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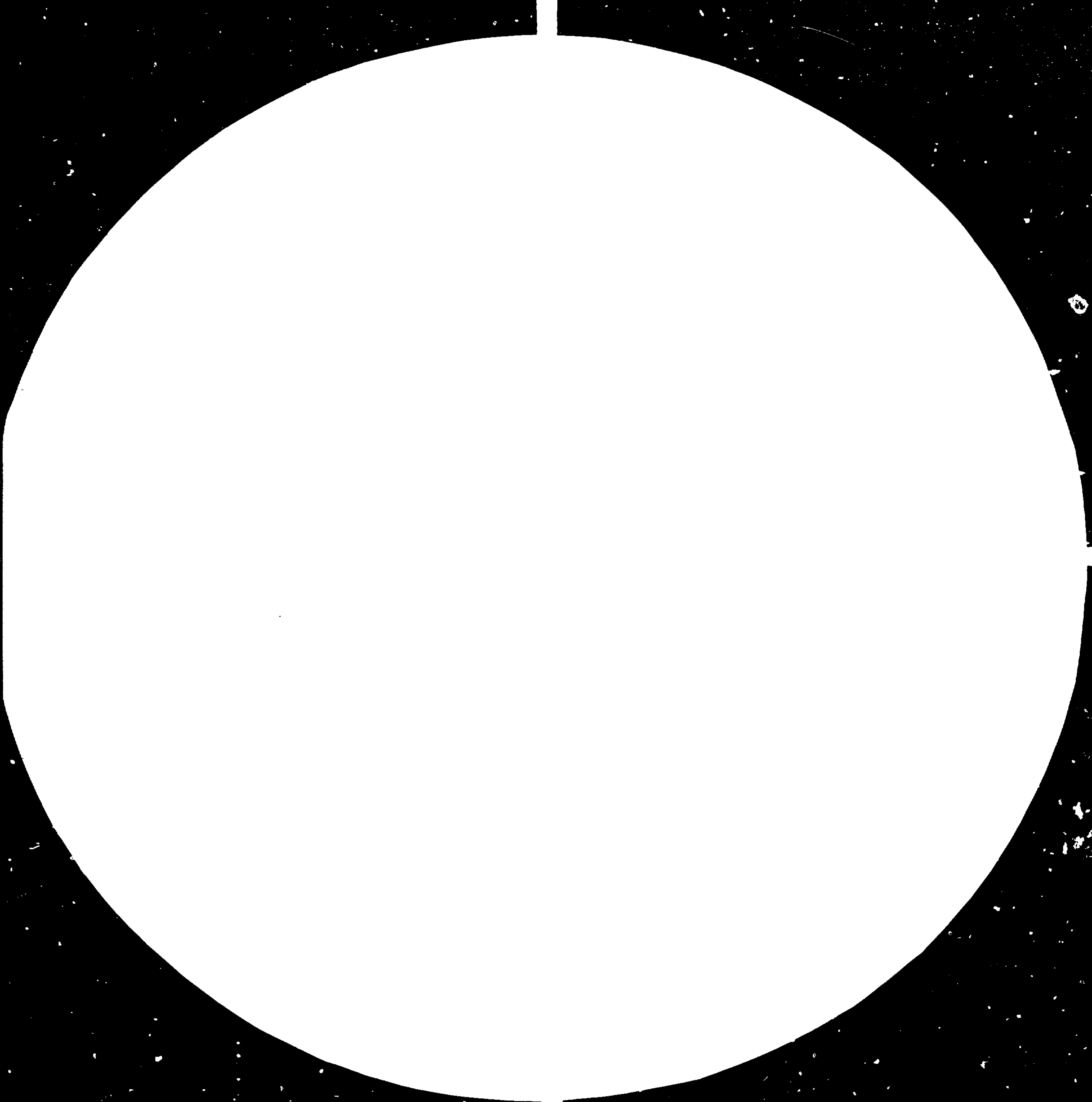

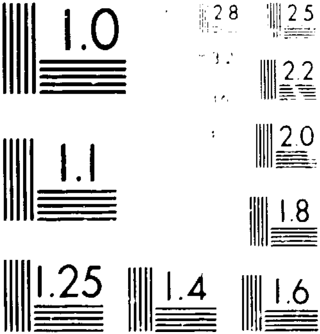
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UNITED NATIONS INDUSTRIAL
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Distr.
LIMITED

UNIDO/IO.484
24 November 1981

ENGLISH

PRACTICAL ENERGY CONSERVATION AND COST REDUCTION IN INDUSTRY

THE INTEGRATED ENERGY MANAGEMENT APPROACH*

by

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V.81-32757

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1. Preface

This paper attempts to clarify the various issues and concepts involved when talking of "industrial energy management", what it means at the factory, enterprise and national level and how to approach it from the practical point of view to arrive at optimum energy usage by industry, to assure that the economically most advantageous energy resources are utilized by industry, and to help Governments to develop sound industrial energy policies.

2. Introduction and Problematic

Industrial energy use accounts for 30 to 40% of the total energy consumption in the developing countries, depending on their level of development, industrialization and other factors. For this reason, information about energy use in industry is critically necessary for the formulation of both public and private policies regarding energy conservation, allocation and production.

Because of the multitude of factors and choices involved, the management of the use of energy by industry is very complex. The problem is that accurate details of energy use by industry are more difficult to develop and to validate than are corresponding data for the residential, commercial, transportation and utility sectors, since industry frequently uses different types of energy sources (e.g. oil, coal, electricity, gas, etc.) within a single factory. Secondly, energy does not flow through industry in simple, direct ways, as it becomes incorporated into waste material streams embodied in chemical feedstocks or fixed in industrial products. And third, industry frequently is reluctant to divulge the proprietary details of how efficiently it uses or conserves energy as could give an undesirable advantage to competitors.

While industrial energy usage is very complex, a large number and variety of opportunities for improved energy utilization are available for industry. These include possibilities in the production process (e.g. alternate choices for, and regeneration and recycling of energy) as well as in product design (e.g. lower energy content), in the use of alternate raw materials, lower energy usage in the application of the product, etc.

In addition to the purely technological options, as applicable to a factory or an enterprise, the entire energy usage by industry has to be looked upon from an overall, national point of view as well, because often what appears to be the best energy alternative to the manager of an industrial enterprise from his point of view, it might not be true if looked at on a national or long-term scale. This then superimposes another dimension on the issue of industrial management which also has to be considered.

Research and development efforts undertaken within the last decade by developed and developing countries resulted in numerous technologies, know-how, innovative devices and other technological and non-technological means for the conservation and more effective usage of energy in industry. This information, although generally available, does not reach the developing countries regularly through effective channels, so that there is no awareness on the various possibilities for such energy savings. Furthermore, the developing countries frequently do not possess specialized expertise for the application of energy conservation measures in industry. Energy saving potentials are not taken into consideration in the planning of energy resources and, just because being unaware, switch to the development of much more expensive, new sources of energy instead of using available economical energy saving measures. Moreover, enterprises and factories do not know to whom to apply for assistance regarding energy conservation, because there is no institution dealing specifically with the problems of energy management in industry.

3. What is Integrated Industrial Energy Management?

The emerging art of "energy analysis" seeks to determine how much energy is required to provide goods and services. An Integrated Industrial Energy Management System (IIEM) is based on the method of process analysis to allow explicit treatment of the flow of energy involved in the flow of goods across boundaries (factory, enterprises or national level), which has key significance for the question of energy self-sufficiency.

There are many reasons for wanting to quantify the energy content (and cost) of goods and services. For one, we are motivated by an interest in energy conservation and the potential for saving energy through improved efficiency, substitution of products and services, capacity utilization, seasonal impact. Or, one might want to calculate the natural resources requirements for a number of consumer goods, including energy, and the system will produce the "embodied energy" in the product, i.e. its total energy "content" as it passes through process boundaries. For example, the energy burned or dissipated by a sector of the economy (e.g. steel mill) is passed on embodied in its products.

Applying this to every sector yields the following picture: primary energy is extracted from the earth, is processed by the economy and ultimately gravitates to final demand through such continuous analysis, the system also yields the "energy intensity" (i.e. the embodied energy per unit of output) for each economic sector (or factory). Integrated Industrial Energy Management is an approach which encompasses all the factors and parameters involving energy inputs, losses and efficiency incurred during the manufacture of materials and products to arrive at an overall picture, based on which sound decisions can be made regarding energy usage, optimization and energy resources planning.

4. Industrial Energy Management at the Enterprise Level - Integrated Energy Management in Factories

a) The Objective of Integrated Energy Management

The importance of energy in the industrialized and particularly the developing countries cannot be overemphasized and it requires a more comprehensive and methodological approach for its total optimization. The objective of energy management lies beyond the scope of traditional conservation action. Yet integrated management control systems and primary energy standards per unit of production are not a common management practice in the industrial sector. Quantitative answers are needed for such questions as:

- How much energy should be used for a given production?
- Which is the specific energy target?
- How is the energy performance being measured and controlled?
- Why does the actual performance vary against standard?

Whereas it is relatively easy to give an answer to similar questions related to, for instance, personnel cost, it will be more than difficult to explain the energy performance if no primary consumption standards per unit of production are available and there is no control system that monitors the total energy performance in an integrated way.

There are three steps involved in achieving practical energy cost reduction.

Step I - Enterprise or Factory Energy Survey and Identification of Improvement Opportunities

The goals of energy surveys are:

- to evaluate the quality and structure of available energy controls (i.e. measurement, monitoring, etc.);
- to zero-in on equipment that operates inefficiently and to pinpoint specific energy leaks;

- to identify the past and actual energy performances;
- to identify energy savings opportunities in the form of projects designed to correct each energy wasting situation;
- to analyse the potential reasons that may lie behind the performances.

Such an energy survey - as it includes the two major aspects of energy usage, i.e. energy efficiency and control - is the first step towards defining an "enterprise energy action programme". Not only will the specific cost savings be quantified, but real priorities will be assigned to the different projects pertaining to the programme and those related to their individual feasibility.

Step II - Installation of an Energy Control System

Unless the actual situation - and later on the results - are monitored accurately, it will never be known how successful the energy cost reduction programme is. This is a very important consideration. By proving this success, not only does it show how profitable energy conservation has been, but it also provides the strongest possible incentive to continue with energy conservation programmes. If it is required to provide a case for investment to management, then accurate data are the only way to prove a need.

The integrated energy control system delivers the following information (usually on a monthly basis and cumulative):

- the actual consumption of primary energy by individual area and related costs, which is integrated into an "overall plant energy balance";
- the distribution of the primary energy used into type of utilization:
  - (i) heating and cooling;
  - (ii) production process;
  - (iii) auxiliary units and administration;
- the modification of the anticipated specific primary energy consumption resulting from variations in production output;

- the strategy for the reduction of energy consumption as a result of the interpretation of abnormal performance against "standard", which is identified by the system;
- the planning of the total energy demand of the facility for a given volume of production and/or a given rate of capacity utilization;
- the planning of the product mix to satisfy the projected financial balance in a crisis scenario (e.g.: if 10 % less primary energy is supplied, what will happen to profits?).

It is essential to realize that an Energy Control System by itself is only a means to an end, and the end is the establishment of an optimum Standard for each variable. To reach this Standard and with the help of the System, the maintaining of the Standard is the objective.

Step III - Implementation of Savings

The implementation of savings opportunities usually cover the design, specifications and supervision for energy related projects, such as:

- boiler plants
- furnaces
- heat recovery devices
- heating and ventilation
- lighting schemes
- insulation and controls
- buildings and factory services
- process optimization.

Furthermore, the Energy Management System enables the detailed evaluation of savings and/or profit improvement possibilities in the area of the company's logistics such as:

- adaptation of present capacity utilization and production scheduling techniques in order to better utilize a given primary energy volume;
- change of the product mix on priority basis in cooperation with marketing and thereby improving the total margin contribution by using less energy for the same sales volume;
- adaptation of product quality (value analysis of present quality levels versus actual potential energy utilization);
- adaptation or change of mix of primary energy sources;
- change of seasonal production rhythms.

b) Benefits from Integrated Energy Management in Factories

The integrated energy management system provides the following benefits:

- it gives control over total energy usage;
- it sets standards;
- it quantifies the impact of production output and product mix on energy;
- it quantifies the impact of meteorological conditions of the site on energy;
- it allows for a quantification of the "net energy" used in processes;
- it quantifies the impact of process changes and conservation action on energy;
- it quantifies the opportunities for the implementation of energy conservation.

The following further benefits are delivered as a by-product of the **Integrated Energy Management System:**

- it establishes a commonly understandable language related to energy for its utilization by all management disciplines (technical and commercial);
- the energy performances and the reasons behind become transparent so that energy becomes a manageable aspect for top management;
- it supplies relevant and more accurate cost information for product costing and profit analysis purposes also establishing the link with labor cost;
- it requires no additional manpower and can be easily maintained by the Energy Manager (which in case of smaller enterprises and factories can be an added but clearly identified function of a manager having other functions as well);
- it allows to reevaluate energy targets in the light of varying circumstances (evaluation of new machinery, etc.);
- it allows the interpretation of energy trends and the initiation of preventive actions;
- it allows to establish a crisis scenario for the restructuring of the production in case of a more severe energy shortage, thereby maintaining reasonable profit levels.

5. Industrial Energy Management at the National Level

Industrial energy management at the national level is concerned with:

a) Development of National Energy Policies, based on:

(i) - the monitoring of aggregate industrial energy usage;

(ii) - anticipation of responses to changes in energy prices and availability;

(iii) - comparative energy costs of alternative production technologies;

(iv) - identification of fuel substitution options;

(v) - comparative process efficiencies.

b) Monitoring of Energy Linkages among Industries.

c) Measurement of Policy Impact on Industrial Energy Usage.

Energy accounting data are needed for policy making with respect to the impact of policy changes upon economic and physical variables such as: national employment, sectoral employment, international accounts, aggregate fuel availabilities and aggregate energy measurements by fuel type used and end uses.

On both the macro and micro levels, industrial energy accounting must be based on accurate information about the current energy use. The accuracy of these base data is essential to the reliability of detailed projections and has an impact on the model built upon them.

6. The Institutional Approach for Industrial Energy Management

In order to improve as quickly as possible the capacities of the developing countries to properly manage their industrial energy usage and to provide the necessary support to the Government for the development of appropriate policies regarding industrial energy utilization, the establishment of a "focal point" to deal with all such energy related matters would be of great advantage. It is recommended that an Industrial Energy Management Centre is established in view of the overall magnitude and permanency of the world energy shortage. Such a Centre/Unit should be practically oriented with its main aim being to provide direct assistance to industrial enterprises for improving their energy usage efficiency.

The main objectives of such an Industrial Energy Management Consultancy Centre (or Unit) are visualized as follows:

a) provision of consultancy services to industry in energy management and in implementation of energy saving measures;

b) training of local specialists from industry dealing with the problems of energy usage;

c) conducting research and development for the application of available energy saving technologies in industry and for the development of new ones;

d) collecting and disseminating all energy-related information from developed and developing countries on new energy saving industrial processes, technologies, existing regulations, incentives, etc.;

e) advising Government on energy policy related matters.

7. Practical aspects of Energy Management

This chapter describes various aspects of energy management as regards to practices and methodologies applied at the factory, enterprise and national levels.

a) Energy Data Acquisition System for the Industrial Sector

Among the methods of industrial energy accounting there is no singular "correct" approach; the choice of methods depends upon the purpose of the analysis and upon the resources available for this analysis.

As energy accounting entails the measurement of the energy flow into, through, and out of a system, industrial energy accounting can be defined by limiting the term System to industrial inputs, processes and output. The further limitation of Systems scope depends upon the purpose of the analysis. If the analysis involves determining the effects of the industrial sector upon broad aggregates of economic and social variables, then the scope is deemed "macro level". On the other hand, the analysis at the "micro level" entails the comparison of energy and economic efficiencies associated with specific processes or products. The information generated by the industrial energy analysis has policy applications on both the micro and macro levels. On the micro level, policymakers can be supplied with information upon which to base decision in many areas.

Process analysis is a technical materials balancing approach also applicable to energy accounting. The micro level and the process specific nature of this type of analysis makes it appropriate to a number of areas of policy formulation. More complete knowledge of the process level will allow for calculating the effect of changes associated with new technology and alternative processes and of changes in full types, in intermediate material use and in the rate of the unit process operation. In sectors for which the choice of alternative processes is the major determinant of energy use, the effect of change may be calculated in both the marginal and average terms. Furthermore, because the process analysis is based upon current technologies, it is an appropriate method of analysis in the short run.

The use of the Process Analysis Method will be instrumental in the later development of the required input-output analysis which is an economic model that traces monetary values of material flow from one industrial sector to another. For example, production function relationships derived by Process Analysis have an important role in verifying the technical coefficients which are central to the input-output analysis. Production functions derived from Process Analysis will become the design basis for some dynamic input-output coefficients.

b) Selection of Industries

In broad terms the industrial sector includes all non-household activities that involve the production of goods and services that are used throughout the economy. The most energy consuming industries will have to receive priority attention, which include:

- chemical and allied products
- primary metals
- paper and allied products
- petroleum and coal products
- stone, clay and glass products
- food and kindred products
- fabricated metal products
- transportation equipments
- machinery, except electrical
- textile mill products.

c) Monitoring Structure at the National Level

All the selected energy consumptive industries should report semi-annually to a government agency associated to the Ministry of Industry (Department of Energy) or Ministry of Energy, as the reporting forms should be designed to provide all relevant information used in the Industrial Accounting System. This agency shall be responsible for the publication of the aggregated performances on a regular basis. Knowledge of these data and the consumption of energy used in the industry will be necessary in drawing up appropriate "energy action plans".

d) Monitoring Structure

(i) At the Factory Level

To begin with, a firm management decision is needed that the company does want to conserve and manage energy. Having made this decision, management needs a logical, scientifical and progressive approach for the solution of the energy problem.

A good practical way of achieving this is to assign a person in senior level position to have overall responsibility for masterminding the energy management programme. The higher the standing of this person in the organization is, the more respect energy conservation will have and, therefore, the more effective the programme will be. One of the key functions of this "energy co-ordinator" is to change the attitudes and approach by everyone in the factory in avoiding the wasteful use of fuel and energy.

ii) At the Consultancy Centre/Unit

The size of the staff required for developing the consulting assistance to individual factory depends on the number and/or the size of the factories involved. This centre can be a technical department within the Ministry of Industry or the Ministry of Energy, or be a Unit in an appropriate technological institution, or become an autonomous Centre. The best institutional approach will depend on the country, its institutional infrastructure and other factors.

The energy managers of the largest factories can become members of its technical board.

8. Sequence of Activities for Establishing an Industrial Energy Management Consultancy Centre/Unit and Commencing with Operations

a) Selection of Trainees

Candidates for the Consultancy Centre/Unit will have to have practical experience. Electrical, chemical and mechanical engineers, macro-economists, heating and ventilation engineers would be excellent candidates. Any industrial experience in project engineering branches is of advantage.

b) Training Methodology

The trainees should be given an exposure to the broad field of consulting in energy management and energy conservation and on the role which a consultant plays in industry and what is expected of the consultant on individual company assignments. Each specialist will have to be initiated into details related to the fields in which he will be specialized. Manuals and procedures are used to illustrate the scope and details of the future work involved. The essential feature of this step is to mentally adjust the trainee to the task ahead, to properly orient him to serve the needs of industry from his new position. Training in the extensive use of survey forms, which are especially designed for the specific type of work, is essential including instructions on how to fill out these forms during the survey of a company.

c) Full-Scale Implementation of Integrated Energy Management in Selected Industrial Plants with the Initial Assistance of International Experts/Consultants

Step I - Plant Surveys

At first a few selected plants are visited and surveyed in great detail. All of the required and available information is compiled, even if it necessitates spending considerable time with company personnel in "digging out" the information or developing a "measurement campaign" such as evaluation of thermal efficiency of machines, boilers, etc. (It is important initially for the trainees to become acquainted with all details which are required and to learn of the difficulties which are involved in doing so).

Trainees are given the task of analysing the information which has been obtained and to estimate the improvements which can be made. They have to suggest initial areas where consulting activities should be applied, the benefits to be derived and the time required to complete the suggested activities. Having the trainee make this analysis, the consultant will have a better appreciation of the knowledge of the trainee. The consultant-instructor then compares his own findings with those of the trainees and explains the differences which occur and the basis of the estimates which were made. Following this the areas are identified where consulting services should be initially applied and the reasons for the priorities established.

The consultant/trainee teams then jointly draw up a proposed plan for the consulting work which is recommended at each factory. The time allocated to the selected assignment is designed in agreement with the guidelines set forth by the Centre/Unit and before proposing any assignment to the company selected.

Finally, the proposed action programme is presented to the management of the company involved for agreement on the scope of the assignment.

This approach allows for assessing the knowledge and understanding each trainee has of the consulting tasks being considered.

Step 2 - Implementation of Energy Saving Measures at the Factories

The implementation of the assignments at the factories should commence immediately following the receipt of approval from the management of the company involved. Initially the consultants/instructors carry out the assignments with the trainees, acting as their assistants and purposely involving them in every phase of the work as it progresses and as implementation takes place. The first few progress reports are completed by the consultants but very soon this task is turned over to the trainees. The compilation of "energy manuals" for continued use by the companies is done jointly by the consultant, the trainee and the persons appointed by the companies who are working on the assignments.

After a period of approximately one to two months working with the expert/consultant, trainees are given an independent work programme for the installation of the energy control system and implementation of savings to be completed in a factory, with the consultants providing only advice and reviewing the work at backstage before proceeding further. By this time the expert/consultant can debate his full attention to the second trainee.

The logic for the full scale implementation of energy management in industry is shown in Figure 1.

Step 3 - Preparation of Final Company-Factory Reports

A report on the progress and results of each assignment is submitted to both the management of the companies and the Centre/Unit, with the trainees making most of the contributions to the compilation of these reports, so that in a few months they are able to do these on their own.

d) Energy Data Acquisition System for the Industrial Sector

One to two years after industrial energy management consultancy and training activities have started, the first aggregate energy usage date could be generated for the industrial sector.

After the management consultancy team of the country is established, data collection has to progress to the point that by aggregating data meaningful conclusions can be made. Needless to say that the data base has to be continuously enlarged which also will mandate these periodic revisions of aggregate data. Industrial energy management will have to be tied in with the country's energy generating capacity and energy resources planning as well. The data have to be compiled and reported on the same "standard specific energy" basis to allow meaningful comparison. Figure 2 depicts the logic for the implementation of the energy acquisition data system for the industrial sector.

FIGURE 1.

Logic for the Full Scale Implementation of Energy Management in Selected Plants

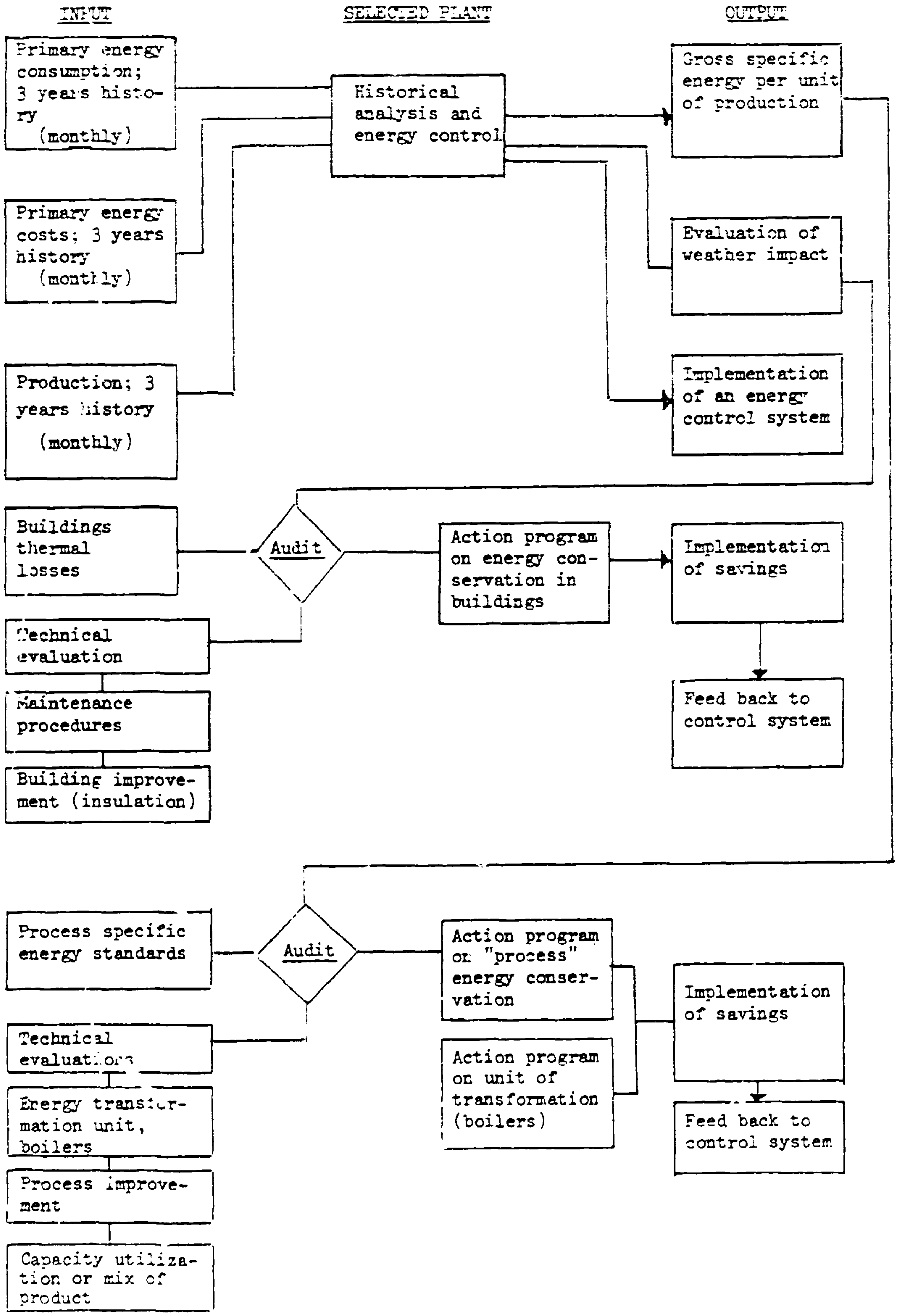
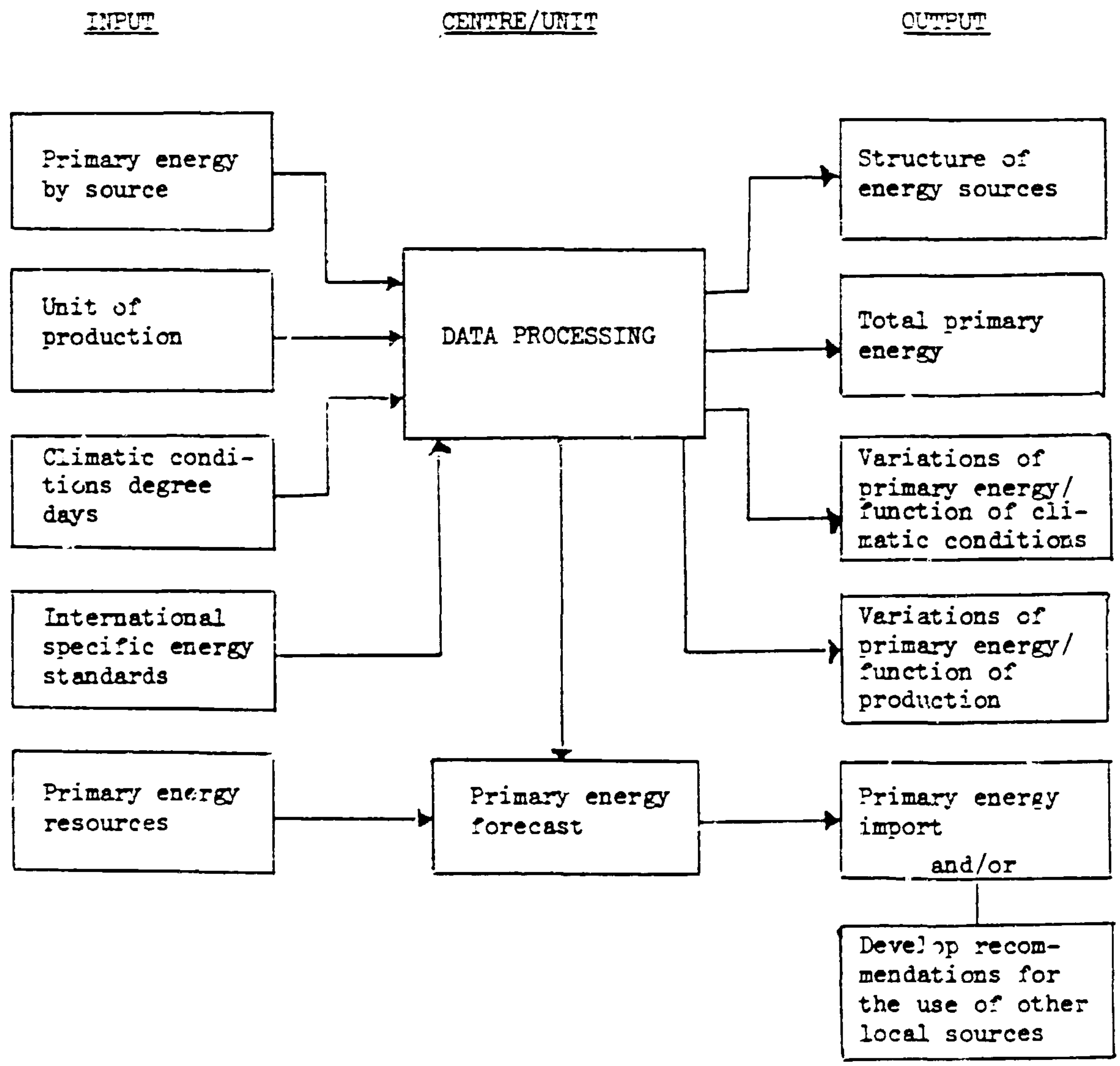


FIGURE 2.

Logic for the Implementation of the Energy Acquisition Data System for the Industrial Sector



9. Concluding Remarks

Industrial energy management is a new discipline, the result of the world-wide energy shortage. Because of the technological complexities involved in industrial processes regarding the use of alternative energy sources on the one hand, and the considerable energy saving possibilities on the other, it is important for the developing countries to realize both the opportunities and the difficulties involved. An integrated approach at the national (macro) and enterprise/factory (micro) level is essential for best results, which are achievable through an institutional mechanism specifically dedicated to the conservation of energy by industry. Therefore, the establishment of national Industrial Energy Management Consultancy Centres/Units in the developing countries (with several Centres in case of larger countries) is recommended. Such a Centre can be established and made operational within a period of 2 - 4 years, and at a relatively modest cost considering the potential energy savings that could be relatively quickly realized. The most important element for an effective and efficiently functioning Centre is that a qualified and dedicated national staff is available, who can acquire the necessary expertise in a relatively short time and pass it on to industry, where ultimately the energy saving measures must be implemented. Training of staff of the developing countries in industrial energy management and consultancy is a major task for the immediate future, sinde such specialists are rare even in the industrialized countries. This paper described in some detail how to proceed with on-the-job training of such specialists, but it has to be recognized that formal training also needs to be pursued on a broad scale with vigor in order to accelerate national capacities in the developing countries in this important and economically rewarding field.