ENERGY MANAGEMENT

for

INDUSTRY AND BUSINESS

[Principles of Energy Management]

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1.0 INTRODUCTION

Energy management is managing energy inputs with the aim of minimising total energy costs, and maximising profits. Energy costs are but one component in the cost of production. If these costs are significant, energy management will offer a very effective way of reducing costs, increasing efficiency and maximising profits as an improved work culture spreads through the business.

Energy management relates specifically to managing energy costs, with the aim being to reduce those costs. In general an energy cost reduction programme would be associated with using less energy and hence would be indicative of a greater energy efficiency. However, there may be some circumstances where a cost reduction could be achieved by increased energy use. Examples would be a fuel substitution for a vehicle converted to run on compressed natural gas, or the use of wood waste to fire a boiler previously fired with natural gas.

The extent to which energy management techniques should be applied in an industrial plant will depend on the following items:

- the total cost of energy,
- the relative cost of energy, i.e. what percentage of production costs is spent on energy, and
- knowledge of the benefits of energy management and energy management methods - technical, innovative and human.

The success of applying energy management techniques will depend on and require ***commitment*** from senior management and the necessary resources to run the programme.

Irrespective of whether energy is managed in a formal way, businesses should know and be aware of their energy costs.

2.0 STARTING POINT

A starting point is required to enable an informed decision to be made on whether to apply energy management techniques in running a business. The best approach is to conduct an internal review of the different energy types, and their costs and usage throughout the plant. For the review to be meaningful, it should include a minimum of two years data with a longer period to be preferred.

At this stage, the annual energy usage and costs should be examined and a decision made on whether further action is warranted and that decision may be difficult. It is likely that the manager facing this decision will not know what potential exists to reduce energy costs even if all energy costs are known. One rough indication may be to look at trends in energy data over a few years to identify variations in energy usage and costs, from which some estimate could be made of potential savings based on the best performance in the data.

If energy usage and costs are related to production a better picture will emerge, particularly if relevant industry benchmarking is available through information papers or trade associations.

No guarantees can be made on how much can be saved through energy management. The savings depend to a large extent on the starting point but significant savings may be achieved through the intelligent application of energy management principles with a thorough understanding of the production processes.

The effect on bottom line profitability will vary. In many instances a significant reduction in energy costs can be achieved. Usually savings of ten percent can be achieved fairly readily and on many occasions savings of twenty to thirty percent or greater can be obtained. The return on the investment (ROI) for energy cost reduction projects will vary greatly. More attractive projects will return the investment in less than one year. ROIs of two to three years are quite common. Also, there will usually be some projects with still longer ROIs but these often do not meet the investment criteria for most businesses. Typical savings are discussed in more detail in section 4.0.

On the basis that a preliminary assessment indicates the possibility of sufficient cost savings, the next step would be to proceed with an energy audit.

3.0 THE AUDIT

3.1 General

An energy audit may be completed internally by competent staff or could be undertaken by a suitably qualified external consultant.

The energy audit should cover all aspects of energy usage in the business and identify worthwhile energy cost reduction projects. The final report should include sufficient detail for any required follow-on work such as project implementation. It may be necessary to engage a consulting engineer or the original consultant to prepare tender specifications and supervise the installation of energy cost reduction projects.

3.2 Data Gathering

The first process of the energy audit is to gather information on energy usage for each energy type over a suitable time period - preferably at least two years. Usually this information is best sourced from copies of electricity accounts, gas accounts etc.

Main energy types include:

- Electricity
- Natural Gas
- Oil (Fuel Oil, Distillate, Petroleum etc)
- Coal
- Water
- Steam
- (Possibly bottled gases)

Note the inclusion of water. Whilst water is not an energy type, it often should be included because water balance, water usage and the energy used for pumping is quite important in the energy management process.

The selection of energy types to be included in the analysis will depend on relative costs and usage levels.

Also, an important part of the auditing process is to gather data on production quantities and costs over the same time periods for gathered energy data.

3.3 Data Presentation

In evaluating the gathered data, the preferred methodology is to use a computer spread sheet to record and present the data. For example, for electricity, it would be appropriate to include data columns of

- Month/Year
- Production Quantity
- Production Costs
- Electrical Energy kWh (+ other columns for kWh peak, shoulder, off peak)
- Electrical Demand kW / kVA (+ other columns for kW/kVA peak, shoulder, off peak)
- Total Cost
- kW or kVA Cost

Additional columns should be added to provide a number of performance indicators. The indicators will depend on the production processes and the electricity tariff. Some useful indicators which may be appropriate are as follows:

Cost Indicators

- Total Energy Cost per Month
- Demand Charges per Month
- Energy Cost per Production Cost
- Energy Cost per Production Quantity

Electricity Usage Indicators

- Electricity Use per Production Quantity
- Electricity Use per Day
- Electricity Demand per Month
- Load Factor (relationship between average demand / maximum demand)

Similar analyses should be carried out for the other energy types. An extract showing a typical analysis is shown below:

Month	kWh	Cost $	Tonnes	c/kWh	c/tonne	kWh/t
Apr	2,763,631	$197,592	2,153,000	7.150	9.178	1.284
May	2,712,117	$209,962	2,030,554	7.742	10.340	1.336
Jun	2,620,012	$207,522	1,927,000	7.921	10.769	1.360
Jul	2,855,059	$210,444	2,213,439	7.371	9.508	1.290
Aug	3,062,637	$226,040	2,430,733	7.381	9.299	1.260
Sep	2,834,220	$211,689	2,123,640	7.469	9.968	1.335
Oct	2,950,377	$217,633	2,365,000	7.376	9.202	1.248
Nov	2,843,316	$214,053	2,294,073	7.528	9.331	1.239
Dec	2,772,746	$202,507	2,248,787	7.303	9.005	1.233
Jan	2,584,946	$191,813	1,938,895	7.420	9.893	1.333
Feb	2,746,089	$206,375	2,214,878	7.515	9.318	1.240
Mar	2,482,915	$207,953	1,908,349	8.375	10.897	1.301

To ensure that the data which has been collected is meaningful, sometimes it is necessary to undertake some detective work. For example, often the billing periods will not align with production periods or there may be more than one product produced. Under these circumstances, adjustments will be necessary to the spreadsheet.

The final result should be an accurate portrayal of energy costs and usage over the two to three years time frame together with production data and costs.

3.4 Data Analysis

Using the spreadsheet, a graphical representation of some of the data and the calculated indicators is quite useful. In this way, historical patterns of energy use, energy use per production, costs, costs per production etc can be seen. Thus it will be relatively straightforward to look for any seasonal or unusual patterns (by fuel type and or production).

The energy performance measures derived from the analysis should be compared with published data if available. Alternatively comparisons can be made within the data itself. A useful comparison would be to compare data between similar plants within the same organisation.

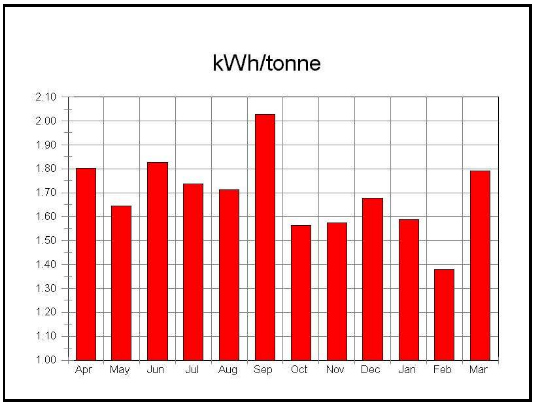
Once the spreadsheet has been completed, it should be studied for trends -

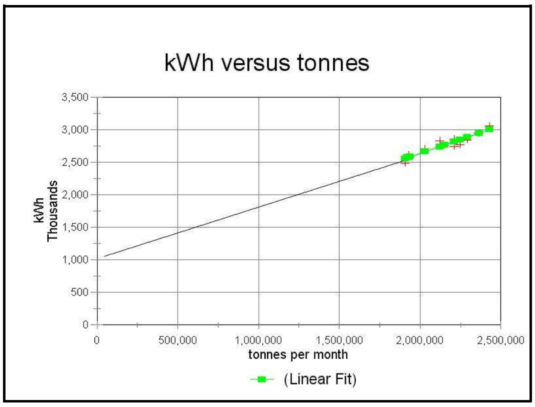
- best performance
- worst performance
- seasonalities

and explanations should be found for the trends.

It may be important for data analysis to separate production for the various energy types? If it has not been possible then consideration should be given to separating the energy data on site by either on-site measurements or the use of in house sub-metering.

At all times, an intelligent overview should be undertaken. For example, is the energy per production unit meaningful? The two diagrams below illustrate how some energy data could be displayed.





Having established the base energy data, consideration can be given to changing fuel types or purchasing arrangements as follows:

1. Electricity - change in tariff, e.g. demand tariff, time of use, high voltage etc. or power factor correction.

   Note 1: a tariff change does not save energy. Power factor correction provides a small energy saving through reducing losses in cables. Sometimes power factor correction will give a better equipment utilisation. Also, the effect of a lower power consumption from energy projects would need to be considered with any change in tariff

   Note 2: In the deregulated electricity market many opportunities may exist to obtain electricity at a lower cost, including contracting for the supply of electricity across one or more sites, purchasing privately, self generation, purchase on the pool etc.

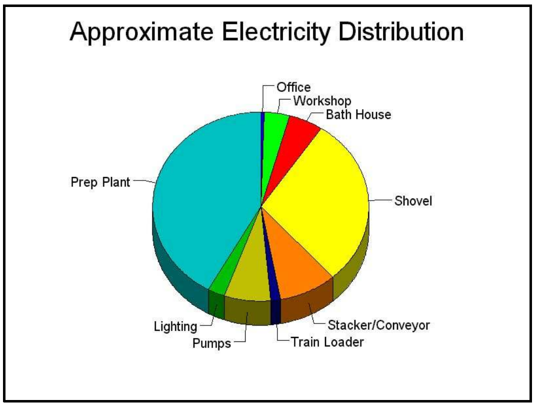
2. Natural Gas - revised contract conditions and possibilities under an increasingly de-regulated gas supply market..

3. Fuel substitution.

3.5 On-Site Measurements and Evaluation

Having completed the base analysis of energy data, the next step in the energy management process is to proceed with inspections on site and measurements of energy usage. The purpose is to produce a distribution chart to account for all energy usage by areas or process within the plant. It is important to build a complete profile of energy use in this way that agrees reasonably well with the overall data analysed in the spreadsheet.

This profile will show where most energy usage occurs and the relative energy costs for various areas. The diagram below shows a typical electrical distribution.



Additionally, the diagram can provide information which can lead to reducing energy costs by a number of methods, for example:

- Identification and rectification of equipment faults
- Alteration to existing processes to achieve cost savings
- Identification and implementation of projects to reduce energy consumption and costs.

In seeking ways to improve processes or introduce cost effective changes it is necessary to:

- be familiar with a range of energy management techniques
- gain an understanding of the products/processes and critical aspects of the process.
- think laterally

3.6 On-Site Measurements

The following sections deal with measurement of specific energy types.

3.6.1 Electricity:

An electrical Load Survey consists of a computerised recording of electrical energy data over a specific time period. The survey may cover only the main supply point or it may include a number of electrical switchboards on the site or it may be a survey for a major item of equipment. The survey results will provide data for evaluating:

- the electricity tariff, or contract purchasing
- need for power factor correction
- the electricity (and costs) consumed in various areas
- the standing load
- the load factor (can be a measure of efficiency)

The power consumption for individual rotating AC machines may be measured (usually using portable power meters) for

- motor efficiency - use of smaller motor or a high efficiency motor?
  - application of variable speed drives
- usage profile (proportion of total energy use and cost)
- heat loss (if relevant)
- running times (can times be reduced?)

Machine power consumption will allow assessment of the process for reduced motor size, application of variable speed drives, high efficiency motors and/or motor controllers (note for v/s drives, a reliable and workable control loop is required), application of other drive systems (e.g. flat belts), and consideration of heat recovery.

The power consumption for individual DC machines may be measured (usually using portable clamp meters) for

- efficiency,
- possible use of an AC system (full analysis should include consideration of harmonics).

The power consumption of electric heating systems may be measured for

- load, efficiency, and operating times
- consideration of alternate heating systems (fuel substitution, solar?)

The electrical load of lighting systems may be measured to examine

- fitting type (efficiency, operation/control, suitability for task) and consider
- replacement with more efficient fitting type, improved controls such as autotransformer control, greater use of daylight, etc.

The electrical load of AC ventilation systems will allow an evaluation of

- plant capacity and adequacy for task (oversized?)
- potential for heat recovery
- potential for computer controls / system optimisation.

3.6.2 General Electrical

In evaluating electricity use, consideration should be given to using computerised or time control systems to switch off plant at pre-determined times to give close control over allowable operating hours. Systems may be direct wired, utilise power line carrier signals, a field bus system, utilise radio links or other carrier means. Often simple time clocks are appropriate though there may be traps in the simple solution such as changing the time settings for summer time and making exceptions for public holidays.

The possibility of computerised control of demand can be awkward and often is process dependent. It may be difficult to find suitable electrical loads that can be shed. If in an industrial plant the maximum demand occurs on one to two days in the month and then only for a short time, some demand lopping should be possible. The cost benefit is dependent on the electricity price signals. In today’s deregulated electricity market, pricing has moved more to energy only making demand management to reduce costs unattractive.

3.6.3 Gas

A load survey of gas usage will determine where and how the gas is used. Depending on the particular installation, on-site measuring may be difficult. Because sub-meters are often not in place, it may be necessary to infer gas usage from appliance rating, observations and operating times. It may be desirable to install sub-meters.

As part of the analysis of gas usage, combustion efficiency measurements of furnaces and boilers should be carried out to determine how efficiently the gas is being used. Combustion efficiency meters will sample the flue gas, measure the temperature and analyse the flue gas for percentages of oxygen, carbon dioxide, carbon monoxide, and other gases. From this

information, the combustion efficiency can be determined allowing analysis of:
- improved controls for better fuel mixing.
- burners with greater efficiency, e.g. recuperative burners and regenerative burners.

3.6.4 Thermographic Surveys
Thermographic surveys utilise infra red cameras to determine temperature profiles over the surfaces of heated or cooled objects, e.g. furnaces, boilers, steam lines, cold stores. Note that the survey usefully may be extended to buildings and electrical installations. The information from the survey will allow
- determination of the condition of furnace refractories, system insulation and will show where losses occur,
- loss calculations - benefits from improved insulation and accurate consideration of different insulation types - light weight or conventional,
- improved heat seals,
- heat recovery and other use of waste heat

3.6.5 Steam
As with analysis of gas, analysis of steam usage may be difficult because of lack of metering equipment. However, if the boiler is equipped with instrumentation, the data from the instruments can be used to review:
- operating temperatures/pressures, and
- load cycle.

Installation of steam meters may be justified on larger installations. However, the installation process is time consuming and costly.

Temperature measurements should be made of all operating surfaces of the steam system so that losses and the operation of the steam system may be analysed.

The combination of temperature, pressure and steam flow measurements and make up water will allow the total system to be analysed for its efficiency. Also, the system should be examined for un-lagged lines and un-used lines, condensate recovery and whether a closed system is appropriate. Other techniques include:
- Boiler Sizing/Modulation Capability
    - altered controls, greater modulation range
    - reduced output
    - close timing of operation - economiser
    - smart heat recovery, e.g., heat exchanger on boiler side of boiler feed water pump
- Can the process be undertaken in another way?
- Is there an application for power generation / combined heat and power?

3.6.6 Compressed Air Systems
The electrical load of compressed air systems should be measured at different times to determine the losses in the system. Of particular importance is an adequate air storage capacity in the system.

Air systems can be very costly if not properly maintained. Consideration should be given to the operating pressures and losses in the system and whether there is potential for heat recovery.

Also, it is important to check the design and installation of the compressed air system for correct sizing and operation of air compressors and receivers, the gradient of the compressed air lines, moisture traps, any pressure let down devices and the need for air dryers.

Whilst the use of compressed air may offer safety advantages, as an energy source it is costly. Up to 85% of the energy consumed by a compressed air system will be used just to compress the air, with the balance available for useful work. Other energy sources should be considered if possible to reduce costs.

3.7 Innovative Solutions

There are a many ways to use energy in an innovative way. Applying these techniques requires a detailed analysis of the existing energy use and a full appreciation of production processes.

One example is co-generation. Co-generation is the simultaneous production and use of heat and electrical power. While there are a myriad of alternatives, one alternative could be a gas turbine engine driving an alternator with the waste heat from the exhaust gases utilised in a waste heat boiler. High efficiencies can be obtained from these processes, typically more than 75%. However, for this type of scheme to be viable it is necessary to have the correct heat and electricity balance.

Similarly, clever management of energy may well utilise waste heat in an appropriate heat exchanger providing there is a need for the energy. Other alternatives could be to burn waste materials in a suitably designed boiler.

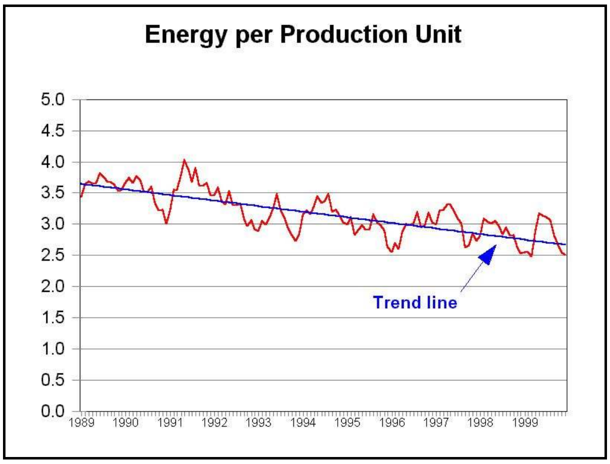
There are many choices for good energy management and each topic in the following list will have some applicability depending on the circumstances:

- co-generation
- waste heat recovery
- flash steam recovery
- use of waste heat within the process
- improved combustion controls
- re-scheduling operations of plant
- demand management
- lighting improvements
- greater use of natural light
- computerised control of plant and equipment
- increased insulation
- solar heating
- appropriate shading
- soft starters
- variable speed drives
- high efficiency electric motors
- change in drive coupling systems
- fuel substitution: e.g. natural gas powered vehicles
- use of a gas engine as a prime mover where previously electricity would only have been considered
- fuel cells for the production of heat and electricity
- distributed generation, etc..

4.0 FINANCIAL BENEFITS FROM ENERGY MANAGEMENT

Energy management projects can provide excellent returns on the investment. It is important to ask, "What can be saved?" Clearly, the possible savings depend on the starting point. If the starting point is one of energy efficiency, savings will be low and conversely if the operation is not energy efficient, savings will be large.

Typically, savings of 15% are common rising to 25 - 30% for energy inefficient operations. The ROI for new equipment and or energy projects can be over 100% in the best case with most projects having reasonable ROIs of from 30% - 50%, i.e. a payback in 2 to 3 years.



The diagram above shows the results for one division of a large industrial group over 10 years. The reduction in energy usage per unit of production over this time was more than 25% which represented annual savings to the group of more than $2.5 million at current energy prices.

Savings in each case requires proper analysis based on accurate data. However ......

Savings through energy management impact directly on the bottom line!

5.0 HUMAN FACTORS IN ENERGY MANAGEMENT

So far, this discussion paper has dealt with technical solutions to technical problems.

However, for energy management to be truly successful in any business it is important to enlist support from staff.

There are many publications available explaining how to involve employees in energy management and they should be considered. An important part of energy management is staff attitude. A positive attitude to energy management will have spin-offs in other areas and lead to an overall improved efficiency.

The key to the overall success of any Energy Management Programme is ***commitment*** from Senior Management and provision of the necessary resources to do the job!

6.0 THE ENERGY MANAGEMENT PROGRAMME

The steps in the Energy Management Programme include:

Initial
- Initial audit of energy consumption - database
- Energy audits of business units and activities as necessary
- Identification and documentation of energy projects
- Project implementation

Ongoing
- Monthly energy recording together with production data
- Monthly energy performance indicators (could be KPIs)
- Monthly performance evaluation
- Use of Energy Data for Process Management
- Feedback on project results

Staff Awareness
- Publicity and Staff awareness programmes
- Staff Training

Policy
- Energy policy, i.e., as related to purchasing, customers, business partners, in-house activities, etc.

Annual Review
- Annual review of programme to evaluate results, identify further projects etc.

Also: a single person should be given responsibility for running the energy management programme.

Projects should be evaluated for their energy savings using an appropriate methodology. Energy performance indicators should be established for the period prior to the project and compared to the period following project commissioning. One method for evaluating projects in this was CUSUM which accumulates the difference between predicted and actual results.

Companies that manage their energy in an efficient and responsible way can promote a healthy image. Wise energy use is good for the environment.

Energy management leads to lower greenhouse gas emissions. In turn this allows ready participation in the Greenhouse Challenge Program, a joint cooperative programme between the Commonwealth government and industry.

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