Energy saving in buildings

– methods for quickly identifying opportunities

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

GENERAL INFORMATION LEAFLET 50

INTRODUCTION

While good housekeeping measures can save at least 10% of the total energy costs of buildings, significantly more savings can be achieved by taking a closer look at individual buildings and how energy is actually being used in them.

The purpose of this General Information Leaflet (GIL) is to suggest ways of quickly identifying potential energy waste in buildings by analysing energy consumption data. The information is written for managers with a responsibility for energy in their organisation, whether they are experienced energy managers or others with little time to spend on considering energy issues.

HOW TO USE THIS DOCUMENT

This GIL provides information on some easy methods to identify opportunities for energy savings. A combination of one or more of the approaches described should assist you in achieving significant savings, depending on the complexity of the energy problem. Some of the approaches are for all energy use, others are applicable to heating alone, eg building energy signatures (see page 5).

Each method should help you quickly identify the information you need, eg from meter readings and fuel bills, to establish roughly where you can reduce energy waste through implementing simple projects. However, this GIL deliberately leaves more detailed explanations of the techniques and methods used to other guides.

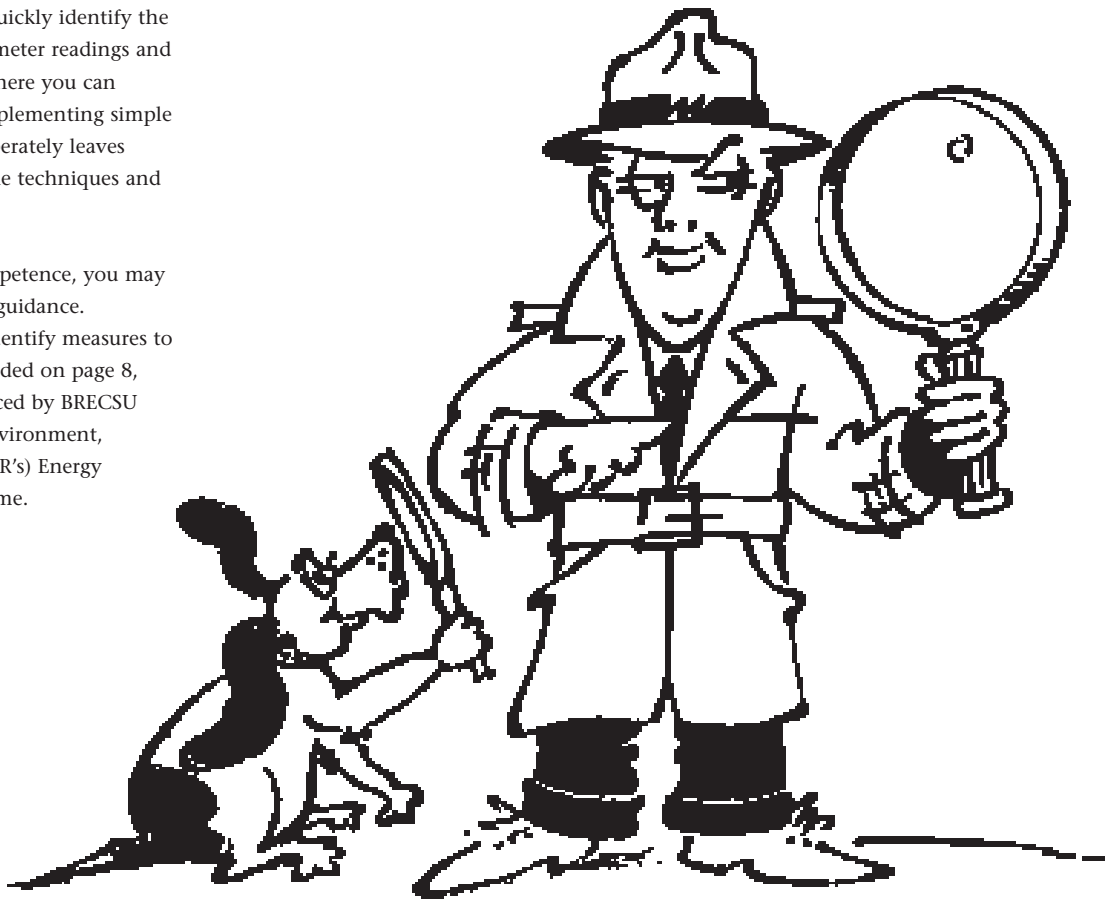
Depending on your level of competence, you may need to seek further advice and guidance. Suggested reading to help you identify measures to implement your projects is included on page 8, including other literature produced by BRECSU under the Department of the Environment, Transport and the Regions' (DETR's) Energy Efficiency Best Practice programme.

DIFFERENT APPROACHES

There are two well-established approaches to identifying wasteful use of energy, and each has its advantages and shortcomings.

- A physical survey:
  - focuses immediately on tangible faults, but can identify only visible faults, depends on the expertise of the surveyor, and may require an external consultant or surveyor.
- Data-based methods which analyse energy-use patterns:
  - can be less expensive because they do not depend on taking expertise to site
  - can initially be based on existing data
  - can identify intermittent faults, but are limited to the types of fault that show up in metered information and by the extent, regularity and timing of meter readings.

This GIL concentrates on different data-based methods, but there are considerable benefits when both approaches are applied. Data can be used to prioritise buildings for further examination, optimise the timing of on-site physical surveys and maximise their effectiveness.



DATA-BASED METHODS

MEASURING THE DATA

One of the benefits of using reliable data is that it takes the guesswork out of making calculations. Energy bills provide an historical record of energy use over a specific period. If considered along with the size, use, location and perhaps thermal insulation of buildings, they can make a useful start to the analysis. However, they are often months behind the times and usually cover too long a period. Actual meter readings are what are needed – the more the merrier. The number of meters and the frequency of readings all improve the ability to detect problems. A compromise has to be reached on cost grounds, but a number of meters read weekly could be a useful interim arrangement.

Reading some meters daily, or even hourly, for a short period may sometimes be worthwhile. Ways of using these readings are outlined on the following pages together with further energy-related issues.

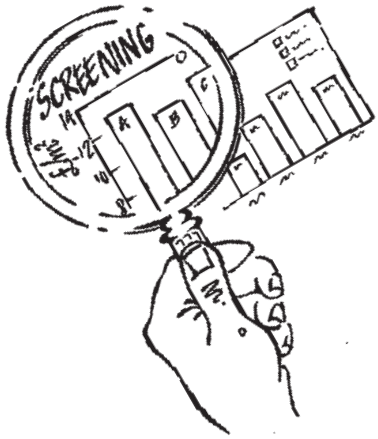
Weather has an important influence on energy consumption in many buildings. Some of the approaches in this GIL refer to 'degree days', which are explained briefly in the box below, and defined fully in Fuel Efficiency Booklet 7, 'Degree Days' (FEB 7)[1].

DEGREE DAYS

Degree days assist in profiling a building's performance, taking account of differing weather through the seasons and across the country.

Degree days are the measure of the number of degrees by which the average external temperature for a particular day in a particular area falls below some reference or 'base' temperature. The usual base temperature is 15.5ºC. You would expect the number of degree days to be higher in the winter than in the summer; the largest numbers indicating colder weather, with its likely increased requirement for heating. Degree days for different areas of the country for each month are published in DETR's 'Energy and Environmental Management' magazine and are also available from several commercial sources.

APPROACHES TO DATA-BASED METHODS

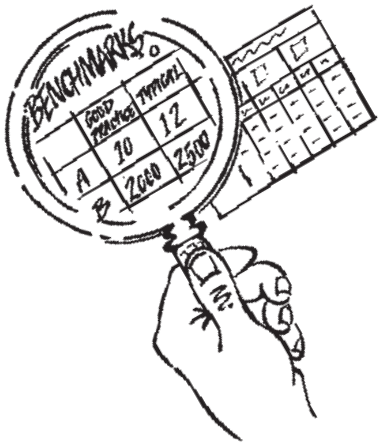


Screening

Screening uses the data to compare the energy performance of each building in a group, or even each floor, in order to identify those with exceptional consumption. It can also provide a valuable comparison with other buildings, based on the assumption that buildings of similar kinds and used for similar purposes should have broadly the same consumption (see Good Practice Case Study 333, 'Energy management practices in further education. Southwark College of Further Education – a low-cost pragmatic approach' (GPCS 333)[2]).

By dividing the total energy consumption or total energy cost by the total floor area you arrive at a consumption figure (kWh/m^2) or energy cost (£/m^2). These data can then be used to rank buildings or floors in order of performance, perhaps by drawing bar charts or graphs. Screening will quickly highlight buildings or floors where the energy performance deviates significantly from that of similar buildings or floors, and thus point to areas where further investigation is clearly worthwhile.

DATA-BASED METHODS



Benchmarking

For better comparison, especially if you have only a few buildings, you can compare each building's energy performance against national benchmarks. Building energy benchmarks provide representative values for common building types. Comparison with annual energy use per square metre of floor area allows the standard of energy efficiency to be assessed and can help pinpoint problem areas.

When using benchmarks make sure they are relevant to your building category. Benchmarks are not necessarily expressed as kWh/m^2. School benchmarks may need to be expressed as £/pupil and those in hospitals as kWh/bed/yr.

Benchmarks are available for a wide range of building types and are published as Energy Consumption Guides by BRECSU on behalf of DETR as part of the Energy Efficiency Best Practice programme.

Benchmarks are also published for building services, energy-intensive equipment and small power loads. Benchmark publications for various sectors are listed on page 8.

Building energy signatures

Building energy signatures are a way of separating changes in heating consumption that are due to the weather from those that signal possible problems with energy use. They show a graphical representation of a building's energy use over different weather conditions.

Simply plot the monthly (or weekly) meter readings for the fuel used for heating against the degree days (or average outdoor temperatures) for each month (or week). It does not matter if the meter readings also reflect the fuel used for water heating or catering. See whether or not you can draw a 'best-fit' line between the plot points. If they do not fall reasonably close to the line then energy use, particularly by the heating system, is not being controlled very well. This is probably wasting energy and may be causing discomfort.

ANALYSING ENERGY SIGNATURES

Many common energy-saving opportunities can be identified from whether, and how, the line in a graph deviates from straight, and where the line cuts the axis.

Once the trend line has been found, any new point that lies outside the normal degree of scatter is a sign of a possible problem that requires investigation. An abnormally high value followed by an abnormally low one (or vice versa) often indicates a misread meter, rather than a genuine operating problem!

If the plot points are placed such that it is difficult to draw a single-line best-fit curve, use a standard spreadsheet program to plot the data and identify the curve.

The three features to look for are:

- breaks
- bends
- loops and intercepts.

These are illustrated in figures 2 and 3 (opposite).

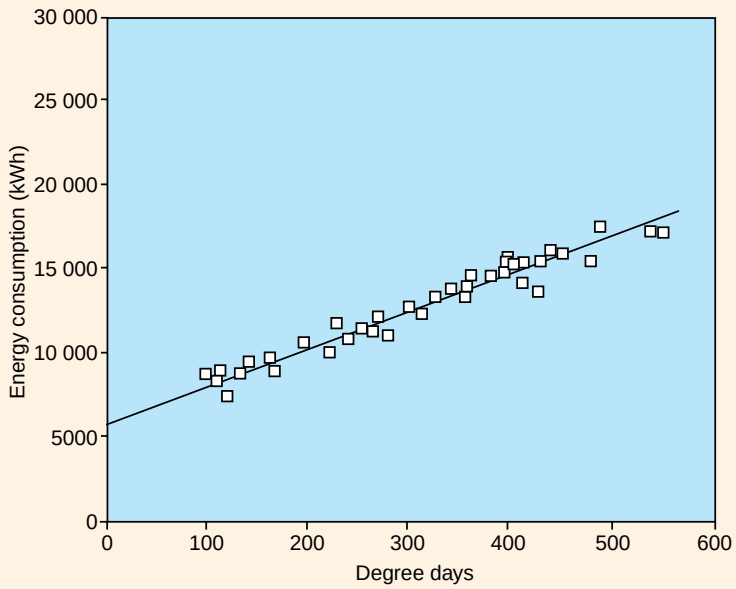


Figure 1 Showing a normal 'signature'

IDENTIFYING PROBLEMS

The energy signature can be used to monitor energy use in several ways:

- to identify unusually high or low consumptions for particular months
- to compare consumption from one year to another
- to identify exceptional control faults.

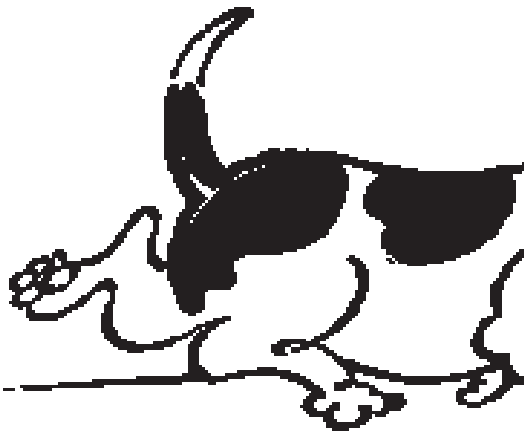
A normal signature is a straight line (see figure 1).

In general terms, the steeper the slope, the greater the heating energy consumption. In warm weather (that is, with few or no degree days), there should be little or no heating consumption. The intercept on the energy consumption axis is the load due to hot water, boiler and/or distribution losses.

Levelling off at high degree days indicates that a boiler has reached its maximum capacity and cannot cope further. It is not usually worthwhile trying to relate the slope of the line to the building heat loss. However, it is important to realise that energy conservation measures should either reduce the gradient of the line, or shift it downwards.

If the energy signature looks like two separate lines, ie has a break (see figure 2), this may indicate that heating is being used to offset the effects of a poorly controlled cooling system.

Loops in the energy signature (see figure 3) can also indicate control faults, such as irrationally set time switches. However, if the building is sensitive to solar gains, loops may simply reflect the fact that, for the same outdoor temperatures, daylength and solar gain are greater in spring than in autumn!



ANALYSING ENERGY SIGNATURES

CUMULATIVE CHANGES FROM SIGNATURES

A sensitive way of identifying systematic changes in consumption pattern is to use the CUSUM technique. This is described in FEB 7[1], but essentially consists of:

- finding the energy signature
- finding any subsequent deviation of consumption from the signature for each month
- calculating a rolling total of the deviations, ie the CUmulative SUM (CUSUM).

Random variations (or misread meters) tend to cancel each other out, but systematic changes cause the rolling total to increase or decrease consistently.

COMPARISON OF CONSUMPTION FROM ONE YEAR TO ANOTHER

If the building and its energy systems are operated consistently from one year to another, all the points should lie on or near the energy signature line. When an energy conservation measure has been added (or the building operation has changed), a new energy signature will appear. The difference between the two signatures indicates the energy saving made (or, for a change of use, perhaps additional consumption).

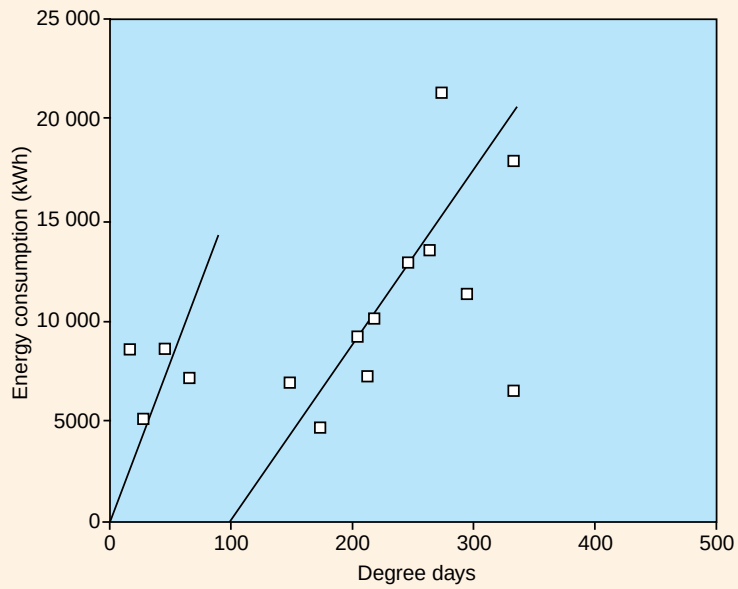


Figure 2 Two separate lines may indicate poor control

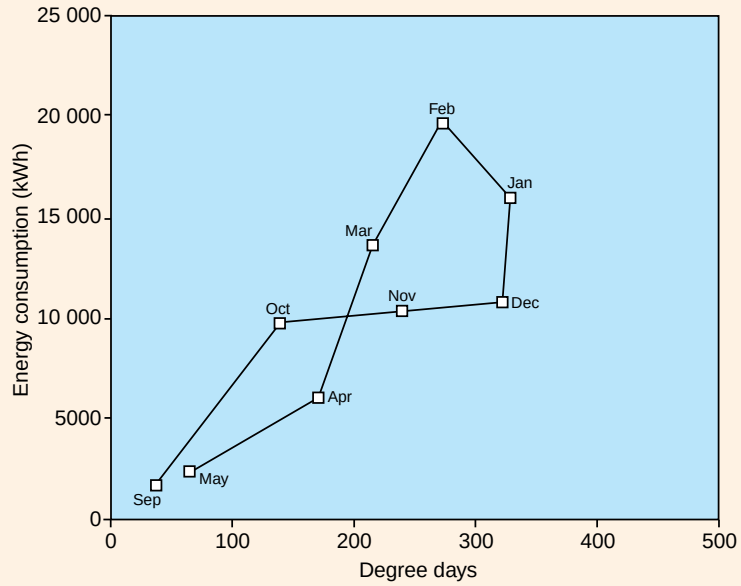
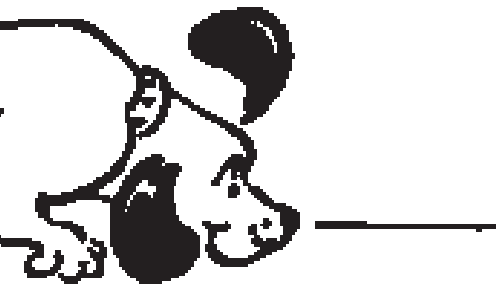


Figure 3 Loops and intercepts can result from building orientation, solar gain or poor control

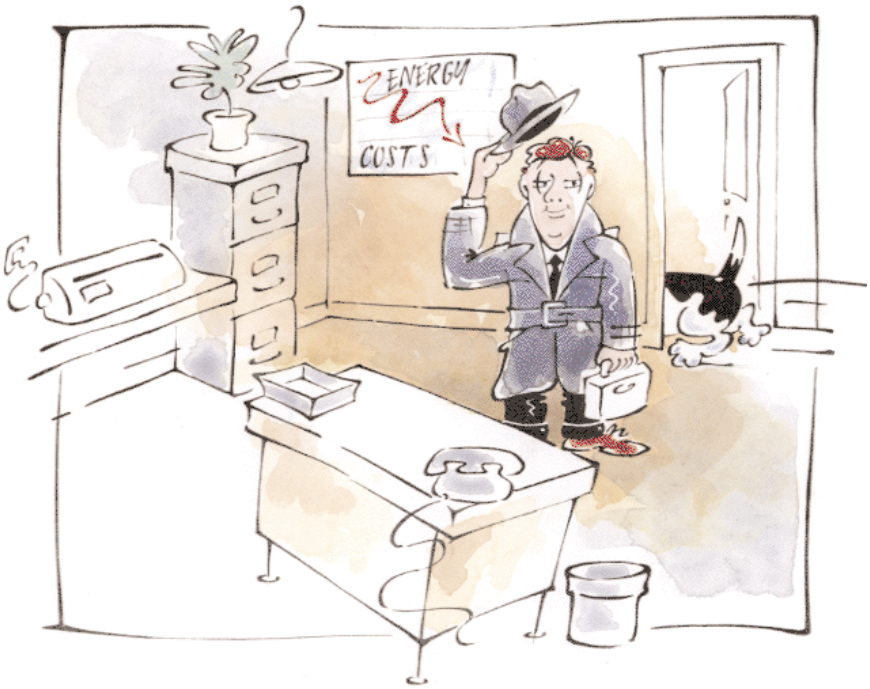


REFERENCES AND FURTHER READING

REFERENCES

[1] ***Department of the Environment, Transport and the Regions.*** Fuel Efficiency Booklet 7, 'Degree Days' (FEB 7). DETR, London, 1993

[2] ***Department of the Environment, Transport and the Regions.*** Good Practice Case Study 333, 'Energy management practices in further education. Southwark College of Further Education – a low-cost pragmatic approach' (GPCS 333). DETR, London, 1996



DETR ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The references above and the following Best Practice programme publications are available from BRECSU Enquiries Bureau. Contact details are given below.

Energy Consumption Guides

18 Energy efficiency in industrial buildings and sites

19 Energy use in offices (updated 1998)

36 Energy efficiency in hotels – a guide for owners and managers

51 Energy efficiency in sports and recreational buildings: a guide for owners and energy managers

54 Energy efficiency in further and higher education – cost-effective low energy buildings

73 Saving energy in schools. A guide for headteachers, governors, premises managers and school energy managers

Good Practice Guides

118 Managing energy use. Minimising running costs of office equipment and related air-conditioning

133 Energy efficiency in the workplace – a guide for managers and staff

160 Electric lighting controls – a guide for designers, installers and users

172 Marketing energy efficiency – raising staff awareness

186 Developing an effective energy policy

200 A strategic approach to energy and environmental management

The Government's Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

Visit the website at www.energy-efficiency.gov.uk

For further information on:

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Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy-efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting, etc.