4-6 Overall Assessment of Market Feasibility

Given the outcomes of the preceding studies, a good and large enough potential market exists. The key factors in the exploitation of the market potential are, as mentioned before, the quality and price of the coal briquettes, and the degree to which the distribution and marketing channels can be employed. If this project could make all these factors competitive with kerosene and also with firewood, though the replacement of the latter perhaps limited to areas not remote from the place of production, the project would make possible increasing sale of coal briquettes, replacing the traditional fuels and developing its own market.

None of the factors considered essential to the success of this project -- quality of the briquettes, cost of production, cost and efficiency of transportation, economic distance of transportation or marketing area, distributors and marketers, burning utensils -- is considered at this stage to pose serious difficulty.

The experimental production has succeeded in producing coal briquettes of the quality close to the target quality level. Concerning the distributors and marketers, the study team have selected four very promising candidate groups -- (1) free merchants including firewood/charcoal dealers, (2) coal dealers of PMDC, (3) PSO's and other kerosene distributors and LPG distributors, and (4) salt dealers of PMDC -- interviewed some of their representative figures, and obtained positive responses.

It was disappointing to learn that the southern part of the nation, assumed to be the main market before the study was actually undertaken, is not a promising market because (1) the area is well-covered by a city gas network, (2) the people in the rural area do not buy firewood, but instead collect firewood, twigs, and other combustible things for their own use, (3) the area is rich in trees in comparison with other areas and the hot climate promotes the rapid growth of trees. It was encouraging on the other hand to learn that the greater part of the nation held enough promise as a market to offset the disappointment the study team had about the southern region. This means that Punjab area where economic activity is most vigorous and the population is the densest would be included in the market. This also means that the northern and western parts where heating is necessary during the winter season would be part of the market. In short, the project could expect a much larger marketing area than had previously been anticipated as far as competition with kerosene is concerned. The economic marketing area would embrace the majority of the population.

The forecast demand of kerosene indicates that the nation will continue to have to rely on the importation of kerosene, or crude oil processed domestically to produce kerosene, for the supply of household fuel. It is important to realize that, at even low rates of replacement, the amount of kerosene to be replaced by coal briquettes will be substantial as shown in Table 4-6-1.

Table 4-6-1 Forecast Coal Briquette Demand

(Thousand tons per year)

Year	Coal Briquette Demand
1990	124
1991	135
1992	148
1993	161
1994	176
1995	192
1996	227
1997	269
1998	318
1999	378
2000	446
2001	493
2002	545
2003	602
2004	665
2005	735
2006	812

Pakistan as a society has sufficient social system to support autonomous development of the market; it has a well-organized and self-sustaining truck transportation system covering the entire nation; a large number of small industries thrive and are ready to provide peripheral supports to the project; such as, mule- or camel-hauled carts for transportation of goods in small lots from shops or centers of storages in town to consumers; cottage industries, small-scaled but staffed with highly experienced and dexterous craftsmen, to manufacture stoves or simple auxiliary parts from iron plates once designs are known; small potteries to bake earthen stoves; road-side shops to display and sell these products. The telephone system operates rather well throughout the nation. With these social infrastructure, the project does not take care of all these tedious details of its own expense but could leave them to the spontaneous mechanism of the market. Neither does the project need to build from scratch its own distribution systems but could utilize existing systems, perhaps with some modifications and guidance as necessary to make them better suited for coal briquettes. These social aspects are very important in the evaluation of the market feasibility. All these mean that with sufficient incentive, economic or otherwise, on the part of the consumers to use coal briquettes in place of kerosene or firewood, the consumers would not be significantly inhibited from using coal briquettes by such social contingencies as insufficient supply of burning utensils, delayed deliveries on account of disruptions of the traffic or communication networks.

4-7 Coal Briquette Market versus Kerosene Price

As a sensitivity, the effect of kerosene subsidy on the coal briquettes market is examined here. As a matter of fact, the price equivalent to the subsidy portion is not explicitly declared in terms of Rupees per liter; therefore, as may be understood from comparison between footnotes of Tables 3-8-4 and 3-8-6, this study assumes the subsidy to be equivalent to the margin by which kerosene is cheaper than HDO on thermal basis. Table 3-8-4 forecasts future kerosene price by removing the subsidy in 1995 while Table 3-8-6 forecasts future kerosene price by retaining the subsidy.

There are basically two concepts for coal briquette prices applicable to this sensitivity study; one is reduced in proportion to the kerosene price reduced from the case which assumes lifting of subsidy; the other maintained as previously developed with subsidy assumed to be removed. The former concept leads to forecast demands of coal briquettes similar to those already developed but the economics of the project is jeopardized because of the reduction of product price; the latter gives smaller demands but the economics of the project will be saved. This study adopts the latter concept, because development of the demands similar to already developed only to be judged infeasible would be meaningless in the light of the purpose of this sensitivity study.

Tables 4-7-1 to 4-7-9 that follow correspond to Table 4-4-4 to 4-4-12.

Table 4-7-1 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

Table 4-7-1 is identical with Table 4-4-4 previously shown.

Table 4-7-2 Comparison between Forecast Kerosene and Coal Briquette Price

	1990	1995	2000	2005
Kerosene				
(Rs/liter)	3.59	4.05	5.27	5.78
(US$/MMBTU)	5.73	6.52	8.42	9.23
Coal Briquette				
(Rs/ton)	1,566	2,063	2,063	2,063
(US$/MMBTU)	4.01	5.28	5.28	5.28

Table 4-7-3

Forecast Differential between Kerosene and Coal Briquettes Price

(Unit US$/MMBTU)

	1990	1995	2000	2005
Kerosene	5.73	6.52	8.42	9.23
Zone				
1	2.23	1.73	3.65	4.46
2	1.97	1.50	3.40	4.21
3	1.72	1.24	3.14	3.95
4	1.47	0.98	2.88	3.69
5	1.21	0.73	2.63	3.44

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

	1990	1995	2000	2005
Kerosene	100	100	100	100
Zone				
1	38.9	26.8	43.3	48.3
2	34.4	23.0	40.4	45.6
3	30.0	19.0	37.3	42.8
4	25.7	15.0	34.2	40.0
5	21.1	11.1	31.2	37.3

Table 4-7-5 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 4-7-6 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

Table 4-7-7 Rate of Replacement versus Price Differential

	Replacement of Conventional Fuel,%	
Price Differential,%	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.

Table 4-7-8 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	26.8	10	25.2	390	43.3	15	58.5	603	48.3	15	90.5
2	160	34.4	10	16.0	248	23.0	10	24.8	384	40,4	15	57.6	594	45.6	15	89.1
3	396	30.0	10	39.6	613	19.0	5	30.7	950	37.3	10	95.0	1470	42.8	15	220.5
4	356	25.7	10	35.6	551	15.0	5	27.6	853	34.2	10	85.3	1321	40.0	15	198.2
5	165	21.1	10	16.5	255	11.1	5	12.8	394	31.2	10	39.4	613	37.3	10	61.3
Total				123.9				121.8				335.8				659.6
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				121.8				335.8				704.5

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

Table 4-7-9 Forecast Coal Briquette Demand

(Thousand tons)

Year	Total demand	40% of total demand	Plant capacity
1990	124	49.6	
1991	124	49.6	
1992	124	49.6	50
1993	124	49.6	50
1994	124	49.6	50
1995	124	49.6	50
1996	151	60.4	50
1997	185	74.0	50
1998	226	90.4	50
1999	275	110.0	100
2000	336	134.4	100
2001	385	154.0	100
2002	440	176.0	100
2003	504	201.6	200
2004	577	230.8	200
2005	660	264.0	200
2006	755	302.0	300

Here, the demand growing much slower than if the subsidy is removed is obtained. This case is treated as Case 3 throughout this report.

CHAPER 5 RAW MATERIALS FOR COAL BRIQUETTES

This project is based upon Lakhra lignite as the main material, and this feasibility study has selected as candidates for subordinate raw materials bagasse, wheat straw, oil extraction residue of cottonseeds, limestone, slaked lime and cement, slack wax and light fuel oil. The availability, properties and price of each raw material are discussed below.

5-1 Raw Materials in Perspective

The coal briquettes should satisfy the following conditions in order to be well-accepted by the consumers:

1. Smokelessness and odorlessness
   The generation of the unburnt residual carbon compounds left after combustion and sulfur oxides should be low.

2. Easiness to start fire
   The easiness of the raw coal to ignite and the blending ratios of the coal, biomass and slack wax/light fuel oil influence the easiness of the product coal briquettes to start fire.

3. Good burning rate
   The burning rate of the coal briquettes should be sufficiently high, especially in the initial stage of combustion.

4. Sufficient physical strength to withstand rough handlings during transportation and consumption
   The potential of the raw coal, biomass and cement to form briquettes under pressure, pressure of the briquetting machine, shape and size of the coal briquettes influence the physical strength of the coal briquette.

5. Sufficient calorific value

The calorific values and blending ratios of raw materials influence the calorific value of the coal briquette.

6. Low product price

The costs of raw materials and of plant operation must be low to achieve the low price of coal briquettes.

7. Stable quality

Stable supply of raw materials and stable plant operating conditions are required to produce the products of stable quality.

In order to satisfy the above conditions, appropriate raw materials and manufacturing process should be selected. Both are closely related with each other; this chapter discusses raw materials for coal briquettes only and the latter is discussed in CHAPTER 12, CONCEPTUAL DESIGN OF COAL BRIQUETTE MANUFACTURING. To achieve the objectives listed before the following items should be given due consideration in the selection of raw materials.

1. Raw coal
   (1) Availability
   (2) Price
   (3) Chemical compositon (contents of sulfur, ash, moisture, volatile matter)
   (4) Physical properties (strength, potential to form briquettes.)
   (5) Burning quality (ignitability, generation of smoke and sulfur oxides, calorific values, quantity of residual ash, etc.)
   (6) Others (fluctuation of quality)

2. Subordinate raw material
   (1) Availability
   (2) Price
   (3) Chemical composition (contents of sulfur, ash moisture, volatile matter, calcium)

(4) Physical properties (crushability, binding potential, cellulose content, fiber strength)
(5) Burning quality (ignitability of biomass/slack wax/light fuel oil, generation of smoke and disagreeable effluent, calorific values, quantity of residual ash, etc.)
(6) Water resistance (slack wax/light fuel oil)
(7) Others (fluctuation of quality)

As a result of the experimental production of coal briquettes elabaorated in Chapter 10 and in consideration of the economic aspects associated with selection of various raw materials developed in this chapter, the following kings and amounts of raw materials for coal briquettes were eventually selected. The process to select these raw materials is explained in CHAPTER 8, PROJECT SCHEME.

Main raw material	Raw material requirement (ton per product ton)
Lakhra coal	1.250
Subordinate raw material	
Bagasse	0.325
Slaked lime	0.0625
slack wax	0.006
Light fuel oil	0.044
Fuel	
Lakhra coal	0.373

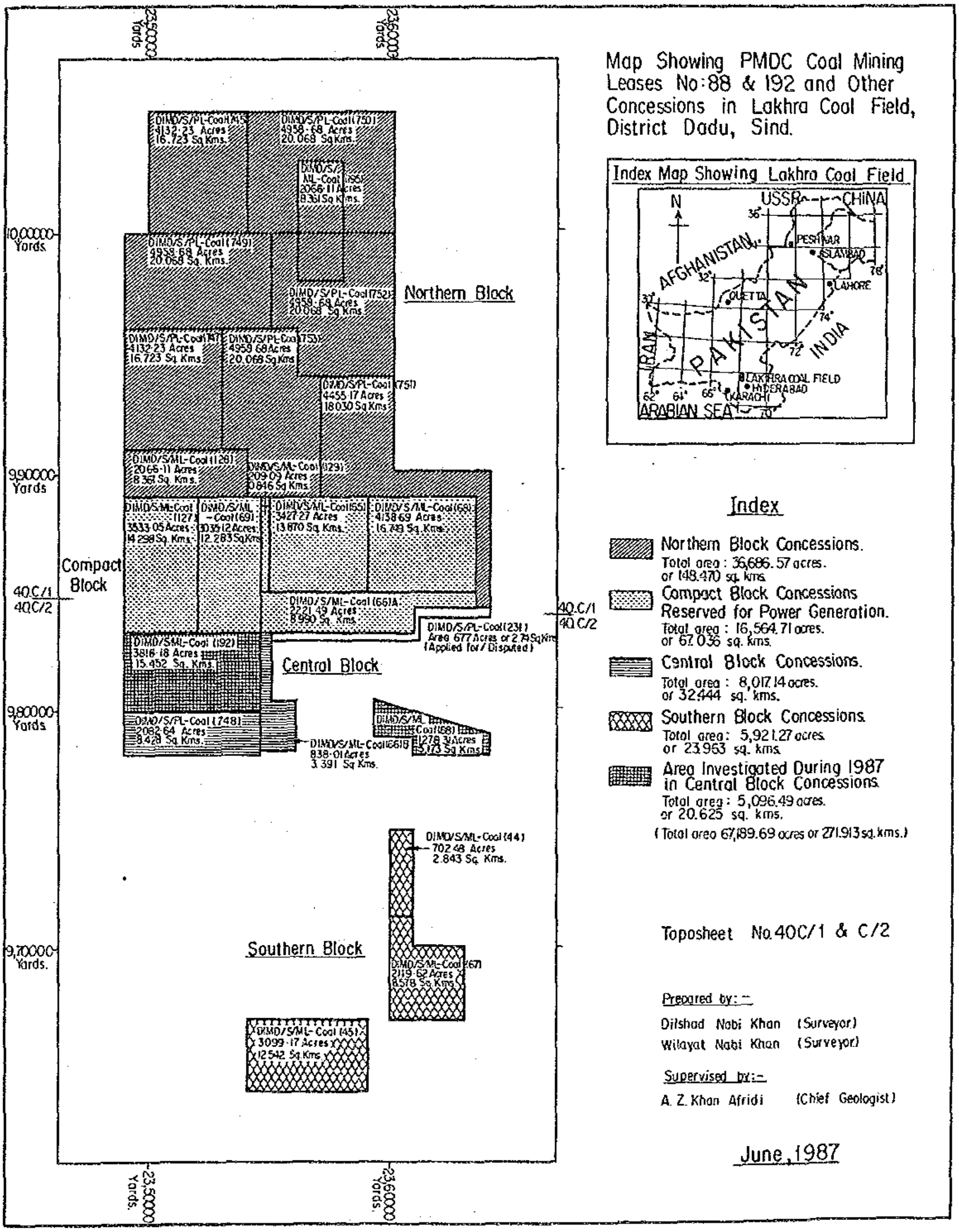
5-2 Lakhra Coal

5-2-1 History of Lakhra Coal Field Development

Lignite coal reserved in the Lakhra area has been mined in a very small scale since the mid-1800s. In Pakistan, the coal fields are all owned by the government; and the mining concessions are afforded to the operators by lease contract. In Lakhra coal field, PMDC and private mining companies hold concessions designated by different lease numbers. Currently, eight private companies produce about 500 thousand tons of coal a year.

PMDC' concession in the Lakhra coal field, as shown in Figure 5-2-1, consists of four blocks; namely, Northern Block, Compact Block, Central Block and Southern Block. Compact Block and Central Block have been developed for supplying chiefly power generation now under planning and brick burning, respectively.

Prior to the full development of these two blocks, Geological Survey of Pakistan (GSP) conducted a systematic geological investigation which indicated that underground mining of lignite would be promising. Subsequent tests by the West Pakistan Industrial Development Corporation (WPIDC) confirmed that the coal is not suited to the production of hard coke but is appropriate for fuel for thermal power generation. In 1966, WPIDC conducted a feasibility study on mining and power generation based on Lakhra coal; the result established that underground mining could produce one million tons of coal per year to sustain a 250 MW thermal power station. Following this WPIDC' study, organizations like Lurgi GmbH, Japan Consulting Institute (JCI), Canadian International Development Agency (CIDA), Japan International Cooperation Agency (JICA), United States Agency for International Development (USAID) have contributed to the evaluation of coal deposits, pilot tests to determine feasibility of large scale commercial uses, and feasibility studies on mining and coal-fired power plants. Presently, based on the results of these studies, a large-scale development of coal mining for power generation is being established in the Compact Block.



Source: Pakistan Mineral Development Corporation.

Figure 5-2-1 PMDC' Coal Mining Concessions in Lakhra Coal Field

Central Block started production in 1982-83 to meet the increasing demand by the brick industry which presently consumes about 97 percent of the coal production; about 2.6 thousand tons of coal was produced in the initial year. Since then, the capacity has been expanded to about 35.2 thousand tons by 1983-84 and more than 100.0 thousand tons by 1987-88. However, the production depends chiefly on manual labor.

5-2-2 General Geological Conditions and Coal Reserves in Lakhra Coal Field

(1) General geologial conditions

The stratigraphic succession of the Lakhra coal field is given in considerable detail in Table 5-2-1. The coal seams in the Lakhra coal field are found in upper part of Lower Ranikot formation of Paleocene age in Tertiary period in Cenozoic Era. The formation contains at least 10 coal seams according to data collected by drilling. Lailian is by far the most important seam, which has been encountered in most of the holes and in undergound mines to the south of PMDC' block. Its depth from the surface ranged from 20 to 60 meters. Beside Lailian, two locally mineable coal seams -- Dhanwari above and Kath below the Lailian -- also exist in the Lakhra coal field.

Ranikot group, including the abovementioned Upper Ranikot formation, the oldest exposed rocks, crops out in the southern part of Lakhra coal field. It underlies Laki limestone of Eocene age unconformably in the northern, eastern and western parts. Manchar formation of Pliocene age unconformably overlies Ranikot and Laki groups in the western area of the central part of the Lakhra coal field.

The strata constitute a doubly plunging anticline. This anticline is popularly known as Lakhra dome, the axis of which runs in north-south direction. The strata generally dip gently towards all sides. The dips are low and do not exceed seven degrees. The coal field is located along the crestal part of the anticline and the seams are almost horizontal.

Table 5-2-1 Stratigraphic Succession in Lakhra Coal Field

Era	Period	Epock	Group	Formation	Unit	Lithology
				Recent & Sub-Recent Deposits		Unconsolidated surficial deposits of silt, sand, clay and gravel. Consolidated deposits of unsorted pebbles and cobbles of Laki limestone and other formations
						Unconformity
				Manchar		Alternations of sand-stones, shales and siltstones with clay and thin grit beds. Fossiliferous. Contains petrified wood mostly.
						Unconformity
				Laki Limestone		Limestones with sub-ordinate shales and marls.
				Basal Laki Laterite		Intermingled lateritic clays, sandstones and gysiferous shales with sub-ordinate pockets of sand. Unfossiliferous. 1.5 metres to 14 metres thick.
						Unconformity
					5	Limestone with sub-ordinate shales. Fossiliferous. 39 metres to 46 metres thick.
					4	Sandstones with minor shales. Fossiliferous. 14 to 15 metres thick.
					3	Interbedded limestones and shales. Fossiliferous. 13 metres to 23 metres thick.
					2	Shales with thin beds of sandy limestone. Fossiliferous. 17 to 24 metres thick.
					1 – 1C	Sandstones and shales interbedded. Fossiliferous. 7 metres to 8.5 metres thick.
					1 – 1B	Shales with sandstone bed. Fossiliferous. 6 metres to 7.5 metres thick.
					1 – 1A	Sandstones and shales interbedded. Fossiliferous. 21 metres to 23 metres thick.
				Lower Ranikot		Predominant sandstones interbedded with shales, claystones and siltstones. Mostly unfossiliferous. Impregnated with 10 coal seams of which Lailian and the one below it are workable. A light grey to grey clay bed up to 3 metres thick above the Lailian seam may prove to be refractory grade fire-clay.
				- Base not seen -		

Source: Feasibility Report for Lakhra Coal Mining and Power Station Project, February, 1981 (JICA)

It is affected by about 46 parallel, generally north-south trending faults, which are normal pivotal faults with dips ranging from 52 degrees to near vertical. But their throws do not exeed 43 meters. The faults displace the coal seams as well.

The coal seams are up to 7 meters thick. However most of the mineable seams persist with average thickness ranging from 0.69 to 2.91 meters.

(2) Estimated coal reserves

There are various estimates of the reserves for the Lakhra coal as summarized in Table 5-2-2.

Table 5-2-2 Estimated Coal Reserves in Lakhra Coal Field

Source	Coal Reserves(Million Tons)	Estimated Area(km^2)
GSP (1966)	240	N.A.
USAID(1984)	Better than 400	At Least 480
MPNR (1985)	498	N.A.
PMDC (1988)	More than 500	N.A.

Note: GSP : Geological Survey of Pakistan
USAID: United States Agency for International Development
MPNR : Ministry of Petroleum and Natural Resources
PMDC : Pakistan Mineral Development Corporation

PMDC has, as mentioned above, four concessional blocks, Northern Block, Compact Block, Central Block, Southern Block, with a combined mining area of 271.913 square kilometers. Table 5-2-3 summarizes the estimated coal reserves in the PMDC' concessions.

Table 5-2-3 Estimated Coal Reserves in PMDC' Concessions

Name of Block	Lease No.	Proved Reserves (Million Tons)	Theoretical Reserves (Million Tons)	Estimated Reserves (Million Tons)
Compact	N.A. ($26\ km^2$)	N.A.	137.09 * 79.782**	N.A.
Central	88 & 192 ($20.625\ km^2$)	11.516	N.A.	21
Southern	45 & 67 ($21.12\ km^2$)	N.A.	N.A.	11.76

Note : * This figure is the total theoretical coal reserves calculated from the data obtained from the JICA report (Fesibility Report for Lakhra Coal Mining and Power Station Project, February, 1981)

** This figure is the coal reserves estimated as practically recoverable by the abovementioned JICA report.

With the reserves of Northern Block, the largest block with 148.407 km^2, still unknown, in view of a comparison between Table 5-2-2 and 5-2-3, it is reasonable to assume that the reserves in the Lakhra coal field should be more than 500 million tons as PMDC claims.

PMDC plans to supply to this project the coal to be mined from Central Block. The combined recoverable coal reserves of Leases No.88 (5.173 km^2) and No.192 (15.425 km^2) in the Central Block may be calculated from the geologic factor (70 %) and the recoverable factor (65 %) used in the JICA feasibility report as shown in Table 5-2-3 to be about 5.24 million tons (11.516 million tons x 0.70 x 0.65). This project requires at the final production capacity of coal briquettes of 300,000 tons per year about 486,900 tons of coal, assuming moisture content of ROM coal to be 20 percent. The residual coal reserves, about 4.9 million tons, obtained by subtracting the amount mined to date from the recoverable reserves, are equivalent to about 10-year requirement of raw coal at 300,000 ton capacity. Central Block has two other concessions, 8.428 km^2 and 3.392 km^2, on the south and on the east of Lease No.192 concession, respectively. Therefore, Central Block may be considered to have enough recoverable reserves to support this Project. In addition, the Southern Block can be mined after Central Block is depleted; consequently, there are enough reserves to feed the project.

5-2-3 Outline of Lakhra Collieries

Central Block is explained in more detail, because PMDC plans to provide this project with the coal mined from this block.

Central Block, as shown is Figure 5-2-2, is located about 60 km to the northwest of Hyderabad and about 17 km to the west of Khanot Station of Pakistan Railway. As shown in Figures 5-2-3 and 5-2-4, PMDC operates small-scale underground collieries in Lease No.88, and Lease No.192/66 in Central Block; they are mined manually and accessed either by shafts or inclines.

Table 5-2-4 indicates each coal pit with identification code and number of coal mining lease. Most collieries in Central Block are in Lease No.88 concession in which there are 10 shafts and seven coal mines.

There are 10 coal seams in the field; their average thickness ranges from 0.69 to 2.91 meters. The thickest portion measures 7 meters. Coal extraction presently comes mainly from the Lailian formation, and probably partly from the Dhanwari formation and the Kath formation in view of the fact that the Lailian formation is 20 to 60 meters deep while the average depth of shaft is 70 meters. No inundation nor gas-blowout has been reported to date. No water-bearing formation has been spotted by the drill hole tests so far conducted to the depth of 130 meters.

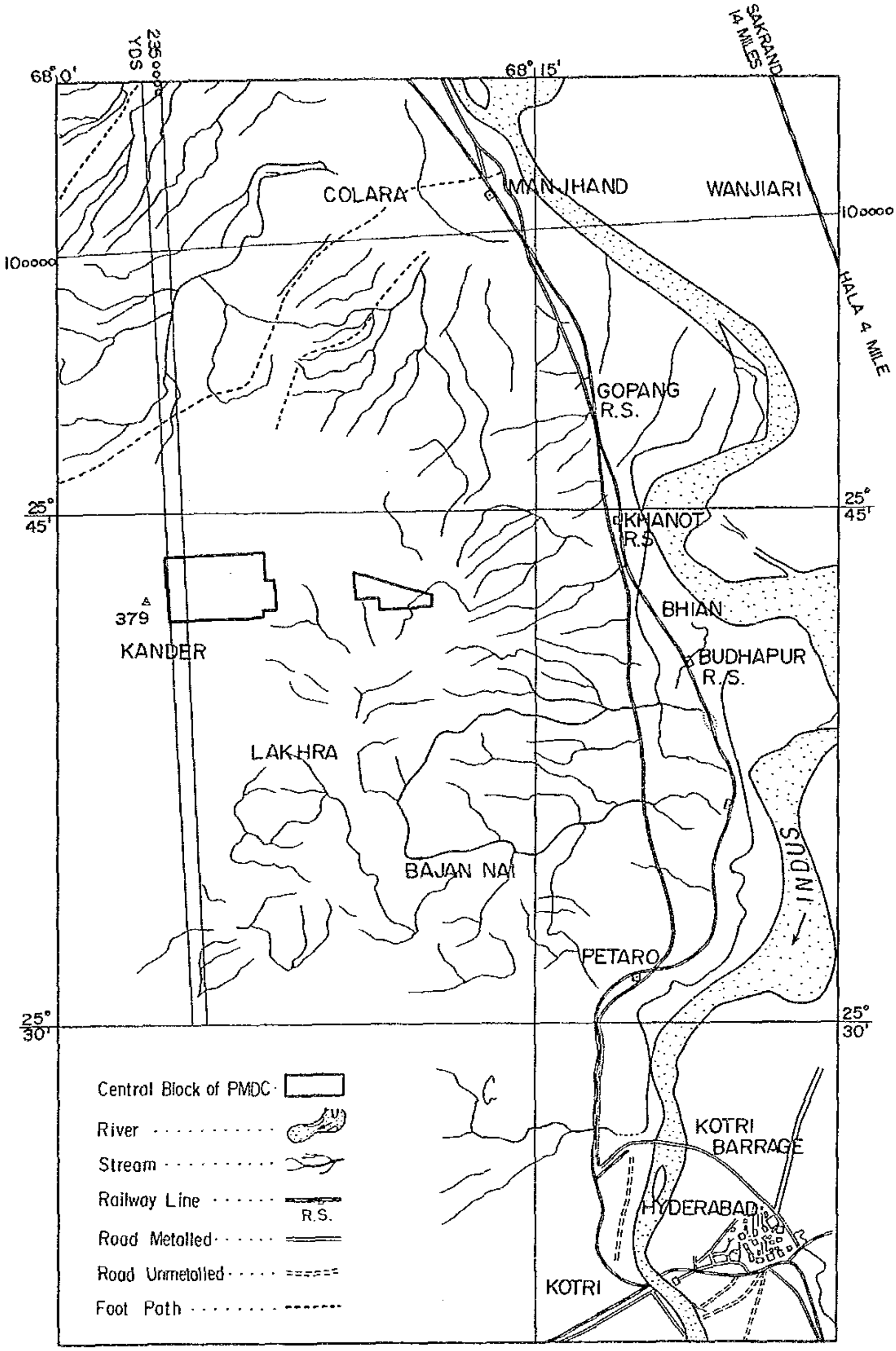


Figure 5-2-2 Central Block of PMDC and Surrounding Areas

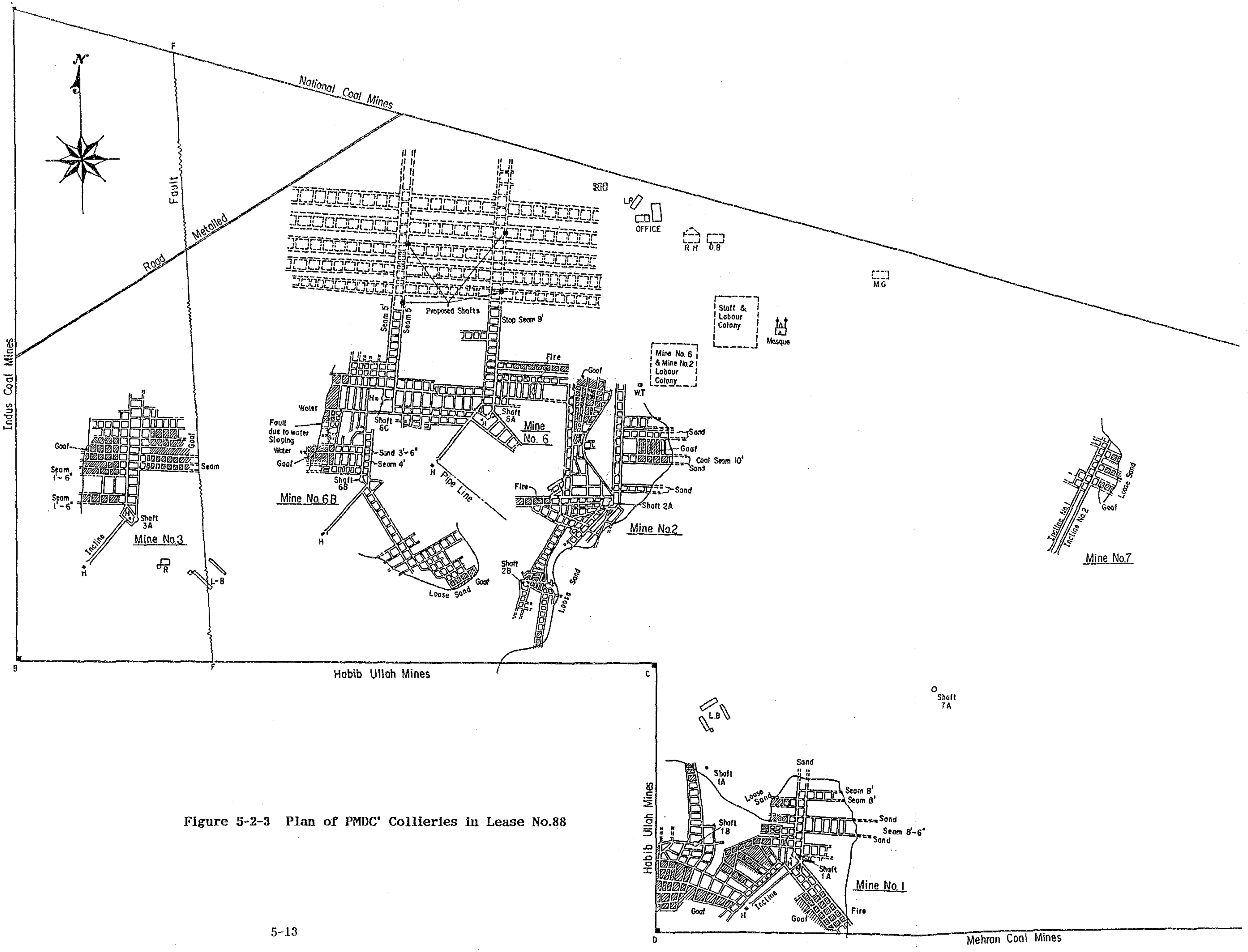


Figure 5-2-3 Plan of PMDC' Collieries in Lease No.88

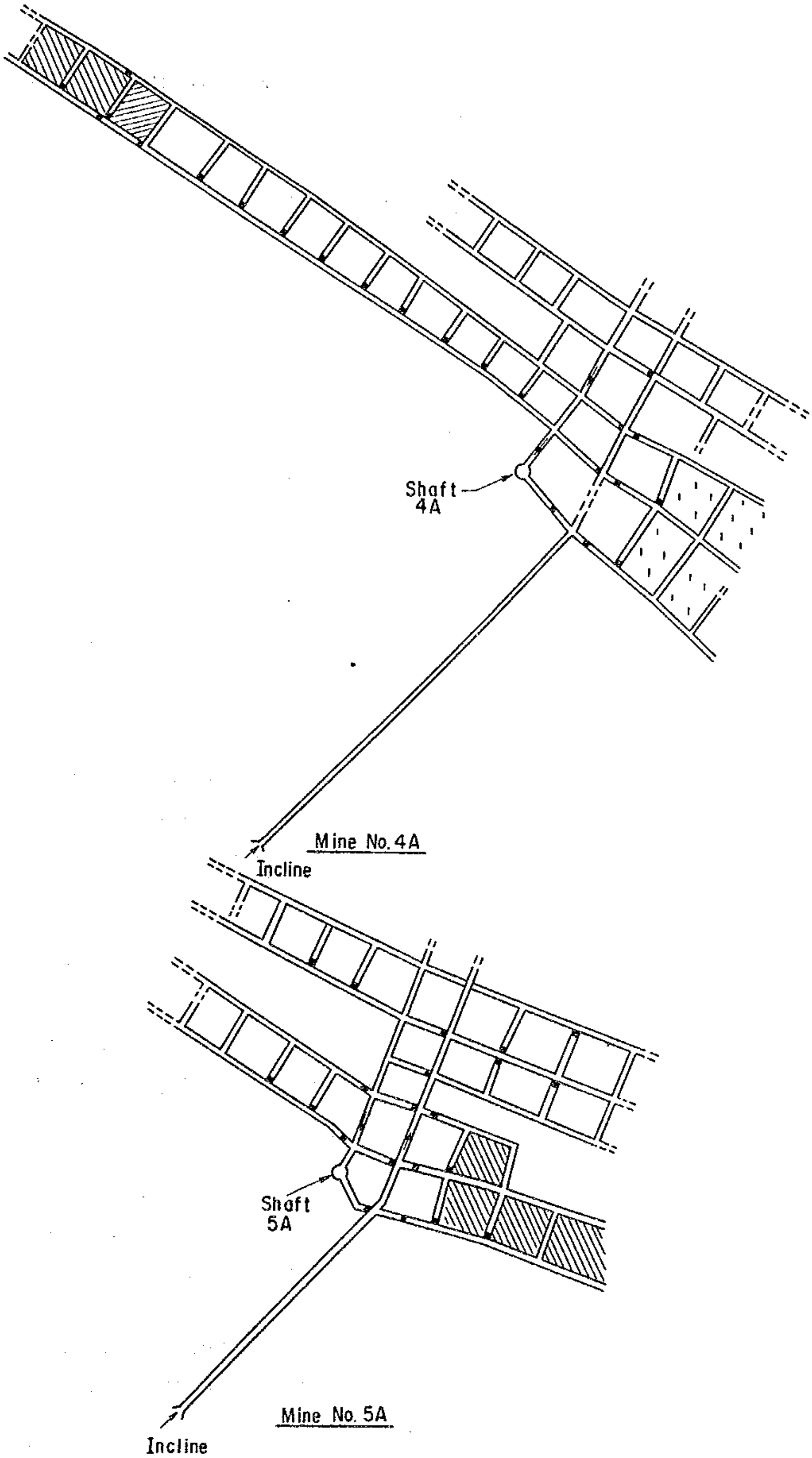


Figure 5-2-4 Plan of PMDC' Collieries in Lease No.192

Table 5-2-4 Code of Coal Pit and Number of Coal Mining Lease

Lease No.	Coal Mine Code	Shaft Code
88	M-1	1A
88	-	1B
88	-	1C
88	M-2	2A
88	-	2B
88	M-3	3A
88	M-6A	6A
88	M-6B	6B
88	M-6C	6C
88	M-7A	7A
66	M-4	4
66	M-5	5
192	M-4A	4A
192	M-5A	5A

Figure 5-2-5 is an isopach map of Laillan coal seam, the most important coal seam in the Lakhra coal field, indicating the locations of drill holes and mines in Lease No.88.

The sequence of operations from the extraction of coal to shipment is as follows:

1. Coal miners manually dig a shaft while preventing the shaft's mouth and outskirt from collapsing by compressing the wall and placing bricks at the mouth.

2. Steel tripod with a pulley is installed just above the hole of shaft, earth, rocks and coal are lifted by means of an electric winch provided with the tripod.

3. A railway line is laid from the mouth of shaft to the coal stock yard to transport earth, rocks and coal. A railway car is placed on the railway line.

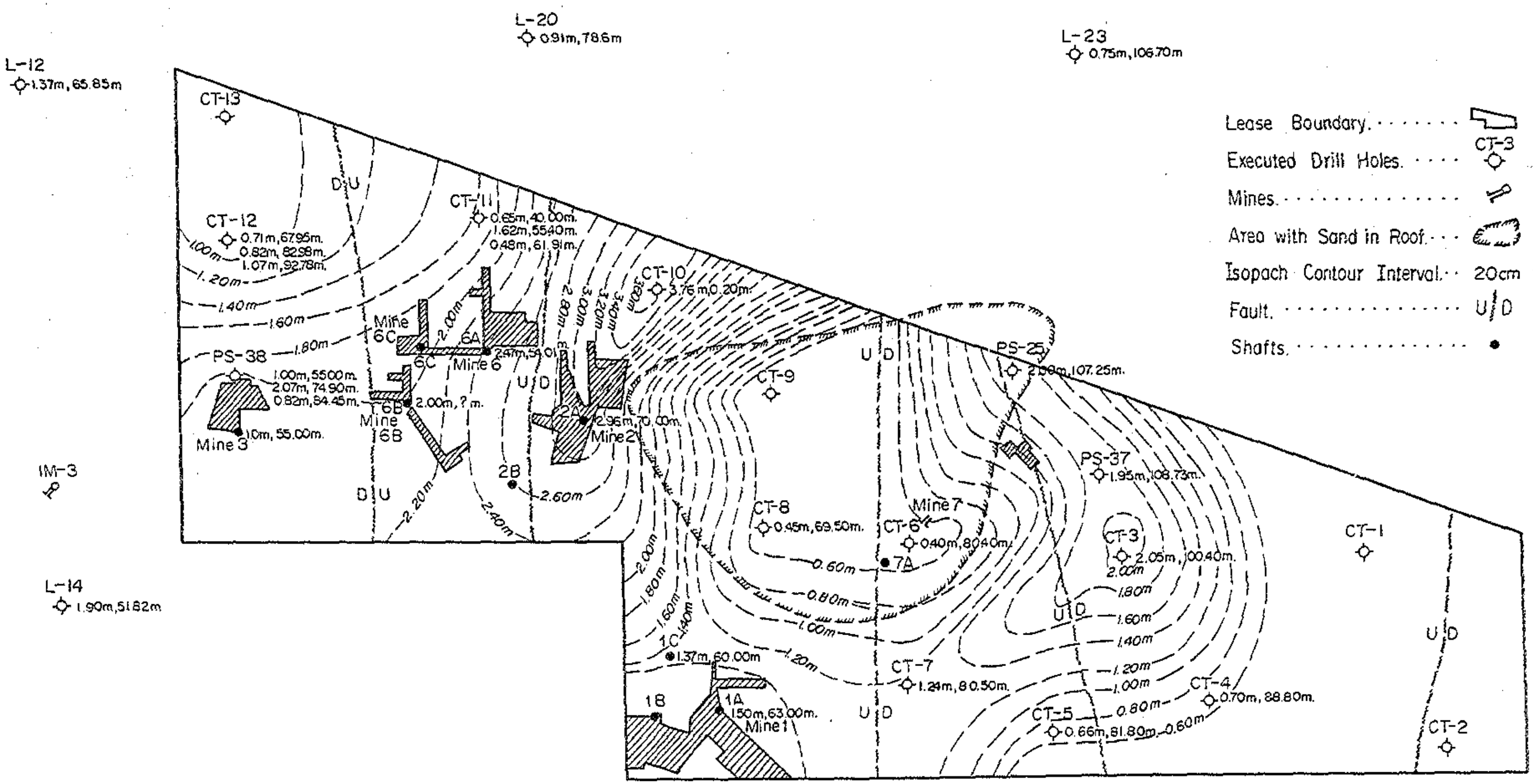


Figure 5-2-5 Isopach Map of Lailian Coal Seam Showing Drill Holes and Mines in Lease No.88

4. The miners manually extract coal in the shaft. They also manually extend coal pits as coal is mined out. The coal is filled in a jute bag each up to about 75 kilograms.

5. About eight jute bags full of coal are put together and wrapped in a net attached to the end of a cable; the bags are lifted by the electric winch from the shaft to the surface.

6. The railway car is moved to beneath the net and the jute bags are placed down on it.

7. A few mine workers push the car to the coal stock yard.

8. At the coal stock yard, other mine workers carry on their backs the jute bags containing coal to a designated point and empty the bags to pile up the coal there.

9. Trucks, usually with ten-ton capacity, arranged by dealers come on a regular basis to the designated stock yards. They transport the coal in bulk to the places of consumption. The tariff for transportation to Karachi, for example, is 10 Rupees per ton.

10. Normally, a shaft of an average depth of 70 meters has the following number of people working:

miner	22 to 25
winch operator	2
car	2
unloader	2 to 3
coal carrier	7 to 8

11. With the above number of workers, about 30 tons per day of coal is produced per shaft. PMDC does not mine or transport coal itself but consigns these works to subcontractors on a fixed rate of 75 Rupees per ton.

Figure 5-2-6 shows the organization charts of PMDC' Lakhra Coal Mines and the Entire PMDC.

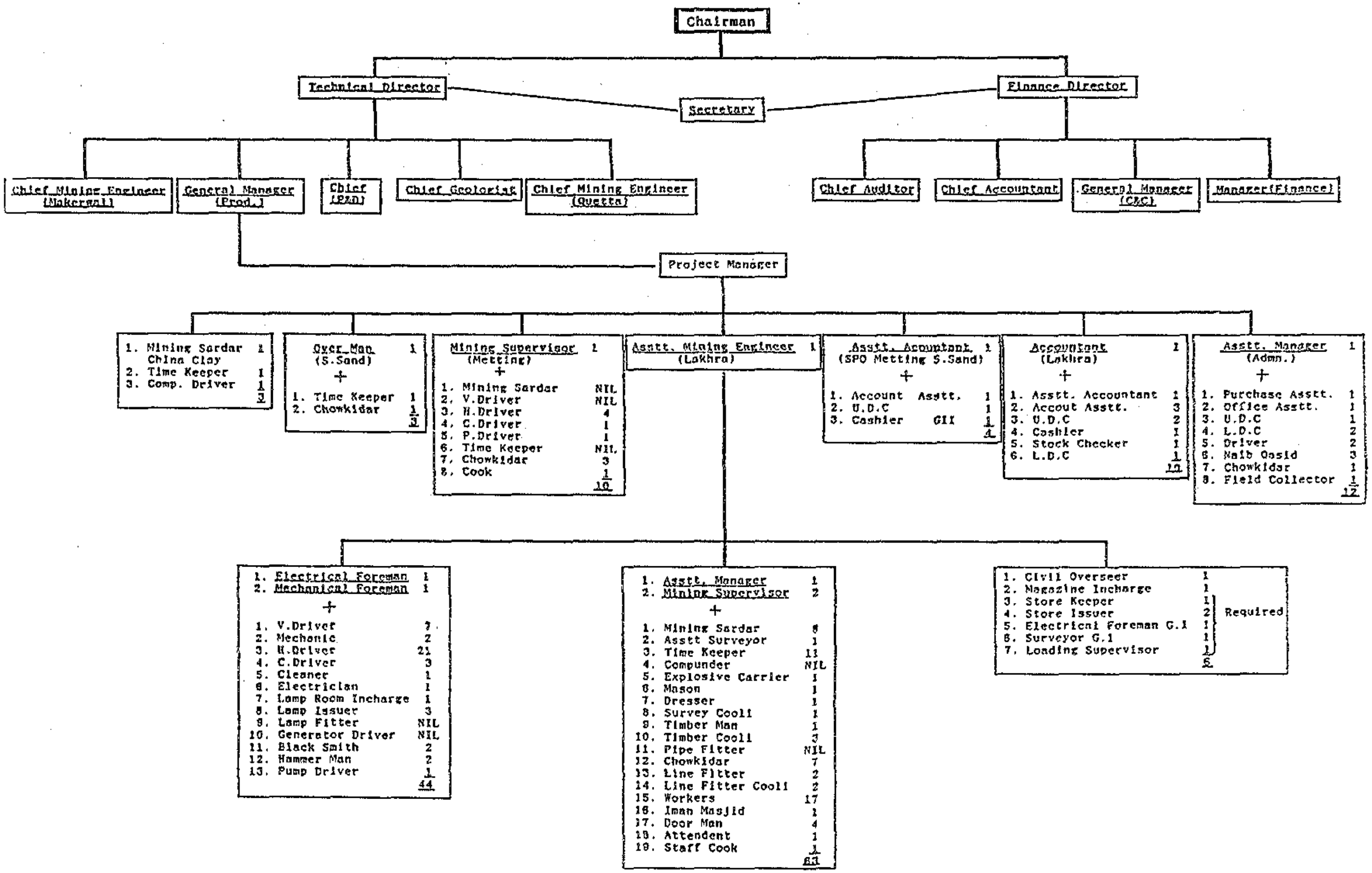


Figure 5-2-6 Shows the Organization Charts of PMDC' Lakhra Coal Mines and the Entire PMDC

5-2-4 Past Production of Lakhara Coal

Table 5-2-4 shows past production of Lakhra coal.

Table 5-2-5 Past Production of Lakhra Coal

(unit : tons)

Sector	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88
Private*	307,330	330,805	477,980	484,823	491,811	N.A.
(Share %)	(99.2)	(90.4)	(89.6)	(89.1)	(87.0)	(N.A.)
(Growth Rate % pa)	-	(7.6)	(44.5)	(1.4)	(1.4)	(N.A.)
PMDC	2,560	35,206	55,482	59,152	73,550	104,581
(Share %)	(0.8)	(9.6)	(10.4)	(10.9)	(13.0)	(N.A.)
(Growth Rate % pa)	-	(1,275.2)	(57.6)	(6.6)	(24.3)	(42.2)
Total	309,890	366,011	533,462	543,975	565,361	N.A.
(Share %)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
(Growth Rate % pa)	-	(18.1)	(45.8)	(2.0)	(3.9)	(N.A.)

Note : * Private sector figures calculated from the total and PMDC figures.
Source: Energy Year Book 1987 and PMDC

The total production from the entire Lakhra coal mine had increased steadily until 1984-85; since then the growth has slowed down registering only 2.0 percent from 1984-85 to 1985-86 and 3.9 percent from 1985-86 to 1986-87. This tendency is even more pronounced in the private sector: the annual growth rates in 1985-86 and 1986-87 both lingered at a one percent level. This was a direct consequence of the slowdown experienced by the brick burning industry which consumed as much as about 97 percent of the nation's coal production. There is a growing trend in Pakistan towards using concrete blocks in preference to bricks for building purposes. Since this tendency is expected to continue to the future, the production of coal by the private sector alone will be 500,000 tons in 1987-88 at most, or some 600,000 tons including the expected production from PMDC' mines which is 104,000 tons.

The PMDC' production has been increasing steadily since production capacity was reinforced in 1983-84; the production capacity as of 1988 reached a level of 100,000 tons per year. However, PMDC' share grew at the expense of the share of the private sector. PMDC probably accounted for 20 percent of the production at Lakhra in 1987-88. This tendency may prevail in the future; however, PMDC cannot continue to increase production for long as long as the principal use of coal is just as fuel for brick burning. In this respect, the implementaton of this project is very important not only from the viewpoint of the coal briquette project itself, which means the introduction of a new commodity to the society, but also in the context of exploiting a new outlet of PMDC' coal production.

5-2-5 Prospect of Lakhra Coal Mines

The production by the private sector can hardly expect any substantial increase in the future unless new large outlets are explored. Regarding use of coal for power generation, JICA, USAID, and other organizations have conducted feasibility studies on utilization of coal from PMDC' Compact Block; correspondingly, supply schedules of coal for the future have been developed. A coal-fired power station with three 50 MW plants (one stand-by for emergency), for instance, is being planned with commissioning scheduled for 1991-92 at Khanot, 17 kilometers to the east of Lakhra. According to the plan, this thermal power station will be supplied with coal from Compact Block, 150,000 tons in the first year, 535,000 tons in the second year, and every 750,000 tons in the third year and each year thereafter.

PMDC' Central Block has produced coal primarily for brick burning. PMDC now plans to provide this coal briquette project with the coal mined from this block. Therefore, the prospect of coal production of this block is particularly important in establishing the feasibility of this project.

It is planned that the capacity of the coal briquetting plant will be at 50 or 100 thousand tons per year during the initial five years and then gradually be increased to 300 thousand tons per year. The plant will consume about 1.6 times as much ROM coal as products. Expansion of coal production capacity up to a

486,900 tons per year level in the near future will not pose great difficulty for PMDC; PMDC currently plans to expand the capacity to 200,000 tons per year level, which represents a growth of 100 percent over the present capacity. It is almost certain that this plan will be realized; no unsurmountable difficulty is foreseen in achieving this goal.

PMDC' coal mines in Central Block are of small scale relyting on manual extraction. This is not necessarily all disadvantageous. There are in fact a few advantages; one is the relatively small investment cost required for the expansion of production capacity within a small range and the other is the short period required from preparation to commissioning. The implementation of this project will require PMDC to open new coal mines, which it will be able to do without great difficulty given these advantages.

5-2-6 Price of Lakhra Coal

The ex-mine price differs between PMDC and the private sector and it also fluctuates by season. The demand for bricks generally falls during the period from July to September, which falls on the monsoon season. Consequently, the demand for coal, as well as the price, falls with the demand for bricks; the price can fall as much as appreximately 50 percent compared with the other seasons. Table 5-2-6 shows the average ex-mine price of PMDC' Lakhra coal.

Table 5-2-6 Average Ex-mine Price of PMDC' Lakhra Coal

(Unit: Rupees/Ton)

Period	Average Ex-mine Coal Price
July,1983-March,1984	212.00
April,1984-June,1984	219.33
July,1984-June,1985	256.00 & 248.00
July,1985-December,1985	193.00
January,1986-June,1986	158.00
July,1986-June,1987	171.00
July,1987-June,1988	215.00
July,1988-June,1989	332.00

Source : PMDC

PMDC has decided that the price of coal to be consumed by this project will be 300 Rupees per ton on ex-mine basis since a stable demand may be expected.

5-2-7 Chracteristics of Lakhra Coal

The Lakhra coal belongs to the rank of lignite and has the following characteristics:

1. The degree of carbonization and calorific value of the Lakhra coal are both lower than those of anthracite or bituminous coal. The Lakhra Coal is not a caking coal and therefore not suited to steel manufacturing purpose.
2. The Lakhra coal contains sulfur at a high content and generates a great deal of sulfur oxides upon combustion; it has great tendency for spontaneous combustion.
3. The content of volatile matter is high; therefore, the Lakhra coal is easy to ignite and burns well with a powerful flame. However, it tends to generate smoke.
4. The Lakhra coal contains ash at a high content and leaves a large amount of ash including fly ash after combustion.
5. The Lakhra coal is available in fragile lumps.
6. Since the content of moisture of the ROM coal is high, the investment cost tends to be higher and efficiency tends to be lower when it is used for thermal power generation.

Overall, the Lakhra coal should be evaluated as coal of inferior quality. The major advantages of the Lakhra coal as the feedstock for this project are as follows:

1. The Lakhra coal is easy to form into briquette.
2. The Lakhra coal is easy to crush to a powder form.
3. The physical strength of the briquettes is high.
4. Since the crushed particles are fine, it helps the briquettes to burn well.
5. The degree of carbonization is low and the content of volatile matter is high; therefore, coal briquettes of good burning quality may be manufactured from the Lakhra coal.

The above advantages can be effectively utilized for manufacturing coal briquettes for cooking purposes which should burn well.

Table 5-2-7 shows representive analysis of the ROM Lakhra coal. Refer to CHAPTER 9, RAW MATERIAL TEST AND EVALUATION, for detailed analysis of samples collected from the candidate mines for this feasibility study.

Table 5-2-7 Analysis of Lakhra ROM Coal

(Unit: present)

Test Item		Coal(1)*	Coal(2)**
Moisture		29.5	25.0
Ash		13.1	18.4
Volatile Matter		29.9	28.9
Fixed Carbon		27.7	N.A.
Total Sulfur		3.66	6.3
Incombustible Sulfur		0.46	N.A.
Combustible Sulfur		3.20	N.A.
Calorific Value	(kcal/kg)	4,150	3,900

Note : All items are in weight percent except for calorific value which is in kcal/kg gross.

Source : * The Preliminary Survey Report on the Smokeless Coal Briquettes Development Project in the Islamic Republic of Pakistan, January, 1988 (JICA)

** Islamic Republic of Pakistan Feasibility Report for Lakhra Coal Mine and Power Station Project, February, 1981. (The data is for the underground mined coal on a received basis.)

5-3 Subordinate Raw Materials

This section discusses availability, properties and prices of subordinate raw materials. The important considerations in their selection were already explained in 5-1. The purposes of using subordinate raw materials are as follows:

1. To act as a binder to facilitate briquetting and increase physical strength of the briquettes,
2. To neutralize and suppress generation of oxides of sulfur upon combustion of the briquettes,
3. To help the briquettes start well and to suppress generation of smoke, and
4. To give the briquettes water repellency resistance.

Various kinds of subordinate raw materials are conceivable; this project selects the following candidate subordinate raw materials:

Subordinate Raw Material	Purpose (Number mentioned above)
Biomass	1 & 3
Cement	1
Limestone/ Slaked Lime	2
Slack Wax/ Light Oil	4

Among the biomass materials, bagasse, wheat sraw and cottonseed oil extraction residue (cottonseed oil cake) were selected for study from the viewpoints of availability and prices. Finally, only bagasse, slaked lime and slack wax/ light fuel oil were chosen for reasons explained in CHAPTER 8, PROJECT SCHEME.

5-3-1 Bagasse

(1) Availability of bagasse

Pakistan is one of the foremost sugarcane producers in the world, producing about 29.9 million tons in 1988-87. Lakhra, the candidate site of the coal briquettes manufacturing plant, is in Sind Province which is the second largest producer of sugarcane next to Punjab Province. In 1986-87 Sind produced about 7.9 million tons of sugarcane, or about 26 percent of the entire production of Pakistan, from about 180,000 hectares of land. The sugarcane is grown in the rainy season from July to September, and harvested in the dry season from October to June, in Sind. Therefore, the production of the bagasse varies with season. Table 5-3-1 shows the recent production of sugarcane in Pakistan and Sind Province.

Table 5-3-1 Recent Production of Sugarcane for Pakistan and Sind

	1982-83	1983-84	1984-85	1985-86	1986-87
Pakistan(Million Tons)	32.53	34.29	32.14	27.86	29.93
Growth Rate(% p.a.)	-11.1	5.4	-6.3	-13.3	7.4
Sind Province(Million Tons)	7.55	7.36	7.43	7.53	7.91
Growth Rate(% p.a.)	1.2	-2.5	1.0	1.3	5.0
Share in Total(%)	23.2	21.5	23.1	27.0	26.4

Source : Pakistan Statistical Yearbook 1988
Statistical Pocket Book of Sind 1988
Development Statistics of Sind 1986

The production of bagasse in Sind in 1986-87 was approxinately 2.4 million tons, or 7.9 million tons x 0.3; generally, approximately 300 kilograms of bagasse, on 50 percent water content base, is produced from one ton of sugarcane. The Pakistan sugar mills generally consume about 75 percent of their production of bagasse as fuel. Bagasse is utilized for manufacturing chip boards/ bagasse board, paper and fertilizer besides for fuel. The present state of utilization is explained below:

1. There is no paper mill in Sind to use bagasse as raw material.
2. The consumption of bagasse for fertilizer is negligible.
3. There is no large-scale plant to manufacture chip board or bagasse board in Sind.

Therefore, the amount of bagasse available to this project is calculated to be about 600,000 tons per year, or 2.4 million tons x 0.25, from the estimated production of bagasse of Sind in 1986-87; this is a Case 1 estimate.

Table 5-3-2 shows the amount of sugarcane crushed and that of sugar produced by the private sugar mills in Sind in 1987-88. Figure 5-3-1 shows the locations of these private sugar mills. The amount of total sugarcane crushed by the all 19 private sugar mills in Sind was about 9.4 million tons in 1987-88. The corresponding bagasse production is calculated to be about 2.8 million tons assuming a 30-percent yield. It is possible for the self-consumption by the mills to increase; in an extreme case the availability of bagasse may go down to about 10 percent of the total production of bagasse. In this case, availability of bagasse becomes approximately 280,000 tons per year. There are other sources, however. Table 5-3-2 does not include the Dadu mill and the Thatta mill of Sind Sugar Corporation Ltd. owned by the provincial government of Sind. It was confirmed during the field survey that 20 to 25 thousand tons of bagasse will be annually available from the Dadu mill. Therefore, it is estimated that the availability of the bagasse to this project from Sind is some 300,000 tons per year on a 1987-88 year production basis; this is a Case 2 estimate.

When this project reaches maturity at 300,000 tons per year production about 98,000 tons of bagasse, containing about 50 percent water as harvested, will be required. It then follows that a sufficient amount of bagasse will be available to this project given that the above conditions exist for either Case 1 or Case 2. Seasonally, there are fluctuations in supply; therefore, as much as 150 day's requirement must be stored before non-harvesting season sets in.

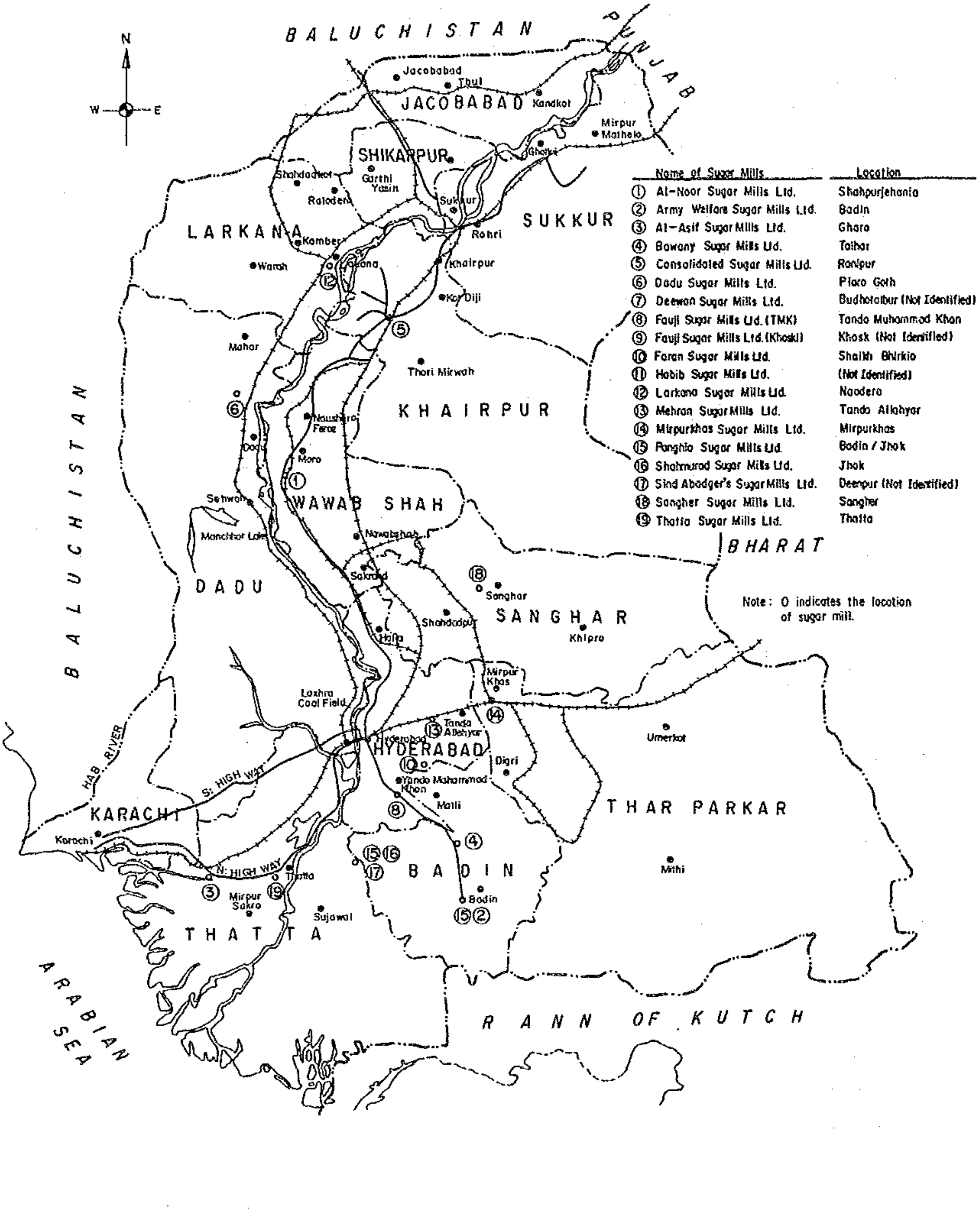


Figure 5-3-1 Location of Private Sugar Mills in Sind Province

Table 5-3-2 Sugarcane Crushed and Sugar Produced by Private Sugar Mills in Sind in 1987-88

(Unit:Tons)

Name of Sugar Mills	Sugarcane Crushed	Sugar Produced
Al-Noor Sugar Mills Ltd.	730,443	61,208
Army Welfare Sugar Mills Ltd.	397,324	38,781
Al-Asif Sugar Mills Ltd.	122,096	9,654
Bawany Sugar Mills Ltd.	537,810	52,591
Consolidated Sugar Mills Ltd.	544,597	45,614
Dadu Sugar Mills Ltd.	559,429	43,846
Deewan Suar Mills Ltd.	411,249	37,454
Fauji Sugar Mills Ltd.(TMK)	629,352	60,304
Fauji Sugar Mills Ltd.(Khoski)	675,791	63,231
Faran Sugar Mills Ltd.	523,694	47,980
Habib Sugar Mills Ltd.	701,748	61,293
Larkana Sugar Mills Ltd.	240,140	18,228
Mehran Sugar Mills Ltd.	581,264	48,801
Mirpurkhas Sugar Mills Ltd.	545,732	47,161
Panghio Sugar Mills Ltd.	526,705	48,910
Shahmurad Sugar Mills Ltd.	597,536	58,581
Sind Abadger's Sugar Mills Ltd.	456,397	45,143
Sangher Sugar Mills Ltd.	112,501	9,350
Thatta Sugar Mills Ltd.	501,324	45,740
Total	9,395,133	843,869

(2) Properties of bagasse

The bagasse in Pakistan is available either in a fine powder form measuring less than two millimeters, or in a form of fiber measuring some five centimeters depending upon the type of crushers used by sugar mills. This project will store bagasse outdoors; therefore, the latter is preferable because the bagasse in a powder form will suffer airborne loss. However, in this case, the plant has a crushing process of bagasse to obtain fine powder. On a prolonged out-door storage the bagasse partially becomes humus by biochemical disintegration, but fibrous tissues would not be affected.

Refer to CHAPTER 9, RAW MATERIAL TEST AND EVALUATION, for analytical results of the sample of bagasse collected in the project area.

(3) Price of bagasse

The price of bagasse fluctuates corresponding to the availability. The price in the rainy season, from July to September when bagasse is difficult to obtain, becomes approximately 50 to 60 percent highter than the dry season, or harvest season. The ex-sugar mill price including 12.5 percent sales tax is 80 to 200 Rupees per ton on a wet basis according the result of field survey.

5-3-2 Wheat Straw

(1) Availability of wheat straw

Pakistan is one of the ten largest producers of wheat in the world; it produced about 12 million tons in 1986-87. Sind is the second greatest producer next only to Punjab. Sind produced about 2.2 million tons in 1986-87 or aproximately 18 percent of the entire production of Pakistan, from about one million hectares of land. In Sind wheat is harvested mostly from March to June; and wheat straw is produced almost concurrently. However, wheat straw is available in the market throughout the year; it is a commodity with regular demand in Pakistan. The dealers maintain a large amount of inventory.

Table 5-3-3 gives the recent production of wheat in Pakistan and Sind.

Table 5-3-3 Recent Production of Wheat in Pakistan and Sind

	1982-83	1983-84	1984-85	1985-86	1986-87
Pakistan(Million Ton)	12.41	10.88	11.70	13.92	12.02
Growth Rate(% p.a.)	9.8	-12.3	7.5	19.0	-13.6
Sind Province(Million Ton)	2.07	1.95	2.08	2.17	2.21
Growth Rate(% p.a.)	0.5	-5.8	6.7	4.3	1.8
Share in Total(%)	16.7	17.9	17.8	15.6	18.4

Source : Pakistan Statistical Yearbook 1988
Statistical Pocket Book of Sind 1988
Development Statistics of Sind 1986

In Pakistan, about two tons of wheat straw is produced for every one ton of wheat. Therefore, it is estimated that the production of wheat straw in Sind was about 4.4 million tons in 1986-87. The consumption of wheat straw is approximately 41 to 48 percent as cattle feed, 30 to 40 percent for paper manufacturing, 17 to 20 percent as fuel and 2 percent for activated carbon manufacturing. Out of this, half the consumption as fuel, or some 10 percent of total (approximately 440,000 tons per year) would be diverted to this project. Accordingly, the same amount of wheat straw as that of bagasse, which is 98,000 tons based on 50 percent water content, could be procurable.

(2) Properties of wheat straw

Wheat straw is sold in small pieces. The properties of wheat straw are similar to those of bagasse, but the ratio of length to diameter of the fiber is larger for wheat straw than for bagasse. For the results of analysis on the wheat straw samples collected at the project area, refer to CHAPTER 9 RAW MATEIAL TEST AND EVALUATION.

(3) Price of wheat straw

The price of wheat straw also fluctuates with availability like bagasse. The dealers collect wheat straw from farmers and sell them in the market. Table 5-3-4 shows the price of wheat straw at different points of distribution; at farmer, wholesaler and marketplace, obtained by the field survey.

Table 5-3-4 Sales Price of Wheat Straw by Point of Sale

Point of Sales	Sales Price(Rupees/Ton)
Farmer	300.00
Wholesaler	800.00 - 900.00
Marketplace	600.00 - 1,100.00

Source : Investment Promotion Bureau

5-3-3 Cottonseed Oil Extraction Residue (Cottonseed Oil Cake)

(1) Availability of cottonseed oil extraction residue

Cotton is a very important agricultural product for Pakistan. Cotton mills separate raw cotton into approximately 33 percent of cotton and 67 percent of cottonseed. The cottonseed separated is sent to cottonseed oil extraction plants where short fiber similar to cotton called cotton linter is cut three times, then the seeds are crushed by crushing mills. Cottonseed oil is produced from the crushed cottonseed either by compression process or by solvent process. The yields of oil and oil cake are 11 to 19 and 81 to 89 percent, respectively. The solvent process gives a better yield of oil.

Cotton linter is a good raw material for manufacturing rayon, explosives, charcoal briquettes and coal briquettes. However, even the cheapest third-cut linter is priced at some 120 Rupees per 40 kilograms, too expensive to consider as a raw material for this project and thus was excluded from the candidate biomass materials for this project. The cottonseed oil extraction residue is now used mainly for cattle feed.

In Pakistan, about 1.3 million tons of cotton was produced in 1986-87, of which 220,000 tons or 16.7 percent was produced in Sind. The cottonseed oil is the most important edible vegetable oil in Pakistan and is chronically in short supply; it is supplemented by import. Almost all cottonseed produced domestically go to oil extraction mills. It is therefore estimated that about 360 to 400 thousand tons, 220 thousand tons x 67/33 x 0.81 to 0.89, of cottonseed oil cake was produced in Sind in 1986-87. Assuming that 10 percent of the above amount would be diverted to this project, as was assumed in the case of wheat straw, 36 to 40 thousand tons per year of cottonseed oil cake will be made available to this project, on wet base containing 7.0 to 7.5 percent moisture. The oil cake required for coal briquettes manufacturing at 300,000 tons per year production is about 52 to 53 thousand tons per year on the same wet base, assuming that cottonseed oil cake requirement is nearly equal to that of bagasse. Thus the above availability represents nearly 100 percent of cottonseed the requirement. The raw cotton is generally harvested from February to July in Pakistan, and so is the production of cottonseed oil cake. Table 5-3-5 shows the recent production of cotton in Pakistan and Sind.

Table 5-3-5 Recent Production of Cotton in Pakistan and Sind

	1982-83	1983-84	1984-85	1985-86	1986-87
Pakistan(Thousand Tons)	823.9	494.6	1,008.7	1,217.0	1,319.9
Growth Rate(% p.a.)	10.1	-40.0	103.9	20.7	8.5
Sind Province(Thousand Tons)	269.5	205.8	251.0	246.5	221.9
Growth Rate(% p.a.)	2.3	-23.6	22.0	-1.8	-10.0
Share in Total(%)	32.7	41.6	24.9	20.3	16.8

Source : Pakistan Statistical Yearbook 1988
Statistical Pocket Book of Sind 1988
Development Statistics of Sind 1986

(2) Properties of cottonseed oil cake

The moisture content is normally from 7.0 to 7.5 percent ex-plant. Refer to CHAPTER 9, RAW MATERIAL TEST AND EVALUATION, for the analyses of cottonseed oil cake collected near the plant site.

(3) Price of cottonseed oil cake

The ex-plant price of cottonseed oil cake fluctuates by season but is generally between 2.0 and 2.5 Rupees per kilogram.

5-3-4 Cement

(1) Availability of cement

Pakistan produced about 6.5 million tons of cement in 1986-87, of which Sind produced about 3 million tons, or about 46 percent. Table 5-3-6 shows the installed capacity of cement works in operation in Sind as of 1986-87. There are six works in the public sector and three works in the private sector in Sind; the combined installed capacity is 3.65 million tons.

Table 5-3-6 Installed Capacity of Cement Works in Operation in Sind

(Unit:Million tons/year)

Factory	Location	Installed Capacity
(Public Sector)		
Associated	Rohri	0.270
Javedan	Karachi	0.300
Javedan(Expanded)	Karachi	0.300
National	Karachi	0.160
Thatta Cement	Thatta	0.340
Zeal Pak	Hyderabad	1.080
Sub Total		2.450
(Private Sector)		
Dada Bhoy	Kalu Kohar	0.300
Pak Land	Dhabeji	0.300
Attock Cement	Hub Chowki	0.600
Sub Total		1.200
Total		3.650

Source : Investment Promotion Bureau, Ministry of Industries

Their average operating factor is about 80 percent. The Zeal Pak Cement Factory, the most up-to-date operating in Hyderabad, can increase production by about 200,000 tons per year from the current level. Based on the results of the experimental production of coal briquettes, cement is not used as long as the quality of coal does not change. In case cement becomes necessary, the annual requirement is less than about 30 thousand tons for 300 thousand tons per year production of coal briquettes. In view of the above, the cement required for manufacturing coal briquettes will be easily supplied from the Zeal Pak Cement Factory.

(2) Characteristics of cement

The cement available from the Zeal Pak Cement Factory is a typical portland cement; which normally shows analysis shown in Table 5-3-7.

Table 5-3-7 Results of Analysis of Zeal Pak Cement

(%)

SiO_2	Al_2O_2	FeO_3	CaO
20-26	4-9	2-5	60-66

Source : Practical Information on Cement, Toyokeizai Shinposha (Orient Economist) Tokyo, Japan

(3) Price of cement

Pakistan had a surplus in cement production as of July, 1988; the price is not likely to increase in the near future. Table 5-3-8 shows the breakdown of cement price obtained from Zeal Pak Cement Factory Ltd. The retail price of cement in Hyderabad was 79 to 80 Rupees per 50 kilograms during the field survey.

Table 5-3-8 Breakdown of Cement Price

Item	Price or Cost (Rs/50kg Bag)
Ex-plant	75.700*
Octroi	0.275
District Council Tax	0.250
Sub Total	76.225
Transportation Cost	Depending on distance
Sales Margin	N.A.

Note : * 12.5 % sales tax is included.
Source : Zeal Pak Cement Factory Ltd.

5-3-5 Limestone and Slaked Lime

(1) Availability of limestone/slaked lime

Limestone or slaked lime is an importand subordinate raw material to be blended as neutralizing agent at the manufacturing stage. Pakistan is rich in limestone and is used effectively for manufacturing cement. Slaked lime is produced by adding water to quick lime which is the product of calcination of limestone. The slaked lime is generally used as stucco, soil neutralizers, raw material for bleaching powder, papers, agricultural chemicals and so on. Pakistan produced about 6.9 million tons of limestone in 1986-87, of which Sind produced about 3.3 million tons, or 48 percent. Table 5-3-9 shows the recent production of limestone in Pakistan and Sind.

Table 5-3-9 Recnt Production of Limestone in Pakistan and Sind

	1982-83	1983-84	1984-85	1985-86	1986-87
Pakistan(Million Tons)	4.23	4.70	4.63	6.31	6.89
Growth Rate(% p.a.)	14.9	11.1	-1.5	36.3	9.2
Sind Province(Million Tons)	2.10	2.29	1.93	2.82	3.31
Growth Rate(% p.a.)	-6.7	9.0	-15.7	46.1	17.4
Share in Total(%)	49.6	48.7	41.7	44.7	48.0

Source : Pakistan Statistical Yearbook 1988

In case this project uses limestone instead of slaked lime, limestone is available in a powder form from Zeal Pak Cement Factory in Hyderabad; it requires, however, permission from the government because Zeal Pak is not normally allowed to sell anything other than cement, like many other corporations in the public sector.

In case this project uses slaked lime, it is available from a large number of small-scale lime kilns operating in Hyderabad area. Slaked lime is used mainly for stucco. It is easy to increase the production of slaked lime; both kilns and their processes are very simple.

Approximately 38 thousand tons of limestone or 19 thousand tons of slaked lime is required at the maximum production capacity, 300 thousand tons per year of coal briquettes. It is estimated that the Zeal Pak has an excess capacity of about 250 thousand tons per year of limestone. The lime kilns are all small industries and their number is not available. A large number of kilns are operating to meet the demand of stucco. The lime kiln is so simple that the production of slaked lime can easily be increased when the demand increases.

It may be concluded from the above discussion that limestone or slaked lime required by this project will be sufficiently available.

(2) Characteristics of limestone/slaked lime

Limestone is generally a sedimentary rock formed by the deposition of calcium carbonate dissolved in the hydrosphere through the action of organisms, i.e., organic-origin limestone; or precipitation of calcium carbonate as a result of some chemical reactions, i.e., chemical limestone. Both types of limestone can sustain physical crushing, re-sedimentation and metamorphosis over time. The limestone in Pakistan may be considered mostly of organicorigin from a geological viewpoint. Table 5-3-10 shows an analysis of limestone obtained during the field survey juxtaposed with that of Japan's limestone.

Table 5-3-10 Chemical Analysis of Pakistan's Limestone and Japan's Typical Limestone

(Unit: percent)

Location	CaO	Ig.Loss	$CaCo_3$	Moisture
Limestone	51.01	37.37	91.09	2.25
Slaked lime	63.14	19.56	-	10.97
Limestone in Japan*	37.40-55.90	36.82-48.16	~99	N.A.

Source : * Hand Book of Plaster and Lime, Gihodo Shuppan, Japan

For the results of analysis on the limestone and slaked lime collected during the field survey, refer to CHAPTER 9, RAW MATERIAL TEST AND EVALUATION.

(3) Price of limestone and slaked lime

The prices of limestone and slaked lime are comparatively stable because they are sufficiently available throughout the year. Table 5-3-11 shows the prices of limestone and slaked lime as of July 1988, respectively.

Table 5-3-11 Prices of Limestone and Slaked Lime

(As of July, 1988)

	Ex-Plant	Wholesale	Retail
Limestone(Rs/Ton)	65.00	-	70.00
Slaked LIme(Rs/40kg)	25.00	27.00	28.00

5-3-6 Slack Wax/Light Fuel Oil

(1) Availability of slack wax and light fuel oil

The coal briquettes are coated with slack wax at the final stage of manufacturing in order to give them waterproofing. Slack wax, in its normal state, is difficult to coat; coal briquettes are therefore immersed in light fuel oil containing dissolved slack wax. In Pakistan, both slack wax and refined wax, or parafin wax, are produced by Natonal Refinery Ltd. as a byproduct of lubricating oils. National Refinery produced about 10,000 tons per year of slack wax as of July, 1988, and can double the production to 20,000 tons. Slack wax is not placed on the market because of lack of demand. National Refinery plants to provide slack wax as a feedstock to the planned 1.3 million tons per year hydrocracker, a plant for converting heavy fractions to light fractions by cracking plus hydrogenation; but this hydrocracker project has not reached the definite stage. In case this hydrocracker project is realized, an alternative source must be found. There is no other plant in Pakistan manufacturing slack wax; the nearest source is one of the refineries located along the coast of the Arabian Sea. Slack wax should be available for import at CIF Karachi price nearly equal to that light fuel oil.

The requirement of slack wax is 0.6 percent of coal briquettes. Therefore, about 1,800 tons of slack wax is annually required at the final stage. This amount of slack wax can be easily secured from National Refinery. However, prior permission from the government for sale of slack wax is required because National Refinery is a state-owned company. The transportation from the refinery to the briquetting plant should be arranged by this project since slack wax is not available on the market.

This project will use light diesel fuel oil as solvent for slack wax. The light diesel fuel oil of Pakistan meets ASTM specification and is normally available at oil depots and service stations. The production of light diesel fuel oil in Pakisan was about 250,000 tons in 1986-87, of which about 96,000 tons, or about 38 percent, was sold via depots of PSO, Pakistan State Oil Co., Ltd., Sind. The consumption of slack wax is about one tenth of that of light diesel fuel oil. The requirement of light diesel fuel oil at maturity of the project is approximately 13,000 tons per year. This amount accounts for about 14 percent of the present total consumption of light diesel fuel oil in Sind, and is considered securable in Sind.

(2) Characteristics of slack wax and light fuel oil

Slack wax is a by-product of lubricating oils. The properties of slack wax at National Refinery was not available; the properties of slack wax produced at National Refinery are estimated as shown in Table 5-3-12 from the processes involved and the source of crude oil, namely Arabian Light crude.

Table 5-3-12 Estimated Property of Slack Wax

Specific Gravity	0.810 - 0.870
Melting Range(C)	50 - 70
Oil Content(Wt %)	5
Average Molecular Weight	350 - 600

Table 5-3-13 shows the specifications of light diesel fuel oil (grade No.2-D) of ASTM (extract from D975-53T).

Table 5-3-13 ASTM Specification of Diesel Fuel (Extract from D975-53T)

Grade of Diesel Fuel Oil	Flash Point, °C	Cloud Point °C (°F)	Water and Sediment, vol %	Carbon Residue on, 10% Residuum, %	Ash, weight %	Distillation Temperatures, °C(°F) 90% Point		Viscosity Kinematic, cSt[F] at 40°C		Viscosity Saybolt, SUS at 100°F		Sulfur[C], weight %	Copper Strip Corrosion	Cetane Number[D]
	Min	Max	Max	Max	Max	Min	Max	Min	Max	Min	Max	Max	Max	Min
No.2-D A distillate fuel oil of lower volatility for engines in industrial and heavy mobile service.	52 (125)	A	0.05	0.35	0.01	282[B] (540)	338 (640)	1.9	4.1	32.6	40.1	0.50	No.3	40[E]

A It is unrealistic to specify low-temperature properties that will ensure satisfactory operation on a broad basis. Satisfactory operation should be achieved in most cases if the cloud point (or wax appearance point) is specified at 6°C above the tenth percentile minimum ambient temperature for the area in which the fuel will be used. This guidance is of a general nature; some equipment designs, use flow improver additives, fuel properties, and/or operations may allow higher or require lower cloud point fuels. Appropriate low temperature operability properties should be agreed on between the fuel supplier and purchaser for the intended use and expected ambient temperatures.

B When cloud point less than -12°C (10°F) is specified, the minimum viscosity shall be 1.7 cSt (or mm^2/s) and the 90% point shall be waived.

C In countries outside the U.S.A., other sulfur limits may apply.

D Where cetane number by Method D613 is not available, ASTM Method D 976, Calculated Cetane Index of Distillate Fuels may be used as an approximation. Where there is disagreement, method D613 shall be the referee method.

E Low-atmospheric temperatures as well as engine operation at high altitudes may require use of fuels with higher cetane ratings.

F 1 cSt = 1 mm^2/s.

Source: American Society for Testing and Materials (ASTM)

(3) Price of slack wax/light fuel oil

Slack wax is an intermediate product usually consumed in the refinery as fuel and not normally sold. A portion is further refined and sold as paraffin wax, or refined wax. This applies to National Refinery too. Table 5-3-14 shows the prices of slack wax, domestic purified wax and imported purified wax, assuming that the price of slack wax is equivalent to that of light diesel fuel oil on weight basis.

Table 5-3-14 Prices of Slack Wax, Domestic Purified Wax and Imported Purified Wax

Type of Wax	Price(Rs/Ton)
Slack Wax	2,690*
Domestic Purified Wax	4,000**
Imported Purified Wax	10,000***

Note : * This figure is derived from the assumption that the ex-plant price of slack wax is equivalent to that of light diesel fuel oil on a weight basis.
** Ex-plant price
*** Wholesale price

5-3-7 Summary of Subordinate Raw Materials

Table 5-3-15 shows the summary of prices and availabilities of coal and subordinate raw materials -- bagasse, wheat straw, cottonseed oil cake, cotton linter, limestone, slaked lime, cement, light diesel fuel oil and slack wax. Selection of proper subordinate raw materials requires consideration of test results and prices. Regarding biomass, bagasse alone was selected chiefly from economic viewpoint. The drawback to bagasse is seasonal fluctuation in availability, which however can be coped with by having sufficient inventory.

Table 5-3-15 Summary of Prices and Availabilities of Coal and Subordinate Raw Materials

Material	Ex-Plant Price	Wholesale Price	Retail Price	Yield	Available Season	Estimated Availability in Sind Province	Location of Source
Coal	300 Rs/Ton* (25-30 wt % Moisture)	Depending on Distance	Depending on Distance	-	All seasons	Appr. 4.9 Million Tons (Remaining Recoverable Reserves in Lease No. 88/192)	Lakhra Coal Mine
Bagasse	80-200 Rs/Ton (50 wt % Moisture)	-	-	0.30 Bagasse Ton/Sugarcane Ton (3.3 Bagasse Ton/Sugar Ton)	October - June (Growing Season :July-September)	570 Thousand Tons/Year (Case 1) 300 Thousand Tons/Year (Case 2)	Several Sugar Mills in Sind Province
Wheat Straw	300 Rs/Ton	800-900 Rs/Ton	600-1,100 Rs/Ton (in Markets)	2.0-2.5 Wheat Straw Ton/ Wheat Ton	All Seasons (Harvest Season: March-June)	440 Thousand Tons/Year	Hyderabad
Cottonseed Oil Cake	2.0-2.5 Rs/kg (7.0-7.5 wt % Moisture)	-	-	0.30 Oil Cake Ton/Cotton Bale (1.7 Oil Cake Ton/Cotton Ton)	February to July	36-40 Thousand Tons/ Year	Several Cottonseed Oil Mills in Sind Province
Cotton Linter							
-1st Cut	200 Rs/40kg	-	-	-			
-2nd Cut	150-180 Rs/40kg	-	-	-	Ditto	Less than Cotton seed Oil Cake	Hyderabad
-3rd Cut	120 Rs/40kg	-	-	-			
Limestone	65 Rs/Ton	-	70 Rs/Ton	-	All Seasons	Enough (Annual Production: Appr. 3.3 Million Tons/Year)	Zeal-Pak Cement Factory in Hyderabad
Slaked Lime	25 Rs/40kg	27 Rs/40kg	28 Rs/40kg	-	Ditto	Enough	Small Lime Kilns around Hyderabad
Cement	75.7 Rs/50kg (including 12.5% Sales Tax)	77-78 Rs/ 50kg	79-80 Rs/kg (including Octroi, District Council Tax and transportation Case)	-	Ditto	Enough (Annual Production: Appr. 3.0 Million Ton/Year)	Zeal-Pak Cement Factory in Hyderabad
Light Diesel Oil	2.26 Rs/Liter	2.34 Rs/Liter	2.8 Rs/50kg	-	Ditto	Enough (Annual Distribution: Appr. 96 thousand Ton/Year)	Pakistan State Oils Depot in Hyderabad
Slack Wax	4,000 Rs/Ton (Domestic Purified Wax) 2,690 Rs/Ton**	10,000 Rs/Ton (Imported Purified Wax)	-	-	Ditto	10 Thousand Tons/Year	National Refinery in Karachi

Note: * This is a special ex-mine price especially for this project, the general ex-mine average price is 332 Rs/Ton from July, 1988 to June, 1989.
** Slack wax is not sold by National Refinery Ltd., therefore, this figure is derived from the assumption that the ex-refinery price of slack wax is equivalent to that of light diesel fuel Oil on a weight basis.

CHAPTER 6 INFRASTRUCTURE, UTILITY AND TRANSPORTATION FOR RAW MATERIALS

6-1 Condition of Infrastructure

6-1-1 Transportation

The transportation system of Pakistan is considered to be the most advanced and efficient in that part of the world. The main transportation route runs from Karachi to Peshaware via Lahore and Islamabad. The routes to Quetta from the above route are also important. As shown on Table 6-1-1, road transportation dominates inland transportation of both passengers and cargo. This situation will remain unchanged in the foreseeable future judging from the continual expansion of the facilities for road transportation.

Table 6-1-1 Outline of Transportation (1984-85)

	Total Volume of Transport	Road %	Railway %	Aircraft %
Passenger (Million passenger-km)	109,200	81.9	16.6	1.5
Freight (Million ton-km)	32,900	73.3	26.7	0.1

Source: Ministry of Information and Broadcasting

(1) Road

The road network is most developed and dense in Punjab Province. The main roads run through the country from the north to Karachi and link Quetta with other cities. The total length of roads is 59,630 kilometers, 60 percent of which are paved. The trunk roads in the major cities are relatively well maintained. The roads in the rural area normally consist only of two lanes. The recent rapid increase of traffic has caused the maintenance cost to increase very rapidly putting a heavy burden on the government. As the conditions of the transportation affect social and economic development of the country, construction of new roads and improvement of the existing ones, particularly those in less-developed regions, is an important government prerogative. Thus, the length of the paved road has been rapidly extended as shown in Table 6-1-2. The Karakoram Highway has recently been contructed to link northern part of Pakistan with as far south as Karachi.

The number of motor vehicles has been increasing at a rate of 10 percent a year as shown in Table 6-1-3, signifying the importance the road transportation has in the nation's transportation system.

Table 6-1-2 Road Kilometers

Year	Paved	Unpaved	Total
1977	22,705	13,763	36,468
1978	23,561	13,718	37,279
1979	24,568	13,837	38,405
1980	24,750	15,393	40,143
1981	25,733	16,802	42,535
1982	28,098	16,571	44,669
1983	29,812	17,036	46,848
1984	32,636	16,821	49,457
1985	34,431	18,589	53,020
1986	36,467	23,163	59,630

Source: Statistical Yearbook 1988

Table 6-1-3 Number of Motor Vehicles

(As on 30th June of the year)

(Unit:number)

Year	Motor Car, jeep & wagon	Motor cab/ taxi	Buses	Trucks	Motor cycle 2wheel	Others	Total
1977	216,224	18,817	42,404	57,802	294,679	113,476	743,402
1978	252,063	21,267	44,501	61,903	358,265	138,105	876,104
1979	280,472	23,156	47,618	66,494	428,546	169,251	1,015,537
1980	262,636	18,951	50,001	58,654	508,335	211,179	1,109,756
1981	282,572	19,571	51,245	59,553	548,242	262,670	1,189,592
1982	304,449	20,715	51,710	63,021	636,196	262,866	1,338,957
1983	339,543	22,889	53,749	66,966	709,213	292,792	1,485,152
1984	382,729	23,176	58,596	70,338	790,004	334,829	1,659,672
1985	428,257	24,720	62,074	75,655	879,108	370,939	1,840,753
1986	474,744	25,419	73,518	81,019	946,861	417,574	2,019,135

Source: Pakistan Statistical Yearbook 1988

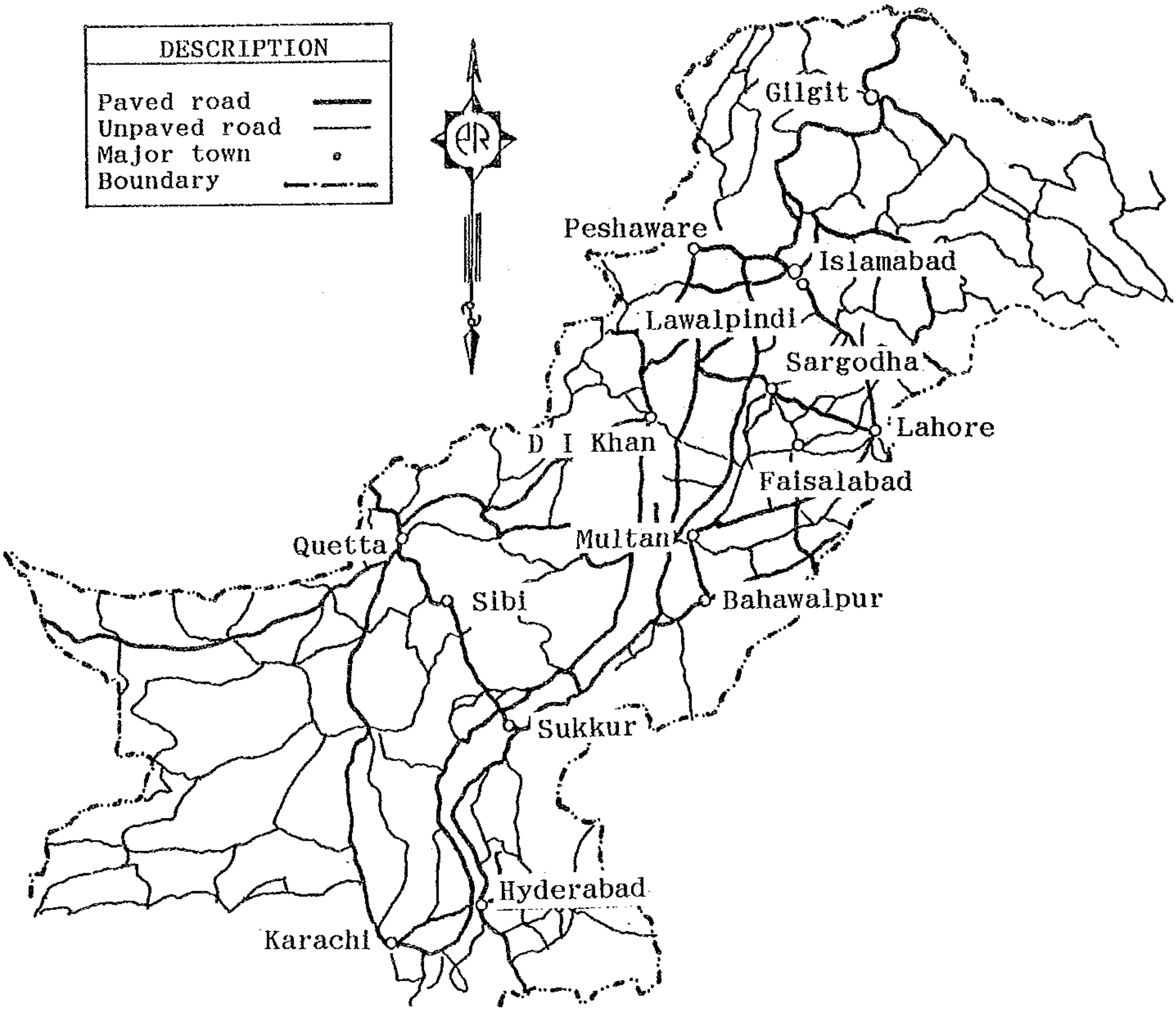


Figure 6-1-1 Road Net Work in Pakistan

(2) Railways

The railways of Pakistan are owned by the nation and under the jurisdiction of the Ministry of Railways, operated by seven operating divisions, and maintained by one separate workshops division. The total route length is 8,775 kilometers; the railways have 875 stations and 106 train halts. Its main route stretches from Khyber Pass near the border with Afghanistan at a north-western frontier to Karachi Port in the south passing through Punjab and Sind. A branch line runs through Quetta in Baluchistan and branches out into two lines, one terminating at Chaman on the Afghan border, and the other connecting with the Iranian Railway. Three gauges are in use; namely broad gauge, meter gauge and narrow gauge; the broad gauge constitutes nearly 80 percent. Diesel locomotives were introduced in 1952 to cope with the lack of fuel for steam locomotives. Since then, diesel locomotives have been steadily replacing the steam locomotives. In 1970, the electric locomotives were introduced with a view to saving foreign currency needed for importation of fuels for both types of locomotives. The track length of 1,037 kilometers was electrified by 1987. The railways had 201 steam locomotives, 547 diesel locomotives and 29 electric locomotives in 1987.

During the year 1986-87, the total earning amounted to Rs. 4,710 million. The freight earnings constituted 60 percent of the total earnings. Table 6-1-4 shows that the length of the railway has scarcely been extended, both the number of the cargo cars and ton-kilometer of the goods carried by the railways are decreasing, in marked contrast to the transportation by road and air which are both expanding very steadily.

Table 6-1-4 Facilities, Passenger Traffic, and Goods Traffic Carried by Pakistan Railways (1975-86)

Year	Facilities				Passenger carried		Goods carried	
	Route-km	Locomotive	Passenger coach	Goods wagon	Number (thousand)	Man-km (million)	Ton (thousand)	Ton-km (million)
1975-76	8,811	1,024	3,111	36,938	147,317	12,957	15,313	9,097
1976-77	8,815	978	2,902	36,720	142,561	13,199	14,368	7,857
1977-78	8,815	978	2,939	36,406	149,000	15,375	13,344	8,557
1978-79	8,815	978	2,926	36,276	145,998	16,713	11,958	9,375
1979-80	8,817	1,003	3,001	36,235	143,674	17,316	11,853	8,598
1980-81	8,817	960	3,032	36,248	123,002	16,387	11,371	7,918
1981-82	8,817	963	3,055	36,213	119,710	16,502	11,446	7,067
1982-83	8,775	979	3,050	35,990	122,710	18,031	11,836	7,323
1983-84	8,775	943	3,014	35,782	107,111	18,287	10,753	7,385
1984-85	8,775	916	3,078	35,341	94,701	17,806	10,520	7,203
1985-86	8,775	879	3,228	35,237	82,928	16,850	11,958	8,270
1986-87	8,775	837	3,178	34,868	78,141	16,920	11,958	7,820

Source Year Book of Information 1986-87
Pakistan Railways

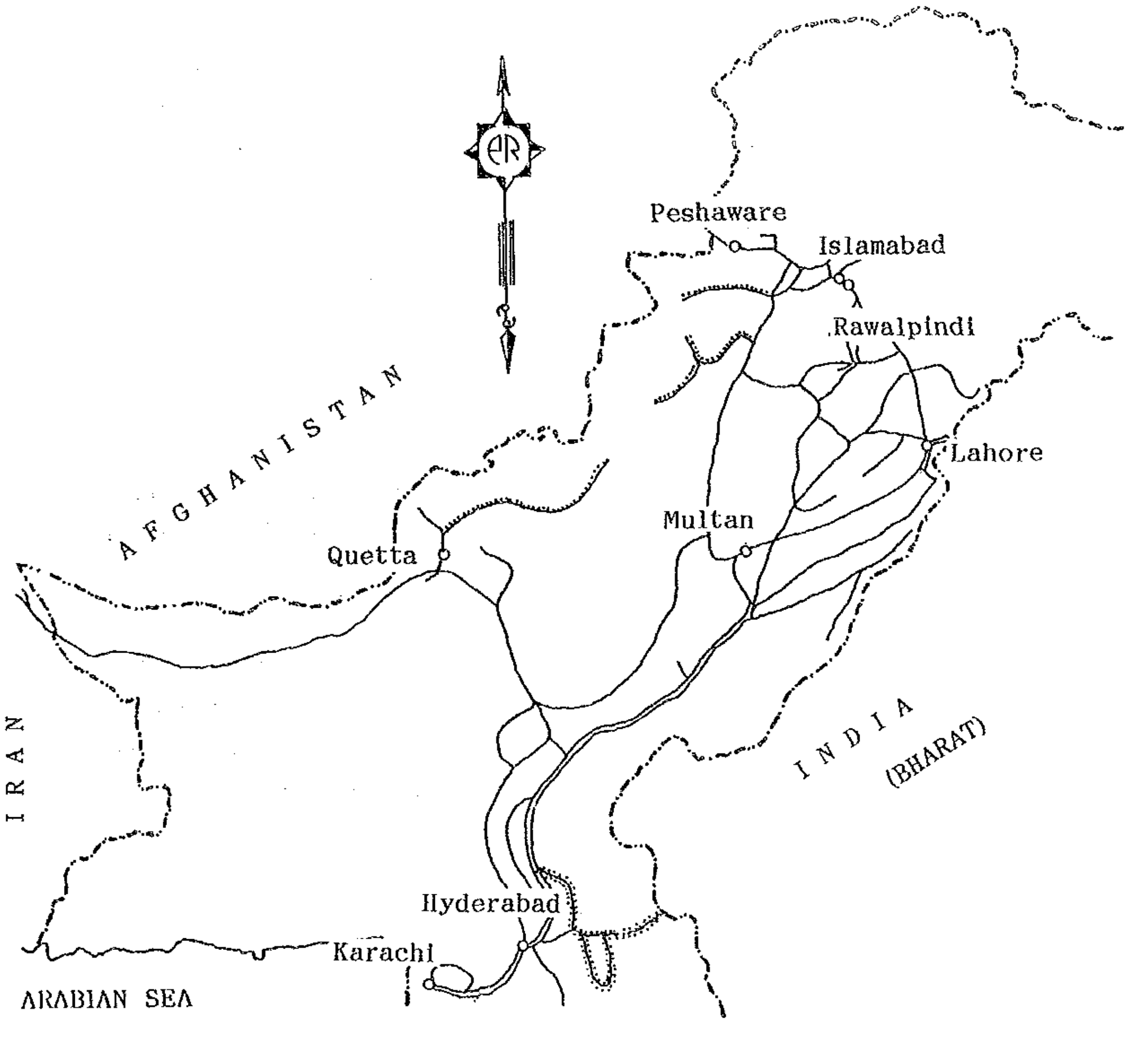


Figure 6-1-2 Net Work of Pakistan Railways

6-1-2 Communication System

(1) Telecommunication

Pakistan Telegraph and Telephone (T&T) Department of the Ministry of Communications operates and maintains inland and overseas telecommunication facilities. In 1986, the number of exchanges, the exchange capacity and telephone density were 1,000 units, 530,000 lines and 0.51 per 100 persons, respectively. The telephone density is near the average among the South Asian countries. The T&T Department manufactures telephone instruments and expands telephone facilities. However, the condition of telecommunication leaves much to be desired. The nation has 420 telegraph offices which handle three million telegraph messages per year; there are 7,180 telex exchange lines and 5,219 working connections in 1987. Overseas telecommunication is sent and received mostly via satellite.

(2) Broadcasting

The Pakistan Broadcasting Corporation (PBC), a public radio service organization, broadcasts in Urdu, English and 25 regional languages. It is estimated that there are seven million radio sets. The radio broadcast covers 95 percent of the population and 75 percent of the area of the country. The radio broadcast is now the biggest medium of mass communication in the country. Television broadcasting is done by the Pakistan Television Corporation (PTV). The broadcasting hours are about 3,000 hours per year. There are an estimated one million television sets in the country.

6-1-3 Electricity

Public electricity is generated and supplied by the Water and Power Development Authority (WAPDA), responsible for nation-wide generation, transmission and distribution and the Karachi Electricity Supply Corporation (KESC). The installed capacity and electricity generation by source are shown in Table 6-1-5 and 6-1-6, respectively. Since the power system of WAPDA depends largely on the hydroelectric generation, power shortage often occurs during the dry season. In addition, due to the rapid increase in electricity consumption and the number of consumers, there is urgent need to construct more power stations throughout the nation. The voltages of 500 kv, 220 kv, 132 kv and 66 kv are used for transmission and those of 33 kv, 11 kv and 0.4 kv for distribution.

During 1985-86, the electricity consumption per capita was 209 kilowatt hours. The shares of consumption by sector are, 39.2 percent for industry, 29.1 percent for domestic, 14.4 percent for agriculture, 7.6 percent for commercial use and 9.7 percent for others. The industrial consumption has occupied more than one third of total consumption but the domestic consumption is steadily increasing in recent years.

The urban areas are relatively well-electrified. As the bulk of the population lives in villages, however, the rural electrification has a high priority. As a result of efforts in this direction, as many as 56 percent of villages were electrified by 1986.

Table 6-1-5 Annual Growth of Electric Energy

Period	Installed Capacity (MW)	Maximum Demand (MW)	Electricity Generation (MM.Kwh)	Units Consumed (MM.Kwh)
1981-82	4,210.0	3,926.0	18,161.2	12,952.2
1982-83	4,965.0	4,524.5	20,291.0	14,432.2
1983-84	5,220.0	4,797.3	22,491.9	16,140.0
1984-85	5,779.0	4,942.2	23,671.4	18,158.2
1985-86	6,389.0	5,888.3	26,454.7	20,107.1

Source Census of Electricity Undertaking 1985-86
Federal Bureau of Statistics, Statistics Division

Table 6-1-6 Installed Capacity and Generation by Source
(1985-86)

Description		Total	Thermal	Hydel	Nuclear
Installed Capacity					
	(MW)	6,389.0	3,355.0	2,897.0	137.0
	(%)	100.0	52.5	45.3	2.2
Electricity Generation					
	(Mn.kWh)	26,454.7	12,220.8	13,804.0	429.9
	(%)	100.0	46.2	52.2	1.6

Source Census of Electricity Undertaking 1985-86
Federal Bureau of Statistics, Division

Table 6-1-7 Length of Transmission and Distribution Lines

(Unit:km)

Period	500 kv	220 kv	132 kv	66 kv	33 kv	11 kv	0.4 kv
1982-83	849	1,328	8,607	7,283	2,106	87,442	46,296
1983-84	1,287	1,341	9,140	7,261	-	93,942	56,612
1984-85	1,287	1,741	9,602	7,482	-	100,848	60,264
1985-86	1,614	1,712	10,790	7,862	2,106	107,146	96,018

Source Census of Electricity Undertaking 1985-86
Federal Bureau of Statistics, Statistics Division

6-2 Conditions of Infrastructure and Utility around Plant Site

6-2-1 Outline of Plant Site

Lakhra coal mine is located to the northwest of Hyderabad, the nearest large city. The coal mine extends about 50 kilometers in the north-south and about 25 kilometers in the east-west directions. This area is a flat desert about 550 feet high from sea level. PMDC has two licensed concessions in this area; one is about 60 square kilometers and situated in the northwest of this area and the other is 5 square kilometers nearly in the center.

The planned candidate site is in the latter, which is about 200 kilometers from Karachi and 80 kilometers from Hyderabad. This area is virtually untouched; a large piece of land is available for the initial plant and future expansions.

6-2-2 Power Supply

(1) Present condition

A public power line is laid on the location shown in Figure 6-2-1. The capacity of the line is 11 kv and the maximum load is 2,000 kW. Presently, the line is not active. However, the project will be able to receive power via this line; PMDC has already paid the energization fee to WAPDA. There are no other consumers of power along the line. The projects to construct power station around the site are listed in Table 6-2-1.

Table 6-2-1 Proposed Power Generation Project

On-going Schemes	Capacity	Location
Oil-fired Power Station	250 MW	Jamshoro
Oil-fired Power Station	2 x 220 MW	Jamshoro
New/Planned Schemes		
Coal-fired (FBC)	3 x 50 Mw	Lakhra
Coal-fired,I	250 MW	Lakhra
Coal-fired,II	250 MW	Lakhra

(2) Supply of power to the plant

To provide power to the plant it is necessary to construct an extention line about 450 meters long from the existing line to the project site. At an annual production of 100,000 tons coal briquettes, the requirement of electric power becomes 2,400 kw exceeding the capacity of the existing line; it is then necessary either to construct an additional line or to install a self-generation system. Table 6-2-2 compares the costs of the two options. The construction of a new line is more advantageous and is adopted for this study. The length of the new line is approximately 50 kilometers from the nearest sub-station at Jamshoro.

Table 6-2-2 Additional Cost for Electricity

(1) Construction of New Electric Transmission

(Unit:Rupee)

Transformer		207,000
Distribution switch		59,000
Overhead high tension line (50 km)	Rs 95,000/km	4,750,000
Total		5,016,000

(2) Self-generation System

Electric generator (diesel) 1,200kW	8,290,000
Generator house	240,000
Total	8,530,000

(3) Electricity cost

Estimated electric consumption and charges are shown in Table 6-2-3.

Table 6-2-3 Estimated Consumption of Electricity and Electricity Charges

Production of Coal Briquettes (Ton/Year)	Installed Capacity (kW)	Consumption (1,000kWh)	Electricity Charge (Rs.1,000/year) Fixed	Consumption	Total
50,000	1,200	6,048	1,296	2,722	4,018
75,000	1,800	9,072	1,944	4,082	6,026
100,000	2,400	12,096	2,592	5,443	8,035
150,000	3,600	18,144	3,888	8,165	12,053
175,000	4,200	21,168	4,536	9,526	14,062
200,000	4,800	24,192	5,184	10,886	16,070
300,000	7,200	36,288	8,294	14,878	23,172

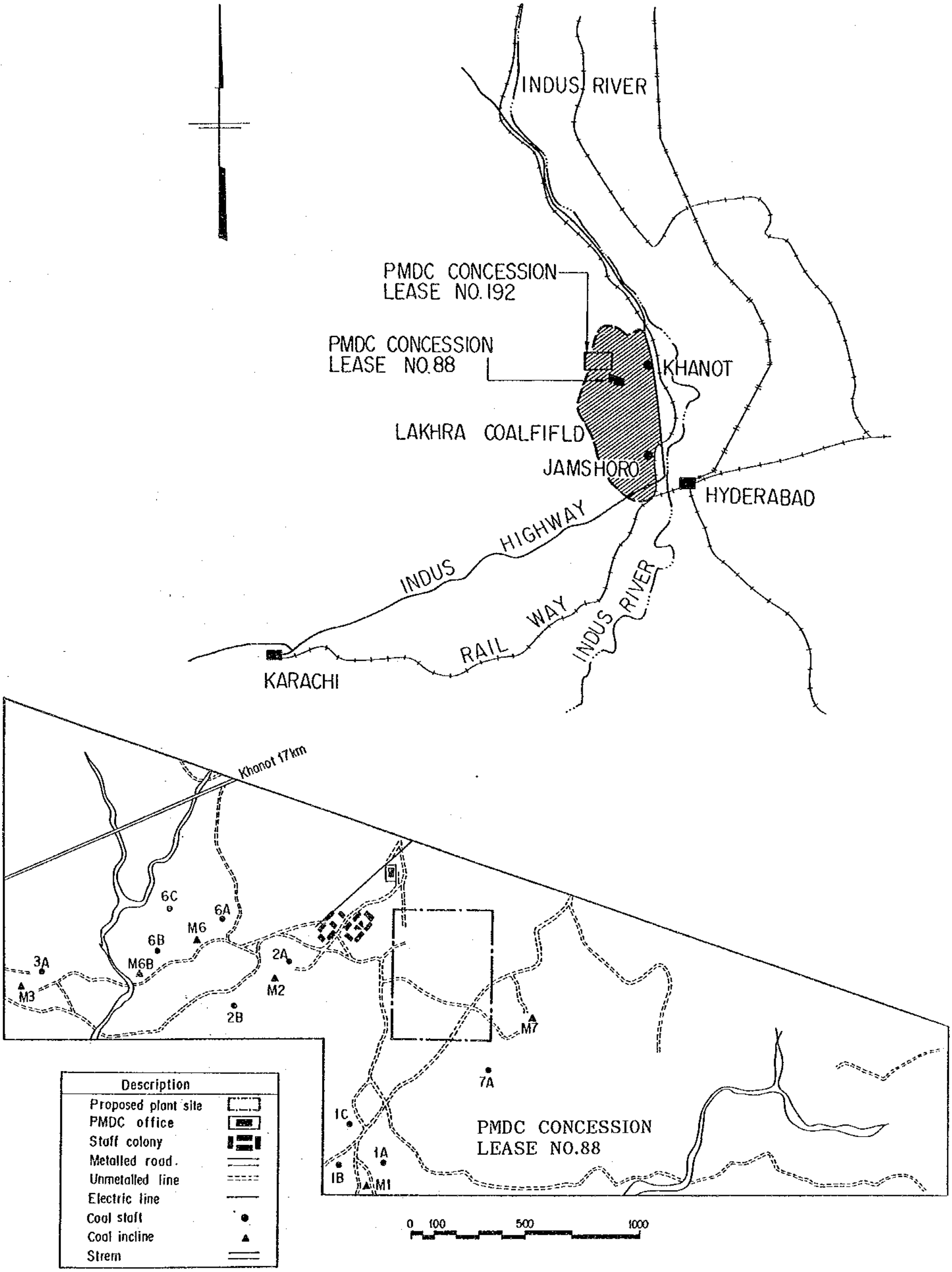


Figure 6-2-1 Map of Plant Site and Surrounding Areas

6-2-3 Water supply and Sewage

(1) Present condition

There is no public or private facility for water supply and sewage in Lakhra. As this area is 130 meters higher than the Indus River where they obtain water, water must be pumped up if supply by water main is considered. Moreover, judging from the present conditions of the coal shafts and the results of the boring tests, there is little possibility of finding fresh underground water. What little water found underground is brackish; therefore, it would be futite to drill wells to obtain water.

PMDC is supplying the mine office with water for drinking and sanitary purposes from the Indus River, 20 kilometers from the site, by a tank truck with 2,000-gallon, or 9,000-liter, capacity, because PMDC does not wash coal and requires very little water. PMDC plans to lay a water pipe from the river up to the coal mines, if and when PMDC' proposal for coal supply to the power plant is accepted by WAPDA.

Drainage system is regulated by the National Building Code. There is no sewage system in Lakhra area, but disposal by simple septic tank is good enough for this project, because the plant does not discharge polluted water.

(2) Transportation of water

Since processing scheme of this project does not need industrial water except for feed pretreatment, namely washing, which requires a very small amount of fresh supply, supply of industrial grade water by tank truck will suffice. Water for drinking and sanitary purposes will also be delivered by tank truck to be consumed in office and dormitories for drinking, shower and sanitation. Assuming that one person consumes 100 liters a day for drinking and sanitary purpose, the required water supply is calculated as indicated in Table 6-2-4. The storage of water for fire-fighting and that for drinking share the same tank.

Table 6-2-4 Estimated Volume of Water Consumption

Production Capacity of Coal Briquette (ton/year)	Living Water (ton/day)	Coal Washing (ton/day)	Total (ton/day)
50,000	6	42	48
75,000	8	63	71
100,000	20	83	103
150,000	27	125	152
200,000	34	167	201
250,000	44	210	254
300,000	51	250	301

(3) Transportation cost

Two types of operation are conceivable for transporting water: transportation by PMDC' own tank truck (case 1) or contract operation by a transport agency (case 2). The conditions of transportation are defined as follows;

(a)Tank truck	
Load capacity, ton	9
Purchase price, Rs./unit	560,000
Service life, year	5
Depreciation, Rs./year	112,000
Driver, Rs./year	14,400
(b)Miscellaneous, Rs./unit/year	96,880
Maintenance cost, Rs./unit/year	56,000
Interest (14.6 % a year), Rs./unit/year	40,880
(c)Fuel (diesel)	
Unit price, Rs./liter	2.34
Distance traveled per liter, km	5
(d)Transportation	
Distance, km	40
Transportation time, hour/trip	2
Number of trips, times/day	4
Working days, day/year	300

In the Case 1, annual transportation cost is calculated as follows:

		Rs/Year
Depreciation		112,000
Driver		14,400
Miscellaneous		96,880
Fuel	Rs.2.34 x 40/5 liter/trip x 4 x 300 =	22,464
	Total	245,744

One tank truck can carry 10,800 tons of water per year as calculated below:

9 ton/trip x 4 trip/day x 300 days = 10,800 ton/year

Transportation cost is calculated to be 22.8 rupees per ton, if the water is transported by PMDC' own trucks. Besides, it is confirmed that the transportation agency will transport water at the rate between 38.9 and 44.4 rupees per ton. Hence, Case 1 is more advantageous.

6-2-4 Road Condition

(1) Conditions of existing roads

The Indus Highway and the Pakistan Railways run in parallel about 20 kilometers to the west of the planned site. They link the site with other places across the country.

The Indus Highway has one lane, or two partial lanes in each direction; however, the traffic load is not very heavy. Although, drainage and guard rails are not provided, the portion of the highway between Karachi and Khanot is maintained rather well. The highway would not be flooded even during the rainy seasons, because the highway is elevated.

The road between Khanot and the plant site, 17 kilometers long, has two lanes and is paved well. The traffic load is small, used mainly for transporting Lakhra coal. In the dry season the conditions are favorable and transportation is not disrupted. Even during the rainy season the traffic is not suspended except during the extraordinarily heavy rains.

Roads are not paved in the area of Lakhra Mine. There are few dry rivers without bridges. During the rainy season, trucks can make detours around the rivers without serious trouble. Generally the roads are maintained by the mining companies and are in fair condition. There is no need to pave the roads on the account of this project.

(2) Necessity of improvement of roads

The necessary transportation of this project is to deliver materials, machines and equipment to the plant site, and routinely ship coal briquettes, and to collect raw materials. For the former purpose, the site is accessible via the existing paved roads from Karachi and other cities without difficulty.

The conditions of the roads are examined from the viewpoint of collecting raw material. The Indus Highway and the paved road up to the project site will be used for transporting all the raw materials to the plant except Lakhra coal. The project will increase the load by a maximum of 175 trucks per day when the project reaches maturity at 300,000-tons-per-year capacity. The present traffic load and the road conditions are not known. However, a rural road can normally sustain up to a load of 4,000 vehicles on one lane per day. The above increase represents about 4.4 percent of this maximum sustainable load; therefore, improvement of the existing paved roads is considered unnecessary.

The transportation of the raw material coal will increase the traffic load in the premise of Lakhra Mine by a maximum of 160 vehicles per day. Similarly, this will have a negligible effect on the present traffic; the improvement of the existing road or construction of a new road is not required. The roads from the proposed site to the main road and on the project site will be given a simple pavement.

Table 6-2-5 Transportation Volume and Vehicles

Description	Required Volume		Required number of vehicle	
	Initial Ton/day	Mature Ton/day	Initial Number/day	Mature Number/day
Coal briquettes	167	1,000	17	100
Bagasse	106	650	11	65
Slaked lime	10	61	1	6
Slack wax	1	6	-	-
Light oil	10	44	1	4
		Sub-total	30	175
Lakhra Coal	205	1,227	21	160

Note:
Initial: Production of coal briquettes is 50,000 tons/year.
Mature: Production of coal briquettes is 300,000 tons/year.

6-2-5 Communication

Telephone lines are not available in Lakhra area; therefore, the PMDC office in Lakhra does not have a telephone. They communicate with Islamabad and Karachi offices through their Hyderabad Office. It is anticipated that a new telephone cable will be installed with the development of Lakhra Coal Mine or the establishment of a thermal power station in Lakhra. Yet, without any guarantee for such development, at least at the initial stage, this project will provde a wireless telephone system, VHF system, to communicate with Hyderabad Office. The installation of a wireless is subject to the approval of the government; it is confirmed that PMDC will be able to get such an approval without difficulty. The installation cost is shown in Table 6-2-6.

Table 6-2-6 Installation Cost for Wireless Telephone

Installation cost	Rs.300,000
Fixed charge	Rs.30/month
Local call charge	Rs.0.7/call (only in Hyderabad)

6-2-6 Accommodation

There are barracks for mining workers at Lakhra coal field. Other than these, there are very few houses around the project site and Khanot area. There are no facilities in this area to adequately support daily needs. The nearest decent residential facilities are found only in Hyderabad and Hala. Therefore it is necessary to provide accommodations for the staff and workers for this project. Following facilities are planned for 50,000-tons-per-year and 100,000-tons-per-year cases.

(1) Production of Coal Briquettes; 50,000 ton/year

Dormitory A for Plant manager, Plant engi. and Assist. chemist
Number of bedrooms 3
Dormitory B for PMDC staff
Number of rooms 2
Foreman, 3 Store-keepers and 5 Chief operators, 14 Shift operators, 5 Day operators, Janitor, Driver and 4 Security men
Barrack for contract workers
Bath room

(2) Production of Coal Briquettes; 100,000 ton/year

Dormitory A for Plant manager, Plant engi. and Assist. chemist
Number of bedrooms 3
Dormitory B for PMDC staff
Number of rooms 2
Foreman, 3 Store-keepers and 9 Chief operators, 27 Shift operators, 10 Day operators, Janitor, Driver, and 4 Security men
Barrack for contract workers
Bath room

6-3 Transportation of Raw Materials

The following five materials have been selected as raw materials for coal briquettes.

(1) Coal
(2) Bagasse
(3) Slaked lime
(4) Slack wax
(5) Light fuel oil

The field survey and subsequent study have confirmed that all raw materials for coal briquettes are transported by road. The transportation system is divided into the following two groups;

(1) Transport from the places of procurement to the stockyard in the plant site
(2) Transportation from the stockyard to the feeder of briquetting plant, hereinafter referred to as "site transportation"

6-3-1 Coal

Coal will be supplied from Lakhra Mine of PMDC. There are 10 operating shafts and 6 inclines around the site. The average production of a shaft is about 190 tons per day. The plant requires 271 tons per day of coal for the initial production of 50,000 tons per year as shown in Table 6-3-1. It is difficult to obtain the necessary volume of coal from just one shaft under the present mining system. Therefore, the truck will have to make routine trips to a number of shafts as described below.

```
| Mining area                    |            | Plant Site                    |
|                                | Transport  |                               |
| Stockyard   (Loading)          | (2.2km)    | (Unloading) Stockyard         |
|    |                           |------------|                  |            |
| Stockyard   (Loading)          | (by Truck) | (Site Transport) |            |
|    |                           |            |                  |            |
| Stockyard   (Loading)          |            |               Feeder          |
```

No particular shaft is designated solely to this project now, because future programs have not been established for each shaft. The distance from the plant to the stock yards at these shafts varies from 0.6 kilometers to 2.2 kilometers; their total distance is 17.8 kilometers. The average distance from the plant to the 16 shafts is 1.1 kilometers. The average mileage of one trip is twice 1.1 kilometers plus the estimated average distance between shafts, 0.8 km; hence, the estimated average distance of one trip is 3 kilometers. There is no facility for truck loading at any of these stock yards. It is not economical to install a loading machine at each stock yard; manual labor will be used to load the coal to 10-ton trucks for transportation of coal to the plant, in line with the current practice. The conditions for the transportation of coal are defined as follows:

Load capacity of truck, ton	A:	10
Average speed, km/h	Vd:	30
Mileage, km	D:	3
Traveling Time,min.		6
Number of workers for loading,number	Ml:	10
Pace of loading,ton/man/hour	Vl:	1.5
Time for loading,min.		40
Number of workers for unloading,number	Mu:	5
Pace of unloading,ton/man/hour	Vu:	5.0
Time for unloading,min.		40

The transportation time required, Cm, for one trip is calculated as:

$$Cm = \frac{D}{Vd} + \frac{A}{Ml \times Vl} + \frac{A}{Mu \times Vu} \text{ (hour)}$$

As one trip takes one hour and half, one truck can make six trips in 9 hours a day. The transportation requirement for coal is summarized in Table 6-3-1.

Table 6-3-1 Required Transportation of Coal

	Annual Production of Coal Briquettes (thousand ton/year)						
	50	75	100	150	200	250	300
Required volume of coal (ton/day)	271	406	541	812	1,082	1,353	1,623
Times of Transport(time/day)	27	41	54	81	108	135	160
Number of Truck (number/day)	5	7	9	14	18	23	27

Note Operation days of the plant 300 days

Blending ratio ton/ton product (wet base) 1.250

Fuel comsumption, ton/ton product (wet base) 0.373

6-3-2 Bagasse

The sugarmills where bagasse will be obtained are located around Hyderabad, about 80 kilometers from the project site. The road transportation by truck is suited to this task. Conditions of transportation are defined as follows:

Load capacity of truck, ton	A:	10 (10 m3)
Average speed, km/h	Vd:	50
Mileage, km	D:	160
Traveling time,min.		200
Number of workers for loading,number	Ml:	10
Pace of loading,ton/man/hour	Vl:	1.5
Time for loading,min.		40
Number of workers for unloading,number	Mu:	5
Pace of unloading,ton/man/hour	Vu:	3.0
Time for unloading,min.		40

As one trip takes 4.5 hours; one truck can make two trips a day. Transportation of this material is summarized below.

Table 6-3-2 Required Transportation of Bagasse

	Annual Production of Coal Briquettes (thousand ton/year)						
	50	75	100	150	200	250	300
Required Volume of Bagasse (ton/day)	108	163	217	325	379	542	650
Times of Transport(time/day)	11	16	22	33	43	54	65
Number of Truck (number/day)	6	8	11	17	22	27	33

Note Operation days of the plant 300 days

Period of collection 150 days

Blending ratio,ton/ton product (wet base) 0.325

6-3-3 Slaked Lime

Slaked lime will be obtained from a number of lime kilns operating around the project area including Hyderabad. As slaked lime is sold as a commercial commodity, loading facilities and workers are considered available at kilns. Slaked lime should be transported by truck or pickup on road. Conditions are defined as follows:

Load capacity of truck, ton	A:	10
Average speed, km/h	Vd:	50
Mileage, km	D:	160
Traveling time,min.		200
Time for loading,min.		30
Number of workers for unloading,number	Mu:	5
Pace of unloading,ton/man/hour	Vu:	5.0
Time for unloading,min.		15

Similarly, one trip takes 4 hours and a truck can make two trips a day. Transportation of this material is summarized in Table 6-3-3.

Table 6-3-3 Transportation of Slaked Lime

	Annual Production of Coal Briquettes (thousand ton/year)						
	50	75	100	150	200	250	300
Required Volume of Slaked lime (ton/day)	10	16	21	31	42	53	63
Times of Transport(time/day)	1	2	2	3	4	5	6
Number of Truck (number/day)	1	1	1	2	2	3	3

Note Operation days of the plant 300 days

Blending ratio,ton/ton product 0.063

6-3-4 Slack Wax

Slack wax can be obtained from National Refinery Ltd. in Karachi. Both railways and road can theoretically be utilized for transporting this stock. However, the railways are not economical in view of the short distance and necessity of transshipment to truck at Khanot Station. Therefore, slack wax will be transported by tank truck. Conditions are specified as follows:

Load capacity of truck,ton	4
Average speed,km/h	50
Mileage,km	400
Traveling time,min.	480

A tank truck can make one trip from Karachi a day. Transportation is summarized below.

Table 6-3-4 Transportation of Slack Wax

	Annual Production of Coal Briquettes (thousand ton/year)						
	50	75	100	150	200	250	300
Required Volume of Slack wax (ton/day)	1.0	1.5	2.0	3.0	4.0	5.0	6.0
Times of Transport(time/day)	0.1	0.2	0.2	0.3	0.4	0.5	0.6

Note Operation days of the plant 300 days

Blending ratio,ton/ton product Slack wax 0.006

6-3-5 Light Fuel Oil

Light fuel oil is considered available at the distributors of Pakistan State Oil Co. Ltd., (PSO) around the site and transported by them as required. Therefore it is not necessary to provide vehicles for transporting light fuel oil. Required volume and time of transportation are shown in table 6-3-5.

Table 6-3-5 Transportation of Light Fuel Oil

	Annual Production of Coal Briquettes (thousand ton/year)						
	50	75	100	150	200	250	300
Required Volume of Light fuel oil (ton/day)	7	11	15	22	29	37	44
Times of Transport(time/day)	1	1	2	2	3	4	5

Note Operation days of the plant 300 days
Blending ratio,ton/ton product Light Fuel Oil 0.044

6-3-6 Site Transportation

The following transportation systems are conceivable for transportation of raw materials from the stock yard to the feeder of the plant. As the inventory of raw material is equivalent to 5-days consumption for coal and 150-days consumption for bagasse at the end of harvest season, the stockyard requires an increasingly bigger piece of land with the expansion of the capacity. For this kind of transportation, it is rather common in this area to use manpower or donkey or camel hauled wagons.

Slaked lime will be stocked in a silo and delivered to the feeder by a screw conveyer. Slack wax and light fuel oil will be mixed in a tank equipped with a heating coil installed near the stock yard. Then the mixture will be delivered to the plant by pipe. Slaked lime, wax and light fuel oil do not require site transportation; therefore, discussion here is limited to coal and bagasse.

```
┌──────────┐   ┌───────────────────────────┐   ┌──────────┐
| Stockyard |   | Cart etc.   (Unloading)  |   |          |
|           |───|                          |───|  Feeder  |
| (Loading) |   | Belt conveyer            |   |          |
└──────────┘   └───────────────────────────┘   └──────────┘
```

Table 6-3-6 Conditions of Transportation at Plant

Description	Unit	(1)Coal	(2)Bagasse
Loading	ton/hour/man	1.5	3.0
Carriage	ton/hour/man	3.0	1.0
Distance	km	1.0	1.5
Speed	km/hour	4.0	4.0
Times of trip	times/hour	3.0	2.0
Weight carried	ton/trip	1.0	0.5
Operation			
Working hour	hour	24	24
Shift	shift	3	3

(1) Coal

Table 6-3-7 Site Transportation of Coal

	Annual Production of Coal Briquettes (thousand ton/year)						
	50	75	100	150	200	250	300
Required volume of coal (ton/day)	271	406	541	812	1,082	1,353	1,623
Workers for Loading(man/day)	24	30	45	69	81	114	135
Carrier (man/day)	12	18	24	36	45	57	69

(2) Bagasse

Table 6-3-8 Site Transportation of Bagasse

	Annual Production of Coal Briquettes (thousand ton/year)						
	50	75	100	150	200	250	300
Required volume of Bagasse (ton/day)	108	163	217	325	433	542	650
Workers for Loading(man/day)	6	9	9	15	18	24	27
Carrier (man/day)	15	21	27	42	54	69	81

6-4 Transportation Cost

Table 6-4-1 shows modes of transportation for each raw material.

Table 6-4-1 Cost Composition of Raw Materials Transportation

	Loading	Unloading	Transport	Site Transport
Coal	*	*	*	*
Bagasse	*	*	*	*
Slaked lime			*	
Slacks wax			*	
Light fuel oil			*	

6-4-1 Conditions of Transportation Cost

Three types of operation system are conceivable for transporting raw materials; namely (Case 1) PMDC owns a fleet of trucks and consigns the transportation to a contractor, (Case 2) PMDC does not own trucks and consign the entire work to a contractor, and (Case 3) direct operation by PMDC. However Case 3 is not applicable to this project, because it is not economical for PMDC to employ a large labor force. Case 1 and Case 2 alone are considered.

The cost elements are shown below at 1988 price.

(1) Case 1

(a)Labor cost	
Unskilled worker,Rs./month	1,000
Driver,Rs./month	1,200
(b)10 ton truck,Rs./unit	525,000
service life,year	5
(c)Fuel (diesel),Rs./liter	2.34
distance traveled per liter,km	5
(d)Miscellaneous Rs./year/unit	90,825
maintenance cost,Rs./year/unit	52,500
interest (14.6 percent a year),Rs./year/unit	38,325

(2)Case 2

(a)Labor cost,Rs/ton		40
(b)Loading cost,Rs/ton		10
(c)Unloading cost,Rs/ton		10
(d)Carriage cost by truck or oil tanker		
Coal,Rs/ton	shaft to plant site	10
Bagasse,Rs/ton	Badin to plant site	120
Slack wax,Rs/ton	Karachi to plant site	183
Light fuel oil,Rs./ton	Hyderabad to plant site	82
Other materials,Rs/ton	Hyderabad to plant site	50
(e)Short distance transportation within plant site		
Bagasse,Rs./ton		10
Other materials,Rs./ton		5

6-4-2 Coal

Ten unskilled workers are employed for loading coal to 10-ton trucks and five workers for unloading. The transportation cost of coal from coal shafts to the site consists of:

Case 1		(Rs.)
Loading cost	Rs.1,000 x 10 person x 12 month	= 120,000
Unloading cost	Rs.1,000 x 5 person x 12 month	= 60,000
Depreciation		105,000
Driver	Rs.1,200 x 12 month	= 14,400
Miscellaneous		= 90,825
Fuel	Rs.2.34 x 3/5 liter/trip x 1,800 trip	= 2,527
	Total	392,752

A 10-ton truck can transport 18,000 tons of coal per year as calculated below:

10 tons/trip x 6 trips/day x 300 days = 18,000 tons/year

The transportation cost for Case 1 is 21.8 rupees per ton, while that for Case 2 is 30 rupees per ton; therefore, Case 1 is selected. The breakdown of Case 2 is below:

Cace 2

Loading cost,Rs/ton	10
Unloading cost,Rs/ton	10
Carriage cost,Rs/ton	10
Total	30

6-4-3 Bagasse

Five unskilled workers are employed for loading bagasse to 10-ton trucks and five workers for unloading.

Case 1		(Rs.)
Loading cost	Rs.1,000 x 10 person x 5 month	= 50,000
Unloading cost	Rs.1,000 x 5 person x 5 month	= 25,000
Depreciation		105,000
Driver	Rs.1,200 x 5 month	= 6,000
Miscellaneous		90,825
Fuel	Rs.2.34 x 32 l/trip x 300 trip	= 22,464
Total		299,289

A 10-ton truck can transport 3,000 tons of coal per year as calculated below:

10 tons/trip x 2 trips/day x 150 days = 3,000 tons/year

The cost for Case 1 is 99.8 rupee per ton, while that for Case 2 is 140 rupees per ton. The breakdown of the cost of Case 2 is as follows:

Case 2

Loading cost,Rs/ton	10
Unloading cost,Rs/ton	10
Carriage cost,Rs/ton	120
Total cost	140 rupees/ton

Case 1 is recommended for transporting bagasse.

6-4-4 Slaked Lime

Workers are not required for loading and unloading as mentioned in 6-4-3. The transportation cost from kilns in the Hyderabad area to the site over 80 kilometers consists of:

Case 1			(Rs.)
Depreciation			105,000
Driver	Rs.1,200 x 12 month	=	14,400
Miscellaneous			90,825
Fuel	Rs.2.34 x 32 l/trip x 600 trip	=	44,292
	Total		255,153

Weight carried

10 tons/trip x 2 trips/day x 300 days = 6,000 tons/year

The cost of Case 1 is 42.5 rupee per ton and that for Case 2 is 70 rupee per ton. Case 1 is adopted.

6-4-5 Slack Wax

Transportation of slack wax does not require loading, unloading and site transportation. As the volume of slack wax is small,it is not economical to have PMDC' own fleet. Therefore, transportation will be on a contract basis at a cost of 183 rupee per ton.

6-4-6 Light Fuel Oil

Light fuel oil will be transported by distributors in the Hyderabad area. The transportation cost is 82 rupee per ton.

6-4-7 Cost of Site Transportation

Tables 6-4-2 and 6-4-3 show the required number of workers for transporting coal and bagasse within the plant site. An average requirement of manpower for transporting 1 ton of coal is 0.125

persons and that for 1 ton of bagasse is 0.175 persons. As a large number of unskilled workers for this simple works are required, contract operation by sub-contractor is recommended. The transportation costs are compared as follows:

	Case (1)	Case (2)
Coal	Rs.5.00/ton	Rs. 5.00/ton
Bagasse	Rs.7.00/ton	Rs.10.00/ton

Note : Labor cost is 40 rupees per person

Table 6-4-2 Site Transportation of Coal

	Annual Production of Coal Briquettes (thousand ton/year)						
	50	75	100	150	200	250	300
Required volume (ton/day)	271	406	541	812	1,082	1,353	1,623
Required workers							
(man/day)	36	48	69	105	126	171	204
(man/ton)	0.133	0.118	0.128	0.129	0.116	0.126	0.126

Table 6-4-3 Site Transportation Cost for Bagasse

	Annual Production of Coal Briquettes (thousand ton/year)						
	50	75	100	150	200	250	300
Required volume (ton/day)	108	163	217	325	433	542	638
Required workers							
(man/day)	21	30	36	57	72	93	108
(man/ton)	0.194	0.184	0.166	0.175	0.166	0.172	0.169

6-4-8 Recommended Transportation System

The following transportation system for raw materials is recommended.

Table 6-4-4 Recommended Transportation System

	Transportation(1)		Transportation(2)	
	Case 1	Case 2	Case 1	Case 2
Coal	*			*
Bagasse	*			*
Slaked lime	*		nil	nil
Slack wax		*	nil	nil
Light fuel oil		*	nil	nil

Note Transportation(1):Transportation from production place to the site

Transportation(2):Site transportation

The transportation costs for the raw materials are summarized as shown in Table 6-4-5.

Table 6-4-5 Summary of Transportation Cost

(Unit:rupee/ton)

	Transportation(1)	Transportation(2)	Total
Coal	21.8	5.0	26.8
Bagasse	99.8	10.0	109.8
Slaked lime	42.5	nil	42.5
Slack wax	183.0	nil	183.0
Light fuel oil	82.0	nil	82.0

Note:

Cost(1) Transportation from production place to the site

Cost(2) Site transportation

CHAPTER 7 PLANT SITE

7-1 Outline of Recommended Plant Site

The recommended candidate site is located in Lakhra Coal Mines, 80 kilometers to the northwest of Hyderabad, Sind Province. This area extends 50 kilometers in the north to south and 25 kilometers in the east to west directions. There are two licensed concessions of PMDC in the field; one is Lease No. 192 in northwest of the area and the other is Lease No. 88 nearly in the center. PMDC mines about 100 thousand tons of coal per year in this area, which represents 37 percent of total production of PMDC during 1987-88. The proposed plant site for the coal briquettes project is selected in Lease No.88 as shown in Figure 7-1-1 in order to increase the production from this Lease. This chapter evaluates this candidate site.

7-2 Selection of Plant Site

The plant site is selected based on evaluation in the light of such criteria as availability of raw materials and labor force, distance to the marketing area of the products, conditions of infrastructure, natural and social environments.This project, the following items need to be studied:

(1) Availability of land to accommodate the planned capacity
(2) Availability of raw materials within economical distance of transportation
(3) Availability of sufficient labor force of good quality
(4) Conditions of the transportation systems available to mobilize for the tranportation of the raw materials and products
(5) Availability of utilities such as electricity, water supply and communication systems
(6) Natural conditions such as rain fall, temperature, topography and possibility of disasters like flood
(7) Geological conditions and easiness of land preparation
(8) Environmental conditions

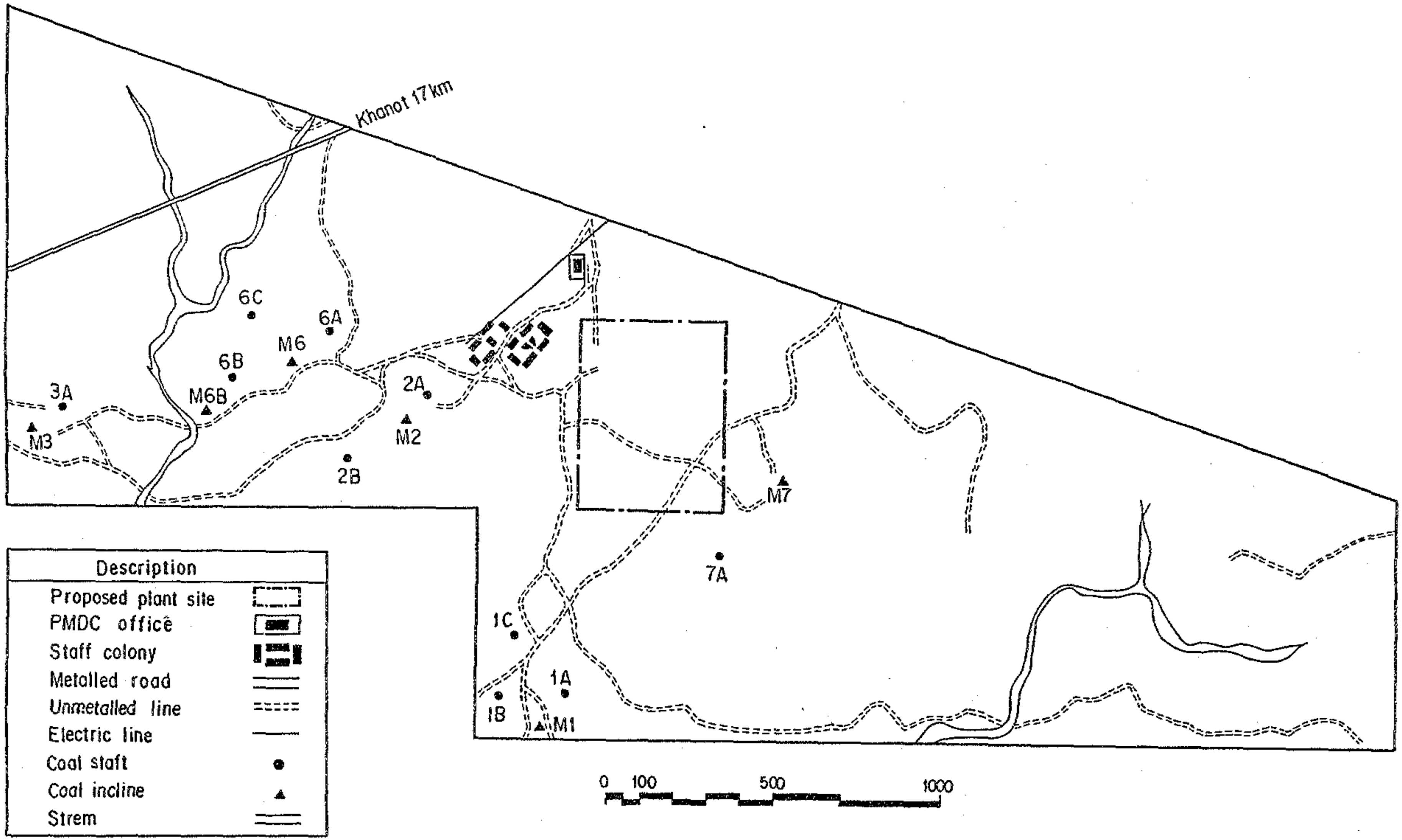


Figure 7-1-1 Location Map of Proposed Plant Site

7-3 Evaluation of Proposed Site

The field survey and subsequent study has confirmed that the the proposed plant site is selected as shown in Figure 7-1-1 for the reason explained below.

7-3-1 Plant Capacity and Plant Area

The necessary plant area is determined by the scale of the plant; production capacity, manufacturing facilities and the area required for stockpiling the raw materials and product. This study examines three cases of capacity; two start with 50,000 tons of production capacity and the other with 100,000 tons per year capacity. All cases plan to expand the capacity stepwide finally to 300,000 tons per year capacity. Based on the expansion plan, of the manufacturing facilities, plant shelters and other associated facilities will be expanded accordingly. The required site area is estimated at 20,000 square meters for the initial stage and 200,000 square meters for the final.

Since the proposed site area is untapped barren plains, sufficient land for the plant can be easily obtained.

7-3-2 Availability of raw materials

The proposed plant site is adjacent to the mining area of PMDC from where coal, main raw material, will be supplied. Since amount of coal reserves in this area is estimated at about 500 million tons, sufficient volume of coal can be supplied within short distance range.

Bagasse will be procured from sugar mills scattered is Sind. The annual production is estimated at 500,000 tons and the project will require 97,500 tons per year at the most. Necessary volume of slaked lime can be procured from a number of lime kilns operating around the project site and Hyderabad.

Slack wax is available at National Refinery Ltd., in Karachi, 200 kilometers from the plant site. The required volume is very small; 1,800 tons per year for the final plant capacity.

Light fuel oil will be supplied by distributors of Pakistan State Oil Co., Ltd. around the site and Hyderabad.

The major raw materials such as coal and bagasse can be supplied within economical distance of transportation and the other materials, slaked lime, slack wax and light fuel oil are also available in this area.

7-3-3 Labor Availability, Quantity and Quality

There are almost no living facilities around the proposed site; therefore, labor is not available nearby. However, since the required numbers of the contract workers are about two hundreds and they will be engaged in simple jobs, necessary number of workers can be procured from surrounding towns, Hyderabad and Karachi by local contractors.

7-3-4 Conditions of Transportation

The product and raw materials, except the raw coal, will be transported by trucks on the existing paved road and Indus Highway. The pavement is good enough and the load of traffic is small. Conditions of the unpaved roads within the coal field are good enough for the purpose and the distance of transportation is short. Trucks can run on these roads.

7-3-5 Availability of Utilities

Presently, utilities such as electricity, water supply and communication system are not available around the plant site.

A public electric line of 11 kilovolts and 2,000 kilowatts exists at the location shown in Figure 7-1-1; it is not energized yet. Power will be supplied in time for the start of the project. Construction of a 200 meters new distribution line is necessary from the existing line to the site. When the annual production of coal briquettes reaches 100,000 tons, required electric power, 2,400 kW, will exceed the capacity of the existing line and an additional line should be constructed. Water for coal washing and sanitary purpose is taken from the Indus River and delivered by tank trucks. The process does not need water except for coal washing. Public telephone system dose not cover the plant area; therefore, a wireless telephone will be installed between the plant and the PMDC office in Hyderabad.

7-3-6 Natural Conditions

The weather conditions around the site are shown in Table 7-3-1. The average temperature varies from 24.2 to 34. 1 degree centigrade during the dry seasons; the humidity ranges from 25 to 34 percent during the rainy seasons. This is a very dry area; in 1915 the annual recorded precipitation was 1.01 inches, or 26 millimeters. The greatest recorded annual precipitation is 21.13 inches, or 537 millimeters, experienced in 1913. The heaviest recorded rainfall in 24 hours is 7.50 inches, or 191 millimeters observed in 1929. The possible natural calamity that could hit the area is cyclone originated in the Indian Ocean. The manufacturing process of coal briquettes are not affected by these climatic conditions. This area occasionally suffers from flood caused by heavy downpours of more than 100 millimeters within a short duration. However, the plant site is immunue to flood, as the site is on a hilly area.

7-3-7 Geological Conditions and Easiness of Land Preparation

According to the geological investigation report for evaluating coal reserves, the proposed site area is a flat desert covered with soil and sand of Upper Ranikot formation of which thickness is about 15 meters. Limestone rock is seen at various places around the site.

There is no indication of water table within the depth of 130 meters. Judging from observation, the soil bearing strength is estimated at 10 tons per square meter. Therefore, the geological conditions are acceptable and land preparation works do not face any difficulty.

7-3-8 Environmental Conditions

Since the inventories are planned to be equivalent to 5 days consumption for coal and 150 days consumption for bagasse at the end of harvest season, these materials will be stockpiled on a large piece of open land. Lakhra coal has a tendency for spontaneous combustion; it burns emitting sulfur dioxide. There is no living facility in the immediate surrounding of the plant site except that the formitory and contractor's barracks are planned there. In case spontaneous combustion takes place, it can be taken care of by burying the burning coal and the resident would not suffer from sulfur dioxide.

Table 7-3-1(1) Meteorological Data

Normals of maximum and minimum temperature

LAT 25° 23′N LONG. 68° 25′E Height of ground(plot of S.S.) a.m.s.l. = 93 ft.(28 m)

MONTH.	MAXIMUM TEMPERATURE (°F)									MINIMUM TEMPERATURE (°F)									Mean Temp. $\frac{(X+N)}{2}$	Mean daily Range of Temperature (X-N)
	Mean			Extremes						Mean			Extremes							
	Daily	Monthly		Highest recorded			Lowest recorded			Daily	Monthly		Highest recorded			Lowest recorded				
	Max.	Highest Max.	Lowest Max.	Value	Date Year	Value	Date & Year	Value	Date & Year	Min.	Highest Min.	Lowest Min.	Value	Date & Year	Value	Date & Year	Value	Date & Year		
23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
JAN.	75.6	85.7	64.7	93	18/32	95	20/02	55	9/57	50.1	57.9	42.4	62	29/49	34	14/35	30	31/29	62.9	25.5
FEB.	883.1	94.0	70.0	103	27/43	103	26/28	54	2/40	55.1	63.9	46.0	69	16/54	37	2/51	36	1/29	69.1	28.0
MAR.	993.5	103.8	81.7	116	28/49	112	26/92	70	11/60	63.9	72.3	52.2	78	28/37	46	5/45	41	2/98	78.7	29.6
APR.	103.0	111.2	92.4	115	18/49	118	26/86	78	7/57	71.9	78.4	63.7	82	22/52	57	3/42	53	31/03	87.5	31.1
MAY.	108.1	16.2	99.9	121	25/32	121	25/32	94	10/55	78.7	83.2	73.3	89	25/43	67	2/53	62	2/16	93.4	29.4
JUNE.	105.0	113.8	98.3	122	9/41	122	14/00	87	27/34	82.3	86.0	77.9	89	22/53	72	1/53	68	26/02	93.7	22.7
JULY.	99.5	108.0	90.8	114	23/51	113	4/81	83	31/46	81.5	85.1	77.0	88	1/60	74	7/53	71	8/10	90.5	18.0
AUG.	97.0	103.9	88.9	111	20/58	110	3/00	82	8/56	79.7	82.9	76.5	88	7/54	73	8/44	71	2/84	88.3	17.3
SEPT.	98.3	106.8	91.6	111	29/51	111	21/39	82	12/59	77.2	81.9	73.2	89	22/48	70	30/50	64	29/23	87.7	21.1
OCT.	98.7	105.8	91.1	113	11/41	110	16/25	80	2/56	70.7	77.4	62.9	84	3/58	52	31/49	55	31/89	84.7	28.0
NOV.	90.0	98.5	79.5	104	2/42	102	1/40	69	29/38	61.1	68.6	53.5	74	5/39	42	29/38	42	29/38	75.5	28.9
DEC.	79.5	89.1	75.0	95	2/53	92	2/35	64	31/37	53.2	61.0	45.5	69	9/41	37	23/45	38	27/03	66.3	26.3
YEAR	94.3	117.0	63.3	122	9th June 1941	122	14th June 1900	54	2nd Feb. 1940	68.8	86.7	41.3	89	May & June & Sept.	34	14th Jan. 1935	30	31st Jan. 1929	81.5	25.5
No.of Years	30	30	30	30		60		30		30	30	30	30		30		60		30	30

"Ather"

Table 7-3-1(2) Meteorological Data

Normals of pressure, temperature, humidity and vapour pressure for 00, 03 and 12 GTM
(based on data 1931-60)

LAT 25° 23' N LONG. 68° 25' E — Height of bar. cistern a.m.s.l. = 98 ft. (30 m)

MONTH.	PRESSURE (Mbs.) STATION LEVEL			PRESSURE (Mbs.) REDUCED MEAN SEA LEVEL			TEMPERATURE (°F) DRY BULB			TEMPERATURE (°F) WET BULB			TEMPERATURE (°F) DEW POINT			RELATIVE HUMIDITY (PERCENT)			VAPOUR PRESSURE (mbs.)		
	00	03	12	00	03	12	00	03	12	00	03	12	00	03	12	00	03	12	00	03	12
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
JAN.	1012.3	1014.5	1011.1	1016.0	1018.2	1014.6	53.7	53.3	72.8	48.6	47.1	56.0	42.3	40.8	40.6	66	62	31	9.2	8.7	8.6
FEB.	1009.7	1011.7	1008.9	1013.3	1015.3	1012.3	58.0	58.7	81.1	52.0	52.1	60.1	45.1	45.7	42.0	64	62	25	10.7	10.4	9.0
MAR.	1006.2	1008.6	1003.6	1009.7	1012.1	1009.0	67.1	69.4	90.5	59.9	60.0	65.0	53.3	53.4	46.0	63	46	22	14.4	13.9	10.7
APR.	1003.3	1004.5	1001.8	1006.7	1007.9	1005.1	73.2	79.0	99.5	65.3	67.7	70.0	59.1	61.5	53.0	13	55	21	18.0	18.8	13.6
MAY.	998.4	1000.1	996.9	1001.8	1003.3	1000.3	79.5	85.5	103.7	72.7	75.4	75.5	68.4	71.5	63.4	70	63	27	24.5	26.3	19.8
JUNE.	994.0	995.4	992.5	997.4	998.8	995.8	82.9	87.1	101.0	77.8	78.8	73.8	75.5	75.0	70.0	78	68	40	30.3	29.9	27.0
JULY.	993.3	994.2	991.9	996.8	997.6	995.2	82.4	85.1	95.2	77.3	78.4	80.2	75.5	78.5	73.4	79	74	50	30.5	30.8	28.3
AUG.	994.9	996.4	994.2	998.9	999.8	997.5	80.5	82.9	93.0	75.7	76.6	79.4	73.6	74.0	73.5	79	75	54	28.3	28.9	28.7
SEPT.	999.5	1001.1	998.8	1002.9	1004.5	1002.1	78.0	81.1	93.9	74.0	74.6	77.1	72.0	72.0	69.9	81	74	46	27.0	27.0	25.8
OCT.	1005.3	1007.3	1004.8	1008.8	1011.0	1008.1	72.2	76.0	94.3	66.3	67.9	70.1	62.4	63.0	57.6	71	64	29	19.4	19.8	16.5
NOV.	1010.2	1011.9	1009.3	1013.8	1015.6	1012.7	63.5	65.8	85.3	57.5	57.3	63.5	52.1	50.0	48.6	67	57	28	13.5	12.2	11.7
DEC.	1012.5	1014.4	1011.7	1016.1	1018.1	1015.2	56.4	56.6	75.8	51.8	50.3	58.8	45.9	45.5	43.8	68	62	33	10.7	9.9	9.9
YEAR	1003.3	1005.0	1002.3	1006.8	1008.5	1005.7	70.6	73.4	90.5	64.9	65.5	69.6	60.4	60.9	56.8	71	64	34	19.7	19.7	17.5
No. of Years	10	30	28	10	30	28	10	30	28	10	30	28	10	30	28	10	30	28	10	30	28

Station. Hyderabad (Estab. 1877)

Table 7-3-1(3) Meteorological Data

Normals of cloud, wind speed and precipitation

LAT 25°23′N LONG 68°25′E Height of anemome above ground – 28 ft. (9 m)

MONTH	WIND SPEED (Knots)				CLOUD AMOUNT (Oktas)						PRECIPITATION (Inches)															
				past 24 hrs.	ALL Clouds.			Low Clouds.			Mean monthly total.			Mean No. of rainy	Total in month / year											
															Wettest				Driest				Heaviest fall in 24 hrs.			
															1931-60		1881 to 1940		1931-60		1881 to 1940		1931-60		1881 to 1940	
	00	03	12		00	03	12	00	03	12	03-12	12-03	03-03		Amt.	Year.	Amt.	Year.	Amt.	Year.	Amt.	Year.	Amt.	Date.	Amt.	Date.
44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
JAN.	3.0	2.5	3.7	3.2	0.7	2.0	1.8	0.1	0.5	0.4	0.12	0.09	0.16	0.5	1.18	1945	1.93	1888	0.00	–	0.00	–	0.70	5/45	0.93	10/87
FEB.	2.2	2.2	3.4	3.1	0.4	1.6	1.6	0.0	0.3	0.2	0.01	0.07	0.19	0.4	1.38	1944	2.17	1906	0.00	–	0.00	–	1.30	23/44	1.49	2/88
MAR.	2.3	2.4	3.9	4.9	0.5	1.6	1.7	0.1	0.1	0.2	0.05	0.00	0.04	0.2	0.48	1960	3.63	1911	0.00	–	0.00	–	0.24	29/39	2.30	16/11
APR.	3.0	3.4	5.7	4.9	0.6	1.2	1.6	0.0	0.0	0.3	0.08	0.01	0.06	0.2	0.67	1957	0.71	1930	0.00	–	0.00	–	0.67	7/57	0.71	1/30
MAY.	5.2	5.7	7.6	7.7	0.5	0.7	0.8	0.1	0.2	0.3	0.20	0.11	0.16	0.4	1.10	1952	2.22	1889	0.00	–	0.00	–	0.55	20/57	2.14	26/89
JUNE.	8.1	8.3	9.3	10.2	1.3	2.0	1.1	0.3	0.8	0.4	0.01	0.42	0.26	0.4	1.87	1934	3.57	1902	0.00	–	0.00	–	1.51	12/38	1.93	24/96
JULY.	7.7	7.7	8.5	9.4	3.6	4.0	3.3	1.1	1.4	1.5	0.10	1.68	2.68	3.5	10.77	1956	15.81	1908	0.00	–	0.00	–	4.31	25/56	7.50	28/29
AUG.	6.7	6.7	7.8	9.2	3.0	3.6	2.8	1.1	1.4	1.0	0.54	1.21	1.72	2.2	10.89	1944	10.13	1893	0.00	–	0.00	–	4.66	3/44	5.08	1/21
SEPT.	5.9	5.4	7.4	7.7	1.2	1.7	1.4	0.5	0.5	0.5	0.50	0.91	0.58	1.0	7.58	1959	8.77	1924	0.00	–	0.00	–	3.07	6/59	6.19	2/24
OCT.	1.9	2.4	3.8	3.8	0.3	0.5	0.5	0.1	0.1	0.2	0.15	0.06	0.11	0.2	1.83	1956	0.95	1937	0.00	–	0.00	–	1.35	2/56	0.95	18/37
NOV.	1.8	1.8	2.7	2.5	0.5	1.0	0.9	0.1	0.2	0.1	0.03	0.08	0.04	0.1	0.54	1959	1.90	1890	0.00	–	0.00	–	0.54	5/59	1.00	27/90
DEC.	2.8	2.6	3.0	2.9	0.8	1.6	1.2	0.0	0.3	0.1	0.07	0.09	0.10	0.2	1.04	1953	0.88	1929	0.00	–	0.00	–	1.04	31/53	0.82	19/29
YEAR.	4.2	4.3	5.6	5.7	1.1	1.8	1.6	0.3	0.5	0.9	2.89	4.52	6.09	9.3	20.73	1956	21.13	1913	1.26	1939	1.01	1915	4.66	3rd Aug. 1944	7.50	28th July 1929
No. of Years	10	19	19	30	10	30	28	10	19	19	10	10	30	30	30		60		30		60		30		60	

Station : Hyderabad (Estab: 1877)

CHAPTER 8 PROJECT SCHEME

8-1 Definition of Project Scheme

In order to proceed with the conceptual design, financial and economic evaluation, and overall evaluation, it is necessary to define this project; in other words, the size of the project or annual production, manufacturing process, quality of the product, site, supply of utility, improvement of infrastructure, methods of procurement and prices of main and subordinate raw materials, price of the product, strategy for marketing, organizational structure, etc. have to be defined. The definition of all these set of conditions outlining the project is called here "PROJECT SCHEME."

The preliminary survey conducted by JICA did not define the project scheme; instead, the JICA preliminary survey team and PMDC, the counterpart agency, chose to have the project scheme to be established as a result of the feasibility study reflecting the result of the field survey, the policy of the counterpart, the result of the home-office work, and optimization of the project in consideration of the technical and economic constraints. This feasibility study established a tentative project scheme at the closing stage of the second-stage field survey with a full participation of PMDC on condition that the tentative project scheme is subject to modification as found necessary by the home-office work. The following section, 8-2 Tentative Project Scheme, explains the contents of the tentative project scheme followed by 8-3, Definitive Project Scheme, which presents the final project scheme with the rationale.

8-2 Tentative Project Scheme

This section presents Tentative Project Scheme as agreed with PMDC at the closing stage of the second-stage field survey.

8-2-1 Initial Capacity

Two cases are proposed, one starting at 50,000 and the other at 100,000 tons per year. There will be subsequent expansions of capacity as demand grows. The timings of initial startup and subsequent expansions will be decided mainly as a result of market studies which have already been done in the first-stage study but will be redone as the production cost is developed.

8-2-2 Plant Site

The manufacturing plant will be located at Lakhra project site along the main road running through the mine area and by the road leading to the operating shafts. A large stretch of flat land is available. The lot should be very wide, because the operating stocks of biomass would require a large piece of land. The land should have allowance for future expansions. A piece of land of 20,000 square meters is necessary for the initial plant and an adjacent stretch of land of 200,000 square meters is considered for future expansions.

8-2-3 Raw Material

The following input materials are considered:

Lakhra coal
Bagasse
Wheat straw
Cotton seed oil extraction residue
Limestone
Slaked lime
Cement
Wax
Light fuel oil

These are all available around Lakhra area except for slack wax which is procurable from National Refinery located near Karachi City. The experimental production of coal briquettes, their burning tests and techno-economic consideration will decide the blending composition of these inputs.

8-2-4 Process Scheme

The process scheme shown on a diagram on the next page is tentatively proposed. This diagram intentionally omits details so as to be readily understandable.

The decision on whether the pretreatment of the raw coal is necessary or not must await the result of the washing test of coal in Japan. The feed coal and biomass are dried, crushed and screened; the insufficiently crushed feed remaining on the screens are returned back to the crushing process. Different kinds of machines suited to coal and biomass respectively are used for drying and crushing them. The study team tentatively plans to employ a drier of rotary-kiln type for coal and a flush drier for biomass.

Working storage will be provided for major raw materials to absorb operating fluctuations, short temporary suspensions of operations for operating maintenance of equipment. The working storage of one-day throughput would be adequate to afford necessary operation flexibility.

The powdered raw materials in working storage are withdrawn at controlled rates and fed to a mixer. Screw conveyers with rotation controlling devices will be used for feeding the powdered raw materials to the mixer. Slaked lime and cement, the latter only if found necessary, are blended at this stage. A paddle mixer will be used for mixing the raw materials into a blend of uniform composition. Now at this stage, the blend is ready for briquetting.

The briquetting will be done by a briquetting machine of which the essential components are two rotating rolls both having grooves or dents on matching surfaces on the opposite rolls. On the rolls is applied a force of some 50 tons. The powdered raw materials are fed between the drums. As the drums rotate the powdered raw materials are drawn into the grooves or dents and compressed and molded under an extremely high pressure. As the materials come under the rolls, the briquettes come off from the grooves or dents by just gravity. The briquettes fresh from the briquetting machine have fringes which are formed by the compression of the raw materials by the flat periphery around the grooves or dents on the rolls. To remove these fringes the briquettes are fed to a drum of rotating wiremesh; the fringes removed drop through the wiremesh and returned to the mixer.

Finally, the briquettes are coated with wax by submerging them in a hot bath of wax dissolved in a light fuel oil. The finished briquettes go to storage silos. On entering the silos the briquettes impinge on an impact flow meter to weigh the product briquettes being introduced to the silos. Three silos would be necessary. The silos will be equipped with devices to facilitate loading to trucks.

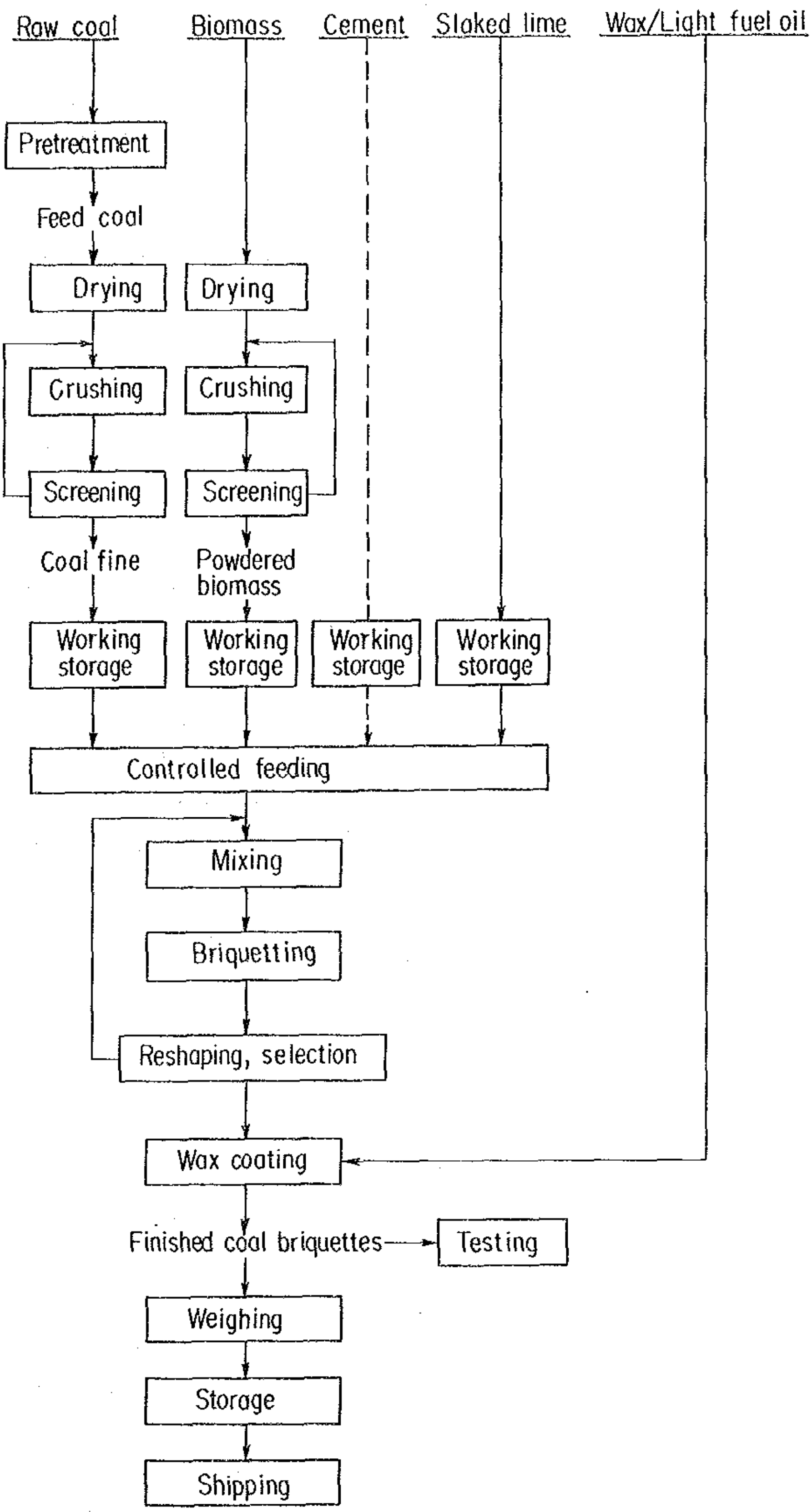


Figure 8-2-1 Process Scheme

8-2-5 Quality of the Product

The target quality is presented in the Interim Report; therefore, the discussion will not be repeated here. The items considered are:

Easiness of ignition

A steady burning condition is reached within five minutes from start of fire.

Strength of flame

The briquettes burn with a powerful flame comparable to that of firewood.

Smokelessness

The briquettes burn producing no or practically acceptable levels of smoke if burned in an average kitchen of Pakistan households.

Odorlessness

The briquettes burn producing no or practically acceptable levels of odor if burned in an average kitchen of Pakistan households.

Non-toxicity and safety

The combustion gas and ashes are safe to humans and animals.

Easiness of control of combustion

The strength of the flame is easily controllable with adjustment of the amount of primary air.

Water resistance

The briquettes repel water and do not allow water to diffuse into their interior when they get wet.

Physical strength

The briquettes have enough physical strength to resist rough handling during transportation and other operations without breaking.

Shape, size

The shape and size of the briquettes are designed to be easy to handle.

8-2-6 Building and Sanitary Facility

The building to house processing machines will be completely roofed but not walled except those portions for which walls are necessary, for example, the switch room and the instrument room where the engineer in charge stays.

A test room equipped with a sink and a set of simple test equipment will be provided.

The sanitary facility includes a toilet, wash tubs, etc.

A dormitory to accommodate the manager, engineers and operators and security personnel will be built close to the plant. A barrack for contract labor is provided.

8-2-7 Utility

There is no water main running close to the plant site. The coal briquettes plant does not require process water or cooling water. The only water required is for sanitary purposes, drinking and fire-fighting. A cistern of about 30 ton capacity would meet all these needs; water will be purchased and delivered to the plant site.

There is no active power line; however, a power line of sufficient capacity runs along the main road but has yet to be energized. The total requirement of power is estimated at about 1,200kw for a 50,000 ton plant. This line can accommodate 1,200-kw; however, whether this line can accommodate the ultimate power requirement of 7,200kw after expansion to 300,000 tons will be investigated at Lakhra.

8-2-8 Infrastructure

No major improvement of infrastructure is planned. Since the plant is isolated and remote from the urban center, a wireless communication device would be necessary between the plant and the PMDC Office in Hyderabad. Construction of roads would not be required except for a very short distance between the main road and the plant premise for which simple pavement would be good enough. Collection of the raw material coal from a number of operating shafts would be done by truck on contract basis. Pavement is not necessary for routes on which contractor's trucks make routine round trips.

8-2-9 Test Equipment

The following set of test equipment will be provided in the test room:

Furnace
Oven
Balance
Sieves
Thermometers
Crush strength meter
Stop watches
Miscellaneous

8-2-10 Manning

A simple and efficient organization is considered for operating the plant. The following organization is tentatively proposed:

Plant manager		1
Plant engineer		1
Foreman		1
Assistant chemist		1
Store-keeper		3
Chief shift operator		4
Shift operator	3 persons/shift x 4 =	12
Janitor		1
Security personnel		4

The above is considered necessary for the operation of the plant. There will also be contracted manpower for transportation of raw materials from the sources to the stock yard beside the plant, from the stockyard to the plant, occasional working maintenance of the facilities, etc. In addition, at the Hyderabad Office the following staff is needed:

Assistant manager	1
Assistant accountant	1
Clerk	2

8-2-11 Operation Rate

This project assumes 24 hour operation per day, 300 day operation per year; this schedule allows 65 days for suspension of operations for maintenance. To allow for small-scale maintenance while the plant is in operation, one day working storage of crushed raw materials is planned.

Although the plant operates 24 hours a day, transportation of the raw materials to the stock yard and shipping of the product will be limited to the daytime.

8-2-12 Inventory of Raw Materials

This issue also concerns the financial evaluation in terms of working capital. The survey conducted on the raw materials suggests the necessity of piling up at the plant site an inventory of bagasse equivalent to the half year's consumption when the harvest season of sugarcane ends. The coal, limestone or slaked lime, cement if necessary, wax and light fuel oil are all readily available and the levels of the inventories required are set to absorb routine fluctuations.

8-3 Definitive Project Scheme

In the light of the result of the home-office work, the project scheme was finalized by defining in detail what remained indefinite in the tentative project scheme and by making necessary modifications.

8-3-1 Initial Capacity and Expansion

Three cases, optimistic, conservative, and one assuming continuation of subsidy on kerosene are proposed, two starting at 50,000 and the other at 100,000 tons per year. Both cases plan expansions of capacity to meet the increasing forecast demands. The three cases are shown below:

Table 8-3-1 Plant Capacity

Year	Capacity installed (thousand tons/year)			Production (thousand tons/year)			Operation rate Percent		
Case	1 con	2 opt	3 sub	1 con	2 opt	3 sub	1 con	2 opt	3 sub
1989	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-
1992	50	100	50	50	52	50	100	52	100
1993	50	100	50	50	57	50	100	57	100
1994	50	100	50	50	62	50	100	62	100
1995	75	100	50	75	68	50	100	68	100
1996	75	100	50	75	81	50	100	81	100
1997	100	150	50	100	96	50	100	64	100
1998	100	150	50	100	113	50	100	75	100
1999	100	150	100	100	134	100	100	89	100
2000	150	200	100	175	158	100	100	80	100
2001	150	200	100	175	180	100	100	90	100
2002	200	300	100	175	203	100	100	68	100
2003	200	300	200	175	230	200	100	77	100
2004	250	300	200	300	260	200	100	87	100
2005	250	300	200	300	293	200	100	98	100
2006	300	300	300	300	300	300	100	100	100

8-3-2 Plant Site

The result of the home-office works basically supports the plant site proposed by TENTATIVE PROJECT SCHEME but moves the site inwands to the middle of Lease 88 from where TENTATIVE PROJECT SCHEME planned along the main road running through the mine area.

The manufacturing plant will be located at Lakhra project site in Lease 88, close to the operating shafts. A large stretch of flat, unused land is available. The lot should be very wide, because the operating stocks of biomass would require a large piece of land. The land should have allowance for future expansions. A piece of land of 20,000 square meters is necessary for the initial plant and an adjacent stretch of land of 200,000 square meters is considered for future expansions.

According to the drilling tests down to some 130 meters by PMDC for purpose of the evaluating the reserves of coal, although the surface is covered by soft sand, the underground formations are generally rigid. Within a depth of 10 meters there is a formation of limestone; there is no water table down to the depth of 130 meters drilled. The site preparation for the construction of the briquette plant will not need particular consideration for underground water; the soils below the sand may be considered rigid which relieves the project of intensive foundation works for the plant. Moreover, the plant does not include particularly heavy equipment.

This recommended candidate site is situated only 1.5 kilometers from the main road running through the Lakhra coal mine area via which Lakhra coal is distributed throughout the nation. This same road may be used mainly by trucks for shipping of the product coal briquettes and for collection of main and subordinate raw materials. This road connects the plant site with Hyderabad, the largest city in this area, in one to two hours. This road is also good enough for the purpose of bringing to the site the construction materials, equipment, construction machines and necessary labor.

At this moment; the public utility such as water and electricity is not provided to the site, the provision of such public utility will be discussed in 8-3-7, Utility.

8-3-3 Raw Material

(1) Recommended blending ratio

In the light of the results of the experimental production of coal briquettes from the samples of raw materials and burning test, and also in consideration of the technology employed and economics of the project, the following blending ratio is proposed:

Table 8-3-2 Recommended Blending Ratio

	Raw material input, ton/ton product
Lakhra coal	1.250
Bagasse	0.325
Slaked lime	0.0625
Slack wax	0.006
Light oil	0.044
Total feed	1.6875

Note: The following representative water contents are used to develop the above blending ratio.

	water content, wt%
Lakhra coal	20.0
Bagasse	50.0
Slaked lime	5.0
Slack wax	0.0
Light oil	0.0
Coal briquette	10.3

(2) Quality

The results of the experimental production of coal briquettes and burning tests are detailed in Chapter 10, EXPERIMENTAL PRODUCTION OF COAL BRIQUETTE and Chapter 11, BURNING TEST. The experimental production covered a wide ranges of compositions with Lakhra coal as main component and biomasses, namely bagasse, wheat straw and cotton seed oil extraction residue as sub-components. The overall quality of the coal briquettes blended with bagasse and wheat straw are quite similar: they both have improved burning quality and the blending ratio required to give a desired improvement is nearly the same for both bagasse and wheat straw. On the other hand, the blend of cotton seed oil extraction residue has been found to give much lower strength than bagasse or wheat straw. Cotton seed oil extraction residue is dropped for this reason. Of these three kinds of biomass, bagasse has the greatest economic advantage as explained below; therefore, there is no reason to use wheat straw in preference to bagasse. There are also technical problems with the cotton seed oil extraction residue as explained in (4), Technical consideration.

The experiment shows that blending of cement is not necessary; the application of pressure alone at the briquetting stage has been found enough to produce briquettes of sufficient mechanical strength, provided that appropriate biomass is blended in a right ratio.

The choice between limestone and slaked lime is studied in terms of effectiveness to arrest sulfur, to assist briquetting, and their respective advantages and disadvantages. The ability to arrest sulfur depends on alkalinity. Given their equal alkalinity, theoretically 1.35 times as much pure limestone as pure slaked lime is required, both on dry basis. In addition, limestone must be thermally decomposed by the heat of combustion of the briquettes before its alkalinity can become active. It is considered that due to these two disadvantages about twice as much limestone as slaked lime is needed to arrest the same amount of sulfur. Moreover, limestone is found to be too slow to react with sulfur in actual burning conditions. However, limestone has a definite economic advantage even at twice the requirement of slaked lime.

Limestone and slaked lime behave quite differently; limestone contains chemically combined carbon dioxide which is released when exposed to temperatures above 650 degrees centigrade or brought in contact with acids. Otherwise limestone is very stable. Slaked lime, on the other hand, is a hygroscopic alkali, or it absorbs from atmosphere moisture and carbon dioxide, which is an acidic gas. One may naturally be concerned that carbon dioxide released from limestone contained in burning briquettes may muffle the fire front, thereby hamper the supply of oxygen to the fire front; however, no discernible effect of limestone on combustion was observed by the combustion test. The worst effect that may be expected from the properties of slaked lime is that slaked lime induces moisture and carbon dioxide to diffuse into the interior of the coal briquettes resulting in loss of physical strength. Such an effect was not observed on our samples of slaked-lime-containing coal briquettes left in open space for a period of one month after preparation, nor is it reported in literature. Thus, as far as the effects on the quality of coal briquettes are concerned, there is no preference between limestone and slaked lime except that twice as much limestone as slaked lime is necessary to arrest the same amount of sulfur and hence limestone contributes to the production of ash twice as much ash. Moreover, limestone is found too slow to react with sulfur in actual burning conditions. Slaked lime is therefore preferred even at some economic penalty.

Limestone and slaked lime do not exhibit noticeable difference in their ability for assist briquetting.

(3) Economic consideration

The economic consideration, a prime factor for the decision of the blending composition, is presented here. The unit costs of raw materials at the plant site in 1988 price are as follows:

Table 8-3-3 Raw Material Cost at Plant

Raw material	Unit cost, Rs/ton dry base
Lakhra coal	326.8
Bagasse	214.8
Wheat straw	2,300
Limestone	115
Slaked lime	668
Wax	2,870
Light fuel oil	2,870

From the above list it is evident that among biomasses bagasse is the most economical, and that limestone has a marked economic advantage over slaked lime even if twice as much limestone is used as slaked lime.

Coal briquettes were experimentally produced with a wide range of biomass content. Economics favors low contents of biomass, however, the strength of briquettes increases with increasing content of biomass. At 20 percent of bagasse the experiment produced satisfactory results; 20 percent thereby adopted in the project scheme.

Selection of bagasse in preference to wheat straw is based chiefly on economic considerations and a study on availability. Bagasse is cheaper in Pakistan than wheat straw and is easier to collect; bagasse is available in large quantities at sugar mills scattered throughout Sind Province.

(4) Technical consideration

Of all the raw materials the easiest and cheapest to collect and transport to the site is coal. Coal is produced nearby; there is no need to have a large stock at the plant site. By contrast, the biomass, particularly, bagasse, has to be stored at the plant site at the end of the harvest season of sugarcane in sufficient quantities to sustain the operation of the plant until the next harvest season comes. This would be a very large a quantity requiring a large piece of land. If bagasse and no other biomass is used, about half year's requirement has to be stored at the end of the sugar cane harvest season; for a 100,000 ton plant 16,250 tons of bagasse will be stored. Assuming the bulk density of a loose pile to be 0.2 tons per cubic meter, 16,250 tons of bagasse amounts to 81,250 cubic meters. It must be kept secure from fire. As mentioned later in 8-3-12, Inventory of raw material, this stockpile could be decreased to 150 days equivalent by scheduling the maintenance shutdown for the off-harvest season. However, the lower the content of the biomass the better it is from the operational viewpoint. Wheat straw is nearly always available for purchase; however, the price difference between wheat straw and bagasse discourages the use of the former.

The production process of coal briquettes includes the process of drying and crushing bagasse down to a powdered form. Wheat straw is available in a dry condition; however, wheat straw was found more difficult to crush than bagasse. Such differences between wheat straw and bagasse are considered not significant enough to be reflected in the plant design and hence would not offset the economic advantages of bagasse.

The outdoor storage of bagasse may result in some deterioration of the quality of bagasse but not to such an extent as to affect its value as a raw material; throughout the world bagasse is commonly stored outdoors. The project area is dry with an average precipitation of less than 200 millimeters. The surface layer of the soil in that area is sandy and allows water to penetrate underground if rare rains drench the piles of bagasse. The only loss would be that attributable to wind. In short, there are technical reasons to prefer wheat straw to bagasse; however, they are not great enough to override the economic advantage of bagasse. The cotton seed oil extraction residue is found difficult to crush and the briquettes made with it exhibit weaker collapse strength.

The relative advantages and disadvantages of technical nature between limestone and slaked lime has been discussed earlier.

The wax can be a crude wax; there is no need to use an expensive refined wax. Slack wax produced by National Refinery located near Karachi as byproduct of lubricating oil production suffices. Diesel fuel obtainable at any service station can be used for the light oil used as a solvent for wax.

(5) Availability

As explained in Chapter 5, RAW MATERIAL FOR COAL BRIQUETTES, there is no availability problem. The prices of the selected raw materials are reasonable.

8-3-4 Process Scheme

At the stage of TENTATIVE PROJECT SCHEME, PMDC and the study team basically agreed on the outline of the process scheme as recorded on the Interim Report except on the necessity for pre-treatment of the raw coal which was left undecided for lack of information and data on the effect of washing on the Lakhra coal. Whether or not the pre-treatment should be incorporated in the process scheme was left to the home-office work to decide on the basis of data of washing tests. There was concern about two possible undesirable effects of washing: one is possible loss of briquetting tendency that may result from wetting and perhaps from removal of certain components of coal and the other is cost of water, potentially prohibitive in the project site since the only means of procurement of water is to bring it by a tank truck.

Because of the concern over the detrimental effect of wetting, a dry method of pre-treatment of coal which is extensively employed in Japan to eliminate foreign substances was tested but was found ineffective. The experiments of wet process, or actual washing, proved quite effective contrary to the above concerns: there is no discernible difference in briquetting potential between before and after washing; marked reduction of ash and sulfur content is attained by washing.

The problem with sulfur in the case of unwashed coal is its great variation and unpredictibleness: the sulfur content can vary greatly, say from as low as 4 to as high as 9 percent, among samples of even the same lot taken at the same time from the same seam of the same shaft and there is no way of detecting such variation while feeding the coal to the plant. This gives rise to a very annoying process-operation problem: since combustion effluent of sulfur, sulfur dioxide, is very irritating to the eyes and throat; it must be suppressed by all means at the consumers end, which is possible only by adding at the manufacturing stage the amount of slaked lime required to completely neutralize the expected maximum content of sulfur in the raw material. The added slaked lime ends up in ash reducing heating value of the product and increasing the cost of distribution per heating value. The ash content of the raw coal is already very high; there is scarcely any room to further increase ash beyond that already contained without adversely affecting the real value of coal briquettes as a household fuel.

There are two types of sulfur contained in the raw coal, namely, combustible and incombustible sulfur; the former could be further classified into organic sulfur and inorganic sulfur; the incombustible sulfur remains inert during combustion and regarded as harmless economically or otherwise provided the content is low, which is the case with the Lakhra coal. The organic sulfur exists as an integral member constituting with other elements like carbon, oxygen and nitrogen the chemical structures of coal itself. The inorganic combustible sulfur exists mostly in the form of pyrites, or a combustible compound of sulfur and iron, known to play an instrumental role in triggering spontaneous ignition of coal. Unlike the combustible organic sulfur, pyrites mingles with coal not as an integral part of the molecular structures of coal but as a heterogeneous existence. By just visual observation, pyrites could be spotted on the Lakhra coal samples as small bright golden specks irregularly scattered over surfaces of any fragment of coal. It is conceivably due to this very heterogeneity of the existence of pyrites in the Lakhra coal that the sulfur content varies greatly almost unpredictably from one lump to another even within the same lot.

Pyrites has a specific gravity of appreximately 5, compared to approximately 1.3, the specific gravity of pure coal; therefore, it is very possible to separate pyrites from coal by using the great difference in specific gravity. The results of washing test on the Lakhra coal attests to this: there is a great decrease in sulfur content from an average of six to less than three percent and also in variation for which pyrites may be considered the main factor.

There is of course a great reduction in ash content from about 30 to less than 10 percent by washing; the reduction of ash to increase calorific value is normally the main objective of washing process rather than reduction of sulfur. Because pyrites constitutes a significant portion of sulfur in coal, it is fortunately possible with the case of Lakhra coal to substantially reduce sulfur content along with ash, and more importantly the irregular variation of sulfur content of the feed coal, by washing. Such experimental results were obtained by using a fluid with a specific gravity adjusted to 1.6; however, similar results may be expected of washing processes using plain water as long as the processes employ difference in specific gravity.

Given these results of the washing tests, an economic analysis is needed to assess advantages and disadvantages of incorporating the washing process in the process scheme. The first step is to develop the material balance around the washing process as shown in Table 8-3-4.

Table 8-3-4 Material Balance of Feed, with and without Washing

	ROM	Without washing		With washing	
	%	Feed	Product	Feed	Product
Coal					
Moisture	20.0	7,290.7	3,976.7	12,500.0	4,250.0
Ash	25.0	9,113.4	9,113.4	15,625.0	3,125.0
Sulfur	5.0	1,822.7	1,822.7	3,125.0	937.5
Net coal	50.0	18,226.7	18,226.7	31,250.0	27,187.5
Sub total	100.0	36,453.5	33,139.5	62,500.0	35,500.0
Bagasse					
Moisture		7,584.8	700.1	8,125.0	750.0
Dry bagasse		7,584.8	7,584.8	8,125.0	8,125.0
Sub total		15,169.6	8,284.9	16,250.0	8,875.0
Slaked lime					
Moisture		303.3	303.3	156.0	156.0
Dry lime		5,772.3	5,772.3	2,969.0	2,969.0
Sub total		6,075.6	6,075.6	3,125.0	3,125.0
Coating agent					
wax		300.0	300.0	300.0	300.0
Light oil		2,200.0	2,200.0	2,200.0	2,200.0
Sub total		2,500.0	2,500.0	2,500.0	2,500.0
Grand total		60,198.7	50,000.0	84,375.0	50,000.0

Note:

(1)Basis 50,000 tons/year coal briquettes

(2)Dried coal/dried bagasse = 8/1

(3)Dried coal moisture 12.0 %

(4)For material balance around coal washing, see Tables 9-6-3 and 12-2-1.

It may be noted from this table that 0.729 and 1.250 tons of ROM coal is required for with and without washing cases respectively to obtain one ton of coal briquettes. The total feed is 1.688 and 1.204 tons respectively. Now economics is compared between cases for with and without washing in Table 8-3-5.

Table 8-3-5 Netback Price of With and Without Washing

Unit Rs/ton

	Without washing	With washing
1) Retail price	1,161	1,566
2) Seller's margin	200	200
3) Transportation	350	350
4) Feed cost credit	170	
5) Capital burden credit	40	
6) Operation cost credit	30	
7) Netback price	851	1,016

Note:

1) See Chapter 4. Prices are proportional to heat of combustion.
2) Seller's margin assumed to be equal to both cases on Rs/ton base
3) See Chapter 4.00 Rs/ton to bring to Punjab
4) Lakhra coal price Rs.326.8/ ton at plant inlet
5) Annual capital burden 20 percent of investment, Rs, 10,181,000
6) Water, MIT, manpower, disposal of the spent

The economics favors pre-treatment of coal before feeding coal to the briquetting plant. In addition, the quality of the product will be greatly improved from the viewpoints of ash content and heating value. For all reasons mentioned, it is recommended at the stage of definitive project scheme to incorporate the washing process in the process scheme.

Although it has a tendency for spontaneous ignition, the spent from washing can be safely disposed of by being dumped on a nearby desert and covered with sand.

The rest of the manufacturing process is basically the same as that proposed by TENTATIVE PROJECT SCHEME.

8-3-5 Quality of the Product

The target quality set by TENTATIVE PROJECT SCHEME has been achieved and confirmed by the experimental production and burning test of the blending composition proposed by the project scheme. Some of the results of experiments are not amenable to quantification but were evaluated by judgement of experts who actually stood by the experiments. The following properties of the experimentally prepared coal briquettes have been confirmed:

Easiness of ignition

A steady burning condition is reached within five minutes from start of fire. The coal briquettes at the proposed blending ratio burns to completion; that is, the ash left after combusion does not contain unburnt carbon as is normally the case with coal burnt in household stoves.

Strength of flame

The briquettes burn with a powerful flame comparable to that of firewood.

Smokelessness

The briquettes burn producing practically acceptable levels of smoke if burned in an average kitchen of Pakistan households. The production of soot is comparable to that of firewood or even lower; moreover, the soot is soft and fluffy unlike that generated by coal. However, smoke of temporary and harmless nature generated before reaching a steady burning condition will have to be tolerated.

Odorlessness

The briquettes burn producing no or practically acceptable levels of odor if burned in an average kitchen of Pakistan households. However, generation of odor of temporary and harmless nature before reaching a steady burning condition will have to be tolerated.

Non-toxicity and safety

The combustion gas and ashes are safe to human beings and animals on condition that they are not allowed to be accumulated indoors.

Easiness of control of combustion

The strength of the flame is controllable with adjustment of the amount of the primary air.

Water resistance

The briquettes repel water and do not allow water to diffuse into their interior when they get wet.

Physical strength

The briquettes have enough physical strength to resist rough handling during transportation and other operations without breaking. For the proposed blending composition collapse strength over 160 kg was obtained. The collapse strength did not show any sign of decline after exposure to atmosphere for one month.

Other, shape, size

The shape and size of the briquettes are designed for easy handling. The shape and the size of the standard briquettes are designed as follows:

Table 8-3-6 Shape and Size of Briquette

Shape	Almond
Length, mm	37 to 41
Width, mm	21 to 25
Thickness, mm	12 to 16

In addition to all these attributes of the coal briquettes, the following properties are obtained for the briquettes of standard blending ratio:

Table 8-3-7 Standard Quality

Heating value, kcal/kg,gross	5,100 to 5,600
Collapse strength, kg	150 min.

8-3-6 Building and Sanitary Facility

This item remains unchanged from the definition of TENTATIVE PROJECT SCHEME. More specifically, the dormitory and contractor's barrack are planned as follows for each 50,000 ton capacity:

Dormitory	
Number of bed rooms	5
Structure	ferro-concrete
Area, square meter	430
Contractor's barrack	
Number of rooms	2
Structure	brick-made
Area, square meter	300

Figures specified above are for initial capacity of 50,000 tons per year; as the capacity expands rooms will be added as required, as explained in Chapter 6, INFRASTRUCTURE.

8-3-7 Utility

This item remains unchanged from the definition of TENTATIVE PROJECT SCHEME except that a provision for water and power required for coal washing is added. It has been confirmed that the existing power line has already been connected to the existing mining office. There will be an extension of 450 meters of power line from the office to the plant. The existing power line can accommodate a maximum of 2,000 kw which is sufficient for a 50,000-ton capacity but insufficient for a 100,000-ton capacity. Installation of an additional power line or diesel-powered generators will be needed for making up for the insufficiency of power. The project scheme selects installation of a new power line from Jamshoro over a distance of 50 kilometers of which cost is estimated at Rs. 5 million against diesel powered generators or Rs. 8.5 million. Water will be purchased and supplied by tank trucks. A cistern with a capacity of 100 tons will be installed for personnel requirements and for coal washing.

8-3-8 Infrastructure

Basic infrastructure exists in the broader project area, although there are problems particularly with respect to communication and living facilities. The plant site is situated on the opposite side of Hyderabad across the Indus River. The river level rises between June and September and causes occasional floods in spite of tremendous works that have been done to control the river. The main road connecting this area with the rest of the country is well protected and usually unaffected. The plant site is on a hill and is immune to floods. The only possible natural calamity that could hit the area is cyclones originated in the Indian Ocean. This area is earthquake-free. This area is a barren arid semi-desert terrain; however, as with many areas with very dry climate, this area is occasionally hit by downpours. Since there is a very rigid, calcareous underground formation near the surface around the plant site, such downpours are not expected to cause operational problems except that transportation, communication or supply of power may be temporarily affected. In short, this project does not need to install any particular facility to protect the plant from natural disasters.

The public telephone system does not cover the plant area in the midst of a desert; therefore, a wireless communication system will be installed between the plant and the PMDC office in Hyderabad. This requires a special permission from the government. The price of the wireless system is estimated at Rs. 300,000.

The transportation of the raw materials to the plant site and shipment of the product will depend upon truck transportation. The existing two-lane paved road running through the Lakhra coal area connects the plant with the national road network and now serves shipment of coal to various parts of the country. The road is not particularly busy with the present transportation load and may be considered to have sufficient allowance for transportation load after the maturity of this project at 300,000-tons-per-year capacity. Accordingly, this project does not need to improve the road system for its own sake but would only require construction of a very short lateral road from the main road to the plant premise, for which a simple, paved road would be sufficient. Collection of the raw material coal from a number of operating shafts would be done by truck on contract basis. Pavement is not necessary for routes on which the trucks collecting coal from the operating shafts make routine round trips.

There is no township around the plant site. The nearest large city is Hyderabad; here, hotels, hospitals, postal and tele-communication facilities are available. The project does not intend to compensate for the lack of these conveniences other than provide a dormitory for its own staff and a barrack for the contract labor.

8-3-9 Test equipment

The test equipment to be installed in the test room is as follows:

Furnace
Oven
Balance
Sieves
Thermometers

Collapse strength meter
Stop watch
Calorimeter
Ph-meter

The calorimeter and ph-meter were not planned for TENTATIVE PROJECT SCHEME but were added at this definitive stage; the former is included for the purpose of better process and quality control and the latter included in connection with the washing of coal.

8-3-10 Manning

The only change made to TENTATIVE PROJECT SCHEME is an increase of operators for the briquetting and washing operations. Table 8-3-8 gives manning plan at the plant for initial one plant.

Table 8-3-8 Manning Plan

Plant manager		1
Plant engineer		1
Foreman		1
Assistant chemist		1
Store-keeper		3
Chief shift operator		5
Shift operator	3 persons/shift x 4 + 2 =	14
Day operator		5
Driver		1
Janitor		1
Socurity personnel		4
Total		37

The above is considered necessary for the operation of the plant. There will also be contracted manpower for transportation of raw materials from the sources to the stock yard beside the plant, from the stock yard to the plant, occasional working maintenance of the facilities, etc. Furthermore, at the Hyderabad Office the following staff is needed:

Table 8-3-9 Manning Plan at Hyderabad Office

Assistant manager	1
Assistant accountant	1
Clerk	2
Total	4

8-3-11 Operation Rate

This remains the same as in the TENTATIVE PROJECT SCHEME; namely:

Daily operating hour	24
Yearly operating day	300
Yearly allowance for maintenance, day	65

Although the plant operates 24 hours a day, transportation of the raw materials to the stock yard and shipping of the product will be limited to the daytime.

The major annual shutdown for overhaul and repair work will be scheduled between May and August; during this season sugarcane is not harvested. By planning the major shutdown for this season, the stockpile of sugarcane at the end of the harvest season may be decreased.

8-3-12 Inventory of Raw Material

The inventories of the raw materials are decided as follows:

Table 8-3-10 Inventory of Raw Material

		Inventory of raw material, day
Coal		5
Bagasse:	end of harvest season	150
	normal operation period	10
Slaked lime		10
Cement		10
Wax		10
Light oil		10

These inventories are not revised from TENTATIVE PROJECT SCHEME except that the inventory of bagasse takes into consideration the effect of scheduling the annual maintenance during the off-harvest season. Coal and bagasse will be stored outdoors in the open. Slaked lime and cement will be stored in bags that are piled and covered with a plastic sheet and put in the silo as necessary. Wax and light oil will be stored in small tanks; the tank for the wax is equipped with a heating coil to circulate hot oil to keep the wax in a molten state.

8-3-13 Project Schedule

As a result of the home-office work the following project schedule is proposed:

Table 8-3-11 Project Schedule

Operation	Duration, month
Study of this report by PMDC	1
Study of this report by government	1
Decision on implementation	1
Study on funding	1
Basic design by consultant	4
Preparation of tender documents	3
Decision on contractor	1
Detailed design	6
Factory fabrication	7
Site installation and erection	8
Completion, test operation	3
Total	36

8-3-14 Product price

The product price has been worked out as shown in Table 8-3-12 as explained in Table 4-5-1 Netback Price of Coal Briquettes in Chapter 4, COAL BRIQUETTE MARKET. The price is on 1988 price base and is considered to go up in keeping pace with kerosene price until 1995 and remain constant thereafter.

Table 8-3-12 Netback Price of Coal Briquettes

Year	Rs/ton
1990	1,016
1991	1,100
1992	1,191
1993	1,290
1994	1,397
1995 onward	1,513

Chapter 9 RAW MATERIAL TEST AND EVALUATION

9-1 Condition of Sample

The raw materials can be classified into:

1. Main raw material: coal
2. Subordinate raw material: biomass
3. Desulfurizer: limestone, slaked lime
4. Binder: cement

The amounts of the samples sent to the Japanese test site are shown in Table 9-1-1.

Table 9-1-1 Amount of Sample

Unit: ton

Sample	Amount
Lakhra coal	8
Bagasse	1
Wheat straw	0.5
Cotton seed cake	0.5
Limestone	1
Slaked lime	0.5
Cement	0.5
Total	12

These samples were collected in and around the project area and sent to Japan by air and then transshipped to the test site.

9-1-1 Condition of Coal Sample

The samples of Lakhra coal were taken from the operating four shafts and one incline located as shown in Figure 9-1-1 in a area designated as DIMD/S/ML-COAL88 close to the planned plant site in the mine area. The samples were contained in drums which were labeled as PMDC-1 to PMDC-5 before shipment to Japan to enable the consignee to identify the origins of the samples. Throughout this presentation the term "lot" is used to distinguish among P-1

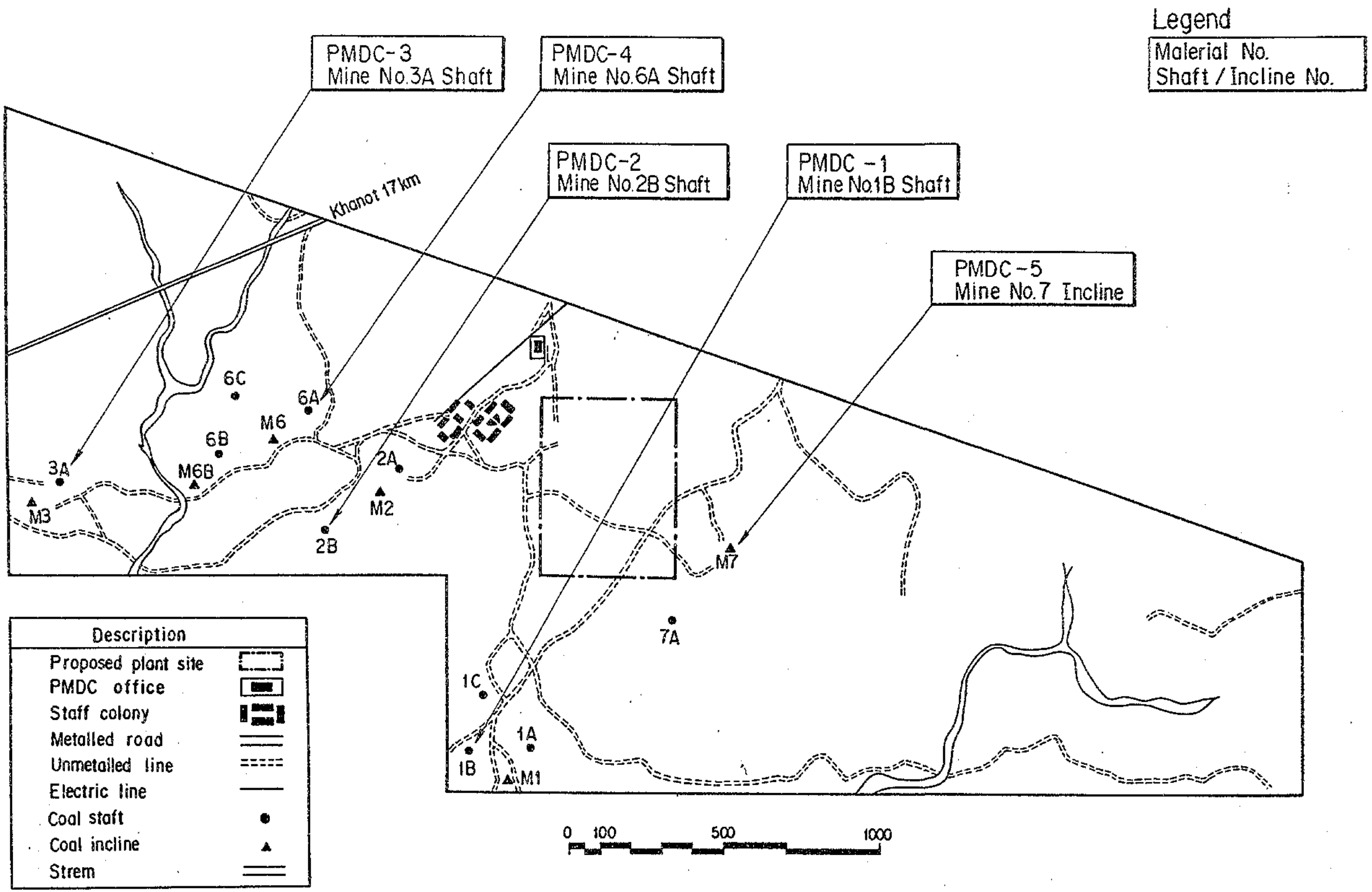


Figure 9-1-1 Coal Sampling Location in Lease No.88 in Lakhra Coal Field