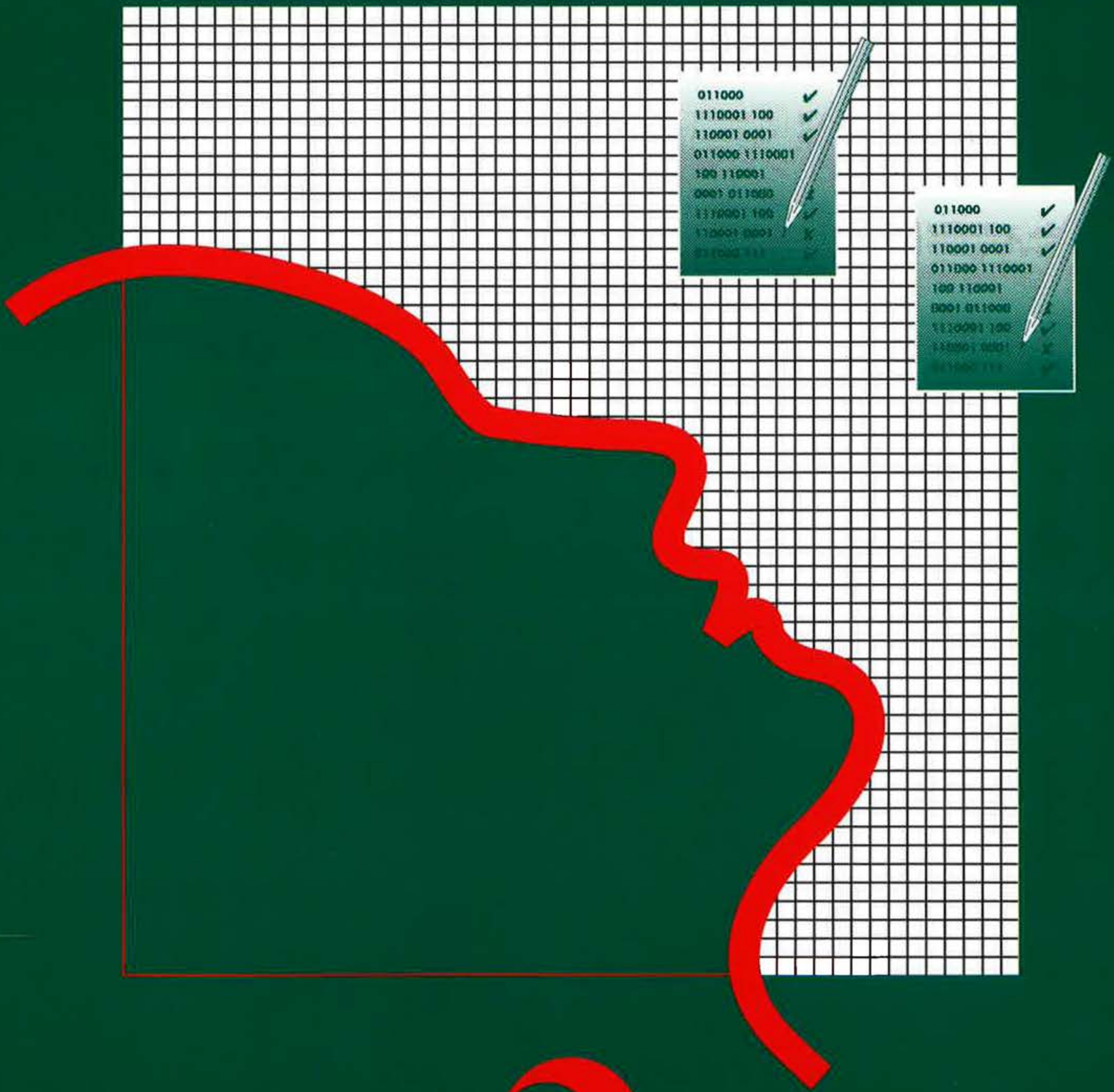
Energy Auditing

6144

Technical Energy Management Series



Energy Management

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Energy Management

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CONTENTS

	Page
INTRODUCTION	**2**
PHASE 1.	
An audit of historical data	**4**
PHASE 2.	
The walk-through energy audit	**7**
PHASE 3.	
Detailed investigation and analysis	**12**
ENERGY MANAGEMENT'S SERVICES	**13**
APPENDICES	
A. Summary of annual energy use	**13**
B. Seasonal energy consumption patterns	**15**
C. Energy systems questionnaire/checklist	**15**
D. General Checklist	**19**
E. Pulsomatic load curve	**24**
F. Detailed consumption data	**IBC**

Energy
Management

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Energy Management (Ministry of Commerce) is committed to promoting the wise and efficient use of energy. Its function is to maximise energy productivity resulting in more competitive businesses; reduce the waste of energy resources; foster increased national security of energy supplies; and protect the natural environment.

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INTRODUCTION

The aim of an energy management programme is to contain or reduce overall costs of energy use per unit of output.

The four basic steps in establishing such a programme are:

1. Set energy management policy - Prepare a policy which details general objectives, the specific goals to be reached when achieving these objectives, the methods to be employed and the organisation of the management resources required.

2. Conduct an energy audit - This provides a detailed information base from which to work. This indicates where the greatest potential for improvement lies.

3. Formulate the plan of action - Pick up those areas responsible for a major proportion of the energy consumption or where expensive fuel is used. A plan of action looks at both conservation and fuel substitution.

4. Evaluate and maintain the energy management programme - The energy management programme will be more cost effective if it is developed into a continuing programme involving reviews, reassessment and revision of the action plan.

This book covers the second step in such a programme - conducting an energy audit and is useful for engineers, production and maintenance managers in the commercial and industrial sectors.

An energy audit is a periodic examination of an energy system (or part of the system) to ensure the most appropriate sources of energy are employed, and this energy is used as efficiently as possible.

There are a number of ways to conduct an energy audit. Generally, energy audits need to be organised as a structured series of exercises. One suggested approach is as follows.

Phase 1 – An audit of historical data

Collect and analyse company records of energy use to determine:

- the cost and physical quantities of energy inputs used
- annual and seasonal trends in energy use and cost
- the energy use per unit of output or time.

Phase 2 – Walk-through energy audit

Undertake a walk-through audit of energy use in the operation. This will be a fairly quick, low cost preliminary investigation of an operation using existing data to indicate:

- major energy consuming plant and processes
- obvious energy waste and inefficiencies
- gaps in the metering and reporting of energy use
- priority areas for further investigation of likely inefficient, inappropriate energy systems.

Phase 3 – Detailed investigation and analysis

Processes or plant identified by the walk-through energy audit as justifying further investigation will have to be examined in order to determine the size of avoidable energy losses and the cost of reducing this waste.

Detailed analysis may incur considerable cost and/or time, therefore it is vital to select only those processes, areas or plant which are most likely to yield significant cost savings for a reasonable effort.

Here's a checklist of information required to undertake an energy audit.

Checklist of information for an energy audit

Energy consumption and cost details for the past 12 months (or last financial year):

- Required in physical units i.e. litres of oil, tonnes of coal, MJ of gas, kWh of electricity etc.
- Required for each month or quarter to show seasonal variation and for each metered area if available.
- If energy consumption figures are not available, purchases of energy will suffice (effects of stockpiles and storage can cause differences).
- A copy of accounts of past 12 months showing consumptions, tariffs and calculations of costs. This enables tariffs and contracts to be critically examined to ensure the most favourable conditions.

Energy consumption costs and output levels for past years enable trends to be noted in total energy use and costs, as well as the trends in the energy use (and cost) to produce a unit of output.

Energy System Details

Layout of buildings and energy systems (site plans) showing:

- location of buildings, names, function, orientation and distances
- materials of construction of buildings (e.g.double brick), insulated areas, approximate floor areas, air conditioned and evaporatively cooled building areas

• reticulation systems (pipework layouts) for steam, hot water (space heating), chilled water, compressed air, condensate return, electricity, water (it is a good idea to use separate overlays for each system)
• locations of plantrooms, switchboards and meters
• location of major items of equipment e.g. boilers, compressors, airconditioning plant, transformers, ovens.

List of energy equipment

• for each major item of plant give type of equipment, name of equipment, capacity, location, usual hours of operation, usual output and usual energy consumption.
• this equipment should include 10 largest electric motors, fuel burning equipment, air conditioning plant (including reverse cycle units), standby generator, waste disposal equipment, computers, the refrigeration plant and office equipment.

PHASE 1 – AN AUDIT OF HISTORICAL DATA

The first step is to collect the available energy accounts and production records in order to:

1. identify and quantify each of the energy forms
2. establish a general trend or pattern in energy use over a number of years.

This will provide a basis on which to evaluate future performances and indicate which areas warrant examination. Figure 1 gives an example of the typical energy consumption patterns. In this example, an historical trend has been established and the projected savings due to an energy management programme has been estimated.

Energy costs and consumption levels

List all forms for the current year and convert them to a common unit. This will give you the relative importance of each energy form. Listing the unit cost and total expenditure of each energy form is also desirable so that priorities may be assessed based on the relative importance of each fuel.

The tables in Appendix A will enable these calculations to be performed, and the results may be depicted using pie charts to help identify priority areas for study.

If similar records are available for several years, the information may be plotted as in Figure 2, which establishes both historical trends and the potential impact of energy saving.

Seasonal patterns

The seasonal consumption patterns for each major form of energy provide valuable information. The space heating or cooling components can often be estimated from such profiles where consumption is not separately metered. For air conditioned areas, the energy consumption profile can indicate problems in the control systems such as 'heating-fighting-cooling' as shown in Figure 3. The worksheet at Appendix B will enable these profiles to be developed.

Figure 1: Typical energy consumption and expenditure patterns

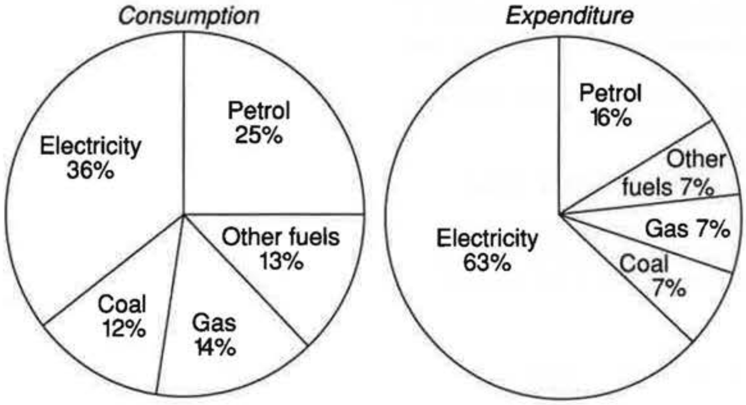


Figure 2: Trends in energy consumption and cost

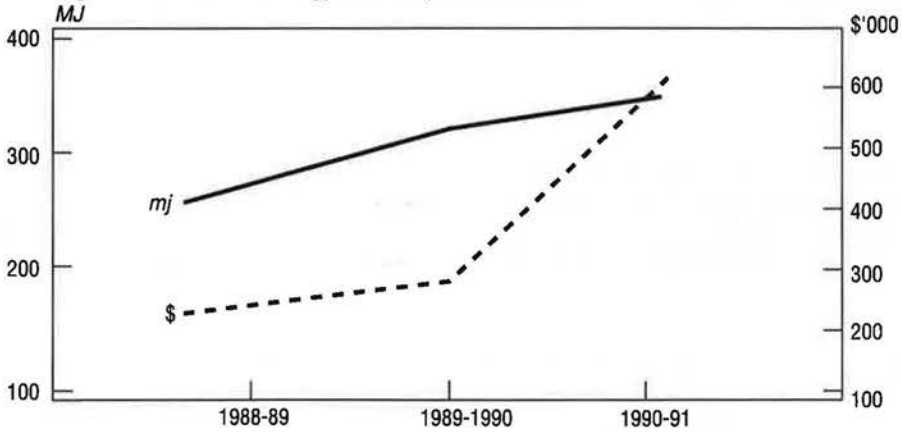
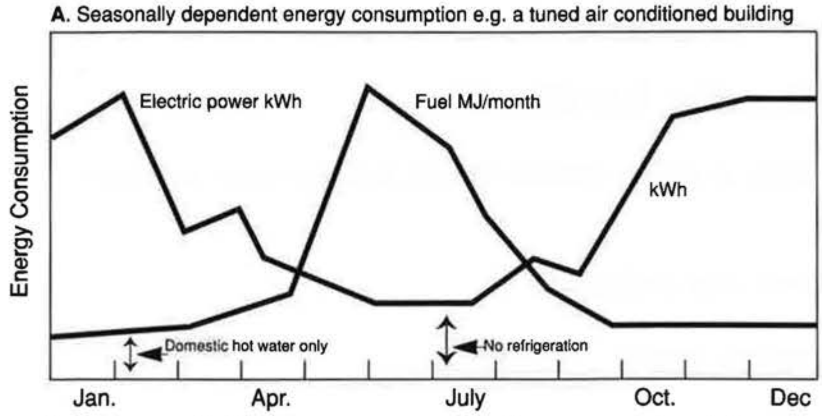
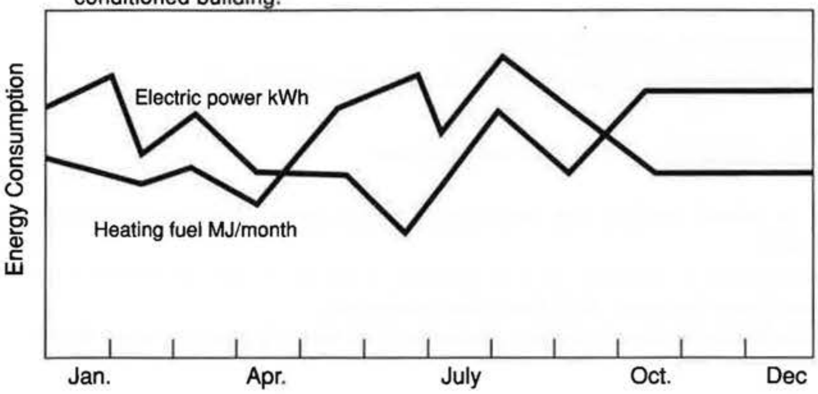


Figure 3: Energy Profiles

A. Seasonally dependent energy consumption e.g. a tuned air conditioned building



B. No seasonal influence on energy consumption, e.g. an untuned air conditioned building.



Review purchasing arrangements

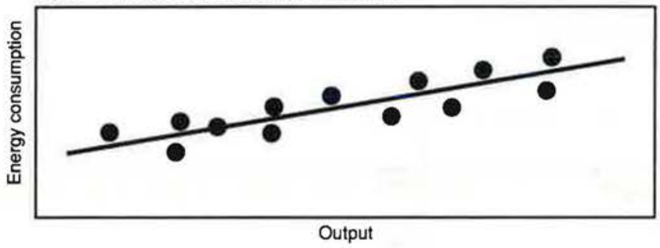
Detailed information on annual and seasonal consumption, costs and average prices enables a preliminary analysis of alternative tariffs, contracts and purchasing agreements for each fuel. A more detailed analysis may be undertaken when energy consumption patterns and load profiles have been established.

Purchasing energy supplies at the most favourable price is an important aspect in minimising energy costs. Most energy supply organisations provide tariff or contract advice.

Plot the energy consumption against output or over time

You should obtain sufficient data to determine the level of output during each billing period and calculate the energy use per unit of service or product e.g. in MJ/tonne of product. Relating consumption and output data in this way gives a broad first estimate of the energy efficiency of the operation.

Figure 4: Energy consumption against output.



If the graph of energy use against output does not show a clear relationship, this generally indicates that energy use is in need of urgent attention. In most situations, the better the energy management, the clearer will be the link between output and energy used.

For many companies it is not possible to determine energy consumption against output. Instead try to reduce energy costs per unit time.

Calculate the specific energy consumption

Where energy use can be related to a single product or single activity, an index provides the best means of comparison of current performances with those of the past. Examples of indices in common use are as follows:

litres/100km............................fuel consumption of motor car
GJ/tonne................................energy consumption per unit of product
GJ/machine hour....................} energy consumption per unit of production time
GJ/labour hour.......................}
MJ/m^2pa................................energy consumption per unit of heated space

It is often very difficult to obtain a clear picture because the majority of industries produce more than one product and because the proportion of each product produced may change. Additionally, the total energy consumption is often attributable to a combination of energy uses including the energy required in the actual manufacturing processes and for such services as space heating and cooling. Often there will be insufficient in-plant metering to permit the disaggregation of the consumption data to the levels required. A combination of detailed studies and historical auditing will often be required to develop suitable indices.

It is also useful to graph the specific energy use per unit of output to indicate how energy efficiency varies with activity level for each process, product or service. Also a plot of specific energy use against time gives an indication of how energy efficiency changes throughout the year and from year to year.

Sometimes it is possible to compare the specific energy data developed for production or services in one firm with similar figures for similar firms in New Zealand and overseas. It provides another indication of how energy efficient your operation is. In some cases, industry trade associations have surveyed members to obtain typical energy consumption levels.

PHASE 2 – THE WALK-THROUGH ENERGY AUDIT

The next step is the walk-through energy audit which establishes:
- the immediate opportunities to reduce energy costs
- the feasibility for potential cost savings in each area of energy consumption and the priority for allocating resources
- a monitoring and reporting procedure
- energy load profiles that may be used in reviews of purchasing agreements

The audit can be very simple in small plants where there may be few fuels and processes, or very complex where there is an array of equipment and processes. However, the basic principles are the same.

Obtain up-to-date plant layouts

A convenient means of presenting these layouts is to prepare:

1. A base diagram showing buildings and major energy-consuming plant items including furnaces, dryers, boilers, compressors etc, and the movement of materials in the plant.

2. Overlays showing:
- the steam system i.e. major hot water/steam lines, boilers, steam-consuming plant and existing metering
- the compressed air system i.e. major compressed air lines, compressors, compressed air using plant and existing metering
- the electricity system i.e. major electricity distribution lines, electricity consuming plant and existing metering
- fuel systems i.e. major supply lines, fuel consuming plant and metering
- other major energy systems in the same manner e.g. refrigeration systems.

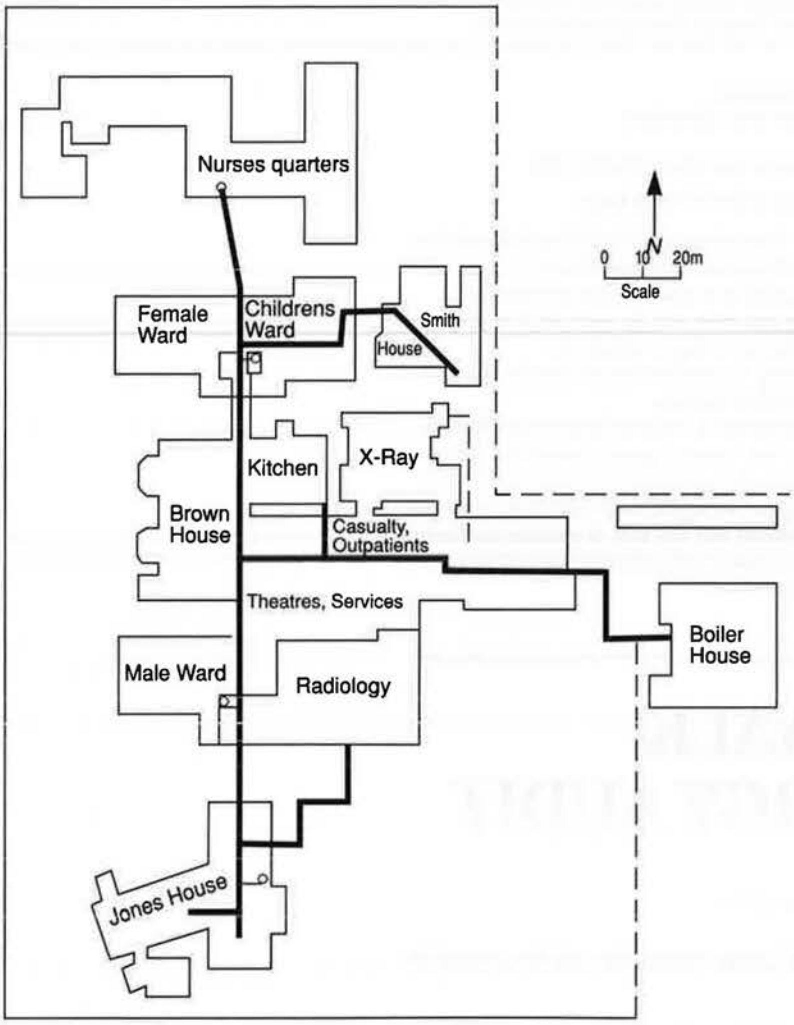
An example of such a layout is shown in Figure 5.

A quick survey

Conduct an initial survey to find out where obvious energy losses are occurring in the plant due to:
- deficiencies in the process or plant used
- poor operating techniques and carelessness
- inefficient procedures and schedules

1. Break the survey up to look at each major system or operation such as steam, compressed air, lighting and hot water etc.

Figure 5: Steam reticulation diagram for a hospital



2. Using a questionnaire like the one shown in Appendix C, collect nameplate and manufacturers' data and operation data for the major energy consuming plant.

3. To identify some common areas of energy wastage in each process use a checklist like that in Appendix D. This survey will indicate some immediate changes which can reduce energy costs, many of which will require minimum capital investment. It is a good idea to place tags on areas requiring maintenance at shutdown e.g. faulty steam traps, instruments and damaged insulation.

4. Tour the energy systems in non-production periods, such as at nights, at weekends or during lunch breaks to see if energy is being used unnecessarily at these times.

IMPORTANT: When touring the plant, keep in mind that sometimes it is better to change a process rather than try to carry out the existing process more efficiently. For example, rather than insulating a long steam line to a small isolated energy user, it may be better to provide a small process heater locally for that application.

Review of recording and reporting system

Energy management requires the measurement of energy flows and losses, and this requires metering. Most industrial plants and buildings are under-metered; often the only existing metering is the utility gas and electricity meters. If this is the case, it will be necessary to install supplementary metering, either on a temporary or permanent basis, to further subdivide energy use in the major energy consuming processes and equipment.

Examine the metering already available on site. First, check that the existing meters are reliable and appropriate for their application. Identify shortcomings in the metering system for energy management purposes.

Also investigate the way the information measured is gathered, recorded and used. Is the data relevant, prepared in a usable form, getting to the right people? Could some, or all, of the information be recorded by automated equipment? If there are deficiencies, recommend changes

to the metering system and the flow of information.

A recommended strategy for data collection is as follows:

Collect data as raw meter readings

Ensure that the previous reading is available at the time the meter is read so that errors are minimised. The person reading the meter should calculate the difference between this reading and the previous reading. Preferably one person should be responsible for reading all meters and calculating the differences. Alternatively, consider automated recording devices to undertake this phase of the task.

Convert meter readings to consumption in physical units

The difference in meter reading should be multiplied by meter factors and conversion factors to give consumption in the most easily related units e.g. kWh of electricity, M^3 of gas, litres of oil. If the energy consumptions are plotted on a graph, errors are identified more easily than when only numerical data are presented. In addition the effects of variations in processes are more readily appreciated.

Report energy consumption in consistent units

Convert all energy consumptions to megajoules or gigajoules so that electricity, steam and gas etc can be added on the same basis.

Compare energy consumption with a standard

Actual consumption should be compared with some standard. Two approaches are possible:

- multiply the standard by the output to obtain what the consumption should have been, then analyse the difference with the actual
- divide the actual consumption by the units of production to obtain the unit consumption which is compared with a unit standard.

The first approach gives an appreciation of the total dollar costs involved when consumption differs from standard, while the second approach gives an appreciation of how energy consumption variations affect unit costs.

It is possible to record and report on energy use manually, but as with many things, this process is greatly eased by the use of a personal computer. Small scale monitoring and targeting software programmes are available and can be adapted specifically for your facility. You won't need a great deal of computer knowledge to run them. These programmes, once historic data is entered, provide automatic trend/comparison graphical reports against past performance or established targets.

Collecting detailed energy consumption data

Establish the amount of each energy form used per month for each process, group of processes, individual items of equipment or building. This will establish the main energy consuming processes. Cost and consumption data similar to that compiled in Appendix A may be tabulated for each major process or building (See Appendix F for tables).

Installation of additional metering is quite expensive so it is important to ensure that any extra meter will be adding enough extra information to justify its installation.

The installation of additional electrical metering can frequently be avoided initially, by estimating the amount of time that an appliance or motor runs in the period on which the reporting scheme is based and multiplying this by its nameplate power consumption. If considerable use is made of `motor and light counts', it is preferable to place an hourly consumption meter in parallel with a machine for an appropriate period, to more accurately determine the fraction of time that a machine is in operation.

Manufacturers' operating handbooks are usually available for major machinery. These frequently contain operating curves which relate performance over the operating range. These can be used to estimate energy use at a typical operating point or at several points.

Estimates of the consumption of other energy forms can also be made initially without metering. For example, boiler feedwater consumption or condensate flows may be used to indicate steam consumption. However, in many cases when detailed analysis is carried out, these initial estimates will often be inadequate and many important energy flows will have to be directly measured.

The cost of installing extra metering is often difficult to justify to management because it does not provide an obvious financial return. However, the existence of sufficient metering is vital for the continual monitoring and control of the energy used in major energy consuming processes and should be justified on this basis, rather than just on the needs of this special study.

Report a plan of action to management

The development of a plan of action for management approval is important to ensure management commitment in both principle and practice for further energy management activities.

The report to management should indicate:

- **Immediate savings attainable**
- **Further investigation required to identify and quantify savings which arise from changes in plant and processes.**
- **Deficiencies in collecting and reporting energy data and control of energy costs.**
- **An estimate of the cost of doing nothing. This should be based on the likely increases in fuel costs and the projected energy consumption in the coming years and represents the cost penalty of not implementing a continuing energy management programme.**
- **A `Plan of Action'. This plan should detail the most important area of energy cost reduction based on the walk-through energy audit. It should also outline the sequence of action necessary to reduce energy costs in the most efficient manner.**

Decide on the best means of improving energy efficiency by considering alternative methods of providing the service, manufacturing the product or providing the required energy. For example, before looking at the heat recovery from a waste heat stream, first check if it can be reduced or eliminated by improving the process.

Items requiring action could be ranked according to the cost and time required for implementation, the expected payback period or rate of return of each project and other factors. The ranking method should be described in detail in the report.

An example of such a "Plan of Action" is shown below.

In the Plan, it is wise to recommend that the low cost or no cost options are undertaken first. Projects requiring substantial funding can be undertaken once some savings have been effected. In practice, several projects will be undertaken simultaneously.

Energy management "Plan of Action"

1. **Review tariff and purchasing arrangements**
2. **Review lighting system**
   - type of lamps
   - lighting levels
   - circuits and controls
   - use
3. **Staff motivation campaign**
4. **Review of combustion systems**
   - maintenance
   - efficiency
   - controls
5. **Review of space heating/air conditioning**
   - thermal loads-insulation/shading
   - outside air
   - controls

6. **Review of domestic hot water**
   - individual versus central systems
7. **Review of compressed air, refrigeration etc**
   - maintenance
   - load shedding, controls
8. **Review of total energy system**
   - purchasing
   - type of fuel
   - type of energy system
   - review of programme
9. **Regular reports to management**
   - highlight results of above reviews, including any cost savings involved
   - recommend the establishment of norms and targets for energy consumption in specific areas of the operation
   - recommend modifications and improvement to the "Plan of Action".

Phase 3 – Detailed Investigation and Analysis

The results of the walk-through energy audit will enable the development of a list of priorities for further detailed studies. The audit also should aim to develop norms and targets for energy consumption which are necessary to control energy use.

To work out whether identified improvements to plant or processes requiring expenditure are economically justified:

* Break up the prospective energy improvements into specific projects. You will need to estimate the capital costs of each initiative. You may have sources of information in-house; equipment suppliers are also useful sources of information, particularly on costs.

* Based on the estimated energy savings determined from the surveys undertaken and the expenditure required for each project, carry out an economic analysis to work out how the payback period or rate of return for the project compares with the company's requirements for capital projects.

Monitoring load profiles and detailed review of purchasing agreements

Electricity tariffs for large users are based not only on total energy consumed in a billing period, but also on the peak demand i.e. the peak rate of consumption during the billing period. Tariffs from some supply authorities also include an energy rate which varies with the time of day.

It is important therefore not only to meter total electricity use, but also the daily and weekly pattern of usage to allow the processes or machines that contribute to the peak demands to be isolated and identified. You are now in a position to specify operational and plant changes which can be made to reduce demand peaks and thus 'flatten' the load pattern. By reducing the maximum demand, it is possible to substantially reduce power bills.

Note that electricity kVA and kW maximum demand meters do not measure the maximum instantaneous electricity use but the maximum consumption over a half hour period.

The load profile should be determined, if possible, over one complete billing period. It is often useful to meter subsections of large plants to obtain more information on the contributors to the overall load pattern.

Monitoring equipment may also be hired for electricity use surveys. (An example of the results of a load survey are presented in Appendix E.)

Reviewing the energy management programme

The results of this detailed investigation and analysis, together with those obtained from the walk-through energy audit, should be used to determine or update your company's energy policy and establish an ongoing energy management programme involving norms and targets for energy efficiency and regular reviews of energy use.

Energy Management Services

If your company does not have the skills to analyse and implement the more complicated measures, it may be worthwhile to engage consultants who have specialist capabilities.

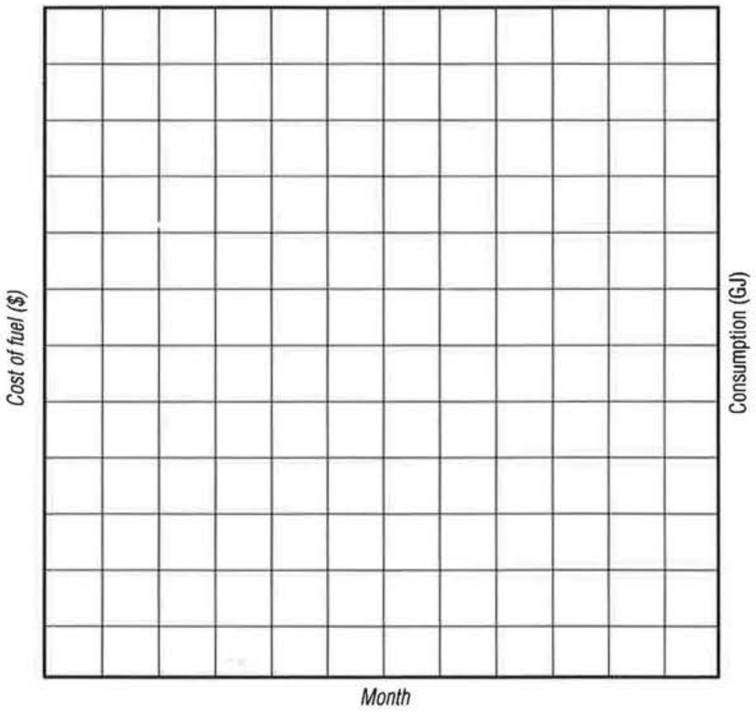
You should carry out the preliminary steps yourself before engaging a consultant, even for a detailed study: specialist knowledge is not required to carry out these preliminary tasks and it will reduce your overall costs. The information you collect will usually be amongst the first items that a consultant requests.

Energy Management (Ministry of Commerce) has engineers on staff who can help. Also available from Energy Management is the Energy Management Yearbook, a directory of companies involved in energy auditing and technical services, and equipment suppliers. The cost for this book is $10.

Appendix A: Summary of annual energy use

Energy form	Units	Annual consumption (unit)	Conversion factor (GJ per unit)	Energy equivalent GJ % Total	Annual cost $ % Total	Unit cost ($) per GJ
Petrol	k litres		x 34.4			
Automotive diesel oil (ADO)	k litres		x 38.4			
	tonnes		x 45.7			
LPG	k litres		x 26.1			
	tonnes		x 50.0			
Industrial diesel fuel (IDF)	k litres		x 39.2			
	tonnes		x 45.5			
Fuel oil	tonnes		High Sulph x 42.9 Low Sulph x 44.5			
Natural Gas	GJ					
Town Gas	GJ					
Electricity	000 kWh	x 3.6				
Coal	tonnes					
Other						
		total				100

Appendix B: Seasonal energy consumption patterns



MONTH		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
CONSUMP-	TONNES													
TION	GJ													
COST ($)														

Comments on use:..

....

....

....

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Appendix C: Energy systems Questionnaire/Checklist

Date

1. Company...

2. Location...

3. Manager...

4. Engineer...

5. Latest 12 months' energy usage
(Record monthly consumption and cost on separate page for each fuel type)

6. Production process
Type of product
Production latest 12 months
Process flow chart (simple block diagram)
Record monthly production
Typical operating hours per week

7. Electricity use
(a) *Motors*
List size and application of 10 largest motors (kW)

(b) *Lighting*
Office (type, wattage, number)

plant process area (type, wattage, number)
warehouse (type, wattage, number)
outside (type, wattage, number)
switching - auto or manual

(c) *Power and load factors*
Is power factor included in rating schedule?
Is power factor control equipment employed?
What is power factor?
Is maximum demand included in rating schedule?
Is demand-limiting equipment installed?
What is maximum demand rate? (kW)
What is average demand rate?
What is load factor?

(d) *Other major uses of electricity*
What electrical process heating?
(identify process and kW used)
Are large areas air conditioned?
Are large areas refrigerated?

8. Steam Production

(a) *Boiler(s) identification*
Rating (kg/hr or kW)
Pressure (kPa)
Fuel used
Package boiler or field type
Approximate age (years)
Economiser/superheater fitted
Blowdown heat exchanger fitted
Feedwater treatment system and testing

(b) *Boiler Performance*
Av fuel input rate (kg/hr)
Av steam output rate (kg/hr)
Peak system output rate (kg/hr)

(c) *Boiler efficiency*
When was boiler efficiency last tested?
How frequently is it tested?
What was its efficiency? (%)
What was the % CO_2 in stack gases?
What was the stack gas temperature? (°C)
What is % blowdown?
What is % feedwater makeup or % condensate return?
Is feedwater tank lagged?
What is feedwater temperature? (°C)
Is boiler well maintained?
How often are the tubes cleaned?

9. Steam use

(a) Steam transport
Are steam pipes, flanges, valves and header lagged? (condition of lagging)
Type of insulation and thickness
Is condensate returned?
Are condensate lines lagged?

(b) Steam application
Type of application
Pressure required (kPa)
Is steam used in process and lost or condensed and returned or vented to atmosphere?

10. Fired heaters

Identification e.g. furnaces, kilns, ovens, driers, other
Average fuel input rate (kg/hr)
Type of fuel fired
Process temperature required (°C)
Gas temperature required (°C)
Stack temperature (°C)
Stack gas flow rate (m/sec.)
Excess air in stack gas (%)
Type of insulation
Condition of insulation
Other heat-retaining equipment
Is heat recovery equipment used?
Are gases in contact with product?
Do gases go through heat exchanger?
Do gases pass through afterburner?

11. Compressed air

For each compressor list:
power consumption (kW)
output rating (m^3/hr)
discharge pressure (kPa)
air cooled or water cooled?
cooling water flow and temperature (l/min.°C)
major uses and pressures required

12. Water usage

Average water consumption (l/hr)
Water discharge to sewer (l/hr)
Temperature of discharge (°C)
Other discharge rates (l/hr)
Other discharge temperatures (°C)
Is water recirculated?
Are cooling towers used?
Number and efficiency of cooling tower
Is effluent treated?

13. Waste disposal

Are wastes incinerated?
Are wastes shredded?
Are wastes compacted?

14. Transportation

Are conveyors or forklifts used?
Are forklifts electric powered?
No of company vehicles (l/100km)
Separately list make and fuel consumption

15. Standby power generation capacity

Type, rating, fuel consumption

Appendix D: General checklist

Processes and equipment

Item	*Why important?*	*Action required*	*How long to implement*	*Who can help?*	*Energy savings*	*Remarks*
1. *Industrial furnaces*	• Heat loss through furnace structure increases energy consumption	• Repair furnace linings. • Inspect insulation for periodic maintenance and/ or update. • Check furnace doors and other openings for tighter closure. • Reduce the holding temperature during idle time. • Schedule work to reduce heat up and cool down periods. • Periodically check on the furnace pressure control. • If the furnace is being cycled, as in heat treating, investigate low thermal mass insulation.	• Immediate inspection.	• Plant maintenance. • Furnace manufacturer. • Plant employees.		
2. *Burners*	• Either incomplete combustion or too great an amount of excess air wastes significant amounts of fuel.	• Perform periodic combustion analysis and adjust burners. • Maintain, repair or replace inefficient burners.	• Usually less than half a day for combustion check per furnace.	• Plant maintenance. • Combustion specialist. • Burner manufacturer. • Fuel supplier representative.		
3. *Combustion gases - heat recovery*	• Products of combustion which leave at temperatures higher than supply air represents a loss of energy.	• Use exhaust to preheat combustion air by use of a recuperator heat exchanger. • Use exhaust gases to generate steam or hot water and to heat secondary fluids or air for other uses.		• Consulting engineer. • Recuperator manufacturer representative. • Energy supplier representative.	• 20 to 40% of fuel consumption can be saved depending upon furnace temperature. • Radiation recuperators for furnace temps greater than 1800°F will usually show a payback period of less than two years.	• Use of recuperators may require changes in burners and combustion air systems.
4. *Process heat distribution system (steam, condensate, hot water and chilled water)*	• Any losses in the distribution system require greater energy input for the same end use.	• Insulate steam condensate, and hot water and chilled water lines. • Repair leaks in any lines. Shut off or remove unused lines. • Provide for periodic maintenance checks on controls, valves, and accessories. • Meter consumption and compare on regular intervals to identify unusual changes.		• Plant employees. • Plant engineer and maintenance. • Energy supplier representative.		
5. *Process fuel distribution system (natural gas, LPG, oil etc.)*	• Any losses in the distribution system require greater energy input for the same end use.	• Repair leaks in any lines. Provide for periodic maintenance checks on controls, valves and accessories. • Meter consumption and compare on regular intervals to identify unusual changes.		• Plant employees. • Plant engineer and maintenance. • Energy supplier representative.		
6. *Incineration of industrial wastes*	• Possible source of energy. Recovered heat can be used for process or building heating.	• Investigate the possibility of incorporating a heat recovery system into the incineration process.		• Consulting engineer/ mechanical or chemical. • Manufacturing representative of heat recovery equipment and of incineration equipment.		• Fumes, vapour and industrial wastes which require incineration, especially at high temperatures, may provide opportunities for significant heat recovery.

Processes and equipment *(cont.)*

Item	*Why important?*	*Action required*	*How long to implement*	*Who can help?*	*Energy savings*	*Remarks*
7. Cooling towers/ evaporative coolers	• Heat rejection is required by many industrial processes such as die-casting machines, plastic moulders and air compressors.	• Investigate the possibility of using the heat for space heating, for preheating boiler feedwater or personnel hot water, for heating stockpiles or other such low temperature applications. • Check whether cooling towers or evaporative coolers are pulling plant air during the heating season. Should use outside air at intake.		• Consulting mechanical engineer. • Heating, ventilating and air conditioning engineer. • Plant engineer.		
8. Paint spray booth	• Air is circulated through the painting area to control the paint spray and vapours. If all the air is exhausted, it would require equal amounts of makeup air from the outside and the energy necessary to heat the air.	• Check the possibility of introducing outside air directly to operation without heating. • If afterburners are used, can the resultant heat be utilised? Heat recovery may be economic.		• Consulting engineer. • Ventilation specialist. • Manufacturer's representative of heat-recovery equipment. • Manufacturer's representative of paints.	• Heat recovery devices usually can save 50-70% of the energy needed to heat the makeup air.	
9. Exhaust over vats, tanks, grinding and other operations	• Energy required to heat the makeup air from the outside. • Energy is also needed to maintain the temperature of the bath.	• Consider the use of heat recovery equipment from the exhaust air to the makeup air. • Check the possibility of introducing outside air directly to operation without heating. • Install covers over vats and tanks. • If covers are unsuitable for vats and tanks consider insulating balls floated on the surface.		• Consulting engineer. • Ventilation specialist. • Plant engineer.		• Check compatibility of heat recovery equipment with the vapours in exhausted air.
10. Compressed air system	• Energy is used to drive the air compressor. • Drive may be either electric motor, engine or turbine drive.	• Use coolest intake air available, possibly from outside of building. • Repair all leaks. • Operate at the lowest air pressure required. • Consider the possibility of using the heat from the aftercooler for supplementing the plant space heat. • Do not use compressed air for cooling equipment or personal comfort. It is expensive ventilation. Use air blowers at required conditions instead. • Investigate the possibility of shutting down the compressor when not in use.		• Plant engineer. • Plant maintenance. • Consulting mechanical engineer. • Plant employees.		
11. Electric power system	• Transmission losses include transformers and line losses. • High peak demand and low power factor both increase the cost. They also increase the electric generating plant size required to service a given job.	• De-energise transformers whenever possible. • Clean transformer heat exchanger surfaces. • Investigate the possibility for scheduling use of power and for reducing demand. • If power factor is low, additional load may involve expensive cabling costs; have a specialist recommend changes.		• Consulting electrical engineer. • Utility representative. • Plant engineer.	• Transformer losses range from 2% at no load to 9% at full load.	• A power factor of greater than 0.8 may be acceptable but a specialist should be consulted for a specific evaluation of your plant.

Processes and equipment *(cont.)*

Item	*Why important?*	*Action required*	*How long to implement*	*Who can help?*	*Energy savings*	*Remarks*
12. Electric Motors		• Turn off equipment when not in use. • If operating efficiency is below 70%, investigate further. • If due for retirement, investigate higher efficiency motors and matching of the motor to the load for best economic return.		• Plant employees. • Plant engineer. • Consulting electrical engineer. • Electric utility representative.		
13. Refrigeration	• Equipment operates 24 hours a day all year. It requires regular cleaning and maintenance for hygenic reasons and to reduce running costs.	• Check refrigerator door gaskets hinges and catches. • Defrost any ice build-up on evaporator regularly. • Clean condensor cooling fins and refrigeration motors regularly. • Call for service if motor refuses to shut down or switch off regularly • Consider adding air curtains or plastic strip curtains for coolroom doorways. • Check refrigeration lines from unit to motor periodically		• Plant maintenance • Refrigeration specialist • Consulting engineer.		• Consider reclaiming waste heat from larger refrigeration systems to heat water or as space heating for offices.

Plant building

1. Plant air-outside air/ exhaust air	• Generally, all the outside air that enters the plant must be heated to interior conditions. Exhaust air represents a loss of heated air.	• Reduce the quantity of outside air required and the quantity of exhaust air required to the minimum amount required for each process and consistent with codes and regulations. • Recover heat from exhaust air to heat incoming air.	• 2-4 weeks.	• Plant manager. • Plant employees. • Consulting mechanical engineer. • Manufacturer's representative. • Utility representative.		
2. Ventilation	• Ventilation air may be required for dilution and makeup.	• Requirements for ventilation may have changed. Evaluate present requirements. • Measure present ventilation. Do not waste energy conditioning air - minimum levels of outdoor air provision are given in NZS 4303: 1990	• 2-4 weeks.	• Consulting mechanical engineer. See Item 1.		
3. Openings in structure (e.g. loading docks)	• Excessive infiltration of cold outside air requires extra energy to provide comfort.	• Close off all unnecessary openings - unused exhaust fans, broken windows, structural openings. • Enclose the trucks or railroad cars at the loading platforms. • Could clear plastic strip partitions be of use? • Investigate the possible use of automatic doors or air curtains.	• 1-2 weeks. • 2-5 weeks.	• Plant maintenance. • Outside contractor. • Plant employees.		• Improves working environment with the possibility of reducing air temperature required for comfort.
4. Wall and roof insulation	• Most uninsulated walls and roof structures may allow 2 to 3 times the heat loss of an insulated structure.	• Insulate roof and walls which reduces heat loss through the building structure.	• Varies with building.	• Plant maintenance. • Outside contractor.	• Heat loss can be reduced by as much as 2/3 or more.	• Increases the inside surface temperature of the walls and roof. • Improves the comfort level for the same air temperature.

Plant building *(cont.)*

Item	*Why important?*	*Action required*	*How long to implement*	*Who can help?*	*Energy savings*	*Remarks*
5. Windows and doors	• Heat loss by transmission/ infiltration.	• Add weather stripping or seal windows. • Erect weather screens externally or internally to help protect doorways. • Add door closers.	• 1-3 weeks.	• Plant maintenance. • Outside contractor.	• Heat loss can be reduced by 1/3 or more.	• Worker discomfort in factory work areas is often due to draughts and the resultant heat loss rather than insufficient heating.
	• Doors and windows on opposite walls permit excessive infiltration by direct flow of air through building.	• Lock, seal or change doors or windows on one wall. • Use door closers. • Break the flow of air by use of airlocks and internal doors.	3-6 weeks	• Plant maintenance. • Outside contractor.		
6. Space heating system	• The space heating system uses energy to provide a comfortable working environment. • It offsets heat losses through the building and heats cold air entering the building.	• Supply only as much heat as is necessary for comfort - do not overheat. • Reduce losses from heating system. • Can it be done with zones of radiant comfort heating? • Relate the heating requirements to the type of work being done.		• Heating, ventilating and air conditioning engineer.		• Have specialist check control system for optimum operation.
7. Central system boilers	• Combustion of fuels to generate steam or hot water.	• Perform periodic combustion analyses and adjust burners. • Consider heat recovery from flue gases. • Clean, blow down to maintain operating efficiency. • Check feedwater chemical control to minimise waterside buildup. • Could a small local electric boiler supply isolated low level requirements?		• Plant engineer. • Combustion specialist. • Consulting engineer. • Original equipment manufacturer.	• Improper adjustment of combustion may be wasting 10% or more of the fuel. • Heat recovery from the stack gases may save 10% of the boiler fuel input even at lower stack temperatures.	• Many boilers operate at low efficiency due to lack of proper maintenance.
8. Steam hot water		• Insulate lines. • Repair leaks. • Check operation of traps. • Use of insulated storage tanks to receive heated water during off-peak hours can improve operating efficiencies.		• Plant maintenance.		
9. Unit heaters direct fired	• Combustion of fuels for heating air.	• Readjust burners for maximum efficiency. • Clean heat exchanger surfaces. • Cycle fan operation.	• Immediately.	• Combustion specialist. • Plant engineer.	• Improper combustion may be wasting 10% or more of the fuel.	
10. Infra-red radiant direct fired or electric for comfort heating		• For applications with low temperatures of the surrounding walls and roof, it may be better to provide direct radiant heating rather than heating the air. • Periodic cleaning and maintenance.		• Heating, ventilating and air conditioning engineer. • Plant engineer. • Manufacturer's representative.	• Many applicants of infra-red space heating show savings of greater than 20% over unit heater systems.	• Good for spot heating.
11. Space air conditioning and heating systems	• The energy required by the heating, ventilating and air conditioning system is used for fan motors, refrigeration systems and heating systems.	• A complete analysis is required to minimise the energy required. • Control settings should not be changed without considering the effect on the whole system. • Clean filters on a regular basis. • Lock out refrigeration system by a return air thermostat.		• Heating, ventilating and air conditioning engineer.		

Plant building *(cont.)*

Item	*Why important?*	*Action required*	*How long to implement*	*Who can help?*	*Energy savings*	*Remarks*
12. Controls systems and settings	• Controls determine the actual operating characteristics of the system.	• Original system design and operation may have been based on different parameters and energy costs. A new look may 'tune-up' system for lower energy costs.		• Control specialist. • Consulting engineer. • Plant maintenance.		• Many systems are out of adjustment and are not operating as designed or with optimum use of energy.
13. Personnel hot water	• Heat is required to raise the temperature of the water from the entering temperature, usually 5 to 20°C, to the desired temperature. • Heating rate required is approximately: power (kW) = 4.2 x flow rate (l/s) x temp. rise (C).	• Repair leaks at hot water taps. • Check to see that hot water taps are shut off when not in use. • Repair leaks in hot water lines. • Reduce hot water thermostat setting to the lowest temperature which is acceptable. • Separate system from space heating or other hot water system. • Clean heaters regularly, following the manufacturer's recommendations. • Should be flushed and cleaned periodically. • Check the standard of insulation on all hot pipework.		• Plant maintenance. • Plant employees.		
14. Lighting		• Turn off lights when not in use. • Install lighting only to that required for task. • Consider replacing lighting with more efficienct lamps - incandescent to fluorescent to gaseous discharge lamp. • Consider using fittings which are more effective in directing the light to the work area. • Consider integration of daylight with electric lighting. • Ducted fittings can be used to recover comfort heat and will improve operating efficiency of suitable lamps. • Lamps and fittings should be cleaned as part of a regular maintenance programme. Utilise daylighting as practicable. Heat reflective coatings may make windows more useful. • Control window brightness. If windows admit excessive light, the general lighting standard may have to rise to reduce contrasts.		• Illuminating engineer. • Electric supply authority representative. • Plant engineer. • Plant employees.		• Approximate light effect per unit electric power (lumen per watt) Incandescent 15 Mercury Vapour 50 Fluorescent 75 Multi-vapour 90 H.P.Sodium 110

Appendix E: Pulsomatic Load Curve