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Development of Industrial Energy Management Programs

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Energy management is a term which has only recently been entered in the business management lexicon. Until recently business managers, even the most successful ones, devoted only casual thought to the need to manage their use of fuels and electricity. Energy was cheap and plentiful. Economic sense dictated that if labor could be replaced by more energy-intense processes or equipment, the smart manager did so. Local and national policy, industrial process design, consumer habits--all these and more encouraged massive energy consumption.

But commerce and industry in the United States--indeed throughout the world--has entered a new era of energy economics. The demand for energy in its several forms has begun to seriously outstrip man's ability to produce it. Nowhere is this more evident than in the U.S. where our prodigious energy appetite has, in a matter of months, overtaken and seriously exceeded the domestic production capacity of our energy industries. The result has been rapidly escalating energy costs and, perhaps even more important, the threat of crippling reductions of the amount of energy available to all sectors of the economy. Suddenly energy economics and energy security have become crucial issues in business management. Several organizations with sufficient managerial and technical resources have established energy management programs. Others have gone outside the company for counsel and assistance in developing energy conservation and management strategies. But the majority of commercial and industrial enterprises in the U.S. have not yet decided how to approach energy supply problems. It is in this climate that the science/art of energy management is born.

Energy management is simply the application of modern business management practice to the purchase, distribution, and utilization of fuels and electricity. In this context, it does not differ significantly in concept from the application of well-established management principles to other elements of a business operation, such as administration, purchasing, production, marketing, or finance. The factor which sets energy management apart from these other management tasks is that it deals with a commodity which, although crucial to commercial and industrial activities, has been almost completely neglected in the design of the management systems and physical facilities which constitute our economy.

An energy management program can range in complexity from an energy conservation effort coupled with careful accounting of energy costs to sophisticated, computer-based programs which continuously monitor energy consumption and include upgrading of energy-inefficient processes, development of advantageous contracts with energy suppliers, employee incentive programs, and numerous other concepts. But to be effective, whatever the complexity, every energy management program must be based on a sound understanding of the energy supply demand characteristics of the particular operation for which the program is designed.

It is a common mistake to regard an energy management program as merely an organized approach to energy conservation in an office or plant. Whereas energy conservation is certainly a central element in any energy management program, it is by no means the only feature. The objectives of an energy management program are to: (1) minimize energy costs in a manner consistent with the productivity and profitability goals of the operations; and (2) decrease the vulnerability of the operation to energy shortages. Energy conservation can make important contributions toward both objectives. But a comprehensive energy management program also includes many other items.

Elements of an Energy Management Strategy

Energy management can encompass the same wide range of complexities as more familiar business management concepts. And, of course, it can utilize many of the same management tools--systems management, operations research, value engineering, cost/benefit analysis, technological forecasting, and others. The response of many businesses to the on-set of an energy short economy has been the development of energy management concepts, or more accurately, the organization of existing contemporary management techniques into a coherent system designed to manage energy in business operations.

Listed below are several steps which constitute a simplified strategy for energy management. The strategy consists of 14 steps which can be carried out to organize, implement, and evaluate an energy management program. Like all management strategies, it is not unique. Numerous variations are possible.

1. Designate a corporate team to investigate energy problems and formulate an energy management policy for each facility. The individuals responsible for energy management at each major facility should serve on this team. It should also have representation from the corporate management and planning staff and the engineering department. It should be vested with authority adequate to investigate prevailing energy supply and demand situations and to implement policy recommendations. The tasks of the energy policy team should be assigned a priority consistent with the current or potential importance of energy problems in the company operation. The team should inventory talents within the firm which could contribute to the analysis and utilize those talents.

As discussed in more detail later, two factors are very important in developing the energy management organization: (1) It should involve a serious and continuing commitment on the part of top management; and (2) one individual should be made ultimately responsible for the success or failure of the program.

2. The energy policy team should specify the need for such a policy and the objectives of the team's efforts. It should examine available corporate energy-related data and prepare a report which outlines the overall energy status of the company. This should serve as baseline information.

3. The need for expert counsel or assistance from outside the company should be determined early in the planning effort. If such assistance is advisable, it should be obtained sufficiently early to contribute to the project planning tasks.

4. A thorough inventory of energy supply and use throughout the firm should be developed. In most cases,

this task will require considerable effort. It should result in a detailed description of how energy is obtained and used in each facility, with information down to the level of specific processes and equipment. It should catalog energy suppliers and tabulate historical data concerning energy supply and price trends. Fuel and energy cost data should be compiled as a basis for future monitoring of the cost impact of energy actions. An inventory of fuel storage capabilities and back-up fuel supplies should be included. This effort should generate a data base for energy policy development.

The key ingredient of this step is the energy audit, a crucial part of the total energy management effort. Energy audits are discussed in more detail later.

5. One member of the team or a consultant should be assigned the task of analyzing regional energy supply, distribution, and consumption characteristics. The objective should be to identify trends which will affect the availability of fuels and energy to the company, such as:

. consumption trends of other firms, industries, or economic sectors which could compete for the same fuel supplies,

. status of the company in fuel allocation programs,

. national issues which impact on the availability of fuels or the distribution of fuels to different regions (e.g., importing crude oil),

. economic trends of the region which could affect energy availability, and

. environmental regulations affecting fuel use.

6. An analysis of energy and fuel curtailments should be conducted. This should consist of case history evaluation of past fuel shortages and power outages with the view toward identifying predictors for such events. For example, have natural gas curtailments been preceded by consistent weather patterns as characterized in terms of degree-days? Assistance should be solicited from energy suppliers in this task.

7. Systematic "energy inspections" of all facilities should be conducted. These are intended to identify specific areas of energy inefficiency and potential for energy conservation. The inspections should be preceded by the development of checklists to help the inspector identify energy-sensitive areas. Each firm, or at least each industry, will probably find it necessary to develop custom-fitted checklists which recognize particular energy use characteristics of the industry. Inspectors should try to spot wasteful practices. Often a list of methods to save energy can help identify areas where wasteful practices prevail. For example, the knowledge that automatic controls can be used to increase combustion efficiency keeps the inspector alert for poor combustion control. The energy inspection should also serve to find operations where loss of energy would be critical, identify processes where back-up fuels could be used, and, in general, develop a comprehensive picture of the energy efficiency of the operating facilities. The inspection should include office, warehouse, and other facilities in addition to the process or manufacturing plants. An inspection report should be filed for each site.

8. An examination should be made of such items as work and production schedules, vehicle fleet operation, staff travel, and other activities which constitute areas for potential energy savings. Recommendations should be developed.

9. A review of new technology related to the principal equipment or processes used by the company should be carried out. The objective should be to identify technical improvements which can upgrade energy efficiency. The results should be correlated with the output of Steps 4 and 7.

10. Maintenance and equipment replacement schedules should be examined to determine their impact on energy efficiency. Recommendations should be made.

11. A study of the tangible and intangible costs associated with fuel or power shortages should be made. This should include the loss of production and service, the costs of plant shutdown, the risk of customer dissatisfaction, factors related to labor agreements, long-term impact on growth, and numerous other considerations. The objective of this analysis is to develop guidelines which, with the cost data from Step 4, can be used to evaluate the cost-effectiveness of energy actions.

12. The energy project team should utilize the output of the steps listed above to develop recommendations for energy-related actions. The recommendations should be classified as directed at energy economy or energy security. This is obviously a crucial task, and the effectiveness with which it is carried out depends on the thoroughness of the preceding efforts. The project team should now have a comprehensive understanding of the role energy plays in the company, the areas where energy savings can be achieved, the actions necessary to achieve those savings, the cost benefits of the savings, the areas in which the energy security of a plant can be reinforced, the problems encountered in obtaining fuels and energy, and many other items. Formulation of the recommendations should draw upon as many elements of company operation as possible. And an important part of this task is to develop methods by which the recommendations can be implemented. A formal report should be prepared which summarizes the project activities, compiles company energy data, and presents the recommendations and the implementation strategies. The latter two items--the recommendations and implementation strategies--should be presented as a series of recommended corporate energy management policies. The recommendations should include methodology for the continued evaluation of the effectiveness of the policies and the modification of the policies to improve effectiveness.

13. Develop an energy emergency plan which outlines steps to be taken for specified energy situations in each facility. For example, specify the procedures to be followed in the event of a natural gas curtailment, or a curtailment followed by depletion of standby fuel. Plans should include both the physical aspects of operation and such items as work and production schedules.

14. Develop an employee energy conservation education program directed at practices and procedures while on the job. Include an incentive system for the suggestion and implementation of energy saving actions. Program might also include means of saving energy at home and on the highway.

Organizing the Energy Management Effort

There are several factors which impact directly on the eventual success of an energy management program.

But none is as important as the commitment made to the effort by top management, including the chief executive. This commitment must consist of talent, resources, responsibility, and authority. Energy management, like other management disciplines, is concerned with the future. True, that future might be as near at hand as the next day or hour, but no management decision ever changed the course of events which had already occurred. The organization of an energy management program, therefore, involves two central tasks: (1) develop a plan; and (2) create an organizational structure specifically designed to carry out the plan. The distinction between these two tasks is often impossible to detect. Is a plan necessary to design an organization or is the organization necessary to devise a plan? The process is to some extent iterative. Some elements of the organization must exist to develop the plan. And the plan can lead to an organization much different than the original.

In its most general context, planning is the development of a desired future strategy and the design of effective methodology for implementing that strategy. Developing the plan for an energy management program involves such factors as: (1) organizing the program; (2) developing energy management information; (3) conducting energy audits; (4) analyzing operations with an energy perspective; (5) implementing the strategy; (6) evaluating progress; and (7) reporting and publicizing the results.

The development of an effective organization for energy management is a major undertaking in project organization. It involves organization within the corporate management structure which, unlike task force projects, touches on all functions of the business. Several items are important:

Top management commitment to the need for energy management is essential. No part of the company can be disinterested in the goals and execution of the program. But this is particularly true of top management, including the chief executive. The most effective programs are often initiated by top-level managers who take the first steps in organizing the program and make their commitment to its success well known throughout the company. Even after an organization has been developed they make their continued interest obvious. Their commitment must include staff, resources, responsibility, and authority. It must be very clear that the company has been firmly committed to a course of improved energy management.

The need to conserve energy in industrial operations is now recognized at all levels in most companies. Therefore, the initial stimulus for an energy management program might come from any one of several points. Many of the early successes, however, originated in the board rooms. The corporate executives and board members usually have wide exposure to the problems being experienced or anticipated by other companies, including the energy industry. They can assess the severity of possible energy-related problems and can interpret the impact of energy-induced changes in the economy of the profit picture of their own company. Usually these preliminary insights show that either expenses could be reduced or significant future adverse effects could be avoided if energy management could be markedly improved. Further study shows that energy consumption has not been considered in much detail in operation management strategies. Frequently, top management is the first to detect conditions outside the company which can have a future deleterious impact on productivity and profits. Middle management and operating staff are usually immersed in day-to-day operating problems to such a degree that they do not foresee long-range problems. Two years ago fuel costs and shortages were long-range problems. Now they are day-to-day events. And more than ever they require the attention of top management.

This commitment might start with top executives identifying the problems and initiating the program. Or it might involve selling the need for the program to top management. The former is better. But the program stands little chance of succeeding without real, substantial, visible, sustained support by top management.

A specific individual must be charged with responsibility for the overall success of the program. He (she) must be empowered to develop plans, make staff assignments, allocate resources, and implement energy conservation measures. He should have direct access to top corporate management and should receive quick decisions when he presents a program or program element for approval. His appointment should be made with internal fanfare as further indication of executive commitment to the energy management program. His responsibilities and authority should be defined (although this definition might have to be updated as the program develops), and his authority should be clearly specified to the other staff with whom he will work to obtain energy savings.

This position might be designated, for example, Corporate Energy Coordinator. The appointee might be made responsible for the entire corporate energy budget, and his performance would be measured in terms of energy economics and energy security. One such measure might be a specified reduction in energy consumption in some process or facility. Or it might be a reduction in energy consumption per unit output... or number of months without an energy-related loss of production.

The investment which can be made in the various staff assignments to the energy management program depends, of course, on the potential return. Although energy stakes are high and becoming higher, not all organizations can afford a full-time appointee in the top position. It's desirable, however, because the magnitude of the task certainly justifies that type of effort. And a rather pragmatic approach must be taken in evaluating the return on investment. Every effort should be made to assign a person full-time to the most responsible position until such time as the optimum involvement can be determined. Any company with annual energy expenses of about $250,000 or more (and that's small by today's standards) can probably justify the equivalent of one or more full-time assignments to an energy management effort.

The leadership position should be filled by someone with a broad knowledge of all aspects of the company's operation. He must have easy access to all elements of the organization and be the type of person who refuses to be made merely a figurehead.

Formal energy management groups should be designated to implement the program in various segments of the company. The people who carry out the day-to-day functions of the business play a key role in program achievement. Plant foremen, shop stewards, union heads, line managers--these and others should be called upon to contribute to the various tasks. The extent of their involvement depends, of course, on the size of the company and the magnitude of the energy management effort. An energy program manager might be designated for each plant in the corporation, or each operating division, or each production operation. These managers, working with the aforementioned corporate energy coordinator, would designate an energy control team for their plant or division or production operation. This team, which would include production workers, maintenance personnel, etc., in addition to supervisory personnel, would be assigned the tasks of the program (such as energy inspections and the other tasks to be discussed later). The team members would periodically carry out these assignments and report the results to the cognizant energy program manager. Again, the number of people involved in the energy control team and the extent of their individual involvement, depends on the magnitude, or potential magnitude, of the energy problem in each company. Usually the position of energy program managers for a plant or production operation is a part-time assignment to someone who has other duties. Involvement of the energy control team is also on a part-time basis. In any case, no assignment is justified unless it can be justified on the basis of cost, accounting loss of production due to energy outages as a cost factor.

Organizational links should be established with the more traditional departmental functions of the company--public relations, personnel, staff development, engineering, sales, marketing, and others. The public relations department or whatever department is responsible for internal communications is important because of the need to keep the goals and benefits of the program in the minds of all employees. The internal employee newsletter is an effective organ for this purpose. Or a special bulletin on energy conservation of energy management might be appropriate. Employee training programs are well-suited as a forum for energy conservation education.

. Assistance from outside the company should be secured when appropriate. There are several highly qualified consultant services available concerning energy conservation and management. Often these firms can be more cost effective in carrying out some program functions than can a company's own staff. And one of the tasks for which they can be most effective is in the development, organization, and initial implementation of your energy management program for subsequent operation by the designated members of the company staff. Training members of the energy program team can also be an appropriate task for outside assistance. Consultants with special expertise can often provide solutions for specialized problems. For example, if inadequate burner controls are found to be the cause of excessive fuel consumption, an expert on burner control systems would be valuable. Perhaps this guideline could be stated as an admonition that having your staff re-invent the energy management wheel is almost never cost effective.

Energy Audits and Inspections

The first problem faced by a new energy management organization is compilation of the data necessary to perform analyses and make decisions. Lack of adequate data is undoubtedly the central factor when an energy management program fails. And it frequently serves as the rationale for inaction. The energy audit is the mechanism by which the data necessary for energy decision-making are compiled. It is usually accompanied by the energy inspection.

An energy audit is simply an accounting of the use of all forms of energy by all elements of the company operation. It should be written both in terms of energy units (BTU's) and dollars, and it should recognize the fact that the use of energy as a commodity can affect corporate profitability. The energy inspection is a detailed check of the physical facilities and equipment to identify areas where energy is not being used as efficiently as possible. The central purpose of the audit is to generate baseline and evaluation data, whereas that of the inspection is to develop recommendations for remedial action.

Like so many other aspects of energy management, the energy audit does not involve new methodology or technology. It is simply the application of common accounting sense to energy supply and consumption within a plant or other definable segment of a company's operation. It is new only in the sense that not until recently was energy regarded as something of sufficient value to warrant accounting.

The primary tool in the audit is the energy balance. The entire operation--both production and non-production units--should be conceptually divided into well-defined elements and an energy balance should be constructed around each element. These balances consist of energy flowcharts which identify where and how much energy of various forms flow into and out of a process or operating element. The flows should be established both in terms of conventional measures of the various energy forms (cubic feet of natural gas, gallons of fuel oil, tons of coal, kilowatt-hours of electricity, etc.) and in BTU's. The latter then represents a common comparative measure.

A simplified energy balance for a refinery is illustrated in Figure 1. This would represent an overall plant balance. Energy balances would also be drawn around the hydrogen plant, the ammonia plant, the steam system, the columns, and other processes. In many cases, the processes will not be adequately instrumented to obtain the necessary measures. One of the functions of the audit should be to determine where additional instrumentation is needed and whether or not potential savings justify the cost of their installation.

After the energy balances have been constructed, determine the theoretical amount of energy of each form required to carry out each process. This step is not as complex as it might seem. However, the time available to compute the energy balances and the capital available to purchase and install instrumentation are likely to be the factors which determine the degree to which operations can be disaggregated, i.e. the fineness with which the boundaries of the energy balances can be drawn. Some companies which have undertaken energy management programs have found that they have some plants where natural gas consumption or electricity demand is measured only at input to the plant. They have no measure of which processes consume the most energy or are the most inefficient. The first audit task in these cases is usually additional measurement.

One format for recording audit data is the audit balance sheet. In its simplest form it consists of a four-column log with entries for: (1) process description; (2) theoretical energy required to carry out the process; (3) actual energy consumed; and (4) energy difference between actual and theoretical requirements. Figure 2 is an example. The frequency with which this audit should be compiled depends on the manpower available and the frequency with which the energy consumption of a given process can be expected to vary.

Daily records of energy use by source (oil, gas, electricity, etc.) for overall operations are essential. For some process or production units, more frequent data will be necessary. One format for plant or facility records is a graph of energy demand for each source, production statistics, and degree days all plotted as a function of time. Degree day data are available from the weather bureau and can be calculated from records of ambient conditions usually made at power plants. Displaying the important elements of the audit data in graph form is an effective way to identify trends and spot unusual energy events.

Energy audits should be the responsibility of the energy control teams. The unit energy program manager should be required to submit energy balances at specified intervals (weekly, monthly) for all process or production units for which he is responsible, the boundaries of such units having been previously defined. Perhaps overall energy balances would be required more frequently, in some cases daily. Development of energy balances can be time consuming. But the audit is the key step in an energy management program and, therefore, deserves the investment. Data collection and storage systems can range in sophistication from manual collection and processing of data from strip charts and instruments to measurement systems which are on line with a central computer and automatically collect and analyze the data.

Tracking charts are a valuable tool in interpreting the information compiled by a continuous audit. They utilize the production or through-put data for a process step or production unit to determine the energy consumption per unit productivity, for example, kilowatt-hour electricity per pound of product or pounds of steam per pound of through-put. These data are plotted as a function of time. Both the theoretical process energy demand and the goal value can be displayed on the graph. Examples of a tracking chart are shown in Figure 3.

At the same time the first energy audit is being carried out, or before, a careful examination of energy costs should be undertaken in order to develop energy cost projections. The objective, of course, is to develop planning data on which to make decisions regarding the amount of effort which can be devoted to an energy management program or the future impact of energy on the corporate budget. And this requires estimates which apply to the specific company--estimates which reflect the realities of a given geographical region and a specific class of energy consumption. Fuel prices must be considered in planning, but developing projections in which one can have confidence is a difficult task. Of the several projections of fuel prices made in 1972, we know of none which has not already been proven to have forecast prices much less than actual. Indeed, prices of most energy forms (especially crude oil and refined petroleum products) which were actual in the first quarter of 1974 exceeded the prices which were projected for much later periods.

Economic models are necessary to forecast price trends. They require assumptions concerning demand, price elasticity, interfuel competition, exploration and finding rates, and numerous other factors. The work of Spencer and Decker* is among the most recent energy cost projections.

*R. S. Spencer, and G. L. Decker, "Fuel Price and Supply Trends--The Ups and Downs of the Energy Challenge," presented to the American Public Power Association, San Francisco, California, June 26-28, 1972.

R. S. Spencer, and G. L. Decker, "Energy Supplies and Cost Trends in the 1970's," presented to the Technical Association of the Pulp and Paper Industry, Chicago, Illinois, March 6, 1973.

But the actual prices paid for energy by a specific company can differ markedly from national averages or from the figures of any given model. Therefore, the energy manager must devote whatever effort he can to the development of fuel price projections which are tailored to the extent possible to his own company. He cannot, of course, simply extrapolate his company's past fuel and electricity price records. Industry is now operating in a new era of energy economics and the past affords no reliable guidelines. Apply common sense and realism to cost projections. Discuss cost trends with energy suppliers. It might even be desirable to develop formal interview instruments to solicit realistic responses from suppliers. And when needed, call upon resources outside the company to help prepare energy cost projections.

Closely related to energy cost projections are the economic analyses which should be carried out to determine the investment which can be justified to save a specified amount of energy. The discounted cash flow, net present value method is an often-used technique for determining how much capital can be invested to conserve energy for a specified number of years. It is based on the recognition that monies currently available can be invested to earn additional funds for the company, whereas monies received at some future date have no earning power until after they are received. Money on hand today is more valuable than money to be earned in the future. Thus a time value must be considered in the analysis of new capital investments. The net present value of an operation is defined as the net cash flow (accounting for cash flows into and out of the company due to the operation) after taxes and discounted to the date at which the operation commences. The results of this type of analysis can be displayed as a plot of the capital which can be invested to save a specified annual dollar amount of energy.

The energy audit is the fundamental mechanism by which information is compiled for an energy management program. It must be well planned and executed, and it must be a continuing effort. It should be the subject of periodic examination which covers four areas. First, a review of the data collection process to identify points at which the process can be improved or updated. Secondly, the energy program coordinator should observe the actual data collection process to see that the specified process is being followed. Third, the accuracy of the data should be periodically checked and compared with that required by the program. And the fourth function is a periodic examination of the costs associated with energy data collection to make sure that the value of the data exceeds the cost of its collection.

Energy inspections are designed to pinpoint energy inefficiencies. They consist of walking inspections of every segment of the company operations--from production units to storage sheds, from stockroom to boardroom. The purpose is to identify and record procedures, equipment, and processes which might be candidate targets for energy conservation. Like the audit, the energy inspection is conducted by the energy control team. But the team members must be trained and the inspection must be planned.

The inspector must be someone familiar with the operations. But more importantly, he must know what to look for to spot wasteful practices. He must be familiar with the energy conservation literature and how the ideas reported therein apply to his operations. For example, if those operations involve use of process steam, he should be aware that inadequately maintained steam traps can be the cause of much lost energy. He should know what parts of his operation are big energy users. He should have copies of the energy audit and the energy balances. This background should be applied to the design of an energy inspection checklist. Numerous lists of many ways to conserve energy in commercial and industrial operations have been published. These can be helpful in the preparation of the inspection checklist.

Inspections can be carried out with less frequency than energy audits. The first inspection might be made at the same time as the initial audit, but the audit data are usually very useful in designing the inspection. Both audits and inspections can be used to evaluate the implementation and progress of various energy conservation actions. Formal inspection reports should be prepared and submitted to the program coordinator. It should include recommendations for remedial action. Case histories of the successes and failures of energy conservation programs in other companies can help in designing the inspection checklist and in formulating ideas to improve energy efficiency.

Figure 1

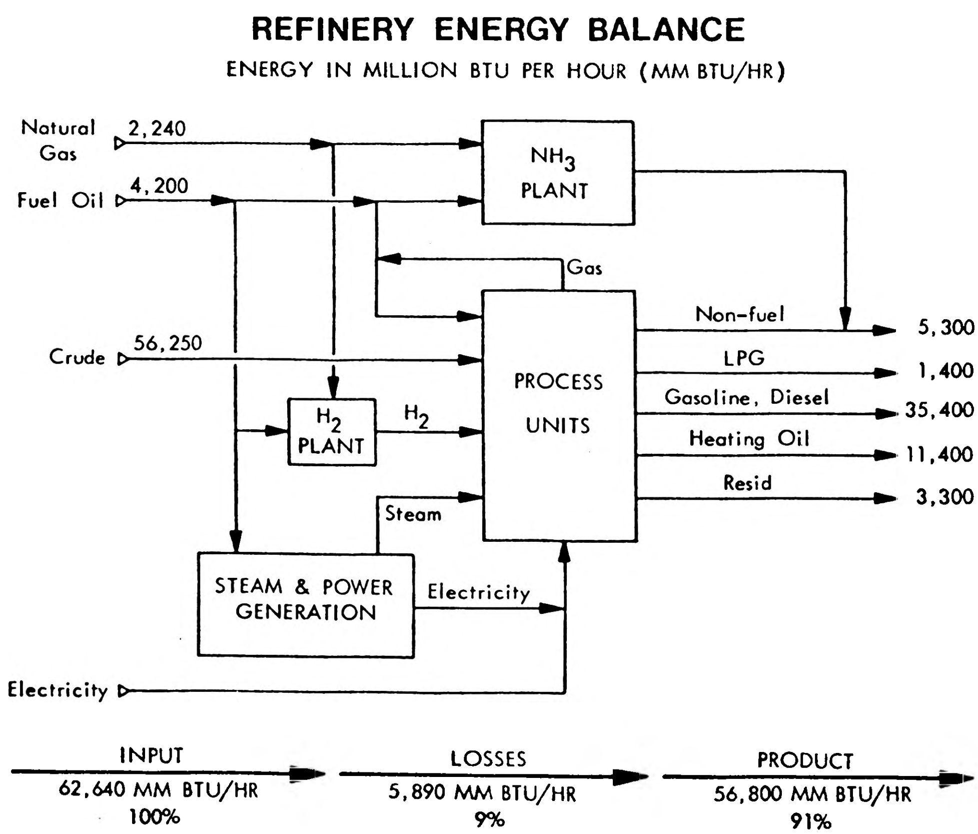


Figure 2

SAMPLE ENERGY AUDIT FORM

ENERGY AUDIT

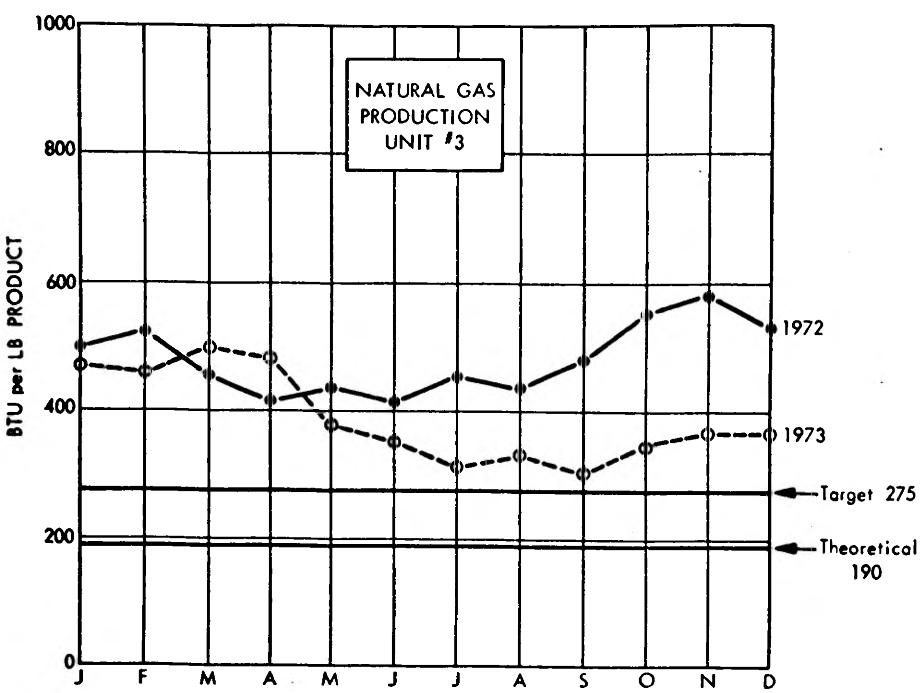
Plant: ______________________ Date: ______________________

Auditor: ______________________

PROCESS DESCRIPTION		THEORETICAL ENERGY		ACTUAL ENERGY		ENERGY DIFFERENCE	
Process	Fuel/Energy	Conventional Units	BTU	Conventional Units	BTU	Measured	Goal

MRI

Figure 3



TRACKING CHART