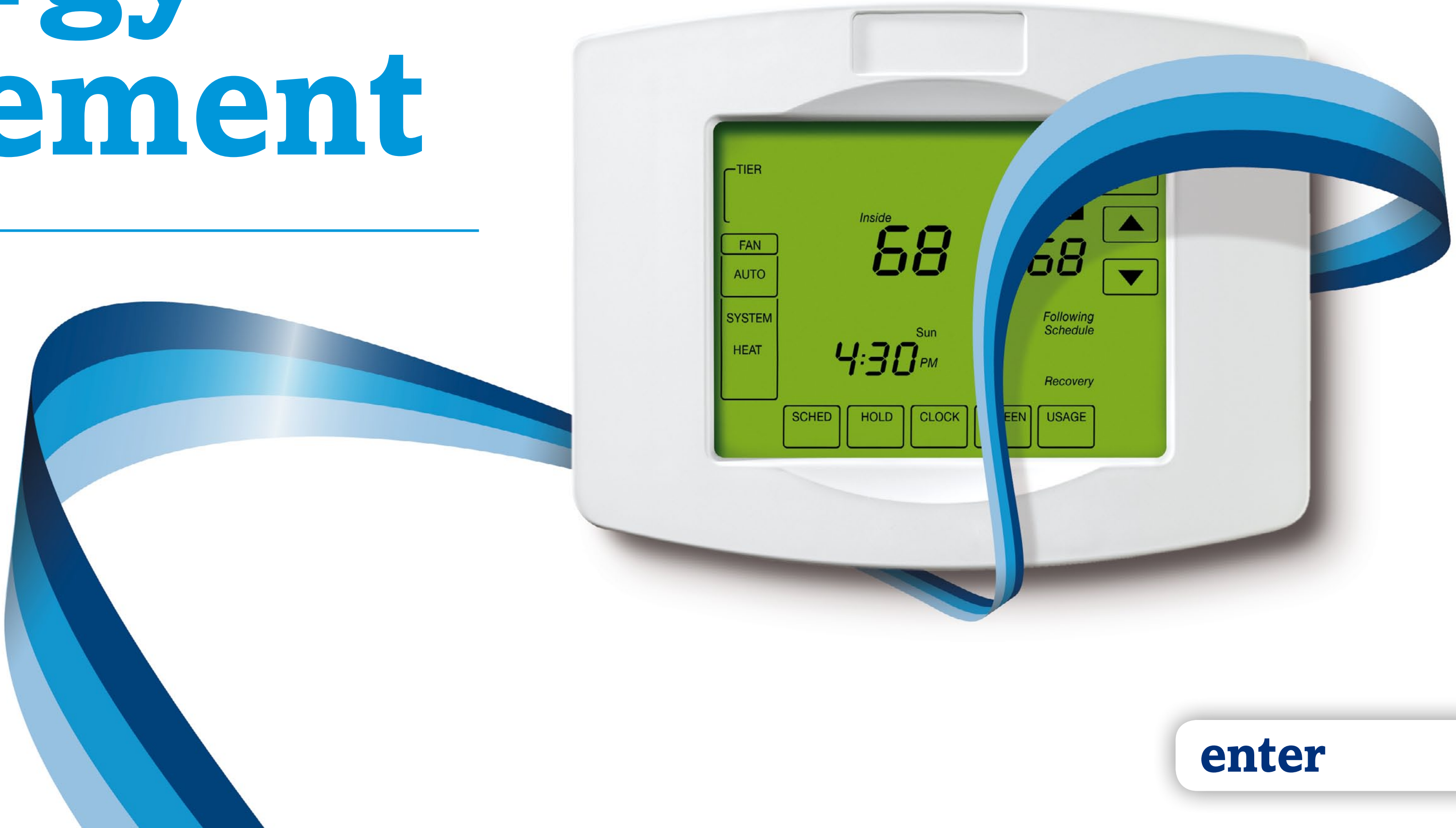
Degree days for energy management

A practical introduction



Preface

Reducing energy use makes perfect business sense; it saves money, enhances corporate reputation and helps everyone in the fight against climate change.

The Carbon Trust provides simple, effective advice to help businesses take action to reduce carbon emissions, and the simplest way to do this is to use energy more efficiently.

This technology guide shows how to use degree days to:

- Monitor changes in heating system operation
- Determine actual savings from energy saving measures
- Produce realistic heating budgets.

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Introduction

Space heating energy for buildings is a major contributor to national carbon dioxide (CO_2) emissions. If heating energy is to be managed effectively it is necessary to monitor and analyse the usage regularly and set realistic targets for improving energy efficiency.

Heating energy consumption depends in part on external (weather-related) temperatures. Degree days provide

a powerful but simple way of analysing weather-related energy consumption. Used with care, the methods described in this guide will provide the energy manager with:

- Overall trends in energy performance
- An indication of whether significant changes have occurred in the operation of the building or plant affecting the building's energy consumption
- A methodology for budgeting energy costs.

Thus degree days can be used both to detect changes in energy performance and to substantiate successes in good energy management.

This guide has been prepared to provide an introduction to the use of degree day analysis as part of a wider energy management programme. It includes the basic principles of relating energy use to weather conditions through the degree day, and how changes in operation can be seen. In the worked example, starting from page 13, significant changes arise from the replacement of a boiler plant. However, much more detailed analysis can be carried out to show subtle trends within existing plant, such as faults with controls or systems, changes within the building usage etc. This can be a powerful aid to the energy management function, but these techniques are beyond the scope of this publication.

Readers wishing to go into greater detail are referred to a publication from the Chartered Institution of Building Services Engineers entitled *Degree Days Application and Theory* (full reference, see page 21).

This provides much more detail on the theory and practice of degree days and also includes an appraisal of cooling degree days. Readers who want a deeper understanding of the subject as a whole are recommended to obtain this publication.

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What are degree days?

Heating degree days are a measure of the severity and duration of cold weather. The colder the weather in a given month, the larger the degree-day value for that month. They are, in essence, a summation over time, of the difference between a reference or 'base' temperature and the outside temperature.

Figure 1 illustrates this summation over four days. The shaded area is the total degree-day value for the four days. Note that when the outside temperature rises above the base temperature, degree days are taken as zero. This summation for each calendar month is published as historical data and is available from the sources listed at the end of this publication.

The rate of heat loss from a building is directly related to the inside-to-outside temperature difference and the energy consumed for space heating is directly related to degree days. This relationship can be exploited to appraise the energy performance of a building to detect energy waste, system faults and to set realistic savings targets and heating budgets.

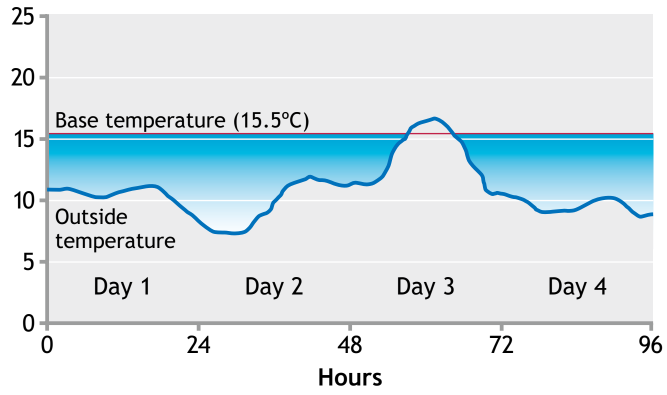
Significance of the base temperature

The base temperature is defined as the outside temperature above which the heating system in a building would not be required to operate. The heat in a building comes from several sources, as well as from the heating system itself. These other sources include the occupants, lights and equipment in the building. This means that a building is partially self-heating and the base temperature is therefore lower than the internal temperature. The proportion of self-heating is usually relatively small.

The exact value varies from building to building depending on the characteristics of the building and on its use.

Published degree days in the UK are calculated to a base temperature of 15.5°C for general use with most buildings (and 18.5°C for hospitals). Higher levels of internal heat gains and insulation in many modern buildings mean that they have lower base temperatures than this. For the applications described in this guide, this is of little importance: published degree-day figures will be adequate.

Figure 1 The shaded area is the degree-day value for the period



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Sources of degree day and weather data

Monthly degree days are published for 18 different regions in the UK. These regions are shown in *Figure 2*. These regions are large, and local degree days will vary within each region.

For the applications covered by this guide, local variations are unimportant. The most appropriate degree days for your site are usually those from the nearest measuring station, which may sometimes be in an adjacent region. Occasionally, however, this may not be the most appropriate choice; for example, Swansea shows more affinity with Bristol – both being near the Bristol channel – than with the physically closer site at Aberporth.

The most important factor is consistency, and once a region has been selected it should continue to be used. Sources of degree day data are given at the end of this guide. These provide degree-day values to the standard 15.5°C base temperature for the 18 regions. Some sources can provide more localised information to other base temperatures and different time frames (e.g. weekly or daily), but there will normally be a charge for the service.

Where a site has its own building management system (BMS), degree days can be calculated in-house by summing the difference between the selected base temperature and the measured hourly outside temperatures, noting that degree days are set to zero when the outside temperature exceeds the base temperature. When adopting this approach it is important to check regularly the calibration of the temperature-measuring devices and to ensure that they are not influenced by solar gains, high air movement or other heat sources.

This guide discusses four valuable energy management uses of degree days. These are:

- Constructing control charts for ongoing supervision
- Evaluating the impact of savings measures taken
- Detecting the existence of faults in heating systems and their controls
- Preparing annual budgets.

For all these uses, it is first of all necessary to establish an accurate database. Therefore, the first step is to collect metered energy consumption and relevant degree-day data, and to check their accuracy using the step-by-step guidelines given from page 7. More modern buildings ought to have sub-meters to make this easier.

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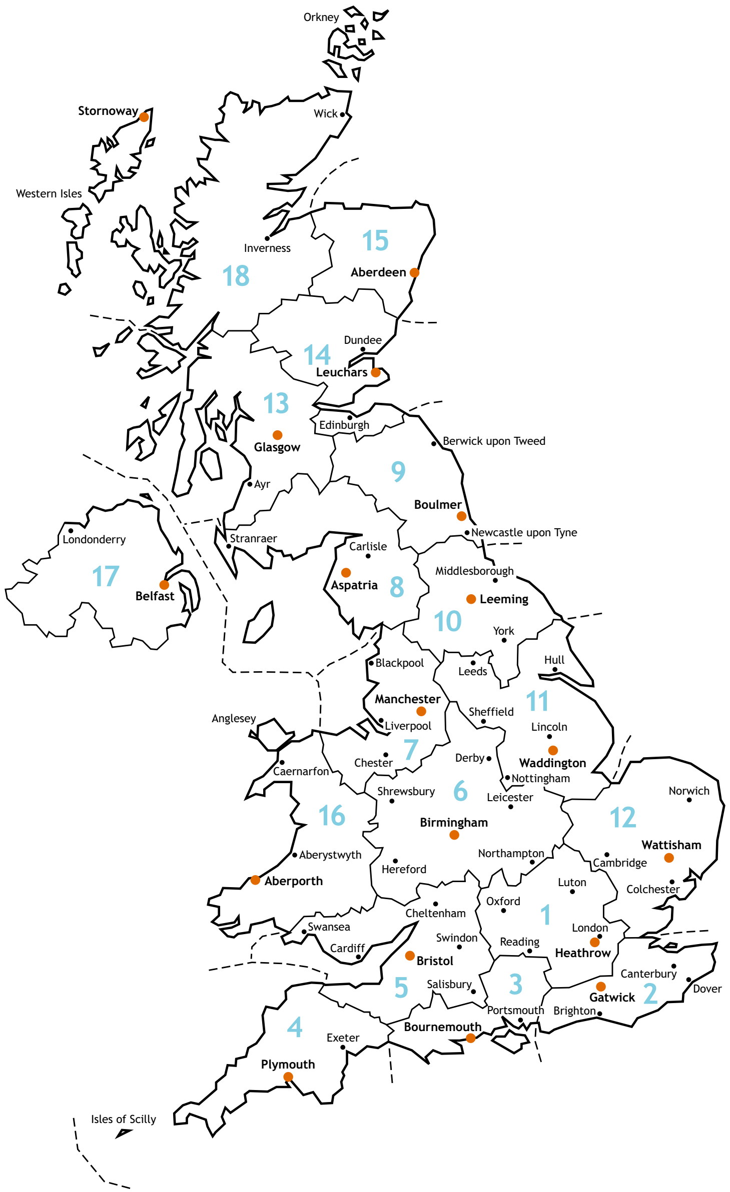
Figure 2 ***Degree day regions and reference sites (•)***



Regions

1 Thames Valley

2 South East

3 South

4 South West

5 Severn Valley

6 Midland

7 West Pennines

8 North West

9 Borders

10 North East

11 East Pennines

12 East Anglia

13 West Scotland

14 East Scotland

15 North East Scotland

16 Wales

17 Northern Ireland

18 North West Scotland

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Using degree days

Use degree days to assess the heating energy performance of buildings.

To assist the reader in undertaking an energy assessment, a step-by-step worked example is included in the next section. The 'steps' below refer to the worked example (starting from page 13).

Step 1

Collection and processing of data

Energy data

Energy data can be collected in three main ways:

- Automatic collection via a BMS or an M&T system involving automatic meter reading
- Manual reading of meters
- From bills.

The method adopted depends on the site complexity, availability of staff, the type of meters and billing accuracy. Where bills are used, great care must be taken to ensure that they are based on meter readings and not estimates. Ideally readings should be on a regular basis, e.g. the first/last day of the month.

Degree days

Degree days should be obtained from one of the sources described on page 21.

Frequency of data collection

The frequency of data collection should be based on practical considerations such as availability of personnel or automated systems, and the nature of the investigation to be conducted. Monthly data are the norm for two reasons: first, because degree days are published per calendar month; second, daily variations in building response and occupancy patterns cause correlations with degree days to become less reliable over short time periods. This does not mean data cannot be collected more frequently, but they should be amalgamated accordingly.

Data quality

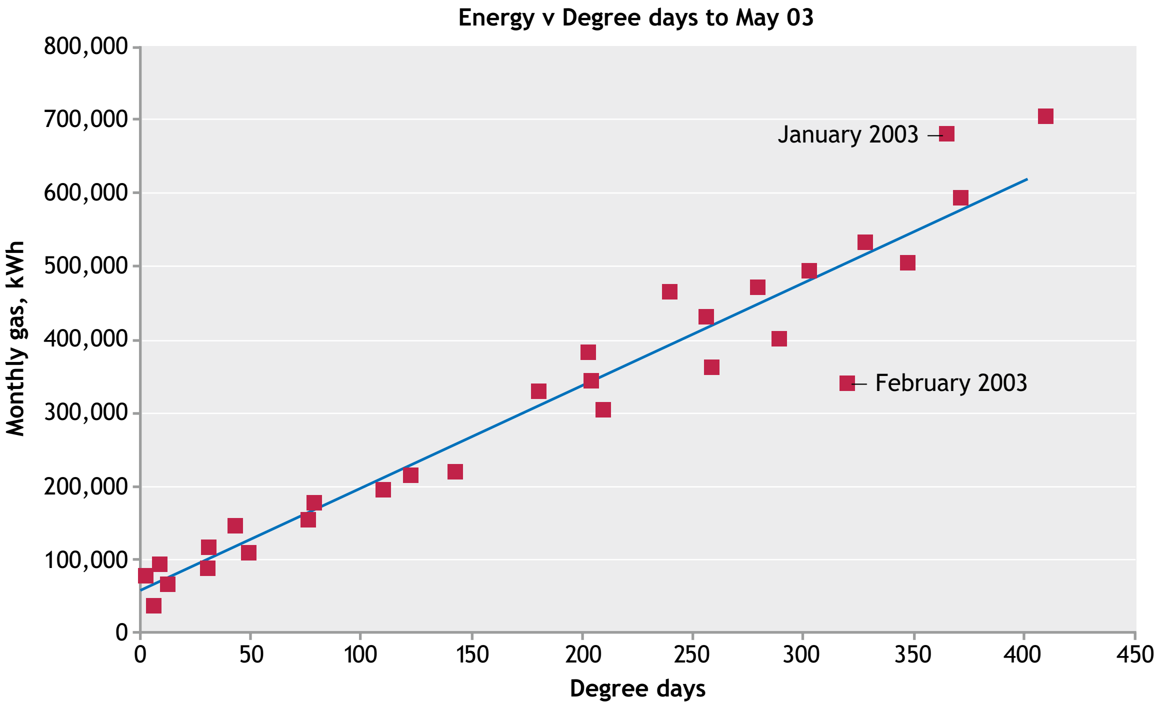
The quality of the data is dependent upon the reliability of the source, including the timing of meter reading, and the accuracy and calibration of the meters. Ideally, meter-reading dates should coincide with the end of the month. It is important, therefore, to be familiar with the data-collection procedures for a particular site. This could include automatic metering.

An initial assessment of data quality can be made by plotting a graph of the monthly energy consumption (Y-axis) against monthly degree days (X-axis). An example of this is shown in *Figure 3* (overleaf). The line through the data is the statistical line of best fit, which can be added to graphs using standard spreadsheet facilities. This line is referred to as the performance line of a building, and the scatter of the points around the performance line can be an indication of the quality of the data.

Scatter in the data may be due to a number of factors, and may be random or systematic. One of the most obvious sources is that meter readings are not taken reliably; missing the start or end of the month by three or four days (which may happen if readings are only taken on Mondays for example) could account for +/-10% of the monthly fuel consumption. In the case of *Figure 3* the labelled points illustrate the effect of a late meter reading. To construct this figure, the data for *Figure 4a* from step 2 (page 13) has been manipulated to show the consequences of taking a reading four days into February instead of at the end of January. The 'January' figure appears unusually high while the 'February' figure is low. In extreme cases, outliers may have to be removed from the data set.

Other contributors to scatter can include wide control dead bands (the difference in temperature between which a thermostat switches a heating system on and off). In addition, there could be lack of weather-related controls, activities of the occupants such as opening and closing of windows and doors, and variations in the length of the working day. Other sources of heat can be another factor. Where wide scatter is observed it is therefore necessary to investigate the possible causes; i.e. whether due to data collection errors or else from control faults or operational factors.

Figure 3 Scatter plot of monthly energy consumption against monthly degree days showing the line of best fit and illustrating the effect of a late meter reading



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Quantity of data

Statistically it is desirable to use as many data as possible when establishing the performance line. However, it should be borne in mind that buildings change form and function over time, and it may be inappropriate to relate current energy consumption to consumption patterns of 10 years ago. The techniques discussed later can go some way to evaluate how many data should be used to plot the performance line.

Where there are very few data available (say a few months) it is still possible to construct a meaningful performance line upon which to build an energy management process. As more data become available then a more reliable picture can be obtained.

What is important is to make a start in collecting energy data accurately and consistently and analysing them at the earliest opportunity. It will be helpful also to keep a diary record of known changes in operation or modifications to the system and building. A Building Log Book may be useful in this regard.

Step 2

Performance lines

The graph of space-heating energy consumption against degree days should show a relationship between the two: expressed as a performance line. It should usually yield something close to a straight line, as shown in step 2 of the worked example. A straight line consists of two components – the slope and the intercept on the vertical axis – and is of the form $y = mx + c$. The slope, m, and intercept, c, can be found from a least squares regression analysis; most common spreadsheet packages can carry out the necessary calculations, display the equation and add the line to the graph. The performance line equation is an expression of how much energy the building can be expected to use for a given number of degree days. The slope is a measure of how much extra fuel is consumed for an increase in degree days; the intercept is an indication of non-weather-related energy uses such as hot water, humidification, canteen cooking or other processes (which in some cases can be high in comparison to the weather-related loads).

The performance line allows the energy use of the building to be compared against its past performance. By entering monthly degree-day values into the equation of the performance line one obtains a prediction of how much energy the building would be expected to use if it continued to operate as it had in the past.

Persistent deviations from the historic performance line mean that something has changed in the way the building consumes energy. Such deviations may result from changes in building use, of control settings, the installation of energy efficiency measures or malfunctioning equipment. The performance line therefore provides the benchmark by which to pick up these changes, and make quantifiable judgements about them (for example the magnitude of savings), or to be alerted to defects. It can also be used as a basis for setting energy budgets. The sections that follow show how to use the performance line equation for each of these purposes.

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Interpretation of performance lines

Before fitting a line to the data, look at the data to see whether a single straight line looks sensible. If it does, the methods described in this guide can be applied. The most likely patterns are as follows, and are illustrated on this and the following page. More information on these and other patterns is given in the CIBSE publication referred to. For example, the base temperature may be other than 15.5°C and the latter publication shows how to calculate what it is – the correct figures' use often resulting in a much better fit.

A straight line with a positive intercept on the energy axis and modest scatter (*Figure 4a*)
This is the most common form. The analysis methods described in this guide may be applied. If there is appreciable scatter, consider first whether a different form of line would better describe the data. Examine whether the time interval between meter readings is consistent, before assuming that there is an operational cause.

Straight line with an intercept on the degree day axis (*Figure 4b*)
The building requires no heat until a certain level of degree days is reached. This could be because heat gains from equipment are high (or have a large effect because the building is well insulated).

The analysis methods described in this guide may be applied irrespective of the fact that the intercept is on the degree-day axis (but exclude the 'no heating' points from the calculation of the performance line).

Figure 4a Straight line with a positive intercept on the energy axis and modest scatter

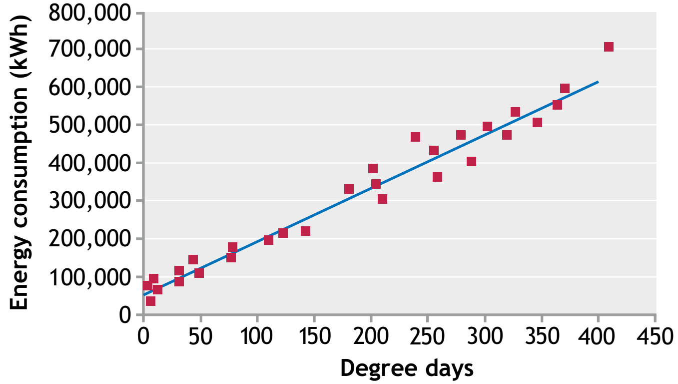
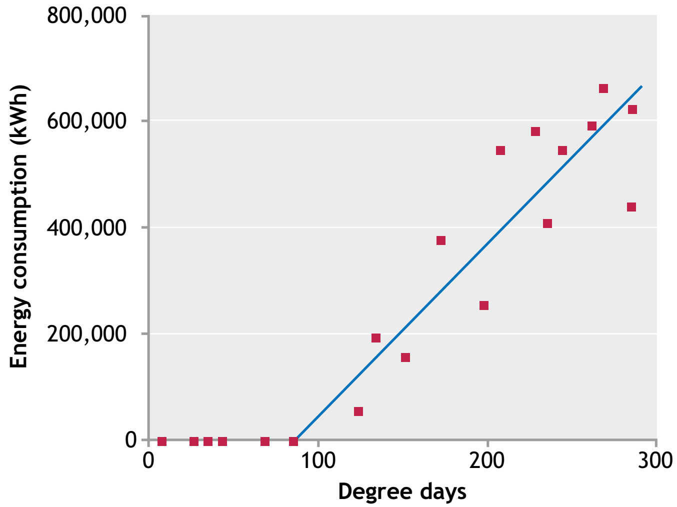


Figure 4b Straight line with intercept on the degree-day axis

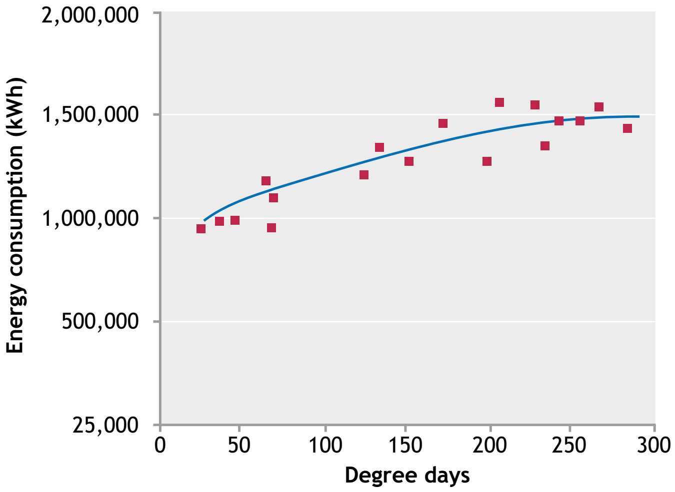


A curve that becomes less steep with increasing degree days (*Figure 4c*)
This can result from the temperature of the building varying with season.

Alternatively, assuming the base temperature is correct, typical reasons might be:

- If the curve becomes horizontal at high degree days – the heating system may have reached the limit of its capacity
- If the curvature is slight and throughout the range – there may, for example, be poor temperature control, leading to energy waste; investigate the cause further.

Figure 4c Curve becomes less steep



Steps 3 to 4

Control charts

The control chart provides the energy manager with a visual display of how actual energy consumption varies from the performance line. This is done by subtracting predicted consumption (the equation of he performance line) from the actual consumption for each month:

Difference between actual and predicted consumption = actual consumption – (slope x degree days + intercept)

These differences are then plotted for each month, as shown in the graph in *Figure 6*, page 15. Note that the convention for determining these differences is always actual minus predicted, and any energy savings against predicted will show up as negative values. It is possible to set limits on the graph that identify the normal expected operating range of the building, as illustrated in *Figure 6*. There are statistical methods for setting these, which are outside the scope of this document, but the value of the control chart is to give the energy manager some feel for the fluctuations in building performance. The next stage – the CUSUM graph – is a more powerful tool for detecting changes in operation, for example the development of a fault in the heating system.

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Table 1 ***Column headings for the CUSUM procedure (see also worked example)***

1	2	3	4	5	6
Month	Degree days (hWh)	Actual consumption (kWh)	Predicted consumption (kWh)	Difference (kWh)	CSUM
	From published or self-calculated values	From meter readings	Slope x Column 2 + intercept	Column 3 minus Column 4	Cumulative sum of figures from Column 5

Steps 5 to 8

CUSUM and the assessment of savings

CUSUM is a statistical procedure originally developed for monitoring industrial production. CUSUM is short for 'cumulative sum of the difference'. The previous section described differences between actual and predicted energy consumption, which can show a rather erratic pattern. Taking the cumulative sum of these differences, on the other hand, can reveal the overall trends that are occurring in the energy performance of the building.

Table 1 shows the column headings of the CUSUM procedure. The CUSUM column represents the total differences to date, and can be plotted as shown in the worked example to reveal trends in building energy performance.

There are some fundamental characteristics of the CUSUM graph. If savings are being made then the slope from one month to the next will be downwards; this slope will be less in the summer months (when consumption, and therefore the scope for savings, is less), especially if most of the effort has been towards savings in space heating. Any upward trend in the line suggests that something has changed to increase energy consumption over the original performance.

Thus the CUSUM graph can reveal when significant changes occur in energy usage, and can be very valuable in alerting the energy manager to potential problems when they might otherwise go undetected. There have been cases where control component failures (often unlikely to be looked for or routinely found) have shown up as dramatic changes in the CUSUM trend.

Steps 7 and 8 of the worked example (on page 18 and page 19) illustrate how CUSUM can be used to quantify the cost implications of a change in performance, such as the implementation of energy saving measures.

Once a sustained performance change has been identified, a new performance line and CUSUM chart should be calculated, including only data after the change.

Worked example

The worked example demonstrates a step-by-step approach to degree-day analysis of energy consumption. It is a straightforward example to demonstrate the basic steps in applying the technique; other buildings may demonstrate different performance lines, control charts and CUSUM graph shapes. Note that sometimes numbers may be rounded to the nearer whole number for ease of presentation.

Step 1

Using a spreadsheet package, collect and tabulate the energy consumption and degree-day data.

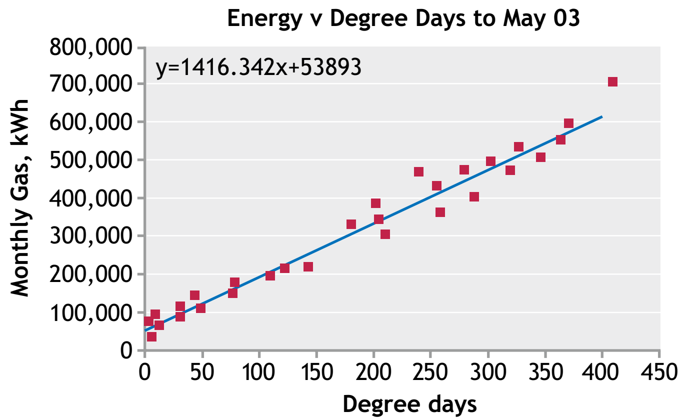
	Monthly consumption (kWh)	Degree days
Jan-01	400334	288
Feb-01	503247	346
Mar-01	430589	255
Apr-01	302496	209
May-01	109235	49
Jun-01	65213	12
Jul-01	115568	31
Aug-01	88959	31
Sep-01	145482	43
Oct-01	195256	110
Nov-01	382548	202
Dec-01	532689	327
Jan-02	703568	409
Feb-02	593458	370
Mar-02	465870	239
Apr-02	218550	142
May-02	152400	76
Jun-02	92556	9
Jul-02	35455	6
Aug-02	76523	2
Sep-02	176889	78
Oct-02	342448	204
Nov-02	361258	258
Dec-02	492550	302

Step 2

(See 'Performance lines' on page 9.) Plot an X-Y scatter graph of all the data. Look at the shape of the plot – it appears to be a straight line, so add a trend line and equation of the line using, for example, spreadsheet facilities. This line will be the initial performance line for the building.

This is an example of a straight line with a positive intercept.Note that, in this example, there is substantial consumption at zero degree days – that is, not related to temperature.

Figure 5 (Figure 4a with equation shown)



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Step 3

(See 'Control charts' on page 11.) Add two more columns to the data table.The first of these will be the prediction column, where each cell will be calculated using the equation of the performance line, which in this case will be:

Predicted energy consumption:
y=1416.342x + 53893kWh

The second new column will be the difference between actual and predicted consumption.

	Monthly consumption (kWh)	Degree days	Predicted consumption (kWh)	Difference
Jan-01	400334	288	461799.3	-61465.3
Feb-01	503247	346	543947.1	-40700.1
Mar-01	430589	255	415060.0	15529.0
Apr-01	302496	209	349908.3	-47412.3
May-01	109235	49	123293.6	-14058.6
Jun-01	65213	12	70888.9	-5675.9
Jul-01	115568	31	97799.4	17768.6
Aug-01	88959	31	97799.4	-8840.4
Sep-01	145482	43	114795.5	30686.5
Oct-01	195256	110	209690.4	-14434.4
Nov-01	382548	202	339993.9	42554.1
Dec-01	532689	327	517036.6	15652.4
Jan-02	703568	409	633176.7	70391.3
Feb-02	593458	370	577939.3	15518.7
Mar-02	465870	239	392398.5	73471.5
Apr-02	218550	142	255013.4	-36463.4
May-02	152400	76	161534.8	-9134.8
Jun-02	92556	9	66639.9	25916.1
Jul-02	35455	6	62390.9	-26935.9
Aug-02	76523	2	56725.5	19797.5
Sep-02	176889	78	164367.5	12521.5
Oct-02	342448	204	342826.6	-378.6
Nov-02	361258	258	419309.0	-58051.0
Dec-02	492550	302	481628.1	10921.9

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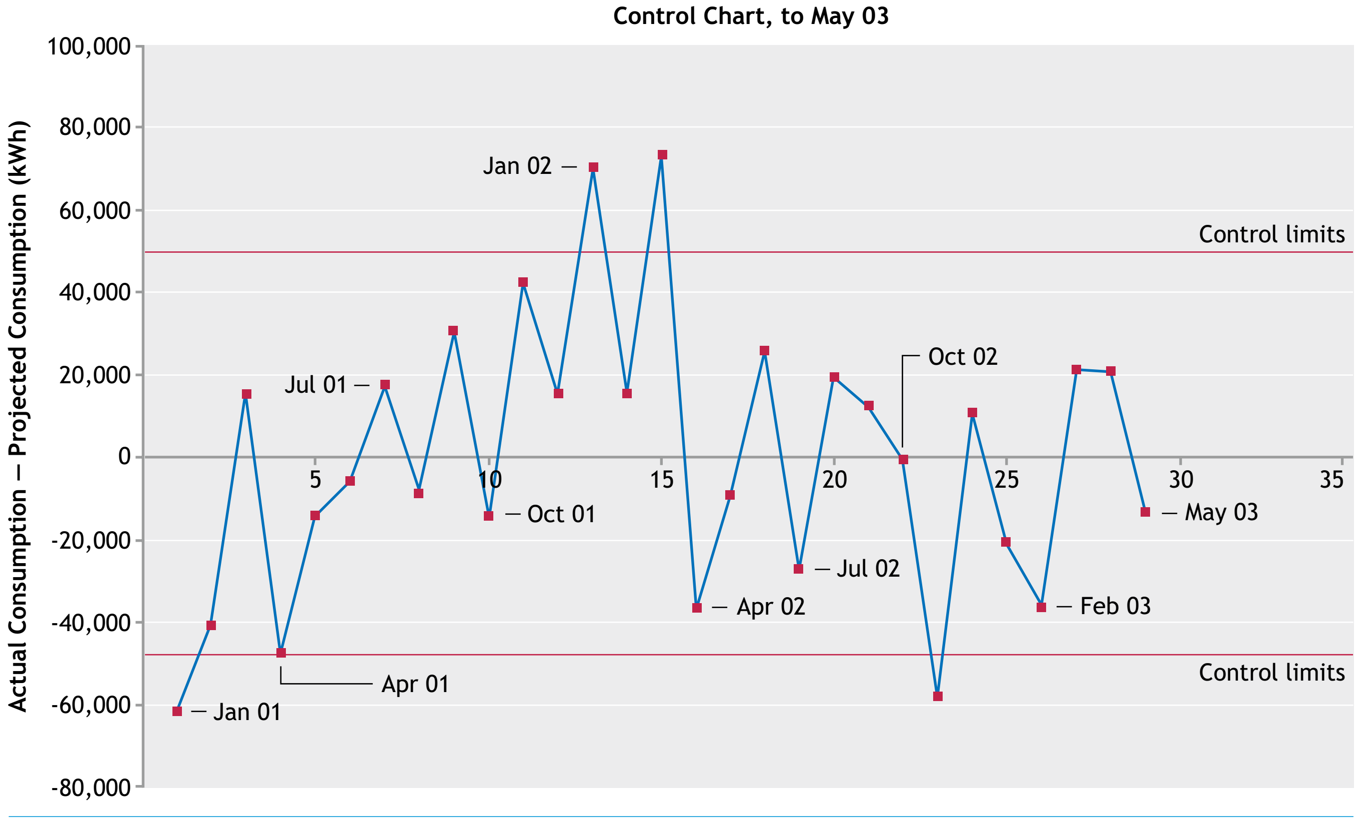
Step 4

(See ‘Control charts’ on page 11.) Construct a control chart by plotting a line graph of the differences against months. In this example the control limits have been set at 1.4 times the standard deviation of all the differences. This is a mathematical approach, which, for this type of example, may typically be expected to be exceeded 17% of the time, or about twice a year.

Figure 6



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Step 5

(See CUSUM and assessment of savings on page 12.) The next step is to add the CUSUM column, where the difference in a particular month is added to the cumulative sum of the differences from the previous month. Note that at this stage the last value in the CUSUM column to May 2003 should be zero, because the same data has been used both to calculate it and predict the consumption.

	Monthly consumption (kWh)	Degree days	Predicted consumption (kWh)	Difference	CUSUM
Jan-01	400334	288	461799.3	-61465.3	-61465.3
Feb-01	503247	346	543947.1	-40700.1	-102165.4
Mar-01	430589	255	415060.0	15529.0	-86636.4
Apr-01	302496	209	349908.3	-47412.3	-134048.7
May-01	109235	49	123293.6	-14058.6	-148107.3
Jun-01	65213	12	70888.9	-5675.9	-153783.2
Jul-01	115568	31	97799.4	17768.6	-136014.6
Aug-01	88959	31	97799.4	-8840.4	-144855.0
Sep-01	145482	43	114795.5	30686.5	-114168.5
Oct-01	195256	110	209690.4	-14434.4	-128602.9
Nov-01	382548	202	339993.9	42554.1	-86048.8
Dec-01	532689	327	517036.6	15652.4	-70396.4
Jan-02	703568	409	633176.7	70391.3	-5.1
Feb-02	593458	370	577939.3	15518.7	15513.6
Mar-02	465870	239	392398.5	73471.5	88985.0
Apr-02	218550	142	255013.4	-36463.4	52521.7
May-02	152400	76	161534.8	-9134.8	43386.9
Jun-02	92556	9	66639.9	25916.1	69303.0
Jul-02	35455	6	62390.9	-26935.9	42367.1
Aug-02	76523	2	56725.5	19797.5	62164.6

	Monthly consumption (kWh)	Degree days	Predicted consumption (kWh)	Difference	CUSUM
Sep-02	176889	78	164367.5	12521.5	74686.2
Oct-02	342448	204	342826.6	-378.6	74307.6
Nov-02	361258	258	419309.0	-58051.0	16256.6
Dec-02	492550	302	481628.1	10921.9	27178.5
Jan-03	548997	364	569441.3	-20444.3	6734.2
Feb-03	469589	319	505705.9	-36116.9	-29382.7
Mar-03	470556	279	449052.2	21503.8	-7878.9
Apr-03	329840	180	308834.4	21005.6	13126.7
May-03	213569	122	226686.5	-13127.5	0.0
Jun-03	81058	24	87885.0	-6827.0	-6827.8
Jul-03	85247	12	70888.9	14358.1	7530.3
Aug-03	54210	2	56725.5	-2515.5	5014.8
Sep-03	160253	115	216772.1	-56519.1	-51504.3
Oct-03	255689	188	320165.1	-64476.1	-115980.4
Nov-03	280256	241	395231.2	-114975.2	-230955.7
Dec-03	395248	321	508538.6	-113290.6	-344246.2
Jan-04	440259	379	590686.4	-150427.4	-494673.6
Feb-04	360589	296	473130.0	-112541.0	-607214.7
Mar-04	290412	221	366904.4	-76492.4	-683707.1
Apr-04	215563	165	287589.2	-72026.2	-755733.3

Step 6

The performance line fit in *Figure 5* shows the operating characteristic of the building with a typical set of meter readings, from January 2001 to May 2003. The control chart in *Figure 6* shows consumption figures outside the tolerance band which may prompt action to investigate their cause. Equally, the analysis may have been carried out using historical data to set a baseline for the future. The strength of the CUSUM technique is that by comparing ongoing consumption data with the historic performance line a trend indicating change can rapidly be seen. *Figure 7* shows the CUSUM data from the table above, by definition at zero in the spring of 2003, but from the autumn showing a consistent and significant decline in consumption. This was the result of replacing old and inefficient boiler plant and controls. Clearly this change was expected, but equally the trend might have been in the opposite sense, for example a failed timeclock leading to continuous heating in a five day occupancy building, which may have gone unnoticed for months. *Figure 8* shows the performance line from mid 2003 on, to the same scale, illustrating the improvement and representing the datum against which future consumption should be measured and targets set. Steps 7 and 8 quantify the cost implications of the reduced consumption after summer 2003.

Step 7

To estimate the financial value of the change in performance, we can use the analysis that predates the change and the new performance line based on data from summer 2003.

Step 8

To quantify the actual savings, the earlier line is used to construct a new table comparing the current consumption and expected fuel use before the change. The savings can be estimated by multiplying the cumulative differences by the price of fuel, in this case gas at 3p/kWh. The analysis here suggests that in the first year of the new plant £22,700 of savings were made. The table shows a higher than expected consumption in July 2003. If this persists, possible faults or changes in building use should be investigated.

Figure 7

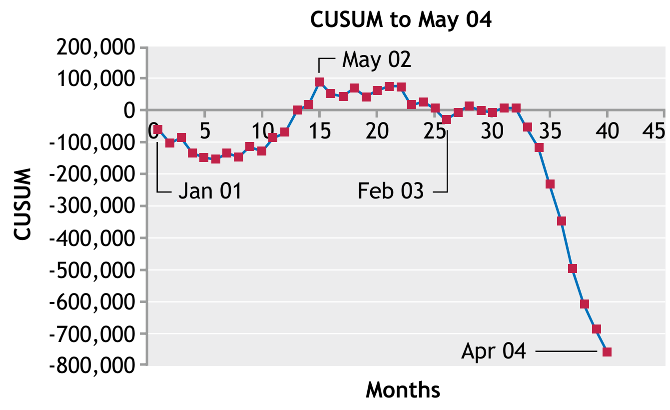
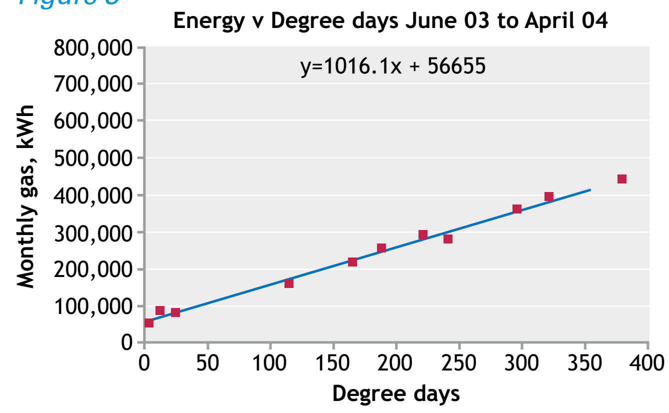


Figure 8



	Actual consumption (kWh)	Degree days	Predicted consumption without change (kWh)[1]	New Difference	New Money savings (£)[2]	New Cumulative money saving from May 2003 (£)
Jun-03	81058	24	87885	-6827	205	205
Jul-03	85247	12	70889	14358	-431	-226
Aug-03	54210	2	56725	-2515	75	-150
Sep-03	160253	115	216772	-56519	1696	1545
Oct-03	255689	188	320165	-64476	1934	3479
Nov-03	280256	241	395231	-114975	3449	6929
Dec-03	395248	321	508539	-113291	3399	10327
Jan-04	440259	379	590686	-150427	4513	14840
Feb-04	360589	296	473130	-112541	3376	18216
Mar-04	290412	221	366904	-76492	2295	20511
Apr-04	215563	a165	287589	-72026	2161	22672

[1] y=1416.342x + 53893
[2] Money savings have been corrected to the nearest £

Budget setting

Budget setting and benchmarking

The setting of energy budgets also needs to take account of the weather. Merely using past energy data to set the following year's budget will give a budget that is very likely to be under or over-spent, especially if the previous year was particularly mild or particularly cold. The performance line can assist in this process too.

Twenty-year average monthly degree days are also published for each region. These give the average weather condition for each month. Use the current performance line (in this case from *Figure 8*) to calculate the predicted future energy consumption that would occur with average weather, based on the 20-year average temperatures.

Of course, by definition the average 20-year degree days can be expected to be exceeded one year in two. In flexible budget regimes this may be tolerable, but this may not be acceptable in more rigid budget regimes. In this case, to reduce the risk of under-setting the budget, it may be necessary to use monthly degree days taken from the upper ranges of the 20-year frequency distribution, for example the upper quartile (75th percentile, exceeded one year in four) or the ninth decile (90th percentile, exceeded one year in 10). This information can be determined from 20-year monthly degree-day values, which are available from some of the sources listed at the end of this guide. All of this presumes that there are no changes to the building use, services, etc. If there are these should, of course, be addressed. There are also trends in the 20-year figures due to global warming.

It is important that the degree days used in this process come from the same source location as those used to plot the performance line.

Energy saving targets should be developed from energy audits and surveys that identify particular savings opportunities. A programme of implementation of savings measures can be drawn up, and the timing of expected savings evaluated. Use of the CUSUM technique allows performance against these expected savings to be monitored, and achievements reported in a positive and understandable way. If targets are not being met then CUSUM sends signals to the energy manager that more can be done, or some aspects of the savings implementation have been unsuccessful. Only by setting targets and adopting a robust monitoring regime can the energy manager truly have the knowledge necessary to manage energy consumption effectively.

Month	20-year average degree days	Budgeted consumption (kWh)[1]
January	362	424483.20
February	318	379774.80
March	299	360468.90
April	235	295438.50
May	156	215166.60
June	90	148104.00
July	45	102379.50
August	52	109492.20
September	95	153184.50
October	183	242601.30
November	270	331002.00
December	348	410257.80
Total	2453	3172353.30

[1] 1015.1x+56655

Sources of information

Degree days data

Degree day data is readily available on the internet for different regions from both free and commercial providers.

Publications

The Carbon Trust has a library of energy saving publications to order or download, including further information on this topic. For more information please visit our website.

This guide deliberately limits its discussion of theory to the minimum necessary to enable users to apply the techniques described in it.

The subject of degree days is an emerging science. For a more comprehensive technical background and discussion about degree days, see CIBSE TM 41 *Degree Days Application and Theory*, published by the Chartered Institution of Building Service Engineers.

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The Carbon Trust is a not-for-profit company with the mission to accelerate the move to a low carbon economy. We provide specialist support to business and the public sector to help cut carbon emissions, save energy and commercialise low carbon technologies. By stimulating low carbon action we contribute to key UK goals of lower carbon emissions, the development of low carbon businesses, increased energy security and associated jobs.

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- setting standards for carbon reduction.

We reduce potential future carbon emissions by:

- opening markets for low carbon technologies
- leading industry collaborations to commercialise technologies
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