference** between the base line (expected or "standard" consumption) and the actual consumption data points over the base line period of time. A Cusum graph therefore follows a trend which represents the random fluctuations of energy consumption and should oscillate about zero. This trend will continue until something happens to alter the pattern of consumption such as the effect of an energy saving measure or, conversely, a worsening in energy efficiency (poor control, housekeeping or maintenance).

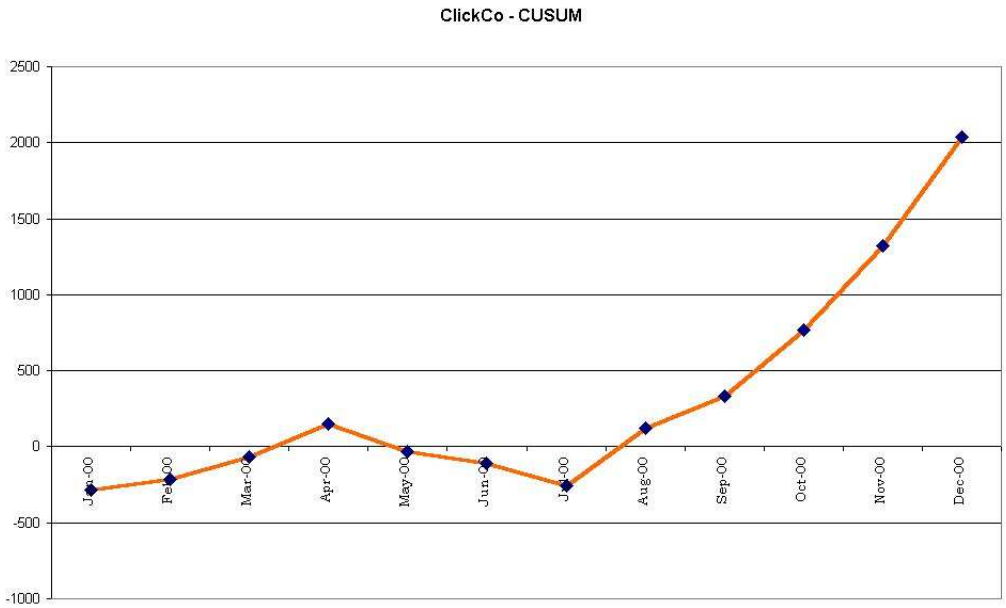
The technique of Cusum is explained in the annex to this guide (page 6) and is also covered in a number of texts.

For ***ClickCo*** the Cusum chart (chart 6) shows what is really happening to the energy performance. Note: We have used the formula derived from the 1999 data to calculate the standard or base energy consumption.

We can see that we started 2000 by performing better than standard. Performance then declined (going up) until April then it started to improve until July. However, from July onwards there is a marked, ongoing decline in performance. i.e. the line shows an upward trend.

When looking at a Cusum chart the changes in direction of the line indicate events that have relevance to the energy consumption pattern. Clearly, site knowledge is needed to interpret what they are. For ***ClickCo*** we know that there were no planned changes in the energy system – so the change in performance is a result of poor control, housekeeping or maintenance.

Chart 6 (see also page 6 for a further explanation of the CUSUM technique)



What next? Well in parallel with this “macro” M&T it would probably be worthwhile conducting a site energy audit to identify what is used where and if sub-metering is appropriate. The next phase might be to look at the site at a “micro” level by monitoring the larger processes. It might also be worth looking at taking readings on a weekly basis and developing a system based on weekly reporting. If you are using the utility meters as the energy data source, it might be worth talking to your utility supplier/metering operator about weekly consumption data. Alternatively, you can read the meters yourself. For companies with an electricity load of 100 kilowatts or more, half hourly data should be available and this is very useful in itself.

Further Guidance

This guide has only been a quick insight into one approach to M&T. The Carbon Trust has a number of very useful, free publications in this area. **These can be ordered from the Carbon Trust Helpline on 0800 085 2005. Further information can also be found on the Carbon Trust web site www.thecarbontrust.co.uk.**

aM&T (automated monitoring & targeting) takes M&T a further, more sophisticated, step forward, by allowing managers to automatically integrate data from different meters and sources and using specialist software applications and the internet. The Carbon Trust can advise further on this approach.

Specific M&T publications are available for different industries from The Carbon Trust - the Carbon Trust Helpline can advise you on the appropriate guide(s) for your specific needs.

See also the Annex (next page) for further advice on the CUSUM technique.

This M&T guide was originally written in 2000 by John Pooley of the John Pooley Consultancy for the Government Office for the South West and sponsored by the (then) Energy Efficiency Best Practice Programme. John Pooley has further assisted in the subsequent updating of this guide in 2005.

Published on the BUSINESS page of www.oursouthwest.com as part of the “Effective Energy Management Guide”

THE CUSUM TECHNIQUE

CUSUM can be a powerful technique for energy management. This annex provides an introduction to the technique that should enable you to produce a CUSUM chart (it is recommended that you refer to specialist publications for more advanced guidance).

CUSUM is the **CU**mulative **SUM** of variances. For the variance to be calculated you need to have a formula for a baseline or 'standard' energy consumption.

Having established this, normally by line of best fit, for each measured period there will be a Standard consumption (Column D) and an actual consumption (Column C) the difference will be the variance (Column E). Plotting this data then gives the CUSUM line.

The table below is taken from the Excel spreadsheet used for Chart 6 on page 4 of this M&T guide.

You can see that in January Standard consumption for 4.24 million clicks (B4) was calculated to be 1,995 kWh (D4). The actual energy use was 1,712 (C4) which was a 'saving' of 283 kWh (E4). This then becomes the first entry for the CUSUM (F4). In the next month the variance was 71 kWh (E5) over the standard, so -283 + 71 = -212 (the cumulative sum), (F5) and so on. It should be noted that some people multiply the CUSUM by -1 so that savings are above the line instead of below the line.

Chart 6 (on page 4) overall shows a system that is not performing well. It started off better than Standard, but was then 'worse' than Standard until April. There was then a period of good performance between April & July. But after July the poor performance continued.

It is fairly straightforward to set up CUSUM with a spreadsheet – no special formulas are required. The line of best fit can be determined using the Excel trendline function.

1	A	B	C	D	E	F
2	Month	Production (Clicks)	Energy (kWh)	Standard (kWh)	Diff (kWh)	CUSUM (kWh)
3						
4	Jan	4,240,000	1,712	1,995	-283	-283
5	Feb	4,000,000	1,970	1,899	71	-212
6	Mar	5,473,930	2,634	2,489	145	-66
7	Apr	7,481,234	3,510	3,291	219	152
8	May	5,270,000	2,220	2,407	-187	-35
9	Jun	6,200,000	2,705	2,779	-74	-110
10	Jul	6,518,740	2,758	2,906	-149	-258
11	Aug	6,268,860	3,188	2,807	381	123
12	Sep	5,360,000	2,652	2,443	209	332
13	Oct	7,600,000	3,774	3,339	435	767
14	Nov	5,800,000	3,172	2,619	553	1,321
15	Dec	7,230,000	3,907	3,191	716	2,036
	Standard:	Energy (kWh) = (production x 0.0004) + 299				

Note: The **Standard** needs to be based on prior data – it is normally recommended that there are between 8 and 12 points in the initial data set used to determine the Standard. It should also be noted that if there are significant changes to the process or building, a new Standard needs to be calculated.