INDUSTRIAL ENERGY STUDY FOR TUNISIA

FINAL REPORT

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1 MANAGEMENT SUMMARY

1.1 Project Objectives

This project was carried out to assist the Government of Tunisia to improve their energy planning capability and to stimulate improved energy efficiency in the industrial sector. The basic objectives were:

(1) To improve the collection of industrial energy data, starting with the collection of basic data at the individual plant level, thereby providing accurate and timely data on which to base regulatory and investment policies and programs.

(2) To analyze data taken from selected plant audits with a view to identifying energy conservation opportunities.

(3) To train Tunisian personnel, in particular at the plant level, to perform practical plant energy audits and to implement in-plant energy efficiency improvements.

1.2 Industrial Conservation Training Courses

Two cycles of training courses were conducted for a total of 21 engineers from industrial plants, STEG and ETAP. The course consisted of lectures on industrial energy conservation principles and techniques; the lectures emphasized the need for a thorough and systematic examination of energy consumption in industrial plants as a prerequisite for the definition of energy conservation opportunities. In conjunction with the lectures, a series of one day visits was made to industrial plants to reinforce the classroom lectures with practical demonstrations of the principles involved and of the use of portable diagnostic instruments.

1.3 Audit Work

An integral part of the training effort was the conduct of audits in selected plants by the Tunisian engineers themselves. The participants were divided into small groups of 4 or 5 engineers and these groups carried out specific tasks in the plants, such as performing heat and material balances around kilns, furnaces and boilers. At all times, the training of the engineers was given an equal

priority to the identification of energy conservation opportunities. Full reports of the audit work have been prepared and the findings discussed with representatives of the plants. In all plants, it was possible to develop recommendations for immediate action to improve energy efficiency.

1.4 General Findings of the Audit Work

A series of findings from the audit work in seven plants is presented in Section 4 of this report. We found a widespread lack of careful energy accounting and a resultant lack of awareness of the possibilities for energy saving. Top management did not always demonstrate a firm commitment to energy efficiency, even where energy costs were known to represent a significant proportion of controllable production costs. A questioning attitude by Tunisian plant engineers is generally absent and an analytical approach to energy data is lacking. Discrepancies are rarely noticed or investigated, possibly because of a lack of interest shown by company management in the few energy-related reports that are produced. There is rarely any focus for energy data, energy conservation and energy management, and we strongly recommend the appointment of full-time energy managers or energy coordinators in all large plants, and part time energy managers in the smaller plants. The motivation of all plant personnel to improve energy efficiency will be a key factor in the future, and the energy managers will have a role to play in stimulating this motivation.

We believe the present management of many of the plants visited in the course of this study are now anxious to make improvements, and therefore increased energy efficiencies will be achieved in time. It is also worth pointing out that measurable improvements will generally be the result of the accumulation of small actions rather than the result of one or two major capital investments. The contribution of housekeeping is clearly important and it is true that energy efficiency improvements through housekeeping are relatively easily obtained in many plants by better management. Regrettably, it is also true that housekeeping successes are relatively easily lost unless the drive for efficiency is maintained over the long term.

1.5 Specific Findings for the Plants

Specific findings and recommendations are discussed fully in the detailed reports of audits carried out at the seven selected plants. A brief review of recommendations is presented in this report. The potential for improved energy efficiency obviously varies from plant to plant, but typical improvements of 15 to 20% should be achieved on average within two years through a combination of better management and moderate capital investment.

1.6 Energy Data Collection

To assemble comprehensive data on industrial sector energy consumption, it was decided to collect data on the supply side from the distributors of oil products and STEG, and on the demand side from a total of 60 industrial consumers. Data on energy consumption and industrial production available from the Institut National de Statistiques (INS) were also examined. The procedures for data collection are described in Section 5 and the data themselves are recorded in Section 6 of this report.

1.7 Energy Use by the Industrial Sector

An examination of the data from plants and distributors shows that the sample of 60 plants represents a coverage of over 80% of the energy consumed in the industrial sector. For the fuels used by large factories, coverage was considerably higher: for heavy fuel oil, the sample represented 95% and for natural gas 98% of industrial sector use of the respective fuels.

Taking coverage factors into account, an estimate of the energy consumption patterns of the industrial sector was made for 1980, with the following result:

	10^3TEP	%
Materials of construction	417.1	39.8
Chemicals	96.4	9.2
Mechanical,metallurgical, electrical	166.1	15.8
Mining	178.9	17.1
Textiles	42.9	4.1
Paper	44.7	4.3
Food processing	89.3	8.5
Miscellaneous	12.1	1.2
	1047.5	100.0

It was also estimated that industry represents at least one third of the national consumption of commercial fuels, and between 25 and 30 percent of the total national energy demand. Full details of plant-by-plant energy consumptions are reported in Section 6.

It should be noted that, although the plant survey was designed to cover a large proportion of industrial sector energy demand by including 60 of the largest enterprises, the energy patterns derived from this project are believed to represent the sector as a whole. In any case, it may be concluded that policy initiatives and plant-level work aimed at relatively few large energy consumers could have a significant impact on the national energy situation. Policies and programs for improving the efficiency of the major energy consuming plants should receive a high priority.

This report discusses the energy efficiency of various subsectors in some detail. With respect to the importance of energy in the manufacturing process, the following percentages of selling prices represented by the cost of energy were derived for selected products:

Products	Energy cost/selling price (%)
Steel (reinforcing bars)	35
Lime	31
Plaster	28
Cement	24-25
Bricks	24
Glass bottles	18
Paper	17
Enriched phosphate rock	12
Sugar	8
Couscous	7
TSP	5
Milk	3
Bread	3
Tomato concentrate	3
DAP	2
Household appliances	2
Textiles	2
Flour	1
Camionette	0.3

The obvious importance of energy costs in the heavy industries is confirmed by these figures. It is also interesting to note the relatively small percentages calculated for staple food products such as milk, bread and flour.

1.8 Projected Energy Demands

An estimate of industrial energy consumption was made for 1986 using subsector growth rates taken from reports on the VIth National Plan. Assuming no change in energy use patterns and in the current energy efficiencies, the total industrial sector demand may be expected to increase to over 2 million TEP by 1986.

A discussion of fuel substitution possibilities appears in Section 6.12, where an estimate of the potential for natural gas is made. With a very vigorous gas conversion program, we estimate that industry could be using almost 900,000 TEP per year by 1986/87 if energy efficiencies remain the same as today: if efficiencies are improved, this figure will drop correspondingly. In any case, the combined demands of the industrial sector and STEG could represent a market of around 2 million TEP for natural gas by the mid-to late 1980s.

1.9 Potential for Energy Conservation

The prospects for energy conservation obviously vary from plant to plant. In the relatively short period of time available to conduct the plant audit work and examine records of energy consumptions, it was not possible to examine all aspects of energy use in sufficient detail to calculate potential savings accurately. However, it is estimated that improvements in energy efficiency of 15 to 20% could be achieved in many of the plants through a combination of improved energy management and capital investments.

Some actions have already been taken in several plants following the training program and audits to improve energy efficiency: these are noted in Section 6.13. For the seven plants audited during this project, reports have been prepared which include specific recommendations for improving plant operating efficiency, and these recommendations have been discussed with plant managements. In several cases, further detailed engineering studies are justified, since the audit reports themselves do not present precise solutions for all the problems encountered; rather, the reports present a case for the various conservation measures, including better management, and show that investment in various items of equipment will be cost-effective.

From the results of the audits and the visits to the other plants in the survey and of a review of specific energy consumption data, estimates of the conservation potential have been made for each subsector. Through a program of"vigorous conservation", we estimate industry demand could be cut by about 13% compared with the "business-as-usual" estimation by 1986/87. By "vigorous conservation", we mean a major program of housekeeping and energy management improvements throughout the industrial sector, and investment in all conservation measures showing reasonable payback periods (say 3 years or better). For new plants, we imply a thorough examination of design parameters and the incorporation at the design stage of cost-effective energy-saving measures to a greater extent than typically included in conventional plant designs.

The "vigorous conservation" case presents a very difficult challenge for Tunisian industry and may take longer than 1986/87 to be fully realised. We have therefore suggested a more realistic scenario for quantifying the probable impact of conservation by 1986. Briefly, this requires that serious efforts be made in the largest of the existing plants to improve energy management (in all 60 plants covered by the current survey, for example) and assumes that these efforts achieve 70% of the full potential by 1986. We also suggest that 50% of cost-effective capital investments are actually effected in existing plants by 1986, and that new plants are commissioned with energy efficiencies 15% better than current subsector averages.

The benefits obtainable under this scenario are estimated to amount to about 220,000 TEP per year by 1986 over the "business-as-usual" case, of which almost 100,000 TEP should be obtained in existing plants:

	10^3 TEP
Housekeeping contribution in existing plants	72
Contribution from investments in existing plants	26
Contribution from improved efficiency of new plants	122
	220

The contribution from improvements in new plant efficiency are clearly important and most of these savings will probably be obtained with relatively minor efforts by Tunisian industry. This is because technical improvements to plants will occur through the normal competitive pressures of the market place. A more active involvement of plant engineers seeking higher levels of efficiency could probably contribute even more significant savings. It is therefore most important that the subject of energy efficiency in new plants be given the attention it deserves in industrial development planning.

For the "realistic" scenario, the cumulative savings from 1982 through 1986 in existing plants -- excluding the contribution from new plant improvements -- amount to about 234,000 TEP, valued at 25 million dinars at world market prices. Of the total, about one-third represents the contribution of capital investments: assuming an average payback period of 1.5 years, this implies a total capital investment in energy efficiency improvements of around 12 million dinars over a four year period to the end of 1986.

These cumulative savings of 234,000 TEP and continuing savings of at least 100,000 TEP per year are considered attainable in existing plants and should be viewed as challenging but realistic targets for Tunisian industry. The resources for promoting conservation in terms of manpower and equipment which can be justified by the 25 million dinars are clearly substantial. The potential also supports our strong recommendation that energy managers be appointed at the plant level, as full-time staff for all large plants and part-time at others. Training programs for energy managers are recommended, and the Government should consider a system of certification of the competence of engineers appointed to the position of plant energy manager. Without a major effort to focus attention on energy problems, an effort in which energy managers have a key responsibility, the undoubted potential for conservation cannot be realized.

1.10 Recommendations for Data Collection

Comprehensive data are essential for energy planning at the national level. To provide timely and accurate energy data which are not currently available, it is recommended that a regular annual report be obtained from major energy consumers, and that reports be obtained from the distributors of petroleum fuels and STEG on their sales of energy products to the industrial sector.

The annual report from industrial companies should be concise. It should be a mandatory requirement for companies and thus the necessary legislative backing will be required. The report should include energy and production data: a recommended format is given in Section 7 of this report. To be of use for planning purposes and for monitoring energy consumption in the industrial sector, the data must be collected promptly each year, and April 1 is suggested as a deadline. A specific individual should be nominated by each factory to complete the report, preferably the energy manager, and the final submission should be signed by the PDG of the enterprise. The report should include a simple calculation of specific energy consumption and a comparison with the previous year made to bring energy efficiency to the attention of all concerned.

The annual report from the distributors of energy products should present sales disaggregated into specified subsectors. Such data are readily available from distributors who proved extremely cooperative in the course of this project. Confidentiality of clients names must, of course, be maintained.

The assembly of data and its analysis could best be performed in future years with the aid of electronic data processing. A complex computerized system could be counterproductive, and we strongly recommend an interactive microcomputer system be utilized.

1.11 Recommendations for Future Work

The potential for improved energy efficiency in the industrial sector has been shown to be very large indeed by the current project. To realise the potential savings available, the Government of Tunisia needs to create a permanent industrial energy conservation capability in Tunisia, including an ability within the private sector to conduct audits and implement recommendations.

Some steps have already been taken by the Ministry of National Economy to maintain the momentum and interest created by the current project. These steps include the formation of a small industrial conservation group within the Ministry and the continuation of training for several engineers. However, the attainment of significant savings cannot rely solely on a technical approach: the development and implementation of effective government policy must be given its due priority. The issue of plant personnel motivation must also be addressed.(1)

We therefore recommend that the Government of Tunisia set up a permanent program:

(1) To encourage and assist industry to use energy more efficiently through improved operating practices and through investment in new equipment

(2) To support energy policy development by creating and maintaining an industrial energy data base for monitoring consumption and for the analysis of policy options.

The program discussed in Section 8 of this report relies on positive but limited government intervention. We recommend an "Industrial Energy Efficiency Group" (IEEG) be formed, with two sections:

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(1) This topic was not covered in the present project and it is suggested that motivation and incentives be studied in a new project.

(1) a Technical Section to be responsible for technical assistance services such as plant surveys, brief audits, development and management of plant-level conservation programs, equipment specifications, and special studies. This section should act as a catalyst for action by the enterprises themselves rather than a resource which can carry out all the necessary work.

(2) a Policy and Analysis Section responsible for regular data collection and analysis, coordination of training programs, preparation and dissemination of publicity materials and technical information, and the support necessary for developing national energy policies and legislative initiatives.

Responsibilities of the IEEG are discussed further in Section 8. We believe it is most important that the two Sections work closely together; each can be highly effective as part of a combined operation. We do not believe either Section working alone would be as effective, and it would be a mistake to proceed with a program relying on the activities of one or other of the Sections in isolation.

The "sponsoring" agency for the IEEG could be the Ministry of National Economy, which has accepted this role to date. Other organizations with governmental backing could be considered, such as the Centre National des Etudes Industrielles (CNEI). Wherever the Group is placed, it is essential it be given authority to act independently and be allocated the necessary resources of manpower and equipment. Strong leadership is essential too, as the work of the group will be a blend of technical work and public relations, with much of its success relying on the establishment of credibility with industrial enterprises.

1.12 Immediate Activities

The ability of the IEEG to achieve credibility throughout industry and with government agencies is a top priority. It is therefore important that the work of the Group be carefully planned and that it be limited initially to avoid over-extending the resources available in the first few months..

We therefore suggest the following activities for the next six months or so:

(1) Technical Section

- complete its present training program on audit techniques by December 1982

- initiate a technical assistance program based on the audits already completed in the current project, emphasizing implementation of conservation actions at major plants (e.g. El Fouledh, SNCPA Kasserine, CPG Metlaoui).

- develop a program of short audits in the brickworks subsector with the cooperation of an interested company.

(2) Policy and Analysis Section

- continue data collection by preparing to assemble 1982 data using the forms and procedures developed in this project (expanding the reporting population to say 200 factories or more).

- prepare the first annual report on industrial energy use for 1982 by mid-1983, with the following types of analyses conducted (as reported for this project):

  (1) distributor data and survey data compared, with estimates of "coverage" by subsectors
  (2) current demand patterns by subsectors and by types of energy used.
  (3) a comparison with previous years data
  (4) a review of industrial energy use in the national context
  (5) cumulative energy consumption by plants
  (6) specific energy consumptions by plant and by subsector
  (7) energy and the value of production
  (8) energy costs as a percentage of product selling prices
  (9) projected energy demands
  (10) the potential for energy conservation
  (11) energy efficiency improvements achieved to date

- conduct one day seminars for industrial managers early in 1983 to publicize the work of the IEEG; conduct similar seminars for university audiences.

- start preparation of publicity materials to promote energy awareness, taking care not to over-sell the capacity of the IEEG to respond to requests for assistance.

- study the question of plant employee behaviour patterns, motivation and incentives to improve performance at the plant level.

- build up a technical library and information center.

- respond as required to requests for analyses to support government policy initiatives.

The success fo the IEEG and its program in Tunisia will not depend on the availability of technological solutions. It will depend almost entirely on the ability of the Government of Tunisia to establish an effective organization which can catalyze activity at the plant level, and which can support the development of the appropriate national energy policy.

2 INTRODUCTION TO THE PROJECT

2.1 Objectives

The Industrial Energy Study in Tunisia, which is now complete, had several objectives, all related to assisting the Government of Tunisia to improve their energy planning capability and to stimulate improved energy efficiency in the industrial sector. The study was designed to:

(1) Improve the collection of industrial energy data, starting with the collection of basic data at the individual plant level, thereby providing accurate and timely data on which to base regulatory and investment policies and programs;

(2) Analyze data taken from selected plant audits with a view to identifying energy conservation opportunities;

(3) Train Tunisian personnel, in particular at the plant level, to perform practical plant energy audits and to implement in-plant energy efficiency improvements.

2.2 The Industrial Sector

As in many developing countries, the mining and manufacturing industries in Tunisia have undergone significant expansion in recent years, as new industries have been developed in the areas of textiles, paper, steel, vehicle assembly, and products derived from phosphates such as the production of fertilizers and chemicals. There are also iron, lead, zinc, potash and iron mining operations in Tunisia, but production in recent years of these materials has been on the decline. Over 75 percent of the energy consumed by industry in Tunisia is derived from the use of petroleum products. With the recent discovery of significant quantities of natural gas, the possibility exists of major shifts by industry to the use of natural gas over the next several years, both as a fuel and as feedstock material.

Prior to the current study, E/DI staff conducted a series of brief energy surveys in nineteen industrial facilities in order to estimate their potential

for significant energy savings and to assess the opportunity in these facilities to achieve these savings through the implementation of house-keeping and low capital-intensive measures.[1] These preliminary assessments formed the basis of the selection in this project of those plants where detailed energy audits and training of plant staff were conducted. A pilot survey was also carried out in this project in order to design an information system which, in addition to the industrial demand-side data, will utilize supply-side data from utilities and petroleum product distributors to establish a comprehensive data bank. Methodologies developed during the course of this study are thus to be applied across the whole industrial sector in Tunisia on a routine basis.

2.3 The Need for Energy Data

Reliable information on the energy consumption patterns of the industrial sector is important in Tunisia because industry plays a major role in determining the national energy needs and shaping national energy policies. This project was therefore designed to improve energy data collection systems, starting from the collection of basic data at the plant level. The full improvement will, of course, take time to achieve, as the methodologies developed and tested in this study are subsequently applied throughout the industrial sector. Even with the limited data obtained in the present study, it is possible to address some of the major issues relating to the industrial sector, such as:

(1) future industrial energy demands and energy resource requirements, and potential effects on the energy supply systems (e.g. oil refining, electricity generation, town gas);

(2) the maximum use of indigenous resources by industry;

(3) future industrial investment strategies and their relationship to the national energy situation;

(4) the potential for more efficient use of energy (energy conservation);

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(1) Reported as part of the Gordian study, 1980

(5) possibilities for fuel switching (e.g. from fuel oil to natural gas);

(6) the possibilities for using renewable energy forms;

(7) potential impacts of changes in energy pricing policy on the various subsectors of industry;

(8) employment impacts of alternative energy use patterns;

(9) environmental impacts of industrial energy use.

With respect to data collection, the approach taken in the study was to examine both supply and demand data. To illustrate the approach, Exhibit 2.1 was prepared. The top part of the diagram corresponds to the "supply" side of the energy balance in the industrial sector, while the bottom part corresponds to the "demand" side. Ideally, supply and demand statistics should be assembled at the national level and should balance provided the data are accurate and complete. On the supply side, data are available from oil product distributors, STEG, STIR, etc., and demand side data are available at the plant level and may be aggregated at the subsector level (e.g. construction materials, textiles, etc.). While all distributors were contacted in this study, the level of effort that could be applied to data collection on the demand side was limited to 10 plants visited during the training program (7 of which were subjected to detailed audits) and 50 plants which were surveyed using a standardized questionnaire.

2.4 The Overall Scope of Work

In order to meet the objectives mentioned previously, this project was organized into six task areas:

Task 1 consisted of project planning activities and characterization of the industrial sector. This task included the identification of data needs, the selection of plants to be audited, and the selection of engineers to participate in the training program.

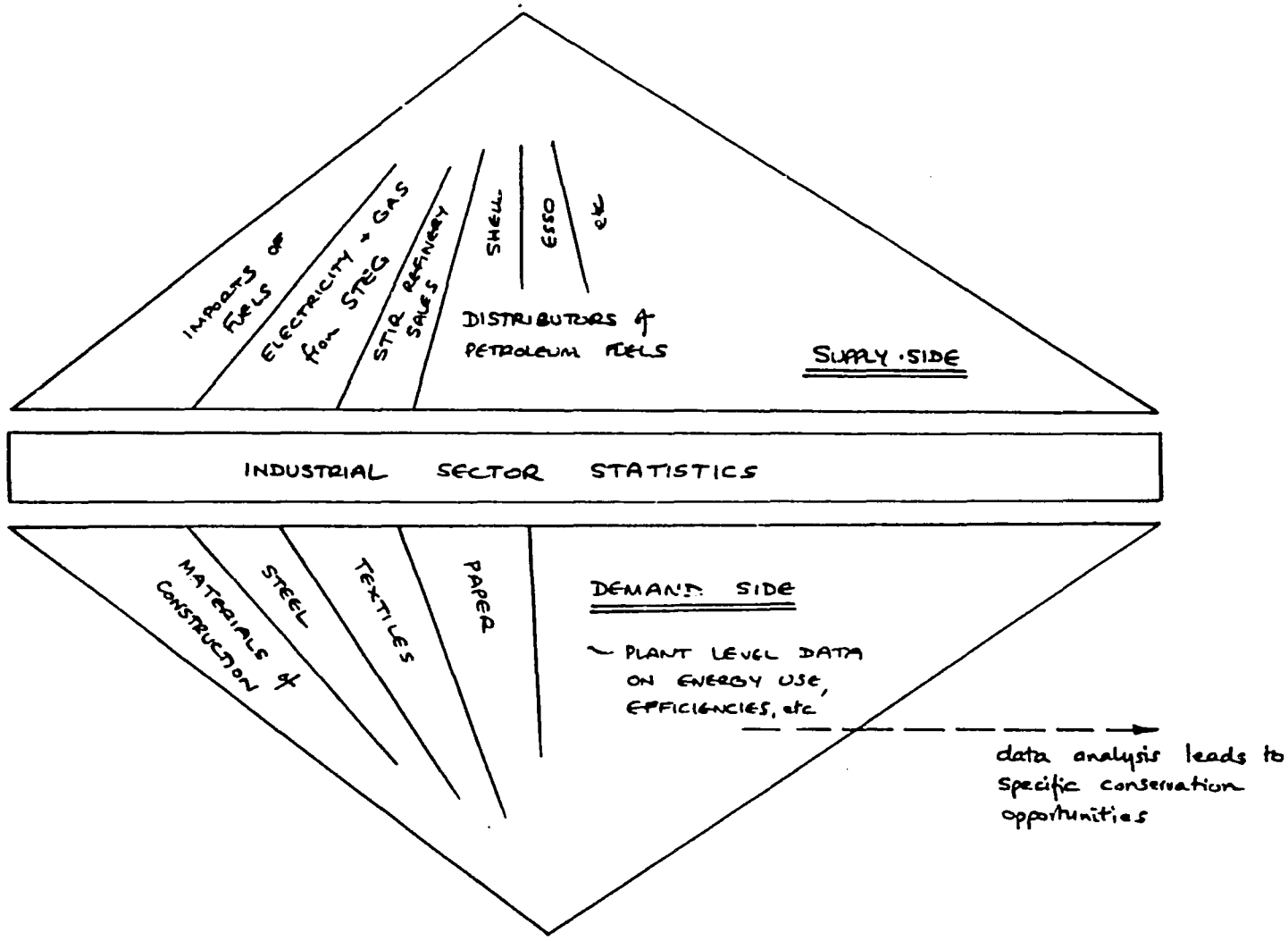

Exhibit 2.1 : INDUSTRIAL SECTOR DATA

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Task 2 consisted of a training program to cover all aspects of energy auditing at the plant level. The program was conducted in two "cycles", each consisting of a series of classroom lectures and of plant visits, which included the demonstration of portable instruments.

Task 3 consisted of detailed energy audits of 7 plants, conducted in two cycles to correspond to the two cycles of classroom training. The audits were carried out by teams of instructors and Tunisian engineers and served to reinforce the initial training activities of Task 2, as well as to provide accurate energy consumption data.

Task 4 consisted of the design and development of improved energy information systems. This task was closely related to Task 2, during which training in data collection and analysis was given, and to Task 3, during which the audits were used to test new plant data forms. In addition, data available on the overall consumption of energy within the industrial sector were examined as part of this task (e.g. data from distributors of oil products, STEG records, etc.).

Task 5 consisted of a pilot survey of 50 industrial facilities, utilizing the plant data forms developed as part of Task 4. For this survey, in-plant measurements were not made (as for Task 3, the plant audits). Rather, existing data covering total fuel consumption, energy demands by fuel type, and energy consumptions for various end-use categories were solicited and assembled wherever available. The results of this pilot survey were used to increase the knowledge of energy consumption in the industrial sector, as well as to identify major areas of data inaccuracy or insufficiency, areas which should be addressed using the methodologies developed in Tasks 2, 3 and 4.

Task 6 consisted of all activities related to the presentation of results, including written reports and presentations held in Tunisia at intermediate and final stages of the project.

The organization of the project took into account the need for better energy planning data and the need to identify practical conservation measures for immediate action. One element of energy planning that is often underestimated is the diagnosis of energy problems. It is important to recognize that absolute accuracy of energy-related data need not be a prerequisite for useful short term action. Indeed, data deficiencies should not become an excuse for inaction. This project was therefore structured to address both data needs and immediate energy problems, while simultaneously taking into consideration the training of Tunisian counterpart staff in the practical techniques of plant energy auditing and in the analysis of data for policy development.

2.5 Study Output

The outputs of the study, most of which are summarized in this final report, are as follows:

1. Energy demand data for the industrial sector, broken down by energy type and consuming subsector (as obtained from plant data, and other information available from energy product distributors);

2. Energy demands by specific end-use categories for several industrial operations, based on the detailed energy audits;

3. Examples of analyses of industrial sector data appropriate for energy policy development.

4. Recommendations for energy conservation actions by government and industry, including specific recommendations for plant-level actions in several plants.

5. A number of trained Tunisian engineers with the skills to perform energy audits in industrial facilities, and the ability to analyse energy data in order to assure maximum energy efficiency in the manufacturing operations; and

6. Recommendations for an information system for collection and analysis of energy-related data for the industrial sector on a continuing basis.

3 INDUSTRIAL CONSERVATION TRAINING COURSES

3.1 Training Courses Conducted

The training elements of the project were conducted primarily as Tasks 2 and 3, although on-the-job training was viewed as important in all phases of the work. Two training cycles were conducted as follows:

	Cycle 1	Cycle 2
Task 2 Training Course, with classroom lectures and brief plant visits	May 4-15, 1981 Visits to: El Fouledh: steel Fouchana : bricks CAT : cement Cim.Bizerte: cement SNS Beja : sugar	October 12-22, 1981 Visits to: SNCPA: paper CPG : phosphates Cim. Gabes: cement El Hamma : bricks SIAPE: fertilisers
Task 3 Detailed plant audits	June 15-26, 1981 Audits of the five plants listed above	November 23-December 3,1981 Audits of: SNCPA (Kasserine) CPG (Metlaoui)

This section of the final report covers the training courses conducted as Task 2 of the project, while section 4 covers the detailed plant audits of Task 3.

3.2 Participants

The training course participants were drawn almost entirely from the plants visited, STEG and ETAP. A total of 21 engineers attended the training courses of Task 2 and participated in small groups in the audit work of Task 3. For the record, the participants were as follows:

Cycle 1

Messrs.	Jenni	Briqueterie Fouchana (SOTIMACO)
	Aouani	El Fouledh
	El Mili	El Fouledh
	Abid	SIAPE
	Rouan	ETAP
	Khalfallah	ETAP
	Boukhicha	STEG
	Ben Rhouma	STEG
	Frigui	SNS
	Hadj Yahia	Cim. Bizerte
	Charfeddine	CAT

Cycle 2

Ben Soltar-	SIAPE
Abid	SIAPE
Kerkeni	CPG
Ammari	CPG
Baccari	SNCPA
Necibi	SNCPA
El Gaied	Cim. Gabès
Boulbaba	Briq. El Hamma
Ben Aissa	Cim. Bizerte
Eccheikh	STEG
Djomaa	Engrais de Gabès

The director of the Tunisian counterpart team, M. Nouri-Ammar, participated in all the training courses and audits.

3.3 Course Contents

The course given in Task 2 consisted of lectures on industrial energy conservation principles and techniques. Certain basic principles apply to energy conservation and an appreciation of the most important of these will put the training program into the appropriate context:

(1) An essential element of energy conservation is the systematic measurement of plant energy and material flows. Consistent units and definitions should be used if comparisons with other plants and other countries are to be meaningful.

(2) In order to carry out accurate energy and material flow measurements, the use of properly calibrated and maintained instrumentation is necessary: these instruments may be portable or permanently installed.

(3) The manner and extent of all energy use should be examined, to the level of detail justified by the level (cost) of energy consumed at each stage of the process.

(4) Experience shows that energy conservation measures fall into three general categories:

- housekeeping measures (short term results)
- minor capital investments (short to medium term)
- major capital investments (medium to long term)

With these points in mind, the training course was developed to emphasize the need for a thorough and systematic examination of energy consumption in industrial facilities, including the development of action plans which are consistent with the opportunities identified for short, medium and long term improvements in energy efficiency.

It is important to note that the training program was conducted with the engineers together for most of the time, irrespective of the industries to which their company belonged. This is because we have found that the greater part of energy conservation work is common to all industries. The principles of measurement, data organization and analysis, cost/benefit evaluations and the elements of conservation programs are of relevance in all industries, and therefore the common approaches to energy management were emphasized in the training course, rather than the relatively minor differences which do exist for specific industries. It is our experience that successful energy conservation is rarely a question of technology: it is almost always a question of systematic data collection and analysis, and of properly organized management.

The topics covered in the classroom lectures were therefore as listed below, and a comprehensive course manual was prepared for distribution to the participants:

(1) An introduction to the training program and the project as a whole (background, objectives, etc.)

(2) A brief review of energy consumption and the energy situation in general in Tunisia

(3) The structure of the training program, including procedures, logistics, participants roles, etc.

(4) Basic principles of energy conservation

(5) Basic information on fuels, their characteristics, common units of measurement, conversion factors and heating values.

(6) Energy audits: the purpose of audits, the scope of an energy audit, data forms and questionnaires, data analysis, benefits of audits, procedures used, the use of instruments (portable and fixed).

(7) Basic unit operations:

- combustion
- heat transfer
- evaporation
- drying
- distillation
- boilers and steam systems
- electrical demand management
- cogeneration

Lectures included the basic theoretical principles, practical aspects and calculation methods, as appropriate.

(8) Process analysis: a brief review of the need for analysis of the specific processes used in different industries, and illustrations of international comparisons of specific energy consumptions.

(9) Industrial lighting

(10) Space conditioning of industrial buildings and offices

(11) Checklists of conservation measures generally applicable to all industries, and measures specific to major industries.

(12) Typical company and plant conservation programs.

(13) Economic aspects of energy conservation, and examples of typical payback periods, rates of returns, etc.

In conjunction with the lectures, a series of one-day visits was made to industrial plants. These visits served to reinforce the classroom lectures with practical demonstrations of the principles involved, and were used to prepare for the longer visits for the detailed plant audit work. The one-day visits therefore gave an introduction to the participants to:

(1) the use of audit forms and techniques for obtaining data,

(2) the identification of problem areas in energy use, by data analysis and by inspection of the physical plant,

(3) the handling of portable instruments for the diagnosis of plant performance.

The course participants were generally divided into two groups for each visit, with participants alternating between these groups for the different visits. The first group (the "inside" group) concentrated on data collection and the use of audit forms. This group obtained basic data on energy consumption and levels of production, and details of the manufacturing processes and major items of equipment. The second group (the "outside" group) inspected specific sections of the factory where they observed the location of important measuring points and checked on the availability (or lack) of data on key operating parameters. The use of portable instruments was demonstrated to this group.

Reports were prepared on each of the plant visits performed in Cycles 1 and 2, and the data collected at each plant are recorded in those reports (see Appendix A for a list of reports).

4 AUDIT WORK PERFORMED

4.1 Procedures

As indicated previously, an integral part of the training effort was the conduct of audit work in selected industrial plants (Task 3). The course participants were divided into small groups, typically 4 or 5 engineers with one instructor for each group. Further work was carried out to improve the plant data and the statistics collected on energy and production, based on detailed examinations of plant records. In addition, specific tasks were carried out within the plants using portable instruments to establish heat and material balances around major items of equipment such as furnaces, kilns and boilers. Heat losses from kilns, storage tanks and uninsulated steam lines were estimated in several plants. The audit work was performed in conjunction with experienced engineers from NIFES Ltd of Birmingham, England.

The audits carried out on the five plants selected for Cycle 1 were performed in 2 or 3 days for each plant. It was found that this did not give enough time to gather data, to train the Tunisian counterparts in data collection and the use of instruments, and to analyse the data with the participants. It was therefore decided that the Cycle 2 audits would be restricted to two plants, with about one week spent in each (the paper plant at Kasserine and the phosphate processing complex at Metlaoui). This allowed additional time to be spent in the plants working with the Tunisian engineers, including one day in each plant devoted entirely to an initial analysis of the data, using sample calculations. This extra time proved most useful. A final review of the audit work and calculations was made at the E/DI Europe offices with a team of Tunisian engineers in January 1982, and their comments were taken into account in the writing of the final report.

The work carried out at Kasserine illustrates the scope of the training program. At this plant, pulp is produced from alfa grass and this pulp is blended with imported long-fibre pulp to produce the finished paper. The manufacturing complex includes supporting activities such as a lime kiln, an electrolytic plant for the production of caustic soda and chlorine, and utility plants for the supply of demineralised water and steam. The plant also produces a significant proportion of its own electricity.

The course participants were divided into three groups and assigned to various tasks:

(1) To examine in detail the available plant records on production levels and energy consumption

(2) To monitor the performance of the black liquor boiler (which incinerates waste materials from the pulp production stage) and determine its combustion efficiency.

(3) To monitor the performance of the lime kiln and attempt to establish an overall heat and material balance.

(4) To conduct a 24-hour test run on the main steam boiler and turbo-alternator system in order to assess the performance of the boiler in terms of output and thermal efficiency, to assess the efficiency of the turboalternator and to identify areas for energy conservation.

(5) To carry out a thorough examination of the fuel oil storage and handling system, from the delivery point for rail wagons through to the burners on the boilers and lime kiln. This work included a check on tank and line heat losses, as the fuel oil requires preheating prior to its combustion.

At all times, the training of the Tunisian engineers was given an equal priority to the identification of opportunities for energy conservation. In the time available at the plant, it was obviously not possible to test the efficiency of all stages of the manufacturing process, but it is believed that the training given to the two plant engineers from SNCPA will enable them to proceed with their own audits of other key equipment such as the pulp and paper dryers.

For the record, the portable instruments used during the plant audits consisted of the following items:

Combustion gas analysers, for O_2 and CO_2 measurement, using both electronic and chemical absorption types.

- Digital temperature indicators using a variety of contact probes

- Infra-red pyrometer for non-contact surface temperature measurements

- Clip-on voltmeter and ammeter

- Pitot tube and manometer set for measuring combustion air and stack gas flow rates

4.2 General Findings

Before commenting on the specific conservation measures identified for the plants, several comments may be made regarding energy management in general, and these comments reflect the overall level of energy management that was observed in the broad range of industrial facilities visited in the course of this project. With some notable exceptions, as described in the specific plant reports, the general standard of energy consumption monitoring and energy management is poor. It is strongly recommended that immediate efforts be made to improve energy management throughout the industrial sector in Tunisia, as it is clear that closer control of operations will lead to significant energy savings in the short term. Based on the series of one-day and extended plant visits, the following remarks may be made which are applicable generally in the industrial sector:

(1) There is a widespread lack of careful energy accounting, and a resultant lack of awareness of the possibilities for energy saving

(2) Where data are assembled regularly, reports are often incorrect, inconsistent and incomplete; there is a need for rigorous checking of all data

(3) Important energy-related data are often missing and no attempt is made to relate energy consumption to production, a fundamental pre-requisite for improving efficiency.

(4) There is a need for top management to demonstrate a firm commitment to energy efficiency

(5) Energy and production data are often quoted in diverse units and confusion between such units as litres and kilogrammes, cubic metres and tonnes, etc. can often occur. In some cases, data records are kept without quoting units, which can lead to further confusion. Electrical consumption is sometimes reported as "kilowatts per hour", which is clearly nonsense. A great deal of improvement could be made in this respect and it is recommended that complete energy reports be prepared regularly with all energy consumptions converted to a common unit for comparison purposes (e.g. kilocalories,TEP, etc.)

(6) On occasions we observed a surprising degree of confusion about the grade of fuel oil used and its calorific value. Quality control of fuel purchases appears non-existent, and control of the quantity of fuel delivered often leaves much to be desired.

(7) When asked about equipment performance or efficiency, plant personnel often quoted design data and were unable to quantify with any certainty the current situation. On one or two occasions, incorrect information was given which confused the true facts relating to energy wastage.

(8) Accurate measurement is essential to establish the priorities for energy efficiency improvement but the standard of instrumentation for measuring important flows and temperatures is generally poor. Much improvement needs to be made with respect to basic instrumentation; at the present time, it is not possible to construct a meaningful steam balance in many of the plants.

(9) A questioning attitude by Tunisian plant engineers is generally absent and an analytical approach to energy data is lacking. Discrepancies are rarely noticed or investigated, possibly because of a lack of interest shown by company management in those few energy-related reports that exist.

(10) A regular, comprehensive and reliable monthly report on energy consumption should always be prepared in a format which will allow comparisons to be made on energy efficiency from one month to the next.

(11) A significantly improved standard of maintenance and housekeeping is necessary in many of the plants to improve the operating performance and to contribute to improved energy efficiency. Safe and clean working conditions are essential for efficient plant operation.

(12) There appears to be a general lack of qualified engineering personnel to identify and implement energy efficiency measures.

(13) There is a general lack of information on basic calculations and standard engineering data.

(14) Above all, there is a widespread lack of focus for energy data, energy conservation and energy management. There is a need for a clear definition of responsibilities for energy matters and it is recommended that an energy manager be considered for all the plants. The responsibilities of an energy manager are discussed below.

As a result of the interest generated in this project, we believe that the present managements of many of the plants are now anxious to make improvements of the kind recommended here, and we can therefore expect to see increased energy efficiency in those plants. Improvements will come as a result of many small actions, rather than for one or two major conservation items; progress will take time, but we believe measurable improvements can be achieved during 1982. However, it is clear that some managements have little or no interest in energy efficiency, and here the problems will not be easily solved.

4.3 Specific Findings for the Plants

The findings for each plant are discussed fully in the detailed reports which have already been prepared and distributed in Tunisia (see Appendix A for the list of reports).

With respect to the overall level of operating efficiency, we found a wide variation amongst the plants visited. In some of the plants, good modern technology is coupled with good management to produce energy efficiencies comparable with those achieved in many countries. On the other hand, the standard of operating efficiency in other plants was frankly very low, and a great deal of improvement

could be made with little or no investment. For example, high excess air rates were frequently found on boilers, furnaces and kilns. In most cases, we believe that simple adjustments to operating conditions would be adequate to reduce air levels to the desired ranges, saving as much as 10% of the fuel in some of the bad cases. In many plants, a poor standard of instrumentation contributes to poor energy efficiency.

We also found the standard of maintenance in several plants to be poor, leading to unsafe working conditions on some occasions. As noted previously, we do not consider that good energy efficiency is achievable without proper working conditions.

The reports prepared for each of the seven plants include specific recommendations for improving operating efficiencies, such as improved instrumentation, additional insulation of hot lines and tanks, and better control of fuel to air ratios. The reports also include recommendations for larger capital investments where appropriate, such as the installation of stack gas recuperators on reheat furnaces at the steelworks.

Details of all such recommendations and associated cost-benefit calculations are given in the plant reports and are not repeated here. However, Exhibit 4.1 provides a summary of the major recommendations for the seven plants, organized according to the three categories of housekeeping, minor investments and major investments. Where capital investments were identified for conservation measures, the payback period was generally 2 years or better.

The potential for improved energy efficiency obviously varies from plant to plant. In the relatively short period of time available to conduct the plant audit work and to examine existing records of energy consumption data, it was clearly not possible to examine all aspects of energy use in sufficient detail to calculate potential savings with any accuracy. However, as a review of the various plant audits will indicate, typical improvements in energy efficiency of 15 to 20% should be achieved in these specific plants within two or three years, through a combination of improved energy management (savings say 10-15%) and capital investments (savings say 5-10%). For the industrial sector as a whole, we have been less optimistic regarding conservation potential, as it will take time and much effort to realise the savings possible. Further discussion of the actions taken to date by specific plants is given in Section 6 of this report.

EXHIBIT 4.1

INDUSTRIAL ENERGY AUDIT STUDY IN TUNISIA

PLANT	HOUSEKEEPING	MINOR INVESTMENTS	MAJOR INVESTMENTS
El Fouledh Steelworks	o Improve site cleanliness,safety o Initiate proper record-keeping o Appoint energy manager o Improve instrument and burner maintenance o Control combustion at boiler and furnaces	o Install automatic control on air/fuel for ladle heating (PBP < 2 years)	o Install stack gas recuperators on reheat furnaces (savings 12.5% PBP 2 years)
Sugar refinery, Béjà	o Initiate monthly reports on energy consumption o Improve operation of fuel oil storage and handling system (e.g. better temperature control)	o Recover heat from boiler blowdown (PBP < 2 years) o Improve condensate recovery (PBP < 2 years) o Modify steam system to supply LP steam to deaerator	(none identified)
CAT wet process cement plant, Tunis	o Improve site cleanliness and maintenance . o Initiate proper monthly energy monitoring (improve data reliability) and improve energy management o Reduce water content in slurry (20% savings) o Repair combustion control instruments	o Replace electric heating of fuel oil by steam heating (PBP 1 year)	(Plant is old and quarry reserves are limited; technology is outdated)
Ciments de Bizerte dry process plant	o Improve format for monthly report o Appoint energy manager	o Improve clinker cooler operation (PBP not established)	(Plant is new, with best modern technology)
Fouchana brickworks	o Initiate proper record keeping o Provide focus for energy management (appoint energy manager) o Reschedule plant operations (40-50% savings) o Remove one of two air fans o Reduce losses/breakage	o Recycle hot exhaust kiln gases to dryers (12% savings, PBP < 2 years) o Test supplementary ceramic fibre insulation (savings 4%, PBP 1 year)	(New plant, but lacks adequate instrumentation)
Compagnie de Phosphates de Gafsa, Metlaoui	o Reduce material losses o Improve maintenance and scheduling o Initiate proper record keeping o Study rail transport and potential losses o Improve control of fuel oil storage and handling	o Reduce water in filter cake entering dryer o Modify control system to control on direct measurement of phosphate exit temperature	(None identified)
SNCPA paper plant, Kasserine	o Initiate proper record keeping o Improve maintenance o Eliminate steam leaks	o Install new burners for black liquor boiler o Insulate steam lines, hot fuel oil lines, etc. o Improve condensate recovery	o Eliminate static letdown of steam at power plant;install new turbogenerator
El Hamma brickworks	o Improve cleanliness, maintenance o Reduce breakages o Initiate proper record keeping o Eliminate flue gas leakages o Improve boiler combustion control	o Modify wiring system to allow selective shutdown of motors, drivers o Modify kiln gas recycle to dryers to increase heat recovery	(None identified)

Finally, it is worth repeating that measurable improvements will generally be the result of the accumulation of small actions rather than the result of one or two spectacular major capital investments. The contribution of housekeeping is clearly important, and it is true that energy efficiency improvements through housekeeping are relatively easily obtained in many plants by better management. Regrettably, it is also true that housekeeping successes are relatively easily lost unless the drive for efficiency is maintained over the long term.

5 ENERGY DATA COLLECTION

5.1 Overview of the Procedures Used

In order to assemble comprehensive data on industrial sector energy consumption, it was decided to obtain data on the supply side from the distributors of oil products and from STEG (for electricity and gas sales), and on the demand side from a total of 60 industrial consumers. The data on energy consumption and industrial production available from the Institut National de Statistiques (INS) were also examined. Throughout this project, efforts were made to obtain data for 1980, although it proved impossible to obtain this data for some plants, for whom 1981 data were substituted.

The data from fuels and electricity distributors allow the plant data to be put into perspective, that is, it was possible to judge the percentage of demand covered by the plant survey for individual fuels and for energy overall. The production data from INS allowed another estimate of coverage to be made in terms of major industrial products (i.e. cement, bricks, household appliances, etc.). The use of the survey data to estimate total industrial sector energy consumption is explained in Section 6 of this report, where the coverage percentages are discussed and used in the calculation procedures.

5.2 Distributors

Visits were made to all the distributors of energy products and data requested on the consumption of energy by industrial consumers categorized into major "lines of business", such as food processing, materials of construction and mining. The distributors agreed to provide even greater detail, allowing consumptions to be allocated to main product lines in most cases, such as cement, bricks, dairy products, etc.

For electricity consumptions, STEG supplied a computer listing of industrial consumers of high and medium tension electricity. From this listing it was possible to obtain disaggregated consumptions according to the main product lines. Unfortunately, no data were available on the consumption of low tension electricity by small industrial consumers, such as bakeries and small metal-working companies. At this time, STEG has no reliable data on these consumers, although the company is investigating the matter.

For gas consumptions, STEG supplied the data for large purchasers of natural gas, but was unable to provide details of the small consumers of natural gas and town gas, most of whom are located in the Tunis area. Again, we believe the small bakeries are amongst the more important users of gas, but there are currently no reliable data. It is to be hoped that the forthcoming study of energy consumption in residential and commercial buildings will provide estimates of consumption by the smaller industrial enterprises.

For oil products, we met with all the suppliers of industrial fuels and obtained their disaggregated data. The problem remains, however, of accounting for the consumption of some fuels (notably gasoil, kerosene and domestic fuel oil) by small consumers who purchase from retail outlets (gasoline stations, kiosks, resellers). These small consumers are not supplied directly by the oil companies, who therefore have no records of consumption. The numerous resellers are apparently unable to specify the end-use of the products: they keep no records to show that some purchases are used for industrial companies while others are used in commercial buildings, for example.

The companies providing petroleum fuels data were:

Shell
Esso
Mobil
Total
Fina
SNDP (Azil)
STIR (direct refinery sales)

5.3 Plant Data

A survey form was developed for use to obtain standard data from all the plants visited as part of the training program, and subsequently within the pilot survey, Task 5. The questionnaire and accompanying notes are presented in Appendix B. The form consists of several parts:

A. Identification of the company, plant, contacts made, etc.

B. Production activities, such as a list of principal products, corresponding plant capacity and actual production, raw materials used, a description of the manufacturing process, value of production, etc.

C. Energy consumption figures and properties of the fuels used.

D. Electricity data, including information on autoproduction where applicable, and breakdown.

E. Steam systems and boilers, including water consumption and level of condensate recycle.

F. Principal uses of fuels, e.g. process heating, steam raising.

G. Renewable energy sources and non-commercial fuels.

H. Energy management aspects, such as the energy manager, energy conservation committees, data and reports on energy use, principal energy-related problems, conservation activities, etc.

The questions and spaces for answers have been arranged in a format which could be modified relatively easily for data processing purposes if this is required in future. However, there are no specific proposals for data processing in Tunisia that we are aware of, and in any case we would recommend further manual surveys for the time being.

The plants for which data were obtained using the questionnaire are listed in Exhibit 5.1, and the results are discussed in Section 6. In general, the data obtained appear to be reliable. However, comparison of the responses shows some obvious omissions, and we offer the following observations:

(1) Very few plants supplied data concerning the density, calorific value, and other specifications of the fuels consumed. Whilst we do have typical figures for Tunisia for conversion factors, plants should be more aware of the characteristics of the fuels they use.

EXHIBIT 5.1 : PLANT LIST

COMPANY	Q No.	CLASSIFICATION AND MAIN PRODUCT	
Societe Tunisienne d'Engrais Chimiques (STEC)	01	Chemical industry	Fertilisers
Fonderies Reunies de Tunisie (FRT)	02	Mechanical/Metallurgy (MME)	Steel foundry
Societe Anonyme du Domaine de Pontinville	03	Materials of construction	Lime
Le Confort S.A.	04	Mechanical/Electrical (MME)	Appliances
Soc. Metallurgique et Miniere de Tunisie (SMMT)	05	Mechanical/Electrical (MME)	Silver/lead
El Anabib	06	Materials of construction	Reinforced concrete products
Briqueterie Zarrouk (SARL)	07	Materials of construction	Bricks
Le Comptoir National des Plastiques SA	08	Mechanical/Electrical (MME)	Household articles
Briqueterie Ali M'Heni	09	Materials of construction	Bricks
Tunisie Lait SA	10	Food processing	Milk
Siter (Soc. Industrielle des Textiles Reunis)	11	Textiles	Textiles
Sitex- Usine de Ksar Helal	12	Textiles	Textiles
Soc. Tunisienne d'Industrie Automobile STIA	13	Mechanical/Electrical (MME)	Bus, car, coach assembly
Union Generale (Briqueterie Jemmal)	14	Materials of construction	Bricks
Societe Tunisienne de Verrerie (SOTUVER)	15	Materials of construction	Glass bottles
Societe Nationale de Pneumatiques (SONAP)	16	Chemical industry	Tyres/rubber
Societe Tunisienne d'Industrie Laitiere	17	Food processing	Milk
Omnium des Materiaux Prefabriques (OMP)	18	Deleted from analyses due to data deficiencies	
Societe Generale Industrielle (SGI)	19	Mechanical/Metallurgy (MME)	Gas bottles
Societe Tunisienne de Biscuiterie (SOTUBI)	20	Food processing	Biscuits
Societe Tunisienne de Chocolaterie (SOTUCHOC)	21	Food processing	Chocolate products
Les Platres Tunisiens de Meknassey	22	Materials of construction	Plaster tiles
Ceramique de l'Ouest	23	Materials of construction	Bricks
La Ceramique Tunisienne (Usine Jendouba)	24	Materials of construction	Bricks
La Ceramique Tunisienne (Usine Tabarka)	25	Materials of construction	Clay tiles
Ciments Artificiels Tunisiens (usine a chaux)	26	Materials of construction	lime
Ali Majoul et Compagnie	27	Food processing	Tomato concentrate
Soc. Industrielle et Commerciale d'Ouvrages en Amiante	28	Materials of construction	Asbestos cement pipes/roofing sheets
Ciment Amiante Tunisie (CIAMIT)	29	Materials of construction	Asbestos cement pipes
Pain et Patisserie Ouarda (SARL)	30	Food processing	Bread, cakes

EXHIBIT 5.1

COMPANY	Q No.	CLASSIFICATION AND MAIN PRODUCT	
Societe de Materiel Electrique Chakira	31	Mechanical/Electrical (MME)	Electric/telephone cables
Granuphos	32	Chemical industry	Fertilisers
Soc. Indust. d'Acide Phosphorique et d'Engrais (SIAPE B)	33	Chemical industry	Fertilisers
Manufacture Tunisienne de Ceramique (MTC)	34	Materials of construction	Porcelain products
Les Refractaires de Tunisie	35	Materials of construction	Refractory bricks
Societe Tunisienne d'Oxygene et d'Acetylene (STOA)	36	Chemical industry	Oxygen/acetylene gas production
Societe La Brique Tunisienne	37	Materials of construction	Bricks
Societe des Industries Chimiques Maghrebines (ICM)	38	Chemical industry	Fertilisers
Societe Arabe des Engrais Phosphate et Azotes	39	Chemical industry	Fertilisers
Engrais de Gabes	40	Chemical industry	Fertilisers
Industrie Chimique du Fluor (ICF)	41	Chemical industry	Aluminium fluoride
Societe de Fonderie et de Mecanique (SOFOMECA)	42	Mechanical/Metallurgy (MME)	Steel foundry
Societe Monasterienne (SOMOTEX)	43	Textiles	Textiles
Les Ateliers Mecaniques du Sahel	44	Mechanical/Electrical (MME)	Household articles
Societe Frigorifique et Brasserie de Tunis	45	Food processing	Beer, fizzy drinks
Regie des Alcools	46	Food processing	Alcohol
Cooperative Agricole Izidihar	47	Food processing	Preserved fruit
Sfax Ceramique	48	Materials of construction	Bricks
Societe Tunisienne de Production Alimentaire (STPA)	49	Food processing	Flour, semolina
Les Couscousseries du Sud (CDS)	50	Food processing	Couscous
Cimenterie d'om Khelil (ex-Sico)	51	Materials of construction	Cement
Other Plants (visits/audits)	**Code**		
Ciments Artificiels Tunisiens (Djebel Djelloud)	(B)	Materials of construction	Lime/cement
Briqueterie Fouchana	(C)	Materials of construction	Bricks
Briqueterie El Hamma (Ceramique Tunisienne)	(F)	Materials of construction	Bricks
Ciments de Bizerte	(A)	Materials of construction	Lime/cement
Societe de Ciments de Gabes	(G)	Materials of construction	Lime/cement
SIAPE (Plant A)	(H)	Chemical industry	Fertilisers
El Fouledh Steelworks	(D)	Mechanical/Metallurgy (MME)	Steel billets
Compagnie de Phosphates de Gafsa	(J)	Chemical industry	Fertilisers
Societe Tunisienne du Sucre	(E)	Food processing	Sugar
SN de Cellulose et de Papier Alfa	(I)	Paper	Paper

(2) The breakdowns of electricity and other fuel uses are clearly areas of major deficiencies but we are not optimistic that better data will be forthcoming in the short term. Detailed energy audits will probably be necessary in most plants in order to account properly for all energy uses.

(3) Many plants did not supply data showing details of the average quantities of steam actually produced by boilers or the quantities of fuel/water consumed in steam production. For national planning purposes these data are not generally required but they would be useful for evaluating conservation opportunities in individual plants.

(4) Many plants claimed to have an Energy Manager when it was clear that the person named as Energy Manager was in fact employed in another capacity (for example, Technical Director or Production Chief). We believe that the position of Energy Manager is an important position and not a part-time responsibility in a large energy consuming facility. Of course, we recognize that not all plants consume enough energy to justify a full time energy manager.

(5) In many questionnaires, no details were provided of the energy records maintained by the plant and in other cases the description supplied was so brief as to be of little use.

(6) Few plants reported any energy related problems other than frequent STEG electricity cuts and voltage drops. Furthermore, even those plants which did mention STEG cuts did not quantify the frequency and duration of cuts. Without this data it is, of course, quite impossible to determine accurately the cost of the STEG cuts in terms of lost production, damage to machinery, etc., and thus provide clear support in financial terms for an improved STEG service.

(7) Few plants gave details of the energy conservation measures already undertaken or planned for the future. This lack of reported activity may, of course, be a true reflection of the lack of concern by industry for energy matters, indicating that few plants are actually trying to minimise their energy costs.

(8) The discrepancies and omissions apparent from our examination of the questionnaires reconfirms our view that personal visits by trained engineers are essential and a first step to building a comprehensive and reliable data collection system.

5.4 INS Data

From each of the questionnaire responses it was possible to obtain figures for the production levels achieved in the plants. To estimate the coverage obtained by the survey for each major product (such as bricks, cement, dairy products), the industrial production data published by INS were examined. These data for 1980 and 1981 were taken from the appropriate copies of the Bulletin Mensuel des Statistiques.

With regard to energy data, the figures reported monthly by INS are not disaggregated sufficiently by lines of business to allow meaningful comparison with the plant questionnaire responses. However, INS conduct an annual census of manufacturers and thus obtain disaggregated data which could be compared to our survey results. The 1980 census results were not available from INS at the time of writing of this report (September 1982) and therefore no direct comparisons have been made as yet. We believe that the plant survey data will be more reliable because special efforts were made by the engineers conducting the survey to identify fuel types properly and to clarify with senior plant management any apparent anomalies in their reported energy use.

It is appropriate at this point to mention that the major limitations to the use of the existing INS data collection systems appear to be the delay in obtaining disaggregated and comprehensive energy data and the doubt that the fuel consumption data are accurate. For example, we have observed significant discrepancies in prior years between INS data and the plant figures for such items as heavy fuel oil consumption. We believe that accuracy in data collection can only be obtained by using engineers to carry out the surveys, at least in the early years, in order to verify data on-the-spot and to question plant personnel about obvious discrepancies or technical inconsistencies (e.g. lack of appropriate fuel data for plants known to operate kilns or boilers). The collection of data by energy engineers should also result in information being available in a timely fashion, suitable for its use in day-to-day energy planning work.

We would also comment that data handling by energy engineers using microcomputers would be much more effective than the use of a complex main-frame system by INS to produce comprehensive and timely energy data. The close interaction of the engineers with the computerised data base should improve their ability to conduct meaningful analyses and will provide effective training for them. A microcomputer system would enable the data to be examined and manipulated readily by engineers and economists, rather than simply by INS statisticians.

5.5 Some Problem Areas

Several problem areas have already been mentioned including, for example, the lack of disaggregated data for energy consumption by small consumers (e.g. low tension electricity, town gas, domestic fuel oil from resellers). The plants covered in the survey were chosen to ensure that a high percentage of industrial energy use could be "examined" in the course of this project, and the message that effective energy management was in the interests of both the enterprise and the country could be passed to those plants using the most energy in absolute terms. Thus the largest plants in those industrial subsectors which represent the largest consumption are well reported, while the small energy consumers have necessarily been omitted for the time being.

Fortunately, the lack of data for the small consumers does not detract from the usefulness of this study. Indeed, the data presented in Section 6 of this report clearly confirms that energy consumption is concentrated in a relatively small number of large plants. There is therefore much to be said for initiating an energy conservation program which focuses on achieving significant energy efficiency improvement in say 10 to 20 plants. This small number of plants represents a reasonable "target" for a small group of skilled energy audit engineers, whose efforts and financial resources are limited. Direct contact can be maintained with all the plants, and specialist advice can be provided at moderate cost. The expenses incurred in giving this close attention to a few plants will undoubtedly be repaid many times over each year. A conservation program oriented to hundreds of small energy consumers clearly requires a different approach, as personal visits by audit teams simply cannot hope to satisfy more than a handful of the small plants. For this reason, we do not view the lack of small plant data as a serious problem, but we do recommend that a reporting system be instituted which will allow their data to be obtained in the future and taken into account in policy development (see Section 7).

In terms of data collection, there were a variety of other problems which were encountered. Data deficiencies and discrepancies noted in the plant questionnaire responses have been discussed in Section 5.3. In addition, we should point out the inclusion in many plant responses of the consumption of gasoil and gasoline. Few plants were able to allocate these fuels to process uses as against transportation uses, and none indicated a breakdown of in-plant and other transportation. Strictly speaking, we would wish to exclude all transportation energy consumption which corresponds to the supply of raw materials and the delivery of finished products, and to record in-plant transportation fuels quite separately from process energy consumption. The reason for this is that the conservation measures appropriate to manufacturing industry are quite distinct from those appropriate to transportation. In this project, it was generally impossible to separate out the transportation energy consumption, and thus gasoil was included in the analysis where reported by the plant. However, it should be clearly recognized that the gasoil consumption figures shown in the analyses in Section 6 are incomplete because of the variations in the responses by plants.

5.6 Conversion Factors

For the record, the conversion factors applied in the data analyses which were performed as part of this project are indicated in Exhibit 5.2. These factors were used to convert physical quantities of fuels (e.g. litres of domestic fuel oil) into a standardized energy unit, tonnes oil equivalent (TEP). One tonne oil equivalent is defined as 10^7 kilocalories in the Tunisian statistical system.

EXHIBIT 5.2

CONVERSION FACTORS FOR ENERGY PRODUCTS

The following values have been used unless specific values given by the plants themselves.

1. Petroleum Fuels

	TEP/tonne	SG
Heavy fuel oil (F.O. No.2)	0.970	0.95
Gasoil, diesel	1.030	0.83
Domestic fuel oil (F.O.D.)	1.029	0.83
Light fuel oil	1.003	0.88
Gasoline	1.044	0.74
Kerosene (petrole lampant)	1.040	0.73
LPG (as liquid)	1.100	0.56

2. Solid Fuels

Coke	0.676 TEP/tonne
Coal	0.72 "

3. Gaseous Fuels

	RD	TEP/1000 Nm^3
El Borma natural gas	0.60	0.990
Town gas	0.55	0.405
Butane/propane mix	-	1.60

4. Electricity

A factor equivalent to 330 gm. heavy fuel oil per kilowatt-hour was used to take into account the inherent inefficiencies of electricity generation and of the distribution system. The implied efficiency is about 27%:

0.32 TEP/1000 kwh

5. Other

	Kcal/kg	TEP/tonne
Grignons d'olive	4000	0.4
Charcoal (0.2 T/M^3)	7000	0.7
Wood (0.5 T/M^3)	3100	0.31

6 ENERGY USE BY THE INDUSTRIAL SECTOR

6.1 Introduction

The collection of energy-related data has been discussed in previous sections. Here we report on the actual data obtained and conduct various analyses as examples of the use of the data base which has been assembled. The analyses are discussed briefly in terms of their policy and planning implications. While the analyses and findings are based on data from only 60 plants out of perhaps 2000 to 3000 enterprises engaged in industrial activities, a large percentage of industrial sector energy use has been examined, and a very significant additional effort would be needed to extend the analyses by just a few percent of the total energy consumption. It is our judgement that the findings reported here are representative for the industrial sector as a whole and are entirely adequate for defining the main priorities for policy development and program implementation.

It is perhaps appropriate to point out some of the characteristics of the different manufacturing industry subsectors which make energy data collection and corresponding analyses different for the subsectors. Manufacturing industry may be viewed as a matrix, with the columns representing the complexity of the finished products (from single products such as steel and glass, to complex products such as integrated circuits) and the rows representing the progression from basic materials to assembled products and installed projects. This type of matrix is shown in Exhibit 6.1[1].

It is possible to locate each industrial subsector within the matrix and some examples are shown in Exhibit 6.2. Those industrial activities found in the top left hand area are those which are organized with standardized production lines and which produce basic materials, while those in the bottom right hand area are those which are organized to manufacture complex products, often involving a series of assembly stages. In general, one can say that the "simple" industries are the large energy consumers, both in the sense of being highly energy-intensive activities and being found typically as large factories with high annual productions. The more "complex" industries and those involving assembly operations are often less energy-intensive and are conducted more often in small

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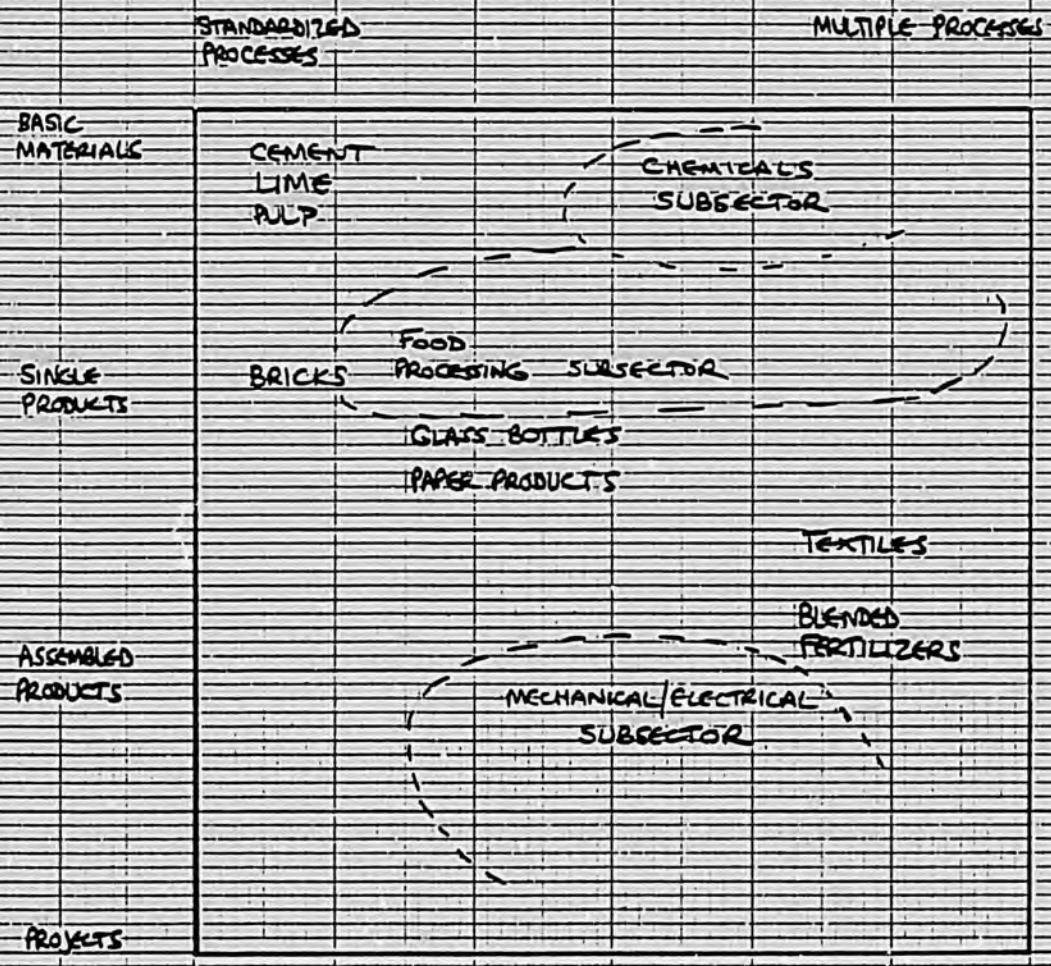
(1) See "An enlarged product-process matrix for industrial organizations", Alpander, Botter and Marchesnay; Economies et Societes, Tome XV, (ISMEA, Paris) Oct-Dec 1981, p. 1682 et seq.

Exhibit 6.1 : Manufacturing Industry Product-Process Matrix

	STANDARDISED PROCESSES FOR SINGLE PRODUCTS →			SPECIFIC PRODUCTION LINES FOR MULTIPLE PRODUCTS (MULTIPLE PROCESSES)
BASIC MATERIALS	IRON CEMENT			INTEGRATED CIRCUITS
SINGLE PRODUCTS		ELECTRONIC PARTS / PCB's		
ASSEMBLED PROD'TS	CARS			FURNITURE DIESEL ENGINES
INSTALLED PROJECTS				DEFENCE SYSTEMS

Exhibit 6.2: Industries and the Product-Process Matrix



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factories. These industries are thus more scattered in terms of energy consumption, and consequently they are much more difficult to analyse from an energy point of view. This difficulty is demonstrated through the data reported here.

6.2 Distributor Data and Sample Coverage

The Tunisian economy may be disaggregated into a number of subsectors for the reporting of national statistics of many kinds. In this study, we have attempted to utilize the standard breakdowns by branches and classes, although this has been restricted somewhat by the availability of energy consumption data at a sufficiently disaggregated level.

An estimate of the total energy consumption of the industrial sector, as well as an initial breakdown by subsectors, may be obtained from the distributors data. Exhibit 6.3 shows the quantities of major energy products sold to the industrial sector(1) in 1980 according to the various distributors. In addition to the energy sources listed in this exhibit, industry consumes gasoil, LPG, solid fuels and miscellaneous waste products: reliable and comprehensive data on these fuels cannot be obtained from the major distributor sources.

The sales by the distributors are shown disaggregated by industrial subsectors in Exhibit 6.4. Great care must be taken to use consistent definitions for the subsectors, and indeed for the industrial sector as a whole. It was found that some distributors included hotels and other commercial buildings in their so-called "industrial sector" totals, and it was only through a careful analysis of disaggregated data(2) that it was possible to obtain the figures presented in Exhibits 6.3 and 6.4. For this reason, we would suggest that disaggregated distributor data be requested annually, and that the figures always be examined and compared for consistency before being used for analytical work.

The energy consumptions derived from the plant questionnaire responses are summarized in Exhibit 6.5 and compared with the distributors data, subsector by subsector. In terms of the industrial sector totals for the different energy

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(1) Throughout this report, unless specifically indicated otherwise, the consumption of fuels by STEG and by the STIR refinery are excluded from the industrial sector energy consumption figures.

(2) To the individual client level in most cases.

EXHIBIT 6.3

SUMMARY OF DISTRIBUTORS ENERGY DATA - INDUSTRIAL SECTOR 1980

(all figures TEP)

	Major petroleum fuels						
	FOD	Light F.O.	Heavy F.O.	TOTAL	Natural gas	Electricity	TOTALS
Esso	801	2348	49242	52391			
Shell	5206	-	28141	33347			
Mobil	2077	4249	30707	37033			
Total	1767	2087	6440	10294			
Fina	2448	353	2670	5471			
SNDP	11519	-	266032	277551			
STIR	-	-	63380	63380			
	23818	9037	446612	479467			479467
STEG	-	-	-	-	75297	338470	413767
	23818	9037	446612	479467	75297	338470	893234
TOTALS FROM QUESTIONNAIRE RESPONSE	11292	5338	424510	441140	73861	209551	724552
% coverage	47.4	59.1	95.1	92.0	98.1	61.9	81.1

EXHIBIT 6.4

DISTRIBUTORS DATA FOR INDUSTRIAL SECTOR (1980)

	F O D		F.O. Leger		F.O. Lourd		Natural Gas		Electricity		TOTAL	
	M^3	TEP	T	TEP	T	TEP	$10^6 M^3$	TEP	10^6 kwh	TEP	TEP	%
I. MATERIALS OF CONSTRUCTION	7273	6218	5418	5434	233321	226321	45.584	45128	349.649	111888	394989	44.2
II.CHEMICALS	2414	2064	123	123	44019	42698	30.227	29925	61.804	19777	94587	10.6
III.MECH, METALL, ELEC.	6884	5885	-	-	23214	22518	-	-	164.773	52727	81130	9.1
IV.MINING	1855	1586	1525	1530	83784	81270	-	-	205.577	65785	150171	16.8
V. TEXTILES	2939	2513	654	656	12435	12062	-	-	85.710	27427	42658	4.8
VI.PAPER	334	286	-	-	27904	27067	0.021	21	52.908	16931	44305	5.0
VII.FOOD PROCESSING	4840	4138	1219	1223	31015	30085	0.088	87	118.538	37932	73465	8.2
VIII.MISCELLANEOUS	1320	1128	71	71	4733	4591	0.137	136	18.759	6003	11929	1.3
	27859	23818	9010	9037	460425	446612	76.057	75297	1057.718	338470	893234	100.0

EXHIBIT 6.5 INDUSTRIAL SECTOR ENERGY CONSUMPTION PATTERNS

	Distributors Data (1980)					Questionnaire and Plant Visit Data (1980-81)				
	F.O.D. (M^3)	F.O.Leger (T)	F.O. Lourd (T)	Natural gas ($10^6 Nm^3$)	Electricity (10^6 kwh)	F.O.D (M^3)	F.O.Leger (T)	F.O.Lourd (T)	Nat.gas ($10^6 Nm^3$)	Electric. (10^6kwh
I MATERIALS OF CONSTRUCTION										
Bricks	155	3528	32163	5.117		0	2770	39887	5.400	46.619
Cement	-	-	173460	40.295		0	0	162635	40.295	208.747
Glass	1366	-	4902	0.172	349.649	0	0	4660	0.173	6.114
Ceramics	4896	1233	17354	-		3061	0	4187	-	3.453
Other (1)	856	557	5442	-		483	611	2010	-	11.413
Totals	7273	5418	233321	45.584	349.649	3544	3381	213379	45.868	276.346
(% of distributors data)						(48.7%)	(62.4%)	(91.5%)	(100%)	(79.0%)
II CHEMICALS										
Total	2414	123	44019	30.277	61.804	156	0	42398	28.710	39.625
(% of distributors data)						(6.5%)	(0%)	(96.3%)	(95.0%)	(64.1%)
III METALLURGICAL,ELECTRICAL										
Steelmaking	4688	-	22298	-	164.773	4710	-	22298	-	96.667
All other	2196	-	916	-		2327	1865	895	-	20.256
Totals	6884	-	23214	-	164.773	7037	1865	23193	-	116.923
(% of distributors data)						(100%)	(100%)	(99.9%)	(-)	(71.0%)
IV MINING										
Total	1855	1525	83784	-	205.577	1464	-	95000	-	127.197
(% of distributors data)						(78.9%)	(-)	(100%)	(-)	(61.9%)
V TEXTILES										
Total	2939	654	12435	-	85.710	261	11	9023	-	15.687
(% of distributors data)						(8.9%)	(1.7%)	(72.6%)	(-)	(18.3%)
VI PAPER										
Total	334	-	27904	0.021	52.908	303	-	28145	-	48.582
(% of distributors data)						(90.7%)	(-)	(100%)	(-)	(91.8%)
VII FOOD PROCESSING										
Conserves & concentrates	733	673	7634	-		0	-	1707	-	0.900
Sugar	587	31	16241	-		31	20	16800	0	0.654
Dairy products	816	-	3152	-		16	0	2602	0	9.328
Baking and biscuits	1008	-	-	0.088	118.538	118	0	0	0.029	0.786
Pasta	936	87	636	-		0	-	0	-	-
Drinks (1)	231	96	2752	-		84	0	2665	0	4.697
Confectionery	160	-	-	-		172	0	0	0	0.510
Other	369	332	-	-		22	21	1008	0	6.359
	4840	1219	31015	0.088	118.538	443	41	24782	0.029	23.234
(% of distributors data)						(9.2%)	(3.4%)	(79.9%)	(33.0%)	(19.6%)
VIII ALL OTHER	1320	71	4733	0.137	18.759	0	24	1719	0	7.253
(% of distributors data)						(0%)	(33.8%)	(36.3%)	(0%)	(38.7%)
TOTAL	27859	9010	460425	76.057	1057.718	13208	5322	437639	74.607	654.847
(% of distributors data)						(47.4%)	(59.1%)	(95.1%)	(98.1%)	(61.9%)

sources, Exhibits 6.3 and 6.5 indicate the following "coverage" has been obtained by the survey of 60 plants:

	Consumption (TEP)		Coverage
	Distributors	Plant Questionnaires	%
FOD	23818	11292	47.4
Light fuel oil	9037	5338	59.1
Heavy fuel oil	446612	424510	95.1
Total fuel oil	479467	441140	92.0
Natural gas	75297	73851	98.1
Electricity	338470	209551	61.9
Total	893234	724552	81.1

For the industrial sector, therefore, the 60 plant survey covers over 80% of the energy demand. The high coverage figures for heavy fuel oil and natural gas reflect the fact that large industrial plants are major users of these fuels, while it is the smaller plants which use FOD and light fuel oil. All plants use electricity, and clearly there will be a very large number of small consumers who use electricity as their sole source of energy, often at low tension, and who thus represent a major data collection problem. Comprehensive surveys of the type used by INS for their annual "recensement" of manufacturers are necessary to raise the coverage figure.

Exhibit 6.5 also indicates the coverage of the plant questionnaire data for individual subsectors. The figures are as follows:

Estimated Sample Coverage by Subsector (%)

	Petroleum fuels			Nat.gas	Electricity
	FOD	Light F.O.	Heavy F.O.		
Materials of construction	49	62	92	100	79
Chemicals	7	0	96	95	64
Mining	79	-	100	-	62
Mechanical/electrical	100	100	100	-	71
Textiles	9	2	73	-	18
Paper	91	-	100	-	92
Food processing	9	2	73	33	20
Overall	47	59	95	98	62

These figures show that reasonable coverage has been obtained of consumers of heavy and light fuel oil in most subsectors, but many domestic fuel oil users have not been reached by the survey. The survey shows least coverage for the food processing and textiles subsectors, in which there are large numbers of small establishments which may use town and natural gas and low tension electricity, energy forms for which STEG has no reliable disaggregated data. To a lesser degree, this is also seen in the chemicals subsector.

In general, however, we believe the questionnaire responses from the first 60 plants provide an acceptable sample of energy data for carrying out most analyses related to policy development. The significant extra effort involved in increasing the coverage through further plant visits does not appear justified for policy work at this time. However, data should be collected on a routine basis from a larger sample of the industrial sector in future years, at least partially by mail, and this undoubtedly will result in improved national statistics with higher coverage.

6.3 Current Demand Patterns

The main data obtained from the questionnaire responses are tabulated in Exhibit 6.6 by specific plants, and arranged according to subsectors:

I Materials of construction
- cement
- bricks
- glass
- others

II Chemicals

III Mechanical, metallurgical, electric
- steel
- others

IV Mining

V Textiles

EXHIBIT 6.6 PLANT DATA

SUBSECTORS/PLANTS	PLANT NUMBER	OUTPUT DATA: YEAR	QUANTITY	PRIMARY PRODUCT	ENERGY CONSUMPTION DATA (TEP): ELEC.	NAT.GAS	GASOIL	FOD	F.O.LEGER	F.O. LOURD	OTHER	TOTAL ENERGY	SPECIFIC CONSUMPTION TEP/T	NOTES
MATERIALS OF CONSTRUCTION														
Cement														
CAT (Djebel Djelloud)	B	1980	436618 T	clinker	13450	-	-	-	-	74133	-	87583	0.201	
Ciments de Bizerte	A	1980	721350 T	clinker	23254	-	1139	-	-	66554	-	90947	0.126	
Soc. de Ciments de Gabès	G	1980	482500 T	clinker	22516	39892	689	-	-	-	-	63097	0.131	
Cimenteries d'om Khelil (SICO)	51	1981	769624 T	clinker	30316	-	780	-	-	68276	9	99381	0.129	1
			2,410,092 T		89,536	39,892	2,608	0	0	208,963	9	341,008	0.141	
Bricks														
Briqueterie Fouchana	C	1980	97147 T	bricks	2312	-	204	-	-	6172	-	8688	0.089	
Briqueterie Zarouk	07	1980	178223 T	bricks	3686	-	904	-	-	12353	-	16943	0.095	
Briqueterie M'Hana	09	1980	155540 T	bricks	2272	-	579	-	-	5728	-	8579	0.055	
Briqueterie El Hamma	F	1980	89302 T	bricks	1200	5346	534	-	-	-	-	7080	0.079	
Ceramique de l'Ouest	23	1981	55360 T	bricks	641	-	307	-	-	3131	-	4079	0.074	
Ceramique Tunisienne (Jendouba)	24	1981	55000 T	bricks	860	-	271	-	-	2609	-	3740	0.068	
Union Generale (Jemmal)	14	1981	n.a.	bricks	2391	-	-	-	2777	4576	1767	11511	n.a.	4
Soc. La Brique Tunisienne	37	1980	39985 T	bricks	642	-	17	-	-	1571	-	2230	0.056	
Sfax Ceramique	48	1981	30000 T	bricks	570	-	123	-	-	1761	-	2454	0.082	
			700,557 T		14,574	5,346	2,939	0	2,777	37,901	1,767	65,304	0.077	2
Les Refractaires de Tunisie	35	1981	4500 T	ref.bricks	344	-	51	-	-	789	-	1184	0.263	
Glass														
Sotuver	15	1980	17656 T	glass containers	1956	171	386	-	-	4520	1166	8199	0.464	3
Others														
S.A. de Potinville	03	1981	64500 T	lime	341	-	26	-	-	-	3082	3449	0.053	5
CAT (Tunis)	26	1980	56000 T	lime	345	-	37	-	-	-	2975	3357	0.060	5
Ceramique Tunisienne (Tabarka)	25	1981	835000 M^2	tiles	771	-	122	900	-	4061	-	5854	(0.007 TEP/M^2)	
Manufact. Tunisienne de Ceramique	34	1980	3600 T	porcelain	334	-	30	1714	-	-	-	2078	0.577	
El Anabib	06	1980	131462 T	reinforced concrete prod.	826	-	148	28	-	1741	-	2743	0.021	
Les Platres Tunisiens de Meknassy	22	1981	8209 T	plaster	169	-	90	-	-	210	-	469	0.057	
Soc.Ind.Comm.D'Ouvrage Amiante et Ciment	28	1980	22100 T	asbestos tiles and pipes	956	-	-	385	-	-	-	1341	0.061	
Ciments Amiantes Tunisiens	29	1981	28000 T	asbestos cement pipes	1015	-	47	-	613	-	-	1675	0.060	
TOTAL SUBSECTOR ENERGY USE					111,167	45,409	6,484	3,027	3,390	258,185	8,999	436,661		

Notes

1. Actual data for 3 months have been prorated to estimate full year operation, i.e. 4 x actual figures reported
2. Specific consumption and production figures exclude Union Generale
3. Production does not include breakages, etc.; the gross furnace output as reported is 25520 tonnes, on which basis the specific consumption is 0.321 TEP/t. Other fuel is LPG.
4. Other fuel refers to coal (733 tonnes) and grignons d'olives (3,098 tonnes).
5. Other fuel refers to coal.

SUBSECTORS/PLANTS	PLANT NUMBER	OUTPUT DATA: YEAR	QUANTITY	PRIMARY PRODUCT	ENERGY CONSUMPTION DATA (TEP): ELEC.	NAT.GAS	GASOIL	F.O.D.	F.O.LEGER	F.O.LOURD	OTHER	TOTAL ENERGY	SPECIFIC CONSUMPTION TEP/T	NOTES
II. CHEMICALS														
Soc.Tun. d'Engrais Chimiques (STEC)	01	1980	70148 T	SSP & blended fertilisers	423	-	89	-	-	-	3	515	0.007	
Soc. Indus.Acide Phosph. et Engrais (SIAPE A)	H	1980	317416 T	TSP	2159	-	-	-	-	22030	-	24189	0.076	6
Soc Indus.Chimiques Maghrebines (ICM)	38	1980	-	TSP, sulphuric, phosphoric acid & Fert.	2319	12063	158	133	-	-	-	14673	-	7
Soc. Indus.Acide Phos. et Engrais (SIAPE B)	33	1981	418074 T	TSP	72	-	225	-	-	17130	-	17427	0.042	8
Soc.Arabe des Engrais Phos. et Azotes (SAEPA)	39	1981	514974 T	DAP	2547	12580	154	-	-	-	-	15281	0.030	9
Engrais de Gabès	40	1980	62611 T	MAP	571	707	-	-	-	-	-	1278	0.020	
Granuphos	32	1980	59965 T	mix.fertil.	935	-	129	-	-	1966	-	3030	0.051	
			1,524,033	mix.fert. and related prod.	9,026	25,350	755	133	-	41,126	3	76,393	0.135	
Indus.Chimique du Fluor (ICF)	41	1980	19730 T	alum.fluoride	1958	3072	63	-	-	-	-	5093	0.258	
Soc.Tun.d'Oxygène et Acétylène (STOA)	36	1981	-	indus.gases (oxygen, acetylene, CO_2)	1696	-	-	-	-	-	957	2653	-	10
TOTAL SUBSECTOR					12,680	28,422	818	133	-	41,126	960	84,139		
III. MECHANICAL, METALLURGICAL, ELECTRICAL														
Basic Steel														
El Fouledh Steelworks	D	1980	177937 T	steel billets (for rolling, etc.)	30933	-	414	4025	-	21629	76480	133481	0.750	11
Others														
Soc. de Materiel Electrique (Chakira)	31	1980	2847 T	elec.cables	534	-	8	100	-	-	1	643	0.226	
Soc. Gen. Industrielle (SGI)	19	1980	120000 units	gas bottles	216	-	-	-	-	-	64	280	(2.3 TEP/1000 bottles)	
Soc. Metallurgique et Minière Tunis (SMMT)	05	1980	19200 T	lead	1306	-	-	421	1580	-	5021	8328	0.434	12
Le Confort SA	04	1980	70338 units	household appliances	924	-	39	318	-	868	12	2161	(0.031 TEP/unit)	16
Soc.Tun.D'Industrie Automobile (STIA)	13	1980	8777 units	assembly of cars, trucks & buses	536	-	-	547	-	-	-	1083	(0.159 TEP/unit)	14,15
Fonderies Réunies de Tunis	02	1980	2300 T	castings	192	-	28	154	-	-	322	696	0.290	13
Soc. de Fonderie et de Mécanique (SOFOMECA)	42	1980	4787 T	iron & steel mouldings	1504	-	-	354	-	-	582	2440	0.510	17
Les Ateliers Mécaniques du Sahel	44	1980	-	household fittings & ironmongery	1270	-	-	95	290	-	9	1664	-	
TOTAL SUBSECTOR					37,415	-	489	6,014	1,870	22,497	82,491	150,776		

NOTES:
6. "Other" excludes fuel value of sulphur burnt in the sulphuric acid manufacturing process. Plant recovers heat and generates own electricity (32.198×10^6 kwh = 10303 TEP in 1980). Actual heat value of sulphur was 27397 TEP (123,636 Tonnes at 2216 Kcal/kg heating value)
7. "Other" excludes heating value of sulphur (264,879 tonnes)
8. "Other" excludes heating value of sulphur (82,028 tonnes)
9. Net electricity shown (19,574,666 kwh less export of 11,616,100 kwh). Excludes heating value of 115,151 tonnes of sulfur.
10. Includes heating value of kerosene used for gas manufacture.
11. Includes 74811 TEP coke, 1669 TEP LPG
12. Includes 25 TEP wood, 4996 TEP coke and coke dust.
13. Includes 21 TEP wood, 301 TEP coke
14. Production 7707 cars, 938 trucks, 132 buses.
15. Excludes diesel and gasoline for the finished vehicles
16. Wide range of appliances assembled: figures refer to refrigerators (55946 units) and cookers (14392 units)
17. Includes 569 TEP coke, 13 TEP LPG

Exhibit 6.6 continued

SUBSECTOR/PLANTS	PLANT NUMBER	OUTPUT DATA YEAR	QUANTITY	PRIMARY PRODUCT	ENERGY CONSUMPTION DATA (TEP) ELEC.	NAT.GAS	GASOIL	FOD	F.O.LEGER	F.O.LOURD	OTHER	TOTAL ENERGY	SPECIFIC CONSUMPTION TEP/1	NOTES
IV. MINING														
Compagnie de Phos. de Gafsa (CPG)	J	1980	4328667 T	enriched phos. rock	40703	-	7852	1250	-	92150	-	141955	0.033	18
V. TEXTILES														
Soc.Indus.des Textiles Réunis(SITER)	11	1980	13.6×10^6m	finish.textil.	106	-	-	191	-	5672	36	6005	(0.442 TEP/1000 metres)	22
Sitex - Usine de Ksar Helal	12	1980	16.1×10^6m	denim textiles	2550	-	-	32	-	2490	193	5265	(0.327 "	22
Soc. Monastrienne (SOMOTEX)	43	1980	-	cloth&thread	2365	-	-	-	11	591	-	2967	-	
TOTAL SUBSECTOR					5,021	-	-	223	11	8,753	229	14,237		
VI. PAPER														
Soc. de Cellulose et Papier Alfa (SCPA)	I	1980	23808 T	paper	15546	-	127	259	-	27301	-	43233	1.816	19
VII. FOOD PROCESSING														
Dairy Products														
Tunisie Lait	10	1980	41×10^6L	proces.milk, yoghurt	1657	-	316	13	-	1550	5	3541	(86 TEP/10^6 litres)	22
Soc.Tun.D'Industrie Laitière (STIL)	17	1980	56×10^6L	processed milk, cheese,yoghurt	1328	-	267	47	-	974	8	2624	(47 TEP/10^6 litres)	23
					2,985	-	583	60	-	2,524	13	6,165	(35 TEP/10^6 litres)	
Baking,Biscuits														
Soc. Tun. de Biscuiterie (SOTUBI)	20	1981	2210 T	biscuits	228	29	-	-	-	-	-	257	0.116	
Boulangerie Ouarda	30	1980	3200 T (flour)	bread&cakes	24	-	51	101	-	-	-	176	(0.055 TEP/t flour)	
					252	29	51	101	-	-	-	433	-	
Sugar														
Soc. Tunisienne de Sucre	E	1980	60615 T	sugar	209	-	-	26	20	16296	509	17060	0.281	23
Drinks														
Soc. Frigorifique et Brasserie de Tunis (SFBT)	45	1980	-	beer,soft drinks, ice	1444	-	295	53	-	1758	43	3593	-	24
Régie des Alcools	46	1981	1.8×10^6L	alcohol	59	-	28	19	-	827	4	937		
					1,503	-	323	72	-	2,585	47	4,530		
Others														
Soc.Tun. de Chocolaterie (SOTUCHOC)	21	1981	539 T	chocolate	163	-	-	147	-	-	-	310	0.575	
Ali Majoul & Cie	27	1981	3704 T	tomato concent.	141	-	-	-	-	657	-	798	0.215	
Coop. Agricole Izidihar	47	1980	-	preserved fruits & tomatoes	147	-	171	-	-	999	-	1317	-	
Soc.Tun.de Produc. Alimentaire(STPA)	49	1980	73988 T	flour&semolina	1543	-	56	19	-	-	-	1618	0.022	
Les Couscousseries du Sud	50	1981	9291 T	couscous	492	-	-	-	21	978	-	1491	0.160	
TOTAL SUBSECTOR					7,435	29	1,184	425	41	24,039	569	33,722		

NOTES:

18. Includes all electricity reported, although approx 20% is believed to be for domestic use in Metlaoui area. Also includes all diesel/gasoil reported, although much of this is for transportation uses. Gasoline has been excluded.
19. Excludes fuel value of black liquor which is incinerated in a boiler and steam generated on site.
20. Output was 30.99 million litres sterilised milk and 62 million containers of yoghurt. "Other"fuel excludes 27 TEP gasoline for transportation uses; figure remaining under "other" is town gas.
21. Total output of all products quoted as 56 million litres.Other fuel is town gas.
22. Other fuel is LPG
23. Other fuel is coke
24. Other fuel is coal.

Exhibit 6.6 continued

SUBSECTOR/PLANTS	PLANT NUMBER	OUTPUT DATA YEAR	QUANTITY	PRIMARY PRODUCT	ENERGY CONSUMPTION DATA (TEP) ELEC.	NAT.GAS	GASOIL	FOD	F.O.LEGER	F.O.LOURD	OTHER	TOTAL	SPECIFIC CONSUMPTION TEP/T	NOTES
VIII. MISCELLANEOUS (IND. DIVERSES)														
Le Comptoir National des Plastiques	08	1980	8200 T	misc. household articles	1519	-	66	-	-	-	10	1595	0.195	25
Soc. Nationale de Pneumatique (SONAP)	16	1980	160000 units	tyres	802	-	-	-	24	1667	5	2498	(15.6 TEP/1000 units)	25
					2,321	-	66	-	24	1,667	15	4,093		

Notes

25. Other fuel is LPG

Exhibit 6.6 continued

VI Paper

VII Food processing
- dairy products
- baking, biscuits
- sugar
- drinks
- others

VIII Miscellaneous

To estimate the total energy consumption of the industrial sector, the plant production data were first compared with the corresponding production data published by INS in their monthly Bulletin Mensuel de Statistiques. From these sets of production figures, percentage coverages were estimated, with adjustments made where capacity data were inconsistent with the actual production figures. Where national production figures were unavailable from the monthly INS reports, coverage was estimated using the INS "recensement" for 1979. The energy consumptions reported by the questionnaires were then prorated upwards according to the percentage coverage that the reporting plants represented. This implies that the sample plants have the same average energy efficiency as the subsector itself, as well as the same fuel consumption patterns. The total energy consumption figures so derived were compared with the available distributors data. Where the distributors data were greater than the prorated plant data, the differences were generally allocated to miscellaneous activities for which "coverage" was meaningless and thus undetermined (e.g. in the subsector for materials of construction). Where plant data were judged to be more reliable than distributors data, the plant data were accepted.

The coverages estimated for the various activities were as follows:

	%
cement	100
bricks	60
lime	60
plaster	46
glass	100
phosphate mining	100(1)

(1) About 90% of the mining subsector itself.

	%
dairy products	100
sugar	100
beer	100
other drinks	66
fruit and vegetable conserves	21
flour milling	10
baking	2.5 of large bakeries
	1 of total bread production
couscous	180[1]

Exhibit 6.7 tabulates the estimates of energy consumption for the entire industrial sector for 1980, showing the following breakdown:

	% of total
Materials of constructruction	39.8
Chemicals	9.2
Mechanical, metallurgical, electrical	15.8
Mining	17.1
Textiles	4.1
Paper	4.3
Food processing	8.5
Miscellaneous	1.2
	100.0

The total energy consumption was estimated to be 1.047 million TEP.

As mentioned previously, these figures for total industrial sector consumption do not include all the gasoil used by industrial enterprises for transportation purposes, and also exclude gasoline which is used entirely for transport. The figures for LPG consumption may also be low; although many of the questionnaire responses include LPG, this fuel may well be used by small plants to a greater extent than the typical large plant, which would result in our calculation procedure underestimating its use in the sector as a whole. However, the breakdown shown in Exhibit 6.7 is believed reliable for policy analysis purposes.

(1) Couscous production in 1980 was less than production in 1981 because a large new plant was commissioned in 1981. The questionnaire data gave figures for 1981 which were therefore adjusted downwards to provide an estimate of energy consumption in 1980.

EXHIBIT 6.7

ESTIMATE OF INDUSTRIAL SECTOR ENERGY USE, 1980 (TEP)

	ELEC.	NAT. GAS	GASOIL(3)	FOD	LIGHT F.O.	HEAVY F.O.	OTHER(1)	TOTAL
I. MATERIALS OF CONSTRUCTION								
Cement	59220	39982	1828	0	0	140687	0	241627
Bricks	24290	6066	4898	0	4628	67013	2945	108839
Lime	1143	0	105	0	0	0	10095	11343
Plaster	367	0	196	0	0	457	0	1020
Glass	1956	171	386	0	0	4520	1166	8199
Other	24912	0	398	6218	806	13644	0	45978
	111888	45218	7811	6218	5434	226321	14206	417096 (39.8%)
II CHEMICAL INDUSTRY	19777	29926	818	2064	123	42698	960	96365 (9.2%)
III MECHANICAL, METALLURGICAL, ELECTRICAL								
Steel	30933	0	414	4025	0	21629	76480	133481
Other	21794	0	75	1989	1870	889	6011	32628
	52727	0	489	6014	1870	22518	82491	166109 (15.8%)
IV MINING								
Phosphates	40703	0	7852	1250	0	92150	0	141955
Other	25082	0	785	336	1530	9215	0	36948
	65785	0	8637	1586	1530	101365	0	178903 (17.1%)
V TEXTILES	27427	0	0	2513	656	12062	229	42887 (4.1%)
VI PAPER	16931	21	127	286	0	27301	0	44666 (4.3%)
VII FOOD PROCESSING								
Dairy	2985	0	583	60	0	2524	13	6165
Baking	2400	0	5100	10100	0	0	0	17600
Sugar	209	0	0	26	20	16296	509	17060
Beer	1444	0	295	53	0	1758	43	3593
Other drinks	89	0	42	29	0	1253	6	1419
Fruit/vegetable/fish conserves	1342	0	797	0	0	7711	0	9850
Flour	15430	0	560	190	0	0	0	16180
Couscous	273	0	0	0	12	543	0	828
Other	15200	87	0	147	1191	0	0	16625
	39372	87	7377	10605	1223	30085	571	89320 (8.5%)
VIII MISCELLANEOUS	6003	136	176	1128	71	4591	40	12145 (1.2%)
GRAND TOTAL (2)	339910	75387	25435	30414	10907	466941	98497	1047491

Notes

(1) 'Other' includes coal, coke, wood, charcoal, LPG and miscellaneous waste products (e.g. grignons d'olives)

(2) A comparison of industry energy consumption with national energy demands - as reported by the INS Bulletin Mensuel de Statistiques - may be made as follows:

	Industry estimate--% of--		National figures
	TEP		TEP
Electricity	339910	(43.7%)	778048
Natural gas	75387	(97.2%)	77528 (4)
Gasoil (3)	25435	(3.1%)	810404
FOD	30414 } 41321	(25.6%)	161656
Light fuel oil	10907 }		
Heavy fuel oil	466941	(98.5%)	474136 (4)
Other	98497	(89.4%)	{ 100000 (5)
			{ 10148 (6)
Total major fuels	1047491	(43.4%)	2411920
Gasoline, kero, LPG	-		498298
Total commercial fuels	1047491	(36.0%)	2910218
Allowance for non-commercial fuels	- (8)		970073 (7)
	1047481	(27%)	3880291

(3) Gasoil figures known to be incomplete, and split between "manufacturing" functions and transportation uses is unclear.

(4) After STEG consumption for electricity generation

(5) Approximate estimate for coal, coke, etc. (solid fuels)

(6) Manufactured town gas

(7) Estimated as at least 25% of total national energy demand.

(8) No data from current study to permit estimate.

A comparison of industrial energy consumption with the national consumption was made using INS figures for the total demands of the different energy forms. The following figures were derived (see Exhibit 6.7 for explanatory notes):

	Industry consumption (TEP)	National consumption (TEP)	Industry demand as a percentage of national demand
Electricity	339910	778048	43.7
Natural gas	75387	77528	97.2
Gasoil	25435	810404	3.1
Domestic fuel oil (A)	30414	N/A	-
Light fuel oil (B)	10907	N/A	-
Subtotal (A+B)	41321	161656	25.6
Heavy fuel oil	466941	474136	98.5
Other	98497	110148	89.4
Subtotal - major fuels	1047491	2411920	43.4
Gasoline, kerosene, LPG	0	498298	0
Subtotal - commercial fuels	1047491	2910218	36.0
Allowance for non-commercial fuels	N/A	970073	-
Grand totals	1047491	3880291	27.0

These data show that industry represents at least one third of the national consumption of commercial fuels, and between 25 and 30 percent of the total national energy demand.

6.4 Cumulative Energy Use and Plant Consumption Distribution

Tables and graphs of cumulative energy use for the plants participating in the survey are shown in Exhibits 6.8 through 6.15: the data are presented for heavy fuel oil, domestic fuel oil, purchased electricity and total energy consumption. All the curves show that a few large consumers represent major proportions of industrial sector demand for each energy form. For example, five plants account for almost two-thirds of the reported electrical demand, and over one-third of the entire industrial sector electrical demand. For heavy fuel oil,

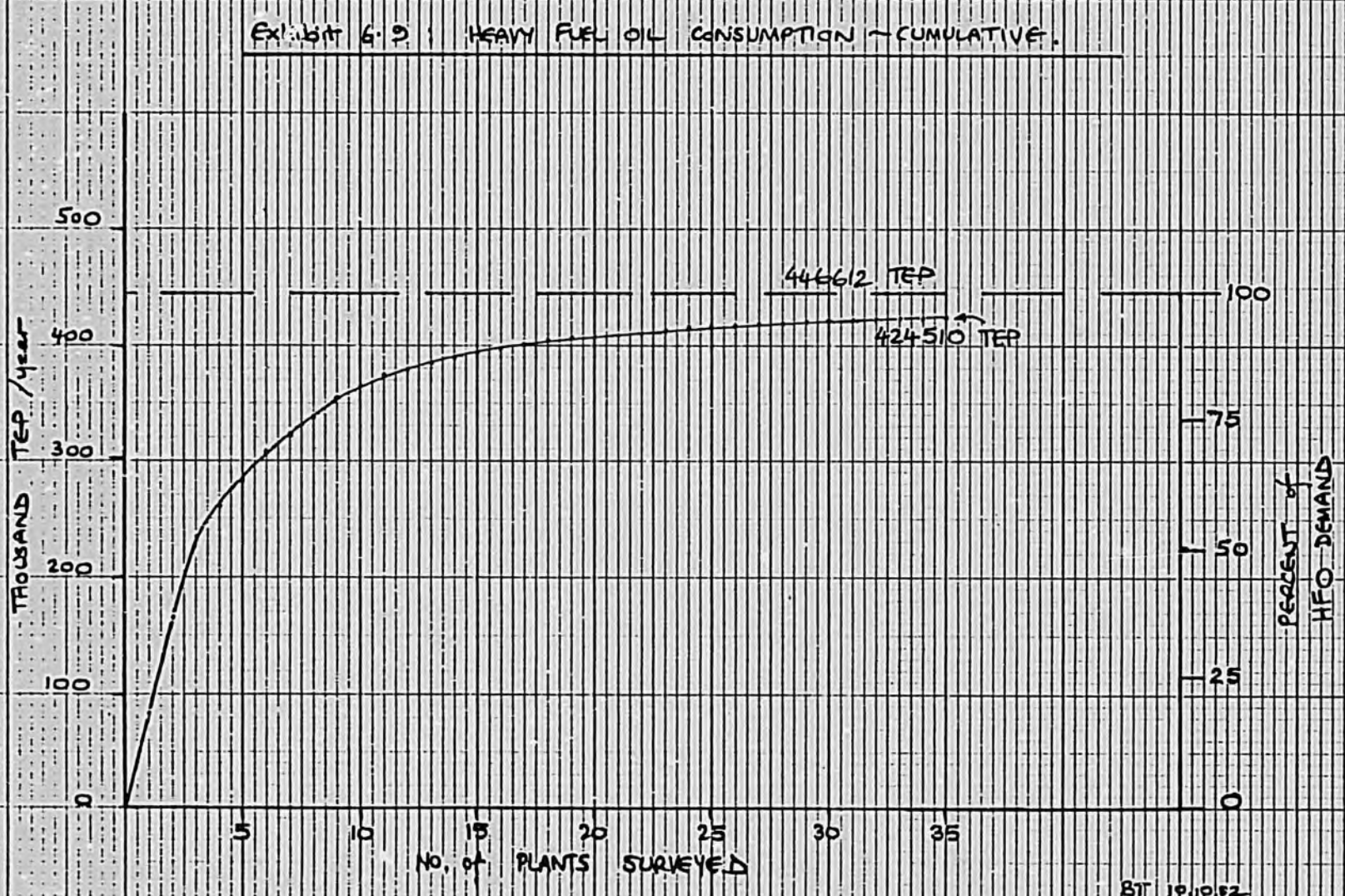
EXHIBIT 6.8

REPORTED HEAVY FUEL OIL CONSUMPTION

ORDER	QUESTIONNAIRE	PLANT	QUANTITY (TEP)
1	J	Compagnie de Phosphate de Gafsa	92,150
2	B	Ciments Artificiels Tunisiens (Tunis)	74,133
3	A	Ciments de Bizerte	66,554
4	I	S.N. de Cellulose et de Papier Alfa	27,301
5	B	Société Industrielle Acide Phosphorique et Engrais - SIAPE 'A'	22,030
6	D	El Fouledh Steelworks	21,629
7	33	Société Industrielle Acide Phosphorique et Engrais - SIAPE 'B'	17,130
8	51	Cimenterie d'om Khelil	17,069*
9	E	Societe Tunisienne du Sucre	16,296
10	07	Briqueterie Zarouk	12,353
11	C	Briqueterie Fouchana	6,172
12	09	Briqueterie Ali M'Henni	5,728
13	11	Société Industrielle des Textiles Réunis - SITER	5,672
14	14	Union Generale (Jemmal)	4,576
15	15	SOTUVER	4,520
16	25	La Ceramique Tunisienne (Tabarka)	4,061
17	23	Ceramique de l'Ouest	3,131
18	24	La Ceramique Tunisienne (Jendouba)	2,609
19	12	SITEX - Usine de Ksar Helal	2,490
20	32	Granuphos	1,966
21	48	Sfax Ceramique	1,761
22	45	Société Frigorifique et Brasserie de Tunis - SFBT	1,758
23	06	El Anabib	1,741
24	16	Société Nationale de Pneumatiques	1,667
25	37	Société La Brique Tunisienne	1,571
26	10	Tunisie Lait S.A.	1,550
27	47	Cooperative Agricole Izidihar	999
28	17	STIL	974
29	50	Les Couscousseries du Sud	970
30	04	Le Confort S.A.	868
31	46	Régie des Alcools	827
32	35	Les Refractaires de Tunisie	789
33	27	Ali Majoul et Compagnie	657
34	43	Société Monasterienne - SOMOTEX	591
35	22	Les Platres Tunisiens de Meknassy	210
			424,510

* 3 months'data only

Exhibit 6.9 : HEAVY FUEL OIL CONSUMPTION – CUMULATIVE.



BT 19.10.82

EXHIBIT 6.10

DOMESTIC FUEL OIL CONSUMPTIONS (TEP)

OTHER	QUESTIONNAIRES	PLANT	QUANTITY (TEP)
1	D	El Fouledh Steelworks	4,025
2	34	Manufacture Tunisienne de Ceramique	1,714
3	J	Compagnie de Phosphate de Gafsa	1,250
4	25	La Ceramique Tunisienne (Faiencerie de Tabarka)	900
5	13	Société Tunisienne d'Industrie Automobile - STIA	547
6	05	Société Metallurgique et Minière de Tunis	421
7	28	Société Industrielle Commerciale d'Ouvrage Amiante et Ciment	385
8	42	Société de Fonderie et de Mécanique	354
9	04	Le Confort S.A.	318
10	I	SN de Cellulose et de Papier Alfa	259
11	11	Société Industrielle des Textiles Réunis	191
12	02	Fonderies Réunies de Tunis	154
13	21	Société Tunisienne de Chocolaterie	147
14	38	Société des Industries Chimiques Maghrebines - ICM	133
15	30	Patisserie Ouarda	101
16	31	Société de Materiel Electrique (Chakira)	100
17	44	Les Ateliers Mécaniques du Sahel	95
18	45	Société Frigorifique et Brasserie de Tunis	53
19	17	STIL	47
20	12	SITEX - Usine de Ksar Helal	32
21	06	El Anabib	28
22	E	Société Tunisienne du Sucre	26
23	46	Régie des Alcools	19
24	49	Société Tunisienne de Production Alimentaire	19
25	10	Tunisie Lait	13
			11,331

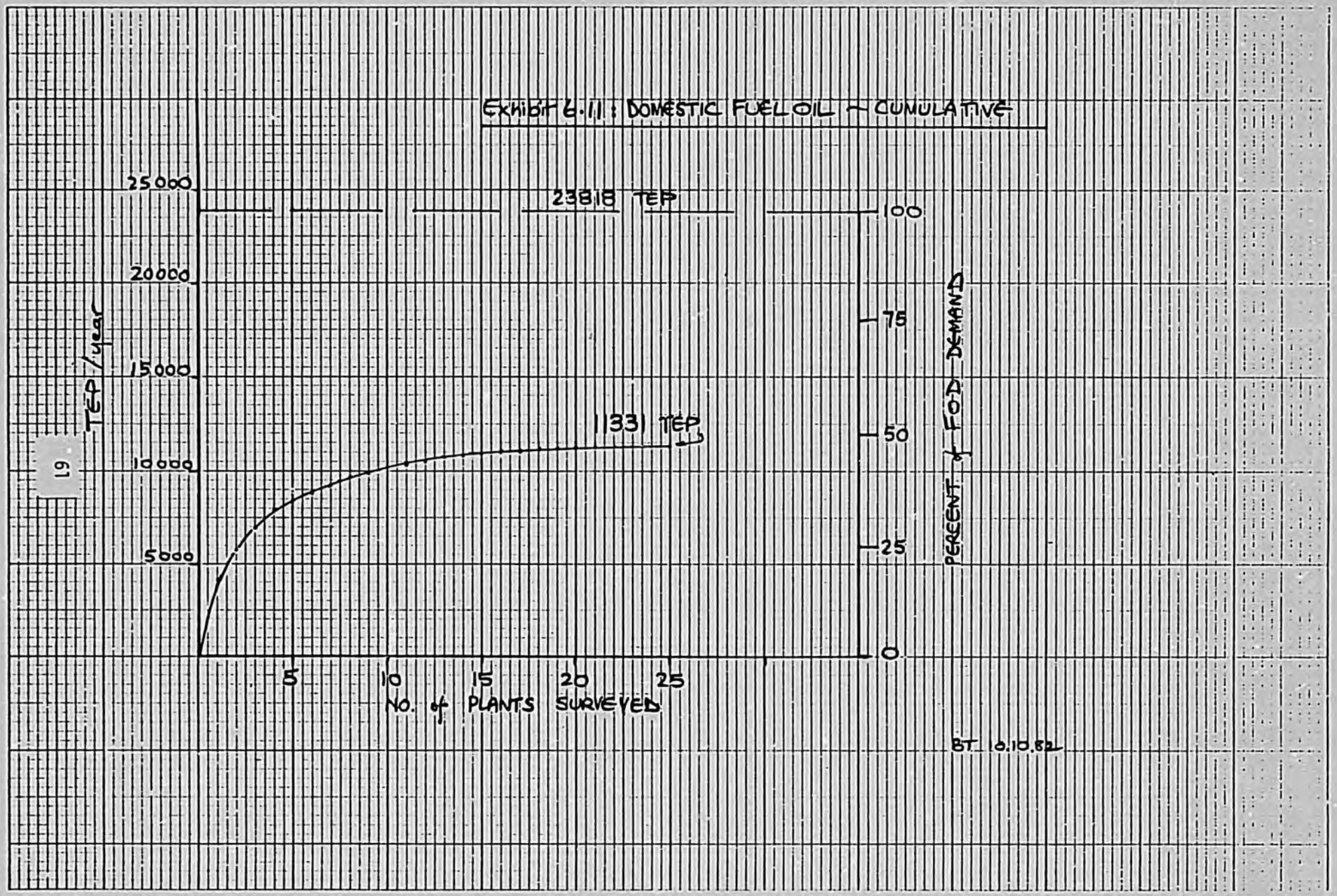


Exhibit 6.11 : DOMESTIC FUEL OIL – CUMULATIVE
23818 TEP
1133 TEP
TEP/year
25000
20000
15000
10000
5000
100
75
50
25
0
PERCENT of F.O.D. DEMAND
5
10
15
20
25
NO. of PLANTS SURVEYED
BT 16.10.82

EXHIBIT 6.12

PURCHASED ELECTRICITY CONSUMPTIONS

(Basis: 1 kwh = 330 grams F.O. No.2 = 0.32 TEP/1000 kwh)

ORDER	QUESTIONNAIRE	PLANT	QUANTITY (TEP)
1	J	Compagnie de Phosphate de Gafsa	40,703
2	D	El Fouledh Steelworks	30,933
3	A	Ciments de Bizerte	23,254
4	G	Societe de Ciments de Gabès	22,516
5	I	S.N. de Cellulose et de Papier Alfa	15,546
6	B	Ciments Artificiels Tunisiens (Djebel Djelloud)	13,450
7	51	Cimenterie d'om Khelil	7,579 (1)
8	07	Briqueterie Zarouk	3,686
9	12	SITEX - Usine de Ksar Helal	2,550
10	39	Société Arabe des Engrais Phosphates et Azotes	2,547 (2)
11	14	Union Generale - Jemmal	2,391
12	43	Société Monasterienne (SOMOTEX)	2,365
13	38	Société des Industries Chimiques Maghrebines (KM)	2,319
14	C	Briqueterie Fouchana	2,312
15	09	Briqueterie Ali M'Henni	2,272
16	H	Société Industrielle Acide Phosphorique et Engrais - SIAPE 'A'	2,159
17	41	Industrie Chimique du Fluor - ICF	1,958
18	15	SOTUVER	1,956
19	36	Société Tunisienne d'Oxygène et Acétylène	1,696
20	10	Tunisie Lait	1,657
21	49	Société Tunisienne de Production Alimentaire - STPA	1,543
22	08	Le Comptoir National des Plastiques	1,519
23	42	Société de Fonderie et de Mécanique - SOFOMECA	1,504
24	45	Société Frigorifique et Brasserie de Tunis	1,444
25	17	STIL	1,328
26	05	Société Metallurgique et Minière de Tunis - SMMT	1,306
27	44	Les Ateliers Mécaniques du Sahel	1,270
28	F	Briqueterie El Hamma	1,200
29	29	Cimenterie Amiantes Tunisie et Ciment	1,015
30	28	Société Industrielle Commerciale d'Ouvrage Amiante et Ciment	956
31	32	Granuphos	935
32	04	Le Confort	924
33	24	La Ceramique de Tunisie	860
34	06	El Anabib	826
35	16	Société Nationale de Pneumatiques - SONAP	802

Exhibit 6.12 continued

ORDER	QUESTIONNAIRE	PLANT	QUANTITY (TEP)
36	25	La Ceramique Tunisienne (Tabarka)	771
37	37	Société La Brique Tunisienne	642
38	23	Ceramique de l'Ouest	641
39	40	Engrais de Gabès	571
40	48	Sfax Ceramique	570
41	13	STIA	536
42	31	Société de Materiel Electrique (Chakira)	534
43	50	Les Couscousseries du Sud	492
44	01	Société Tunisienne d'Engrais Chimiques - STEC	423
45	26	Ciments Artificiels Tunisiens - Tunis	345
46	35	Les Refractaires de Tunisie	344
47	03	Société Anonyme de Potinville	341
48	34	Manufacture Tunisienne de Ceramique	334
49	20	Société Tunisienne de Biscuiterie - SOTUBI	228
50	19	Société Generale Industrielle - SGI	216
51	E	Société Tunisienne du Sucre	209
52	02	Fonderies Réunies de Tunis - FRT	192
53	22	Les Platres Tunisiens de Meknassy	169
54	21	Société Tunisienne de Chocolaterie - SOTUCHOC	163
55	47	Cooperative Agricole Izidihar	147
56	27	Ali Majoul et Compagnie	141
57	11	Société Industrielle des Textiles Reunis - SITER	106
58	33	Société Industrielle Acide Phosphorique et Engrais - SIAPE 'B'	72
59	46	Régie des Alcools	59
60	30	Pain et Patisserie Ouarda	24
			209,551

Notes: (1) 3 months consumption only

(2) The company actually purchases 19,574,666 kwh from STEG (62658 x 10^6 Kcal) but sells back to STEG, from their own autogenerators, 11,616,100 kwh (37182 x 10^6 Kcal). The figure given in this list is the net figure, i.e. 7.958,566 kwh or 2,547 TEP.

Exhibit 6.13: ELECTRICITY CONSUMPTION – CUMULATIVE

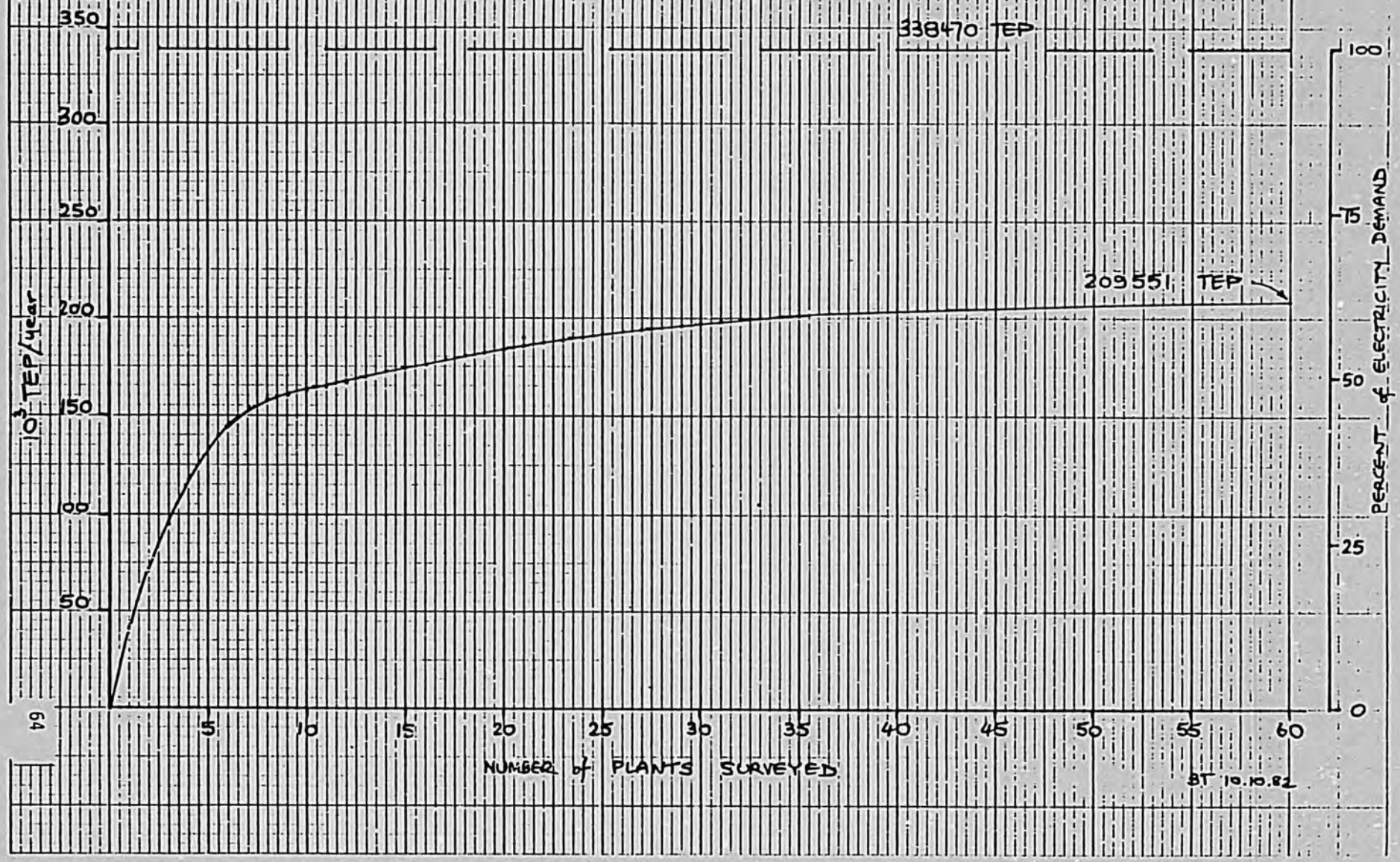


EXHIBIT 6.14

TOTAL ENERGY CONSUMPTIONS REPORTED

ORDER	QUESTIONNAIRE	PLANT	QUANTITY (TEP)
1	J	Compagnie de Phosphates de Gafsa	141,955
2	D	El Fouledh Steelworks	133,481
3	A	Ciments de Bizerte	90,947
4	B	Ciments Artificiels Tunisiens	87,583
5	G	Société de Ciments de Gabès	63,097
6	I	S.N. de Cellulose et de Papier Alfa	43,233
7	51	Cimenterie d'om Khelil	24,845 (1)
8	H	Société Industrielle Acide Phosphorique et Engrais-SIAPE 'A'	24,189 (2)
9	33	Société Industrielle Acide Phosphorique et Engrais-SIAPE 'B'	17,427 (2)
10	E	Société Tunisienne du Sucre	17,060
11	07	Briqueterie Zarouk	16,943
12	39	Société Arabe des Engrais Phosphatés et Azotés-SAEPA	15,281 (2)
13	38	Société des Industries Chimiques Maghrebines - ICM	14,673 (2)
14	14	Union Générale (Jemmal)	11,511
15	C	Briqueterie Fouchana	8,688
16	09	Briqueterie Ali M'Henni	8,579
17	05	Société Métallurgique et Minière Tunis	8,328
18	15	Sotuver	8,199
19	F	Briqueterie El Hamma	7,080
20	11	Société Industrielle des Textiles Réunis	6,005
21	25	La Céramique Tunisienne (Tabarka)	5,854
22	12	SITEX - Usine de Ksar Helal	5,265
23	41	Industrie Chimique du Fluor - ICF	5,093
24	23	Céramique de l'Ouest	4,079
25	24	La Céramique Tunisienne	3,740
26	45	Société Frigorifique et Brasserie de Tunis	3,593
27	10	Tunisie Lait S.A.	3,541
28	03	Société Anonyme de Potinville	3,449
29	25	Ciments Artificiels Tunisiens	3,357
30	32	Granuphos	3,030
31	43	Société Monastérienne - SOMOTEX	2,967
32	06	El Anabib	2,743
33	36	Société Tunisienne d'Oxygène et Acétylène	2,653
34	17	STIL	2,624
35	16	Société Nationale du Pneumatique	2,498

EXHIBIT 6.14 continued

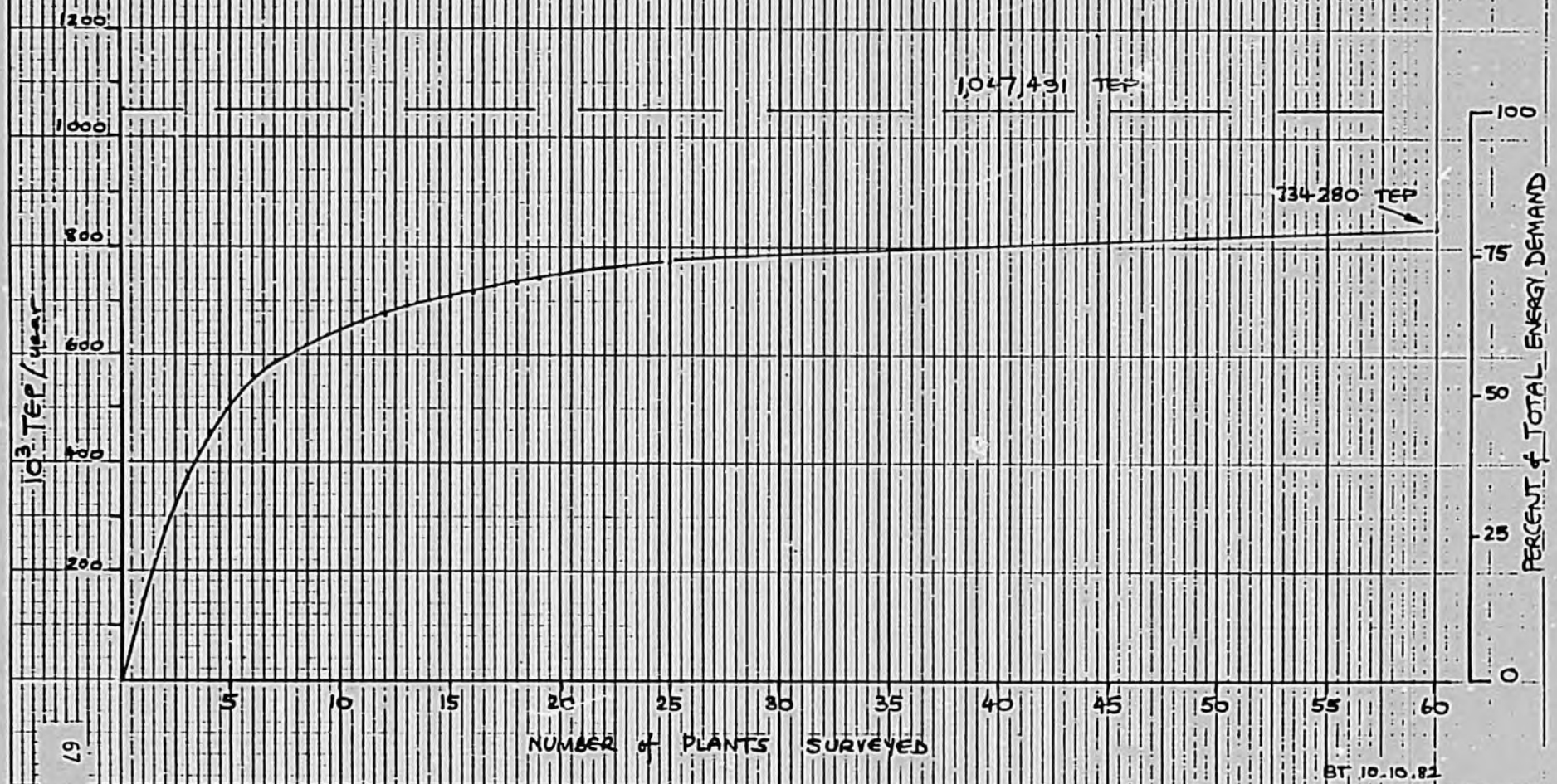
ORDER	QUESTIONNAIRE	PLANT	QUANTITY (TEP)
36	48	Sfax Céramique	2,454
37	42	Société de Fonderie et de Mécanique	2,440
38	37	Société La Brique Tunisienne	2,230
39	04	Le Confort	2,161
40	34	Manufacture Tunisienne de Céramique	2,078
41	29	Ciments Amiantes Tunisiens	1,675
42	44	Les Ateliers Mécaniques du Sahel	1,664
43	49	Société Tunisienne de Production Alimentaire	1,618
44	08	Le Comptoir National des Plastiques	1,595
45	50	Les Couscousseries du Sud	1,491
46	28	Société Industrielle Commerciale d'Ouvrage Amiante et Ciment	1,341
47	47	Coopérative Agricole Izidihar	1,317
48	40	Engrais de Gabès	1,278
49	35	Les Réfractaires de Tunisie	1,184
50	13	Société Tunisienne d'Industrie Automobile - STIA	1,083
51	46	Régie des Alcools	937
52	27	Ali Majoul et Compagnie	798
53	02	Fonderies Réunies de Tunis	696
54	31	Société de Matériel Electrique (Chakira)	643
55	01	Société Tunisienne d'Engrais Chimiques	515
56	22	Les Plâtres Tunisiens de Meknassy	469
57	21	Société Tunisienne de Chocolaterie	310
58	19	Société Générale Industrielle	280
59	20	Société Tunisienne de Biscuiterie	257
60	30	Pain et Pâtisserie Ouarda	176
			834,280

Notes:

(1) 3 months consumption only

(2) Exclude fuel value of sulphur burnt in the process

Exhibit 6.15 : TOTAL ENERGY CONSUMPTION - CUMULATIVE



where sample coverage was better, the figures are as follows:

Number of consumers	Percent of sector demand
3	50
6	65
10	79

From the total energy consumption reported, it may be seen that five plants account for almost 50% of the consumption of the sector, and fifteen plants almost 70%.

Exhibit 6.16 is a histogram indicating the size distribution of the plants participating in the survey. This exhibit confirms the fact that the survey sample was chosen to cover the largest plants and thus a high percentage of the overall sector energy demand. We may make a very approximate estimate of the average size of Tunisian enterprises using INS information:

	Entire Industrial Sector	Plants covered by survey	Other plants
Energy demand, TEP	1,000,000	800,000	200,000
Number of plants	2,000	60	1,940
Average size TEP/plant	500	13,300	100

Thus the average energy consumption of plants not covered by the present study is of the order of 100 TEP per year: it should be noted that the smallest plant for which a questionnaire was completed reported a consumption of 176 TEP in 1980. These figures give an indication of the magnitude of the task of continuing with the collection of reliable plant data through personal visits and questionnaire responses: the situation is shown graphically in Exhibit 6.17.

The conclusion we would draw from all these exhibits is that policy initiatives, and plant-level work such as audits and training programs, could have a significant impact on the national energy situation even though the effort is aimed at relatively few large consumers. The lack of data on small consumers need not limit the effectiveness of conservation work. Policies and programs affecting the efficiency of the major energy consuming plants should therefore receive a high priority in Tunisia.

Exhibit 6.16 : ENERGY CONSUMPTIONS of PLANTS SURVEYED

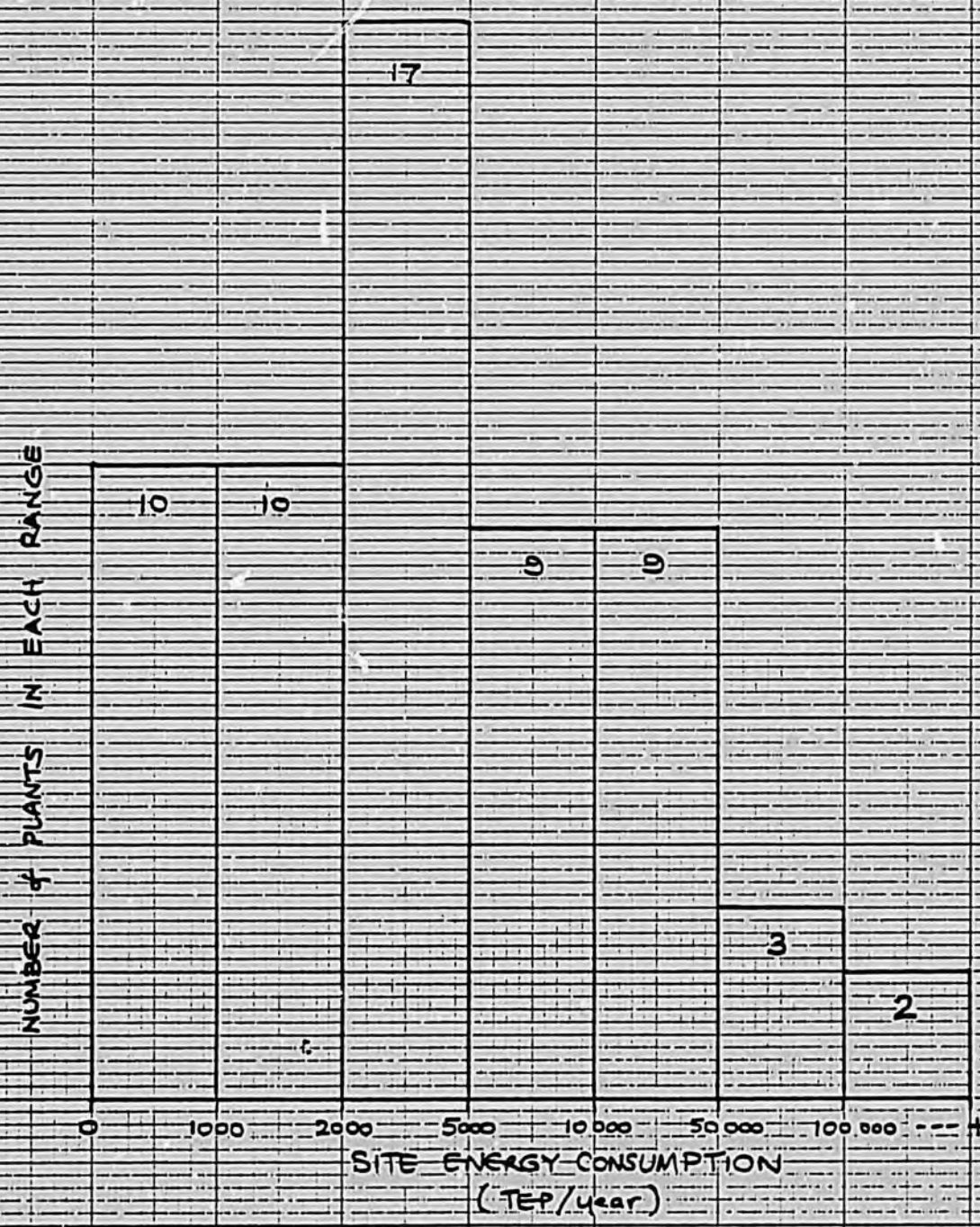
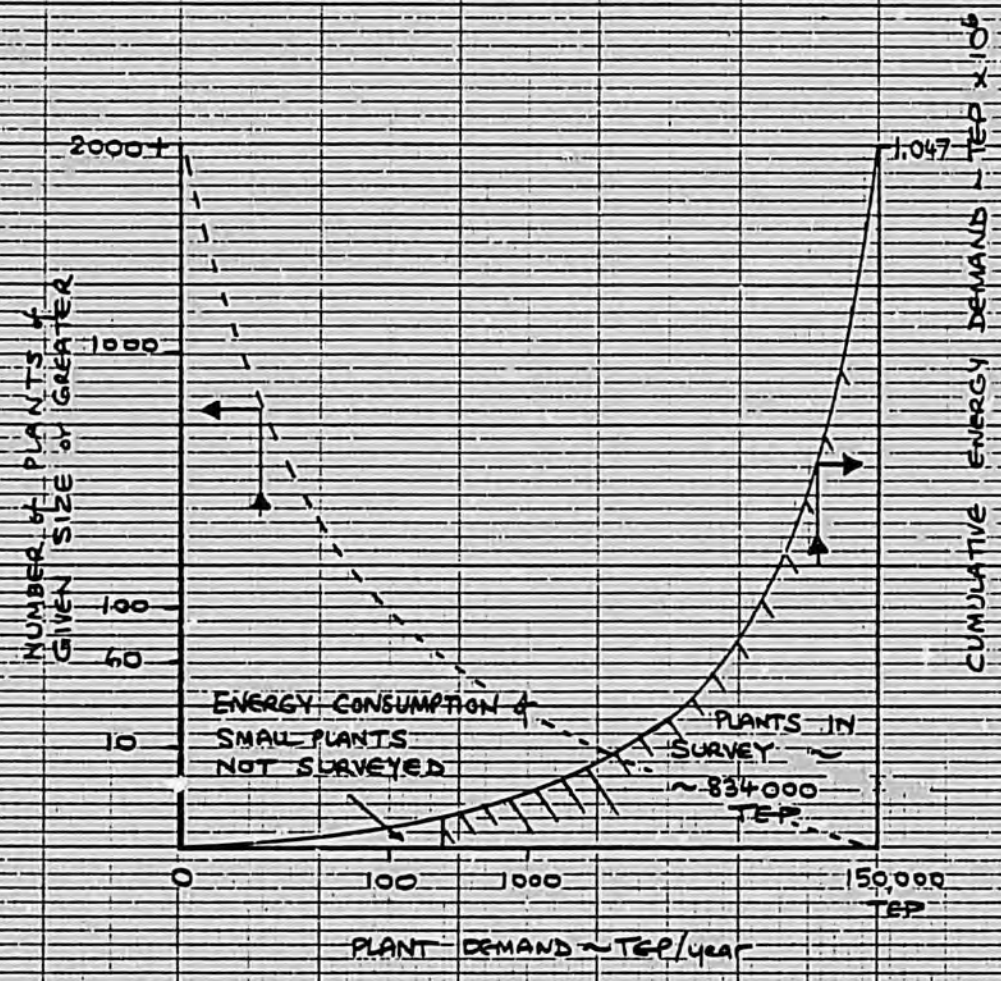


Exhibit 6.17 ENERGY DEMAND & NUMBER of PLANTS

(DIAGRAMMATIC)



6.5 Specific Energy Consumptions

Production data were obtained from the plant questionnaire responses and therefore it has been possible to calculate specific energy consumptions for the majority of the plants. These figures are reported in Exhibit 6.6.

Comparisons may be made of the calculated specific energy consumptions with corresponding data for other countries, as well as comparisons from plant to plant within Tunisia for similar industrial activities. Significantly better performance by one plant, or major discrepancies between subsector performance and data reported for other countries, indicates that there may be scope for improving the efficiency in some plants. Great care must be taken, of course, that the comparisons are carried out properly: for example, the qualities of raw materials and the specifications of products must be truly comparable for different plants as these factors can have a very substantial effect on energy consumption. The simple comparison does not show how or why better performance is being achieved in a particular plant, and careful investigation at the plant level is necessary before reliable conclusions can be drawn regarding the technical and economic viability of energy efficiency improvements. At best, a comparison of specific energy consumptions can indicate technical possibilities for improvement and thus areas worthy of further investigation; it cannot indicate if such improvements would be economic. Bearing in mind the limitations of comparisons of specific energy consumption, the following comments may be made:

(1) Cement

The specific consumptions of the four plants in the survey were estimated in terms of fuel and electricity:

	Process	Fuel Kcal/kg clinker	Electricity kwh/t cement	Total TEP/t cement
CAT	Wet	1698	91	0.201
Cim.Bizerte	Dry	938	96	0.126
Cim.Gabes	Dry	841	139	0.131
D'om Khelil	Dry	897	117	0.129

These figures may be compared with "good modern practice":(1)

	Kcal/kg clinker	kwh/t cement	TEP/t cement
Wet process	1250-1300	100	0.159-0.164
Dry process (suspension preheater)	800-850	100	0.114-0.119

(1) As quoted in "The Cement Industry", NATO Committee on the Challenges of Modern Society (1976), and based on discussions with cement industry managers and plant design contractors in the USA and Europe in reference to plants designed using the latest technologies and operated efficiently.

The figures from the plant survey are all somewhat higher than good practice would suggest. In the case of CAT which uses the wet process, electricity consumption is good but fuel use is quite high. This plant was visited during the Cycle 1 audits and several reasons for the poor efficiency are noted in the audit report. For example, combustion efficiency was not good and the water content of the slurry was higher than recommended. Efforts had started at the plant to reduce the water content; tests of slurry thinner additives were begun in 1981. A reasonable estimate of the fuel saving potential at CAT is thus[1]:

$$\frac{1698 - 1300}{1698} = 0.234 = \text{say } 20\%$$

For the other plants, the potential fuel savings are unlikely to exceed 5% on average, as the plants are already running at a reasonable level of efficiency. On average, we would expect 5% savings to be made throughout the sector in electricity consumption. Better operations could be achieved if the reliability of the STEG electricity supply were improved. In the long term, and provided coal ash were to be available, the use of blended cements might prove of interest.

(2) Bricks

Specific consumption figures are available for eight plants producing ordinary bricks. The average consumption for the subsector is 0.077 TEP/tonne, which may be compared with the figure of 0.263 TEP/tonne reported for refractory brick manufacture, clearly a more energy intensive process.

For those plants manufacturing ordinary bricks, there will obviously be some differences in the exact specifications of the products. However, the processes are broadly comparable for all brickworks. The range of specific consumptions reported in the survey is quite wide, and it is interesting to examine capacity utilization in conjunction with energy use:

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(1) Conversion from wet to dry process would not be economically viable: the existing plant is old and quarry reserves are limited.

BRICKWORKS DATA

Year		Capacity 10^3 T/yr	Production 10^3 T/yr	% utilization	Spec.Cons. TEP/t
1981	Ceramique de l'Ouest	80.0	55.360	69.2	0.074
1980	Briqueterie Zarrouk	270.0	178.223	66.0	0.095
1980	Briqueterie M'Henni	160.0	155.540	97.2	0.055
1981	Ceram.Tunisienne (Jendouba)	75.0	55.000	73.3	0.068
1981	Sfax Ceramique	42.0	30.000	71.4	0.082
1980	Soc. La Brique Tunisienne	50.0	39.985	80.0	0.056
1980	Briqueterie Fouchana	200.0	97.147	48.6	0.089
1980	Briqueterie El Hamma	100.0	89.302	89.3	0.079

These data are plotted in Exhibit 6.18, which also shows data from the brick industry in the U.S. and the U.K.(1). It will be seen that the specific consumptions for the Tunisian brickworks are all rather high. It will also be seen that many of the Tunisian brickworks are apparently operating well below full capacity. In the manufacture of bricks, it is important to schedule operations to maximize capacity utilization, otherwise standing losses from the structure of the kiln itself become significant at low throughputs, and thus energy efficiency drops rapidly (see also the audit report for Fouchana Brickworks).

Under-utilization appears to be the most important single factor for poor energy efficiency in the brickworks subsector. Based on the trends indicated in Exhibit 6.18 and on the observations made at Fouchana, we estimate that 20% energy efficiency improvement could be obtained through improved scheduling. In addition, we estimate that 10% savings should be obtained through housekeeping activities at each of the plants.

In the long term, it may be possible to achieve greater savings through capital investments in heat recovery systems and improved insulation, such as the use of ceramic fiber linings to the combustion zones of the brick kilns. Each plant will require a detailed audit to establish the technical and economic options: since the brick industry is a large energy consumer (representing about 10% of industrial sector demand), a program of audits appears fully justified.

(1) Sources of U.S. data are "Energy Efficiency Improvement Target for SIC 32"; Stone, Clay and Glass, Battelle Columbus Labs., June 1976, and the regular reports of the energy efficiency monitoring program of the U.S. Department of Energy. U.K. data obtained from the audit report on the brick industry by the Department of Energy and Department of Industry.

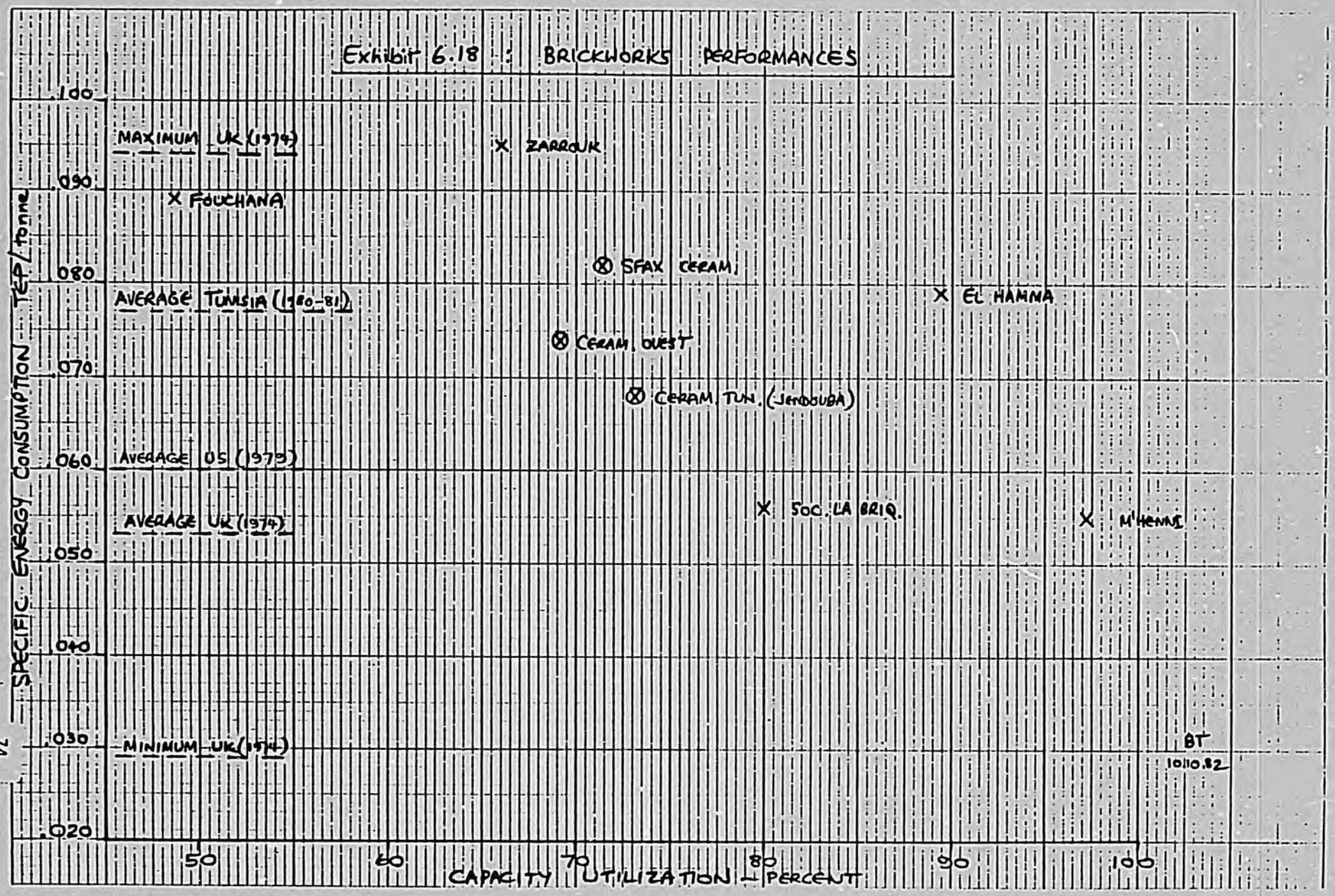
Exhibit 6.18 : BRICKWORKS PERFORMANCES
SPECIFIC ENERGY CONSUMPTION — TEP/tonne
.100
.090
.080
.070
.060
.050
.040
.030
.020
MAXIMUM UK (1974)
X ZARROUK
X FOUCHANA
⊗ SFAX CERAM.
AVERAGE TUNISIA (1980-81)
X EL HAMMA
⊗ CERAM. OUEST
⊗ CERAM. TUN. (JENDOUBA)
AVERAGE US (1973)
X SOC. LA BRIQ.
X M'HENNI
AVERAGE UK (1974)
MINIMUM UK (1974)
BT
10.10.82
50
60
70
80
90
100
CAPACITY UTILIZATION — PERCENT

(3) Glass

The single glass plant included in the survey reports a specific consumption of 0.464 TEP/tonne of good glass containers. The glass plant data also indicate an "efficiency" of under 70%, defined as follows:

$$\text{Efficiency} = \frac{\text{Good glass}}{\text{Glass melted}} = \frac{17{,}656\ \text{t}}{25{,}520\ \text{t}} = 69\%$$

Data obtained in 1978 from audits in the U.K.[1] showed figures of 76 to 85% were obtained in a range of different glassworks. The figure of 69% thus leaves room for significant improvement.

With regard to the specific energy consumption, data for the U.S. glass container industry show a trend from about 0.27 to about 0.23 TEP/tonne from 1972 to 1979, which represents a significantly better performance than that recorded for the Tunisian glass plant[2].

Other data from U.K. audit reports show the following specific consumptions for the glass industry as a whole:

	GJ/t	TEP/t
1970	20.14	0.483
1971	20.88	0.501
1972	19.53	0.469
1973	17.27	0.414
1974	18.30	0.439
1975	16.38	0.393
1980 (est.)	15	0.36

Six glass plants, audited in 1978, reported these specific consumptions:

GJ/t	TEP/t	GJ/t	TEP/t
10.5	0.252	17.8	0.427
15.1	0.362	12.6	0.302
13.9	0.334	11.2	0.269

(1) Energy Audit Series No.5, The Glass Industry (U.K. Departments of Energy and Industry, July 1979)

(2) Energy Efficiency Improvement Target for SIC 32: Stone, Clay and Glass (Vol.1) Battelle Columbus Labs, Ohio (June 1976), and the Annual Reports on the industrial energy efficiency monitoring program by the U.S. Department of Energy.

Differences from factory to factory are due to many factors including the color of the glass melted, the construction of the glass tanks, the method of firing, the fuel used, and the proportion of cullet in the raw materials. Nevertheless, the consumption reported in Tunisia in 1980 of 0.464 TEP/t is rather high. Action that might improve energy efficiency includes:

(1) Steadier operations (e.g. improved reliability of STEG supply)
(2) Improved insulation of melting tanks
(3) Improved power factor (currently around 0.77)
(4) Better energy management, including the installation of certain meters and analyzers to assist audits and energy monitoring
(5) Reduced breakage, with maximum recycle of broken glass
(6) Waste heat recovery (e.g. to preheat combustion air)
(7) Insulation and gas recirculation in the Lehrs and forehearth.

A detailed audit of the glass plant is suggested: potential savings in the medium to long term are judged to be 20 to 25%.

(4) Tiles

Comparison with other plants was not possible due to lack of data, but observations made during the conduct of the survey visit suggests improvements in energy management should be made; better insulation and lower water content of the raw materials were also identified as possible means of saving energy.

(5) Chemicals

There are many diverse activities in this subsector, making comparisons with specific consumptions reported elsewhere impossible. However, the visits to plants made during the training program and the survey itself showed that there were many improvements possible: a lack of instruments was noticed in some plants, and standards of housekeeping were frequently low. Since this subsector is a large energy consumer, detailed audits appear well justified.

(6) Steel

A report on the U.K. steel industry[1] reports an industry-wide specific consumption of 0.575 TEP/tonne, while El Fouledh reports 0.750 TEP/tonne. There appears to be much scope for improvement, and the visits and audits conducted during this project confirm this fact. Indeed, many other countries report better energy efficiencies, such as the following for 1976[2]:

	TEP/t
France	0.57
Fed. Rep. of Germany	0.52
Japan	0.44

Industry-wide energy consumption by the US industry is about 0.73 TEP/tonne, according to annual reports on industrial energy efficiency published by the U.S. Department of Energy.

With respect to coke rate, the figures quoted by El Fouledh correspond to about 500 to 520 kg coke per tonne of molten iron (and some other fuels are used), while other countries report figures somewhat below 500 kg coke [2]. The electric furnace at El Fouledh reports a consumption of 816 kwh/tonne, while a figure for good modern practice is around 500 kwh/tonne. Of course, the reasons for these differences should be investigated thoroughly, as the full improvement may not be technically or economically viable. However, we would expect significant improvement to be possible, beginning with improved energy management and housekeeping throughout the site. Visits have been made to El Fouledh since 1979, and little improvement is obvious. The operation of the reheating furnaces is described in detail in the audit report for El Fouledh; recommendations for improvement are made, including the installation of stack gas recuperators. In addition, we would comment as follows:

(1) Investigate operation of the sinter plant (improve control of combustion air, consider preheating)

(2) Check the operation of the billet cutting system to see if better control of billet length could reduce the quantity recycled to the electric arc furnace (currently around 5-10% of production, say 20,000 t/year).

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(1) Energy Audit Series No.16, U.K. Department of Energy, 1982

(2) CCMS Study on the Steel Industry, U.S. Department of Energy, 1979

(3) Check all losses of fuels to drain or onto the ground (it is believed that significant quantities of kerosene are lost).

A thorough audit of the complete site is justified. This could require a team of say 4 experts for 1 to 2 months on site. We would estimate that medium to long term savings of 30% should be attainable.

(7) Mechanical, metallurgical, electrical

The remainder of this subsector is very diverse and comparisons of specific energy consumption are not possible. Observations made at the plant visits suggest that much greater attention to energy management would produce significant energy savings.

(8) Dairy products

The energy consumption in this industry can vary considerably according to the type of products made. US data for the fluid milk processing industry suggests an energy consumption of about 40 TEP per million litres of milk[1]. An audit report from the U.K.[2] gives the following energy consumption figures:

	TEP/10^6 litres
Liquid milk processing	
Heat treatment and bottling of pasteurised milk	21
Sterilised milk	69
Manufacturing	
Cheesemaking	77
Other products	66

The figures reported for two Tunisian plants are 86 and 47 TEP/10^6 litres, and these plants produce a range of products including cheese and yoghurt. The large discrepancy between the two Tunisian plants deserves further investigation in the hope of identifying areas for energy conservation.

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(1) Energy efficiency target documentation prepared for the US Federal Energy Administration by Development Planning and Research Associates Inc., Manhattan, Kansas, July 1976.

(2) Energy Audit Series, The Dairy Industry: U.K. Departments of Energy and Industry, October 1978.

In this industry, there is usually no single area which has the potential to reduce energy consumption overall by large amounts. Rather, reliance must be placed on saving smaller amounts in a number of areas, such as:

(1) improved housekeeping in all process areas (e.g. improved efficiency of steam raising and utilization)

(2) improved monitoring of operations and energy usage (which may require the installation of some meters)

(3) heat recovery, possibly in conjunction with refrigeration using heat pump systems.

The U.K. report suggested savings of about 15% of fuel and say 10% of electricity through housekeeping over 3 or 4 years.

(9) Brewing

The energy consumed in brewing beer is not reported separately from the other activities carried out by SFBT. However, a rough estimate was made:

$$\frac{3{,}000}{300{,}000} \; \frac{\text{TEP}}{\text{hectolitres}} = 0.010 \text{ TEP/hectolitre}$$

Figures from Portugal and the U.K. suggest this is a reasonable energy consumption, as these countries report 0.008 and 0.007 respectively[1]. There is, of course, a wide range of specific consumptions reported for different types of breweries; the U.K. figures generally range from about 0.005 to 0.014 TEP/hectolitre. Improved efficiency of steam raising and utilization are particularly important areas for housekeeping and minor capital investments in the brewing industry. The plant visit for the project suggested a good standard of operation, which is confirmed by the specific energy figure. Obviously, attention should always be paid to energy management, and the total consumption of energy at the single site (over 3,500 TEP per year) suggests a detailed energy audit is justified. It may well be necessary to install additional meters to allow proper monitoring and control to be effected.

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(1) U.K. data from Energy Audit Series No.8, The Brewing Industry, U.K. Department of Energy and Industry, October 1979.

(10) Sugar

Representative specific consumption figures for cane sugar and beet sugar processing in the U.S. were given in the Training Course manual as 0.142 TEP/tonne of sugar and 0.1 TEP per tonne of beet sliced, respectively[1]. Using these figures and the quantities of cane and beet sugar reported produced at Béjà, we estimated an annual energy consumption of 14,000 TEP. The figure reported by SNS was about 17,000 TEP (corresponding to 0.281 TEP/tonne) suggesting that savings of 10 to 15% should be attainable in the short to medium term. A thorough energy audit of the Béjà plant is justified.

(11) Paper

The audit visits to Kasserine indicated scope for a great deal of improvement. The specific consumption was calculated to be 1.8 TEP/tonne; an audit of a fully integrated plant in the U.K. reports a consumption of 1.2 TEP/tonne, and industry-wide data for the U.S. industry give about 0.9 TEP/tonne for 1972[2]. These figures suggest savings of perhaps 30% should be attainable in the medium to long term. Measures recommended for Kasserine are discussed fully in the comprehensive audit report produced after the training program visits and audit work.

(12) Textiles

The diversity of this industry makes direct comparisons of specific consumption very difficult. From the visits made in this project, we conclude that detailed audits are justified for the larger plants: there appears to be a lack of instrumentation for adequate monitoring and control, especially with respect to combustion control.

(13) Phosphate beneficiation

The figure of 0.033 TEP/tonne of enriched phosphate was reported, and energy use will vary with the raw material and product purities. Our observations on the operations at Metlaoui are discussed fully in the audit report produced for this plant, and we believe significant savings are obtainable through better control of the drying process, especially with respect to the water contents of the phosphate rock entering and leaving the rotary driers. It is also important to note that the energy embodied in one tonne

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(1) Energy efficiency improvement target documentation by Development Planning and Research Associates Inc., Kansas, July 1976.

(2) Target documentation for the paper industry (SIC 26) prepared for the U.S. Federal Energy Administration.

of enriched rock amounts to over 3 dinars (at world energy prices) or almost 15% of the selling price: proper materials handling in the Metlaoui complex is thus very important from a cost and energy point of view.

6.6 Energy Used by End-Use Categories

A detailed knowledge of energy use by different end-use categories (process heat, motive power, space conditioning, etc.) is often of value to energy planners. For example, it may be desirable to evaluate the potential for substituting a renewable energy form (low temperature solar heat) for a fossil fuel used for process heating. In general such data are less important to plant engineers, who are usually more concerned with detailed data oriented to the performance of capabilities of specific equipment, and which is obtained through plant energy audits.

The availability of disaggregated energy consumption data according to end-use categories, suitable for longer term energy planning, was poor. Few plants were able to quantify accurately the uses of fuels and electricity for process heat, lighting, rotating machinery, steam raising, etc., although some plants did attempt estimates of the uses of electricity. It appears unlikely that improvement in the quality of data will be achieved without many more audits of plants, and even in these audits, data may be restricted by lack of metering.

Conclusions are difficult to draw from the few responses recorded in the questionnaires. Data on fuel use are essentially non-existent. Data on electricity use suggest that over 90% of this energy form is used for motive power and 10% for lighting in the typical factory in the mechanical, metallurgical and electrical sector. For industries such as cement and bricks, lighting represents around 2% of electricity use and motive power 98%. A few factories reported large uses for special purposes (e.g. electric arc furnaces, refrigeration).

In the course of the Cycle 1 audits, some data on energy end uses were collected and these are reported in the full report of audit work. The reader is referred to that report for further details. As a general rule, we found a lack of individual meters in most plants meant that meaningful breakdowns of energy utilization could not be made.

6.7 Energy and Value of Production

As an indication of the importance of energy costs to a company, the ratio of energy cost to value of production is an interesting parameter. Exhibit 6.19 is a tabulation of energy consumption and the reported value of output. The consumption of energy (in TEP) per thousand dinar of output is shown in the last column but one; figures range from less than 0.1 to over 45. The lowest values are reported for "assembly" industries in the mechanical sector and "high-value-added" industries in the chemicals sector, while the highest values are found for bricks and cement. This would suggest that it would be reasonable to find a low concern by management for energy in those industries with the lowest energy consumption per dinar of output, and that the promotion of energy conservation in such industries would be difficult (see also Section 6.8).

The inverse ratio is also of interest in some circumstances, that is, the average value of production per TEP (or dinar) of energy input. These figures are also shown in Exhibit 6.19 and can be used by planners to design macro investment strategies, as they represent one measure of the "efficiency" of energy use. From the data collected in this project, the efficiency of energy investment in the cement and brick industries is seen to be low, while the efficiency in the chemical industries, for example, is relatively high.

6.8 Potential Impact of Energy Price Increases

Another measure of the incentive for management to pursue energy consumption is the proportion of the product selling price represented by the embodied energy costs. For this analysis, we tabulated the energy contents of major products in terms of TEP per tonne of product (or per unit) and calculated the corresponding energy cost, using today's representative energy costs for Tunisian industry. Exhibit 6.20 shows the basic calculations. Exhibit 6.21 presents the results of these calculations, indicating the percentage increases in product prices for specified increases in energy prices, assuming the full impact of the energy cost increase is passed along to the consumer. This represents the worst case, for the short term[1], as it is likely that higher energy prices would encourage some degree of energy conservation and thus result in lower impacts on the final consumer prices.

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(1) Of course, this assumes no control of product prices by the government, or a lack of competition in the market place which might otherwise restrict the ability of companies to pass cost increases through to the consumer.

EXHIBIT 6.19 - ENERGY AND VALUE OF OUTPUT

	TOTAL ENERGY CONSUMPTION (TEP)	OUTPUT	VALUE OF OUTPUT (dinars)	REMARKS (1)	TEP/THOUSAND DINAR OUTPUT	THOUSAND DINARS PER TEP
I. MATERIALS OF CONSTRUCTION						
CEMENT						
1. Ciments Artificiels Tunisiens (Djebel Djelloud)	87,583	436,618 T(2)	1,920,000	chiffre d'affaires,TTC	45.6	0.02
2. Ciments de Bizerte	90,947	721,350T	-	-	-	-
3. Societe de Ciments de Gabès	63,097	482,500T	-	-	-	-
4. Cimenterie oum Khelil (1)	24,845	192,406T	-	-	-	-
BRICKS						
1. Briqueterie Fouchana	8,688	97,147T	-	-	-	-
2. Briqueterie Zarrouk	16,943	178,223T	3,279,303	selling price,TTC	5.2	0.19
3. Briqueterie Ali M'Henni	8,579	155,540T	2,109,219	selling price	4.1	0.25
4. Briqueterie El Hamma	7,080	89,302T	-	-	-	-
5. Ceramique de l'Ouest	4,079	55,360T	1,127,500	selling price, TTC	3.6	0.28
6. La Ceramique Tunisienne (Jendouba)	3,740	66,000T	890,766	chiffre d'affaires,TTC	4.2	0.24
7. Union Generale	11,511	-	-	-	-	-
8. Société La Brique Tunisienne	2,230	39,985T	746,000	selling price,TTC	3.0	0.34
9. Les Refractaires de Tunisie	1,184	4,500T	869,493	chiffre d'affaires,TTC	1.4	0.73
10. Sfax Ceramique	2,454	30,000T	536,830	chiffre d'affaires,TTC	4.6	0.22
GLASS						
SOTUVER	8,199	-	2,923,984	chiffre d'affaires,TTC	2.8	0.36
OTHERS						
1. S.A. de Potinville	3,449	64,500T	1,018,212	chiffre d'affaires, HT	3.4	0.30
2. Ciments Artificiels Tunisiens (Tunis)	3,357	56,000T	1,920,000	" " TTC	1.7	0.57
3. La Ceramique Tunisienne	5,854	-	2,400,000	" " "	2.4	0.41
4. Man. Tunisienne de Ceramique	2,078	3,600T	1,978,941	" " "	1.1	0.95
5. El Anabib	2,743	131,462T	13,966,046	" " "	0.2	5.09
6. Les Platres Tunisiens de Meknassy	469	8,209T	350,000	" " "	1.3	0.75
7. Soc. Industrielle et Commerciale d'Ouvrage	1,341	22,100T	4,900,000	" " "	0.3	3.65
8. Ciment Amiante Tunisien	1,675	28,000T	7,000,000	" " "	0.2	4.18
II. CHEMICAL INDUSTRY						
1. Soc. Tunisienne d'Engrais Chimiques	515	70,148T	2,000,000	selling price, HT	0.3	3.88
2. SIAPE 'A'	24,189	317,416T	-	-	-	-
3. Soc. Des Industries Chimiques Maghrebines	14,673	80,845T	40,000,000	chiffre d'affaires, TTC	0.4	2.73
4. SIAPE 'B'	17,427	-	19,700,000	" " "	0.9	1.13
5. Granuphos	3,030	59,965T	1,382,702	cost of prod., HT	2.2	0.46
6. Soc. Arabe des Engrais Phos. et Azotes	15,281	514,974T	72,660,651	selling price, TTC	0.2	4.76
7. Engrais de Gabès	1,278	62,611T	57,069,968	" " "	<0.1	44.66
8. Industrie Chimique du Fluor (ICF)	5,093	19,730T	5,588,600	chiffre d'affaires,HT	0.9	1.10
9. Soc. Tunisienne d'Oxygene et d'Acetylene	2,653	N.A.	2,000,000	" " "	1.3	0.75
III MECHANICAL, METALLURGICAL, ELECTRICAL						
BASIC STEEL PRODUCTION						
El Fouledh Steelworks	133,481	177,937T	-	-	-	-

(1) TTC = Toutes Taxes Comprises (includes all taxes)
HT = Hors Taxes (taxes excluded)

EXHIBIT 6.19 CONTINUED

	TOTAL ENERGY CONSUMPTION (TEP)	OUTPUT	VALUE OF OUTPUT (dinars)	REMARKS	TEP/THOUSAND DINAR OUTPUT	THOUSAND DINARS PER TEP
OTHERS						
1. Soc. de Materiel Electrique (Chakira)	643	2,847 T	5,081,000	chiffre d'affaires, TTC	0.1	7.90
2. Soc. Generale Industrie (SGI)	280	N.A.	4,000,000	" " TTC	0.1	14.29
3. Soc. Metallurgique et Miniere de Tunis	8,328	19,200 T	9,592,336	" " TTC	0.9	1.15
4. Le Confort S.A.	2,161	N.A.	6,240,723	selling price, HT	0.3	2.89
5. Soc. Tunisienne d'Industrie Automobile	1,083	N.A.	41,125,737	chiffre d'affaires, HT	< 0.1	37.97
6. Fonderies Reunies de Tunis	696	2,300 T	2,691,208	" " TTC	0.3	3.87
7. Soc. de Fonderie et de Mecanique	2,440	4,787 T	3,000,000	" " TTC	0.8	1.23
8. Les Ateliers de Mecanique du Sahel	1,664	N.A.	2,229,233	selling price, HT	0.7	1.34
IV MINING						
Compagnie de Phosphates de Gafsa	141,955	4,328,667 T	-	-	-	-
V TEXTILES						
1. Soc. Industrielle des Textiles Reunis	6,005	13,612 x 10^3 linear metres	3,345,256	processing cost	1.8	0.56
2. SITEX - Usine de Ksar Helal	5,265	16,068x10^3 LM	16,064,869	chiffre d'affaires, TTC	0.3	3.05
3. Soc. Monasterienne - SOMOTEX	2,967	N.A.	9,570,000	" " , HT	0.3	3.23
VI PAPER						
SN de Cellulose et de Papier Alfa	43,233	23,808 T	-	-	-	-
VII FOOD PROCESSING						
DAIRY PRODUCTS						
1. Tunisie Lait SA	3,541	N.A.	7,549,043	chiffre d'affaires, TTC	0.5	2.13
2. Soc. Tunisienne d'Industrie Laitiere	2,624	56,000,000 L	8,847,828	" " "	0.3	3.37
BAKING, BISCUITS						
1. Soc. Tunisienne de Biscuiterie	257	2,210 T	1,250,000	selling price, HT	0.2	4.86
2. Pain et Patisserie Ouarda SARL	176	N.A.	212,753	" " TTC	0.8	1.21
SUGAR						
Soc. Tunisienne du Sucre	17,060	60,615 T	-	-	-	-
DRINKS						
1. Soc. Frigorifique et Brasserie de Tunis	3,593	441,641 HL	8,298,000	chiffre d'affaires, TTC	0.4	2.31
2. Regie des Alcools	937	18,000 HL	600,000	prix de revient, HT	1.6	0.64
OTHERS						
1. Soc. Tunisienne de Chocolaterie	310	539 T	1,350,000	prix de revient, HT	0.2	4.35
2. Ali Majoul et Compagnie	789	3,704 T	1,800,000	chiffre d'affaires, HT	0.4	2.28
3. Cooperative Agricole Izdihar	1,317	1,076 T	2,500,000	" " TTC	0.5	1.90
4. Soc. Tunisienne de Production Alimentaire	1,618	73,987 T	8,694,603	" " TTC	0.2	5.37
5. Les Couscousseries du Sud	1,491	9,291 T	1,848,000	" " TTC	0.8	1.24
VIII MISCELLANEOUS						
1. Soc. Nationale des Pneumatiques	2,498	N.A.	5,000,000	chiffre d'affaires, TTC	0.5	2.00
2. Le Comptoir National des Plastiques	1,595	8,200 T	4,200,000	" " TTC	0.4	2.63

EXHIBIT 6.20

WORKSHEET FOR PRICE IMPACT CALCULATIONS

(1) PRICES ASSUMED FOR ENERGY PRODUCTS

	Basic information and source (1)	DINARS/TEP
Natural gas (Gabes)	65 D/TEP -- STEG	65
" " (Tunis)	0.130 D/M^3 -- STEG	131.3
Gaz de ville (Tunis)	0.054 D/M^3 -- STEG	133.3
LPG	178 D/T -- Min. Econ. Nat.	162
Electricity (HT)	Approx. 27 mill/kwh; applies to large works, e.g. cement, steel, -- STEG	84.4
Electricity (MT)	For most industrial consumers, approx. 37 millimes/kwh -- STEG	109.4
Coal	91 D/T -- Min. Econ. Nat. (questionnaires)	126
Coke	83 D/T -- " " " "	123
FOD	110 D/T for purchases under 3 M^3 -- SNDP	107
	(130 D/T for larger purchases)	-
Heavy fuel oil	65 D/T -- Min. Econ. Nat.	67
Gasoil	125 millimes/litre -- Min. Econ. Nat.	146

(2) "ENERGY CONTENTS" OF MAJOR PRODUCTS (2)

		Elec.	Nat.Gas	Gasoil	FOD	Hy FO	Other	Total	Product price (1) (representative figure)
A: Cement - gas fired plant	TEP/t	.0444	.0787	.0014	-	-	-	.1245	
	Dinars/t	3.747	5.116	0.204	-	-	-	9.067	38
B: Cement - oil fired plant	TEP/t	.0331	-	.0009	-	.1032	-	.1373	
	Dinars/t	2.794	-	0.131	-	6.914	-	9.839	38
C: Bricks - gas fired plant	TEP/t	.0134	.0599	.0060	-	-	-	.0793	
	D/t	1.466	3.694	0.876	-	-	-	6.236	26
D: Bricks - oil fired plant	TEP/t	.0180	-	.0039	-	.0545	-	.0764	
	D/t	1.969	-	0.569	-	3.652	-	6.190	26
E: Glass (bottles)	TEP/t	.1108	.0097	.0219	-	.2560	.0660 LPG	.4644	
	D/t	12.122	1.274	3.197	-	17.152	10.692	44.437	250
F: Lime	TEP/t	.0057	-	.0005	-	-	.0503 coal	.0565	
	D/t	0.624	-	0.073	-	-	6.338	7.035	23
G: Plaster	TEP/t	.0206	-	.0110	-	.0256	-	.0872	
	D/t	2.254	-	1.606	-	1.715	-	5.575	20
H: TSP	TEP/t	.0030	-	.0003	-	.0532	-	.0565	
	D/t	0.328	-	0.044	-	3.564	-	3.936	80 (export price)
I: DAP	TEP/t	.0049	.0244	.0003	-	-	-	.0296	
	D/t	0.536	1.586	0.044	-	-	-	2.166	130
J: Steel (ronds de beton/billets)	TEP/t	.1738	-	.0023	.0226	.1216	.4298 coke	.7501	
	D/t	14.669	-	0.336	2.418	8.147	52.865	78.435	225
K: Household appliances (refrig;cooker)	TEP/unit	.0131	-	.0006	.0045	.0125	-	.0307	
	D/t	1.433	-	0.088	0.482	0.838	-	2.841	175

Notes: (1) Energy costs and product prices for 1982

(2) Energy consumption patterns based on 60 plant survey

Exhibit 6.29 continued

		Elec.	Nat.Gas	Gasoil	FOD	Hy FO	Other	Total	Product Price
L: Camionette	TEP/unit	.0611	-	-	.0623	-	-	.1234	
	D/unit	6.684	-	-	6.666	-	-	13.350	4000/unit
M: Enriched phosphate	TEP/t	.0094	-	.0018	.0003	.0213	-	.0328	
	D/t	0.793	-	0.263	0.032	1.427	-	2.515	21
N: Textiles (denim jeans material)	TEP/10^3 m	.0894	-	-	.0075	.2825	-	.3794	
	D/10^3 m	9.780	-	-	0.803	18.928	-	29.511	1700/10^3 metres
O: Paper	TEP/t	.6530	-	.0053	.0109	1.1467	-	1.8159	
	D/t	55.110	-	0.774	1.166	76.829	-	133.079	800
P: Milk (sterilised)	TEP/10^3 l	.0311	-	.0061	.0006	.0264	-	.0642	
	D/10^3 l	3.402	-	0.891	0.064	1.769	-	6.126	240 (i.e. 240 Mill/l)
Q: Bread	TEP/t	.0075	-	.0159	.0316	-	-	.0550	
	D/t	0.821	-	2.321	3.381	-	-	6.523	240(i.e.240 mill/kg)
R: Sugar	TEP/t	.0034	-	-	.0008	.2688	.0084 coke	.2814	
	D/t	0.372	-	-	0.086	18.010	1.033	19.501	260
S: Tomato concentrate	TEP/t	.0381	-	-	-	.1774	-	.2155	
	D/t	4.168	-	-	-	11.886	-	16.054	570(i.e.570 mill/kg)
T: Flour	TEP/t	.0209	-	.0008	.0003	-	-	.0220	
	D/t	2.286	-	0.117	0.032	-	-	2.435	200 (i.e.200 mill/kg)
U: Couscous	TEP/t	.0530	-	-	.0023	.1053	-	.1606	
	D/t	5.798	-	-	0.246	7.055	-	13.099	200(i.e.200 mill/kg)

EXHIBIT 6.21 ENERGY PRICE IMPACTS

		A Cost of Energy D/tonne	B Selling price D/tonne	A/B Percentage %	Percent increase in prod.price for 10% increase in: Electricity	Natural gas	FO 2	Coal or coke	All energy forms
1	Cement - gas-fired plants	9.067	38	23.9	1.0	1.3	-	-	2.4
2	Cement - oil-fired plants	9.839	38	25.9	0.7	-	1.8	-	2.6
3	Bricks - gas-fired plants	6.236	26	24.0	0.6	1.5	-	-	2.4
4	Bricks - oil-fired plants	6.190	26	23.8	0.8	-	1.4	-	2.4
5	Glass bottles	44.437	250	17.8	0.5	< 0.1	0.7	-	1.8
6	Lime	7.035	23	30.6	0.3	-	-	<0.1	3.1
7	Plaster	5.575	20	27.9	1.1	-	0.9	-	2.8
8	TSP	3.936	80	4.9	<0.1	-	0.4	-	0.5 (1)
9	DAP	2.166	130	1.7	< 0.1	0.1	-	-	0.2 (1)
10	Steel	78.435	225	34.9	0.7	-	0.4	2.3	3.5
11	Household appliances	2.841 per unit	175 per unit	1.6	0.1	-	<0.1	-	0.2 (2)
12	Camionette	13.350 per unit	4000 per unit	0.3	<0.1	-	-	-	<0.1 (2)
13	Enriched phosphate rock	2.515	21	12.0	0.4	-	0.7	-	1.2
14	Textiles	29,511 per 10^3 metres	1700 per 10^3 metres	1.7	< 0.1	-	0.1	-	0.2
15	Paper	133.879	800	16.7	0.7	-	1.0	-	1.7
16	Milk	6.126	.240 D/litre	2.6	0.1	-	0.1	-	0.3
17	Bread	6.523	.240 D/kg	2.7	< 0.1	-	-	-	0.3 (3)
18	Sugar	19.501	260	7.5	< 0.1	-	0.7	< 0.1	0.9
19	Tomato concentrate	16.054	570	2.8	0.1	-	0.2	-	0.3
20	Flour (semoule)	2.435	200	1.2	0.1	-	-	-	0.1
21	Couscous	13.099	200	6.5	0.3	-	0.4	-	0.7 (3)

Notes:
Excluding any secondary effect of an increase in the price of (1) phosphates
(2) steel
(3) flour

In summary, the percentages of selling price represented by the cost of energy used in the manufacturing process are as follows:

Product	Energy cost/selling price (%)
Steel (reinforcing bars)	35
Lime	31
Plaster	28
Cement	24-25
Bricks	24
Glass bottles	18
Paper	17
Enriched phosphate rock	12
Sugar	8
Couscous	7
TSP	5
Milk	3
Bread	3
Tomato concentrate	3
DAP	2
Household appliances	2
Textiles	2
Flour	1
Camionette	0.3

The obvious importance of energy in the heavy industries (steel, materials of construction, glass, paper) is seen in these figures. It is also interesting to note the relatively minor importance of energy costs in the food processing industry, indicating that large increases in energy prices should have a relatively small effect on the selling price of staple food products such as milk, bread and flour.

The variation in energy cost as a percentage of selling price also indicates that the response of plant managers in the different industries to energy conservation is likely to vary considerably. Those who operate plants where the energy cost is a high percentage are likely to be highly motivated to improve energy efficiency, while those where the percentage is lowest are likely to feel (quite justifiably) that energy efficiency is a low priority. To achieve better energy efficiency in the latter plants, the government may have to consider, for example, generous investment tax credits or even regulatory action.

6.9 Energy Use per Employee

Other analyses of energy use can be carried out using the questionnaire data. Exhibit 6.22, for example, shows two parameters for each reporting plant, energy use per employee and plant output per employee. Both parameters are measures of "productivity", and may be used for making rough estimates of energy consumption and job creation associated with investment in, and expansion of, specific industries.

6.10 Power Factor Data

In most industrial plants, the greater part of the electrical load is made up of induction motors or other equipment such as welders and various types of electric furnace. These draw from the electrical supply system more current than is really required to provide the power to operate the equipment. In basic terms, the extra current is used in magnetizing parts of the machines. The ratio of the current effectively used to the current supplied is known as the power factor:

$$\frac{\text{current effectively used}}{\text{current supplied}} = \frac{\text{kilowatt (kW)}}{\text{kilovolt amperes (kVA)}} = \text{power factor}$$

If the power factor of a consumer's system is low, then the electricity supply company has to provide extra current to the factory and thus at the same time provide larger transformers, switchgear and cables to carry the higher current. A low power factor will also result in increased voltage drops throughout the system. The following table demonstrates the total current drawn from a circuit for a fixed end-user power requirement as the power factor drops, as well as the additional resistance losses which are incurred:

Power factor	1	0.9	0.8	0.6	0.5	0.33
Relative current	1	1.11	1.25	1.67	2	3
Relative resistance losses	1	1.23	1.56	2.8	4	9

The uncorrected power factor of a typical factory will generally be between 0.6 and 0.85, but for arc welding plant the power factor may be as low as 0.35. Power factor may be improved in various ways, the most common being the installation of capacitors at the main plant transformers or distributed throughout the plant near the major power consuming equipment.

EXHIBIT 6.22

ENERGY CONSUMPTION AND OUTPUT PER EMPLOYEE

	EMPLOYEES	ENERGY CONSUMPTION TEP/EMPLOYEE	OUTPUT PER YEAR, TONNES/ EMPLOYEE
I MATERIALS OF CONSTRUCTION			
Cement			
Ciments Artificiels Tunisiens	650	135	672
Ciments de Bizerte	650	140	1110
Ciments de Gabes	540	117	894
Cimenterie d'om Khelil (1)	511	194	1506
	2351	145	1025
Bricks			
Briqueterie Fouchana	220	39	442
Briqueterie Zarouk	500	34	356
Briqueterie Ali M'Henni	250	34	622
Briqueterie El Hamma	250	28	357
Ceramique de l'Ouest	145	28	382
La Ceramique Tunisienne (Jendouba)	173	22	382
Union Generale (Jemmal)	700	16	N/A
Societe La Brique Tunisienne	96	23	417
Sfax Ceramique	150	16	200
	2484	26	393 (2)
Les Refractaires Tunisie	105	11	43
Glass			
Sotuver	508	36	35
Others			
S.A. de Potinville (lime)	150	23	430
CAT - Tunis (lime)	130	26	431
La Ceramique Tunisienne	278	21	-
Manufacture Tunisienne de Ceramique	283	7	13
El Anabib	1130	2	116
Les Platres Tunisiens de Meknassy	96	5	86
Société Industrielle et Comm.D'Ouvrage	310	4	71
Ciment Amiante Tunisien	150	11	190
II CHEMICALS			
Soc. Tunisienne d'Engrais Chimiques (STEC)	230 (3)	2	305
SIAPE 'A'	570	42	557
Soc.des Indus.Chim. Maghrebines (ICM)	600	24	-
SIAPE 'B'	490	36	853
Granuphos	110	28	545
Soc.Arabe des Eng.Phos.et Azotes (SAEPA)	555	28	928
Engrais de Gabès	75	17	835
Industrie Chimique du Fluor (ICF)	141	36	140
Soc.Tun. d'Oxygene et Acetylene (STOA)	170	16	-

(1) Based on 3 months data, 1981 (2) Subsector average excludes Union Generale

(3) Includes seasonal workers

Exhibit 6.22 continued

	EMPLOYEES	ENERGY CONSUMPTION TEP/EMPLOYEE	OUTPUT PER YEAR TONNES/ EMPLOYEE
III MECHANICAL,METALLURGICAL,ELECTRICAL			
Steel			
El Fouledh	2400	56	74
Others			
Soc. de Materiel Electrique (Chakira)	174	4	16
Soc. Generale Industrie (SGI)	420	1	-
Soc. Metal. et Miniere de Tunis (SMMT)	530	16	36
Le Confort	1000	2	-
Soc.Tun.d'Industrie Automobile (STIA)	1600	1	-
Fonderies Reunies de Tunis	404	2	6
Soc. de Fonderie et de Mecanique	580	4	8
Les Ateliers Mecaniques du Sahel	900	2	-
IV MINING			
Compagnie de Phosphate de Gafsa	13500	11	321
V TEXTILES			
Soc. Indust. des Textiles Reunis	700	9	-
SITEX - Usine de Ksar Helal	970	5	-
Soc. Monasterienne (SOMOTEX)	950	3	-
	2620	5	
VI PAPER			
SN de Cellulose et de Papier Alfa	1700	25	14
VII FOOD PROCESSING			
Dairy			
Tunisie Lait	327	11	-
Soc. Tun. d'Industrie Laitière (STIL)	435	6	-
Baking, biscuits			
Soc. Tun. de Biscuiterie	128	2	17
Pain et Patisserie Ouarda	48	4	-
Sugar			
Soc. Tun. du Sucre	435 (1)	39	139
Drinks			
Soc. Frigorif. et Brasserie de Tunis	970	4	-
Regie des Alcools	56	17	-
Others			
Soc.Tun. de Chocolaterie (SOTUCHOC)	64	5	8
Ali Majoul et Cie	108	7	34
Cooperative Agricole Izidihar	300	4	-
Soc.Tun. de Prod. Alimentaire (STPA)	220	7	336
Les Couscousseries du Sud	69	22	135

(1) Includes seasonal

Exhibit 6.22 continued

	EMPLOYEES	ENERGY CONSUMPTION TEP/EMPLOYEE	OUTPUT PER YEAR TONNES/EMPLOYEE
VIII MISCELLANEOUS			
Soc.Nat. des Pneumatiques (SONAP)	330	8	-
Le Comptoir National des Plastiques	270	6	30

Exhibit 6.23 is a tabulation of power factor data obtained as part of the survey. The overall level of power factor is reasonable, most plants reporting 0.85 or better. However, in spite of the fact that the majority of plants claimed to have installed power factor correction equipment, we would suggest that the economics of capacitor installation be investigated for at least the largest plants. We would expect correction to levels of at least 0.90 should be economic under current STEG tariffs.

6.11 Projected Energy Demands

The plant data were aggregated to produce an estimate of industrial sector energy consumption for 1980: this was reported as Exhibit 6.7. An estimate of sectoral energy consumption may be made for 1986, using annual growth rates for the sub-sectors indicated by the VIth National Plan.

The subsector growth rates for 1980 to 1986 used for the calculation are as follows (see also Exhibit 6.24):

	Annual growth %
Materials of construction	14.5
Chemicals	10.2
Mechanical, metallurgical, electrical	14.3
Mining	4.9
Textiles	9.3
Paper	10.2
Food processing	5.0
Miscellaneous	6.3

Energy consumed in each subsector was compounded at the rates shown to produce a "basic estimate" of energy consumption for 1986.(1) This procedure implies that there is no change in the pattern of energy use in each subsector, and assumes no changes in specific energy consumption. The results of the calculation are presented as Exhibit 6.24, which shows that the total industrial sector demand may be expected to increase to over 2 million TEP/year by 1986.

(1) Provided present energy efficiencies are maintained in existing and new plants.

EXHIBIT 6.23 - POWER FACTOR DATA

	Power factor	Correction equipment	1980 Annual (10^3 kwh) consumption	KVA
I MATERIALS OF CONSTRUCTION				
CEMENT				
Ciments Artificiels Tunisiens (Djebel Djelloud)	N.A.	N.A.	42,031	20,000
Ciments de Bizerte	0.88/0.90	N.A.	72,668	
Societe de Ciments de Gabes	0.95	N.A.	70,362	
Cimenterie oum Khelil*	0.85	YES	23,684 (5)	22,000
BRICKS				
Briqueterie Fouchana	0.87		7,225	2,500
Briqueterie Zarrouk SARL	0.85/0.95	YES	11,519	4,630
Briqueterie Ali M'Henni	0.75/0.84	YES	7,101	2,000
Briqueterie El Hamma	N.A.	YES	3,750	
Ceramique de l'Ouest*	0.7	NO	2,004	N.A.
La Ceramique Tunisienne* (Jendouba) (24)	0.87	YES	2,686	1,200
Union Generale*	0.98	YES	7,473	2,815
Societe La Brique Tunisienne	0.82	YES	2,006	630
Les Refractaires Tunisie*	0.86	YES	1,074	945
Sfax Ceramique*	0.80	YES	1,782	800
GLASS				
Sotuver	0.77	YES	6,114	3,750
OTHERS				
S.A. de Potinville*	0.80	YES	1,064	375
Ciments Artificiels Tunisiens (Tunis)	0.90	YES	1,077	400
La Ceramique Tunisienne* (25)	0.78	YES	2,408	1,030
Manufacture Tunisienne de Ceramique	0.70	YES	1,045	750
El Anabib	0.85/0.95	YES	2,583	1,655
Les Platres Tunisiens de Meknassy*	0.82	YES	527	1,260
Soc. Industrielle et Comm. d'Ouvrage	0.90	YES	2,987	1,200
Ciment Amiante Tunisien*	0.96	YES	3,172	2,000
II CHEMICAL				
Societe Tunisienne d'Engrais Chimiques	0.96	YES	1,322	625
SIAPE 'A'	N.A.	N.A.	38,946 (1)	
Societe des Industries Chimiques Maghrebines	0.90	NO	87,041 (1)	27,500 (1)
SIAPE 'B' *	0.96	YES	45,661 (1)	10,430 (1)
Granuphos	N.A.	N.A.	2,923	1,890
Soc. Arabe des Engrais Phosphates et Azotes*	0.99	YES	96,619 (2)	37,500 (1)
Engrais de Gabes	0.85	YES	1,784	1,600
Industrie Chimique du Fluor (ICF)	0.87	YES	6,119	6,700
Soc. Tunisienne d'Oxygene et Acetylene*	0.80	YES	5,300	3,480
III MECHANICAL, METALLURGICAL, ELECTRICAL				
BASIC STEEL PRODUCTION				
El Fouledh Steelworks	0.82/0.99		115,801 (1)	

Exhibit 6.23 continued

		Power factor	Correction equipment	Annual (10^3 kwh) consumption	KVA
	OTHERS				
	Societe de Materiel Electrique	0.75	NO	1,670	3,345
	Societe Generale Industrie (SGI)	0.82	YES	675	1,250
	Soc. Metallurgique et Miniere de Tunis	0.81/0.85	YES	4,081	1,720
	Soc. Tunisienne d'Industrie Automobile	0.97	YES	1,675	1,750
	Fonderies Reunies de Tunis	0.76/0.82	YES	599	400
	Le Confort S.A.	0.80	YES	2,887	2,510
	Soc. de Fonderie et de Mecanique	0.92	YES	4,699	2,980
	Les Ateliers Mecaniques du Sahel	0.86	YES	3,970	2,500
IV	MINING				
	Compagnie de Phosphate de Gafsa	-	-	101,758 (3)	
V	TEXTILES				
	Societe Industrielle des Textiles Reunis	0.75	YES (4)	330	1,260
	SITEX - Usine de ksar Helal	0.90	YES	7,967	3,020
	Soc. Monasterienne - SOMOTEX	0.81	YES	7,389	3,250
VI	PAPER				
	SN de Cellulose et de Papier Alfa	-	-	65,552 (1)	
VII	FOOD PROCESSING				
	DAIRY				
	Tunisie Lait SA	0.85	YES	5,179	2,040
	Soc. Tunisienne d'Industrie Laitiere	0.80	YES	4,150	1,350
	BAKING, BISCUITS				
	Soc. Tunisienne de Biscuiterie*	0.96	YES	713	715
	Pain et Patisserie Ouarda SARL	No data		74	65
	SUGAR				
	Soc. Tunisienne du Sucre	0.76		6,911	
	DRINKS				
	Soc. Frigorifique et Brasserie de Tunis	0.82	YES	4,511	3,865
	Regie des Alcools*	0.70	NO	186	400
	OTHERS				
	Soc. Tunisienne de Chocolaterie*	0.98	YES	510	1,200
	Ali Majoul et Compagnie*	0.75	NO	441	630
	Cooperative Agricole Izidihar	0.90	YES	459	815
	Soc. Tunisienne de Production Alimentaire	0.80	YES	4,823	1,515
	Les Couscousseries du Sud*	0.80	YES	1,538	630
VIII	MISCELLANEOUS				
	Le Comptoir National des Plastiques	0.85/0.92	YES	4,746	1,250
	Soc. Nationale de Pneumatiques (SONAP)	0.89	YES	2,505	750

* Data for 1981

(1) Includes consumption of self-generated electricity
(2) Net consumption figure: excludes 11,616,100 kwh self-generated but sold to STEG.
(3) Net consumption figure: excludes estimated 25,439,400 kwh consumed by households.
(4) Power correction equipment installed but not in working condition at time of survey.
(5) Data for three months only, October- December 1981

EXHIBIT 6.24 BASIC ESTIMATE OF INDUSTRIAL SECTOR ENERGY CONSUMPTION, 1986 (TEP) (1)

		Elec.	Nat.Gas	Gasoil	FOD	Light F.O	Heavy F.O.	Other	Total	Annual growth rate assumed 1980-86 (2) % p.a.
I	MATERIALS OF CONSTRUCTION	252128	101892	17601	14012	12245	509992	32012	939882	14.5
II	CHEMICALS	35420	53595	1465	3697	220	76471	1719	172587	10.2
III	MECH, METALL, ELEC.	117574	0	1090	13410	4170	50212	183943	370400	14.3
IV	MINING	87656	0	11508	2113	2039	135064	0	238380	4.9
V	TEXTILES	46763	0	0	4285	1118	20565	390	73122	9.3
VI	PAPER	30323	38	227	512	0	48896	0	79996	10.2
VII	FOOD PROCESSING	52762	117	9886	14212	1639	40317	765	119697	5.0
VIII	MISCELLANEOUS	8661	196	254	1627	102	6624	58	17523	6.3
		631287	155838	42031	53868	21533	888141	218887	2011587	11.5
	Weighted average growth,% p.a., for different energy forms	10.8	12.9	9.0	10.0	12.0	11.3	14.3	11.5	

Notes (1) "Consumptions" imply continuing patterns of consumption of energy products (no fuel switching) and no change in specific energy consumption for the different industries (no conservation), hence these figures represent the"basic estimate" for 1986.

(2) Based on the "Note d'Orientation pour la IIIème Decennie de Developpement et le VIeme plan" - Ministere du Plan et des Finances, Novembre 1980. Where not explicitly stated, growth rates assumed: chemicals - manufacturing industry average; mining - non-manufacturing average; paper - manufacturing average; food processing - same as growth rate for agriculture; miscellaneous - overall average for GDP (PIB). Growth rates assumed to apply from 1980 through 1986 (VIeme Plan actually refers to 1981-86)

6.12 Fuel Substitution

The data shown in Exhibit 6.24 may be used to estimate the potential impact of fuel substitution.

The use of coal in industry does not appear attractive if significant quantities of gas can be made available at reasonable prices (from Miskar and other new Tunisian fields or from the Algerian gas pipeline as royalty gas, for example). Coal could be used in the cement plants at Bizerte and Tunis (CAT), but the cements plants at Gabes and D'oum Khelil will presumably use gas or fuel oil. The quantity of coal required for the first two plants mentioned represents a substitution of about 140,000 TEP/year of heavy fuel oil for coal. Coal use in the rest of the subsector is unlikely to be attractive, as most of the plants are relatively small consumers.

We would not expect significant switching to coal in the chemicals, mechanical and mining sectors, nor in the paper sector. We would estimate a potential use for coal for boilers in the textiles sector and food processing amounting to around 5,000 TEP (currently heavy oil fired) and 15,000 TEP (currently provided by heavy fuel oil, light fuel oil and FOD) respectively.

The total coal-firing potential for industry is thus perhaps 160,000 TEP to 200,000 TEP by the mid-to-late 1980s, or about 7 to 10% of total industrial sector energy use; it is unlikely to be much greater.

The use of renewables in the industrial sector is not promising in the period up to 1986. A small contribution from solar heating of boiler feed water is possible, but we believe most installations will be set up as tests or technology demonstrations. A serious contribution of this technology to industrial energy use is unlikely before the 1990s.

With respect to photovoltaic and wind-generated electricity, this is believed to be too costly for serious consideration by industry until the mid-1990s or later.

Biomass is already used by some plants (e.g. grignons d'olives) but a significant increase in its use is not likely. There is, of course, a significant use of wood and charcoal in Tunisia, and it is probable that much of it is used in small-scale industry such as bakeries. No reliable data are available on such consumption.

Natural gas is the most obvious option for fuel switching in the industrial sector. An estimate of the potential gas consumption by industry may be made as follows:

I Materials of Construction. The biggest consumers are most likely to find switching to gas is economically attractive and can expect to have a suitable gas distribution system installed, although in principle most of the sector could use gas on technical grounds. Assuming however that only the largest cement plants and brickworks convert, we estimate a switch of 80% of the subsector would be realistic, amounting to 408,000 TEP of gas (assumed to replace 408,000 TEP of heavy fuel oil).

II Chemicals. We judge that 90% of the heavy fuel oil use could be switched to gas assuming a reasonable extension of gas distribution systems: this amounts to a switch of 69,000 TEP from tne "business as usual" case.

III Mechanical/electrical. The major heavy oil consumers are Le Confort and El Fouledh. We assume these could convert 100% to gas and that new plants will adopt gas (50,200 TEP).

IV Mining. We assume 90% of the heavy oil used by this sector could be converted to gas (121,600 TEP).

V Textiles. We assume 65% of the heavy oil used in the sector could be converted to gas firing, with much of the rest being subject to coal conversion or the use of municipal waste for boilers (13,400 TEP).

VI Paper. The plant representing most of the sector (Kasserine) could be converted entirely to gas firing (48,900 TEP).

VII Food Processing. Here we assume only the largest consumers will find gas conversion economically attractive. Based on the plant survey, we estimate 80% of the heavy fuel oil used in the sector will be "convertable" (32,200 TEP).

VIII Miscellaneous. Here we assume that most consumers are small enterprises and gas conversion on a major scale is not likely.

We have implied in our assumptions that large existing energy consumers will find gas conversion to be economic, while most new plants will adopt gas also. The rate of installation of new gas distribution networks will obviously be an important factor, in addition to the price of natural gas itself,either from the Algerian gas pipeline or from the development of new Tunisian gas fields. Our estimates for the potential gas demand in 1986 are therefore considered to be somewhat optimistic, representing a vigorous gas conversion program for large energy users. We have assumed that most users of FOD and light fuel oil will not find gas conversion attractive.

Our natural gas and heavy fuel oil projections are therefore as follows:

	Potential 1986 demands (10^3 TEP)	
	Natural gas	Heavy fuel oil
Materials of construction	509.9	102.0
Chemicals	122.6	7.5
Mechanical/electrical	50.2	0
Mining	121.6	13.5
Textiles	13.4	7.2
Paper	48.9	0
Food processing	32.3	8.1
Miscellaneous	0.2	6.6
	899.0	144.9
("Business-as-usual"	155.8	888.1)

The new gas market is about 824,000 TEP, the present consumption of natural gas by industry being about 75,000 TEP. Of course, these projections assume that energy efficiencies are not changed from existing levels for existing or new plants. An approximate estimate of the possible additional gas consumption by industry and STEG (which may be high because energy efficiencies should in fact improve) is thus:

	Million TEP
Industry	0.824
STEG	1.400
	2.224

The STEG figure is based on 100% conversion from existing fuel oil use and the use of gas for all new plants. Existing gas use by industry and STEG is about 0.5 million TEP, taking the total potential usage by 1986/87 to about 2.7 million TEP. The availability of natural gas is likely to be about 3 million TEP:

	Million TEP
Algerian royalty gas	1.0-1.1
Miskar gas	1.0-1.2
Other Tunisian gas fields	say 1.0
	3.0-3.3

Thus industry and STEG could account for the bulk of the gas available, leaving a relatively small amount for residential and commercial sector use. Industry itself would then rely on gas for almost 45% of sectoral energy consumption, as opposed to 7% at the present time.

6.13 Potential for Energy Conservation

Discussion of the potential for energy conservation has already been presented in connection with the data for specific energy consumption. A review of the few questionnaire responses shows that the efforts already made or planned by plants are not likely to lead to significant energy savings. However, some companies have taken action since the training program was initiated, and it is to be hoped that some of the largest plants will achieve major savings over the next year or so. A summary of actions taken to date appears in Exhibit 6.25.

The potential for improved energy efficiency obviously varies from plant to plant. In the relatively short period of time available to conduct the plant audit work and to examine existing records of energy consumption data, it was clearly not possible to examine all aspects of energy use in sufficient detail to calculate potential savings with any accuracy. However, as a review of the various plant audits will indicate, typical improvements in energy efficiency of 15 to 20% should be achieved on average within two years, through a combination of improved energy management (savings say 10 to 15%) and capital investments (savings say 5 to 10%). As a general rule, measurable improvements will be the result of the accumulated effort of many small actions, rather than the result of one or two spectacular major capital investments, and thus the improvements must be expected to come steadily over the first year or two. Estimates of the potential for conservation in the various subsectors are given in Exhibit 6.25.

EXHIBIT 6.25 ACTIONS TAKEN AND POTENTIAL FOR CONSERVATION

Actions resulting from the project	Potential for Conservation in Existing Plants (1)(2)	
	Impact by 1986 (3)	Longer term impact
MATERIALS OF CONSTRUCTION - CEMENT M. Haj Yania appointed Energy Mgr. at Ciments de Bizerte; data analyses improved.	Fuel: 5% generally, 20% at CAT Elec.: 5% overall	- same -
MATERIALS OF CONSTRUCTION - BRICKS M. Jenni appointed Energy Mgr. for SOTIMACO group; improved system of monthly reporting and monitoring of progress against targets.	Fuel: say 30% (up to 20% from scheduling, 10%+ from housekeeping) Elec.: 5%	Fuel: 35-40% (invest in ceramic fibres for kiln insulation, heat recuperation, etc.) Elec: 10%
MATERIALS OF CONSTRUCTION - GLASS -	All energy forms 15%	20-25%
MATERIALS OF CONSTRUCTION - OTHER -	All energy forms 10%	20%+
CHEMICALS -	Detailed audits needed - say 10%	20%+
MECHANICAL M. Mili appointed Energy Mgr. at El Fouledh Will undergo training course Sept-Nov 1982. Studies made on conservation potential on furnaces in rolling shop (confirming 20% savings of project audit). Economics to be studied	Steel - say 20% throughout Others - 10% for all energy forms	30%+ 20%+
MINING Planning to set up energy management group, to improve data collection and analysis. For plants audited briefly in this project, plan to conduct detailed studies; for other "laveries" plan to initiate first audits. Planning also to study water content in phosphate product and its energy (and other) implications, including - for example - losses in transport.	Fuel - 15% Elec - 5%	Fuel 25% Elec 15%
TEXTILES -	Fuel - 10% Elec - 5%	Fuel 15% Elec 10%
PAPER SNCPA management trying to recruit new graduates specifically for training in energy management. M. Baccari to be responsible for energy matters, including setting up program to study energy-related problems. He will attend training course Sept-Nov.	Fuel - 20% Elec - 10%	Fuel - 30% Elec - 20%
FOOD PROCESSING -	Fuel 10% Elec 5%	Fuel 20% Elec 10%
MISCELLANEOUS -	All energy forms 10%	15-20%

Notes
(1) Based on comparisons of specific consumptions with international data, on plant visits, and on questionnaire responses
(2) Gasoil savings are taken as 5% throughout.
(3) Assumes a vigorous program of housekeeping (energy management) and moderate investments in insulation, instruments, etc.

For the seven plants already audited, reports have been prepared which include specific recommendations for improving plant operating efficiency by housekeeping measures and for capital investments where appropriate. These recommendations show where detailed engineering studies are justified, since the audit reports themselves do not present precise solutions for all the problems encountered during the visits.

Based on the estimates made of conservation potential for each subsector, the projections of energy consumption in 1986 shown in Exhibit 6.24 may be modified to reflect a "vigorous conservation" scenario. The results are presented in Exhibit 6.26, which indicates that industry demand could be cut by about 13% compared with the "business-as-usual" case in Exhibit 6.24, resulting in a total consumption of about 1.7 million TEP/year.

By "vigorous conservation", we mean a major program of housekeeping and energy management improvements in essentially all the existing plants, and investment in all conservation measures showing reasonable payback periods (say 3 years or better). For new plants, we imply a thorough examination of design parameters and the incorporation at the design stage of cost-effective energy-saving measures using proven technology. For example, we would expect heat exchangers to be installed to a much greater extent than normally seen in standard designs from contractors, who will often bid for a turnkey project on the basis of lowest capital cost to the customer. It has to be understood by customers that energy efficiency in new plants requires additional capital expenditure, but that the extra investment can be fully justified by lower operating costs. Exhibit 6.26 therefore includes the effect of an improvement in energy efficiency of 15% for new plants, which we believe is a conservative figure.

The figures in Exhibit 6.26 present a difficult challenge for Tunisian industry. The efforts required to achieve the savings suggested in the Exhibit are significant: energy management will have to be improved greatly throughout the sector, and many major capital investments will be necessary. The economic attractiveness of retrofitting energy efficiency improvement measures will have to be presented clearly to company managements: experience in other countries shows that the payback period for many of these investments is usually very short, but management may only be convinced of this with difficulty. For example, the audits conducted in this project have indicated the attractiveness of a number of capital investments, and

EXHIBIT 6.26

INDUSTRIAL SECTOR ENERGY CONSUMPTION, 1986

ESTIMATE BASED ON "VIGOROUS CONSERVATION"

Consumption 10^3TEP	ELEC.	NAT.GAS	GASOIL	FOD	LIGHT FO	HEAVY FO	OTHER	TOTAL	SAVINGS %
MATERIALS OF CONSTRUCT.	225.4	90.3	15.8	12.3	9.6	433.3	27.2	813.9	13
CHEMICALS	31.2	47.2	1.3	3.2	0.2	67.5	1.5	152.1	12
MECH/MET/ELECTRICAL	99.5	0	0.9	11.3	3.7	41.5	152.3	309.2	17
MINING	82.1	0	10.8	1.8	1.7	114.8	0	211.2	11
TEXTILES	42.9	0	0	3.8	1.0	18.2	0.4	66.3	9
PAPER	26.8	0.1	0.2	0.5	0	40.0	0	67.5	16
FOOD PROCESSING	49.4	0.1	9.3	12.4	1.5	36.0	0.7	109.4	9
MISCELLANEOUS	7.7	0.2	0.2	1.5	0.1	5.9	0.1	15.7	10
TOTAL	565.0	137.8	38.5	46.8	17.8	757.2	182.2	1745.3	13
SAVINGS BY ENERGY TYPE, %	11	12	8	13	17	15	17	13	

Notes

1. Assumes existing plants consume approximately 15% additional energy above 1980 levels due to operation at near maximum capacity.

2. Assumes no fuel switching from current use patterns.

3. Assumes new plants designed to achieve energy efficiencies 15% better than current efficiencies.

a high priority should therefore be given by the Government of Tunisia to conducting comprehensive engineering and economic feasibility studies to provide the necessary justifications on which investment decisions may be based.

Nevertheless, the "vigorous conservation" implied by these savings may well take longer than 1986 to be fully realised. We therefore suggest that a more realistic scenario be taken for estimating the probable impact of conservation by 1986:

(1) Strong efforts are made in the largest of the existing plants to improve energy management (in all 60 plants covered by the survey, for example) and these efforts are 70% successful by 1986.

(2) About 50% of all minor capital investments which are economically justified (such as adding insulation to lines and tanks and upgrading the standard of instrumentation generally) are effected in existing plants.

(3) About 50% of all major capital investments with payback periods of say 3 years or better are effected in existing plants.

(4) New plants are offered with energy efficiencies 15% better than the current efficiencies observed in the Tunisian industrial sector ("standard designs" provided by the contractors) and no further improvement is achieved. This technical improvement will occur through the normal competitive pressures of the market place.

The quantitative benefits of savings obtained under this scenario may be estimated as follows, assuming that existing plants are operated close to full capacity(1):

	1986 consumption for BAU	Housekeeping savings (2)		Investment savings		Design savings	
	10^3TEP	%	10^3TEP	%	10^3TEP	%	10^3TEP
Existing plants	1,200	6.0	72	2.2	26	-	-
New plants	812	-	-	-	-	15	122
Total	2,012		72		26		122

(1) We have assumed that existing plant would use about 15% more energy than in 1980 for the BAU case.

(2) Potential savings estimated to be 8.5% for housekeeping and 4.5% for projects requiring investment (total 13%). Of these savings, 70% of the housekeeping (6%) and about 50% of the investment savings (2.2%) are actually achieved.

The total industrial sector energy consumption is therefore expected to be reduced from 2,012 to 1,792 thousand TEP per year (11%).

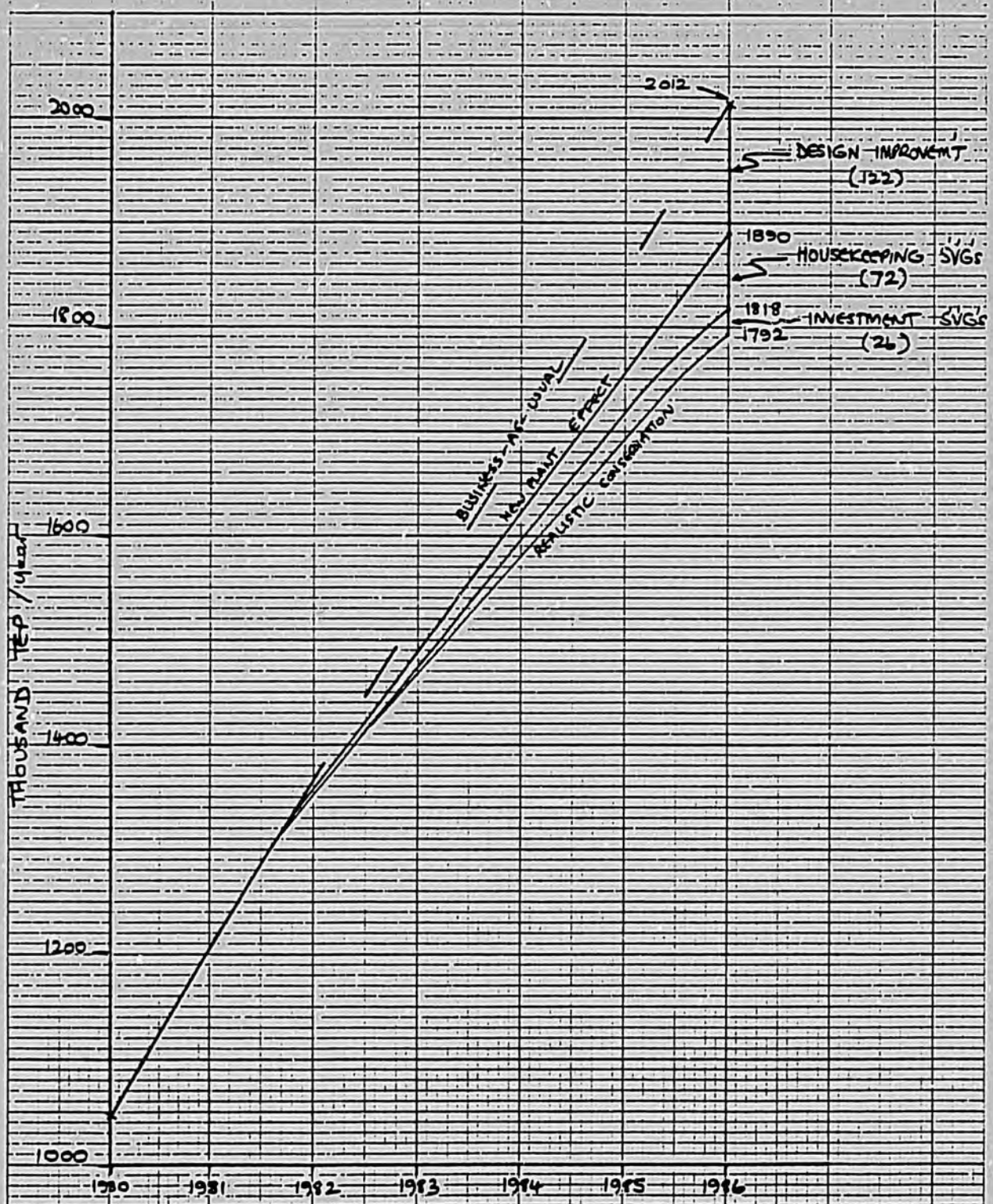
It is important to note the large contribution to the savings from improved energy efficiency in new industrial plants. A simple calculation shows that, at a growth rate of only 8% per year for new plants and a retirement rate of 1% for old plants, about 60% of the output of the industrial sector would be provided by new plants within ten years, and over 80% within twenty years. The energy efficiency of new plants is therefore always a very important element in the industrial sector energy situation, and must play a part in long-term planning at the national level.

The savings mentioned above are illustrated graphically in Exhibit 6.27, and an estimate of the rate at which savings are accrued is included. Excluding new plant design improvements, the cumulative savings for the conservation in existing plants shown in Exhibit 6.27 are about 234,000 TEP over the period 1982 to 1986:

	BAU after new plants effect 10^3 TEP	Realistic conservation 10^3 TEP	Savings 10^3 TEP
1981	1,207	1,207	0
1982	1,360	1,352	8
1983	1,490	1,468	22
1984	1,622	1,580	42
1985	1,756	1,692	64
1986	1,890	1,792	98
			234

Of this total, about 159,000 TEP can be attributed to housekeeping and 75,000 TEP to capital investments. The cumulative savings are valued at 25 million dinars at world energy prices. Assuming an average 1.5 year payback period for the conservation measures requiring investment, a rough estimate of the total investment needed to achieve the savings indicated is about 12 million dinars over a period of about 4 years (1983-1986).

Exhibit 6.27 PROJECTED DEMANDS



The cumulative savings of 234,000 TEP and continuing savings of at least 100,000 TEP per year are considered attainable through reasonable efforts in existing plants and should be viewed as challenging but realistic targets for the industrial sector in the short term. Indeed, vigorous conservation efforts in existing plants, coupled with special efforts to ensure new plants meet the best possible levels of energy efficiency justified by world energy prices, could result in significantly greater savings being achieved in the mid- to late 1980s. The resources in terms of manpower and equipment which can be justified by the 25 million dinars accumulated savings are clearly substantial.

6.14 Energy Management in the Plants

A key factor in the achievement of the energy savings discussed in the previous section will be the performance of management at the plant level. We strongly recommend the appointment of energy managers in all plants to provide a focus for energy efficiency programs. Wherever possible, we believe the energy manager should be a full time position: certainly a full time manager can be justified for many of the large plants visited during the survey.

The precise duties of an energy manager will depend on the size and type of organization in which he works, but they will include some or all of the following:

(a) To generate interest in energy conservation and sustain the interest with new ideas and activities.

(b) To maintain summaries of energy purchases, stocks and consumption, and to review and report on energy utilization regularly.

(c) To be the focal point for departmental records of energy use, and to ensure that the records and accounting systems are uniform and in consistent units.

(d) To co-ordinate the efforts of all energy users and to set challenging but realistic targets for improvement.

(e) To give technical advice on energy-saving equipment and techniques, or to identify suitable sources of sound technical guidance on specialised subjects.

(f) To identify where major energy waste is occurring, to quantify the losses in physical and financial terms, and to develop practical recommendations for reducing them (including studies of economic viability).

(g) To identify areas of plant activity which require detailed study and to give priority to such activities.

(h) To maintain records of all in-depth studies and to review progress.

(i) To provide a basic handbook of good energy practice for the plant operating department.

(j) To give specialist advice to purchasing, planning, production and the other functions on all aspects of energy conservation, especially on the long term implications.

(k) To ensure that, in making improvements in energy efficiency, health and safety are not adversely affected.

(l) To liaise with committees and working groups within his own industry and, provided no confidential data are involved, to exchange ideas on cost-cutting techniques and performance figures for similar processes.

(m) To maintain contacts with research organizations, equipment manufacturers and professional bodies to ensure that he is up-to-date on significant developments in the field of energy conservation.

To enable energy managers to carry out such responsibilities, some training in energy conservation is suggested. Energy managers, who should be recruited from plant engineers with practical knowledge of the manufacturing processes, should receive a minimum of a basic one-week training in conservation principles, the practical aspects of plant energy audits, and other elements of energy management such as the economic evaluation of capital investments in energy efficient equipment. The Government of Tunisia may wish to consider defining a basic curriculum for the training course and setting up a "certification" procedure for industrial energy managers as a means of ensuring certain minimum qualifications and competence for the job.

In conclusion, the Government of Tunisia should encourage plants to appoint energy managers who will initiate plant-level programs to improve energy efficiency. Without a major effort to focus attention on energy problems, an effort in which energy managers have a key responsibility, the undoubted potential for conservation in Tunisian industry cannot be realized.

7 RECOMMENDATIONS FOR DATA COLLECTION

7.1 General Remarks

As discussed in Section 2 of this report, comprehensive data are essential for energy planning at the national level. The data obtainable from INS are often aggregated to a level which makes them of little value for energy planning at the subsector level. The highly detailed annual survey carried out by INS produces comprehensive data too late for practical use in planning or for monitoring industrial sector energy efficiency in a timely way which would allow conservation policies to be put into effect or modified in response to the actual situation in industry.

It is therefore recommended that a regular annual report be obtained from major energy consumers, thus providing information on energy consumption and production levels suitable for energy planning purposes. It is also recommended that reports be obtained from the distributors of petroleum fuels and STEG on their sales of energy products to the industrial sector.

7.2 Annual Report from Industrial Plants

It is recommended that a concise annual report be requested from all companies in the industrial sector. Lists of such companies may be obtained from INS, who regularly conduct surveys for all enterprises with 10 or more employees. Initially, it may be desirable to restrict the annual reporting exercise to companies with say 50 or more employees, in order to set up and test the data collection and analysis system with fewer companies than the full 2000 to 3000 which are known to operate in the industrial sector.

The annual report should be a mandatory requirement for companies: the necessary legislative backing should therefore be enacted on the initiative of the Ministry of National Economy.

The report should include energy and production data in the format shown in Exhibit 7.1. To be of use for planning purposes, the data should be collected promptly each year: we suggest April 1 as a deadline. The report should be completed by a specific person nominated by the factory, preferably the energy manager where such an appointment has been made. The nomination of a specific individual is desirable in order to encourage the appointment of an energy manager or energy coordinator by the plants. The annual report should be signed by the managing

director of the company (PDG), who is thereby encouraged to review the energy consumption data provided by his plants. We would recommend that the report contain a simple calculation of the plant specific energy consumption, which should bring energy efficiency to the attention of all concerned. Reports should be verified on a random sample basis by conducting brief visits to the selected plants.

7.3 Annual Report from Distributors

A simple form should be completed by the distributors of petroleum products using data which are readily available from their records. The distributors were extremely cooperative in providing information for this project. It is, of course, essential that proper confidentiality be maintained. The distributors in question are:

Shell	SNDP
Esso	STIR
Mobil	BP(1)
Fina	Mory(1)
Total	

A recommended format for the petroleum fuels distributors report is shown in Exhibit 7.2.

Data on natural gas and electricity sales should be requested from STEG; the data provided for this project was readily obtained from STEG records. A form for gas sales to industrial consumers is shown as Exhibit 7.3, while the data for electricity sales can be obtained from STEG computer records by aggregating the consumptions of individual customers and classes of customers (see Exhibit 7.4).

7.4 Assembly of Data

The collection and analysis of data should be carried out by the industrial sector group currently attached to the Ministry of National Economy. It should be possible to produce a full report of industrial energy consumption for the previous year by about August 1 of each year; the use of electronic data processing is recommended in future in order to speed up the collection of data, to ensure accuracy is maintained, and to allow easy access to the records for the purposes of analysis.

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(1) These distributors do not normally sell fuels to enterprises for use in manufacturing industries.

EXHIBIT 7.1 PLANT INDUSTRIAL REPORT

Calendar year [ ]

Control No. [ ]

ANNUAL ENERGY REPORT
to the MINISTRY OF NATIONAL ECONOMY

Plant Name _____

Address _____

_____

Industrial subsector _____

Number of employees _____

Person preparing this report

Name _____

Position _____

Telephone _____

Signature _____

I confirm that this report presents accurate data on the energy consumption of the plant named.

Signed _____ (PDG)

Name _____

PRODUCTION

Main product _____

Production (B) _____ units _____

Value of production _____

Energy form	Units	Amount consumed	Energy expressed in TEP	Unit cost	Cost in Dinars
Purchased electricity					
Natural gas					
Town gas					
Coal					
Charcoal					
Wood					
Coke					
LPG					
Petrole lampant					
Gasoil					
Domestic fuel oil					
Light fuel oil					
Heavy fuel oil (No.2)					
Others (specify)					
_____					
_____					
Total			(A)		
Self-generated electricity					

SPECIFIC ENERGY CONSUMPTION

Total energy consumed (TEP) = (A)_____ = _____(C)
Production (-units) (B)

Previous years figure _____(D)

Change since previous year = $\frac{(D)_____ - (C)_____}{(D)}$ x 100 = _____%

NARRATIVE SECTION	Page 3 of 3
(A) Remarks on energy used and specific consumption figures. Include description of any plant newly commissioned or shut down during the year.	
(B) Actions taken towards improving energy efficiency and results achieved (quantified)	
(C) Actions planned in relation to improving energy efficiency	
(D) Describe any targets set for improving energy efficiency next year.	

EXHIBIT 7.2 DISTRIBUTORS REPORT

SALES OF ENERGY PRODUCTS TO INDUSTRIAL ENTERPRISES

Company name _____ Control Number _____

Address _____

Person preparing report

Name _____ Title _____

Signature _____ Telephone _____

Number of customers	Subsector/industry	LPG tonnes	Gasoil litres	FOD M^3	Light Fuel Oil tonnes	Heavy Fuel Oil tonnes	Others (specify)
	Mat. of Construction - cement - bricks - glass - other						
	Chemical industry						
	Mechanical/metallurgical/ electrical						
	Mining						
	Textiles						
	Paper						
	Food processing - dairy prod. - baking - sugar - drinks - all others						
	Miscellaneous						
	Totals						
	Calorific value upper lower						

EXHIBIT 7.3 GAS REPORT

SALES OF GAS TO INDUSTRIAL ENTERPRISES Control No._____

Department_____(STEG)

Address _____

Person preparing report

Name_____ Title_____

Signature_____ Telephone_____

Number of customers	Subsector/industry	Natural gas Nm^3	Town gas Nm^3
	Mat. of construction - cement - bricks - glass - others		
	Chemical industry		
	Mechanical/metallurgical/electrical		
	Mining		
	Textiles		
	Paper		
	Food processing - dairy products - baking - sugar - drinks - all others		
	Miscellaneous		
	Totals		
	Calorific value - upper - lower		

EXHIBIT 7.4 EXAMPLE OF STEG COMPUTER PRINT OUT

LISTING-CES ABONNES MT PAR ACTIVITE ECONOMICLE

PERIODE (01/80,12/80) EMIS LE 15/02/82

CECP	UR	FEF	NOM	AE	TR	T.A	P.STE	P.TR	TR1/JOUR	TR2/POINTE	NUIT	TC1/KWH	TOTAL	MS
1	72	415560	SONDAGE-LAMPES AI	C1	01	030	50	80	664270	47961		732231	23553311	12
2	71	440017	LES-CULTURES DE NASSEN	01	01	03C	80	315	233525	124783		358308	11360773	12
3	61	1[illegible]	MR-DECHIK KOLIKA	C1	01	03C	160	160	168112	14086		182198	6433003	11
4	75	415560	POMPAGE H.	01	01	030	50	125	143209	22801		166010	6000717	12
5	62	111CC1	FERME-LAMRI MOHNAG	01	04	03C	9	40	95288		44705	139993	3886105	12
6	76	230135	BELLASSEN-KAROLI ET SALAH	01	01	03C	80	80	78693	42812		121505	4035211	12
7	73	2[illegible]	KAFTI-FEBAI	01	04	030	24	80	64005		54812	118817	2976743	12
8	70	2[illegible]	STATICK AVICOLE	01	03	03C	55	80	37255	18375	55813	111447	3389578	12
9	62	1111[illegible]	MR-MOHAMED HAMZA	C1	01	030	20	40	71541	28892		100433	3530845	12
10	73	440128	DCCIJR-NACLAL FOLYE KHLECIA	01	01	03C	100	160	75775	4583		80358	3015157	12
11	73	440155	MONSIEUR-MUSTAPHA D ZAZIA	C1	01	030	80	100	55262	16014		71276	2506520	12
12	60	114C33	PLE-ICCUT-IR ELTCHEFI	C1	01	030	125	160	65661			65661	2398060	4
13	71	4[illegible]12	MR-FERID-AKKOUT KOLIE MC 34	01	01	03C	50	80	43511	19875		63386	2114963	12
14	73	44[illegible]13	MR-MOHAMED HADLAI	C1	03	030	5	125	25440	9210	22580	57630	2205508	12
15	75	412[illegible]	L.C.P-MAKJA 2 RTE DE JENDOUBA	C1	01	03C	50	63	39743	17421		57164	1865352	12
16	69	1CC5CC	FERME-BELLALOUNA	C1	01	03C	10	63	24193	21121		45314	1541295	12
17	62	1111[illegible]	LES-VERGERS DE TUNISIE	01	01	03C	50	80	32510	11775		44285	1566860	12
18	73	440[illegible]	MR MOHAMED HARBEGLE	01	01	030	15	40	32663	7871		40534	1523735	12
19	75	412[illegible]	FERME-BEDI-KHELIL	C1	01	030	25	40	25041	15213		40314	1257112	12
20	74	46[illegible]	FERME-SLI BEN CHIBELO	C1	01	030	50	80	33503	4929		38432	1366197	12
21	73	2[illegible]	TIJANI-GRIRA	01	01	03C	30	40	31675	6125		37800	1308186	12
22	74	4C[illegible]	PID-CCKAINE DE THIBAR	C1	01	005	25	40	28381	9066		37447	1265577	12
23	70	24C2[illegible]	LES-FRERES DAMRI	01	03	030	25	40	27176	2693	4262	34131	1433747	12
24	63	2[illegible]	SIECE-DE-L OMMAN	C1	01	030	125	125	30092			30892	1408317	12
25	73	2[illegible]	JARAK-JARECUK	C1	01	030	70	80	27909			27909	1112461	8
26	71	411[illegible]	FERME-MOHAMED TELILI	01	01	030	60	100	26720	678		27398	1101742	12
27	73	2[illegible]	MOHAMED-BOUJEMAA	01	01	03C	60	125	19520			19520	811541	12
28	62	111[illegible]	FERME-LAOULATLI KHALED	01	01	030	20	63	12292	3006		15258	532648	12
29	73	2[illegible]047	FERME COUSSET EL BEY	01	01	030	25	40	13148	1816		14964	550286	12
30	70	2[illegible]	IMPRIMERIE CHAMMI	01	01	03C	100	125	14891			14891	1093436	12
31	71	44[illegible]	MME-FATICA FERCHICHI	C1	01	030	20	40	10561	3567		14128	485548	12
32	62	1110[illegible]	FERME-RANDAOUI KM 18 RTE DE	01	01	03C	10	25	10767	2643		13410	465902	12
33	73	41C[illegible]	FUJA-JABARKA CENTRE JENDOUBA	01	01	C3C	25	40	11552	501		12053	463846	12
34	62	114[illegible]	AHMED-LAOULATLI	01	01	030	40	40	11462	881		12343	483432	12
35	61	114[illegible]	MR-SAIF-GLISSI	C1	01	C3C	120	125	12127			12127	642904	12
36	71	44[illegible]	FERME-LAMRI	01	01	030	9	40	8686	2998		11684	385676	12
37	75	412[illegible]	L.C.P-FERME ZMAKZA I	01	01	030	60	80	11580			11580	482704	12
38	77	21[illegible]	POMPINIERE E.P.O.A MABELL	C1	01	03C	50	63	9931			9931	503656	12
39	73	2[illegible]	FERME RHEZIYA	C1	01	03C	25	25	9468			9468	385030	12
40	70	23C[illegible]	FERME MEC SALAH BEN AMOR	01	01	03C	30	40	9269			9269	371008	12
41	71	44[illegible]	LCP-2 FERME OUCHNA ROUTE DE	C1	01	03C	20	25	9060			9060	352568	12
42	70	2[illegible]	FERME-ESSEGHAIR	C1	01	030	10	25	7099	1447		8546	301595	12
43	70	23C[illegible]	FERME KHAIS EL KHAZMI	01	01	030	25	25	7949			7949	322830	12
44	61	1[illegible]	FERME JADID TRADELSI	C1	01	030	15	25	7729	167		7896	304168	12
45	70	23C[illegible]	MR ALI FERCHICHI	C1	01	030	25	25	7695			7695	318148	12
46	94	E[illegible]	STIL OLED EL MALAH KEBILI	C1	01	03C	16	40	7667			7667	301264	12
47	60	1C[illegible]	COCEDLE	01	01	010	70	70	7418			7418	375987	7
48	77	2[illegible]	COMAINE CHADLAOI	C1	01	03C	60	63	7395			7395	363068	12
49	71	41[illegible]	COOPERATIVE REG PETCCULTURE	01	01	03C	80	80	7213			7213	587194	12
50	62	111[illegible]	FERME CHEDLI TELILI	01	01	03C	10	40	5101	66		5167	334185	12
51	62	111[illegible]	MOHAMED MERBEGUE	C1	01	03C	60	63	5093			5093	287358	11

KWH

Best Available Document

8 RECOMMENDATIONS FOR FUTURE WORK

8.1 Program Objectives and Philosophy

The potential for energy savings in the industrial sector has been shown to be very large indeed by the current project. An estimate of the cumulative savings through to 1986 resulting from a moderately successful conservation program suggest a figure of 25 million dinars should be attainable. Aggressive conservation efforts should be even more successful. In order to realise the potential savings available, the Government of Tunisia needs to create a permanent industrial energy conservation capability in Tunisia, including an ability within the private sector to conduct audits and implement recommendations.

Some steps have been taken by the Ministry of National Economy to maintain the momentum and interest created by the current program. These steps include the formation of a small industrial conservation group within the Ministry and the continuation of training for about three or four engineers over a period of several months. However, the attainment of energy conservation savings cannot rely solely on a technical approach: the development and implementation of effective government policy must be given its due priority, in conjunction with the technical work. In addition, the issue of motivation (which was not studied within the current project) will be a critical element in the attainment of worthwhile savings, and this, together with the question of incentives at the plant level, should be studied for a cross-section of Tunisian industry.

We therefore recommend that the Government of Tunisia set up a permanent industrial energy conservation program with the following basic objectives:

- To encourage and assist industry to use energy more efficiently through improved operating practices and through investment in new equipment when such investment is economic in the national interest.

- To support energy policy development in Tunisia through creating and maintaining an industrial energy data base, to be used for monitoring energy conservation progress for planning purposes and for the analysis of policy options.

In order to define an effective program, it is necessary to understand the major characteristics of industrial energy conservation. Firstly, companies need an incentive in order to take action. In general, energy policies such as the implementation of energy tariffs based on world market prices and the withdrawal of subsidies provide much of the necessary incentive. Secondly, companies must have the means to identify and quantify potential energy savings. Thirdly, there must be the means to implement improved operating procedures and equipment changes.

Tunisia is already moving to increase industrial energy prices and continued upward price movements will help to create a receptive climate for conservation activities. A further key to conservation progress in Tunisia is the identification of potential improvements. As improvements are identified, greater emphasis will be placed on implementation. National energy policy must therefore recognize the priorities which should be given to identification and implementation.

It can be argued that high energy prices are sufficient encouragement for industry to take the initiative in energy conservation. However, many industrialized countries (e.g. France, U.K., West Germany, Sweden) have concluded that further intervention is required to stimulate conservation activity. Government intervention can include the provision of audit services (either directly or indirectly by grants for private sector consultants), the funding of new technology development, demonstrations of conservation technology, publicity, training, assistance with investment in new equipment, and regulatory measures. In all cases, the purpose of government intervention is to accelerate the rate at which conservation improvements are made.

A recent report on investment in industrial energy conservation in the U.K.(1) shows that the problems observed in Tunisia are by no means unique. The report found that methods of measuring energy in many U.K. firms were inadequate and very few had implemented the full variety of possible conservation measures. The potential exists to save 14% of current energy use by U.K. industry with projects offering 3 year paybacks or less. The report confirms that there is a gap between the potential for profitable energy conservation measures and the measures that are actually being undertaken. Three main barriers to conservation are quoted:

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(1) The "Armitage Norton" report for the U.K. Department of Energy, 1982 (unpublished: summary given in "Energy Manager", September 1982, page 5)

(1) The knowledge barrier. Many U.K. companies have not recognized many technically possible and financially attractive opportunities for energy savings,and have made little use of the sources of information and advice that are available.

(2) Energy management and motivation. There is clear evidence that the companies with the most sophisticated energy management systems have made the most progress. The effect on management attitudes of even the simplest energy monitoring and target setting system is particularly noticeable.

(3) Capital budgeting. The financial appraisal of conservation investments is often crude, based on short payback periods which ignore many of the special features of energy conservation investments such as long life, low risk, and savings linked to fuel price inflation.

The report recommends several actions for the U.K. government, including improved publicity redirected to increase top management's interest in energy conservation, extended training programs for management on the potential benefits of conservation, promotion of energy technology demonstrations, and vigorous promotion of government-sponsored projects for monitoring energy use and setting energy efficiency improvement targets. A definite responsibility for the government is seen for the stimulation of energy conservation and the achievement of significant savings for the nation.

The philosophy of the overall program recommended for Tunisia is also that of positive government intervention. Based on the work already carried out, it is clear that most companies do not have the data collection and analysis procedures and the trained personnel necessary for the identification of conservation opportunities. Specific training in audit work will thus be necessary for selected engineers. In addition, the country does not possess an active energy conservation capability amongst private sector contractors and consultants. The Ecole Nationale d'Ingenieurs de Tunis has recently introduced engineering courses which place emphasis on energy subjects, but it appears that many of the initial group of graduates will take up positions which are unlikely to have a direct involvement in energy conservation. Promoting energy awareness, particularly at the college level, is an appropriate area for government assistance. This support for industry, combined with a realistic energy pricing policy and the provision of financial assistance to companies wishing to invest in energy efficiency improvements, should result in measurable savings of energy within one or two years.

Within this context, the proposed activities of an "Industrial Energy Efficiency Group" are described below. The emphasis is placed on data analysis and the development of appropriate national energy policies which will provide the essential incentives for the public and private sectors to implement conservation actions and to maintain higher energy efficiency.

8.2 Organization and Responsibilities

We recommend that the Industrial Energy Efficiency Group be divided into two sections, each with up to 5 engineers and technicians with industrial experience, and preferably some experience of energy analyses. Some training may well be necessary for the group members. Two section leaders should be appointed, one for the "Technical Section" and the other for the "Policy and Analysis Section". Initially we would suggest a start be made with no more than four engineers and one technician, and that the activities of the group be limited at the beginning in order to test and establish working procedures, and thus to achieve recognition and credibility in the industrial sector.

The Technical Section should be responsible for the following activities:

(1) Technical assistance services, ranging from brief survey visits (1-2 days), to simple diagnostic audits (4-5 days) and more detailed audits (maximum duration say 2 weeks). The Section should act as a catalyst for action by the enterprises themselves and must not spend too long in any one factory. The Section should maintain frequent contacts with the factories following the visits and audits, to assist with the definition of conservation programs and in the implementation of recommendations in general.

(2) Assist enterprises to find technical solutions to energy-related problems, including assistance with equipment specifications, for example.

(3) Define the scope of special studies, such as the use of coal in brickworks; the Technical Section could also carry out some studies if appropriate, and work with outside consultancy groups where necessary.

(4) Help enterprises set up and maintain conservation programs at the plant and company levels.

The Policy and Analysis Section should be responsible for the following activities:

(1) Data collection, including data on energy supplies, energy demands (factory questionnaires), energy prices and key product prices. This function includes the preparation of an Annual Statistical Report on industrial energy use, and carries on from the work described in this report. The data are essential for the proper analysis of policy options.

(2) Training service, to include brief seminars for management, engineers and plant operators. This section should provide coordination for extended training programs, including overseas courses.

(3) Preparation of publicity materials, such as reports on the work of the energy efficiency group, articles for journals, technical reports on audits, technical reports on new technologies, and materials for energy awareness campaigns at the factory level. This section should also set up and administer a technical library and information center.

(4) Development of national energy policies, initiatives for legislation, etc. including the appropriate research and data analyses to support energy policies. Policies such as government grants or tax incentives to enterprises for conservation investment and government-sponsored technology demonstrations will require technical and managerial support for their implementation, and we would suggest this support be provided through the Industrial Energy Efficiency Group. A study of behaviour patterns, motivation and incentives for improving plant personnel performance should also be undertaken through this Group.

The responsibilities of the two Sections may well change as the program evolves. For example, as energy conservation awareness in Tunisian industry increases, the demand for audits and related conservation activities may become strong enough to encourage private sector contractors and consultants to offer services. We would expect this to occur within five years. This should be viewed as a positive development, but some regulation might be advisable in order to ensure the maintenance of proper standards. In this event, it is recommended that the Group be assigned the task of checking the qualifications and performance of the private sector contractors and consultants. This activity is of greatest importance if

the government is providing financial assistance to industry for energy audits carried out by private sector companies. Defining and applying performance criteria could become a responsibility of the Industrial Energy Efficiency Group within a year or two, as their direct involvement in audits decreases after the "startup" period and the availability of such services from the private sector increases.

In time, we would expect the Group to concentrate more on the promotion of private services and on government policy activities rather than on the technical work, such as conducting audits and performing feasibility studies, which is a necessity for the initial work of the Group. A review of the responsibilities suggested at the beginning of this Section shows that most of the Technical Section items should be available from private sector consultants in time, and thus the Group should seek to maintain only a minimum effort on the technical work and should concentrate on some of the key items listed for the Policy and Analysis Section, such as data collection and the development of National Energy Policies.

From the beginning, we believe it is most important that the two Sections work very closely together to cover all aspects of data collection, analysis, policy development and program implementation. Each Section can be highly effective as part of a combined operation: we do not believe either Section working alone would be as effective. For example, data collection by the Policy and Analysis Section will be improved in terms of accuracy if the Technical Section is providing assistance to many plants through initial audits and continuing contacts. In addition, the audit work and findings of the Technical Section may be useful to the individual plants but could also be of immense value throughout the industrial sector with the proper assistance of the Policy and Analysis Section to disseminate the results and recommendations. We believe it would be a mistake to proceed with a program relying on the activities of one or other of the Sections in isolation.

With respect to the "sponsoring" agency for the proposed Energy Efficiency Group, we suggest the engineers be attached to the Ministry of National Economy, or to some other agency with governmental backing. The Centre National des Etudes Industrielles (CNEI) is one possibility. Wherever the Group is placed , it is essential that it be given authority to act independently and be allocated the necessary resources of manpower and equipment. Strong leadership of the group is also most important, as the work of the group will be a blend of technical work and public relations, with much of its success relying on the establishment of credibility with industrial enterprises.

8.3 Resources

To date, industrial conservation activities have been assigned to a small group within the Ministry of National Economy. The work on data collection, analysis, policy development publicity and related activities, as well as the technical assistance services, will require the recruitment of several engineers and technicians. A Manager for the Group should be appointed officially, as should the two Section Heads. The persons selected for these positions should be senior and capable of working with other government departments and industry at a high level. Additionally, the Manager and the Section Head of the Policy and Analysis Section should be able to work with institutions such as banks and international agencies at the highest levels.

The engineers in the Technical Section must have industrial experience and practical experience in energy auditing. The staff of the Policy and Analysis Section should also have had industrial experience, and its Section Head should have an engineering background coupled with a knowledge of economics.

The Group will, of course, be an entirely new venture in Tunisia. The intention of this program is to create an effective and active local energy conservation group which will be staffed by Tunisian personnel at all levels and which will become a permanent institution. Initially, however, the staff will be inexperienced in the organization and execution of the proposed range of activities. It is essential that the Group becomes effective and gains credibility within industry and government as quickly as possible. In fact, the credibility of the unit within industry will be one of the major factors determining the success of the venture, both in terms of energy savings realised and of effective policies initiated. It may therefore be necessary for outside expertise to be made available to the Group, and an appropriate budget must be allowed for this. However, it is important that the local personnel assume a high degree of responsibility and initiative from the outset. It is considered that this approach will enable the unit to become effective in the shortest possible time. At the end of a two year period, the need for consultant assistance would be reassessed.

8.4 Immediate Activities

The ability of the Group to achieve credibility throughout industry and the Ministry is a top priority. It is therefore important that the work of the Group be carefully planned and that it be limited initially to avoid over-extending the resources available in the first few months.

We therefore suggest that the Technical Section complete its additional training in energy audit techniques and then embark on a technical assistance program based on the audits already completed in the course of this project. We recommend that emphasis be given to implementation of conservation actions at several of the major plants -- e.g. El Fouledh, SNCPA Kasserine, CPG Metlaoui. A modest program of short audits (4-5 days) could be initiated in the brickworks subsector with the participation of the larger companies (e.g. Sotimaco) who have already shown interest in energy efficiency improvement.

The Policy and Analysis Section should continue with data collection activities and should prepare to collect energy data for 1982 using the forms and procedures developed in the current project. The reporting sample should be expanded to include at least 200 factories (this may require the cooperation of the Technical Section who could assist in making a number of visits to the "new" factories not already covered in this project). Initially, we do not recommend that a major effort be put into organizing training programs for plant engineers: rather, experience should be built up by the Group themselves. Some seminars (one day maximum) could be arranged early in 1983 to publicize the work of the Group to plant managers and to explain its objectives and the services offered to enterprises. Seminars could also be given to universities, and lectures on conservation could be given as part of the course material for undergraduates. A start should be made with publicity materials, but care must be taken not to over-sell the capabilities of the Group, as its capacity to respond to requests for assistance by enterprises must necessarily be limited in the first few months. The Policy and Analysis Section should also devote time to building a technical library and information center, as this will be needed by the Industrial Energy Efficiency Group itself and could also be made available to industrial enterprises.

As we have stated previously in this report, the success of the Industrial Energy Efficiency Group and its program in Tunisia will not depend on the availability of technological solutions. It will depend almost entirely on the ability of the Government of Tunisia to establish an effective organization which can catalyze activity at the plant level. Management will be the key to energy savings.

APPENDIX A

LIST OF REPORTS

1. Report on the Cycle 1 Lectures and Initial Plant Visits; May 1981
2. Training Course Manual; July 1981
3. Cycle 1 Plant Audits Report; July 1981
4. Report on Seminar and Initial Plant Visits, Cycle 2; October 1981
5. Cycle 2 Audit Report, SNCPA, Kasserine; December 1981
6. Cycle 2 Audit Report, CPG, Metlaoui; December 1981
7. Industrial Energy Study for Tunisia, Status Review; February 1982
8. Progress Report on Plant Data; May 1982

APPENDIX B: QUESTIONNAIRE

ENQUETE SUR LA CONSOMMATION ENERGETIQUE DANS L'INDUSTRIE

Date de la visite: [ ][ ][ ][ ][ ][ ] (jour mois année)

Nom de l'enquêteur : _____

N° de contrôle: [ ][ ][ ][ ]

A. IDENTIFICATION

A1. Nom de la Société

A2. Adresse

A3. Téléphone

A4. Personnes rencontrées à l'usine :

	NOM	POSITION
Interlocuteur principal		
Autres :		

A5. Nombre d'employés

A6. Date de mise en service

A7. Branche industrielle

OBSERVATIONS (0.6) :

A8. Propriété Public [ ] Privé [ ]

TOUTES LES DONNEES QUI SUIVENT SONT POUR :

L'année _____ _____ OU les mois _____ à _____ OU une autre période (spécifier) _____

B. ACTIVITES LIEES A LA FABRICATION (PRODUCTION)

B1. PRODUITS PRINCIPAUX	CAPACITE NOMINALE (Unité)	PRODUCTION REELLE (unité)	OBSERVATIONS

B2. MATIERES PREMIERES PRINCIPALES	CAPACITE NOMINALE DE TRAITEMENT	TRAITEMENT REEL (unités)	SOURCE	OBSERVATIONS

B4. Flowsheet simple joint ? Oui ☐ Non ☐

B5. Périodes de travail :

Toute l'année ☐

Travail saisonnier ☐ Spécifier ☐

Nombre postes/jour ☐ Nbre total heures/jour ☐

B6. Valeur totale de la production : ☐ dinars

C. ENERGIE CONSOMMEE

C1.	FORME D'ENERGIE	UNITES	QUANTITE CONSOMMEE	SOURCE	COUT UNITAIRE moyen	COUT TOTAL
a.	Electricité achetée					
b.	Gaz Naturel . . .					
c.	Charbon . . .					
d.	Bois . . .					
.	Coke . . .					
f.	G.P.L. . . .					
g.	Kérosène . . .					
h.	Gasoil . . .					
i.	Fuel lourd . .					
j.	Autres (spécifier) _____					
k.	_____					
l.	_____					
m.	Electricité autoproduite					

C2. Types de combustibles liquides/caractéristiques :

TYPE DE COMBUSTIBLE	DENSITE	POUVOIR CAL.INF. (spécifier unité)	POUVOIR CAL.SUP. (spécifier unité)	OBSERVATIONS

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C3. Caractéristiques des combustibles gazeux :

TYPE DE COMBUSTIBLE	DENSITE	POUV.CAL.INF. (spéci.unité)	POUVOIR CAL.SUP. (spécifier unité)	OBSERVATIONS

C4. Caractéristiques des combustibles solides :

TYPE DE COMBUSTIBLE	POUVOIR CAL. INF. (spécifier unité)	POUVOIR CAL.SUP. (spécifier unité)	OBSERVATIONS

C5. Electricité :

a. Connection au réseau ; puissance transformateur [ ]

b. Autoproduction ; puissance installée [ ]

c. Alimentation électrique de l'usine [ ]

d. Voltages utilisés au sein de l'usine [ ] [ ] [ ] [ ]

D. BESOINS D'ENERGIE ELECTRIQUE

D1. Besoin d'énergie électrique à pleine capacité [ ] KW

D2. Electricité achetée consommée [ ] KWH

D3. Electricité autoproduite consommée [ ] KWH

D4. Combustibles utilisés pour l'autoproduction d'électricité :

FORME DE COMBUSTIBLE	UNITES	QUANTITE

D5. Description de l'équipement de l'autoproduction :

TYPE	TYPE DE COMBUSTIBLE	PUISSANCE (KW)	PRODUITS (KWH)

D6. Facteur de puissance [ ]

D7. Est-ce que l'équipement de correction du facteur de puissance est installé ? oui [ ] non [ ]

D8. Utilisations principales de l'électricité :
pas de compteurs divisionnaires.

UTILISATIONS	QUANTITE DE KWH	%
Energie d'entrainement (moteur)		
Chauffage		
Eclairage		
Réfrigération		
Conditionnement d'air		
Electrolyse		
Autres (spécifier)		

E1. Description des chaudières

	ITEM	UNITES	1 ERE CHAUDIERE	2 EME CHAUDIERE	3 EME CHAUDIERE	4 CHAU
IDENTIFICATION	. MARQUE					
	. TYPE					
	. MODELE					
CARACTERISTIQUES	. CAPACITE DE VAPEUR					
	. PRESSION DE VAPEUR					
	. TEMPERATEUR DE VAPEUR					
	. TYPE DE COMBUSTIBLE					
FONCTIONNEMENT	. PRODUCTION MOY. VAPEUR					
	. CONSOMMATION COMBUSTIBLE					
	. RENDEMENT					

E2. Source d'eau alimentaire de la chaudière [ ]

E3. Consommation d'eau de la chaudière : Quantité [ ] Unité [ ]

E4. Le condensat est-il réutilisé? : OUI [ ] NON [ ]

E5. Si Oui, dans quelle proportions? [ ] %

F. UTILISATION PRINCIPALE DE COMBUSTIBLES CONVENTIONELS PAR USAGE

UTILISATION PAR USAGE OU PAR EQUIPEMENT	TYPE DE COMBUSTIBLE	CONSOMMATION (SPECIFIER LES UNITES)
. Chauffage/Conditionnement d'air		
. Autres (specifier) :		

G. COMBUSTIBLES DIVERS, USAGE D'ENERGIE RENOUVELABLE ET NON-COMMERCIALE

Décrire les usages des divers combustibles (ex : sous produits de procédé, pertes et rebuts de matières, paille), des énergies renouvelables (ex : énergie solaire) et de l'énergie non commerciale (ex : bois, charbon de bois). _____

H. GESTION DE L'ENERGIE

H1. Existe-t-il un coordinateur de questions énergetiques? Oui ☐ Non ☐

H2. Si Oui, indiquer son nom _____ sa position _____

H3. Décrire brièvement ses attributions et responsabilités et quel est son chef immédiat : _____

H4. Existe-t-il un comité d'énergie ? OUI ☐ NON ☐

H5. Si Oui, quels sont ses membres:

NOM	POSITION

H6. Décrire brièvement les relevés de données faits sur la consommation d'énergie. Ces données sont-elles analysées ? Quelles sont les activités menées ? _____

.../...

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17. Quels sont les principaux problèmes d'énergie soulevés par la Direction de l'usine ?

18. Quelles sont les actions relatives à la conservation de l'énergie qui ont été déjà menées ou initiées ? Chiffrer les économies d'énergie réalisées ou prévues.

19. Quelles sont les actions relatives à la conservation de l'énergie qui sont programmées ? Chiffrer les économies prévues.

REMARKS RELATING TO THE SURVEY FORM (QUESTIONNAIRE)

1. Introduction/General remarks on procedures

This form is to be used to obtain energy -- and related production -- data from industrial plants. The most important data are the consumptions of all forms of energy and the corresponding production, of the major product, from each plant. Data should also be collected on the end uses of energy --- e.g. heating, lighting, process heat, etc. The data collected from plants will be used by the Government of Tunisia to develop energy policies, and to monitor the effect of policies, legislation, etc.

It is recommended that a copy of the survey form be sent to plants in advance --- say 2-3 weeks before the personal visit is made. This should give the plant a reasonable amount of time to collect together the necessary data. At the time of the actual plant visit, the interviewer should ask all the questions on the form in the order laid out; this is important, in order not to miss any of the required data items. The interviewer should ask to see confirmation of energy consumptions, in the form of fuel supplier invoices and STEG bills, for example. Copies of regular reports (monthly, annual, etc.) and of any available special study reports should be inspected during the visit.

Above all, the interviewer must seek to draw out the needed data from the plant personnel; he should be a good, and careful, listener. A comfortable relationship between the interviewer and the respondent is essential, Removing a respondent's doubts can be accomplished by brief statements about the general purpose of the study, the confidential nature of the interview, and the important and impersonal use of the survey information. In addition, the interviewer must be able to answer any general questions that respondents may have about the survey, and the potential uses of the data.

In asking the questions, the interviewer must maintain a neutral attitude so as not to suggest that one answer is preferable to another. The interviewer must be careful that nothing in his words or manner implies criticism, surprise, approval or disapproval of either the questions asked or of the respondent's answers.

Respondents sometimes miss the point of a question; they may provide some kind of answer, but they do not answer the question. It is easy to be misled by a respondent who is talkative and gives a long and detailed response -- a response, however, which is not directly relevant to the question asked. Such answers must be "probed" by the interviewer; probing is the technique of questioning by the interviewer to obtain a full, complete and relevant answer from the respondent. Imprecise or confused responses must be probed immediately, and a response should be sought. If the interviewer does not truly understand a response, he should ask for clarification.

At the end of the plant interview, it is recommended that a brief walk be taken around the physical plant facilities. An observant interviewer can obtain a good impression of the overall efficiency of operations, and the probable potential for energy conservation, during a short plant tour.

The Survey Form

Fill in the questionnaire number, the date of the plant visit, and the interviewer's name carefully.

A. Identification

A.1 Enter the legal name of the company

A.2 Enter the full postal address of the plant visited, so that further communication with personnel interviewed may be made at a later date if necessary.

A.3 Enter the telephone number for the principal plant contact

A.4 List the full names and titles of all personnel interviewed at the plant.

A.5 Indicate the number of full time employees. Where a plant uses a significant proportion of seasonal or part time workers, this should also be noted on the form under "remarks". The total number of employees is useful information in order to characterise a plant as small, medium or large.

A.6 The year of initial start-up of the plant should be entered, and any observations added, such as the start-up of a major expansion or new product line. The date of start-up is often useful in gaining an idea of the type of technology and equipment employed, and the probable life of the plant (important for assessing the economic viability of major capital investments and process changes).

A.7 Note here the "branch" of the industrial sector in which the plant is classified for statistical purposes. Choose from the following list:

- Metallurgical, mechanical and electrical (e.g. steel works, vehicle assembly plants, manufacture of domestic appliances, manufacture of

electric motors and transformers, foundries, refining of copper, lead and other metals).

- Materials of construction (e.g. cement, bricks, tiles, lime, glass)
- Paper (e.g. manufacture of pulp, paper conversion, printing).
- Food processing (e.g. milk and dairy products, drinks, beer, flour milling, pasta, bakeries, meat products).
- Chemicals (e.g. organic chemicals, intermediates such as ethylene, inorganic chemicals, phosphoric acid, fertilisers, etc.)
- Textiles, including leather (e.g. spinning and weaving of cotton, wool and synthetic fibres, finishing of cloth, making-up of clothes, tanneries, shoe factories, etc.)
- Extractive industries (e.g. phosphate mining and beneficiation, iron ore mining, production of salt).
- Miscellaneous (all other manufacturing activities not classified elsewhere).

A.8 Indicate whether the plant is privately owned or has a majority shareholding by a public-sector agency or Ministry.

A.9 Indicate the exact time period for which the subsequent data are valid. It is normally preferable for the data to be collected on an annual basis for a complete calendar year.

B. Activities related to production

B.1 Indicate in this table the principal final products shipped from the plant, the plant nominal capacity (indicate clearly the appropriate units of production), the actual production achieved in the period previously defined, and add any pertinent observations (e.g. product quality, mode of transport used for distribution). Where intermediate products are utilised in a second manufacturing stage and also may be shipped from the plant, care should be taken to avoid misunderstanding and double-counting of production

activities. Use the "observations" column to explain. Note that an industrial plant which generates its own electricity should not consider electricity as a principal "product".

B.2 Indicate in this table the major raw materials used by the plant, including the nominal input and actual input achieved (specify the units carefully). The source of raw materials should be indicated, to show whether they are locally obtained, imported, transported over long distances, etc. Means of supply to the plant (e.g. road, rail) should be indicated under "observations".

B.3 Give a brief description of the manufacturing activities performed at the plant, identifying the major items of equipment and the major energy consuming steps of the process. Indicate by name any proprietary or special process used.

B.4 Indicate if a simple plant flowsheet was obtained; note that every effort should be made to obtain a flowsheet which indicates the main processing stages and the interrelationship of important process equipment.

B.5 Indicate here the normal working system for the plant. Many manufacturing plants operate all year round, but some industries operate seasonally (specify clearly the typical operating period where appropriate). In addition, indicate the number of shifts worked each day, and the total number of hours worked (e.g. "2 shifts", 20 hours" would indicate that two shifts of 10 hours each are normally worked).

B.6 Enter the total value of production (or, if not available, total sales) for the period of operation previously defined. This figure is used to indicate the importance of energy costs on the total value of plant production.

C. Energy Consumption

(These data should correspond to the production levels quoted in B)

C.1 Enter in this table the quantities of each energy form consumed in the period defined previously. Note carefully the units for each type of energy, and specify the source (e.g. the name of the distribution company, the electric utility company, etc.). The average unit cost should be shown, together with the total expenditure on that energy form for the period in question. The interviewer should collect separately any information available on specific energy tariffs (e.g. night, day, and peak rates for electricity). Note that the electricity data should be entered carefully, with purchased electricity shown on Line A and the fuels used for self-generation of electricity on the appropriate lines. The actual quantity of self-generated electricity which was consumed by the plant should be entered on Line M. Take care not to double-count the energy consumed. Use Lines J, K and L for specifying energy products not already listed .

C.2* Enter here the major characteristics of all the liquid fuels consumed, specifying the units used. Note where available any important fuel properties such as sulphur content. Use this section to specify the properties of liquified gases such as butane and LPG.

C.3* Enter here the major characteristics of all the gaseous fuels used. Specify the units used.

C.4* Enter here the major characteristics of all solid fuels used, specifying the units used. Properties of wood, charcoal, biomass residues, etc. should be entered here. Under "observations" indicate clearly if the characteristics quantified refer to the fuel as collected or as burnt, and indicate moisture content if necessary.

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* Under "observations", indicate if the fuel properties are determined regularly by laboratory analysis by the consumer or by the supplier, and indicate if the figures quoted are typical, or averages for the period. Note any applicable specification numbers (e.g. ASTM, DIN, etc.)

C.5 Enter here the requested information relating to electricity consumption. Transformer capacity in service is a rough guide to the maximum electrical demand of the plant

D. Electricity Demands

(these data should correspond to the production levels quoted in B)

D.1 Enter the maximum electrical demand in kilowatts at full plant production rate.

D.2, D.3 Enter the total consumptions of purchased and self-generated electricity in kilowatt-hours (the figures should agree with corresponding items from question C.1)

D.4 Identify the types of fuels used and corresponding quantities consumed in self-generation of electricity.

D.5 Enter here the key characteristics of self-generation equipment, including the installed generation capacity (kilowatts) and the actual electricity generated (kilowatt-hours).

D.6 Enter the average system power factor for the period defined previously (as a decimal, e.g.0.85).

D.7 Indicate whether or not power factor equipment is installed in the plant (e.g. capacitors). If only a minor amount of equipment has been installed and it is judged that significant improvement remains to be made, enter "no" for this question and make a special note of the situation. Note if separate meters exist for measuring the power factor for different sections of the factory, or for different uses (e.g. welding, motors, warehouses)

D.8 Specify here the principal end uses for electricity, such as space heating, lighting, air conditioning, electric motors, etc. Indicate where possible the actual kilowatt-hours consumed for each purpose, or indicate an estimated breakdown by percentage if kilowatt-hours are not available.

E. Steam System and Boilers

E.1 Provide the specific details requested of all boilers installed in the plant. Note that the data may be divided into two types, that which can be considered as "design" (e.g. steam raising capacity) and that which refers to actual operation (e.g. average steam production, corresponding fuel consumption, operating efficiency).

E.2 Indicate the source of boiler feed water (e.g. well water, town mains, etc.) The interviewer should also determine the treatment used, if any (e.g. ion exchange).

E.3 Enter the quantity of boiler feed water consumed (the net quantity of fresh make-up water in cases where condensate is recycled). Note the units used (e.g. litres per hour, cubic meters per day).

E.4, E.5 Indicate if steam condensate is re-used as boiler feed water or not-, and enter the quantity re-used as a percentage of the boiler feed water used by the boilers. Note any limitations to the potential re-use of condensate (e.g. risk of contamination by corrosive materials).

F. Uses of Process Fuels

(These data should correspond to the production levels quoted in B)

F.1 Specify here the principal end uses for process fuels, such as space heating, process heat, steam raising, etc. Indicate the units used for each specified fuel and end use. The interviewer should ensure that the total quantity of each fuel, as listed in Section C, is properly accounted for. Where data are incomplete or lacking entirely, this should be clearly stated.

G. Miscellaneous Energy uses, and the Use of Renewable and non-commercial Energy Forms

(These data should correspond to the production levels quoted in B)

G.1 Describe and quantify any miscellaneous uses of fuels, such as the use of process by-products, purchased waste materials, and the use of renewable resources (e.g. solar energy for water heating) and so-called "non-commerci energy, such as wood and charcoal. Specify carefully the uses to which these energy forms are put, and check that they are properly included in Section C.

H. Energy Management

This section includes questions relating to various aspects of energy management,the responses to which are of great value in assessing the potential for improved energy efficiency in the plant.

H.1 Enter here whether or not the plant has a single person responsible for energy matters, an "energy manager" or "energy coordinator". The interviewer should note that many plants have one person in charge of electricity and another in charge of fuel purchases; it is important that this situation requires the response "no" for this question.

H.2 Where a single person is responsible for all energy matters, his name and title should be entered here.

H.3 Describe briefly here his authority, his responsibilities and the person to whom he reports.

H.4 Indicate here if there is an "energy committee" for the plant.

H.5 Where there is a plant energy committee, list here the names and titles of the committee members.

H.6 Describe briefly here the records kept by the plant relating to energy consumption. The interviewer should determine what type of analysis is conducted on the energy data, and what type of actions are normally taken as a result of the analysis of energy consumption figures.

H.7 Describe briefly the principal energy-related problems, as viewed by plant management.

H.8 Indicate here the activities relating to energy conservation that have already been conducted or initiated in the plant. Quantify capital investments made, and energy savings already realised or anticipated (e.g. in terms of physical quantities of fuels saved per tonne of output or per month) and indicate the timing of these improvements.

H.9 Indicate here the activities relating to energy conservation which are planned, and quantify expected savings. Indicate also the timing of these planned activities and savings, and quantify any planned capital investments