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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

INTRAG

Achieving Industrial Energy Savings in Pakistan

Final Report

Submitted to:

Director General, Energy Resources
Ministry of Petroleum and Natural Resources
Islamabad, Pakistan

and

United Nations Industrial Development Organization
Islamabad, Pakistan, and
Vienna, Austria

Prepared by:

INTRAG, Inc.
Boston, Massachusetts, U.S.A.
Lahore, Pakistan

May 1986

Contents

CONTENTS

TITLE	PAGE

CONTENTS

TITLE PAGE

CONTENTS

CONTENTS

Exhibits

EXHIBITS

EXHIBITS

Appendixes

APPENDIX		PAGE

1 INTRODUCTION

This report represents the completion by INTRAG, Inc., of an assessment of industrial energy conservation in Pakistan. This assessment was being carried out for the Director General of Energy Resources (DGER) in the Ministry of Petroleum and Natural Resources. The assessment was being funded by the United Nations Industrial Development Organization (UNIDO). To provide a perspective for the results to date, in this introductory chapter the background and objectives of the study as described in the terms of reference and the INTRAG proposal are reviewed, then the Final Report organization is outlined.

BACKGROUND

The sharp rise in oil prices over the past decade has had a serious and sometimes devastating effect on the economies of most oil-importing countries of the world. Although Pakistan has recently discovered indigenous resources of crude oil, it is currently dependent on imports for over 80 percent of its petroleum requirements. The cost of this imported petroleum represents a large drain on Pakistan's foreign currency reserves, and thus constrains its capacity to fund its internal development programs.

The Planning Commission of the Government of Pakistan developed a National Energy Plan as part of the Sixth Five-Year Plan. A major objective of this Plan is to overcome energy shortages through energy conservation, more efficient use of energy, and fuel switching. Since Pakistan industry currently consumes 40-50 percent of Pakistan's energy supply, the success of an industrial energy conservation program is crucial to meeting the energy goals of the overall Plan.

Currently, oil and gas are the major fuels consumed by Pakistan -- constituting three-quarters of its total primary fuel consumption. While Pakistan currently produces enough natural gas to support its use, energy forecasts through 1990 indicate that natural gas production will begin to decline by that point, and a natural gas shortage could occur. Table 1 shows the current trends in primary energy consumption.

Given the importance of minimizing the use of oil and gas, the Government of Pakistan has given significant emphasis to energy conservation, and to development of

Table 1

PRIMARY ENERGY CONSUMPTION

	1982-83		Estimated 1987-88		
	Energy Consumption MTOE	Percent Share of Total	Energy Consumption MTOE	Percent Share of Total	Annual Growth Rate
Oil (excluding bunkers and non-energy use)	5.85	39.0	10.01	42.2	11.3
of which: Domestic	(0.65)	(4.3)	(1.04)	(4.4)	9.9
Gas (excluding feedstock)	5.81	38.7	8.32	35.0	7.4
Coal	0.76	5.1	1.16	4.9*	8.8
Hydro	2.49	16.6	4.01	16.9	10.0
LPG	0.07	0.5	0.22	0.9	25.7
Nuclear	0.02	0.1	0.02	0.1	--
Total	15.00	100.0	23.74	100.0	9.6

* The share will increase significantly in later years as a result of investments stimulated by the Sixth Five-Year Plan.

SOURCE: "The Sixth Five-Year Plan, 1983-88 (Draft," Planning Commission, Government of Pakistan, May 1983, p. 210.

non-conventional sources of energy. As specified in the terms of reference provided by the DGER, the Government is interested in developing an integrated program in energy conservation, with special attention to national policy measures, institutional development, and plant-level assistance. This will call for a mix of legislative, technological, and financial measures to be instituted by the Government of Pakistan.

Recognizing this need in the late 1970s, the Government of Pakistan held a National Symposium on Energy Conservation in February 1980. During the six sessions of the Symposium, recommendations were formulated for:

- Energy conservation policy
- Energy conservation in the transport sector
- Energy conservation and cascading in industry
- Energy conservation in the domestic and commercial sectors
- Role of renewable resources of energy.

The recommendations of this Symposium were carried forward in further initiatives. One of these is this assessment. As called for by the DGER, the specific objectives of the assessment were:

1. Survey 30 industrial plants in the textile, metal-mechanic, and paper and chipboard industries to

identify opportunities for energy conservation and improved efficiency, without reducing industrial output.

2. Analyze the plant-level energy data and assess the potential for energy conservation.

3. Identify opportunities for fuel substitution.

4. Aggregate the data on energy conservation measures and provide recommendations for industrial energy savings.

With the concurrence of the DGER, UNIDO commissioned Intrag, Inc., to carry out the study, assisted by Zelin Limited. At the commencement of the study an intitial work plan was agreed to that included the following major steps:

a. Carry out background data analyses, and conduct eight test surveys.

b. Order specific energy-use diagnostic equipment to support the specific survey requirements

c. Prepare an Interim Report based on the first eight plant surveys.

d. Carry out 22 additional surveys.

e. Prepare and submit a Draft Report.

f. Prepare and submit a Final Report.

FINAL REPORT

This Final Report completes the above steps, and provides a substantial amount of information and data in response to the study objectives. There are particularly detailed analyses of industrial energy savings in the findings chapter.

Given the limitation of one day with the team at each site, there was a special effort made to validate the data by comparing it with process data in the United States. This check showed that 3/4 of the data obtained could be meaningfully compared to similar process data from the U.S. Based on this, the team believes the findings are solid, and the recommendations, if enacted, can lead to substantial energy savings.

The reader should be cautioned, however, on the general limitations of the data. It is not sufficient to make final conclusions about the equipment configurations or economic viability of specific equipment investments at any of the plants. This would require a much more extensive and detailed energy audit and technical and economic feasibility analysis for each plant, consisting of 1-2 person-weeks of effort per plant. To avoid any misrepresentation of the detail and final accuracy of the data, energy input and output values were not attached to the process flow diagrams (see Appendix A), although "check energy balance indicators" were examined for each of the plants surveyed. Detailed energy balances, using the data as is, would not be meaningful. However, a great amount of the useful data that would come from energy balances is presented by plant function in Exhibits 3.13 - 3.26, and for the plants overall in Exhibits B.1 - B.30.

Based on the plant surveys and followup analyses, it was concluded that energy conservation improvements of 15-40%, depending on the plant, were achievable, a conclusion that confirms the significance of energy conservation to Pakistan, and its importance in supporting Pakistan's national energy goals.

In the three remaining chapters of this report, the work carried out by the INTRAG team is described in detail, as follows:

Chapter 2 -- Characteristics of and Approaches to Industries Analyzed

Chapter 3 -- Energy Conservation Findings and Opportunities

Chapter 4 -- Targeted Energy Conservation Actions: A Framework for an Industrial Energy Conservation Plan

Exhibits supporting these chapters are provided in a separate section, and the following six appendixes are also enclosed:

Appendix A -- Manufacturing Process Flow Diagrams by Plant

Appendix B -- Detailed Energy Use and Costs by Plant

Appendix C -- Energy Audit Data Sheet Format

Appendix D -- Introduction Letter and Example Acceptance Form

Appendix E -- Methodology for Estimating Energy Savings

Appendix F -- Individual Plant Summaries

2 CHARACTERISTICS OF AND APPROACHES TO INDUSTRIES ANALYZED

The Director General of Energy Resources (DGER) initially provided INTRAG a list of 33 industrial plants for energy surveys (Exhibit 2.1), from which 30 were to be selected for energy surveys.

The plants identified covered three industry sectors: textiles, metal-mechanic, and paper and chipboard products. The list consisted of seventeen textile, three paper and chipboard, and thirteen metal-mechanic plants. Twenty three (23) of these plants are located in the Punjab Province, six (6) in the Sind Province, and four (4) in the North West Frontier Province (NWFP). During efforts to schedule Energy Audit Surveys (EASs), it was discovered that at least 13 industrial plants listed in the original list were not available for surveys. Some had closed (or had essentially gone out of business), and some simply did not respond to our correspondence or calls. Some new textile and metal-mechanic plants were substituted for the ones not in operation, after consulting with the DGER's office.

CHARACTERISTICS OF AND APPROACH TO INDUSTRIES ANALYZED

In accordance with the work plan finalized and approved at the start of the study, this Final Report is based on 30 Energy Audit Surveys (listed in Exhibit 2.2). In this chapter, the energy use and cost data for the plants surveyed are presented, and the approach to the survey and data collection is described.

2.1 ENERGY USAGE AND COSTS

As expected, the energy usage characteristics of these industries vary considerably in accordance with their specific manufacturing processes, size, and production capacity. Manufacturing process flow diagrams for each of these industries are shown in Appendix A. Energy inputs at each processing stage are shown as inputs by fuel type.

Exhibit 2.3 shows the average annual energy consumption by specific energy source for each of the plants audited. The data is based on the average monthly fuel bills that were made available by the industry management. In some cases records for the last five years were available, while in others only the last one or two years data were available. The minimum record of data obtained was for at least one year. Appendix B contains a detailed record of monthly energy use and costs for each plant. Exhibit 2.4 is a profile of average monthly consumption for all the industries audited. The monthly consumption reflects the overall pattern in energy usage and does not take into account factors such as size, production capacity, and advantages or disadvantages of operating procedures of a particular industry over the other. Several factors account for the variations indicated in the monthly consumption pattern. These include, but are not limited to: operating procedures; market conditions; seasonal trends; financial state of the industry; size; and forced outages such as electric load shedding, equipment failure, etc.

Exhibit 2.5 shows the breakdown of energy consumption by source. In the plants audited so far natural gas and electricity are the primary source of energy supply. Natural gas accounts for about 80 percent of the total energy consumption, electricity about 13 percent, and oil about 7 percent.

2.2 APPROACH TO THE ENERGY AUDIT SURVEYS

The EASs were carried out in accordance with the following steps:

Step 1: Develop first draft of an energy audit data sheet (EADS).

Step 2: Develop equipment list, prepare specifications, and order equipment to be used for EASs.*

Step 3: Select, schedule, and conduct a test energy audit survey at one plant.

Step 4: Revise/modify first draft of EADS, contact plants, and schedule EASs for eight plants.

Step 5: Conduct EASs at eight plants.

Step 6: Prepare an Interim Report.

After obtaining DGER's/UNIDO's comments and guidance on the Interim Report, the rest of the EASs were carried out in the following steps:

Step 7: Complete delivery of energy auditing equipment and van to the project area.

Step 8: Develop final draft of EADS and modify procedures/analysis to reflect DGER/UNIDO's guidance.

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* Due to the fact that inviting quotations from various manufacturers of energy auditing equipment, placement of orders, delivery period, and governmental procedures for clearance required considerable time, it was decided that the first eight energy audit surveys would be conducted using INTRAG's and Zelin's existing equipment in order to obtain some early results.

Step 9: Contact and schedule EASs with the remaining 22 plants.

Step 10: Conduct EASs at 22 plants.

Step 11: Prepare Draft Report

Step 12: Prepare Final Report

2.3 DATA COLLECTION AND RECORDING

Each EAS was conducted during a one-day visit after careful advance planning and scheduling. The draft survey forms used for the EASs are shown in Appendix C. The information on the EADs has been organized into the following categories:

- General
- Purchase of Utilities
- Operating Information
- Ancilliary Equipment
- Production Costs
- Economic Data
- Plant and Machinery
- Energy Inputs
- Energy Outputs
- Summary Sheet
- Manufacturing Process Description
- Monthly Energy Cost Data (Electricity, Natural Gas, and Other Fuel Costs)

- General State of the plant
- Boiler Data Sheets
- Comments/proposed energy conservation measures/ Identification of losses by manufacturers and details of investments in energy conservation.

The categories listed above are quite comprehensive, the objective being to obtain as much base information as possible, even though the surveys were not intended to be complete, detailed audits.

In addition to the information recorded on the EADS, oral interviews with the plant managers were conducted, and selectively tape recorded.

2.4 EQUIPMENT USED FOR ENERGY AUDITS

The energy audit equipment used to carry out the audits is listed in Exhibit 2.6. The environmental and operating conditions of the first eight plants surveyed were evaluated in preparing specifications for the equipment. These conditions included expected operating temperatures, robustness, allowance for maximum ranges of voltage, current, power, process steam flow rate, flue gas velocity, pressure, and emissivity ranges of different parts in the plants.

The energy auditing equipment package included an Energy Mobile Diagnostic Unit (EMD) as well as the energy auditing instruments. The EMD unit was used for transportation of personnel and equipment from one plant to another. It was decided in consultations with the DGER/UNIDO to procure a VW van for use as an EMD Unit.

Specifications for the instruments were developed and approved by DGER/UNIDO. Quotations were solicited and received from various suppliers for the equipment, and delivery of the equipment to Pakistan was completed in April 1985 for the instruments, and May 1985 for the VW van.

2.5 SURVEY PROCEDURE AND APPROACH

Using an introductory letter and an acceptance form (Appendix D), team members visited (or phoned) different plants to explain the objectives of the project to management and obtain their acceptance.

This approach resulted in an additional effort but was preferred over a simple dispatch of letters and acceptance forms, because INTRAG felt that a verbal explanation of the project would prompt a quicker and more positive response.

Team members explained the procedure to management and obtained agreements for an energy survey at a mutually-agreed date and time.

The survey team consisted of two-three staff members from INTRAG, two from Zelin, and staff member(s) from the DGER's office. The INTRAG team was headed by a senior industrial and instrumentation engineer, one support engineer to record data, and one management analyst/economist to collect economic and management-related data and to conduct oral interviews with plant managers. Zelin provided two engineers, one expert in industrial processes and the other expert in plant measurements and data recording.

Initially, a manufacturing process flow diagram was developed and points for taking readings identified. This was followed by on-the-spot measurements and recording of data. Areas of major energy usage and losses were identified on the spot. While some team members conducted the energy survey in the plant, one or two other team members conducted interviews with the plant management regarding the general state of the industry, energy usage and conservation opportunities, and other relevant issues facing the industry.

3 ENERGY CONSERVATION FINDINGS AND OPPORTUNITIES

Based on the findings of the 30 plants surveyed, energy savings of 15 to 40 percent, depending on the plant, could be achieved through a range of actions. The specific survey results leading to this conclusion are discussed in the following sections of this chapter:

3.1 Energy Losses and Inefficiencies

3.2 Improvement Opportunities.

The first section describes the various types of losses and inefficiencies identified during the energy audit surveys and discusses their causes. The second section outlines the improvement opportunities that can be implemented in the plants, ranging from simple low-cost energy conservation measures such as "good housekeeping practices" to major investments such as installing or retrofitting new energy-conserving equipment. A description of technically suitable energy conservation opportunities based on recoverable potential is given. A summary and ranking of energy conservation opportunities based on recoverable potential is also presented.

3.1 ENERGY LOSSES AND INEFFICIENCIES

The type and magnitude of the energy losses and inefficiencies in the 30 plants surveyed vary by manufacturing process, size, plant age, product type, financial circumstances, and general state of the industry. The following types of losses and ineffiencies were identified:

- Boiler losses
- Steam system losses
- Waste heat losses
- Hot water losses
- Electric power losses
- Furnace/metal-mechanic process losses
- Inappropriate equipment design and layout
- Inefficient energy supply and conversion
- Management/administrative inefficiencies.

Exhibit 3.1 shows the presence of these losses by industry sector, and Exhibit 3.2 provides plant specific presence of these losses. Most areas of loss or inefficiency offer potential for improvement.

3.1.1 Boiler Losses

Boilers are used in all three industry sectors. Their use is much more extensive in the textile and paper/chipboard plants than in the metal-mechanic industry. In the plants surveyed, only one metal-mechanic plant was using a boiler for process heat generation. Exhibit 3.3 shows the energy used in boilers as a percentage of total energy input for all industries, as well as for textile and paper/chipboard plants. On average the energy used in boilers accounts for about 41 percent of total input energy in all plants surveyed: 43 percent of total input energy in the textile and 40 percent of total input energy in the paper/chipboard industries. Therefore, boiler operations offer one of the largest potential opportunities for energy savings.

Processes using process steam from the boiler are, in descending order of magnitude, heating setting (stenters), jet dyeing, wet finishing processes and drying. See Appendix A for manufacturing process flow diagrams of plant showing the stages of process steam utilization. The boilers in plants surveyed are of different types, sizes, ages and capacities. Most of the boilers were procured second hand at low cost and employ outdated equipment for steam generation. Exhibit 3.4 shows the different types of boilers installed in the plants surveyed, their ages, capacities and average operating efficiencies.

The average operating efficiencies were calculated using graphical approach for efficiency determination, and the heat loss method.* In the graphical approach graphs based on specific fuel compositions and ambient conditions were used to determine the efficiencies. While this may not represent an absolute measure of efficiency due to variations in loading conditions, fuel composition and ambient conditions for a specific plant, it is a fairly accurate approach because the fuel composition of natural gas/ furnace oil and ambient conditions of the plants surveyed are almost the same and do not differ greatly.

The average operating efficiency of all boilers installed ranges from a low of 45 percent (Government Textile Weaving and Finishing Center) to a high of 83 percent (Kohinoor Textile Mills). The average for all plants is 67.5 percent, well below the normal industry range of 80-85 percent; this indicates a substantial potential for energy savings in this area.

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* Heat loss method accounts for energy loss in the stuck flue gas and evaluates boiler efficiency. This method was used for plants where instrument readings of prevalent conditions on the site were out of range of the parameters used in the graphical approach. Appendix E gives the details of these calculation procedures for all plants with boilers.

The causes for the lower boiler operating efficiencies are:

- Inadequate or no insulation
- No condensate return system
- No feedwater preheating
- No preheating of combustion air
- No burner tuning/improper Air/Fuel ratios
- High idling losses
- Excessive unburned gases
- Excessive stack gas heat loss, including lack of flue-gas dampers
- No heat recovery from blow-down water
- Inadequate cleaning and maintenance procedures (fouling and scaling)
- Improper location of boiler house, causing excessive pressure drops in pipes
- Lack of professionally qualified manpower and instrumentation.

Exhibit 3.2 shows the plant-specific presence of these problems.

Quantitative assessments of energy savings potential in terms of energy usage and costs per year due to improvements in boiler efficiency in each of the plants surveyed are presented in Section 3.2.1a of this report.

3.1.2 Steam System Losses

There were excessive steam system losses in virtually all plants. The causes are:

- Poor insulation
- Defective steam traps
- Leakages
- Inefficient steam distribution network.

The quality of insulation is extremely poor, with lagging often hanging loosely from the steam distribution network; several spaces along the path of the distribution network have no insulation at all. The piping shows rust and excessive corrosion caused by prolonged operation without adequate maintenance (carbon dioxide and oxygen in the steam cause corrosion in any piping network and require continuous maintenance).

Steam trap failures are quite frequent; in some cases, steam bypass systems had been installed permanently without any effort to rectify the defective steam trap. This results in excessive use of steam in subsequent processing stages due to the high content of condensation and air in the steam.

Steam leakage is evident at several spots, particularly at the joints. The INTRAG/Zelin team recorded the velocity, pressure, temperature, and quantity of heat lost at selected leakage spots. Exhibit 3.5 shows the relationship between size of leakage and annual heat loss. For several leakages the total loss can be very high resulting in excessive costs.

Unnecessary piping in the distribution network exists in some plants. Additions and new equipment were installed in the existing plant without planning for an overall optimal piping layout, with the result that steam still travels through pipes connected to machinery no longer in use. Furthermore, loads have been added or dropped without any consideration for original design of the network, this results in disproportionate pressure drops in the distribution network causing excessive heat losses in the distribution system.

The amount of heat lost through the entire steam distribution system caused by factors such as poor insulation, defective steam traps, leakages, and an inefficient distribution network, is too great to measure in a one-day energy survey. However, data available from energy audit surveys of other industries suggests that 20 to 30 percent of input fuel used could be saved by improving the quality of insulation on the piping network, rectifying faulty steam traps, preventing leakages through proper maintenance, optimizing the steam distribution network, and avoiding unnecessary piping. Quantitative assessments on estimated savings due to corrective/preventive measures to improve steam system losses in the plants surveyed are presented in section 3.2.1d.

3.1.3 Waste Heat Losses

Waste heat losses include heat carried away by flue gases and heat wasted in the process stage. Although some portion of heat is lost during the process stage, flue gas waste heat is by far the more significant problem.

Exhibit 3.6 shows flue gas analysis from boilers in the plants audited. Flue gas temperatures ranged from 107°C to 521°C, and excessive amounts of unburned gases (due to incomplete and inefficient utilization of input fuel) were present. The levels of oxygen and carbon dioxide are far above the industrial average reported in other countries. This percentage of excess air supplied to ensure complete combustion is extremely high (nearly 200 percent in one instance). Exhibit 3.7 shows the relationship between excess air and total heat loss. Inadequate supply results in incomplete combustion and fuel wastage; excess air supply causes heat loss through stack without any use. An optimum air supply should be maintained for efficient combustion. In general, for natural gas an efficient boiler would use about 15 percent excess air. In the plants surveyed, the industry average is 85.2 percent, which is way too high and indicates excessive wastage.

The above mentioned losses are significant and provide a great opportunity for heat recovery and efficient energy utilization. This waste heat could be recovered and used in pre-heating boiler feedwater and combustion air ensuring substantial fuel savings. Exhibit 3.8 shows the relationship between combustion air temperature and fuel savings in boilers. It is clear from the exhibit that preheating could save significant amounts of input fuel. Quantitative estimates on actual recoverable potential of waste heat (and subsequent fuel cost savings) for each of the plants surveyed is given in section 3.2.1c.

3.1.4 Hot Water Losses

At several processing stages there is excessive waste of water at high temperatures. In particular, wet processing stages, such as jet dyeing in the textile industries, require extensive use of hot water for washing and preparing raw cloth for printing and finishing. Used wash water at high temperatures is allowed to drain without any measures to recover the wasted heat. For example, in one plant 100°C water was being simply drained through a pipe into waste dumps around the plant. Idling of jet dyeing machines and excessive usage result in significant amounts of wasted heat that could be recovered.

Plants using steam in their processes invariably have hot water as condensate. In the plants audited there is no means of recovering this heat with the exception of a few.

Water at high temperature could be used to recover wasted heat for use in several processing stages as well as for recycling. This offers substantial potential for conservation of heat energy being wasted. There exist several process specific heat exchangers that could utilize heat from hot water waste. Plant specific applications warrant detailed engineering studies which is beyond the scope of the present study. Exhibit 3.2 summarizes plants in which excessive hot water losses were identified.

3.1.5 Electric Power Losses

Energy losses in electric power include:

- Poor power factors
- Poor maintenance of moving parts
- Idling
- Improper matching of motors with load
- Excessive fan power usage for drying
- Poor lighting
- Poor distribution network
- Frequent voltage variations.

Poor power factor is a direct indication of inefficient electric power utilization. The industry average is 0.75. Keeping in mind the operating constraints and typical practices followed by industry in Pakistan, this could still be improved to a minimum of 0.85, ensuring efficient utilization of electric power.

Most of the electric energy supplied is consumed by motors used to drive moving parts such as rollers or cylinders, which are generally poorly maintained. The parts are neither properly nor frequently greased; they offer high friction, thereby overloading the motors. Energy efficiency measures concerning motors are summarized in Exhibit 3.9. On existing motors not much can be done regarding efficiency improvements in design (changes without rewinding the motor or purchasing a new one); therefore, emphasis must be given to efficient operational procedures. Running motors at low load wastes energy and lowers power factor. Motors should be operated as close to fully loaded conditions as possible. This improves efficiency and power factor. Beside losses in motors and distribution wiring, low power factors can overload transformers, cause poor voltage regulation and excessive voltage drops.

Power factor correction is generally achieved by installing capacitors. There are two approaches to capacitor installation: at the load or at the switch board or distribution panel. The first is convenient because capacitors are switched on and off with load and reactive currents are reduced. The second method requires that larger (therefore cheaper unit cost) capacitors can be used, but the savings in branch circuits are not obtained. This approach primarily leads to savings in the primary feeders and main transformer, but not on the load side of the distribution.

Idling of moving parts causes a waste of electric power. In several instances, machines were running without any use. In one particular instance yarn was being spun on a warping machine to form four cones, whereas the machine has the capacity to spin sixty-eight cones; all other winders were being driven by the motor without any yarn. Machine operators rarely turn off the machine's moving parts when no processing of materials or cloth is being carried out.

Most of the motors installed are not properly matched to their load, which results in overloads on motors and inefficient operation. Drying in textile industries employs extensive use of fans to blow air. There are no controls to optimize drying times, and fabrics are in general over-dryed because of excessive use of fan power.

In most of the plants surveyed, the quality of lighting is very poor. Excessive deposits of dirt on lamps and flourescent tubes results in excessive power usage due to extra lighting loads and higher temperatures. Some of the measures to reduce energy comsumption are: improving color and reflectivity of walls, ceilings, and floors to reduce lighting energy needs and train personnel to turn lights off when not needed (employee energy awareness and motivation programs.)

In distribution networks, wires and cables have poor insulation, as well as improper conductor sizes and ratings for their requisite loads. Variations in supply voltage are common, resulting in efficient operation and reduced equipment life. This has been further aggravated by frequent load sheddings by the electric utility, Water and Power Development Authority (WAPDA).

3.1.6 Furnace/Metal-Mechanic Process Losses

Furnaces are used in the metal-mechanic/steel industries primarily for melting scrap and in some industries for pre-heating intermediate products. Majority of them are scrap based-electric furnaces employing low frequency electric or gas heating. In general, melting consumes almost 90 percent of input energy. In almost all the plants surveyed the quality of insulation is extremely poor resulting in unnecessary losses. There has been no effort to improve the quality of insulation, in some instances furnace doors have been completely burnt out, no replacement was made resulting in permanent heat loss.

Most of the furnaces are not very well designed for the specific applications in which they are being used. The designs are old, having little or no consideration for energy conservation and in most cases, fabrication is done locally. Major losses are due to:

- poor insulation
- poor design
- high idling
- poor temperature and pressure controls; and
- inadequate cleaning and maintenance procedures.

Most of the energy conservation meaasures in plants using furnaces warrant process specific considerations since the production stages are quite diversified depending on the final product. Furthermore, the size and production capacities of these plants is very small, this limits the use of any capital intensive energy conservation measures. However, under existing conditions considerable savings could be achieved by:

- improving inter process delivery/transportation conditions
- improving quality of input scrap material
- pre-heating scrap by waste heat
- improved furnace insulation
- higher speed rolling
- reducing melting times by using Ultra High Power (UHP) furnaces; and
- better monitoring of temperatures in processing stages.

Production stages in the metal-mechanic/steel plants require intermittent heating and cooling. A bottleneck at a specific stage can result in significant energy losses, therefore steps should be taken to ensure continuity of processes and improving interprocess delivery/transportation conditions. The total energy used depends highly on the quality of scrap material, in some cases difference in scrap quality can result in twice the amount of energy used with poor quality scrap. This is an important factor in energy savings and steps should be taken to procure scrap material that requires less energy for melting.

Pre-heating of scrap material with process waste heat could result in substantial savings. In all the plants surveyed, no waste heat preheating is used. Improvement in furnace insulation is required in almost all the plants surveyed.

High speed rolling uses less energy than slow speed rolling. Steps should be taken to increase rolling speeds.

Ultra high power furnaces (UHPFs) reduce melting times and use less energy but in general require higher transformer capacity, specifically, 600 to 800 KVA as compared to more conventional types which require about 250 to 300 KVA. Experience in similar plants has indicated that use of

UHPFs can save up to 10 percent of current energy usage in furnaces.

The discharging temperatures at each production stage should be monitored so as to minimize losses in inter-process handling and efforts be made to conserve and utilize as much heat as possible in the product for subsequent processes that require preheating. Quantitative assessments due to the above losses in plants surveyed are presented in Section 3.2.1b.

3.1.7 Inappropriate Equipment Design

The equipment installed is, in general, outdated and does not employ any state-of-the-art processing techniques or heat recovery systems. The machinery installed was typically procured second-hand, and any additions or modifications to the process were done without planning for optimum layout and without using any of the modern energy-efficient monitoring techniques (such as computerized process control automation) or process technologies (such as microwave drying in the textile industry). However, it must be recognized that these second-hand installations probably cost a fraction of new equipment costs. Therefore, what was an energy inefficient option may have been the lowest cost option. Another reason is that wherever there was a conflict between efficient energy utilization and plant expansion, the latter was almost invariably preferred resulting in inappropriate equipment layout and energy intensive design changes/modifications.

3.1.8 High Cost Energy Supply and Inefficient Conversion

In the plants audited, the primary sources of energy are natural gas, electric power, and furnace oil. The cost per Gigajoule or million Btus is high, and the efficiencies of conversion of these fuels are poor. Exhibit 3.10 shows the cost per energy unit for the textile, paper/chipboard and metal-mechanic steel industries. With achievable energy conservation, the cost per unit of energy could be reduced by 15 to 40 percent.

Natural gas is often used, when, for some reasonable investment, coal or some biomass or waste product could be used. Further, because of inefficiencies in combustion and processing stages, the use of this high-value fuel is excessive. Exhibit 3.11 shows the energy use per unit of output in the plants audited. On average, the energy use is higher by 20 to 30 percent than that in similar industries in other countries. For 6-8 of the plants surveyed, the comparison of these ratios suggests that the energy use data is in error, or the process was not actually run as described to the Intrag/Zelin team.

3.1.9 Management and Administrative Inefficiencies

Several areas in the management and administration of these plants could be improved; these include:

- Production planning
- Operator knowledge
- Employee incentives
- Recordkeeping.

3.1.9a Production Planning

In almost all cases in which production is carried out on a day-to-day basis, large and small orders are run without sufficient planning. This results in under-utilization of facilities and energy lost per unit of output. In one extreme instance, production planning was so inadequate as to override the case for any energy conservation measure. In other words, measures for energy conservation would not have resulted in any potential savings. In this plant, time is allocated to various customers for processing raw cloth. When plant time is promised, the whole plant is started up in anticipation of use; customers often do not show up as scheduled, and the plant has to be shut down after having run idle for several hours. In such cases, measures to conserve energy are of little consequence in the absence of proper production schedules.

3.1.9b Operator Knowledge

Most of the operators employed have insufficient initial training or up-to-date knowledge of technology. Operator know-how is learned directly on the machine, without formal classroom instructions.

In the absence of any specific fault, operators tend to assume that the plant is functioning properly. Plant managers and supervisors concentrate on production, and spend little time checking energy losses.

There are two training institutes for textile operators in Pakistan. Operators who have had formal instruction at these institutions have a better understanding of processing technology and trouble-shooting, and tend to operate the plant on a basis that keeps energy losses down, compared to those directly employed without any formal training. Though the institutes offer better and proper direction for training, much needs to be done to improve the courses taught.

3.1.9c Employee Incentives

From comments made during interviews, it appears that, in addition to the lack of awareness of employees and managers, there is no particular incentive for employees to minimize energy usage. Benefit programs and rewards for better performance are practically non-existent, except in a few industries. In many cases the organizational structure of the plants and their operating practices do not include employee incentives. There is considerable uncertainty in terms of job security for the employees, and many of them seemed uninterested in what they were doing.

3.1.9d Recordkeeping

With the exception of fuel bills, plant management does not maintain records on machine performance, maintenance, and energy usage. Records on breakdowns, repairs, and other maintenance are not of any consequence to industry management. Plants managers usually pay the bills on energy consumption without making any effort to ensure better production through efficient energy utilization.

3.2 IMPROVEMENT OPPORTUNITIES

There are several improvement opportunities that can lead to substantial savings in energy. Improvement opportunities are of three types (see Exhibit 3.12):

- Improvements or modifications in the existing plant
- Plant design
- Management and administration.

3.2.1 Improvements or Modifications in Existing Plant

There is a wide range of improvements or modifications that can be implemented in existing plants, ranging from simple "good housekeeping practices" to retrofitting new energy conservation equipment to fuel substitution. Plant modifications and improvement opportunities are of eight types:

- Improvements in boiler efficiency
- Improvements in furnace efficiency
- Utilization of flue gas waste heat
- Reduction of steam system losses
- Reduction of hot water losses
- Reduction of electric power losses
- Utilization of process waste heat.
- Identification of fuel substitution opportunities

3.2.1a Improvements in Boiler Efficiency

The average operating efficiency of the boilers in the plants audited is 67.5 percent, which is below what is expected in similar industries. By employing different energy conservation measures, similar industries have attained boiler efficiencies higher than 85 percent. Despite the operating constraints and other problems in operating practices in Pakistan, a conservative target for improving boiler efficiency could be set at 80 percent. Exhibit 3.13 shows the recoverable potential in energy savings by improving boiler efficiency to a base minimum of 80 percent for each of the plants audited. The total savings for the three industries are 437 x 10^3GJ of energy, amounting to Rs 6.6 million per annum.

The above savings could be realized through very simple measures on existing plants without any substantial capital outlay. The estimated savings computations are based on conservative estimates and one time efficiency measurements on site, in contrast to monitoring of plant specific boiler operating characteristics over a period of time which would take into account variations with loading conditions, idling, temperature of feedwater and other day to day plant specific operating conditions. All these would tend to increase the above estimated energy savings potential, leading to higher savings than those estimated above.

Most of the savings could be realized in the textile and paper/chipboard industries since boilers are primarily used in these industries with the exception of one metal-mechanic plant that uses boiler for process heat. The three paper/chipboard plants account for 44.7 percent of total savings, in contrast to 53.8 percent in twelve textile plants. This is primarily due to larger boilers in the paper industry and the smaller size of the textile plants. Also, relatively large boilers in the textile plants were found to be operating at higher efficiencies.

Higher efficiencies can be attained in the plants surveyed by:

- Improving combustion efficiency through burner tuning
- Recovering waste heat and using it for preheating feedwater or combustion air
- Improving burner design
- Recovering boiler blow-down
- Utilizing boiler condensate return

- Pretreatment of feedwater
- Improving maintenance and cleaning
- Improving insulation.

3.2.1aa Combustion efficiency/burner tuning. Exhibit 3.14 shows the chemical composition of natural gas as supplied to the industries audited; it consists mainly (94.42 percent) of methane (CH_4). Ignoring the other constituents, the complete combustion of methane is given by the following chemical equation:

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

The mass balance of this equation and the theoretical air requirements for complete combustion can also be computed (see Appendix E); however, in actual practice, complete combustion rarely occurs, and unburned gases with excessive air leave through the stack. This is usually detected through flue-gas analysis using a combustion analyzer. One indication of incomplete combustion is the formation of carbon monoxide, as shown by the following chemical equation:

$$C + 1/2\ O_2 \longrightarrow CO \text{ (incomplete combustion)}$$

In practice, excess air is supplied to ensure complete combustion. An efficient boiler comparable to sizes in the plants surveyed requires about 10 to 15 percent excess air. With few exceptions the plants had very high values of excess air (in some cases as high as 180 percent), with stack flue gas temperatures in the range of 200°C to 400°C. Optimal values are in the range of 120-140°C. This indicates inefficient combustion and excessive heat loss.

Experience with similar industries has shown that, with flue gas temperatures as low as 120°C, savings up to 10 to 15 percent in input fuel can be achieved by utilizing this waste heat. Industrywide estimated savings in plants audited are given in Section 3.2.1c "Utilization of Flue-Gas Waste Heat."

Combustion efficiency can be improved by optimizing the air-fuel ratio during combustion. Some of the common means of doing this are controlled air flow and proper burner tuning to adjust with pressure, temperature, and loading. Several commercially available means are available to achieve this. The latest form is an automatic combustion control system (APCS) that automatically adjusts air flow and burner settings to optimize the air-fuel ratio with changes in loading conditions, pressure, and temperature. A periodic spot check of combustion measuring temperature, excess oxygen and CO is also an effective way. A step by step boiler tuning procedure can be followed and a boiler log be maintained for variations under different operating conditions for long term plant specific adjustments.

3.2.1ab Boiler waste heat recovery. Excess waste heat can be recovered from flue gases and used to preheat the boiler feedwater or combustion air. Specific techniques employed are discussed in Section 3.2.1c below. Using recovered waste heat to preheat the boiler feedwater results in fuel savings because the boiler feedwater requires less heat for steam formation.

3.2.1ac Burner design. Burner design can be improved for specific installations to adjust flame geometry and suit specific fuel type. Some burner designs employ preheating of combustion air. Modifications in burner design require investment and have been ignored by the industry primarily because of lack of awareness on its energy savings potential and importance in improving overall efficiency. Existing plant measures requiring little or no capital expenditure to improve combustion efficiency through burner timing adjustments can be implemented by ensuring the following:

- Cleanliness of gas/oil injection traps
- Cleanliness of filter and moisture traps
- Cleanliness and proper movement of fuel valves (correct for jamming or excessive play)
- Adequate pressure to all pressure regulators.

3.2.1ad Boiler blow-down. Boiler blow-down can be recovered for use in preheating feedwater or combustion air. There are two types of boiler blow-down recovery systems, intermittent and continuous. Of the two types, continuous systems are more popular and offer more efficient heat recovery. Utilization of boiler blow-down in general tends to increase the equipment life as well. In plants surveyed, none employed any method of heat recovery from boiler blow-down.

3.2.1ae Boiler condensate return/pretreatment of feedwater. Condensate is usually higher quality and purer water with fewer corrosive elements in it; it requires less heat than ordinary water to form steam. Installation of a condensate recovery system can reduce the total fuel requirement for steam formation. Pretreatment of boiler feedwater ensures rapid evaporation and less build-up of corrosive elements in the boiler.

There are several factors involved in feedwater treatment that are relevant to the cost and ease of treatment, and consequences of improper treatment.

1. The higher the pressure and temperature of the boiler, the greater the corrosion and stress-induced damage to the boiler. Generally, above 600 psig/800°F boiler conditions, a demineralizer capital investment is warranted to maintain consistently high feedwater quality. The cost of chemicals and feedwater treatment procedures is significantly higher for 900 psig and higher pressures than for 600 psig and lower pressures.

2. The ease and cost of feedwater treatment for boilers below 600 psig/800°F are manageable with a minimum of chemical treatment and manual feedwater quality monitoring. The key

to good plant performance and mininum component corrosion is strict regularity of feedwater quality control. For a small but regular maintenance effort and cost, a major cost from boiler downtime and repairs can be avoided.

3. With the lower pressure/temperature boilers in use in most of the plants surveyed (and in many smaller Pakistan industrial plants), the training of semi-skilled labor can provide the in-house expertise necessary to keep feedwater quality under control. Training courses, and even in-house review of boiler and feedwater manuals can quickly provide the expertise needed to maintain the boiler and feedwater systems in a high state of performance, with minimum corrosion.

Exhibit 3.15 shows the estimated annual energy savings with a condensate return system in plants surveyed. The total energy savings are estimated to be 131.7 x 10^3 GJ, amounting to Rs 2.7 million per year. In general, larger plants are equipped with condensate return systems and savings were also computed for improvements in existing condensate return systems. Improvements/modifications are primarily those related to provision of high quality, high temperature condensate to ensure rapid steam formation.

3.2.1af Maintenance and cleaning. Over time, the shell and tube of the boiler get deposits of various salts present in the feedwater mixtures and air. These salt deposits reduce surface conductivity and thus increase heat transmission losses. Although frequency of maintenance and cleaning is specific to each industry, depending on factors such as feedwater quality and operating environment conditions, routine maintenance and cleaning should be carried out 3 times per year. Regular cleaning of boiler shell and tubes would improve heat transmission and thus reduce fuel requirements.

Comparing fuel bills in plants audited before and after cleaning indicated an average saving of approximately 7 percent in input fuel. This difference suggests the savings potential to be realized with proper maintenance and cleaning procedures. If the frequency of maintenance and cleaning is increased to, for example, 3 times per year, savings of about 20 percent* in input fuel could be attained.

* The savings would follow an exponential decay function over time. The number has been rounded to give an approximate average with continued operation.

Exhibit 3.16 shows estimated savings with improved cleaning and maintenance procedures in the plants surveyed. The total savings are 184.8 x 10^3 GJ of energy, amounting to Rs 4.1 million per year. Savings from pre-treatment of feedwater are included in these estimates. It was observed during the surveys that 80 percent of the plants are using raw water without any pretreatment. Those that did pretreatment were confronted with difficulties in obtaining good quality chemicals. These chemicals are priced very high, partly due to import duties imposed by the government. The quality of water in terms of its hardness and thermal conductivity showed regional variations so no one standard pretreatment procedure could be applied. Detailed plant specific water quality evaluation and pretreatment procedures are required to reduce scaling. Exhibit 3.17 shows that the potential savings from feedwater pretreatment are 65614 GJ, amounting to Rs 1.25 million annually.

3.2.1ag Insulation. Exhibit 3.18 shows the quality of insulation on boilers in the plants audited and heat losses through radiation. The estimated savings based on using good insulation were determined by measuring surface radiation losses from the boilers using an infrared scanner. The total annual savings in energy are estimated at 88855.2 mwh, and amount to Rs 594532 per year. Most of the plants have poor to fair quality insulation. The primary factor determining the effectiveness of insulation is the quality of insulation material used.

3.2.1b Improvements in Furnace Efficiency

Exhibit 3.19 shows the quality of insulation and estimated heat loss on furnaces in plants surveyed. The quality of furnace insulation varies from fair to none at all and in most of the plants, furnaces are poorly insulated. Exhibit 3.20 shows the estimated average annual savings in the metal-mechanic plants due to improved furnace efficiency.

The total estimated savings are 42.1 x 10^3 GJ per year, amounting to Rs 3.6 million per year. Among the most significant measures for improving furnace efficiency are:

- improved insulation
- better design
- usage of ultra high power furnaces.

3.2.1c Utilization of Flue-Gas Waste Heat

In all the plants audited, the heat carried away by the flue gases is excessive. This waste heat could, if recovered, be used in attractive energy-conserving applications such as preheating feedwater or combustion air, or as process air, etc. The overall effect would be more efficient use of energy and more productive operation of the plant.

Exhibit 3.21 shows the temperature, volume, and quantity of heat carried away by the flue gases in the plants audited. The temperatures of flue gases are high (up to 521°C), and the heat carried away is excessive. Experience in similar industries overseas has shown that typical values of stack temperatures range from 120°C to 140°C. Experience with flue gas heat recovery indicates that, with stack temperatures as low as 120°C, 10 to 15 percent savings in input fuel can be attained.

The total heat lost accounts for 15 percent of total input energy in the plants audited. Exhibit 3.22 shows the estimated savings for these plants with flue gas waste heat utilization. The total would save 255 x 10^3 GJ per year of input energy amounting to Rs 13.1 million per year.

There are several techniques for recovering waste heat in flue gases; some applications are industry-specific and are not applicable to all industries. Some potentially suitable technologies that can be implemented in the plants audited to recover waste heat are:

- Economizers
- Recuperators
- Rotating regenerators
- Heat pipe heat exchangers
- Run-around coil heat exchangers
- Gas-coupled indirect heat exchangers.

3.2.1d Reduction of Steam System Losses

Exhibit 3.23 shows the typical condition of steam distribution piping in the plants audited. Leakages are present at various points along the piping, particularly at joints; pipes are rusted, badly insulated, and their overall layout indicates an inefficient distribution system.

Steam system losses can be reduced by:

- Improving piping insulation
- Eliminating steam traps
- Eliminating leakages
- Improving the layout of the steam distribution network.

No data or layout plan was available on total piping for the steam system, so it was not possible to take complete measurements. Steam traps and leakages were spotted at many points, and readings of heat losses were obtained at those specific points. While exact calculations could not be performed, a conservative estimate based on approximations indicates that a total of 18 percent of savings in input fuel could be attained by providing good quality insulation, detection and proper elimination of steam traps, elimination of leakages, and improving the layout of the steam distribution network. Exhibit 3.24 shows average annual industry-wide savings resulting from improved steam distribution system. The total savings are 403 x 10^3 GJ of energy, amounting to a savings of Rs 10.7 million per year.

3.2.1e Reduction of Hot Water Losses

In the plants surveyed, there is excessive waste of hot water at high temperatures. Hot water losses could be reduced by:

- Condensate return
- Efficient use of wash water.

3.2.1ea Condensate return. Substantial savings in fuel used for steam raising could be achieved by using condensate return to the boiler feedwater.

The condensate from steam is generally high-quality water that requires little or no pre-treatment; it rapidly evaporates, and because it is at a higher temperature, less fuel is required to form steam. It is generally considered that retrofitting a condensate return system in a plant yields about 10 to 30 percent savings in fuel used to raise steam.

Referring back to Exhibit 3.15, it shows recoverable heat from condensate return for the plants surveyed. The calculation assumes no heat loss in additional piping required for retrofitting a condensate return system. The total for the plants surveyed amounts to 131.7×10^3 GJ per year, amounting to Rs 2.7 million per annum.

3.2.1eb Wash water. Processes such as jet dyeing that use hot water can reduce waste by:

- Using taps that automatically shut off when no water is required
- Insulating storage tanks
- Reducing temperature of the wash water by a few degrees
- Avoiding excessive use.

In addition to the basic measures suggested above, specific heat-recovery systems could be installed to recover the heat in high-temperature water for use in other processing stages within the plant. This type of analysis requires detailed, industry-specific engineering feasibility studies and cannot be evaluated on one-day energy audits. Heat recovery can lead to significant savings in energy and overall improvement in plant efficiency. Some of the heat-recovery systems and their potential for energy savings are discussed in Section 3.2.1g below (Utilization of Process Waste Heat).

3.2.1f Reduction of Electric Power Losses

Electric power losses can be reduced by:

- Improving power factor of the plant
- Correct matching of motors
- Voltage stabilization
- Improving maintenance and operating practices of moving parts.

The industry average of recorded power factors is 0.75. If the power factor is improved to 0.80 by installing capacitors and ensuring correct matching of load, a total of 21437 Mwh (amounting to Rs 1.6 million per year) could be saved in the plants surveyed. Industry-specific savings are shown in Exhibit 3.25. The total potential for saving is about 12 percent of current electricity consumption in the plants surveyed.

Most of the electric energy is used in motors to drive moving parts. Matching of motors to load and proper lubrication of moving parts would save electric power.

Standard procedures for maintenance of all moving parts should be set. Another important factor is voltage stabilization. Voltage variations are very common and, because of frequent load shedding by WAPDA, it is even more important to install voltage stabilizing devices.

Voltage stabilization would improve the operating efficiency of all electric equipment and increase equipment life.

3.2.1g Utilization of Process Waste Heat

There is excessive waste heat in almost all processes in the plants audited. Several techniques involving moderate to substantial capital outlay can be used to reduce and utilize process waste heat. Since most of these techniques involve retrofitting and design changes, they are discussed in detail in the section describing improvement opportunities in design. In this section, potential savings through modifications and changes in existing practices are discussed.

Another important energy-intensive process is that of drying in textile plants. Current operating practices do not employ any set procedures for optimizing drying times; in general, fabrics are overdryed. Overdrying results in excessive energy usage. If the drying times are optimized using process controls, savings of about 20 percent in input energy can be achieved. Industry-specific savings are given in Exhibit 3.26. The total savings for the fifteen plants using drying processes are 105.7 x 10^3 GJ amounting to total savings of Rs 3.0 million per year.

3.2.1h Identification of Fuel Substitution Opportunities

The study called for identification of fuel substitution oportunities. These were identified through management discussions at each plant and INTRAG's analysis of plant size and operating requirements. Short of an indepth examination of all fuel options in a detailed energy audit, the fuel substitution thought most practicable and valuable to Pakistan is a mixture of coal and oil. Four plants were identified as having the potential for a coal-oil mixture, based on the plant size and type of operations:

- Pakistan Paper Mills in Charsada.
- Adamjee Paper Mills in Nowshera.
- Colony Textile Mills in Multan.
- Bannu Woolen Mills in Bannu.

The technology for using coal-oil mixtures is established, and receiving increasing attention in many countries. Part of the task of achieving the use of coal-oil mixtures in Pakistan lies in providing the necessary technology transfer from these other countries. Such technology transfer will be part of a large program now being implemented by Enercon, a recently established Pakistan organization receiving its initial funding from the U.S. Agency for International Development.

In addition to the coal-oil mixtures that could be substituted in the above plants, other actions described in this report also displace primary fuels and are a form of fuel substitution. Refer to the sections on:

- Utilization of process waste heat.
- Installation of new types of equipment.
- Installation of cogeneration equipment.
- Utilization of flue gas waste heat.
- Microwave heating.

3.2.2 Design

Modifications and improvement opportunities in design generally require higher capital outlays and offer the greatest potential for energy conservation. This implies that any implementation or modifications in the design must be analyzed in terms of its economic attractiveness.

In this section, different energy-conserving techniques and their applicability to the plants audited are discussed. Improvement opportunities in design are of two general types:

- Upgrading/retrofitting in existing equipment
- Replacement with new equipment.

3.2.2a Existing Equipment

Design modifications in an existing system can range from small changes to a major overhaul of existing processes. A wide range of modifications have been successfully employed and, because many of them are process-specific, it is not possible to generalize the merits of one successful implementation to entire industry sectors. Several constraints and industry-specific problems restrain general applications of design changes. For instance, the plant layout of a particular industry may not permit application of a new system that has been successfully used in other plants. However, for the purposes of the present analysis and based on the findings of the plants audited, the design modifications described below can generally be implemented in the industries. The proposed design modifications on existing plants are of two types:

- Automatic process control systems
- Waste heat recovery systems.

3.2.2aa <u>Automatic process control systems (APCS)</u>. The most attractive application for APCSs are in the areas of combustion and drying. Both of these processes are energy-intensive and consume maximum energy.

Combustion APCS optimizes the air-fuel ratio by automatically adjusting to any changes in loading, temperature, pressure, inlet air, exhaust, and humidity. Several versions of APCSs are commercially available for installation at boilers, dryers, and furnaces. Modern APCSs offer automatic burner-tuning facilities and automatic control of isolators on chimneys. Isolators are devices that automatically close and do not allow heat to escape when a boiler or a furnace is not in operation. The most modern ones have reported savings on the order of 35 to

40 percent of input fuel through optimization of air-fuel ratios for boilers or furnaces.

APCSs on dryers optimize drying times through constant on-line monitoring and control of humidity. There are several APCSs available for use on dryers. An industry-wide survey of applications indicates that installing APCSs on dryers would result in an average potential savings of about 24 percent. Exhibit 3.26 shows the industry-wide savings in terms of energy and Rupees per annum that could be achieved by optimizing drying times.

3.2.2ab Waste heat recovery systems. In the plants surveyed, excessive waste heat is lost in many processes, and there exists no system to recover and utilize it. In fact, this area offers the second highest energy savings potential among the plants surveyed. Waste heat recovered from various processes has many attractive energy-savings opportunities: for example, preheating feedwater; preheating boiler air; and preheating air or gas in the same process rejecting heating.

There are many waste heat recovery systems commercially available. Each system has its own advantages and potential for energy conservation, depending on design, ratings, and suitability to a specific process. It is beyond the scope of this study to investigate optimal plant-specific designs and carry out analysis of savings accruing from each one. However, some waste heat recovery systems potentially applicable to the plants audited are summarized in Exhibit 3.27. Typically, such systems can save 10-20 percent of total plant energy use. Specific installations would require a detailed engineering and economic study for each system, and some cases may also require design modifications to suit process-specific needs.

3.2.2b New Equipment

Some of the machinery in the plants audited is outdated and warrants replacement. This section describes modern and state-of-the-art equipment. Investments in these are substantial but offer a very high energy-savings potential.

3.2.2ba Microwave heating. In many textile manufacturing processes, particularly drying, microwave heating techniques could be used. This would completely eliminate the use of steam heating. Some of the advantages of microwave heating are: uniform and rapid heating, thereby reducing drying times; control of moisture content; on-off switching, which avoids idling; simple operation; and clean atmosphere.

Such a system would yield savings of half or more of the total cost of drying.

3.2.3 Management and Administration

Management and administrative procedures play a vital role in energy consumed per unit of output and, in some instances, improvements in these can have a greater impact in overall plant energy usage than investments in technologies for energy conservation. Areas that need improvement are as follows:

- Production planning
- Operating procedures
- Maintenance procedures and recordkeeping
- Training and incentives.

3.2.3a Production Planning

In almost all the plants audited so far, managers are unfamiliar with planning procedures. Orders are often handled in complete disarray without any one giving consideration to an optimal plan for routing responsibilities. Inventory control is carried out very informally, and orders are often delayed. Mismanagement in handling orders and responsiblities leads to machines being started up only to stand idle, which results in increased energy used per output item.

The training institutes should include courses in proper production planning and teach the techniques to implement it.

3.2.3b Operating Procedures

In most of the plants audited, the operators did not monitor and operate the plant on a routine, regular basis to keep energy losses down.

Operating procedures need to be modified by incorporating:

- Routine audit checks
- Idle time monitoring.

Routine energy audit checks should be performed to ensure efficient operation of all plants. These audits need not be done with the help of outside consultants or experts, but could be accomplished by good recordkeeping practices and monitoring properly installed energy data-recording instruments by industry staff. These data, if recorded on routine basis, would be of immense help in evaluating overall plant operation and considering future investments.

Many processing stages operate in batches, and the idle time between product processing tends to waste energy. This idle time should be efficiently utilized without losing any useful energy content in the product. Some of the plants audited operate without any regard to idling of machines; many machines are underutilized, resulting in higher energy usage per output item. Operating times to meet certain fixed demands should be properly scheduled in order to minimize idle running time of machines. Where facilities are rented out to outside customers on time-charge basis for processing cloth or other products, penalties or charges to cover energy cost should be recovered in case of no-shows. In general, idle time monitoring is a serious problem in almost all the plants audited so far.

3.2.3c Maintenance and Recordkeeping

In general, little or no information is available on maintenance, machine operation, repairs, or breakdowns.

No records were made available on machines, and INTRAG teams recorded information available only on nameplates or on the machines. Maintenance records receive very little attention by plant management. Proper equipment records, along with analysis of performance such as trend graphs, would provide an excellent basis for comparing machine and plant performance with regard to operation and efficiency. Such records would also be useful in directly identifying problem areas and taking necessary improvement actions.

3.2.3d Training and Employee Incentives

Most of the operators and managers lack initial training or up-to-date knowledge of technology, which leads to poor and inefficient operation. Some of the smaller plants do not employ a single graduate engineer. Operating knowledge is passed on to newcomers by directly introducing them to the on-off type machine operations. Little attention or concern is given to energy conservation by either managers or operators. The training institutes should revise their curriculum to bring them up to date on present practices; courses on energy conservation should be taught in order to develop an understanding of plant energy usage.

3.2.4 Energy Conservation Findings

Based on average annual use of energy in the eight plants audited, the achievable energy conservation per plant ranges from 15 to 40 percent. Major opportunities exist in:

- Improving boiler efficiency and operation
- Improvements in furnace insulation
- Flue gas heat recovery and utilization
- Improving steam distribution systems
- Power factor improvement
- Optimizing drying times/Using process controls on dryers.

Exhibit 3.28 summarizes the estimated energy and financial savings from implementing actions for each of the above opportunities. Exhibits 3.13-3.26 provide a detailed breakdown of energy and financial savings by plant for each of the improvement opportunities. The following assumptions and factors must be understood to appreciate Exhibit 3.28:

- The estimated savings discussed earlier for improvement in boiler cleaning and maintenance, boiler insulation, condensate return, and feedwater pre-treatment are not included in the exhibit, because they would partly "double count" the savings shown for improved boiler efficiency. However, because they would undoubtedly improve the boiler-related savings, the enclosed exhibit does not fully reflect the boiler-related opportunities.

- A value of 3.6 million joules/kWh is assumed for the energy content of on-site electric power use. In fact, the actual primary energy saved would be closer to 15-20 million joules/kWh, as actually experienced by the electric utility power plants supplying the power. It is for this reason, and the higher relative price per energy unit of electricity, that the energy savings from improved power factor are disproportionately lower than the financial savings.

- The energy and financial savings vary among plants, which fall within a range of 15-40 percent. Exhibits 3.13-3.26 show the plant-specific savings.

The power factor improvement and flue gas heat recovery opportunities are clearly the most significant, accounting for 30% and 25%, respectively, of the total available energy savings estimated.

This chapter described the findings on conservation potential and improvement opportunities, providing a basis for evaluating and ranking available improvement opportunities for purposes of an energy conservation action plan. Chapter 4 addresses these next steps.

4 TARGETED ENERGY CONSERVATION ACTIONS: A FRAMEWORK FOR AN INDUSTRIAL ENERGY CONSERVATION PLAN

Determining energy losses and inefficiencies and identifying general improvement opportunities, as described in Chapter 3, are only two steps -- although critical ones -- towards achieving real energy savings in Pakistan. Just as important is the formulation of specific improvement actions that are technically, financially, and institutionally feasible. That is, the financial payoff of the actions and equipment investments must be attractive, the plants must have available to them in Pakistan conservation technologies and equipment relevant to their needs, they must have access to capital, they must have the technical resources to select and install the equipment, and they must have the capability for ongoing maintenance and operation of the equipment so that the energy savings are achieved year after year.

Therefore, the improvement opportunities, numerous as they appear to be, must be carefully analyzed for their economic attractiveness and implementation feasibility. This Draft Report addresses these requirements, based on completion of 30 energy surveys. The sections of Chapter 4 cover:

4.1. Energy use trends and the role of energy conservation

4.2. Economic evaluation of industrial conservation improvement actions

4.3. Barriers to implementation of needed actions

4.4. Framework for an overall industrial energy conservation plan.

Each of these sections is discussed below.

4.1 ENERGY USE TRENDS AND THE ROLE OF CONSERVATION*

In April, 1985, members of the governmental Working Group on Energy Conservation reviewed Pakistan's energy situation and the related need for conservation. The following discussion is extracted from materials prepared by the Working Group; it provides a clear and concise backdrop for setting energy conservation objectives, and formulating an action plan.

Pakistan's total primary energy consumption in 1983/1984 was estimated at 24.5 million tons of oil equivalent

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* The discussion in this section was extracted from materials prepared in April, 1985, by the governmental Working Group on Energy Conservation.

(TOE), of which 16.5 million TOE or 67 percent was commercial energy. Over the Fifth Five-Year Plan period, which ended in 1983, primary energy consumption grew at 8.5 percent per year. In Pakistan, energy consumption is growing at a rate 35 to 40 percent greater than the Gross National Product (GNP), whereas in industrialized countries annual energy consumption is increasing at only half the rate of the GNP. Even in the newly industrializing countries of Southeast Asia and the Far East, the energy consumption elasticity has been less than 1.0 in recent years. Pakistan must reduce its energy/GNP ratio if it wants to sustain economic growth and social development.

Moreover, as an oil importing developing country, Pakistan faces major economic and financial challenges. World oil price increases and a relatively high rate of domestic economic growth has pushed the cost of oil imports from $50 million in 1972 to about $1.6 billion for the fiscal year 1984/1985. The continuing need for rapid economic development, together with a 3 percent annual population growth rate (the highest in Asia), is creating a demand for energy that strains Pakistan's physical, financial, and human resources. Although the country has valuable coal, gas, oil, hydropower, and renewable energy resources, the generally long lead times and/or high investment costs required to develop them will require continued increases in oil imports in the short and medium term.

The extent to which these increases are kept economically and politically manageable will depend on how efficiently energy is used and how effectively the institutions in the public and private sectors are mobilized to execute a comprehensive national program of energy conservation.

4.1.1 Pakistan's Energy Imbalance

Over the past 10 years, Pakistan's energy supply/demand imbalance has increased as demand has outpaced domestic production and imports. As a result, electricity and natural gas shortages, which first occurred in the early eighties, are expected to continue into the foreseeable future.*

The adverse effect of Pakistan's energy imbalance on foreign exchange, economic output, debt and resource

* The most recent estimate projects the electric power capacity deficit for WAPDA at 995 MW in 1987/1988, approximately 20 percent of peak demand, and at more than 3,100 MW, or almost 40 percent of peak demand, in 1992/1993. The natural gas deficit is projected to remain as high as 18 percent of peak load demand in 1987/1988, and 11 percent in 1992/1993.

mobilization imperils its ability to provide a satisfactory quality of life for its people and attain its desired self-reliance and progress.

Pakistan's options for correcting its energy imbalance include measures to increase supply and moderate the rate of energy consumption. However, even if vigorously pursued, many of these measures will not be effective or practical in the short run.

With respect to supply, the expansion of domestic oil and gas production, although extremely important, will not be enough to keep pace with demand. Increases in refinery and electrical capacity cannot resolve the problem because of the time needed to bring new capacity on line. The Sixth Five-Year Plan's capacity targets have already fallen behind schedule in the power sector and less than one-half the originally projected capacity additions will be realized by the end of 1985. The high levels of oil imports will continue, but this alone cannot be relied upon to meet demand because of other urgent demands of foreign exchange and the limited ability of the installed refining and distribution system to handle a higher level of imports.

With respect to demand, additional load shedding, factory rescheduling and shutdowns, and other severe demand reduction measures are becoming politically and economically more painful. Even if major short-term price adjustments beyond those already contemplated are made, producers and consumers would need time to adjust. Although such adjustments are critical to solving Pakistan's energy problems in the long run, they are not likely to have an immediate and major effect on the energy balance without causing sharp dislocations and other problems in production and employment. In the short term, therefore, Pakistan's options for improving the energy situation lie in energy demand management and conservation activities. These activities include increasing the efficiency of energy use in existing power generation, reducing energy waste in all sectors of the economy and, where feasible, switching from expensive and unreliable fuels to cheaper and more reliable energy sources such as domestic coal.

4.1.2 Sixth Five-Year Plan and Conservation

The Sixth Five-Year plan, whose prime objectives in the energy sector are to provide additional energy supplies to support economic growth, and to prevent current shortages in supply from re-emerging at a later date, has set targets for reducing the elasticity of energy demand from 1.4 (over the Fifth Five-Year Plan period) to 1.15 by 1988 and to less than 1.0 during the Seventh Five-Year Plan period. The plan has allocated some Rs. 116.5 billion for the overall energy program. Of this amount, the Government of Pakistan (GOP) intends to allocate Rs. 350 million, or 0.3 percent of the budget, for energy conservation.

The main focus of the conservation strategy outlined in the plan is on energy pricing that will bring Pakistan's energy prices in line with international prices within a socially acceptable time frame. The plan also contains proposals for spurring conservation by actions in several key areas: providing incentives for the purchase of energy-efficient equipment; conducting an energy conservation awareness campaign; labeling equipment and appliances with energy efficiency information; improving the level of fuel substitution; and setting minimum standards for energy-efficient equipment and banning equipment that does not meet those standards. The plan also encourages certain basic changes in life style, such as using public transport instead of personal vehicles, decreasing the use of household electrical appliances and improving architectural design standards to reduce building heating and cooling requirements. The Sixth Five-Year Plan's conservation-related proposals are both valid and appropriate; however, most of them have not so far been implemented.

4.2 EVALUATION OF INDUSTRIAL CONSERVATION IMPROVEMENT ACTIONS

4.2.1 Improve or Modify Existing Plant

In Chapter 3, a range of industrial energy conservation actions were identified, based on the plant surveys and management interviews. As shown in Exhibit 3.12, the types of improvement opportunities were almost universally applicable. It is important to note that, for each plant, each of the specific improvements listed was determined to have achievable energy savings potential.

These opportunities must be translated into specific improvement actions through economic analyses and positive decisions by plant management. To facilitate an understanding of the economic attractiveness of such actions, Exhibit 4.1 summarizes the economic evaluation of actions to: (1) improve or modify the existing plant configuration, (2) make design changes to the plant configuration, and (3) carry out management and administrative actions. For each of the specific actions shown, the nature of the improvement action is evaluated -- equipment investment requirement, operating and maintenance action, or the ease and financial attractiveness of the management and administrative actions. The types of energy conservation improvement actions evaluated are discussed below.

1. Improve boiler/furnace efficiency. Because 40% of the energy used in the plants surveyed is boiler fuel, the energy savings opportunities from improving boiler/furnace efficiency are significant. In Chapter 3, the energy savings opportunities from boiler and furnace efficiency improvements were discussed and quantified. When the range of investment costs and paybacks are considered for these types of boiler/furnace efficiency improvements, the range of payback periods is less than one to as much as three years. In virtually all cases, this would provide an acceptable return to management, if a proper engineering feasibility study could be done, capital were available, and management and operating expertise were sufficient. In several cases (combustion efficiency, temperature/pressure control improvements, and maintenance and cleaning) immediate actions can be taken at virtually no cost to save energy.

2. Utilize flue gas waste heat. Experience in all industrial countries indicates that, with few exceptions, utilizing flue gas waste heat through the installment of recuperators or other heat transfer mechanisms proves economically worthwhile. Typical uses of flue gas waste heat are for feedwater preheating and process air preheating. It is not uncommon for a two-year payback or better to be provided by such investments.

3. Reduce steam system losses. Steam system losses occur in a variety of ways, including inadequate insulation of steam pipes, leaky steam traps, and other steam system leaks. To better insulate steam piping and to repair the majority of steam system leaks, a minor cost (relative to other energy conservation investments) is necessary. Typical paybacks for such investments are usually less than three years, and often less than one year. Further, minor repairs of steam traps require little or no capital, and can provide immediate and economic energy savings.

4. Reduce hot water losses. Hot water losses, as with steam system losses, can occur in a variety of ways. One example -- heat loss in hot wash water -- is shown. As opposed to actions to reduce steam system losses, investments to reduce hot water losses typically have a

longer payback. It may be, given the payback of other actions, that hot water losses may not be economic enough to address in many plants.

5. Reduce electric power losses. Low cost actions to adjust the power factor, stabilize voltage or better maintain moving parts can quickly reduce electric power losses, and generally provide paybacks of less than three years. Correctly sizing motors to the particular loads involves new motor investments, and the payback is typically longer for such investments, perhaps four years. Some actions -- certain power factor adjustments and moving parts maintenance -- can be taken with virtually no capital, and can provide immediate energy savings.

6. Utilize process waste heat. Like flue gas heat recovery, certain processes emit concentrated streams of capturable waste heat. Depending on the location of this waste heat, it can be routed through dryers or through spaces requiring heating, thus reducing primary fuel usage. Such actions typically have a 4-5 payback, and may not prove economic when ranked against other actions.

4.2.2 Make Design Changes

The above actions can largely be taken as modifications or enhancements to an existing plant. In some cases, it may be economic to replace existing equipment with newer design, more efficient equipment. Actions that appear worthwhile at most plants are discussed below.

1. Replace existing equipment. In many plants, there were existing waste heat recovery systems or process control systems that were simply of an older design, and which posed technical limits on the amount of energy savings possible. By replacing this equipment with newer design systems, significant additional energy savings could occur. Typically, the investment required for new waste heat recovery systems are significant, while the cost of new design process control systems are lower. The latter, incorporating emerging microprocessor systems, are becoming cheaper and more effective all the time. The payback period for the above types of investments is roughly 2-3 years.

2. Install new types of equipment. Technology development over the past decade or more has produced new types of equipment not available twenty years ago. One good example is microwave or R.F. heating and drying systems. While these systems involve a relatively significant cost, when compared to other actions, the payback can often be two years or less.

3. Install cogeneration equipment. In a number of plants where a significant and relatively steady steam demand exists, the technical opportunity to install a cogeneration system exists.* In cases where cogeneration makes technical sense, primary energy savings of 10-40% of primary fuel use can occur. Furthermore, cogeneration may offer the opportunity for substitution of coal or renewable fuels for oil or natural gas. And importantly, the on-site production of electric power along with steam makes a direct contribution to one of Pakistan's worst energy problems -- inadequate electric power capacity. For any plant where cogeneration equipment is installed, the availablity of electric power is increased, and the effects of load-shedding from the electric power system are greatly reduced.

However, there is a key issue affecting the attractiveness of cogeneration -- subsidized electric power rates. Usually, the major economic benefit from cogeneration is the savings in electric power costs paid by the industrial plant. The lower the electric power tariff to the plant, the lower the savings for a given amount of electric power displacement. This can have the effect of making a

* Cogeneration is defined as the production of both electric power and useful thermal energy in an efficient, sequential manner from a single power plant.

cogeneration plant less economic, while the overall energy and cost savings for the nation are significant. Even so, for plants with a year-round and fairly steady demand for steam and electric power, the payback from investment in cogeneration equipment is expected to be 2-3 years.

For cogeneration configurations where electric power in excess of the industrial plant need is produced, at least during parts of the day or year, a second economic and institutional barrier can exist. The electric power company (WAPDA or KESC) may not readily agree to a long term power purchase rate, which is necessary for the investment to take place. Typically, in many of other countries where cogeneration has been tried or is actively under consideration, there is a reluctance of the governmental or regulated utilities to accept privately owned power. Depending on the rate that would be paid for excess power from WAPDA or KESC, the payback could range from 2-5 years.

Cogeneration applications were not analyzed for any of the plants surveyed because of the need to gather hourly steam and electric power data, and ascertain with WAPDA or KESC that such on-site power generation would be technically and economically workable.

4.2.3 Carry Out Management and Administrative Actions

As shown in Exhibit 4.1, page 2, there are a range of management and administrative actions that can reduce energy use. Many of these can be taken through an immediate change in plant procedures, with relatively minor costs and almost always paybacks of less than one year.

For several of the actions, however, changes cannot be made without some additional, external training, or through technology transfer activities not currently in place. These external support requirements are shown in Exhibit 4.1 in order of their ease and immediacy of implementation of the actions.

Regardless of the ease of implementing the actions, none requires significant investments, and all can provide paybacks that make the actions worthwhile.

4.3 ANALYZE BARRIERS TO IMPLEMENTING CONSERVATION ACTIONS

While there are a broad range of energy conservation actions that could provide significant energy savings, not all of them are likely to be economic enough to warrant investment or management time. Further, there are substantial non-economic barriers to their implementation. These barriers must be understood and addressed by a national energy conservation plan if any significant conservation benefit is to be achieved in Pakistan industry.

As part of the Intrag/Zelin surveys, management interviews were conducted, and barriers to conservation investments and actions were identified and discussed. The results of these interviews are discussed in this section. It is important to note that, in the absence of solid economic analysis, sometimes the technical barriers are perceived as economic barriers, and vice versa. Nevertheless, it is instructive to note the barriers identified by industrial plant managers. In Exhibit 4.2, the reasons for taking no conservation action are summarized in terms of the percent of managers citing each reason. The barriers are technical, economic, financial, management or administrative, and governmental policies.

Virtually all of the managers cited the lack of technically suitable or overly expensive equipment as a barrier. While this may seem partly an economic barrier, the lack of ready availability of certain types of equipment (e.g., small recuperators) is a technical availability barrier that becomes an economic barrier if individual components are imported on a low volume-high price basis from other countries.

20-30 percent of the managers cited inadequate savings or too long a payback period as a reason not to make conservation investments. While these barriers seem clearly economic, it may be that the best technical/economic alternative was not considered by plant management. Given the limited total interview time, the team was unable to ascertain this.

A great majority of the managers cited lack of capital as a reason for not making otherwise economic investments. This is a typical and critical barrier to conservation investments in countries with rapid economic growth.

More than 3/4 of the managers cited staff resistance to new practices and lack of suitably trained staff as reasons that energy conservation actions could not be implemented. The team believes that addressing this barrier could yield great dividends at a limited cost through training and special technology transfer activities.

An important barrier affecting the economics is the subsidized cost of energy, and the lack of other governmental incentives to offset it. While, for the nation as a whole, certain energy conservation actions would be economic, only a part of the savings is seen by the industrial facility. If, on the basis of his portion of the savings, the investment is not worthwhile, it is not made. This institutional barrier must be addressed in an energy conservation plan, if the potential energy savings is to be achieved.

A final barrier ("more important problems facing the company") was cited by over half of the managers. These more important problems covered a range of factors. and is not surprising. However, with better information availablity through good technology transfer, and better staff training and awareness of energy conservation options, the management time required to evaluate and make conservation decisions is reduced. In this case, the "more important problems" would likely be less of a barrier.

4.4 FORMULATE OVERALL INDUSTRIAL ENERGY CONSERVATION PLAN

4.4.1 Conservation Plan Perspective

An effective industrial energy conservation plan is one that facilitates and directly assists the private industries' management practices and investment decision processes. While some management practices are easy to implement (e.g., housekeeping improvements), the process for evaluating and deciding upon the more significant and complicated conservation equipment investments must be clearly understood. This investment decision process is illustrated in Exhibit 4.3. Based on the results in this report, a majority of the industrial companies will need external technical and financial assistance to supplement their internal capabilities in evaluating, making, and implementing major conservation decisions.

In light of the above, a joint industry-government conservation effort will be needed to achieve the maximum fuel savings potential in the nation. A broad range of actions at the plant level and governmental level must be identified, such as:

- Plant equipment investment actions -- by type and cost
- Economic incentives needed that are not now present

- Regulatory actions that may be needed to remove barriers or, in some cases, require certain plant practices
- Technical assistance or technology information transfer across industrial sectors or from other relevant national governmental efforts
- Training programs at the national and plant level
- Incentives for the private engineering and construction infrastructure needed to support the detailed audits and the conservation investments decisions.

Once this broader set of actions is identified, a set of evaluation criteria must also be formulated to determine which actions are worthwhile. These criteria would include:

- Direct financial payoff for the plants
- Fuel savings for the nation as a whole
- Increased use of internal Pakistani energy resources (e.g., coal)
- Overall implementation feasibility from an industrial sector point of view
- New jobs and other economic benefits.

Given this perspective, a framework for a national industrial conservation plan is provided in the following section.

4.4.2 Framework for an Industrial Energy Conservation Plan

A well-prepared National Industrial Energy Conservation Plan is essential because of the coordination required among the end-users, the Government of Pakistan, and the technical, financial, and other support services required to achieve the energy conservation.

A number of energy conservation studies, assessments, and audits, with a particular focus in industrial plants, have already been carried out. This work has revealed areas offering significant energy conservation opportunities, and must serve as a point of departure to expand and build up energy conservation activities in Pakistan.

Before one can develop a complete and coherent Plan, there are prerequisites to be accomplished -- the analysis of issues and the concurrent setting of energy conservation objectives -- which then allow a plan to be developed. The prerequisites to the Plan and the framework for the Plan are discussed in the following two sections.

4.4.2a Prerequisites

There are several steps to be carried out prior to developing the Plan:

1. Review energy conservation assessments and work already done; synthesize the issues. There are a number of important governmental documents and periodic reports to be carefully reviewed and understood prior to discussions on objectives with cognizant government officials. For instance, the most recent five-year plan objectives, and the preparation activities associated with the next five-year plan, must be carefully understood.

   Further, special studies and forecasts of energy supply and demand should be reviewed -- the Power Market Survey by the planning deparment of the Power Wing of the Water and Power Development Authority (WAPDA). Finally, there are annual or other periodic reports provided on energy use in Pakistan. One example is the Energy Yearbook published by the Ministry of Petrolum and Natural Resources. Other examples are the regular editions of Power Systems Statistics published by WAPDA.

2. Interview and gain commitment from governmental officials regarding specific energy conservation objectives and priorities among these objectives. Different ministries have different responsibilities, and insights to provide that must be understood immediately. Discussions with these governmental officials, as well as key industrial sector leaders, will ensure that the Plan is developed on a realistic basis and addresses all of the industrial conservation needs of Pakistan.

3. Evaluate key issues, and set up action plans to resolve or address them. Some issues (e.g., capital constraints) may have a solution through such vehicles as the recently instituted US AID Energy Commodities and Equipment Program. Other issues (e.g., subsidized power prices) involve a range of social and economic considerations beyond the scope of an energy conservation plan. While there may be ways to work with governmental officials to resolve these to some extent to stimulate energy conservation, there likely will be no immedi te resolution and further analysis and coordiantion actions to deal with these issues must be built into the long-term energy conservation plan.

With a clear understanding of Pakistan's objectives, a meaningful Plan can be developed, as outlined in the framework below.

4.4.2b Framework for the Plan

Introduction and Objectives. The Introduction should provide a discussion of the overall energy situation in Pakistan, the need to take action in the areas of energy supply, energy demand and conservation, and the legislative and pricing actions that can affect or constrain certain supplies and uses of energy.

In the light of the overall energy picture, the broad objectives of the Plan can be laid out in terms of:

a. Reduction of energy waste
b. Increases in the efficiency of energy use.

The above broad objectives must be achieved for a given level of economic output, since cutting back in economic output to save energy may be self-defeating. Within the context of the above broad objectives, fuel substitution opportunities should be examined.

The major obstacles to be overcome in achieving energy conservation must be clearly identified. To reinforce the discussion in Section 4.3, these obstacles include:

- Lack of awareness on the part of industry sector managers on actions they can take and equipment investment opportunities that could save them money.

- Technology constraints requiring selected applied research, demonstration projects, or other commercialization activities.

- Constraints in the capacity of the technical, financial, and other services' infrastructure that must be addressed before the objectives can be fully achieved.

- Legislative or regulatory obstacles to more efficient use of energy, e.g., energy prices, tax factors.

With the objectives and obstacles to be addressed well-understood, the plan will then discuss the specifics in the following parts.

End-Use Sectors to be Addressed. Energy use patterns, technologies relevant to energy use, and management and administrative practices vary significantly across different industrial sectors. Industrial sectors to be evaluated at the plant level as well as in total include:

- Textiles
- Metal/mechanic
- Paper and chipboard
- Refining
- Fertilizer and chemicals
- Cement
- Iron and steel

The different processes in the above and other industries require different audit procedures, different areas of technical expertise for evaluation, and must be diffenti-ated in terms of meaningful energy conservation actions.

<u>Types of Conservation Actions to be Considered</u>. Different types of conservation actions are appropriate for different needs. For each of the sectors to be evaluated, the following types of actions should be considered:

1. <u>Develop better awareness of energy conservation opportunities</u>. This can be accomplished through publications, special mailings to key organizations and companies in the different sectors, and through special conferences or seminars that allow face-to-face information contact. To increase energy conservation awareness, a program for technology information and expertise transfer may be set up.

2. Carry out audits and develop related implementation plans. It is important to note that the basis for achieving benefits in any sector is the plant-level survey and evaluation of energy use, and the implementation of specific actions to reduce waste and increase the efficiency of use.

3. Establish selected applied research and commercialization support activities. There may be technological constraints that prevent certain energy conservation actions without some change in electrical, electronic, or mechanical equipment capabilities.

4. Reduce energy-intensiveness of manufactured products. The main opportunities for reducing energy use in certain end-use sectors may rest in the use of more efficient equipment -- e.g., certain types of electric motors. Therefore, selected actions affecting Pakistani manufacturing requirements or types of equipment allowed for import, could be considered.

5. Initiate new national policies and legislation. There may be certain actions not under the control of plant managers that could result in significant

energy conservation. These actions could be a mix of incentives (e.g., energy pricing and tax incentives) and absolute requirements for energy-use efficiency (e.g., efficiency targets and periodic reports). The need for and effect of such actions must be evaluated and weighed against any broader social and other effects that could occur from them.

Infrastructural Support. The organizational structure and capacity needed within Pakistan to support and allow the energy conservation actions to be implemented is critical. Some of the main components of this energy conservation infrastructure could be:

a. A permanently staffed conservation planning coordination center.

b. Establishment of energy conservation cells or organizational units in each governmental agency with responsibility for interface with the industrial sectors.

c. Training support and development of additional capacity in key areas of expertise needed to audit, engineer, and assist in energy conservation for all sectors. This could include the establishment of certain conservation training centers or schools not now available, and involve certifications of energy auditors and other specialties.

d. Capital support. While the US AID Energy Commodities and Equipment Program recently established is one vehicle for financing support, a permanent vehicle(s) with enough capacity to support those equipment financing requirements that are proven economic must be put in place.

e. User-oriented organizations at the regional or national level who can effectively support, at the grassroots level, the awareness and technology transfer activities that will likely be needced. One possible example is a Pakistan Energy Management Association (PEMA).

With the analysis of key energy conservation issues and the identification of overall, multi-year workload requirements for supporting Pakistani technical, financial, and other services, other infrastructural and organizational requirements should be identified, and directly addressed as part of the Plan.

Detailed Implementation Plan. The benefits of an energy conservation plan are tied as much to the quality of detailed implementation plans as they are the identification of meaningful opportunities in the first instance. The content of an implementation plan is straightforward, and involves four components, each of which is absolutely necessary if plans are to work:

1. Detailed breakdowns of the actions and supporting steps. These should be developed in enough detail that the expected output of a particular action step is clear and achievable within a relatively short time frame. If this is not the case, the action plan has not been detailed out enough, and will not likely work within any reasonable schedule.

2. The result or end product expected from each detailed action step. It is the definition of the expected result or end product that is the real test of whether an action step is meaningful. Therefore, the inclusion of this component for each step in the action plan is critical.

3. Identification of the organization and person responsible for each action step. There are two levels of responsibility for each action. One is

the overall management responsibility -- i.e., who will see that the action is carried out in the face of problems that arise. The second set of responsibilities is for persons who must assist in carrying out a particular action. Key organizations or persons who will assist in implementing each action must be identified.

4. Resources required. The amount of human resources required in terms of man-months or man-years must be identified, so that meaningful budgets and commitments can be provided by the parties involved in implementation. Further, any equipment, computer support, and other non-labor resources required, must be identified if they are significant.

Where appropriate, a budget or financial commitment sufficient to provide the resources must be established. In the final analysis, both the private-sector management commitment as well as budget commitments by certain governmental agencies for support activities are required for a successful Plan.

A final feature of a workable implementation plan is a process for updating the plan. In reality, no plan is ever complete enough for pure implementation over any period of time. There is a constant staging of further planning and further implementation on a continuing basis. The likely mechanism required for the Plan will be a quarterly monitoring and updating of actions and reassignment of resources, with a more formal revision and review of the Plan on an annual basis.

Exhibits

EXHIBITS

EXHIBITS

Exhibit 2.1

LIST OF INDUSTRIAL PLANTS
AS PROVIDED BY THE DGER

No.	Industry	Type	Location	Products	Annual Production Capacity
1.	Chenab Steel Mills	Metal-mechanic	Faisalabad (Punjab)	M.S. bars Centrifugal pumps	6,000 tons
2.	Sunshine Group of Industries	Metal-mechanic	Lahore (Punjab)	Bicycles	60,000 nos.
3.	Oriental Engg. Works	Metal-mechanic	Gujranwala (Punjab)	Copper wire	236 tons
4.	Rajwa Metal Industries	Metal-mechanic	Gujranwala (Punjab)	Metal wire	30 tons
5.	Bombay Brass Works	Metal-mechanic	Lahore (Punjab)	Utensils	250 tons
6.	Lahore Engg. and Foundry Workshop	Metal-mechanic	Lahore (Punjab)	Pig iron Electric fans Road rollers Machine tools Agr. implements Centrifugal pumps	24,000 tons
7.	Industrial Corp.	Metal-mechanic	Lahore (Punjab)	Drums	159,500 nos.
8.	Abdul Rahim Allah Ditta	Metal-mechanic	Lahore (Punjab)	Crankshafts	500 nos.
9.	Sialkot Foundry	Metal-mechanic	Burewala (Punjab)	Foundry products	Rs.1.35 lacs
10.	Metropolitan Corp., Ltd.	Metal-mechanic	Karachi (Sind)	M.S. bars	9,000 tons
11.	Dada Steel Mills	Metal-mechanic	Karachi (Sind)	M.S. bars	11,000 tons

Exhibit 2.1 (continued)

LIST OF INDUSTRIAL PLANTS
AS PROVIDED BY THE DGER

No.	Industry	Type	Location	Products	Annual Production Capacity
12.	General Steel Co.	Metal-mechanic	Gujranwala (Punjab)	Utensils	220 tons
13.	Khalil Metal Works and Rolling Mills	Metal-mechanic	Gujranwala (Punjab)	Utensils	200 tons
14.	Adamjee Paper and Board Mills	Paper and chipboard	Nowshera (N.W.F.P)	Paperboard	
15.	Pakistan Paper Mills	Paper and chipboard	Charsadda (N.W.F.P)	Paper	3,000 MT
16.	Pakistan Chipboard	Paper and chipboard	Jhelum (Punjab)	Chipboard	
17.	Dost Mohammad Cotton Mills, Ltd.	Textile	Karachi (Sind)	Yarn Cloth	
18.	Mohammad Farooq Textile Mills	Textile	Karachi (Sind)	Yarn Cloth	
19.	The Paracha Textile Mills, Ltd.	Textile (Sind)	Karachi	Towels Cloth	
20.	Government Textile Weaving and Finishing Center	Textile	Lahore (Punjab)	Towels Bedsheets	
21.	Kohinoor Textile Mills, Ltd.	Textile	Rawalpindi (Punjab)	Cloth	
22.	Zeenat Textile Mills, Ltd.	Textile	Faisalabad (Punjab)	Cloth Yarn	
23.	Chenab Textile Mills, Ltd.	Textile	Multan (Punjab)	Cloth	

Exhibit 2.1 (continued)

LIST OF INDUSTRIAL PLANTS
AS PROVIDED BY THE DGER

No.	Industry	Type	Location	Products	Annual Production Capacity
24.	Colony Textile Mills, Ltd.	Textile	Multan (Punjab)	Printed cloth	5,425,000 m
25.	Alahwasaya Textile and Finishing Mills, Ltd.	Textile	Multan (Punjab)	Printed cloth	3,252,215 m
26.	Bannu Woolen Mills	Textile	Bannu (N.W.F.P)		
27.	Lawrencepur Textile Mills, Ltd.	Textile	Lawrencepur	Cloth	
28.	Chand Cloth Printing Mills	Textile	Gujranwala (Punjab)	Cloth	2,194,560 m
29.	Kashmir Art Industries	Textile	Lahore (Punjab)	Dyeing screen Printing	1,828,800 m
30.	Modern Weaving Factory	Textile	Lahore (Punjab)	Art silk Fabrics	546,806 m
31.	Habib Textile Industries	Textile	Gujranwala (Punjab)	Cloth	2,194,560 m
32.	Rehmania Silk Mills	Textile	Swat (N.W.F.P)		
33.	Karim Silk Mills, Ltd.	Textile	Karachi (Sind)	Art silk	

Exhibit 2.2

FINAL LIST OF THIRTY INDUSTRIAL PLANTS AUDITED

Textile	Location
Abid Industries	Karachi (Sind)
Allawasaya Textile & Finishing	Multan (Punjab)
Bannu Woolen Mills	Bannu (N.W.F.P.)
CeeBee Textile Industries	Lahore (Punjab)
Chenab Textile Mills	Lahore (Punjab)
Colony Textile Mills	Multan (Punjab)
Farooq Textile Mills	Karachi (Sind)
Government Textile Weaving	Lahore (Punjab)
Karim Silk Mills	Karachi (Sind)
Kohinoor Textile Mills	Rawalpindi (Punjab)
Lawrencepur Woolen & Textile Mills	Lawrencepur (Punjab)
National Dyeing & Finishing Center	Gujranwala (Sind)
Paracha Textile	Karachi (Sind)
Shaheen Calico Printing Works	Gujranwala (Sind)
Sunshine Cotton	Lahore (Punjab)
Sunshine Jute	Lahore (Punjab)

Paper and Chipboard	Location
Adamjee Paper & Board Mills	Nowshera (N.W.F.P)
Pakistan Chipboard Ltd.	Jhelum (Punjab)
Pakistan Paper Corp. Ltd.	Charsadda (N.W.F.P)
Metal-Mechanic/Steel	
Ashraf Engineering Works	Lahore (Punjab)
General Steel Tools Company	Gujranwala (Punjab)
International Metal Industries	Gujranwala (Punjab)
Kamran Steel Re-Rolling Mills	Lahore (Punjab)
Khalil Metal Works	Gujranwala (Punjab)
Metropolitan Steel	Karachi (Sind)
Ravi Steel & Re-Rolling Mills	Lahore (Punjab)
Sh. Abdur Rahim A. Ditta Steel	Lahore (Punjab)
Shakir Metal Industries	Gujranwala (Punjab)
United Iron & Steel	Lahore (Punjab)
Yazdani & Co. Ltd.	Lahore (Punjab)

Exhibit 2.3

AVERAGE ANNUAL ENERGY CONSUMPTION OF NATURAL GAS, OIL AND ELECTRICITY FOR INDUSTRIAL PLANTS AUDITED

Industry	Electricity (MWH)	Natural Gas (HM^3)	Oil (Litres)
Textile			
Abid Industries	1125	5513	--
Allawasaya Textile & Finishing	8242	--	--
Bannu Woolen Mill:	886	--	958202
CeeBee Textile Industries	1120	22990	--
Chenab Textile Mills	5981	--	--
Colony Textile Mills	23133	144207	--
Farooq Textile Mills	12521	27011	--
Government Textile Weaving	96	1063	--
Karim Silk Mills	1435	37042	--
Kohinoor Textile Mills	8893	21556	--
Lawrencepur Woolen & Textile Mills	3664	21567	--
National Dyeing & Finishing Center	463	11496	--
Paracha Textile	1350	20734	--
Shaheen Calico Printing Works	335	17102	--
Sunshine Cotton	11238	--	--
Sunshine Jute	2805	--	--
Paper and Chipboard			
Adamjee Paper & Board Mills	25755	199651	--
Pakistan Chipboard Ltd.	764	--	510312
Pakistan Paper Corp Ltd.	36148	142386	7603605
Metal-Mechanic/Steel			
Ashraf Engineering Works	5217	--	--
General Steel Tools Company	176	1312	--
International Metal Industries	877	711	--
Kamran Steel Re-Rolling Mills	10934	26096	--
Khalil Metal Works	804	2693	--
Metropolitan Steel	10768	90226	--
Ravi Steel & Re-Rolling Mills	238	4282	--
Sh. Abdur Rahim A. Ditta Steel	213	4770	--
Shakir Metal Industries	883	448	--
United Iron & Steel	6424	--	--
Yazdani & Co. Ltd.	3002	--	--

Exhibit 2.4

Average Monthly Energy Consumption in the Plants Surveyed

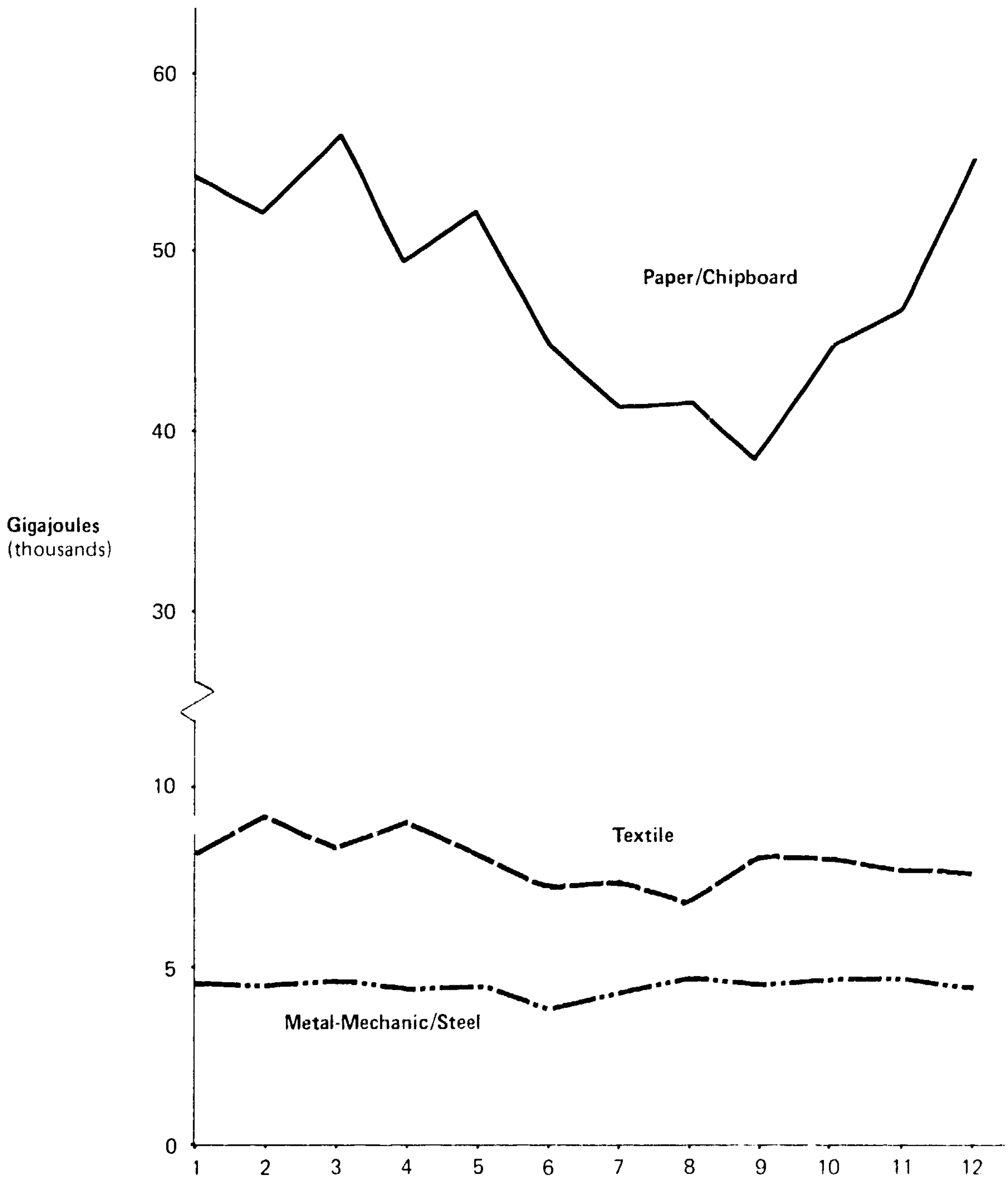


Exhibit 2.5

Percentage of Natural Gas, Oil and Electricity Consumed in the Thirty Industries Surveyed

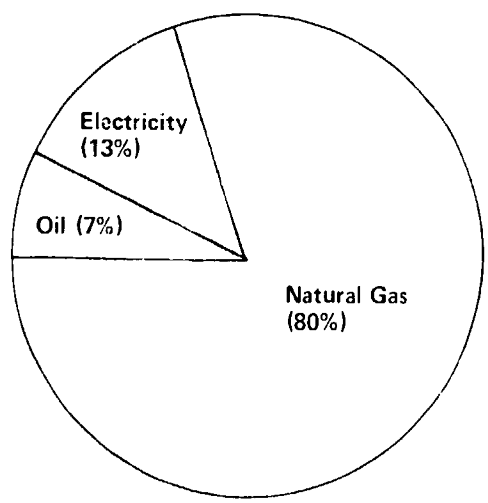


Exhibit 2.6

LIST OF EQUIPMENT USED IN
ENERGY AUDIT SURVEYS

Equipment	Type	Parameters	Operating Range/ Specifications
Infrared Pyrometer	- Microprocessor Accuracy - Five modes of operation - Digital Emissivity Adjustment - Spectral Filtering - Automatic Power Off - Rugged Housing	Direct readout of temperature including self calibration	-20° to 2500F°
Combustion Efficiency Analyzer	- 3 digit display - 5 preprogrammed fuels	- Oxygen and carbon monoxide test - Efficiency test - Smoke test - Draft test	- Low range 0-999 p.p.m.* - high range 1000-4000 p.p.m.
pH Meter	- LED digital display - Portable - Batteries/AC Adapter - Sturdy case	- Measurement of pH potentials	0 to 14 pH Accuracy ± 0.05 pH Drift ± 0.01 pH/8 hrs
Exergen Heat Radiation Scanner	- Heat/temp display - Range display - Low Battery indicator - Range switcher - Sun switch - Photo button & flash charge switch - Viewfinder - Battery slot - Date & time module	- Measure radiation heat	- Heat sensor - 30° - Heat sensor spectral/ response 0.5 to 50 micron - Heat sensor time constant .06 second - Total radiation accuracy ±1% - 'Net' radiation accuracy ±1% - T/C accuracy ±1% - Ambient temp. range 40 to 120°F. - Range/scale factor accuracy ± 5%

* P.P.M. = Parts per million.

Exhibit 2.6 (continued)

LIST OF EQUIPMENT USED IN
ENERGY AUDIT SURVEYS

Equipment	Type	Parameters	Operating Range/ Specifications
Air Flow Meter with Temperature Indicator	Portable	Air flow velocity temperature	- Accuracy ±1% - 0.2 m/s 35 m/s minus 30°C-200°C
Multimeter		Voltage, current resistant conductivity	- 0-750 VAC 0-200m, 160 amps Accuracy ±0.07%
Power Factor Meter	Clamp-on	- Plant power factor - Motor efficiency - Motor loads	30% - 100% on 100-500 VAC 900 AC 50 HZ
Micro Scanner	Portable Infrared Wave	Temperature	Accuracy ± 1% Temp. 1000-2000°C
Psychrometer	- 'Pistol' with wet & dry sensor - aspiration fan - wick & water supply - measurement circuitry - rechargeable batteries - digital readout	- dry bulb temp. - difference between dry & wet bulb temp.	Fixed output slope 1.0 mv/°C Total system current 40 ma
Thermometer	- Digital	Temperature	0-900°C
Cassette Recorder	Portable Battery operated	Oral interview	
Pressure gauges Mechanics tool set			

Exhibit 3.1

PRESENCE OF IDENTIFIED LOSSES AND INEFFICIENCIES BY INDUSTRY

	Textiles	Paper & Chipboard	Metal-Mechanic/ Steel
Boiler losses	X	X	X
Steam system losses	X	X	X
Waste heat losses	X	X	X
Electric power losses	X	X	X
Furnace losses			X
Inefficient equipment design and layout	X	X	X
Inefficient energy supply and conversion	X	X	X
Management/administrative inefficiencies	X	X	X

Exhibit 3.2 LOSSES AND INEFFICIENCES IN PLANTS SURVEYED

Losses and Inefficiencies	Abid Industries	Bannu Woolen Mills	CeeBee Textile Industries	Colony Textile Mills	Farooq Textile Mills	Govt. Textile Weaving	Karim Silk Mills	Kohinoor Textile Mills	Lawrenceour Woolen & Text. Mills	National Dyeing & Finishing	Pracha Textile Mills	Shaheen Calico Printing	Adamjee Paper & Board	Pakistan Chipboard Ltd.	Pakistan Paper Corp. Ltd.	Sh. Abdur Rahim A. Ditta
Boiler Losses																
Inadequate or no Insulation		x		x		x	x	x		x	x	x	x	x	x	x
No Condensate Return	x	x	x			x	x			x	x	x		x		x
No Feedwater Preheating	x	x	x		x	x	x	x		x	x	x	x	x		x
No Preheating of combustion air	x	x	x			x	x	x	x	x	x	x		x	x	x
No pretreatment of Feedwater			x		x	x	x			x			x	x		x
No Burner tuning	x	x	x			x	x	x	x	x	x	x		x	x	x
Poor Cleaning and Maintenance		x	x			x	x	x	x	x	x	x	x	x	x	x
High idling losses		x	x			x	x	x	x	x	x	x	x	x	x	x
Excessive unburned gases		x	x			x	x	x		x	x	x	x	x	x	x
No flue gas dampers	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
No heat recovery from blowdown	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Gas consuming pilot flames instead of electrical ignition	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Improper location of boiler house causing excessive pressure drops in pipes																
Lack of professionally qualified manpower and proper instrumentation	x	x	x			x	x			x	x	x	x	x	x	x

Exhibit 3.2 (continued) LOSSES AND INEFFICIENCIES IN PLANTS SURVEYED

Losses and Inefficiencies	Abid Industries	Bannu Woolen Mills	CeeBee Textile Industries	Colony Textile Mills	Farooq Textile Mills	Govt. Textile Weaving	Karim Silk Mills	Kohinoor Textile Mills	Lawrencepur Woolen & Text. Mills	National Dyeing & Finishing	Pracha Textile Mills	Shaheen Calico Printing	Adamjee Paper & Board	Pakistan Chipboard Ltd.	Pakistan Paper Corp. Ltd.	Sh. Abdur Rahim A. Ditta
Steam System Losses																
Poor insulation	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
Defective steam traps	x	x	x	x		x	x			x	x	x	x	x	x	
Excessive leakages	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
Inefficient distribution network	x	x	x			x	x			x	x	x	x	x	x	x
Waste Heat Losses																
Flue gas losses	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
No waste heat recovery	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Hot Water Losses																
Lost high-temperature wash water	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Heat lost in condensate	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Exhibit 3.2 (continued) LOSSES AND INEFFICIENCES IN PLANTS SURVEYED

Losses and Inefficiencies	Abid Industries	Allawasaya Textile & Finishing	Bannu Woolen Mills	CeeBee Textile Industries	Chenab Textile Mills	Colony Textile Mills	Farooq Textile Mills	Govt. Textile Weaving	Karim Silk Mills	Kohinoor Textile Mills	Lawrencepur Woolen & Text. Mills	National Dyeing & Finishing	Pracha Textile Mills	Shaheen Calico Printing	Sunshine Cotton	Sunshine Jute
Electric Power Losses																
Poor power factors	x	x	x	x	x	x		x	x	x	x	x	x	x		x
Poor maintenance of moving parts	x	x	x	x	x	x		x	x	x	x	x	x	x		
Idling	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Improper matching of motors with loads	x	x	x	x	x	x		x	x	x	x	x	x	x		
Excessive fan power usage for drying	x		x	x		x	x	x	x	x	x	x	x	x		
Poor distribution network	x	x	x	x	x	x		x	x	x	x	x	x	x		
Frequent voltage variations	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Inappropriate Equipment Design																
Inadequate or no process control monitoring	x	x	x	x	x	x		x	x	x	x	x	x	x		
Outdated technologies	x	x	x	x	x	x		x	x	x	x	x	x	x		
Inefficient Energy supply and conversion																
Unnecessary use of high value fuels	x		x	x		x		x	x	x	x	x	x	x		
Management/Administration																
Poor production planning	x	x	x	x	x	x		x	x	x	x	x	x	x		x
Poor operator knowledge	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
No employee incentive	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Poor maintenance of records and procedures	x	x	x	x	x	x		x	x	x	x	x	x	x		x

Exhibit 3.2 (continued) LOSSES AND INEFFICIENCES IN PLANTS SURVEYED

Losses and Inefficiencies	Adamjee Paper & Board	Pakistan Chipboard Ltd.	Pakistan Paper Corp. Ltd.	Ashraf Engineering Works	General Steel Tools CO.	International Metal Industries	Kamran Steel Re-Rolling	Khalil Metal Works	Metropolitan Steel	Ravi Steel Re-Rolling Mills	Sh. Abdur Rahim A. Ditta	Shakir Metal Industries	United Iron & Steel	Yazdani & Co. Ltd.
Electric Power Losses														
Poor power factors	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Poor maintenance of moving parts	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Idling	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Improper matching of motors with loads	x	x	x	x	x	x	x	x	x	x		x		x
Excessive fan power usage for drying	x	x	x											
Poor distribution network	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Frequent voltage variations	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Inappropriate Equipment Design														
Inadequate or no process control monitoring	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Outdated technologies	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Inefficient Energy supply and conversion														
Unnecessary use of high value fuels	x	x	x								x			
Management/Administration														
Poor production planning	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Poor operator knowledge	x	x	x	x	x	x	x	x	x	x	x	x	x	x
No employee incentive	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Poor maintenance of records and procedures	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Exhibit 3.2 (continued) LOSSES AND INEFFICIENCIES IN PLANTS SURVEYED

Losses and Inefficiencies	Ashraf Engineering Works	General Steel Tools CO.	International Metal Industries	Kamran Steel Re-Rolling	Khalil Metal Works	Metropolitan Steel	Ravi Steel Re-Rolling Mills	Sh. Abdur Rahim A. Ditta	Shakir Metal Industries	United Iron & Steel	Yazdani & Co. Ltd.
Furnance Losses											
No preheating of combustion air/scrap	x	x	x	x	x	x	x	x	x	x	x
Excessive heat loss in flues	x	x	x	x	x	x	x	x	x	x	x
Poor insulation	x	x	x	x	x	x	x	x	x	x	x
No heat conservation steps in intermittent processing stages	x	x	x	x	x	x	x	x	x	x	x
High idling losses	x	x	x	x	x	x	x	x	x	x	x
Poor or no temperature controls	x	x	x	x	x	x	x	x	x	x	x
Poor pressure control	x	x	x	x	x	x	x	x	x	x	x
Over firing or flames in flue	x	x	x	x	x	x	x	x	x	x	x
Poor maintenance	x	x	x	x	x	x	x	x	x	x	x
Poor design	x	x	x	x	x	x	x	x	x	x	x
No waste heat recovery	x	x	x	x	x	x	x	x	x	x	x

Exhibit 3.3

Energy Used in Boilers as Percent of Total Input Energy

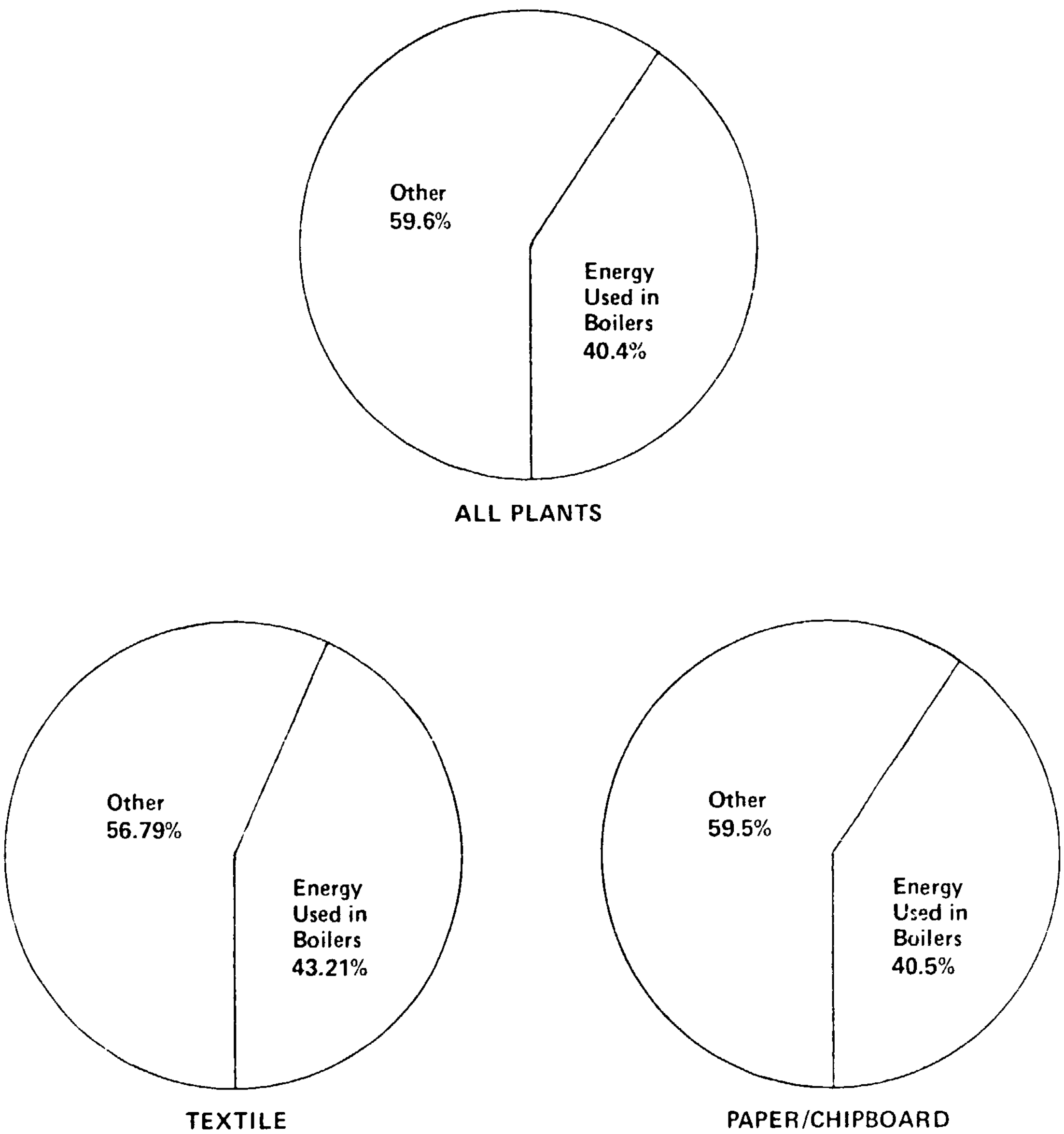


Exhibit 3.4

BOILER TYPES, CAPACITY, AGES, AND
AVERAGE OPERATING EFFICIENCIES IN PLANTS SURVEYED

Industry	Boiler Type	Quantity Installed	Steam Capacity (lbs/hr)	Age (Yrs.)	Average Operating Efficiency (%)
Textile					
Abid Industries	Fire-tube Loos:Gunzenhauser	1	7000	17	78.5
Allawasaya Textile & Finishing*	--	--	--	--	--
Bannu Woolen Mills	Vertical	2	2000	32	59
CeeBee Textile Industries	Scotch Marine	2	6000	20	55
Chenab Textile Mills	--	--	--	--	--
Colony Textile Mills	Water-tube	3	14T/10T	20	70
Farooq Textile Mills	Fire-tube (Packaged) Standard-Kessel	2	8000	16	78.7
Government Textile Weaving	Cochran, Lancashire	2	2000	15	45
Karim Silk Mills	Lancashire	2	6420/4320	15/25	64.95
Kohinoor Textile Mills	Fire-tube (Packaged)	2	18000	19	83.1
Lawrencepur Woolen & Textile Mills	Water-tube/Fire-tube Lancashire	3	17000/34000/7000	30	74.2
National Dyeing & Finishing Center	Scotch Marine	1	6000	14	57
Paracha Textile	Fire-tube (Packaged)	1	8640	18	76
Shaheen Calico Printing Works	Water-tube Babcock, U.K.	1	3000	--	71
Paper & Chipboard					
Adamjee Paper & Board Mills	Water-tube John Thomson	3	25000/37000	31/19	77.2
Pakistan Chipboard Ltd.	Water-tube	1	700	20	42.3
Pakistan Paper Corp. Ltd.	Water-tube	4	20T(2)/17T(2)	14	78
Metal-Mechanic/Steel					
Sh. Abdur Rahim A. Ditta Steel	Lancashire	1	2500	5	70

* Allawasaya Textile Mills spinning section and its boilers are not in operation anymore.

Exhibit 3.5

Heat Loss from Steam Leaks

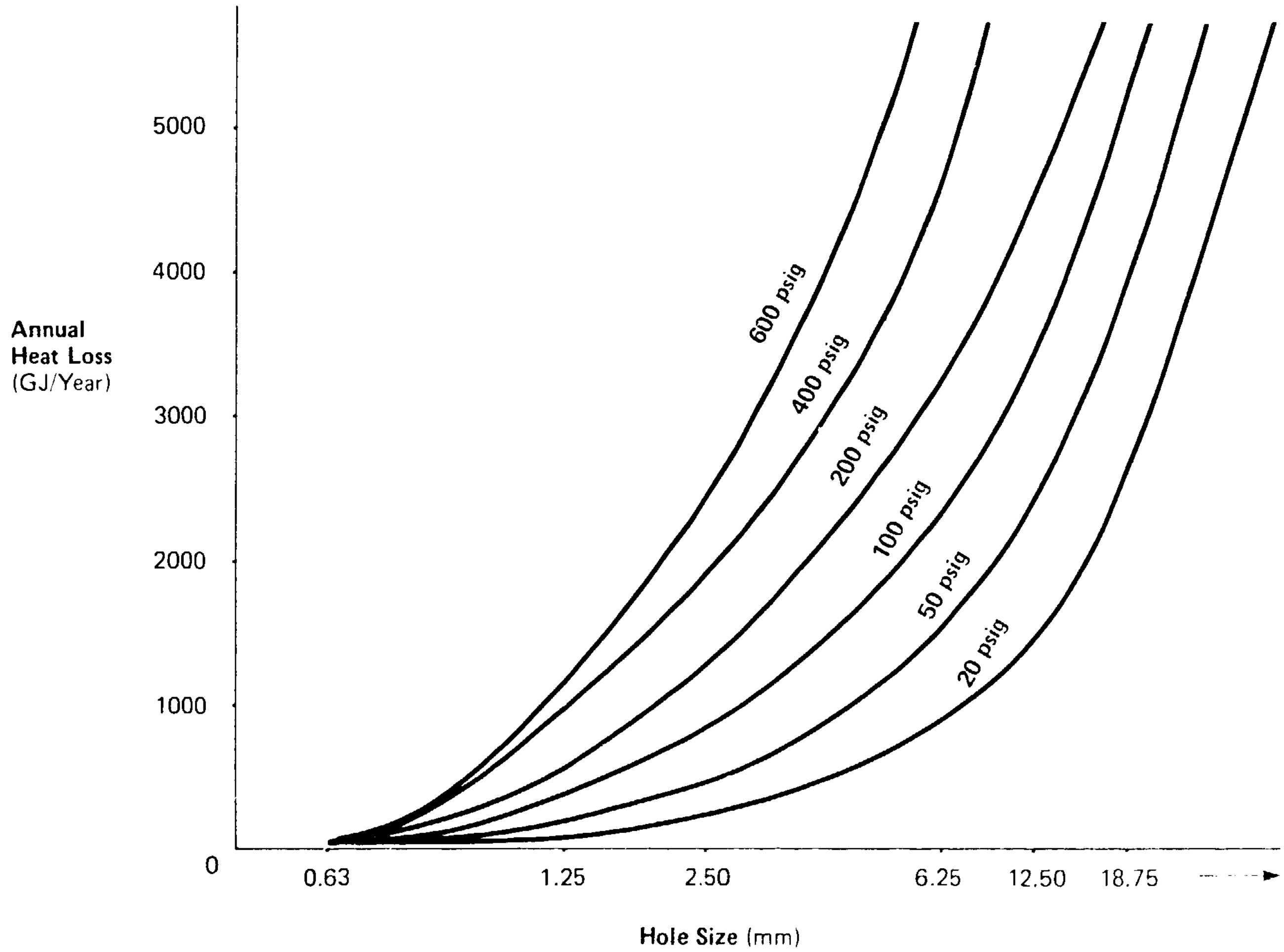


Exhibit 3.6

FLUE GAS ANALYSIS IN PLANTS SURVEYED

Industry	Flue Gas Analysis			
	02 (%)	CO PPM	Excess Air (%)	Temperature F(C)
Textile				
Abid Industries	5.6	35	32.36	254 (123)
Allawasaya Textile & Finishing	--	--	--	-- --
Bannu Woolen Mills	6	375	35.4	970 (521)
CeeBee Textile Industries	14	350	180	318 (159)
Chenab Textile Mills	--	--	--	-- --
Colony Textile Mills	7.5	300	50	320 (160)
Farooq Textile Mills	0.8	998	3.5	370 (188)
Government Textile Weaving	14	700	180	318 (159)
Karim Silk Mills	20.5	330	190	280 (138)
Kohinoor Textile Mills	6.9	56	43.33	317 (158)
Lawrencepur Woolen & Textile Mills	4.8	40	26.35	400 (204)
National Dyeing & Finishing Center	15	330	50	475 (246)
Paracha Textile	6.5	240	40	225 (107)
Sheheen Calico Printing Works	13	200	145	400 (204)
Sunshine Cotton	--	--	--	-- --
Sunshine Jute	--	--	--	-- --
Paper & Chipboard				
Adamjee Paper & Board Mills	7.8	460	52.48	400 (204)
Pakistan Chipboard Ltd.	18.6	516	115	882 (472)
Pakistan Paper Corp. Ltd.	13.7	121	110	300 (149)
Metal-Mechanic/Steel				
Sh. Abdur Rahim A. Ditta Steel	13.7	121	110	303 (151)

Exhibit 3.7

Relationship Between Percent Excess Air and Stack Heat Loss

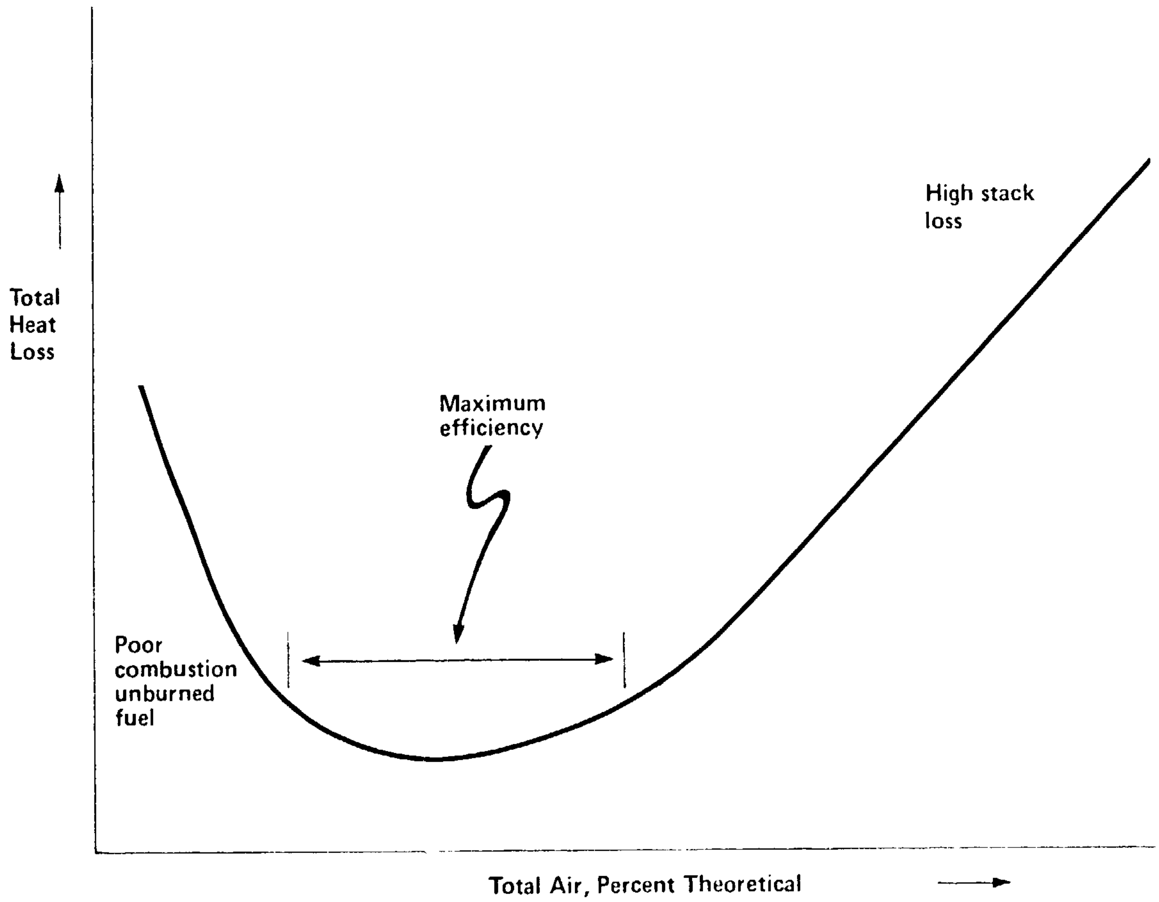


Exhibit 3.8

Approximate Fuel Savings with Preheated Combustion Air in Boilers

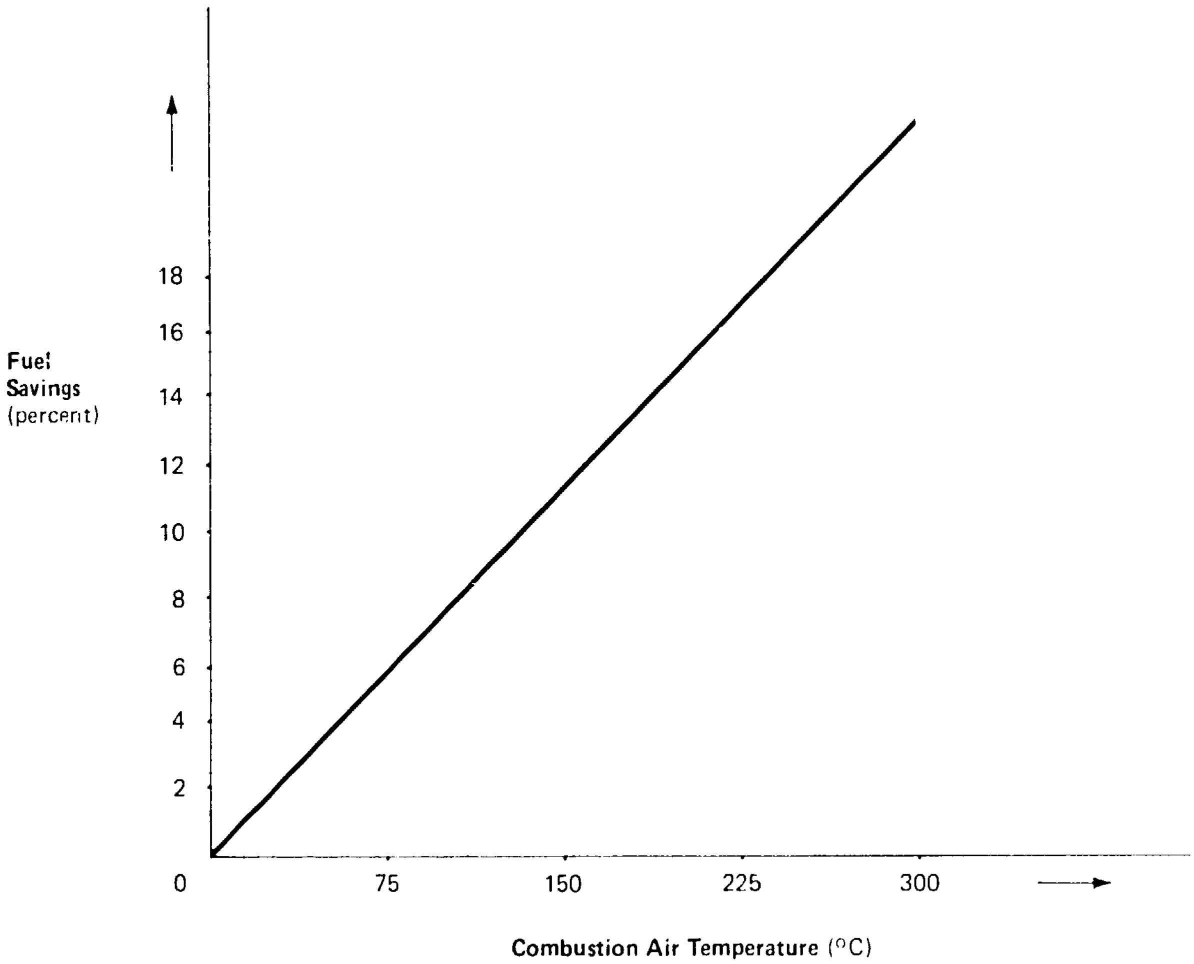


Exhibit 3.9

ENERGY EFFICIENCY MEASURES
FOR ELECTRIC MOTORS

Type of Improvement Action	Action
• Operational	- Supply rated voltage, properly balanced between phases - Improve controls, avoid idling - Schedule regular maintenance - Provide regular lubrication - Reduce peak demand by rescheduling motor operation
• Retrofit	- Improve power factor - Improve cooling - Replace old inefficient motors with new ones - Properly size motors to run at full load
• Design	- Purchase more efficient motors based on life cycle basis - Consider variable speed motors if loads vary - Use three phase rather than single phase motors - Use higher voltage for motor drives

Exhibit 3.10

ENERGY COSTS IN PLANTS SURVEYED

Industry	Cost per GJ (Rs/GJ)	Cost per MBtu (Rs/MBtu)
Textile		
Abid Industries	76.39	80.60
Allawasaya Textile & Finishing	176.93	186.68
Bannu Woolen Mills	64.77	68.33
CeeBee Textile Mills	25.23	26.62
Chenab Textile Mills	139.54	147.23
Colony Textile Mills	44.45	46.89
Farooq Textile Mills	116.42	122.84
Government Textile Weaving	33.09	34.92
Karim Silk Mills	28.18	29.73
Kohinoor Textile Mills	107.71	113.64
Lawrencepur Woolen & Textile Mills	64.89	68.47
National Dyeing & Finishing Center	27.03	28.52
Paracha Textile	67.69	71.42
Shaheen Calico Printing Works	24.20	25.53
Sunshine Cotton	97.19	102.55
Sunshine Jute	250.91	264.74
Average (Textile)	84.02	88.66
Paper & Chipboard		
Adamjee Paper & Board Mills	35.50	37.46
Pakistan Chipboard Ltd.	82.80	87.36
Pakistan Paper Corp. Ltd.	45.93	48.46
Average (Paper/chipboard)	54.74	57.76
Metal-Mechanic/Steel		
Asraf Engineering Works	212.08	223.77
General Steel Tools Company	120.09	126.71
International Metal Industries	128.97	136.08
Kamran Steel Re-Rolling Mills	79.98	84.39
Khalil Metal Works	29.33	30.95
Metropolitan Steel	53.39	56.33
Ravi Steel & Re-Rolling Mills	51.72	54.57
Sh. Abdur Rahim A. Ditta Steel	24.04	25.36
Shakir Metal Industries	140.96	148.72
United Iron & Steel	183.28	193.38
Yazdani & Co. Ltd.	212.85	224.58
Average (Metal-Mechanic/Steel)	112.43	118.62

Exhibit 3.11

COMPARISON OF U.S. PLANT DATA
TO PROJECT DATA

Industry/Plant	Feedstock	Final Product	1984 Annual Production Sq. Meters Per Year	United States Data Fuel BTU/Sq. Meter	United States Data Power kWh/Sq. Meter	Pakistan Plant Data Fuel BTU/Sq. Meter	Pakistan Plant Data Ratio to U.S. Data	Pakistan Plant Data Power kWh/Sq. Meter	Pakistan Plant Data Ratio to U.S. Data
Textile									
Abid Industries	Polyester Chips	Woven Polyester	1,970,000	2,474	0.71	9,685	3.91	0.57	0.80
Allawasaya Textile & Finishing	Raw Cotton	Cotton Thread	3,933,193	17,460	2.15	No Data	--	2.10	0.98
Bannu Woolen Mills	Wool	Woolen Cloth	357,225	29,520	2.06	93,159	3.16	2.48	1.20
CeeBee Textile Industries	Cotton Cloth	Printed Cloth	553,352	16,887	0.35	143,786	8.51	2.02	5.71
Chenab Textile Mills	Raw Cotton	Cotton Yarn	1,357,785	17,460	2.15	Insufficient Data	--	4.40	2.05
Colony Textile Mills			Insufficient Data						
Farooq Textile Mills			8,326,807			Insufficient Data			
Government Textile Weaving	Cotton Yarn	Finished Cloth	30,000	11,759	1.33	122,633	10.43	3.20	2.41
Karim Silk Mills	Silk Yarn	Silk Cloth	1,168,189	11,759	1.33	109,739	9.33	1.23	0.92
Kohinoor Textile Mills	Raw Cotton	Cotton Cloth	12,906,000	5,352	1.21	5,780	1.08	0.69	0.57
Lawrencepur Woolen Mills	Raw Wool	Woolen Cloth	1,250,000	29,520	2.06	59,712	2.02	2.93	1.42
National Dyeing & Finishing	Cotton Cloth	Finished Cloth	6,200,000	16,890	0.33	6,417	0.38	0.075	0.23
Paracha Textile	Cotton Cloth	Finished Cloth	8,750,000	16,890	0.33	8,200	0.49	0.15	0.46
Shaheen Calico Print Works	Gray Cotton Cloth	Finished Cotton Cloth	2,000,000	16,890	0.33	29,594	1.75	0.17	0.52
Sunshine Cotton			Insufficient Data						
Sunshine Jute	Raw Jute	Jute Bags	7,000,000	5,352	1.21	Insufficient Data	--	0.40	0.33

Source: Data Consultants - August 1985

Exhibit 3.11 (continued)

COMPARISON OF U.S. PLANT DATA
TO PROJECT DATA

Industry	Feedstock	Final Product	1984 Annual Production Tons/Year	United States Data		Pakistan Plant Data			
				Fuel BTU/Ton	Power kWh/Ton	Fuel BTU/Ton	Ratio to U.S. Data	Power kWh/Ton	Ratio to U.S. Data
Paper and Chipboard									
Adamjee Paper & Board Mills	Pulp	Paperboard	21,450	13.4×10^6	731	30.6×10^6	2.28	1200	1.64
Pakistan Chipboard Ltd.	Raw Wood	Particle Board	5,000	1.46×10^6	280	4.43×10^6	3.03	191	0.68
Pakistan Paper Corp., Ltd.	Waste Cotton/ Waste Paper	Paper	24,500	16.6×10^6	1248	30.9×10^6	1.86	1475	1.18
Metal-Mechanic/Steel									
Ashraf Engineering Works	Scrap	Billets	7,221	--	500	--	--	722	1.44
General Steel Tools Company	Billets	Special Steel Products	840	4.03×10^6	150	5.4×10^6	1.34	210	1.40
International Metal Industries	Scrap	Sheets	400	4.03×10^6	150	6.2×10^6	1.53	220	1.47
Kamran Steel Re-Rolling Mills	Scrap	Ingots & I-Shapes	15,000	4.03×10^6	578	6.02×10^6	1.49	729	1.26
Khalil Metal Works	No Flow Sheet		1,080						
Metropolitan Steel	Billets	Wire & Shapes	74,701	4.03×10^6	128	4.18×10^6	1.04	144	1.13
Ravi Steel & Re-Rolling Mills	Billets	Shapes	2,400	4.03×10^6	78	6.17×10^6	1.53	99	1.27
Sh. Abdur Rahim A. Ditta Steel	Scrap	Billets	2,400	5.36×10^6	40	6.88×10^6	1.28	888	0.22
Shakir Metal Industries			450			Insufficient Data			
United Iron & Steel	Scrap	Ingots	5,476	--	500	--	--	1173	2.34
Yazdani & Co., Ltd.	Scrap	Ingots	2,655	--	500	--	--	1130	2.26

Source: Data Consultants - August 1985

Exhibit 3.12

IMPROVEMENT OPPORTUNITIES IN PLANTS AUDITED

Improvement Opportunities	Abid Industries	Allawasava Textile & Finishing	Bannu Woolen Mills	Ceepee Textile Industries	Chenab Textile Mills	Colony Textile Mills	Farooq Textile Mills	Govt. Textile Weaving	Karim Silk Mills	Kohinoor Textile Mills	Lawrencepur Woolen & Text. Mills	National Dyeing & Finishing	Pracha Textile Mills	Shaheen Calico Printing	Sunshine Cotton	Sunshine Jute
Improve or Modify Existing Plant																
Improve Boiler Efficiency, e.g. combustion efficiency/ burner tuning	x		x	x		x	x	x	x	x	x	x	x	x		
Recover Waste Heat	x		x	x		x	x	x	x	x	x	x	x	x		
Blow-down recovery	x		x	x		x	x	x	x	x	x	x	x	x		
Maintenance and Cleaning	x		x	x		x	x	x	x	x	x	x	x	x		
Insulation			x	x		x		x	x	x	x	x	x	x		
Improve Furnance/Process Efficiency																
Combustion efficiency																
Insulation																
Temperature/pressure controls																
Maintenance																
Utilize Flue waste Heat, e.g. Feedwater preheating	x		x	x		x		x	x	x		x	x	x		
Process air waste heat	x	x	x	x		x	x	x	x	x	x	x	x	x		
Reduce Steam System Losses, e.g. Pipe insulation	x		x	x		x		x	x	x	x	x	x	x		
Steam traps	x		x	x		x		x	x	x	x	x	x	x		
Steam leakage	x		x	x		x	x	x	x	x	x	x	x	x		
Distribution network	x		x	x		x		x	x	x	x	x	x	x		
Reduce hot water Losses, e.g. heat loss in hot wash water	x		x	x		x	x	x	x	x	x	x	x	x		
Reduce Electric Power Losses Power factor	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Correct matching of motors	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Voltage stabilization	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Moving parts maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Exhibit 3.12 (continued)

IMPROVEMENT OPPORTUNITIES IN PLANTS AUDITED

Improvement Opportunities	Adamjee Paper & Board	Pakistan Chipboard Ltd.	Pakistan Paper Corp. Ltd.	Ashraf Engineering Works	General Steel Tools Co.	International Metal Industries	Kamran Steel Re-Rolling	Khalil Metal Works	Metropolitan Steel	Ravi Steel Re-Rolling Mills	Sh. Abdur Rahim A. Ditta	Shakir Metal Industries	United Iron & Steel	Yazdani & Co. Ltd.
Improve or Modify Existing Plant														
Improve Boiler Efficiency, e.g. combustion efficiency/ burner tuning	x	x	x								x			
Recover Waste Heat	x	x	x								x			
Blow-down recovery	x	x	x								x			
Maintenance and Cleaning	x	x	x								x			
Insulation	x	x	x								x			
Improve Furnance/Process Efficiency														
Combustion efficiency				x	x	x	x	x	x	x	x	x	x	x
Insulation				x	x	x	x	x	x	x	x	x	x	x
Temperature/pressure controls				x	x	x	x	x	x	x	x	x	x	x
Maintenance				x	x	x	x	x	x	x	x	x	x	x
Utilize Flue Waste Heat, e.g. Feedwater preheating	x	x	x		x	x	x	x	x	x	x	x	x	x
Process air waste heat	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Reduce Steam System Losses, e.g. Pipe insulation	x	x	x											
Steam traps	x	x	x											
Steam leakage	x	x	x											
Distribution network	x	x	x											
Reduce Hot Water Losses, e.g. Heat loss in hot wash water	x	x	x											
Reduce Electric Power Losses Power factor	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Correct matching of motors	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Voltage stabilization	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Moving parts maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Exhibit 3.12 (continued)

IMPROVEMENT OPPORTUNITIES IN PLANTS AUDITED

Improvement Opportunities	Abid Industries	Allawasaya Textile & Finishing	Bannu Woolen Mills	CeeBee Textile Industries	Chenab Textile Mills	Colony Textile Mills	Farooq Textile Mills	Govt. Textile Weaving	Karim Silk Mills	Kohinoor Textile Mills	Lawrencepur Woolen & Text. Mills	National Dyeing & Finishing	Pracha Textile Mills	Shaheen Calico Printing	Sunshine Cotton	Sunshine Jute
Utilize Process Waste Heat, e.g.																
Drying	x		x	x		x	x	x	x	x	x	x	x	x		
Space Heating	x		x	x		x	x	x	x	x	x	x	x	x	x	x
Design																
Upgrade Existing Equipment, e.g.																
Waste heat recovery systems	x		x	x		x	x	x	x	x	x	x	x	x		
Process control systems	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Replace with New Equipment, e.g.,																
Microwave/R.F. heating	x		x	x		x	x	x	x	x	x	x	x	x		
Management and Administration																
Reduce Total Process Energy Use Through Better Production Planning,																
Throughput scheduling	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Formalize Operating Procedures, e.g.,																
Routine audit checks	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Idle time maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Formalize Maintenance Procedures and Recordkeeping, e.g.,																
Equipment records	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Trend graphs	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Provide Employee Incentive, e.g.,																
Operators	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Managers	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Exhibit 3.12 (continued)

IMPROVEMENT OPPORTUNITIES IN PLANTS AUDITED

Improvement Opportunities	Adamjee Paper & Board	Pakistan Chipboard Ltd.	Pakistan Paper Corp. Ltd.	Ashraf Engineering Works	General Steel Tools Co.	International Metal Industries	Kamran Steel Re-Rolling	Khalil Metal Works	Metropolitan Steel	Ravi Steel Re-Rolling Mills	Sh. Abdur Rahim A. Ditta	Shakir Metal Industries	United Iron & Steel	Yazdani & Co. Ltd.
Utilize Process Waste Heat, e.g.														
Drying	x	x	x											
Space Heating	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Design														
Upgrade Existing Equipment, e.g.														
Waste heat recovery systems	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Process control systems	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Replace with New Equipment, e.g.,														
Microwave/R.F. heating	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Management and Administration														
Reduce Total Process Energy Use Through Better Production Planning,														
Throughput scheduling	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Formalize Operating Procedures, e.g.,														
Routine audit checks	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Idle time maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Formalize Maintenance Procedures and Recordkeeping, e.g.,														
Equipment records	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Trend graphs	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Provide Employee Incentive, e.g.,														
Operators	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Managers	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Exhibit 3.13

ESTIMATED AVERAGE ANNUAL SAVINGS
WITH IMPROVED BOILER EFFICIENCY

Industry	Average Operating Efficiency (%)	Current Average Annual Energy Consumption (10^3GJ)	Estimated Annual Energy Consumption at 80% Boiler Efficiency (10^3GJ)	Estimated Annual Savings in Energy Used (10^3GJ)	Estimated Annual Savings (Rs/Yr)
Textile					
Abid Industries	78	10.871	10.599	0.271	3734
Bannu Woolen Mills	59	35.114	25.897	9.217	273781
CeeBee Textile Industries	55	45.332	31.166	14.166	156092
Colony Textile Mills	70	315.946	276.453	39.493	600415
Farooq Textile Mills	78.7	59.179	58.217	0.961	15980
Government Textile Weaving	45	2.329	1.310	1.019	11754
Karim Silk Mills	64.95	81.156	65.888	15.267	153589
Kohinoor Textile Mills	83.1	47.227	46.171*	1.055	16313
Lawrencepur Woolen & Textile Mills	74.2	47.252	43.826	3.426	52968
National Dyeing & Finishing Center	57	25.187	17.946	7.241	98787
Paracha Textile	76	45.427	43.155	2.271	34689
Shaheen Calico Printing Works	71	37.469	33.254	4.215	40899
Subtotal (Textiles)		752.489	653.882	98.602	1459002
Paper & Chipboard					
Adamjee Paper & Board Mills	77.2	463.987	447.747	16.239	189928
Pakistan Chipboard Ltd.	42.3	16.831	8.899	7.932	260757
Pakistan Paper Corp. Ltd.	78	718.708	700.740	17.967	301187
Subtotal (Paper/chipboard)		1199.525	1153.386	42.138	751872
Metal-Mechanic/Steel					
Sh. Abdur Rahim A. Ditta Steel	70	10.451	9.145	1.306	20672
TOTAL		1962.465	1818.413	142.046	2231546

* 85 percent target used for analysis.

Exhibit 3.14

CHEMICAL COMPOSITION OF NATURAL GAS
SUPPLIED TO PLANTS AUDITED

Processed Gas	MOl (%)
Methane	94.42
Ethane	1.08
Propane	0.25
I-Butane	0.06
N-Butane	0.06
I-Pentane	0.03
Nitrogen	3.80
Carbon dioxide	0.02
Oxygen	0.17
Total	100.00

Source: Sui Northern Gas Pipelines, Ltd.

Exhibit 3.15

ESTIMATED AVERAGE ANNUAL SAVINGS
WITH CONDENSATE RETURN SYSTEM

Industry	Energy Input in Absence of Condensate Return (10^3GJ/yr)	Energy Input With Condensate Return (10^3GJ/yr)	Estimated Annual Energy Savings (10^3GJ/yr)	Estimated Annual Savings (Rs/yr)
Textile				
Abid Industries	10.871	8.105	2.765	279455
Bannu Woolen Mills	35.114	32.067	3.046	154993
CeeBee Textile Industries	45.332	38.100	7.231	116640
Colony Textile Mills	315.946	308.034	7.911	353418
Farooq Textile Mills	59.179	57.610	1.568	38126
Government Textile Weaving	2.329	1.091	1.237	3211
Karim Silk Mills	81.156	77.965	3.190	217856
Kohinoor Textile Mills	47.227	46.177	1.049	61371
Lawrencepur Woolen & Textile Mills	47.252	45.629	1.623	95478
National Dyeing & Finishing Center	25.187	23.137	2.049	41083
Paracha Textile	45.427	42.883	2.543	57048
Shaheen Calico Printing Works	37.469	35.654	1.815	34222
Subtotal (Textile)	752.489	716.452	36.027	1201454
Paper & Chipboard				
Adamjee Paper & Board Mills	463.987	423.774	40.212	687641
Pakistan Chipboard Ltd.	16.831	15.983	.847	41045
Pakistan Paper Corp. Ltd.	718.708	679.936	38.771	699055
Subtotal (Paper/Chipboard)	1199.526	1119.693	79.832	1427741
Metal-Mechanic/Steel				
Sh. Abdur Rahim A. Ditta Steel	10.451	9.630	.820	9549
TOTAL	1962.466	1845.770	116.679	2638744

Exhibit 3.16

ESTIMATED AVERAGE ANNUAL SAVINGS
WITH IMPROVED CLEANING AND MAINTENANCE
IN PLANTS SURVEYED

Industry	Average Annual Energy Consumption in Boiler (10^3GJ)	Average Annual Energy Consumption With Improved Cleaning & Maintenance (10^3GJ)	Estimated Annual Savings (Rs/Yr)
Textile			
Abid Industries	10.781	9.566	48929
Bannu Woolen Mills	35.114	29.847	229968
CeeBee Textile Industries	45.332	40.799	135985
Colony Textile Mills	315.946	288.023	623800
Farooq Textile Mills	59.179	57.404	72324
Government Textile Weaving	2.329	2.096	6583
Karim Silk Mills	81.156	73.040	200027
Kohinoor Textile Mills	47.227	43.432	86239
Lawrencepur Woolen & Textile Mills	47.252	43.944	125307
National Dyeing & Finishing Center	25.187	22.920	75772
Paracha Textile	45.427	41.338	153017
Shaheen Calico Printing Works	37.469	34.846	62371
Subtotal (Textiles)	752.489	687.255	1820320
Paper & Chipboard			
Adamjee Paper & Board Mills	463.987	445.427	476424
Pakistan Chipboard Ltd.	16.831	15.316	81479
Pakistan Paper Corp. Ltd.	718.708	689.960	1706245
Subtotal (Paper/chipboard)	1199.525	1150.703	2264148
Metal-Mechanic/Steel			
Sh. Abdur Rahim A. Ditta Steel	10.451	9.510	36480
TOTAL	1962.465	1847.468	4120950

Exhibit 3.17

ESTIMATED AVERAGE ANNUAL SAVINGS
WITH FEEDWATER TREATMENT

Industry	Estimated Avg. Annual Energy Savings (10^3GJ)	Annual Savings (Rs/yr)
Textile		
Abid Industries	1.130	22896
Bannu Woolen Mills	.754	32960
CeeBee Textile Mills	1.200	19440
Colony Textile Mills	4.349	97200
Farooq Textile Mills	1.060	25920
Government Textile Weaving	.382	6480
Karim Silk Mills	2.190	32400
Kohinoor Textile Mills	2.565	58320
Lawrencepur Woolen & Textile Mills	7.602	172800
National Dyeing & Finishing Center	.969	19440
Paracha Textile	1.154	25920
Shaheen Calico Printing Works	.655	9360
Subtotal (Textiles)	24.010	503136
Paper & Chipboard		
Adamjee Paper & Board Mills	11.720	201600
Pakistan Chipboard Ltd.	.201	9777
Pakistan Paper Corp. Ltd.	29.550	532800
Subtotal (Paper & Chipboard)	41.471	744177
Metal-Mechanic/Steel		
Sh. Abdur Rahim A. Ditta Steel	.125	2918
TOTAL	65.606	1250231

Exhibit 3.18

LOSSES AND SAVINGS RELATED TO BOILER INSULATION

Industry	Insulation Quality Good	Fair	Poor	None	Recorded Surface Losses (Watts/m2)	Estimated Savings With Good Insulation (Rs./yr)
Textile						
Abid Industries	X				400.00	4536
Bannu Woolen Mills			X		510.00	15093
CeeBee Textile Industries	X				350.00	10702
Colony Textile Mills		X			62.00	80442
Farooq Textile Mills	X				200.00	9125
Government Textile Weaving				X	507.00	23425
Karim Silk Mills			X		210.00	9663
Kohinoor Textile Mills	X				150.00	4950
Lawrencepur Woolen & Textile Mills			X		150.00	31628
National Dyeing & Finishing Center			X		416.00	15232
Paracha Textile			X		403.00	12413
Shaheen Calico Printing Works			X		501.00	15865
Subtotal (Textiles)					3859.00	233074
Paper & Chipboard						
Adamjee Paper & Board Mills		X			360.00	142706
Pakistan Chipboard Ltd.			X		423.60	20293
Pakistan Paper Corp. Ltd.		X			380.00	150071
Subtotal (Paper/chipboard)					1163.60	313070
Metal-Mechanic/Steel						
Sh. Abdur Rahim A. Ditta Steel				X	300.00	66029
TOTAL					5322.60	612174

Exhibit 3.19

LOSSES RELATED TO FURNACE INSULATION IN PLANTS

Industry	Insulation Quality: Good	Fair	Poor	None	Estimated Average Annual Losses (GJ/yr)
Metal-Mechanic/Steel					
Ashraf Engineering Works			X		3757.074
General Steel Tools Company			X		1247.659
International Metal Industries		X			495.054
Kamran Steel Re-Rolling Mills		X			16159.630
Khalil Metal Works		X			1822.136
Metropolitan Steel			X		88379.087
Ravi Steel & Re-Rolling Mills			X		4122.791
Sh. Abdur Rahim A. Ditta Steel			X		4373.645
Shakir Metal Industries		X			332.169
United Iron & Steel			X		4626.976
Yazdani & Co. Ltd.			X		2378.450
TOTAL					127694.670

Exhibit 3.20

SAVINGS RELATED TO FURNACE INSULATION

Industry	Average Annual Consumption (10^3GJ/yr)	Average Annual Consumption With Improved Insulation (10^3GJ/yr)	Estimated Savings With Improved Insulation (10^3GJ/yr)	Estimated Annual Savings Rs/yr
Metal-Mechanic/Steel				
Ashraf Engineering Works	18.785	18.233	.551	117306
General Steel Tools Company	5.424	4.301	1.122	134849
International Metal Industries	2.912	2.466	.445	57465
Kamran Steel Re-Rolling Mills	134.663	124.078	10.585	2300000
Khalil Metal Works	10.122	8.483	1.639	48099
Metropolitan Steel	368.246	349.370	18.876	420000
Ravi Steel & Re-Rolling Mills	16.491	12.780	.371	191923
Sh. Abdur Rahim A. Ditta Steel	17.494	13.558	3.936	94609
Shakir Metal Industries	1.953	1.654	.298	42139
United Iron & Steel	23.134	22.169	.965	177000
TOTAL	599.224	557.092	38.788	3583390

Exhibit 3.21

AVERAGE TEMPERATURE, VOLUME, AND ENERGY CARRIED IN FLUE GASES

Industry	Average Temperature of Exhaust F	(C)	Total Volume of Exhaust (Boiler & Other Equip.) (m3/hr)	Total Energy Carried in Exhaust (GJ/yr)
Textile				
Abid Industries	254	(123)	7000	5685.29
Bannu Woolen Mills	970	(521)	3398	12744.577
CeeBee Textile Industries	318	(159)	9126	10138.848
Colony Textile Mills	320	(160)	55000	61617.649
Farooq Textile Mills	370	(188)	9769	16531.134
Government Textile Weaving	318	(159)	3200	1678.822
Karim Silk Mills	280	(138)	25675	26633.555
Kohinoor Textile Mills	317	(158)	41749	44904.634
Lawrencepur Woolen & Textile Mills	400	(204)	20700	30061.944
National Dyeing & Finishing Center	475	(246)	7362	13574.508
Paracha Textile	225	(107)	46218	31283.208
Sheheen Calico Printing Works	400	(204)	7297	10899.975
Subtotal (Textiles)			236494	265754.483
Paper & Chipboard				
Adamjee Paper & Board Mills	400	(204)	69056	114614.637
Pakistan Chipboard Ltd.	882	(472)	2023	8415.093
Pakistan Paper Corp. Ltd.	300	(149)	129878	244529.299
Subtotal (Paper/chipboard)			200957	367559.029
Metal-Mechanic/Steel				
Sh. Abdur Rahim A. Ditta Steel	303	(151)	5501	4533.358
TOTAL			442952	637846.870

Exhibit 3.22

ESTIMATED SAVINGS WITH
RECOVERING HEAT FROM FLUE GAS

Industry	Average Annual Consumption (10^3GJ)	Average Annual Recoverable Energy From Flue Gases (10^3GJ)	Average Annual Consumption With Flue Gas Waste Heat Recovery (10^3GJ)	Estimated Average Annual Savings (Rs./yr)
Textile				
Abid Industries	24.181	2.274	21.906	173737
Bannu Woolen Mills	38.302	5.097	33.204	330162
CeeBee Textile Industries	87.983	4.055	83.927	102340
Colony Textile Mills	609.880	24.647	585.233	1095456
Farooq Textile Mills	143.718	6.612	137.106	769827
Government Textile Weaving	4.227	.671	3.555	22223
Karim Silk Mills	1357.785	10.653	1347.131	300211
Kohinoor Textile Mills	110.737	17.961	92.775	1934650
Lawrencepur Woolen & Textile Mills	91.946	12.024	79.921	780341
National Dyeing & Finishing Center	43.643	5.429	38.213	146751
Paracha Textile	80.573	12.513	68.059	846994
Shaheen Calico Printing Works	63.654	4.359	59.294	105512
Subtotal (Textiles)	2656.629	106.295	2550.324	660821
Paper & Chipboard				
Adamjee Paper & Board Mills	785.261	45.845	739.415	1627630
Pakistan Chipboard Ltd.	21.451	3.366	18.085	278713
Pakistan Paper Corp. Ltd.	928.737	97.811	830.925	4492412
Subtotal (Paper/chipboard)	1735.449	147.022	1588.425	639875
Metal-Mechanic/Steel				
Sh. Abdur Rahim A. Ditta Steel	17.494	1.813	15.681	43584
TOTAL	4409.572	255.130	4154.300	13050553

Exhibit 3.23

Photographs of a Typical Steam Distribution System

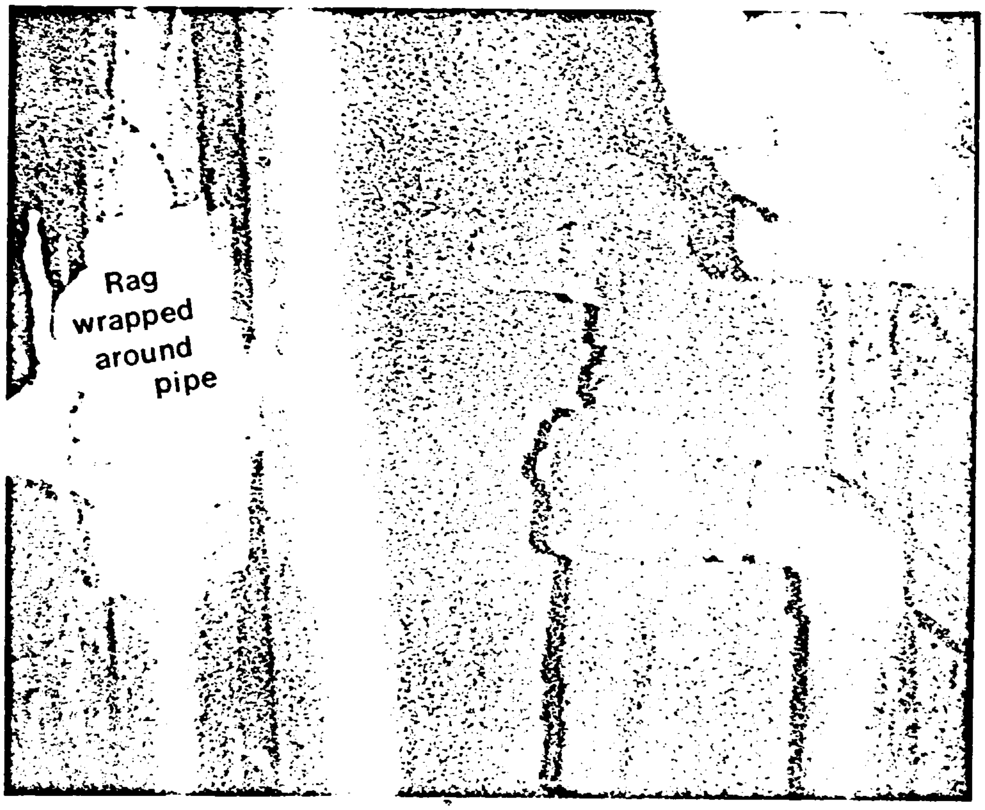


Exhibit 3.24

ESTIMATED ANNUAL SAVINGS WITH IMPROVED STEAM DISTRIBUTION NETWORK

Industry	Average Annual Energy Used in Steam Generation (10^3GJ)	Estimated Annual Energy Used With Improved Steam Distribution (10^3GJ)	Estimated Annual Savings (Rs./yr)
Textile			
Abid Industries	10.871	8.914	39633
Bannu Woolen Mills	35.114	29.847	229968
CeeBee Textile Industries	45.332	37.173	132178
Colony Textile Mills	315.946	259.076	1271012
Farooq Textile Mills	59.179	55.628	86788
Government Textile Weaving	2.329	1.910	7109
Karim Silk Mills	81.156	58.432	336045
Kohinoor Textile Mills	47.227	38.727	193226
Lawrencepur Woolen & Textile Mills	47.252	38.746	193330
National Dyeing & Finishing Center	25.187	20.653	90926
Paracha Textile	45.427	35.433	224425
Sheheen Calico Printing Works	37.469	30.725	96230
Subtotal (Textile)	752.489	615.263	2900870
Paper & Chipboard			
Adamjee Paper & Board Mills	463.987	361.910	1755623
Pakistan Chipboard Ltd.	16.831	13.464	162958
Pakistan Paper Corp. Ltd.	718.708	560.592	5845529
Subtotal (Paper/Chipboard)	1199.525	935.966	7764110
Metal-Mechanic/Steel			
Sh. Abdur Rahim A. Ditta Steel	10.451	8.152	53505
TOTAL	1962.465	1559.381	10718485

Exhibit 3.25

SAVINGS RELATED TO POWER FACTOR IMPROVEMENT IN PLANTS SURVEYED

Industry	Recorded Value of Power Factor	Current Average Annual Consumption at Measured Power Factor (Kwh/yr)	Estimated Annual Savings in Electricity at 0.9 Power Factor (Kwh/yr)	Estimated Annual Savings (Rs/yr)
Textile				
Abid Industries	0.8	1124.763	90.192	115433
Allawasaya Textile & Finishing	0.75	8241.677	1057.408	673707
Bannu Woolen Mills	0.75	885.570	113.619	121572
CeeBee Textile Industries	0.7	1120.405	205.354	157693
Chenab Textile Mills	0.7	5980.615	1096.162	550818
Colony Textile Mills	0.8	23133.120	1854.988	1229913
Farooq Textile Mills	0.88	12520.535	182.544	208795
Government Textile Weaving	0.75	96.058	12.324	9504
Karim Silk Mills	0.7	1435.417	263.092	358689
Kohinoor Textile Mills	0.77	8893.310	963.192	1098039
Lawrencepur Woolen & Textile Mills	0.78	3663.770	361.586	423308
National Dyeing & Finishing Center	0.68	462.516	95.993	70076
Paracha Textile	0.66	1350.220	314.970	875616
Shaheen Calico Printing Works	0.7	334.753	61.355	119030
Sunshine Cotton	0.7	11237.844	2059.737	720908
Sunshine Jute	0.75	2805.115	359.896	325182
Subtotal (Textiles)		83285.688	9092.411	7058283
Paper & Chipboard				
Adamjee Paper & Board Mills	0.75	25754.750	3304.336	2049688
Pakistan Chipboard Ltd.	0.77	763.953	82.740	94324
Pakistan Paper Corp. Ltd.	0.75	36148.383	4637.839	2947992
Subtotal (Paper & Chipboard)		62667.086	8024.915	5091003
Metal-Mechanic/Steel				
Ashraf Engineering Works	0.7	5216.628	956.134	730228
General Steel Tools Company	0.77	176.001	19.062	35318
International Metal Industries	0.8	87.707	7.033	14277
Kamran Steel Re-Rolling Mills	0.75	10933.767	1402.803	1097637
Khalil Metal Works	0.75	80.364	10.311	9177
Metropolitan Steel	0.8	10767.800	863.443	988598
Ravi Steel & Re-Rolling Mills	0.67	237.511	52.304	121345
Sh. Abdur Rahim A. Ditta Steel	0.8	21.315	1.709	1214
Shakir Metal Industries	0.8	88.320	7.082	13102
United Iron & Steel	0.76	6424.470	759.187	501063
Yazdani & Co. Ltd.	0.8	3002.213	240.740	184526
Subtotal (Metal-Mechanic/Steel)		37036.096	4319.807	3696484
TOTAL		182988.870	21437.134	15845770

Exhibit 3.26

ESTIMATED AVERAGE ANNUAL SAVINGS
WITH OPTIMIZED DRYING TIMES

Industry	Average Annual Energy Used in Drying (10^3GJ)	Estimated Savings in Energy Input With Optimized Drying Times (10^3GJ)	Estimated Annual Savings (Rs/yr)
Textile			
Abid Industries	9.672	1.934	147783
Bannu Woolen Mills	15.321	3.064	198455
CeeBee Textile Industries	35.193	7.038	177618
Colony Textile Mills	243.952	48.790	316853
Farooq Textile Mills	57.487	2.051	238859
Government Textile Weaving	1.690	.338	11192
Karim Silk Mills	56.171	6.232	175621
Kohinoor Textile Mills	44.295	2.360	254200
Lawrencepur Woolen & Textile Mills	36.778	4.427	287343
National Dyeing & Finishing Center	17.457	3.491	94364
Paracha Textile	32.229	1.826	123604
Shaheen Calico Printing Works	25.461	5.092	123235
Subtotal (Textiles)	575.711	86.647	2149127
Paper & Chipboard			
Adamjee Paper & Board Mills	314.104	9.944	353029
Pakistan Chipboard Ltd.	8.580	1.716	142099
Pakistan Paper Corp. Ltd.	371.494	7.430	341291
Subtotal (Paper/Chipboard)	694.180	19.091	836419
TOTAL	1269.891	105.738	2985546

Exhibit 3.27

POTENTIALLY APPLICABLE WASTE
HEAT RECOVERY SYSTEMS

Techniques	Applications and Operating Characteristics
Heat pipe heat exchangers	• Waste steam reclamation • Heat recovery from exhaust • Drying • Effective recovery up to 50 percent • Operating temperatures up to 350°C
Run-around coil heat exchangers	• Waste heat recovery from flue gases • Permits transfer of heat to remote locations • Effective recovery up to 40 percent
Regenerators	• Waste heat recovery from exhaust • Heat-setting heat recovery
Recuperators	• Waste heat recovery from exhaust • Heat-setting heat recovery • Preheating of combustion air
Economizers	• Preheating of boiler feedwater • Waste heat recovery from flue gasses

Exhibit 3.28

SUMMARY OF ESTIMATED ENERGY AND COST SAVINGS

Estimated Energy Savings (000 GJ)

Industry	Improved Boiler Efficiency	Improved Furnace Insulation	Flue Gas Heat Recovery	Improved Steam Distribution System	Improved Power Factor*	Optimized Drying Times	Total Energy Savings
Textiles	99	--	2550	615	33	87	3384
Paper & Chipboard	42	--	1588	936	29	19	2614
Metal-Mechanic	1	128	16	8	15	--	168
Total	142	128	4154	1559	77	106	6166

* 1 kWh is assumed to require 3.6 million joules of on-site energy use. This is equivalent to 3412 Btu/kWh.

Estimated Cost Savings (Rs Million)

Industry	Improved Boiler Efficiency	Improved Furnace Insulation	Flue Gas Heat Recovery	Improved Steam Distribution System	Improved Power Factor	Optimized Drying Times	Total Cost Savings	Total Energy Costs	Percent Cost Savings
Textiles	1.4	--	6.6	2.9	7.0	2.2	20.1	94.7	21%
Paper & Chipboard	0.7	--	6.4	7.7	5.1	0.8	20.7	72.3	29%
Metal-Mechanic	0.1	3.6	0.1	0.1	3.7	--	7.6	43.8	17%
Total	2.2	3.6	13.1	10.7	15.8	3.0	48.4	210.8	23% (Overall)
Percent of Savings	5%	7%	27%	22%	33%	6%	100%		

Exhibit 4.1

ENERGY CONSERVATION IMPROVEMENT OPPORTUNITIES

	Equipment Investments			Operating and Maintenance	
Improvement Actions	Major Cost[1]	Minor Cost[2]	Likely Payback (Years)	Estimated Cost Per Plant (Rs 000)	Likely Payback (Years)
Improve or Modify Existing Plant					
Improve Boiler/Furnace Efficiency					
• Combustion efficiency/ burner tuning		X	<1	Nil	Immed
• Temperature/pressure controls		X	2	Nil	Immed
• Recover Waste Heat	X		3		
• Blow-down recovery		X	2		
• Maintenance and Cleaning				Nil	Immed
• Insulation		X	3		
Utilize Flue Gas Waste Heat					
• Feedwater preheating	X		2		
• Process air preheating	X		2		
Reduce Steam System Losses					
• Pipe insulation		X	3		
• Steam traps		X	2	Nil	Immed
• Steam leakage		X	<1		
Reduce Hot Water Losses					
• Heat loss in hot wash water		X	4		
Reduce Electric Power Losses					
• Power Factor Adjustments		X	1-3	Nil	Immed
• Correct matching of motors	X		4		
• Voltage stabilization		X	3		
• Moving parts maintenance		X	1-2	Nil	Immed
Utilize Process Waste Heat					
• Drying	X		4		
• Space Heating	X		5		
Make Design Changes					
Replace Existing Equipment					
• Waste heat recovery systems	X		2		
• Process control systems		X	3		
Install New Type Equipment					
• Microwave/R.F. heating	X		2		
Install Cogeneration Equipment					
• Displace power	X		2-3		
• Produce excess power	X		2-5		

[1]Several million Rs investment likely required.

[2]Less than Rs 2 million investment likely required.

Exhibit 4.1

ENERGY CONSERVATION IMPROVEMENT OPPORTUNITIES
(continued)

	Ease and Immediacy of Implementation			Financial Attractiveness	
Improvement Actions	Can Establish Immediate Change in Plant Procedure	Out-of-Plant Training Required and Available	Technology Transfer Assistance Required	Estimated Cost (Rs)	Likely Payback (Years)
Management and Administrative					
Reduce energy use from better production scheduling		X	X	<10,000	<1
Institute periodic standard "checklist" audits	X	X		< 5,000	<1
Formalize routine maintenance "checklist" activities	X			Nil	Immed
Formalize maintenance records/trend graphs	X	X		< 5,000	<1
Incorporate energy expertise criteria into hiring practices	X			Nil	Upon Hiring
Establish in-house energy savings incentive program		X	X	<10,000	<1
Implement training programs					
• Minimum requirements done in house	X			Nil	Immed
• Additional requirements provided externally		X	X	<10,000	<1

Exhibit 4.2

Barriers Constraining Industrial Energy Conservation in Plants Audited

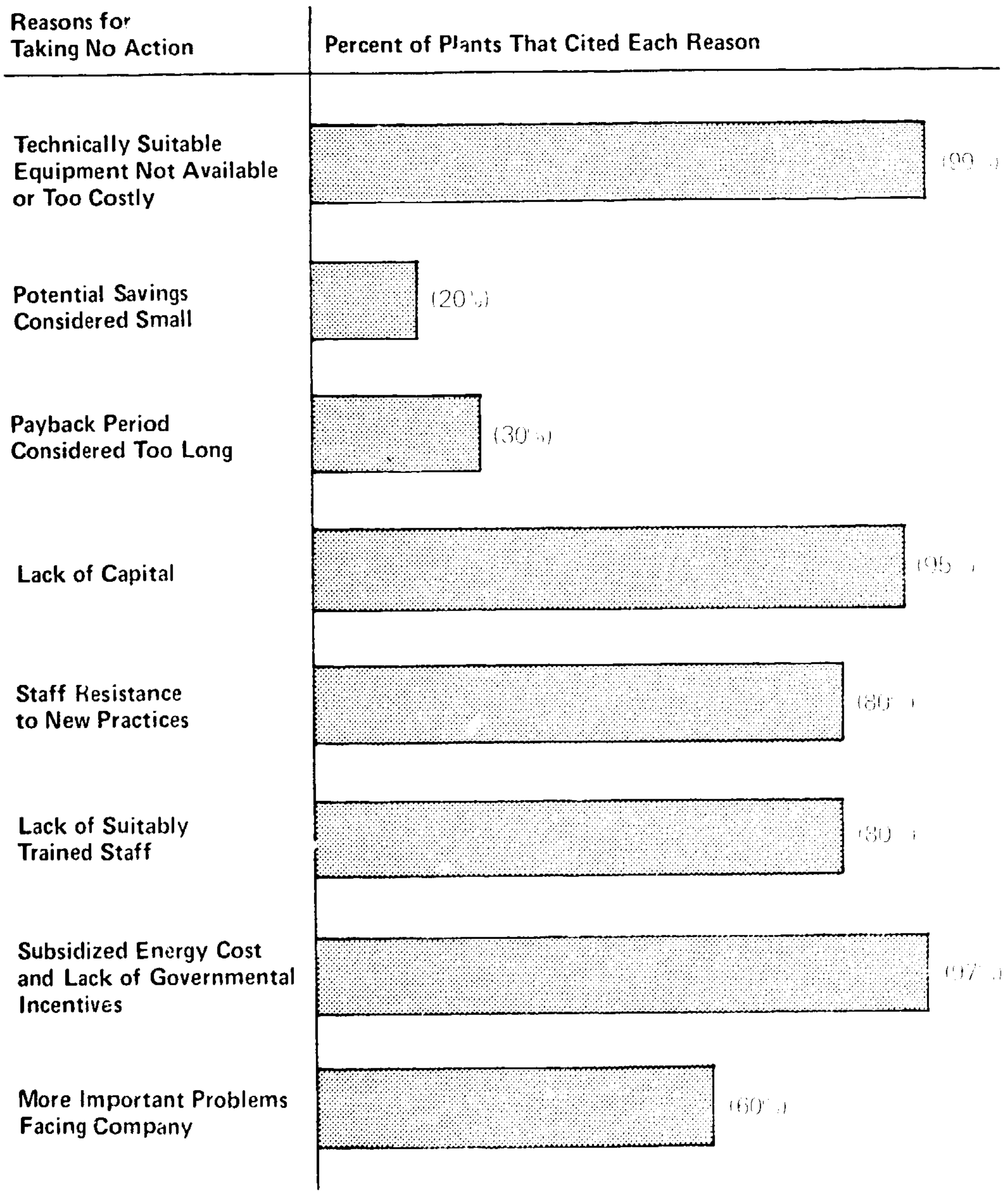
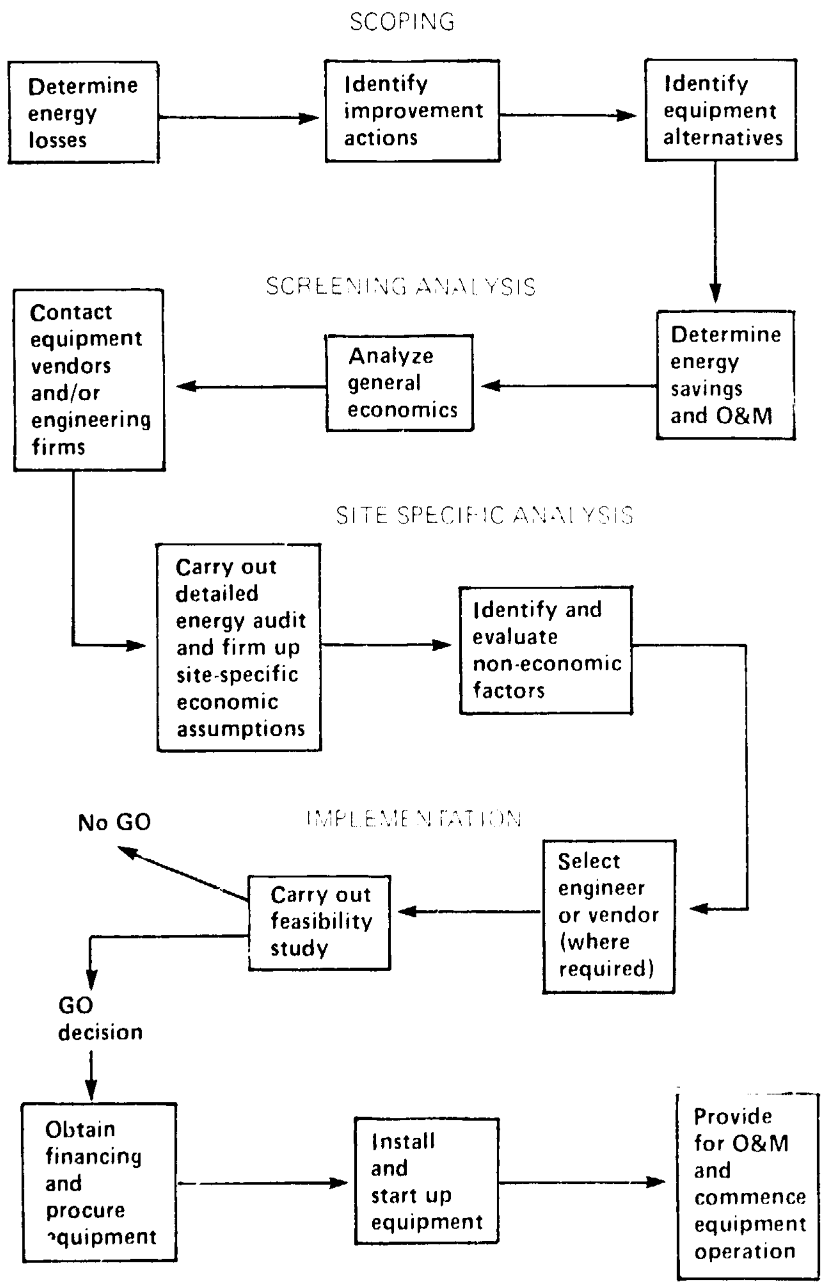


Exhibit 4.3

Evaluation/Decision Process for Energy Conservation Investments



Appendix A

MANUFACTURING PROCESS FLOW DIAGRAMS
BY PLANT

Exhibit A.1

Manufacturing Process Flow Diagram of Abid Industries

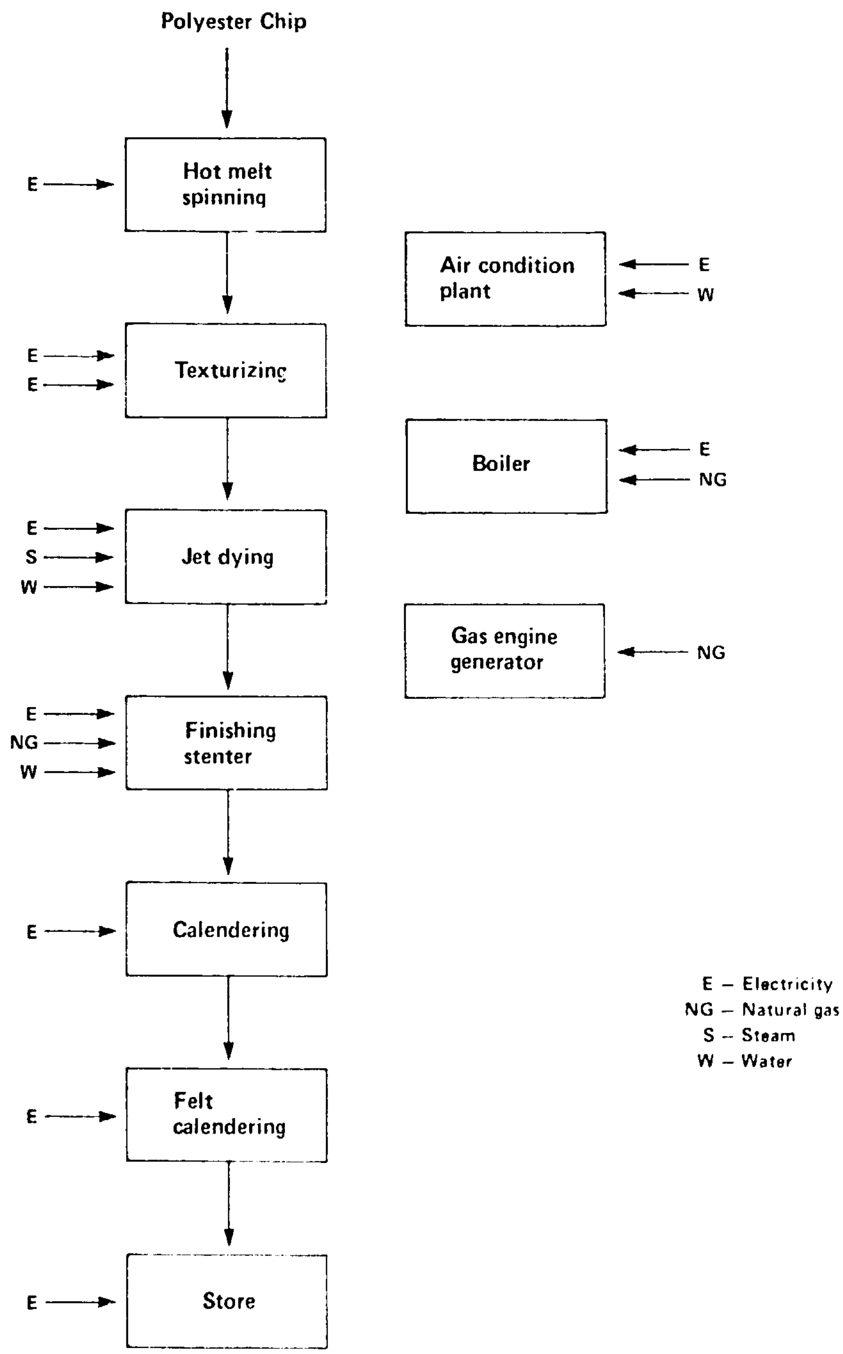
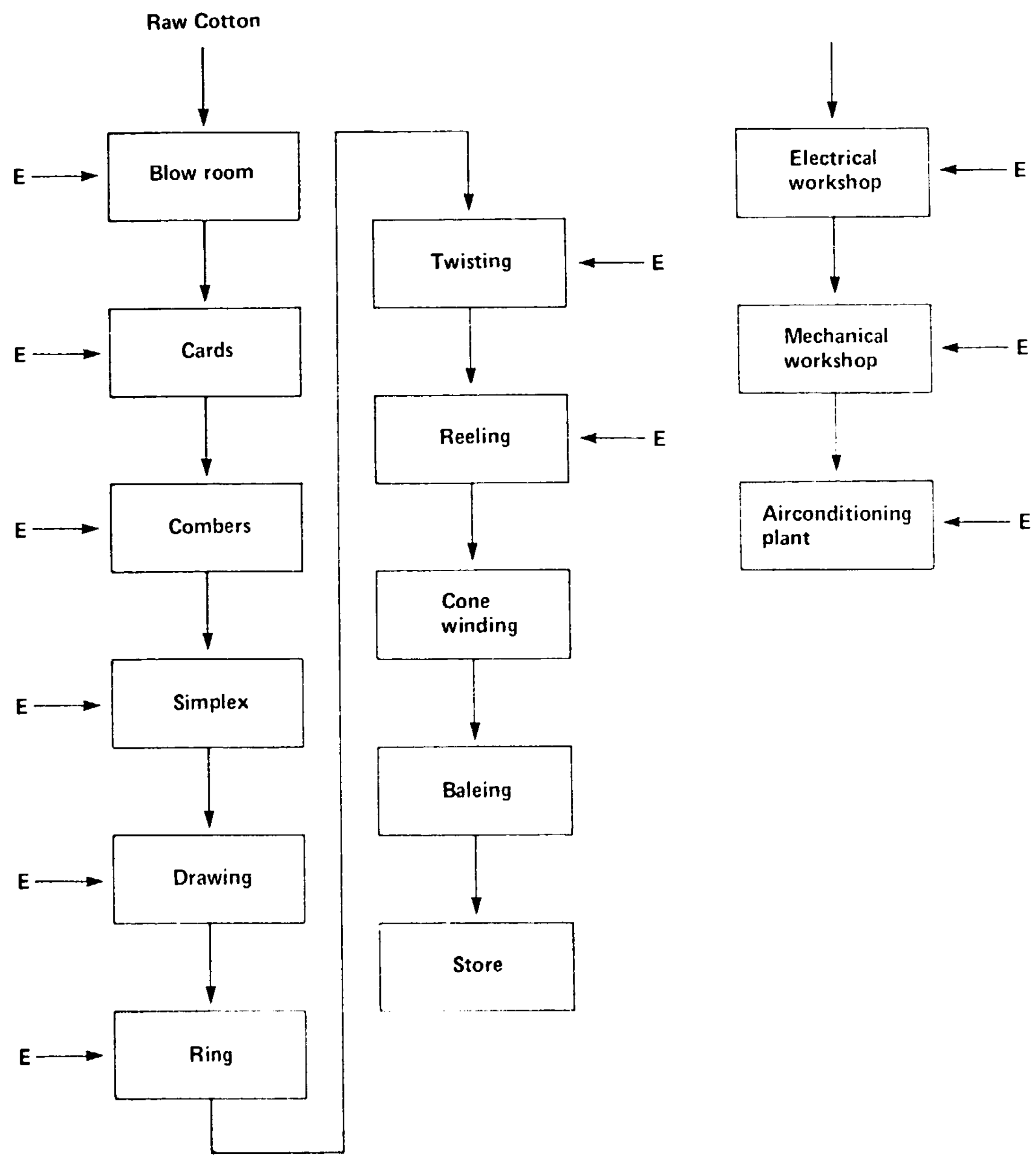


Exhibit A.2

Manufacturing Process Flow Diagram of Allawasaya Textile and Finishing



E – Electricity

Exhibit A.3

Manufacturing Process Flow Diagram of Bannu Wollen Mills

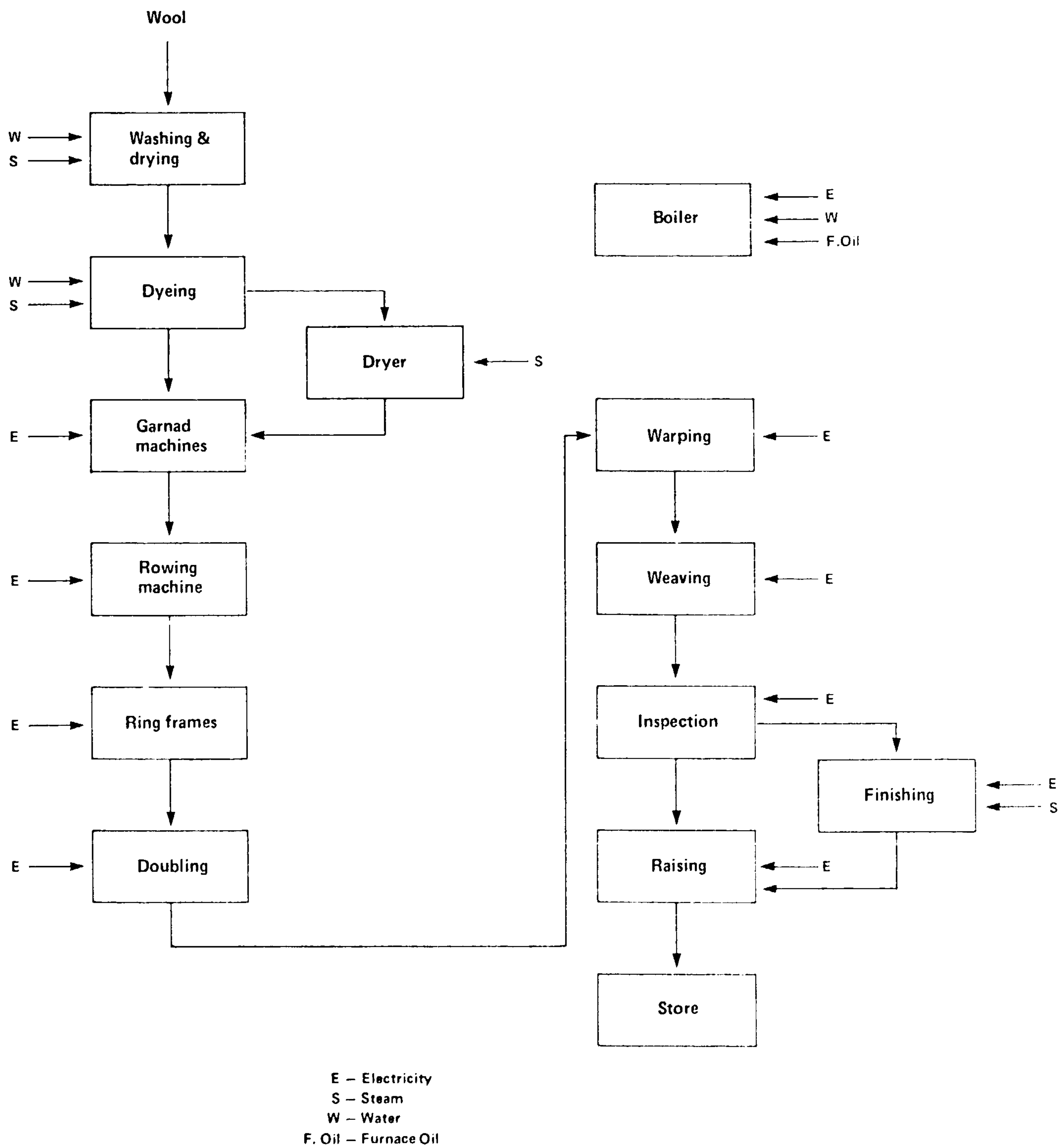


Exhibit A.4

Manufacturing Process Flow Diagram of Cee Bee Textile Industries

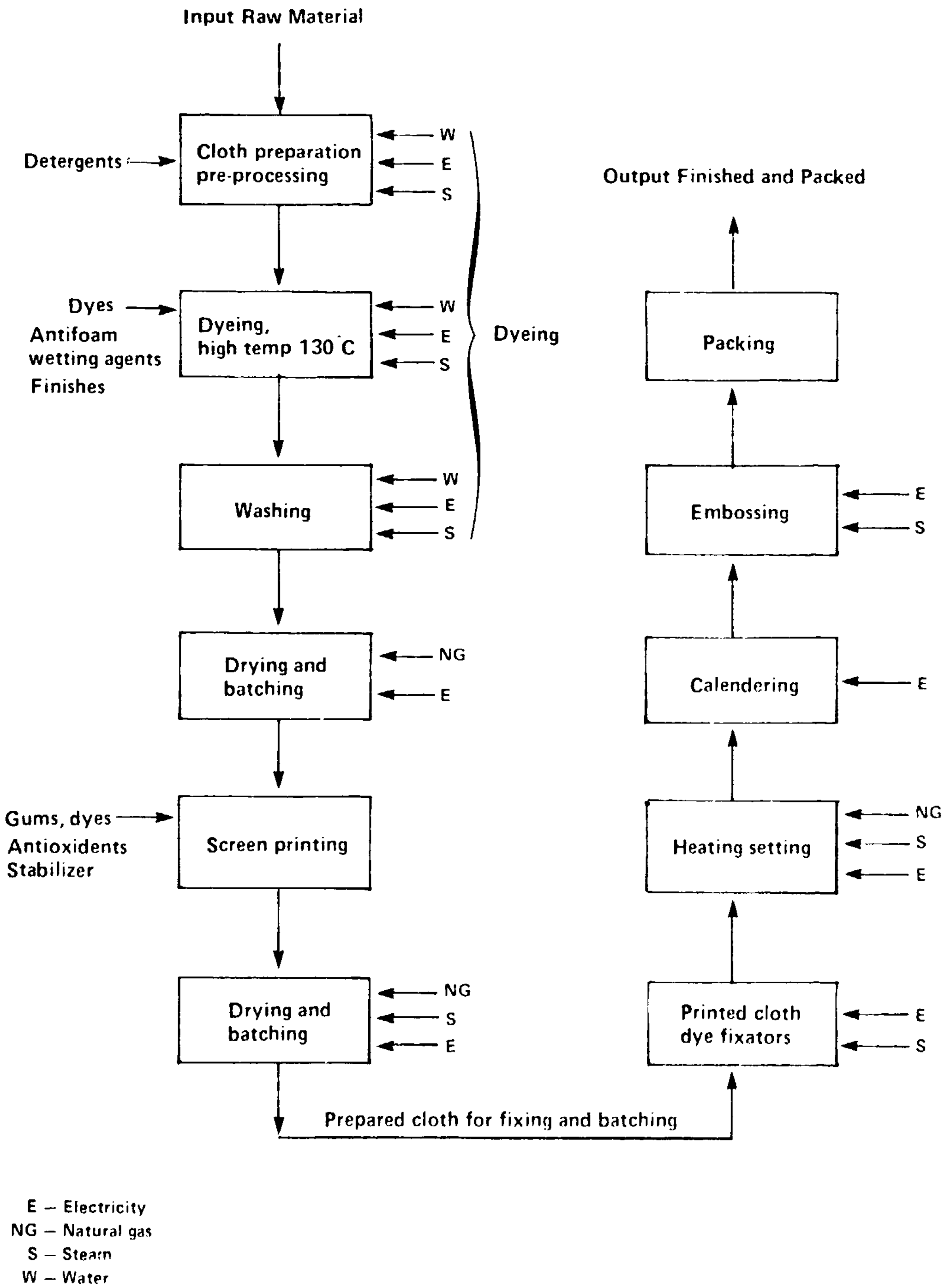


Exhibit A.5

Manufacturing Process Flow Diagram of Chenab Textile Mills

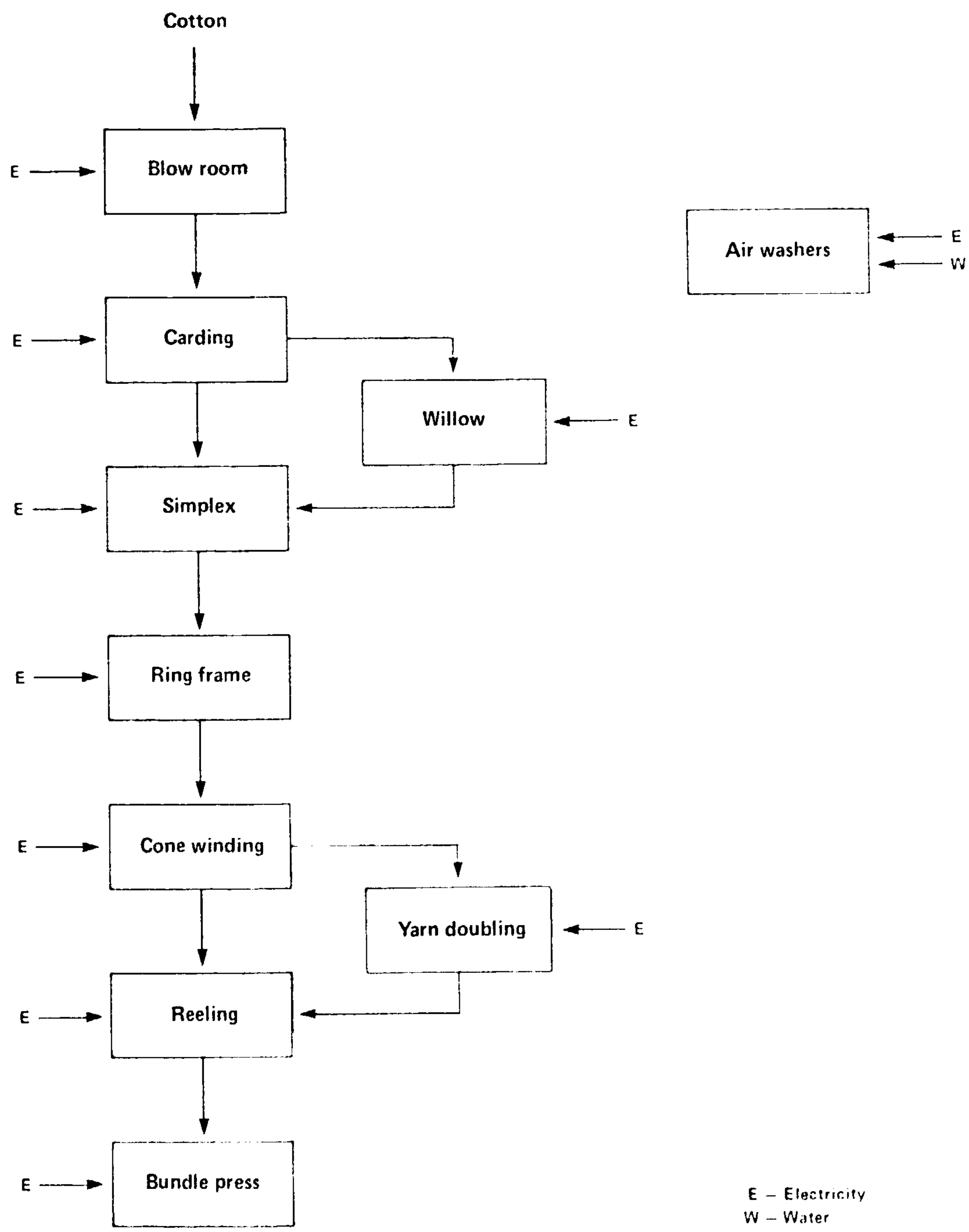
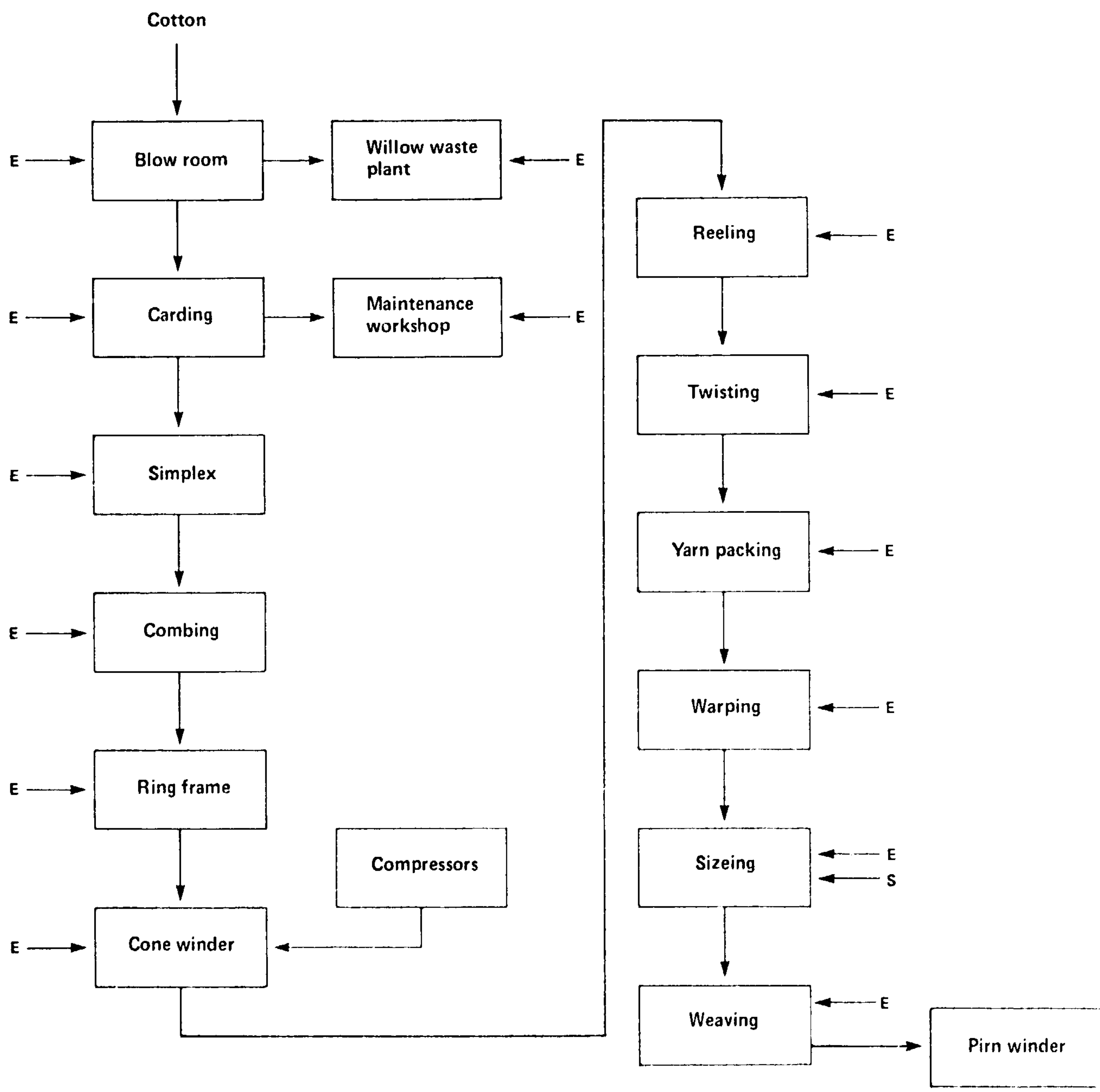


Exhibit A.6

Manufacturing Process Flow Diagram of Colony Textile Mills



E – Electricity
NG – Natural gas
S – Steam
W – Water

Exhibit A.6 (continued)

Manufacturing Process Flow Diagram of Colony Textile Mills

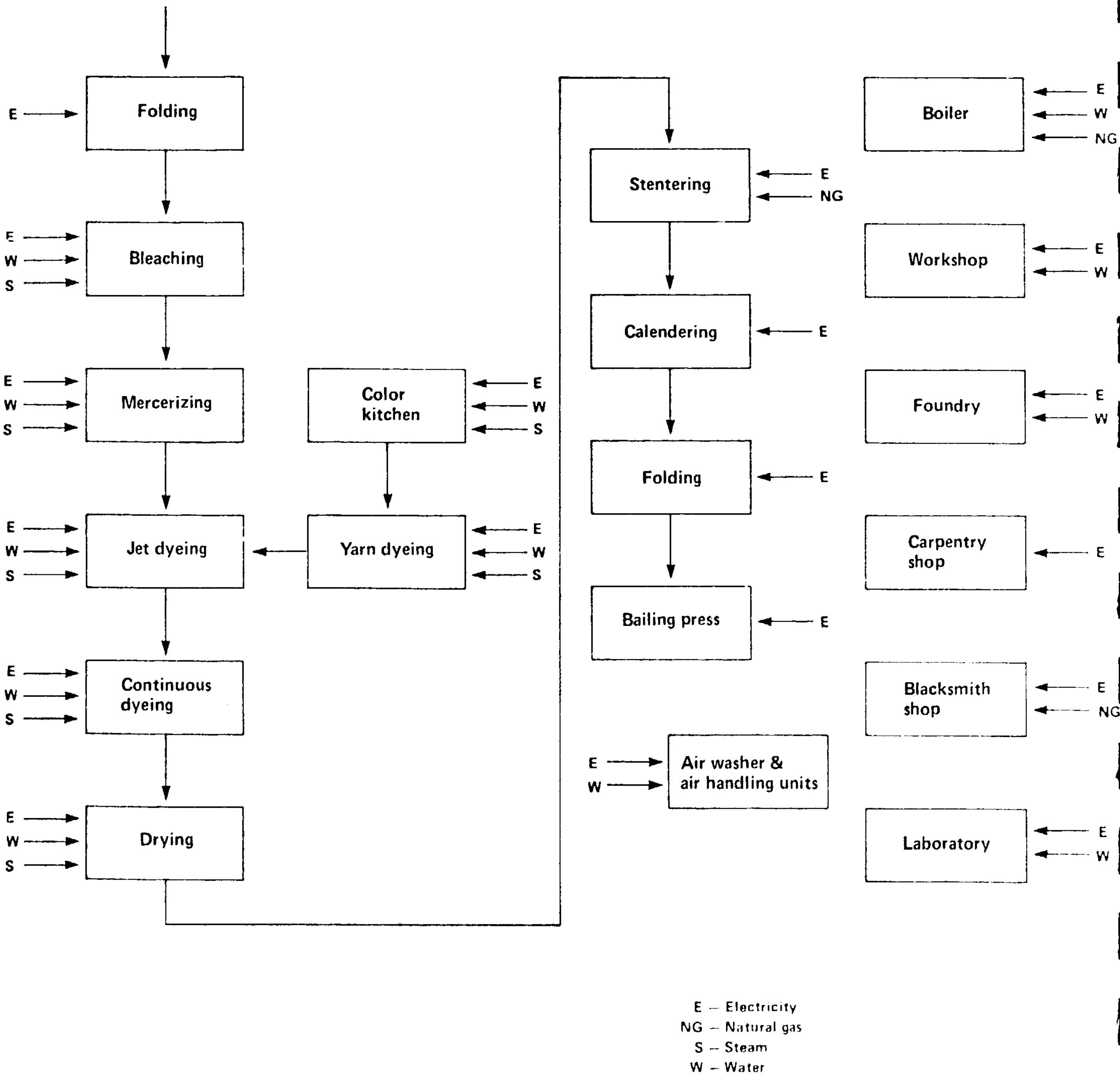


Exhibit A.7

Manufacturing Process Flow Diagram of Farooq Textile Mills

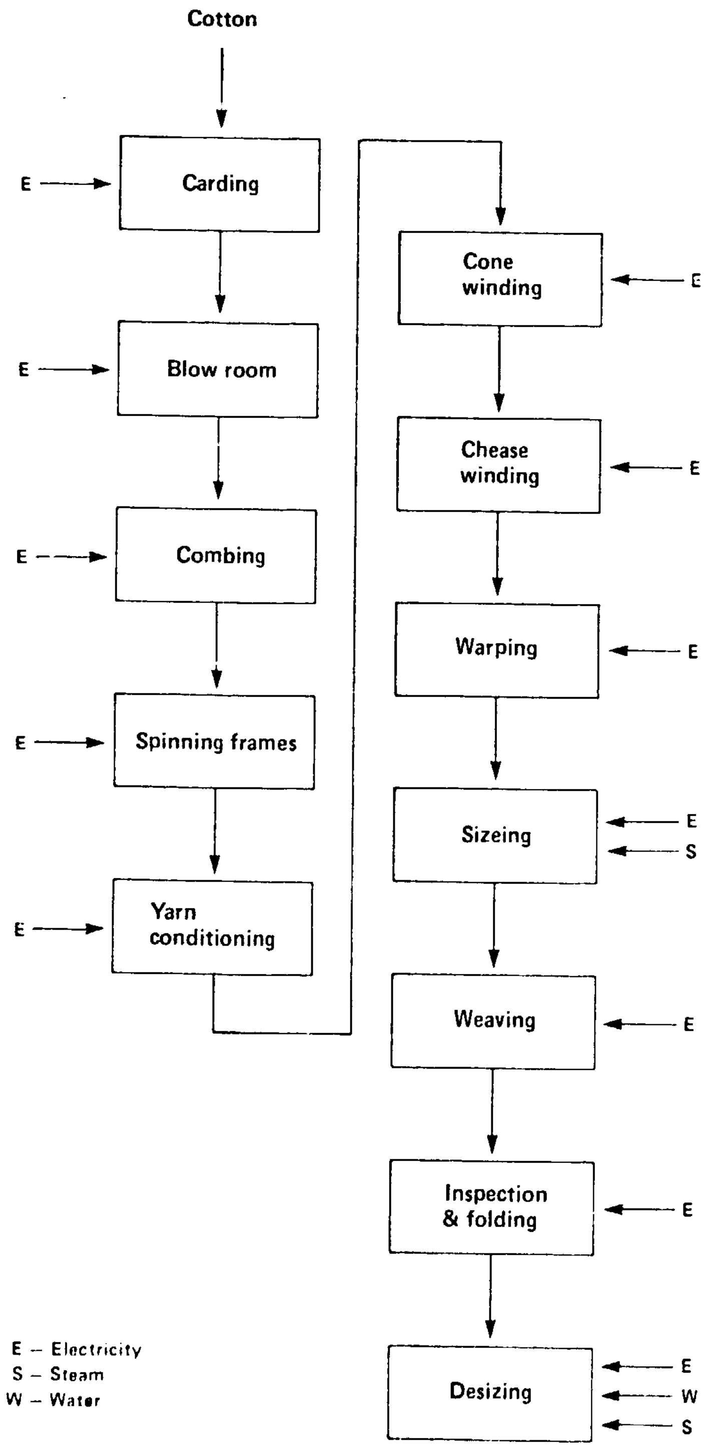


Exhibit A.7 (continued)

Manufacturing Process Flow Diagram of Farooq Textile Mills

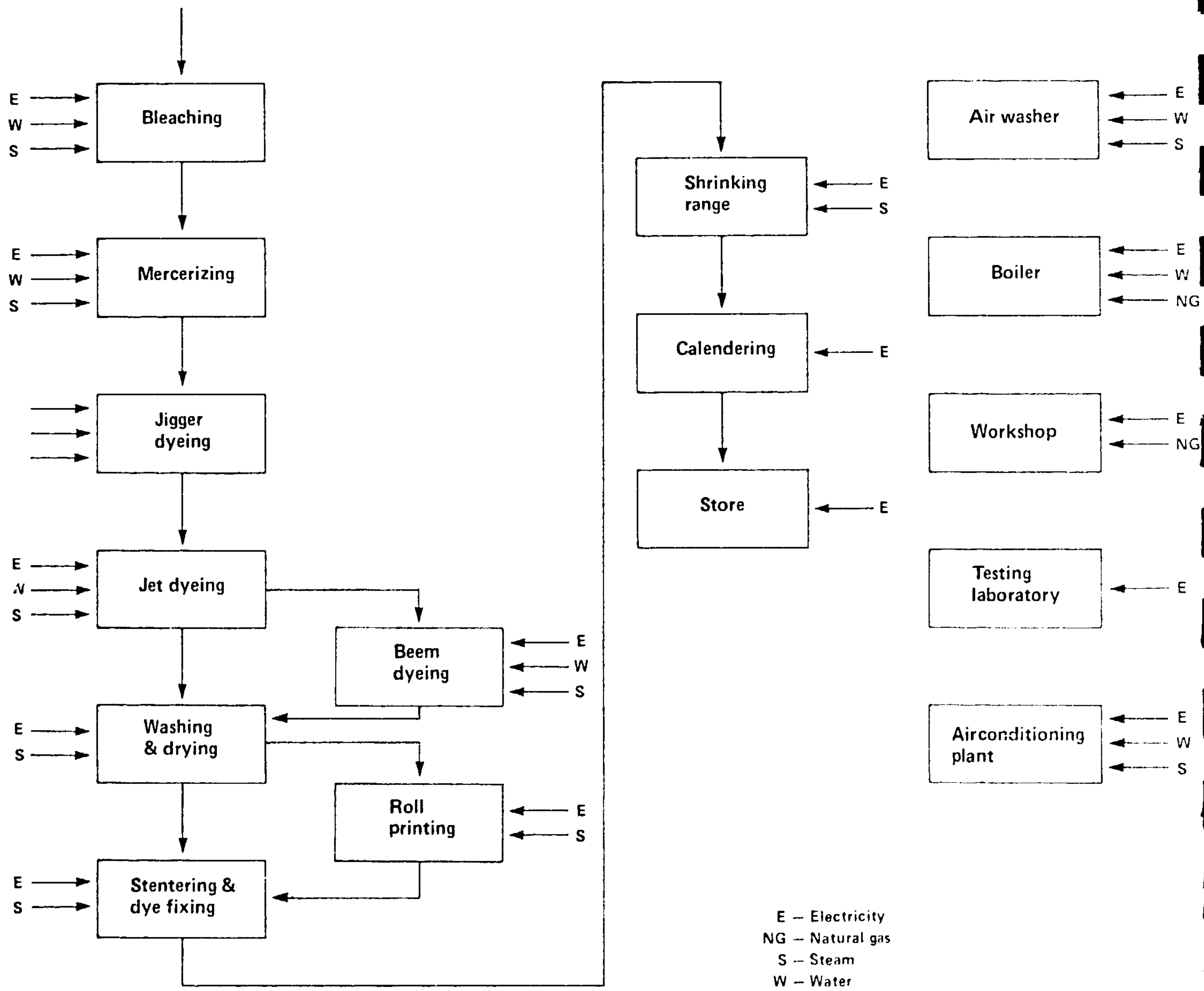
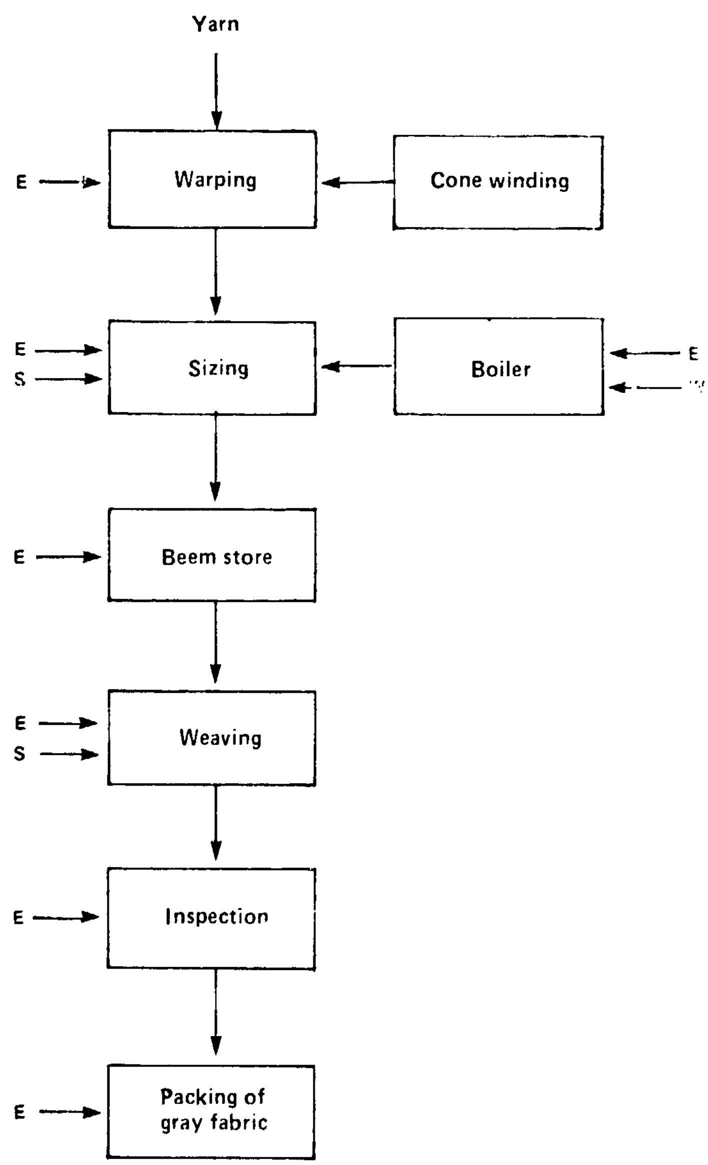


Exhibit A.8

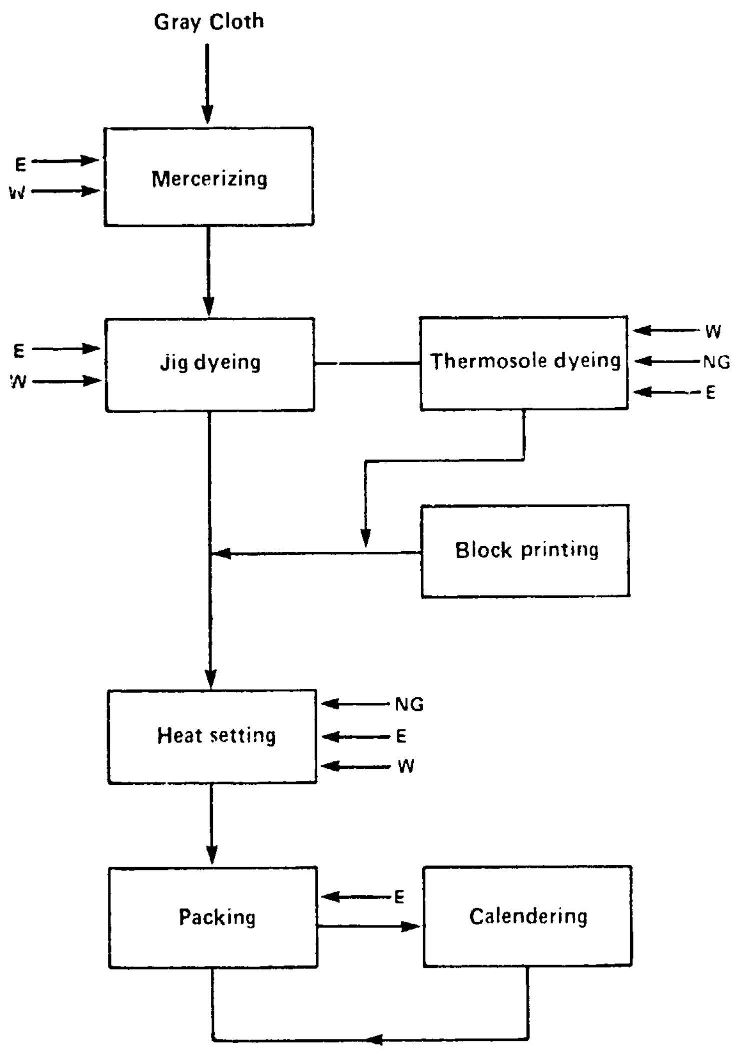
Manufacturing Process Flow Diagram of Government Textile Weaving Center



E – Electricity
NG – Natural gas
S – Steam
W – Water

Exhibit A.8 (continued)

Manufacturing Process Flow Diagram of Government Textile Weaving Center



E – Electricity
NG – Natural gas
S – Steam
W – Water

Exhibit A.9

Manufacturing Process Flow Diagram of Karim Silk Mills

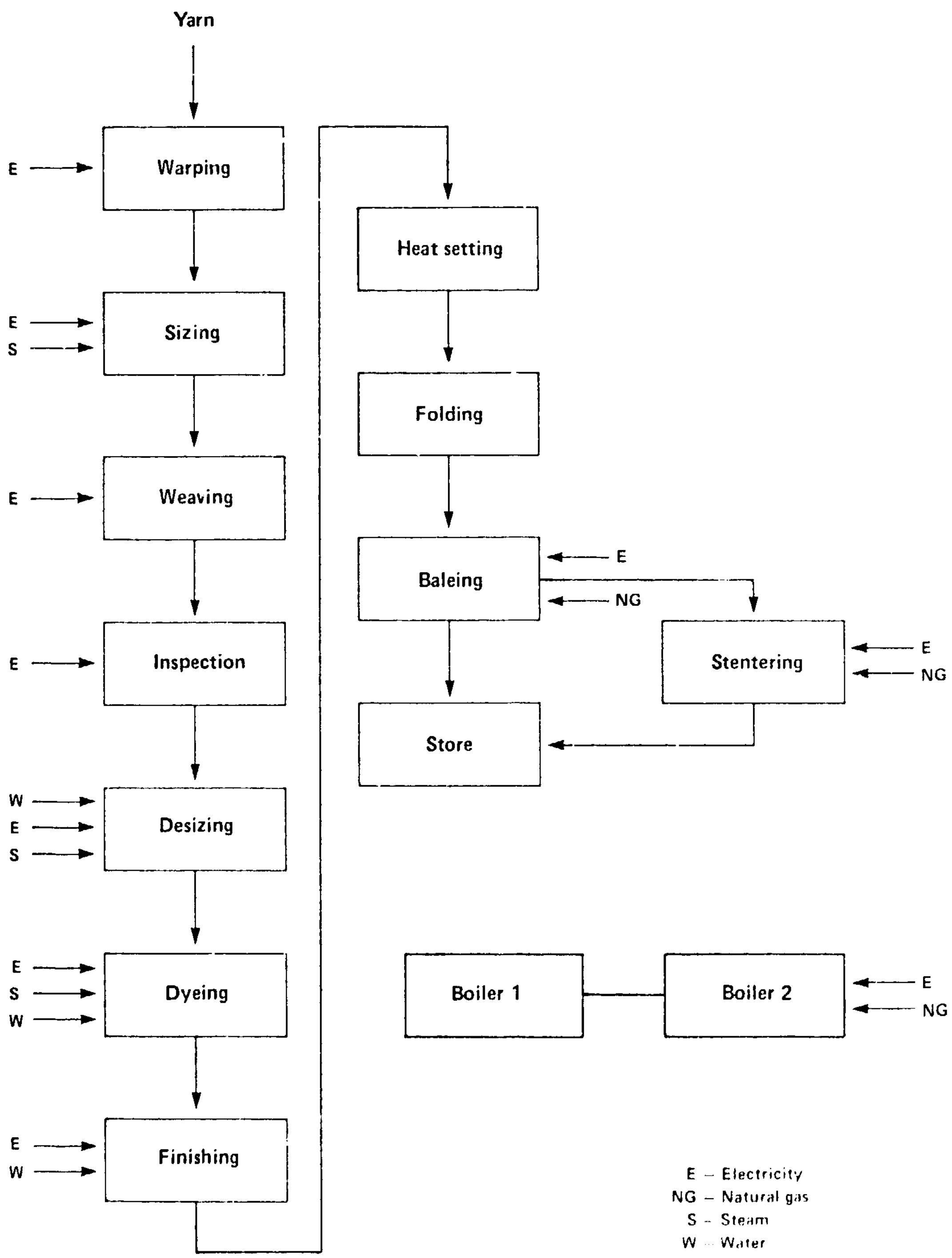
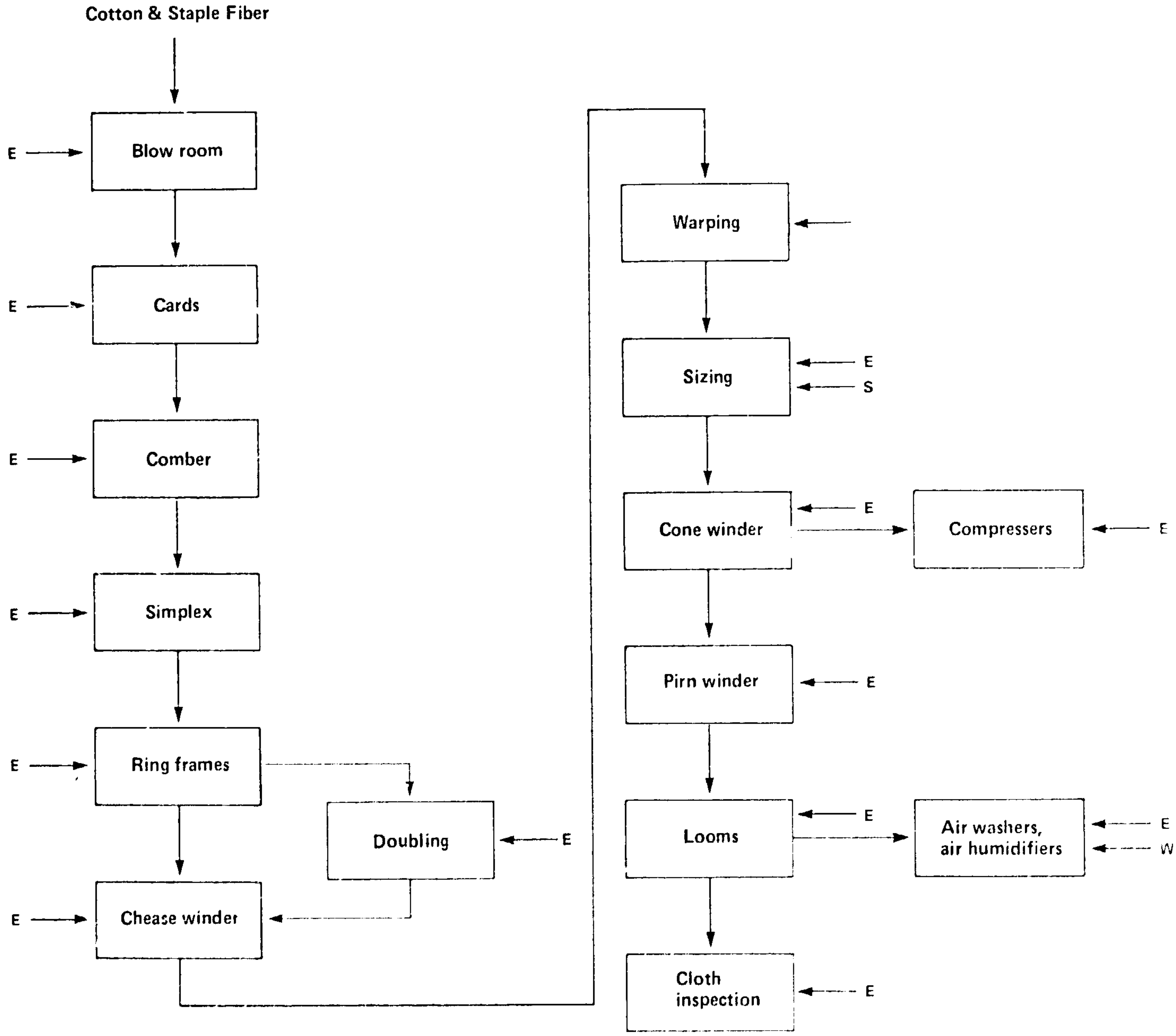


Exhibit A.10

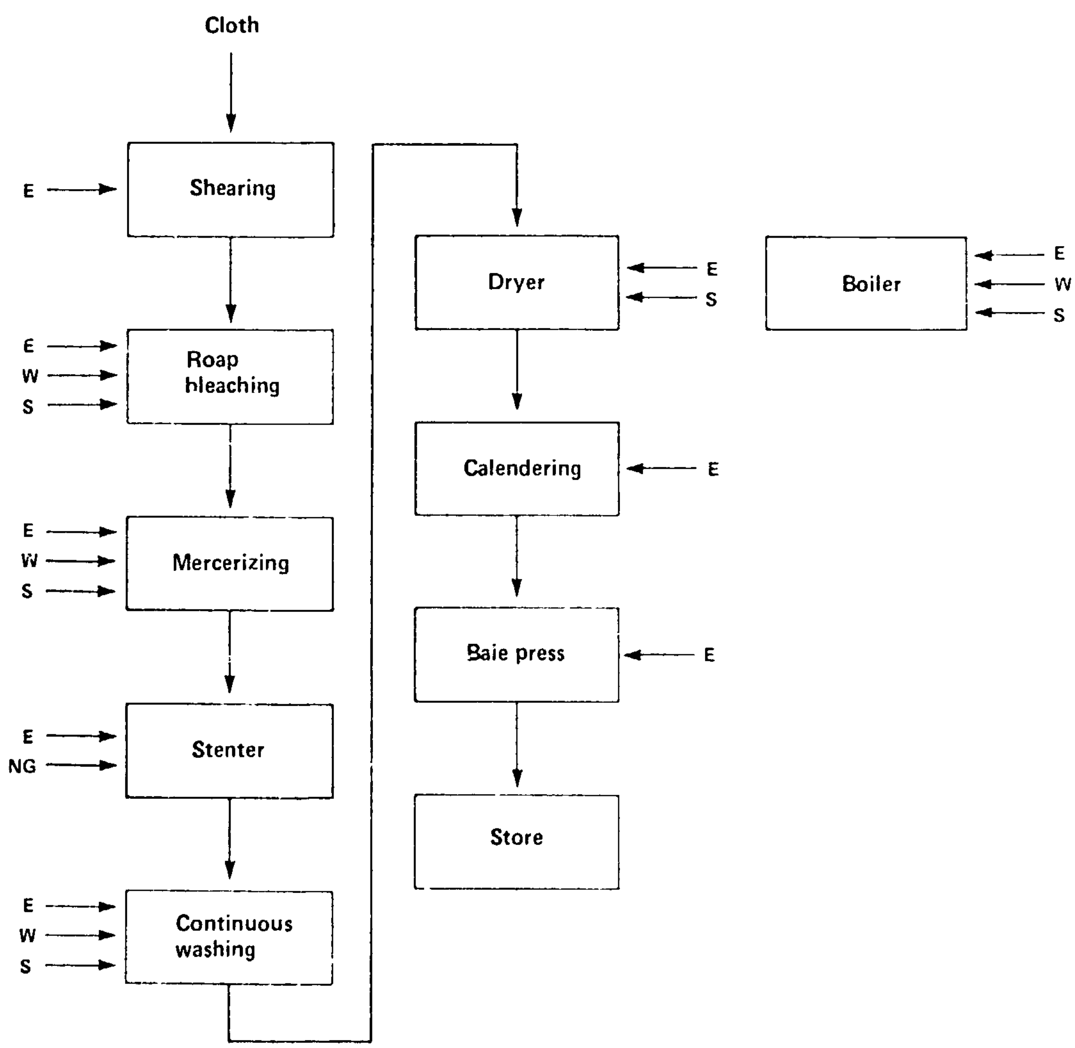
Manufacturing Process Flow Diagram of Kohinoor Textile Mills



E – Electricity
S – Steam
W – Wate

Exhibit A.10 (continued)

Manufacturing Process Flow Diagram of Kohinoor Textile Mills



E – Electricity
NG – Natural gas
S – Steam
W – Water

Exhibit A.11

Manufacturing Process Flow Diagram of Lawrencepur Woolen & Textile Mills

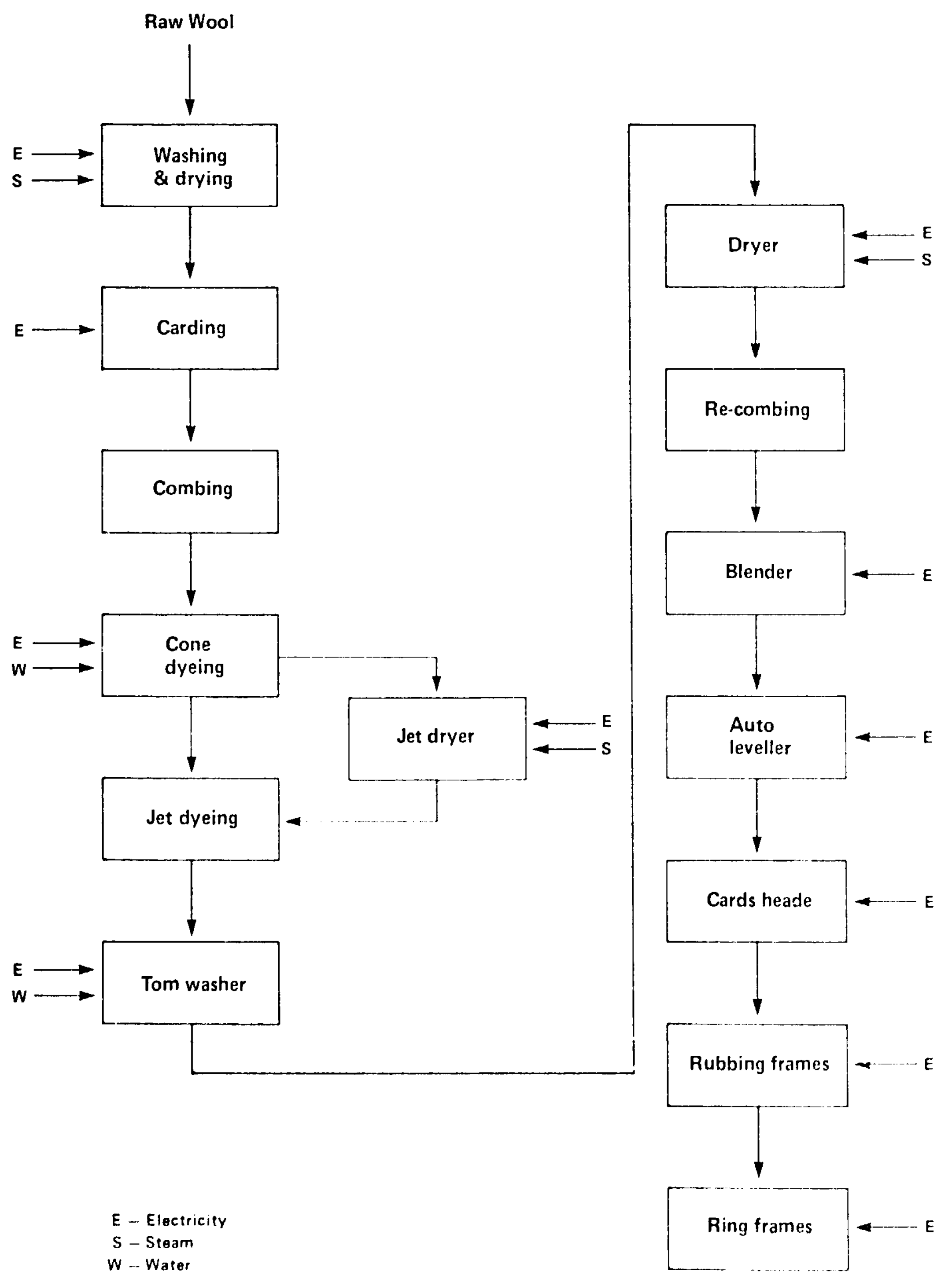


Exhibit A.11 (continued)

Manufacturing Process Flow Diagram of Lawrencepur Woolen & Textile Mills

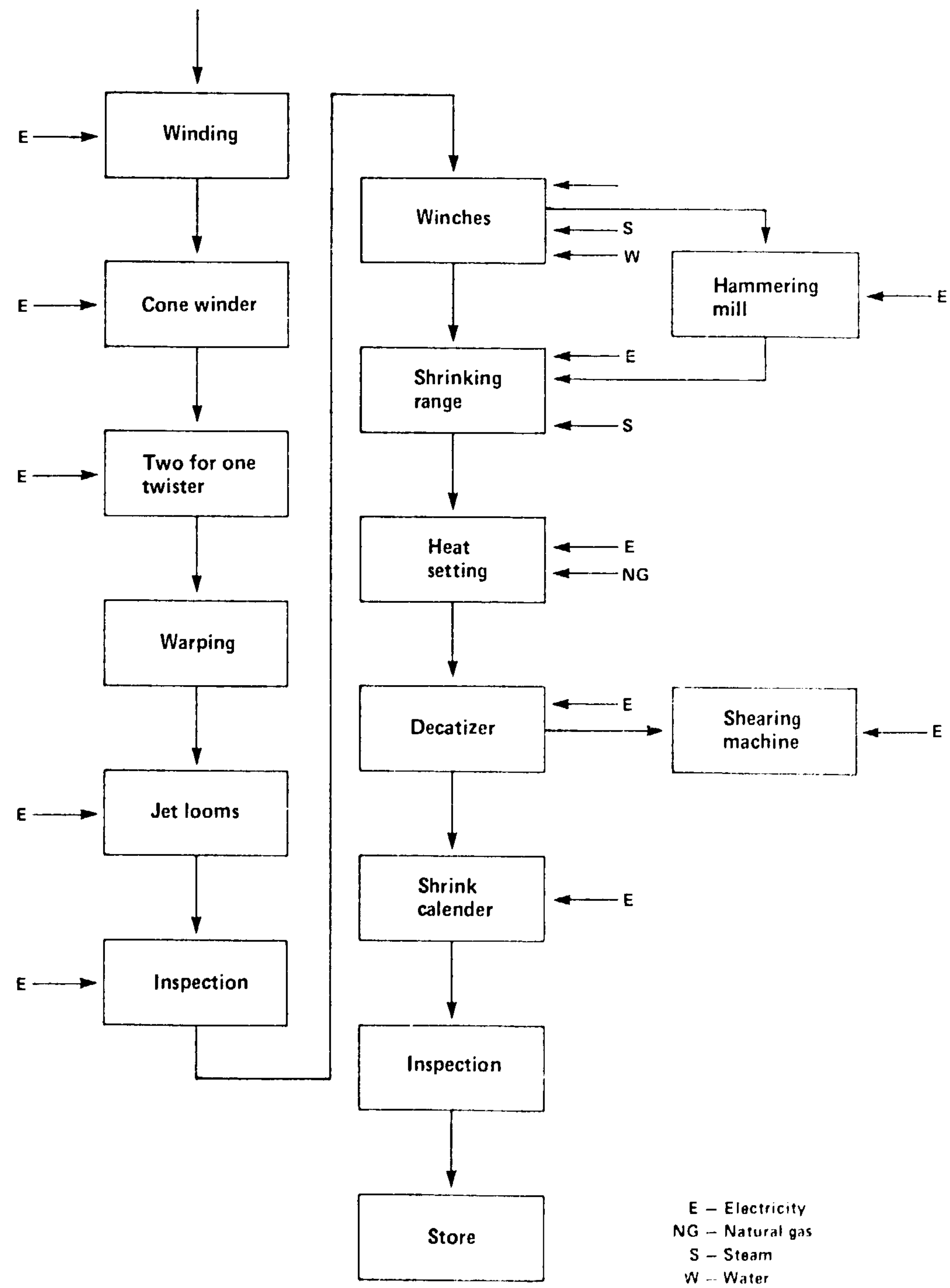
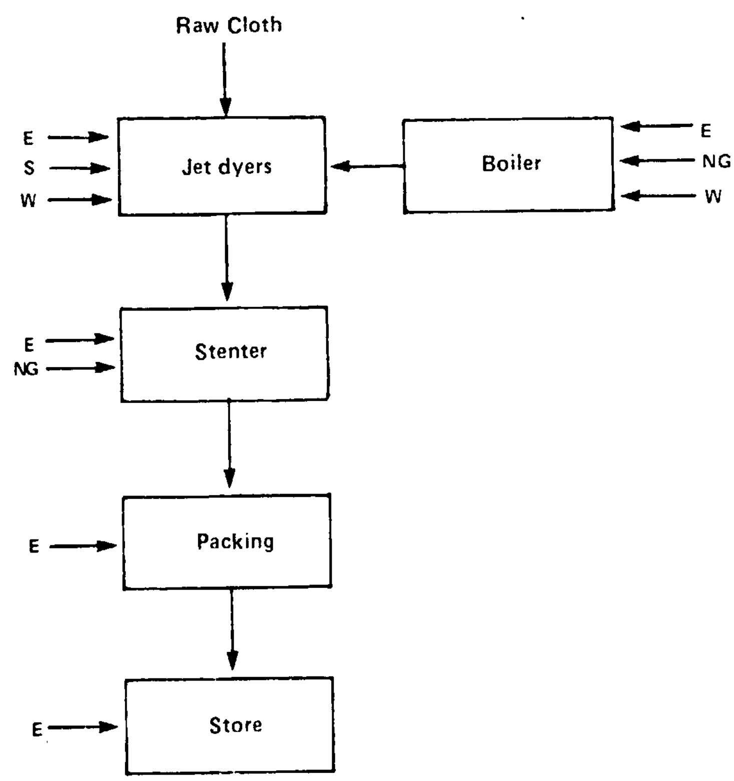


Exhibit A.12

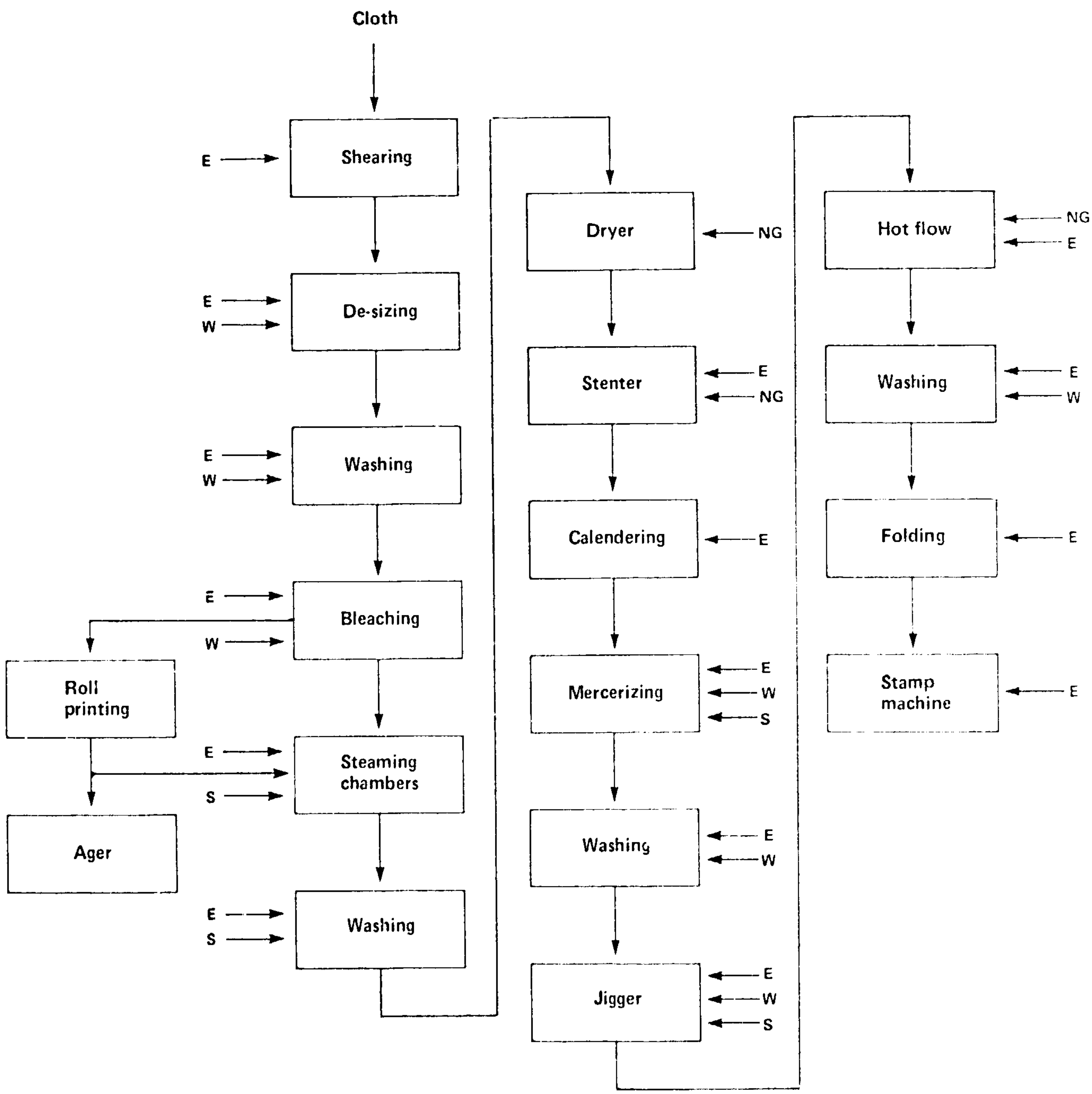
Manufacturing Process Flow Diagram of National Dyeing and Finishing Center



E – Electricity
NG – Natural gas
S – Steam
W – Water

Exhibit A.13

Manufacturing Process Flow Diagram of Paracha Textile



E – Electricity
NG – Natural gas
S – Steam
W – Water

Exhibit A.14

Manufacturing Process Flow Diagram of Shaheen Calico Printing Works

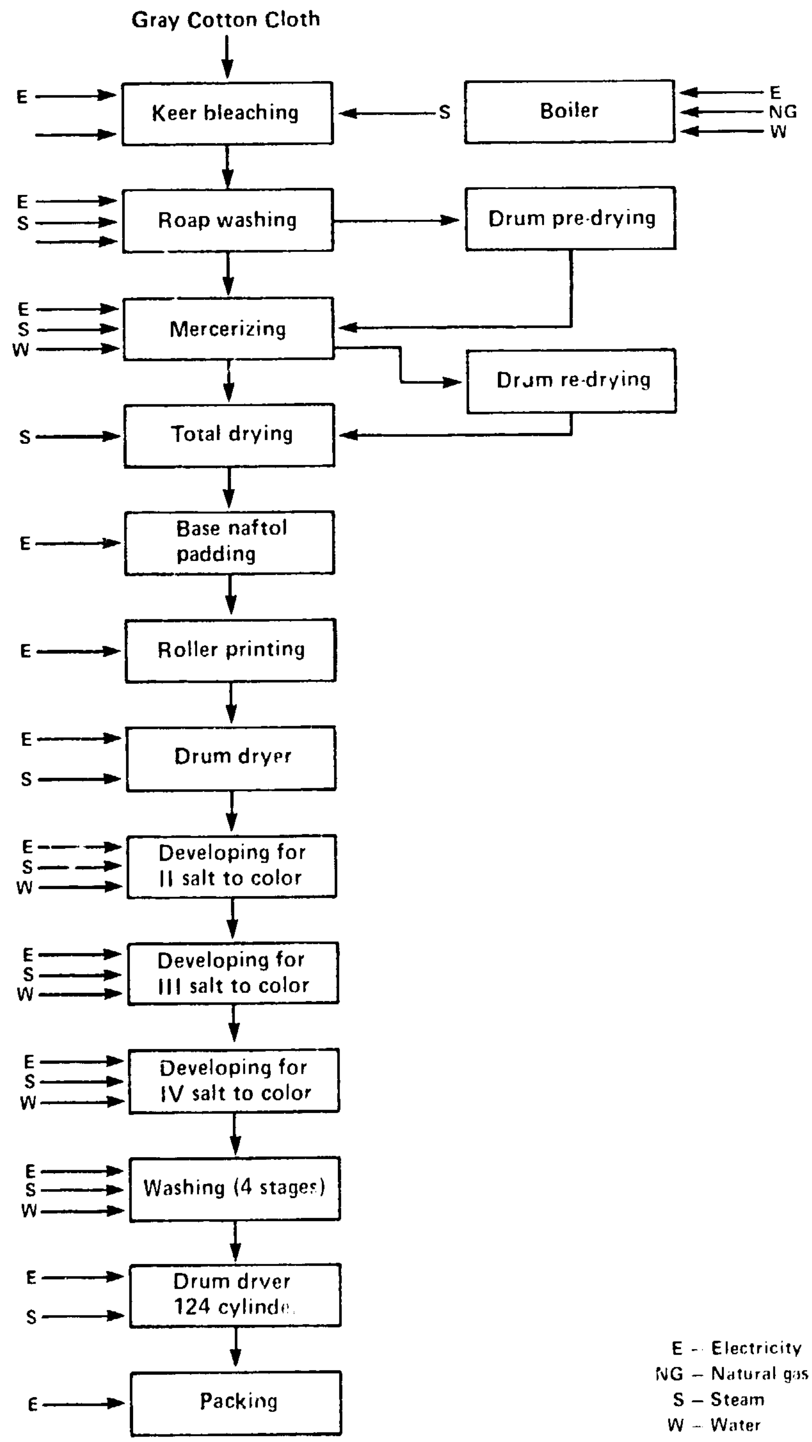


Exhibit A.15

Manufacturing Process Flow Diagram of Sunshine Cotton Mills

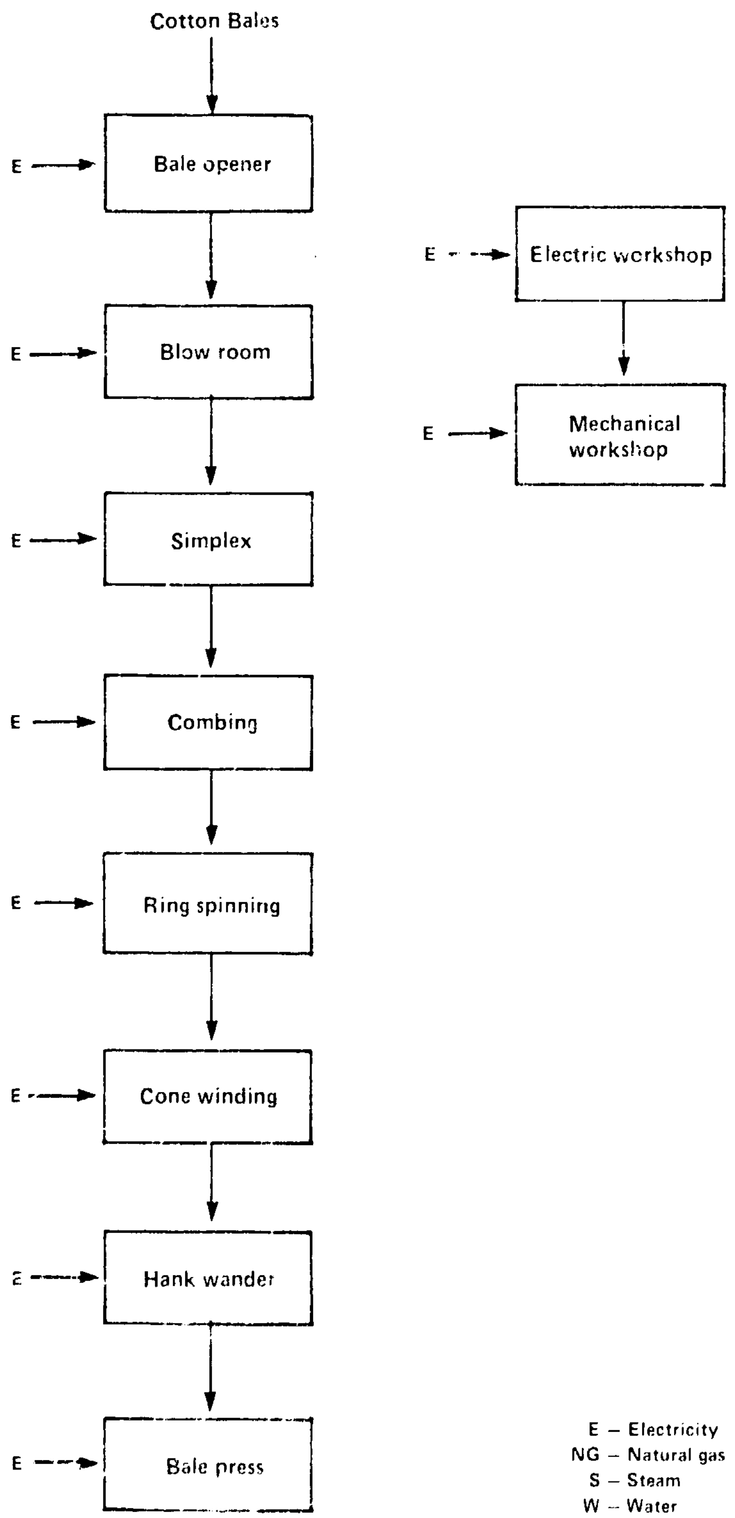


Exhibit A.16

Manufacturing Process Flow Diagram of Sunshine Jute Mills

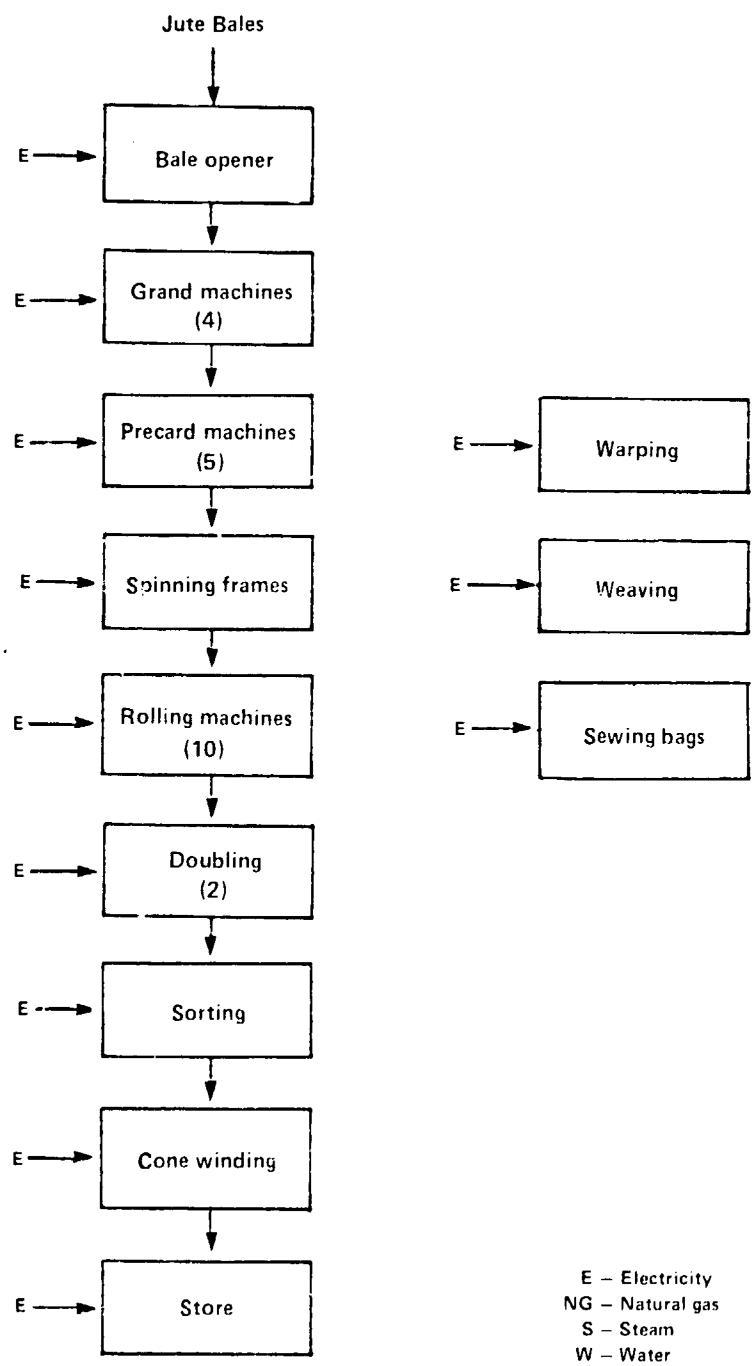


Exhibit A.17

Manufacturing Process Flow Diagram of Adamjee Paper & Board Mills

WASTE PAPER TREATMENT PLANT

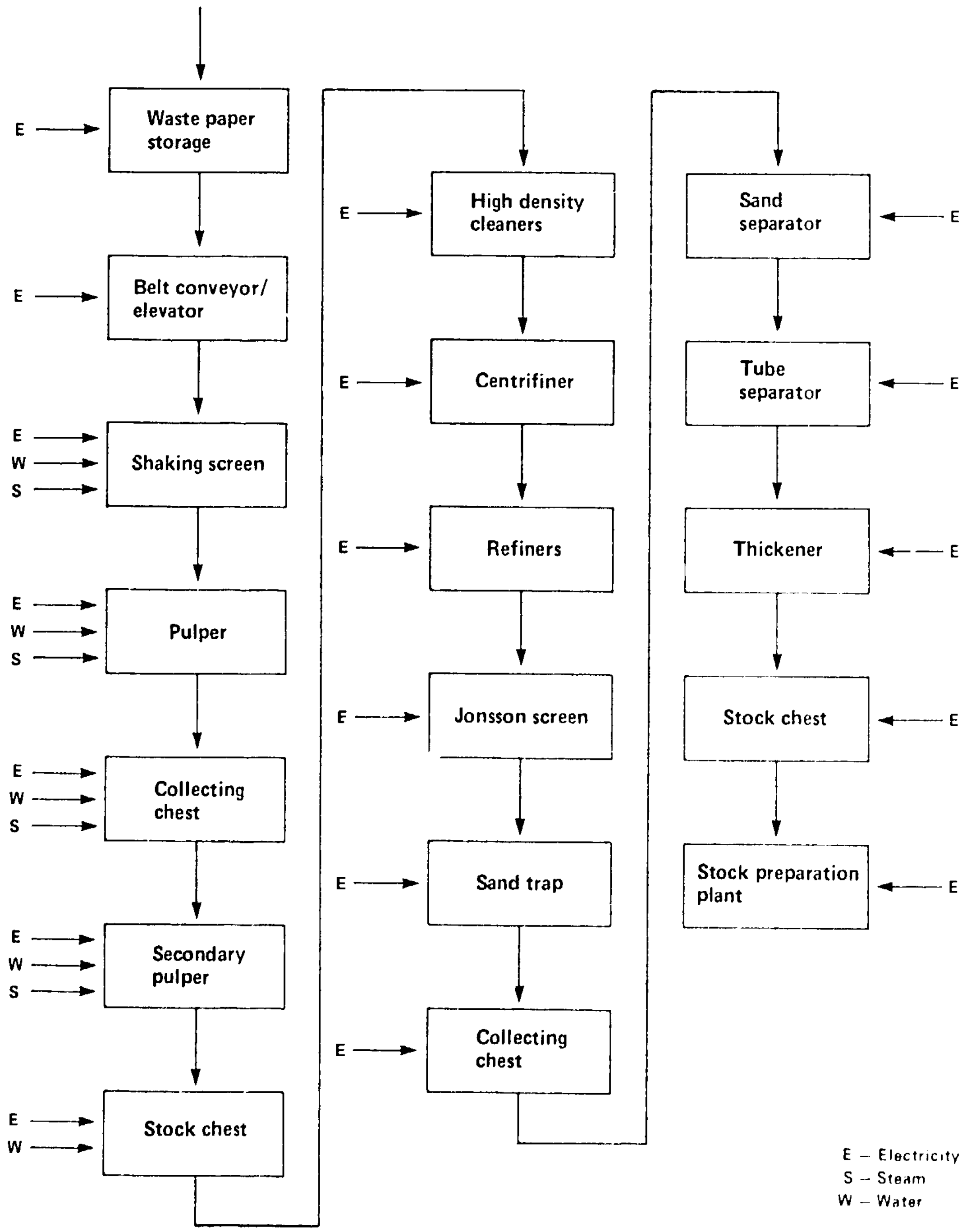


Exhibit A.17 (continued)

Manufacturing Process Flow Diagram of Adamjee Paper & Board Mills

PAPER BOARD MACHINE

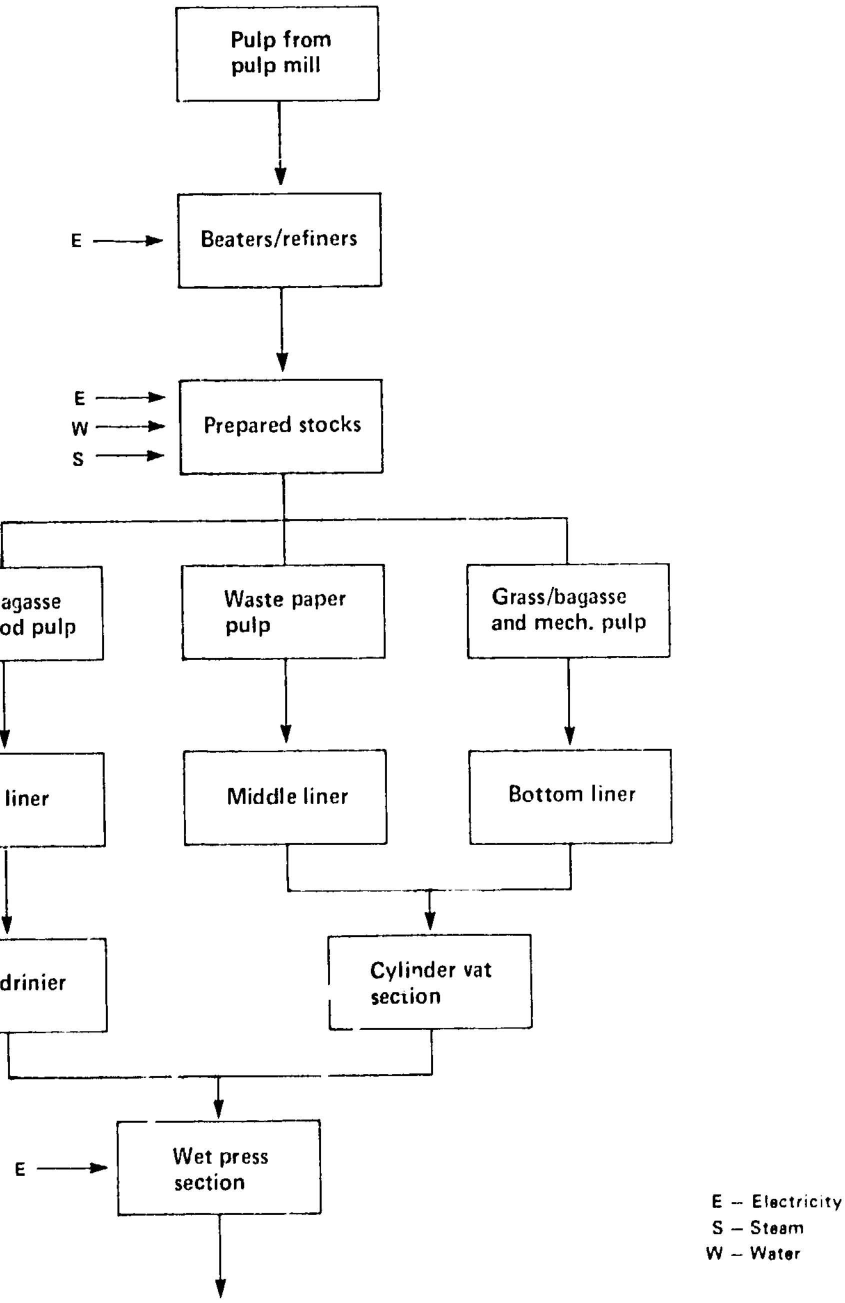


Exhibit A.17 (continued)

Manufacturing Process Flow Diagram of Adamjee Paper & Board Mills

PAPER BOARD MACHINE (continued)

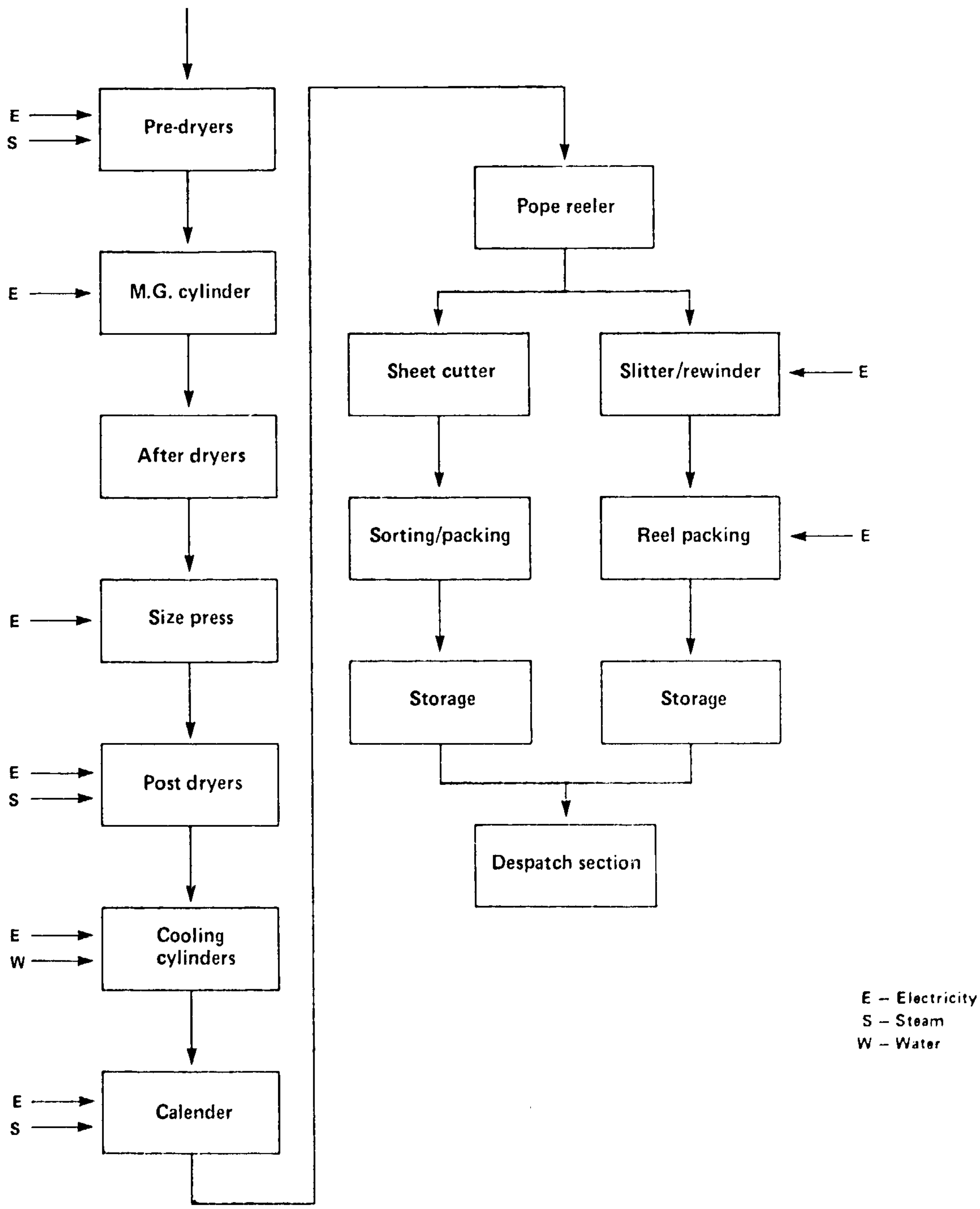


Exhibit A.17 (continued)

Manufacturing Process Flow Diagram of Adamjee Paper & Board Mills

PAPER BOARD MACHINE II

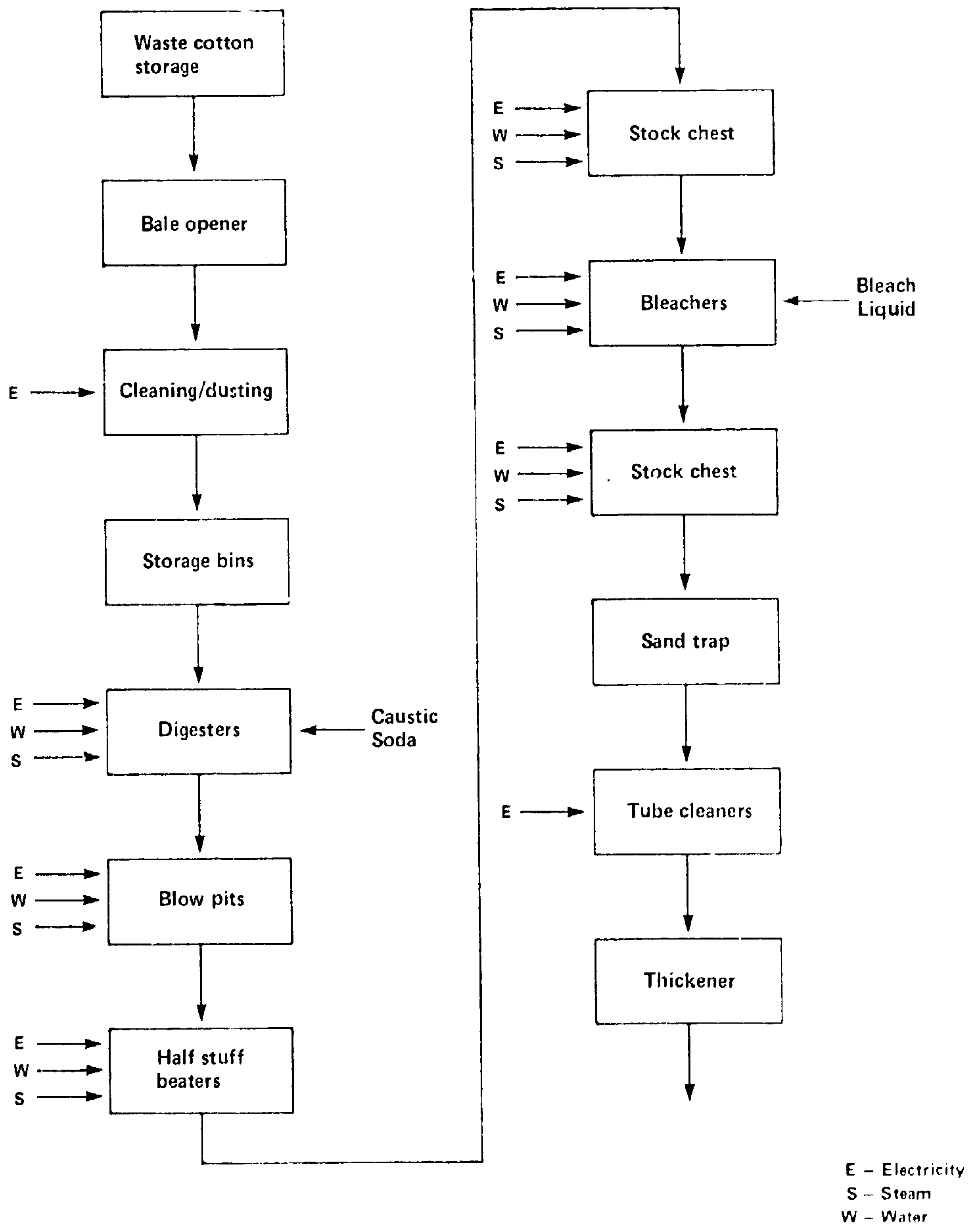


Exhibit A.17 (continued)

Manufacturing Process Flow Diagram of Adamjee Paper & Board Mills

PAPER BOARD MACHINE II (continued)

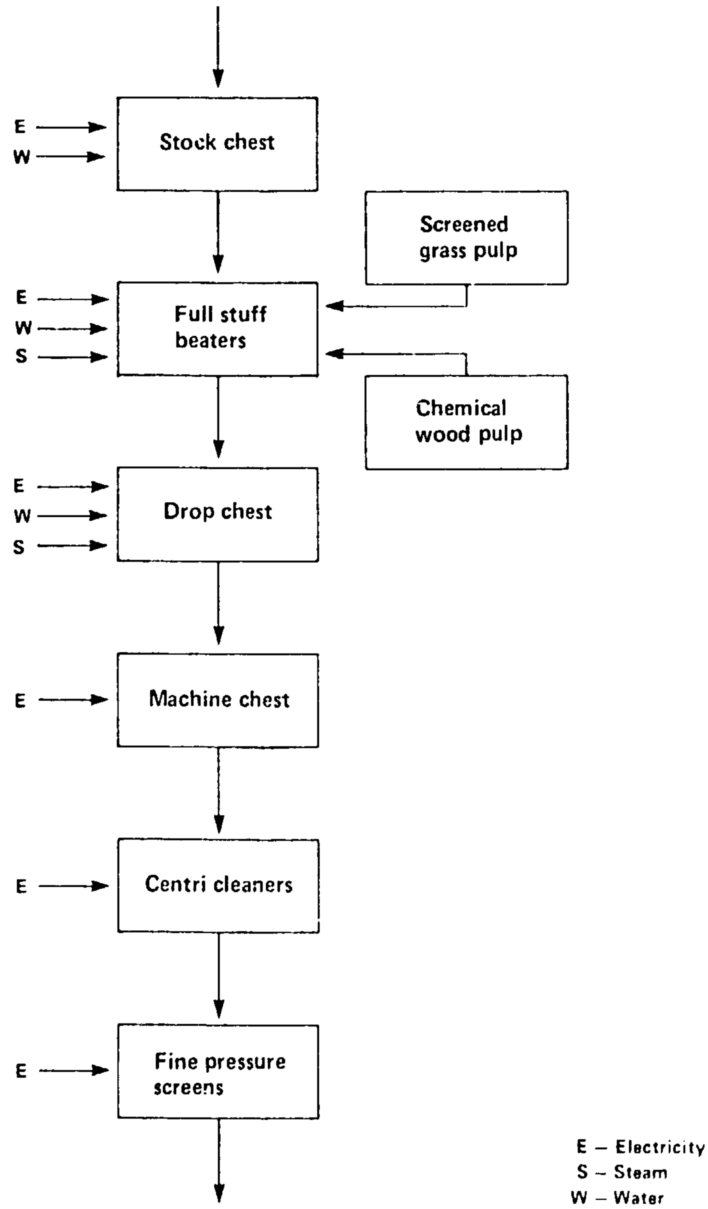


Exhibit A.17 (continued)

Manufacturing Process Flow Diagram of Adamjee Paper & Board Mills

PAPER BOARD MACHINE II (continued)

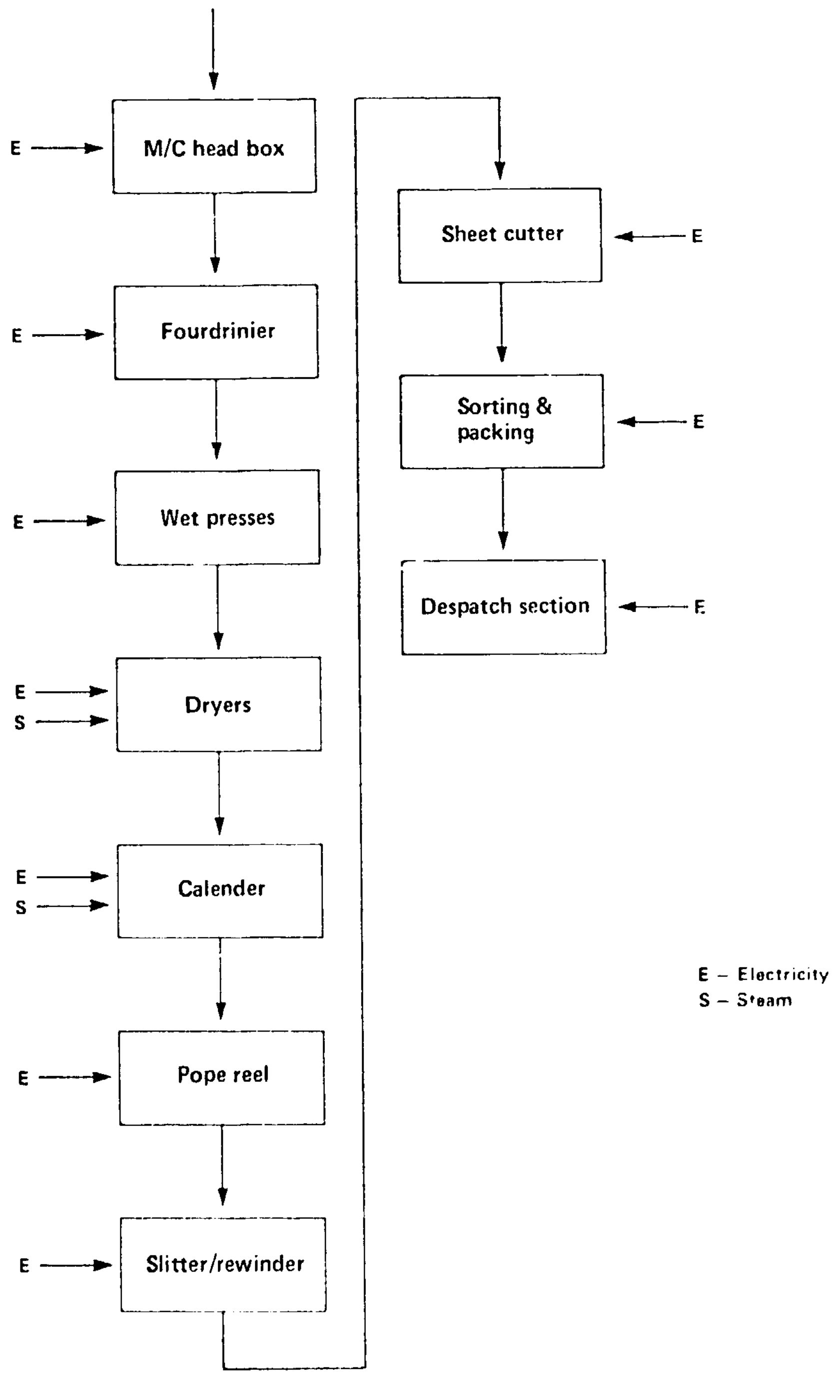
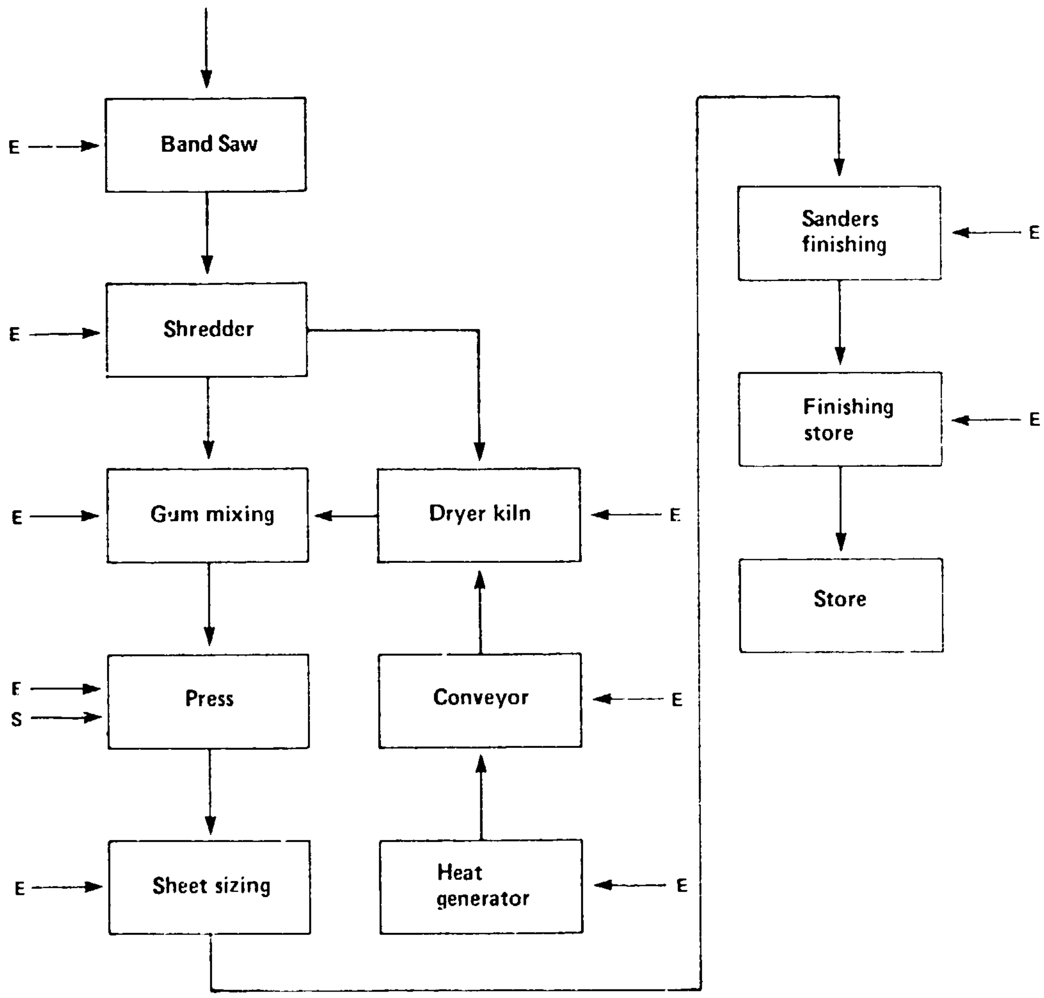


Exhibit A.18

Manufacturing Process Flow Diagram of Pakistan Chipboard Ltd.



E – Electricity
S – Steam

Exhibit A.19

Manufacturing Process Flow Diagram of Pakistan Paper Corp. Ltd.

PAPER BOARD MACHINE II

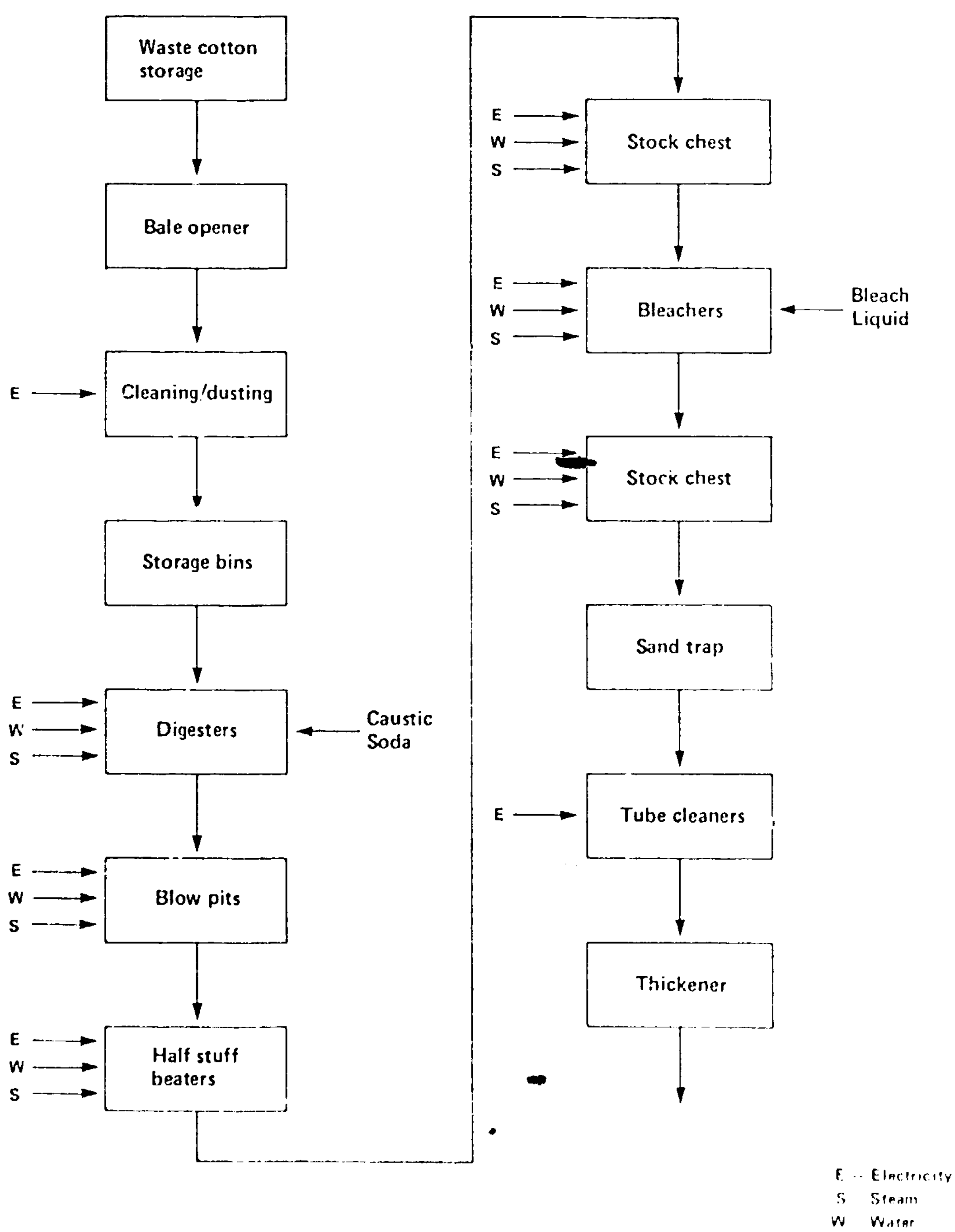


Exhibit A.19 (continued)

Manufacturing Process Flow Diagram of Pakistan Paper Corp. Ltd.

PAPER BOARD MACHINE II (continued)

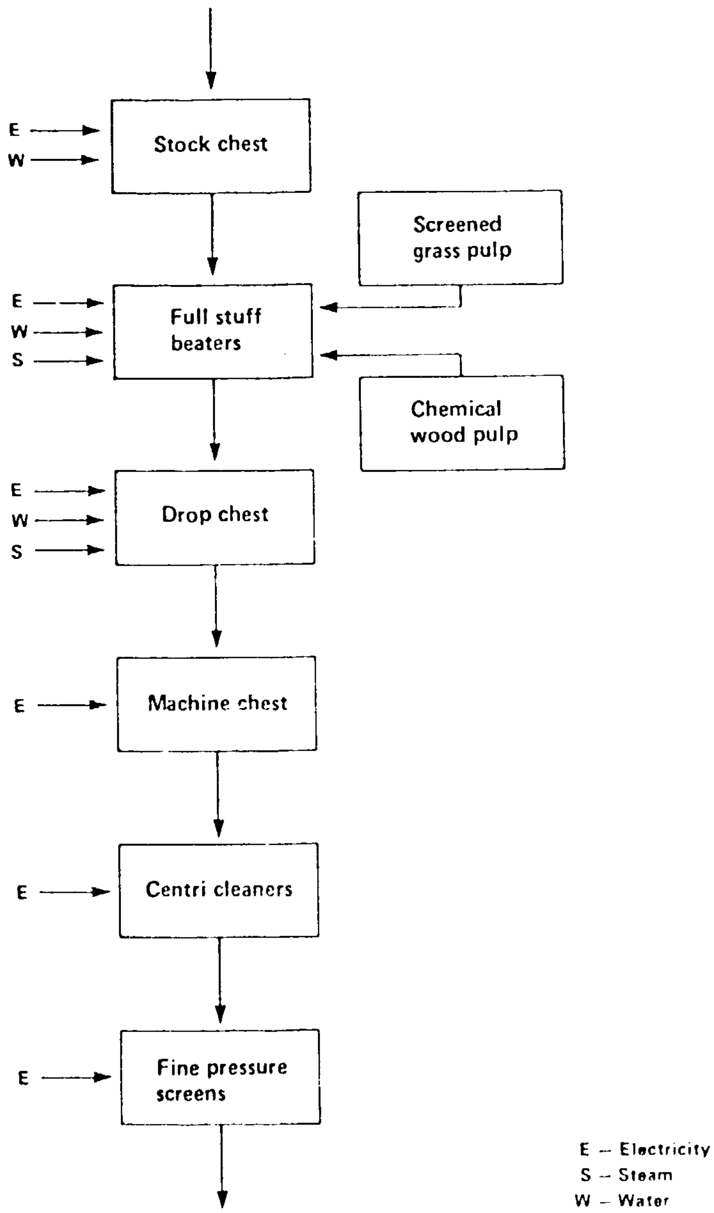
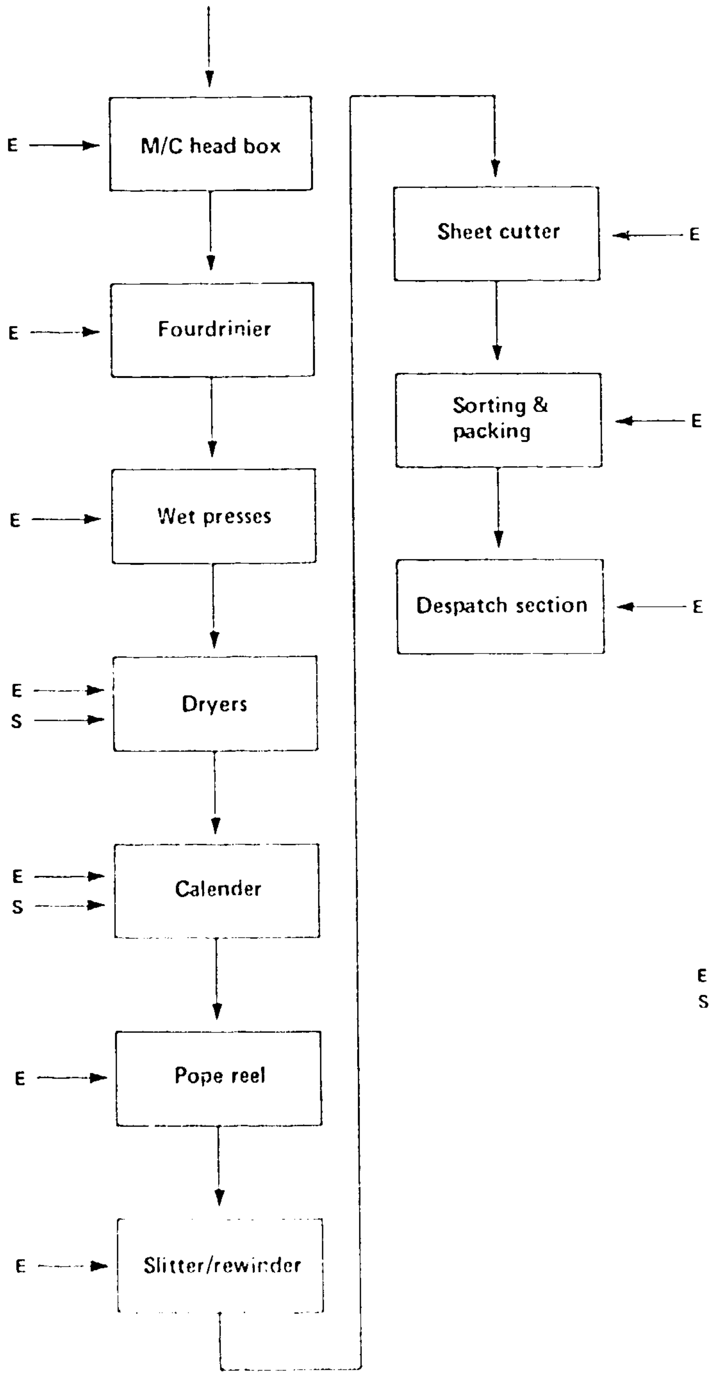


Exhibit A.19 (continued)

Manufacturing Process Flow Diagram of Pakistan Paper Corp. Ltd.

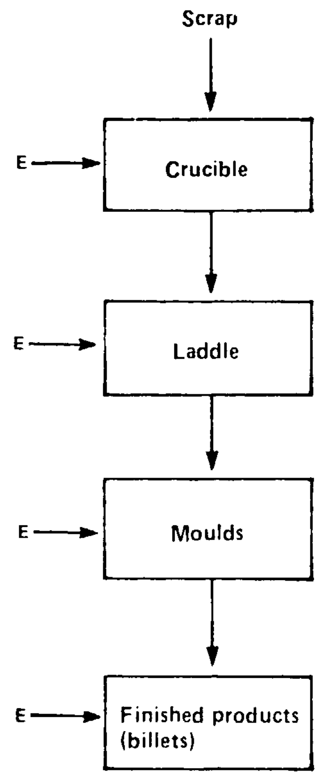
PAPER BOARD MACHINE II (continued)



E – Electricity
S – Steam

Exhibit A.20

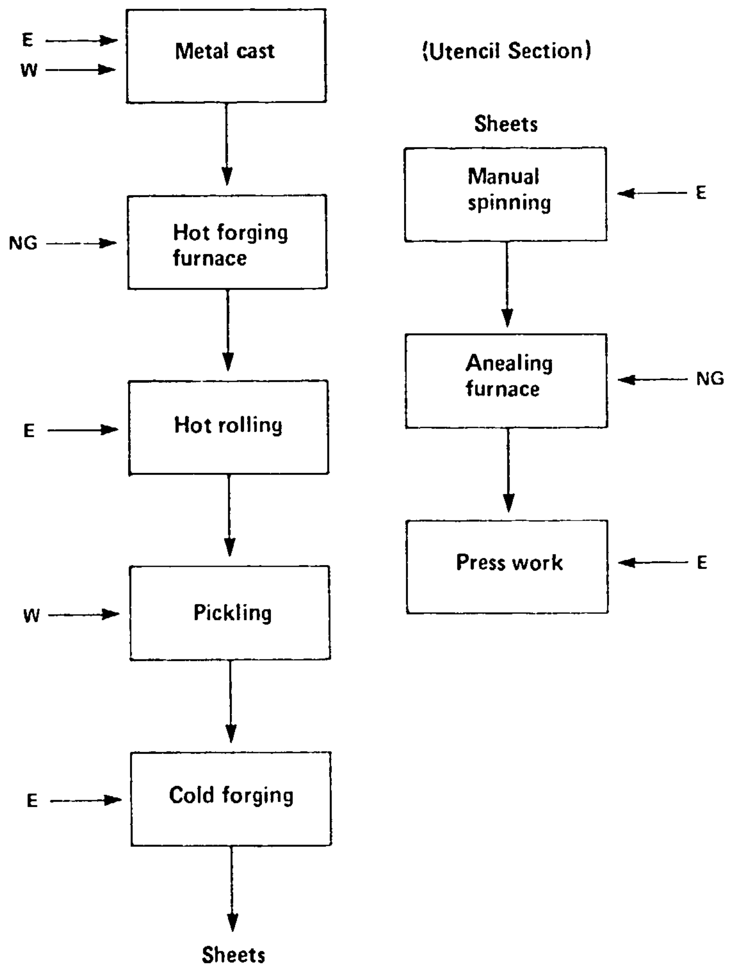
Manufacturing Process Flow Diagram of Ashraf Engineering Works



E – Electricity
NG – Natural gas
S – Steam
W – Water

Exhibit A.21

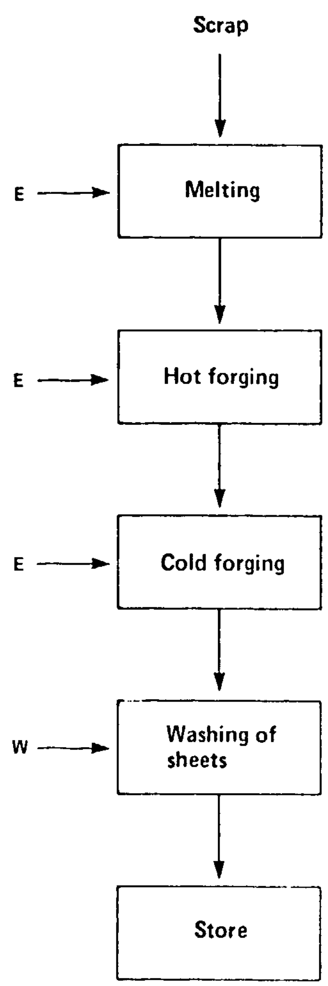
Manufacturing Process Flow Diagram of General Steel Tools Company



E – Electricity
NG – Natural gas
W – Water

Exhibit A.22

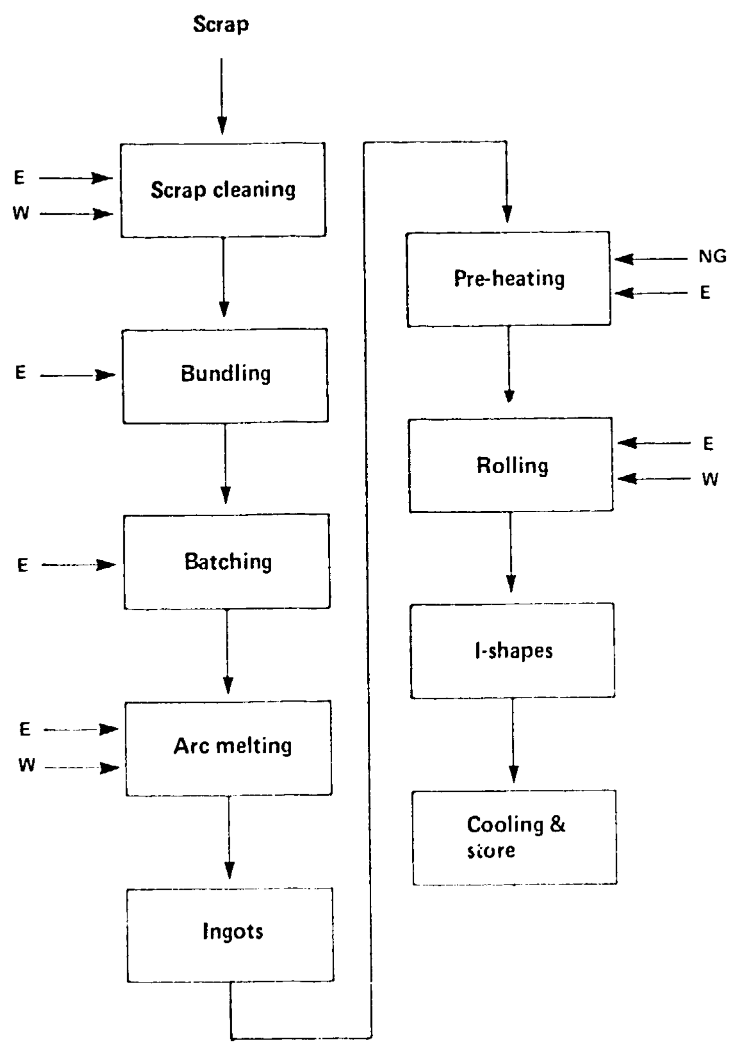
Manufacturing Process Flow Diagram of International Metal Industries



E – Electricity
W – Water

Exhibit A.23

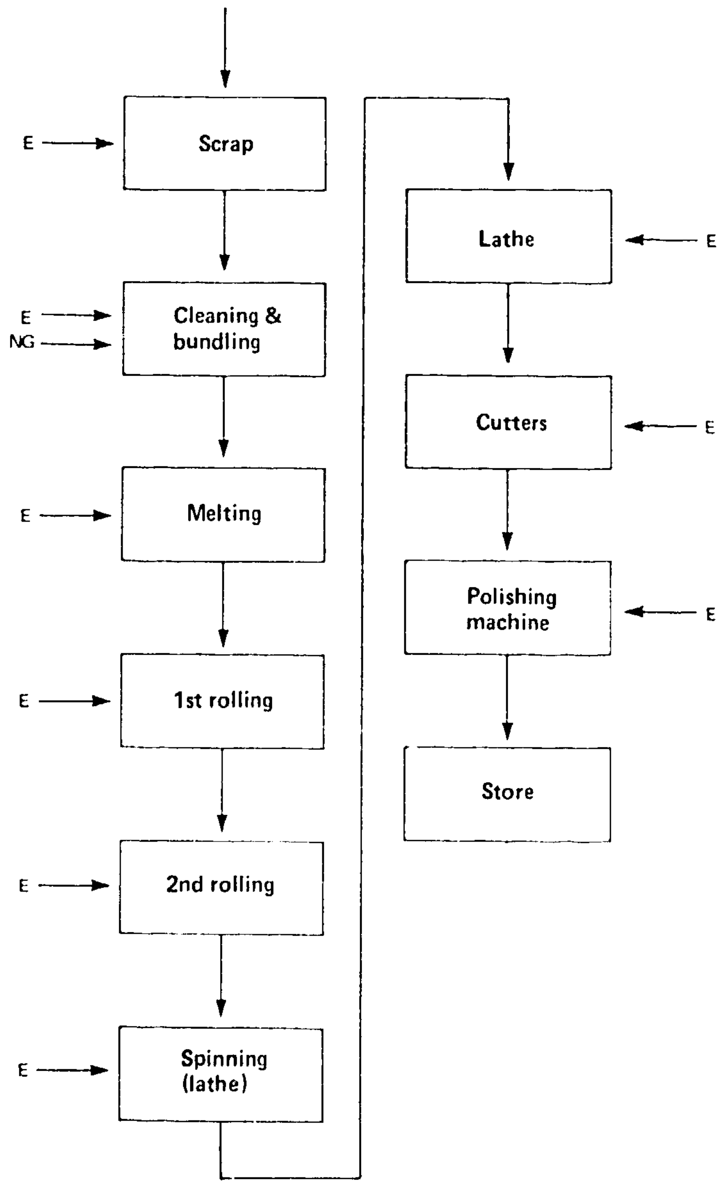
Manufacturing Process Flow Diagram of Kamran Steel Re-Rolling Mills



E – Electricity
W – Water
NG – Natural Gas

Exhibit A.24

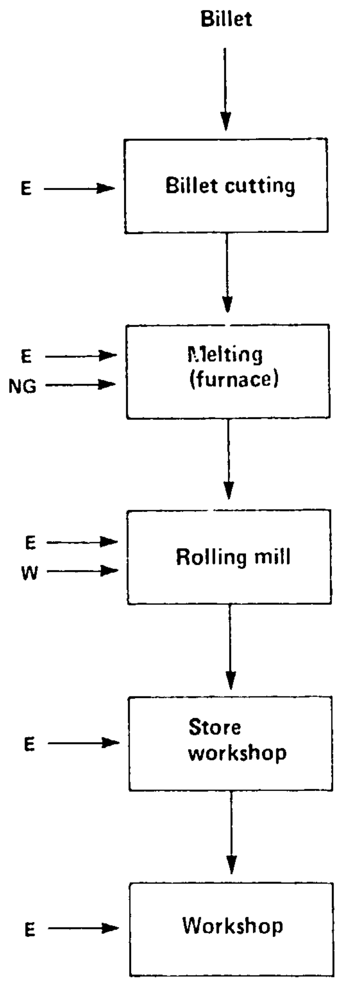
Manufacturing Process Flow Diagram of Khalil Metal Works



E – Electricity
NG – Natural gas

Exhibit A.25

Manufacturing Process Flow Diagram of Metropolitan Steel



E – Electricity
NG – Natural gas
W – Water

Exhibit A.26

Manufacturing Process Flow Diagram of Ravi Steel & Re-Rolling Mills

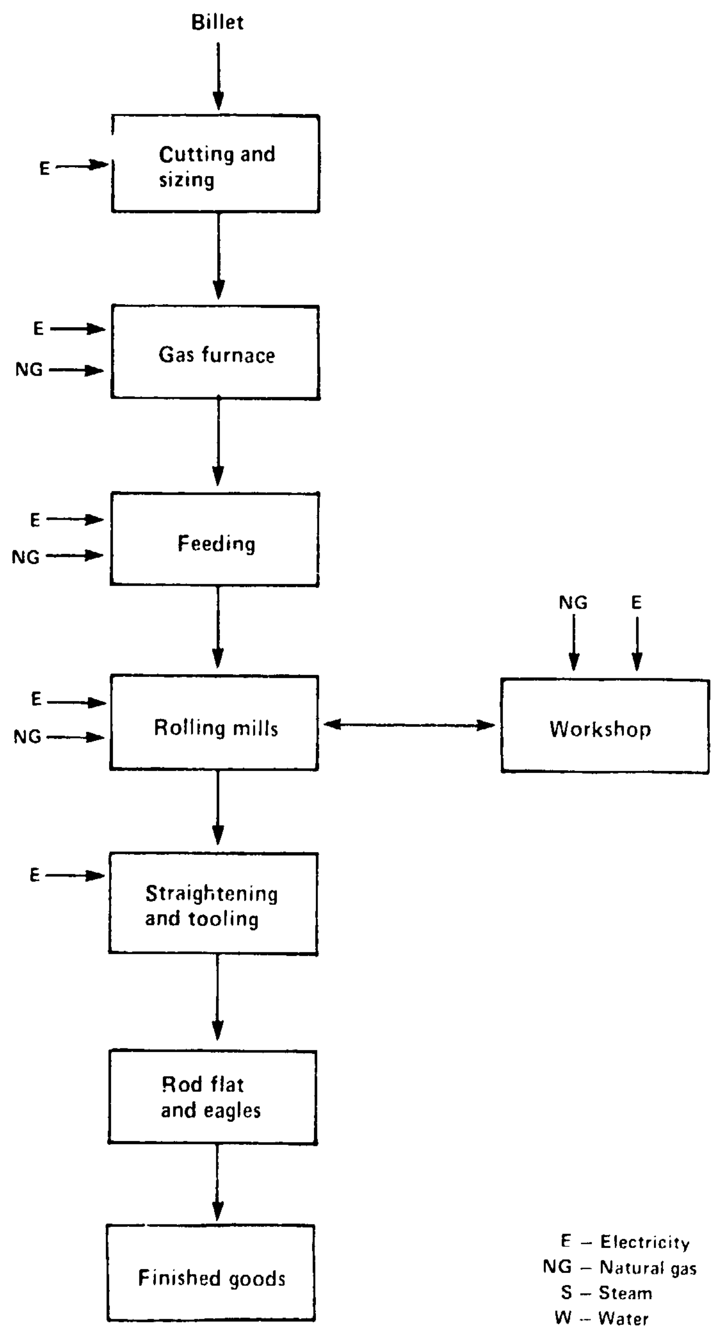
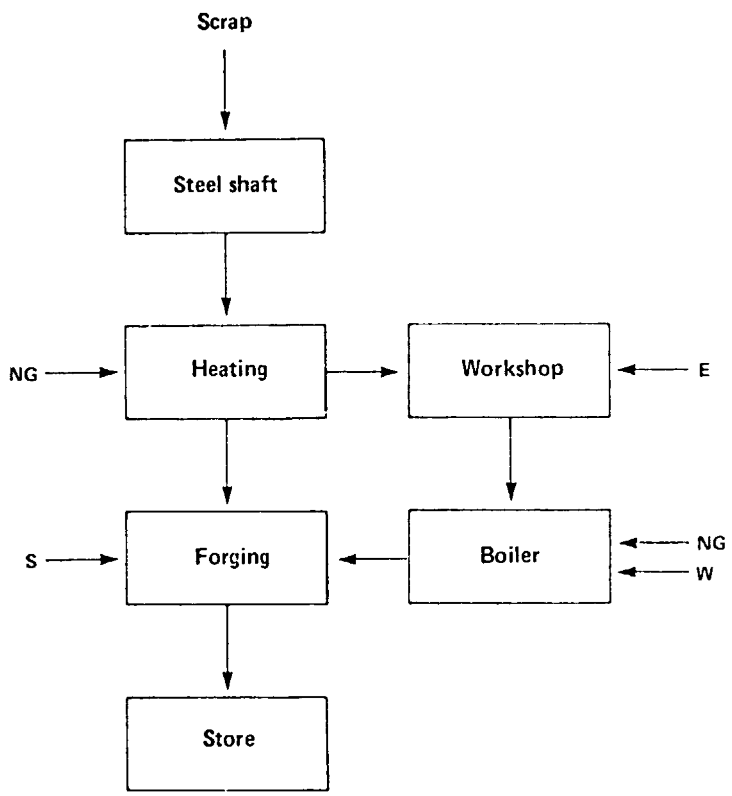


Exhibit A.27

Manufacturing Process Flow Diagram of Sh. Abdur Rahim A. Ditta Steel



E – Electricity
NG – Natural gas
S – Steam
W – Water

Exhibit A.28

Manufacturing Process Flow Diagram of Shakir Metal Industries

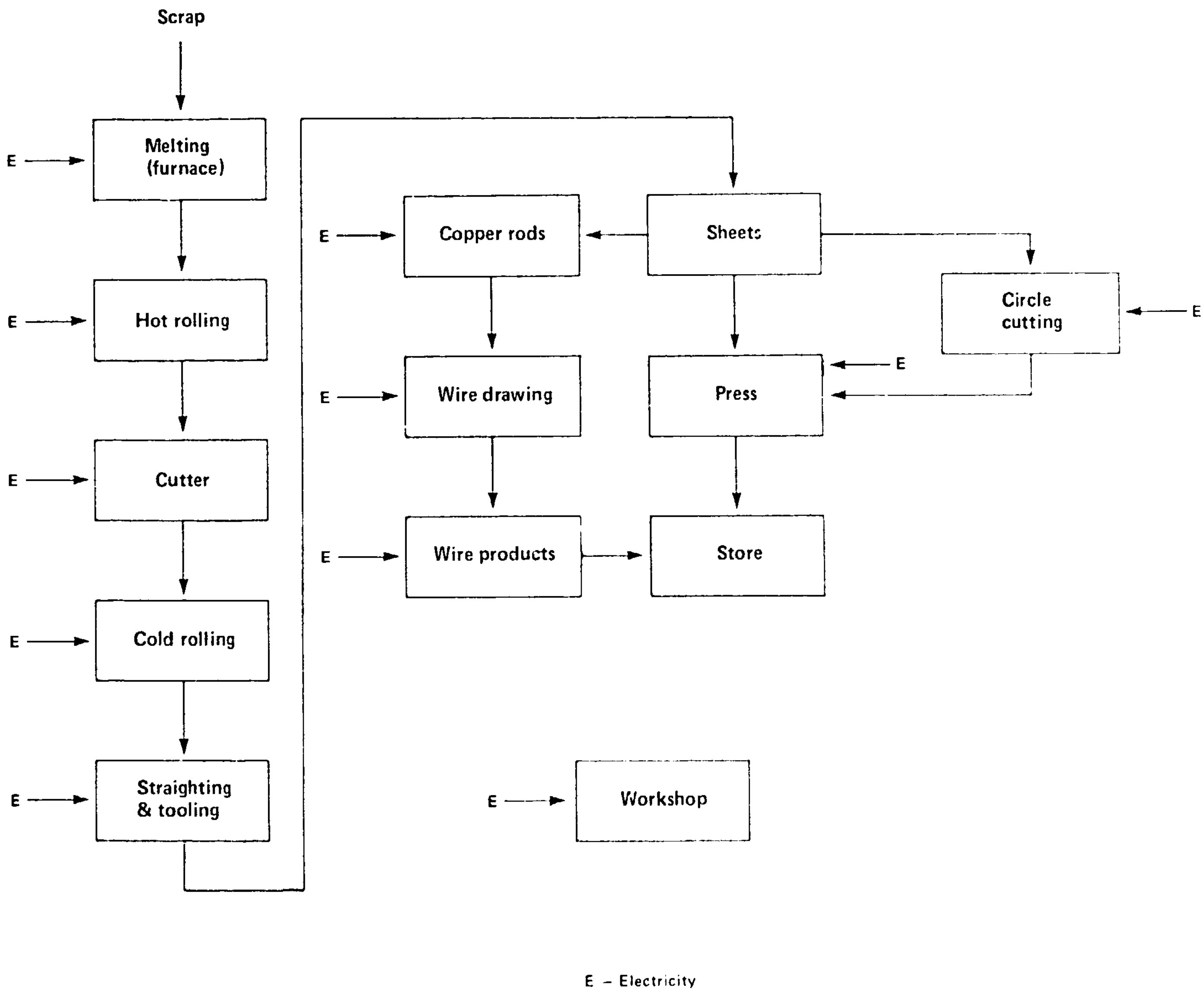
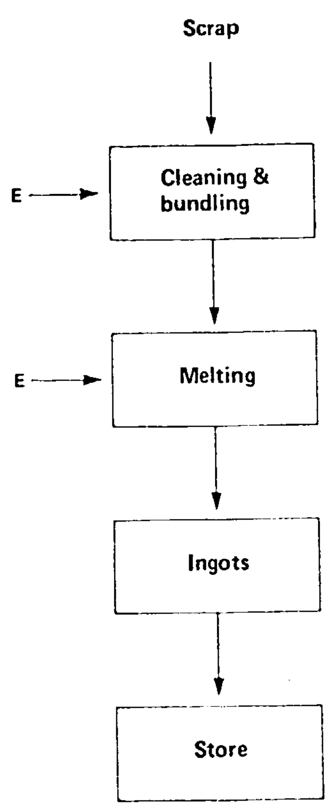


Exhibit A.29

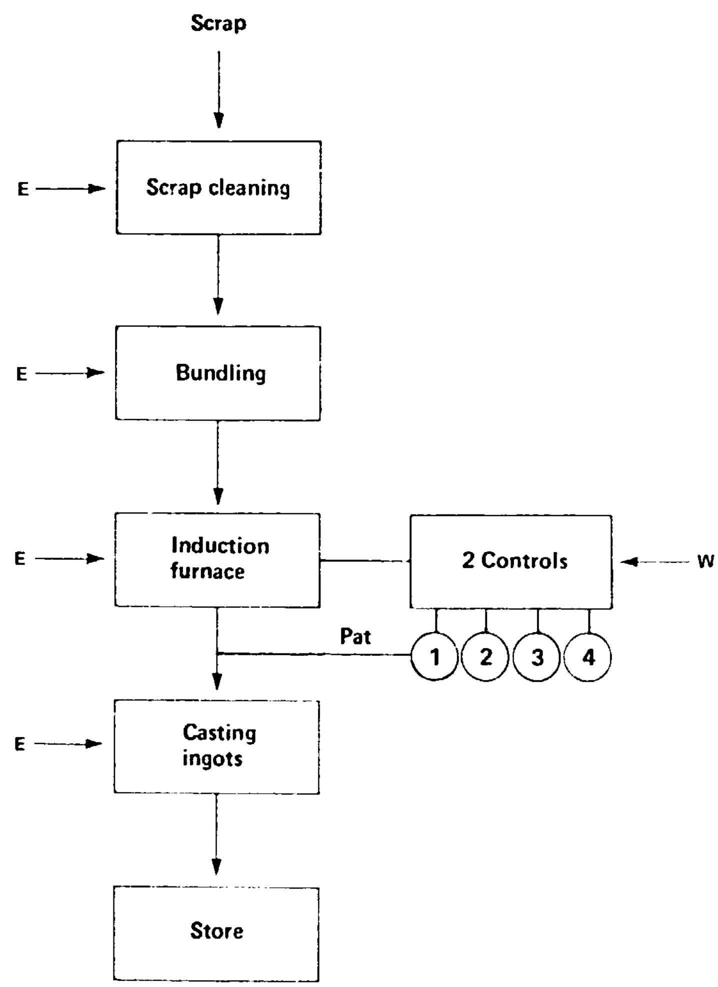
Manufacturing Process Flow Diagram of United Iron & Steel



E – Electricity

Exhibit A.30

Manufacturing Process Flow Diagram of Yazdani & Co. Ltd.



E – Electricity
W – Water

Appendix B

DETAILED ENERGY USE AND COSTS BY PLANT

Exhibit B.1

DETAILED ENERGY USE AND COSTS - Acid Industries

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	119506.6	408	421.9666	1460	1868	1971	152951.802	31209.9374	184161.739
Feb.	79210	270	385.8	1335	1606	1694	101377.710	28534.9408	129912.651
Mar.	109766.6	375	404.5	1400	1775	1872	140511.563	29918.0496	170429.612
Apr.	87003.33	297	410.4333	1420	1717	1812	111352.086	30356.8970	141708.983
May	107183.3	365	434.5533	1504	1870	1973	137179.661	32140.8855	169320.546
Jun.	95706.66	327	340.8366	1180	1506	1589	122491.134	25213.0141	147704.148
Jul.	93356.66	319	436.21	1510	1828	1929	119483.463	32263.4176	151746.881
Aug.	109000	372	492.8333	1706	2078	2192	139504.74	36451.4515	175956.191
Sep.	99393.33	339	499.9	1730	2069	2183	127209.551	36974.1236	164183.675
Oct.	75583.33	258	586.3933	2029	2287	2413	96736.085	43371.4335	140107.519
Nov.	75006.66	256	438.0333	1516	1772	1870	95998.0324	32398.2769	128396.309
Dec.	74026.66	253	661.2666	2289	2541	2681	94743.7696	48909.2939	143653.063
Total	1124763	3339	5513	19079	22918	24180	1439540	407742	1847281

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.2

DETAILED ENERGY USE AND COSTS - Allawasaya Textile & Finishing Mills Ltd.

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	611946.6	2089	0	0	2089	2204	389890.191	0	389890.191
Feb.	708863.3	2413	0	0	2413	2545	450364.542	0	450364.542
Mar.	562936.6	1921	0	0	1921	2027	358664.401	0	358664.401
Apr.	686985.6	2345	0	0	2345	2474	437700.501	0	437700.501
May	714213.3	2438	0	0	2438	2572	455047.455	0	455047.455
Jun.	722970	2467	0	0	2467	2603	460626.599	0	460626.599
Jul.	636060	2171	0	0	2171	2290	405253.543	0	405253.543
Aug.	767600	2620	0	0	2620	2764	489061.755	0	489061.755
Sep.	715720	2443	0	0	2443	2577	456007.399	0	456007.399
Oct.	676580	2309	0	0	2309	2436	431070.091	0	431070.091
Nov.	715000	2440	0	0	2440	2575	455548.665	0	455548.665
Dec.	724800	2474	0	0	2474	2610	461792.548	0	461792.548
Total	8241677	28129	0	0	28129	29679	5251028	0	5251028

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.3

DETAILED ENERGY USE AND COSTS - Bannu Woolen Mills

Mo.	Kwh	MBtu (El)	Litres	MBtu (Oil)	Total MBtu	GJ	Rs.(E)	Rs.(Oil)*	Total Rs.
Jan.	76380	261	99312.66	3450	3711	3916	81726.6	158900.266	240626.866
Feb.	79500	271	88987.33	3092	3363	3548	85065	142379.733	227444.733
Mar.	67345	230	245200.7	8519	8749	9231	72059.15	392321.136	464380.286
Apr.	73470	251	62031.66	2155	2406	2538	78612.9	99250.6666	177863.566
May	75885	259	56192.33	1952	2211	2333	81196.95	89907.7333	171104.683
Jun.	65690	224	41270	1434	1658	1749	70288.3	66032	136320.3
Jul.	49848.33	170	36660.66	1274	1444	1524	53444.7166	58657.0666	112101.783
Aug.	75210	257	52911.66	1835	2091	2207	80474.7	84498.6566	164973.366
Sep.	77820	266	50339.33	1749	2015	2126	83267.4	80542.9333	163810.333
Oct.	75233.33	257	50087	2083	2344	2474	80499.6666	96139.2	176638.866
Nov.	83598.33	285	76130.33	2645	2930	3092	89450.2166	121808.533	211258.75
Dec.	85490	292	89178	3098	3390	3577	91474.3	142684.8	234159.1
Total	885570	3022	958202	33290	36313	38314	947560	1533123	2480683

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs(NG) = Rupees (Natural Gas)
6. Rs(E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.4

DETAILED ENERGY USE AND COSTS - Ceebee Textile Industries

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	93973	321	1605	5555	5875	6199	72162.7124	94935.4129	167098.125
Feb.	84868	290	5268	18232	18521	19542	65170.9010	311601.093	376771.994
Mar.	99342	339	1601	5541	5880	6204	76285.6158	94698.8137	170984.429
Apr.	138332	472	1966	6804	7276	7677	106226.387	116288.487	222514.874
May	106256	363	2059	7126	7489	7901	81594.9387	121789.417	203384.355
Jun.	143685	490	1701	5897	6377	6729	110337.004	100613.792	210950.797
Jul.	65532	224	1876	6493	6716	7086	50322.6125	110965.006	161287.618
Aug.	74916	256	1324	4582	4838	5104	57528.6706	78314.3219	135842.992
Sep.	84339	288	1226	4243	4531	4780	64764.6771	72517.6425	137282.319
Oct.	79237	270	1367	4731	5001	5277	60846.8054	80857.7629	141704.568
Nov.	63684	217	1423	4925	5142	5425	48903.5167	84170.1511	133073.667
Dec.	86241	294	1574	5447	5742	6058	66225.2400	93101.7694	159327.009
Total	1120405	3824	22990	79565	83389	87983	860369	1359854	2220223

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs(NG) = Rupees (Natural Gas)
6. Rs(E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.5

DETAILED ENERGY USE AND COSTS - Chenab Textile Mills Ltd.

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	543430	1855	0	0	1855	1957	273071.944	0	273071.944
Feb.	553466.6	1889	0	0	1889	1993	278115.339	0	278115.339
Mar.	539846.6	1842	0	0	1842	1944	271271.330	0	271271.330
Apr.	560540	1913	0	0	1913	2019	281719.918	0	281719.918
May	525080	1792	0	0	1792	1891	263851.124	0	263851.124
Jun.	690900	2358	0	0	2358	2488	347175.177	0	347175.177
Jul.	313875	1071	0	0	1071	1130	157721.245	0	157721.245
Aug.	384090	1311	0	0	1311	1383	193004.072	0	193004.072
Sep.	422100	1441	0	0	1441	1520	212103.983	0	212103.983
Oct.	405752	1385	0	0	1385	1461	203889.162	0	203889.162
Nov.	498810	1702	0	0	1702	1796	250650.528	0	250650.528
Dec.	542625	1852	0	0	1852	1954	272667.434	0	272667.434
Total	5980615	20412	0	0	20412	21537	3005241	0	3005241

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.6

DETAILED ENERGY USE AND COSTS - Colony Textile Mills

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	2165280	7390	14112.3	48840	56231	59329	1435645.59	1151693.37	2587338.97
Feb.	2148000	7331	16310.4	56448	63779	67293	1424189.44	1331078.53	2755266.97
Mar.	2328960	7949	13259.2	45888	53837	56803	1544170.34	1082072.57	2626242.92
Apr.	2060160	7031	15449.7	53469	60500	63834	1365947.88	1260837.50	2626785.38
May	2285280	7800	12087.4	41833	49632	52367	1515209.19	986442.923	2501652.12
Jun.	1556160	5311	8529.9	29521	34832	36751	1031780.76	696118.229	1727898.99
Jul.	1756320	5994	9846.5	34077	40072	42279	1164492.84	803564.889	1968057.73
Aug.	1897440	6476	9174	31750	38226	40332	1258059.64	748682.709	2006742.35
Sep.	1644000	5611	10657.3	36883	42494	44836	1090021.32	869733.620	1959754.94
Oct.	1749600	5971	12985.4	44940	50912	53717	1160037.28	1059727.97	2219765.26
Nov.	1781280	6080	12680	43883	49963	52716	1181042.07	1034804.52	2215846.60
Dec.	1760640	6009	9115.1	31546	37555	39624	1167357.13	743875.927	1911233.06
Total	23133120	78953	144207	499078	578032	609881	15337953	11768633	27106585

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs(NG) = Rupees (Natural Gas)
6. Rs(E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.7

DETAILED ENERGY USE AND COSTS - Farooq Textile Mills

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	1313347	4482	1808.76	6260	10742	11334	1502215.49	161434.941	1663650.43
Feb.	869264	2967	2118.77	7333	10300	10867	994270.248	189103.866	1183374.11
Mar.	982078	3352	2040.63	7062	10414	10988	1123307.69	182129.737	1305437.42
Apr.	1008822	3443	3034.9	10503	13946	14715	1153897.66	270870.045	1424767.71
May	1043378	3561	2251	7790	11351	11977	1193423.06	200905.621	1394328.68
Jun.	1043378	3561	2251	7790	11351	11977	1193423.06	200905.621	1394328.68
Jul.	1043378	3561	2251	7790	11351	11977	1193423.06	200905.621	1394328.68
Aug.	1043378	3561	2251	7790	11351	11977	1193423.06	200905.621	1394328.68
Sep.	1043378	3561	2251	7790	11351	11977	1193423.06	200905.621	1394329.68
Oct.	1043378	3561	2251	7790	11351	11977	1193423.06	200905.621	1394328.68
Nov.	1043378	3561	2251	7790	11351	11977	1193423.06	200905.621	1394328.68
Dec.	1043378	3561	2251	7790	11351	11977	1193423.06	200905.621	1394328.68
Total	12520535	42733	27011	93481	136214	143719	14321076	2410784	16731859

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs(NG) = Rupees (Natural Gas)
6. Rs(E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.8

DETAILED ENERGY USE AND COSTS - Government Textile Weaving and Finishing Center

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	9917	34	77.53	268	302	319	7647.23670	4801.32883	12448.5649
Feb.	17153	59	137.9	477	536	565	13227.0899	8539.96083	21767.0508
Mar.	7581	26	108.57	376	402	424	5845.89104	6723.59353	12569.4845
Apr.	6588	22	94	325	348	367	5080.16491	5821.2931	10901.4580
May	9336	32	90.7	314	346	365	7199.21366	5616.92855	12816.1422
Jun.	5841	20	76.73	266	285	301	4504.13538	4751.79531	9255.93069
Jul.	7101	24	66.5	230	254	268	5475.75152	4118.25522	9594.00674
Aug.	6315	22	65.9	228	250	263	4869.64806	4081.09803	8950.74609
Sep.	8766	30	96.5	334	364	384	6759.67298	5976.11472	12735.7877
Oct.	8973	31	55.1	191	221	234	6919.29565	3412.26861	10331.5642
Nov.	4935	17	88.7	307	324	342	3805.49694	5493.07125	9298.56819
Dec.	3552	12	104.8	363	375	395	2739.03244	6490.12252	9229.15496
Total	96058	328	1063	3679	4006	4227	74073	65826	139898

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.9

DETAILED ENERGY USE AND COSTS - [illegible]

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)	Total Rs.
Jan.	111434	380	2605	9015	9396	9914	151984.99[illegible]	[illegible]	[illegible]
Feb.	121149.5	413	2153.6	7474	7888	8322	165170.745	[illegible]	[illegible]
Mar.	218425.5	745	2646.05	9158	9903	10449	297793.244	[illegible]	[illegible]
Apr.	187651	640	3311.35	11460	12101	12767	255835.430	178812.9	[illegible]
May	123900	423	3857.89	13352	13774	14533	168920.675	[illegible]	[illegible]
Jun.	147340	503	3720.67	12877	13380	14117	200877.904	[illegible]	[illegible]
Jul.	95346	325	2792.9	9565	9891	10542	129991.21[illegible]	[illegible]	[illegible]
Aug.	103913	355	2645.3	9155	9510	10034	141671.139	[illegible]	[illegible]
Sep.	90520	309	2601.4	9003	9312	9825	123411.618	[illegible]	[illegible]
Oct.	78627	268	2632.5	9111	9379	9895	107197.142	[illegible]	[illegible]
Nov.	66512	234	3042.5	10530	10763	11357	92406.7258	[illegible]	[illegible]
Dec.	88599	302	5026.87	17397	17700	18675	120793.539	[illegible]	[illegible]
Total	1435417	4899	37042	128197	133096	140429	[illegible]	[illegible]	[illegible]

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.10

DETAILED ENERGY USE AND COSTS - Kohinoor Textile Mills

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Feb.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Mar.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Apr.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
May	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Jun.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Jul.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Aug.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Sep.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Oct.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Nov.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Dec.	741109.2	2529	1796.31	6217	8746	9228	844864.488	149093.73	993958.218
Total	8893310	30353	21556	74601	104954	110737	10138374	1789125	11927499

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.11

DETAILED ENERGY USE AND COSTS - Lawrencepur Textile & Woolen Mills

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Feb.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Mar.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Apr.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
May	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Jun.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Jul.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Aug.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Sep.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Oct.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Nov.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Dec.	305314.2	1042	1797.282	6220	7262	7662	348058.188	149174.406	497232.594
Total	3663770	12504	21567	74641	87146	91948	4176698	1790093	5966791

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.12

DETAILED ENERGY USE AND COSTS - National Dyeing & Finishing Center

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Feb.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Mar.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Apr.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
May.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Jun.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Jul.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Aug.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Sep.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Oct.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Nov.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Dec.	38543	132	958	3315	3447	3637	28136.9681	70158.9958	98295.9640
Total	462516	1579	11495	39785	41364	43644	337644	841908	1179552

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.13

DETAILED ENERGY USE AND COSTS - Paracha Textile Mills

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	250020	887	1019	3527	4414	4657	722855.6	83558	806413.6
Feb.	248890	849	1345	4655	5504	5808	691914.2	110290	802204.2
Mar.	174300	595	1827	6323	6918	7299	484554	149814	634368
Apr.	117500	401	2063	7140	7541	7956	326650	169166	495816
May	92920	317	1702	5890	6207	6550	258317.6	139564	397881.6
Jun.	120170	410	1939	6711	7121	7513	334072.6	158998	493070.6
Jul.	114440	391	2199	7610	8001	8442	318143.2	180318	498461.2
Aug.	113960	389	1728	5980	6369	6720	316808.8	141696	458504.8
Sep.	45490	155	1728	5980	6136	6474	126462.2	141696	268158.2
Oct.	22030	75	1728	5980	6056	6389	61243.4	141696	202939.4
Nov.	21820	74	1728	5980	6055	6388	60659.6	141696	202355.6
Dec.	18680	64	1728	5980	6044	6377	51930.4	141696	193626.4
Total	1350220	4608	20734	71757	76365	80573	3753612	1700188	5453800

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs(NG) = Rupees (Natural Gas)
6. Rs(E) = Rupees (Electricity)
7. Total Ps = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.14

DETAILED ENERGY USE AND COSTS - Shaheen Calico Printing Works

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs (E)	Rs. (NG)*	Total Rs.
Jan.	49213	168	2100	7258	7433	7845	95476.22	109410	[illegible]
Feb.	12673	43	489	1692	1736	1831	24585.62	25476.9	[illegible]
Mar.	23567	80	611	2115	2195	2316	42719.95	[illegible]	[illegible]
Apr.	30417	104	1137	3935	4039	4261	[illegible]	59237.7	[illegible]
May	25707	88	1127	3900	3988	4208	49871.59	58716.7	[illegible]
Jun.	25363	87	1179	4080	4167	4396	49204.22	[illegible]	[illegible]
Jul.	48838	157	1225	4240	4405	4649	54741.84	[illegible]	[illegible]
Aug.	17846	61	1196	4139	4200	4432	34521.24	62311.6	[illegible]
Sep.	28154	96	2102	7275	7371	7777	54518.76	[illegible]	[illegible]
Oct.	21221	72	2459	8545	8617	9092	41168.74	[illegible]	[illegible]
Nov.	29253	100	1573	5444	5544	5849	56750.62	[illegible]	138704.12
Dec.	22503	77	1994	6555	6632	6997	[illegible]	[illegible]	[illegible]
Total	334753	1143	17102	59187	60330	63654	649421	[illegible]	[illegible]

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.15

DETAILED ENERGY USE AND COSTS - Sunshine Cotton Mills

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	882654	3012	_	_	_	3178	_	_	308929
Feb.	912320	3111	_	_	_	3284	_	-	319312
Mar.	896516	3060	_	_	_	3227	_	-	313780
Apr.	919926	3140	_	_	_	3312	_	-	321974
May	1191501	4067	_	_	_	4289	_	-	417025
Jun.	812912	2774	_	_	_	2926	_	-	284519
Jul.	1036118	3536	_	_	_	3730	_	-	362641
Aug.	936487	3192	_	_	_	3371	_	-	327770
Sep.	936487	3196	_	_	_	3371	_	-	327770
Oct.	891146	3041	_	_	_	3208	_	-	311901
Nov.	952529	3251	_	_	_	3429	_	-	333385
Dec.	869248	2967	_	_	_	3129	_	-	304237
Total	11237844	38350	_	_	_	40454	_	_	3933243

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.16

DETAILED ENERGY USE AND COSTS - Sunshine Jute Mills

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	177206	605	-	-	-	637	-	-	221508
Feb.	196086	699	-	-	-	706	-	-	207672
Mar.	190896	652	-	-	-	687	-	-	201833
Apr.	227533	777	-	-	-	819	-	-	227533
May	214185	731	-	-	-	771	-	-	228794
Jun.	380559	1298	-	-	-	1370	-	-	273480
Jul.	240326	820	-	-	-	865	-	-	233270
Aug.	235044	802	-	-	-	846	-	-	240250
Sep.	240960	822	-	-	-	867	-	-	178889
Oct.	196200	670	-	-	-	706	-	-	156487
Nov.	235800	805	-	-	-	849	-	-	173949
Dec.	270320	923	-	-	-	973	-	-	190889
Total	2805115	9574	-	-	-	10096	-	-	2534546

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs(NG) = Rupees (Natural Gas)
6. Rs(E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value
of natural gas = 980 Btu/ft^3

Exhibit B.27

DETAILED ENERGY USE AND COSTS - Adamjee Paper & Board Mills

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	2227800	7603	17521.3	60638	68242	72002	1381236	1100383.37	2481619.37
Feb.	2141400	7309	15505.3	53661	60970	64329	1327668	973773.308	2301441.30
Mar.	1898240	6479	16971.26	58735	65214	68807	1176908.8	1065839.64	2242748.64
Apr.	2152133.	7345	16033.63	55490	62835	66297	1334322.66	1006954.02	2341276.68
May	1923506.	6565	16638.13	57582	64147	67681	1192574.13	1044918.19	2237492.33
Jun.	2406840	8215	16581.9	57387	65602	69217	1492240.8	1041386.59	2533627.39
Jul.	1905653.	6504	13111.84	45378	51882	54741	1181505.06	823457.773	2004962.84
Aug.	1939226.	6619	13950.24	48280	54898	57923	1202320.53	876111.482	2078432.01
Sep.	2305253.	7868	13432.5	46488	54356	57351	1429257.06	843596.058	2272853.12
Oct.	2196800	7498	15594.96	53972	61469	64856	1362015	979404.609	2341420.60
Nov.	2402363.	8199	17218.46	59590	67790	71525	1489465.26	1081364.64	2570829.91
Dec.	2255533.	7698	17091.86	59152	66850	70534	1398430.66	1073413.83	2471844.50
Total	25754750	87901	189651	656354	744255	785263	15967945	11910604	27878549

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit 8.18

DETAILED ENERGY USE AND COSTS - Pakistan Chipboard Ltd.

Mo.	Kwh	MBtu (El)	Litres	MBtu (Oil)	Total MBtu	GJ	Rs. (E)	Rs(Oil)	Total Rs.
Jan.	59986.66	205	42526	1477	1682	1775	68384.8	75443.2928	143828.092
Feb.	73706.66	252	42526	1477	1729	1824	84025.6	75443.2928	159468.892
Mar.	73840	252	42526	1477	1729	1825	84177.6	75443.2928	159620.892
Apr.	69693.33	238	42526	1477	1715	1810	79450.4	75443.2928	154893.692
May	68266.66	233	42526	1477	1710	1805	77824	75443.2928	153267.292
Jun.	81813.33	279	42526	1477	1757	1853	93267.2	75443.2928	168710.492
Jul.	62133.33	212	42526	1477	1690	1783	70832	75443.2928	146275.292
Aug.	62400	213	42526	1477	1690	1784	71136	75443.2928	146579.292
Sep.	75520	258	42526	1477	1735	1831	86092.8	75443.2928	161536.092
Oct.	40266.66	137	42526	1477	1615	1704	45904	75443.2928	121347.292
Nov.	45926.66	157	42526	1477	1634	1724	52356.4	75443.2928	127799.692
Dec.	50400	172	42526	1477	1649	1740	57456	75443.2928	132899.292
Total	763953	2607	510312	17729	20337	21457	870907	905320	1776226

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs(NG) = Rupees (Natural Gas)
6. Rs(E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit P.1?

[illegible] — [illegible] Paper [illegible] Ltd.

Mo.	kWh	MBtu (E)	hm3	MBtu (Gas)	Oil (Litres)	MBtu (Oil)	Total MBtu	GJ	Rs. (E)	Rs. (NG)	Rs. [illegible]	Total Rs.
Jan.	2255380.	11453	12299.98	42563	869645.1	[illegible]	84312	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Feb.	[illegible]	11304	[illegible]	46240	812229.5	[illegible]	85756	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mar.	[illegible]	12482	14509.47	50215	916528.7	[illegible]	94530	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Apr.	[illegible]	11595	11374.75	39366	741065.9	35772.90	76735	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
May	[illegible]	11749	12245.47	42381	821315	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Jun.	[illegible]	[illegible]	[illegible]	[illegible]	557845.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Jul.	[illegible]	[illegible]	[illegible]	[illegible]	473297.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aug.	[illegible]	[illegible]	[illegible]	37664	431656.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sep.	[illegible]	7482	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oct.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nov.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dec.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tot.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.20

DETAILED ENERGY USE AND COSTS - Ashraf Engineering Works

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	289050	987	-	-	-	1040	-	-	394350
Feb.	491580	1678	-	-	-	1770	-	-	373713
Mar.	516120	1762	-	-	-	1858	-	-	343825
Apr.	423660	1446	-	-	-	1525	-	-	342350
May	427140	1458	-	-	-	1537	-	-	293059
Jun.	462030	1577	-	-	-	1663	-	-	316306
Jul.	407040	1389	-	-	-	1465	-	-	290184
Aug.	433780	1480	-	-	-	1561	-	-	324148
Sep.	433950	1481	-	-	-	1562	-	-	315252
Oct.	434719	1484	-	-	-	1564	-	-	332007
Nov.	462840	1580	-	-	-	1666	-	-	326894
Dec.	434719	1484	-	-	-	1565	-	-	332007
Total	5216628	17806	-	-	-	18776	-	-	3984092

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.21

DETAILED ENERGY USE AND COSTS - General Steel Tools Company

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	16018.66	55	118.3	409	464	490	29679.3856	29338.4	59017.7856
Feb.	16224.33	55	121.3333	420	475	501	30060.4448	30090.6666	60151.1114
Mar.	15405.33	53	119.5666	414	466	492	28543.0016	29652.5333	58195.5349
Apr.	18668	64	102.8666	356	420	443	34588.0704	25510.9333	60099.0037
May	15798.66	54	101.2333	350	404	427	29271.7696	25105.8666	54377.6362
Jun.	17003.66	58	97.9	339	397	419	31504.3936	24279.2	55783.5936
Jul.	11797	40	111.0666	384	425	448	21857.4816	27544.5333	49402.0149
Aug.	10689.33	36	85.92333	297	334	352	19805.1968	21308.9866	41114.1834
Sep.	13394.33	46	120.5666	417	463	488	24817.0208	29900.5333	54717.5541
Oct.	11715.33	40	110.2	381	421	445	21706.1696	27329.6	49035.7696
Nov.	15770.66	54	101.8666	353	406	429	29219.8912	25262.9333	54482.8245
Dec.	13515.33	46	121.0666	419	465	491	25041.2096	30024.5333	55065.7429
Total	176001	601	1312	4540	5141	5424	326094	325349	651443

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs(NG) = Rupees (Natural Gas)
6. Rs(E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit 3.22

DETAILED ENERGY USE AND COSTS - International Metal Industries

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	8078.666	28	57.95136	201	228	241	16399.6933	16110.4799	32510.1732
Feb.	5774	20	71.93897	249	269	283	11721.22	19999.0355	31720.2555
Mar.	5908.333	20	63.29346	219	239	252	11993.9166	17595.5828	29589.4994
Apr.	7698.333	26	62.09479	215	241	254	15627.6166	17262.3530	32889.9696
May	7090.333	24	60.96219	211	235	248	14393.3766	16947.4902	31340.8668
Jun.	7005.333	24	50.43845	175	198	209	14220.8266	14021.8900	28242.7166
Jul.	5740.333	20	59.48981	206	225	238	11652.8766	16538.1685	28191.0452
Aug.	6566.333	22	50.35350	174	197	208	13329.6566	13998.2753	27327.9319
Sep.	7110	24	58.57429	203	227	239	14433.3	16283.6544	30716.9544
Oct.	5453	19	53.14725	184	203	214	11069.59	14774.9368	25844.5269
Nov.	6988.666	24	58.27227	202	226	238	14186.9932	16199.6910	30386.6843
Dec.	14293.66	49	64.05796	222	270	285	29016.1433	17808.1151	46824.2585
Total	87707	299	711	2459	2759	2911	178045	197540	375585

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.23

DETAILED ENERGY USE AND COSTS - Kamran Steel Re-Rolling Mills Ltd.

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	723600	2470	1948.233	6743	9212	9720	566188.056	165378.689	731566.745
Feb.	1013666.	3460	2241.233	7757	11216	11834	793153.62	190250.430	983404.050
Mar.	921000	3143	2607.5	9024	12168	12838	720645.66	221341.522	941987.182
Apr.	1010333.	3448	2457.133	8504	11952	12611	790545.42	208577.424	999122.844
May	900666.6	3074	2307.8	7987	11061	11670	704735.64	195901.041	900636.681
Jun.	920000	3140	1240.6	4294	7433	7843	719863.2	105310.179	825173.379
Jul.	723000	2468	2285.6	7910	10378	10950	565718.58	194016.561	759735.141
Aug.	958000	3270	2330.5	8065	11335	11960	749596.68	197827.964	947424.644
Sep.	938000	3201	2082.05	7206	10407	10980	733947.48	176737.916	910685.396
Oct.	912000	3113	2391.4	8276	11389	12016	713603.52	202997.552	916601.072
Nov.	992500	3287	2284.5	7906	11294	11916	776591.55	193923.186	970514.736
Dec.	921000	3143	1919.3	6642	9786	10325	720645.66	162922.640	883568.300
Total	10933767	37317	26096	90314	127631	134663	8555235	2215185	10770420

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.24

DETAILED ENERGY USE AND COSTS - Khalil Metal Works

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	7595.5	26	214	741	767	809	6759.995	17907.52	24667.515
Feb.	4915	17	139.5	479	496	523	4374.35	11589.68	15964.03
Mar.	6131	21	246.8	854	875	923	5456.59	20652.224	26108.814
Apr.	5330	18	223.3	773	791	835	4743.7	18685.744	23429.444
May	6455	22	265.4	919	941	992	5744.95	22208.672	27953.622
Jun.	7153	24	265.4	919	943	995	6366.17	22208.672	28574.842
Jul.	8332	28	259.2	897	925	976	7415.48	21689.856	29105.336
Aug.	5200	18	224.4	777	794	838	4628	18777.792	23405.792
Sep.	7377	25	238.2	824	850	896	6565.53	19932.576	26498.106
Oct.	5810	20	200	692	712	751	5170.9	16736	21906.9
Nov.	7500	26	191.2	662	687	725	6675	15999.616	22674.616
Dec.	8565	29	227	786	815	860	7622.85	18995.36	26618.21
Total	80364	274	2693	9321	9596	10124	71524	225384	296907

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules

= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.25

DETAILED ENERGY USE AND COSTS - Metropolitan Steel

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	944700	3224	8575	29677	32901	34714	1081632.37	696805.129	1778438.50
Feb.	1059500	3616	7664	26524	30140	31801	1213072.40	622778.096	1835850.50
Mar.	1127500	3848	7329	25365	29213	30822	1290928.87	595555.932	1886484.80
Apr.	567000	1935	7267	25150	27085	28578	649185.516	590517.800	1239703.31
May	567000	1935	7375	25524	27459	28972	649185.516	599293.901	1248479.41
Jun.	896400	3025	6160	21319	24344	25685	1014881.90	500562.770	1515444.67
Jul.	711000	2427	7200	24918	27345	28851	814058.029	585073.368	1399131.39
Aug.	1002650	3422	7858	27195	30617	32304	1147982.11	638542.573	1786524.68
Sep.	1006650	3436	7661	26514	29949	31599	1152561.90	622534.315	1775096.21
Oct.	933050	3184	7916	27396	30581	32266	1068293.73	643255.664	1711549.39
Nov.	1045950	3570	7410	25645	29215	30824	1197558.36	602138.007	1799696.36
Dec.	916400	3128	7813	27040	30167	31829	1049230.34	634885.864	1684116.21
Total	10767800	36751	90228	312265	349015	368246	12328571	7331944	19660515

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.26

DETAILED ENERGY USE AND COSTS - Ravi Steel & Re-Rolling Mills

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs.(E)	Rs.(NG)*	Total Rs.
Jan.	25974	89	422	1460	1549	1634	60259.68	29759.44	90019.12
Feb.	23397	80	417	1443	1523	1607	54281.04	29406.84	83687.88
Mar.	18489	63	315	1090	1153	1217	42894.48	22213.8	65108.28
Apr.	17339	59	243	841	900	950	40226.48	17136.36	57362.84
May	24285	83	334	1156	1239	1307	56341.2	23553.68	79894.88
Jun.	17308	59	384	1329	1388	1465	40154.56	27079.68	67234.24
Jul.	13660	47	307	1062	1109	1170	31691.2	21649.64	53340.84
Aug.	20720	71	412	1426	1497	1579	48070.4	29054.24	77124.64
Sep.	20204	69	444	1537	1606	1694	46873.28	31310.88	78184.16
Oct.	15354	52	310	1073	1125	1187	35621.28	21861.2	57482.48
Nov.	19616	67	330	1142	1209	1276	45509.12	23271.6	68780.72
Dec.	21165	72	364	1260	1332	1405	49102.8	25669.28	74772.08
Total	237511	811	4282	14819	15630	16491	551026	301967	852992

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.27

DETAILED ENERGY USE AND COSTS - Shiekh Abdur Rahim Allah Ditta

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	1545.5	5	400.75	1387	1392	1469	1097.86910	34056.9973	35154.8664
Feb.	1257	4	339.95	1177	1181	1246	900.032455	28890.0218	29790.0542
Mar.	1490	5	473.3	1638	1643	1734	1058.44385	40222.5248	41280.9687
Apr.	1199	4	383.45	1327	1331	1404	851.727635	32586.7888	33438.5165
May	2069.5	7	390.6	1352	1359	1434	1470.10036	33194.4183	34664.5187
Jun.	2341.5	8	243.25	842	850	897	1663.31964	20672.1512	22335.4708
Jul.	2402.5	8	398.2	1378	1386	1463	1706.65191	33840.2903	35546.9422
Aug.	2238	8	508.4	1759	1767	1864	1589.79687	43205.4334	44795.2303
Sep.	1535	5	374.4	1296	1301	1373	1090.41027	31817.6913	32908.1016
Oct.	1598	5	306.4	1060	1066	1125	1135.16327	26038.8371	27174.0004
Nov.	2026.5	7	511.1	1769	1776	1874	1439.55467	43434.8879	44874.4426
Dec.	1602.5	5	439.9	1522	1528	1612	1138.35991	37384.0876	38522.4475
Total	21315	73	4770	16507	16580	17493	15141	405344	420485

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs(NG) = Rupees (Natural Gas)
6. Rs(E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.28

DETAILED ENERGY USE AND COSTS - Shakir Metal Industries

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	8013.333	27	47.60695	165	192	203	14824.6666	11901.7383	26726.405
Feb.	6138	21	36.71511	127	148	156	11355.3	9178.77916	20534.0791
Mar.	8310.666	28	34.28546	119	147	155	15374.7333	8572.36625	23947.0955
Apr.	8773.666	30	39.00863	135	165	174	16231.2833	9752.15791	25983.4412
May	7823.666	27	33.95912	118	144	152	14473.7833	8489.78083	22963.5641
Jun.	6771.666	23	34.47823	119	142	150	12527.5833	8619.55791	21147.1412
Jul.	5056	17	34.97846	121	138	146	9353.6	8744.61583	18098.2159
Aug.	7267.333	25	30.70436	106	131	138	13444.5666	7676.09125	21120.6579
Sep.	7240.666	25	31.16537	108	133	140	13395.2333	7791.34416	21186.5775
Oct.	6962	24	37.11152	128	152	161	12879.7	9277.88166	22157.5316
Nov.	7501	26	38.94255	135	160	169	13876.85	9735.64083	23612.4908
Dec.	8462	29	49.15484	170	199	210	15654.7	12288.71	27943.41
Total	88320	301	448	1551	1852	1954	163392	112029	275421

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.29
DETAILED ENERGY USE AND COSTS - United Iron and Steel Ltd

Mo.	Kwh	MBtu (El)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	523853.3	1788	-	-	1788	1886	345743.2	-	345743.2
Feb.	539240	1840	-	-	1840	1942	355898.4	-	355898.4
Mar.	543440	1855	-	-	1855	1957	358670.4	-	358670.4
Apr.	517533.3	1766	-	-	1766	1864	341572	-	341572
May	537546.6	1835	-	-	1835	1936	354780.8	-	354780.8
Jun.	606453.3	2070	-	-	2070	2184	400259.2	-	400259.2
Jul.	454190	1550	-	-	1550	1636	299765.4	-	299765.4
Aug.	522493.3	1783	-	-	1783	1882	344845.6	-	344845.6
Sep.	522186.6	1782	-	-	1782	1880	344643.2	-	344643.2
Oct.	509093.3	1738	-	-	1738	1833	336001.6	-	336001.6
Nov.	588853.3	2010	-	-	2010	2120	388643.2	-	388643.2
Dec.	559586.6	1910	-	-	1910	2015	369327.2	-	369327.2
Total	6424470	21927	-	-	21927	23135	4240150	-	4240150

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Exhibit B.30
DETAILED ENERGY USE AND COSTS - Yazdani & Co. Ltd.

Mo.	Kwh	MBtu (E1)	hm3	MBtu (Gas)	Total MBtu	GJ	Rs. (E)	Rs. (NG)*	Total Rs.
Jan.	290560	992	0	0	992	1046	222713.077	0	222713.077
Feb.	242900	829	0	0	829	875	186181.878	0	186181.878
Mar.	291746.6	996	0	0	996	1051	223622.653	0	223622.653
Apr.	239426.6	817	0	0	817	862	183519.582	0	183519.582
May	256140	874	0	0	874	922	196330.285	0	196330.285
Jun.	211520	722	0	0	722	762	162129.233	0	162129.233
Jul.	245040	836	0	0	836	882	187822.179	0	187822.179
Aug.	216440	739	0	0	739	779	165900.394	0	165900.394
Sep.	240540	821	0	0	821	866	184372.947	0	184372.947
Oct.	281260	960	0	0	960	1013	215584.664	0	215584.664
Nov.	237680	811	0	0	811	856	182180.769	0	182180.769
Dec.	248960	850	0	0	850	897	190826.844	0	190826.844
Total	3002213	10247	0	0	10247	10811	2301185	0	2301185

Key:

1. kWh = Electricity
2. MBtu = Btu x 10^6
3. hm^3 = 100 x m^3 (cubic meters)
4. GJ = joule x 10^9
5. Rs (NG) = Rupees (Natural Gas)
6. Rs (E) = Rupees (Electricity)
7. Total Rs = Total Rupees

Assumptions:

1 kWh = 3413 Btu

1 Btu = 1055.86 joules
= 34608.43 Btu/m^3 of NG

MBtu x 1.0551 = GJ (Total)

Heating value of natural gas = 980 Btu/ft^3

Appendix C

ENERGY AUDIT DATA SHEET FORMAT

ENERGY AUDIT RECORD – SHEET 1

NAME OF INDUSTRY ______________________ DATE : ______________

ADDRESS : ____

PERSON PROVIDING INFORMATION : ____________________________

TITLE/DESIGNATION ______________________ TELEPHONE : __________

I. GENERAL

TYPE OF INDUSTRY ______________________________________

LOCATION/ADDRESS ______________________________________

COVERED AREA ______________________________________

AGE OF INDUSTRY ______________________________________

(DATE OF COMMISSIONING) ______________________________

CAPACITY FACTOR (HRS/YR). ______________________________

(DESIGN/ACTUAL) ______________________________________

NUMBER OF EMPLOYEES ______________________________

PRODUCTS ______________________________________

ANNUAL PRODUCTION CAPACITY ______________________________

ESTIMATED CAPITAL COST ______________________________
(YEAR PURCHASED) ______________________________________

II. PURCHASE OF UTILITIES

PURCHASE OF UTILITIES	UNITS/YEAR	PRICE/UNIT	DEMAND CHARGE/ OTHER COST	ANNUAL COST
ELECTRICITY (VOLTATE)				
PROCESS STEAM				
NATURAL GAS				
FUEL OIL (TYPE ASA NO.)				
COAL (TYPE)				
COOLING WATER (TEMP.)				
BOILER FEED WATER				
CHEMICALS				
OTHER				
TOTAL UTILITIES				

III. OPERATING INFORMATION

SHIFTS/WEEK ______________________________________

HOURS/WEEK ______________________________________

FREQUENCY OF MAINTENANCE ______________________________

AVERAGE DOWNTIME (HRS/MONTH) ______________________________

FORCED OUTAGE (HRS/MONTH) ______________________________
(including Load Shedding).

IV. ANCILLIARY EQUIPMENT

ANCILLIARY EQUIPMENT	QUANTITY	RATED(KW)/UNIT	TOTAL KW
LIGHTING			
AIRCONDITIONING			
FANS			
HEATERS			
OTHERS			
TOTAL ANCILLIARY EQUIPMENT			

ENERGY AUDIT RECORD SHEET – 2

NAME OF INDUSTRY ____________________ DATE : ____________

V. PRODUCTION COST	YEAR	198___	198___	198___	198___	198___
A) UTILITIES						
B) OPERATING COSTS –						
LABOUR AND SUPERVISORS						
MAINTENANCE (MATERIAL LABOUR)						
TOTAL OPERATING COSTS						
C) CHEMICALS/OTHER MATERIALS						
D) OVERHEAD EXPENSES (TAXES,						
DEPRECIATIONS, INSURANCE).						
TOTAL PRODUCTION COST :						

VI. ECONOMIC DATA :

YEAR	ENERGY COST PER YEAR	ENERGY USED PER OUTPUT ITEM	ENERGY INTENSIVENESS BY OUTPUT	ENERGY INTENSIVENESS BY VALUE ADDED	ENERGY INTENSITY EMPLOYEE

C.2

ENERGY AUDIT RECORD SHEET – 3

NAME OF INDUSTRY ______________________

VII. PLANT AND MACHINERY

DATE ______________

Process Name/ Equipment Type	Quantity	Age (Yrs.)	Surface Area	Function	Type of Operation	Approx. Operating (Hrs./Wks.)	Approx. Outage Time (Hrs/Yrs)	Capital Cost	Manufacturer	Energy Inputs				Percentage of Total Energy Input	Remarks
										Elec.	Natural Gas	Steam	Others		
								TOTAL ENERGY INPUTS							

TOTAL ENERGY INPUTS (   )

ENERGY AUDIT RECORD – SHEET 4 – ENERGY INPUTS

PROCESS EQUIPMENT ____________________

NAME OF INDUSTRY ____________________

AMBIENT TEMPERATURE ____________________ HUMIDITY ____________________

ITEM	PARAMETERS	VALUE	ENERGY RATE		COST PER UNIT (RS/UNIT)	COST PER YEAR (RS/YR.)	REMARKS
			KW	%			
PROCESS STEAM	FLOW RATE						
	INLET PRESSURE						
	INLET TEMP.						
	INLET DRYNESS FRACTION						
ELECTRIC POWER	INPUT KW						
	PROPORTION OF ENERGY INTO PRODUCT						
	POWER DRIVE						
	HEATERS						
	OTHER						
NATURAL GAS	FLOW RATE						
	TEMPERATURE						
	PRESSURE						
	HEATING VALUE						
FUEL OIL (ASA NO.)	FLOW RATE						
	TEMPERATURE						
	HEATING VALUE						
	VISCOSITY						
	SOURCE						
COAL	TYPE OF COAL						
	HEATING VALUE						
	SIZE						
CHEMICALS							
TOTAL							

ENERGY AUDIT – SHEET 4A – ENERGY INPUTS

PROCESS EQUIPMENT ____________________

ITEM	PARAMETERS	VALUE	ENERGY RATE		COST PER UNIT (RS/UNIT)	COST PER YEAR (RS/YR)	REMARKS
			KW	%			
PRODUCT IN	FLOW RATE						
	TEMPERATURE						
INLET AIR	FLOW RATE (AIR)						
	TEMPERATURE (AMBIENT)						
	HUMIDITY (AMBIE.)						
	FLOW RATE (WATER)						
	PRESSURE						
	TOTAL						

USAGE INTERMITTENT ☐ CONTINUOUS ☐

FRACTIONAL USE TIME PER/WEEK	____________
PER/MONTH	____________
PER/YEAR	____________

ENERGY AUDIT RECORD SHEET-5-MACHINE CASE HEAT LOSSES

NAME OF INDUSTRY : ______________________

MACHINE	BTU / HR-SQFT	TOTAL SQ.FT.	HRS PER YEAR	RS. PER MIL. BTU	LOSS RS/YEAR	REMARKS

REMARKS : --

ENERGY AUDIT RECORD SHEET - BAD HOUSEKEEPING LOSSES

NAME OF INDUSTRY : ____________________

PROCESS EQUIPMENT : ____________________

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NO	"U" VALUE	TOTAL SQ. FT	DEG-DAYS	RS. PER MIL. BTU	LOSS RS./YEAR

REMARKS: --

ENERGY AUDIT RECORD SHEET-58-HEAT FLUX DATA REDUCTION

NAME OF INDUSTRY : ____________________

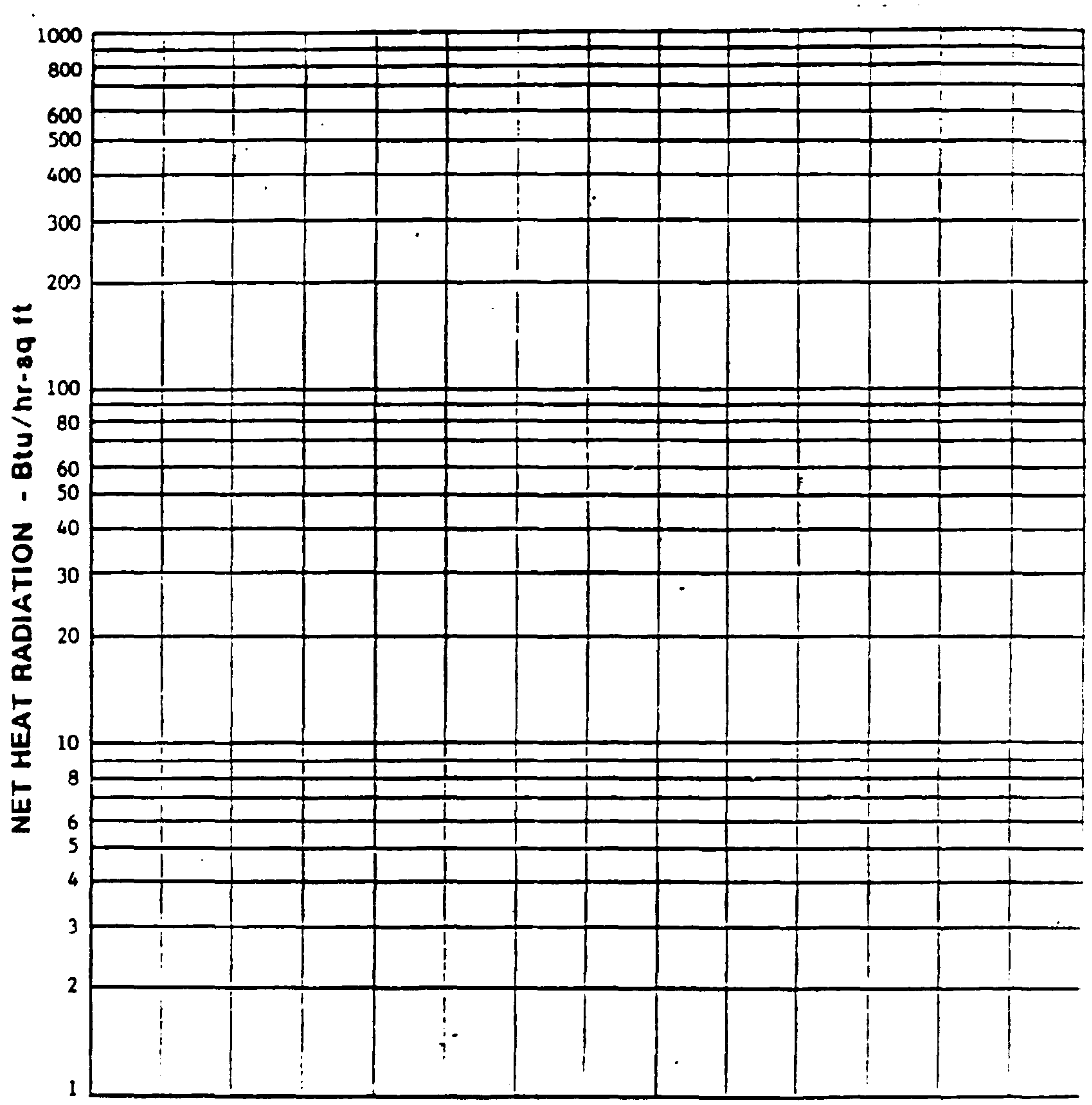
	TIME	DATE	SCALE	AIR T	IND SURF T	NET R	AREA	SURF T	BGND T	CONV	BTU / HR-SQ FT	"U" VALUE, REMARKS, etc.
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

REMARKS : --

ENERGY AUDIT RECORD SHEET-5C-THERMAL ANALSIS

NAME OF INDUSTRY ____________________

PROCESS EQUIPMENT ____________________



REMARKS : --

ENERGY AUDIT RECORD SHEET-SD-EXHAUST OUT FLOW LOSSES

NAME OF INDUSTRY : ____________________

PROCESS EQUIPMENT : ____________________

____

____

____

____

____

____

____

____

____

FLOW RATE (FLUE GAS)	TEMP	RELETIVE HUMIDITY	VOLUME BTU/CM	LOSS/YR: (RS)

REMARKS : --

ENERGY AUDIT RECORD SHEET-5E-CONDENSATE RETURN

NAME OF INDUSTRY ______________________

PROCESS EQUIPMENT ______________________

NO	VOLUME (PER/HR)	TEMP.	BTU/ CM^3	LOSSES/ YR(RS.)

REMARKS --

ENERGY AUDIT SUMMARY SHEET – 6

WORK THROUGHOUT

STEAM PRESSURE AND TEMPERATURE

INITIAL MOISTURE CONTENT OF ________ IN ________

FINAL MOISTURE CONTENT OF ________ OUT ________

WEIGHT OF WATER EVAPORATED FROM ________

WEIGHT OF WATER EVAPORATED FROM INCOMING AIR

PLANT HEAT INPUT

TOTAL HEAT INPUT FROM STEAM CONSUMPTION ________

HEAT INPUT VIA PRODUCT ________

HEAT INPUT VIA ELECTRIC ENERGY ________

HEAT INPUT VIA NATURAL GAS ENERGY ________

HEAT INPUT VIA FUEL OIL ENERGY ________

HEAT INPUT VIA COAL ENERGY ________

HEAT INPUT VIA CHEMICAL ENERGY ________

HEAT INPUT VIA OTHER ENERGY ________

TOTAL HEAT INPUT

FLOW RATE OF EXHAUST GASES OUT

VOLUME OF EXHAUST GASES OUT ________

TEMPERATURE OF EXHAUST GASES OUT ________

EQUIVALENT WEIGHT OF DRY AIR SUPPLIED (AMBIENT TEMP.)

PLANT HEAT OUTPUTS

TOTAL HEAT CONTENT OF EXHAUST GASES ________

HEAT CONTENT OF CONDENSATE RETURN ________

HEAT LOSSES FROM MACHINE CASINGS ________

HEAT LOSSES IN PRODUCT OUT ________

TRANSIENT MACHINE HEATING UP AND COOLING LOOSES ________

DOWN TIME AVERAGE ________

TOTAL HEAT OUTPUT

HOUSE KEEPING LOSSES – STEAM LEAKS, HOT AIR ESCAPES FROM MACHINE

UNACCOUNTED LOSSES.

TOTAL

TOTAL

ENERGY AUDIT RECORD SHEET – 7

NAME OF INDUSTRY ____________________ DATE ________

DESCRIPTION OF MANUFACTURING PROCESS AND STAGES ACCOUNTING FOR APPROXIMATELY MORE THAN 80 PER CENT OF PLANT ENERGY USE

(ATTACH PROCESS FLOW DIAGRAM) :

ENERGY AUDIT RECORD – SHEET – 8

NAME OF INDUSTRY ______________

XIII. COMMENTS/SYNOPSIS

____
____
____
____
____
____

XIV. PROPOSED ENERGY CONSERVATION MEASURES (ON SITE).

____
____
____
____
____
____

XI. IDENTIFICATION OF MAJOR ENERGY LOSSES BY THE MANUFACTURERS.

____
____
____
____
____
____

XII. WHETHER ANY INVESTMENTS WERE MADE IN THE PAST FOR ENERGY CONSERVATION, IF SO PLEASE SPECIFY IF NONE WHY NOT ?

____
____
____
____
____
____

ENERGY AUDIT RECORD SHEET – 9

NAME OF INDUSTRY ______________________ DATE : ____________

ENERGY COSTS

DATA RECORDED BY

	ELECTRIC POWER				NATURAL GAS				FUEL OIL			COAL			CHEMICALS		
	KWH	Other Charges/ Demand Charge	Rate Rs/Ton	Total Cost Rs.	KCUFT	Other Charges/ Demand Charge	Rate Rs/ KCUFT	Total Cost Rs.	GAL	Rate Rs/Gal	Total Cost Rs.	TONS	Rate Rs/Ton	Total Cost Rs.	UNIT	Rate Rs/cwt	Total Cost Rs.
JAN																	
FEB																	
MAR																	
APR																	
MAY																	
JUN																	
JULY																	
AUG																	
SEP																	
OCT																	
NOV																	
DEC																	
YEAR																	
JAN																	
FEB																	
MAR																	
APR																	
MAY																	
JUN																	
JULY																	
AUG																	
SEP																	
OCT																	
NOV																	
DEC																	

ENERGY AUDIT RECORD SHEET – 10

NAME OF INDUSTRY ______________________ DATE : ______________

MONTHLY PLANT ENERGY USE ________________ YEARS ______________ Data Recorded by : ________________

	ELECTRIC POWER			NATURAL GAS			FUEL OIL			COAL			TOTAL BTU	NUMBER OF UNITS PRODUCED	BTU PER UNIT OF PRODUCTION
	KWH	BTU/KWH	BTU	KCUFT	BUT/KCUFT	BTU	GAL	BTU/GAL	BTU	TONS	BTU/IB	BTU			
JAN															
FEB															
MAR															
APR															
MAY															
JUNE															
JULY															
AUG															
SEPT															
OCT															
NOV															
DEC															
JAN															
FEB															
MAR															
APR															
MAY															
JUNE															
JULY															
AUG															
SEPT															
OCT															
NOV															
DEC															

ENERGY AUDIT RECORD SHEET – 11

NAME OF INDUSTRY____________________ DATE ______

GENERAL STATE OF INDUSTRY

NUMBER OF QUALIFIED ENGINEERS/PLANT MANAGERS (LEVEL OF QUALIFICATIONS AND EXPERIENCE) ____________________

BOILERS (EFFICIENCY) ☐ MAXIMUM ☐ MEDIUM ☐ POOR ____________________

NON-PRODUCTIVE IDLING OF BOILERS ☐ HIGH ☐ MEDIUM ☐ LOW ____________________

SPACE HEATING BY BOILERS ☐ YES ☐ NO ____________________

ELIMINATION OF STEAM LEAKS ☐ EXCELLENT ☐ GOOD ☐ POOR ____________________

INSULATION OF STEAM PIPES ☐ EXCELLENT ☐ GOOD ☐ POOR ____________________

AVOIDANCE OF PRODUCING STEAM IN EXCESS OF PROCESS NEEDS ☐ YES ☐ NO ____________________

ENERGY AUDIT RECORD SHEET – 11A

NAME OF INDUSTRY____________________ DATE __________

GENERAL STATE OF INDUSTRY

STEAM DISTRIBUTION SYSTEM
☐ EXCELLENT ☐ GOOD ☐ POOR

CONDENSATE RETURN TO PREHEAT BOILER FEED WATER ☐ YES ☐ NO

RE-USE OF HOT WASHING WATER ☐ YES ☐ NO

AVOIDANCE OF OVERDRYING ☐ YES ☐ NO

RECOVERY OF WASTE HEAT FROM BOILER FLUE GASES ☐ YES ☐ NO

INSTALLATION OF CAPACITORS TO RAISE POWER FACTOR ☐ YES ☐ NO

ELIMINATION OF OVERSIZE, DUPLICATIVE AND INEFFICIENT PUMPS AND MOTORS ☐ YES ☐ NO

ENERGY AUDIT RECORD SHEET – 11B

NAME OF INDUSTRY ____________________ DATE ____________

GENERAL STATE OF INDUSTRY

RE-USE OF HOT WATER ☐ YES ☐ NO ____________________

IDLING LOSSES ☐ HIGH ☐ MEDIUM ☐ LOW ____________________

OVER-DRYING ☐ YES ☐ NO ____________________

DYE-FIXATION TIMES (SPECIFY) ☐ HIGH ☐ MEDIUM ☐ LOW ____________________

MONITORING OF HUMIDITY OF DRYING PROCESSES ☐ YES ☐ NO ____________________

MEASURES TO REDUCE EXHAUST AIR TO MINIMUM ☐ YES ☐ NO ____________________

ENERGY AUDIT RECORD SHEET – 11C

NAME OF INDUSTRY____________________ DATE __________

GENERAL STATE OF INDUSTRY

IS EXHAUST AIR SWITCHED OFF DURING IDLING ☐ YES ☐ NO

____

____

____

HEAT RECOVERY FROM EXHAUST AIR ☐ YES ☐ NO

____

____

____

HEAT RECOVERY, ANYWHERE

____

____

____

BOILER DATA SHEET – 1

1. **BOILER DATA**

   a) TYPE ______________ DATE INSTALLED ______________
   b) PRESSURE (RATED) ______________ OPERATING ______________
   c) CAPACITY (RATED) ______________ OPERATING ________ MAXIMUM ________
   d) HEATING SURFACE ______________
   e) NO. OF BURNERS ______________
   f) INSULATION TYPE ______________ QUALITY ______________
   g) COMBUSTION CHAMBER SIZE ______________

2. **STEAM USE** :

   ☐ FOR PROCESS ☐ FOR HEATING ☐ FOR POWER ☐ OTHER

   ____
   ____
   ____

3. **OPERATING INFORMATION** :

   APPROX. HRS./DAY ______________ ☐ CONTINUOUS
   ☐ INTERMITTENT

BOILER DATA SHEET-1A-FLUE GAS ANALYSIS.

SMOKE TEST RESULT. ______________________

CARBON MONOXIDE P.P.M ______________________

OXYGEN PERCENTAGE. ______________________

NET TEMPERATURE. ______________________

EFFICIENCY ______________________

VOLUME OF EXHAUST ______________________

TEMP. OF EXHAUST ______________________

TOTAL HEAT VALUE LOSS ______________________

COMBUSTION EFFICIENCY ______________________

BOILER DATA SHEET – 2

5. **FEED WATER TREATMENT**

☐ YES ☐ NO ☐ MANUAL ☐ AUTOMATIC

CONDUCTIVITY ________ PH. VALUE ________ LEVEL ________ FLOW ________

TEMPERATURE ________

PREHEATER/ECONOMIZERS

☐ YES ☐ NO

MAINTENANCE

CLEANING FREQUENCY OF BOILER ________________

DATE WHEN LAST CLEANED ________________

6. **FUEL TYPE**

☐ OIL ☐ NATURAL GAS ☐ FURNANCE OIL ☐ COAL ☐ BAGASSE

☐ LPG ☐ OTHER.

BTU/KG. ________

BTU/M3 ________

PRESSURE ________ TEMPERATURE ________ FLOW RATE ________

INDICATION ________ ☐ CONTROL ________ ☐ RECORD

FACILITY FOR OTHER TYPE OF FUEL

☐ YES ☐ NO.

TYPE OF FUEL ________

BOILER DATA SHEET — 3

7. **BURNER**

TYPE : ________ ☐ GAS ☐ OIL ☐ DUAL

NO. OF BURNERS ________

DATE INSTALLED ________

RATINGS :

LOW FIRING ________ BTUH ________ FT^3/HR GAS

HIGH FIRING ________ BTUH ________ FT^3/HR GAS

PILOT BURNER PRESSURE ________ W.C.

PILOT BURNER CAPACITY ________ FT^3/HR

PILOT IGNITION SOURCE ☐ SPARK ☐ MANUAL

8. **COMBUSTON AIR**

PRESSURE ________

TEMPERATURE ________

FLOW ________

9. COMMENTS

10. PROPOSED ENERGY CONSERVATION MEASURES (ON SITE)

Appendix D

INTRODUCTION LETTER AND EXAMPLE ACCEPTANCE FORM

UNITED NATIONS
DEVELOPMENT PROGRAMME
IN PAKISTAN

ادارۂ ترقیاتِ اقوامِ متحدہ پاکستان

D.1

P. O BOX 1051, ISLAMABAD, PAKISTAN

TELEPHONE 22071

CABLE ADDRESS : U N D E V P R O, ISLAMABAD

STREET ADDRESS. UNITED NATIONS OFFICES
DIPLOMATIC ENCLAVE, NO. 1, BLOCK NO. 2
RAMNA 5, ISLAMABAD

REFERENCE PAK/83/009

26 Augusut 1984

TO WHOM IT MAY CONCERN

This will certify that Messrs International Resource Assessment Group, Inc., (INTRAG), Consultants in Natural Resource and Energy Assessment and Implementation Management, USA, have been awarded contract No. 84/25 covering UNDP/UNIDO Project PAK/83/009, Energy Saving in Industry. The Project Manager of INTRAG in Lahore is Mr. Tafweez E. Chauhan. His address is: INTRAG, 4-Canal Bank, Upper Mall, Lahore.

INTRAG will implement the project in close coordination with Mr. Sohail Qureshi, Director General, Energy Resources Cell, Ministry of Petroleum and Natural Resources, House No. 3, Street 88, G-6/3, Embassy Road, Islamabad and Dr. Kenneth S. Stephens, Senior Industrial Development Field Adviser of UNIDO Islamabad.

The aims of the contract, among other things, are :

(i) to undertake analysis of at least thirty industrial units regarding the scope for adoption of fuel efficiency measures in short and long time perspective which will lead to lesser consumption of fuel oil/gas without affecting industrial output in the plants. Such a survey on industrial sector basis will give a guideline for achieving savings on short/medium/long term approach;

(ii) to prepare in-depth analysis of plant level total energy demand, plant level peak energy demands, recovery of waste heat, improving performance of steam boiler, steam applications, and check list for industrial conservation of energy;

(iii) to prepare proposals for suitable fuel substitutes;

(iv) to compile available data on measures and recommendations for energy saving in industry.

We request the concerned factories/plants/companies to extend all courtesies and co-operation to Mr. T.E. Chauhan, INTRAG and his staff in their efforts to carry out the study.

K. S. Stephens
UNIDO Senior Industrial
Development Field Adviser

INTRAG
INTERNATIONAL RESOURCE
ASSESSMENT GROUP INC.
Consultants in Natural Resource & Energy
Assessment and Implementation Management

4. Canal Bank
Upper Mall
Lahore - Pakistan

Tel : 881765
330297
Tlx : 44897 IMPAK PK

15 - Clark Road
Wellesley Hills
Massachusetts 02181 U.S.A. (617) - 237 - 6085

Attention :

SUBJECT : SURVEY OF YOUR FACTORY/PLANT FOR ENERGY CONVERSATION STUDY ON BEHALF OF UNIDO/DGER

Dear Sir,

We are pleased to advise you that your factory/plant has been selected for consideration for the subject study.

BACKGROUND

The United Nations Industrial Development Organisation (U.N.I.D.O.) in collaboration with the Directorate General Resources (DGER) Ministry of Petroleum and National Resources, Government of Pakistan is undertaking a study of about thirty select industrial units in the steel, textile and paper/board sectors, to determine existing utilisation and consumption patterns of energy sources mix and advise on potential for conservation of energy sources without affecting productivity.

The study recommendations would enable plant management in these sectors to take steps for cutting down their energy costs, increase efficiency and improve quality.

The conbtract for preparation of the study has been awarded by U.N.I.D.O. to M/s INTRAG of USA while ZELIN LIMITED has been commissioned to assist M/s INTRAG in conducting the survey and collecting data from the selected plants.

......2/

SURVEY PROCEDURE

On receiving acceptance from plant management to carry out survey, the Intrag/Zelin survey team will visit the plant, interview the plant manager regarding machinery, equipment installed and their energy use. Using the documentation (electrical drawings, steam system layouts at and historical records of fuel and electricity) made available the team will take measurements on the energy consumption of major energy user equipment through their own portable instrumentation.

We would be grateful if you would kindly fill out the attached ACCEPTANCE FORM and return to us at the earliest, to enable us to schedule our visit.

In case you need further information about the project please call :

Mr. Tafweez E. Chauhan	Lahore, Phones:	334058-330297
Mr. Amer Qari		330100

Looking forward to an early response.

Yours sincerely,
For International Resource Assessment Group (INTRAG) Inc.

TAFWEEZ E. CHAUHAN
PROJECT MANAGER

EXAMPLE

ACCEPTANCE FORM

Name of Industry : 1) Sunshine Cotton Mills Limited, Sheikhupura
2) Sunshine Jute Mills Limited, Sheikhupura

Address : Kilometer 29, Lahore-Sheikhupura Road, Sheikhupura

Telephone : Sunshine Cotton SKP 3661
Sunshine Jute SKP 3409
Telex : 44243 Hasan Pk (Head Office at Gulberg)

Person to Contact : 1) ~~Sunshine Cotton - Mr. M. Faheem, GM~~
2) Mr. David T. Gamble - Sunshine Jute Mills

Designation : ~~General Managers of both the Companies~~

Telephone : a) Sunshine Cotton Mills Ltd., Sheikhupura Phone No: [illegible]
b) Sunshine Jute Mills Ltd., Sheikhupura Phone No: [illegible]

We agree to have our factory/plant surveyed by M/s INTRAG/ZELIN for the purpose of the UNIDO/DGER Study on Energy Conservation on (Proposed Date) SCML 12-9-1984 Sunshine Jute 13-9-1984 or (Alternate Date)

We will provide all assistance to enable making the study a sucess.

Signed : [signature]

Name in Block Letters : (Azaiz Mazhar Hussain)

Designation : DIRECTOR/GENERAL MANAGER,
SUNSHINE GROUP OF INDUSTRIES, 71-B/C-2, Gulberg III, [illegible]

Date : 29th August, 1984

Appendix E

METHODOLOGY FOR ESTIMATING ENERGY SAVINGS

In this appendix, the methodologies used to estimate energy savings for the following energy conservation actions are provided:

IMPROVED BOILER EFFICIENCY

1. Graphical Approach to Boiler Efficiency Calculation

This approach uses graphs on fuel compositions and ambient conditions. Standard graphs for exact composition of natural gas as supplied to the industries surveyed were not available. Since these must be developed through a testing procedure, it was decided to use graphs that were closest in composition to the natural gas supplied and prevalant ambient conditions for the plants surveyed. The tradeoff in accuracy is not significant and a good estimate of average operating efficiency can be obtained through this procedure. However, a precise estimate of efficiency would require continuous monitoring of boiler operating conditions over a period of time to take into account changes due to loading and ambient conditions.

Figures 1 and 2 illustrate the relationship, for natural gas, of boiler thermal efficiency as a function of stack temperature and excess air.

Stack gas temperature, O_2 and CO_2 were recorded for each plant. The stack outlet temperature and percent CO_2 are entered on the graph to obtain the estimate of overall boiler thermal efficiency.

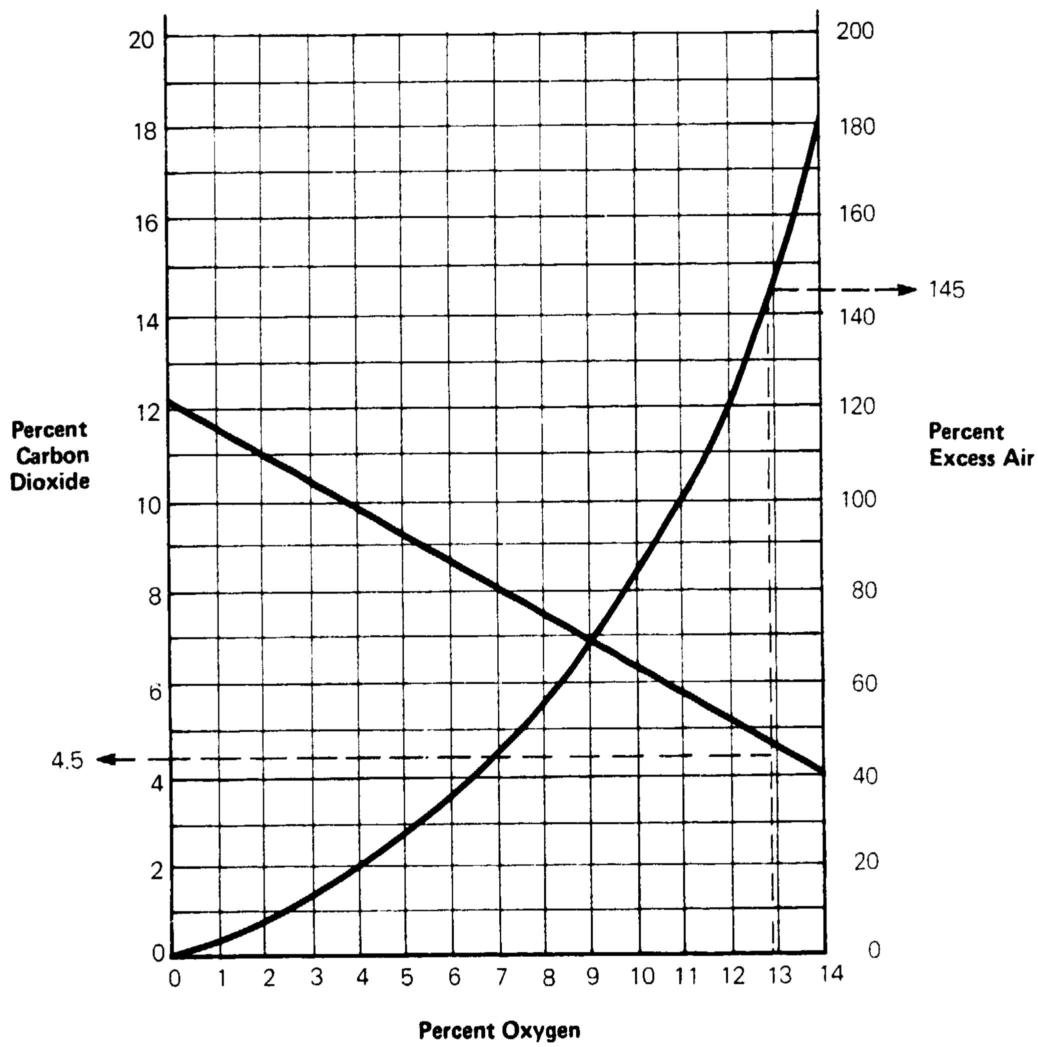
Percent excess air can be calculated in two ways:

a. Graphical Approach

Figure 1 shows the relationship between percent excess air and O_2 and CO_2 levels for typical fuels. Given levels

Figure 1

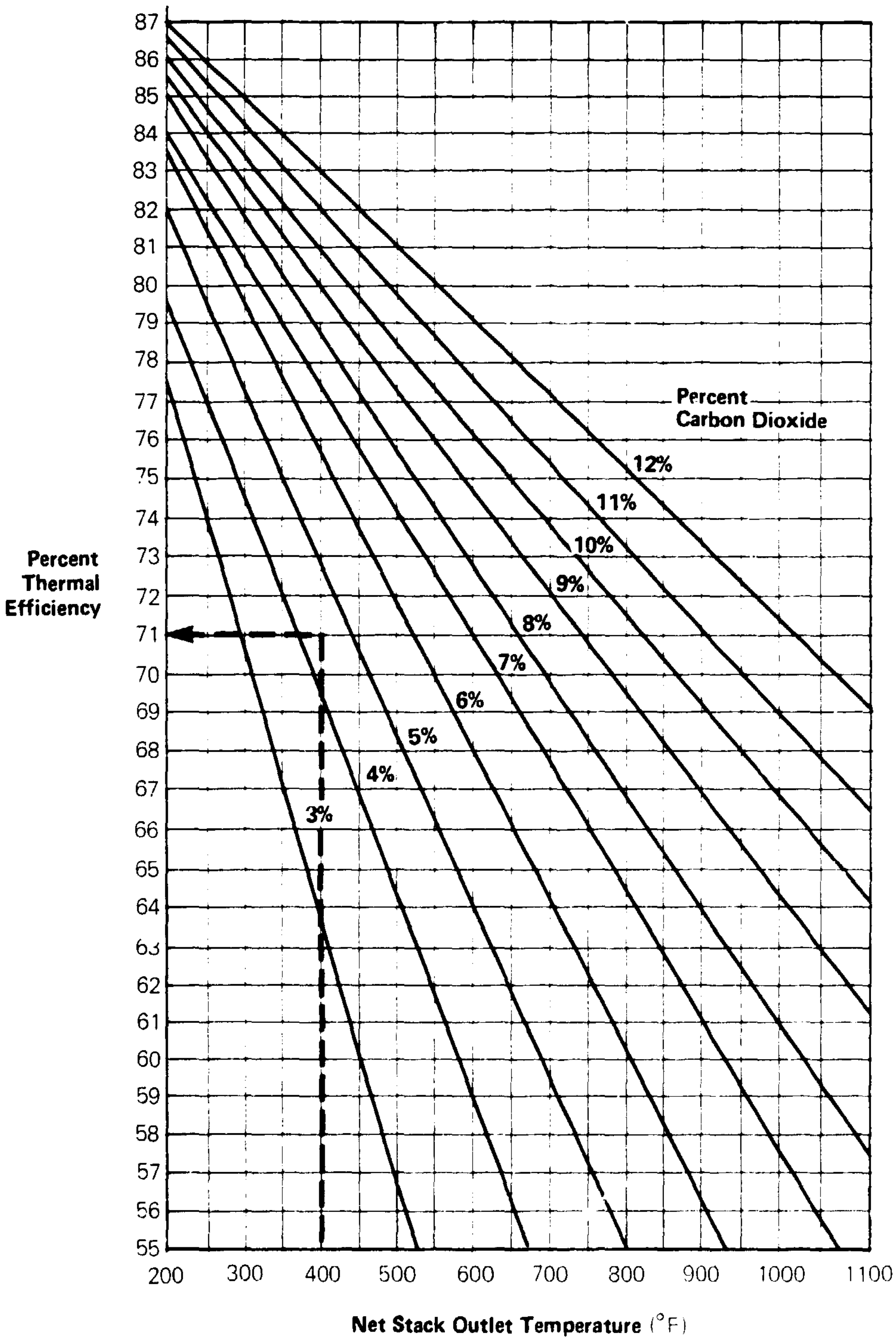
Relationship of Percent Excess Air to Percent Oxygen and Carbon Dioxide for Natural Gas as a Boiler Fuel



NOTE: Figure not to scale.

Figure 2

Thermal Efficiency Nomograph for Natural Gas: Shaheen Calico Example



of O_2, CO_2, and percent excess air can be read directly from the graph.

b. Formula*

The percent excess air (EA) can also be calculated using the following relationship:

$$EA = 100 \times \frac{O_2}{.2682\ N_2 - O_2}$$

2. Heat Loss Method for Calculating Boiler Efficiency

Below is a sample calculation for boiler efficiency using the heat loss method for one of the plants surveyed (Bannu Woolen Mills).

			Recorded	
Rated Pressure	$= p_r$	$=$ 100 psi	O_2	= 6%
Operating pressure	$= p_o$	$=$ 80 psi	$T_{Exhaust}$	= 970°F
Rated capacity	= 2000 lbs/hr		CO (ppm)	= 375
			CO_2	= 11.5%

* Source: Thumann, Albert, P.E.. Energy Audit Sourcebook, Fairmont Press, Inc., 1983, p. 32.

a. Heat Loss Due to Dry Flue Gas:

The equation used for calculating Dry Flue Gas (DFG) per lb of fuel fired is:

$$DFG = \frac{11\ (CO_2) + 8\ (O_2) + 7\ (N_2 + CO)}{3\ (CO_2 + CO)} \times \frac{C}{100}$$

$$\frac{11\ (11.5) + 8\ (6) + 7\ (82.5)}{3\ (11.5)} \times \frac{87}{100}$$

$$DFG = 18.9635$$

$$\Delta Q_{DFG} = DFG \times Cp \times (t_{ex} - t_A)$$

where: Cp = specific heat

t_{ex} = exhaust temperature

t_A = ambient temperature

$$\Delta Q_{DFG} = 18.9635 \times (.24) \times (970 - 80)$$

$$\Delta Q_{DFG} = 4050.6 \text{ Btu/lb}$$

Percent of fuel (Heating Value) as fired $= \dfrac{4050.6 \times 100}{18.3 \times 10^3} \approx 22.13\%$

b. Heat Loss Due to Moisture in Fuel = ΔQ_{H_2OF}

Δq = enthalpy change of moisture from inlet to exit (flue gas) conditions

$$\Delta q = (1089 + 0.46\ t_{ex} - t_{A})$$

$$= (1089 + (.46)\ (970) - 80) = 1455.2$$

$$\Delta Q_{H_2OF}) = H_2OF \times \Delta q$$

$$\Delta Q_{H_2OF} = (0.05) \times 1455.2 = 72.76$$

$$\text{Percent of fuel as fired} = \frac{72.76}{18.3 \times 10^3} \times 100 = 0.4\%$$

c. Carbon Monoxide Heat Loss:

$$\text{Fuel Oil: \% Heat Loss} = \frac{.00623 \times CO\ ppm}{21 - \%\ O_2}$$

$$= \frac{.00623 \times 375}{21 - 6} = .156\%$$

d. Heat Loss Due to H_2O From Combustion of H_2

$$\Delta Q_{H_2O} = 9 \times \frac{H_2}{100} \times \Delta q$$

$$= 9 \times \frac{11.3^*}{100} \times 1455.2 = 1479.94 \text{ Btu/lb}$$

$$\text{Percent of fuel as fired} = \frac{1479.94}{18.3 \times 10^3} \times 100 = 8.08$$

e. Unmeasured + Radiation Losses** = 10%

$$\eta = 100 - (22.13 + .156 + .4 + 8.08 + 10)$$

$$\eta = 59.23\%$$

* Assumed value.

** Percent of radiation losses were measured using Exergen Scanner and given total surface area.

CALCULATIONS OF ANNUAL SAVINGS DUE TO IMPROVED BOILER EFFICIENCY

Annual savings due to improvement in boiler efficiency were calculated using the nomograph shown in Figure 3. The nomograph is based on the following equation:

$$S = W \times (\Delta E / E) \times C$$

where S: is the potential fuel savings in Rs/hr

W: is the boiler fuel-use rate in MBTU/hr

E: is achievable efficiency

ΔE: is the difference between achievable and actual efficiency

C: is the fuel cost in Rs/MBTU

Sample calculation: Farooq Textile Mills: S_r = 8000 Lbs/hr

$$r = Rs/MBTU = \frac{2410784}{93480.83} = 25.79$$

$$r = Rs\ 25.79/MBTU$$

Draw a straight line from the average steam flow through the fuel cost line and across to the fuel savings. The intersection at fuel savings shows the savings for a 1% gain in unit efficiency.

$$\text{i.e.} \quad \frac{ds}{d\eta} = 85000$$

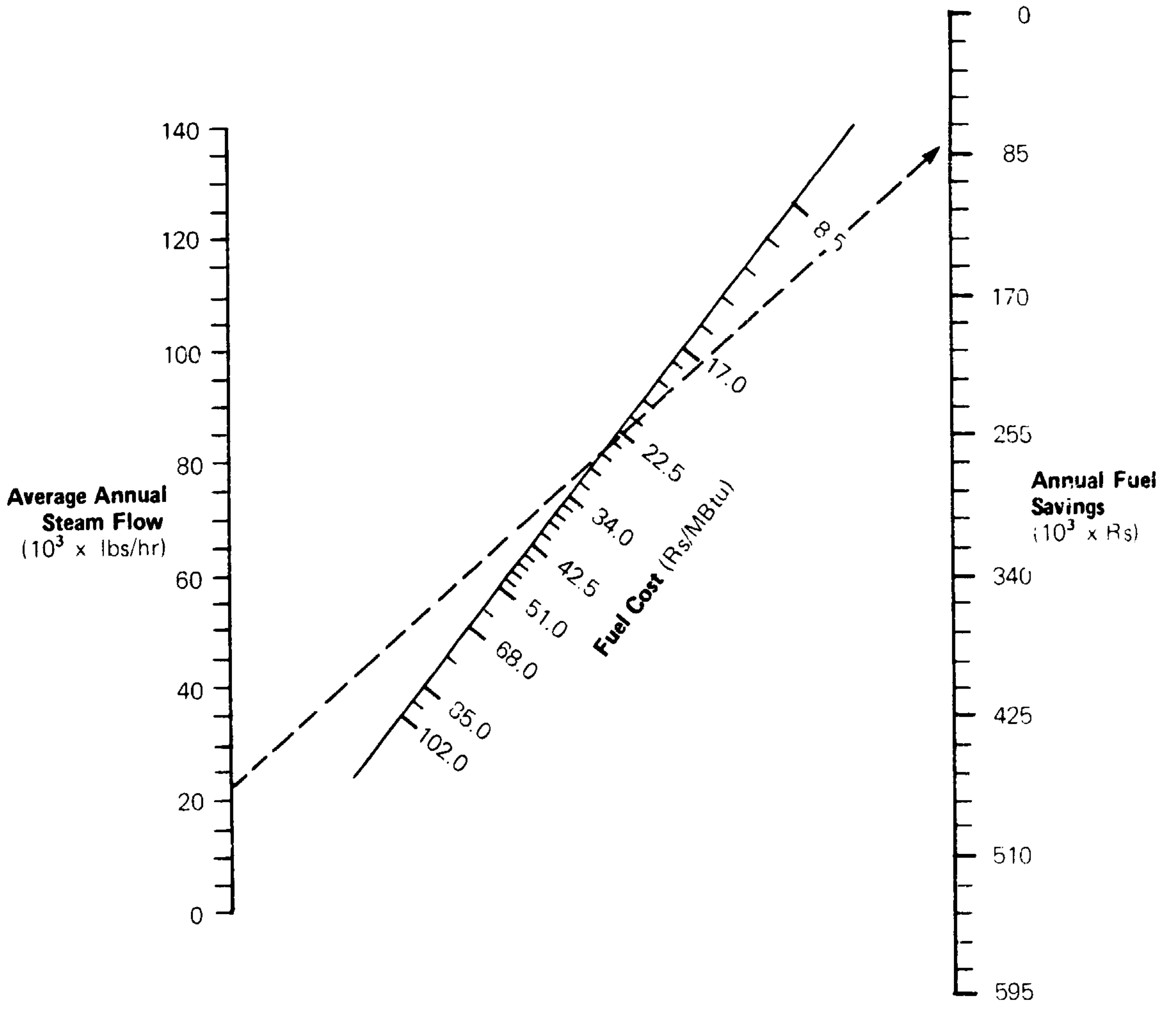
To adjust for actual boiler efficiency, multiply the saving by (80 / actual η)

$$\text{i.e.} \quad 85000 \times \frac{80}{78.7} = \text{Rs. } 86404.07\text{/unit gain in efficiency}$$

$$\Sigma S = (80 - 78.7) \times 86404.07$$
$$\Sigma S = Rs\ 112325.29/yr$$

Figure 3

Annual Fuel Savings for 1% Gain in Unit Efficiency



NOTE: Nomograph shown is not to actual scale; it is for illustrative purposes only.

CALCULATION PROCEDURE FOR ESTIMATING SAVINGS RELATED TO BOILER CLEANING AND MAINTENANCE

E_O = Average energy input to boiler prior to cleaning

E_1 = Average energy input to boiler after cleaning

For each plant E_O and E_1 were obtained from data corresponding to the dates when the boiler was last cleaned.

S_i = Savings for plant i

$$S_i = (E_O - E_1) \times r_i$$

where

r_i = rate (Rs/GJ) for plant i.

CALCULATION PROCEDURE FOR SAVINGS RELATED TO BOILER INSULATION

l = recorded surface losses (watts/m^2)
t = operating hours
a = surface area (m^2)
r = Rs/kWh
p = percent factor for insulation quality
s = estimated savings

$$S = \frac{l \times a \times t \times (p)}{1000} \times \frac{3413}{10^6} \times 1.0551 \times r$$

Example: Adamjee Paper Mills

$$S = \frac{360 \times 1000 \times 8000 \times .8}{1000} \times \frac{3413}{10^6} \times 1.0551 \times 17.20$$

S = Rs 142705.54/yr

CALCULATION PROCEDURE FOR SAVINGS RELATED TO FURNACE INSULATION

l = recorded surface losses (watts/m²)
t = operating hours
a = surface area (m²)
r = Rs/GJ
p = percent factor for insulation quality
s = estimated savings

$$S = \frac{l \times a \times t \times (p)}{1000} \times \frac{3413}{10^6} \times 1.0551 \times r$$

Example:

$$S = \frac{320 \times 100 \times 6000 \times .8}{1000} \times \frac{3413}{10^6} \times 1.0551 \times 212.08$$

S = Rs 117306.17/yr

CALCULATION PROCEDURE FOR COMPUTING SAVINGS DUE TO FLUE GAS WASTE HEAT RECOVERY

Q_i = Average annual energy consumption for plant i

V_f = Volume of exhaust gases (ft^3/hr)

C_p = Specific heat of exhaust gases (BTU / Lb - F)

P = Density of exhaust gases (Lb / ft^3)

Q_F = Energy carried in flue gases

$Q_{F'}$ = Average annual recoverable energy from flue gases

$Q_{i'}$ = Average annual energy consumption with flue gas waste heat recovery in plant i

r_i = Rate Rs/GJ for plant i

S_i = Estimated average annual savings for plant i

H = Annual operating hours

T_{ex} = Temperature of exhaust gases

T_A = Ambient temperature

$Q_F = V_F \times C_P \times P \times (T_{ex} - T_A) \times H$

Example: CeeBee Textile Industries

Q_i = 87983.441 GJ

Q_F = 10138.848 GJ

$Q_{F'}$ = (0.4) x (10138.848) = 4055.539 GJ
(assuming 40% recoverable potential from flue gases)

$Q_{i'}$ = 87983.411 - 4055.539 = 83927.902

S_i = (4055.539) x (25.234)

S = Rs 102339.73/yr.

CALCULATION PROCEDURES FOR ESTIMATING SAVINGS RELATED TO IMPROVED STEAM DISTRIBUTION SYSTEM

Q_i = Average annual energy used in steam generation in plant i

P = Percent factor for input energy reduction for plant i

Q_i = Average annual energy use with improved steam distribution system in plant i

$Q_i' = Q_i \times (1 - p)$

S_i = Annual savings due to improved steam distribution system

$S_i = \Delta Q \times r_i$

$S_i = (Q_i - Q/_i) \times r_i$

where r_i = Rs/GJ for plant i

Example: CeeBee Textile Industries

$Q_i = 45.332 \times 10^3$ GJ

$Q_i' = (45.332 \times 10^3)\ (1-.18) = 37.173$

$S = (45.332 - 37.173) \times 16.3 \times 10^3 = 132177.81$

CALCULATION PROCEDURES FOR SAVINGS RELATED TO INCREASED CONDENSATE RETURN

Pr = Pressure (KN/M^2)

Q_a = Total heat value of feedwater at ambient temperature (KJ/Kg)

Q_s = Total heat value of steam at operating pressure and temperature (from steam tables) (KJ/Kg)

r = Rate (Rs/GJ) for plant i

P = percent factor for condensate return quality

Sr = Steam Rate (Kgs/hr)

t = Operating hours

E = Energy Savings (GJ/yr)

S_i = Savings in Rs/yr

FC = Percent Saving of Fuel Cost

TC = Percent Saving of Total Cost

$$E = \frac{P \times (Q_s - Q_a) \times S_r \times .454 \times t}{10^6}$$

$$S_i = E \times r_i$$

$$FC = \frac{S_i}{Rs\ (fuel)} \times 100$$

$$TC = \frac{S_i}{Rs\ (Total)} \times 100$$

Example: Abid Industries

$$E = \frac{.05 \times (2759.5 - 9.24) \times 3178 \times .454 \times 7200}{10^6} = 1382.810$$

$$S_i = \frac{407742}{20130.91} \times 1382.810 = 28008.15$$

$$FC = \frac{28008.15}{407742} \times 100 = 6.8\%$$

$$TC = \frac{28008.15}{1847282} \times 100 = 1.51\%$$

CALCULATION PROCEDURE FOR DETERMINING SAVINGS RELATED TO POWER FACTOR IMPROVEMENT

E_i = Total input electric energy for plant i

P_i = Input power at measured power factor

P_j = Input power at improved power factor

h_i = Operating hours of plant i

i_L = Line current

v_L = Line voltage

$\cos\phi_1$ = Power factor (recorded)

$\cos\phi_2$ = Power factor (improved) = 0.9

r_i = Rate (Rs/kWh)

S_i = Savings for plant i (Rs/yr)

$$P_i = \frac{E_i}{h_i}$$

also

$$P_i = \sqrt{3}\ i_L v_L \cos\phi_1$$

$$\frac{P_i}{\sqrt{3}\cos\phi_1} = i_2{}^2R\text{(losses)}$$

Similarly

$$\frac{P_j}{\sqrt{3}\cos\phi_2} = i_2{}^2R \text{ (losses)}$$

$$\Delta p = \frac{P_i}{\sqrt{3}\cos\phi_1} - \frac{P_j}{\sqrt{3}\cos\phi_2}$$

$$S_i = \Delta p \times h \times r_i$$

Example: Abid Industries

$$E_1 = 1124763 \text{ kWh}$$

$$P_1 = \frac{1124763}{7200} = 156.217 \text{ kW}$$

$$\frac{156.217}{\sqrt{3}\ (.8)} = i_2{}^2R = 112.740$$

at pf = .9

$$\frac{156.217}{\sqrt{3}\ (.9)} = i_2{}^2R = 100.213$$

$$\Delta p = 12.52672 \text{ kW}$$

$$S_1 = (12.52672) \times (7200) \times (1.2798)$$

$$S_1 = \text{Rs. } 115433.16/\text{yr.}$$

CALCULATION PROCEDURE FOR DETERMINING SAVINGS RELATED TO OPTIMIZING DRYING TIMES

Q_i = Input energy in plant i

E_d = Estimated energy use in drying (assumed to be 40 percent of input energy)

p = percent factor for savings

It was assumed that 20 percent of drying energy could be saved with optimization of drying times.

E_o = Estimated energy saved with optimized drying time

r_i = Rate (Rs/GJ)

S_i = Savings (Rs/GJ)

$E_d = (.4) \times Q_i$

$E_o = E_d \times (p)$

$S_i = E_o \times r$

Example: Abid Industries

Q_i = 24181.25 GJ

$E_d = (.4) \times (24181.25) = 9672.5$ GJ

$E_o = (.2) \times 9672.5$

E_o = 1934.5 GJ

$S_i = (1934.5) \times (76.3931)$

= Rs 147782.56/yr.

Appendix F

INDIVIDUAL PLANT SUMMARIES

This appendix contains a separate summary sheet for each plant surveyed in the study. Each summary sheet contains the following:

1. Potential areas of energy conservation improvements.

2. The type of improvement action or equipment required.

3. The likely timing of the action and the estimated energy and cost savings.

4. A measure of the equipment invested needed, and the financial payback period.

Because of the 1-day survey time, the following limitations in these summary sheets should be recognized:

- Most of the opportunities shown on the tables are probably technically feasible, but must be borne out by more detailed analysis.

- A careful evaluation must be made of the economics of the energy conservation actions and investments.

- The financing viability fo the energy conservation equipment investments was not addressed in the study. This is critical to the implementation of several of the actions.

PLANT SUMMARY

ENERGY CONSERVATION OPPORTUNITIES*

Abid Industries
(Plant)

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Payback Period (Years)
Boiler	Combustion Efficiency/ Burner	Automatic Tuning	X			.271	3734	.20	X		<1
	Recover Waste Heat	Waste Heat Recovery System			X	2.274	173737	9.4		X	3
	Blow Down Recovery	Economizers		X					X		2
	Maintenance & Cleaning	Cleaning	X			1.215	48929	2.64		Nil	
	Insulation	Insulate		X			4536		X		3
	Condensate Return	Piping		X		2.765	279455			X	3
	Feedwater Pretreatment	Chemicals	X			1.130	22896	1.24	X		1
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger			X					X	2
	Air Waste Heat	Heat Exchanger		X			5685	.31			1
Steam Losses	Pipe Insulation	Insulate							X		3
	Steam Traps	Steam Traps	X			1.957	39633	2.15	X		2
	Steam Leakages	Repair	X								<1
	Distribution Network										
Hot Water	Hot Water Control			X					X		4
Electric Power	Power Factor	Adjustments	X						X		1-3
	Matching of Motors	Change			X	.325	115433	6.2		X	4
	Voltage Stabilization	Stabilizers		X					X		1-2
	Moving Parts Maintenance		X						X		1-2
Process Heat	Drying	Heat Exchanger		X	X	1.934	147783	8.0	X		1/2
	Space Heating									X	
Re-Designing	Waste Heat Recovery System			X					X		
	Process Control System				X					X	
	Microwave Heating				X					X	

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

International Metal
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Furnace	Combustion	Tuning	X						X		<1
	Insulation	Insulate		X		.445	57465	15.30			3
	Temperature/Pressure	New Controls			X					X	3
	Maintenance		X						Nil		
Flue Waste Heat	Feedwater Preheating										
	Air Waste Heat	Heat Exchanger		X							
Electric Power	Power Factor	Adjustment	X						X		1-3
	Motors	Match vs. Load		X		0.25	14277	3.80		X	4
	Voltage Stabilization	Stabilizer	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X						
Re-Designing	Waste Heat Recovery System			X							
	Process Control Systems				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Kamran Steel Re-Rolling Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Furnace	Combustion	Tuning	X						X		<1
	Insulation	Insulate		X		10.585	2300000	21.35			3
	Temperature/Pressure	New Controls			X					X	3
	Maintenance		X						Nil		
Flue Waste Heat	Feedwater Preheating										
	Air Waste Heat	Heat Exchanger		X							
Electric Power	Power Factor	Adjustment	X						X		1-3
	Motors	Match vs. Load		X		5.050	1097637	10.19		X	4
	Voltage Stabilization	Stabilizer	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X						
Re-Designing	Waste Heat Recovery System			X							
	Process Control Systems				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Khalil Metal Works
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Medium Term	Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Major	Payback Period (Years)
Furnace	Combustion	Tuning	X						X		<1
	Insulation	Insulate		X		1.639	48099	16.20			3
	Temperature/Pressure	New Controls			X					X	3
	Maintenance		X						Nil		
Flue Waste Heat	Feedwater Preheating										
	Air Waste Heat	Heat Exchanger		X							
Electric Power	Power Factor	Adjustment	X						X		1-3
	Motors	Match vs. Load		X		.037	9177	3.09		X	4
	Voltage Stabilization	Stabilizer	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X						
Re-Designing	Waste Heat Recovery System			X							
	Process Control Systems				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

Metropolitan Steel
(Plant)

PLANT SUMMARY

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Furnace	Combustion	Tuning	X						X		<1
	Insulation	Insulate		X		18.876	420000	2.13			3
	Temperature/Pressure	New Controls			X					X	3
	Maintenance		X						Nil		
Flue Waste Heat	Feedwater Preheating										
	Air Waste Heat	Heat Exchanger		X							
Electric Power	Power Factor	Adjustment	X						X		1-3
	Motors	Match vs. Load		X		3.108	988598	5.03		X	4
	Voltage Stabilization	Stabilizer	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X						
Re-Designing	Waste Heat Recovery System				X						
	Process Control Systems				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Sh. Abdur Rahim A. Ditta Steel
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Medium Term	Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Major	Payback Period (Years)
Boiler	Burner	Tuning	X			1.306	20673	4.92	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		1.813	43584	10.37		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			.941	36481	8.68		Nil	
	Insulation	Insulate		X			66029	15,70	X		3
	Condensate Return	Recovery System		X		.820	9549	2.27		X	2
	Feedwater Pretreatment	Chemicals	X			.125	2918	.69	X		
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X						X	3
	Process Air Waste Heat	Heat Exchanger		X						X	3
Steam Losses	Pipe Insulation	Insulate		X					X		3
	Traps	Steam Traps	X			2.299	53505		X		2
	Leakage	Repair	X						X		<1
	Distribution Network	Piping		X						X	3
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs. Load		X		.006	1214	.29		X	4
	Voltage Stabilizer	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control System				X					X	3
	Microwave Heating				X					X	2
Furnace	Insulation	Insulate		X		3.936	94609	22.49		X	
	Combustion Temperature/ Pressure Maintenance		X								

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Sunshine Cotton
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs Load		X						X	4
	Voltage Stabilization	Stabilizers	X			7.415	720908	18.33	X		1-2
	Moving Parts Maintenance										

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Ravi Steel Re-Rolling Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Medium Term	Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Major	Payback Period (Years)
Furnace	Combustion	Tuning	X						X		<1
	Insulation	Insulate		X		3.710	191923	22.49			3
	Temperature/Pressure	New Controls			X					X	3
	Maintenance		X						Nil		
Flue Waste Heat	Feedwater Preheating										
	Air Waste Heat	Heat Exchanger		X							
Electric Power	Power Factor	Adjustment	X						X		1-3
	Motors	Match vs. Load		X		.1887	121345	14.23		X	4
	Voltage Stabilization	Stabilizer	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X						
Re-Designing	Waste Heat Recovery System			X							
	Process Control Systems				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Shakir Metal Industries
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Furnace	Combustion	Tuning	X						X		<1
	Insulation	Insulate		X		.298	42139	15.30			3
	Temperature/Pressure	New Controls			X					X	3
	Maintenance		X						Nil		
Flue Waste Heat	Feedwater Preheating										
	Air Waste Heat	Heat Exchanger		X							
Electric Power	Power Factor	Adjustment	X						X		1-3
	Motors	Match vs. Load		X						X	4
	Voltage Stabilization	Stabilizer	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X	.025	13102	4.76			
Re-Designing	Waste Heat Recovery System			X							
	Process Control Systems				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

United Iron & Steel
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Furnace	Combustion	Tuning	X			.966	177000	4.17	X		<1
	Insulation	Insulate		X							3
	Temperature/Pressure	New Controls			X					X	3
	Maintenance		X						Nil		
Flue Waste Heat	Feedwater Preheating										
	Air Waste Heat	Heat Exchanger		X							
Electric Power	Power Factor	Adjustment	X			2.73	501063	11.82	X		1-3
	Motors	Match vs. Load		X						X	4
	Voltage Stabilization	Stabilizer	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X						
Re-Designing	Waste Heat Recovery System			X							
	Process Control Systems				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

Yazdani & Co. Ltd.
(Plant)

PLANT SUMMARY

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X						X	3
	Process Air Waste Heat	Heat Exchanger		X						X	3
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs. Load		X		.87	184526	8.02		X	4
	Voltage Stabilizer	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X						
Re-Designing	Waste Heat Recovery System			X							
	Process Control System				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Shaheen Calico Printing Works
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Boiler	Burner	Tuning	X			4.215	40899	2.66	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		4.359	105512	6.85		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			2.623	62371	4.05	Nil		
	Insulation	Insulate		X			15865	1.03	X		3
	Condensate Return	Piping		X		1.815	34222	2.22		X	3
	Feedwater Pretreatment	Chemicals	X			.656	9360	.60	X		1
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X							
	Process Air Waste Heat	Heat Exchanger		X							
Steam Losses	Pipe Insulation	Insulate		X		6.744 (Pipe Insulation, Traps, Leakage)	96230	6.25	X		3
	Traps	Steam Traps	X						X		2
	Leakage	Repair	X						X		<1
	Distribution Network			X							
Electric Power	Power Factor	Adjustments	X			.220 (Power Factor, Motors, Voltage Stabilizer)	119030	7.72	X		1-3
	Motors	Match vs. Load		X						X	4
	Voltage Stabilizer	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		5.092	123235	8.00		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System									X	2
	Process Control System				X					X	3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

Fig. 12

PLANT SUMMARY

Sunshine Jute
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Electric Power	Power Factor	Adjustments	x			1.295	325182	12.83	x		1-3
	Motors	Match vs. Load		x						x	4
	Voltage Stabilization	Stabilizers	x						x		3
	Moving Parts Maintenance		x						x		1-2
Waste Heat	Space Heating				x						
Re-Designing	Waste Heat Recovery System				x						
	Process Control Systems				x						
	R. F. Heating				x						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Pakistan Chipboard Ltd.
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Boiler	Burner	Tuning	X			7.932	260757	3.61	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		3.366	278713	15.69		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			1.515	81479	4.59	Nil		
	Insulation	Insulate		X			20294	1.14	X		3
	Condensate Return	Piping		X		.847	41045	2.31		X	3
	Feedwater Pretreatment	Chemicals	X			.202	9777	.55	X		1
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X							
	Process Air Waste Heat	Heat Exchanger		X							
Steam Losses	Pipe Insulation	Insulate		X		}			X		3
	Traps	Steam Traps	X			3.367	162958	9.17	X		2
	Leakage	Repair	X			}			X		<1
	Distribution Network			X							
Electric Power	Power Factor	Adjustments				}			X		1-3
	Motors	Match vs. Load		X		.297	94324	5.31		X	4
	Voltage Stabilizer	Stabilizers	X			}			X		[illegible]
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		} 1.716	142099	8.00		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System		X							X	2
	Process Control System			X					X		3
	Microwave Heating			X						X	4

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

ENERGY CONSERVATION OPPORTUNITIES*

Pakistan Paper Corp. Ltd.
(Plant)

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Payback Period (Years)
Boiler	Burner	Tuning	X			17.967	301187	.71	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		97.812	4492412	10.53		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			28.748	1706245	4.00	Nil		
	Insulation	Insulate		X			150071	.35	X		3
	Condensate Return	Piping		X		38.771	699055	1.64		X	3
	Feedwater Pretreatment	Chemicals	X			29.551	532800	1.25	X		1
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X							
	Process Air Waste Heat	Heat Exchanger		X							
Steam Losses	Pipe Insulation	Insulate		X					X		3
	Traps	Steam Traps	X			158.116	5845529	13.70	X		2
	Leakage	Repair	X						X		<1
	Distribution Network			X							
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs. Load		X		16.696	2947992	6.91		X	4
	Voltage Stabilizer	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		7.431	341291	.800		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control System				X					X	3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Paracha Textile
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Medium Term	Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Major	Payback Period (Years)
Boiler	Burner	Tuning	X			2.271	34690	.62	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		12.513	846994	15.53		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			4.089	153017	2.80	Nil		
	Insulation	Insulate		X			12413	.22	X		3
	Condensate Return	Piping		X		2.543	57048	1.05		X	3
	Feedwater Pretreatment	Chemicals	X			1.155	25920	.47	X		1
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X						X	2
	Process Air Waste Heat	Heat Exchanger		X						X	2
Steam Losses	Pipe Insulation	Insulate		X					X		3
	Traps	Steam Traps	X			9.994	224425	4.11	X		2
	Leakages	Repair	X						X		<1
	Distribution Network			X							
Electric Power	Power Factor	Adjustment	X						X		1-3
	Motors	Match vs. Load		X		1.133	875616	16.06		X	4
	Voltage Stabilization	Stabilizer	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		1.826	123604	2.27		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System				X					X	2
	Process Control Systems				X				X		3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Adamjee Paper & Board Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Boiler	Burner	Tuning	X			16.239	189928	.68	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		45.846	1627631	5.84		X	3
Flue Gas Waste Heat	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			18.560	476424	1.71	Nil		
	Insulation	Insulate		X			142706	.51	X		3
	Condensate Return	Piping		X		40.212	687641	2.46		X	3
	Feedwater Pretreatment	Chemicals	X			11.721	201600	.72	X		1
Steam Losses	Pipe Insulation	Insulate		X					X		3
	Traps	Steam Traps	X			102.077	1755623	6.29	X		2
	Leakage	Repair	X						X		<1
	Distribution Network			X							
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs. Load		X		11.895	2048688	7.34		X	4
	Voltage Stabilizer	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		9.944	353029	1.26		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control System				X				X		3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Allawasaya Textile & Finishing
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Payback Period (Years)
Electric Power	Power Factor	Adjustment	X			3.807	673707	12.83	X		1-3
	Motors	Match vs. Load		X						X	4
	Voltage Stabilization	Stabilizers		X					X		3
	Moving Parts Maintenance	Planning	X						X		1-3
Re-Design	Process Control System				X				X		3

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

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PLANT SUMMARY

Ashraf Engineering Works
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Medium Term	Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Major	Payback Period (Years)
Furnace	Combustion	Tuning	X						X		<1
	Insulation	Insulate		X		.552	117306	2.9			3
	Temperature/Pressure	New Controls			X					X	3
	Maintenance		X						Nil		
Flue Gas Waste Heat	Feed Water Preheating										
	Process Air Waste Heat	Heat Exchanger		X							
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs. Load		X		3.442	730227	18.33		X	4
	Voltage Stabilization	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X						
Re-Designing	Waste Heat Recovery System				X						
	Process Control Systems				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Bannu Woolen Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Medium Term	Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Major	Payback Period (Years)
Boiler	Burner	Tuning	X			9.217	273781	11.0	X		<1
	Feedwater Pretreatment		X			.754	32960	1.33	X		
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		5.098	330162	13.30		X	2
	Blow Down Recovery	Economizer		X						X	2
	Maintenance and Cleaning	Maintain & Clean	X			5.267	229968	9.27	Nil		
	Insulation	Insulate		X			15093	.60	X		3
	Condensate Return	Piping		X		3.046	154993	6.25		X	3
Flue Gas Waste Heat	Feed Water Preheating	Heat Exchanger			X					X	2
	Process Air Waste Heat	Heat Exchanger		X						X	2
Steam System	Pipe Insulation	Insulate		X					X		3
	Steam Traps	Steam Traps	X			5.267	229968	1.60	X		2
	Steam Leakage	Repair	X								<1
	Distribution Network										
Electric Power	Power Factor	Adjustments	X						X		1-3
	Match Motors	Change Accordingly			X		121572	4.9		X	4
	Voltage Stabilization	Stabilizers		X					X		3
	Moving Parts Maintenance		X						X		1-2
Process Heat	Drying	Heat Exchanger/ Microwave Heating		X		3.064	198455	8.00		X	4
	Space Heating									X	5
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control Systems				X				X		3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

CeeBee Textile Industries
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Boiler	Condensate Return					7.231	116640	5.25			
	Burner	Tuning	X			14.166	156092	7.32	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		4.056	102340	14.87		X	2
	Blow Down Recovery	Economizer		X		(included in heat)			X		2
	Maintenance & Cleaning	Maintain & Clean	X			4.533	135985	6.12	Nil		
	Insulation	Insulate		X			10702		X		3
	Feedwater Pretreatment	Chemicals	X			1.200	19440		X		1
Flue Gas Waste Heat	Feedwater Preheating			X						X	2
	Process Air Waste Heat	Heat Exchanger		X						X	2
Steam System	Pipe Insulation	Insulate		X		} 8.159	132178	5.95	X		2
	Traps	Steam Traps	X								
	Leakages	Repair	X								
	Distribution Network			X							
Electric Power	Power Factor	Adjustment	X						X		1-3
	Motors	Match vs. Load		X		} .739	157693	7.10		X	4
	Voltage Stabilization	Stabilizer	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		7.039	177618	8.00		X	4
Space Heating					X					X	5

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Chenab Textile Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Payback Period (Years)
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs. Load		X		3.946	550813	18.32		X	4
	Voltage Stabilization	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Re-Designing	Process Control System				X					X	3

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Colony Textile Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Boiler	Burner	Tuning	X			39.493	600415	2.21	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		24.647	109545	4.04		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance and Cleaning	Maintain & Clean	X			27.923	623800	2.30		Nil	
	Insulation	Insulate		X			80442	1.30	X		3
	Condensate Return	Piping		X		7.911	353418			X	3
	Feedwater Pretreatment	Chemicals		X		4.349	97200	.36	X		1
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X							
	Process Air Waste Heat	Heat Exchanger									
Steam System	Pipe Insulation	Insulate		X		} 56.870	1271012	4.69	X		3
	Steam Traps	Steam Traps	X						X		2
	Steam Leakage	Repair	X						X		<1
	Distribution Network										
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs. Load		X		} 6.677	1229913	4.9		X	4
	Voltage Stabilizers	Stabilizers	X					4.53	X		3
	Moving Parts Maintenance	Planning	X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		} 48.790	316853	1.17		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control Systems				X					X	3
	Microwave Heating				X					X	

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Farooq Textile Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Boiler	Burner	Tuning	X			.961	15980	.10	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		6.612	769827	4.60		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance and Cleaning	Maintain & clean				1.775	72324	.43	Nil		
	Insulation	Insulate		X			9125		X		3
	Condensate Return	Piping		X		1.568	38126	.23	X		3
	Feed Water Pretreatment	Chemicals	X			1.060	25920	.15	X		1
Flue Gas Waste Heat	Feed Water Preheating	Heat Exchanger		X							
	Process Air Waste Heat	Heat Exchanger		X							
Steam Losses	Leakage, Exhaust		X			3.551	86788	.52	X		<1
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs Load		X		.657	208795	1.25		X	4
	Voltage Stabilization	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		2.051	238859	1.43	X		4
	Space Heating				X						5
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control Systems				X					X	3
	Microwave Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

General Steel Tools Company
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Furnace	Combustion	Tuning	X						X		1-3
	Insulation	Insulate		X		1.123	134849	20.70	X		<1
	Temperature/Pressure	New Controls			X					X	3
	Maintenance		X						Nil		
Flue Waste Heat	Feedwater Preheating										
	Air Waste Heat	Heat Exchanger		X							
Electric Power	Power Factor	Adjustment	X						X		1-3
	Motors	Match vs. Load		X						X	4
	Voltage Stabilization	Stabilizer	X			.068	35318	5.42	X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Space Heating				X						
Re-Designing	Waste Heat Recovery System				X						
	Process Control Systems				X						
	R. F. Heating				X						

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Government Textile Weaving
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Payback Period (Years)
Boiler	Burner	Tuning	X			1.109	11754	8.65	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		.671	22223	15.89		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			.223	6583	4.7	Nil		
	Insulation	Insulate		X			23425	16.74	X		3
	Condensate Return	Piping		X		1.237	3211	2.29	X		3
	Feedwater Pretreatment	Chemicals	X			.382	6480	4.63	X		1
Flue Gas Waste Heat	Feedwater Preheating	Peat Exchanger		X							
	Process Air Waste Heat	Heat Exchanger		X							
Steam Losses	Pipe Insulation	Insulate		X					X		3
	Traps	Steam Traps	X						X		2
	Leakage	Repair	X			.419	7109	5.08	X		<1
	Distribution Network			X							
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs Load		X		.044	9504	6.79		X	4
	Voltage Stabilizer	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		3.38	11;92	8.0u		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control System				X					X	3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Karim Silk Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Medium Term	Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Major	Payback Period (Years)
Boiler	Burner	Tuning	X			15.267	153589	3.89	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		10.653	300211	7.57		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			8.116	200027	5.05		Nil	
	Insulation	Insulate		X			9663	.24	X		3
	Condensate Return	Piping		X		3.190	217856	5.51		X	3
	Feedwater Pretreatment	Chemicals	X			2.191	32400	.81	X		1
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X							
	Process Air Waste Heat	Heat Exchanger		X							
Steam Losses	Pipe Insulation	Insulate		X		} 22.724	336045	8.49	X		3
	Traps	Steam Traps	X						X		2
	Leakage	Repair	X						X		<1
	Distribution Network			X					X		
Electric Power	Power Factor	Adjustments				} .947	358689	9.06	X		1-3
	Motors	Match vs. Load		X						X	4
	Voltage Stabilizer	Stabilizers							X		3
	Moving Parts Maintenance								X		1-2
Waste Heat	Drying	Heat Exchanger		X		} 6.232	175621	4.44		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control System				X					X	3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Kohinoor Textile Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Medium Term	Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Major	Payback Period (Years)
Boiler	Burner	Tuning	X			1.055	16313	.13	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		17.961	1934660	16.22		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Matain & Clean	X			3.795	86239	.72	Nil		
	Insulation	Insulate		X			4950		X		3
	Condensate Return	Piping		X		1.049	61371	.04		X	3
	Feedwater Pretreatment	Chemicals	X			2.566	58320	.49	X		1
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X							
	Process Air Waste Heat	Heat Exchanger		X							
Steam Losses	Pipe Insulation	Insulate		X		} 8.500	193226	1.62	X		3
	Traps	Steam Traps	X						X		2
	Leakage	Repair	X						X		<1
	Distribution Network			X							
Electric Power	Power Factor	Adjustments	X			} 3.467	1098039	9.20	X		1-3
	Motors	Match vs. Load		X						X	4
	Voltage Stabilizer	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		} 2.360	254200	2.13		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery Systewm			X						X	2
	Process Control System				X					X	3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

Lawrencepur Woolen & Textile Mills
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Medium Term	Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Major	Payback Period (Years)
Boiler	Burner	Tuning	X			3.426	52968	.89	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		12.025	780341	13.08		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			3.308	125307	21.00		Nil	
	Insulation	Insulate		X			31628	.53	X		3
	Condensate Return	Piping		X		1.623	95479	1.60	X		3
	Feedwater Pretreatment	Chemicals	X			7.602	172800	2.89	X		1
Flue Gas Waste Heat	Process Air Waste Heat	Heat Exchanger		X							
Steam Losses	Pipe Insulation	Insulate		X					X		3
	Traps	Steam Traps	X						X		2
	Leakage	Repair	X			8.506	193330	3.24	X		<1
	Distribution Network			X							
Electric Power	Power Factor	Adjustments	X						X		1-3
	Motors	Match vs. Load		X		1.301	423308	7.09		X	4
	Voltage Stabilizer	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		4.427	287343	4.81		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control System				X					X	3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.

PLANT SUMMARY

National Dyeing & Finishing Center
(Plant)

ENERGY CONSERVATION OPPORTUNITIES*

Process/ Equipment	Area of Improvement	Improvement Action/ Equipment Required	Timing of Action: Short Term	Timing of Action: Medium Term	Timing of Action: Long Term	Estimated Annual Energy Savings (10^3GJ)	Estimated Cost Savings (Rs)	Percent Saving of Total Energy Cost	Equipment Investment: Minor	Equipment Investment: Major	Equipment Investment: Payback Period (Years)
Boiler	Burner	Tuning	X			7.241	98787	8.35	X		<1
	Flue Gas Waste Recovery	Waste Heat Recovery System		X		5.429	146751	12.44		X	3
	Blow Down Recovery	Economizer		X					X		2
	Maintenance & Cleaning	Maintain & Clean	X			2.267	75772	6.42	Nil		
	Insulation	Insulate		X			15232	1.29	X		3
	Condensate Return	Piping		X		2.049	41083	3.48		X	3
	Feedwater Pretreatment	Chemicals	X			.969	19440	1.65	X		1
Flue Gas Waste Heat	Feedwater Preheating	Heat Exchanger		X							
	Process Air Waste Heat	Heat Exchanger		X							
Steam Losses	Pipe Insulation	Insulate		X		4.534	90926	7.71	X		3
	Traps	Steam Traps	X						X		2
	Leakage	Repair	X						X		<1
	Distribution Network			X							
Electric Power	Power Factor	Adjustments				.345	70076	5.94	X		1-3
	Motors	Match vs. Load		X						X	4
	Voltage Stabilizer	Stabilizers	X						X		3
	Moving Parts Maintenance		X						X		1-2
Waste Heat	Drying	Heat Exchanger		X		3.491	94364	7.99		X	4
	Space Heating				X					X	5
Re-Designing	Waste Heat Recovery System			X						X	2
	Process Control System				X					X	3
	Microwave Heating				X					X	2

* Requires detailed engineering plant feasibility study to finalize savings and verify economics. This summary is provided as a rough guide. For some improvement actions, the preliminary audit data was not sufficient to provide energy and cost savings estimates.