LECTURE 12

Total Quality Management (TQM) is another emphasis that many businesses and other organizations have developed over the last decade. TQM is an integrated approach to operating a facility, and energy cost control should be included in the overall TQM program. TQM is based on the principle that front-line employees should have the authority to make changes and other decisions at the lowest operating levels of a facility. If employees have energy management training, they can make informed decisions and recommendations about energy operating costs.

• Maintaining energy supplies that are:

— Available without significant interruption, and

— Available at costs that do not fluctuate too rapidly.

SOME SUGGESTED PRINCIPLES OF ENERGY MANAGEMENT

If energy productivity is an important opportunity for the nation as a whole, it is a necessity for the individual company. It represents a real chance for creative management to reduce that component of product cost that has risen the most since 1973. Those who have taken advantage of these opportunities have done so because of the clear intent and commitment of the top executive. Once that commitment is understood, managers at all levels of the organization can and do respond seriously to the opportunities at hand. Without that leadership, the best designed energy management programs produce few results. In addition, we would like to suggest four basic principles which, if adopted, may expand the effectiveness of existing energy management programs or provide the starting

point of new efforts. The first of these is to *control the costs of the energy function or service provided, but not the Btu of energy.* As most operating people have noticed, energy is just a means of providing some service or benefit. With the possible exception of feed stocks for petrochemical production, energy is not consumed directly. It is always converted into some useful function. The existing data are not as complete as one would like, but they do indicate some surprises. In 1978, for instance, the aggregate industrial expenditure for energy was $55 billion. Thirty-five percent of that was spent for machine drive from electric motors, 29% for feedstocks, 27% for process heat, 7% for electrolytic functions, and 2% for space conditioning and light. As shown in Table 1.1, this is in blunt contrast to measuring these functions in Btu. Machine drive, for example, instead of 35% of the dollars, required only 12% of the Btu. In most organizations it will pay to be even more specific about the function provided. For instance, evaporation, distillation, drying, and reheat are all typical of the uses to which process heat is put. In some cases it has also been useful to break down the heat in terms of temperature so that the opportunities for matching the heat source to the work requirement can be utilized. In addition to energy costs, it is useful to measure the depreciation, maintenance, labor, and other operating costs involved in providing the conversion equipment necessary to deliver required services. These costs add as much as 50% to the fuel cost. It is the total cost of these functions that must be managed and controlled, not the Btu of energy. The large difference in cost of the various Btu of energy can make the commonly used Btu measure extremely misleading. In November 1979, the cost of 1 Btu of electricity was nine times that of 1 Btu of steam coal. Table 1.2 shows how these values and ratios compare in 2005.

Table 1.1 Industrial Energy Functions by Expenditure and Btu, 1978

Function	Dollar Expenditure (billions)	Percent of Expenditure	Percent of Total Btu
Machine drive	19	35	12
Feedstocks	16	29	35
Process steam	7	13	23
Direct heat	4	7	13
Indirect heat	4	7	13
Electrolysis	4	7	3
Space conditioning and lighting	1	1	1
Total	55	100	100

Source: Technical Appendix, *The Least-Cost Energy Strategy,* Carnegie-Mellon University Press, Pittsburgh, Pa., 1979, Tables 1.2.1 and 11.3.2.

One of the most desirable and least reliable skills for an energy manager is to predict the future cost of energy. To the extent that energy costs escalate in price beyond the rate of general inflation, investment pay backs will be shortened, but of course the reverse is also

true. A quick glance at Table 1.2 shows the inconsistency in overall energy price changes over this period in time. Even the popular conception that energy prices always go up was not true for this period, when normalized to constant dollars. This volatility in energy pricing may account for some business decisions that appear overly conservative in establishing rate of return or payback period hurdles.

Availabilities also differ and the cost of maintaining fuel flexibility can affect the cost of the product. And as shown before, the average annual price increase of natural gas has been almost three times that of electricity. Therefore, an energy management system that controls Btu per unit of product may completely miss the effect of the changing economics and availabilities of energy alternatives and the major differences in usability of each fuel. Controlling the total cost of energy functions is much more closely attuned to one of the principal interests of the executives of an organization — controlling costs.

NOTE: The recommendation to control energy dollars and not Btus does not always apply. For example, tracking building energy use per year for comparison to prior years is best done with

Btus since doing so negates the effect of energy price volatility. Similarly, comparing the heating use of a commercial facility against an industry segment benchmark using cost alone can yield wild results if, for example, one building uses natural gas to heat while another uses electric resistance; this is another case where using Btus yields more meaningful results.

Table 1.2 Cost of Industrial Energy per Million Btu, 1979 and 2005

Fuel	Cost (1979)	Cost (1979) Adjusted to 2004 Dollars	Cost (2005)	Pct Change in 25 years (constant dollars)
Industrial Coal	1.11	2.32	1.78	<-23%>
Natural Gas	2.75	5.75	8.41	+46%
Residual Fuel	2.95	6.17	8.74	+41%
Distillate Fuel	4.51	9.65	10.82	+12%
Electricity	10.31	21.58	17.57	<-18%>
		Approximated as 3% inflation per year over 25 years	Source: EIA Annual Energy Outlook, 2004 dollars per million Btu	

A second principle of energy management is to *control energy functions as a product cost, not as a part of manufacturing or general overhead.* It is surprising how many companies still lump all energy costs into one general or manufacturing overhead account without identifying those products with the highest energy function cost. In most cases, energy functions must become part of the standard cost system so that each function can be assessed as to its specific impact on the product cost. The minimum theoretical energy expenditure to produce a given product can usually be determined en route to establishing a standard energy cost for that product. The seconds of 25-hp motor drive, the minutes necessary in a 2200°F furnace to heat a steel part for fabrication, or the minutes of 5-V electricity needed to make an electrolytic separation, for example, can be determined as theoretical minimums and compared with the actual figures. As in all production cost functions, the minimum standard is often difficult to meet, but it can serve as an indicator of the size of the opportunity. In comparing actual values with minimum values, four possible approaches can be taken to reduce the variance, usually in this order:

- **An hourly or daily control system can be installed to keep the function cost at the desired level.**
- **Fuel requirements can be switched to a cheaper and more available form.**
- **A change can be made to the process methodology to reduce the need for the function.**

- **New equipment can be installed to reduce the cost of the function.**

The starting point for reducing costs should be in achieving the minimum cost possible with the present equipment and processes. Installing management control systems can indicate what the lowest possible energy use is in a well-controlled situation. It is only at that point when a change in process or equipment configuration should be considered. An equipment change prior to actually minimizing the expenditure under the present system may lead to oversizing new equipment or replacing equipment for unnecessary functions.

The third principle is to *control and meter only the main energy functions*—the roughly 20% that make up 80% of the costs. As Peter Drucker pointed out some time ago, a few functions usually account for a majority of the costs. It is important to focus controls on those that represent the meaningful costs and aggregate the remaining items in a general category. Many manufacturing plants in the United States have only one meter, that leading from the gas main or electric main into the plant from the outside source. Regardless of the reasonableness of the standard cost established, the inability to measure actual consumption against that standard will render such a system useless. Submetering the main functions can provide the information not only to measure but to control costs in a short time interval. The cost of metering and submetering is usually incidental to the potential for realizing significant cost improvements in the main energy functions of a production system.

The fourth principle is to put *the major effort of an energy management program into installing controls and achieving results.* It is common to find general knowledge about how large amounts of energy could be saved in a plant. The missing ingredient is the discipline necessary to achieve these potential savings. Each step in saving energy needs to be monitored frequently enough by the manager or first-line supervisor to see noticeable changes. Logging of important fuel usage or behavioral observations are almost always necessary before any particular savings results can be realized. Therefore, it is critical that an energy director or committee have the authority from the chief executive to install controls, not just advise line management. Those energy managers who have achieved the largest cost reductions actually install systems and controls; they do not just provide good advice.

As suggested earlier, the overall potential for increasing energy productivity and reducing the cost of energy services is substantial. The 20% or so improvement in industrial energy productivity since 1972 is just the beginning. To quote the energy director of a large chemical company: “Long-term results will be much greater.” Although no one knows exactly how much we can improve productivity in practice, the American Physical

Society indicated in their 1974 energy conservation study that it is theoretically possible to achieve an eightfold improvement of the 1972 energy/production ratio.9 Most certainly, we are a long way from an economic saturation of the opportunities (see, e.g., Ref. 10). The common argument that not much can be done after a 15 or 20% improvement has been realized ought to be dismissed as baseless. Energy productivity provides an expanding opportunity, not a last resort.

Energy Conservation measures in boilers:

Effect of preheat air temp on fuel saving:

Energy conservation in Transportation: The manufacturing unit should be located near source of raw material to minimize the transportation of raw material which is usually more than finished products.

1. Incase of agricultural products like cotton, fruits a primary processing may be done in the rural area, so that an intermediate product is only transported which is lesser height than the total produce.
2. The service unit should be located near the consumer to reduce the unnecessary transportation cost.
3. The proper quantity and packing of materials should be selected for economic transportation.
4. The economic means transportation should be chosen from the various available means. i.e. ship, rail, truck, belt conveyor etc.
5. The effective use of local resources in each area/zone should be encouraged with innovation rather than encouraging material consumption from large distances.
6. Design the development and manufacturing of such transport vehicles which consume minimum fuel and lubricants.
7. Design the development and manufacturing of such transport vehicles based on renewable source of energy.
8. The operation of automobile should be so performed as to reduce the consumption of fuel and lubricants.