# FEASIBILITY STUDY REPORT
# ON
# THE SMOKELESS COAL BRIQUETTES
# DEVELOPMENT PROJECT
# IN
# THE ISLAMIC REPUBLIC OF PAKISTAN

JANUARY, 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

# FEASIBILITY STUDY REPORT
# ON
# THE SMOKELESS COAL BRIQUETTES
# DEVELOPMENT PROJECT
# IN
# THE ISLAMIC REPUBLIC OF PAKISTAN



JANUARY, 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

# PREFACE

In response to a request from the Government of the Islamic Republic of Pakistan, the Japanese Government decided to conduct a study on the Smokeless Coal Briquettes Development Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Pakistan a study team headed by Mr. Koji Tanaka, Techno Consultants, Inc. on two occasions: from March 15 to March 26 and from June 20 to July 20, 1988.

The team held discussions with concerned officials of the Government of the Islamic Republic of Pakistan, and conducted field surveys. After the team return to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the development of the project and to the promotion of friendly relations between our two countries.

I wish to express my sincerest appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the team.

January, 1989

Kensuke Yanagiya
President
Japan International Cooperation Agency

# INTRODUCTION

The purpose of this feasibility study is to investigate the feasibility of a government-sponsored plan for establishing a coal briquette plant at Lakhra to produce coal briquettes of good quality that could substitute for kerosene and, if possible, firewood, and to present appropriate recommendations regarding the implementation if the project is found feasible. This project has particular importance in the context of balance of payments problem, because a large sum of foreign exchange is spent for the importation of kerosene and the consumption of kerosene is forecast to increase.

Broadly speaking, the study consists of a market study, social study, technical study and financial and economic evaluations. The market study played an instrumental role in determining the capacity of the plant and the price of coal briquettes. The social study looked into the availability and prices of the main and subordinate raw materials and conditions of infrastructure and public utility. The technical study covered process and mechanical aspects. The study on process aspect included experimental production of coal briquettes from the local raw materials and their burning test to determine the optimum blending ratios of the raw materials and the process best suited to the planned coal briquettes. The study on mechanical aspect covered, in addition to the design of the manufacturing facilities and estimation of the cost, evaluation of the capability of promising local constructors, machine manufacturers and engineers. The technical study also included development of the design of stoves ideal for burning the coal briquettes. The financial and economic evaluations assessed the project regarding the financial feasibility and economic feasibility of the the project, the latter being a national and social benefits and costs analysis.

In accordance with the agreement between Pakistan Mineral Development Corporation (PMDC) and the Japan International Cooperation Agency (JICA), this feasibility study was executed in two

stages: the first-stage study from March to June and the second-stage from June to December 1988. The first-stage study examined the market aspect and completed with the presentation of Interim Report to PMDC in June; the second-stage study immediately succeeded the first-stage study given that good prospect of market feasibility was confirmed. The second-stage study was a techno-economic study comprising all aspects with the exception of the market which normally make up an industrial feasibility study. This feasibility study report includes not only the results of the second-stage study but the market study, with some corrections made to the previous submission.

The scope of work given to the study team did not define the project except that the main raw material would be the Lakhra coal and (an) appropriate kind(s) of biomass would be blended. It was up to this feasibility study to make recommendations as to the size of the project, i.e., initial capacity of the manufacturing plant and subsequent expansions, quality of the product, kinds of raw materials to be used, the blending ratios of the raw materials, processing scheme, location of the plant, strategy for marketing the product, the system of management, and the price structure. The first-stage study, or market study, determined the desired quality of the coal briquettes, forecast the demand of the coal briquettes, and developed the price of the coal briquettes. The second-stage investigated all techno-economic aspects of the project. The results of the first-stage study were reviewed and corrected as necessary in the light of the results obtained from the second-stage study.

Three cases of the capacity were developed: Cases 1, 2 and 3. Case 1 supposes that the plant will always be run at 100 percent capacity. Case 2 will be run not at full capacity but with some allowance for increasing production in case the demand suddenly increases. Case 3 assumes continuation of the subsidy price now given to kerosene. Cases 1, 2 and 3 are further divided into Cases 1A, 2A and 3A and Cases 1B, 2B and 3B, respectively. Cases with A presume use of imported washing and mixing/briquetting facilities for the initial plants while Cases with B will use all domestically produced machines. Case 1A shows sound financial

feasibility; therefore, this feasibility study evaluates Case 1A of this project as worth promoting and presents recommendations regarding the effective methods of its implementation.

To grasp the major conclusions and recommendations only, reference should be made to a summary version which is submitted together with this report.

## CONTENT

# CHAPTER 1 BACKGROUND

## 1-1 Outline of the Project

This project plans to produce coal briquettes by processing the lignite produced in Lakhra Coal Mine and other subordinate domestic raw materials produced in the Province of Sind. It is up to this feasibility study to make appropriate recommendations as to the size of the project, or the initial capacity of the manufacturing plant and subsequent expansions to be exact, kinds of raw materials to be used, the blending ratios of the raw materials, processing scheme, location of the plant, quality of the product, strategy for marketing the product, the system of management, and the price structure.

The most important objective of this project is to provide coal briquettes which could be used for household consumption as a safe and inexpensive substitute for kerosene and thus save foreign currency required for importation of kerosene.

This project will be implemented by Pakistan Mineral Development Corporation, or PMDC for short, a governmental organization.

As a result of this feasibility study, the project scheme has been established as follows:

(1) The following cases were established for study.

| | Capacity, tons/year | | Facility | |
|---|---|---|---|---|
| Case | Initial | Ultimate | Washing plant Mixing/Briquetting | Others |
| Case 1A | 50,000 | 300,000 | imported | domestic |
| Case 1B | 50,000 | 300,000 | domestic | domestic |
| Case 2A | 100,000 | 300,000 | imported | domestic |
| Case 2B | 100,000 | 300,000 | domestic | domestic |
| Case 3A | 50,000 | 300,000 | imported | domestic |
| Case 3B | 50,000 | 300,000 | domestic | domestic |

(2) Plant location

A flat piece of land close to the mine office near the operating shafts located about one and half kilometers from the main road running through Lakhra Coal Mine, 80 kilometers to the northwest of Hyderabad of Sind Province. The site is in Lease No.88.

(3) Raw material requirement, ton per ton product

| | |
|---|---|
| Main raw material | |
| Lakhra coal | 1.250 |
| Subordinate raw material | |
| Bagasse | 0.325 |
| Slaked lime | 0.0625 |
| Slack wax | 0.006 |
| Light oil | 0.044 |
| Fuel | |
| Lakhra coal | 0.373 |

(4) Process scheme

The process scheme is proposed as indicated on Figure 1-1-1, Process Scheme, shown at the end of this section.

(5) Quality of product

Ignition

The coal briquettes should be easy to ignite and reach a steady state burning condition within five minutes of ignition.

Strength of flame

The strength of the flame should be comparable with the flame of firewood.

Smokelessness

The coal briquettes should not produce an objectionable level of smoke when burned in average Pakistani kitchens.

Odorlessness

The coal briquettes should not produce an objectionable level of odor when burned in average Pakistani kitchens.

Safety

The coal briquettes should not produce combustion gas and ash poisonous to man and animals.

Easiness of control

The strength of the flame should be simple and easy to control.

Water resistance

The coal briquettes should not allow water to diffuse inside them.

Physical strength

The coal briquettes should have sufficient physical strength to withstand rough handling associated with transportation and storage.

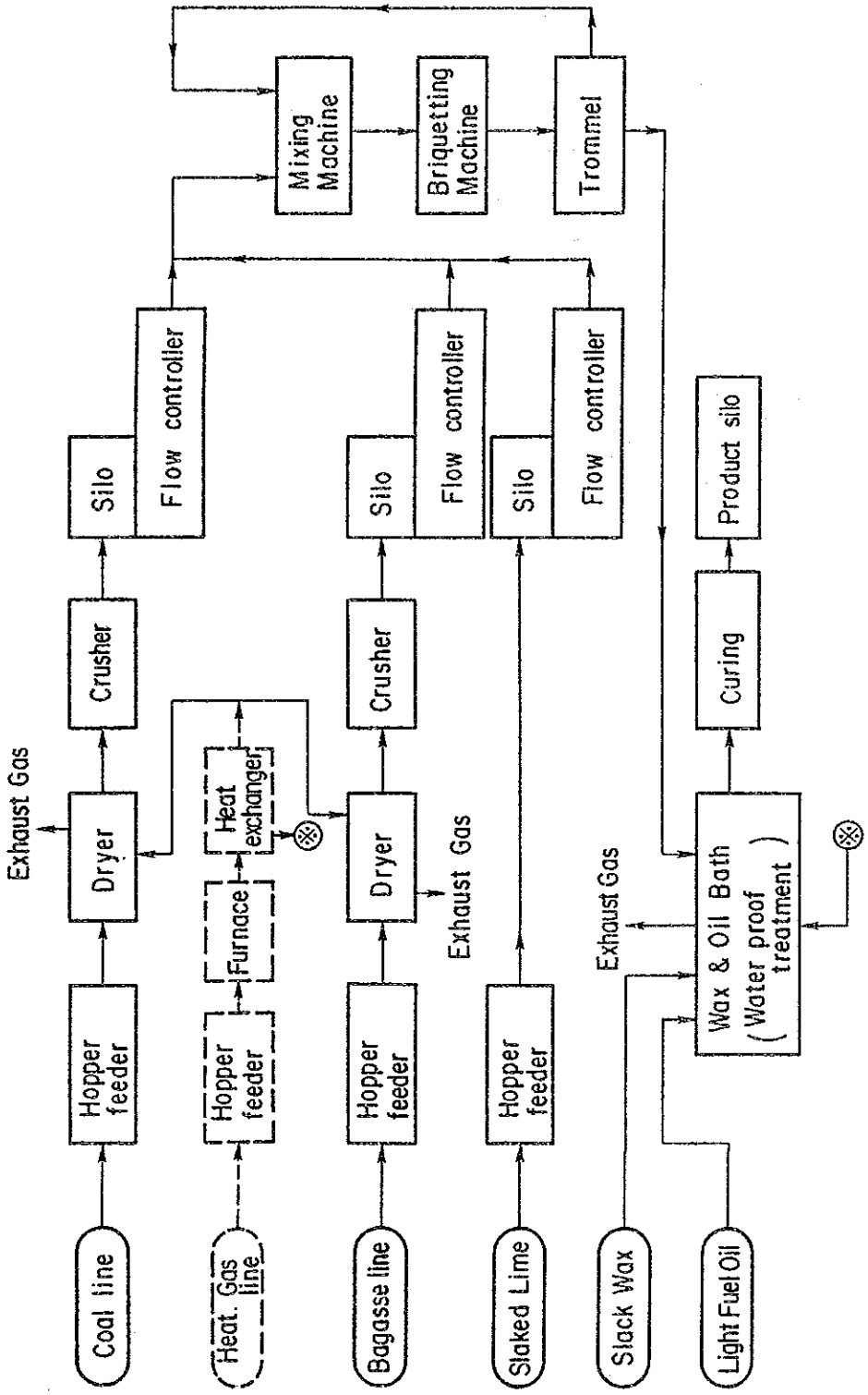



Figure 1-1-1 Process Scheme

## 1-2 Social and Natural Background

Pakistan extends from latitude 37 degrees North to latitude 24 degrees North close to the Tropic of Cancer. Pakistan shares borders with India on the east, with China on the northeast, with Afghanistan on the northwest, and with Iran on the west. On the south the country is open to the sea. The major cities and centers of population develop along the Indus River. The Province of Baluchistan which borders Afghanistan and Iran is arid and is only thinly populated. The northern part of the country occupies part of the Himalayan mountains.

The area of the country and its breakdown is given in Table 1-2-1.

**Table 1-2-1 Area by Province**

| | Area, square kilometer |
|---|---|
| Punjab | 205,345 |
| Sind | 140,914 |
| NWFP | 74,521 |
| Baluchistan | 347,190 |
| FATA | 27,220 |
| Islamabad | 906 |
| TOTAL | 796,096 |
| | |
| Gilgit Agency | 35,156 |
| Disputed Area | about 210,000 |

Source: Atlas of Pakistan

Winter is severe in the northwestern part of the country. However, the area along the Indus River is blessed with mild climate, although temperature often exceeds 40 degrees Celsius. Table 1-2-2 shows precipitation and range of temperature variation for major cities.

**Table 1-2-2 Climatic Feature of Major City**

| | Precipitation millimeter | | | Mean Max. Temp. degree Celsius | | | Mean Min. Temp. degree Celsius | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1985 | 1986 | 1987 | 1985 | 1986 | 1987 | 1985 | 1986 | 1987 |
| Punjab | | | | | | | | | |
| Faisalbad | 235 | 344 | 363 | 31.4 | 30.3 | 31.5 | 17.0 | 16.5 | 17.0 |
| Lahore | 736 | 612 | 490 | 31.7 | 30.7 | 31.9 | 18.3 | 17.7 | 18.4 |
| Multan | 158 | 219 | 109 | 33.3 | 32.1 | 33.1 | 17.8 | 17.6 | 18.3 |
| Islamabad | 1124 | 937 | 859 | 29.8 | 28.1 | 29.7 | 14.5 | 12.3 | 14.2 |
| Sind | | | | | | | | | |
| Hyderabad | 116 | 179 | 16 | 34.5 | 34.5 | 35.9 | 20.8 | 20.9 | 21.5 |
| Karachi | 155 | 92 | 16 | 32.1 | 31.7 | 32.6 | 20.0 | 19.8 | 20.4 |
| NWFP | | | | | | | | | |
| D.I.Khan | 139 | 335 | 159 | 33.1 | 31.0 | 32.2 | 14.9 | 15.8 | 17.2 |
| Peshawar | 341 | 416 | 343 | 30.5 | 29.5 | 30.5 | 16.3 | 15.5 | 14.5 |
| Baluchistan | | | | | | | | | |
| Quetta | 257 | 244 | 156 | 25.3 | 23.9 | 25.7 | 7.6 | 8.7 | 7.7 |

Source: STATISTICAL POCKET BOOK OF PAKISTAN 1988

The Province of Punjab, although not blessed with sufficient rainfall, supports a well developed agriculture, thanks greatly to high temperature and abundant supply of water from the River Indus and constitutes the backbone of the nation's economy. The arboreal vegetation is very sparse in spite of the natural conditions which could support forest development. In the Province of Sind agriculture and forestry develop only along the River Indus; desert or semi-desert stretches over dry terrain where there is no irrigation to supply water. In the Province of Baluchistan precipitation is generally less than 250 millimeters and desert predominates except at oases and along small rivers. There are some areas in the northeastern region where precipitation exceeds 500 millimeters; cultivation of wheat prospers there. Overall,

forests are sparse even in areas where agriculture is feasible; wood and timber are not abundantly available and generally very valuable. The houses of the general populace are made of bricks and make very little use of wood. The most common fuel for the great majority of people living outside the areas covered by city gas networks is biomass; however, firewood accounts for only about half the biomass consumption, the rest being a variety of agricultural wastes and cow dung. The fact that there is not even sufficient supply of firewood for the great mass of middle and low income strata constitutes a very important background of this project.

Now, the distribution of population is looked into. Table 1-2-3 gives distribution of population by province.

**Table 1-2-3 Distribution of Population by Province**

| Province | Population 1,000 | Area sq km | Population Density |
|---|---|---|---|
| Islamabad | 340 | 906 | 376 |
| Punjab | 47,292 | 305,344 | 230 |
| Sind | 19,029 | 140,914 | 135 |
| Baluchistan | 4,332 | 347,190 | 12 |
| NWFP | 11,061 | 74,521 | 148 |
| Fata | 2,199 | 27,220 | 81 |
| Pakistan Total | 84,253 | 796,095 | 106 |

Source: 1981 Census

It should be noted that the Province of Punjab has more than half the entire population. This deserves particular consideration in the formulation of this project: along with the status of this province being the mainstay of the nation's economy mentioned previously, the largest population represents the most promising market for this project.

Pakistan is not richly endowed with underground resources including fossil energy resources. Table 1-2-4 gives the proven reser-

ves of petroleum and natural gas and estimated reserves of coal.

**Table 1-2-4 Fossil Energy Endowment**

| | | | Oil equivalent million ton |
|---|---|---|---|
| Petroleum | 139.4 | million barrels | 18.8 |
| Natural gas | 16,070 | billion cubic feet | 405 |
| Coal | 510 to 1,180 | million tons | 708 |
| Total | | | 1,132 |

Note: For coal the larger extreme is taken to calculate the total.

Source: Energy Year Book 1986

Against such endowment of the reserves, the past consumption of fossil commercial energy is as shown in Table 1-2-5.

**Table 1-2-5 Consumption of Fossil Commercial Energy**

(thousand ton oil equivalent)

| Year | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Petroleum products | 4,367 | 4,847 | 5,514 | 6,100 | 6,615 | 7,057 |
| Natural gas | 5,955 | 6,591 | 6,632 | 6,641 | 7,026 | 7,226 |
| Coal | 1,577 | 1,750 | 1,609 | 1,869 | 2,238 | 2,202 |
| Total | 11,898 | 13,188 | 13,755 | 14,610 | 15,878 | 16,485 |

Source: Energy Year Book 1986

Note: Metric ton is used for petroleum Products.
Imported metallurgical coal is excluded.

The economy of Pakistan depends largely on petroleum and natural gas. Further, it is obvious from the comparison between Tables 1-2-4 and 1-2-5 that the consumption of fossil commercial energy does not follow the patterns of resource endowment: the consumption of petroleum products is disproportionately large while that of coal is disproportionately small. It should be remembered

that petroleum is supplied predominantly by import with an associated large foreign currency outflow. It is largely against such a background that the government of Pakistan is very keen about promotion of effective utilization of domestic coal. It might be added that the potential for further development of hydroelectric power is not very promising and that the nuclear power development is only in the nascent stage.

Looking at household energy consumption, non-commercial energy is still predominantly large on one hand but the consumption of kerosene has been very rapidly increasing recently on the other as shown in Table 1-2-6. The latter trend is undesirable from the standpoint of balance of payments; Pakistan may be classified as a non-oil producing country.

**Table 1-2-6 Household Energy Consumption**

(thousand ton oil equivalent)

| Year | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Kerosene | 599 | 650 | 754 | 828 | 882 | 969 |
| Natural gas | 562 | 664 | 755 | 875 | 995 | 1,071 |
| Electricity | 767 | 893 | 1,079 | 1,208 | 1,391 | 1,620 |
| Coal | 10 | 10 | 10 | 7 | 6 | 3 |
| Non-com. Energy | | | | | 8,962 | |

Source: Energy Year Book 1987 and 1985

Note: Electricity is indicated in primary input which is to be multiplied by 0.3422 to obtain end consumption.

Any further increase of the supply of non-commercial energy is something unexpected of in view of the severely depleted forest resources. The government is in the process of reviewing the price formula of various types of energy with a view to rationalizing the nation's pattern of energy consumption. As a practical result of such reviewal, consumption of gas by certain industries has been banned. The government has also decided to promote effective utilization of coal hitherto used almost entirely for baking bricks; a plan to install a 50 megawatt coal-fired

power station has been almost decided. Further, the Sixth Five Year Plan explicitly mentions a plan to install at strategic locations plants to produce coal briquettes from domestic coal for household consumption.

The cooking places of the traditional houses are normally just outside the living quarters and are of semi-open structure. Their cooking stoves are mostly made of earth placed on the floor against one of the walls; the simplest and most extensively used ones are of the shape of hoof with the front side open for feeding fuels. This type of stove can burn just about everything that burns; however, with this type of stove it is not possible to control volumes of the primary and the secondary air and therefore not ideally suited to combustion of the coal briquettes. Accordingly, it is desired that stoves suited to burning coal briquettes be made available at cheap prices as coal briquettes are introduced to the market. Since Pakistan has well-developed and highly capable cottage industries serviced by skilled craftsmen, it is not necessary to produce machine-made stoves; all that is needed is to make the standard design of stoves for briquettes known among the craftsmen and let them produce and sell them at roadside.

## 1-3 History of the Feasibility Study

The production of coal briquettes presumably started in 1942 when a coal briquette manufacturing plant, which was initially constructed in Assam of India in the 1930s, was moved to Quetta, Buluchintan, and put to operation. Although the plant has become very obsolete by now, the plant is still operated by PMDC feeding the coal produced in that area. The capacity of the plant is 50,000 tons per year. However, the plant is now operated only in winter producing about 5,000 tons per year. The coal briquettes produced in Quetta are not necessarily suited for household consumption because of the coal briquettes being not easy to ignite in addition to the smoke produced upon combustion. The coal briquettes are demanded mainly by the local army.

In the household sector the consumption of kerosene, electricity and natural gas has been increasing; particularly that of kerosene is increasing at a rate almost alarming to non-oil producing Pakistan causing a serious concern over the associated adverse effect on the balance of payments situation. As one of measures to counter such a trend the government has explicitly declared as part of the Sixth Five Year Plan for 1983/1988 an intention to construct plants of economic scale at major coal mines for manufacturing smokeless coal briquettes that could substitute for kersene discussed in Chapter 11 on MINERALS: ACCELERATED EXPLORATION AND DEVELOPMENT. This should be taken as a manifestation of the policy to curb the increasing consumption of kerosene and at the same time to promote effective utilization of coal. In line with such a grand policy of the government, PMDC had been conducting research experiments for the production of smokeless coal briquettes of its own as well as in cooperation with various research institutes.

Against such a background, the government of Pakistan filed a request with the government of Japan for cooperation in the form of a feasibility study on manufacturing coal briquettes for household consumption based on Lakhra lignite. Japan produces of its own technology coal briquettes of various quality; therefore, Japan was able to properly respond to the request of Pakistan.

The government of Japan sent a preliminary survey team of Japan International Cooperation Agency (JICA) to Pakistan from November 30 to December 9, 1987 to conduct necessary surveys and to have talks with the government officials of Pakistan. The preliminary survey team of JICA concluded the mission by agreeing with PMDC, the counterpart agency, and the Ministry of Petroleum and Natural Resources on SCOPE OF WORK (S/W).

As agreed on S/W this study has been conducted in two stages; the first-stage study specializing in studying feasibility of marketing and the second-stage study in techno-economic investigation. The first-stage study started in March and ended with the presentation of of Interim Report in June of 1988.

## 1-4 Objective of Study

The primary objective of this study is to investigate techno-economic feasibility of a coal briquettes project which aims at producing coal briquettes from domestic raw materials, specifically Lakhra coal and domestic subordinate raw materials, for household consumption to substitute for imported kerosene thereby contributing to decreasing foreign currency outflow.

More specifically, the objective is to accomplish the items below:

1. Market study

(1) To review the prices of competing fuels at consumers end and to work out a competitive price structure of the coal briquettes at the consumers end which would make this project feasible;

(2) To develop quality design of the coal briquettes which would make the coal briquettes acceptable to most consumers, reflecting the ways the general consumers use various fuels;

(3) To look into the business practices, distribution of commodities, means for distribution and marketing of other fuels, and the resources the project promoter has at its disposal, and to recommend the method of marketing best suited to this project; and

(4) To forecast the demand of coal briquettes in the future and to develop the initial capacities of the plant and programs for future expansion;

2. Techno-economic study

(1) To collect and airfreight to the Japanese test site necessary primary and subordinate raw materials, and test them and experimentally establish the process of manufac-

turing coal briquettes of the quality close to that found desirable by the above market study;

(2) To study the long-term availabilities and prices of the primary raw material, coal, and subordinate raw materials, biomass, slaked lime, etc.;

(3) To select and evaluate the plant site and conditions of infrastructure and public utility, availability and prices of such public utility as water and electricity;

(4) To collect information and data on costs of construction and operation of the manufacturing plant;

(5) To develop the conceptual design of the plant, its material and utility balance;

(6) To estimate the cost of construction of the plant, total capital requirement and operating cost;

(7) To conduct financial and economic evaluation of the project and present overall evaluation;

(8) To present appropriate recommendation as to the implementation of the project; and

(9) To recommend designs of stoves found suited to the combustion of coal briquettes based on the burning tests of the experimentally produced coal briquettes.

## 1-5 Scope of Work

In accordance with the Scope of Work agreed between PMDC and JICA, the scope of work of this feasibility study consists of the items below:

First-stage study

1. Survey on the background of the project

(1) National policy on, and present situation of the energy in Pakistan

(2) National policy on, and present situation of coal industry in Pakistan

2. Survey on the energy consumption

(1) Classification of energy use by industrial sectors and household sectors

(2) Trend of energy consumption by sectors

(3) Acts and regulations governing usage of fuels

3. Survey on the coal briquettes market and its distribution system

(1) Review of reports available on the above and the studies carried out so far

(2) Price trends of coal briquettes and its alternatives

(3) Quality and quantity demand for the coal briquettes by sectors

(4) Reasonable price structure for the consumer side by sectors

(5) Consumers' response to different types of fuels

(6) Present and potential distribution system of coal briquettes and other fuels

4. Overall evaluation on the market feasibility

Second-stage study

1. Resources and materials for producing the coal briquettes

(1) Volume and quality of lignite at the Lakhra coal mine

(2) Quality and supply of other materials for briquettes production

2. Production technology for producing coal briquettes

(1) Review of coal briquettes production technology and its combustion technology developed in Pakistan

(2) Review and evaluation of available data/reports

(3) Test and analysis of production of smokeless briquettes made from Lakhra coal

(4) Test and analysis of combustion of smokeless briquettes

(5) Preparation of production process flow diagram

(6) Transportation and supply scheme of coal and other relevant raw materials

3. Construction study of the briquettes manufacturing plant

(1) Site selection

(2) Conceptual design and cost estimation of the plant

(3) Supply methods of resources and material

(4) Utilities (water, sewerage, electricity, etc.)

(5) Construction schedule

4. Operation plan

(1) Operation schedule

(2) Operation and management organization of the project

5. Economic evaluation of the project

(1) Economic comparison between coal briquettes and other existing fuels

(2) Financial analysis of the project

(3) Economic and social evaluation

6. Conclusion and recommendations

## 1-6 Method of Study

Figures 1-6-1 and 1-6-2 schematically show the study flows for the first-stage and second-stage studies. The first-stage study aimed at establishing market feasibility of coal briquettes was concluded by presenting the Interim Report which bridged the first- and second-stage studies. After the first-stage study had found the market quite promising, the second-stage study was started.

### 1-6-1 First-stage study

The first-stage study began with a field survey which started on March 15 and ended on March 26, 1988 to collect information and data. This project aims to produce coal briquettes mainly to replace household kerosene and firewood. Therefore, the demands and prices of kerosene and firewood had to be forecast at first; the forecast of the demand was done by means of simplified econometric methods using as parameters GDP, population, household number, elasticity of the increase of household energy consumption with respect to the growth of GDP per household. Since there is little room for further increase of the supplies of firewood and other biomass fuels, it was assumed that the most of the increase in demand will have to be met by kerosene. In parallel with this demand study, supply possibility of kerosene was studied. By combining the demand side study and supply side study, the future demands of kerosene was developed as a function of assumed growth rate of GDP. The price of kerosene was derived from the forecast crude oil price plus phasing out of the subsidy price now given to kerosene.

Along with this, price of coal briquettes at the market as function of transportation cost from the plant was worked out using assumed raw coal cost, transportation cost obtained during the field survey and assumed manufacturing cost plus some margin of profit for the operation. The entire Pakistan was divided into five zones in the order of increasing cost of transportation; different prices of coal briquettes were developed for these zones. Thus, the distances of transportation within which coal

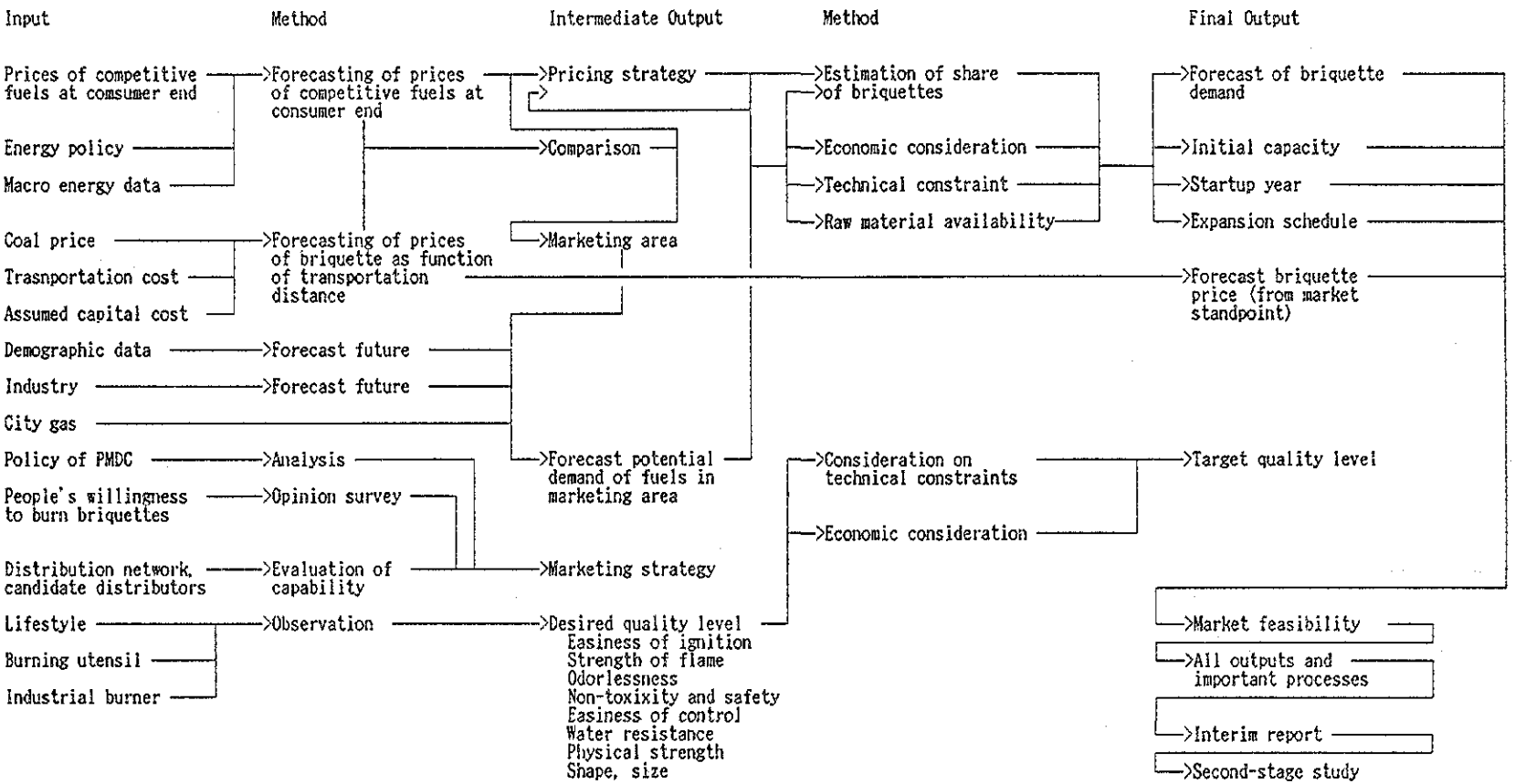



**Figure 1-6-1 First-stage Study Flow**

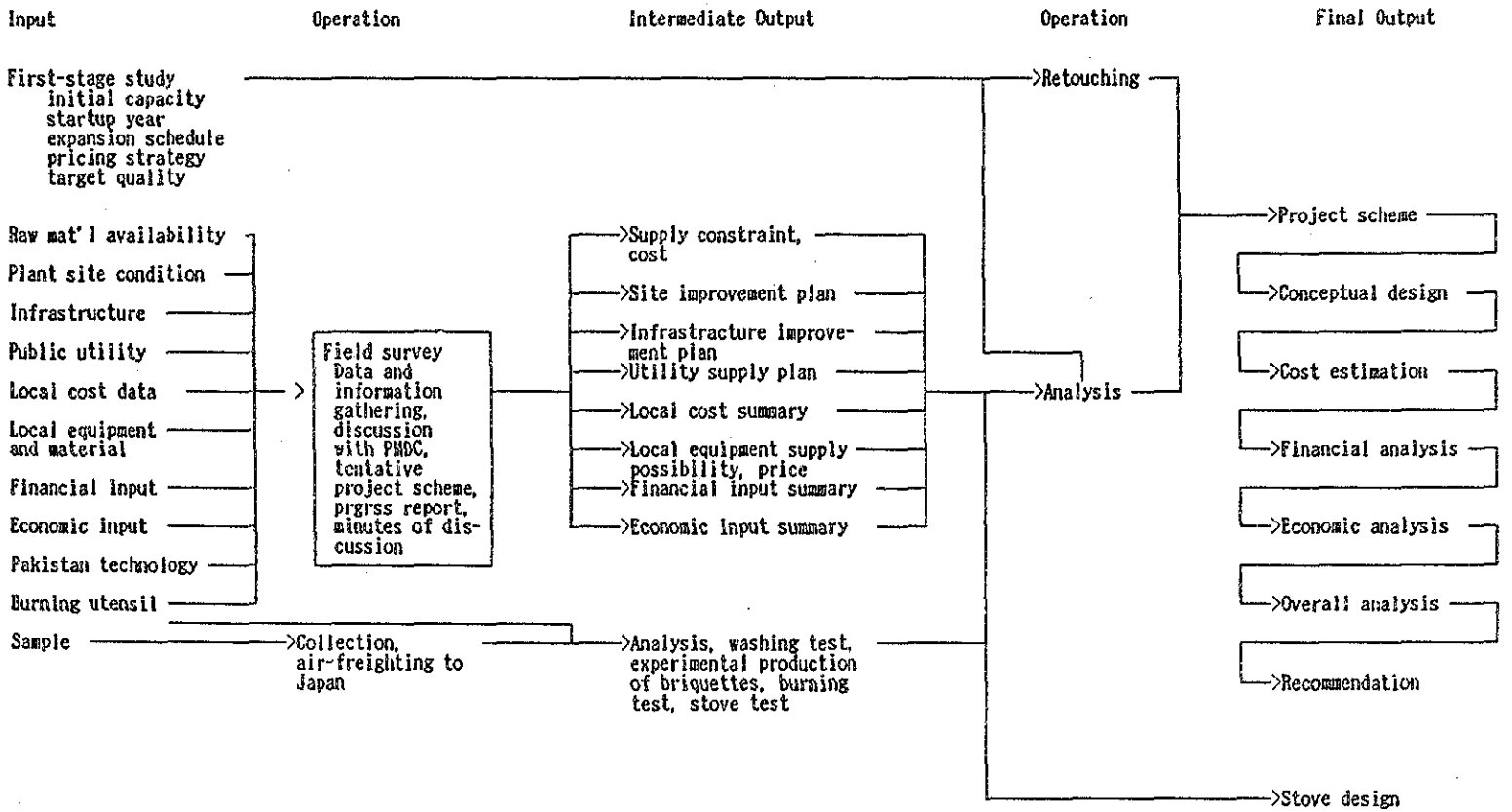



Figure 1-6-2 Second-stage Study Flow

briquettes could be competitive with kerosene, or firewood, were obtained.

The next question was how big is the forecast demands of competitive fuels, kerosene or firewood, for each zone and to what extent the competitive fuels may be expected to be replaceable by the coal briquettes. The approach to this question required estimation of the demands of the competitive fuels for each zone. This was done firstly by estimating the population that burns kerosene and firewood in each zone and then by distributing the forecast nationwide demand of kerosene and firewood to each zone in proportion to the population. In the estimation of the demand for each zone those who would be served by city gas were not counted and the effect of winter temperature on space heating demand was considered.

To what extent the competitive fuels may be replaceable by coal briquettes were determined in terms of percentage of coal briquette price on the prices of competitive fuels. The extent of replacement of the competitive fuels by the coal briquettes was translated into forecast annual production of coal briquettes and then the initial capacities and programs for expansions of the capacity. Two cases were developed for the initial capacity and expansion program. While working out the capacities, economic aspects of the project and technical constraints were considered.

Regarding the distribution and marketing, the existing organizations of demonstrated capability were examined; PMDC' rock salt dealers, PMDC' coal dealers, PSO's kerosene dealers, and free merchants including firewood/charcoal dealers were examined; some of them were actually interviewed for evaluation of their capability and confirmation of interest in the business. In figuring out the strategy for marketing, the marketing practice actually done by PMDC for marketing rock salt and coal were referred to: PMDC sells them ex-mine; in other words, the dealers actually command distribution and marketing, promote sales, finance their operations and come to PMDC with the transportation they arrange. The fact that PMDC does not maintain and operate a large organization required for marketing was also considered.

Consumers acceptance was given a serious thought, because this feasibility study did not allow time for a large-scale opinion survey with demonstrations of briquette burning in the presence of the potential consumers. To facilitate consumers acceptance the quality of the briquettes was so designed that the consumers could burn them just as they burn kerosene or firewood without having to learn anything new. This is not entirely possible but the study team came as close to this objective as possible under the prevailing circumstance of Pakistan. The desired quality of the briquettes thus obtained from the consumers acceptance viewpoint was reviewed in the light of technical and economic constraints and the target quality level was determined for experimental production to be conducted in the second-stage study.

The first-stage study concluded with the presentation to PMDC of the Interim Report in June 1988 and acceptance of the report by PMDC.

### 1-6-2 Second-stage study

The second-stage study succeeded the first-stage study without recess. The field survey started on June 16 with the arrival in Pakistan of the members of the second-stage study team. The information and data collected concerned raw material availability and cost, plant site condition, infrastructure, public utility, local cost data, local equipment and materials, conditions of inputs to financial evaluation and economic evaluation, etc. Visit to the project site for observation and collection of the raw material samples and air-freighting them to Japanese test site were important assignments in the field survey. Unfortunately, the study team was unable to visit the project site because of the civil unrest that occurred in that area during the field survey period. The first-hand observation of the project site the study team intended to get by the visit to the site had to be supplemented by information and data collected in Karachi and Islamabad: this was particularly so with the plant site condition, infrastructure around the plant site and conditions of public utility at the site. In addition to Islamabad and Karachi the study team visited Quetta to see the PMDC' existing coal

briquette plant.

The information and data obtained were analyzed and evaluated with the counterparts while they were being collected. An important key step for the second-stage study is establishment of the project scheme; it was done in two steps: first establishing a tentative project scheme at the closing stage of the field survey, and then establishing a definitive project scheme at the home-office. A series of discussions were held between the counterpart and the study team to establish a common understanding about the tentative project scheme. The project scheme actually defines the project in terms of all the constraints surrounding the project, policy of the government and the promoter, economic and technical consideration, etc. The process to arrive at the project scheme will be elaborated in Chapter 8, PROJECT SCHEME.

The samples of Lakhra coal, bagasse, wheat straw, cotton seed oil extraction residue, limestone, slaked lime and cement were collected by PMDC in necessary amounts and sent to the Japanese test site. At the Japanese test site all the samples were tested for chemical and physical properties. The coal samples were first tested for amenability to coal washing operation for reduction of ash and sulfur. The raw coal and washed coals were subjected to briquetting experiments with the subordinate raw materials to establish ranges of compositions in which coal can be briquetted into hard solids. Within such a range, the recommended composition was determined mainly from techno-economic standpoint and availability constraints of the raw materials. After the recommended composition had been finalized, conceptual design of the plant and associated facilities was carried out.

By that time, the local cost data, prices of locally procured equipment and materials, and also inputs to the financial evaluation had been assessed and the program for financial evaluation developed. The costs of investment and operation were estimated of the conceptual design. The total capital requirement was calculated using the estimated capital investment and financial inputs. Financial and economic evaluations were done on the

profits and benefits against the investment and costs.

Finally, the following three cases were established for evaluation:

Case 1: This case starts with 50,000 tons per year and is expanded as the demand develops in a manner to maintain a full-capacity operation.

Case 2: This case starts with 100,000 tons per year and is expanded as the demand develops but in a manner to have some allowance in capacity.

Case 3: This case assumes that the subsidy on kerosene will remain; therefore, the growth of the demand of coal briquettes is slower.

These three cases have two sub-cases of A and B; namely Case 1A and Case 1B, Case 2A and 2B, and Case 3A and 3B. Cases with A assume use of imported washing and mixing/briquetting machines for the initial plant; while cases with B use domestic machines only.

The overall evaluation was passed on the project from various angles: technical constraints, raw material availability, results of financial and economic evaluation, contribution to the nation and society, compliance with the policy of the government, etc. Based on all these, appropriate recommendations were presented to help realize the maximum benefit from the project and to facilitate smooth implementation.

## 1-7 Study Team

The study team for this feasibility study consists of the following members:

First-stage study member

| | |
|---|---|
| Koji TANAKA | Team leader |
| Masayuki INOUE | Fuel market and distribution |
| Taizo HAYASHI | Energy study, socio-economic analysis |

Second-stage study member

| | |
|---|---|
| Koji TANAKA | Team leader |
| Ryuichi HIRAIWA | Coal briquette |
| Saburo ARAI | Design and cost estimation |
| Kenju CHIMURA | Raw materials |
| Shizuo KAMIKURA | Infrastructure & utility |
| Yasunori KATO | Financial & economic evaluation |
| Mamoru MIYAMORI | Coal briquettes production and burning test |

# CHAPTER 2 GENERAL CONDITIONS OF THE ISLAMIC REPUBLIC OF PAKISTAN

## 2-1 Natural Conditions of Pakistan

### 2-1-1 Geographical Aspects

Pakistan is located in the west edge of the Indo-Asia Continent, facing Iran and Afghanistan to the west, the USSR and China to the north, and the Arabian Sea to the south. The total area of the country is about 800 thousand sq. km. The country consists of a mountainous area in the north and plains mainly along the basin of the Indus River. The Karakoram Range and Hindu Kush of the Himalaya System run in the northeast; the Baluchistan Plateau stretches along the west, and the Indus River flows from the north through the center of the country to the south into Arabian Sea. The country is latitudinally located in the subtropical zones, but has a hot and dry climate, especially in the southern and the western parts of the country with deserts. The Punjab area in the heart of the country is an alluvial plain surrounded by the four tributaries of the Indus River, namely from north the Jhelum River, the Chenab River, the Ravi River, and the Sutlej River, and comprises the most important agricultural area.

### 2-1-2 Climate

The climate of Pakistan is roughly divided into three types: The mountainous area in the northern part has an alpine climate. The Punjab area in the central part has a steppe climate or a temperate-rainy-summer climate and is hot with some rain in summer due to monsoons. The area is cool in winter. The southern part has a dry steppe and desert climate with the Sind area and the Thar Desert in the southeast and Baluchistan in the southwest. The scenery changes from evergreens in the mountains to tropical shrubs toward the lowlands, and changes from semi-desert to desert in approaching the Thar Desert. The seasons change as follows: the summer season starts in April and lasts until October, during which there is a monsoon season from July to Septem-

ber. The cold season starts in November and lasts until March. Pakistan is one of the regions with the least rainfall in the whole of the Indo-Asia Continent; the average annual rainfall ranges from only 200 mm to 300 mm. There are only about ten rainy days a year in Karachi. The average temperature is very high, 19 degrees centigrade in January and 30 degrees centigrade in June; but it is more comfortable than hot and humid climate because of dry air and cool nights.

## 2-2 Social Conditions of Pakistan

### 2-2-1 Population and Ethnic Composition

The total population of Pakistan was about 100.7 million and the average population density was about 125.3 persons per square kilometer as of 1987. The average growth rate from 1982 to 1987 was approximately 3.1 percent per year.

Pakistan is a mosaic of ethnic groups. Each group has its own geographic and linguistic boundaries. The four dominant groups correspond roughly to the four provinces; Punjabis in Punjab, Sindhis in Sind, Baluchis in Baluchistan, and Pushturs in the Northwest Frontier Province (NWFP).

### 2-2-2 Language

By the 1973 Constitution, Urdu is declared the official language, though English remains a semi-official medium of communication up to date.

### 2-2-3 Religion

Islam is the official religion followed by about 97 percent of the population, followed by Hindu, 1.6 percent, and Christianity, 1.4 percent.

### 2-2-4 Politics

Pakistan became independent from the United Kingdom, the ex-suzerain, on August 14, 1947, and founded a federal republic based on the Islamic doctrine. The parliamentary institutions consist of two Houses; namely the Upper House and the Lower House. Pakistan is a federal republic consisting of four provinces; namely Punjab, Sind, Baluchistan and N.W.F.P., and federally administered tribal areas. Islamabad is the capital. Each province has its own governor, chief minister, cabinet and assembly.

## 2-3 Economy and Industries in Pakistan

### 2-3-1 Economy

The Pakistan's economy recorded a remarkable growth in the 1960s; however, since the beginning of the 1970s it faced many difficulties, coping with the worsening international economic situation starting with the first oil crisis in 1973 and a stagnation of agricultural sector in 1975, etc. The average annual GDP growth rate was slightly sluggish with 3.7 percent per year from 1970-71 to 1976-77; however, it increased sharply at 6.6 percent per year from 1977-78 to 1981-82 and returned to good figures. In 1983-84, the first year of the Sixth Five-year Plan (1983-88), agriculture, especially cotton, encountered a stagnation of production, and the economic growth rate decreased to 4.8 percent per year, compared to 6.7 percent the previous year. However, after 1984-85 onward the average annual economic growth rate recovered to 6.5 percent per year for past five years up to 1987-88. The target economic growth rate of the Sixth Five-year Plan, 6.5 percent per year, was consequently achieved.

Table 2-3-1 shows major economic indicators of Pakistan. The gross national product (GNP) and the gross domestic product (GDP) in 1987-1988 at constant factor cost were approximately 86,170 million Rupees and 88,890 million Rupees, respectively and the GNP per capita at current factor cost in the same year was 6,252

Rupees, or US$ 245.2 at Rs/US$ of 18.11. The inflation rate measured by GDP deflator shows a slight upward trend after registering the lowest at 5.2 percent per year in 1985-86. The trade balance and the balance on current account are both still in the red; however, both deficits show decreasing trends from 1984-85 onward. This tendency can be seen from petroleum crude import. That is, the import of petroleum crude, including partially refined petroleum crude but excluding natural gasoline, decreased sharply from approximately 4,108 thousand tons, or 12.15 billion Rupees, or 15.8 percent of the toal imports in 1983-84, the first year of the sixth five-year plan to approximately 3,714 thousand tons, or 7.08 billion Rupees, or 7.7 percent of the total imports in 1986-87.

### 2-3-2 Industries

(1) Agriculture

Pakistan has promoted industrialization after becoming independent; however, agriculture is the central industry as shown in Table 2-3-2, Breakdown of GDP of Pakistan by Sector (at Constant Factor Cost/Prices of 1959-60). Agriculture as of 1987-88 accounts for 49.2 percent of the total workers and 24.5 percent of the GDP at constant factor cost. The most important agricultural area is Punjab, an alluvial plain formed by the Indus River and its tributaries. The area is well-irrigated with developed canals to make up for lack of rainfall and is a leading producer of such products as wheat, cotton, rice, and sugarcane. In addition, stock farming also flourishes in the area with breeding of cattle, sheep, goat, etc. The agricultural production in 1986-87 of major important crops was the following; cotton approximately 1.3 million tons, wheat 120 million tons, rice 3.5 million tons, sugarcane 29.9 million tons and maize 11.0 million tons. When the production of cotton as a cash crop decreases due to damage by blight and insects, etc., its affect is directly felt in the reduction of yarns or cloths for export. Besides the above crops, seeds for oil extraction, barley, beans, tobacco, are produced.

(2) Manufacturing

The industries of Pakistan depend structurally on agriculture to a considerable extent. Beginning with cotton spinning, the largest industry in the country, the industries of sugar, edible oils and fats, tobacco, jute, leather, etc. are all processing industries based on agricultural products. These industries depend not only on the domestic agricultural market but also on the international agricultural market for supply of raw materials, thus they may be considered to be vulnerable to market fluctuations. In Pakistan, besides the products mentioned above, steel, car, cement, chemical fertilizer, paper are manufactured. As shown in Table 2-3-2, the growth rate of GDP of the manufacturing sector has been over 7.0 percent per year for several recent years. The average growth rate for the period of the Sixth Five-year Plan recorded a fairly high rate of 7.7 percent per year, though it fell short of the target growth rate of 9.3 percent per year.

## Table 2-3-1 Major Economic Indicators of Pakistan

| | 1982-83 | 1983-84 | 1984-85 | 1985-86 Final | 1986-87 Revised | 1987-88 Provisional |
|---|---|---|---|---|---|---|
| Gross Domestic Product (GDP) (at Constant Factor Cost) (Million Rupees) | 62,975 | 65,968 | 72,014 | 77,023 | 81,427 | 86,166 |
| Economic Growth Rate (on a GDP Basis) (% p.a.) | 6.7 | 4.8 | 9.2 | 7.0 | 5.7 | 5.8 |
| Gross National Product (GNP) (at Constant Factor Cost) (Million Rupees) | 67,069 | 69,892 | 75,586 | 80,903 | 84,733 | 88,887 |
| GNP per Capita (at Current Factor Cost) (Rupees) | 4,121 | 4,521 | 4,997 | 5,434 | 5,783 | 6,252 |
| GDP Deflator (% p.a.) | 6.0 | 9.6 | 5.8 | 5.2 | 5.4 | 7.1 |
| Growth Rate of Consumers Price Index (CPI) (464 Items) (% p.a.) | 4.7 | 7.3 | 5.7 | 4.4 | 3.6 | 5.8* |
| Growth Rate of Wholesale Price Index (WPI) (690 Items) (% p.a.) | 5.4 | 10.0 | 5.2 | 4.6 | 5.0 | 10.3* |
| Growth Rate of Sensitive Price Indicator (SPI) (46 Items) (% p.a.) | 3.0 | 7.4 | 8.7 | 3.1 | 2.4 | 7.2* |
| Merchandise Exports (FOB) (Million US$) | 2,627 | 2,669 | 2,457 | 2,942 | 3,498 | 2,040** |
| Merchandise Imports (FOB) (Million US$) | -5,616 | -5,993 | -6,009 | -5,984 | -5,792 | -3,279** |
| Trade Balance (Million US$) | -2,989 | -3,324 | -3,552 | -3,042 | -2,294 | -1,239** |
| Balance on Current Account (Million US$) | -517 | -997 | -1,680 | -1,236 | -719 | -740** |

Note: * These are annalized changes based on July-March Averages.
** These are provisional figures for July December, 1987.

Source: Pakistan Economic Survey 1987-88
Pakistan Statistical Yearbook 1988

## Table 2-3-2 Breakdown of GDP of Pakistan by Sector(at Constant Factor Cost/Prices of 1959-60)

(Unit : Million Rupees)

| Sectors | 1982 - 83 | 1983 - 84 | 1984 - 85 | 1985 - 86 Final | 1986 - 87 Revised | 1987 - 88 Provisional |
|---|---|---|---|---|---|---|
| Agriculture | 17,637 (28.0) [ 3.8] | 16,571 (25.1) [-6.0] | 18,600 (25.8) [12.2] | 19,788 (25.7) [ 6.4] | 20,224 (24.8) [ 2.2] | 21,124 (24.5) [ 4.5] |
| Mining and Quarrying | 319 ( 0.5) [ 4.2] | 326 ( 0.5) [ 2.2] | 401 ( 0.6) [23.0] | 484 ( 0.6) [20.7] | 510 ( 0.6) [ 5.4] | 548 ( 0.6) [ 7.5] |
| Manufacturing | 11,858 (18.8) [ 7.0] | 12,792 (19.4) [ 7.9] | 13,828 (19.2) [ 8.1] | 14,872 (19.3) [ 7.5] | 15,991 (19.6) [ 7.5] | 17,201 (20.0) [ 7.6] |
| Construction | 3,175 ( 5.0) [12.0] | 3,727 ( 5.6) [17.4] | 3,838 ( 5.3) [ 3.0] | 4,086 ( 5.3) [ 6.5] | 4,512 ( 5.5) [10.4] | 4,820 ( 5.6) [ 6.8] |
| Electricity and Gas Distribution | 1,916 ( 3.0) [ 7.8] | 2,249 ( 3.4) [17.4] | 2,345 ( 3.3) [ 4.3] | 2,709 ( 3.5) [15.5] | 2,859 ( 3.5) [ 5.5] | 2,927 ( 3.4) [ 2.4] |
| Transport, Storage and Communication | 4,356 ( 6.9) [ 7.8] | 4,821 ( 7.3) [10.7] | 5,156 ( 7.2) [ 6.9] | 5,546 ( 7.2) [ 7.6] | 5,960 ( 7.3) [ 7.5] | 6,322 ( 7.3) [ 6.1] |
| Wholesale and Retail Trade | 9,271 (14.7) [ 6.3] | 9,611 (14.6) [ 3.7] | 10,611 (14.7) [10.4] | 11,373 (14.8) [ 7.2] | 12,094 (14.9) [ 6.3] | 12,836 (14.9) [ 6.1] |
| Banking and Insurance | 1,762 ( 2.8) [22.7] | 2,105 ( 3.2) [19.5] | 2,196 ( 3.0) [ 4.3] | 2,325 ( 3.0) [ 5.9] | 2,458 ( 3.0) [ 5.7] | 2,508 ( 2.9) [ 2.0] |
| Ownership of Dwellings | 2,053 ( 3.3) [14.4] | 2,355 ( 3.6) [14.7] | 2,595 ( 3.6) [10.2] | 2,732 ( 3.5) [ 5.3] | 2,876 ( 3.5) [ 5.3] | 3,028 ( 3.5) [ 5.3] |
| Public Administration and Defence | 6,169 ( 9.8) [ 5.6] | 6,658 (10.1) [ 7.9] | 7,377 (10.2) [10.8] | 7,707 (10.0) [ 4.5] | 8,186 (10.1) [ 6.2] | 8,715 (10.1) [ 6.5] |
| Services | 4,459 ( 7.1) [ 6.6] | 4,753 ( 7.2) [ 6.6] | 5,067 ( 7.0) [ 6.6] | 5,401 ( 7.0) [ 6.6] | 5,757 ( 7.1) [ 6.6] | 6,137 ( 7.1) [ 6.6] |
| Gross Domestic Product (GDP) | 62,975 (100.0) [ 6.7] | 65,968 (100.0) [ 4.8] | 72,014 (100.0) [ 9.2] | 77,023 (100.0) [ 7.0] | 81,427 (100.0) [ 5.7] | 86,166 (100.0) [ 5.8] |

Note: A figure in ( ) shows a share in the total.
A figure in [ ] shows a growth rate over the preceding year.

Source: Pakistan Statistical Yearbook 1988

## 2-4 The Sixth Five-Year Plan

The Sixth Five-Year Plan (1983-88) (hereafter called "the Sixth Plan") commenced in July, 1983, aims at rapid and equitable development of the country so that the benefits of growth are widely shared by the people.

The Sixth Plan calls for relaxation of existing complicated regulations in order to promote private investments so that they stimulate the development of the country and at the same time help the benefits of growth be shared by all the people, especially by the socially and economically disadvantaged such as underprivileded local farmers. The Sixth Plan emphasizes the cooperation between the government and the private sector in all the sectors of economic activity such as industry, agriculture, construction, education, health, service, and trade. Among the sectors mentioned above the industrial sector and the agricultural sector especially will depend on private activities. Moreover, the Sixth Plan requires the private sector to participate in the construction of express highways, air terminals, energy development, telephone facilities, etc. The government of Pakistan itself invests in the large-scale projects which can not be covered by the private sector or in fields in which the recovery of investment is uncertain, and assists the private sector by training personnel for implementation of economic activities and by developing new technology.

Table 2-4-1 shows the Fifth Five-year Plan (hereafter called "the Fifth Plan") and the Sixth Plan outlays. The table indicates that the outlay of the Sixth Plan was 490 billion Rupees, which is more than twice the outlay of the Fifth Plan (226 billion Rupees) on nominal terms and an increase of 58 percnet over that of the Fifth Plan in 1982-83 prices. The Sixth Plan aims for a target growth rate of GDP during its period of 6.5 percent per year and for those rates in the agricultural sector and the manufacturing sector of 4.9 percent per year and 9.3 percent per year, respectively.

**Table 2-4-1 Fifth and Sixth Plan Outlays**

(Unit: Billion Rupees)

| | Nominal Terms | | | In 1982-83 Prices | | |
|---|---|---|---|---|---|---|
| | Public Sector | Private Sector | Total | Public Sector | Private Sector | Total |
| Fifth Plan | 153 | 73 | 226 | 171 | 81 | 252 |
| Sixth Plan | 290 | 200 | 490 | 237 | 162 | 399 |
| Percentage Increase | 90 | 174 | 117 | 39 | 100 | 58 |

Source: Planning Commission, Government of Pakistan

Table 2-4-2 shows the planned outlays by sectors during the Fifth and Sixth Plans. As shown in the table, the energy sector, the social sector, and the agricultural sector increased sharply in the Sixth Plan, indicating that Sixth Plan places emphasis on the development of these sectors. The development of coal has a high priority in development within the energy sector since Pakistan is relatively rich in coal reserves and its development is considered effective for promoting development of rural communities.

Table 2-4-3 shows the annual phasing of the fifth and sixth plan outlays. The table shows that the share of the total private sector in the total outlays increases sharply from 32.4 percent in the Fifth Plan to 40.8 percent in the Sixth Plan, indicating the importance of the roles played by the private sector.

Table 2-4-2 Planned Outlays by Sectors during the Fifth and Sixth Plans

| | Fifth Plan | | Sixth Plan | |
|---|---|---|---|---|
| | Outlays (Billion Rs.) | Percentage Share | Allocation (Billion Rs.) | Percentage Share |
| Agriculture and Water | 36.05 (21.83) | 15.9 (14.2) | 89.95 (44.45) | 17.8 (14.5) |
| Energy | 38.83 (38.83) | 17.2 (25.3) | 116.50(116.50) | 23.1 (38.2) |
| Transport & Communications | 44.36 | 19.6 | 83.52 | 16.5 |
| Industry | 45.59 | 20.2 | 82.40 | 16.3 |
| Minerals | 0.66 | 0.3 | 6.85 | 1.4 |
| Social Sectors* | 17.13 (15.23) | 7.6 ( 9.9) | 48.01 (43.65) | 9.5 (14.3) |
| Others | 43.40 | 19.2 | 77.77 | 15.4 |
| Total(Gross) | 226.02 | 100.0 | 505.00 | 100.0 |
| Plus: Special Development Programmes | 0.60 | | 15.00 | |
| Less: Operational Shorttall | - | | 30.00 | |
| Total(Net) | 226.62 | | 490.00 | |

Figures in parenthesis relate to Public Sector ouslays.
*Social Sectors Outlays include expenditures on education, health, water supply and Sanitation and population.

Source: Planning Commission, Government of Pakstan

**Table 2-4-3 Annual Phasing of Fifth and Sixth Plan Outlays**

(Current Billion Rupees)

| | ADP | Public Corporations | Special Development Programmes | Total Public Sector | Total Private Sector | Percent of GNP | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ADP | Total Public Sector | Total Private Sector | Total (Public and Private Sector) |
| Fifth Plan | | | | | | | | | |
| 1978-79 | 20.5 | 4.5 | - | 25.0 | 9.7 | 9.5 | 11.6 | 4.5 | 16.1 |
| 1979-80 | 21.8 | 5.5 | - | 27.3 | 12.9 | 8.6 | 10.8 | 5.1 | 15.9 |
| 1980-81 | 25.8 | 5.8 | - | 31.6 | 14.8 | 8.7 | 10.7 | 5.0 | 15.7 |
| 1981-82 | 26.5 | 6.7 | - | 33.2 | 16.5 | 7.7 | 9.6 | 4.8 | 14.4 |
| 1982-83 (estimated actuals) | 28.0 | 7.5 | 0.6 | 36.1 | 19.5 | 7.0 | 9.0 | 4.9 | 13.9 |
| Total Fifth Plan | 122.6 | 30.0 | 0.6 | 153.2 (67.7%) | 73.4 (32.4%) | 8.1 | 10.1 | 4.9 | 15.0 |
| Sixth Plan | | | | | | | | | |
| 1983-84 | 31.9 | 8.4 | 1.2 | 41.5 | 26.2 | 7.0 | 9.1 | 5.7 | 14.8 |
| 1984-85 | 36.4 | 10.9 | 1.8 | 49.1 | 30.2 | 7.1 | 9.6 | 5.9 | 15.5 |
| 1985-86 | 41.5 | 13.3 | 2.6 | 57.4 | 37.5 | 7.1 | 9.9 | 6.4 | 16.3 |
| 1986-87 | 46.9 | 15.2 | 3.8 | 65.9 | 46.5 | 7.1 | 10.0 | 7.1 | 17.1 |
| 1987-88 | 53.3 | 17.2 | 5.6 | 76.1 | 59.6 | 7.1 | 10.2 | 8.0 | 18.1 |
| Total Sixth Plan | 210.0 | 65.0 | 15.0 | 290.0 (59.2%) | 200.0 (40.8%) | 7.1 | 9.8 | 6.8 | 16.6 |

Source: Planning Commission, Government of Pakistan

## Chapter 3 ENERGY SITUATION

### 3-1 Present Situation of Energy

An excerpt from energy balance sheet taken from ENERGY YEAR BOOK, 1986, is shown below for an overview.

**Table 3-1-1 Energy Balance Sheet**

| Source | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| | | | | | (thousand ton oil equivalent) | |
| A. Oil | | | | | | |
| (a) Prod.fm dom.cr | 406 | 421 | 396 | 361 | 629 | 940 |
| (b) Prod.fm imp.cr | 3,631 | 4,092 | 3,926 | 4,047 | 4,106 | 3,866 |
| (c) Imp.petr prod | 1,611 | 1,633 | 1,924 | 2,210 | 2,339 | 2,415 |
| (d) opening stock | | | skip | | | |
| (e) gross supply | 5,969 | 6,360 | 6,417 | 6,778 | 7,228 | 7,492 |
| (f) export | 1,077 | 1,205 | 652 | 341 | 294 | 304 |
| (g) net supply | 4,891 | 5,156 | 5,855 | 6,436 | 6,933 | 7,188 |
| (h) closing stock/loss | | | skip | | | |
| (i) consumption | 4,405 | 4,953 | 5,627 | 6,204 | 6,719 | 6,982 |
| (j) % on total | 33.8 | 34.6 | 36.8 | 38.0 | 37.7 | 37.2 |
| B. Gas | | | | | | |
| (a) consumption | 5,160 | 5,506 | 5,507 | 5,503 | 5,868 | 6,068 |
| (b) % on total | 39.6 | 38.5 | 36.1 | 33.6 | 32.9 | 32.3 |
| C. LPG | | | | | | |
| (a) consumption | 42 | 50 | 50 | 72 | 75 | 75 |
| (b) % on total | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 |
| D. Coal | | | | | | |
| (a) consumption | 705 | 783 | 719 | 836 | 1,001 | 985 |
| (b) % on total | 5.4 | 5.5 | 4.7 | 5.1 | 5.6 | 5.2 |
| E. Electricity | | | | | | |
| (a) consumption | 2,710 | 3,022 | 3,368 | 3,744 | 4,185 | 4,680 |
| (b) % on total | 20.8 | 21.1 | 22.1 | 22.9 | 23.4 | 24.9 |
| F. Gross Consmptn | 13,022 | 14,314 | 15,271 | 16,359 | 17,848 | 18,790 |
| G. GDP mp,MMRs | 278 | 322 | 362 | 418 | 478 | 539 |
| H. Population (1,000) | 83,840 | 86,440 | 89,120 | 91,880 | 94,730 | 97,670 |
| I. Kg/Capita | 155 | 166 | 171 | 178 | 188 | 192 |

source: ENERGY YEAR BOOK 1986

Table 3-1-1 gives a general perspective of commercial energy consumption in Pakistan. From the point of view of consumption there are two predominantly important sources, petroleum and natural gas collectively accounting for some 70 percent; although both have been increasing in absolute terms, petroleum has been increasing more rapidly overtaking natural gas in 1982/1983. The consumption of LPG is very small. The consumption of coal has remained low at around five percent. Electricity shows a steady increase of about five percent over five years. Gross consumption of total energy per capita shows a steady increase.

A short account of supply by source is given below.

(1) Petroleum

Petroleum, together with natural gas, now supplies some 80 percent of the primary commercial energy requirement. In 1984/85 the consumption of petroleum crude oil and petroleum products amounted to 7.5 million tons, constituting 38 percent of the requirement, of which 87 percent was imported. The nation consumes more kerosene, diesel fuel, HOBC, aviation fuel and fuel oil but less naphtha than the nation's refineries produce; the shortage of these products are supplemented by import while the excess naphtha is exported.

The confirmed reserve of crude oil is 139.4 million barrels as of July 1986. The share of domestic crude oil in the total processed has been increasing but is still very low at 20 percent.

(2) Natural gas

The confirmed reserve of natural gas as of July 1986 is 16.07 trillion cubic feet. The production in 1985/86 is 355.4 billion cubic feet, or 7.5 million tons oil equivalent, of which 94 percent was supplied by Sui and 18 percent Mari Fields.

(3) Coal

The share of coal in the supply of primary energy is 7.5 percent in 1985. The exploration has not been done sufficiently to make an accurate estimate of the reserves. The estimated reserve, therefore, ranges from 510 to 1,180 million tons. About two thirds of the reserve is believed to exist in Lakhra area. The production by province was 1,169,018 in Baluchistan, 425,572 in Punjab, 570,849 in Sind and 36,168 in NWFP in 1985/86 all in thousand metric tons.

(4) Electricity

The generating capacity as of 1985/86 was 6,299 MW, of which hydroelectric capacity was 2,898 MW, nuclear capacity was 137 MW, and the rest was thermal. Electricity actually generated in 1985/86 was 25,638 GWH, the breakdown of which is 53.8 percent hydro, 44.3, percent thermal, and 1.9 percent nuclear.

## 3-2 National Policy on Energy

Pakistan produces natural gas which meets some 30 percent of nation's commercial energy requirement and crude oil and coal which collectively account for about 10 percent of the consumption of commercial energy; Pakistan depends for a substantial portion of the supply of energy on imported crude oil. Accordingly, the impact of the energy crises of the 1970s were felt severely. In 1981, the payment for oil amounted to 1.7 billion US$ which represented 69 percent of the export income. The decline of petroleum price in the international market which took place thereafter and increase of the domestic production of crude oil helped relieve the situation to some extent; still in 1985 Pakistan had to pay 1.04 billion US$, or 58 percent of the export earnings. The dependence on import of crude oil remains as ever a crucial economic as well as security problem. Against such a background the government of Pakistan promulgated the following policies in its Sixth Five Year Plan covering a period from 1983 to 1988:

1. To ensure adjustments for realizing growth targets of the Sixth Plan in an energy-efficient manner;

2. To arrange inter-fuel adjustments with the objective of minimizing import-dependence within the Plan period;

3. To prepare the ground for growing self-reliance in energy during the Seventh Plan and beyond;

4. To develop indigenous resources of energy, intensify the search for yet undiscovered resources, develop nuclear and renewable energy resources and to acquire full command on technology relating to energy substitutes;

5. To ensure coverage of the entire rural population residing in compact villages by rural electrification;

6. To develop mechanisms for greater participation of the private sector in meeting the energy requirement of the nation;

7. To ensure proper institutionalization of longer-term energy planning, monitoring and evaluation;

8. To rationalize energy prices.

The eighth policy particularly concerns the pricing of natural gas. The price of natural gas for industrial and household uses has been held down low; while this policy has stimulated industry and contributed to the welfare of the people, it has been indirectly suppressing the use of coal. This will continue to be an important issue.

## 3-3 National Policy on, and Present Situation of Coal Industry

The government considers it not easy nor recommendable from economic viewpoint to continue to depend on imported oil for the supply of forecast increase of energy in the future. It is therefore becoming urgently essential that the role of the domestic coal be increased. In particuler, domestic coal should replace natural gas, kerosene and burner fuel in the power generation, manufacturing and domestic sectors. The Sixth Plan calls for production of 5.4 million tons of coal, the achievement of which depends upon the market demand. The brick burning industry, currently absorbing nearly entire production of coal, has not been very brisk for the past two years. Nor is it the intention of the government to increase the consumption of coal in the brick industry. The past production of coal is as shown below:

**Table 3-3-1 Domestic Production of Coal**

(thousand tons per year)

| Source | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Sor-range | 156 | 166 | 157 | 194 | 207 | 172 |
| Degari | 106 | 92 | 68 | 117 | 147 | 183 |
| Sharigh | 37 | 35 | 33 | 44 | 59 | 42 |
| Sinjidi | 172 | 139 | 139 | 180 | 204 | 202 |
| Much | 77 | 70 | 65 | 91 | 93 | 65 |
| Harnai | 12 | 11 | 13 | 18 | 43 | 60 |
| Duki | 114 | 224 | 198 | 202 | 219 | 225 |
| Pir Ismail Ziarat | 135 | 65 | 90 | 85 | 163 | 202 |
| Abegum | 16 | 57 | 17 | 38 | 34 | 17 |
| Makerwal | 426 | 534 | 450 | 473 | 471 | 427 |
| Lakhra | 236 | 288 | 310 | 366 | 533 | 544 |
| Jhimpir | 35 | 28 | 25 | 31 | 30 | 27 |
| Makerwal/Kohat | 55 | 41 | 42 | 31 | 34 | 36 |
| Total | 1,577 | 1,750 | 1,607 | 1,870 | 2,237 | 2,202 |

Source ENERGY YEAR BOOK 1986

As may be calculated from Table 3-3-1, the total production of

coal has increased at a rate of 6.9 percent a year for the five years shown on the table; during the same period that of Lakhra coal registered a growth rate of 18.2 percent per year. The growth of coal production lags behind the increase of the consumption of petroleum.

To promote the production and consumption of coal, the government set forth the following policy plans in the Sixth Five Year Plan:

1. To upgrade reserves from inferred/indicated to proven status through appropriate investigation;

2. To develop coal infrastructure, marketing and utilization;

3. To encourage mining venture on a cooperative basis;

4. To introduce fiscal incentive;

5. To apply dual firing systems in heat processing units;

6. To establish small thermal energy plants near coal mines (with participation of WAPDA and KESC, as well as provincial governments) on joint venture or equity basis;

7. To carry out feasibility studies of gasification of Lakhra coal for medium/low Btu gas;

8. To introduce the unit-train concept at railways for moving coal from the mines to the centralized delivery points;

9. To adopt pricing policies in relation to competing fuels on a more rational basis to encourage increased coal development and use; and

10. To set up smokeless briquetting plants of economic sizes based on major coal fields as a substitute for kerosene.

Regarding the promotion of coal utilization, the government plans to increase the production of Lakhra Mines to sustain the operation of a 300 MW power station. The development program aims at further increasing the production of Lakhra to meet the requirement of another 300 to 600 MW steam power capacity in the years beyond the Sixth Plan. The government also controls the use of gas and oil in the cement industry and encourage use of coal. The government considers it equally important to promote the use of coal as substitute of kerosene of which consumption is rapidly increasing. The coal briquette project is a very effective means of achieving such a goal. The government contemplates to install not just one coal briquette plant but several at major coal fields. The project under study by this feasibility study is a pioneering project and will be a cornerstone of Pakistan's future coal briquette industry.

## 3-4 Trend of Energy Consumption

Section 3-1, Present Situation of Energy, presents the general overview of energy consumption and its trends during five recent years. This chapter gives a more detailed account of the trends of consumption of important types of energy.

(1) Petroleum

Petroleum products are by far the most important source of energy keeping the economy of Pakistan running. Given below are production and consumption of more important petroleum products.

**Table 3-4-1 Production and Consumption of Major Petroleum Product**
(thousand metric tons)

| PRODUCT | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Motor sprit | | | | | | |
| Production | 473 | 531 | 542 | 612 | 628 | 621 |
| Consumption | 316 | 320 | 331 | 341 | 346 | 373 |
| Super kerosene | | | | | | |
| Production | 169 | 211 | 240 | 258 | 307 | 300 |
| Consumption | 529 | 553 | 604 | 690 | 760 | 811 |
| High octane blending component(HOBC) | | | | | | |
| Production | 38 | 42 | 28 | 30 | 47 | 92 |
| Consumption | 115 | 127 | 138 | 153 | 168 | 180 |
| High speed diesel(H.S.D) | | | | | | |
| Production | 944 | 1,165 | 1,172 | 1,163 | 1,323 | 1,404 |
| Consumption | 1,956 | 2,287 | 2,521 | 2,473 | 2,560 | 2,731 |
| Light diesel oil(L.D.O) | | | | | | |
| Production | 171 | 118 | 170 | 178 | 225 | 240 |
| Consumption | 188 | 132 | 173 | 180 | 224 | 249 |
| Furnace oil(F.O) | | | | | | |
| Production | 1,495 | 1,669 | 1,459 | 1,534 | 1,539 | 1,542 |
| Consumption | 729 | 911 | 1,195 | 1,662 | 1,942 | 2,070 |
| Aviation fuel | | | | | | |
| Production | 540 | 512 | 468 | 474 | 463 | 467 |
| Consumption | 316 | 320 | 331 | 341 | 346 | 373 |
| Naphtha | | | | | | |
| Production | 165 | 210 | 185 | 103 | 145 | 146 |
| Consumption | | | | | | |
| Total | | | | | | |
| Production | 3,993 | 4,460 | 4,264 | 4,352 | 4,668 | 4,842 |
| Consumption | 4,367 | 4,847 | 5,514 | 6,100 | 6,615 | 7,057 |

Source: ENERGY YEAR BOOK 1986

This table compares domestic production by the nation's refineries with domestic consumption; however, these figures can be misleading because the crude oil is almost entirely imported. The shortages or excesses between the production and consumption are balanced by either import or export. Important characteristics of energy consumption are shown in this table. First of all, the consumption of petroleum products increased during the period at a rate of ten percent a year; while the domestic production increased at a rate of only 3.9 percent a year. Those petroleum products which have shown remarkable rates of increase are super kerosene, or commonly called just kerosene, at 8.9, HOBC at 9.3, H.S.D at 6.9 and F.O. at 23.2 percent a year; all these reflect changes taking place in the economy of Pakistan.

The consumption of petroleum products by sector is as follows:

**Table 3-4-2 Sectoral Consumption of Petroleum Product**

(thousand metric tons)

| SECTOR | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Domestic | 517 | 543 | 594 | 679 | 748 | 800 |
| Industry | 261 | 304 | 391 | 689 | 814 | 946 |
| Agriculture | 179 | 124 | 161 | 173 | 219 | 243 |
| Transport | 2,487 | 2,745 | 2,890 | 3,067 | 3,239 | 3,410 |
| Power | 183 | 442 | 754 | 766 | 944 | 1,004 |
| Other Govt | 679 | 688 | 723 | 726 | 649 | 654 |
| Total | 4,307 | 4,847 | 5,514 | 6,101 | 6,615 | 7,057 |

Source: ENERGY YEAR BOOK 1986

The domestic sector accounts for nearly the entire consumption of kerosene. The industry and power sectors show tremendous growths, the former registering 29.4 and the latter 40.6 percent a year. In the 1985/86 records the consumption by industry sector consists 95 percent of F.O. and 4.7 percent of H.S.D. and the rest of L.D.O. The consumption by

power sector is 14.8 percent of H.S.D., 4.5 percent by L.D.O. and 85.1 percent of F.O. The consumption in the transport sector is predominantly L.D.O. meaning that the nation's vehicles consist mainly of trucks and buses.

(2) Natural Gas

Table 3-4-3 shows consumption of natural gas by sector. Since Pakistan neither exports nor imports gas, the consumption equals the domestic supply.

Pakistan has two kinds of sources, natural gas or dry gas and associated gas, the latter being a co-product of crude oil accounting for only eight percent of the total gas supply in 1985/86. There are four fields of natural gas; they are Sui, Mari, Asri/Hundi and Rirkoh. Sui is predominantly large followed by Mari, the former produced 76.1 and the latter 15.1 percent in 1985/86. The fields of associated gas are Toot, Dhullian, Meyal and Dhurnal of which Meyal and Dhurnal are large.

**Table 3-4-3 Gas Consumption by Sector**

(thousand ton oil equivalent)

| SECTOR | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Domestic | 415 | 562 | 664 | 755 | 875 | 995 |
| Commercial | 176 | 195 | 208 | 213 | 230 | 232 |
| Cement | 610 | 616 | 497 | 241 | 194 | 170 |
| Fertilizer | 1,325 | 1,808 | 1,875 | 1,896 | 1,929 | 1,930 |
| Power | 1,959 | 1,831 | 1,739 | 1,823 | 2,051 | 2,148 |
| Gen. Industry | 1,468 | 1,579 | 1,650 | 1,712 | 1,746 | 1,752 |
| Total | 5,955 | 6,591 | 6,632 | 6,641 | 7,026 | 7,226 |

Source: ENERGY YEAR BOOK, 1986

The consumption of gas has increased at an annual rate of 3.9 percent. The fastest growing among all sectors is domestic sector which has increased at 19.1 percent. The consumption

by the cement industry has been decreasing steadily in line with the policy of the government to rationalize the consumption of this valuable resource.

(3) Electricity

The largest supplier of electricity is hydro closely followed by thermal; there is a small nuclear capacity as shown below.

**Table 3-4-4 Generation of Electricity gy Source (Public Utility)**

(thousand ton oil equivalent)

| SOURCE | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Hydro | 2,152 | 2,266 | 2,705 | 3,053 | 2,913 | 3,285 |
| Thermal | 1,635 | 1,900 | 1,929 | 2,076 | 2,479 | 2,702 |
| Nuclear | 36 | 44 | 54 | 77 | 82 | 114 |
| Total | 3,823 | 4,210 | 4,688 | 5,206 | 5,474 | 6,102 |

Source: ENERGY YEAR BOOK, 1986

Hydroelectric power is the largest supplier of electricity. It should be noted, however, that thermal power generation is catching up very rapidly.

**Table 3-4-5 Fuel Consumption for Thermal Generation**

(thousand ton oil equivalent)

| SOURCE | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Fuel oil | 149 | 258 | 417 | 535 | 750 | 832 |
| Diesel oil | 31 | 182 | 335 | 223 | 180 | 145 |
| Coal | 14 | 1 | 15 | 11 | 14 | 11 |
| Gas | 1,959 | 1,831 | 1,739 | 1,823 | 2,051 | 2,148 |
| Total | 2,153 | 2,272 | 2,505 | 2,592 | 2,995 | 3,136 |

Source: ENERGY YEAR BOOK, 1986

Natural gas supplies about two thirds of the thermal electric

power followed by fuel oil which supplies about one quarter. It is quite natural from these figures that the government considers it very important to promote construction of coal-fired power plants.

The consumption by sector is shown in Table 3-4-6.

**Table 3-4-6 Distribution of Electricity by Sector (Public Utility)**

(thousand ton oil equivalent)

| SECTOR | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Domestic | 642 | 767 | 893 | 1,079 | 1,208 | 1,391 |
| Commercial | 227 | 249 | 250 | 306 | 336 | 363 |
| Industrial | 1,077 | 1,190 | 1,326 | 1,400 | 1,487 | 1,735 |
| Agriculture | 508 | 564 | 609 | 636 | 666 | 690 |
| Street Light | 33 | 25 | 26 | 24 | 25 | 31 |
| Traction | 10 | 10 | 10 | 9 | 9 | 9 |
| Other Govt | 213 | 217 | 253 | 288 | 454 | 461 |
| Total | 2,710 | 3,022 | 3,368 | 3,744 | 4,185 | 4,680 |

Source: ENERGY YEAR BOOK, 1986

The domestic and industrial consumptions were large, 29.7 and 37.1 percent of the total in 1985/86, and have been increasing very rapidly at annual rates of 16.7 and 10.0 percent over the period shown, respectively. The agricultural, commercial and other government sectors also show increase.

(4) Coal

The reserves of coal varies greatly depending upon sources of information. ENERGY YEAR BOOK, 1986, gives the following three estimates:

**Table 3-4-7 Coal Reserves in Pakistan**

(million metric tons)

| Source | Measured | Proven | Indicated | Inferred | Total |
|---|---|---|---|---|---|
| M/S Chemical Consultant | 84.70 | | 149.80 | 528.60 | 763.10 |
| M/S IEDC Consultant | | 102 | 1,076 | | 1,178 |
| Geological Survey | | 102 | 217 | 289 | 508 |

Source: ENERGY YEAR BOOK, 1986

The production of coal by province is shown on Table 3-3-1. Therefore, it would suffice here to say that the production in 1985/86 registered 2.2 million tons and that the production has been increasing at an annual rate of 6.9 percent for the past five years. The consumption of coal as shown in Table 3-4-8 shows a very peculiar pattern unique to this country. Nearly all the domestic production of coal has been used for brick burning; in other words, coal has not been properly used as industrial fuel, fuel for power generation or household purposes. Such a situation should not be criticized without a fair understanding of the importance bricks have in the society as well as in the economy of Pakistan. It is noted from this table that the increase in coal utilization is accounted for almost exclusively by the increase in brick-burning coal.

**Table 3-4-8 Sectoral Consumption of Coal**

(thousand metric ton)

| SECTOR | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Power | 31 | 2 | 33 | 24 | 32 | 26 |
| Brick Kiln | 1,517 | 1,715 | 1,546 | 1,811 | 2,174 | 2,148 |
| Domestic | 8 | 23 | 22 | 22 | 16 | 14 |
| Other Govt | 21 | 10 | 8 | 13 | 15 | 13 |
| Total | 1,577 | 1,750 | 1,609 | 1,869 | 2,238 | 2,202 |

Source: ENERGY YEAR BOOK, 1986

Against such a background, and given the large reserves of coal in Lakhra area and the foreign currency problem associated with the importation of increasing amount of petroleum, it is ntural that the government should encourage promotion of coal utilization. The government of Pakistan is planning to install a series of thermal power plants that burn coal.

In addition to the domestic coal, metallurgical coal is imported for iron and steel production by PAKISTAN STEEL MILL CORPORATION, the amount of which is shown in Table 3-4-9.

**Table 3-4-9 Import of Metallurgical Coal**

(thousand metric tons)

| 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|
| 312 | 540 | 520 | 491 | 716 | 852 |

Source: ENERGY YEAR BOOK, 1986

The importation of metallurgical coal has increased at an average rate of 22.2 percent.

(5) Non-commercial Fuel

The term, non-commercial fuel, is an accepted term to indicate firewood, charcoal, vegetable wastes, cow dungs, and other combustibles extensively used in rural area; however, this term is really a misnomer, because firewood and charcoal are commercial commodities, although a large amount of them are collected by consumers themselves. Non-commercial fuels still account for the majority of the household fuel though not indicated by any statistics. ENERGY YEAR BOOK, 1985, gives an estimated consumption of non-commercial fuel of 8,963 thousand tons oil equivalent for 1985/86. This amount is compared in Table 3-4-10 with the consumption of other fuels for household purpose.

**Table 3-4-10 Household Fuel Consumption**
(thousand tons oil equivalent)

| Non-commercial fuel | Petroleum | Gas | Coal | Electricity | Total |
|---|---|---|---|---|---|
| 8,963 | 882 | 995 | 6 | 476 | 11,322 |
| Percent 79.2 | 7.8 | 8.8 | 0.05 | 4.2 | 100 |

Note:

(1) Petroleum includes LPG.

(2) 34.2% generation/transmission efficiency is employed for electricity.

(3) Non-commercial fuel is converted into oil equivalent from information in ENERGY YEAR BOOK, 1985.

Firewood including charcoal is considered to constitute about 55 percent of the non-commercial. The firewood and charcoal are traded; the other fuels are mostly not traded. It is evident from this table that from the standpoint of livelihood of common people firewood is the most important fuel of all; this crucial importance however tends to be overlooked or ignored because of the non-commercial fuel being not accurately grasped, recorded, nor related to international trade. The predominantly large consumption of non-commercial fuel, particularly that of firewood, implies a potentially dangerous situation where a small short supply of non-commercial fuel, say ten percent decline, can hardly be supplemented by the increase of commercial fuels. Unless a large-scale plantation of firewood is made possible by irrigation of some appropriate measures, substantial increase in firewood supply seems unlikely.

## 3-5 Household Energy Consumption

Household energy consumption is summarized in Table 3-5-1 using the consistent unit, thousand tons oil equivalent.

**Table 3-5-1 Household Energy Consumption**

(thousand ton oil equivalent)

| Source | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Commercial Fuel | | | | | | |
| Petroleum | 533 | 560 | 612 | 700 | 772 | 826 |
| Natural Gas | 415 | 562 | 664 | 755 | 875 | 995 |
| Electricity | 642 | 767 | 893 | 1,079 | 1,208 | 1,391 |
| Coal | 3 | 10 | 10 | 10 | 7 | 6 |
| LPG | 32 | 39 | 38 | 54 | 56 | 56 |
| Comm. Fuel Total | 1,625 | 1,938 | 2,216 | 2,598 | 2,918 | 3,274 |
| Non-commercial Fuel | | | | | | 8,963 |

Source: ENERGY YEAR BOOK, 1986

The increases in consumption of petroleum, natural gas and electricity are noticeable; their rates of increase over the period are 9.1, 19.1 and 16.7 percent, respectively. Likewise, both coal and LPG increased very rapidly; however, their consumptions are still very small. This table explains problems Pakistan has for household energy supply. Total energy consumption for household use is destined to increase as living standard improves. If consumption of petroleum, mostly kerosene and a small amount of LPG, is allowed to increase, the nation will inevitably be under an even greater pressure of balance of payments problem. There is no room for drastic increase of the supply of firewood without impairing the already deteriorated environmental conditions. The reasonable solutions to this problem are consideration of more domestic natural gas, petroleum and hydroelectric power and perhaps large-scale biomass plantations with all associated investment in irrigation and drainage; however, the most promising and practical near-term solution is utilization of domestic coal, its use yet to be expanded, its reserves being large, and processing and delivering it to the consumers in a form acceptable to them, namely, coal briquettes.

### 3-6 Industrial Energy Consumption

Shown below is the consumption by sector of commercial energy. The increases in commercial, industrial, transport and power sectors show steady and rapid expansion of the economy of this nation. In 1985/86 the industrial sector consumption consists 16.6 percent of petroleum, 34.7 percent gas, 17.4 percent coal, 31.3 percent electricity.

**Table 3-6-1 Energy Consumption by Sector**

(thousand tons oil equivalent)

| SECTOR | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Domestic | 1,625 | 1,938 | 2,216 | 2,598 | 2,918 | 3,274 |
| Commercial | 414 | 457 | 470 | 538 | 585 | 614 |
| Industrial | 4,092 | 4,453 | 4,550 | 4,837 | 5,196 | 5,538 |
| Agriculture | 693 | 692 | 775 | 814 | 891 | 919 |
| Transport | 2,582 | 2,272 | 2,505 | 2,592 | 2,995 | 3,136 |
| Power | 2,153 | 2,272 | 2,505 | 2,592, | 2,995 | 3,136 |
| Fertilizer | 530 | 723 | 750 | 758 | 772 | 772 |
| Other Govt | 934 | 934 | 1,006 | 1,043 | 1,134 | 1,139 |

Source: ENERGY YEAR BOOK, 1986

The consumption of coal almost entirely represents fuel for brick burning. Natural gas is generously supplied for industrial consumption. The consumption by transport sector consists almost exclusively of petroleum products. With the sole exception of railway transportation for which electricity is the best suited energy for most cases, petroleum products are generally the best forms of energy for transportation purposes. High speed diesel fuel constituted 65.8 percent of the total energy consumption in the transport sector indicating the importance of trucks, buses and diesel locomotives as compared with passenger cars. The fertilizer sector consumed in 1985/86 1,930 thousand tons oil equivalent of natural gas of which 772 thousand tons oil equivalent shown in the above table represents consumption for energy only, and the rest consumption as feedstock. Use of natural gas

is very reasonable since it is the best feedstock for the manufacture of nitrogenous fertilizer, specifically ammonia and urea. Agriculture will continue to be the mainstay of the economy of Pakistan; the supply of fertilizer to the farmers at prices acceptable to them is mandatory for increasing the productivity of agriculture.

It can be concluded that the economy of Pakistan depends too much upon natural gas and imported petroleum. These two are indubitably the most efficient and easy-to-use fuels, yet the financial burden on the nation will be very great if petroleum and petroleum products are allowed to be imported as demand rises. There are some who rightly insist that natural gas should be used in sectors in which natural gas is the best, for example, manufacture of fertilizer and chemicals; other fuel, specifically coal, should be used more for generation of electricity and industrial purposes.

## 3-7 Demand Forecast of Kerosene and Firewood

The growth of the consumption of kerosene as household fuel in the past few years is tremendone as shown in Table 3-7-1.

**Table 3-7-1 Consumption of Kerosene**

| Year | Consumption | | |
|---|---|---|---|
| | Household | | Total |
| | ton | % | |
| 1980/81 | 516,958 | 97.79 | 528,652 |
| 1981/82 | 543,720 | 98.23 | 553,496 |
| 1982/83 | 593,887 | 98.31 | 604,114 |
| 1983/84 | 678,987 | 98.40 | 690,036 |
| 1984/85 | 748,426 | 98.53 | 759,555 |
| 1985/86 | 800,449 | 98.68 | 811,194 |

Source ENERGY YEAR BOOK, 1986

The domestic consumption of kerosene is almost entirely for household use which has increased at an annual rate of 9.14 percent. Firewood on the other hard, although the estimated consumption is ten times that of kerosene, is not much discussed, because the data and information about its demand, supply, transportation, reserves and trade are not sufficiently available. The coal briquettes are to replace portions of these fuels; therefore, the demands and prices of these two fuels, called traditional fuels as against the coal briquettes, are very important. Of these two traditional fuels, kerosene is more important from the viewpoint of possibility of replacement by coal briquettes, because the coal briquettes could hardly compete with firewood in price.

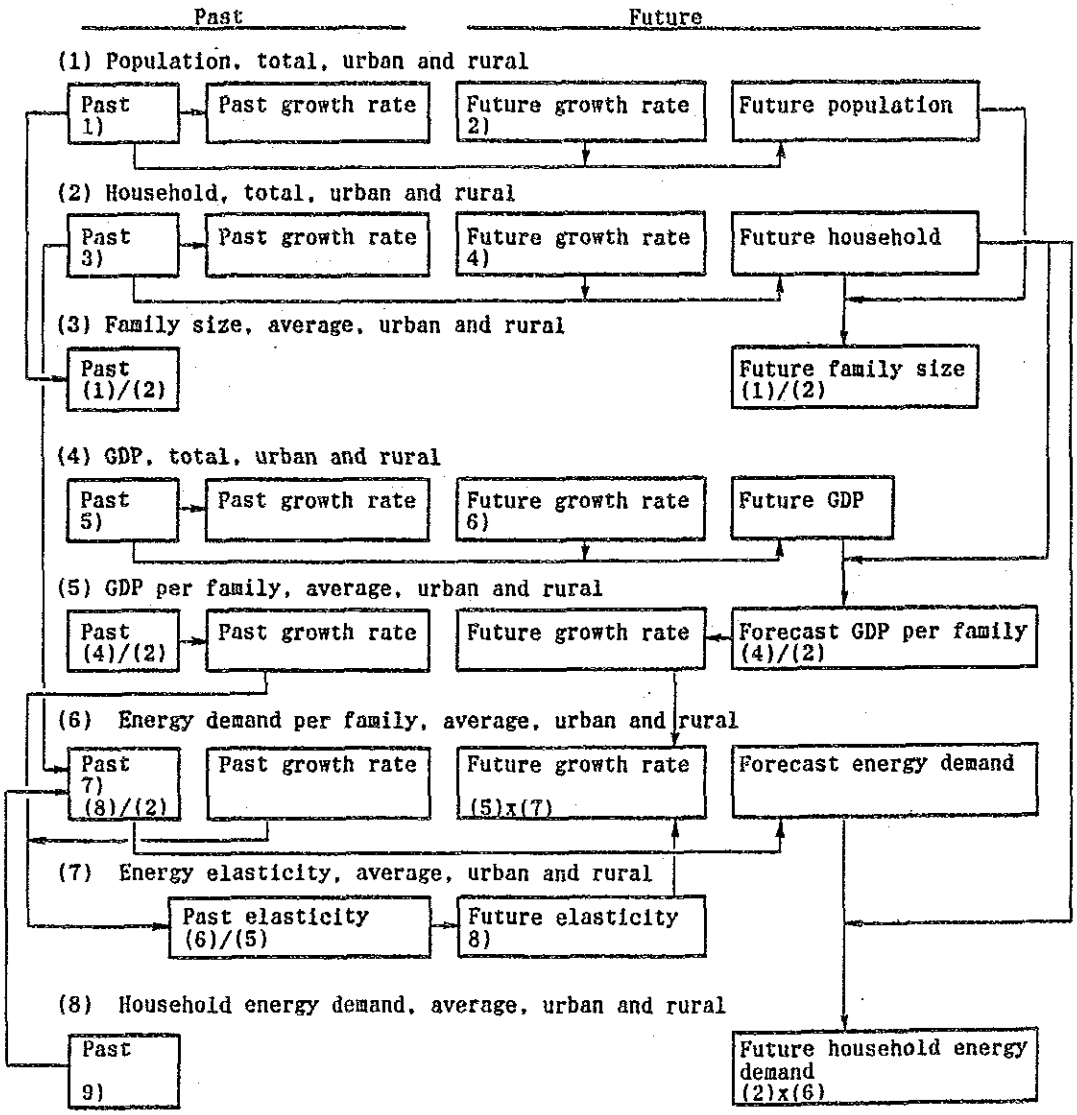
Two methods are employed for estimating the future demands of kerosene up to 2006. One is a simplified econometric method using elasticity between the growth rate of fuel consumption per family and the growth rate of GDP per family. The other is a simple projection based upon the past rate of increase of kero-

sene consumption. The forecast demands of kerosene by both methods were examined for supply possibility.

The problem with this econometric method is that more than 80 percent of the household energy consumption in the past is supplied by non-commercial fuels -- firewood, cow dung, bagasse, cotton sticks, shrubs, saw dust, weeds, twigs, tobacco stick -- which was not fully registered in statistics. Therefore, the basic inputs required for econometric analysis could not be developed from the past records of Pakistan. Under this condition such essential data as energy demand per family, elasticity of energy consumption per family versus GDP per family, population distribution between urban and rural areas had to be supplemented from other sources.

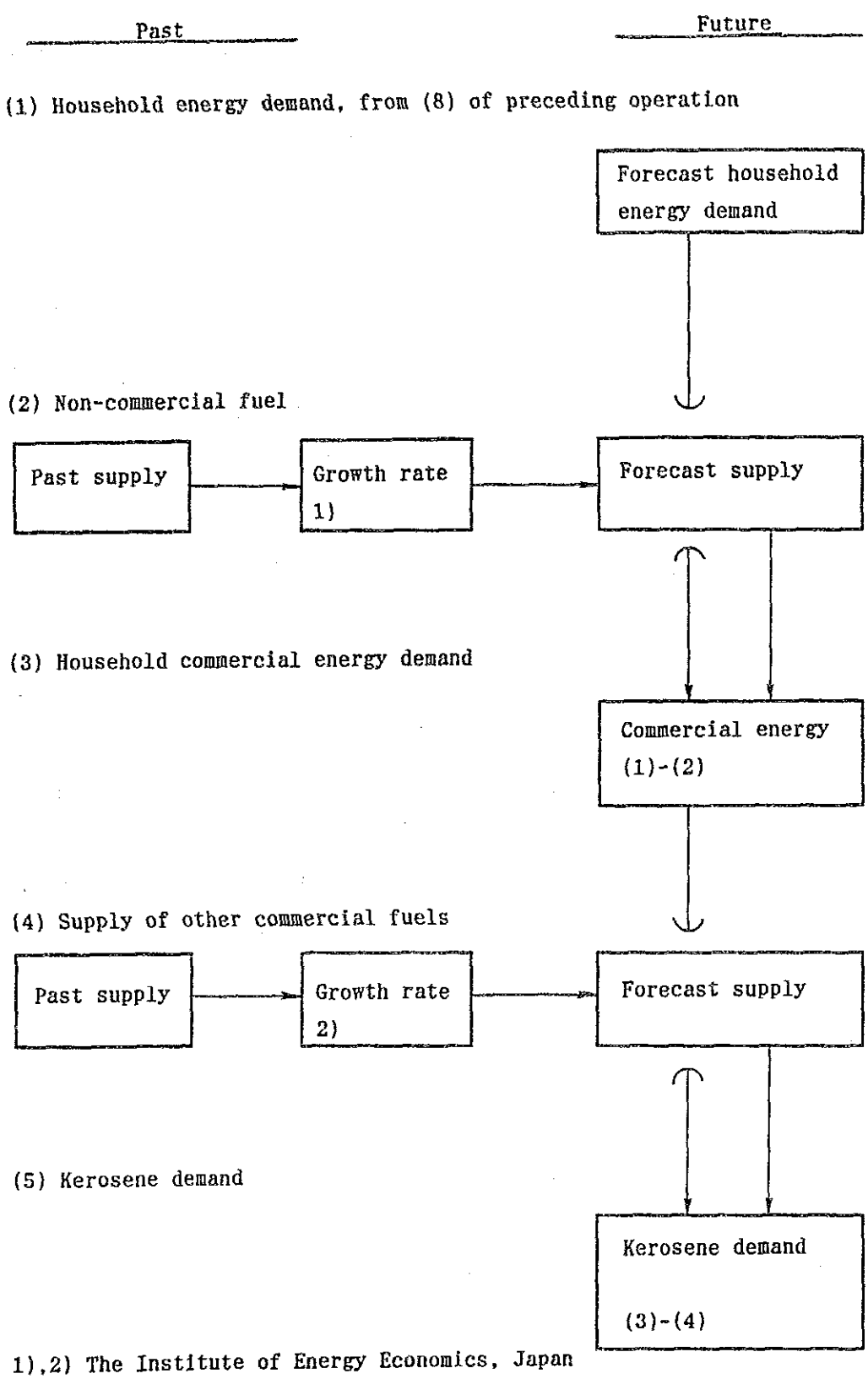
The approach employed for the econometric analysis is schematically shown on the next two pages. At first past data are analyzed; population, number of households, GDP, family size, GDP per family, GDP per capita, consumption of energy per family, Each item is broken down into urban and rural areas, because of the different styles these two areas exhibit about energy usage. The energy consumption per family is derived from an international source because of the lack of accurate information on non-commercial fuel, which constitutes the bulk of household energy.

The ten-year period from 1975 to 1985 is used to develop the rates of changes, with growth rates of the past broken down into two five year periods 1980/1975 and 1985/1980.




Sources of information:
1) Demographic Yearbook 1985, United Nations
2) World Development Report 1987, IBRD
3) Demographic Yearbook 1985, United Nations
4) The Institute of Energy Economics
5) International Financial Statistics 1987, IMF
6) Sixth Five Year Plan of Pakistan
7) Technical Paper No. 67, Household Energy Handbook, IBRD
8) The Institute of Energy Economics, Japan
9) Energy Year Book of Pakistan, 1986

**Figure 3-7-1 Development of Household Energy Demand**




1),2) The Institute of Energy Economics, Japan

**Figure 3-7-2 Development of Forecast Household Kerosene Demand**

**Table 3-7-2 Input to Demand Forecast**

| | 1975 | 1980 | 80/75 (%/year) | 1985 | 85/80 (%/year) |
|---|---|---|---|---|---|
| (1) Population,(1,000) | 70,260 | 82,140 | 3.17 | 96,180 | 3.21 |
| Urban | 18,710 | 24,220 | 5.30 | 30,670 | 4.84 |
| Rural | 51,550 | 57,920 | 2.36 | 65,510 | 2.49 |
| (2) Household,(1,000) | 11,343 | 12,588 | 2.10 | 13,966 | 2.10 |
| Urban | 3,037 | 3,554 | 3.19 | 4,147 | 3.13 |
| Rural | 8,306 | 9,033 | 1.69 | 9,819 | 1.68 |
| (3) Family size (1)/(2) | 6.19 | 6.53 | 1.08 | 6.89 | 1.08 |
| Urban | 6.16 | 6.81 | 2.03 | 7.40 | 1.68 |
| Rural | 6.21 | 6.41 | 0.64 | 6.67 | 0.80 |
| (4) GDP(Billion US$) | 10.09 | 13.26 | 5.62 | 18.03 | 6.34 |
| Urban | 3.68 | 5.14 | 6.91 | 7.41 | 7.59 |
| Rural | 6.41 | 8.12 | 4.84 | 10.62 | 5.51 |
| (5) GDP(US$) per family | 890 | 1,053 | 3.42 | 1,291 | 4.16 |
| Urban (4)/(5) | 1,212 | 1,446 | 3.59 | 1,787 | 4.33 |
| Rural (4)/(5) | 771 | 899 | 3.12 | 1,082 | 3.78 |
| (6) GDP(US$) per capita | 144 | 161 | 2.26 | 187 | 3.04 |
| Urban (8)/(2) | 197 | 212 | 1.48 | 242 | 2.68 |
| Rural (8)/(2) | 124 | 140 | 2.46 | 162 | 2.96 |
| (7) Energy,kgOE,per family | 606 | 676 | 2.20 | 811 | 3.71 |
| Urban | 579 | 600 | 0.72 | 678 | 2.47 |
| Rural | 616 | 705 | 2.74 | 867 | 4.22 |
| (8) Energy elasticity (6)/(5) | | | 0.643 | | 0.892 |
| Urban | | | 0.201 | | 0.570 |
| Rural | | | 0.878 | | 1.116 |

Source:
(1)&(2) Demographic Yearbook 1985, United Nations
(4) International Financial Statistics 1987, IMF
(7) Technical Paper No. 67, Household Energy Databook, IBRD, An Interim Guidebook and Reference Manual

**Table 3-7-3 Projection of Inputs to Demand Forecast**

| | 1980 | 1985 | 1989 | %/year 89/85 | 2006 | %/year 2006/89 |
|---|---|---|---|---|---|---|
| (1)GDP(Billion US$, 1975 price) | | | | | | |
| | 13.26 | 18.03 | 23.02 | 6.3 | 67.15 | 6.5 |
| Urban,% | 38.8 | 41.1 | 42.9 | | 50.7 | |
| Rural,% | 61.2 | 58.9 | 57.1 | | 49.3 | |
| (2)Population,(1,000) | 82,140 | 96,180 | 108,640 | 3.1 | 171,300 | 2.7 |
| Urban,% | 29.5 | 31.9 | 33.5 | | 39.5 | |
| Rural,% | 70.5 | 68.1 | 66.5 | | 60.5 | |
| (3)Family size (2)/(4) | 6.53 | 6.89 | 7.16 | | 8.06 | |
| Urban | 6.81 | 7.40 | 7.80 | | 8.65 | |
| Rural | 6.41 | 6.67 | 6.87 | | 7.72 | |
| (4)Household,(1,000) | 12,588 | 13,966 | 15,182 | | 21,247 | |
| Urban | 3,554 | 4,147 | 4,665 | 2.99 | 7,822 | 3.09 |
| Rural | 9,033 | 9,819 | 10,517 | 1.73 | 13,425 | 1.45 |
| (5)GDP(US$) per family (1)/(4) | | | | | | |
| Urban | | 1,787 | 2,118 | 4.34 | 4,353 | 4.32 |
| Rural | | 1,082 | 1,249 | 3.66 | 2,466 | 4.08 |
| (6)Energy elasticity | | | | | | |
| Urban | 0.201 | 0.570 | 0.87 | | 0.93 | |
| Rural | 0.878 | 1.116 | 1.09 | | 1.03 | |
| (7)Rate of energy consumption per family, (5)x(6) | | | | | | |
| Urban | | | | 3.78 | | 4.02 |
| Rural | | | | 3.98 | | 4.20 |
| (8)Growth rate of total energy demand, compound growth rate of (4) and (7) | | | | | | |
| Urban | | | | 6.88 | | 7.23 |
| Rural | | | | 5.78 | | 5.71 |

Note:
(1) Sixth Five Year Plan
(2) World Development Report, 1987, IBRD
(4) The Institute of Energy Economics, Japan
(6) The Institute of Energy Economics, Japan
Note: Growth of GDP is estimated to be 6.3 and 6.5 percent per year for 1985/89 and 1989/2006, respectively from the actual performance and target growth of the Sixth Five Year Plan.

Using the estimated inputs thus developed, the projected household energy demand is calculated as follows:

**Table 3-7-4 Projected Household Energy Consumption**

(thousand tons oil equivalent)

| | 1985 | 1989 | 2006 | Rate of Increase 89/85 %/year | Rate of Increase 2006/89 %/year |
|---|---|---|---|---|---|
| (1)Total Energy Demand | 11,322 | 14,323 | 39,408 | 6.1 | 6.1 |
| Urban | 2,811 | 3,667 | 12,038 | 6.9 | 7.2 |
| Rural | 8,511 | 10,656 | 27,370 | 5,8 | 5.7 |
| (2)Non-commercial Energy | 8,963 | 10,139 | 12,651 | 3.1 | 1.3 |
| Urban | 1,285 | 1,224 | 1,871 | -1.2 | 2.5 |
| Rural | 7,678 | 8,916 | 10,679 | 3,8 | 1.1 |
| (3)Commercial Energy | 2,359 | 4,184, | 26,858 | 15.4 | 11.6 |
| Urban (1)-(2) | 1,526 | 2,443 | 10,167 | 12.5 | 8.7 |
| Rural (1)-(2) | 833 | 1,740 | 16,691 | 20.2 | 14.2 |
| (4)Petroleum | 882 | 1,765 | 14,521 | 18.9 | 13.2 |
| Urban | 130 | 186 | 662 | 9.4 | 7.8 |
| Rural | 752 | 1,579 | 13,859 | 20.4 | 13.6 |
| (5)Natural Gas | 995 | 1,579 | 8,112 | 12.2 | 10.1 |
| Urban | 995 | 1,579 | 6,537 | 12.2 | 8.7 |
| Rural | 0 | 0 | 1,575 | 0 | - |
| (6)Coal | 6 | 7 | 15 | 3.9 | 4.6 |
| Urban | 0 | 0 | 0 | 0 | 0 |
| Rural | 6 | 7 | 15 | 3.9 | 4.6 |
| (7)Electricity | 476 | 833 | 4,210 | 15.0 | 10.0 |
| Urban | 401 | 678 | 2,968 | 14.0 | 9.0 |
| Rural | 75 | 155 | 1,272 | 19.9 | 13.0 |

Reference:

Growth rate of non-commercial energy: ENERGY YEAR BOOK 1985

Growth rates of commercial energy other than kerosene: Report on a long-term energy plant, a 20-year outlook, 1983 IED Consultants. S.A.

Using the above projected inputs, the following projected consumption of kerosene and firewood are developed.

**Table 3-7-5 Projected Consumption of Kerosene and Firewood**
(thousand tons oil equivalent)

| Year | Petrlm | LPG | Kero. | Kero. | Non-com.fuel | Firewood |
|---|---|---|---|---|---|---|
| | | | (1,000 ton) | | | |
| 1985 | 882 | | | | 8,963 | |
| 1989 | 1,765 | 56 | 1,709 | 1,657 | 10,139 | 5,576 |
| 1990 | 1,998 | | 1,935 | 1,876 | 10,272 | 5,650 |
| 1995 | 3,713 | | 3,595 | 3,485 | 10,963 | 6,030 |
| 2000 | 6,901 | | 6,682 | 6,477 | 11,700 | 6,435 |
| 2005 | 12,826 | | 12,419 | 12,039 | 12,486 | 6,867 |
| 2006 | 14,521 | | 14,060 | 13,630 | 12,651 | 6,958 |

Note: Firewood is assumed to account for 55 percent of non-commercial fuels. LPG is assumed to account for a fixed percentage of petroleum.

This is the result of the econometric study based greatly on forecast population and GDP and energy elasticity relationship. It is noted from this table that a large amount of kerosene, much larger than one could easily imagine, will be demanded. Therefore, a sensitivity analysis is conducted of the kerosene demand with respect to GDP growth rate.

**Table 3-7-6 Sensitivity of Household Energy Demand to GDP Growth**

| (1) GDP Growth rate | | (2) GDP Bill US$ 2006 | (3) House-hold 2006 | (4) GDP per family 1989 | (5) GDP per family 2006 | (6) %/year | (7) Rate of energy per family | (8) Growth rate of total energy | (9) Total energy |
|---|---|---|---|---|---|---|---|---|---|
| 6.5 | | 67.15 | | | | | | | 39,408 |
| | U | 34.04 | 7,822 | 2,118 | 4,353 | 4,32 | 4.02 | 7.23 | 12,038 |
| | R | 33.10 | 13,425 | 1,249 | 2,466 | 4.08 | 4.20 | 5.71 | 27,370 |
| 5.0 | | 52.76 | | | | | | | 30,983 |
| | U | 26.75 | 7,822 | 2,118 | 3,420 | 2.86 | 2.66 | 5.83 | 9,608 |
| | R | 26.01 | 13,425 | 1,249 | 1,937 | 2.61 | 2.69 | 4.18 | 21,357 |
| 4.0 | | 44.84 | | | | | | | 28,617 |
| | U | 22.74 | 7,822 | 2,118 | 2,907 | 1.88 | 1.75 | 4.89 | 8,256 |
| | R | 22.10 | 13,425 | 1,249 | 1,646 | 1.63 | 1.67 | 3.14 | 20,361 |
| 3.0 | | 42.82 | | | | | | | 25,158 |
| | U | 21.71 | 7,822 | 2,118 | 2,775 | 1.60 | 1.49 | 4.63 | 7,917 |
| | R | 21.11 | 13,425 | 1,249 | 1,572 | 1.36 | 1.40 | 2.87 | 17,241 |

Note (7)= (6)x elasticity ( 0.93 for urban and 1.03 for rural)
(8)= compound growth rate of household number and (7)
energy, thousand ton oil equivalent
household number, 1,000
GDP per family US$

Assuming non-commercial fuel consumption to be unaffected by growth rate of GDP and commercial fuels other than petroleum to be affected in proportion to the effect of GDP on the total household energy, the following consumption of kerosene is obtained for 2006 with respect to the growth rate of GDP.

**Table 3-7-7 Kerosene Consumption vs GDP Growth Rate**

| Growth rate of GDP | 6.5 | 5.0 | 4.0 | 3.0 |
|---|---|---|---|---|
| Total household energy | 39,408 | 30,983 | 28,617 | 25,158 |
| Non-commercial energy | 12,651 | 12,651 | 12,651 | 12,651 |
| Commercial energy total | 26,757 | 18,332 | 15,966 | 12,507 |
| Other commercial energy | 12,337 | 9,693 | 8,959 | 7,876 |
| Petroleum | 14,521 | 8,639 | 7,007 | 4,631 |
| Kerosene | 14,060 | 8,364 | 6,785 | 4,483 |

Using this result, the consumption of kerosene from 1989 is calculated below at constant growth rates.

**Table 3-7-8 Growth of Kerosene Demand vs GDP Growth Rate**

| Growth rate of GDP | 6.5 | 5.0 | 4.0 | 3.0 |
|---|---|---|---|---|
| 1989 | 1,709 | 1,709 | 1,709 | 1,709 |
| 1990 | 1,935 | 1,876 | 1,853 | 1,809 |
| 1995 | 3,596 | 2,993 | 2,780 | 2,402 |
| 2000 | 6,683 | 4,775 | 4,171 | 3,191 |
| 2005 | 12,421 | 7,618 | 6,256 | 4,238 |
| 2006 | 14,060 | 8,364 | 6,785 | 4,485 |
| %/year | 11.32 | 9.79 | 8.45 | 5.84 |

As against the simplified econometric analysis, a simple projection is made based on the past record. Starting from the consumption in 1985 of 800.4 thousand tons as kerosene the projection is made to 2006 on 9.14 percent per year, which is the past growth rate of Kerosene consumption for household use from 1980 to 1985. The result of this operation is shown in Table 3-7-9.

**Table 3-7-9 Demand of Kerosene by Projection**

| year | thousand tons |
|---|---|
| 1989 | 1,136 |
| 1990 | 1,239 |
| 1995 | 1,919 |
| 2000 | 2,971 |
| 2005 | 4,601 |
| 2006 | 5,021 |

Here supply possibility is analyzed. Since kerosene and aviation fuels are almost identical in quality, both products compete with each other for supply. Tables 3-7-10 and 3-7-11 show respectively the supply and consumption of kerosene and aviation fuel for the past five years.

**Table 3-7-10 Supply of Kerosene Fraction**

(thousand tons)

| | PRODUCTION | | | | | | | | | IMPORT | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kerosene | | | | Aviation fuel | | | | Ttl | Kero | A | |
| | A | P | N | Ttl | A | P | R | Ttl | | | | |
| 1980 | 43 | 26 | 100 | 169 | 4 | 330 | 206 | 540 | 709 | 377 | 2 | 1,088 |
| 1981 | 41 | 38 | 132 | 211 | 7 | 304 | 201 | 512 | 723 | 352 | 4 | 1,078 |
| 1982 | 36 | 70 | 135 | 241 | 9 | 279 | 180 | 468 | 709 | 390 | 2 | 1,065 |
| 1983 | 26 | 83 | 149 | 258 | 15 | 290 | 169 | 474 | 732 | 411 | 0 | 1,143 |
| 1984 | 60 | 148 | 99 | 307 | 20 | 277 | 166 | 463 | 770 | 489 | 2 | 1,261 |
| 1985 | 105 | 87 | 107 | 299 | 19 | 304 | 170 | 493 | 792 | 492 | 4 | 1,288 |

Note: A; Attock Refinery, Ltd. P; Pakistan Refinery Ltd.
N; National Refinery Ltd. T; subtotal.

**Table 3-7-11 Consumption of Kerosene Fraction**

| | Kero | JP-1 | Av.fuel | Total |
|---|---|---|---|---|
| 1980 | 529 | 218 | 316 | 1,063 |
| 1981 | 553 | 187 | 320 | 1,060 |
| 1982 | 604 | 143 | 330 | 1,077 |
| 1983 | 690 | 125 | 341 | 1,156 |
| 1984 | 760 | 113 | 346 | 1,219 |
| 1985 | 811 | 126 | 373 | 1,310 |

Source: ENERGY YEAR BOOK 1986

The following could be noted from the above tables:

(1) The supply and consumption figures are in agreement within the accuracy of statistics.

(2) The production of kerosene fraction, or total of kerosene and aviation fuel reached 16.5 percent of crude in 1985, which is considered maximum yield from the crude Pakistan is processing. In other words, the domestic production has already reached the maximum; any further increase of supply must come from refinery expansions and import.

The future supply is estimated as shown in Table 3-7-12. This could be considered maximum because the refinery expansion and import are incorporated to the maximum extent.

**Table 3-7-12 Supply Possibility of Kerosene Fraction**

| | Supply possibility | | | | Consumption | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1989 | 792 | 628 | | 1,420 | 150 | 388 | 538 | 882 |
| 1990 | 792 | 669 | 672 | 2,133 | 150 | 396 | 546 | 1,587 |
| 1995 | 792 | 916 | 1,007 | 2,715 | 150 | 444 | 594 | 2,121 |
| 2000 | 792 | 1,255 | 1,679 | 3,726 | 150 | 497 | 647 | 3,079 |
| 2005 | 792 | 1,720 | 2,015 | 4,527 | 150 | 557 | 707 | 3,820 |
| 2006 | 792 | 1,832 | 2,015 | 4,527 | 150 | 570 | 720 | 3,807 |

Note:

(1) Production from the existing capacity

(2) Maximum allowable import assumed to increase at the rate of GDP growth, 6.3% for 1989/85 and 6.5% for 1989/2006

(3) Production from increased capacity, assumed as follows:

1990: a new 100,000 BPSD refinery onstream, kerosene fraction yield at 16.0 percent

1995: a new hydrocracker added to the new refinery increasing the kerosene yield to 24.0 percent

2000: a new 100,000 BPSD refinery onstream

2005: a new hydrocracker added

(4) (1)+(2)+(3)

(5) JP-1 production assumed from the past record

(6) Aviation fuel assumed to increase at the past trend

(7) (5)+(6)

(8) (4)-(7) Maximum allowed for kerosene consumption

Viewed in this manner from the supply constraints, the increase of supply as indicated by the result of the econometric method would not be very easy. It would be possible to increase the amount of importation of kerosene faster than GDP grows; however, in the light of the result of supply possibility analysis one should be more conservative about the supply of kerosene than the econometric analysis indicates. For this reason in the forecast of the demand of coal briquettes, the result of the simple projection shown in Table 3-7-9, which gives a far smaller forecast than the econometric method, is used.

## 3-8 Price Forecast of Kerosene and Firewood

### 3-8-1 Present Price of Fuel at Consumers End

The present prices of common fuels were investigated during the field survey by means of interviews; the results are summarized in Table 3-8-1.

**Table 3-8-1 Current Consumer Price of Fuel**

| | | Rs/MMBTU | US$/MMBTU |
|---|---|---|---|
| Kerosene | 3.5 Rs/liter | 101.25 | 5.59 |
| | 4.5 Rs/liter | 130.18 | 7.19 |
| Firewood | | | |
| Hala | 16.0 Rs/40kg | 30.24 | 1.67 |
| Islamabad, Hyderabad | 26.0 Rs/40kg | 49.14 | 2.71 |
| Quetta | 35.0 Rs/40kg | 66.15 | 3.65 |
| Lahore | 40.0 Rs/40kg | 75.60 | 4.17 |
| City gas | 18.0 Rs/MCFT | 18.36 | 1.01 |
| | 27.0 Rs/MCFT | 27.55 | 1.52 |
| Electricity | 0.5 Rs/kwh | 146.46 | 8.09 |
| Charcoal | 50.0 Rs/40kg | 43.62 | 2.41 |
| | 80.0 Rs/40kg | 69.79 | 3.85 |
| Burner fuel | 1980.0 Rs/ton | 48.55 | 2.68 |

Source: Interviews, Energy Year Book 1986

Note: Heat of combustion used in the above calculation:
Kerosene 19,600 Btu/lb; Specific gravity 0.800
Firewood 6,000 Btu/lb
City gas 980 Btu/SCF
Charcoal 13,000 Btu/lb
Burner fuel 18,500 Btu/lb
Conversion rate 1US$=Rs18.11
1 lb=0.4536 kg
1 kwh=3414 Btu

For some fuels different prices were obtained from one place to

another or depending upon the use, for such cases various prices are shown.

These prices are converted into equivalent prices of coal briquettes of this project; the representative expermentally produced sample has a heat of combustion of 5,381 Kcal/kg.

**Table 3-8-2 Consumer Price of Fuels in Coal Briquette Equivalent**

| | | Rs/MMBtu | Rs/ton |
|---|---|---|---|
| Kerosene | 3.5 Rs/liter | 101.25 | 2,183 |
| | 4.5 Rs/liter | 130.18 | 2,807 |
| Firewood | | | |
| Hala | 16.0 Rs/40kg | 30.24 | 652 |
| Islamabad, Hyderabad | 26.0 Rs/40kg | 49.14 | 1,059 |
| Quetta | 35.0 Rs/40kg | 66.15 | 1,426 |
| Lahore | 40.0 Rs/40kg | 75.60 | 1,630 |
| City gas | 18.0 Rs/MCFT | 18.36 | 396 |
| | 27.0 Rs/MCFT | 27.55 | 594 |
| Electricity | 0.5 Rs/kwh | 146.46 | 3,158 |
| Charcoal | 50.0 Rs/40kg | 43.62 | 940 |
| | 80.0 Rs/40kg | 69.79 | 1,505 |
| Burner fuel | 1980.0 Rs/ton | 48.55 | 1,047 |

Table 3-8-2 gives an indication of the prices of coal briquettes at which coal briquettes become equivalent with other fuels in the price of heat at the consumers end.

### 3-8-2 Price Forecast of Kerosene and Firewood

(1) Past trend

Table 3-8-3 gives official statistics about past trends of the consumer prices of kerosene and firewood and some data that have relevance to the prices of these commodities.

Table 3-8-3 Past Trends of Kerosene and Firewood Prices

| Year | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 | %/year |
|---|---|---|---|---|---|---|---|
| GDP deflator | 448.75 | 490.81 | 519.14 | 568.16 | 595.25 | | 7.318 |
| Con.price index | 159.81 | 175.79 | 183.67 | 199.03 | 213.87 | 224.21 | 7.007 |
| Wholesale price index | | | | | | | |
| General | 163.69 | 176.16 | 182.27 | 201.38 | 208.92 | 217.38 | 5.837 |
| Fuel | 231.98 | 243.64 | 263.28 | 278.40 | 298.13 | 329.72 | 7.285 |
| Wholesale price | | | | | | | |
| Gasoline Rs/l | 4.83 | 5.08 | 5.72 | 6.02 | 6.56 | 7.14 | 8.131 |
| Diesel Rs/l | 2.69 | 2.77 | 2.77 | 2.79 | 3.04 | 3.27 | 3.982 |
| Kerosene Rs/l | 2.69 | 2.77 | 2.77 | 2.79 | 3.04 | 3.29 | 4.109 |
| Retail price | | | | | | | |
| Kerosene Rs/l | 3.14 | 3.22 | 3.24 | 3.26 | 3.54 | 3.88 | 4.323 |
| Firewood Rs/40kg | 23.86 | 27.84 | 28.67 | 31.06 | 32.84 | 33.35 | 6.926 |

It may be noted that the consumer price of firewood has increased in keeping pace with the rise in consumer price index; while on the other hand the consumer price of kerosene rose at a much lower rate, or rather controlled at a lower price. This was posssible partly because a decreasing trend of crude oil prices prevailed during that period.

(2) Future price

The future price of kerosene is forecast from correlations existing between the price of imported crude oil and the prices of petroleum products, and further from the correlation between the price of kerosene and other petroleum products. It is also assumed that the subsidy price now given to kerosene will be phased out in accordance with the result of interviews conducted during the field survey. The result of the forecast is shown in Table 3-8-4.

**Table 3-8-4 Forecast Kerosene and Firewood Prices**

(1988 price)

| Year | Imported Crude | | Oil Products | Kerosene | Firewood |
|---|---|---|---|---|---|
| | $/BBL | Rs/ton | Rs/ton | Rs/ton | Rs/40kg |
| 1980/85 1) | 30.1 | 2,765 | 4,051 | 3,457 | |
| 1989 | 19.0 | 2,519 | 3,691 | 2)4,375 | 7)32.0 |
| 1990 | 19.5 | 2,585 | 3,787 | 3)4,489 | 7)32.8 |
| 1995 | 22.0 | 2,916 | 4,272 | 4)5,915 | 7)37.0 |
| 2000 | 26.0 | 3,447 | 5,050 | 5)7,691 | 7)43.8 |
| 2005 | 28.5 | 3,779 | 5,537 | 6)8,433 | 7)48.0 |

Note: Crude oil specific gravity 0.8591

Conversion rate: 1 US$=Rs18.11

1) See next page

2) 3.5 Rs/liter at consumers end converted into 4,375 Rs/ton using specific gravitiy of kerosene being 0.800

3) 4,375x3,787/3,691=4,489

4) Subsidy on kerosene is assumed to be lifted.
4,272/3,787x4,489x1.168=5,915

| | |
|---|---|
| ex-refinery price of kerosene | 2.14340 Rs/liter |
| ex-refinery price of HDO | 2.62923 Rs/liter |
| specific gravity of kerosene | 0.840 |
| specific gravity of HDO | 0.810 |

(2.62923/2.14340)x(0.800/0.840)=1.168

5) Normally, kerosene should be 10 percent higher than HDO.
5,050/4,272x5,915x1.1=7,691

6) 5,537/5050x7,691=8,433

7) Assumed to increase in proportion to petroleum product price. starting from Rs 30.0/40 kg in 1989.

Table 3-8-5 shows past relationship among the prices of imported crude oil, average prices of petroleum products and kerosene prices.

**Table 3-8-5 Prices of Crude Oil, Products and Kerosene**

| | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 |
|---|---|---|---|---|---|---|
| Crude price, million US$ | 994.74 | 1,139.30 | 989.23 | 916.41 | 842.72 | 602.00 |
| Crude volume, thousand metric ton | 4,041 | 4,396 | 4,186 | 4,294 | 4,028 | 3,797 |
| Average price, US$/M.T. | 246.2 | 259.2 | 236.3 | 213.4 | 209.7 | 158.6 |
| Average price, Rs/M.T. | 2,437.4 | 2,566.1 | 2,953.8 | 2,902.2 | 3,145.5 | 2,585.2 |
| Average petroleum product price, Rs/M.T. | 3,543 | 3,480 | 3,982 | 4,292 | 4,472 | 4,536 |
| Kerosene price, Rs/M.T. | 3,087 | 3,086 | 3,395 | 3,395 | 3,704 | 4,074 |

AVERAGE CRUDE, PRODUCTS, AND KEROSENE PRICES

| | | | |
|---|---|---|---|
| Crude price | 30.1 $/BBL | 220.3$/ton | 2,765 Rs/ton |
| Average product price | | | 4,051 Rs/ton |
| Average kerosene price | | | 3,457 Rs/ton |

(3) Assumption of kerosene subsidy remaining

Along with the forecast prices of kerosene shown in Table 3-8-4, the prices of kerosene are forecast assuming the subsidy on kerosene price to continue. The operation of forecasting the prices is shown in Table 3-8-6.

**Table 3-8-6 Forecast Kerosene and Firewood Prices**

(1988 price)

| Year | Imported Crude Oil | | Products | Kerosene | Firewood |
|---|---|---|---|---|---|
| | $/BBL | Rs/ton | Rs/ton | Rs/ton | Rs/40kg |
| 1980/85 1) | 30.1 | 2,765 | 4,051 | 3,457 | |
| 1989 | 19.0 | 2,519 | 3,691 | 2)4,375 | 7)32.0 |
| 1990 | 19.5 | 2,585 | 3,787 | 3)4,489 | 7)32.8 |
| 1995 | 22.0 | 2,916 | 4,272 | 4)5,064 | 7)37.0 |
| 2000 | 26.0 | 3,447 | 5,050 | 5)6,585 | 7)43.8 |
| 2005 | 28.5 | 3,779 | 5,537 | 6)7,220 | 7)48.0 |

Note: Crude oil specific gravity 0.8591
Conversion rate: 1 US$=Rs18.11

1) See next page
2) 3.5 Rs/liter at consumers end converted into 4,375 Rs/ton using specific gravity of kerosene being 0.800
3) 4,375x3,787/3,691=4,489
4) Subsidy on kerosene is assumed to remain.(See Table 3-8-4) 4,272/3,787x4,489=5,064
5) Price is increased by 10% in addition to escalation. See Table 3-8-4. 5,050/4,272x5,064x1.1=6,585
6) 5,537/5050x6,585=7,220
7) Assumed to increase in proportion to petroleum product price starting from Rs.30.0/40kg in 1989.

# CHAPTER 4 COAL BRIQUETTES MARKET

## 4-1 How People Use Fire

One of the basic principles for the development of this feasibility study is that the nation cannot force the people to use coal briquettes instead of kerosene or firewood by artificially raising their prices or restricting their supplies because of the merits this project could bring to the nation. Instead, the project should provide enough incentives to induce people to choose to buy and burn coal briquettes in preference to kerosene or firewood. For this purpose, the quality of coal briquettes should be such that the consumers would not be put to any inconvenience when they switch from kerosene or firewood to coal briquettes.

Kerosene, firewood and coal briquettes are all different in nature, each having its distinct characteristics. As fuel kerosene may be definitely superior to firewood or coal briquettes in some respects, but in others firewood may be superior to kerosene. Take heating value per unit weight of fuel, for example, coal briquettes and firewood are both no match with kerosene. With respect to easiness and safety of handling, firewood and coal briquettes may be preferred to kerosene.

Although different fuels have different properties, the study team has been convinced, through actual observation on the lifestyle, cooking habits and burning utensils of the common people of Pakistan, that they do not necessarily have reason to stick to their present fuels, but are flexible enough to use almost any fuel, provided that the alternative fuel provide comparable convenience, or quality, at a comparable price, Exceptions would be users of city gas and LPG, the former being more economical and convenient than any other fuels, the latter not necessarily economical but similarly convenient, and because the kitchens and burning utensils do not easily accommodate burning of solid fuels once geared to a gaseous fuel.

During the field survey, short as it may have been, the study team took every opportunity to see how people use fire. There are two types of kerosene stoves commonly in use: one is of pressurized type, the other of wick type. The former is equipped with a cylinder in which is placed kerosene under pressure generated by a small hand-operated air pump. The burner is connected with the cylinder via a small copper tube through which kerosene is supplied to the burner by the air pressure. The pump is worked as necessary to maintain the necessary pressure. The strength of flame is controlled by adjusting the opening of a small valve installed on the tube, to which the strength of flame responds quickly. This type of stove generates smoke and odor which is a definite drawback when used indoors. The other type in extensive use has a wick partly dipped in kerosene stored in the vessel forming the bottom of the stove; the strength of the flame is controlled by ups and downs of the wick. This type burns kerosene in a clean blue flame without generating smoke or disagreeable odors but responds rather slowly to the control of wicks. It takes about five minutes from ignition to reach a steady burning condition.

There are a number of designs for stoves to burn firewood; the most common for family use is made of earth or brick enclosing on three sides with front side open for feeding firewood. The stoves are installed directly on the floor against a wall. This type of stove could burn anything burnable. When a cooking is over, the flame is extinguished by covering ash over the burning firewood; this practice does not completely kill the fire but maintains the firewood in smoldering conditions. When they need fire next time, the flame can easily be rekindled by removing the ash and putting kindlings like paper or dry leaves on the firewood and blowing them. This is done in a matter of a few minutes. Stoves of this type are generally installed in a semi-open space just outside the living quarters of houses in the suburbs of Islamabad where winter temperature goes down considerably low as well as in Hyderabad Area where temperature is generally high. The fact that the cooking stoves are placed in semi-open spaces should be remembered, because this has bearing on the quality requirement of coal briquette, particularly that of

smokelessness.

Whether kerosene or firewood is used, starting a fire is very simple. Cooking is an unavoidable daily routine; therefore, people should not be put to any inconvenience by switching to coal briquettes if coal briquettes are to be accepted by the consumers. With this principle in mind, the important attributes of household fuels are examined and incorporated in the quality design of coal briquettes; these are, in addition to easiness of ignition and strength of flame which have already been mentioned, smokelessness, odorlessness, non-toxicity of combustion effluents and ashes, easiness of control, water resistance and physical strength, to say nothing of heat of combustion and price.

The northern and western parts of the nation require heating in winter when the temperature goes down considerably low. The estimate done by this study indicates that the region where heating is needed embraces a population of 10 to 20 million (Refer to 4-4, Demand Forecast of Coal Briquettes). In Pakistan inexpensive stoves equipped with a chimney are commercially available for burning coal. Such stoves could burn coal briquettes of the quality adequate for the cooking purpose. Even if the briquettes are burnt indoors, the chimney would draw the smoke and combustion effluents to outdoors; therefore, there is no need to be too meticulous about the smoke and volatile matters.

With regard to industrial consumption of coal briquettes, this study presumed that coal briquettes would be a promising alternative fuel for small industries; typical of these would be potteries, tile manufacturers, bakeries, soap factories, small-scale food processing industries, and small-scale textile industries. Brick burners scattered throughout the nation now burning most of the nation's coal production need not switch to coal briquettes, because coal is good enough for their purpose. Large-scale industries now burning natural gas or burner fuel are those kinds of industries which survive on inexpensive gas or require rather precise control of temperature possible only with gas or oil. These industries should therefore be excluded from the list of candidate industries for burning coal briquettes. It follows

then that the industries that could burn coal briquettes are mostly small-scale industries now burning firewood. However, the price of firewood is still low; the immediate switch from firewood to coal briquettes is not likely.

## 4-2 Quality Design of Coal Briquettes

This section presents quality design of coal briquettes from the point of view of the market based partly on the preceding discussions. The properties for which targets should be set are as follows:

1. Easiness of Ignition
2. Strength of Flame
3. Smokelessness
4. Odorlessness
5. Non-toxicity and Safety
6. Easiness of Control
7. Water Resistance
8. Physical Strength
9. Others

### 4-2-1 Easiness of Inition

In Pakistan, firewood is kindled in a matter of a few minutes. Between consecutive cooking periods, the firewood is maintained in a slow burning condition; and the firewood can be rekindled without using a match but with a small amount of kindlings like paper of dry leaves. Kerosene stoves can be started by a strike of a match and reaches a steady burning condition within five minutes. The coal briquettes of this project should be no less easy to start. A very important factor to consider in quality design is that the coal briquettes should be as easy as firewood to start and quick enough to reach a steady burning condition within five minutes.

### 4-2-2 Strength of Flame

The strength of flame is an important element in cooking. As far as the study team was able to observe the cooking behavior, the flame contacts a good portion of the bottom of pans. The coal briquettes of this project should burn with a long enough and powerful enough flame so that consumers could use them as if they were cooking with firewood or kerosene; thus their cooking beha-

vior would not be adversely affected by the introduction of coal briquettes.

### 4-2-3 Smokelessness

As the title of this project implies this project should produce smokeless briquettes. When this term "smokeless" is too rigorously applied, it could mean that the coal briquettes should burn like charcoal which burns without smoke but does not produce a flame. If so desired, complete smokelessness of coal briquettes can be achieved by subjecting the raw material coal to carbonization. The carbonization process eliminates smoke by removing a substantial portion of the volatile matter from coal, an important component which burns with a flame. The carbonization process, if applied to this project, would discard a significant portion of the heat content of the raw material coal by removing the volatile matter, of which the content is very high in the case of Lakhra lignite, besides incurring additional investment and operation costs.

The study team intends to retain the volatile matter to enable the briquettes to burn with a powerful flame and also to preserve as much heat contained in the coal as possible. A practical compromise must be worked out between this objective and the goal to achieve complete smokelessness. Since kitchens and fireplaces of the most Pakistani households are not of a completely closed type and since cheap stoves equipped with a chimney are available for heating, it would be practical and most beneficial to the project to tolerate a small amount of smoke for a short period immediately following the start of fire when the fire is not hot enough than choose to remove the volatile matter. Smoke is generated by incomplete combustion of fuel; practically complete combustion can be achieved by introducing sufficient air to the stove and also by giving a proper composition and texture to the fuel to make it easier to burn. It was assumed that this latter objective would be achieved by using a technology known as biocoal; this assumption has been proven right by experimental production of coal briquettes and their burning tests.

### 4-2-4 Odorlessness

This property is closely linked with smokelessness. If smoke is generated and permeates in the kitchen it naturally smells. Suppression of smoke decreases the problem of odor. Another source of an irritating smell is sulfur dioxide. This has to be taken care of by appropriate measures.

### 4-2-5 Non-toxicity and Safety

The safety of a fuel should be viewed from a variety of angles: spontaneous combustion, inflammability or tendency to catch fire from a heat source nearby, tendency to generate static electricity and to cause sparks, spills, danger of explosion, pressure, health hazards when the fuel itself or combustion products are inhaled or allowed to contact the skin. Coal briquettes are a stable solid fuel and are free from such safety concerns as inflammability, static electricity and sparks, spills, explosion, pressure of fuel peculiar generally to liquid or gaseous fuels.

All there is to do about safety is to: (1) eliminate the tendency the raw material Lakhra coal has for spontaneous combustion through appropriate treatments in the manufacturing process, (2) suppress the formation of sulfur dioxide generated by the combustion of sulfur carried over to the coal briquettes from the raw material Lakhra coal, and (3) present designs of burning utensils together with guidelines for burning coal briquettes in the safest way.

### 4-2-6 Easiness of Control

Use of fire must be simple and easy. This is one of the most important requirements of any household fuel. Cooking is often relegated to the least experienced member of a family; the coal briquettes therefore should never be more difficult than firewood or kerosene to burn and control the strength of fire and to extinguish.

### 4-2-7 Water Resistance

Coal briquettes may get wet during transportation and storage from the plant to the consumers. Even after reaching the consumers, the semi-open structure of the fireplace may allow the coal briquettes to get wet. If the coal briquettes absorbs moisture, the net heat of combustion by weight will decrease by the amount of moisture. Since coal briquettes are sold and bought by weight, the consumers will suffer if the coal briquettes have a great tendency to absorb moisture. Still worse, if coal briquettes absorb a considerable amount of water, the coal briquettes are liable to slake, losing its physical strength. It would incur an incremental cost if water-repelling paper bags are used to pack coal briquettes.

It would be ideal if the coal briquettes could be made water repellent. This was considered as one of the target properties of the coal briquettes of this project; and it has been achieved in the experimental production by giving wax coating to the briquettes

### 4-2-8 Physical Strength

The coal briquettes will be handled quite roughly from the plant all the way to the consumers. The product coal briquettes are dumped into the storage bins, thrown into the trucks, dumped on the storage yards of the depots or wholesalers, shoveled to be reloaded to pickup trucks and donkey carts for delivery to retailers, and finally transported to the consumers. The coal briquettes should have sufficient physical strength to withstand all this hard handling. The coal briquettes should not wear out to produce too much particles and fines before reaching the consumers.

### 4-2-9 Others

Other properties like size, shape, appearance should be decided to give the maximum convenience to the consumers.

All those quality requirements are difficult to define quantitatively in the form of specifications. Performance of the coal briquettes samples on the burning tests will be given importance in the evaluation of the quality.

### 4-2-10 Comparison between Kerosene and Coal Briquettes

Among the several differences between coal briquettes and kerosene fundamental difference lies in the fact that one is a liquid fuel and the other is a solid fuel. This basic difference defies attempts to compare these two fuels on the same level. However, it is worth while to summarize important features of these two from the viewpoint of household consumption, because the coal briquettes of this project are to replace kerosene.

(1) Form

Kerosene is a liquid and can spill. Once spilt there is no means of recovering it on a household level. Kerosene needs containers. Coal briquettes is a solid fuel in a uniform shape and size. Coal briquettes can be piled up. Coal briquettes can be recovered when spread from a truck.

(2) Safety

Modern kerosene is designed to be safe. However, if it is exposed to temperatures higher than the flash point of the kerosene, it can catch fire from the nearest source of fire. Normally, the flash point is higher than 40 degree centigrade; therefore, kerosene does not exhibit tendency to catch fire except under extremely hot conditions. Kerosene is a mineral oil of high solvency. It can very easily extract fat from skin causing an acute rash. The vapor has an intoxicating effect when inhaled. Coal briquettes have better marks in safety. Coal briquettes have no tendency to catch fire unless deliberately lit. Coal briquettes do not irritate skins. The only health problem is that associated with frequent inhalations of dust which could be conceivable only at manufacturing sites.

(3) Thermal efficiency

The thermal efficiency of fuels decreases in the order of gas to liquid and to solid if all are burnt in a similar apparatus. In well designed stoves kerosene burns as it is fed to the combustion zone; no excess kerosene exists in the burning zone. Solid fuels, unless pulverized into a fine powder form and burnt like a gas, have to be fed to the burning zone as a mass which burns from the surface and then gradually to the center. There is usually leftover of fuels after fire is used. Solid fuels do not mix well with air unlike gas or liquid fuel; therefore, more air than necessary for ideal combustion must be admitted which reduces the efficiency.

(4) Storage

Coal briquettes are much easier to store than kerosene. Kerosene has to be stored in such as way as not to absorb moisture. Coal briquettes designed to be water repellent do not deteriorate on prolonged exposure to atmosphere.

(5) Easiness of use

It is difficult to say which is easier to use. In most cases it is probably right to say that kerosene is easier to use. It does not require kindlings. However, if coal briquettes are well designed and well manufactured to ensure easy ignition and smokeless combustion, coal briquettes may be easier to use for those people who do not know how to use kerosene safely and are accustomed to using firewood.

(6) Cleanliness

Kerosene has advantages over coal briquettes at all stages.

(7) Pollution

Kerosene is pollution free in most cases. Whether coal briquettes are pollution free or not, at manufacturing phase, distribution phase or consumption phase, depends upon the design of the facilities and quality of the briquettes. If coal briquettes are designed and produced to be dust free, smokeless, odorless, coal briquettes may be considered to be virtually pollution free.

## 4-3 Distribution of Coal Briquettes

### 4-3-1 Transportation Cost

Generally, the cost of transportation constitutes a significant portion of the fuel price at the consumers end. It is therefore of vital importance in planning an energy project to examine the cost, dependability and efficiency of the systems of transportation available to the project. For a long-haul transportation, transportation by rail and that by road on truck were examined during the first-stage field survey, the result of which is very much in favor of truck transportation. The costs of transportation by truck from a truck station in Hyderabad and that by rail from Khanot Railway Station, both the nearest to the planned plant site, are schematically shown on Figures 4-3-1 and 4-3-2. The cost of transportation is found to be cheaper by road than by rail, if the standard rate for coal is applied.

The trucks in service are mostly 10-ton trucks. On the roadsides, restaurants, repair workshops and service stations are available. Coal produced in Lakhra is transported almost entirely by trucks. By truck, cargos travel rather fast throughout the country; trucks could run from Lakhra to Rawalpindi in 36 to 40 hours if they are expedited. Pilferage on the way is not reported and unheard of. The project owners need not have their own fleet of trucks; trucks are available for hire. In short, trucks are a very efficient, handy, fast, readily available and reliable means of transportation. The total number of truck registration is 81,019 as of 1986. The truck registration has increased for the past ten years at a rate of 2.7 percent a year.

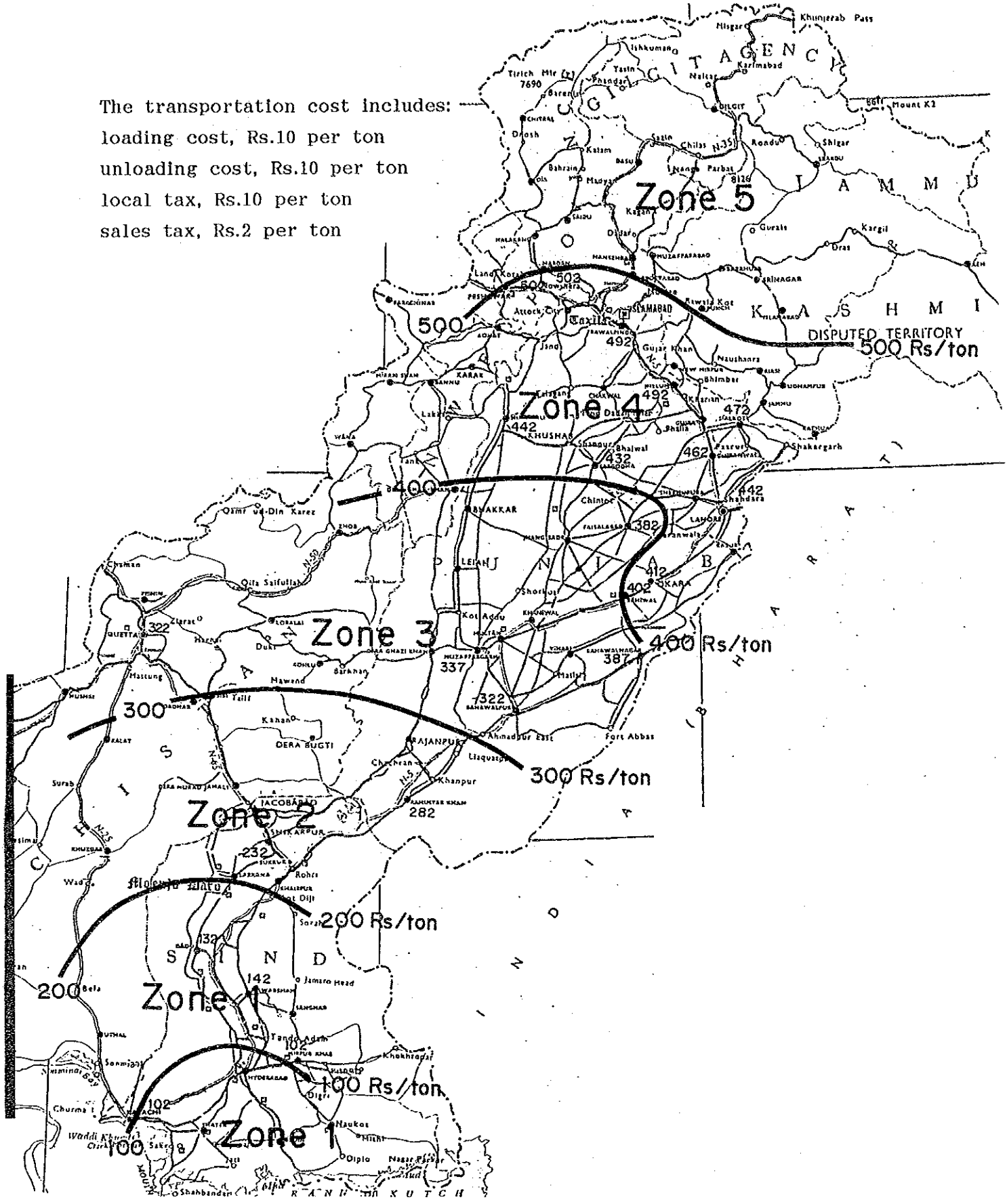
On the other hand, the railway transportation may be considered to be better suited to long-haul transportation; however, it normally takes much longer than truck transportation. Besides, the cost of transportation is found even higher than trucks. The truck transportation cost from Hyderabad to Multan, for example, is Rs.342.00 per ton including loading and unloading costs, local tax and excise tax. The railway would cost some Rs.600.00 per ton from Khanot, the nearest station to Lakhra, to Multan apply-

ing the rate for coal transportation. The Lakhra coal is now being transported mainly by truck even as far as Islamabad or even further. Normally the consigners arrange the trucks but the consignees pay the truck freight.

### 4-3-2 Distribution of Traditional Fuels

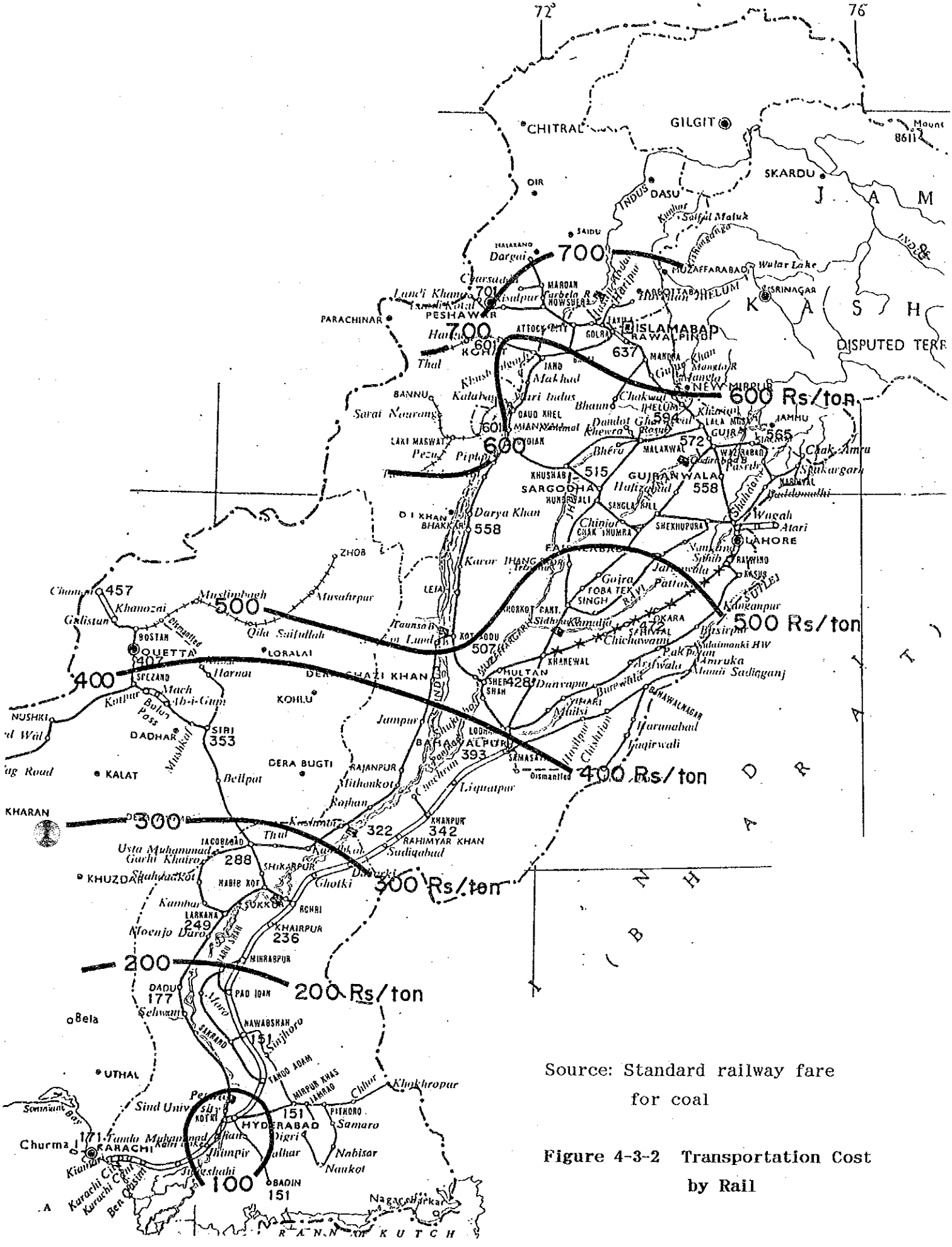
The distribution and cost of kerosene is under control of the government down to depots to prevent general consumers from being affected by shortage of supply or price fluctuations. The largest distributor is Pakistan State Oil Co Ltd., or PSO for short. At the time of the field survey the price of kerosene is 2.14340, 3.0 and 3.5 to 4.5 Rs. per liter at refinery or import terminal, wholesale depot and retail, respectively. The uniform price is applied throughout the nation down to the depot irrespective of actual transportation cost. The distribution from the depot down to the consumers is not controlled; the mechanism of market works quite well in the downstream distribution. The consumers buy kerosene in 18-liter pail or come to the retailers with their own containers and buy kerosene by measure. Kerosene retailers generally deal in other daily commodities.

The system for distribution of firewood and charcoal is not well organized nor nationwide unlike that of kerosene; the system is very much the result of spontaneous growth of commerce. As far as the study team was able to determine from the interviews of the retailers, the retailers take care of procurement instead of the producers taking care of supply to the retailers. Since there is no overwhelmingly great center of production of firewood and charcoal supplying nationwide, the systems of distribution are rather local. The retailers interviewed in Hyderabad area said that their goods came from some 100 kilometers north. The kind of wood sold as firewood is quite uniform both in Hyderabad and Islamabad areas, mostly hard wood taken from a local tree called tikiker cut to nearly a same length. This may be because this species of tree is rather abundant; but this may also be taken as an indication of steadfastness of this trade, having long been practiced and established under unwritten understandings about quality between the sellers and consumers, about




Source: Standard truck fare from the struck station at Hyderabad

**Figure 4-3-1 Transportation Cost by Truck**




Source: Standard railway fare for coal

**Figure 4-3-2 Transportation Cost by Rail**

supply/purchase relation between the producers and retailers. The distribution systems of firewood and charcoal would not be like their modern counterparts of kerosene distribution network; but it would be right to think that they are mostly time-honored, firmly established and reliable.

### 4-3-3 Distribution and Marketing Networks of Coal Briquettes

Before the field survey of March was actually carried out, it had been assumed that the main market of this project would be limited to the southern part of the nation. Major cities and towns of this area as represented by Karachi and Hyderabad are provided with city gas. As a result of the field survey it has become apparent first that this project could expect a much broader area to be the market, and second that the rural area of the southern part of the nation would not be a promising market.

If this project is to market the product nationwide, what is needed is a broader and more comprehensive marketing strategy than had previously been contemplated for marketing mainly in the south. Marketing nationwide would perhaps be too extensive a task for PMDC per se to get directly involved in and manage with its present limited number of human resources. It would be better for PMDC, or any agent to be appointed by PMDC to operate this project, to concentrate on the manufacturing aspect of this project and let other entities of demonstrated capability to take care of the distribution and marketing aspects under some forms of agreement with PMDC. The qualification for distributors and marketers must meet certain requirements: well established organization with offices and storage depots or wholesalers deployed at strategic locations throughout the nation, experience with nationwide marketing and distribution of fuels or similar commodities, compatibility with PMDC' policy, trust by general consumers, good financial standing, and above all, willingness to deal in coal briquettes. Organizations meeting all these requirements are hard to come by. The following four organizations are selected because they may be considered to meet some, though not necessarily all, of the requirements.

1. Free merchants including firewood/charcoal dealers
2. Coal dealers of PMDC
3. PSO, or Pakistan State Oil Co Ltd., and other kerosene distributors and LPG distributors
4. Salt dealers of PMDC

The idea behind the options 1 to 4 is that the project sells the product ex-factory and let the distributors and marketers take care of the downstream business. This market study does not recommend that the project employ a sole distribution and marketing agent; instead the project should have different channels to distribute and sell the product.

The first option, free merchants including firewood/charcoal dealers, would let anyone who comes to the plant with transportation buy the coal briquettes ex-factory and sell them as he likes. If firewood and charcoal dealers sell the coal briquettes, the coal briquettes could be sold together with firewood and charcoal on time-honored fuel distribution channels. This could also help avoid confrontation between firewood/charcoal and coal briquettes as competing fuels. This could also be very convenient for general consumers who wish to buy firewood and coal briquettes at the same time. Besides firewood and charcoal dealers, those dealing in daily commodities like soap, medicines, food, beverages may find coal briquettes an interesting commodity to sell. This option will allow a number of free merchants to participate in the sales on a basis of free competition; and therefore, this will let the mechanism of free competition work to the maximum extent. The result would be the most beneficial to the consumers.

The second option is the extension of the facility PMDC presently has. PMDC now gives marketing rights of coal on an annual contract basis to selected dealers. The dealers have depots and offices deployed at strategic locations throughout the nation. Their local offices take orders from customers and send the order to the head office. The head office arranges the cargo and transportation to the customers. The problem with the coal dealers is that their customers are mostly brick burners; and there-

fore, they have to develop effective channels to reach the general consumers. One solution would be to employ local firewood and charcoal dealers as retailers who take the product from the coal dealers' storage yards and sell to the consumers.

The third option would incorporate what seems to be competitors in the camp of this project, or conversely let the potential competitors handle the product of this project. PSO is the largest distributor of petroleum products owned 25.5 percent by the government, 48.1 percent by the governmental financial organizations. There are other distributors of petroleum products like Caltex. The supply of kerosene is restricted: domestic production limited by lack of cracking facilities in the nation's petroleum refineries to increase production of kerosene from crude oil, foreign currency problems associated with the importation of kerosene, limited capacities of ports and terminals, just to name a few. The distributors of kerosene as represented by PSO would be in a position not to be able to meet the potential demands of kerosene in the long-range perspective.

Under such a circumstance these kerosene dealers might be interested to deal in coal briquettes together with kerosene instead of confronting competition with coal briquettes. There would be enough incentive on the part of these kerosene dealers if a profit margin equal to or better than that of kerosene dealing is found in the dealing of coal briquettes. There is a marked advantage on the part of this project in the mobilization of the kerosene dealers; they have depots throughout the nation and also retailers tributary to the depots on which channel the coal briquettes could be distributed and marketed. These kerosene dealers also have rich human resources and firm financial status. It is not unusual for petroleum businesses to deal in coal and coal products in USA, Japan and elsewhere. It has been confirmed that there is no legal restriction which may prevent PSO's and other kerosene dealers from handling coal briquettes. In response to the interviews some of kerosene dealers expressed interest in the sale of coal briquettes. PSO, on its part, does not have intention to discourage their dealers from dealing in coal briquettes.

The LPG dealers are in a similar position; there is no way of expanding their business since supply is limited. The experience those LPG dealers have had in educating the consumers in safe handling of LPG and the cylinders as they promoted the sales of LPG may prove to be of help in introducing coal briquettes to the market where people know nothing of coal briquettes, though coal briquettes are inherently much safer than LPG.

The fourth option, use of salt dealers of PMDC, is a development and extension of a resource PMDC already has. PMDC has under its own control some 2,000 salt dealers deployed throughout the nation. They are in intimate contact with local people. Salt is an indispensable daily commodity, so is fuel. The expertise of these salt dealers in the sale of salt will undoubtedly be very helpful in the sale of coal briquettes. Besides, their close connection with local people would facilitate the sale of coal briquettes to the local people.

The study team conducted interviews with some of PSO's kerosene dealers and LPG dealers, PMDC' coal and rock salt dealers and free merchants; they all without exception showed keen interest.

For the reason explained in the next section, 4-4 Demand Forecast of Coal Briquettes, it would be better to employ all four channels than selecting one or two from them.

Tables 4-3-1 and 4-3-2 show respectively deployment of PSO's kerosene dealers and PMDC' rock salt dealers across the nation. It may be noted from these tables that these dealers cover the entire nation fairly well.

**Table 4-3-1 Deployment of PSO's Kerosene Dealers**

| Location | Number |
|---|---|
| Karachi | 9 |
| Thatta | 1 |
| Hyderabad | 3 |
| Mirpurkhas | 5 |
| Dadu | 1 |
| Khairpur | 1 |
| Sukkur | 2 |
| Larkana | 1 |
| Rahimyarkhan | 1 |
| Loralai | 1 |
| Zhob | 1 |
| Khuzdar | 1 |
| Gawadar | 2 |
| Turbat | 3 |
| Panjgur | 2 |
| Pishin | 1 |
| Nasirabad | 1 |
| Quetta | 4 |
| Bahawalpur | 2 |
| Bahawalnagar | 2 |
| Multan | 5 |
| Muzaffargarh | 2 |
| Deraghazi Khan | 2 |
| Sahiwal | 3 |
| Leiah | 1 |

( continued on next page)

| | |
|---|---|
| Pajanpur | 1 |
| Okara | 2 |
| Vehari | 4 |
| Lahore | 17 |
| Gujranwala | 3 |
| | |
| Sheikhupura | 2 |
| Sialkot | 4 |
| Kasur | 4 |
| Shujabad | 1 |
| Khanewal | 2 |
| | |
| Lodhran | 3 |
| Faisalabad | 9 |
| Jhang | 4 |
| Nianwali | 1 |
| Sargodha | 5 |
| | |
| Khushab | 1 |
| Jhelum | 3 |
| Gujrat | 5 |
| Rawalpindi | 3 |
| Attock | 3 |
| | |
| Dir | 1 |
| D.I.Khan | 4 |
| Bannu | 2 |
| Peshawar | 10 |
| Abbottabad | 2 |
| | |
| Kohat | 1 |
| Karak | 2 |
| Mansehra | 1 |
| Muzaffarabad | 1 |
| | |
| Total | 158 |

**Table 4-3-2 Deployment of PMDC' Rock Salt Dealers**

| Location | Number |
|---|---|
| Faisalabad | 97 |
| Gujralwala | 98 |
| Gujrat | 63 |
| Hazara | 43 |
| Islamabad | 4 |
| Kasur | 58 |
| Lahore | 277 |
| Okara | 43 |
| Quetta | 18 |
| Rawalpindi | 80 |
| Sahiwal | 44 |
| Sheikhupura | 73 |
| Sialkot | 87 |
| Swat | 1 |
| Jhelum | 17 |
| Chakwal | 7 |
| Attock | 27 |
| Bahawal Nagar | 50 |
| Bhawalpur | 45 |
| Hyderabad | 8 |
| Jhang | 156 |
| Karachi | 12 |
| Khairpur | 14 |
| Multan | 61 |
| Rahim Yar Khan | 54 |
| Sargodha | 131 |
| Khushab | 36 |
| Sukkur | 25 |
| Samundri | 38 |
| Toba Take Singh | 68 |
| Mianwali | 20 |
| Bhakkar | 8 |
| Muzaffargarh | 21 |
| Laiah | 9 |
| D.G.Khan | 17 |
| Taunsa Sharif | 4 |
| Rajanpur | 8 |
| D.I.Khan | 4 |
| Shaujabad | 12 |
| Khanewal | 18 |
| Vehari | 17 |
| Total | 1,873 |

## 4-4 Demand Forecast of Coal Briquettes

### 4-4-1 Factors affecting Demand

Before getting into the discussion, it would be appropriate at this stage to list the factors affecting the demand of coal briquettes and review them for household and industrial consumptions. The following factors may be considered to have significant effects on the demand:

Household demand

1. Quality of coal briquettes versus those of competitive fuels
2. Capabilities of distribution and marketing channels and intensity of their promotion activities
3. Price of coal briquettes at consumers end versus those of competitive fuels
4. Cooking habits
5. Population in the marketing area
6. Temperature of the marketing area
7. Burning utensils

Industrial demand

1. Quality of coal briquettes versus those of competitive fuels
2. Price of coal briquettes versus those of competitive fuels
3. Applicability of coal briquettes to the industry and the facility of the plant

Among these factors quality of coal briquettes and capabilities of distribution and marketing channels have already been discussed. Therefore, the discussion proceeds to the price of coal briquettes, a factor of prime importance.

### 4-4-2 Development of Price and Demand of Coal Briquettes

Of all these items the price needs some discussion. The price at the consumers end directly affects the demand. Basically, there

are two conceivable price formulas: uniform price at least down to the wholesalers' storages throughout the nation irrespective of actual transportation and sales costs, or alternatively variable price reflecting the costs of transportation and sales, the latter meaning that the longer is the distance of transportation and higher the transportation cost the higher is the price at the consumers end. The first principle is a controlled price now applied to kerosene. The application of this system is possible only when the distribution network is thoroughly under the command of the operating organization.

Unlike kerosene, the first formula is difficult to apply to this project, mainly because it would be too heavy a burden to establish and run from the outset a distribution and marketing network under complete control of this project. Perhaps, in the future when coal briquettes have become an important fuel of Pakistan representing a significant portion of the fuel consumption, a uniform price throughout the nation may become mandatory. Therefore, this study assumes and recommends the second formula for the consumer price of coal briquettes; that is to say, cheaper prices near the plant and higher prices distant from the plant reflecting actual transportation costs. The second formula has its own drawbacks, however. First, the fact that consumers located distant from the plant are disadvantaged may give a feeling of unfairness to the project promoters as well as to the consumers; but this is how economy works.

### 4-4-3 Premise for Demand Forecast

The process of forecasting the demand of coal briquettes is shown on Figure 4-4-1. The principle of this method lies in selling coal briquettes to consumers at prices reflecting the cost of transportation and marketing. The cost of transportation constitutes a substantial portion of the end price of the coal briquettes, the prices should vary depending upon the cost of transportation. Accordingly, it is necessary to divide the nation into several zones according to the cost of transportation, more specifically transportation cost by truck since truck transportation is more efficient and economical than railway transporta-

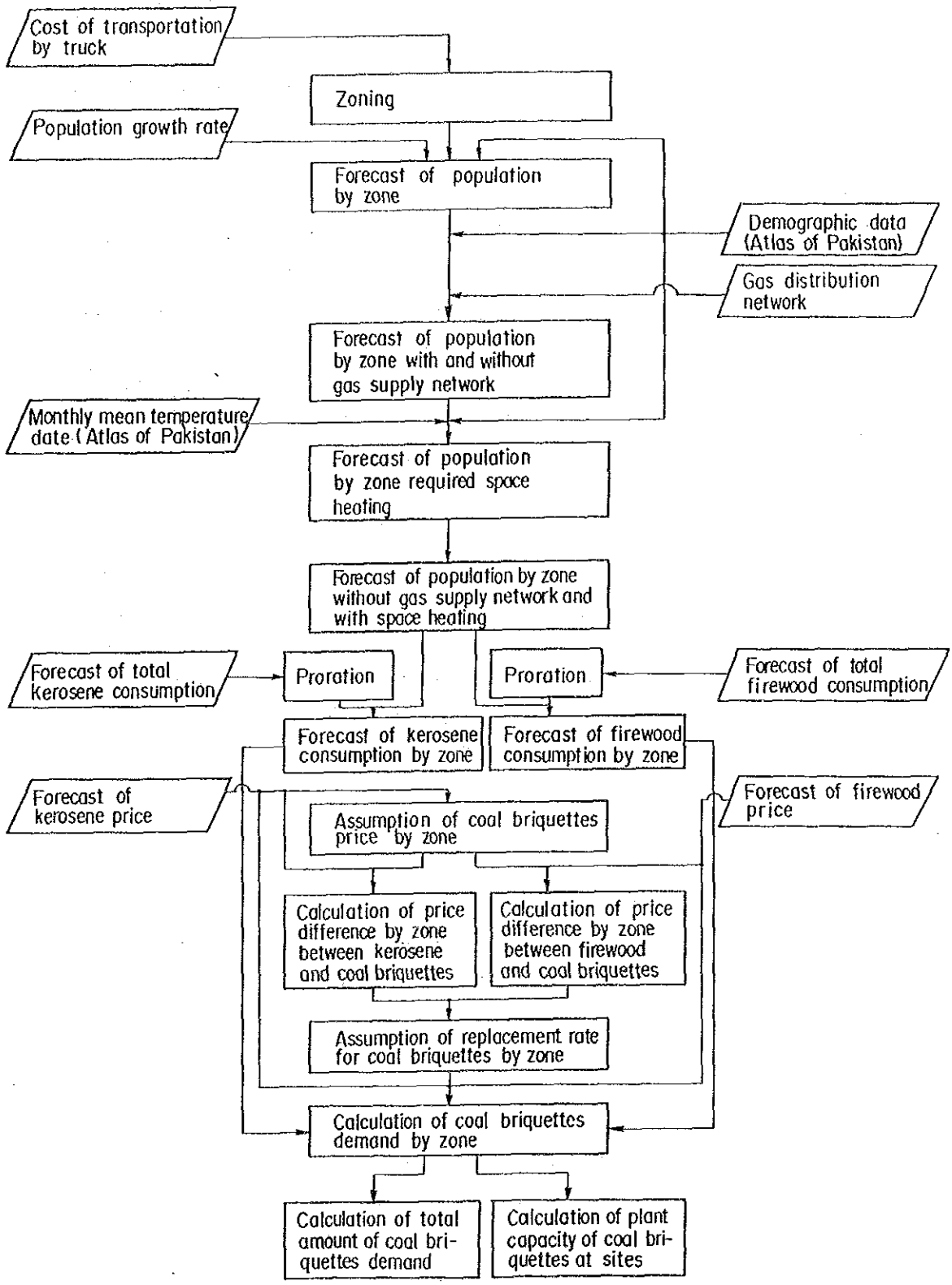


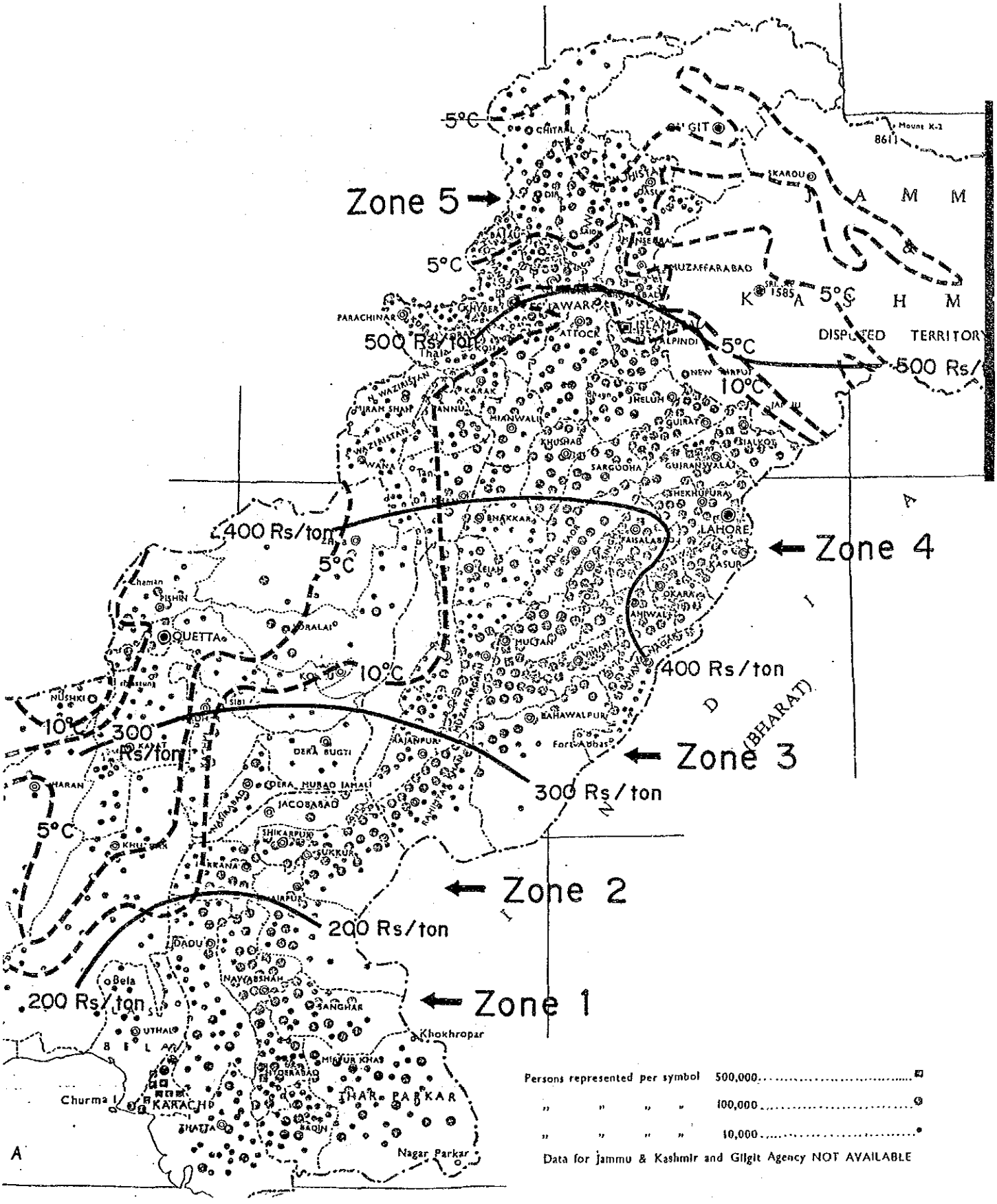

**Figure 4-4-1 Development of Coal Briquettes Demand**

tion. The nation is divided into five zones; namely, Zones 1, 2, 3, 4, and 5 for transportation cost of less than 200, 200/300, 300/400, 400/500 and more than 500 Rupees per ton of coal briquettes. This operation is done on a demographic map to enable counting of population for each zone.

Next step is to estimate the future consumption of kerosene and firewood for each zone. The data on the past consumption and forecast for the future consumption of kerosene and firewood developed in Chapter 3 are for the entire nation. Since the price of coal briquettes varies from one zone to another reflecting the cost of transportation while the price of kerosene is uniform throughout the nation, the relative price between these two fuels, or the driving force for the replacement varies from zone to zone. Therefore, the forecast kerosene consumption and price difference have to be developed for each zone. The first operation is to draw contours on a demographic map connecting equal transportation costs and divide the nation into the five zones. The demographic map is shown Figure 4-4-2. The population is enumerated on the demographic map for each zone but corrected to the present and future population on the assumption that geographical distribution of the population will not vary significantly in the future.

The population distribution obtained this way includes people using gas; adjustments are needed because gas users can hardly be considered as target. The gas users are estimated from Figures 4-4-2 and 4-4-3 by enumerating the number of people shown in the areas on the map where gas is provided. The population distribution corrected for gas is shown on Table 4-4-2.

Since forecast kerosene consumption is prorated to each zone according to the population distribution, the population has to be given weight according to the local character, or necessity of heating. Those areas where monthly mean air temperature goes below 10 degree centigrade are given 10 percent more weight. For each zone the percentage of population living in such areas are enumerated and given 10 percent weight. The result is shown in Table 4-4-3. Figure 4-4-2 indicates such areas.




Source: Atlas of Pakistan

**Figure 4-4-2 Demographic Map**

# PAKISTAN INDIGENOUS ENERGY SOURCES

**OIL AND GAS FIELDS**

1. Khaskheli*
2. Laghari*
3. Golarchi
4. Tajedi
5. Tandoalam*
6. Hundi
7. Sari
8. Mazarani
9. Khair Pur
10. Mari*
11. Kandhkot*
12. Sui*
13. Uch
14. Zin
15. Pirkoh*
16. Rodho
17. Dhodak
18. Toot*
19. Dakhni
20. Balkassar & Fimkassar*
21. Joyamir*
22. Dhulian*
23. Meyal*
24. Karsal
25. Dhurnal*
26. Adhi
27. Khaur*
28. Dhabi*
29. Nari
30. Turk
31. Mazari*
32. South Mazari
33. Nandpur
34. Panjpir
35. Loti
36. Chak Naurang
37. Sonaro
38. Bukhari
39. South Dhabi
40. Matli
41. Jabo
    Ghotana*

**SOLAR STATIONS**

42. Mumniala
43. Kankoi
44. Miro Padiar
45. Mira Rehmat Khan
46. Malmari
47. Dittal Khan Leghari
48. Khurkhera
49. Gakhar
    Dhok Mian Jewen
    Baiker

**HYDEL STATIONS**

50. Renala
51. Chickoki malian
52. Rasul
53. Shadiwal
54. Nandipur
55. Mangla
56. Kunram Ghari
57. Malakand
58. Dargai
59. Warsak
60. Chitral
61. Tarbela

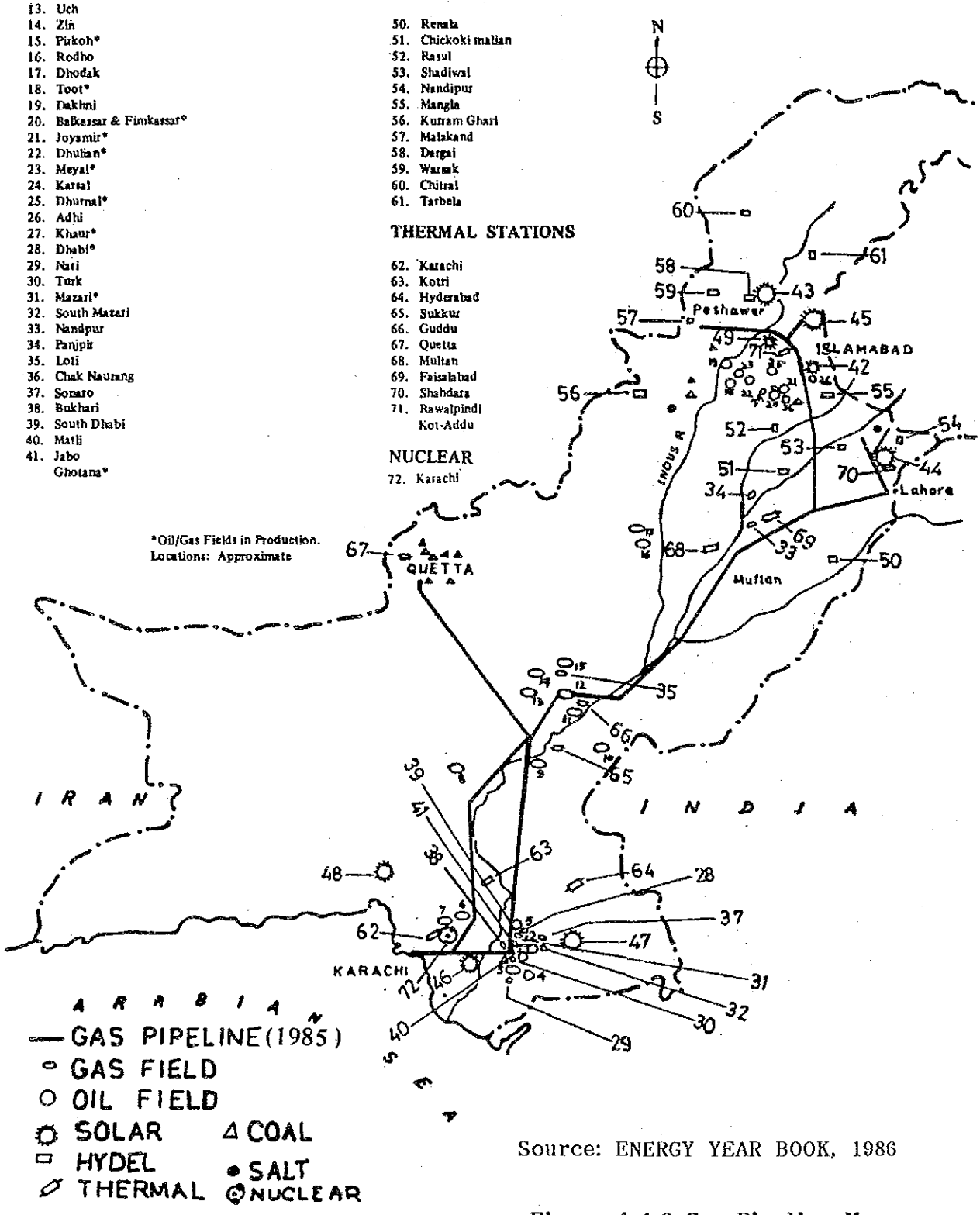
**THERMAL STATIONS**

62. Karachi
63. Kotri
64. Hyderabad
65. Sukkur
66. Guddu
67. Quetta
68. Multan
69. Faisalabad
70. Shahdara
71. Rawalpindi
    Kot-Addu

**NUCLEAR**

72. Karachi

*Oil/Gas Fields in Production.
Locations: Approximate




Source: ENERGY YEAR BOOK, 1986

**Figure 4-4-3 Gas Pipeline Map**

**Table 4-4-1 Forecast Population and Distribution**

(unit: million)

| Year | | 1985 | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|---|---|
| Population | | 96.18 | 111.59 | 127.58 | 145.86 | 166.77 |
| Zone | | | | | | |
| 1. | -200 | 18.85 | 21.87 | 25.01 | 28.59 | 32.69 |
| 2. | 200/300 | 10.10 | 11.72 | 13.40 | 15.32 | 17.51 |
| 3. | 300/400 | 25.58 | 29.68 | 33.94 | 38.80 | 44.36 |
| 4. | 400/500 | 32.12 | 37.27 | 42.61 | 48.72 | 55.70 |
| 5. | +500 | 9.53 | 11.05 | 12.62 | 14.43 | 16.51 |

**Table 4-4-2 Forecast Non-gas Users Population and Distribution**

(unit: million)

| Year | | 1985 | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|---|---|
| Population | | 76.92 | 89.24 | 102.04 | 116.64 | 133.39 |
| Zone | | | | | | |
| 1. | -200 | 10.31 | 11.96 | 13.68 | 15.64 | 17.88 |
| 2. | 200/300 | 10.08 | 11.69 | 13.37 | 15.29 | 17.48 |
| 3. | 300/400 | 24.77 | 28,74 | 32.86 | 37.57 | 42.96 |
| 4. | 400/500 | 22.23 | 25.80 | 29.50 | 33.72 | 38.56 |
| 5. | +500 | 9.53 | 11.05 | 12.62 | 14.43 | 16.51 |

**Table 4-4-3**

**Forecast Population Distribution without Gas and with heating**

(unit: million)

| Year | | 1985 | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|---|---|
| Population | | 76.66 | 91.27 | 104.36 | 119.28 | 136.42 |
| Zone | | | | | | |
| 1. | -200 | 10.31 | 11.96 | 13.68 | 15.64 | 17.88 |
| 2. | 200/300 | 10.16 | 11.78 | 13.48 | 15.41 | 17.62 |
| 3. | 300/400 | 25.14 | 29.17 | 33.35 | 38.13 | 43.60 |
| 4. | 400/500 | 22.57 | 26.20 | 29.96 | 34.24 | 39.16 |
| 5. | +500 | 10.48 | 12.16 | 13.89 | 15.86 | 18.16 |

### 4-4-4 Forecast of demand and price of kerosene and firewood

Now, the forecast consumption of kerosene is prorated to each zone according to the forecast population distribution corrected for gas and heating. The result is shown in Table 4-4-4.

**Table 4-4-4 Forecast Demand of Kerosene and Firewood by Zone**

| | 1985 | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|---|
| Kerosene, thousand metric ton | | | | | |
| Zone 1 | 105 | 162 | 252 | 390 | 603 |
| 2 | 103 | 160 | 248 | 384 | 594 |
| 3 | 255 | 396 | 613 | 950 | 1,470 |
| 4 | 230 | 356 | 551 | 853 | 1,321 |
| 5 | 107 | 165 | 255 | 394 | 613 |
| Total | 800 | 1,239 | 1,919 | 2,971 | 4,601 |
| Firewood, thousand metric ton oil equivalent | | | | | |
| Zone 1 | 646.2 | 709.2 | 767.6 | 830.3 | 898.1 |
| 2 | 636.7 | 698.6 | 756.4 | 818.1 | 885.1 |
| 3 | 1,575,5 | 1,729.8 | 1,871.3 | 2,024.3 | 2,190.0 |
| 4 | 1,414.5 | 1,553.7 | 1,681.1 | 1,817.8 | 1,967.0 |
| 5 | 656.8 | 721.1 | 779.4 | 842.0 | 912.2 |
| Total | 4,929.7 | 5,412.4 | 5,855.8 | 6,332.5 | 6,852.4 |

These forecast kerosene and firewood demands represent the theoretical maximum which coal briquettes could replace if favorable conditions to coal briquettes prevail. The discussion here concentrates on how much replacement could be expected. Now, having divided all of Pakistan into five zones according to the transportation cost, the price in each zone becomes an important factor in forecasting the demand of coal briquettes. In the zones nearer to the plant, the difference between the price of coal briquettes and those of conventional fuels is greater, or greater incentive on the part of consumers to use coal briquettes in place of the conventional fuels. Between two consecutive zones there exists Rs100 per ton, or 0.2561 US$ per MMBTU, difference

in coal briquettes price, all in 1988 price.

From the point of view of the magnitudes of the demands of kerosene and firewood that may be substituted by coal briquettes, it may be noted from the table that Zone 1, the nearest to the plant, has a small potential due partly to availability of city gas and partly to the relatively thin population in the rural area; while Zones 3 and 4 represent a strong potential because of their large populations and their status as being the center of the economy of the nation; and Zone 5 shows a relatively strong potential because of the heating demand. However, the driving force for replacement of conventional fuels by coal briquettes decreases from Zone 1 to Zone 5 as transportation cost of coal briquettes increases.

As indicated by the distribution of population and their economic status, Zones 3 and 4 should be regarded as the most promising market and therefore should be treated accordingly. The burning test on the experimentally produced coal briquettes under a condition simulated to the cooking indicates that the thermal efficiency of coal briquettes is over 70 percent of kerosene. On this ground the retail price of coal briquettes is set at 70 percent of the coal briquettes in real terms of the kerosene on thermal basis in Zone 3 for initial few years of operation. This means that in other zones the consumer price of coal briquettes is higher or lower by the increase or decrease of the transportation cost.

Before becoming too optimistic about the impact of this 70 percent price advantage, an objective analysis of the cooking habit is necessary. Kerosene can be ignited, extinguished or controlled as needed. The response to control is quick enough for practical cooking and heating purposes. Kerosene stoves can be extinguished and re-started after five minutes without excessive loss of fuel. Coal briquettes on the other hand, though designed to start up easily, would deviate in actual use from the most economical practice of burning: introducing a greater than ideal amount of primary air, leaving some briquettes in the stove when the cooking is over to burn out, feeding more than an ideal

amount of coal briquettes to the stove to ensure a powerful flame. The 30 percent price advantage can very easily be wiped out in actual cooking practices. At a 70-percent bargain, the consumers would not feel a significant economic advantage of coal briquettes. Accordingly, the price advantage of coal briquettes would not be significant in the immediate 70 percent price of kerosene price but rather in higher prices of kerosene of the future; higher prices of kerosene would be inevitable in the future by lifting the subsidy now given to kerosene, due to increasing petroleum price in the international market, compounded by the burden of investment of importing and distributing ever-increasing amounts of kerosene.

According to the above assumptions one could not expect the coal-briquette demand to pick up drastically from the outset. During the initial period substitution would take place in Zones 1 or 2 where price differential will be greater. As the price of kerosene increases in comparison with coal briquettes, substitution would occur more significantly in Zone 3, and gradually in Zone 4 and then in Zone 5. Chapter 3 forecasts a modest increase of kerosene price in real terms over the project years. Here, the consumer price in Zone 3 is set at 70 percent of the kerosene price until 1995 inclusive; thereafter, the price of coal briquettes would remain virtually unchanged in real terms, or increase in nominal terms in proportion to the average price of commodities. Shown in Table 4-4-5 is a comparison of the forecast kerosene and coal briquette prices.

**Table 4-4-5**
**Comparison between Forecast Kerosene and Coal Briquette Price**

| | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|
| Kerosene | | | | |
| (Rs/liter) | 3.59 | 4.73 | 6.15 | 6.75 |
| (US$/MMBTU) | 5.73 | 7.55 | 9.80 | 10.78 |
| Coal Briquette | | | | |
| (Rs/ton) | 1,566 | 2,063 | 2,063 | 2,063 |
| (US$/MMBTU) | 4.01 | 5.28 | 5.28 | 5.28 |

### 4-4-5 Forecast of Household Briquette Demand

The forecast prices of coal briquettes given above are the price in Zone 3. In other zones the price of coal briquettes differs from the forecast kerosene price as given in Table 4-4-6.

**Table 4-4-6**
**Forecast Differential between Kerosene and Coal Briquettes Price**
(Unit US$/MMBTU)

| | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|
| Kerosene | 5.73 | 7.55 | 9.80 | 10.78 |
| Zone | | | | |
| 1 | 2.23 | 2.78 | 5.03 | 6.01 |
| 2 | 1.97 | 2.53 | 4.78 | 5.76 |
| 3 | 1.72 | 2.27 | 4.52 | 5.50 |
| 4 | 1.47 | 2.01 | 4.26 | 5.24 |
| 5 | 1.21 | 1.76 | 4.01 | 4.99 |

Table 4-4-7 shows the price differentials between kerosene and coal briquettes in terms of percentage of the price of coal briquettes to that of kerosene.

**Table 4-4-7**
**Percentage of Price Differentials on Forecast Kerosene Price**

| | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|
| Kerosene | 100 | 100 | 100 | 100 |
| Zone | | | | |
| 1 | 38.9 | 36.8 | 51.3 | 55.8 |
| 2 | 34.4 | 33.5 | 48.8 | 53.4 |
| 3 | 30.0 | 30.1 | 46.1 | 51.0 |
| 4 | 25.7 | 26.6 | 43.5 | 48.6 |
| 5 | 21.1 | 23.3 | 40.9 | 46.3 |

This table summarizes the forecast driving force in price to replace kerosene by coal briquettes. It is seen from this table that the price driving force will not be great enough during the initial period of the project but it will pick up through the project period.

Similarly, Tables 4-4-8 and 4-4-9 are developed for the relation between firewood and coal briquettes.

**Table 4-4-8**
**Comparison between Forecast Firewood and Coal Briquettes Price**

| | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|
| Firewood | | | | |
| (Rs/40kg) | 32.8 | 37.0 | 43.8 | 48.0 |
| (US$/MMBTU) | 3.42 | 3.86 | 4.57 | 5.00 |
| Coal Briquette | | | | |
| (Rs/ton) | 1,566 | 2,063 | 2,063 | 2,063 |
| (US$/MMBTU) | 4.01 | 5.28 | 5.28 | 5.28 |

**Table 4-4-9**
**Percentage of Price Differentials on Forecast Firewood Price**

| | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|
| Firewood | 100 | 100 | 100 | 100 |
| Zone | | | | |
| 1 | -2.3 | -15.8 | -4.48 | 4.6 |
| 2 | -9.6 | -30.1 | -9.8 | -0.4 |
| 3 | -17.3 | -36.8 | -15.5 | -5.6 |
| 4 | -24.9 | -43.5 | -21.2 | -10.8 |
| 5 | -32.2 | -50.0 | -26.7 | -15.8 |

As are evident from these two tables the coal briquettes are not competitive in price with firewood except in areas very close

to the plant site.

Now, estimates are made of the extent to which the conventional fuels will be replaced by coal briquettes in relation to percentage of price differential. The estimates are made based on the discussions between the counterpart and study team during the field surveys of March and July 1988, but were shifted towards the conservative side to avoid becoming optimistic. The estimates for both kerosene replacement and firewood replacement are shown in Table 4-4-10.

**Table 4-4-10**
**Rate of Replacement versus Price Differential**

| Price Differential,% | Replacement of Conventional Fuel,% | |
|---|---|---|
| | Kerosene | Firewood |
| -60 | 0 | 0 |
| -50 | 0 | 0 |
| -40 | 0 | 0 |
| -30 | 0 | 0 |
| -20 | 0 | 0 |
| -10 | 0 | 0 |
| 0 | 5 | 5 |
| 10 | 5 | 5 |
| 20 | 10 | 10 |
| 30 | 10 | 10 |
| 40 | 15 | 15 |
| 50 | 15 | 15 |
| 60 | 20 | 20 |

Note: Negative differentials indicate that coal briquettes are more expensive than conventional fuels. To be exact, the figures are not percentage of kerosene replaced, but the demand of coal briquettes generated expressed in terms of weight percent of kerosene.

Development of these rates requires knowledge of the practice of the Pakistani people in general. To obtain a very accurate estimate for the rate of replacement, one would need to conduct an opinion poll for a wide range of people -- kerosene users, firewood users, people in different income brackets, with different lifestyles, with different levels of education. Since the Scope of Work and time available did not permit such time-consuming work, the study team had to depend upon the results of discussions with a few selected parties including the counterparts. The degrees of replacement given in Table 4-4-10 are more conservative estimates than those thus obtained.

Regarding replacement of kerosene, coal briquettes is designed so that replacement by them would not present practical inconvenience. However, the way kerosene is actually used is more thermally efficient than the way coal briquettes will be used. It is assumed, therefore, that the consumers begin to discern economic advantage of coal briquettes when the percentage of price differential is 30 percent or more. Even at a higher percentage of price differentials, say 50 percent, many consumers would prefer kerosene to solid fuels like briquettes, even at some economic penalty, due to the inherent merits of kerosene as household fuel and this needs to be taken into account when estimating the rate of replacement of kerosene by coal briquettes. This is well exemplified in the very rapid rate with which kerosene has replaced firewood even though kerosene was priced nearly twice firewood at consumers end.

Conversely, non-economic factors may favor replacement. Even in the cases where coal briquettes are definitely disadvantaged in price, some would prefer to use coal briquettes than kerosene, because they consider kerosene a dangerous fuel or dislike the smell peculiar to kerosene. This is why some replacement is assumed when the percentage of price differential is zero.

By applying the rates of replacement of kerosene and firewood thus developed to their forecast demands for Zones 1 to 5 and summing them up over the project years, the forecast demand of coal briquettes as shown in Table 4-4-11 has been obtained.

## Table 4-4-11 Forecast Coal Briquette Demand

| Zone | 1990 | | | | 1995 | | | | 2000 | | | | 2005 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | KD | PR | RR | BD | KD | PR | RR | BD | KD | PR | RR | BD | KD | PR | RR | BD |
| 1 | 162 | 38.9 | 10 | 16.2 | 252 | 36.8 | 10 | 25.2 | 390 | 51.3 | 15 | 58.5 | 603 | 55.8 | 15 | 90.5 |
| 2 | 160 | 34.4 | 10 | 16.0 | 248 | 33.5 | 10 | 24.8 | 384 | 48.8 | 15 | 57.6 | 594 | 53.4 | 15 | 89.1 |
| 3 | 396 | 30.0 | 10 | 39.6 | 613 | 30.1 | 10 | 61.3 | 950 | 46.1 | 15 | 142.5 | 1470 | 51.0 | 15 | 220.5 |
| 4 | 356 | 25.7 | 10 | 35.6 | 551 | 26.6 | 10 | 55.1 | 853 | 43.5 | 15 | 128.0 | 1321 | 48.6 | 15 | 198.2 |
| 5 | 165 | 21.1 | 10 | 16.5 | 255 | 23.3 | 10 | 25.5 | 394 | 40.9 | 15 | 59.1 | 613 | 43.6 | 15 | 92.0 |
| Total | | | | 123.9 | | | | 191.9 | | | | 445.7 | | | | 690.3 |

| Zone | 1990 | | | | 1995 | | | | 2000 | | | | 2005 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FD | PR | RR | BD | FD | PR | RR | BD | FD | PR | RR | BD | FD | PR | RR | BD |
| 1 | | | | | | | | | | | | | 898.1 | 4.4 | 5 | 44.9 |
| 2 | | | | | | | | | | | | | 885.1 | -0.4 | 0 | |
| 3 | | | | | | | | | | | | | 2190.0 | -3.6 | 0 | |
| 4 | | | | | | | | | | | | | 1967.0 | -10.3 | 0 | |
| 5 | | | | | | | | | | | | | 912.2 | -17.1 | 0 | |
| Total | | | | | | | | | | | | | | | | 44.9 |

| Grand total | 123.9 | 191.9 | 445.7 | 735.2 |
|---|---|---|---|---|

Note:
KD: kerosene demand
FD: Firewood demand
PR: price ratio
RR: rate of replacement
BD: briquette demand

The capacities of the coal briquette plant are planned based on the result of demand forecast shown on Table 4-4-11. Cases 1 and 2, conservative and optimistic cases, are respectively developed. In accordance with the government policy to install coal briquette plants of economical size at major coal fields, it is assumed that this project will fill 40 percent of the forecast demand. To avoid placing the project under too heavy a burden of capital recovery cost, capacities are added stepwise as demand develops.

**Table 4-4-12 Plant Capacity From Market Viewpoint**

| Year | Capacity installed (thousand tons/year) | | Production (thousand tons/year) | | Operation rate Percent | |
|---|---|---|---|---|---|---|
| Case | 1 con | 2 opt | 1 con | 2 opt | 1 con | 2 opt |
| 1989 | - | - | - | - | - | - |
| 1990 | - | - | - | - | - | - |
| 1991 | - | - | - | - | - | - |
| 1992 | 50 | 100 | 50 | 59 | 100 | 59 |
| 1993 | 50 | 100 | 50 | 64 | 100 | 64 |
| 1994 | 50 | 100 | 50 | 70 | 100 | 70 |
| 1995 | 75 | 100 | 75 | 77 | 100 | 77 |
| 1996 | 75 | 100 | 75 | 91 | 100 | 91 |
| 1997 | 100 | 150 | 100 | 108 | 100 | 72 |
| 1998 | 100 | 150 | 100 | 127 | 100 | 85 |
| 1999 | 100 | 150 | 100 | 150 | 100 | 100 |
| 2000 | 150 | 200 | 175 | 178 | 100 | 89 |
| 2001 | 150 | 200 | 175 | 197 | 100 | 99 |
| 2002 | 200 | 300 | 175 | 218 | 100 | 72 |
| 2003 | 200 | 300 | 175 | 241 | 100 | 80 |
| 2004 | 250 | 300 | 300 | 266 | 100 | 89 |
| 2005 | 250 | 300 | 300 | 294 | 100 | 98 |
| 2006 | 300 | 300 | 300 | 300 | 100 | 100 |

It should be remembered that all the work for the demand forecast exclude the coal briquettes now being produced in Quetta, which are quite different in quality from the planned product of this project and therefore should be treated as a different fuel.

### 4-4-6 Industrial Consumption of Coal Briquettes

As mentioned in the eighth paragraph of 4-1, How People Use Fire, coal briquettes should be a promising alternative fuel for small industries; namely potteries, tile manufacturers, bakeries, soap factories, small-scale food processing industries, and small-scale textile industries currently mostly burning firewood. However, the price of firewood is very cheap. Brick burners scattered throughout the nation now burning most of the nation's coal production need not switch to coal briquettes, because coal is good enough for their purpose. Large-scale industries now burning natural gas or burner fuel are those kinds of industries which survive on the inexpensive gas or require rather precise control of temperature possible only with gas or oil.

Some of the industries around Hyderabad area interviewed during the field survey were burning firewood before the natural gas network was installed. Their boilers and furnaces have been modified to burn only natural gas. It would not make sense to re-modify their facilities to enable them to burn coal briquettes unless supply of coal briquettes at prices much cheaper than natural gas is guaranteed, which of course would not be the case.

Some of the spinning and textile industries situated in Punjab area now burning burner fuel may be potential consumers of coal briquettes. These industries require a great deal of steam to keep threads moist to maintain necessary strength when they undergo a series of processes. Their boilers do not require precise control. If these industries could be included they would represent a significant demand. It is questionable, however, that coal briquettes will reach them at a price competitive with burner fuel. It would therefore be unrealistic in the opinion of the study team to regard their consumption of fuel as potential demand of coal briquettes.

## 4-5 Price Structure for Coal Briquettes

The most important points about the price structure are the following:

1. The price of coal briquettes should be competitive with those of competing fuels at consumers end. At the initial stage of the project, the target price of coal briquettes is set at 70 percent of the price of kerosene on thermal basis at consumers end based upon the comparative burning test on thermal efficiencies of kerosene and coal briquettes.

2. The variable price system, or free market price system in which price at the consumers end varies reflecting the costs of transportation and marketing is considered appropriate for this project, because:

   (1) this system would let different distribution and marketing channels compete with each other to bring the product to the consumers most economically,

   (2) unlike kerosene which has already become a commodity of vital importance to the security of daily life of common people, there is little need to control the price of coal briquettes to protect the welfare of people,

   (3) by keeping the distribution and marketing of coal briquettes unrestricted, coal briquette marketing would be a reasonably lucrative business; then PMDC would be able to invite capable marketers, including kerosene and LPG dealers, to engage in coal briquette marketing, thus avoiding confrontation with traditional fuels,

   (4) by this system, PMDC could leave the distribution and marketing to the selected dealers; this system would spare PMDC the very tedious task of controlling the

marketing and the price throughout the nation.

3. The ex-plant price should be set to give the manufacturing part of this project a reasonable profit after paying all the required costs.

Based upon the above principle, the price of coal briquettes is estimated in the preceding section, 4-4 Demand Forecast of Coal Briquettes. The netback ex-factory prices are developed as shown in Table 4-5-1.

**Table 4-5-1 Netback Price of Coal Briquettes**

(1988 price)

| Zone | Consumer | Transportation | Margin | Year 1990 Ex-factory |
|---|---|---|---|---|
| 1 | 1,366 | 150 | 200 | 1,016 |
| 2 | 1,466 | 250 | 200 | 1,016 |
| 3 | 1,566 | 350 | 200 | 1,016 |
| 4 | 1,666 | 450 | 200 | 1,016 |
| 5 | 1,766 | 550 | 200 | 1,016 |

| Zone | Consumer | Transportation | Margin | 1995 and onward Ex-factory |
|---|---|---|---|---|
| 1 | 1,863 | 150 | 200 | 1,513 |
| 2 | 1,963 | 250 | 200 | 1,513 |
| 3 | 2,063 | 350 | 200 | 1,513 |
| 4 | 2,163 | 450 | 200 | 1,513 |
| 5 | 2,263 | 550 | 200 | 1,513 |