Practical Energy Management
WORKSHOP SUPPORT DOCUMENT

A practical guide to energy auditing in buildings

The material presented in this workbook will be subject to review and updating as the workshop series proceeds.

We would be pleased to receive any comments you may have for improving the content or presentation.

Prepared by BRECSU for the EEO

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**Introduction**

This booklet is intended for facilities managers, departmental managers and budget holders responsible for expenditure on energy. It describes simple practical methods which you and your staff can use as first steps towards getting energy consumption under control, and then keeping it there, in the accommodation you occupy.

These methods do not require specialist training. Nor do you need highly developed technical expertise to employ them. They simply require you to use your observational and administrative skills, plus your own understanding of the premises you occupy, to identify where, when and how energy is being used - and how much of it is being wasted.

The guide offers step by step advice - summarised in the highlighted boxes - to help you identify the pattern of your energy consumption. The step by step approach is intended to help you to structure how you go about the auditing task. The first six steps can all be carried out using your fuel bills; the guide shows the types of analyses which can be carried out using this simple billing information. Subsequent steps will require you to make an energy inspection of your premises, and again the guide will help you to plan how you conduct these inspections.

It is not essential to read the guide from cover to cover. Some of the steps are self contained - and the boxes will help you to identify quickly the key elements of each step.

The guide is based on extensive practical experience of how to achieve results. Its objective is to help you to ensure that the required standards of service are provided at the minimum cost. The approach taken will help you to identify the avoidable waste of energy - that is, the excess over that required for efficient operation. Once this has been identified, decisions on how to reduce avoidable waste are much easier to make. The same techniques can be used to check that the expected savings are achieved.

These processes define costs far more closely than you have probably been able to do previously. Not only will you know what your essential spend is on energy, you will know how much energy you are wasting. That information will help you to manage your energy costs competently, to the benefit of you and your organisation.

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**What is energy auditing?**

Energy auditing is the systematic assessment of where, how and why energy is used within a building, together with an evaluation of how well controlled its use is. Energy auditing your building or building stock will help you to identify the opportunities that exist for reducing your use of energy while maintaining, or improving, standards of comfort and service.

This guide offers a series of practical steps to help you to keep your energy costs in check and ensure you are using energy efficiently.
### Why audit your energy consumption?

Managing energy well is simply one of the components of good management. Like all management tasks it requires information as the basis of effective decisions. You need sufficient information about your consumption of energy to decide whether you are using more than is necessary to support your activities and operations. Fortunately, you don't need enormous amounts of information to be able to take useful actions. Auditing will help you acquire the level of information you need to make practical progress. At the same time, it will enable you to compare your performance with others and to set yourself targets for making improvements.

Your expenditure on energy is probably only a small fraction of your overall costs, probably less than 5%. But it is also likely to be one of your largest controllable costs. It is certain to be one of the few areas in which you can make really significant savings and, at the same time:

- improve the working conditions of your staff
- improve your profitability or the unit cost of the service you deliver, and
- lessen your organisation's impact on the environment, for example, by reducing your emission of carbon dioxide - a major way in which you contribute to global warming.

**Energy efficiency** - which is defined as the provision of specified internal environmental conditions for the minimum energy cost - is a vital part of good management, and is positively associated with the comfort of staff and with high staff productivity.

So there are four clear reasons - cost, comfort, performance and pollution - for you to save energy. Before you can do this effectively, you need to know:

- how much energy you are consuming
- what that energy costs
- where and when it is being consumed
- how much of it is being needlessly wasted.

The procedures in this guide offer you a series of practical steps for keeping your energy consumption and costs in check. It will enable you to allocate energy costs more accurately to your various buildings, departments and sections. And it will also provide you with a sounder basis for budgeting for your future energy needs.

### Why energy auditing?

Understanding how much energy you are using, where it is being used and whether it is being used efficiently, is the essential first step towards better energy management. The benefits to your organisation include:

- reduced energy costs
- improved working conditions for staff
- improvements in profitability
- reduced impact on the environment.

**Good energy management is just good management.**

---

### An overview of energy auditing

The initial steps in energy auditing are:

- obtaining all your fuel bills
- collating the information they contain
- analysing seasonal variations, patterns and trends
- identifying what energy is used for
- comparing your use of energy with typical norms
- locating sources of possible savings.

If these analyses reveal the potential for savings, the next steps are to inspect the building and its services by:

- taking your own meter readings
- checking internal temperatures
- estimating uses of energy within the building
- inspecting the services and fabric
- identifying ways to reduce energy use and avoid waste.

To be effective, the results of the audit need to be reported to those who can act on them. Different people will require different information, presented in ways most suited to their needs:

- senior management: annual summary, trends, budgeted proposals
- middle management: departmental performance, comparative performance
- staff: publicity of your efforts and how they can contribute to saving energy.

**This guide describes practical steps to help you to carry out all these auditing functions in your buildings.**
THE FOUR STAGES OF ENERGY AUDITING

There are four different types of activity that can be applied to auditing your energy consumption:

- **Stage 1**: A historical energy audit - examining the data you already have on file about your consumption over time.
- **Stage 2**: An energy inspection - an observational tour of your premises and operations.
- **Stage 3**: An energy survey - a more detailed investigation of the energy efficiency of your buildings, mechanical plant and services, and description of your organisation's energy performance.
- **Stage 4**: An energy balance sheet - an input/output description of your organisation's energy performance.

These stages may, but need not necessarily, be carried out in sequence. They can be conducted individually or as part of a rolling programme of work. Each has its own particular purpose and each requires a different level of time, effort, equipment, and expertise.

Only the first two of these stages are described in this guide. They are simple, quick and easy enough for you to carry out for yourself. And they should provide you with more than enough information to start making effective decisions about how to manage your energy consumption.

---

**Energy auditing is a team effort**

If you are in a large organisation, many individuals will hold the separate items of information you will need to piece together a comprehensive understanding of how, where and when energy is used in your buildings. You will need to enlist the assistance of, for example:

- Accounts department, for details of fuel invoices
- Property department, for information on the size of the building(s)
- Personnel manager, about the numbers of staff
- Maintenance, for assistance in reading meters and inspecting plant and services
- Catering manager, on the number of meals served
- Staff, about internal comfort levels
- Equipment suppliers, about power ratings of equipment.

In smaller organisations the information may be held by only one or two people. If their time is limited, check the steps in the following pages to see how limited data can provide initial but useful results. You may find that these results help them to manage more effectively - which will help to justify their time in providing you with the full data.

The sample memo below may help you to introduce the topic to management.

---

**Sample memo seeking approval to commence an energy audit**

To: Alan Hayes, Director of Property

From: Brian Bee, Facilities Manager

Subject: Energy auditing

I have been looking at the pattern of our annual energy expenditure over the last three years in Block C. Even though it was renovated two years ago and energy costs were expected to go down, they have continued to rise. With your approval, I should like to undertake an energy audit of the block. Initially, this would involve obtaining all the fuel invoices from Finance and a set of the floor plans from your Department, in order to work out our fuel costs and the pattern of consumption.

If performance is poor by comparison with similar buildings, I want to do a more detailed inspection of how and when energy is being used. It often seems to me too warm on the upper floors even in winter, and regular temperature readings would help me to assess whether this is normal and if it is the result of poor heating controls. We could be wasting 5-10% of the heating of these floors. I want to begin taking regular meter readings every week so we can quickly spot unexplained increases in energy use. And I want to take some sample meter readings over a weekend or two to see how much energy the equipment which is left on overnight is using. The hot water in the WCs seems very hot too, which must be wasting energy.

I see this audit as a long term exercise needing only about 1 day per month but continuing over the next six months or so. I shall need to liaise with Maintenance to do some of the inspections; and I shall need help from Finance with getting copies of the fuel invoices. Mrs Bird says her staff could help with taking temperatures on the top floors.

The main benefit will be savings in energy costs and increased productivity. I reckon we ought to be able to identify ways to save 5-10% of our fuel costs over the next year without capital expenditure. And there should be fewer complaints and days off in Block C if we can sort out that overheating problem. We shall need to agree the standards for availability and use of energy for heating, hot water, lighting and for office equipment. We will need to discuss who should contribute to this before I make proposals for decision.

I believe the Managing Director is planning to sign us up under the Energy Efficiency Office's 'Making a Corporate Commitment' campaign - and this exercise could make a useful contribution to our efforts to reduce our costs by becoming more efficient, as well as cutting the nation's carbon dioxide emissions.

Can you please issue a general request for cooperation with this activity, which has the potential to reduce to a noticeable extent our expenditure on fuel and water.
Flow chart of energy auditing

STAGE 1

1. Obtain all fuel bills (step 1)
2. Collate information from fuel bills (step 2)
3. Analyse patterns of consumption (step 3)
4. Identify where energy is used (step 4)
5. Compare energy use with norms (steps 5 and 6)

Is energy use under control?

- Ensure it is kept there

STAGE 2

- Take regular meter readings (steps 7-9)
- Check internal temperatures (step 10)
- Assess where energy is used (steps 11-17)
- Inspect building fabric and services (step 18)
- Identify ways to reduce waste

Report to management and staff (step 19)

STAGES 3 AND 4

Consider outside help for energy survey and drawing up of energy balance (step 20)

These stages are not dealt with in this guide
STAGE 1: AUDITING HISTORICAL DATA

Step 1: Acquire information about energy consumption

Even without leaving your office, you can learn a lot about your energy consumption and costs just by looking at your fuel bills. The recorded information common to all the fuels and sources of energy which you use is the supplier's invoice. If you don't already have copies of these on file, ask your accounts or purchasing department to provide you with them. These invoices tell you the amount supplied, the cost, and the date the fuel was delivered or the meter was read, see Figure 1. Remember that meter readings may have been estimated. It is a good precaution to read your meters regularly and compare the consumption shown with invoices received, see Steps 7 and 8.

Your suppliers' invoices are the best place for you to start your energy auditing. Collect together all the available fuel invoices you have received from your energy suppliers - at least for the preceding twelve months, preferably for the previous two or three years. The latter will help you form a more comprehensive overview of the trends in your energy consumption over time.

In a small building, you may only be invoiced every quarter, often with up to three quarters based on estimates. This will not provide you with enough information to audit your consumption accurately. Instead you will need to take regular meter readings of your own, see Step 7.

If you have many buildings in your estate, you should consider restricting your initial activity to no more than five of them. At this stage your priority should be to prove to management that the activity is worthwhile. Too many buildings may delay your being able to produce the important first results.

Each of your buildings will be supplied with fuel, water, sewerage, etc. by a number of utility suppliers. Not all the accounts will have identical names and addresses for the building. Before proceeding with more detailed analyses, it is worth conducting an initial validation of the premises data to check that all the information refers to the same building. In practice, simple checks at this early stage take far less time than dealing with inconsistencies later.

Later on, as you gain confidence that your initial checks provide a sure base for progress, you will be able to check for additional inconsistencies. This validation process is worthwhile. On some large estates, incorrect accounting has been found for more than 5% of buildings. Do not assume that audited accounts are error-free.

Eventually, you may want to transfer much of this information to a computer database. Programs such as spreadsheets and word-processors with mail merging facilities may help at these early stages. But only consider increased use of computing when the initial stages are complete, your priorities are established and your activities are supported by management because of the results achieved.

---

Step 1: Acquire the basic information

You should obtain copies of all fuel bills, preferably for the last two or three years. Try to obtain copies of original invoices; very rarely do accounting system print-outs include consumption, tariff, demand and metering details. The initial data collection is commonly paper based, because computer data is often insufficiently complete for energy analysis purposes.

In addition for later steps, you may find it useful to start a series of folders, comprising three sets of information as shown below. Concentrate on the data marked "*". If the other data is made available at this stage, keep it for future use.

**Estate information**
- floor areas of the building being audited*
- information about the number of occupants*
- maintenance schedules
- contact details, such as premises and staff directories
- cleaning contract room and floor area schedules.

**Premises data**
- summary card with premises details, contacts, accounts (see box below)*
- premises plans*
- occupation details
- sales/production figures
- number of oil tanks and their capacity
- percentage splits of account between budget holders
- delivery point numbers for oil and solid fuel
- lease details
- maintenance schedules.

**Revenue expenditure data:**
- copies of fuel invoices*
- water and sewage invoices*
- your own meter readings*
- accounts summary tabulations*
- servicing invoices
- small works orders
- copies of matrices (as in Step 16)
- copies of information that you issue
- copies of memos
- fuel use targets, budget information.

---

Summary of building information

<table>
<thead>
<tr>
<th>Description</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address of the building</td>
<td>..................................................</td>
</tr>
<tr>
<td>Meter location (gas)</td>
<td>..................................................</td>
</tr>
<tr>
<td>Meter reference (gas)</td>
<td>..................................................</td>
</tr>
<tr>
<td>Account reference (gas)</td>
<td>..................................................</td>
</tr>
<tr>
<td>Meter location (electricity)</td>
<td>..................................................</td>
</tr>
<tr>
<td>Meter reference (electricity)</td>
<td>..................................................</td>
</tr>
<tr>
<td>Account reference (electricity)</td>
<td>..................................................</td>
</tr>
</tbody>
</table>

Additional information can be clipped to this card, such as fuel invoices and meter readings, and annual summaries of fuel expenditure.
Initial validation of the premises data

For each of your premises, check:

- all delivery addresses refer to the same building
- fuel, water and sewerage account details match your accounting records
- invoice totals match the tabulation details (invoices can be posted to the wrong account; VAT may be included/excluded)
- that maintenance/equipment hire charges are separately accounted
- whether accounts tabulations apportion accounts to different budget holders (as in the case where one meter supplies two or more departments or cost centres).

As you confirm each item of information, enter the details onto the premises summary sheet (see box).

At the end of this step you will have a box file of the basic data needed to carry out most of Stage 1.

---

**Figure 1 Monthly gas invoice**

<table>
<thead>
<tr>
<th>ACCOUNT REFERENCE NUMBER</th>
<th>DATE OF ACCOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/96/1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CURRENT METER READING</th>
<th>PREVIOUS METER READING</th>
<th>CUBE MULTIPLIER</th>
<th>PREVIOUS</th>
<th>CURRENT</th>
<th>CUBE MULTIPLIER</th>
<th>CHARGE</th>
<th>AMOUNT</th>
<th>VAT</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>8472</td>
<td>6785</td>
<td>2309</td>
<td>2345.944</td>
<td>37.000</td>
<td>864.00</td>
<td>A</td>
<td>0.00</td>
<td>A</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Figure 2 Monthly electricity invoice**

<table>
<thead>
<tr>
<th>METER READING</th>
<th>ADVANCE</th>
<th>CONSTANT</th>
<th>UNITS CONSUMED</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESENT</td>
<td>DEC</td>
<td>DEC</td>
<td>DEC</td>
</tr>
<tr>
<td>252072</td>
<td>204740</td>
<td>47332</td>
<td>1500</td>
</tr>
<tr>
<td>192759</td>
<td>175636</td>
<td>7125</td>
<td>1500</td>
</tr>
</tbody>
</table>

**DESCRIPTION OF CHANGE**

<table>
<thead>
<tr>
<th>DESCRIPTION OF CHANGE</th>
<th>NUMBER OF UNITS, KVA OR KW</th>
<th>RATE OF CHARGE</th>
<th>KVA OR KW TRICT</th>
<th>AMOUNT OF CHARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIT CHARGE</td>
<td>7009980</td>
<td>0.03860</td>
<td></td>
<td>27,405.23</td>
</tr>
<tr>
<td>FUEL VARIATION</td>
<td>7009980</td>
<td>0.0015675</td>
<td>8988</td>
<td>1.112</td>
</tr>
<tr>
<td>MAXIMUM DEMAND STEP 1</td>
<td>300</td>
<td>1.176</td>
<td></td>
<td>522.00</td>
</tr>
<tr>
<td>MAXIMUM DEMAND STEP 2</td>
<td>1665</td>
<td>1.66</td>
<td></td>
<td>2,763.90</td>
</tr>
<tr>
<td>SUPPLY CAPACITY</td>
<td>300</td>
<td>0.62</td>
<td></td>
<td>186.00</td>
</tr>
<tr>
<td>SUPPLY CAPACITY STEP 2</td>
<td>1700</td>
<td>0.48</td>
<td></td>
<td>816.00</td>
</tr>
<tr>
<td>FUEL VARIATION</td>
<td>256845</td>
<td>0.01850</td>
<td></td>
<td>4,751.63</td>
</tr>
</tbody>
</table>

**YOUR REFERENCE NUMBER**

<table>
<thead>
<tr>
<th>FUEL COST</th>
<th>MAXIMUM DEMAND</th>
<th>TOTAL CHARGE NOW DUE FOR THE MONTH OF</th>
</tr>
</thead>
<tbody>
<tr>
<td>4725 p</td>
<td>1965</td>
<td>34,929 27</td>
</tr>
</tbody>
</table>
Step 2: Analysing your fuel bills

Make a list of each type of energy you use. For each type, compile the monthly consumption figures. Then add these up to produce an annual total of the number of units of energy consumed for each type of fuel, see Figure 3. A calculator is all you need to do this but a simple computer spreadsheet will save time in the long run.

Now you need to convert these totals into a common unit so that you can make comparisons between them, see Figure 4. Unless your fuel bills are very large, the kWh is probably the most convenient unit to use. It is the unit used for measuring electricity and natural gas in your own home heating bills. Once you have done this, you can use the information in Figure 5 to calculate the cost/kWh for each of the fuels you use and the carbon dioxide emissions caused by consuming them.

The figures which you have generated can be used to produce simple charts illustrating energy consumption, expenditure and pollution, see Figure 6. These will show the relative significance, in terms of each of these factors, of each type of energy you consume. Notice that in cost terms (in the UK) electricity is usually just as, and often more, important than fossil fuels (natural gas, oil, coal, LPG) because of its high unit cost. Increasing energy efficiency is, contrary to what most of your staff probably think, as much about reducing electricity consumption as about cutting down on heating. Notice also that there is a fairly close correlation between the cost of a fuel and its emission of carbon dioxide.

Maximum demand tariffs for electricity

This is not the only tariff available but it is commonly used in commercial buildings. If this tariff is selected, the electricity charges will be based on:

standing charge + charge per unit used + maximum demand charge

The maximum demand is measured every half hour by a separate meter. When the maximum demand is similar to the average demand through the day, the combination of demand charge and unit charge gives a reasonable overall cost. However, if there are high peaks in demand above the average, the maximum demand charge will be high. The peak demand may be the highest which occurs in a month, quarter or even in a year, depending on the tariff agreement. Just one peak in the period can be very expensive indeed.

Step 2: Collate and analyse the information

- make a monthly table of each type of energy you use (preferably using a spreadsheet)
- enter monthly (or quarterly) readings, consumption figures and costs for each fuel
- if necessary, convert consumptions to common unit (kWh)
- for each separate fuel, add monthly (or quarterly) consumptions and costs to obtain annual totals
- for each separate fuel divide total annual cost in pence by total annual consumption in kWh to compare costs of different fuels in p/kWh.
- create a simple chart (bar chart or pie chart) of your total fuel costs split into expenditure by each fuel type.

By the end of this step, you will have an overall picture of the relative significance of each fuel in your building on a year by year basis.

Figure 4 Useful fuel conversions

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Unit of supply</th>
<th>Conversion to kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>1 therm 100 cu ft</td>
<td>9.83 / 10.56 kWh</td>
</tr>
<tr>
<td>Oil</td>
<td>1 litre oil class D (35 sec)</td>
<td>1 litre heavy fuel oil</td>
</tr>
<tr>
<td>Solid fuel</td>
<td>1 tonne of: house coal anthracite smokeless</td>
<td>8,200 - 9,300 kWh</td>
</tr>
</tbody>
</table>

1 Gigajoule = 9.52 therms
1 Gigajoule = 278 kWh
1 kWh = 3412 BTU
1 BTU = 1.056 joules
1 barrel of oil = 159 litres

Figure 5 Fuel costs and carbon dioxide emissions per kWh

<table>
<thead>
<tr>
<th>Fuel</th>
<th>kg carbon dioxide per unit</th>
<th>kg carbon dioxide per kWh</th>
<th>cost p/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>electricity</td>
<td>0.83 kg/kWh</td>
<td>0.83</td>
<td>7</td>
</tr>
<tr>
<td>gas</td>
<td>5.7 kg/therm</td>
<td>0.21</td>
<td>1.5</td>
</tr>
<tr>
<td>oil</td>
<td>3.1 kg/litre</td>
<td>0.29</td>
<td>1</td>
</tr>
<tr>
<td>coal</td>
<td>2.7 kg/therm</td>
<td>0.34</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Figure 6 Bar charts of energy consumption, cost and pollution for typical offices (from reference 3)
## Summary table of fuel use from invoices

Figure 3 Building up a summary table of your fuel use and expenditure from utility invoices

### Electricity

**Period:** Jan-Dec 1994  
**Completed by:**  
**Date:**

<table>
<thead>
<tr>
<th>Meter reading date</th>
<th>kWh used</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 1994</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb 1994</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar 1994</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Annual total**

### Gas

**Period:** Jan-Dec 1994  
**Completed by:**  
**Date:**

<table>
<thead>
<tr>
<th>Meter reading date</th>
<th>kWh used</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 1994</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb 1994</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar 1994</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Annual total**

### Oil

**Period:** Jan-Dec 1994  
**Completed by:**  
**Date:**

<table>
<thead>
<tr>
<th>Oil delivery date</th>
<th>Litres delivered</th>
<th>Litres used</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Annual total**

### Summary sheet of all fuel use and expenditure

**Period:** Jan-Dec 1994  
**Completed by:**  
**Date:**

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Supply units</td>
<td>kwh equivalent</td>
</tr>
</tbody>
</table>

| Electricity     |          |      |          |   |    |
| Gas             |          |      |          |   |    |
| Oil             |          |      |          |   |    |
| Solid fuel      |          |      |          |   |    |
| Other           |          |      |          |   |    |
| Total annual quantity and cost |          |      |          |   |    |
Step 3: Identifying patterns and trends

Now you can use the analyses you have produced to examine patterns and trends in your energy consumption.

- Is your total annual energy consumption and cost increasing or decreasing?
- Is your annual consumption and cost of particular fuels rising or falling?
- Which of your fuels is costing you most on a unit cost basis?
- Which of your fuels gives rise to the largest proportion of your total expenditure on energy?
- Which of the fuels you use causes the most environmental pollution?

If your have several buildings on your site, or if your building is subdivided in some way, there may be sub-meters which record consumption for each individual building, part of a building, section or area. If so, these sub-meters will allow you to identify who has consumed what. You can then use simple bar charts to illustrate the energy costs of each of your buildings, departments, sections, specific areas or equipment items.

There are several ways in which you can express these costs - per unit floor area, per member of staff, per unit of production, by volume of sales, per month, per year. You need to choose whichever bases are most appropriate to your own situation. The calculations required are simple to do. For example, divide the monthly costs by the number of people you employ and then present the result in a bar chart. Consumption and pollution indicators can be produced in just the same way.

Besides raising your own understanding of energy consumption, there are several other purposes to which you can put these types of charts, graphs and indicators. You can distribute them regularly to management and staff to raise their awareness about energy consumption and its cost and environmental implications. They can also be circulated or put on display, as part of a Good Housekeeping Campaign, first to encourage staff to take the actions required to save energy and then to act as feedback to let them know how effective their actions have been.

If you have data for two years or more, consumption trends can be shown using a chart showing a moving average. The chart shows the average over a twelve month period, moved along one month at a time. For example, the first month sums the consumption from January 1992 to December 1992 inclusive. The next month on the chart shows it from February 1992 to January 1993 inclusive. This is progressed up to the current date. The annual consumption will therefore show a trend, which may be related to weather, efficiency, or business factors. The use of a one-year period is commonly chosen to average weather or annual sales; other periods can be used if appropriate.

Figure 7 gives a worked example of the analysis of patterns and trends in an office building, including the use of a moving average.
Fuel bill analysis

Figure 7 An example of fuel bill analysis

The site consists of 2,500 sqm of office accommodation, half in a block with gas-fired radiator heating, and half in an extension with mechanical ventilation and on- and off-peak electrical heating.

The electricity bills are all available and show the amount payable, tariff details, the meter reading date, the meter readings and the number of day units and night units consumed.

You wish to examine these bills to understand the pattern of consumption behaviour. The first thing you find is that there is only one meter for the two buildings. A separate check meter for the extension would be desirable, to identify separately the consumption in the two buildings.

To begin to understand the consumption, make a table which records, in separate columns, the reading date and the day and night meter readings. Do not record the units consumed, because if you make an error here it will be cumulative. The units consumed can be calculated by subtracting readings, and these can be checked against the billed units.

The table is conveniently set up on a computer spreadsheet, which can do all the necessary calculations and graphs automatically. Later the spreadsheet can be extended as new bills come to hand or you wish to do more analysis.

CHART 1 shows a bar chart of total day and night consumption in kWh for the months concerned, in the form of stacked bars. In the period ending January 1990, for example, about 31,000 day units and 12,000 night units were used, totalling 43,000 kWh. While clear seasonal variations are visible, the pattern is rather ragged.

In CHART 2 the consumption in each monthly billing period has been divided by the length of the period in days. The pattern is now much clearer. Even more distinct patterns would be obtained if you were to read the meters weekly at a set time. Note the following features:

- Daytime and night-time electricity consumption rises substantially in the winter, probably owing to a greater use of electric heating. Again, meters on the heating supplies would be very helpful.

- The consumption pattern from December to February varies substantially from year to year. This will be affected by the severity of the weather, and also the Christmas/New Year holiday period, which will tend to depress the January reading. What happened in the period to 30 January 1992? Was it very cold or did someone leave the heating on too high over Christmas? (In fact Dec 89, Dec 90, Jan and Feb 91, and Dec 91 and Jan 92 were particularly cold.)

Methods are available to correlate heating energy consumption with the severity of the weather in each month. Further information is in fuel efficiency booklet number 7 degree days, available from the energy efficiency office.

Within this variable pattern of consumption, can one tell whether energy use as a whole is growing, declining, stable or erratic? A useful way to do an initial review is to calculate average daily energy consumption for a rolling 12-month period as over a whole year seasonal fluctuations almost balance out.

CHART 3 shows how this works. The first bar shows the average energy consumption per day for the period from 28 Sep 89 to 27 Sep 90, the next from 31 Oct 89 to 30 Oct 90, and so on. Consumption dropped from 1990 to mid-1991, but since then both daytime and total consumption has been rising. This clearly needs investigating. Is energy management slackening, is additional legitimate consumption by new office equipment occurring, or is it the effect of climatic fluctuations?

(In this example, energy management in fact improved substantially in the earlier period, reducing consumption in spite of increasing severity of the weather, but with a slight slackening off in winter 1991-92. Over the whole period, consumption by office equipment rose gradually but relentlessly.)
Step 4: Identifying your energy 'end uses'

The fuels you purchase are used for different purposes, called end uses, in your building. Table 1 shows the end uses for which electricity and fossil fuels are commonly consumed. They may not all apply to your building. Make a list of all the end uses in your building. Some items of electrical equipment may use low-rate electricity when running overnight. Ask caretaking or maintenance staff which fuels your building relies on for each end use.

Once you know:
- how much you are spending on electricity and fossil fuels, respectively, and
- which fuels are used for which end uses
then you can begin to establish priorities for improving energy efficiency and reducing energy costs.

Depending on the type of building you have, your energy consumption may be dominated by:

1. providing space heating (including or excluding heating for hot water)
2. running mechanical plant (such as ventilation, refrigeration, fans and pumps)
3. running equipment (such as computer rooms and associated equipment).

Try to find out which of these end uses dominates the energy costs in your building. The examples in Figure 8 give some guidance. Overall, the end use which dominates energy costs in your building probably represents the area in which improvements in energy efficiency are most likely to deliver significant energy and cost savings.

**Step 4: Where energy is being used?**

- identify, with assistance as necessary, the fuels used for each 'end use'
- by considering costs of each fuel from Step 3 and seasonal trends from Step 4, deduce which end uses dominate your consumption
- prioritize areas for action according to dominant energy uses.

At the end of this Step, you will have located the main energy uses and established priority areas for action.

<table>
<thead>
<tr>
<th>Typical fuels for different end uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
</tr>
<tr>
<td>lighting</td>
</tr>
<tr>
<td>part of catering</td>
</tr>
<tr>
<td>refrigeration</td>
</tr>
<tr>
<td>fans, pumps and controls</td>
</tr>
<tr>
<td>escalators, lifts</td>
</tr>
<tr>
<td>distributed office equipment (personal computers, copiers, fax)</td>
</tr>
<tr>
<td>small power items (laboratory equipment, machinery, tools, klin, vending machines)</td>
</tr>
<tr>
<td>central computer suite</td>
</tr>
<tr>
<td>low rate electricity may be used for vending machines, security lighting, early morning plantroom pumps and burner fans, office equipment left on overnight</td>
</tr>
</tbody>
</table>

Table 1

**Figure 8** Pie charts of total annual fuel costs, split by fuel type for three different buildings

![Pie charts](image)

- **Example A**: In this building, fossil fuel costs represent more than half the total annual energy costs, implying that space heating dominates energy use.
- **Example B**: Here fossil fuel costs at 40% of total annual energy costs suggest that the operation of mechanical plant dominates energy use.
- **Example C**: Fossil fuel accounts for less than a quarter of the total annual costs in this highly serviced building which has a large air conditioned computer suite that dominates energy use.
Step 5: Comparing your energy performance with others

The traditional method for establishing the energy efficiency of your premises is to compare your energy consumption with a performance indicator for your type of building. This allows you to make a comparative judgement about your own energy consumption against external norms and targets. Typically annual consumption figures are totalled then divided by some measure - often floor area, but sometimes building volume or number of occupants - depending on the type of building.

The most common performance indicator is based on adding annual consumption in kWh of all fuels together - then dividing the total by the floor area in square metres. If you adopt this method, remember different fuels have different unit costs and also different environmental pollution implications. Fossil fuels are broadly similar in their costs and carbon dioxide emissions, but they differ considerably from electricity. Adding together kWh for electricity and fossil fuels may result in your losing sight of these important differences. It may also disguise a very high consumption of one fuel, if this is partly compensated for by a low consumption of another. For these reasons at the very least you should keep the consumption of fossil fuels separate from those of electricity.

The accuracy of your consumption in kWh/sqm for comparison with a performance indicator is directly dependent on floor area measurement. Ideally the 'treated' (heated or cooled) area should be used. In practice, two sources of error can occur. First, leased, cleaning or net floor areas may be used, although the treated area can differ from these floor areas by 10% or more. This is often due to the way in which circulation, storage and other similar spaces have been considered. Second, available measurements may not be accurate; and may not reflect physical changes to the building(s) since the survey date.

If your building is in a sector where an Energy Consumption Guide prepared under the Energy Efficiency Office's Best Practice programme is available, you will be able to assess your consumption of fossil fuels and electricity separately (see References 2, 3 and 4).

An alternative single performance indicator can be obtained by weighting (that is multiplying) electricity consumption by 3.5 before adding it to the fossil fuel consumption. This will reflect approximately the cost, primary energy, and carbon dioxide emission factors of electricity versus fossil fuels.

When technical specialists undertake this procedure, they produce a more complicated normalised performance indicator (NPI). This uses weighting factors that attempt to correct for weather conditions, wind exposure and hours of occupation. Table 3 shows the advantages, and disadvantages, of normalisation.

It is important that the impact of uncertainties and variabilities on the input information is assessed. Unless extreme care is taken, the absolute accuracy of the normalised performance indicator including floor area errors may be worse than +/- 25%.

Step 5: Compare your energy use with a performance indicator for your building type

- define what unit you will use, for example, kWh/sqm/year (or £/sqm/year)
- calculate your treated floor area in square metres
- decide whether or not to normalise your space heating consumption (see text)
- add your annual kWh (or annual costs in £) for the different fuels
- if you use kWh/sqm remember that the cost per kWh of different fuels vary widely
- divide total annual kWh (or cost) by total floor area
- compare resulting figures with norms for your building type (see Figure 9)

At the end of this step, you will be able to assess, broadly, how your energy consumption compares with published figures, and whether your consumption is good, fair, or poor.

Normalisation: the pros and cons

ADVANTAGES
- allows year-on-year comparisons - corrected to compensate for differences in weather conditions and occupancy
- helpful for comparing consumption directly with similar buildings - as in a league table
- useful in exceptional circumstances, for example in a very cold year, where a direct comparison of heating energy consumption against a fixed yardstick would be unfair
- useful where a building has an area of exceptional energy use, for example a computer room in an office or a swimming pool in a hotel, for which allowance should clearly be made

DISADVANTAGES
- depends on accuracy of floor area measurements and of fuel consumption figures, and validity of assumptions about occupancy
- risk of overcompensating for exceptional feature (such as a swimming pool) and losing sight of building in fact having poor performance
- may use degree-day information with inappropriate base temperature - 15.5C used in published information works best on poorly insulated buildings. Inappropriate use with well insulated buildings can lead to errors of 50% or more
- can introduce as much error as it resolves - for example heating a building used for 12 hours a day does not use twice as much energy as heating one used for only six hours per day
- if the process is not understood, it may mislead you.

On balance, normalising for weather and hours of occupancy is only worth doing if you are aware of the error sources and fully understand the implications on the results.

Table 3
Ideally, normalisation should enhance your understanding of your energy performance - but it can also obscure it. For example, senior management are much more likely to consider investment in energy efficiency measures if told:

"the building costs 25% more to heat than usual, partly owing to the exposed site"

than:

"after normalising for the exposure of the site, heating consumption is 10% higher than average."

Equally if you inform senior management:

"the building uses twice as much energy than average for lighting, owing to the extended occupancy hours"

they are likely to respond:

"what extended occupancy hours, not all that many people stay here in the evenings, certainly not enough to use twice as much lighting!"

However, if you say:

"after normalising for occupancy hours, lighting energy consumption is typical"

then nobody will take any notice.

For all these reasons, normalisation is recommended only where there are exceptional features of the building or its occupancy.

The higher your building's performance indicator compared with norms for your building type, the more money and energy you are likely to be able to save through good energy management.

In practice, your performance indicator is likely to be only a crude, broad brush measurement, not least because of difficulties in establishing the appropriate floor area to use for your calculation. The figures available to you may be measured in a variety of ways: the gross external area - between the external faces of the building, the gross internal area - inside the external skin of the building, the area specified for cleaning purposes, or the net usable area as defined in your lease. None of these may match precisely the area of your building which is treated by heating, lighting, ventilation and/or cooling. Area differences of between 5% and 15% are not uncommon.

All these factors - uncertainty about floor area and about annual consumption - mean that any decision you make about whether you are wasting energy, if based solely on your performance indicator, may not be very precise. Other methods described later are more robust because they have less dependence on data that may contain common errors. One such approach is 'avoidable waste' as described in the next step.

Accuracy and relevance of invoice information

Significant errors can arise from shortcomings in the data you have about your buildings energy consumption. How relevant, accurate or complete is your data:

- Do the invoices cover sequential periods or are there date gaps? It is wise to check the continuity of previous/current readings.
- Do you have all the relevant accounts for the building - are all fuels accounted for, are there any accounts for other buildings?
- Do the invoices span an 'annual consumption' period close to 365 days?
- Were any of them estimated? Are such estimates accurate?
- Were all the meter readings taken correctly?
- Do the meter readings refer only to consumption in the building under examination, or do they include consumption occurring elsewhere on your site?
- Where oil is being consumed, are all the invoices present? Has all the invoiced fuel been delivered or could there be fraud?
- Was the oil tank full at the beginning of the year and empty at the end? (Oil tank capacity is often 12% to 15% of annual consumption)

Where you use fuels stored on site, you will need to set up your own system of measurement, see Step 7.

Estimating floor areas

Sources of floor area information include:

- using architects' plans if these can be located - check they are up to date and include recent extensions and alterations
- sketch plans retained to meet the Fire Officer's requirements - note these may not be to scale
- floor areas identified in cleaning schedules.

Quick ways to estimate floor areas of simple rectangular buildings include:

- measuring externally with a tape measure - allow for wall thicknesses
- pacing each facade
- using window modules as a unit of measure
- using floor or ceiling tiles as a module
- using the spacing between columns.

Multiply the plan area by the number of floors to obtain the total floor area - allowing for mezzanines and other floors that maybe of different size.
**Typical energy consumption figures**

**Figure 9 Energy consumption in buildings - typical figures**

<table>
<thead>
<tr>
<th>Building type</th>
<th>Good performance less than:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td></td>
</tr>
<tr>
<td>- naturally ventilated cellular</td>
<td>140 kWh/sqm per year</td>
</tr>
<tr>
<td>- naturally ventilated, open plan</td>
<td>160 kWh/sqm per year</td>
</tr>
<tr>
<td>- air conditioned standard</td>
<td>240 kWh/sqm per year</td>
</tr>
<tr>
<td>- air conditioned prestige</td>
<td>400 kWh/sqm per year</td>
</tr>
<tr>
<td>Schools</td>
<td></td>
</tr>
<tr>
<td>- primary, no pool</td>
<td>180 kWh/sqm per year</td>
</tr>
<tr>
<td>- secondary, no pool</td>
<td>190 kWh/sqm per year</td>
</tr>
<tr>
<td>- secondary, with pool</td>
<td>250 kWh/sqm per year</td>
</tr>
<tr>
<td>Universities</td>
<td></td>
</tr>
<tr>
<td>College of Further Education</td>
<td>325 kWh/sqm per year</td>
</tr>
<tr>
<td>Hotels</td>
<td></td>
</tr>
<tr>
<td>small hotel or guest house</td>
<td>230 kWh/sqm per year</td>
</tr>
<tr>
<td>business or holiday hotel</td>
<td></td>
</tr>
<tr>
<td>luxury hotel</td>
<td></td>
</tr>
<tr>
<td>Hospitals</td>
<td></td>
</tr>
<tr>
<td>small acute</td>
<td>320 kWh/sqm per year</td>
</tr>
<tr>
<td>large acute</td>
<td>340 kWh/sqm per year</td>
</tr>
<tr>
<td>Industrial buildings</td>
<td></td>
</tr>
<tr>
<td>- general manufacturing</td>
<td>300 kWh/sqm per year</td>
</tr>
<tr>
<td>- factory / office</td>
<td>220 kWh/sqm per year</td>
</tr>
<tr>
<td>- light manufacturing</td>
<td>220 kWh/sqm per year</td>
</tr>
<tr>
<td>- storage and distribution</td>
<td>160 kWh/sqm per year</td>
</tr>
<tr>
<td>Public houses</td>
<td></td>
</tr>
<tr>
<td>- alternative measure</td>
<td>2.3 kWh/sqm/£1000 turnover per year</td>
</tr>
<tr>
<td>Library</td>
<td></td>
</tr>
<tr>
<td>Museum</td>
<td>340 kWh/sqm per year</td>
</tr>
<tr>
<td>Retail</td>
<td></td>
</tr>
<tr>
<td>- department store (mechanically ventilated)</td>
<td>200 kWh/sqm per year</td>
</tr>
<tr>
<td>- other non-food shop</td>
<td>220 kWh/sqm per year</td>
</tr>
<tr>
<td>- superstore/hypermarket (mechanically ventilated)</td>
<td>300 kWh/sqm per year</td>
</tr>
<tr>
<td>- supermarket (no bakery) (mechanically ventilated)</td>
<td>220 kWh/sqm per year</td>
</tr>
<tr>
<td>- supermarket (own bakery) (mechanically ventilated)</td>
<td>160 kWh/sqm per year</td>
</tr>
<tr>
<td>- small food shop - general</td>
<td>220 kWh/sqm per year</td>
</tr>
<tr>
<td>- small food shop - fruit and vegetables</td>
<td>300 kWh/sqm per year</td>
</tr>
<tr>
<td>Restaurants</td>
<td></td>
</tr>
<tr>
<td>Fast food outlets</td>
<td>410 kWh/sqm per year</td>
</tr>
<tr>
<td>Banks and post offices</td>
<td>1450 kWh/sqm per year</td>
</tr>
<tr>
<td>Building societies</td>
<td>180 kWh/sqm per year</td>
</tr>
<tr>
<td>Estate agents</td>
<td>130 kWh/sqm per year</td>
</tr>
<tr>
<td>Insurance brokers</td>
<td>175 kWh/sqm per year</td>
</tr>
<tr>
<td>Travel agencies</td>
<td>140 kWh/sqm per year</td>
</tr>
<tr>
<td>Sports centres</td>
<td>165 kWh/sqm per year</td>
</tr>
<tr>
<td>- swimming pool</td>
<td></td>
</tr>
<tr>
<td>- sports centre with pool (pool less than 20% of total)</td>
<td>1050 kWh/sqm per year</td>
</tr>
<tr>
<td>- sports centre (no pool)</td>
<td>570 kWh/sqm per year</td>
</tr>
<tr>
<td>- sports club</td>
<td>200 kWh/sqm per year</td>
</tr>
</tbody>
</table>

The above figures are taken from two sources:

- the Energy Efficiency in Buildings series of "yellow books" published by the Energy Efficiency Office, which deal with various sectors, and
- Energy Consumption Guides published by the Energy Efficiency Office under the Best Practice programme.

In addition to providing performance indicators, which include "fair" and "poor" categories as well as the "good" figures given above, both sources of information contain much additional detail about energy consumption, energy efficiency and energy management. They cover individual sectors, such as offices, schools, hotels and many other building types as listed above.
Step 6: Identifying avoidable waste

There is an alternative approach to identifying excess energy consumption which can eliminate many of the weaknesses inherent in performance indicators. This method is called ‘Avoidable Waste’. A definition of avoidable waste is:

'The difference between the energy actually consumed, and the energy needed to provide the required standard of service assuming best practice levels of management and control.'

The energy required to provide the required standard of service - if best practice levels of management and control are used - can be called the 'base energy'. Typically, only the best 10% of buildings in any sector achieve 'base energy' consumption figures. Lower consumptions are possible, but they demand higher capital cost and possibly increased maintenance supervision that may not be viable for your own situation.

Avoidable waste may be a new phrase, but it is instantly recognisable by many as something that should be reduced or eliminated. As a concept it will help you to promote improvements to energy efficiency, especially when the concept of 'ownership of waste' is added. Avoidable waste can be owned by a person in a department - that person should then have the responsibility and authority to correct it.

Reporting on energy efficiency to shareholders and elected representatives in 'avoidable' waste terms can be very effective. A typical level of overall avoidable waste in a large organisation is 30-40% of annual consumption. Since the phrase and its implications are so easily understood, it can stimulate action and overcome inertia.

At this stage do not attempt to undertake a complete avoidable waste analysis. This will require you to begin the energy inspection and spot-checks described under Stage 2. It is sufficient to identify one significant area of avoidable waste. If you can achieve results in one area it will generate confidence in your ability to act, and may help you to obtain support when you begin to look at other aspects of energy performance.

Avoidable waste is determined by selecting appropriate times of day, days of the week, or parts of the year when a fuel is being used mainly for one purpose. Avoidable waste techniques work with very little data. Three avoidable waste techniques are described in the boxes on this page and following pages. In most organisations at least one of them should produce a result of significant interest. By using rules of thumb, this approach sidesteps the need for accurate information on floor area. The minimum data required is limited to your energy use in summer and winter - which you will have already compiled when you collated your information on total annual consumption.

**Summertime hot water**

If your building is not air conditioned and hot water is provided from a boilerhouse or plantroom heated by gas, oil or coal, then this calculation is appropriate. The steps are:

1. identify the rate of boiler fuel consumption in mid-summer, when heating is not needed. Preferably check invoices for July and August over two years to confirm that the consumption is reasonably even. Ensure that the periods selected do not include office or works shutdowns that would artificially reduce consumption
2. convert to kWh per year using kWh conversion factors for the fuel and adjust to 12 months consumption period
3. divide the floor area in square metres (assume 10 square metres per person if floor area data is not available). The figure you will produce will be the annual consumption in kWh per square metre for hot water service
4. compare you consumption with a 'base energy' figure (see box below for a simplified example)
5. to calculate the percentage avoidable waste, subtract the base energy figure from your own consumption then divide the result by your consumption. Multiply by 100 to obtain a percentage figure (see box below)
6. find the annual cost of hot water based on the summertime rate of consumption
7. multiply the summertime rate of consumption by the avoidable waste percentage to determine the annual cost of avoidable waste on hot water.

If the premises are shut during a month, eg a school during August, or a factory for two weeks, and fuel is still used, most if not all the consumption during the closed period could be avoidable waste.

Note that the level of avoidable waste is normally so high that errors in floor area have little impact on the findings. Typical avoidable waste figures for this calculation lie between 40% and 90%.

Assess the percentage figure and cost of avoidable waste, use your knowledge of the organisation's objectives and policies to determine which figure - percentage or cost, or both - will best illustrate the need for improvement.

Include these figures in your initial report to management.

**Calculating the 'base energy' - a simplified example for hot water per person at taps for hand washing**

- hot water used assuming 5 litres/person/day = 1250 litres/yr
- hot water temperature rise 10°C to 60°C = 50°C
- energy required to raise 1250 litres through 50°C = 82,500 KJ
- convert to KJ (82,500 x 4.187) = 340,000 KJ
- convert to kWh (261,688 / 3600) = 73 kWh
- kWh required at 40% efficiency (a reasonable target) = 182 kWh

In this example the 'base energy' is 182 kWh/person/year. Assuming 10 square metres of floor area per person, the base energy for this hot water use at the efficiency shown would be 18.2 kWh/sqm/yr.

If hot water consumption were, say, 30 kWh/sqm/yr, the avoidable waste would be (30 - 18.2)/30 or 39%.
Who is responsible for avoidable waste?

One of the strengths of this approach is that it enables you to ask explicit questions about who owns the problem of excess energy consumption. Who has the responsibility for the avoidable waste that is occurring in your building? What is the size of the waste? Once this responsibility has been identified and quantified, then the budget holders concerned can be made more accountable. Likewise, actions needed to tackle the problem will become easier to specify and the resources required easier to justify.

Remember that your objective is to reduce energy waste in the building. If you suspect that avoidable waste exists, one tactic is to inform those who may be responsible that you are planning a report to management on the subject. Make it clear that you wish to be able to report positively about how waste is being reduced. This approach can result in action being taken with very little effort on your part.

It may be that those responsible are contractors. At this stage their contracts may not include any specific energy efficiency responsibilities. Or they may be lax in translating the contract terms into action. If you inform them that you have checked one building - and may be repeating the checks in others - this may be sufficient encouragement to them to take action to reduce waste now.

If services such as heating and hot water are paid under service level agreements, there is joint interest in reducing avoidable waste. There may be different responsibilities and different departmental budgets for revenue and capital costs. Try to ensure that one person owns the problem, and thus has the responsibility and authority to take corrective action. You should seek to create awareness that an opportunity to save money exists. It may be that the benefits to the organisation of investing in energy efficiency are as large or larger than equivalent investment in the main business or activity.

Further information about avoidable waste techniques can be found in References 6 and 7.

Water consumption

If the water use in your office premises is mostly for domestic purposes such as washrooms, toilets, and beverages, this is applicable. An adjustment is necessary if you have a catering facility. The procedure is:

1. identify the rate of water consumption throughout the year; check that it does not rise in summer for the watering of plants or grass. Select the lower rate of consumption that exists for more than five months each year
2. convert to cubic metres per year by adjusting to a 12-month consumption period
3. find the number of people in the building served by that water meter
4. determine the annual water consumption in cubic metres per person per year
5. use the water consumption figures in the box below to determine the appropriate consumption per person per year
6. allow water consumption for hot and cold water used in preparation of meals in the canteen or restaurant
7. to calculate the percentage avoidable waste, subtract the base energy figure from your own consumption then divide the result by your consumption. Multiply by 100 to obtain a percentage figure. This is the percentage avoidable waste
8. find your annual cost of water and sewerage (it normally costs more to dispose of water than to purchase it)
9. multiply the annual cost of water plus sewerage by the avoidable waste percentage to determine the annual cost of avoidable waste.

Note that avoidable waste will mostly occur because of leaks. In many estates that are not regularly checked for leaks, 10% to 30% of older premises are likely to have significant leaks or to develop them within 10 years.

If a leak is suspected from the avoidable waste analysis, then remember that water lost by leakage will not have been returned to the sewer. A refund for up to six years waste can then be negotiated with the sewerage authority.

If the avoidable waste is above 5 cubic metres per person per year, then a leak should be suspected. Report this suspicion to management, confirming that it will be included in Stage 2: Energy Inspection.

Water consumption figures - typical m³/person per year

| Cold water service            | 4 - 8 |
| offices, no canteen           | 2.5 - 6 |
| primary schools               | 4 - 9 |
| secondary schools             | (4-8 litres per person per day) | 1 - 2 |
Conclusion of stage 1

Air conditioning

Many air conditioning systems distribute air from central plant at 12°C, to balance heat from equipment, occupants, and solar gains. This air is taken from outside air which, depending on its temperature and humidity, will need heating and/or refrigeration energy. When the outside air temperature is close to 12°C then little energy will be required. These conditions occur during May and October in southern England. Energy requirements should therefore be at a minimum during these months. In practice, controlling air conditioned buildings is far easier by making the heating and refrigeration work against one another. This results in the boilers working for more of the year and the refrigeration working more to pump the heat away to waste.

To perform a simple check for avoidable waste, the pattern of boiler fuel consumption needs to be checked. If the boilers are used to heat air as part of the air conditioning process, then wasteful operation can be detected by high boiler fuel consumption in all but the hottest summer months. Ideally (but dependent on the building and the way it is used) there should be little boiler fuel used over the summer, most being consumed from November through to April, peaking in January and February. Later on, electricity use will be also checked. The procedure is:

1. obtain the month by month boiler fuel consumption figures
2. inspect the figures to define the three adjacent months of highest fuel consumption; find the average consumption
3. inspect the figures to define the three adjacent months of lowest fuel consumption; find the average consumption
4. subtract the low consumption figure from the high consumption figure, call this the difference
5. add 30% of the difference to the lowest fuel consumption figure, call this the threshold figure
6. if the consumption for the months where the average temperature is close to 12°C (May and October in southern England) is above the threshold figure, then this indicates avoidable waste is present
7. if this threshold figure is exceeded, then the cost of this avoidable waste of boiler fuel is likely to be at least 20% of the boiler fuel cost. Calculate the cost of this waste.

It can reasonably be expected that the refrigeration consumption will also increase to pump away this wasted boiler heat. Whilst avoidable waste of electricity is likely to be significant, you do not have good enough information to give this figure to any reasonable accuracy for the present.

By the end of stage 1 you will have made extensive use of your fuel bills to:

- know the relative cost of each fuel
- know how much you are spending on each fuel
- compare your building’s performance with others of the same type
- know broadly where your fuel is being used
- know how your energy costs vary seasonally
- know how well you energy costs are controlled.
STAGE 2: ENERGY INSPECTION

What is an energy inspection and why should it be carried out?

An energy inspection takes you into the building to look at what is actually happening. This part of the audit is undertaken through observation, together with simple analyses to help you to understand better your building’s energy use. The observations you will need to make are not highly technical. Nor do they involve you making any adjustments or alterations to any item of plant or equipment. If you are in any doubt about gaining access to appropriate locations of the building in order to carry out the inspection and take readings, ask an appropriate member of maintenance or other staff to accompany you.

The aim of this stage is to identify those parts of the building and its services and equipment which are causing unnecessary, excessive or inefficient energy consumption. The recommended procedures take advantage of the fact that you have on-going access to your building. You can wait for suitable weather or occupation conditions that simplify analysis of your energy and water use.

This stage will help you to choose areas with the greatest potential for savings, to establish priorities for action, and to prove achievement of savings. Many of the savings opportunities can be achieved quickly and at no capital cost. This will help you to demonstrate the value of your actions, and build confidence in your ability to achieve results.

Most avoidable waste of energy occurs when systems in the building are only partly loaded, as opposed to being fully loaded or not required at all and switched off. For heating, spring and, to a lesser extent, autumn, are the times when internal temperatures are often maintained at unnecessarily high levels because the services are set up to respond to deep winter conditions rather than to the milder conditions at the beginning and end of the heating season.

For lighting, avoidable waste most frequently occurs on overcast days, when lighting has been switched on early and left on; as opposed to dull days when the lights are genuinely needed, or bright days when they are left off completely. If water heating is by a central boiler plant, waste is greater in summer when the plant may be operating just to provide very small quantities of hot water for hand washing; whereas in winter the boiler is operating anyway and most of the heat given off by the pipes and calorifier at least contributes to heating the rooms of the building.

By taking your own readings, checking temperatures and inspecting the fabric and services, and using the information and rules of thumb in this guide, you should be able to build up a comprehensive picture of your building’s energy performance and the actions which you need to take as a first step towards getting your energy use under control and keeping it there.

Your goal should be to use energy as efficiently as you can. This means ensuring that required service levels are first established (see box opposite) and then achieved - using the minimum level of energy consumption and cost.

What is an energy inspection?

An energy inspection involves three activities:

- monitoring actual consumption by taking meter readings both regularly, and as spot-checks
- determining the actual operation of plant and equipment to identify needless operation and under/over supply of the required service
- inspecting various parts of the services and fabric to identify actual or potential causes of waste.

Why conduct an energy inspection?

The aim of the energy inspection is:

- to identify unnecessary or inefficient consumption.

When you have completed this stage you should be able:

- to establish the areas which have the greatest potential for savings
- to set priorities for action to improve efficiency and reduce costs
- to detail audit methods to prove that the savings have been achieved.

Your actions will be most likely to achieve results - and in turn this will help you to demonstrate management and staff the benefits of energy auditing.

Sample service level statement

Typically this should define the following:

- maximum and minimum comfort temperatures to be provided, and at what times
- maximum and minimum humidity levels
- ventilation rates
- lighting levels appropriate to the various tasks undertaken within the building
- hot water supply temperatures

The service level statement may also set out additional requirements such as hot water storage temperatures, limits on the extent of standing losses from hot water systems, and limits on the consumption of energy for heating outside the hours of occupation.

Each of these will vary according to the type of building, the type of occupants, and the activity or activities within the building. Reference 1 contains typical values.
Step 7: Taking your own meter readings

Ideally, you should take regular meter readings weekly in order:

- to be able to check fuel invoices and to ensure you are paying only for fuel used
- to be alerted without undue delay to unexpected changes in consumption
- to assess the pattern of consumption such that avoidable waste can be determined.

A routine of reading meters weekly on a Monday morning is recommended. This provides data of high value for analysis, and shortens the time between excess consumption occurring and its detection. Importantly, events that caused excess consumption within the last week can often be remembered, whereas month old events are difficult, if not impossible, to recall. Despite the best of intentions, the regular taking of monthly or four-weekly meter readings is not commonly achieved. Monthly readings also hide the detail that is essential for good analysis. With large fuel accounts, or in large sites, daily readings may be warranted. Conversely, there may be some small supplies where the cost of failure to operate economically is so small that quarterly readings are appropriate.

It is not always possible to take readings at the routine time or day. With care, allowance for early or late readings can be made. The actual reading can be adjusted (or standardised) by adding or subtracting the number of hours multiplied by the hourly rate of consumption. Allowance should be made for different rates of consumption with occupancy, time of day, and season of the year. Some meters have separate registers for recording normal and low-rate electricity. In this case the low-rate reading should only be standardised for consumption occurring in the low rate period.

If a reading is missed entirely, then the weekly readings before and after can be averaged. When the figure entered is not the actual reading, it is always advisable to note the date and time of the actual reading, and mark the ‘reading’ as estimated.

If monthly readings are used, correct for the different numbers of days in each month, for example by converting consumption to a daily figure. Alternatively, four-weekly readings (giving 13 lunar months per year) can be used.

As well as regular readings, spot check readings will help you:

- to see whether the building services are well controlled daily and weekly
- to assess the fuel used by equipment running overnight or at weekends
- to check the operation of services or equipment when specified operating conditions exist, to eliminate variations due to occupancy, weather and other factors
- to record the rate of consumption at the time of the spot check.

A comparison between the actual readings and expected consumption will enable you to identify if there is excess consumption, for example arising from items which are left on needlessly at night or over a weekend.

Regular and spot-check meter readings

Identify which readings should be given priority as the most important to take, based on previous steps.

Regular meter readings will help you:

- to know actual (as opposed to estimated) consumptions
- to understand better how the pattern of consumption is related to weather and occupancy
- to be able to respond quicker to unexpected changes in consumption
- to be able to target and budget fuel consumption more accurately.

Spot check readings will help you:

- to diagnose avoidable waste when items of plant and equipment operate needlessly out of hours
- to determine fuel consumption during occupied hours when there is small or nil requirement for the service.

When taking and recording meter readings

- always ensure you understand how meters are related (Figure 10)
- record the date and time of the reading
- note the actual reading and enter this into your spreadsheet - then use the spreadsheet to work out the consumption and any interpolation. This will provide a more useful record if some weekly readings are unavoidably missed. When you read the meter, mentally check that the consumption since the last reading is close to the expected increase. If it is not, re-check the reading. Do not try to record the consumption on the spot - hand calculations are notorious for cumulative errors.

- Figure 11 gives advice on reading meters.

Labelling of meters

When your holidays come, will anyone else reading the meters correctly allocate the reading to your records? If there is any possibility of meters or their registers (recording digits or dials) being confused with other meters, it is essential to label each separate meter or register. A number of options exist. Either use adhesive labels on the meter panel or wall, or mark the meters on a sketch plan kept by the meters. Do not put the labels on the meters or on anything which can be easily removed or replaced in different positions. Keep a record of the meter layout with the premises summary sheet described in step 1.
Meters and how to read them

Figure 10 Meters and sub-meters

The first task is to locate your meters. If necessary, obtain assistance from maintenance or other appropriate staff. Have you identified all the meters?

You may find it useful to make a small drawing of the meters and to identify on it which areas of the building each meter serves, or for which “end use” it records the fuel. Alternatively you could label the meters or tie an identification tag to each one.

Also make sure you work out how your main and sub-meters are related. Prepare a diagram for yourself (like the ones below) to show the metering arrangement.

Oil fuel consumption

There are two main methods of measuring oil consumption:
- use of a tank gauge (and/or dipstick) together with recorded fuel deliveries
- by use of an oil flow meter in the burner oil feed pumps
  - this needs access to the boiler house and is not described here.

The method is as follows:
- record the tank contents at the start of the monitoring period
- record deliveries made during the monitoring period
- record tank contents on completion of the monitoring period.

The consumption can be calculated by adding a to b and subtracting c.

Figure 11 How to take meter readings

There are two basic types of meter:
- those with dials
- those with digital register

Digital meters

If you meter register looks like this:

![Digital meter example]

simply make a record of the reading. Ignore the number in the last window, labelled 1/10 - it records fractions of units.

Some digital gas meters include a multiplying factor. The actual consumption is obtained by multiplying the recorded consumption by the multiplying factor. There may also be a separate pointer dial, which can be ignored unless you are taking spot-check readings. In the following example the reading is 140067 hundreds of cubic feet.

CUBIC FEET

Dial meters

Some dial meters have five dials in black, others have four.
(There may also be one or two additional dials - usually printed in red - which record fractions of units. Ignore these - unless you are taking spot-check readings.)

If your meter has five black dials, with the following readings

then the meter reading for this illustration is 58297.

The direction of the numbers round the dials may be shown in reverse compared with this illustration.

It is easy to make a mistake with dial meters, especially when the next dial is near 9. Whenever a pointer is between two numbers always read the lower number.

Note that on each dial the pointer travels in the opposite direction to the one on the previous dial.
Step 8: Checking your meter readings against fuel invoices

First you may wish to reconcile your readings with fuel utility invoices. The dates of meter reading by the utility may not correspond with your own meter reading routine, so you will need to interpolate between two of your own readings to work out the reading you would expect to see on the invoice on that date. If the utility appears to have made an error, you should contact them without delay and ask for your own reading to be used instead. If the utility has estimated the consumption, and it is clearly too high, again you may be able to challenge the estimate and to have your own reading used as the basis for a revised invoice.

Step 9: Interpreting spot-check meter readings

Spot-check readings, such as those comparing day consumption with night consumption, or those taken over a weekend, are likely to be of most value in buildings where the expected fluctuations are large. For example in offices, which are typically unoccupied for more hours per year that they are occupied, night time consumption is expected to be very low. Seasonal comparisons, on the other hand, are likely to be valuable in any type of building.

The precise details of when you take spot-check readings will vary according to your building and its use pattern. For electricity meters supplying office loads such as equipment and lighting, up to a quarter of the annual consumption can be used whilst no-one is in the building. This obviously excludes buildings where electricity supplies space heating. To check consumption during unoccupied hours, take meter readings after the end of the working day and again early in the morning before staff begin to arrive. Subtract the new reading from the old and ask yourself whether the consumption is reasonable for the use and size of the building. A similar exercise immediately before and after a weekend will reveal similar information. Water leaks are checked by a similar process.

Seasonal comparisons in non-air-conditioned buildings will help to identify how well controlled your services are in relation to external conditions. Estimate the base load (largely comprising hot water and catering) by comparing summer and winter consumptions in the same way you did for invoiced fuel (step 6). The remainder represents space heating. By taking weekly (or monthly) readings you will be able to identify both space heating and base load consumptions. You can then use both to compare your consumptions with the norms for your building type, and to identify whether your space heating fluctuates logically with the outside temperature. This is described in more detail under steps 11 and 12.

Step 9: Spot check readings

Use these to check:
- Is consumption justified by the use made of the building and any energy consuming equipment within it?
- Are services working needlessly at night?
- Is equipment left on unnecessarily?
- How much energy is used when the only activity is the cleaning of the building?
- Is the energy used by security staff in line with your expectations?

Calculating the rate of consumption directly from the meter

Electricity meters with a spinning disk have a calibration factor of \( x \) revolutions per kWh. The value of \( x \) depends on the capacity of the meter. Typically it may range from 200 down to 3 or less.

If \( x = 10 \) then 1 kWh is registred for 10 revolutions of the disk. If this disk is turning at 5 revolutions per minute, then 0.5 kW is being consumed per minute, so the rate of consumption is 30 kW per hour. This is equal to 1 kWh being used every 2 minutes.

If \( x = 200 \) and the disk is spinning at 1 revolution per minute, then 0.005 kW is being consumed per minute and the rate of consumption is 0.3 kW per hour. This is equal to 1 kWh being consumed every 3 hrs 20 mins.

Water and gas meters with digital displays need to be read differently. Consumption needs to be assessed by timing the period between successive digits on the smallest register.
When taking spot check meter readings, it is good practice to note the consumption rate at the time of reading (see box opposite which shows how the calculation is made). Electricity meters with a spinning disk have a calibration factor of \( x \) revs/kWh. Depending on the capacity of the meter, \( x \) typically ranges from 200 down to 3 or less. If \( x \) is 10, then one kWh is registered for every ten turns of the spinning disk. The disk will have at least one mark on the dial to show its movement. At the time of reading, determine and note the number of seconds between complete revolutions. If the disk is spinning fast, count the number of rotations in one minute.

Whilst looking at the dial, check to see if the rate of rotation is steady. If it is, the period over which the check is made can be kept short, say less than two minutes. If there is obvious variation in the rate of rotation, check for long enough to ensure that a good average rate is noted. If there are two distinct rates of rotation, calculate the consumption for both - this may help you find out which loads are responsible.

With water metering, the first checks you should make consist of over-night consumption, plus the instantaneous consumption rates. If the overnight consumption is consistent with the instantaneous rates, then the consumption is at a steady rate.

When taking spot-check meter readings, check to see if the consumption rate is even or consists of spurts of consumption. This may help you to determine the type of load connected. Electricity meters supplying thermostatically controlled loads, such as water heaters, refrigerators, or lifts, will show spurts of consumption for, say, one minute in ten or twenty minutes. Gas meters supplying boilers may show gas being used for two minutes, then nothing for ten minutes. During the spot check, the rate of consumption can be determined. This may give a clue as to the load.

Comparisons of new readings with previous equivalent readings

Make sure that both the older and current readings cover the same number of days or hours - within reasonable accuracy. It is preferable to take weekly readings close to the same time each week, ideally no more than one hour different. As the time difference increases, errors increase and this lowers the usefulness of the data. In practice, very few observers correct variations two hours or less between reading times.

You will need to seek explanations for any changes between this reading and the previous one, for example in terms of occupancy, weather or equipment.

Reading instantaneous electricity consumption from the meter

The register in the electricity meter and/or the spinning disk can be used to measure consumption on different occasions as part of your spot checks.

Use the spinning disk to measure instantaneous consumption both during the period of occupation and outside this period.

Readings taken during the period of occupation will include consumption incurred by a wide variety of equipment used by occupants, as well as the electricity used by the building services including lighting. To check the building services consumption, you will need to turn off the other equipment (copiers, vending machines, refrigerators, etc etc) for a short period. Ensure staff are fully informed before you do so.

To check the consumption of the equipment which runs outside the period of occupation using an instantaneous reading from the meter, you will need to ensure there is no consumption arising from the building services (pumps, fans, etc). These pumps and fans can come on early in the morning, so your check will need to be conducted before they do so. Avoid trying to disable the electricity supply to the boiler house in order to take the reading, unless you have expert assistance. Doing so can cause time controls to lose their settings, and some magnetically operated valves may default to closed; in some cases these may set off fire alarm systems. Other operational problems may also ensue after even a short period of disconnection.

Comparisons with previous week's reading

- Is the new reading in line with what you would expect?

Comparison with previous year's reading

- Are any changes consistent with weather conditions?
- is the operation of the building the same as last year?
- is the level of activity (occupation, production) the same as last year?
- have the maintenance arrangements changed?
- has the equipment in the building been changed?

Try to find out the causes of any unexplained differences between new and previous readings. Simply asking occupants may reduce any careless consumption.
Step 10: Identifying room temperatures

The energy you pay for should be consumed, not to keep your building warm and well lit, but to provide a comfortable environment for you and your staff as and when they need it. So it is important to establish what level of service your energy consumption is actually delivering.

Consider a building which is occupied between 0800 and 1800 hours. The profile of the desired internal temperature, during the heating season, would show a straight level line at, say, 18.5°C during the 10 hour occupancy period, see Figure 13. Outside this period, when the building is unoccupied, it is not critical to keep the internal temperature at this level. Winter or summer, it is only necessary to keep it above or below some desirable minimum or maximum in order to protect the articles and equipment inside the building. How closely does the profile of internal temperature in your building conform to the ideal pattern shown in Figure 13?

The internal temperature quoted here is the former Property Services Agency's recommended standard for offices. It differs from the Offices Shops and Railway Premises Act which specifies a legal minimum temperature of 16°C. The legal maximum temperature for heating is 19°C: premises may not be heated above this temperature by the use of electricity or fuels - see Statutory Instrument 1980 No. 1013 (SI 1013).

The position in a room where room temperatures are measured is critical if unnecessary temperatures are to be avoided. The standard position is in the middle of the room at one metre above the floor. Temperature measurements taken near a wall can be influenced by the wall temperature which can be 1-2 degC below the air temperature. Measurements near windows can receive heat from the sun, or be affected by cold air from the window. Measurements should avoid heat sources such as radiators and office copiers.

It is useful to measure temperatures in your building, especially during the heating season, before, during and after the period of occupation. This will enable you to compare what is actually being delivered with required temperatures. These measurements should be taken in various parts (called zones, in heating terms) of your building. You should also take them at various times during the heating season, particularly in spring and autumn when your building may be heated more than is necessary. Avoid taking readings on a day with very sunny intervals because few heating systems respond adequately to sudden changes in weather conditions and the results could be misleading.

Remember that a 1degC rise in internal temperature above what is required can cost you 5-10% more to heat the spaces where this occurs.

Why take room temperatures?

Taking room temperatures will allow you:
- to identify how close your measured temperatures are to the recommended minimum during the period of occupation
- to discover how much measured temperatures fluctuate during this period - if the internal temperature is too high for significant periods of time, this may indicate that your room temperature controls are set too high.
- to find out what happens to temperatures outside you period of occupation - if internal temperatures reach the recommended minimum well before occupation begins, and/or they remain high long after it has ended, then the timer or programmer to your boiler has not been set to minimise fuel consumption
- to detect whether reasonably uniform temperatures are being maintained throughout your building - if some parts are hotter than others on an averagely sunny day, this may mean either that zonal controls for heating are not responding adequately to outside weather conditions, or that the heating system is poorly balanced so that some spaces receive too much, or too little, heat from the boiler.
- to check whether rooms reach comfort conditions adequately on Monday mornings or after other periods of non-use. If they are slow to do so, the most probable causes are likely to be poor balancing of the heat emitters, poor circulation in the heating system, lack of heating boost temperatures during the pre-heat period, or excess ventilation through doors or windows.

If your measurements reveal any of these problems, maintenance staff should be asked to investigate the causes and to make the adjustments necessary to correct them.

How to record room temperatures

Ideally your temperature measurements should be taken with a "mini-globe thermometer", see Figure 12. This simple instrument gives a better indication of thermal conditions, in terms of the way in which they affect whether you feel comfortable, than a simple (air) thermometer. It is made up of a mercury in glass thermometer with its bulb, supported uppermost, enclosed in a 40mm blackened globe. However if you do not have such an instrument, you can still get reasonable results with either a modern digital thermometer with an air probe, see Figure 12, or a mercury- or alcohol-in-glass thermometer.

Using whichever type of thermometer you choose, place it in a representative, central position in each space you measure. Site it out of direct sunlight and draughts, and away from surfaces such as hot radiators, cold windows or walls. Leave the thermometer to settle down for five minutes and then take readings at five minute intervals until two consecutive readings are identical.

You may find it more practical to purchase a thermograph for this task - this is a recording thermometer that marks a temperature line on a graph or prints out the daily pattern.
Figure 12 Examples of different types of thermometer

Mini globe thermometer

Remote probe thermometer

Figure 13 Example of thermograph chart of space temperatures.

Required temperatures are show hatched, while the actual temperature is shown by the solid line.
Step 11: Checking fuel use for hot water

It is fairly simple to estimate your fuel consumption for hot water production if you have a central boiler which heats water stored in a calorifier that in turn supplies water to the hot taps. The main causes of excess consumption in such a system are the standing losses, that is heat being lost from your boiler, your calorifier and your pipework. Much fuel is wasted by the system keeping itself warm even where there is little demand for hot water. Only infrequently are the standing losses less than 50% of the fuel consumption. Typical figures range from 60% to 90%.

Alternative systems, such as those located near to the point of use and especially point-of-use water heaters without storage tend to be more economical, especially during the summer months when a large boiler may be operating to supply small quantities of hot water to the taps.

Where hot water is provided by a boiler using fossil fuel which serves both space heating and a calorifier, use the procedure in the box opposite.

### Table 4 Annual fuel consumption for hot water service.
(figures in brackets are typical of installations where simple modifications have been made to reduce standing losses)

<table>
<thead>
<tr>
<th>Type of installation</th>
<th>Annual consumption kWh/person</th>
<th>kWh/sqm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calorifier served by boiler</td>
<td>800 (400)</td>
<td>80 (40)</td>
</tr>
<tr>
<td>Electric immersion with local storage</td>
<td>120-200</td>
<td>10-20</td>
</tr>
<tr>
<td>Gas instant heater, no storage</td>
<td>120-180</td>
<td>10-15</td>
</tr>
<tr>
<td>Point of use instant electric</td>
<td>30</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Note the figures given in this table apply only to buildings where hot water use is limited to handwashing, refreshments, and light catering. It does not apply to buildings such as hotels or restaurants where hot water is used intensively. The box below shows some figures for offices. More detailed figures are available for various building types in Reference 1.

### Estimating standing losses from a centrally supplied hot water system

This spot check assumes a gas-fired boiler serving a calorifier, which in turn supplies taps.

* choose a period for the spot check, such as a summer weekend or public holiday, when the heating is not on, nor is there any other use of the fuel (e.g. there is no catering use) and when no hot water is drawn. The longer this period is the more accurate the result will be.
* leave the hot water system switched on.
* read the fuel supply meter at the beginning of the check period and again at the end, to find the consumption.
* divide the consumption by the number of hours of the check period to obtain an hourly consumption rate.
* then multiply this hourly consumption figure by the number of hours that the system actually operates per year.

The resulting figure is an estimate of the annual standing losses.

Divide this figure by the total hot water energy consumption to find what fraction of hot water energy consumption is made up of standing losses.
Step 12: Checking fuel use for space heating

Conventionally the space heating season covers the 30-week period between 1 October and 30 April, although the need for heating is influenced by the weather.

Space heating is frequently provided by the same boiler which supplies hot water, and is fuelled by gas (or other fossil fuel). Step 11 of this guide has suggested a way to identify what proportion of the total boiler fuel should be allocated to the hot water. If the same fuel - gas - is used for catering, you can use Step 14 to estimate how much is due to catering. Commonly

\[ \text{total gas} = \text{space heating} + \text{hot water} + \text{catering} \]

So the remainder of your total gas consumption may be allocated to space heating. Fuel consumption for space heating varies widely - not only according to the hours of use of the building and the temperatures which are maintained, but also how much heat is lost through the fabric of the building and through ventilation and draughts. Step 10 has already shown how to detect excessive temperatures being provided.

Energy used for space heating can be conveniently split into that used for pre-heating to bring the space temperature up to the required level, ideally just as occupation starts. The remainder is used to keep the space temperature at a satisfactory level during occupied hours.

The pre-heat energy makes up the heat lost after the last occupation, through fabric and air infiltration losses. Ensuring that the pre-heat period is minimised will help to reduce unnecessary waste. The better heating controllers have an optimum start function that will get the building up to temperature within 20 minutes of occupation time for more than 60% of heating starts. Because occupants do not like cold buildings, poor optimum start controllers are set to heat the building earlier, so that the optimum start error is hidden. If the building is up to temperature one hour earlier through poor control, the annual heating cost can rise by 5-10%.

Make sure the heating is not operating unnecessarily at weekends.

You may be able to do little about heat losses through the fabric of the building - although insulating accessible lofts and roofs, and draught-stripping, all have very short pay back periods. You may have more opportunity to look at ventilation losses occurring during occupied hours. In particular look at window opening during the spring and autumn - and in different parts of the building. If windows are opened to combat excessive warmth (as opposed to meeting fresh air needs) try to find out where and when the overheating is occurring, and take steps to prevent it.

Excess ventilation that increases fuel use can be caused by gaps around windows and doors. These gaps can be detected by listening for sounds from outside the building. Well-sealed doors and windows muffle higher frequency noise from external sources such as wind and traffic.

Heat given off by lighting contributes to space heating. If levels of artificial lighting are high, and the heating system responds to these heat gains, then the amount of heating energy required will be reduced.

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**Step 12 Space heating**

If you have gas heating you can use the following method to assess space heating.

- subtract the annual gas base load (as measured in summer) from the total annual gas consumption - then the difference can be allocated (approximately) to space heating.
- divide this space heating load by the floor area to give a space heating load for the building in kWh/sqm.

When you have completed this step you will have derived a figure for your energy consumption, and cost, due to space heating.

As a very rough guide, 200-250 kWh/sqm is sometimes taken as a yardstick above which consumption is considered to be excessive. See references 2, 3 and 4 for more detailed consumption figures.

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**In the boiler house**

Many buildings have several boilers installed in parallel. In the coldest weather all will need to be operating simultaneously, and for about 60% of the time, to keep the building warm. But, most of the time, this is not necessary and some of the boilers can be switched off. The boiler sequencing control governs which boilers come on to meet the heating load.

**Boilers whose heat is not needed should be cold or cooling.**

In April and October the total run time of the boilers should have reduced to about one fifth of that during the coldest months - equivalent to a total run time of only about 12%. As an example, if there are three boilers, and only one is operating, it should be operating for 3 x 12%, or 36%, of the time during these mild months, with the others cold.

Older boilers consume up to 7% of their fuel keeping themselves hot - they act as big radiators heating the boilerhouse and the flue. More efficient boilers bring this figure down to 1% or slightly less. If there are three boilers hot when only one is required, then one third of the fuel consumed is wasted keeping the unwanted boiler hot.

If the boiler house is very warm this may be because the boiler and/or pipe insulation is in poor condition or missing.
There are other potential sources of waste in heating systems. These include the degree of efficiency with which the boiler burns the fuel and extracts the useful heat from it; tests can be performed by maintenance staff with combustion analysers to minimise this source of waste. Other sources are related to the output of the boiler. Here your aim should be to ensure it is controlled to operate only when and to the extent required to heat the building. Your boiler and heating system probably has various controls which do this. The box opposite will help you to diagnose possible causes of inefficiency.

**Diagnosing causes of inefficiency in your space heating**

If your space heating system is bringing the temperature of the building up to the required standard too far before it is needed, and/or if the temperature stays high long after the occupancy period, probably your time controls need checking. If the building is too warm in autumn and spring the boiler output control settings need checking.

Heating controls are often set for too great an output to compensate for underheating or high heat losses in a small part of the overall heated space. To ensure satisfactory temperatures in the less well heated areas, the heat output for the whole building is increased. This wastes fuel for possibly 80% of the building, as well as contravening Statutory Instrument 1013:1980. The proper, but more difficult, solution is to ask for the heating system to be properly balanced. It may be that previous maintenance actions have disturbed the heating balance and not restored it to a balanced condition. In other words, the job was never competently completed and you are left to pay 10% or 20% more on your heating fuel bill. Cheap maintenance can end up being very expensive!

Heating may be left on unnecessarily during holidays simply because no-one has the responsibility to adjust the appropriate controls. A specific question should be asked at senior and lower organisational levels - the intention may not match the practice.

In buildings with security staff, it is not unknown for the staff to turn on the heating for the whole building to keep themselves warm. Some spot checks on fuel consumption, or the use of recording thermometers, may be warranted.

**Space heating - some useful rules of thumb on energy consumption**

The following are rules of thumb consumption figures in kWh/sqm per year and are typical of 1960's offices and school buildings.

<table>
<thead>
<tr>
<th>kWh/sqm/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient operation, well controlled and maintained</td>
</tr>
</tbody>
</table>

**Disaggregated energy assuming efficient operation**

- heat into room (varies with gains from equipment) 70-150
- boiler standing losses 10
- pipework losses from boiler house to room 10
- control errors leading to overheating 15
- excess time that service is available 10
- combustion losses 10

In practice, overheating, excess heating time and combustion losses can add 60 kWh/sqm per year or more. This brings the total heating energy up to 200 kWh/sqm per year, which is a typical consumption figure.

Boilers used for heating and hot water commonly operate for 250 days per year at 12 hours per day = 3000 hours. Typical boiler operating hours at full load are 1000 hours. A typical boiler has 5% standing losses from the case and from heat lost up the flue. And, as these losses occur all the time the boiler is hot (3,000 hours per year), the standing losses can equal 15% of total consumption.

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Step 13: Estimating lighting consumption

It is not difficult to estimate the electricity you use for lighting. You can do so by:
- counting up the number of lamps
- working out, with assistance if necessary, their power ratings
- estimating their hours of use annually.

Figure 14 provides a sample calculation to help you to do this.

You will probably find it easiest to do these calculations using a simple spreadsheet. This will also allow you to look at “what if” scenarios, to estimate the savings arising through reduced running hours and more efficient lamps.

If a clip-on ammeter or the choke current is used to estimate power consumed, significant errors can be caused by failure to account for the effects of power factor.

<table>
<thead>
<tr>
<th>Lamp types:</th>
<th>fluorescent tubes</th>
<th>compact fluorescents</th>
<th>tungsten filament</th>
</tr>
</thead>
<tbody>
<tr>
<td>F multiplication factor for gear losses (see below)*</td>
<td>1.25</td>
<td>1.25</td>
<td>1.0</td>
</tr>
<tr>
<td>B resulting wattage of luminaire (D x F)</td>
<td>50</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>N count the number of lamps</td>
<td>30</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>W installed wattage (multiply B x N)</td>
<td>1500</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>A measure the floor area served (sqm)</td>
<td>100</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>L measure the lighting level, in lux</td>
<td>300</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>calculate installed power rating in W/sqm per 100 lux [P/(L/100)]</td>
<td>15/(300/100) = 5</td>
<td>3.75/(150/100) = 2.5</td>
<td>30/(100/100) = 30</td>
</tr>
</tbody>
</table>

Refer to table 5 and assess performance

| H hours of use per year (found by hours of use per day x days per week x weeks per year) | 2,600 | 2,600 | 2,600 |
| C lighting consumption in kWh [W x H]/1000 | 3,900 | 600 | 600 |
| P cost of electricity in pence per kWh | 7 | 7 | 7 |
| annual cost in £ (multiply C x P/100) | £273 | £42 | £42 |

Total annual cost of running these lights (add costs across the columns) | £357 |

Total annual consumption in kWh (add consumption across the columns) | 5,100 kWh |

Multiplication factors for converting lamp wattage to luminaire wattage

- Tungsten filament lamps (except where on dimmers) 1.0
- conventional fluorescent lamps 1.25
- high intensity discharge lamps 1.1
- fluorescent lamps in high frequency circuits use manufacturer’s data
A PRACTICAL GUIDE TO ENERGY AUDITING IN BUILDINGS

Step 14: Fuel consumption for catering

If significant catering is undertaken in your building, it will increase your consumption of fuel. In a building where catering is intensive, such as a hotel, it can have quite a large impact on total fuel use and catering practices are often very wasteful - with hobs and other equipment left on for much of the day. Most of the fuel used for meals goes on food storage, cooking and serving, but also extra hot water is used and ventilation rates are high.

Some buildings with a large catering operation where cooking is by gas, have a separate meter to measure the catering gas separate from other uses. Try to find out if you have one. If so, take meter readings and, using the number of meals served, work out your gas consumption due to catering in kWh per meal. You may compare your consumption against the figures given in table 7, which shows some typical fuel consumptions for food storage, cooking and serving. If you have no metered consumptions for catering, use these figures initially as part of your overall reconciliation of energy use, described in step 17.

In buildings with maximum demand accounts, a sudden rise of 8-12 kW in the maximum demand may be caused by the installation of a flow heater in a dishwasher. These are often less than 300mm long, fitted underneath a sink with the dishwasher. Though the kW consumption may be small since they may be used to heat water for less than one hour per day, the dominant cost will be the maximum demand charges.

Step 14: Catering

If you have a significant amount of catering:

- obtain details of the number of meals served daily or weekly from the catering manager.

If cooking is by gas, and the catering gas is separately metered:

- calculate the gas consumption in kWh/meal.

As a rule of thumb in a gas kitchen, electricity consumption is broadly equal to gas. Therefore double the gas consumption to get the total kWh/meal. Compare with the figures in table 6. If you do not have any metered consumptions for catering, use the figures in table 6 as a first estimate when reconciling total energy use in step 17.

At the end of this step, you will have a broad indication of the cost and consumption due to catering in your building.

<table>
<thead>
<tr>
<th>Type of catering</th>
<th>Typical consumption in kWh/meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee shop, fast food outlet</td>
<td>1</td>
</tr>
<tr>
<td>Employee catering</td>
<td>1 to 2</td>
</tr>
<tr>
<td>University and school catering</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Restaurant</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Five star hotel</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 7

Step 15: Mechanical ventilation and air conditioning systems

This step applies only to buildings which rely on mechanical plant to introduce fresh air into the rooms.

Mechanical ventilation systems use a system of ducts and electric fans to bring fresh air into a building. This air is pre-heated in winter, and a proportion of the exhausted air may be recirculated. Mechanical ventilation raises consumption of both fossil fuel and electricity in a building. Space heating is increased because of an increase in the air change rate within the rooms - more warm air is exhausted from the building that is normally lost through natural ventilation. And the fans used to move the air around are operated by electricity. Electricity consumption for mechanical ventilation is very dependent on its design, but can vary from 30-200 kWh/sq.m.

Air conditioning should not be confused with mechanical ventilation. Air conditioning systems provide warmed air in winter and cooled or conditioned air in the summer months. They therefore include refrigeration plant. Buildings which have full air conditioning tend to be highly serviced and high consumers of energy. Typically they use considerably more electricity than buildings without - around 50% to 100% more. Space heating consumption is often also higher - by 20% or more. This is because of additional ventilation rates and the common problem of refrigeration fighting the heating. Unfortunately air conditioning systems can be delivering the desired conditions in your building while operating extremely inefficiently and at the expense of high or very high fuel consumptions. This inefficiency may not be easy to detect without access to specialist expertise - although it may be one of the first areas to address if your electricity consumption appears excessively high.

Detailed inspections by specialists often reveal faults in air conditioning systems. One that is frequently found is in the dampers (both motorised and manually adjusted) which govern the intake of fresh air; these and their controls should be regularly maintained to ensure dampers open and close as required.

If your building needs air conditioning in one area (such as a computer room) all year round, try to ensure that this does not result in the whole system operating just to supply that one area. It is worth checking that you have not got the heating and cooling operating simultaneously and working against each other! If this is going to occur it is most likely to be in May and October. Unfortunately it is often difficult or impossible to turn the heating off in air conditioned buildings. If those responsible for maintenance of the air conditioning system are not the same staff who maintain the heating system, try to ensure there is liaison between them to prevent the systems working against each other.

Air conditioning in a well-controlled standard office uses about 100 kWh/sq.m/year of electricity - and far more in a less well-controlled office (Reference 3).
Step 16: Estimating other uses of electrical energy

Here you can apply the same logic that was applied to the lights. You will need to locate the items concerned and find out their average power rating. Then, to assess their annual consumption, you will need to work out the number of hours they are used per year. The total consumption is given by

number of units x average power rating x annual hours of use

You will find it useful to draw up a spreadsheet similar to the one in Figure 15 (on lighting) for your equipment. Reference 8 contains detailed information about power ratings and hours of use for office equipment, and will help you to make estimates of consumption arising from these sorts of equipment. This reference shows the wide differences between the manufacturer’s quoted rating on office equipment and the typical power consumption. Typically office equipment consumes 20-60% of its nameplate rating.

To assess consumption of items like escalators the use of portable metering equipment is recommended, for which you will probably need outside assistance.

Step 16: Other uses of electricity

Identify other items which use electricity, such as:

- computers, typewriters and photocopiers, which are distributed around the building
- other items like laboratory equipment, vending machines, catering equipment and kilns

Then use the formula:

number x average x annual hours of units power rating of use

to calculate annual consumption, just as you did for lighting.

See Reference 8 for information about power ratings and hours of use of office equipment.

At the end of this step you will have have calculated the electricity used by ancillary items of electrical equipment.

Step 17: Reconciling total fuel use with individual 'end uses'

If you have been able to undertake all the steps so far and are confident of having reasonably good data about consumption, both total consumption as metered, and estimates of the consumption arising from the various end uses, you will be in a position to compare the two. If you have not already done so, you will find a simple spreadsheet useful for making the comparison. Ideally, when you add together all your estimates for the various quantities of fuels consumed by individual items of plant and equipment the totals will agree with the metered consumptions.

In the case of fossil fuels this will almost certainly be the case because, under steps 11 and 12, space heating use was worked out by subtracting the base load from the total fossil fuel consumption. The question you should ask yourself here is whether consumption is reasonable in comparison with yardsticks.

In the case of electricity you may find it more difficult to reconcile actual consumption with the amounts you would expect your plant and equipment to use. You may need to re-assess the power ratings and run-hours of equipment to reconcile total consumption with that of the individual items. If, having done so, metered consumption is higher than expected, you may require more specialist advice to help you to locate the sources of the extra consumption.

But, even if you are able to reconcile total consumption with that of the individual items, the key question you should ask yourself is whether your use of energy is as efficient as it ought to be. The final step in this guide provides you with a structured way to assess the operation of your services and the physical condition of both them and the fabric.

Step 17: Reconciling total fuel use

You should by now:

- know what items of plant and equipment use energy
- have measured or estimated consumptions for all these separate items
- have collated records of your total energy consumption.

Now you should reconcile the two sets of information, using a spreadsheet.

You may have to cycle through the information several times to try to make the disaggregated figures add up to the total. If your total consumption remains higher than the total of the separate items, recheck those consumptions which had to be estimated. If you are unable to identify the causes, you may find outside help valuable to locate the reasons for the discrepancies.

For most purposes an accuracy of 10% is good enough. Better accuracy is possible, but takes considerably longer and may not achieve a significantly better analysis. The end result is the most important - from the time invested what savings can realistically be achieved.

At the end of this step you will have detailed understanding of where energy is used in your building. Broadly your priorities for actions to reduce energy use should be towards the those uses which have the largest consumptions.
Step 18: Inspecting services and fabric

The matrices on the next pages have been prepared to provide you with a structured way to survey the condition and operation of your building. Each matrix deals with one particular part of the services or fabric of the building. Within each of the matrices, the column headings identify the key aspects of operation.

The matrices provide an immediate check in the situation in your building. Level 4 is a level of best practice that is a convenient reference. Level 0 indicates that significant improvement is needed if operating costs are to be reduced. An approximate guide is that each level represents a 10% change in operating costs. Practical experience from large estates is that energy costs in poor buildings is double that of best practice buildings.

Decide where best to start then, taking each matrix in turn, use the descriptions in each of the cells to identify at which level you are in each column.

You may wish to use the matrices to prepare a profile of energy management as it operates in practice in your building. Within each column, mark the cell which best describes the state of your premises. Then join the marks across the columns to produce a graph. This will help you to understand how well balanced your management of energy is. It will also help you to assess those parts of the operation of the building which are the least efficiently managed. And it will help you to identify how you can move up the columns to the higher levels.

How to interpret the profiles

You can use the profiles you have drawn to assess how balanced your approach to the management of the services and fabric is in practice. Peaks indicate where your management activities are most well-developed, troughs where there is still scope for improvement.

The examples below show a balanced matrix and an unbalanced one.

![Balanced Matrix](image1)

![Unbalanced Matrix](image2)

Drawing these profiles may give you new insights into where energy is being used more - and less - efficiently. You can put this awareness into practice by identifying priority areas for introducing improvements. You may wish to give priority to those that:

- are least advanced
- are easiest, or cheapest, to implement
- will have the most impact on energy savings.

Step 18: Inspecting the services and fabric

Decide what order to conduct the inspection - according to the potential for increased efficiency identified in previous steps.

Use the matrices at the back of the booklet to undertake a structured approach to the inspection.

In each column mark the cell which best describes the state of your premises. Join the marks to produce a graph of how well balanced your premises are.

Try to identify means to move up to the higher levels. These are likely to include:

- good housekeeping measures, such as adjustments to the controls which govern how, when and to what extent the services in the building operate
- presentations to, and discussions with, staff on more efficient ways of using equipment and lighting
- capital investment on new more efficient building services or on improvements to fabric insulation.

At the end of this step you will have an assessment of the physical condition of your fabric and services, as well as how well controlled they are in use.
## Matrix 1: inspecting hot water

Matrix 1: Inspecting and assessing the efficiency of your hot water system

<table>
<thead>
<tr>
<th>Date:</th>
<th>Building:</th>
<th>Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level</th>
<th>Type of installation</th>
<th>Timer/programmer settings</th>
<th>Calorifier insulation</th>
<th>Pipework insulation</th>
<th>Actual water temperatures at taps</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Instantaneous local point of use water heaters or water heaters with localised storage with time controls.</td>
<td>Two or more visual and functional checks made each year against a formal document and results recorded. No pump or heating fuel used when building is unoccupied.</td>
<td>Not applicable.</td>
<td>Not applicable.</td>
<td>Water temperature at the taps is hand hot and no cold water has to be added for comfort.</td>
</tr>
<tr>
<td>3</td>
<td>Instantaneous local point of use water heaters or water heaters with localised storage without time controls.</td>
<td>Annual visual checks made using formal procedures and results recorded. No pump or heating fuel used when building is unoccupied.</td>
<td>Not applicable.</td>
<td>All pipework in both unheated and heated spaces is well insulated and insulation feels cool to the touch.</td>
<td>Water temperature at the taps is hand hot but on occasions a little cold water has to be added for comfort.</td>
</tr>
<tr>
<td>2</td>
<td>Hot water is provided from a central boiler plant with 7-day timer/programmer that allows different settings for heating versus hot water and for weekend versus weekday.</td>
<td>Times of availability closely matched to demand. Separate time switching for water heaters, boilers and pumps. Regular checks on timeswitch settings.</td>
<td>The calorifier is well insulated with insulation known to be more than 75mm thick.</td>
<td>All pipework in both unheated and heated spaces is well insulated and insulation feels cool to the touch.</td>
<td>Water temperature at the taps is hand hot and cold water has to be added regularly for comfort.</td>
</tr>
<tr>
<td>1</td>
<td>Hot water is provided from a central boiler plant, with timer/programmer serving both heating system and hot water.</td>
<td>Times of availability not specifically checked. Some pump or heating fuel used when building unoccupied.</td>
<td>The calorifier is insulated with 25-50mm insulation.</td>
<td>Pipework in unheated spaces is well insulated and cool to the touch.</td>
<td>Water temperature at the taps is too hot for comfort and some cold water has invariably to be added for comfort.</td>
</tr>
<tr>
<td>0</td>
<td>The only boiler controls are on/off and the boiler thermostat.</td>
<td>Times of availability not specifically checked. Significant use of pump(s) or heating fuel when building unoccupied.</td>
<td>The calorifier is poorly insulated and losing heat badly.</td>
<td>Pipework generally is uninsulated, or the insulation is thin, damaged or in poor condition.</td>
<td>Water temperature at the taps is very hot, and significant amounts of cold have to be added for safety.</td>
</tr>
</tbody>
</table>
## Matrix 2: inspecting space heating

### Matrix 2: Inspecting and assessing the efficiency of your space heating

<table>
<thead>
<tr>
<th>Date:</th>
<th>Building:</th>
<th>Name:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Level</th>
<th>Equipment</th>
<th>Maintenance</th>
<th>Operation</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Boiler operation is controlled by a building energy management system, programmed for weekends and holidays, and with self-learning optimum start and stop.</td>
<td>Radiators have thermostatic valves, fan convectors have individual controls, and different areas of the building each have internal temperature sensors (thermostats).</td>
<td>Rigorous checking of controls function, settings, and system balance carried out once per year. Documented procedures and comprehensive records of results.</td>
<td>Temperatures are even throughout the building - within the range 18°C to 20°C during the periods of occupancy, and reducing to lower temperatures outside those periods.</td>
</tr>
<tr>
<td>3</td>
<td>An optimum start controller varies the start time of the boiler according to outside temperatures, and an optimum stop does the equivalent at the end of the day.</td>
<td>Radiators and fan convectors have individually operated controls. The water supplying radiators only is hotter in mid winter and cooler in autumn and spring.</td>
<td>Full checking of controls function, controls settings, and system balance carried out once per year. Documented procedures exist for each check. Some results on record.</td>
<td>Temperatures are even throughout the building, but in some parts they occasionally rise over 20°C during spring or autumn. 20°C is maintained only during the hours of occupancy.</td>
</tr>
<tr>
<td>2</td>
<td>There is an optimum start fitted to the boiler.</td>
<td>All boilers become hot only when boiler output is required. Boilers are cold at all other times.</td>
<td>Radiators and fan convectors have individually operated controls but water temperature to the radiators is the same all year round.</td>
<td>Informal checking of controls function and system balance carried out once per year. Schedule of checks exists but no proof of compliance exists.</td>
</tr>
<tr>
<td>1</td>
<td>The boiler has a simple timer that can be easily set. Timer settings are adjusted manually to suit seasonal heating requirements.</td>
<td>All boilers remain hot during pre-heat and building occupation hours during summer and winter.</td>
<td>Radiators and heat emitters have basic controls, and there is only one internal temperature sensor to control them.</td>
<td>Annual functional check carried out under contract. No evidence exists on extent of checks or of results obtained.</td>
</tr>
<tr>
<td>0</td>
<td>The timer is in a poor state of repair and cannot easily be adjusted.</td>
<td>All boilers remain hot including when building is unoccupied for at least seven months per year.</td>
<td>Radiators and heat emitters have no controls and all get hot together Radiator temperatures appear to be the same all year round.</td>
<td>Maintenance is on a breakdown basis and controls are checked only when things go wrong.</td>
</tr>
</tbody>
</table>
Matrix 3: inspecting lighting

Matrix 3: Inspecting and assessing the efficiency of your lighting

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Maintenance</th>
<th>Operation in use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>Small lights</td>
<td>Lighting diffusers and shades</td>
</tr>
<tr>
<td>4</td>
<td>A high proportion of strip lights are 28mm diameter high efficiency tubes with high frequency ballasts and specular reflectors.</td>
<td>Lights are switched in separate banks whose locations correspond to available daylight. Switches are clearly labelled to show which lamps they operate.</td>
</tr>
<tr>
<td>3</td>
<td>A high proportion of strip lights are 28mm diameter high efficiency tubes with specular reflectors.</td>
<td>75% are compact fluorescent with tungsten in remainder. Lights are switched in separate rows with switches located near the lights they operate. Switches are clearly labelled.</td>
</tr>
<tr>
<td>2</td>
<td>Most strip lights are 25mm diameter tubes with prismatic reflectors.</td>
<td>50% are compact fluorescent, with the remainder compact fluorescent. Lights are switched in rows and switches are in the same space as the lights they operate. But rows do not correspond with daylight, nor are switches labelled.</td>
</tr>
<tr>
<td>1</td>
<td>Strip lights are 38mm diameter tubes with prismatic diffusers.</td>
<td>25% are compact fluorescent, with the remainder tungsten.</td>
</tr>
<tr>
<td>0</td>
<td>Strip lights are 38mm diameter tubes with egg-crate or opal diffusers.</td>
<td>Traditional tungsten filament General Lighting System (GLS) lamps throughout.</td>
</tr>
</tbody>
</table>

Date: [ ] Building: [ ] Name: [ ]
Matrix 4: Inspecting and assessing the condition of your building fabric

<table>
<thead>
<tr>
<th>Level</th>
<th>Windows</th>
<th>External Doors</th>
<th>Roof Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>All windows are double glazed, and draught-stripped, and window catches hold them tightly shut.</td>
<td>All external doors are draughtstripped and have self-closing devices. Draught lobbies are provided.</td>
<td>Roof insulation is at least 150mm thick and continuous over whole roof area.</td>
</tr>
<tr>
<td>3</td>
<td>Most windows are double glazed and draught stripped.</td>
<td>Most external doors are draughtstripped and have self-closing devices. Door locks hold them tightly closed.</td>
<td>Roof insulation is at least 100mm thick and continuous over whole roof area.</td>
</tr>
<tr>
<td>2</td>
<td>Windows generally are single glazed and draught stripped, and window catches hold them tightly shut.</td>
<td>External doors generally are draughtstripped.</td>
<td>Roof insulation is 150mm or 100mm thick generally but there are visible gaps in the insulation.</td>
</tr>
<tr>
<td>1</td>
<td>Windows are single glazed but fit well with minimal draughts.</td>
<td>External doors fit well and catches hold them tightly closed.</td>
<td>Parts of the roof are insulated.</td>
</tr>
<tr>
<td>0</td>
<td>Windows are single glazed and poorly fitting with gaps visible around the edges.</td>
<td>External doors are poorly fitting and gaps are visible around the edges.</td>
<td>There is no roof insulation installed.</td>
</tr>
</tbody>
</table>
### Matrix 5: building overview

**Matrix 5: overall efficiency of fabric and services - compiled from matrices 1 to 4**

This matrix is intended to provide a summary of the four previous matrices. Take each of the previous matrices in turn. For each one, work out the average level achieved across the columns. Then use this average to place your building's performance on each of the four columns below. Once you have done this, it is possible to take the average of these four to obtain a building overview. Although this will give you only a broad brush picture, it may be useful when reporting to others in your organisation who are less concerned with the individual details of building performance.

- **Date:** [ ]
- **Building:** [ ]
- **Name:** [ ]

<table>
<thead>
<tr>
<th>Level</th>
<th>Overview of Matrix 1 - hot water</th>
<th>Overview of Matrix 2 - heating system</th>
<th>Overview of Matrix 3 - lighting</th>
<th>Overview of Matrix 4 - fabric</th>
<th>Building overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Hot water system is based on point of use heaters. Provided these are adequately maintained, no further action is required.</td>
<td>Sophisticated controls and plant are installed which result in a highly efficient installation.</td>
<td>Lighting system is up to date and well controlled in practice and provides an energy efficient installation.</td>
<td>The building fabric offers good resistance to the passage of heat and low infiltration of unwanted cold air from outside.</td>
<td>Fabric and services are up to date, well maintained, and used efficiently. No improvements are required.</td>
</tr>
<tr>
<td>3</td>
<td>Hot water system is based on hot water generators. Provided these are adequately maintained, no further action is necessary.</td>
<td>Controls and plant condition are both adequate, but managerial and technical improvements are possible.</td>
<td>Lighting system is good, but some improvements are still possible.</td>
<td>The building fabric offers good resistance to heat losses, but improvements are still possible.</td>
<td>To assess the overall level of the building take the average across the four columns. Fabric and services are in good order, and used efficiently. Some improvements are possible.</td>
</tr>
<tr>
<td>2</td>
<td>Hot water equipment is well insulated, and has appropriate controls. Settings are appropriate and standing losses from the system are minimised. No action is required.</td>
<td>Simple controls and plant are installed but they are operated competently.</td>
<td>Efficiency of installation is fair, but operation in practice is poor, leading to poor overall performance.</td>
<td>The building fabric offers fair resistance to heat losses, but there are many improvements that could be made to raise efficiency.</td>
<td>Fabric and services are in fair condition, although there is considerable scope for improving efficiency and making substantial savings in energy.</td>
</tr>
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<td>1</td>
<td>Some of the energy used for hot water is being wasted, and several aspects of water heating and storage require remedial actions to improve efficiency.</td>
<td>Controls are crude, and they are not operated efficiently.</td>
<td>System is not very efficient and requires improvement.</td>
<td>Fabric is poorly insulated and a large proportion of the heating energy is being wasted.</td>
<td>Fabric and services are not efficient, nor are they being maintained properly. Considerable savings are possible.</td>
</tr>
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<td>Hot water production is inefficient and much of the energy used is wasted. Remedial measures are likely to have a very short pay-back period.</td>
<td>Controls are inadequate and poorly maintained, and their operation results in serious inefficiencies.</td>
<td>System and operation are inherently inefficient and needs updating.</td>
<td>The building fabric is very poorly insulated and draughty, leading to lack of comfort and high levels of wasted heat.</td>
<td>Fabric and services are in poor shape, poorly maintained, and used very inefficiently. Large improvements in energy efficiency will significantly reduce consumption.</td>
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Step 19: Reporting your findings

Unless you report your energy auditing activities effectively, your efforts may well be wasted, or only partly utilised. How should you communicate your findings? And to whom? In practice, everyone has a responsibility for energy use at an individual level in the building, and should therefore be targeted by your reporting. Some staff though will be better placed than others to act on your findings. Try to identify who these people are in your organisation, and the sorts of information they will be most likely to understand and act on. Then communicate your findings to them in ways which are relevant to their roles in the organisation, and using terms and concepts with which they are familiar. The box opposite gives some suggestions.

Step 19: Reporting your findings
To be effective, the results of the audit need to be reported to those who can act on them. Decide who to report to, use simple direct language, and give them relevant information:

- senior management: summary report of annual energy expenditure, trends, and budgeted proposals for improvements
- middle management: departmental performance report, showing trends over time and comparison with other departments
- staff: explanations of what you are doing and what they can do to help you to save energy, via staff newsletter, publicity campaign, competition.

When you have completed this stage, you will have ensured those who are in a position to act on your findings have the necessary information, whether at director or individual level.

Step 20: Deciding what to do next

The introduction to this booklet suggested that there are four stages to energy auditing, and that only two of them would be dealt with here. If you have followed the steps in this guide, you should have sufficient information to make effective decisions about managing the energy used in your building. But, if you have found high levels of fuel consumption which you cannot explain, or if there are gaps in the information which you are unable to fill, you may need to continue to the latter two stages - the conduct of an energy survey and the preparation of an energy balance sheet. These latter stages are more time-consuming. They also require greater technical expertise and may need specialist equipment. If and when they become necessary, you should commission them from technical specialists, either within your own organisation or bought in from outside. Detailed information about surveys and balance sheets, including how to brief consultants to do them for you, is contained in Reference 1.

Step 20: What next?
If you have successfully gained control over your organisation's energy consumption, consider investing some of the savings in a more searching energy survey of your buildings and their services and equipment. This may need more technical expertise than you have in house, but it may reveal areas for even greater savings.
**List of References**

2. Energy Consumption Guide 16: Schools
5. Good Practice Guide 33, Energy Efficiency in Offices: Understanding energy use in your office

**List of Figures**

7. Example of analysis of patterns and trends in an all-electric office, provided by Bill Bordass.
8. Pie charts of dominant energy use, made up for this guide by Eclipse
10. Relationships between meters and sub-meters, based on information supplied by Bill Bordass
11. How to read meters, based on information from the PSA Accommodation Managers Guide and elsewhere
12. Based on temperature chart from CIBSE AM5, figure 10.6, page 54
13. Illustrations of thermometers, from PSA Accommodation Managers Guide and elsewhere
14. Tabular calculation of lighting consumption prepared by Eclipse
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