Lecture 6: Energy Management

Definition:

“The efficient and effective use of energy to maximize profits (minimize costs) and enhance competitive positions”

This rather broad definition covers many operations from services to product and equipment design through product shipment. Waste minimization and disposal also presents many energy management opportunities.

The primary objective of energy management is to maximize profits or minimize costs. Some desirable sub objectives of energy management programs include:

1. Improving energy efficiency and reducing energy use, thereby reducing costs.
2. Reduce greenhouse gas emissions and improve air quality.
3. Cultivating good communications on energy matters.
4. Developing and maintaining effective monitoring, reporting, and management strategies for wise energy usage.
5. Finding new and better ways to increase returns from energy investments through research and development.
6. Developing interest in and dedication to the energy management program from all employees.
7. Reducing the impacts of ***curtailments****, brownouts, or any interruption in energy supplies.

****Curtailments occur when a major supplier of an energy source is forced to reduce shipments or allocations (sometimes drastically) because of severe weather conditions and/or distribution problems. For example, natural gas is often sold to industry relatively inexpensively, but on an interruptible basis. Even though curtailments do not occur frequently, the cost associated with them is so high—sometimes a complete shutdown is necessary—that management needs to be alert in order to minimize the negative effects. There are several ways of doing this, but the method most often employed is the storage and use of a secondary or standby fuel.***

Although energy conservation is certainly an important part of energy management, it is not the only consideration. Other considerations include: Curtailment-contingency planning, load shedding, power factor improvement.

6.1 THE NEED FOR ENERGY MANAGEMENT

6.1.1 Economics

In any free enterprise system, any new activity can be justified only if it is cost effective; that is, the net result must show a profit improvement or cost reduction greater than the cost of the activity. Energy management has proven time and time again that it is cost effective.

An energy cost savings of ***5-15 percent*** is usually obtained quickly with little to no required capital expenditure when an aggressive energy management program is launched. An eventual savings of 30 percent is common, and savings of 50, 60, and even 70 percent have been obtained. These savings all result from retrofit activities. New buildings designed to be energy efficient can operate on 20 percent of the energy (with a corresponding 80 percent savings) normally required by existing buildings. In fact, for most manufacturing, industrial, and other commercial organizations *energy management is one of the most promising profit improvement-cost reduction programs available today.*

6.1.1 National and Global Good

Energy management programs are vitally needed today. One important reason is that energy management helps the nation face some of its biggest problems. i.e Growing population, Energy/Oil imports, Reliance on imported oil.

Energy use has also resulted to major environmental, economic and industrial competitiveness problems. Reducing energy use can help minimize these problems by:

i. **Reducing acid rain.** Acid rain has been reduced mainly through national and regional environmental policies around the world.
ii. **Limiting global climate change.** Carbon dioxide, the main contributor to potential global climate change, is produced by the combustion of fossil fuel, primarily to provide transportation and energy services. In 1992, many countries of the world adopted limitations on carbon dioxide emissions. Reducing fossil energy use through energy

efficiency improvements and the use of renewable energy is without doubt the quickest, most effective, and most cost-effective manner for reducing greenhouse gas emissions, as well as improving air quality, in particular in densely populated areas.

iii. **Reducing ozone depletion.** The Montréal Protocol of 1987, and its subsequent updates, is one of the most successful environmental protection agreements in the world. The Protocol sets out a mandatory timetable for the phase out of ozone depleting substances.

iv. **Improving national security.** Oil imports directly affect the energy security and balance of payments of our country. These oil imports must be reduced for a secure future, both politically and economically.

v. Improving a country's competitiveness.

Some possible solutions to the energy problem.

i. Many look to coal as the answer. Yet coal burning produces sulfur dioxide, and carbon dioxide which produce acid rain and potential global climate change. Research and development on "clean coal" technology is currently underway.

ii. Synfuels require strip mining, incur large costs, and place large demands for water in arid areas. On-site coal gasification plants associated with gas-fired, combined-cycle power plants are presently being demonstrated by several electric utilities. However, it remains to be seen if these units can be built and operated in a cost-effective and environmentally acceptable manner.

iii. Solar-generated electricity, whether generated through photovoltaics or thermal processes, is still more expensive than conventional sources and has large land requirements. Technological improvements are occurring in both these areas, and costs are decreasing. Sometime in the near future, these approaches may become cost-effective.

iv. Biomass energy is also expensive, and any sort of monoculture would require large amounts of land. Some fear total devastation of forests. At best, biomass can provide only a few percentage points of our total needs without large problems.

v. Wind energy is only feasible in limited geographical areas where the wind velocity is consistently high, and there are also some noise and aesthetic problems. However, the cost of wind generation systems has come down, and they are cost-effective in windy areas. Operating costs are also very low.

vi. Fuel cells and their ability to cleanly produce electricity from hydrogen and oxygen are what make them and hydrogen attractive. However, hydrogen is not a primary source of energy. It is made from other forms of energy; most hydrogen production today is by steam reforming natural gas. Natural gas is a fossil fuel, so the carbon dioxide released in the reformation process adds to the greenhouse effect. Only when hydrogen is made cost effectively from renewable energy sources does it have any significant value as a fuel source for a fuel cell.

vii. Alcohol production from agricultural products raises perplexing questions about using food products for energy when large parts of the world are starving. Newer processes for producing alcohol from wood waste are still being tested, and may offer some significant improvements in this limitation.

viii. Fission has the well-known problems of waste disposal, safety, and a short time span with existing technology. Without breeder reactors or nuclear fuel reprocessing, we will soon run out of fuel, but breeder reactors dramatically increase the production of plutonium—a raw material for nuclear bombs. Nuclear fuel reprocessing could provide many years of fuel by recycling partially used fuel now being kept in storage.

ix. Fusion seems to be everyone's hope for the future, but many claim that we do not know the area well enough yet to predict its problems. When available commercially, fusion may very well have its own style of environmental-economic problems.

Time and again energy management has shown that it can substantially reduce energy costs and energy consumption through improved energy efficiencies. This saved energy can be used elsewhere. In fact, energy available from energy management activities has almost always proven to be the most economical source of "new" energy. Furthermore, energy management activities are gentler to the environment than large-scale energy production, and they certainly lead to less consumption of scarce and valuable resources. Thus, although energy management cannot solve all the nation's problems, *perhaps it can ease the strain on our environment and give us time to develop new energy sources.*

6.2 DESIGNING AN ENERGY MANAGEMENT PROGRAM

6.2.1 Management Commitment

The most important single ingredient for successful implementation and operation of an energy management program is commitment to the program by top management. Without this commitment, the program will likely fail to reach its objectives. Thus, the role of the energy manager is crucial in ensuring that management is committed to the program.

Two situations are likely to occur with equal probability when designing an energy management program. In the first, management has decided that energy management is necessary and wants a program implemented. This puts you—the energy manager—in the ***response*** mode. In the second, you—an employee—have decided to convince management of the need for the program so you are in the aggressive mode. Obviously, the most desirable situation is the response mode as much of your sales effort is unnecessary; nonetheless, a large number of energy management programs have been started through the ***aggressive*** mode.

Response mode

In a typical scenario of the response mode, management has seen rapidly rising energy prices and/or curtailments, has heard of the results of other energy management programs, and has then initiated action to start the program. In this case, the management commitment already exists, and all that needs to be done is to cultivate that commitment periodically and to be sure the commitment is evident to all people affected by the program.

Aggressive mode

In the aggressive mode, you, the employee, know that energy costs are rising dramatically and that sources are less secure. You may have taken a course in energy management, attended professional conferences, and/or read papers on the subject. At any rate, you are now convinced that the company needs an energy management program. All that remains is to convince management and obtain their commitment. The best way to convince management is with facts and statistics. Sometimes the most startling way to show the facts is through graphs. Follow this data with quotes on programs from other companies showing these goals are realistic.

6.2.2 Energy Management Coordinator/Energy Manager

To develop and maintain vitality for the energy management program, a company must designate a single person who has responsibility for coordinating the program. If no one person has energy management as a specific part of his or her job assignment, management is likely to find that the energy management efforts are given a lower priority than other job responsibilities. Consequently, little or nothing may get done.

The energy management coordinator (EMC) should be strong, dynamic, goal oriented, and a good manager. Most important, management should support that person with resources including a staff. The energy management coordinator should report as high as possible in the organization without losing line orientation.

6.2.3 Backup Talent

Several engineering disciplines may be necessary to accomplish a full-scale study of the plant steam production, distribution, usage, and condensate return system. For this reason, most successful energy management programs have an energy management committee. Two subcommittees that are often desirable are the technical and steering subcommittees.

The technical committee

The technical committee is usually composed of several persons with strong technical background in their discipline. Chemical, industrial, electrical, civil, and mechanical engineers as well as others may all be represented on this committee. Their responsibility is to provide technical assistance for the coordinator and plant-level people. For example, the committee can keep up with developing technology and research into potential applications company-wide. The results can then be filtered down.

While the energy management coordinator may be a full-time position, the technical committee is likely to operate part-time, being called upon as necessary.

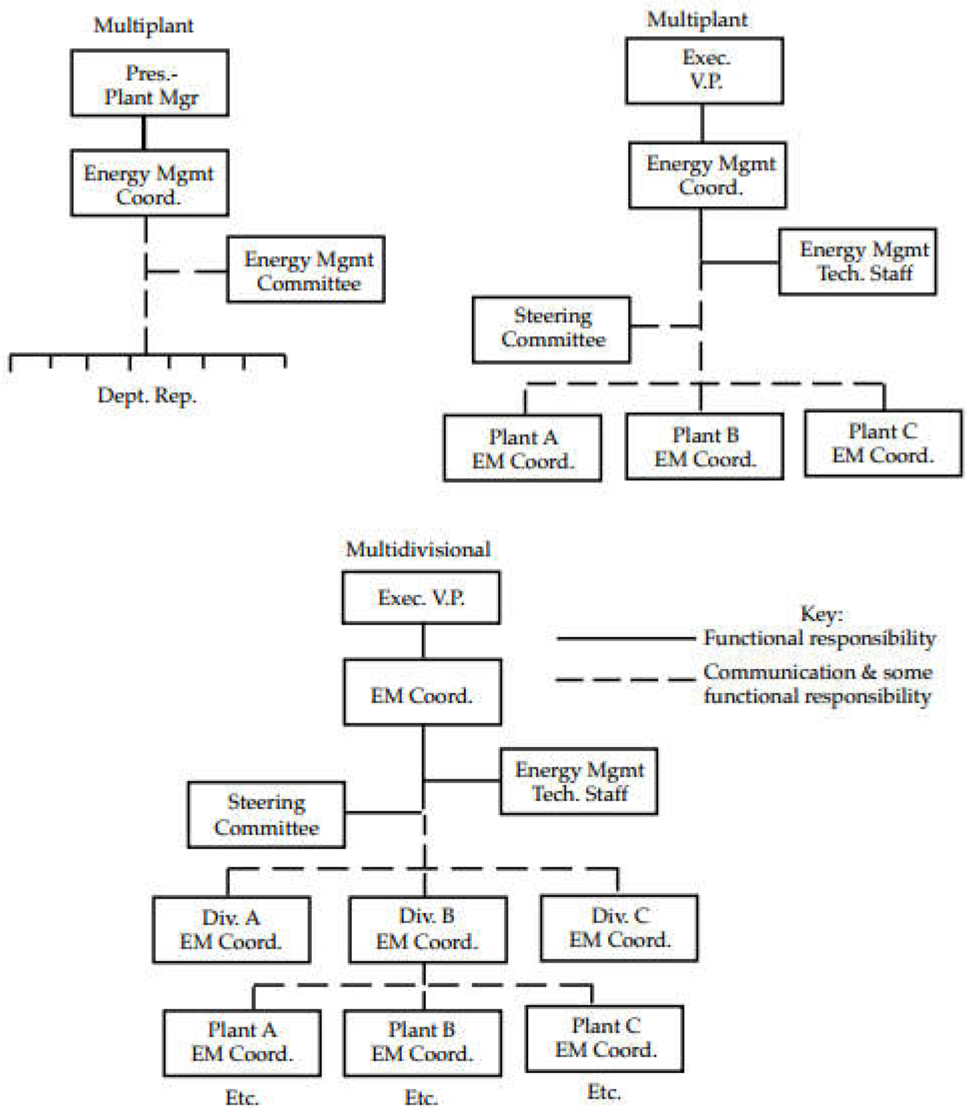

Figure 6.1.Typical Organization Designs for Energy Management Programs

The steering committee

The steering committee has an entirely different purpose from the technical committee. It helps guide the activities of the energy management program and aids in communications through all organizational levels. The steering committee also helps ensure that all plant personnel are aware of the program. The steering committee members are usually chosen so that all major areas of the company are represented. Steering committee members should be selected because of their widespread interests and a sincere desire to aid in solving the energy problems.

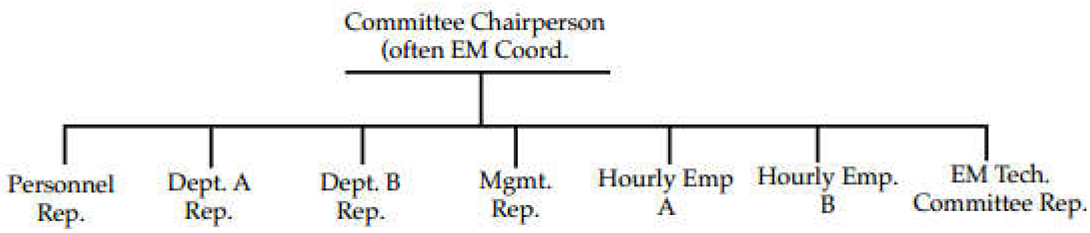

Figure 6.2.Energy Management Steering Committee.

6.2.4 Cost Allocation

One of the most difficult problems for the energy manager is to try to reduce energy costs for a facility when the energy costs are accounted for as part of the general overhead. In that case, the individual managers and supervisors do not consider themselves responsible for controlling the energy costs. This is because they do not see any direct benefit from reducing costs that are part of the total company overhead. The best solution to this problem is for top management to allocate energy costs down to "cost centers" in the company or facility. Once energy costs are charged to production centers in the same way that materials and labor are charged, then the managers have a direct incentive to control those energy costs because this will improve the overall cost-effectiveness of the production center. That is to say, they will have ***a skin in the game***.

6.2.4 .Reporting and Monitoring

It is critical for the energy management coordinator and the steering committee to have their fingers on the "pulse of energy consumption" in the plant. This is best achieved through an effective and efficient system of energy reporting. The objective of an energy reporting system is to measure energy consumption and compare it either to company goals or to some *standard of energy consumption.* Ideally, this should be done for each operation or production cost center in the plant, but most facilities simply do not have the required metering devices. Many plants only meter energy consumption at one place—where the various sources enter the plant. Most plants are attempting to remedy this, however, by installing additional metering devices when the opportunity arises. As always, the reporting scheme needs to be reviewed periodically to ensure that only necessary material is being generated, that all needed data is available, and that the system is efficient and effective.

6.2.5 Training

Most energy management coordinators find that substantial training is necessary. Training cannot be accomplished overnight, nor is it ever “completed.” Changes occur in energy management staff and employees at all levels, as well as new technology and production methods. All these precipitate training or retraining. The energy management coordinator must assume responsibility for this training.

Personnel involved	*Type of necessary training*	*Source of required training*
1. Technical committee	1. Sensitivity to EM	1. In house (with outside help ?)
	2. Technology developments	2. Professional societies universities, consulting groups, journals
2. Steering committee	1. Sensitivity to EM 2. Other Industries' experience	1. See 1 above 2. Trade journals, energy sharing groups, consultants
3. Plant-wide	1. Sensitivity to EM 2. What's expected, goals to be obtained, etc.	1. In house 2. In house

Figure 6.3.Energy Management Training

6.3 STARTING AN ENERGY MANAGEMENT PROGRAM

Several items contribute to the successful start of an energy management program. They include:

1. Visibility of the program start-up.
2. Demonstration of management commitment to the program.
3. Selection of a good initial energy management project.

6.3.1 Visibility of Start-up

To be successful, an energy management program must have the backing of the people involved. Obtaining this support is often not an easy task, so careful planning is necessary. The people must:

1. Understand why the program exists and what its goals are;
2. See how the program will affect their jobs and income;
3. Know that the program has full management support; and
4. Know what is expected of them.

Communicating this information to the employees is a joint task of management and the energy management coordinator.

6.3.2 Demonstration of Management Commitment

Management commitment to the program is essential, and this commitment must be obvious to all employees if the program is to reach its full potential. Management participation in the program start-up demonstrates this commitment, but it should also be emphasized in other ways. For example:

1. **Reward participating individuals**. Recognition is highly motivating for most employees. An employee who has been a staunch supporter of the program should be recognized.
2. **Reinforce commitment**. Management must realize that they are continually watched by employees.
3. **Fund cost-effective proposals.** All companies have capital budgeting problems in varying degrees of severity, and unfortunately energy projects do not receive the same priority as front-line items such as equipment acquisition. However, management must realize that turning down the proposals of the energy management team while accepting others with less economic attractiveness is a sure way to kill enthusiasm.

6.3.3 Early Project Selection

The energy management program is on treacherous footing in the beginning. Most employees are afraid their heat is going to be set back, their air conditioning turned off, and their lighting reduced.

If any of these actions do occur, it's little wonder employee support wanes. These things might occur eventually, but wouldn't it be smarter to have less controversial actions as the early projects.

An early failure can also be harmful, if not disastrous, to the program. Consequently, the astute energy management coordinator will "stack the deck" in his or her first set of projects. These projects should have a rapid payback, a high probability of success, and few negative consequences.

6.4 MANAGEMENT OF THE PROGRAM

6.4.1 Establishing objectives in an Energy Management Program

Creativity is a vital element in the successful execution of an energy management program, and management should do all it can to encourage creativity rather than stifle it. Goals need to be set, and these goals should be tough but achievable, measurable, and specific. They must also include a deadline for accomplishment. Once management and the energy management coordinator have agreed on the goals and established a good monitoring or reporting system, the coordinator should be left alone to do his/her job.

The following list provides some examples of such goals:

- Total energy per unit of production will drop by 10 percent the first year and an additional 5 percent the second.
- Each plant in the division will have an active energy management program by the end of the first year.

6.5 ENERGY ACCOUNTING

Energy accounting is a system used to keep track of energy consumption and costs. A basic energy accounting system has three parts: energy use monitoring, an energy use record, and a performance measure. The performance measure may range from a simple index of Btu/m^2 or Btu/unit of production to a complex standard cost system complete with variance reports. In all cases, energy accounting requires metering. Monitoring the energy flow through a cost center, no matter how large or small, requires the ability to measure incoming and outgoing energy. The lack of necessary meters is probably the largest single deterrent to the widespread utilization of energy accounting systems.

6.5.1 Levels of Energy Accounting

As in financial accounting, the level of sophistication or detail of energy accounting systems varies considerably from company to company. A very close correlation can be developed between the levels of sophistication of financial accounting systems and those of energy accounting systems.

6.5.2 Performance Measures.

6.5.2.1. Energy Utilization Index

A very basic measure of a facility's energy performance is called the Energy Utilization Index (EUI). This is a statement of the number of Btu's of energy used annually per square foot or metre of conditioned space. To compute the EUI, all of the energy used in the facility must be identified, the total Btu content tabulated, and the total number of square metre of conditioned space determined. The EUI is then found as the ratio of the total Btu consumed to the total number of square feet of conditioned space.

Financial	*Energy*
1. General accounting	1. Effective metering, development of reports, calculation of energy efficiency indices
2. Cost accounting	2. Calculation of energy flows and efficiency of utilization for various cost centers; requires substantial metering
3. Standard cost accounting historical standards	3. Effective cost center metering of energy and comparison to historical data; complete with variance reports and calculation of reasons for variation
4. Standard cost accounting engineered standards	4. Same as 3 except that standards for energy consumption are determined through accurate engineering models

Figure 6.4. Comparison between Financial and Energy Accounting

Example 6.1

Consider a building with 100,000 square feet of floor space. It uses 1. 76 million kWh and 6.5 million cubic feet of natural gas in one year. Find the Energy Utilization Index (EUI) for this facility.

Solution: Solution: Each kWh contains 3412 Btu and each cubic foot of gas contains about 1000 Btu. Therefore the total annual energy use is:

$$Total\ energy\ use = (1.76 \times 10^{6} kWh) \times (3412 Btu/kWh) + (6.5 \times 10^{6} ft^{3}) \times (\frac{1000Btu}{ft^{3}})$$

$$= 6.0 \times 10^{9} + 6.5 \times 10^{9}$$

$$= 1.25 \times 10^{10} Btu/yr$$

$$Dividing\ the\ total\ energy\ use\ by\ 10^{5} ft^{2}\ gives\ the\ EUI:$$

$$EUI = (1.25 \times 10^{10} Btu/yr)/(10^{5} ft^{2})$$

$$= 125{,}000 Btu/ft^{2}/yr$$

6.5.2.2. Energy Cost Index

Another useful performance index is the Energy Cost Index or ECI. This is a statement of the shilling cost of energy used annually per square foot of conditioned space. To compute the ECI, all of the energy used in the facility must be identified, the total cost of that energy tabulated, and the total number of square feet of conditioned space determined. The ECI is then found as the ratio of the total annual energy cost for a facility to the total number of square feet of conditioned floor space of the facility.

Example 6.2.

Consider the building in Example 6.1. The annual cost for electric energy is KSh115, 000 and the annual cost for natural gas is KSh.32, 500. Find the Energy Cost Index (ECI) for this facility.

Solution: The ECI is the total annual energy cost divided by the total number of conditioned square feet of floor space.

$$Total\ energy\ cost = 115{,}000 + 32{,}500 = 147{,}000/yr$$

$$Dividing\ this\ total\ energy\ cost\ by\ 100{,}000\ square\ feet\ of\ space\ gives:$$

$$ECI = \frac{\frac{147{,}500}{yr}}{100{,}000ft^2} = KSh.\frac{1.48}{ft^2}/yr$$

6.5.2.3. One-Shot Productivity Measures

Here the energy utilization index is plotted over time, and trends can be noted. Significant deviations from the same period during the previous year should be noted and explanations sought. This measure is often used to justify energy management activities or at least to show their effect.