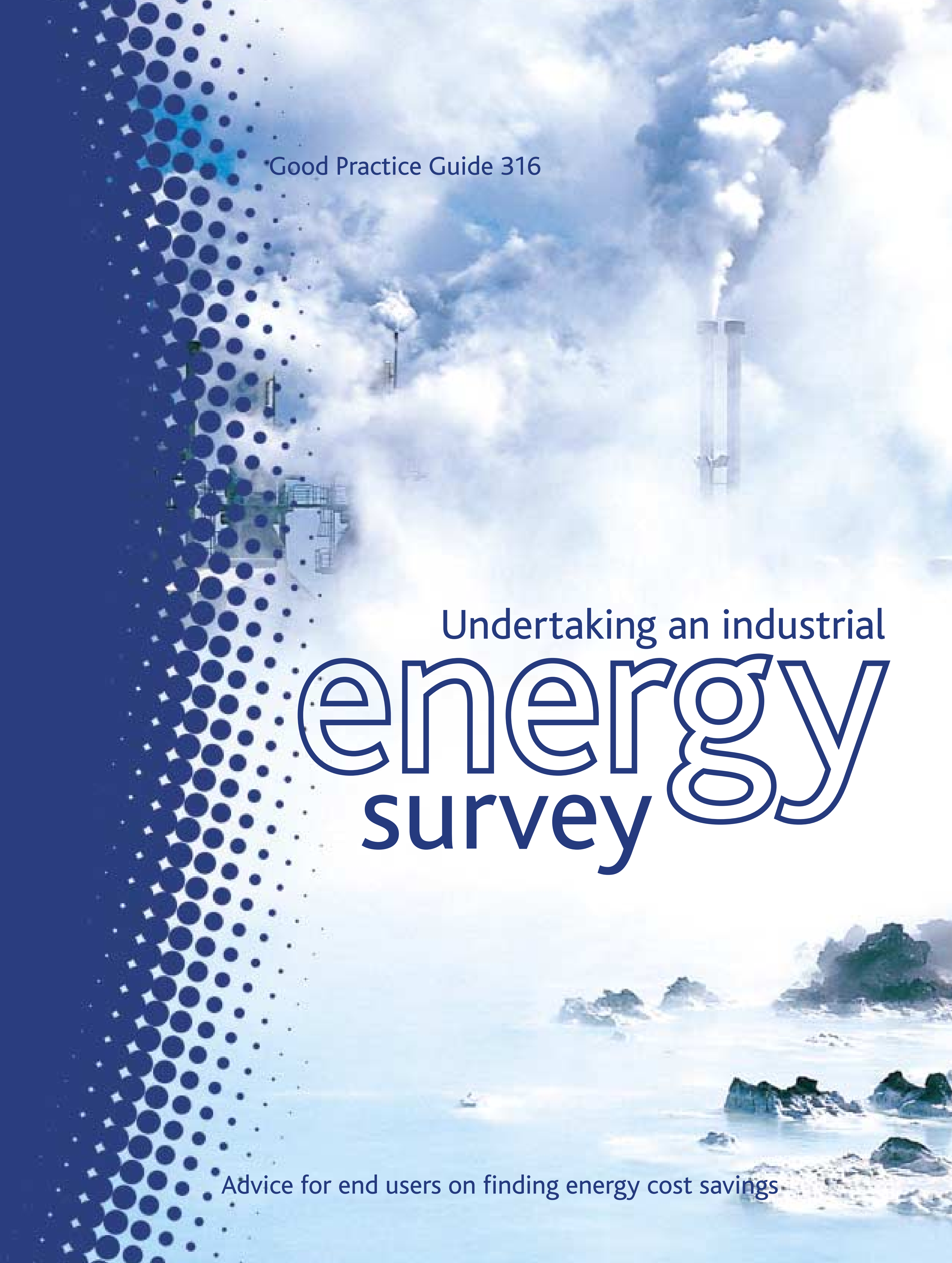

Good Practice Guide 316

Undertaking an industrial energy survey

Advice for end users on finding energy cost savings

contents

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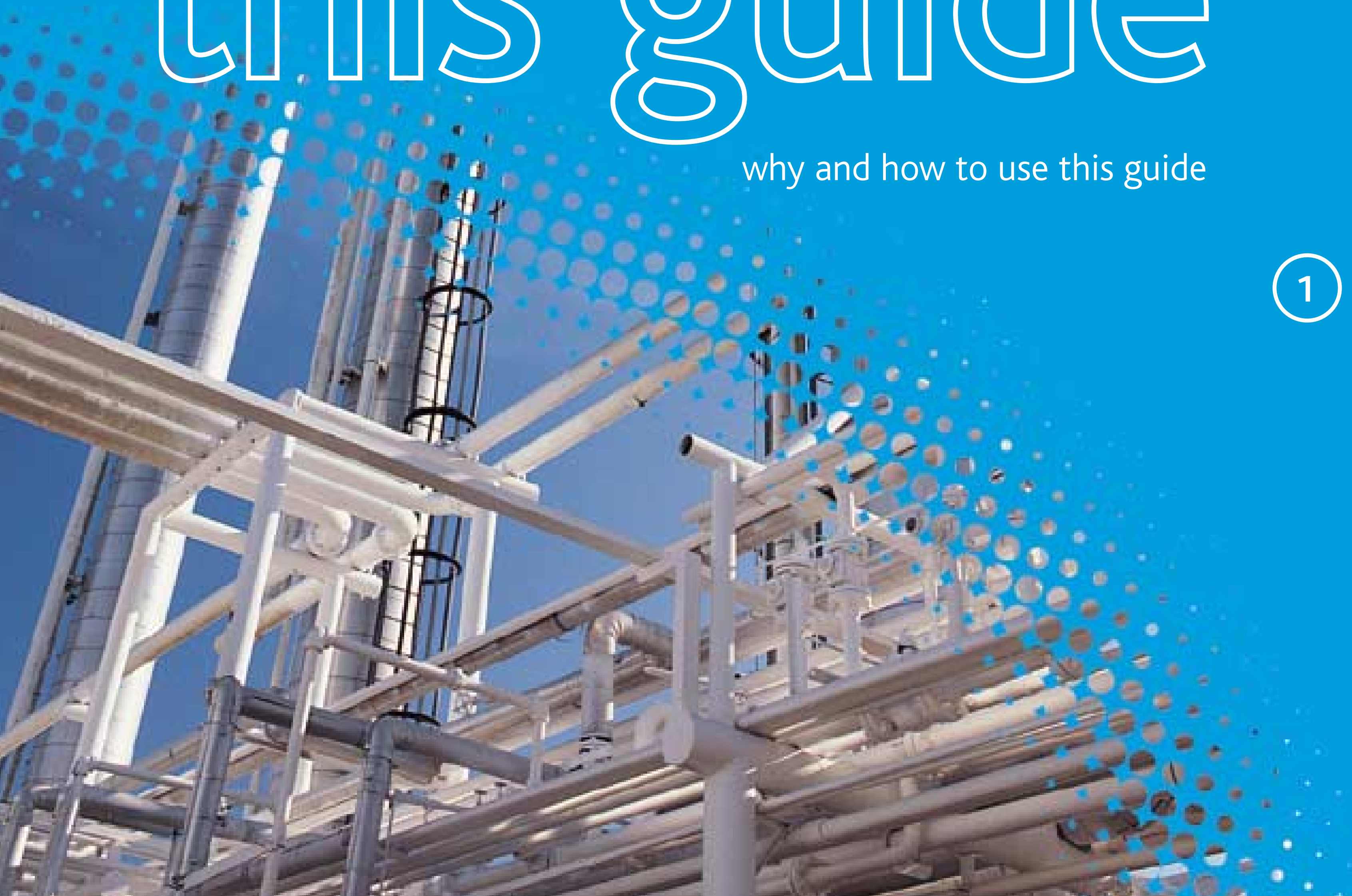

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Background

The UK industrial sector uses the equivalent of about 36 million tonnes of oil each year, and the service sector 21 million. Between them, they spend over £10 billion a year and account for over a third of total inland energy consumption. Transport uses a similar amount. There is now little doubt that the resultant carbon dioxide emissions contribute to global warming, and the Government is committed to reducing our output of CO_2 to 20% below 1990 levels by 2010. So what? How does this big picture relate to your everyday business needs, when you are focused on costs, and energy probably doesn't account for even 2% of your overall business purchases? Four reasons:

1 Financial

Energy bills are often regarded as an overhead charge to be paid 'on the nod' without rigorous scrutiny. This view can be challenged. Energy costs may be a small proportion of total costs, but they are a significant proportion of controllable costs, and furthermore carry a high risk of being partly unnecessary. The cost of eliminating avoidable excess energy expenditure can be much lower than the cost of ignoring it, and cost savings of 5%-25% are generally achievable. Moreover, for a company operating on slender margins, this small saving on energy can give a disproportionate boost to profit. An equivalent boost to profit might be achieved by increasing sales; but that would obviously entail far higher costs (otherwise the company would already be doing it) and might require investment in extra production facilities.

2 Environmental

Most scientists believe that global warming is a real threat. In a busy industrial site, such global considerations may seem remote. But your workforce may be sympathetic to the environmental message, and may even include enthusiasts who would welcome their employer adopting a socially responsible, proactive stance. Green credentials may also influence customers, and relations with local communities may benefit. If you have environmental certification, you will need a continuous flow of quantifiable improvements if you are to retain your status; an energy-saving campaign is one of the few ways of guaranteeing demonstrable year-on-year improvement. It will also help if your company is applying for ISO14001 or a similar environmental management certification.

3 Operational

Active energy management often results in reduced plant running hours, bringing reduced maintenance costs, less frequent breakdowns, and less noise and unwanted heat. Sometimes, working conditions are improved as well. For example, modern high-frequency fluorescent lamps are flicker free as well as cheaper to run, and heating systems recommissioned to operate economically sometimes work more effectively too. These factors improve staff morale and productivity. Even a small reduction in electricity demand can be valuable because of the reduced peak demands; this has enabled some factories to avoid paying for costly upgrades to supply transformers when extra capacity is needed. And advanced techniques of energy management can even inform and enhance other cost-reduction activities.

4 Legislative

If your company is covered by Part A of the Pollution Prevention and Control (PPC) Regulations you will find that you are under a legal obligation to save energy. And if you are a party to a Climate Change Agreement (CCA), you could lose a valuable Climate Change Levy (CCL) discount by failing to make progress against your agreed energy saving targets. Loss of CCL discount would typically be the equivalent of a fine equal to more than 10% of your non-oil energy bills. Finally, the new Building Regulations compel businesses to incorporate energy-efficiency measures when even relatively minor work is carried out on existing buildings.

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The role of senior management

A successful energy saving campaign demands the active support of senior management. There is no suggestion that energy saving should enjoy 'special pleading' unless the company's policy says otherwise. You will need to create the right corporate conditions for progress:

- The company should appoint an 'energy manager' - somebody (possibly acting part time) whose task it will be to originate and coordinate energy-saving projects and procedures.
- The appointed energy manager must be allowed reasonable specialist training to make them fully effective, and their knowledge and experience must be respected.
- The company must back the appointed energy manager when they cannot get the required help and information from department heads.
- If levels of service provided by energy systems are inadequate, the company must be willing to resolvethese issues. Otherwise there will be no support for energy-saving initiatives.
- The company must be prepared to adopt an energy policy, in the interests of curtailing argument about whether and how certain things should be done.
- When faced with proposals for spending on energy saving projects, the company must assess the financial case fairly. Just because a cost-reduction project increases profit without increasing sales should not count against it.

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if...

...you are a general manager, please focus on:
Section 1 and the management topic guides **2.a to 2.d**

...you are given an energy management responsibility please start on **Sections 1 and 2** and then move on to the other sections

Section 1
Contains introductory material

Section 2
Contains a series of **survey topic guides,** each focussed on a particular factory service or generic process. There are also four **management topic guides.**

Section 3
Provides guidance on **reporting** including examples of usefull **tables**

Section 4
Contains **reference material**

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1.1 PURPOSE OF THIS GUIDE

The purpose of this guide is to help you find practical opportunities to save energy in your business. It is based on the assumption that while you may know little about energy, you nevertheless have eyes and ears, and common sense. The guide provides a structured framework for a simple 'walk-through' energy survey, supported by 'topic guides' which deal with the more common industrial processes and factory services.

The survey which you will carry out with the help of this guide is only a first step on the journey to lower energy costs, improved environmental performance, and all the other incidental benefits of active energy management. It will be a snapshot – with all the limitations that implies. But it will be a start, and in the course of your survey you will probably make immediate economies by detecting and rectifying some obvious things which are wasting money.

You will also establish how much energy you are using through the year, and how much it is costing. You may be able to attribute some of the consumption to specific processes or activities and if consumption is driven by production and/or other factors, you will have calculated a headline performance ratio which you will be able to use for tracking future progress.

Saving energy requires action. A survey will provide a list of opportunities with associated costs and savings from which priorities can be determined. Some measures will involve no expenditure (eg resetting heating controls). Some will require investment.

Once you have listed a number of opportunities for further investigation, you will know where to turn for more information and advice on a particular topic. In some cases, using the 'tips and tricks' mentioned in some of the topic guides, you will have been able to estimate current energy losses and associated costs. This will put you in a stronger position when assessing the viability of solutions proposed to you by suppliers of energy-saving equipment and services.

This guide does *not* set out to provide tuition in the principles of energy management, nor to act as a substitute for the wealth of useful information published by the Energy Efficiency Best Practice Programme.

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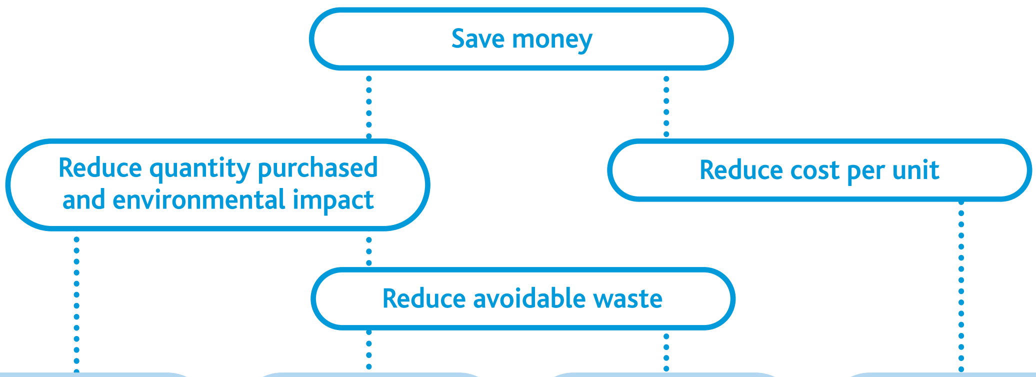
1.2 ENERGY SURVEYS IN PERSPECTIVE

Energy surveys are important because they identify how savings can be achieved. But there is more to energy management than surveys alone. This diagram structures the task of saving money through energy management, and thereby sets surveys in perspective:



Improve underlying efficiency

This is the activity for which an energy survey is most relevant, especially where money is available to carry out remedial works or modifications. The survey explicitly reveals the opportunities for such physical changes, which also have the benefit of reducing the environmental impact of an organisation.

Prevent foreseeable waste

During an energy survey, examples of bad practice may be revealed. These will often have 'no-cost' or 'low-cost' solutions. The question also needs to be asked: are there procedures in place which would prevent these things happening again?

Detect, diagnose and rectify unexpected waste

A one-off energy survey is of limited use in support of this activity because it is only a snapshot. The detection of randomly-occurring waste is best dealt with by regular long-term routine monitoring and targeting. However, periodical snap inspections based on energy survey principles could provide some measure of defence.

Purchase competitively and monitor for billing errors

Because energy surveys focus exclusively on the physical aspects of energy consumption, they have little relevance to this activity – with one major exception. Where costs are dependent to any extent on peak demand, the energy survey may reveal opportunities to improve load factor and thereby cut the peak-demand element of energy charges.

Fig 1.1 Energy management- an overview

1.3 SURVEYS AND AUDITS

Introduction

At the beginning of an energy management initiative it is important to determine the current position. Once this has been established it is then possible to set goals and priorities for future improvement.

To determine the current position it is important to be able to answer questions such as:

- What types of energy are used?
- How much is being used?
- How much does it cost?
- Where is the energy being used?
- How efficiently is energy being converted, distributed and used?
- What are the potential savings?
- How can they be achieved?
- How much will it cost to achieve the savings?
- What are the priority areas?

All the questions posed are important and can be answered by conducting an energy survey.

Definition

Energy audit: a study to determine the quantity and cost of each form of energy to a:

- Building...
- Process/manufacturing unit...
- Piece of equipment...
- Site...

...over a given period, usually a year.

Example

This example is from a food manufacturing site with data from a 12-month period:

	Consumption		Cost		Average cost
Energy type	kWh	%	£	%	p/kWh
Natural gas	5,856,979	67.2	39,375	25.1	0.672
Gas oil	202,967	2.3	3,398	2.2	1.674
Electricity	2,662,700	30.5	114,187	72.7	4.288
Total	8,722,646	100	156,960	100	1.799

Energy survey: a technical investigation of the control and flow of energy in a:

- Building...
- Process/manufacturing unit...
- Piece of equipment...
- Site...

...with the aim of identifying cost-effective energy saving measures.

Energy surveys can be conducted on entire sites, individual manufacturing units, utility systems or specific items of equipment.

Usually surveys include an examination of:

- Energy conversion: where energy is converted from one form to another, eg heaters, boilers, furnaces, refrigeration units, compressors, turbines, etc.
- Energy distribution: where energy is distributed, eg electricity, gas, steam, air, water, hot oil systems.
- Energy end use: where energy is used in plant, equipment and buildings.
- Management systems: how information is obtained, analysed, and used. Management and people issues.

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An energy survey will usually give a management summary and divide recommendations into three main categories:

- No-cost measures (good housekeeping).
- Low-cost measures.
- High-cost measures.

Examples of these three categories are given below:

NO-COST MEASURES

Measure	Estimated annual saving £	kWh	Estimated costs £	Simple payback years
Reset cooling plant time switch controls	3,237	45,278	-	Immediate
Reset AHU time switch controls	16,712	233,611	-	Immediate
Reset conditioned areas temperature set point during summer	1,390	19,444	-	Immediate
Isolate skirting heating during cooling season	-	-	-	Immediate
Reinstate AHU heating coils	(1,027)	(97,778)	-	Immediate
Switch off air conditioning plant	3,100	95,833	-	Immediate
Total	**23,412**	**296,388**	**-**	Immediate

LOW-COST MEASURES

Measure	Estimated annual saving £	kWh	Estimated costs £	Simple payback years
Install dehumidifier in building 10	670	40,870	400	0.6
Insulate boiler headers	150	9,120	350	2.3
Totals	**820**	**49,990**	**750**	**0.9**

HIGH-COST MEASURES

Measure	Estimated annual saving £	kWh	Estimated costs £	Simple payback years
Overhaul flue gas dampers, flow isolation controls and sequence control on main boilers	2,000	122,000	1,000	0.5
Presence-detector control of lighting	480	6,000	1,000	2.1
Insulate valves on heating pipework	320	19,800	900	2.8
Total	**2,800**	**147,800**	**2,900**	**1.0**

BE YOUR OWN CONSULTANT

When an outside consultant does an initial energy survey to identify likely avenues for further investigation, they will usually cover the following ground:

- gather base data on monthly consumption and expenditure over the last year;
- become familiar with the site and the work done there;
- become familiar with how energy is currently managed;
- study the main services facilities (boilers, compressed air, lighting, etc) searching for energy saving opportunities;
- review opportunities for saving energy at the point of use;
- estimate likely implementation costs, savings, and paybacks, usually from insufficient data;
- write a report in a prescribed format and have it checked for accuracy.

The consultant's advantages are primarily depth of technical expertise, breadth of experience, and freedom from urgent interruptions. The consultant can look at your site and its problems and opportunities with a fresh pair of eyes. An appropriately-chosen consultant will have surveyed many sites and will know the likely sources of possible energy savings in your sector. But he or she usually has limited time: perhaps only one day on site and two days for analysis and reporting. Your ability to take your time, spreading the work over a longer period if you wish, is only one advantage which you enjoy. Here are the others:

- You will already be familiar with the site and its activities.
- You will be freer to come and go, and won't need an escort.
- You know who has the information you need, and if you overlook something, you can go back at any time.
- You can ask others to help you, parcel out some parts of the survey to more appropriate colleagues if you want, or mobilise a workplace study group in the style of a quality improvement team.
- If there are other surveys going on (on safety, quality, or environmental themes), you may be able to join forces.
- If the base data which you need is not forthcoming, you can 'pull strings' or even get into the ledgers yourself – or simply busy yourself with other aspects while the data works its way through the system.
- You are not obliged to write a formal report (although it would be unwise not to record your findings, calculations and recommendations for others to read later; you may also need a summary to obtain funds for investment in energy saving measures).
- You can legitimately build on the work of others before you.
- You can elect to ignore whole aspects.
- You can improvise measurement techniques, even turning things on and off (within reason) to gauge their effect on consumption.
- You may be able to experiment with variations to processes.

This guide has been designed so that you can work within the limits of your own expertise. Once you need to go beyond those limits, or cannot devote the necessary time, using the guide will not only equip you better to brief an outside expert; it will have helped you establish that his or her fee is justified.

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1.4 DOING YOUR OWN ENERGY SURVEY

Establish current patterns of overall consumption and expenditure at site level.

This provides a backdrop to your eventual findings and helps to set the subject in a meaningful context for general management. Copies of energy invoices should be available in your accounts department, but suppliers will sometimes provide historical summaries.

Does a meaningful yardstick energy ratio exist for your industrial sector?

YES → Calculate the figure for your site.

NO

Tabulate where in the works you have examples of particular processes and services (eg compressed air, treatment vats).

You can use the topic matrix at the beginning of Section 2 as a guide.

Visit each area or department in turn. Using the appropriate topic guides as a prompt, look for things which are obviously wrong and need to be corrected.

Common generic processes and services are each covered by a survey topic guide sheet in Section 2.
If you are not sure what to look at first, start with the principal central services and the largest process users.

Report your findings, and put into effect whatever low-cost and no-cost measures you have identified.

There is a selection of pro forma recording sheets in Section 3.

Might funding be available for energy-saving projects?

YES → Identify opportunities which may apply to your site in particular.

By measurement, experiment, or inference, estimate present energy consumptions of affected plant, and likely savings in each case.

Obtain quotations for possible energy-saving solutions.

Calculate the financial viability of the projects you are proposing, and present recommendations for those most likely to receive approval.

Implement approved projects.

NO

Continue to monitor performance systematically in order to track and verify subsequent savings.

Systematic monitoring against targets can save money in itself, by revealing the onset of unexpected hidden waste. Further advice on this topic is in management topic guide sheet C.

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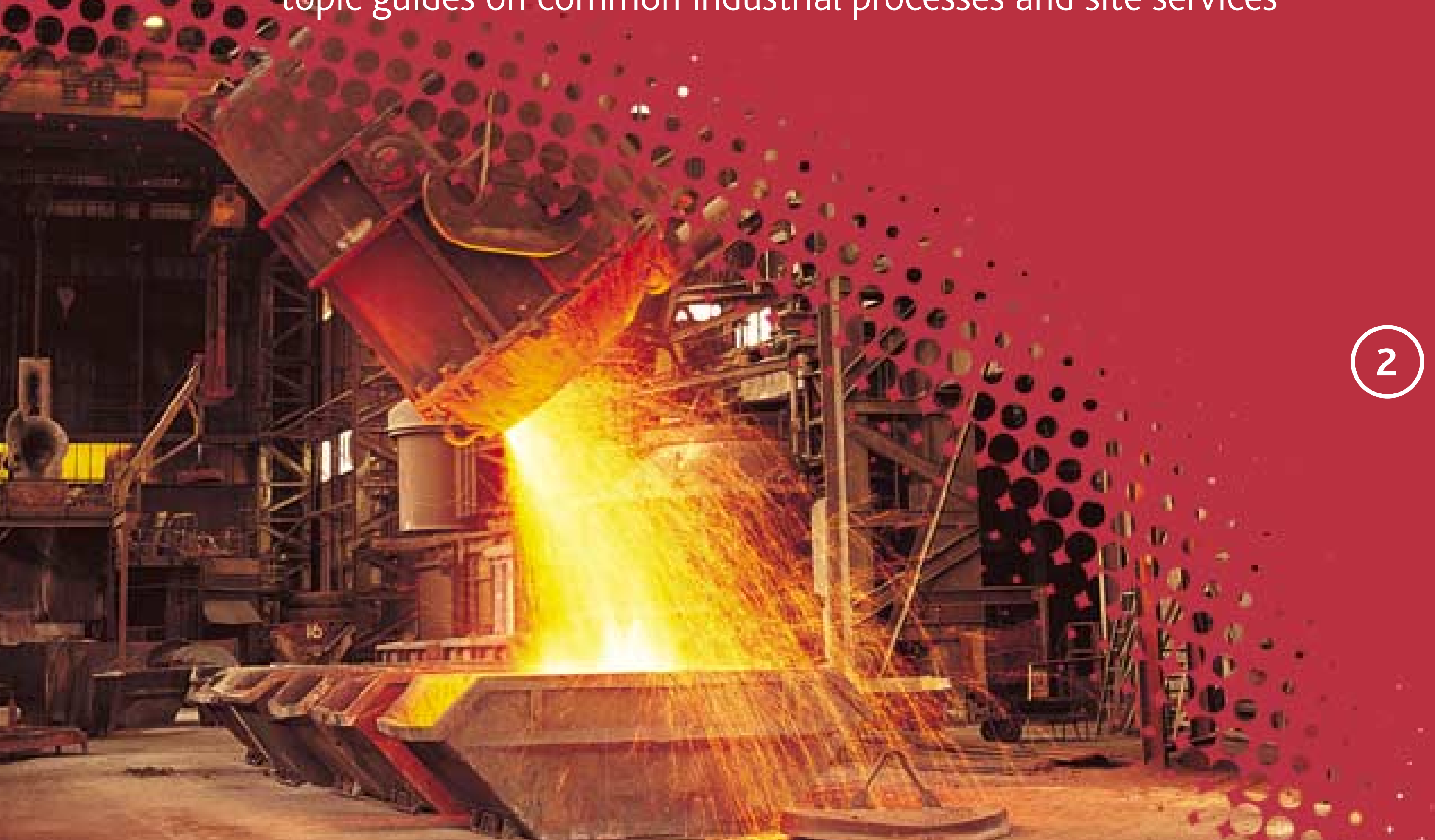
finding savings

topic guides on common industrial processes and site services



2

finding savings

topic guides on common industrial processes and site services

2 FINDING SAVINGS

SURVEY TOPIC GUIDES

The topic guides in this section provide a framework for your survey. They are structured as follows.

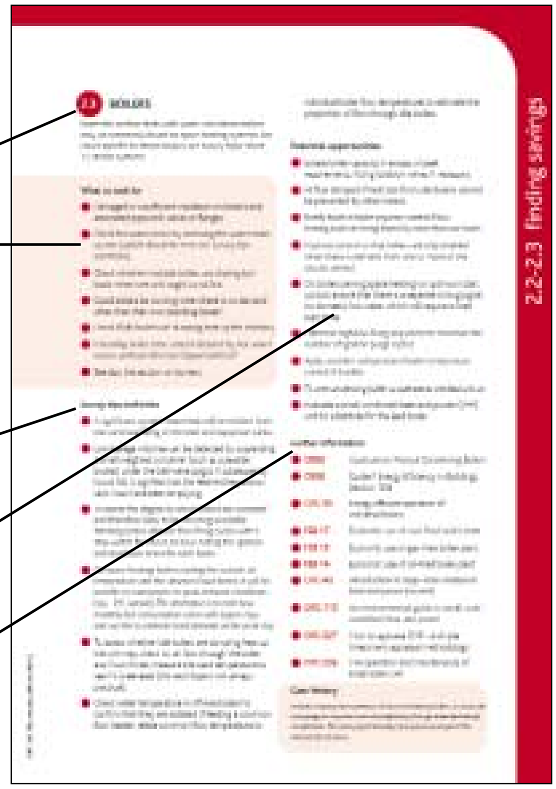
Each deals with a generic industrial process (boilers, for example) or a site service such as lighting or compressed air.

Each starts with a list of **things to look for.** These are things which are often amiss, where common sense and local knowledge will normally be sufficient to dictate an appropriate remedy, and where it should be quick and cheap – or even free – to put the problem right. This may be as far as you need to go.

For those who want to go further, each topic guide has a selection of **tips and tricks.**

Next comes a list of **potential opportunities.** These only apply if you are prepared to contemplate moderate to high cost remedial works.

Finally, each topic guide includes references to **further information.** Much of this is free information from the Energy Efficiency Best Practice Programme.



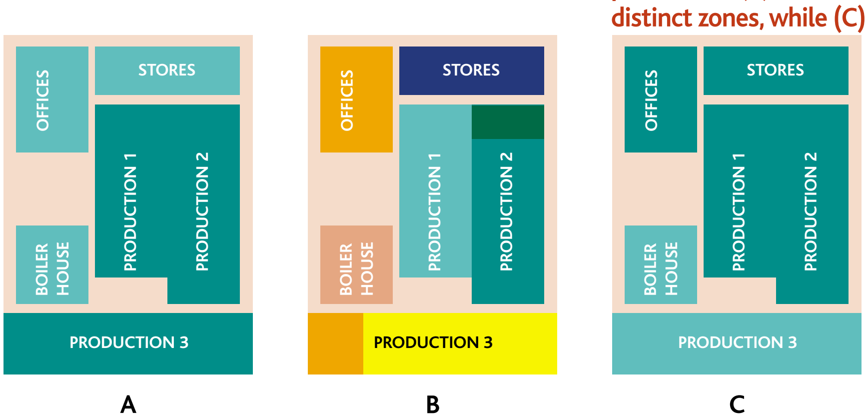
Note: other common sources of information are listed in Section 4, 'Sources of Assistance'.

Before carrying out any experiments or modifications, prepare a method statement and assess the risk of unintended consequences.

Not all of your site will feature every kind of process and service covered by the topic guides. You can use the matrix to record which topics are relevant where. First divide the establishment into appropriate zones and label each column of the matrix accordingly.

A 'zone' might be a boiler house or plant room, an entire production floor, a store, a canteen block, or however you decide to define it. Take the matrix with you on your initial walk-round and tick off which topic guides you will need for each zone. The completed matrix will help ensure that you later investigate (and report) every aspect.

The site can be zoned however you wish. Illustration (A) shows just two zones – production and non-production. (B) has six buildings split into eight distinct zones, while (C) is a geographical split.



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2.a MANAGEMENT TOPIC GUIDE: ORGANISING ENERGY MANAGEMENT

Success factors to look for

- An enthusiastic champion.
- A motivated and energy-aware workforce.
- A culture of engagement and co-operation.
- Support from senior management.
- True accountability for energy costs.
- Corporate willingness to rectify problems with existing energy-related services.
- Training for those whose day-to-day work impinges on energy efficiency.
- A team approach on the part of the relevant players.
- Continuous feedback of results and achievements.
- Opportunities created by external factors (eg supply capacity constraining growth).

Assessment and goal-setting

The energy management matrix (fig 2.1) is divided into six key organisational aspects of energy management:

- Policy
- Organising
- Training
- Performance measurement
- Communicating
- Investment

To obtain an indication of the current state of the organisational aspects on your site complete the matrix by putting one cross in each column. The box you mark under each column should represent the current status on your site. Then join your crosses across the columns to produce your organisational profile. This will show your strengths and weaknesses. Weaknesses can undermine strengths so the ideal profile is one which is relatively flat. From that position it is important to advance on all aspects up the matrix.

Some companies find it useful to copy the matrix and get a group of managers to individually complete the matrix in a meeting and then compare findings. It provides useful management overview in a pictorial form and highlights points for further action.

In the rest of this section each of the organisational aspects are covered briefly with pointers to further information.

Fig 2.1 Energy management matrix

	Policy	Organising	Training	Performance measurement	Communicating	Investment
4	Energy Policy, action plan and regular review have active commitment of top management	Fully integrated into management structure with clear accountability for energy consumption	Appropriate and comprehensive staff training tailored to identified needs, with evaluation	Comprehensive performance measurement against targets with effective management reporting	Extensive communication of energy issues within and outside organisation	Resources routinely committed to energy efficiency in support of business objectives
3	Formal policy but no active commitment from top	Clear line management accountability for consumption and responsibility for improvement	Energy training targeted at major users following training needs analysis	Weekly performance measurement for each process, unit, or building	Regular staff briefings, performance reporting and energy promotion	Same appraisal criteria used as for other cost reduction projects
2	Unadopted policy	Some delegation of responsibility but line management and authority unclear	Ad-hoc internal training for selected people as required	Monthly monitoring by fuel type	Some use of company communication mechanisms to promote energy efficiency	Low or medium cost measures considered if short payback period
1	Unwritten set of guidelines	Informal mainly focused on energy supply	Technical staff occasionally attend specialist courses	Invoice checking only	Ad-hoc informal contacts used to promote energy efficiency	Only low or no cost measures taken
0	No explicit energy policy	No delegation of responsibility for managing energy	No energy related staff training provided	No measurement of energy costs or consumptions	No communication or promotion of energy issues	No investment in improving energy efficiency

Further information on energy policy

- **GPG 186** Developing an effective energy policy
- **GPG 200** A strategic approach to energy and environmental management

Further information on organising energy management

- **GPG 119** Organising energy management - a corporate approach
- **GPG 167** Organisational aspects of energy management: a self-assessment manual for managers
- Standards for managing energy

Further information on energy training

- **GPG 85** Energy efficiency training and development
- **GPG 235** Managing people, managing energy

Further information on measuring energy performance

- **FEB 13** Waste avoidance measures
- **GPG 112** M&T in large companies
- **GPG 125** M&T in small and medium sized companies
- **GPG 231** Introducing information systems for energy management

Further information on communication

- **GPG 84** Managing and motivating staff to save energy
- **GPG 172** Marketing energy efficiency - raising staff awareness
- **GPG 235** Managing people, managing energy
- **GPG 251** Maintaining the momentum
- Running an awareness campaign action pack

Further information on energy-saving investment

- **GPG 69** Investment appraisal for industrial energy efficiency
- **GPG 75** Financial aspects of energy management in buildings
- **GPCS 251** An energy management and investment campaign in a

2.b MANAGEMENT TOPIC GUIDE: PEOPLE ASPECTS OF ENERGY MANAGEMENT

Communicating

Every employee can make a contribution to saving energy. Often, contractors should also be included. Two key aspects are required: awareness and motivation.

Raising awareness covers the knowledge and skills so that people see the potential for saving energy as an integral part of their daily work. Awareness is knowing what to do.

Motivation is more complex. It varies from person to person. Key factors include 'external' motivators, e.g. incentives, targets, competition to perform and 'internal' motivators related to personal outlook and values (e.g. concerns for the environment).

Good housekeeping campaigns need to be integrated into other energy management initiatives if momentum is to be maintained.

Training

On every site there are key people who can have a large influence on energy consumption because of their job function. These people need to be identified along with their training needs so that they receive appropriate training to be energy efficient. Individuals are usually saving energy or wasting it and there is rarely any neutral ground. In many industrial sites the Pareto principle rules: 20% of the workforce control 80% of the energy.

If energy efficiency investment measures are not supported by appropriate training then potential savings will not be fully realised because of poor operation, control and maintenance practices.

Investment in vocational training for key staff (e.g. boiler or plant operators) not only saves energy but also improves environmental performance and standards of health and safety. The specialised needs of the individual energy manager must not be overlooked. Note that since 1997 when the National Vocational Standards for Managing Energy were introduced, it has been possible for individual energy managers to gain a National Vocational Qualification (or a Scottish NVQ) by compiling an evidence portfolio based on their work.

In addition, the Standards may help you review or specify the energy management function within your organisation.

A framework for training needs

In a large operation, an integrated programme of training may be worth developing. This will need to address three categories of training need, and the matrix below shows what topics might typically be covered and at what level:

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Subject	Audience		
	Operatives and maintenance fitters	Engineers and line managers	General management and technical services
Overview of energy efficiency and energy management; Climate Change Levy, grant schemes	A	A	A
Energy billing and procurement		A	V
Performance monitoring and targeting	A	V,T	T
Meter reading	V	T	
Energy considerations specific to the process used at the target site	A	V,T	A
Boiler operation	V	T	A
Steam distribution, utilisation, and condensate recovery	V	T	A
Pumps and fans	A	V,T	A
Electric motors and drives	A	V,T	A
Compressed air services	V	T	A
Lighting	A	V,T	A
Heat recovery		V,T	A

Key:

V **Vocational.** Material directed at improving skills, enabling trainees to do their jobs better. Likely to include some practical element.

T **Theoretical.** Material aimed at improving knowledge and understanding, enabling better analysis and decision making.

A **Awareness.** Brief coverage to help trainees understand other people's objectives and activities, to put their own contribution in context, and to defuse potential conflicts.

Case studies

At a small injection-moulding plant, about £2,000 was spent on meters to make staff more aware of where and how energy was being used. They saved £21,000 in the first year.

A manufacturer of decorative tiles persuaded its suppliers to donate prizes for an energy awareness campaign.

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2.c MANAGEMENT TOPIC GUIDE: MONITORING AND TARGETING

Purpose

An energy survey can only ever be a snapshot. It is therefore best at detecting opportunities for permanent modifications to plant, equipment, buildings, and operating procedures. However, your organisation may be incurring considerable hidden costs through avoidable waste occurring at random and remaining undetected. Examples could include

- Timeswitches and other self-acting controls failing in the 'on' position.
- Maintenance errors, such as fitting an oversized replacement motor.
- Operating errors, such as running an air compressor against a closed isolation valve.
- Lax discipline, for example leaving auxiliaries to run when not required.
- Leaks.

A management technique called monitoring and targeting (M&T) is the most effective defence against these kinds of loss, which a one-off survey would miss. The next-best option - a regular programme of routine energy inspections – would be a more costly exercise, and would anyway miss many kinds of energy-wasting fault because they are frequently of an unforeseen nature.

M&T works by combining regular consumption data (usually weekly or monthly) with corresponding data on production throughput, weather, or other driving factors (called 'variables' in the older literature). An M&T scheme is primed with targets for each stream of consumption, these targets being related to the relevant driving factor, so that given the level of activity in the facility, a 'correct' ration of energy can be estimated at each point of use. The deviation between actual and expected consumptions indicates the extent of any unexpected loss, which can then be converted to its implied cost in order to establish its significance.

When a fault detected in this way proves persistent, the pattern of deviation can be analysed as an aid to diagnosis.

An effective M&T scheme provides, in effect, a continuous review of the site's performance, and as well as revealing random unexpected losses, it can be used to monitor and verify the effectiveness of other energy conservation measures. Verification is doubly significant if your company is engaged in emissions trading.

Common shortcomings

If any of the following apply in your organisation, your ability to manage the consumption of energy will be compromised:

- Unable to provide routine weekly assessment of performance and losses.
- Prime drivers of consumption (eg production flows) not catalogued.
- Quantitative relationship between each consumption stream and its drivers not known.
- 'Best achievable' relationships between consumptions and drivers not used as targets.
- Regular records of driver values not kept in synchronism with consumption data.
- Inadequate submetering of significant processes.
- No regular in-house meter readings or other consumption figures.
- No stocktake of bulk-delivered commodities in synchronism with meter readings.
- Analysis and reporting starts afresh each year (instead of being continuous).
- Reliance on crude 'specific energy ratios' as targets for management control.
- Reliance on same-period-last-year as a basis for comparison.
- Focus on percentage deviations (instead of their absolute cost).
- No system for initiating and pursuing investigations into unexplained deviations.

Specialist advice should be sought to rectify any such shortcomings, and thereby maximise the value to be obtained from regular meter readings and other returns.

Case studies

Steam losses worth £9,000 a year were detected at a paper mill. Someone had left a bypass valve open on a steam trap.

At another paper mill, losses of £13,000 a year were detected when it was found that an oversized replacement motor had been fitted to a vacuum pump following a breakdown.

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2.d MANAGEMENT TOPIC GUIDE D: MAKING THE CASE

Most organisations can achieve significant energy savings through low and no cost measures, such as good housekeeping. At some point investment will be needed.

Energy is one of the few cost elements present in the manufacture of every industrial product. It is also one of the key measurable and controllable contributors to cost in at least 80% of all industrial production. Commercially available equipment exists to reduce UK energy consumption by 25%.

Barriers to energy-saving investment

There are three main barriers to overcome:

- the low priority given to energy efficiency in most organisations;
- application of inappropriate standards of investment appraisal;
- decision taken at wrong level in the organisation.

Investment appraisal is merely a rational method of making choices. Any healthy commercial enterprise ought to be able to identify more viable opportunities than it can afford to fund. It therefore has to choose which projects are priorities for investment.

Very often energy managers use simple payback as the criterion, even when promoting large projects. More sophisticated methods are needed if the people judging the case, who will usually have an accountancy or business management training, are to take it seriously. Suitable methods are explained fully in GPG 69 (see details below).

Assessing costs and savings

A short energy survey carried out by a consultant can often provide nothing more than indicative payback periods for each recommended energy-saving measure. As the end user (and therefore the potential customer) you are in a better position to get more definite figures, and indeed it is in your interests to do so if your proposal for capital expenditure is to be acceptable. The sources of cost information are, in descending order of preference:

- Estimates or quotations from suppliers.
- Knowledge gained from other people who have done similar projects.
- Generic estimates from engineers' yearbooks.

The procedure for calculating savings is

- Estimate the reduction in unit consumption achieved by each proposed measure. This can either be done as a 'before-and-after' calculation (based on, say, a change in running hours) or a percentage reduction can be assumed. Equipment and service providers will often help with such estimates, but check their assumptions and arguments critically – remember they have an optimistic bias.
- Multiply the reduction in units by the unit cost of energy saved. Remember that the cost per unit saved will often be less than the overall average unit price.
- Add any quantifiable incidental savings, such as in manpower, maintenance, or capacity charges.
- Note any additional costs which will offset the expected savings.

Assembling the information

Before making a proposal the energy manager needs to know the following:

- The cost of the proposed work.
- Any subsequent recurring costs.
- The expected savings.
- Risks and incidental benefits.
- The criteria against which other capital expenditure projects are assessed.

Presenting the case

An effective proposal will have the following attributes:

- There should be a single unequivocal recommendation (not a selection of choices).
- The full costs must be stated.
- Known risks must be disclosed and accounted for.
- Against the risks, incidental benefits must be presented as bonuses.
- The method of analysing the financial return must be as used for all other projects.
- The proposed investment must satisfy the company's current criteria.

A proposal will always stand a better chance of acceptance if it can be aligned with the goals of any current corporate campaign. Energy projects for example often have beneficial environmental impacts and can improve reliability.

Further Information

- **GPG 69** Investment appraisal for industrial energy efficiency
- **GPG 75** Financial aspects of energy management in buildings
- **GPCS 251** An energy management and investment campaign in a glass plant.

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A. Identify appropriate zones →

B. Check which topic guides are needed for each zone ↓

Services	1. Lighting								
	2. Ventilation								
	3. Boilers								
	4. Space heating								
	5. Air conditioning								
	6. Hot water services								
	7. Compressed air								
	8. Central vacuum								
Processes and devices	9. Electric motors and drives								
	10. Fans and pumps								
	11. Burners								
	12. Steam systems								
	13. Crushing and grinding								
	14. Mixing and blending								
	15. Drying								
	16. Baking and curing								
	17. Machining and fabrication								
	18. Tanks and vats								
	19. Treatment booths/cabinets								
	20. High temperature processes								
	21. Cooling systems								
	22. Heat recovery								
Other	23. Mechanical handling								
	24. Motor transport								
	25. On-site catering								
	26. Building fabric								

Copy the matrix if you need to define more zones.

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2.1 LIGHTING

Things to look for

- People not even knowing where the light switches are.
- Tungsten filament lamps running more than four hours per day.
- Excessive light levels for the type of work being done.
- Large banks of lights controlled by a single switch.
- Lack of labels on switches controlling shared workspace.
- Outside lights on fixed timeswitch or manual control.
- Dirty or discoloured diffusers and shades.
- Empty areas lit unnecessarily.
- Dirty rooflights or other opportunities to use more daylight.
- Artificial lighting in areas with sufficient daylight.

Survey tricks and tips

- Estimate the lighting load by means of a controlled test with the building unoccupied: read the electricity meter at (say) ten-minute intervals first with lights off, then with lights on.
- Make a point of examining areas which have had a change of use.
- Subject to safety considerations, turn off some lights and see if anyone notices.
- Walk the site at night or during shutdowns to see what lights get left on.
- An inexpensive light meter will give enough accuracy to establish if lighting is in line with the following 'adequate' levels:

Type of use	Lux
Close detailed work	1,000-2,000
Offices	400
Workshops	300
Stairs and corridors	200
Rest rooms	100
Street lighting	20
Security lighting	5

- Use time-lapse video recording to study intermittently-occupied spaces.

Potential opportunities

Note: the new Building Regulations compel you to treat replacement lighting systems as if the building were a new one.

- Brief security staff and cleaners to turn off lights when leaving unoccupied areas.
- Improve labelling of switches, combined with a staff awareness and motivation campaign.
- Replace lamps with more efficient equivalents (e.g. T12 tubes with T8 tubes if fittings are suitable).
- Convert fluorescent lights to high frequency fittings.
- Fit more switches per bank of lights, if wiring permits.
- Fit automatic lighting controls (carefully chosen to suit the circumstances) especially in infrequently occupied rooms. Photocells can be used for external lighting.
- Fit more effective reflectors and remove a proportion of lamps.
- In areas where colour rendering is unimportant, use high-pressure sodium discharge lighting.

Further information

- **FEB 21** Simple measurements for energy and water efficiency in buildings
- **CIBSE Guide F** Energy Efficiency in Buildings, Section 19.6
- **GPCS 169** Energy efficient lighting in factories
- **GPCS 309** Energy efficient lighting in industrial buildings
- **GPG 158** Energy efficiency in lighting for industrial buildings
- **GPG 159** Converting to compact fluorescent lighting - a refurbishment guide
- **GPG 199** Energy efficient lighting - a guide for installers
- **GPG 272** Lighting for people, energy efficiency and architecture - an overview of lighting requirements and design
- **CIBSE AM5:1991**-Energy Audits and Surveys
- **www.lightswitch.co.uk** - grants for lighting efficiency improvements for small and medium enterprises

Case histories

A cosmetics manufacturer invested £17,000 on automatic lighting controls. Even with today's lower electricity prices the project would have yielded about 20% internal rate of return.

A plastics moulding factory refurbished its very inefficient lighting at a cost of £9,640 and saved £47,750 a year.

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2.2 VENTILATION

What to look for

- Local extract ventilation likely or able to run when not required.
- Eroded or fouled fan blades.
- Clogged or obstructed grilles or filters.
- Stuck or overridden dampers.
- Failure to exploit any existing air-recirculation facilities.
- Inappropriate timeswitch settings.

Survey tips and tricks

- If fans are not visible or audible, air movement can be detected by various means, including improvising with a child's bubble maker. Thin strips of tissue paper can be suspended near extract grilles to provide a more permanent 'tell-tale'.
- Pay special attention to areas which have had a change of use where the original ventilation requirements were more demanding.
- To make a rough estimate of air flow into a building through an air handling unit (AHU) measure the cross-section of its inlet duct and assume an average air velocity of 1.5 m/s. The AHU may also carry a rating plate stating its design capacity. Commissioning test reports may exist.
- In the absence of other evidence, assume air handling plant was designed to prevailing design codes for the type of use.

Potential opportunities

- Interlock local extract ventilation to occupancy and/or activity.
- Where dampers are used to control air flow rates, consider variable speed control of the fans (or even just two-speed motors) instead.
- Fit high-efficiency motors to fans.
- If excessive ventilation rates are confirmed, reduce fan speed by changing pulley ratios.

Further information

- **CIBSE Guide F** Energy Efficiency in Buildings, Section 19.3
- **GPG 257** Energy-efficient mechanical ventilation systems
- **GPG 139** Draught-stripping of existing doors and windows

Case study

A pigment manufacturer was discharging extract air containing water vapour and traces of fine powder. A spray condenser, fitted at a cost of £284,000, recovered the heat and scrubbed the powder from the extract air. At today's fuel prices the investment would have realised an internal rate of return close to 50%.

2.3 BOILERS

Note: this section deals with water-circulation boilers only, as commonly found on space heating systems. For issues specific to steam boilers, see survey topic sheet 12, steam systems.

What to look for

- Damaged or insufficient insulation on boilers and associated pipework, valves or flanges.
- Check for water losses by assessing the water make up rate (which should be zero: see Survey tips and tricks).
- Check whether multiple boilers are sharing low loads, when one unit ought to suffice.
- Could boilers be running when there is no demand other than their own standing losses?
- Check if idle boilers are dumping heat up the chimney.
- Is heating-boiler time control dictated by hot-water service preheat time (see Opportunities)?
- See also the section on burners.

Survey tips and tricks

- A significant system-water leak will be evident from the continual filling of the feed and expansion tanks.
- Low leakage volumes can be detected by suspending a small weighted container (such as a seaside bucket) under the ball-valve spigot. If subsequently found full, it signifies that the feed-and-expansion tank must have been emptying.
- To assess the degree to which boilers are oversized and therefore likely to be incurring avoidable standing losses, observe their firing cycles with a stop-watch for about an hour, noting the ignition and shutdown times for each boiler.
- On space heating boilers, noting the outside air temperature and the observed load factor, it will be possible to extrapolate to peak demand conditions (say -3°C outside). The alternative is to note how monthly fuel consumption varies with degree days and use this to estimate total demand on the peak day.
- To assess whether idle boilers are dumping heat up the chimney, check for air flow through the boiler, and if confirmed, measure the stack temperature to see if it is elevated (this technique is not always practical).
- Check water temperature in off-line boilers to confirm that they are isolated. If feeding a common flow header, relate common flow temperature to individual boiler flow temperatures to estimate the proportion of flow through idle boilers.

Potential opportunities

- Isolate boiler capacity in excess of peak requirements, fitting isolation valves if necessary.
- Fit flue dampers if heat loss from idle boilers cannot be prevented by other means.
- Rectify faults in boiler sequence control if low heating loads are being shared by more than one boiler.
- Improve control so that boilers are only enabled when there is demand from one or more of the circuits served.
- On boilers serving space heating on optimum start control, ensure that there is a separate timing signal for domestic hot water, which will require a fixed start time.
- Optimise high/low firing sequences to minimise the number of ignition purge cycles.
- Apply weather-compensated boiler temperature control if feasible.
- Fit one condensing boiler to operate as the lead unit or;
- Evaluate a small combined-heat-and-power (CHP) unit to substitute for the lead boiler.

Further information

- **CIBSE** Applications Manual Condensing Boilers
- **CIBSE Guide F** Energy Efficiency in Buildings, Section 19.6
- **GPG 30** Energy efficient operation of industrial boilers
- **FEB 17** Economic use of coal-fired boiler plant
- **FEB 15** Economic use of gas-fired boiler plant
- **FEB 14** Economic use of oil-fired boiler plant
- **GPG 43** Introduction to large-scale combined heat and power (revised)
- **GPG 115** An environmental guide to small scale combined heat and power
- **GPG 227** How to appraise CHP - a simple investment appraisal methodology
- **GPG 226** The operation and maintenance of small scale CHP

Case history

A water company had numerous old cast-iron heating boilers. It conducted a campaign to improve combustion efficiency through a standard retrofit modification. The same project at today's fuel prices would yield 70% internal rate of return.

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2.4 SPACE HEATING

Note: Survey Guide Sheets 2.2 (Ventilation) and 2.10 (Fans and Pumps) will also be relevant.

What to look for

See also the sections on hot-water boilers or steam-raising plant, regarding inefficiency and losses in the boiler room.

- Heating outside working hours (whether deliberate or accidental).
- Excessive space temperatures (even if only in localised areas).
- Uncontrolled heat output from distribution pipework.
- Unauthorised supplementary electric heating.
- Circulation pumps running when no heat is required.
- Mechanical ventilation runs (or able to run) when building is unoccupied.
- Irregular or irrational relationship between heating fuel demand and prevailing weather.
- High ceilinged buildings in which warm air remains at high level.
- Uncontrolled heat release from uninsulated distribution pipework, or from fan assisted convectors in the 'idle' mode.
- Temperature sensors and thermostats situated in inappropriate locations.
- Wrong thermostat type.
- Frost thermostats set too high.
- Anything which restricts heat output. This includes blocked grilles, obstructed radiators, clogged air filters, and missing air filters which have allowed convector tubes to become fouled.
- Risk of cooling and heating being used simultaneously.
- Doors and windows which require draught proofing or repair.
- Automatic door closers not working.
- Holes in the building, for example under the eaves, through which warm air can escape.
- Walls and ceilings which have inadequate insulation.
- Vehicle access doors which may be left open for long periods.

Survey tips and tricks

- Check that monthly fuel demand varies in a rational way with changing weather (as recorded in published degree day figures).
- To measure temperature at high levels, use a digital thermometer with a thermocouple on the end of a long pole.
- A 1°C drop in average space temperature can cut fuel consumption by about 8%.
- Temporary datalogging can provide valuable evidence. As a minimum record the inside and outside air temperatures at ten-minute intervals. In 'wet' systems record the boiler casing or flue temperature to detect when the system starts and stops, and the circulation temperature to check that heat distribution is appropriately controlled.
- The rate of heat loss from a building can be estimated from the rate of temperature decay when the heating, lights and equipment are turned off at the end of the day.

Potential opportunities

- Fit improved heating system controls including possibly zone isolation. Additional features could include optimum start and weather compensation.
- Fit de-stratification fans to prevent warm air pooling at high level.
- Fit fast-acting roller shutter doors, or secondary doors to create an air lock.
- Ventilation fans controlled on indoor air quality (eg CO_2 sensing).
- Interlock loading-bay doors with heating.
- Use docking seals around vehicles during loading/unloading.
- In high-bay buildings, replace convective 'blown air' heaters with radiant tube or plaque heaters.
- Have the heating system rebalanced to prevent some areas having to be overheated in order to satisfy others.
- Replace electromechanical thermostats with electronic equivalents, which give more precise control. Use the opportunity to locate the thermostats in more appropriate positions.
- Fit thermostatic radiator valves in rooms which suffer from overheating.
- Fit black-bulb sensors to thermostats in areas served by radiant heaters.
- Where there is occasional out-of-hours working, provide an extension timer to avoid having to reset the main time control.
- Fit a seven-day programmable controller if circumstances warrant it. These can be applied not only to heating systems but also to mechanical ventilation.
- In mechanically-ventilated buildings, investigate the possibility of increased recirculation.
- Possibly recover heat from air compressors (for example).
- Implement two-stage frost protection (eg when below zero outside, start circulation pumps only; boilers not to fire until internal temperature falls below say 5°C)

Further information

CIBSE Guide F	Energy Efficiency in Buildings, Section 19.6
FEB 7	Degree days
FEB 3	Economic use of fired space heaters for industry and commerce
FEB 16	Economic thickness of insulation for existing industrial buildings
FEB 10	Controls and energy savings
GPG 132	Heating controls in small commercial and multi residential buildings
GPG 197	Energy efficient heat distribution

Case study

A local authority halved the cost of heating its surveyor's depot when someone discovered that a maintenance contractor had left the heating running 24 hours a day.

2.5 AIR CONDITIONING

Note: Survey Guide Sheets 2.2 (Ventilation) and 2.10 (Fans and Pumps) will also be relevant.

Things to look for

- Excessively-low cooling set point (say below 22°C).
- Lack of time control, excessive hours of operation, or risk of time-schedule being overridden.
- Excessively tight control of relative humidity.
- Blocked filters.
- Uninsulated supply ductwork.
- Portable electric heaters.
- Frost on pipework and fittings.
- Air-recirculation potential not exploited.
- Ventilation outside working hours (other than for free cooling benefit).
- Risk of simultaneous heating and cooling.
- Risk of doors and windows being left open, holes in building structure, or other infiltration routes.
- Risk of air exchange with non-conditioned spaces.
- Fouled evaporator or condenser coils.
- Electrical appliances (e.g. computer monitors) and lighting running unnecessarily.

Survey tricks and tips

- Log chiller run hours regularly to detect running during cool weather.
- Observe operating patterns of air conditioning chillers, cooling towers, etc., relative to outside conditions; look for excessive running or frequent on/off cycling.
- Compare refrigerant suction/discharge temperatures and condenser water temperatures on similar plant items. Significant differences may point to physical problems or incorrect settings.

Potential opportunities

- Discontinue control of relative humidity if possible.
- Consider alternatives to electric evaporative humidifiers.
- Increase air re-circulation.
- Make maximum use of fresh air for cooling, including pre-cooling at night.
- Implement enthalpy control.
- Selectively inhibit out-of-hours ventilation to optimise energy requirement.
- Provide 'spot cooling' systems for zones with year round cooling requirement, so that the main central system need only be operated seasonally.

Further information

- **CIBSE Guide F** Energy Efficiency in Buildings, Section 19.3
- **GPG 118** Managing energy use - minimising running costs of office equipment and related air-conditioning
- **GPG 290** Ventilation and cooling option appraisal - a client's guide
- **GPG 291** A designer's guide to the options for ventilation and cooling

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2.6 HOT WATER SERVICES

What to look for

- Summer immersion heaters running simultaneously with boilers, or at risk of doing so.
- Long runs of uninsulated hot water pipework.
- Hot taps being allowed to run to overflow.
- Hot water being used where cold water would suffice.
- Poor insulation on hot water storage vessels.
- Excessive temperatures at hot taps (unless essential for control of legionella).
- Unreasonable quantities of hot water being used (see Survey tips and tricks).

Survey tips and tricks

- If a hot water cylinder is fed from its own break tank you may be able to estimate the draw-off rate by shutting off the rising cold feed and timing the fall in water level.
- Clamp-on ultrasonic flow meters can be hired but are very prone to error and should be calibrated in situ, at least approximately.
- When measuring hot water flow, remember to account for secondary recirculation if necessary.
- Run a hot tap which has not been used for a while and time how long it takes to deliver hot water.
- Establish the number of full-time-equivalent occupants and how they use hot water, in order to estimate their requirements.

Potential opportunities

- Fit point-of-use water heaters in order to dispense with central storage and long distribution runs. These may be wall-mounted electric types in washrooms, or direct gas fired for catering and other larger users.
- Fit flow restrictors to wash hand basins.
- Fit time control to point-of-use heaters, immersion-heater elements, and secondary circulation pumps.
- If HW is generated from main heating boilers, consider alternative heat source for use outside heating season.
- If central HW generation is to be retained look for alternative heat sources such as hot process drains (beware contamination risk), flash steam or hot condensate.
- Rationalise multiple storage cylinders if demand is low relative to stored volumes.
- Recover heat from water-cooled equipment and processes.

Further information

- **GPG 188** Maintaining the efficient operation of heating and hot water systems a guide for managers

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2.7 COMPRESSED AIR SERVICES

Things to look for

- Air leaks; particularly on connectors, flanges, and flexible hoses.
- Are compressors running when there is no demand for air?
- Air intakes drawing in warmer air than necessary. Use the coldest possible air source to maximise compressor efficiency.
- Inappropriate uses. Low-grade duties (like swarf blowing, or agitating liquids in tanks) do not warrant clean, dry, air from the central system. See 'Potential opportunities'.
- Excessive distribution pressure. Higher pressure means greater losses through leaks and higher power requirement for the same delivered air volume.
- Dead legs on distribution pipework. These present a leakage risk.
- Safety valves operating frequently, or leaking continuously.
- Manual drains left cracked open.

Survey tricks and tips

- Look and listen. Are air-pressure safety valves operating? If so, control is inadequate. Can you hear air escaping during meal breaks and after hours? Are compressors starting and stopping frequently?
- If the compressors have hours-run meters, read them all at intervals through the day to see whether you have more units running than necessary.
- Compare on-load hours against total run hours to check for idle running.
- If the air supply is metered, read regularly through the day to establish patterns of use relative to production activity. Look for unexplained idle losses.
- Air meters can be unreliable. If a meter provides a chart recording, look for symptoms such as the trace being unexpectedly smooth, clipped off at maximum, or never returning to zero.
- After hours, shut off the compressors and either (a) record the rate at which pressure subsequently falls or (b) time the load/unload periods.
- A ten-percent air loss might be considered acceptable.
- Power delivered to air tools is ten times the cost of electricity to do the same job.
- Reducing air inlet temperature by 6°C increases output by 2%
- Ask how often the filters are replaced. Blocked filters cause pressure drop.

Potential opportunities

- Use low-pressure blowers for applications such as air knives, air lances, air agitation, blow guns, product ejection, powder transfer, etc.
- Control pressure at the point of critical demand, not necessarily at the compressor.
- Divert compressor cooling air to where heat is required. Look for a nearby application which could benefit from air preheat. Even preheating boiler combustion air is beneficial.
- Heat rejected from oil coolers can assist hot water generation.
- Fit improved control of central compressors. Computerised sequence controls could reduce compressor run hours and prevent air loss and wasted power through pressure overshoot.
- Fit zone-isolation valves. These can be under time control, or interlocked to the packing/production line served, to enable parts of the site to operate out of hours without air going to the whole works. If combined with a pressure gauge, local leakage tests would be possible.
- To permit zone isolation it may be necessary to rationalise air supply lines to eliminate cross-feeds between different production units.
- Install local air blowers for low-grade duties, for example, liquid agitation, where low pressure and high volumes of air are required without drying or filtering. A separate blower reduces demand on the central system and may permit a pressure reduction or reduced operating hours.
- Substitute alternatives for air tools. Would the operators prefer electric tools (especially cordless ones) capable of doing the same job? This is most beneficial where a whole zone of air supply can be cut out. But note: cordless tools are attractive targets for theft.
- When production is shut down, isolate constant bleed pneumatic controls.
- Use actuators to time blowers instead of constant air flow.
- Use specially-designed nozzles for blowing applications.
- Replace timed receiver drains with water-sensing or float traps.
- Switch to high-performance lubricants.
- Consider high-efficiency motors and variable-speed drives. See the Survey Guide Sheet 2.9 on Motors and Drives.

Further information

FEB 4	Compressed air and energy use
GPG 126	Compressing air costs
GPG 216	Energy saving in the filtration and drying of compressed air
GPG 241	Energy savings in the selection; control and maintenance of air compressors

Case history

In 1991 a vehicle manufacturer spent £32,000 on an automatic sequence control of its air compressors. Although electricity was then more expensive in real terms, the same project today would still yield an internal rate of return of 70%.

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2.8 CENTRAL VACUUM SERVICES

What to look for

- Air getting in through leaks.
- Ineffective closure flaps on vacuum hoses.
- Oversized nozzles on hoses.
- Redundant legs of vacuum pipework.
- Manual on/off control, with risk of out-of-hours running.
- Seal water running to drain from liquid-ring vacuum pumps.

Survey tips and tricks

Run vacuum pumps against shut-off conditions, and measure air flow in the outlet duct. This equates to upstream air in-leakage. Measure vacuum at inlet manifold under these conditions and compare with manufacturer's load curve. Low vacuum at the measured flowrate indicates loss of pump efficiency.

If necessary a manometer for low pressure differentials can be improvised from a length of transparent tubing bent into a 'U' with water in the bottom, but beware any risk of water getting into the measured system

Repeat these measurements at appropriate intervals (quarterly or annually) depending upon the degree of risk.

Potential opportunities

- Install variable-speed drive controls on vacuum manifold pressure.
- Consider refrigeration circuits for liquid-ring water cooling.
- Replace vacuum-pump motors with high efficiency equivalents.
- Upgrade complete vacuum pump sets with more efficient units during replacement.
- Where vacuum is provided for local cleaning of components and assemblies at workbenches, alternative methods (e.g. dedicated local systems or even brushes and pans) may be feasible (but consult the user).
- Increase system working pressure.

Further information

- **GPG 83** Energy efficient liquid ring vacuum pump installations in the paper industry
- **GPCS 127** Cooling and recirculating liquid ring sealing water

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2.9 ELECTRIC MOTORS AND DRIVES

Things to look for

- Driven equipment not doing a useful job.
- Oversized motors.
- Risk of unnecessary running.
- Voltage imbalance, low or high voltages, harmonic distortion or poor power factor.
- Unusually hot or noisy gearboxes.
- Worn or slack V-belts.
- Individual belt broken on multi-belt drive.
- Misaligned pulleys or couplings.
- Worn bearings in motors, driven equipment, or intermediate drive train.

Survey tips and tricks

- Start with the largest motors and longest running hours first.
- Pay particular attention to the noisiest machines.
- 3-phase motor power is derived from the ammeter reading (I) by the following formula, where V is the supply voltage and PF is the power factor (typically 0.8 - 0.9)

  $$\text{Power} = \frac{\sqrt{3} \times V \times I \times PF}{1000} \quad \text{(kW)}$$

  Compare the result with the motor's nameplate rating to see if it is only part-loaded.
- Thermal imaging equipment can help pinpoint frictional transmission losses.

Potential opportunities

- Introduce time switching.
- Fit automatic stop/start control (this might include motor load sensing).
- Substitute a high-efficiency motor when replacement is necessary.
- Consider soft-start controllers for intermittent running motors.
- Reduce losses in the driven equipment.
- Change pulley ratios to run driven equipment at optimum speed.
- If permanently lightly-loaded, switch to permanent star connection or fit a smaller motor.
- On a part-loaded multi-belt drive, remove one or more belts to leave only the minimum required for the power actually being transmitted.
- Consider variable speed drive or multi-speed motor depending on the circumstances.
- Where the duty toggles between high and low load, consider replacement with a multi-speed motor (up to four load steps may be accommodated by MSM).
- When V-belt pulleys need replacing opt for wedge belts (2% improvement) or synchronous, flat, or ribbed belts (5-6% improvement).
- Where possible replace gearboxes with variable speed direct drives.
- Adopt high-performance lubricants.

Further information

- **GPG 2** Energy savings with motors and drives
- **GPCS 215** Automatic switch-off of power presses
- **GPCS 219** Two-speed motors on ventilation fans
- **GPCS 337** Low cost speed reduction by changing pulley size
- **GPCS 170** Variable speed drives in a chemical plant
- **GPCS 222** Purchasing policy for higher efficiency motors
- **GIL 56** Energy savings from motor management policies

Case history

Changes at a food manufacturer had left them with excessive capacity on a pneumatic conveying system. They spent £58 on a new pulley for the blower (to reduce its speed from 2,420 to 1,700 rpm) and claimed annual savings of £4,960.

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2.10 FANS AND PUMPS

What to look for

- Unintended recirculation paths.
- Oversized motors.
- Excessive fan/pump speed.
- Excessive system resistance (for example because of dirty filters, stuck valves or dampers).
- Unbalanced distribution networks with excessive flow in some branches at the expense of others being starved of flow.

Survey tips and tricks

- Measure the flow and inlet/outlet pressures. Compare them not only with manufacturer's data but with system design intent.
- Air movement can be detected with tissue paper, a smoke generator, or even a child's bubble maker.
- Compare the performance of identical duty and standby units.

Potential opportunities

- Where fans and pumps have variable duties (controlled by dampers or valves), variable speed drives should be considered as an option.
- Inlet dampers are preferable to discharge dampers.
- Where fans or pumps are operating continually at part load, consider reducing the impeller size or changing the speed by using a different drive ratio.
- Avoid sharp bends in ducts or pipework and consider low-friction pipework when refitting.
- On a pumped distribution network, reduce general supply pressure and use a small booster pump for the index circuit.
- Rebalance any distribution system in which throttling valves or dampers are being used to regulate flow, so as to achieve design flow in all branches with the minimum total flow.
- On primary heating and chilling systems, replace three-port diverting valves with two-port valves and use variable-speed control of pumps to regulate pressure.

Further information

- **GPG 2** Energy savings with motors and drives
- **GPG 14** Retrofitting AC variable speed drives
- **GPCS 88** Variable speed drives on water pumps
- **GPCS 124** Variable speed drives on secondary refrigeration pumps
- **GPCS 170** Variable speed drives in a chemical plant
- **GPCS 215** Automatic switch-off of power presses
- **GPCS 219** Two-speed motors on ventilation fans
- **GPCS 222** Purchasing policy for higher efficiency motors
- **GPCS 232** Variable speed drives for wood dust extract fans
- **GPCS 300** Energy savings by reducing the size of a pump impeller
- **GPCS 337** Low cost speed reduction by changing pulley size

Case history

An airport operator fitted variable-speed drives to chilled-water circulating pumps in 1990, achieving payback of a £50,000 investment in just under two years. Even at today's lower real electricity prices, payback would still be less than three years, with an internal rate of return approaching 30%.

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2.11 BURNERS

Things to look for

- Poor burner tuning resulting in flue losses through excess air or unburned fuel (evidence by yellow flame, soot in flue-ways, etc.).
- Unusual-shaped or unstable flame.
- Flame impingement.
- No probe-hole in exhaust flue, making combustion tests impossible.
- Results from earlier combustion tests chalked up nearby.
- Combustion results identical from one test to another.
- Combustion test reports where the reported efficiency is inconsistent with measured parameters.

Survey tips and tricks

- If testing for combustion efficiency by means of CO_2 percentage, remember to test for smoke (in the case of oil and solid fuel) and carbon monoxide (in the case of gas). Without these measures it is impossible to say whether a given percentage of CO_2 represents lean or rich combustion; a rich mixture will cause losses in unburned fuel.
- Compare similar units. Is one appreciably better than the others?
- Where several items of combustion plant discharge into a common flue, beware the effects of variable suction. Record draught-gauge measurements.
- With pressure-jet oil burners, ask when the nozzles were last cleaned or replaced. It is often economical to replace them at every service; whereas 'cleaning' usually damages them.
- Look for hot spots on casings (may indicate impingement or refractory damage).
- Time on/off/purge cycles.

Potential opportunities

- Locate a source of preheated combustion air, such as the exhaust from a dryer or other waste heat, or even just ducting from the roof space. But note: if preheat is not consistent, this can cause the air:fuel ratio to vary.
- Consider direct recuperation.
- Reduce burner ratings to reduce stack exit temperature and minimise on-off cycling; or consider high/low or modulating burners.
- Use a larger number of smaller, self-proportioning burners.
- Improve combustion control; consider oxygen-trim control.
- Pressure-regulation of combustion chambers enables tighter adjustment of air:fuel ratio.
- In some high-temperature furnace applications, using pure oxygen instead of air can be economical and may for example give a hotter flame or better product quality.

Further information

- **GPCS 356** Conflict control of a combustion air fan on a large continuous furnace
- **GPG 252** Burners and their controls
- **GPCS 35** Variable speed drives on a boiler fan
- **GPCS 125** Variable speed drive on a batch furnace combustion air fan

Case history

In 1993 an engineering works installed recuperative burners, improved burner control, and fitted low-thermal-mass insulation to a heat treatment furnace. £21,000 investment was recovered in 1.5 years and the indicative internal rate of return at current fuel prices is just under 50%.

2.12 STEAM SYSTEMS

Things to look for

- Steam leaks.
- Missing, wet or damaged insulation.
- Flooding in pipe ducts.
- Steam traps passing steam.
- Steam traps not passing condensate.
- Condensate running to waste.
- Flash steam being lost from receivers and hotwell.
- Dead lengths of pipework, or long runs of pipework with very small users at the end.
- Potential water pockets caused by concentric reducers, large globe valves or wrongly-fitted strainers.
- Group trapping (several heat exchangers sharing one trap).
- Bypass valves on traps (not strictly necessary and may be left cracked open).
- Manual temperature control of process items.
- Condensate overflowing to waste at collecting points.
- Pipework which does not have a fall towards drain pockets.
- Low feed tank temperature.
- Manual control of dissolved solids.
- Unnecessarily-low total dissolved solids.
- Insufficient reserve volume in feed tank to accommodate peak condensate return during start-up.

Survey tricks and tips

- Ask the boilerman about the frequency and quality of maintenance.
- Steam traps may be fitted with sight glasses or 'Spiratec' devices to verify operation.
- Thermodynamic traps may be heard opening and closing frequently.

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- It may be possible to divert condensate temporarily downstream of the trap, into a bucket or barrel. Note the volume or weight at intervals,as a means of estimating steam demand. The weighing vessel must contain cold water because of the potential hazard of flash steam from the condensate.
- If condensate is pumped from a receiver of known volume, intermittently, timing the pumping cycles will provide a load estimate.
- Check the temperature of condensate pipework after each trap. If significantly below 100°C, the trap is not working.
- Put a temperature logger on blowdown pipework to record timing and duration of blowdown.
- Estimate the percentage of condensate returned to the boiler.
- Ineffective insulation in underground ducts can manifest itself through the ground drying unusually quickly after rain, frost clearing sooner, etc.

Potential opportunities

- Consider dispensing with steam and adopting alternative heating techniques.
- Rationalise pipework to reduce distances travelled (and reduce diameters where feasible).
- Make alternative provision for small loads at the ends of long dedicated pipe runs (or relocate them).
- Insulate fittings.
- Find a use for flash steam (e.g. sparging it into the feedwater tank or cascading to lower-pressure users) or use condensate coolers on calorifiers and heater batteries where feasible.
- Fit thermostatic air vents to reduce warming through times.
- Measure warming-up time to establish the minimun necessary
- Eliminate bypass valves on steam traps and if necessary fit better-matched traps.
- Fit automatic temperature controls in place of manual valves.
- Use an engine or turbine for pressure reduction.
- Reduce steam pressure if possible, to give improved performance and less flash-steam loss.
- Recover heat from boiler blowdown.
- Implement automatic TDS control on boilers.
- Reduce boiler pressure.
- Put a lid on the feed tank.
- Increase feed temperature to aid oxygen removal, reduce dosing requirements and resultant blowdown.
- Where steam is exclusively used at high pressure and there is no use for flash steam, consider using CBA pumps in a pressurised condensate return loop directly injected into the boiler feedwater (see GPCS 153 under 'Further information').
- If condensate is all dumped because of potential contamination risk, fit automatic quality measurement to control a diverting valve and recover what is safe to reuse.

Further information

ECG 66	Steam generation costs
ECG 67	Steam distribution costs
FEB 2	Steam
GPCS153	Differential drainage and boiler return system
GPG 18	Reducing consumption costs by steam metering
GPG 30	Energy efficient operation of industrial boilers
GPG 197	Energy efficient heat distribution

Case histories

A tyre manufacturer installed flash steam recovery and improved condensate collection, cutting boiler make-up from 70% to 10%. The project cost £20,000 and (including the incidental savings on boiler make-up water and chemicals) would yield an internal rate of return exceeding 100% at today's fuel prices.

A chemical company spent £21,000 insulating pipe fittings in 1994, achieving a nine-month payback period (equivalent to an internal rate of return of 170% at today's values).

A food ingredients manufacturer noticed that a fluidised-bed spray dryer was the only unit needing steam overnight. They fitted a standby electric air heater for overnight use, and proceeded to recover the £1,350 installation cost eight times a year.

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2.13 CRUSHING AND GRINDING

Things to look for

- Mill speeds higher than necessary; continuous running at lower speed and throughput is more efficient than intermittent operation at high speed.
- Crushing techniques used on too small particles, or grinding used on oversized particles (30 mm is the approximate energy-efficient particle size to change from crushing to grinding).
- Continuous stop/start operation because of downstream operations.

Survey tips and tricks

- Examine how size sampling is carried out.
- Question the method of control.

Potential opportunities

See also Survey Topic Guide 2.23, mechanical handling.

- Convert open to closed-circuit milling with efficient size separation.
- Fit higher-efficiency separators (on ball or roller mills).
- Replace ball mills with roller-based systems if feed conditions permit; or use roller mill for pre-grinding.
- Optimise mill internals, feed/discharge system, and milling parameters such as speed and air flow.
- Use buffer store if downstream operations impose stop/start regime.
- Fit variable speed drives, especially on fans.
- Use soft start on main motors.
- Improve instrumentation and control (for example using laser fineness sensors).
- Use grinding aids if product conditions permit, especially if increased throughput is required.

Further information

- **GPG 181** Energy efficient crushing and grinding systems
- **GPG 212** Reducing energy costs in flour milling

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2.14 MIXING AND BLENDING

What to look for

- Manual control of batch blending operation with inadequate end-point detection.
- Unnecessarily long mixing times.
- Lax ingredient control.
- Blade wear (increases mixing time).
- Inadequate insulation on mixing vessels.
- Use of compressed air to agitate mixtures.

Survey tips and tricks

- Record mixing times and look for suspicious inconsistencies.
- Question the nature and frequency of end-point tests.
- Try to identify physical properties which could be used to determine completeness.

Potential opportunities

- Convert to low-loss stirrers.
- Fit high efficiency motors.
- Optimise stirring speed.
- Improve end-point detection and control.
- Use soft start motor control.
- Consider intermittent rather than continuous mixing.
- Convert batch mixing processes to continuous.

Further information

- **ECG 20** Rubber compounding in the rubber processing industry
- **GIL 53** Optimising energy use in pulpers and refiners

Case history

A manufacturer of rubber seals put a soft-start motor controller on a 100 kW mixing mill motor which was operating four minutes on, six minutes off. The £1,600 investment (1990 prices) was paid back twice in the first year.

2.15 DRYING

What to look for

- Product over-dried.
- Manual control of end-point at operators' discretion.
- Raw material moisture higher than necessary, for example because of damp storage conditions.
- Excess airflow into dryers.
- Hot external surfaces on dryers (missing insulation).
- Dryers actually running empty, or able to do so.
- Air filters clogged or ripped.
- Air leaks into or out of the dryer.
- Airflow imbalance on multiple tunnel dryers (evidenced by wet or overdried product from different driers).

Survey tips and tricks

- In direct-fired dryers, variations in exhaust oxygen content will indicate the degree of dilution by air ingress.
- Measure the moisture content of the dried product as it enters the next process stage, especially if it goes through a buffer store. Drying below this 'natural regain' moisture level is pointless.
- Measure the energy input per kg of water evaporated. Compare this against dryer manufacturer's data sheets, or one dryer against another.
- Repeat the measurement from time to time to guard against future deterioration in performance.
- In theory a perfectly efficient dryer would require only 0.63 kWh of input energy per kg of water removed.

Potential opportunities

- Prevent accidental moisture gains to feedstock.
- Mechanical de-watering (pressing, centrifuging, etc.) can reduce the need for thermal drying.
- Preheating the feedstock may aid drying.
- Avoid high air supply temperatures and use more air if necessary.
- Insulate dryer casings to reduce heat loss.
- Fit recirculation fans to improve internal velocities, reduce dead spots, and maximise relative humidity in exhaust.
- Recover heat from exhaust air. If contaminated by dust, etc., consider use as preheated combustion air.
- Control dryer end-point automatically, for example on exhaust relative humidity.
- Two-stage drying may be more economical when the product contains both large and small particles.
- Investigate whether the output dryness specification can be relaxed.
- Are you drying product to stabilise for storage pending subsequent processes which add water? If so, can storage be eliminated?
- Mechanical de-watering of powders (and subsequent drying) can both be accelerated by reducing the proportion of fines.
- Where product is conveyed on perforated belts or trays, reduce the blank supporting area under the product.
- Increase air velocity over the product.
- Subdivide or granulate the product.
- In direct-fired dryers, if dilution air is introduced before the combustion zone, mix it after the combustion zone instead to avoid flame chilling.
- Cascade chamber dryers from dry through intermediate to wet, reheating as required to avoid condensation.
- Reduce supply air temperatures over weekend closures if full of partially-dry product.
- On major processes use mechanical vapour recompression to recover exhaust heat.
- Consider matching CHP to a continuous drying system.

Further information

- **GPG 66** Rotary drying in the chemical industry
- **GPG 149** Rotary drying in the food and drink industry (page 18 shows a method for calculating rough gas balances)
- **GPG 185** Spray drying
- **GPG 243** Drying of particulate solids - survey finding and auditing guide
- **GPG 248** Energy efficient operation of dryers in the ceramics industries
- **GPG 343** Model-based predictive control systems

Case histories

A chinaware manufacturer dispensed with 'open-shop' drying in favour of a microwave/vacuum dryer costing £562,500. The investment would have yielded an estimated 45% internal rate of return at today's prices.

A major sugar factory implemented model-based predictive control of dryers in 1996. The project gave energy savings, increased yield, and quality improvements which at today's fuel prices equate to an internal rate of return of 120%.

An animal-feed producer eliminated some dryers completely by rebranding the product and selling it undried.

2.16 BAKING AND CURING

Things to look for

- Part-loaded ovens or autoclaves.
- Excessive equipment preheat times.
- Oven doors left open longer than necessary.
- Air ingress especially at seals, sightholes, access panels.
- Potential useful heat gains to surrounding space.
- Plant in unnecessarily cold or exposed location.
- Incorrect damper settings.
- Excessive exhaust volumes.

Survey tricks and tips

- Use a datalogger to record local air temperature above oven doors.

Potential opportunities

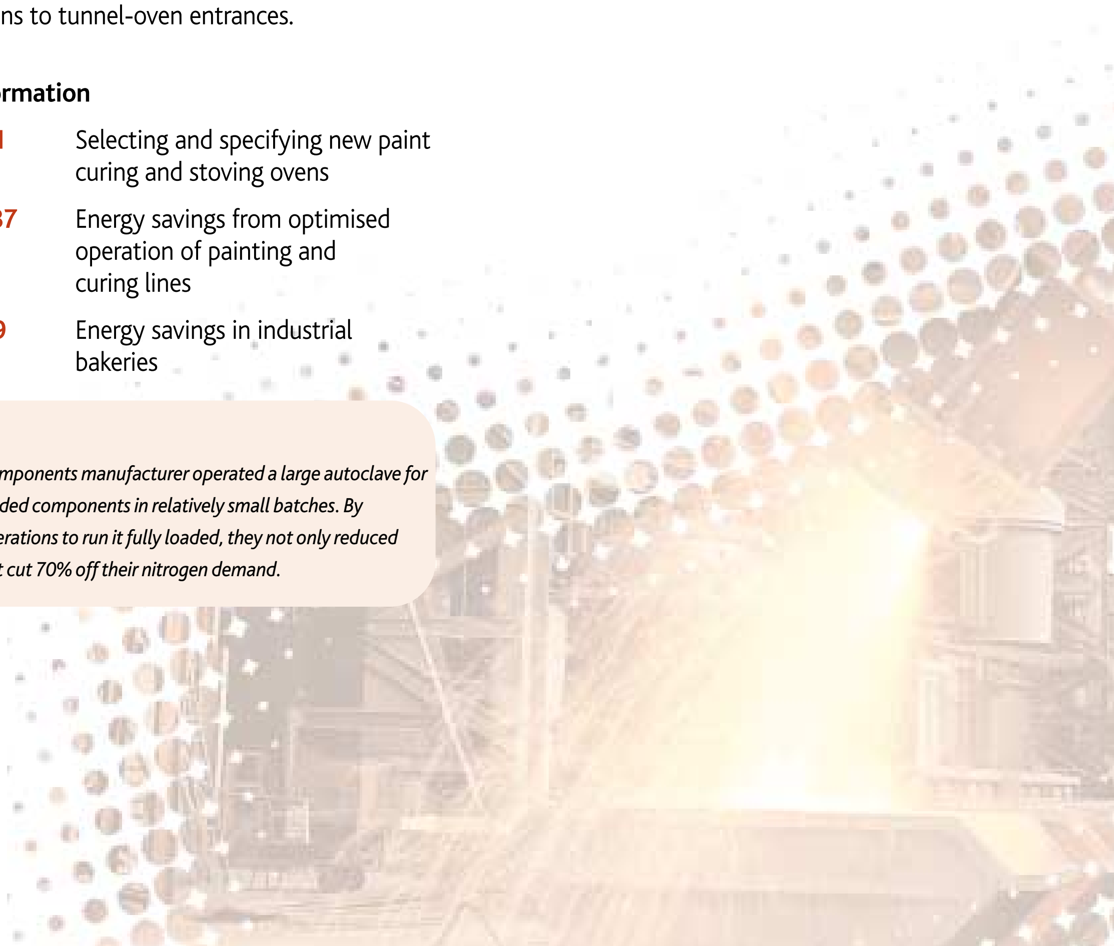
- Optimise loading schedules to operate equipment for shorter periods at full capacity.
- Use combined heat and power.
- Review supply options, eg, substitute gas for steam or radiant tube; electric radiant; microwave; gas radiant, etc.
- Fit curtains to tunnel-oven entrances.

Further information

- **GPG 271** Selecting and specifying new paint curing and stoving ovens
- **GPCS 387** Energy savings from optimised operation of painting and curing lines
- **GPG 309** Energy savings in industrial bakeries

Case study

An aerospace components manufacturer operated a large autoclave for curing resin-bonded components in relatively small batches. By rescheduling operations to run it fully loaded, they not only reduced energy costs, but cut 70% off their nitrogen demand.



2.17 MACHINING, FORMING, AND FABRICATION

What to look for

- Auxiliaries such as hydraulic packs, coolant pumps, waste removal, etc., running on idle machines.
- Hydraulics, compressors, chillers and other services or auxiliaries able to run when main machine is idle.
- Uninsulated cooling systems.
- Dirty skylights.
- Blunt tooling.
- Open or slow-acting vehicle access doors.
- Incorrect temperature settings on product cooling or baking.
- Worn extruder screw surfaces.

See also Survey Guide Sheets 2.1 (Lighting), 2.7 (Compressed air), 2.8 (Central vacuum), 2.18 (Treatment booths/cabinets)

Survey tips and tricks

- Fit run-hours meters (if not already present) and reconcile running hours of auxiliaries against work schedules.
- Compare similar machines and use the fastest or most efficient as the benchmark.
- Canvass the views of machine operators.
- Observe operations during meal breaks and other quiet periods.

Potential opportunities

- Interlock auxiliaries to the main machines which they serve.
- Use machines with lowest specific energy consumption.
- Fit high-efficiency motors when replacing failed ones.
- Replace centralised heat supply with locally controlled gas radiant heaters.
- Fit power-factor correction capacitors if necessary.
- Implement zoning and variable speed pumps on central cutting-fluid systems.
- Recover waste lubricating oil for use as heating fuel.
- Fit quick-acting doors for vehicle access.
- Redecorate in lighter shades for improved illumination.
- Fit destratification fans in high-bay buildings.
- Insulate barrels of plastics extrusion presses.
- Change to near-final-size castings.
- Variable-speed AC drives to replace failed DC drives (for example on filament or film uptake drives).
- Variable-speed drives on hydraulic packs to limit pressure or spill-back when off load.
- Optimise source of compressed air for blowing (eg poly bottles).
- Soft-start motor controllers.
- Additives to assist flow of polymers.
- Improved lubrication.

Further information

- **GPG 48** Reducing electricity use in injection moulding
- **GPG 92** Reducing electricity use in extrusion-blow moulding of thermoplastic
- **GPG 239** Energy efficient thermoplastics extrusion
- **GPG 292** Energy in plastics processing – a practical guide
- **GPCS 215** Automatic switch-off of power presses

Case histories

A company making metal pressings spent £630 on controls which automatically turned off motors on presses which had been idle for a preset period. At today's prices the project would have yielded close to 100% internal rate of return.

An injection moulding company put heat shields around heated press platens at a cost of £2,000. At today's prices this project's internal rate of return would have been about 200%.

Another injection moulding company spent £500 in the early 1990's on timers to turn off the heaters on idle presses. They recouped their investment once a month thereafter.

2.18 TANKS AND VATS

Things to look for

- Tanks preheated for excessive periods.
- Tanks heated while not in use.
- Lack of insulation (including associated pipelines).
- Lack of lids on tanks.
- Oversized tanks or levels higher than needed.
- Excessive extract air velocities over exposed liquid surfaces.
- Continuous uncontrolled top-up and overflow or run to waste.
- Excessive or unwarranted agitation.
- Agitation by compressed air from a high-quality central source.
- Tank contents boiling when 95°C would be effective.
- Steam blowing through directly-heated tank contents.
- Local ventilation extract drawing air from general heated space.

Survey tricks and tips

- On vessels open to atmosphere, look for temperature controls set at 100°C (impossible to achieve without risk of boiling).
- Assess tank leakage by observing how the fluid level falls when not topping up.

Potential opportunities

- Reduce temperature if only being maintained to assist drainage from treated parts; consider alternative methods of accelerating drainage if necessary.
- Use lids or ball blankets to reduce heat loss and evaporation.
- Local fresh air supply duct to conserve heated air in surrounding space.
- Use contra-flow arrangement for sequential rinsing tanks.
- Where there are steam coils and condensate is dumped because of contamination risk, consider direct steam injection via sparge pipe.
- Consider switching to direct gas firing where appropriate.
- Maintain lowest possible tank level.
- Insulate sides and bottoms of tanks.
- Recover heat from effluent fluid.

Further information

- **FEB 19** Process plant insulation and fuel efficiency
- **GPCS 133** External spray insulation on furnace regenerators
- **GPCS 30** Heat recovery from contaminated effluent
- **NPCS 122** Reducing tank evaporative losses using hexagonal floats

Case histories

A supplier of colours, glazes and clays to the pottery industry added microprocessor control to reduce unnecessary stirring of agitator tanks. Although the project cost £56,000 in 1985, it achieved a 1.3 year payback and even at today's lower real electricity prices it would give an internal rate of return of 45%.

A manufacturer of decorative tiles went further and switched off agitation of glaze tanks completely outside working hours, saving £16,000 a year without prejudicing quality, and achieving 100% IRR.

A maker of metal tubing used floating hexagonal polypropylene shapes to insulate the fluid surfaces of treatment tanks. For an investment of £2,500 he saved an estimated £4,000 a year, giving an internal rate of return of the order of 1,000%.

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2.19 TREATMENT BOOTHS AND CABINETS

Things to look for

- Lighting or air extract running, or able to run, when not required (Note: containment booths need to run continuously).
- General ventilation relied on where local extract could be applied.
- Local extract systems drawing heated air from surrounding space.
- Inadequate insulation if heated or cooled.
- Defective seals where airtightness is needed.
- Common air extract from multiple cabinets.
- Unnecessarily high air extraction rates.

Survey tips and tricks

- Use smoke generator or strips of tissue to track air movement.
- Use the site's list of local extract ventilation (LEV) equipment as a checklist.
- Observe pattern of use, especially during breaks.

Potential opportunities

- Arrange air extract and cabinet lighting to run on demand, with automatic switch-off.
- Recover exhaust heat.
- Arrange dedicated extract for lightly-used cabinets.
- Install dedicated fresh air supply ducts to avoid drawing in heated air.
- Implement reduced or variable fan speed.
- Fit more-efficient fans.

Further information

- **GPG 303** The designer's guide to energy efficient industrial buildings

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2.20 HIGH TEMPERATURE PROCESSES

Things to look for

Note: see also Survey Guide Sheet 2.11 (Burners)

- Evidence of unnecessarily long preheat periods.
- Unnecessarily high processing temperatures.
- Extended holding periods at high temperature (for example while awaiting results of chemical analysis on product).
- Batch process plant maintained at temperature between charges.
- Batch oven/furnace doors left open for longer than necessary.
- Evidence on external casing of hot gas leakage.
- Product allowed to pick up moisture between dryer and kiln.

Survey tricks and tips

- A thermocouple on the end of a pole can be used to check surface temperatures on large plant.
- Use infra-red thermography to detect hot spots.
- Compare actual energy ratio per tonne with theoretical requirement based on specific heats and temperature rise.

Potential opportunities

- Maximise hearth loading.
- Automatic pressure control of furnaces permits tighter control of combustion efficiency.
- Reduce furnace temperatures if excessive.
- If heavy refractory lining is used in an intermittent furnace, replace inner face with a ceramic-fibre insulation blanket or tiles.
- Move stock into heated space if stored outside; preheat further if suitable waste heat sources are available.
- Where parts need to be reheated for successive operations, use insulated transit containers.
- Fit permeable radiation walls in furnaces.
- Recover heat from exhaust.
- Reduce the mass of refractory furniture in tunnel kilns.
- Optimise speed of kilning.
- Use direct gas firing if possible on furnaces with radiant tubes, or electric induction for metal heating or melting.
- Reduce air ingress into tunnel kilns using end doors.
- Ensure sand traps create an effective seal.
- Subject to product requirements, aim for lowest oxygen content at exhaust.
- Use hot-gas recirculation to reduce temperature stratification and promote heat transfer to product.
- Transfer clay goods direct to kiln from dryer to avoid moisture pickup.

Further information

- **GPG 50** Efficient operation of coreless induction furnaces
- **GPG 77** Continuous steel reheating furnaces: operation and maintenance
- **GPG 164** Energy efficient operation of kilns in the ceramic industries
- **GPG 244** The use of low thermal mass materials and systems in the ceramic industries
- **GPG 252** Burners and their controls
- **GPG 253** A manager's guide to optimising furnace performance
- **GPG 255** Electroheating in industry: making the right choice
- **GPCS 135** Furnace scheduling advisory system
- **GPCS 160** Expert system improves performance of PLC controlled plant

Case histories

A forge installed a fluid-bed furnace for heating bar ends, replacing a less efficient conventional furnace. Their investment of £45,000 in 1984 offered a payback every 8 months, which translates into an internal rate of return of 70% (in today's terms).

A glass container manufacturer installed recuperative heat recovery at a cost of £16,000, giving a present-day internal rate of return exceeding 80%.

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2.21 COOLING SYSTEMS

What to look for

- Fouling of cooling tower.
- Uninsulated pipework and fittings.
- Excessively low chilling medium temperatures.
- For an air-cooled condenser, check for short-circuit air path to evaporator inlet.
- Air bypass or recirculation in cooling towers.
- Fouled coils, air filters, air inlet screens or cooling tower spray nozzles.
- Excessive cooling water flow rate and hence pumping power.
- Abnormal temperatures or pressures in refrigeration circuit; avoid low evaporating temperatures.
- Multiple cooling towers with more units running than necessary.

Survey tips and tricks

- The temperature efficiency of a water cooled condenser can be checked against the manufacturer's specification.
- Measure refrigerant liquid temperature upstream and downstream of the strainer. A high differential implies clogging.
- Excessive cooling water flow rate can be inferred from lower-than-expected temperature rise.

Potential opportunities

- Inhibit chillers below a certain ambient temperature, or exploit other free cooling potential.
- Satisfy localised winter cooling demand with dedicated package chillers instead of a central system.
- Fit a chiller load management system.
- Raise the chilled water temperature to its feasible limit.
- Where duty is shared by diverse chillers, optimise by letting the best take the lead.
- Use thermal storage to smooth the load profile, reduce start/stop cycling, maximise use of most efficient chiller, and possibly stand down excess capacity.
- Buy in liquid nitrogen rather than generating on site.

Further information

- **GPG 38** Commercial refrigeration plant: energy efficient installation
- **GPG 42** Industrial refrigeration plant: energy efficient operation and maintenance
- **GPG 44** Industrial refrigeration plant: energy efficient design
- **GPG 59** Energy efficient selection and operation of refrigeration compressors
- **GPG 225** Industrial cooling water systems
- **GPG 256** An introduction to absorption cooling
- **GPG 278** Purchasing efficient refrigeration – the value for money option
- **GPG 279** Running refrigeration plant efficiently – a cost saving guide for owners
- **GPG 280** Energy efficient refrigeration technology – the fundamentals
- **GPG 283** Designing energy efficient refrigeration plant
- **CG 7** Energy efficient cooling water systems in chemicals manufacture
- **FEB 11** The economic use of refrigeration plant
- **GIL 52** The engine of the refrigeration system: selecting and running compressors for maximum efficiency
- **GPCS 301** Use of larger condensers to Improve refrigeration efficiency
- **GPCS 302** Improving refrigeration performance using electronic expansion valves

Case history

An acid manufacturer installed heat recovery on an exothermic process at a cost of £51,000. The equivalent internal rate of return in today's terms would be 10%.

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2.22 HEAT RECOVERY

Note: heat recovery is itself sometimes an opportunity. These points concern opportunities to improve existing heat-recovery installations.

Things to look for

- Fouled heat exchangers.
- Fans fouled, worn, or even stopped.
- In air re-circulation systems verify operation of control dampers.
- Incorrect configuration or control of batch heat reclaim.
- Lost fluid or failed pumps in run-around coil system.
- Dumping of heat because of mismatched sources and loads.

Survey tips and tricks

- Check temperature differentials against manufacturer's specification or original design intent.
- Compare temperature efficiencies of similar units.
- Note the temperature and heat content of the high-temperature stream at outlet, in case there is potential for further heat recovery.

Potential opportunities

- On HVAC, inhibit heat recovery between 16-24°C to prevent heat gain to chiller plant.
- Consider variable-speed drives on fans and pumps.
- Fit thermal storage to improve utilisation where heat is being dumped because of mismatched supply and demand profiles.

Further information

- **GPG 13** Guidance notes for the implementation of heat recovery from high temperature waste streams
- **GPG 242** Process integration
- **GPG 89** Guide to compact heat exchangers
- **GPCS 355** The use of pinch technology in a food processing factory
- **GPG 141** Waste heat recovery in the process industries
- **VI004** Low temperature heat recovery

Case histories

An animal-feed producer had bypassed a heat recovery unit because it was fouled and thought to be beyond repair. An enterprising employee devised a method of unblocking it, which was done at a cost of £1,000 including equipment hire. Once recommissioned, it resumed saving £30,000 a year.

A dairy ran into a constraint on increasing output because it appeared to be short of chiller capacity for cooling the milk output from its pasteurisers. However, on investigation, it was found that the pasteuriser's regenerator was performing well below industry norms. The regenerator partly cools the milk output by exchanging heat with the cold input stream. By improving the regenerator heat exchanger, at a cost of £25,000, the company obviated the need to spend £150,000 on a new chiller and incidentally saved £10,000 a year on electricity.

2.23 MECHANICAL HANDLING

Things to look for

- Conveyors running empty.
- Motors running lightly loaded.
- Compressed air used for positioning or sorting without proper nozzles.
- Compressed air bleeding during inactive periods.
- Electric trucks charged during daytime tariff period.

In pneumatic handling systems:

- Dust on fan blades or filters.
- Air leaks.
- Transport velocities higher than necessary.

Survey tricks and tips

- Use infra-red thermography to detect hot spots caused by friction.
- Listen for air being discharged when handling system is idle.
- Stand and watch during production, at breaks, and during shift changes.

Potential opportunities

- Reduce the thermal capacity of conveying equipment and transit containers which go through heating or chilling equipment.
- Optimise carrying capacity; use buffer stores to isolate from downstream stoppages.
- Reduce distances and minimise or eliminate vertical lifts.
- Use control with sensors to enable conveyors to run only on demand (ideally combined with short runs).
- Manually control to run intermittently at full load rather than continuously at part load or empty.
- Replace pneumatic conveyors with bucket conveyors or other mechanical alternatives.
- Apply low-friction coatings to conveyors.
- Where conveyors pass through heated process equipment, insulate the return leg, route it through the heated equipment, or cool it to preheat air.
- Where product passes from heating to cooling zone, use separate conveyors.
- Fit purpose-designed nozzles and isolating valves to air jets.
- If possible, charge truck batteries overnight; if this is not possible, at least avoid charging on winter weekday afternoons.

Further information

- **GPCS 222** Purchasing policy for higher efficiency motors
- **GPG 63** Metal distribution and handling in iron foundries

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2.24 MOTOR TRANSPORT

Things to look for

- Unexplained discrepancies in fuel consumption.
- Vehicles left with engines idling.

Survey tips and tricks

- Check vehicle mileage and fuel consumption records.
- Analyse performance by driver if vehicles are pooled or shared.
- Check tyre pressures.
- Compare similar vehicles doing similar duties.
- Ask how routes and loads are planned.

Potential opportunities

- Provide driver training.
- Improve load and route planning.
- Improve vehicle aerodynamics.
- Use alternative-fuel vehicles, at least for intra-site duties.
- Outsource transportation.

Further information

- **ECG 59** Fuel consumption in freight haulage fleets
- **ECG 64** Fuel consumption in UK car and van fleets
- **FEB 20** Energy efficiency in road transport
- **GPCS 311** Energy saving through improved driver training
- **GPCS 342** Fuel management for transport operations
- **GPG 218** Fuel-efficient fleet management
- **GPG 307** Fuel management guide

Case history

A parcel delivery company provided driver training and achieved a 14% reduction in fuel use.

2.25 ON-SITE CATERING

Things to look for

- Kitchen ranges turned on before they are needed.
- Kitchen ranges used as source of space heating.
- Vending machines running 24 hours per day.
- Badly-fitting door seals on refrigerators and freezers.
- Hot water left running into kitchen sinks.
- Kitchen ventilation fans drawing heated air from dining area.
- No 'night blinds' on chilled display cabinets.
- Ovens and sterilisers preheated for excessive periods.
- Dishwasher running part-loaded or empty.
- Fridges and freezers next to heat sources.
- Inadequate ventilation for condenser units of cold rooms.
- Heated cabinets or counter display lighting left running.
- Vigorous boiling of unlidded pans.

Survey tricks and tips

- If kitchen supplies are sub-metered, take frequent readings throughout the day to establish patterns of demand.
- Visit directly after meal time to see if cooking equipment is still running.
- Observe activity during preparation period at start of working day.
- Gas consumption during summer months may indicate catering demand.

Potential opportunities

- Provide energy training for catering staff.
- Fit soft-start motor controllers on freezers, refrigerators, and chilled display cabinets.
- Fit night blinds on open chilled display cabinets.
- Control vending machines, bains maries, heated cabinets, and counter lighting by timeswitches.
- Heat recovery from kitchen extract.
- Motor controllers on refrigerators and freezers.
- Provide efficient fixed water boilers to obviate the need for kettles.
- Replace conventional ovens with microwave cookers in mess rooms.

Further information

- **GPG 222** Reducing catering costs through energy efficiency
- **GPCS 223** Night blinds on refrigerated cabinets
- **GPCS 350** Strip curtains on chilled display cabinets
- **EEB002** Catering establishments

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2.26 BUILDING FABRIC

Things to look for

- Poorly-utilised space.
- Doors and windows propped open.
- Broken windows and rooflights.
- Dirty windows and rooflights.
- Holes in walls or roof.
- Substandard or damaged insulation.
- Damp which may have compromised existing insulation.
- Substandard or damaged draughtproofing.

Survey tricks and tips

- An infra-red camera can be used on cold nights to detect hot spots (from outside) or cold spots (from inside).
- A bubble-maker or smoke generator can be used to sense unwanted air movement.
- A building's heat loss characteristics can be estimated from the rate of temperature decay at the end of the working day, taking outside temperature into account.

Potential opportunities

- Repair holes and broken windows.
- Apply draughtproofing.
- Apply insulation.
- Clad and insulate over roof lights.
- Fit air-locks or high-speed doors.

Further information

- Building Regulations, Part L
- **CIBSE Guide F** Energy Efficiency in Buildings, Section 19.1
- **CIBSE AM5: 1991 -** Energy Audits and Surveys
- **CIBSE TM22**
- **GPG 139** Draught stripping of existing doors & windows
- **GPG 303** The designer's guide to energy efficient buildings for industry
- **GPG 304** The purchaser's guide to energy efficient buildings for industry

Case study

In 1989 a steel company applied sprayed insulation to a corrugated roof. Their investment of £235,000 would have yielded a 10% internal rate of return at current fuel prices.

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survey pro formas and reporting

data sheets for recording survey data and results

3

survey pro formas and reporting

data sheets for recording survey data and results

3.1 SITE ENERGY CONSUMPTION AND EXPENDITURE

Tables like these can be used to record information about annual energy consumption and expenditure. Table 3.1.A is applicable in all cases, and is typical of the background information which would normally be recorded in a consultant's report.

Table 3.1.A: Site total statistics (actual)

A table in this form could be used to record statistics for at least the most recent year, and preferably two years. The 'quantity purchased' and 'cost' columns can be completed by aggregating data from invoices for the year(s) in question. The CO_2 figure must be derived by applying the conversion factors shown below, if necessary first converting quantities into kWh units.

Table 3.1.B Major energy-using equipment

Where possible, you should estimate the annual energy used in major plant items (or in services such as heating or lighting). This will later help you to estimate likely savings. Where dedicated submeters are not fitted, it may be possible to infer consumption from the equipment nameplate rating, by making assumptions about annual running hours. Note that some equipment may be fitted with hours-run counters to facilitate this.

The cost column can be calculated by multiplying the units consumed by the prevailing price. To avoid overstating any likely savings, it is better to use the marginal unit price rather than the average cost per unit of energy. The marginal price is the amount saved by consuming one unit less than expected.

Table 3.1.A

		Year: Jan-Dec 2001			
Energy source	Units of delivery	Quantity purchased (in original units)	Quantity purchased (converted to kWh)	Cost (£)	CO_2 (kg)
Electricity	kWh	46,789,012	46,789,012	£1,871,560	20,119,000
Gas	kWh	9,876,543	9,876,543	£79,012	1,876,000
Oil (35 second)	litres	23,400	248,040	£4,680	6,000
LPG	kg	5,000	68,900	£920	9,000
	Totals		**56,982,495**	**1,956,172**	**22,010,000**

Table 3.1.B

Plant item description	Utility	Annual units consumed	Annual cost
Air compressor	Electricity N/A	120,000 kWh N/A	£4,000 N/A
Curing Oven 1	Gas Electricity	230,000 kWh 2,400 kWh	£2,000 £800
Etc.	Etc.		

3.2 REGISTER OF SOURCES OF DATA FOR CONSUMPTIONS AND THEIR 'DRIVERS'

These tables provide a site-specific record detailing the sources of data which might be needed for analysis or for future regular monitoring. Although not essential for the purposes of the survey, completing tables like these is good practice and will at least help to ensure that all the requisite information could be obtained if needed later.

Failure to account for 'drivers' (the things which determine demand), when analysing patterns of energy consumption, is a prevalent management fault.

These tables are provided as templates, and may not give you enough room for your entries. You should prepare your own versions with more appropriate layouts, and with provision for more than the four entries illustrated here.

Note: The tables refer to EACs (energy accountable centres). Some managers notionally split their businesses into EACs to improve energy accountability. An EAC usually has these attributes:

- The ability to measure energy flows into it.
- The ability to measure production output from it (or some other determinant of demand).
- A person accountable for the energy used.

Table 3.2.A: Consumption drivers

Energy consumption depends upon the amount of work being done - be it production activity, or space heating to provide comfort in cold weather. Consumption patterns cannot be analysed without reference to these driving factors, and therefore if setting up an energy monitoring scheme, it will be necessary to record them as frequently as the meter readings.

Table 3.2.A

Consumption drivers (eg production, weather, etc)	Unit of measurement (eg tonnes, degree days, etc)	Where is the data available for routine weekly updates?	Which EAC(s) does this relate to?
A1 Popcorn throughput	Cartons	Packing dept	Packing
A2 Biscuit production	Tonnes	Bakery production planning	Bakery
A3 Toffee production	Tonnes	Work study dept	Confectionery
A4 Heating demand	Degree days	Web	Offices and stores

Table 3.2.B: Consumption streams – metered

This table catalogues the available energy consumption meters. The information collected about individual meters could subsequently help, for example, to resolve discrepancies in meter-reading records.

Table 3.2.B

Energy source (eg electricity, gas)	Zone or item served	Meter location	Serial number	Units (eg kWh x 10)	Digits on readout	EAC served
B1 Electricity KWh 6 All		Whole site reception	Intake near		ABC123XYZ	
B2 Gas	Whole site	Canal gate	DEF456	Hu cu ft	4	All
B3 Gas 4 Heating	Main boilers	house	Rear of boiler		9876543	M^3

Table 3.2.C: Consumption streams – unmetered

Some energy sources, notably oil, solid fuel and liquefied petroleum gas, are delivered in bulk and stored on site without any provision to meter the quantities used. Failure to measure the consumption, as opposed to deliveries, is a common management fault. Completing this table will help to ensure that consumptions can be calculated from successive stock-level records after taking account of intervening deliveries.

Table 3.2.C

Energy source (eg LPG, oil)	Location of storage	Storage capacity	Units (eg litre)	Method of measuring stocks	EAC served
C1 Oil on tank	Rear of staff car park Heating		20,000	Litre	Sight gauge
C2 etc					
C3					
C4					

3.3 METER READING PRO FORMA

Regular recording of energy consumption (and of the factors which determine how much energy is used) is fundamental to the good management of energy resources. The following pro forma weekly return sheet should first be customised, by completing the shaded boxes only, to suit the specific site where it will be used. The customised sheet can then be used as a master copy for routine weekly return forms. If the design below does not suit your needs, use it as a template for your own design.

The body of the form is in three parts:

- Determinants of demand (consumption drivers).
- Metered supplies.
- Unmetered supplies.

These correspond to the three tables in Section 3.2 above, where the correspond static information is recorded.

Note that the columns headed 'Previous reading' and 'Previous stock level' in parts B and C may not be necessary if you are entering data into a database or spreadsheet where the previous data are already stored.

Weekly energy return

Site name ______________________

Date of return ______________________

Time of readings ______________________

Part A: Consumption drivers

Description	Units	Quantity
A1		
A2		
A3		
A4		

Part B: Metered supplies

Meter or submeter	Units	Current reading	Previous reading
B1			
B2			
B3			
B4			

Part C: Unmetered supplies

Commodity/delivery point	Units	Stock in hand	Previous stock level	Deliveries received
C1				
C2				
C3				
C4				

Name of person making the return **Signature** **Date**

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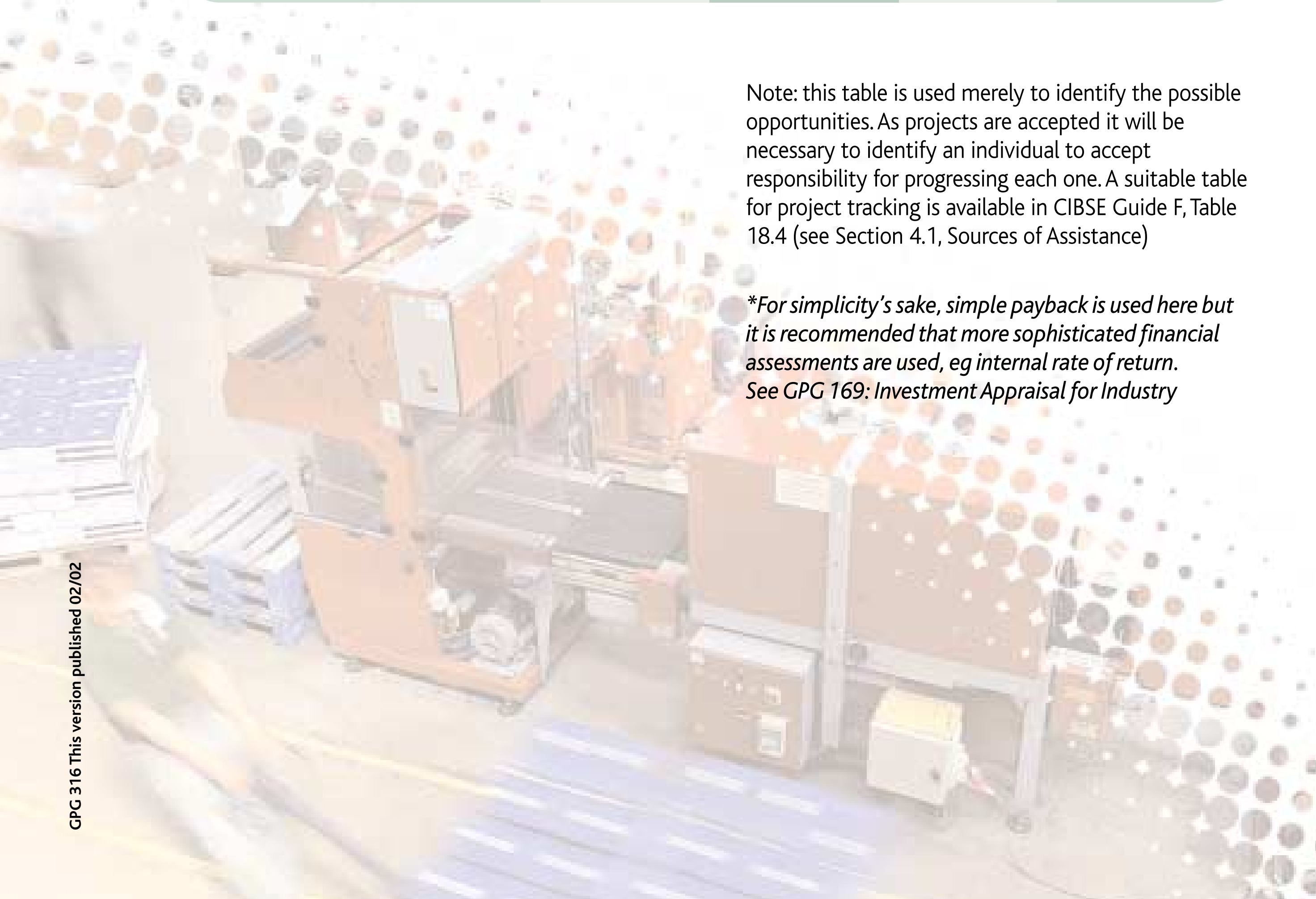
3.4 SCHEDULE OF IDENTIFIED OPPORTUNITIES

A table of this form can be used to register the potential energy-saving projects for which funding might be sought. For example, one measure identified might be a recirculation fan on a dryer. If this had an implementation cost of £4,000, recurring annual costs of £200 (for extra electricity) and expected annual cash savings of £1,200 (through reduced gas consumption), it would offer a simple payback period of 4,000/(1,200-200) = 4 years.

Measure identified	Estimated implementation cost	Recurring annual costs thereafter	Expected annual cash savings	Simple payback* (years)
Destratification fans in packing hall	£3,000	£200	£1,200	3
Draughtproofing offices	£2,000	Nil	£1,000	2
Agitators in intermittent mode at night	£600	Nil	£3,000	0.2
Etc.				



Note: this table is used merely to identify the possible opportunities. As projects are accepted it will be necessary to identify an individual to accept responsibility for progressing each one. A suitable table for project tracking is available in CIBSE Guide F, Table 18.4 (see Section 4.1, Sources of Assistance)

**For simplicity's sake, simple payback is used here but it is recommended that more sophisticated financial assessments are used, eg internal rate of return. See GPG 169: Investment Appraisal for Industry*

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4

reference

supporting data, and sources of further advice

4

reference

supporting data, and sources of further advice

4.1 SOURCES OF ASSISTANCE

The Environment and Energy Helpline (0800 585794)

This service can provide quick answers to simple questions related to energy efficiency and is particularly useful as a starting point for those new to energy saving. Contact the Helpline for free advice and publications from the EEBPP.

Energy Efficiency Best Practice Programme (www.energy-efficiency.gov.uk)

Nearly all the documents cited in the 'further information' sections of this Guide are available free of charge from this Government programme, and can be ordered via the Environment and Energy Helpline or this web site. Many are even available online for immediate downloading. See Institute of Energy for how to obtain the Standards for Managing Energy.

Envirowise (www.envirowise.gov.uk)

This programme can help with wider aspects of waste minimisation. It features a Fast Track visit, which is a confidential on-site waste review, available to companies with fewer than 250 staff. Within the space of one day, a consultant will identify waste minimisation opportunities, and help you plan to make these savings a reality.

Action Energy (www.energy-efficiency.gov.uk)

This is a grant scheme to support the provision of energy-saving advice from consultants. It operates at two levels. Site Energy Assessment (SEA) provides for a short general assessment of energy-saving opportunities, free of charge to the applicant. Specific Measures Assessment (SMA) can subsidise more focussed in-depth help where the need has been identified in an SEA report or its equivalent.

Design Advice (http://collaborate.bre.co.uk/designadvice/)

Design Advice offers professional, independent and objective advice on the energy-efficient and environmentally conscious design of buildings as part of the Energy Efficiency Best Practice Programme. Clients are offered a one-day general consultancy on their chosen building project, paid for by a cashback scheme. The consultancy recommendations, covering energy efficiency, environmental improvements and the potential commercial benefits, are contained in a client report. More detailed specialist consultations will also be supported under the service.

MACC2 (www.macc2.org.uk/whatis/index.htm)

MACC2 is a way of helping organisations improve their resource efficiency and environmental performance in a managed, targeted and transparent way. It is designed to work equally well in industrial, commercial and public sector organisations.

MACC2 is a challenge to individual organisations to bring their use of resources and management of waste into line with targets which the Government has set for reducing greenhouse gases and other emissions and reducing, recycling and recovering waste.

BREEAM (http://products.bre.co.uk/breeam/default.html)

BREEAM is a tool that allows the owners, users and designers of buildings to review and improve environmental performance throughout the life of a building. It is a widely accepted and respected scheme that sets a benchmark for environmental performance and provides a wide range of benefits. It is independent and authoritative, being based on many years of construction and environmental research carried out at BRE together with the input and experience of the construction and property industries, government and building regulators

Energy Efficiency Accreditation Scheme (www.natenergy.org.uk/eeas.html)

This voluntary scheme enables an organisation to prove that it has met testing standards in its approach to energy efficiency. Reviews are carried out by independent assessors using strict criteria, and periodic reaccreditation helps to ensure that momentum is maintained. Being accredited provides qualitative evidence in support environmental systems certification and may help in relation to Climate Change Agreements.

The Chartered Institution of Building Services Engineers (CIBSE) (www.cibse.org)

CIBSE is an international body that represents and provides services to the building services profession. These services include publications and events.

Croner's Energy Management (Croner.CCH Group, 020 8247 1175)

This loose-leaf manual provides a wide range of information and reference material on energy management topics. It is supplemented by a monthly update newsletter, including monthly and weekly degree-day figures, and its content is subject to regular amendments.

Gee's Energy Saver
(Gee Publishing, 020 7393 7666)

This loose-leaf reference manual provides a wide range of information on energy management topics. Its content is subject to regular amendments, including updates to monthly degree-day data.

Energy Systems Trade Association
(www.esta.org.uk)

As the trade association for suppliers of energy-efficiency equipment and services, ESTA provides a useful first point of call in the search for equipment, materials, and expert advice.

Institute of Energy (www.instenergy.org.uk)

The Institute is the UK's professional association for those active in the energy scene (whether as suppliers, users, or academics). As such it can provide energy managers with useful individual contacts. Contact the Institute to get a copy of the Standards for Managing Energy.

CHP Club (www.chpclub.com)

The CHP Club is a new initiative under the Government's Energy Efficiency Best Practice Programme, aimed at helping users and potential users in getting the maximum benefits from CHP. It provides members with a free one-stop-shop, a unique combination of information, exchange of experience and advice facilities on CHP and related topics that will give everybody what they need and when they need it.

Combined Heat and Power Association
(www.chpa.co.uk)

In some circumstances, combined heat and power (CHP) can be an important contributor to energy efficiency. The CHPA exists to promote this technology and can provide a great deal of technical and market information, as well as news on grants and subsidies.

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4.2 RECOMMENDED INSTRUMENTS AND TOOLS

For the purposes of energy surveys, it is not usually necessary to have traceable calibrated instruments because approximate measures usually suffice. Exceptions to this rule are noted below.

- Digital thermometers with type K thermocouple probes. You will need one instrument operating in the range –50 to 200°C, ideally with 0.1°C resolution, and another for 0-500°C with 1°C precision. For high-temperature applications a robust probe is needed. For lower-temperature work, a 'band' probe designed for surface measurements makes a good general-purpose instrument capable also of measuring air temperatures. Even a bare thermocouple junction can be used. Thermocouples can be left in place and read manually by connecting the instrument when required. Compensating extension cable is necessary if the probe will need to be used at a distance (on the end of a pole), for instance.
- A sling hygrometer enables a spot check to be made on wet and dry bulb air temperatures. Alternatively, use a digital relative humidity probe, especially if moisture contents of product need to be measured.
- Non-contact thermometers can be useful to give approximate temperatures of inaccessible surfaces, or to scan for hot spots. An infra-red camera can be hired if large areas need to be assessed in detail. Results of infra-red thermography must be interpreted with caution.
- Miniature data loggers which record temperature, relative humidity, voltage, or pulses, may be useful for extended tests. Pulses may be logged from a variety of sources including PIR sensors (logging occupancy levels) or even improvised temporary contacts on valve linkages and other moving equipment.
- A light meter. An inexpensive unit will suffice, capable of working over the 100-2000 lux range. Photographic light meters are not suitable.
- A clip-on power meter is useful for checking on lighting circuits, motor consumption and small power loads.
- A compact camera. An inexpensive 35mm compact model is adequate, but a powerful flash is recommended.
- A video camera can be very useful. An inexpensive PC-connectible camera can be used in many instances.
- Pressure/vacuum gauges.
- Combustion analysis kit. This is one instrument which ought to be calibrated against a traceable standard. Although relatively expensive, this is a good long-term investment because it enables poor combustion to be detected through regular checks. Always choose one with carbon monoxide measurement. If using oil or solid fuel, you will also need a smoke pump.
- Anemometer to measure air velocities especially in supply and extract ducts.
- Smoke generator to detect air leaks. Alternatively, improvise with tissue-paper tell-tales or a child's bubble maker.
- Torch.
- Stopwatch.
- Pocket tape measure.
- Crowbar (for access to water meter).
- Meter compartment keys.
- Walkie-talkie radio or mobile telephones to coordinate 'drop tests' when one party is reading meters while another starts and stops equipment.
- Permanent metering should not be overlooked as a source of data. Manually read at frequent intervals, it can provide useful profile information. Do not forget that on equipment with fixed power demands, an elapsed-hours counter will provide a rough estimate of demand.

Instruments which are too expensive to buy can be hired.

4.3 ENERGY DATA AND CONVERSION FACTORS

CO_2 equivalents of electricity and fuels

Energy source	$kgCO_2/kWh$
Grid electricity (from 1998)	0.43
Coal , typically	0.30
Coke	0.37
Jet kerosene	0.24
Natural gas	0.19
Gas/diesel oil	0.25
Heavy fuel oil	0.26
Petrol	0.24
Propane	0.21

Energy contents of fuels (gross colorific value basis)

Fuel	Measured units	To get kWh multiply by
Electricity	kWh	1
Natural gas (typically)	m^3	10.86
	hundred cu ft	30.76
	KWh	1
	Therm	29.31
Class D oil (35s) (typical figures)	Litre	10.83
Class E oil (290s) (typical figures)	Litre	11.53
Class F oil (950s) (typical figures)	Litre	11.63
Class G oil (3500s) (typical figures)	Litre	11.66
Propane	Tonne	13,890
	Kg	13.89
Coal (typical industrial)	Tonne	7,970
	Kg	7.97

Note that where figures quoted are 'typical', actual values will be available from your fuel suppliers.

Example

Fuel			kWh	CO_2 ratio	kg CO_2
Gas oil	27,000	Litre =	293,220	0.25	73,305
Natural gas			140,000	0.19	26,600
Electricity			35,000	0.43	15,050
				Total	**114,955**

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APPENDIX A - REPORTING

Although not essential, it is a good idea to record your survey findings in a formal report. It does not need to be lengthy; just sufficient to inform others of what you found and how you arrived at your conclusions. It could also help you to remind yourself of these things should you need to return to the subject at a later date.

If you are seeking authority to spend money on projects, it is absolutely vital to present clear, unambiguous recommendations. Do not give the reader multiple options to choose between. Always support your recommendations with appropriate calculations and estimates.

Your report should contain the following sections:

Introduction

- Background to the site and its operations.
- Energy consumption and expenditure statistics (see tables in section 3.3 above).
- If appropriate and available, the trend in specific energy ratio (and comparison with published norms).
- Any special considerations supporting subsequent recommendations.

Summary

- A table similar to that shown in section 3.4 above.
- Brief narrative introducing the findings and recommendations.

Survey findings

- Detailed discussion of survey findings, presented either by production area, or by technology theme (eg lighting), or both.

Recommendations

- Measures to be taken.
- Expected costs.
- Estimated savings.
- Incidental benefits.
- Payback periods or internal rates of return.

Appendices

- Energy prices.
- Charts and diagrams.
- Data gathered during the survey.
- Calculations of savings.
- Any other information.

APPENDIX B – SELECTING AND BRIEFING A CONSULTANT

There are various circumstances in which you might require the services of an energy consultant.

- In the course of your energy survey, you may find energy-saving opportunities for which expert help is required.
- After attempting a survey unaided, you may conclude that it would be better to engage an outside specialist to do the job for you.
- You may have surveyed only certain aspects of your site, or you may have other sites which you cannot survey in person.
- The terms of a grant scheme may require that a formal energy survey is first carried out by an accredited person.

B1. SELECTING A CONSULTANT

There are several ways of finding a consultant if you do not already know of one:

- Recommendations from contacts in your industry or from your trade association.
- Approaching expert authors writing in the specialist press.
- Registers are maintained by independent bodies such as the Institute of Energy and the Energy Systems Trade Association (details in Section 4.1).

In making your shortlist selection, look for these attributes:

- Relevant experience (not necessarily in your own industrial sector: many energy projects are generic).
- Relevant qualifications: Are they properly qualified? Do they hold membership of a recognised professional body which has a code of conduct? Is it important that they should be chartered engineers?
- True independence. The consultancy should not be tied to any particular product or to any given energy supply company. *Ask who owns them*.
- Professional indemnity insurance. Ask for a copy of their current certificate.
- Quality system: Does the consultancy perform work to a recognised quality standard?
- Affordable rates. Most reputable consultants will quote a fixed fee, although some may quote on a 'shared-savings' basis. Be circumspect about shared-savings offers. Apart from the high risk of costly disputes, there is a risk that the consultant will 'walk away' from a job where he finds nothing he is interested in doing. The other risk is of savings being much higher than promised, inflating the fee well above what was expected.

B2. BRIEFING AND MANAGEMENT

Having found one or more suitable candidates, describe your project and ask them about similar work they have done for other clients. If they are able to provide satisfactory answers, ask for references *and follow them up*.

When you are ready to commission the work, *brief the consultant properly*. The project must have clear objectives and deliverables. Avoid ambiguities about what is or is not included in the fee offer. A model brief for a consultant's report is provided in Section B.4.

When the project has started, expect to spend time with the consultant: perhaps half a day for every day that he works on the project. Do not expect to see the consultant on site for the whole of the project. Most projects would require the consultant's attendance on site for at most one day in three.

B3. FURTHER INFORMATION

- **FL0089** Choosing an energy consultant

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B4. MODEL BRIEF FOR AN ENERGY SURVEY

If you are briefing a consultant to do a general energy survey of the kind dealt with by this Guide, The following model brief can be adapted to suit your particular site's circumstances. It is adapted from CIBSE's Energy Audits and Surveys AM5: 1991.

1. Objectives

The objectives of a concise energy audit and survey are:

- to identify opportunities for reducing energy costs;
- to estimate the potential savings, and where applicable, implementation costs;
- to provide an audit for the site on the basis of the previous 12 months' invoiced accounts.

Methods of achieving these objectives are:

- by observations and, where applicable, analysis of how efficiently energy-consuming equipment is being used;
- by considering possible improvements to energy management control.

2. Report format

A short report shall be written to outline the findings and recommendations arising from the survey. The report shall be preceded by a summary outlining the potential energy savings available at the site. These will primarily be of the good housekeeping and low-cost type but will also indicate where further opportunities may exist. The body of the report shall contain the following sections:

- Site information.
- Energy audit.
- Energy use.
- Energy management.

3. Scope of survey and report

The following shall be covered:

- Site information.
- The site, its functions and services, shall be described.
- Energy audit.

Based on data obtained from the previous 12 months' fuel invoices, a table showing annual fuel consumptions and costs shall be compiled of the site. Performance indicators against published benchmarks shall be determined and commented on.

4. Energy use

Boiler plant

Combustion efficiency, based on waste gas analyses, shall be assessed for the main boiler plant under operating conditions as found. The general condition of the boiler plant and associated pipework insulation shall be checked. Recommendations for improved energy efficiencies within the boiler house shall be based on the above analysis and observations.

Process/manufacturing equipment

Observations on:

- factors affecting consumption;
- product quantity/quality;
- controls;
- operation.

Compressed air

Observations on:

- generation;
- treatment;
- distribution;
- end use;
- controls.

Electrical power and lighting

Observations of power and lighting systems shall be carried out to determine the following:

- the condition of lighting equipment;
- any unnecessary use of lighting;
- the type of existing luminaires and possible replacement by higher-efficiency lighting;
- use of electric heating and its control;
- the operation and loading of refrigerators and air compressors;
- efficient use of large electric motors.

Recommendations to reduce energy costs shall be made on the basis of the above observations.

Ventilation/air conditioning

The settings of existing time and capacity controls shall be obtained and included in the report, together with comments on control, operation and potential energy savings.

Space heating and domestic hot water

The heating and hot water systems shall be assessed and recommendations made on:

- the heating period compared with occupancy periods;
- the condition, settings and siting of existing controllers and sensors;
- instantaneous temperature measurement taken during occupancy periods;
- the condition of insulation on pipework, valves and flanges;
- the condition and siting of heat emitters and any obstruction;
- HWS temperature.

Building fabric

Observations shall be made of:

- insulation standards;
- excessive air leakage into buildings due to badly fitting doors and windows.

Recommendations shall be based on the above observations.

5. Energy management

Existing energy management procedures shall be assessed, and outline recommendations shall be made in any improvement which can be made to the existing system.

Consideration should be given to:

- Energy purchasing/procurement.
- Energy policy.
- Management structure/responsibilities.
- Training of key staff.
- Management information systems (M&T).
- Awareness/motivation of employees.
- Investment strategy.

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