16 Oct 1980

Managing in an Energy Scarce Environment

John Amos
Missouri University of Science and Technology

MANAGING IN AN ENERGY SCARCE ENVIRONMENT

John M. Amos
University of Missouri-Rolla
Rolla, Missouri

Abstract

Present engineering management principles, operations research techniques, and economic theories were mainly developed dealing with only one scarce resource -- capital. Today, the engineer manager must consider another scarce resource -- energy. In the past, energy was never considered a major factor; i.e., equipment was considered a good investment if labor was reduced, regardless of energy cost. Many other managerial decisions are similar; therefore, the engineer manager must understand why many decisions based on traditional techniques may be misleading. The engineer manager must now utilize more complex engineering management techniques instead of evaluating only one factor or using rules of thumb.

Fundamental technological energy decisions are being made and are in the process of being made that are going to have 30, 50 and 100 year impact on the organization of industry society. These decisions are traditionally being made by a very small group relying on rather narrow criteria techniques. In almost all cases these are inadequate criteria.

Engineering management concepts, principles, techniques and theories were developed during the era when energy was not considered a scarce resource. In that time only capital appeared as a scarce resource. Also, many concepts were directed toward solving "people problems" related to labor inputs. For example, most cost data is designed around and emphasize the cost of labor inputs. The term "productivity" is mainly directed toward the measurement of labor inputs not the productive utilization of energy.

Many common engineering management techniques that the engineer manager uses daily provide reasonable solutions to problems when used properly, but often misleading conclusions occur when they are misapplied. This especially occurs when the engineer manager does not have correct data and ignores basic assumptions of the technique. This requires the engineer manager to carefully consider each technique, assumption, and obtain correct data inputs before results can be meaningful.

During the fifties and sixties changes occurred and recessions occurred, but these were solved by government economic policies - mainly monetary policies. However, energy problems cannot be solved in this fashion. Past government policies have not worked for energy problems. As a result governmental agencies' attempts to grapple with energy seem to have no direction and seem unable to detect the deeper effects of the problem.

The engineer manager cannot overemphasize the crucial role that effective energy management must play in an organization and in its various activities; especially since in the past energy policy and decisions have not been a significant part of the managerial design process. It sometimes seems impossible to change this attitude of engineer managers and make them more sensitive to this part of the organizational decision-making process.

MANAGEMENT OF ENERGY

Energy must be considered unique compared to other resources in terms of its management. Capital and labor have well developed concepts and principals making problem analysis rather straightforward. The requirements for most energy components are not well represented by traditional engineering management concepts and principals. The energy resource not only has a cost, but at times, it has scarce supply limitations. Also, energy affects production schedules of both and primary and secondary manufacturing phases, and, because of this dependence, the usual techniques are inappropriate. The determination of optimum energy management must be achieved by separate methods. In addition, the engineer managers often reject solutions to energy problems because they do not trust the techniques or they legitimately feel that the techniques do not take into account other important factors that enter the problem. This causes the engineer manager to have reservations about all results of energy management analysis. Many times these negative conclusions are the result of the inappropriate application of engineering management concepts.

Energy management must provide means of managing energy, since many kinds of energy problems occur in an organization which must be solved by the engineer manager. These interrelated problems require a different approach than those applicable to more independent problems. It is not valid for the engineer manager to consider energy in isolation because energy depends in part on output fluctuations. Energy management requires that the engineer manager gives order and structure to these complex problems because of the complex relationships and interactions among these components. As knowledge of energy management concepts expands, we will be able to determine the effects of the interactions of other variables and activities.

If he examines a given product line, the engineer manager might be shocked to realize that it is energy inefficient. Even though the production operations he is directly responsible for are very energy efficient, the design or parts furnished by suppliers may be manufactured in a very energy inefficient method. The engineer manager must examine the entire product and process, i.e., raw materials, designs, supplier's operations, production, wastes, packaging and shipping. The goal is efficient energy utilization for all activities, not for one particular activity. Then the production operation for a particular manufacturing operation may take on a different and fuller character to the engineer manager. Although at first energy problems seem simple and direct, generally they are more complex. Energy in general is directly related to many factors. To be effectively managed, energy must be coordinated carefully with all operations.

We must remember that many of the techniques must be more than problem solving procedures. More important, one of the functions of energy management must be to help the engineer manager understand the nature of the problems with which he is dealing. If he understands these, he is able to make excellent judgements about how these activities affect the system. When he understands these complex relationships he can understand why traditional management concepts and principals often provide misleading information.

Most concepts lack the context of specific energy situations. They may be, in fact, inputs to a broader problem solving process, and can only be used in this manner as they are subject to, or dominated by, factors that are not even included.

Energy management is complex because it deals with complex and multiple activities. For example, a solution that minimizes cost or maximizes profits is guided by the criteria of cost or profit. However, the engineer manager must always be aware of other complex factors as availability, government actions, and present and future energy situations. This becomes more difficult when we realize that the engineer manager invariably is considering future actions of politicians, and unfortunately these are often in conflict or impossible to predict. These conflicts must be reconciled to the extent the engineer manager is able, and this depends on his level of knowledge and the complexity of the problem.

The engineer manager must realize that not all factors are included in any analysis and often assumptions must be made which require judgement to be used. In energy management, the engineer manager must recognize that he has temporarily narrowed the problem so he can direct his attention more directly on specific variables.

MISUSE OF TECHNIQUES

Several examples will illustrate the complex nature of energy management and the weakness of some common engineer manager techniques. In energy management one of the first decisions that the engineer manager must make is whether to make an investment in energy efficient equipment. This requires the engineer manager to evaluate the investment with the same investment criteria used for other investments. In any of the many criteria used by engineer managers, the most common information that must be developed is:

(1) value of equipment at the end of period
(2) annual cost of operating and maintenances
(3) total investments
(4) life of investment.

One common method of evaluating new projects or comparing alternative courses of action is to calculate a "rate of return." It is computed as follows:

Unadjusted average rate of return % =

$$\frac{100\ (\text{net monetary operation profit} - \text{depreciation})}{\text{average investment}} = \text{average net income}$$

Because no attempt is made to consider interest costs, the resulting figure is referred to as the "unadjusted" rate of return. This only requires the engineer manager to determine the net operating advantage from the new equipment after subtracting change in maintenance cost and labor cost.

Another common method used is the "payoff", the time required for an investment to pay for itself through the net operating advantage that would result from its installation. It is calculated as follows:

Payoff in years -

$$\frac{\text{net investment}}{\text{net annual operating advantage}}$$

Both of these techniques are commonly used by engineer managers and firms in determining which projects should be undertaken. However, when energy projects are evaluated most are not undertaken because they offer less profit than other alternative projects such as acquiring manufacturing equipment.

A piece of equipment costs $6,000, have a 4-year life, depreciated on a straight-line basis, and generate earnings before depreciation as shown below:

Year	Income
1	$1,000
2	2,000
3	3,000
4	2,000

What will be the pay-back period and average rate of return?

Solution:

To accumulate $6,000 the time required is 3 years ($1,000 + $2,000 + $3,000) Therefore the payback period = 3 years.

Average rate of return (depreciation = $1,500 per year) is:

$$\frac{\dfrac{(\$1{,}000-\$1{,}500 = (\$2{,}000-\$1{,}500) + (\$3{,}000-\$1{,}500) + (\$2{,}000-\$1{,}500)}{4}}{\$6{,}000 + \$4{,}500 + \$3{,}000 + \$1{,}500 + 0} \times 100$$

+ 16-2/3%

Financially considered, this might not seem to be a very good investment for many companies that look for two or fewer years of payback period. However, if it is energy related equipment that can be operated on an available energy source when present equipment energy sources may be unavailable, then such an investment is worth making. Down deep in the engineer manager's mind he knows that other factors must be considered but the standard evaluation techniques don't accomodate them. But now it is impossible to put a realistic economic value on these intangible factors. It has been well established that alcohol and gasohol are uneconomical in terms of both costs and BTU's. The total costs are greater than those of other alternative energy sources, even petroleum; and the total BTU's needed to produce gasohol are greater than the BTU's it yields which make it energy inefficient. However, there is still a lot of interest and many enterpreneurs are undertaking the production of alcohol. This indicates something is wrong with the analysis. One defect in the analysis was the exclusion of the factor of availability when regular energy supplies are in short supply or unavailable.

One problem is that both of these techniques work well for projects having an approximate future operating cost by an average period. This is a reasonable assumption, but for a complex project future costs have a pattern in relation to time which is not well represented by an average figure. Both of these ignore the timing of expenditures by using an average investment. These methods represent an approximation and idealization of the general investment problems. But there are many less obvious conceptual factors such as energy which are unaccounted for in these analyses. These criteria are not all equivalent nor interchangeable but are determined by projected life, future expenditures, and the standard schedule for decline in value of assets. Other examples of the overlooking of energy concerns include the design of operation, plant location analysis, and assembly charts. Energy now as in the past can become unavailable to the firm's operation, but this is not even considered in these analyses.

It seems necessary that any analyses considers the important aspect of availability of supplies. To include such a factor in payoff or return on investment analysis is impossible . This makes these impractical for the evaluation of energy projects. But it is a very common practice to use these or similar techniques in evaluating the feasibility of all projects including those concerning energy.

ALTERNATIVES

Successful energy management depends on plans, information systems concerning what is actually happening and how they respond to changes. Fortunately, the situation is not hopeless, there are techniques which the engineer manager can use. Two of these are Linear Programming and Simulation Techniques. These provide the engineer manager with the ability to include a greater number of variables such as possible shortages or current supplies. However, these require the engineer manager to collect additional data which requires the use of computers. Each of these has certain requirements which are even more important and critical than for the rate of return and payoff techniques; otherwise, the engineer manager will reach conclusions which may be more misleading than by using these less complex engineering management techniques.

CONCLUSIONS

In general, engineering management concepts were not designed for energy management, and for many of the concepts and techniques they do not provide the engineer manager with results that are meaningful and useful. This does not imply that these concepts and techniques should be ignored; in fact, these concepts and techniques deserved the full attention of the engineer manager as in many situations they are very useful decision-making techniques. However, for decision making concerning energy, most of these common ones do not consider the unique characteristics of this resource; therefore, conclusions reached are unrealistic and often misleading to the engineer manager.

To overcome this situation, it is necessary to use more complex techniques and analysis, for example, Linear Programming and Simulation in which the special characterists of energy can be included in the analysis.