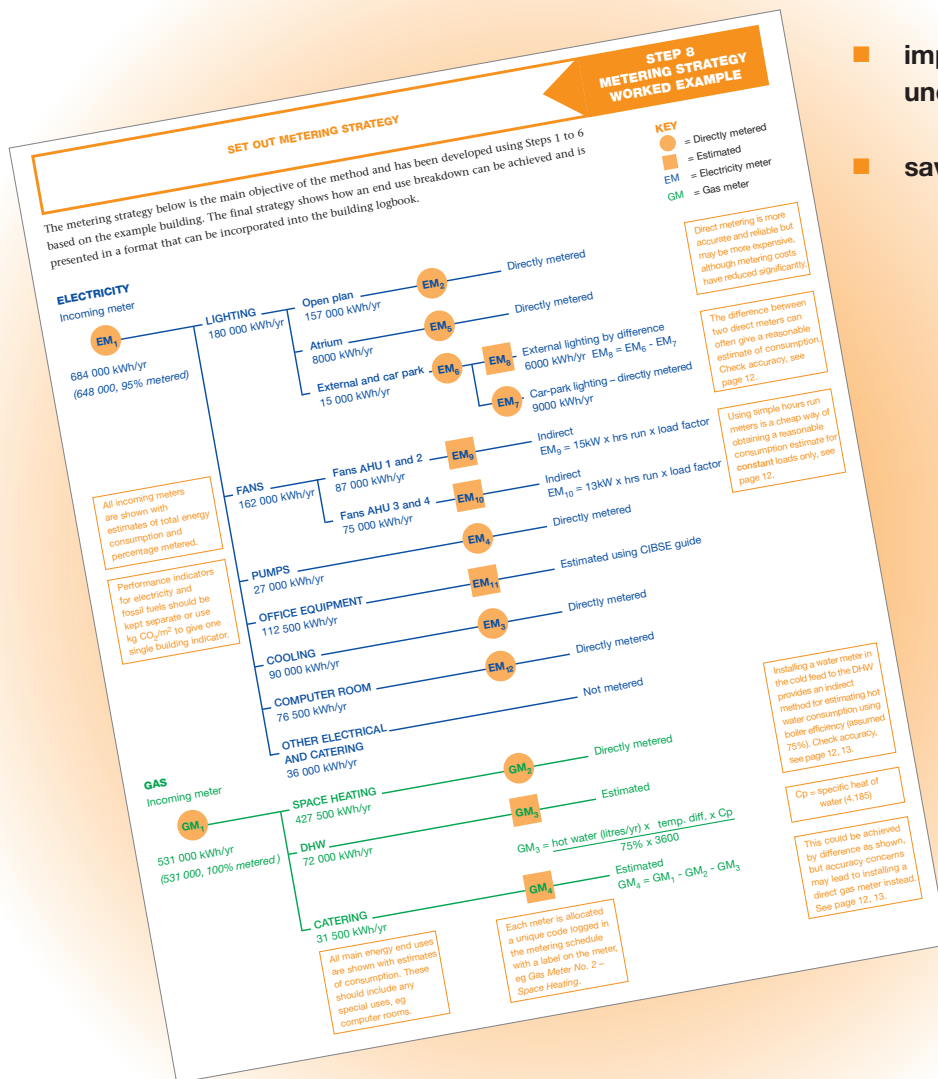


Metering energy use in new non-domestic buildings

A guide to help designers meet Part L2 of the Building Regulations

Develop a metering strategy that can:

- optimise cost, practicality and savings
- improve operators' understanding of their buildings
- save 5-10% of energy or more



ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME



Disk

CIBSE TM 22 Energy Assessment and Reporting Methodology: TM22 for GIL65.RTF
CIBSE TM 22 Worked Example: Worked Example.xls
Worksheets: Worksheets.xls

KEY

Throughout this Guide the following colour coding has been used to aid the reader.

Red text – Denotes excerpts from 'The Building Regulations 2000 – Part L2'

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1 INTRODUCTION

Text that is printed in red is a direct quotation from the *Building Regulations 2000, L2 Conservation of fuel and power in buildings other than dwellings (2002 Edition)*.

The full text can be downloaded from the DTLR website at: www.safety.dtlr.gov.uk
Different Regulations apply in Scotland and Northern Ireland.

Metering *per se* does not save energy. It is the actions taken as a result of installing and monitoring meters that can achieve quantifiable energy savings. Meters that are selected and installed correctly provide the information for the monitoring and targeting process that is an essential part of energy management.

Actions taken as a result of installing and monitoring meters often save 5-10% of the energy being metered. Sometimes they can save more. For example, a meter that identifies pumps being left on for 24 hours, seven days a week, may save 60% of the energy passing through it, whereas a meter measuring well-controlled services, or a meter that is not read (or not acted on) may save nothing.

The Building Regulations 2000 – Part L2 recognise the valuable role of metering and therefore include requirements for sub-metering non-domestic buildings.

The Regulations seek to ensure that building designers include appropriate metering at the design stage so that building operators then have a clear way of establishing where energy is being consumed.

‘To enable owners or occupiers to measure their actual energy consumption, the building engineering services should be provided with sufficient energy meters and sub-meters. The owners or occupiers should also be provided with sufficient instructions, including an overall metering strategy, that show how to attribute energy consumptions to end users and how the meter readings can be used to compare operating performance with published benchmarks’.

Metering also provides feedback to designers, manufacturers, government and the supply-side industry on performance achieved, thus helping them to improve global energy performance by setting better targets.

Metering helps building occupiers to understand where all the energy is going, and enables them to identify and monitor patterns of energy use. The data gathered can reveal useful trends between, say, day/night, summer/winter, weekday/weekend. It can allow operators to:

- compare actual consumption with targets
- spot things going wrong before it is too late
- maintain one year moving averages and CUSUM plots to see which way trends are going.

Although the capital cost of individual meters has reduced in recent years, the cost of installing direct metering throughout a large building can still be significant. However, it is not always necessary to install large amounts of direct metering to establish end-use energy consumption. The Building Regulations include a number of less expensive measurement/estimation options for metering (see page 12).

USING THIS LEAFLET

This document aims to help designers to meet the metering requirements of new non-domestic buildings, as set out in the Building Regulations. It should be used to optimise the cost of metering against practicality; the value of the information gained and future energy savings. A step-by-step method is provided, illustrated by a worked example, that enables you to:

- select appropriate ways of metering energy use
- provide documentation for building owners and occupiers.

Where possible, designers should strive to go beyond the Regulations by including full metering of all end uses. However, this is not always practical or economical, and the Building Regulations recognise this.

Blank copies of the worksheets are provided at the back of this document and on the attached CD (inside front cover).

INTRODUCTION

Enough direct metering should, where possible, be installed to measure all significant services and end uses in new non-domestic building.

‘Reasonable provision would be to enable at least 90% of the estimated annual energy consumption of each fuel to be accounted for’.

The method (see figure 1) in this leaflet is iterative and you will almost certainly need to go back and modify your first approach in order to reach the 90% metering level. Although the method focuses on new build, many of the principles will also help operators of existing non-domestic buildings to introduce metering when replacing controlled services or fittings in accordance with Building Regulations – Part L2 (Section 4) – Work on Existing Buildings.

‘When carrying out a replacement of a controlled service or fitting then... the relevant part of the metering strategy should be prepared or revised as necessary, and additional metering provided where needed so as to enable the energy consumption of the replacement controlled service or fitting to be effectively monitored’.

The objective here is to help operators understand and manage their buildings better by measuring end-use consumption and comparing the results with benchmarks.

WELL-RUN BUILDINGS – THE VIRTUOUS CIRCLE

A high standard of energy efficiency is a good indication of high management standards. Efficiently run buildings tend to have design and operational arrangements that produce good staff relations and satisfied occupants. (From CIBSE Technical Memorandum 22.)

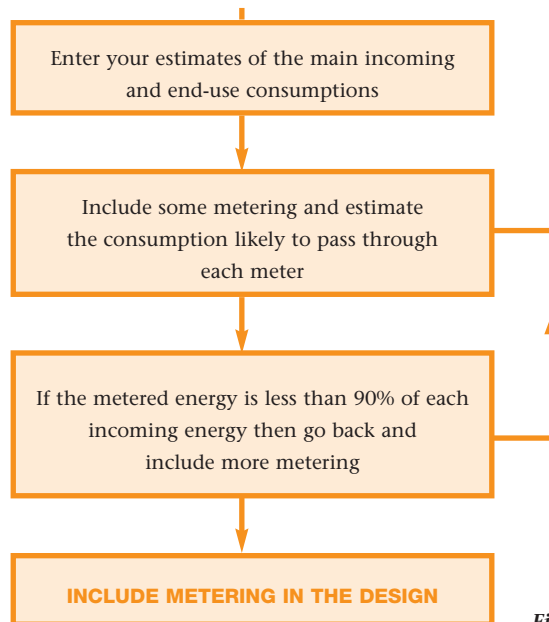


Figure 1 The Method

2 OVERVIEW

This section describes a step-by-step way (see figure 2) to help you ensure that your design complies with the requirements of the Building Regulations – 2000 Part L2.

‘Reasonable provision of meters would be to install incoming meters in every building greater than 500 m² gross floor area (including separate buildings on multi-building sites). This would include individual meters to directly measure the total electricity, gas, oil and LPG consumed within the building’.

In essence, the method is an iterative process that allows you to compare your proposals for metering with the predicted energy use of the building. If your proposal covers less than 90% of incoming energy use, you will need to go back and revise it to incorporate additional meters. If your proposal covers more than 90%, then you can draw up the metering strategy and schedule (see pages 16 and 17)

Initially you will need to gather together all the data about the likely energy requirements of the building. You will then enter the data into a spreadsheet, select metering, test your proposals, and iterate as required (Steps 1 to 6). Finally you will prepare the data needed for the building’s construction, commissioning and operation (Steps 7 to 9).

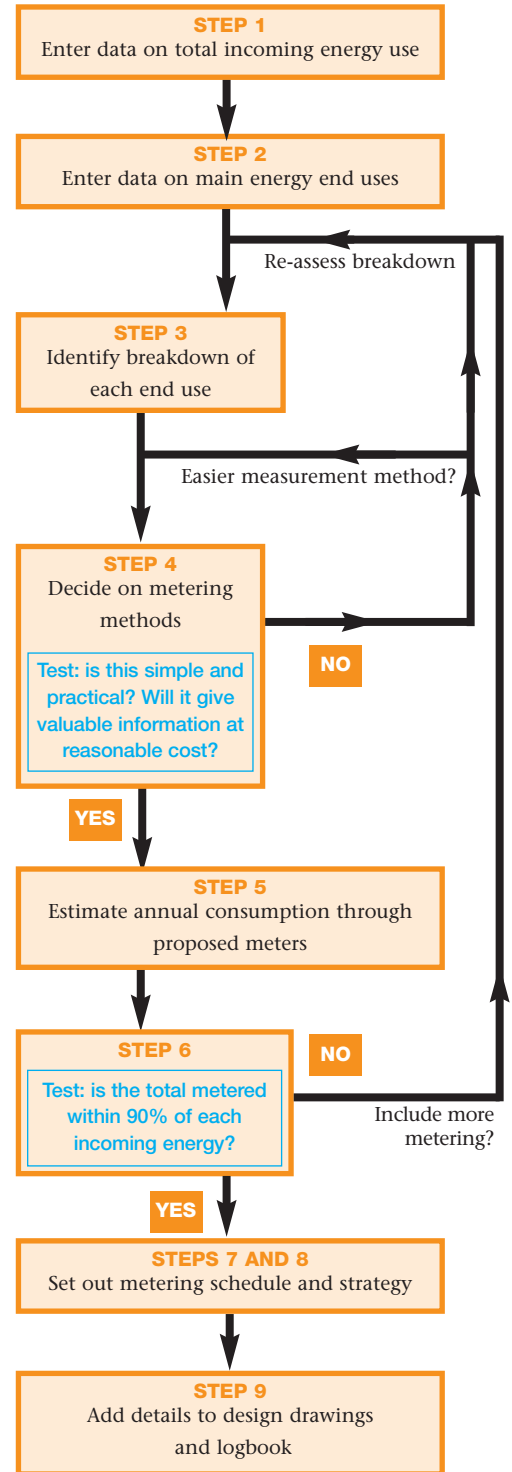


Figure 2 The nine-step approach

3 ESTIMATING ENERGY USES

UNDERSTANDING THE BUILDING'S ENERGY USE

Before you can begin to develop the metering strategy you need to have a clear picture of how energy from each fuel source (electricity, gas, etc) will be used in the building.

CIBSE Technical Memorandum (TM22) 'Energy Assessment and Reporting Methodology: Office Assessment Method' offers three stages to assess energy use in offices:

- Stage 1: a quick assessment in terms of energy use per unit floor area
- Stage 2: an improved assessment accounting for special energy uses, occupancy and weather
- Stage 3: a detailed assessment of the building and all its energy-using systems.

A copy of TM22 and a full worked example of the TM22 methodology is provided on the CD that comes with this leaflet.

Although these assessment methods are designed for offices, they can also be applied to other types of non-domestic building. You must choose an assessment method that is appropriate to the size and complexity of your building.

Designers should be estimating the energy use of the systems which they are including throughout the design process. This document assumes that such a detailed analysis of energy end uses is available. A detailed assessment of the building

and all energy end uses will provide the most accurate picture of total energy use. Don't forget that the building operator may use these estimates as targets in future.

In essence, the detailed assessment requires you to estimate the energy use of all equipment in as much detail as possible.

For example:

- fan consumption (kWh/m²/yr)
= kW/m² × hours run × load factor
- lighting consumption (kWh/m²/yr)
= W/m²/100 lux × light level (100 lux) × operating hours × control factor.

The data on individual energy uses are best understood by entering them into a tree diagram (figure 3). This provides a useful overview of the building. The upper lines of the tree are the 'coarse' picture; the more branches are added, the finer the detail. The value in each box is obtained by multiplying the two values in the boxes below. The main end uses can be added together to obtain an estimate of total consumption.

Bear in mind that the data you are compiling can be used to benchmark the building – at the design stage, and during operation. So it is essential to compare like with like – and to use the same definition of floor area (most commonly TREATED floor area, as defined in TM22). Consumption data relating to different fuels should be presented separately.

TIP

Don't forget to include end uses such as corridor lighting, toilet extracts, conference rooms, reception areas, car park lighting and security systems. Table 1 in TM22 (see disk supplied) gives more examples of end uses.

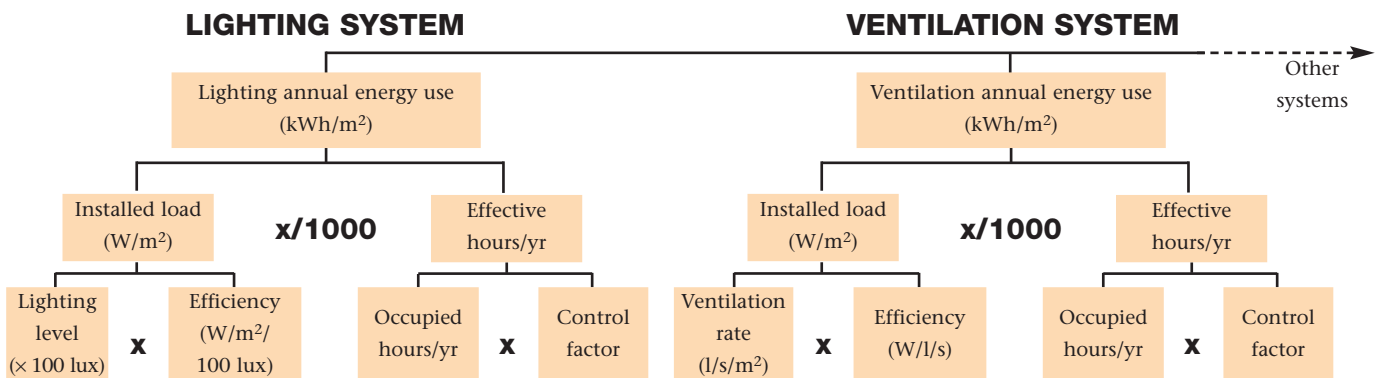


Figure 3 This section of a tree diagram shows two of the electricity end uses (data omitted for ease of reading)

ESTIMATING ENERGY USES

LIGHTING SYSTEM

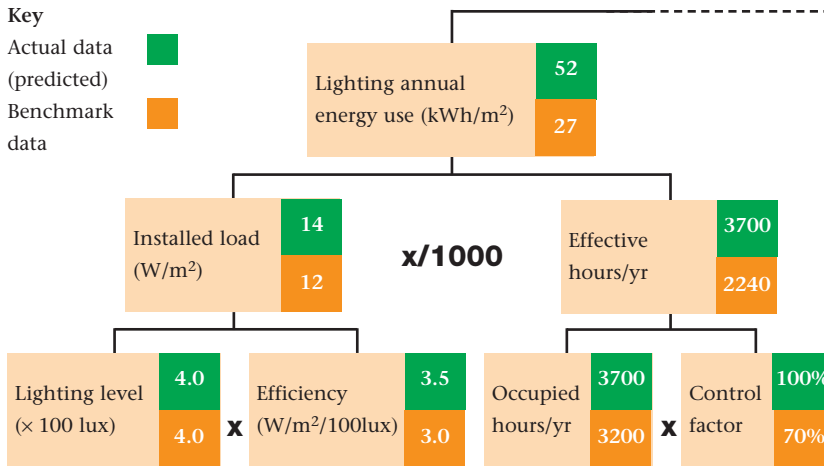


Figure 4 This section of the tree diagram includes values for predicted energy use and benchmark data, so that the two can be compared throughout the design process

BENCHMARKING

The Energy Efficiency Best Practice programme publishes benchmarks for various types of non-domestic buildings (see Further Reading). You can use the tree diagram technique to see how your building might perform compared to the benchmark for a typical building: simply insert actual and benchmark data at each branch of the tree (see figure 4).

As well as being an essential preliminary step in the overall design, this technique will allow you to benchmark throughout the design process across all levels of detail.

For example, you can benchmark:

- each incoming energy consumption (kWh/m²/yr)
- energy consumption of each system (kWh/m²/yr)
- installed equipment loads (W/m²)
- efficiency indicators, eg fan efficiency* (W/l/s) or lighting efficiency* (W/m²/100 lux)
- service level, eg lighting lux or fan l/s/m²
- operating hours (hours/yr)
- control (management) factors.

(* The measurement of efficiency in both these cases is 'specific power', for which a low value is preferable.)

Figure 5 shows how a building operator could use the information to compare actual operation with published benchmarks.

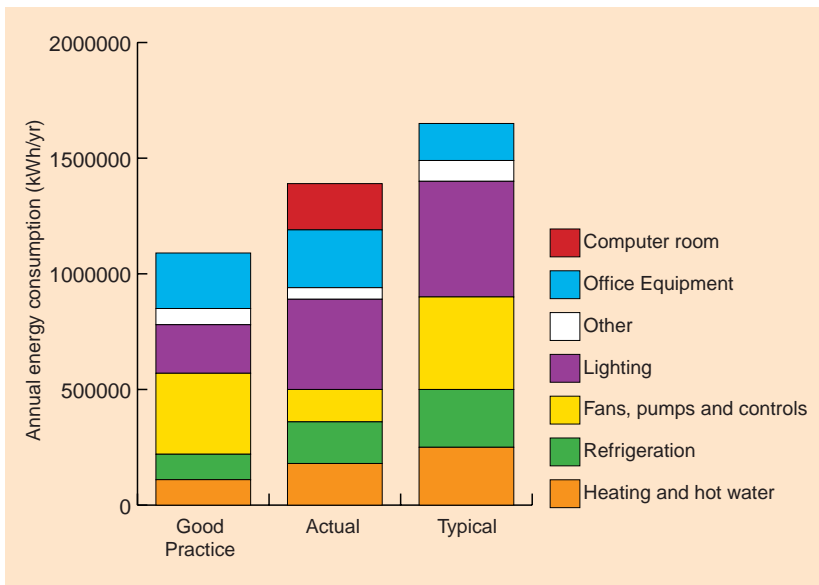


Figure 5 This chart shows how the building operator might use the information from the meters to compare the actual operation with published benchmarks

4 THE METHOD

DEVELOPING A METERING STRATEGY

Having gathered together all the details about the building's energy requirements, you can proceed to develop your strategy. Follow this worked example through to page 17 to understand the method. You can then develop your strategy by filling in the worksheets supplied at the back of this leaflet/on CD.

Worked example

The data presented below and on the sample worksheet (see page 24) refer to a fairly typical

new-build air-conditioned office.

The building is of medium-weight brick construction with mainly open-plan areas. ECON 19 (see Further Reading page 25) splits office buildings into four groups, for the purposes of benchmarking. The example building is comparable with buildings in the Type 3 group.

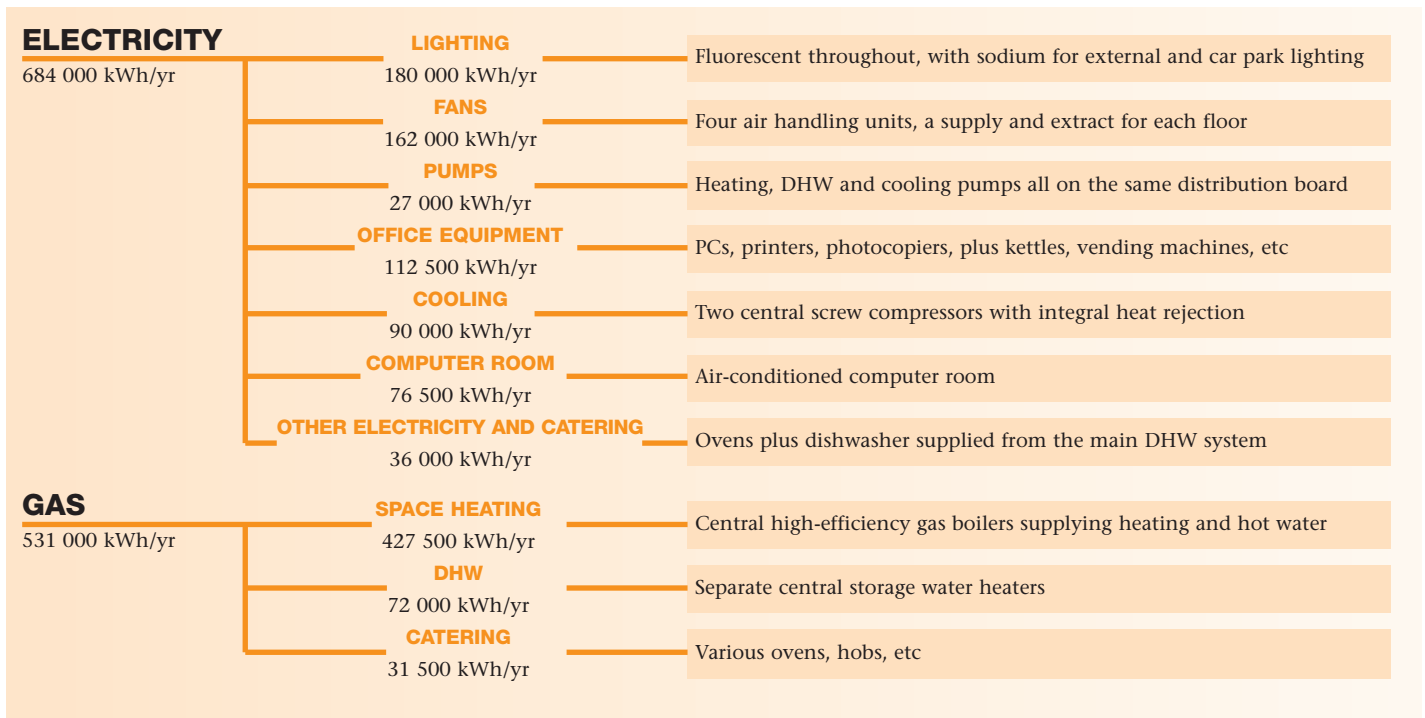
During the design process, the design team estimated the energy use of the building. Their energy-use tree is presented in figure 6.

See fold-out page 24 to follow the worked example

FEATURES OF THE EXAMPLE BUILDING

- Treated floor area is 4500 m² on two floors with an external car park at the front of the building.
- Central boilers supply low-pressure hot water (LPHW) space heating, and separate central gas storage heaters provide domestic hot water (DHW).
- Air handling units provide heating and cooling, but have no humidification.
- Catering is by a mixture of gas and electric appliances. The dishwasher is supplied from the main DHW system.
- Lighting is fluorescent throughout except for the external sodium lighting, which includes an open car park area.
- There is a dedicated computer room with its own air-conditioning.

Figure 6 Estimated energy usage in example building



THE METHOD

STEP 1

ENTER DATA ON INCOMING ENERGY USE

See fold-out page 24 to follow the worked example

Enter the total estimated consumption for each fuel type in the Step 1 box.

'Fuel type' means electricity, gas, oil and LPG. Solid fuels are difficult to meter and so are not included under the Building Regulations' requirements. However, best estimates should be employed.

The estimated total fuel consumption for each fuel type can be taken from the upper, 'coarse' level of your tree diagram.

It is advantageous to treat water in the same way as energy use, and to apply the 90% rule.

STEP 2

ENTER DATA ON MAIN ENERGY END USES

Enter the energy type, use and estimated consumption of the main end uses in the Step 2 columns.

For the first iteration, identify three or four end uses (the largest end uses) that can be metered easily (eg lighting, cooling, fans). These data can usually be found in the second level of the tree diagram.

Don't forget the building operator may use these estimates as targets in the future.

TIP

Consumption data for different fuels should be presented separately.

STEP 3

IDENTIFY BREAKDOWN OF EACH END USE

In the Step 3 column, insert a brief description of how the main end uses, that can be easily measured, can be broken down by area, system, circuit or tenancy.

Sometimes it is difficult to meter main end uses. In this situation, metering sub-divisions of the main end use may be an easier option and will provide more detail for the building's operator. Take account of distribution requirements, layout and physical location.

Breakdown of end uses can be by:

- **area** – eg floor 1,2,3... or zone 1,2,3... etc
- **system** – eg AHU 1,2,3... or boiler 1,2,3...etc
- **circuit** – eg circuit 1,2,3... distribution board 1,2,3...etc
- **tenancy** – eg tenancy 1,2,3...etc.

For subsequent iterations, use the more detailed data that can be found at the lower levels of the tree diagram (for example, break down lighting into its components: atrium lighting, car park lighting, etc).

THE METHOD

For instance, on the second iteration of the worked example lighting is split into three separate end uses in order to meter the total.

See fold-out page 24 to follow the worked example

‘Reasonable provision of sub-metering would be to provide additional meters such that the following consumptions can be directly measured or reliably estimated...
 ... b) energy consumed by plant items with input powers greater or equal to that shown in Table 13...
 ... d) any process load ... that is to be discounted from the building’s energy consumption when comparing measured consumption against published benchmarks’.

Table 13 Size of plant for which separate metering would be reasonable	
Plant item	Rated input power (kW)
Boiler installations comprising one or more boilers or CHP plant feeding a common distribution circuit	50
Chiller installations comprising one or more chiller units feeding a common distribution circuit	20
Electric humidifiers	10
Motor control centres providing power to fans and pumps	10
Final electrical distribution boards	50

DECIDE ON METERING METHODS STEP 4

Use Steps 4.1 to 4.4 to help you develop a metering strategy.

SELECT HOW TO METER MAIN END USES STEP 4.1

Select a metering method and enter details in column 4.1.

Ideally, all energy consumption should be directly metered, but this is not always practical or cost effective. With this in mind, the Building Regulations ask for at least 90% of each incoming energy to be accounted for through the use of metering. The Regulations also allow various estimation methods to be used where direct metering is impractical. This allows you the flexibility to mix and match in order to:

- overcome practical installation problems
- optimise capital and installation costs
- integrate metering into the services as they are designed
- ensure that operators have a practical method of establishing an audit of energy use.

Using a combination of the five methods (see figure 6) you can develop a metering strategy that will meet the Building Regulations while ensuring that the level of metering is appropriate, practical and cost effective for the building or design.

THE METHOD

Direct metering

Direct metering provides high accuracy and increased reliability in the overall energy audit. Many end uses can be directly metered using standard electricity, gas, and oil meters. Some may require heat meters or steam meters.

Hours run meter

An **'hours run' meter** can measure the operating hours of a piece of equipment that operates at a constant known load (eg a fan). (Energy consumption (kWh/yr) = kW × hours run × load factor). This provides a relatively cheap and simple way of reaching a reasonable estimate of consumption.

TIP

Check accuracy – it is always better to measure the true power (Watts) being drawn than to rely on nameplate ratings. Measuring current provides only an intermediate level of accuracy.

Indirect metering

Readings from an **indirect meter** can be used to estimate energy consumption (eg measure cold feed water consumption and temperature difference to estimate hot water consumption). This is a relatively cheap and simple way to reach a reasonable estimate of consumption. (See figure 7.)

TIP

Check accuracy – poor estimation of temperatures and boiler efficiencies, for example, could result in a very poor estimate for annual energy use. You should advise the building operator to supplement estimates with spot measurements of temperature and boiler efficiency. Boiler efficiency will be much lower in summer on combined heating and hot water systems.

By difference

Two direct meters can often be used to estimate a third end use **by difference**. For example, measure the total external and car park lighting consumption, and the car park lighting consumption; and the difference between the two will give you an estimate of the external lighting consumption. (See figure 8.)

TIP

Check accuracy – in particular, this should not be used if you are subtracting an estimated value, because the cumulative accuracy will be very poor. Subtracting a small consumption from a large consumption is also to be avoided, because the accuracy margin on the large meter may exceed the consumption on the smaller meter.

Estimates of small power

Reasonable **estimates of small power** (office equipment, etc.) can be achieved without installing extensive metering using existing methods (outlined in the CIBSE Guide F 'Energy in Buildings', Chapter 11).

TIP

Check accuracy – for example, poor estimation of actual power consumption for office equipment, or for its usage, could result in a very poor annual consumption estimate. You should advise the building operator to supplement estimates with spot measurements of actual power and usage.

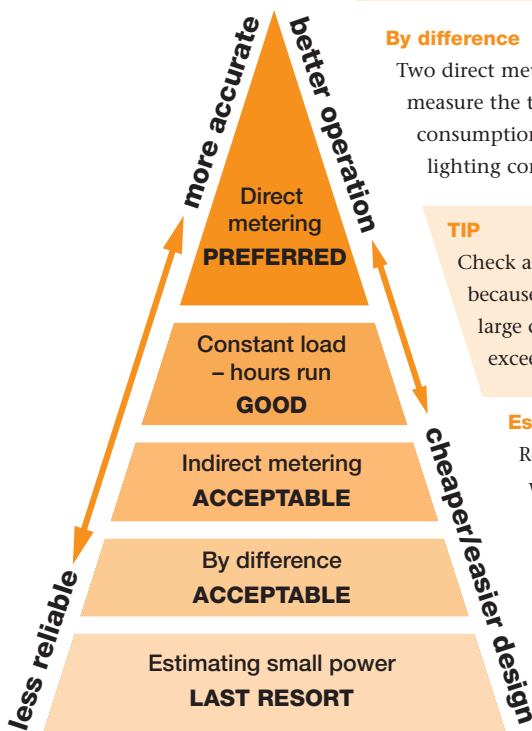
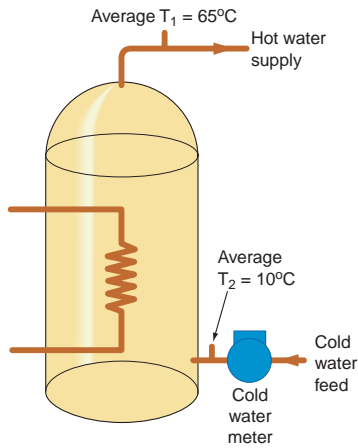
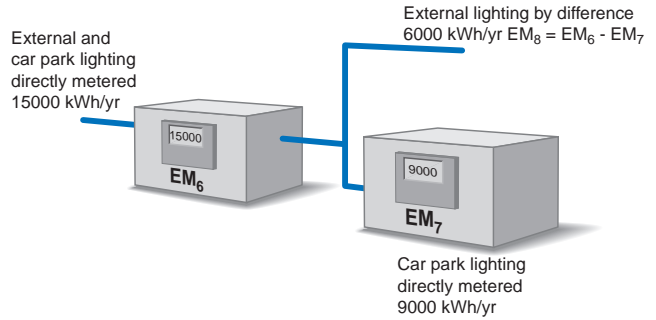


Figure 6 The five methods

THE METHOD



See fold-out page 24 to follow the worked example



$$\begin{aligned} \text{Estimated consumption} &= \frac{\text{metered feed water (litres/yr)} \times \text{Temp Diff (T1 - T2)} \times 4.185}{\text{boiler efficiency } 75\% \times 3600} \\ &= \frac{844,574 \times (65 - 10) \times 4.185}{0.75 \times 3600} = 72,000 \text{ kWh/yr} \end{aligned}$$

Figure 7 Indirect metering

Figure 8 Metering by difference

ALLOCATE A CODE TO EACH METER

STEP 4.2

Set up a clear coding system to identify each meter in the building (for example, EM₁ for Electricity Meter 1 and GM₁ for Gas Meter 1, etc). Enter details in the Step 4.2 column.

This information will be passed to the building operator via the 'metering schedule', which shows what is being metered and the meter location.

SELECT THE METERS

STEP 4.3

Select the types of meters required, and enter the details in the Step 4.3 column. For uses that are not directly metered, in the adjacent column, note down the calculation method.

In the first iteration, it is acceptable to simply identify a generic meter (electricity, gas, etc). As the strategy firms up these meters need to be specified, costed and any practical installation issues/problems identified and solved. You should keep cost in mind, but remember that accuracy should be the determining factor in deciding whether to meter directly.

Size the meter to match the actual throughput; accuracy falls away when very small throughputs are measured. Smaller meters will cost less and may perform adequately.

THE METHOD

It is almost always cost effective to purchase meters that allow connection to a building energy management system (BEMS) or automatic metering system (AMS). If there is a BEMS where heat needs to be measured, it can be considerably cheaper to install a flow meter and temperature sensors and allow the BEMS to do the calculations. More details about installation issues and connecting to the BEMS are given on page 18.

Table 1 illustrates some of the issues that must be considered when selecting meters.

TIP

- Hours-run meters are very cheap and easy to install.
- Modern energy meters can now automatically switch from measuring heating to cooling, when metering the energy supplied by reversible heat pumps, for example.

	Electricity	Gas	Oil and water	Heat
Type of meter and approximate installed cost	<ul style="list-style-type: none"> ■ Single phase £100 - £200 ■ Three phase £500 upwards 	<ul style="list-style-type: none"> ■ Diaphragm £300 - £700 ■ Turbine £700 - £1300 	<ul style="list-style-type: none"> ■ Oil £350 - £2800 ■ Water £250 - £700 	<ul style="list-style-type: none"> ■ Electromagnetic £450 - £1200 ■ Turbine £400 - £900
Typical accuracy	± 1%	± 2%	± 1%	± 3 to 5%
Key issues	<ul style="list-style-type: none"> ■ Single or three-phase? ■ Are current transformers needed? 	<ul style="list-style-type: none"> ■ Pressure drop? ■ Pressure and temperature compensation needed? (May cost an extra £1000) 	<ul style="list-style-type: none"> ■ Strainer to avoid blockages? 	<ul style="list-style-type: none"> ■ Electromagnetic meters are more accurate ■ Dirty systems can be a problem

Table 1 Key considerations when choosing meters

TEST AT STEP 4

Before moving on, check the practicality of the metering method you are proposing. Will it give valuable information on where energy is being used? If there is another, simpler or more cost-effective way, go back to Step 3, and identify a more suitable breakdown of end uses (finer or coarser). Alternatively, go back to Step 4.1 and identify a different way of metering.

THE METHOD

ESTIMATE ANNUAL CONSUMPTION THROUGH PROPOSED METERS

STEP 5

Using the data from your tree diagram, estimate the total annual energy consumption through each meter. Enter these data in the Step 5 column.

You should be estimating the energy use of all the systems you are including throughout the design process. These energy requirements should be compared with the targets set in the design brief in order to make sure that the building is as energy efficient as possible (see Benchmarking, page 8).

TEST IF METERED IS WITHIN 90% OF INCOMING

STEP 6

For each energy type, add together the consumptions listed at Step 5. Divide that figure by your estimate of total incoming fuel requirements (Step 1). If the resulting value is less than 90%, go back to Step 3 and include more metering.

SET OUT METERING SCHEDULE AND STRATEGY

STEPS 7 AND 8

STEP 7 Once your proposal has passed the 90% test, draw up a **schedule of meters** that includes meter codes, locations and so on, grouped by end use.

STEP 8 You should also prepare a diagrammatic '**metering strategy**' that shows how the scheme fits together.

Suggested layouts for a schedule and strategy, based on the data gathered for the worked example, are presented on pages 16 and 17. The schedule and strategy must include your estimates of consumption for each meter. Blank worksheets are provided on pages 22 and 23.

ADD DETAILS TO DESIGN DRAWINGS AND LOGBOOK

STEP 9

Incorporate your metering decisions on the design drawings. This will require a clear specification of each meter, including any connections to BEMS or AMS.

It is essential that the schedule of meters and the metering strategy are included in the building logbook that will be given to the building operator.

THE METHOD

STEP 7
METERING SCHEDULE
WORKED EXAMPLE **SET OUT METERING SCHEDULE**

The metering schedule below has been developed using Steps 1 to 6, based on the example building. The final schedule is presented in a format that can be incorporated into the building logbook.

Total estimated incoming fuel			Electricity 684,000 kWh/yr Gas 531,000 kWh/yr Other n/a					Actual consumption (to be completed by the building operator)					
Energy			Meters		Method		Meter location		Year _____				
Incoming energy	Main end-use	Estimated end-use consumption (kWh/yr)	Meter no/ code	End-use/area/system/ circuit or tenancy to be measured	Measurement method and calculation (where appropriate)	Estimated consumption through each meter (kWh/yr)	List of physical meters	Location	From _____ (date)	To _____ (date)	Metered consumption kWh/yr	Main end-use consumption kWh/yr	Incoming consumption kWh/yr
ELECTRICITY													
Incoming		684 000	EM ₁				Electricity meter EM ₁						
Lighting		180 000	EM ₂	Open plan lighting	Directly metered	157 000	Electricity meter EM ₂	Main distb. room					
			EM ₅	Atrium lighting	Directly metered	8 000	Electricity meter EM ₅	Main distb. room					
			EM ₆	External and car park	Directly metered	n/a	Electricity meter EM ₆	Ext. sub room					
			EM ₈	External lighting	Est. by difference	6 000							
			EM ₇	Car park lighting	Directly metered	9 000	Electricity meter EM ₇	Main distb. room					
Fans		162 000	EM ₉	Fans AHU 1 & 2	Indirect (hours run)	87 000	Hours run 1	Plant room 2					
			EM ₁₀	Fans AHU 3 & 4	Indirect (hours run)	75 000	Hours run 2	Plant room 3					
Pumps		27 000	EM ₄	Pumps	Directly metered	27 000	Electricity meter EM ₄	Boilerhouse					
Off. Eqpt		112 500	EM ₁₁	Office equipment	Estimated (CIBSE)	112 500							
Cooling		90 000	EM ₃	Cooling (screw chillers)	Directly metered	90 000	Electricity meter EM ₃	Chiller room					
Cmptr		76 500	EM ₁₂	Computer room	Directly metered	76 500	Electricity meter EM ₁₂	Comp. vent. room					
Total electricity metered						648 000							
					% metered	648/684 = 95%							
GAS													
Incoming		531 000	GM ₁				Gas meter GM ₁						
Space		427 500	GM ₂	Space heating	Directly metered	427 500	Gas meter GM ₂	Boilerhouse					
DHW		67 500	GM ₃	DHW	Est. from h/w consumption	72 000	Cold water meter	Boilerhouse					
Catering		22 500	GM ₄	Gas catering	Est. by difference	31 500	Gas meter GM ₄	Kitchen					
Total gas metered							531 000						
					% metered	531/531 = 100%							

THE METHOD

SET OUT METERING STRATEGY

STEP 8
METERING STRATEGY
WORKED EXAMPLE

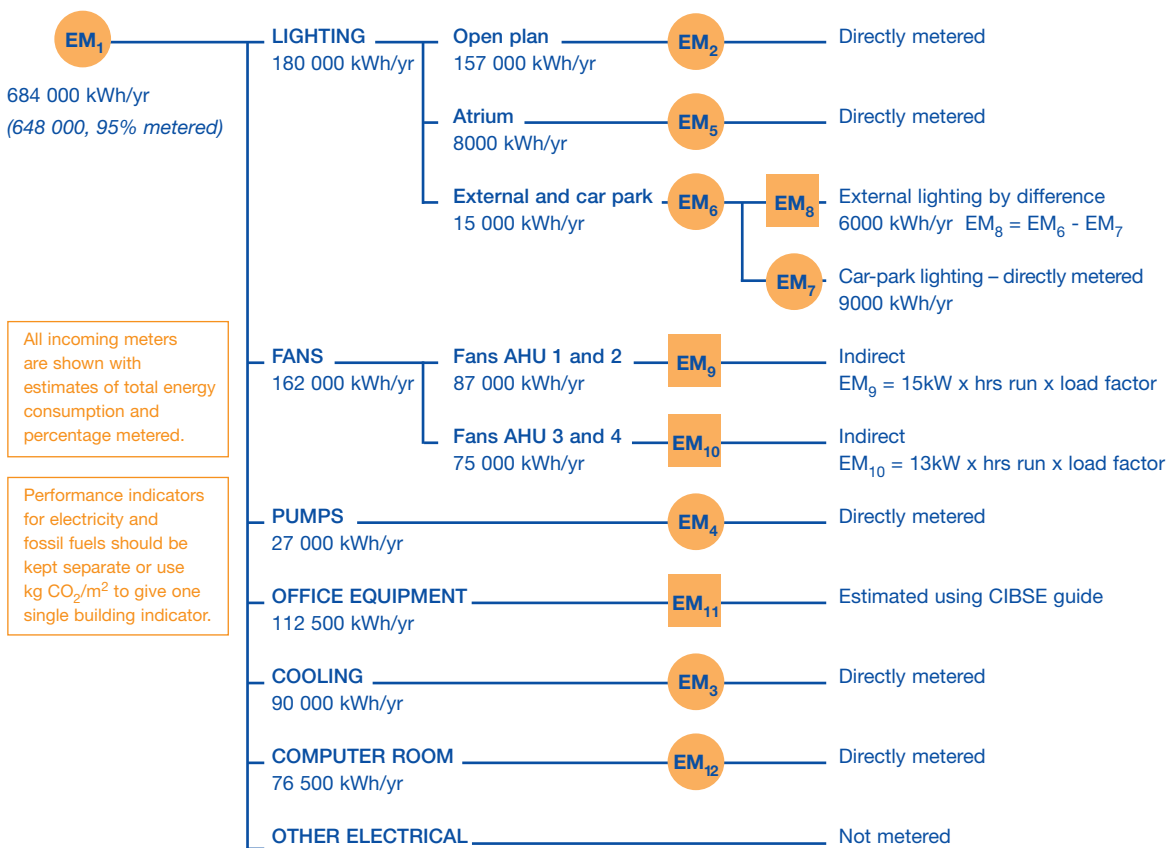
The metering strategy below is the main objective of the method and has been developed using Steps 1 to 6 based on the example building. The final strategy shows how an end use breakdown can be achieved and is presented in a format that can be incorporated into the building logbook.

KEY

- = Directly metered
- = Estimated
- EM = Electricity meter
- GM = Gas meter

ELECTRICITY

Incoming meter



All incoming meters are shown with estimates of total energy consumption and percentage metered.

Performance indicators for electricity and fossil fuels should be kept separate or use kg CO₂/m² to give one single building indicator.

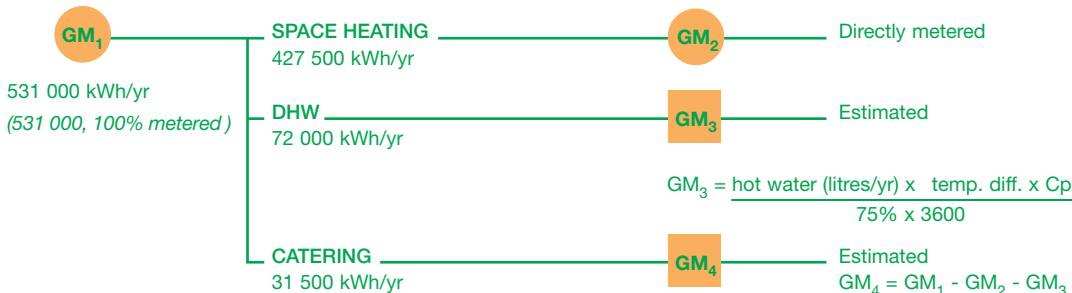
Direct metering is more accurate and reliable but may be more expensive, although metering costs have reduced significantly.

The difference between two direct meters can often give a reasonable estimate of consumption. Check accuracy, see page 12.

Using simple hours run meters is a cheap way of obtaining a reasonable consumption estimate for constant loads only, see page 12.

GAS

Incoming meter



All main energy end uses are shown with estimates of consumption. These should include any special uses, eg computer rooms.

Each meter is allocated a unique code logged in the metering schedule with a label on the meter, eg Gas Meter No. 2 – Space Heating.

Installing a water meter in the cold feed to the DHW provides an indirect method for estimating hot water consumption using boiler efficiency (assumed 75%). Check accuracy, see page 12, 13.

Cp = specific heat of water (4.185)

This could be achieved by difference as shown, but accuracy concerns may lead to installing a direct gas meter instead. See page 12, 13.

5 BUILDING ENERGY MANAGEMENT (BEMS) AND AUTOMATIC METERING SYSTEMS (AMS)

Metering, communication technology and analysis software have all become less expensive while becoming increasingly reliable.

It is almost always cost effective to purchase meters that allow connection to a BEMS/AMS, either to promote future connection or even to use with temporary data logging equipment. This can provide an invaluable means of investigating atypical consumption.

It may be impractical to carry out manual meter reading regularly because of the number of meters and their location. If meter reading becomes too onerous for busy building operators, they may reduce the frequency of reading, and consequently might not spot dynamic wastage that occurs at specific times of the day. This problem can be overcome by introducing automatic meter reading and analysis using BEMS or a dedicated AMS.

BEMS and AMS are ideal in larger buildings, for a large stock of buildings or on multi-building sites. They also promote the introduction of 'energy cost centres' to improve energy management and cost reduction. Automatic systems should reduce the manpower required for monitoring and may provide results more rapidly.

BUILDING ENERGY MANAGEMENT SYSTEMS

Meters should be linked to the BEMS to provide automatic meter reading facilities. This may not be economical or practical for all meters but, as a minimum, the incoming meters should be connected.

TIP

Use encoded meters where possible, because they communicate the meter reading on their face. They are widely available with an in-built data collection facility that can be used to interpret the data collected in terms of consumption and a number of other useful parameters.

Traditionally, pulse output meters are used to allow counters to be read or directly connected to a BEMS. However, pulsed meters can sometimes give false readings due to unreliability, contact bounce, etc.

AUTOMATIC METERING SYSTEMS

AMS provide automatic meter reading and real-time analysis. Consumption data are presented as simple profiles and reports. These reports can be the most practical way to get users to recognise problems and take action. Consumption data can easily be audited against targets or consumption profiles, with 'exception reporting' to highlight waste. The whole process can be automated, providing the busy manager with reports only when something needs to be rectified.

TIP

Automatic metering can be achieved using a BEMS and standard monitoring and targeting (M&T) software, but a dedicated AMS may provide a more tailored solution in many instances.

DEMAND PATTERNS

Demand patterns can be obtained easily from BEMS, AMS and from most energy suppliers. These can be very useful for investigating faults or atypical consumption. Clear analysis is essential; excessive print-outs and incomprehensible analysis are often the downfall of monitoring systems.

Consumption profiles give an immediate indication of where and when the problem has occurred, eg high base/overnight load, out-of-hours consumption (start-up and shut-down), which would otherwise not be seen.

6 TENANCIES AND DISTRICT HEATING

TENANCIES

'Reasonable provision of sub-metering would be to provide additional meters such that the following consumptions can be directly measured or reliably estimated.

... a) electricity, natural gas, oil and LPG provided to each separately tenanted area that is greater than 500 m²...

... c) any heating or cooling supplied to separately tenanted spaces. For larger tenancies, such as those greater than 2500 m², direct metering of the heating and cooling may be appropriate, but for smaller tenanted areas, the heating and cooling end uses can be apportioned on an area basis'.

The Building Regulations require metering to each separately tenanted area greater than 500 m².

Direct metering is always preferred. However, it may be impractical in tenancies supplied by central services, eg central air-handling plant. In smaller tenancies it is acceptable to measure the central plant and allocate the consumption based on the floor area being supplied. Although this is not ideal, it is better than having no idea of consumption at all. It may be possible to make this allocation more appropriate by adjusting for hours of use in specific areas and to take account of any significant special uses of the central services, eg computer suites.

In speculative developments, tenancy sizes and layouts are seldom known at the design stage. If this is the case, you should include a coarse level of sub-metering, eg floor by floor, and provide guidance for those fitting out the building on the additional sub-metering that will be required to meet the Building Regulations.

Landlords should always ensure that all tenants are aware of their energy consumption/expenditure. Direct and accurate billing encourages tenants to use energy wisely. Automatic billing systems are available that can help do this and so you should include these, where appropriate.

DISTRICT HEATING/COOLING

'Reasonable provision of meters would be to install incoming meters in every building greater than 500 m² gross floor area (including separate buildings on multi-building sites). This would include...

... b) a heat meter capable of directly measuring the total heating and/or cooling energy supplied to the building by a district heating or cooling scheme'.

The Building Regulations require that buildings supplied by district heating/cooling systems should have a heat meter to identify incoming energy.

In very small buildings it may be impractical or too expensive to install heat metering and an estimate based on spot checks and floor area may suffice.

7 PUTTING THE PLANS INTO ACTION

BUILDING LOGBOOK

'The owner/occupier of the building should be provided with a logbook giving details of the installed building services plant and controls, their method of operation and maintenance, and other details that collectively enable energy consumption to be monitored and controlled. The information should be provided in summary form, suitable for day-to-day use'.

You must ensure that the final schedule of meters and metering strategy, including the estimates of energy use you have made, are included in the building logbook in order to assist the building operator in monitoring building performance.

INSTALLATION, COMMISSIONING AND BEYOND

Metering needs careful attention during the installation, commissioning and handover stages to ensure that the details in the schedule and metering strategy included in the building logbook are an accurate record of the installed system.

TIPS

Electricity meters

Check that any current transformers are matched to the meters, and the correct meter factors are used. Also check that current transformers are installed the correct way round, otherwise the load on one phase can negate those of the others.

Oil, water and heat meters

Must be installed in straight pipework to ensure accurate operation. (The manufacturer will specify how many 'pipe diameters' of straight pipe should be allowed before and after the meter.) Specify this on the design drawings and check it at the commissioning stage. Install these meters in clean systems, avoiding heating/cooling systems that carry significant amounts of sludge and particulates. Dirty systems reduce accuracy, reliability and can ultimately lead to blockages. Some meters (eg oil) may need to have a strainer installed to prevent blockages.

Gas meters

To ensure accuracy, adjust readings to compensate for pressure and temperature of the supply, particularly where large volumes are being measured. The lack of temperature/pressure compensation can sometimes explain differences between the sum of sub-meters and the main incoming meter.

Meters must always be installed and commissioned in line with the manufacturer's instructions in order to ensure accuracy and good operation. Ask meter suppliers/contractors for a commissioning report to authenticate this. At the very least, check the installation against the schedule of meters and the design drawings, with spot checks to establish that readings fall into the range of expected values.

Each installed meter should be labelled with the end-use being measured and the meter code allocated by the designer, as shown on the schedule of meters.

At the commissioning stage, check that the sum of all the sub-meters is reasonably close to the main meter reading. This may not summate exactly due to differences in accuracy, compensation, etc., but significant differences should be investigated.

FIT-OUT

Where buildings undergo a fit-out stage, any alterations to the services that affect the metering (eg adding local air-conditioning systems to centralised background air handling) must be logged and the schedule/strategy should be updated accordingly. These alterations must not go against the metering strategy. In other words, they must still allow the operator to identify where 90% of each incoming energy is being used.

ALTERATIONS

Where building services undergo significant material alteration at any stage in the building's life then the metering schedule/strategy must be updated accordingly. Again, these alterations must not go against the basic metering strategy. New equipment (eg a computer suite) must include metering facilities and these should be included on the metering schedule/strategy as required by the Building Regulations – Part L (Section 4) – *Work on Existing Buildings*.

WORKSHEET WORKED EXAMPLE

STEPS 1-6 WORKSHEET

Start by identifying the largest three or four end uses that can be metered easily; then iterate until at least 90% of each incoming energy is metered. Refer to Pages 10 to 15 for guidance.

STEP 1		Total annual fuel consumption (estimated) (kWh/yr)							
		Electricity.....	684 000.....	Gas.....	531 000.....	Other.....	n/a.....		
STEP 2			STEP 3	STEP 4			STEP 5	STEP 6	
			<div style="border: 1px solid black; padding: 2px; text-align: center;"> Test: Is this practical, easy, etc? If not, go back to Step 3 or Step 4.1 </div>					<div style="border: 1px solid black; padding: 2px; text-align: center;"> Do the 90% Test </div>	
Fuel type	Main end uses	Estimated consumption (kWh/yr)	End-use/area/system/circuit or tenancy to be measured	Measurement method	Meter code	Meter type	Calculation (Use separate sheet if necessary and reference here)	Estimated energy consumption through meter (kWh/yr)	Metered within 90% of incoming Yes/No?
				Step 4.1	Step 4.2	Step 4.3			If not go back to Step 3
ELECT.	Incoming	684 000			EM₁				
1st iteration – Electricity									
	Lighting	180 000	Open-plan lighting	Directly metered	EM ₂	Electricity		157 000	
	Cooling	90 000	Cooling (screw chillers)	Directly metered	EM ₃	Electricity		90 000	
	Pumps	27 000	Pumps	Directly metered	EM ₄	Electricity		27 000	
							Total metered	274 000	274/684 = 40%
				Is this 90% of incoming electricity?					No! – add more metering
2nd iteration – Electricity (additional metering)									
	Fans	162 000	All fans	Directly metered	EM	Electricity			Rejected as impractical
	Lighting		Atrium lighting	Directly metered	EM ₅	Electricity		8000	
	Lighting		External and car park lighting	Directly metered	EM ₆	Electricity			
	Lighting		Car park lighting	Directly metered	EM ₇	Electricity		9000	
	Lighting		External lighting	Estimated by difference	EM ₈		= EM ₆ – EM ₇	6000	
	Fans	162 000	Fans AHU 1 & 2	Indirect (hrs run)	EM ₉	Hours run		87 000	
	Fans		Fans AHU 3 & 4	Indirect (hrs run)	EM ₁₀	Hours run		75 000	
	Office equip.	112 500	Office equipment	Estimated (CIBSE)	EM ₁₁			112 500	
	Comp. room	76 500	Computer room	Directly metered	EM ₁₂	Electricity		76 500	
							Total metered (1st and 2nd iteration)	648 000	648/684 = 95%
				Is this 90% of incoming electricity?					Yes!
GAS	Incoming	531 000			GM₁				
1st iteration – Gas									
	Space heating	427 500	Space heating	Directly metered	GM ₂	Gas		427 500	
	DHW	72 000	DHW	Estimated from h/w consump.	GM ₃	Cold water		72 000	
	Catering	31 500	Gas catering	Estimated by difference	GM ₄		=GM ₁ -GM ₂ -GM ₃	31 500	
							Total metered	531 000	531/531 = 100%
				Is this 90% of incoming gas?					Yes!

FURTHER READING

FURTHER INFORMATION

The Building Regulations 2000, L2 Conservation of fuel and power in buildings other than dwellings, (2002 Edition), The Stationery Office

Energy Efficiency in Buildings, CIBSE Guide F (1998)

Energy Assessment and Reporting Methodology: Office Assessment Method, CIBSE Technical Memorandum TM22 (1999)

Field J, Soper J, Jones P, Bordass W, Grigg P, Energy Performance of Occupied Non Domestic Buildings, BSER&T 18(1) (1997)

Energy audits and Surveys CIBSE Applications Manual AM5 (1991)

Energy Demands and Targets for Heated and Ventilated Buildings, CIBSE Building Energy Code 1 (1998)

Energy – Containing the costs, DETR (1992)

Bordass W et al, Post-Occupancy Evaluation, Building Research and Information, Vol 29, No.2, March 2001

ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following publications are available from the Energy Efficiency Best Practice programme. Details are given below.

Energy Consumption Guides

- 19 Energy use in offices
- 35 Energy efficiency in offices – small power loads
- 36 Energy efficiency in hotels – a guide for owners and managers
- 54 Energy efficiency in further and higher education – cost-effective low energy buildings
- 72 Energy consumption in hospitals
- 73 Saving energy in schools. A guide for headteachers, governors, premises managers and school energy managers
- 75 Energy use in Ministry of Defence establishments
- 78 Energy in sports and recreation buildings
- 81 Energy efficiency in industrial buildings and sites

Good Practice Guides

- 231 Introducing information systems for energy management
- 287 The design team's guide to environmentally smart buildings
- 310 Degree days for energy management

Good Practice Case Studies

- 334 The benefits of including energy efficiency at the design stage

Fuel Efficiency Booklet

- 21 Simple measurements for energy and water efficiency in buildings

This leaflet is based on material drafted by Phil Jones of Building Energy Solutions under contract to BRECSU for the Energy Efficiency Best Practice programme

The Government's Energy Efficiency Best Practice programme

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

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

Call the Environment and Energy Helpline on **0800 585794**

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

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

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

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

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

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

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