3.2 Coal mine development plans

3.2.1 Selection of potential coal mines

In order to contribute to planning the development of coal resources, the potential abilities were examined for major coal deposits based on the following geological and mining conditions.

- Large coal reserves estimated over 100 million tons
- Simple geological structure and shallow occurrences
- Easy mining and large production ability
- Sufficient coal quality for existing and/or future coal utilization

As the result, a total of 14 coal deposits were selected as potential coal mines. The summary of 14 coal deposits is shown at long list (Table 3.7).

3.2.2 Required surface facilities for potential coal mines

Surface facilities required for potential coal mines which are listed on the long list (Table 3.7) are studied in this section. Usually the following service facilities are required for the mines; workshops and warehouses, power supply and distribution, water supply, steam and hot water supply, dewatering and drainage, crushing/sizing/loading, office, stockpile, transportation, communication, quality control system and etc.

Outline of individual facility is as follows;

1) Workshops and warehouses

Workshops must be equipped with sufficient facilities for the inspection, repair and maintenance of the plant and mining equipment. Repair shops are required the following spaces or bays for:

- Equipment repair,
- Heavy duty vehicle repair,
- Light weight vehicle repair,
- Electric repair,
- Undercarriage repair.

Workshop areas are composed of repair shop areas, service facility areas, warehouses, material handling areas, vehicle washing areas, vehicle parking areas and etc.

Mine fleet services are performed, in general, near the working areas and include refuelling,

Table 3.7 Long List

Coal Deposit	Megablock	Coal Class	Use	Calorific Value (kcal/kg) (are)	Calorific Value (kcal/kg) (daf)	Sulfur (%)	Reserves Mineable	Reserves Geological	Mining Method
1 (1) Nuurstkhotogor	West	Bituminous ~ Subbituminous	Steaming	5,400 ~ 6,100	7,560 ~ 8,430	0.3 ~ 0.5	142.3	166.6	O/C
2 (11) Tevshiingovi	Middle-South	Lignite	Steaming	3,370	6,450	0.7	587.7	960.0	O/C
3 (12) Tavantolgoi	Middle-South	Bituminous ~ Subbituminous	Steaming Coking	6,500	7,700 ~ 8,400	0.8	3,500	6,500	O/C
4 (17) Chandgantal	East	Lignite	Steaming	3,000 ~ 3,400	6,580	0.9	122.9	213.0	O/C
5 (16) Shivee Ovoo	East	Lignite	Steaming	2,690 ~ 3,610	6,660	0.5 ~ 0.9	564.1	2,700	O/C
6 (18) Talbulag	East	Lignite	Steaming	2,850	6,000	0.8	48.6	421.3	O/C
7 (19) Aduunchuluun	East	Lignite	Steaming	2,400	6,480	1.1	230.0	400	O/C
8 (20) Narynsohait	Middle-South	Anthracite ~ Subbituminous	Steaming Coking	(6,500)	(7,700 ~ 8,400)	(0.8)	40 ~ 50	200 ~ 250	O/C
9 (22) Khoot	Middle-East	Bituminous ~ Lignite	Steaming	4,800	7,030	0.7	82.3	190.9	O/C
10 (23) Tsaidamnuur	Middle-East	Lignite	Steaming	3,600 ~ 3,800	6,800 ~ 7,100	0.4 ~ 0.7	-	1,700	O/C
11 (24) Ovdok Huduk	Middle-East	Lignite	Steaming (Liquefying)	3,070	6,300	2.8	159.5	168.2	O/C
12 (25) Sainshand	Middle-East	Bituminous ~ Subbituminous	Steaming	5,050 ~ 6,730 (base unknown)		n.a	0.6	1,053	O/C
13 (26) Hulstnuur	East	Lignite	Steaming	4,430 (ad base)	6,470	0.7	11.2	190	O/C
14 (27) Tugrugnuur	East	Lignite	Steaming	-	6,240	0.8	-	695	O/C
(Note) 1)Above coal quality isn't coal quality standard in Mongolia									
2)Ulaan ovoo (Under construction)	Midle-East	Bituminous ~ Lignite	Steaming	4,270	7,370	0	24	42	O/C

routine servicing, tire maintenance and etc.

Mine fleet service facilities provide:

- Light weight vehicle services,
- Heavy duty vehicle services,
- Washing services,
- Refuelling and greasing services.

Mines are usually located in remote areas, therefore they should maintain stocks of spare parts, expendable items and replacement components required for plants and equipment in the warehouses.

2) Power supply and distribution facilities

Power is to be supplied from the CES (Central Energy System) through existing transmission line or an extension. Sometimes power is also supplied through a private generating station.

Distribution facilities, including transformers provide power at the required working voltage. Power is generally transmitted via overhead line to transformers, then by on ground cable to the equipment.

3) Water supply facilities

Potable water and industrial water are required for mining operations and townships. Hot water is also needed for both mining operations and townships as well. Underground water from the dewatering wells and drainage water may not be suitable for drinking, but is usually used for industrial purposes after water treatment. All sources such as rivers, lakes, ground water etc to be supplied should be considered optimum balance among them. It is necessary to investigate to prove the sustainability of a water source. Water is taken out from rivers, lakes or groundwater, then sent to the pump station through pipelines, sometimes directly, sometimes via water treatment facilities at the mining complex, and then delivered to places required.

4) Steam and hot water supply facilities

A number of processes require steam and hot water for heating and industrial purposes. Therefore boilers are to be constructed to meet the demand. Sometimes electric power generator is installed. Steam and hot water are delivered from the coal-fired boilers to places required through insulated pipelines.

5) Dewatering and drainage facilities

If the groundwater level is high and has effects on mining conditions and coal quality, it is necessary to dewater and lower the water level before mining. The groundwater is to be dewatered for a certain period before mining starts. It will be very difficult to mine the coal seams of which moisture content is very high and the dewatering would not be conducted. Therefore, it is necessary to dewater the groundwater without any delay. Water drainage is of prime importance for open pit mining operations. Ditches and pumps should be dug in and around the pit, and pumping facilities should be installed for the drainage. Water treating system should be installed when underground water quality needs the treatment.

6) Crushing/sizing/loading facilities

In regard to the coal quality, end users of coal suffer seriously from poor quality of coal including uncrushed run-of-mine coal, mixing with lumpy waste and foreign materials. A crushing, sizing and loading plant is needed for the coal mine, and all the run-of-mine coal should be processed at the plant before shipping.

7) Office facilities

In order to maintain mine and plant operations, an operational center will be required for management, planning and control of daily activities.

8) Stockpile facilities and transportation facilities

Crushed coal is delivered from the crushing / sizing plant to a loading section. Most of the coal is directly transhipped to train loading silos through a conveyor system. In case that freight cars are not available for loading, crushed coal is diverted to stockpile areas for temporary stock. Spontaneous combustion characteristics of coal must be seriously studied and proper procedures and facilities should be provided in both a raw coal stockyard and a product coal stockyard. A process of natural drying of coal may be required to reduce moisture content.

9) Communication

It is important to consider any communication both the external and internal services. Telephone, facsimile and mobile radio services would be required for the mine as well as for residential area.

10) Quality control system

- A selective mining method should be performed with a proper combination of mining equipment.
- Crushing / sizing / loading facilities.
- Laboratory of coal quality analysis.

3.2.3 Conceptual plans of viable coal mines

Among coal fields listed in the long list, most promising ones are selected for the preparation of the short list. The primary reason for the selection of the coal fields is possibility of supply of coal or electricity to Central Energy System. Table 3.8 and Table 3.9. show the results of the conceptional design for each coal mine listed in the short list. The conceptional design was implemented in the accordance with the following procedures :

(1) Estimation of minable coal reserves

Minable coal reserves (that is, available cumulative coal production) is calculated on the common mining conditions as follows :

stripping ratio : up to 4.2
mining depth : Less than 200m

Above-mentioned mining conditions are the same with those of the Baganuur coal mine renovation plan. Therefore, the economics of each coal mine development can be compared with that of the Baganuur coal mine renovation.

(2) Plan of annual coal production

The capacity of each coal mine is designed by the following manner :

Coal reserves	annual production
Larger than 100 million tons	2 million t/y
Smaller than 100 million tons	1 million t/y

Table 3.8 Short List

Coal Deposit	Megablock	Coal Type	Reserves (million tons)		Distance from railway	Distance from CES line	Estimated Production/ Ability million tons / year
			Mineable	Geological			
1 (12) Tavantolgoi	Middle-South	high-calorie steaming & coking coal	3,500	6,500	440 km	300 km	>1,000
2 (16) Shivee Ovoo	East	low-calorie steaming & coking coal	564.1	2,700	-	-	> 200
3 (17) Chandgantal	Middle-East	medium-calorie steaming & coking coal	122.9	213.0	160 km	100 km	> 200
4 (22) Khoot	Middle-East	low-calorie steaming & coking coal	82.3	190.9	90 km	50 km	> 100
5 (23) Tsaidamnuur	Middle-East	low-calorie steaming & coking coal	-	1,700	20 km	-	> 200
6 (27) Tugrugnuur	Middle-East	low-calorie steaming & coking coal	-	695	20 km	-	> 100

Table 3.9 Short List of Coal Development Plans

No	Area Name		Coal seam condition: Thickness (m)	Dip (°)	Strike length (km)	Reserves (10^6t): Depth (m)	Stripping ratio	Reserves	Coal mine development plan: Annual Production ($\times 10^3$t)	Average Over-burden removal ($\times 10^3$m³)	Volume of coal Production ($\times 10^3$m³)	Average mining volume ($\times 10^3$m³)	Fleet number	Capital (m$)	Operating cost ($/t)
1	Chandagantal		40	5	2	200	2.3	230	2,000	4,600	1,600	6,200	2.5	68	4.4
2	Tugrugnuur		5 / 50 / 15	7	15	88	4.2	288	2,000	8,400	1,600	10,000	4.0	95	7.1
3	Tsaidamnuur		15 / 40 / 30 / 20 / 15	5	4 / 5 / 6 } 5	200	2.3	864	2,000	4,600	1,600	6,200	2.5	68	4.4
4	Khoot	II	7	5	3	65	4.2	20	1,000	4,200	800	5,000	2.0	51	7.1
		III	6	5	3	55	4.2	15							
		V	7	2	3	58	4.2	50							
		Total						85							
5	Shivee Ovoo No. 2		8	6	4	71	4.2	29	1,000	4,200	800	5,000	2.0	51	7.1
			6 (100)	8	3	51	4.2	9							
			5	8	4	43	4.2	8							
			Total					46							
6	Tavantolgoi		VII 25 (100)	12	3	200	4.2	95	2,000	8,400	1,600	10,000	4.0	95	7.1
			IVD 10 / 20 / IVA 10 (70)	3	4	132	4.2	265							
			III 13	12	4	105	4.2	35							
			Total					395							

(3) Coal mine development plan

The mining system and equipment design are planned in accordance with the result of the Baganuur coal mine renovation study. The outline is as follows:

1) Bench cut method by using shovel and dump is applied.
2) The fleet of mining machines for overburden removal consists of $12m^3$ shovel and 80 - ton - dump trucks. The fleet of mining machines for producing coal consists of $10m^3$ front end loader and 40 - ton - trucks.
3) Overall averaged stripping ratio is adopted for all operation term and is considered to be constant.
4) The capacity of mining machines should be able to support the average amount of overburden removal and the amount of annual coal production.
   The capital investment is the sum of ones for mining machines, general purpose equipment and surface facilities.
5) Operating cost is calculated by multiplying the unit operating cost ($1.43/BCM) and total mining volume divided by annual coal production.

3.2.4 Exploration plans required for coal mine development

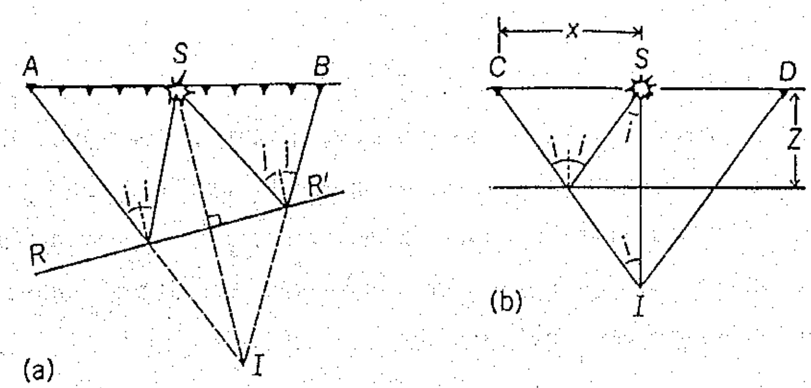
(1) Required exploration plans

On some of viable coal mines above selected, further additional exploration activities should be required because the existing geological information is not sufficient to detailed studies for the development plan. In regard to the method of exploration, the high-resolution seismic reflection survey should be recommended to be newly applied with the conventional drilling survey. The seismic reflection survey, which is not yet introduced into Mongolia, has been contributing largely to the field of recent coal exploration since it can directly produce a kind of geologic profile along the prospecting line. In particular, geologic events which are important factors for the coal evaluation such as faulting, folding and variation of coal seam thickness can be easily detected on the seismic reflection profiles, although the results of drilling survey are restricted within the geologic conditions at the drilled point. Considering the quality of seismic data mainly depends on surface topographic features and underground geologic features, these selected coal deposits have the most suitable conditions for conducting the seismic survey; the surface is formed of flat to gently undulated steppes and coal seams gently dip in general.

1) Introduction of seismic reflection survey

Seismic survey is the predominant geophysical activity. Seismic waves are generated by one of several types of energy sources and detected by arrays of sensitive devices called geophones or hydrophones. The most common measurement made is of the travel times of seismic waves. Although attention is being directed increasingly to the amplitude of seismic waves or changes in their frequency content or wave shape. Seismic survey is divided into two major classes, refraction and reflection. The refraction survey is used in engineering geophysics and mining and ground water survey to map bedrock under unconsolidated overburden because it can detect rocks characterized by high seismic velocity.

In reflection survey, seismic-wave energy partially reflects from interfaces where velocity or density changes. The measurement of the arrival times of reflected waves (Figure 3.22) permits mapping the interfaces that form the boundaries between different kinds of rock. This, the predominant geophysical exploration method, can be thought of as similar to echo sounding. In the figure (a) shown below, a seismic source S generates seismic energy which is received at detectors located at intervals from A to B. The distance to the reflector RR' can be obtained from the arrival time of the reflection if the velocity is known. If the reflector dips as shown, the reflection will arrive sooner at B than at A; the difference in arrival times is a measure of the amount of dip. The angles between ray paths and perpendiculars to the reflector (i) are equal at any reflecting point. The image point I is used as an aid in constructing the diagram.



(a) Dipping reflector (b) Flat reflector

Figure 3.22 Measuring Reflected Seismic Wave Energy

In field operation, seismic lines are often run parallel to each other at right angles to the geologic strike with occasional perpendicular tie lines, often run on a regular grid. Most seismic work has the objective of mapping interfaces continuously along the seismic lines to map the geologic structure. Geophone groups are usually spaced 5 to 20 m apart with 48 to 120 adjacent groups of 1 to 6 geophones each being used for each recording. The source is sometimes located at the center of the active groups ("split spread"), sometimes at one end ("end-on spread"). Following a recording, the layouts and sources are advanced down the line by half the distance over which the geophone groups are disposed (the "spread length") for continuous coverage. With surface sources such as vibrators, explosives and weight droppers, source trucks stop to deliver energy into the ground for a recording. They then move forward multiplied geophone spacing and repeat, and so on down the line.

Seismic data are corrected for elevation and near-surface variations on the basis of survey data and observations of the travel time of the first energy from the source to reach the detectors, which usually involve either travel in direct path or in shallow refractors. Data are usually processed by computers. A number of data outputs and displays are made during the processing sequence. These are analyzed for control and to determine parameters for subsequent processing steps.

The travel times of seismic reflections are usually measured from record section displays, which result from processing. A typical seismic section recorded at coal exploration is shown at Figure 3.23.

2) Exploration plans

Exploration activities are divided into two stages of first and second. At the first stage, general geological conditions of the projected area will be obtained with a grid interval of 500 to 1,000 m. At the second stage, more detailed prospecting will be carried out in order to clarify the coal seam conditions of such a portion as selected first mining site and blocks where additional information are required.

Excepting two deposits of the Tavantolgoi and Chandgantal of which coal seam conditions are already clarified by former detailed exploration, recommendable exploration plans for the other four deposits were preliminary examined as follows:

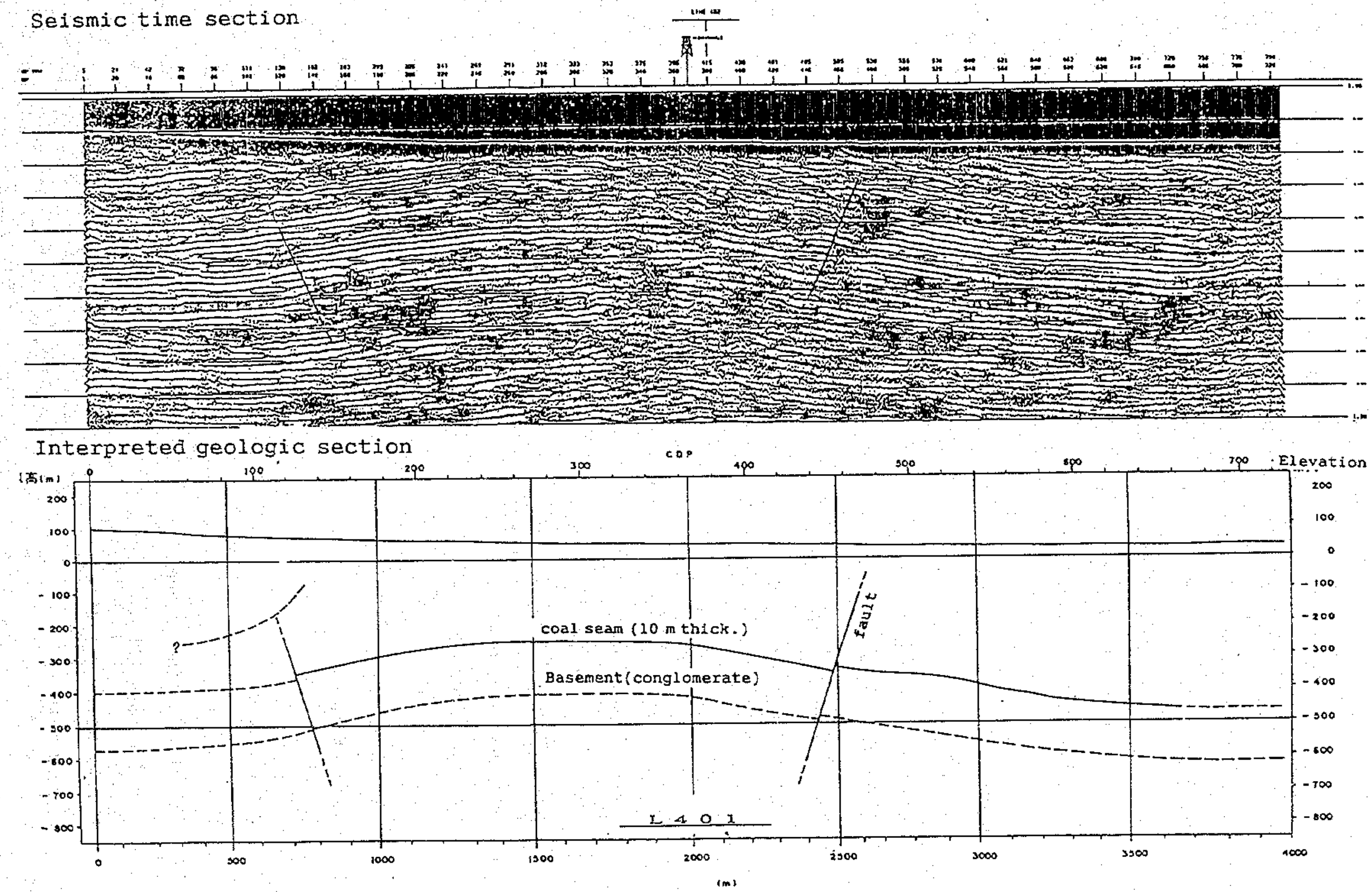


Figure 3.23 Example of Seismic Record

(a) Tsaidamnuur Deposit

The projected area is located at the central area of Tsaidamnuur Deposit, extending for 10 km north and 8 km northeast with an area of about 80 km^2. The information of geological conditions, in particular with regard to the continuity of minable coal seams are insufficient for the study, although the preliminary prospecting was carried out in 1980s. The field survey plan of the first stage is shown at Figure 3.24, and the tentative exploration schedule is shown at Table 3.10. All exploration activities are as follows:

First stage:

- Seismic survey
  NS lines : 6-11 km x 3 = 24 km
  EW lines : 4-10 km x 5 = 36 km
  total : 8 lines, 60 km
- Drilling survey (all coring)
  100 m x 10 = 1,000 m
  200 m x 10 = 2,000 m
  300 m x 7 = 2,100 m
  400 m x 4 = 1,600 m
  500 m x 1 = 500 m
  total : 32 holes, 7,200 m
  hole interval : 1,000 m
- Geophysical logging survey
  total : 32 holes
- Sample analysis
  total : 300 pieces

Second stage:

- Seismic survey
  total : 30 km
- Drilling survey (non coring)
  total : 30 holes, 4,000m
- Geophysical logging survey
  total : 30 holes

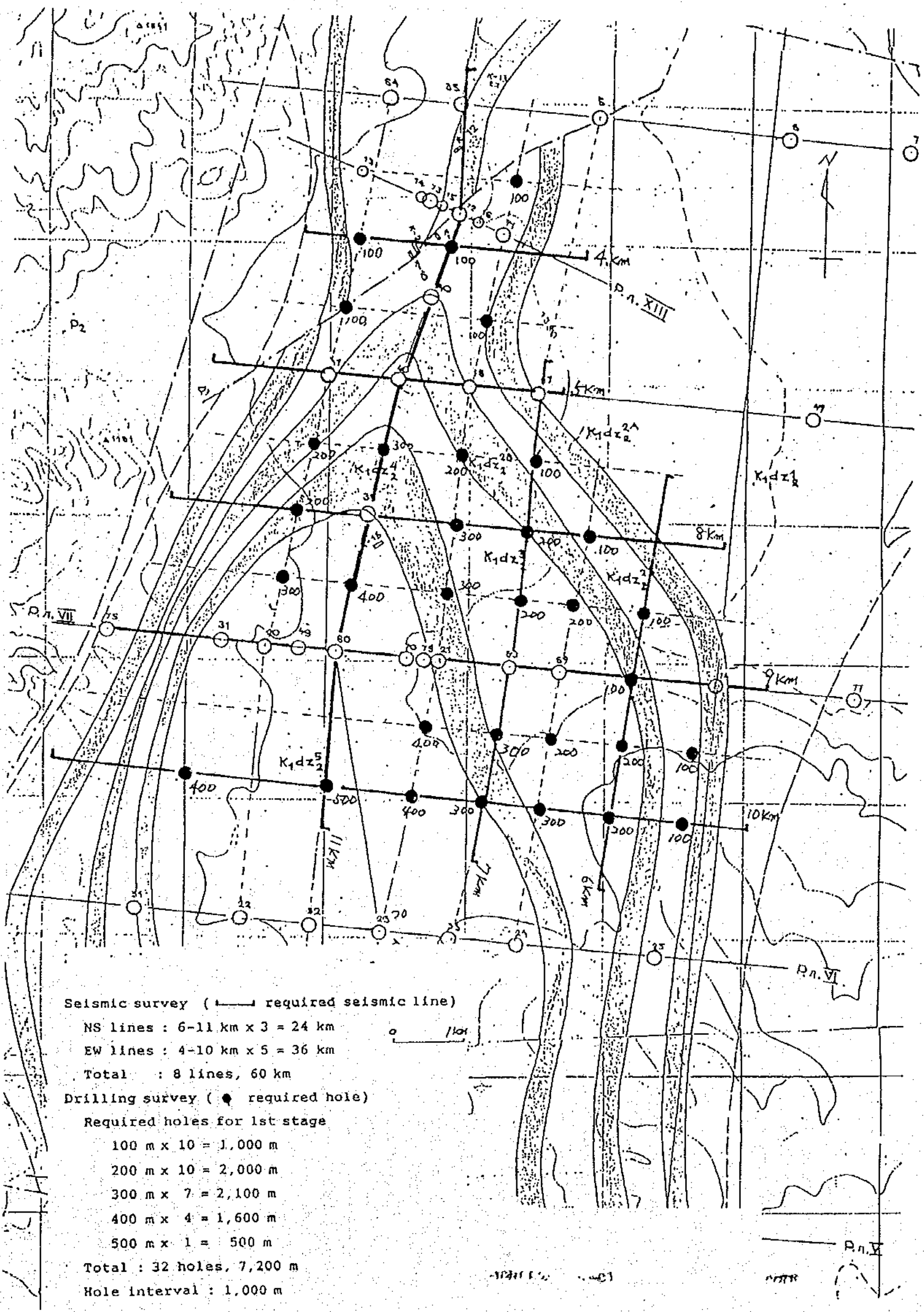


Figure 3.24 Field Survey Plan (1st stage) of Tsaidamnuur Deposit

Table 3.10 Exploration Schedule of Tsaidamnuur Deposit

	1 (4 5 6 7 8 9 10 11 12 1 2 3)	2 (4 5 6 7 8 9 10 11 12 1 2 3)	3 (4 5 6 7 8 9 10 11 12 1 2 3)	4 (4 5 6 7 8 9 10 11 12 1 2 3)
Advance arrangement				
· Reconnaisance survey	0.5			
· Planning & preparation	1.0			
<First stage>				
Seismic survey				
· Field operation	20km 2.0	40km 3.0		
· Data processing	2.0	2.0		
· Data analysis	2.0	2.0		
Drilling survey				
· Field operation	5 holes (2,100m) 3.5	10holes (2,700m) 5.0	17holes (2,400m) 5.0	
· Data analysis	3.0	3.0	3.0	
<Second stage>				
Seismic survey				
· Field operation			30km 2.0	
· Data processing			2.0	
· Data analysis			2.0	
Drilling survey				
· Field operation			15holes (2,000m) 3.0	15holes (2,000m) 3.0
· Data analysis			3.0	2.0
Geological interpretation & reporting	3.0	0.5, 2.0	1.5, 2.0	0.5, 1.0, 1.0, 2.0, 0.5
Geologist (class 2)	0.5, 1.0, 1.0, 3.0	1.0, 1.0, 3.0	1.0, 1.0, 3.0	1.0, 1.0, 1.0, 2.0, 0.5
(class 3)	3.5, 5.0	5.0, 5.0	5.0, 5.0	3.0, 3.0, 1.0, 2.0, 0.5
(class 4)	3.5, 3.0	5.0, 3.0	5.0, 2.0, 4.0, 0.3	3.0, 6.0
Geophysicist (class 2)	0.5, 1.0, 1.0, 1.0	1.0	1.0	1.0, 1.0, 0.5
(class 3)	2.0, 3.0	3.0, 2.0, 1.0	2.0, 2.0, 1.0	1.0, 1.0, 1.0
(class 4)	2.0, 2.0	3.0, 2.0	2.0, 2.0	

(b) Tugrugnuur Deposit

The projected area is for the whole area of Tugrugnuur Deposit, extending for 10 km north-south and 12 km east-west with an area of about 120 km^2. The geological information, in particular with regard to minable coal seam conditions, is restricted within few drill holes to be insufficient for the study. The field survey plan of the first stage is shown at Figure 3.25, and the tentative exploration schedule is shown at Table 3.11. All exploration activities are as follows:

First stage:

- Seismic survey
  EW lines : 2.5-13.0 km x 6 = 48.5 km
  NS lines : 3.0-15.0 km x 8 = 56.5 km
  total : 14 lines, 105 km
- Drilling survey (all coring)
  100 m x 10 = 1,000 m
  200 m x 30 = 6,000 m
  total : 40 holes, 7,000 m
  hole interval : 1,000 m
- Geophysical logging survey
  total : 40 holes
- Sample analysis
  total : 500 pieces

Second stage:

- Seismic survey
  total : 40 km
- Drilling survey (non coring)
  total : 50 holes, 7,000 m
- Geophysical logging survey
  total : 50 holes

(c) Khoot Deposit

The projected area is located around the existing mining site, extending for 8 km northeast and 6 km northwest with an area of about 40 km^2. The general geological conditions of

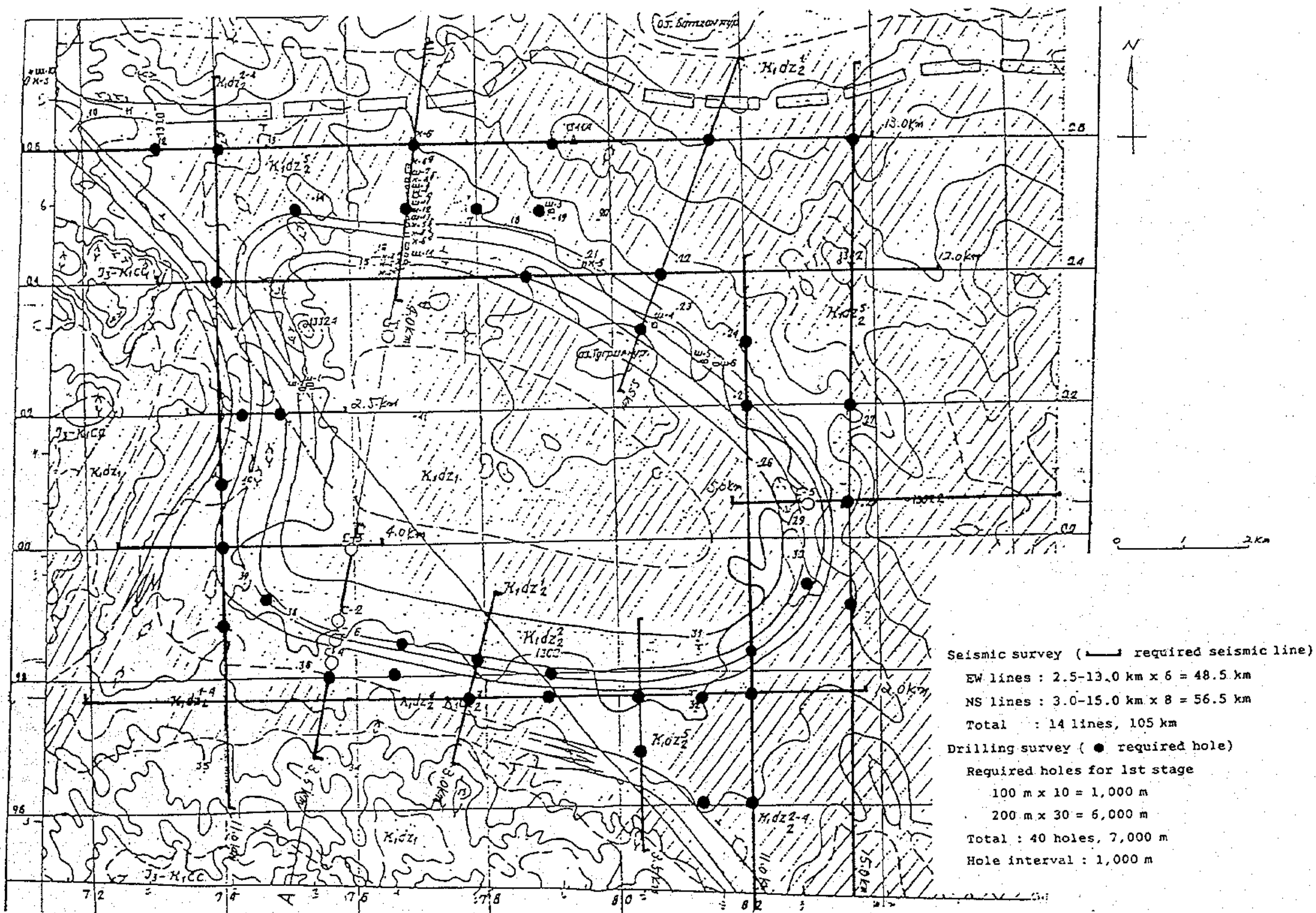
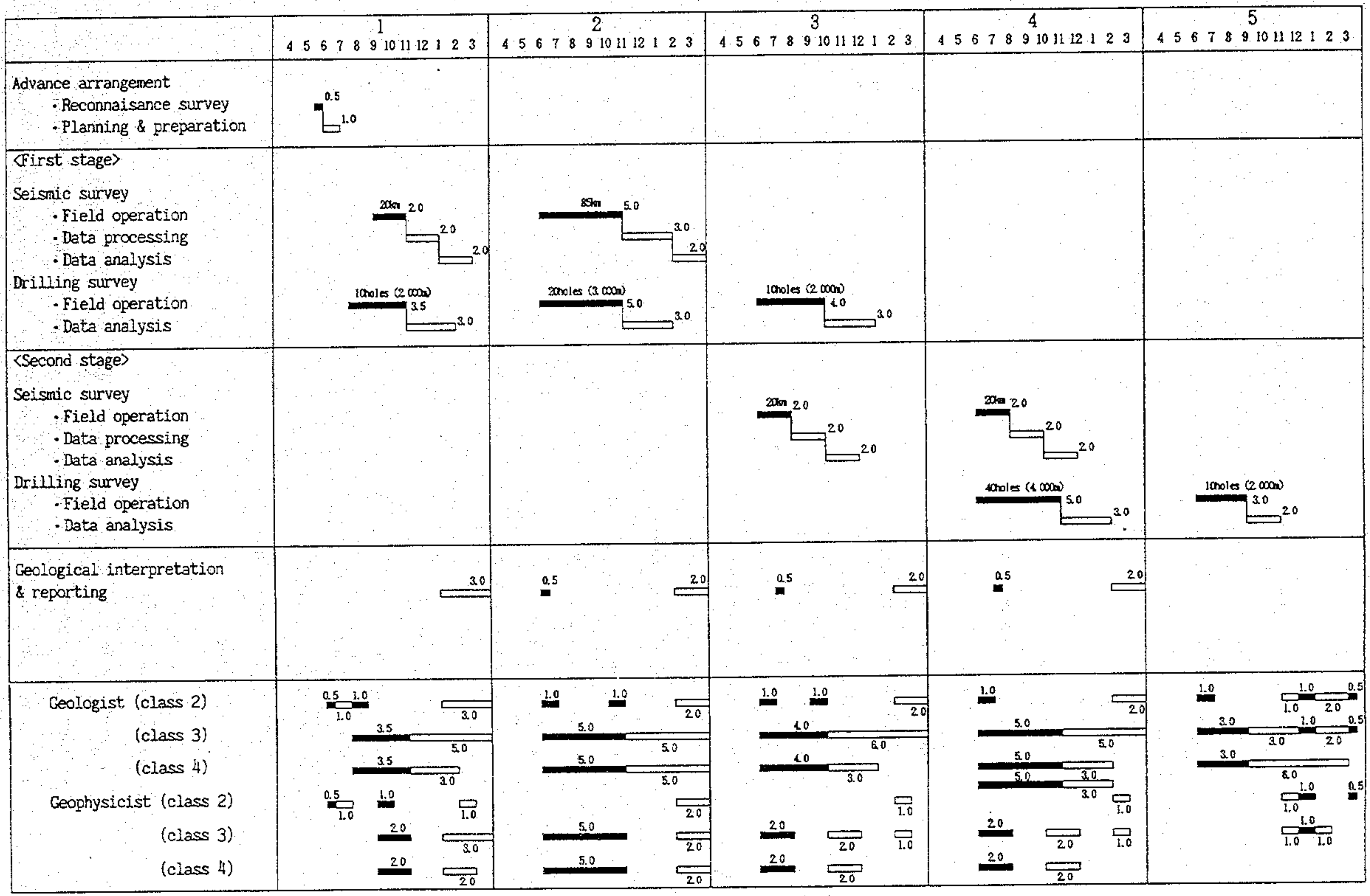


Figure 3.25 Field Survey Plan (1st stage) of Tugrugnuur Deposit

Table 3.11 Exploration Schedule of Tugrugnuur Deposit



whole area have not yet been clarified, although the detailed exploration was carried out partially. The field survey plan of the first stage is shown at Figure 3.26, and the tentative exploration schedule is shown at Table 3.12. All exploration activities are as follows:

First stage:

- Seismic survey
  NS lines : 6-7 km x 4 = 25 km
  EW lines : 7-8 km x 2 = 15 km
  total : 6 lines, 40 km
- Drilling survey (all coring)
  100 m x 3 = 300 m
  150 m x 7 = 1,050 m
  200 m x 12 = 2,400 m
  300 m x 3 = 900 m
  total : 25 holes, 4,650 m
  hole interval : 500-1,000 m
- Geophysical logging survey
  total : 25 holes
- Sample analysis
  total : 150 pieces

Second stage:

- Seismic survey
  total : 20 km
- Drilling survey (non coring)
  total : 20 holes, 3,000 m
- Geophysical logging survey
  total : 20 holes

(d) Shive Ovoo Deposit

The projected area is located at central area of Shivee Ovoo Deposit, extending for 5 km northwest and 4 km northeast with an area of about 20 km^2. The geological conditions such as structure and continuity of minable coal seams have not yet been obtained, Seismic survey (required seismic line)

NS lines : 6-7 km x 4 = 25 km

EW lines : 7-8 km x 2 = 15 km

Total : 6 lines, 40 km

Drilling survey (● required hole)

Required holes for 1st stage

100 m x 3 = 300 m

150 m x 7 = 1,050 m

200 m x 12 = 2,400 m

300 m x 3 = 900 m

Total : 25 holes, 4,650 m

Hole interval : 500-1,000 m

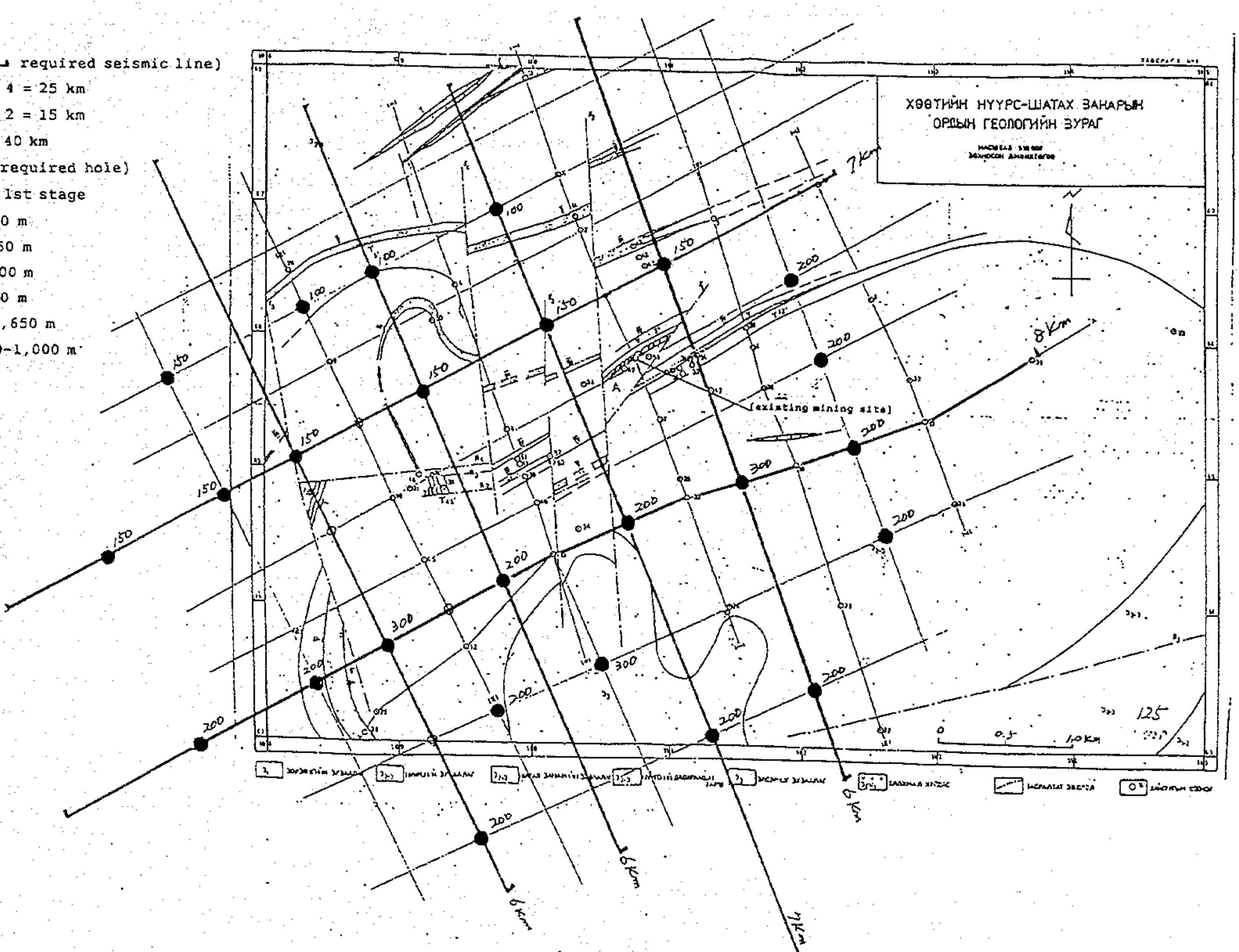
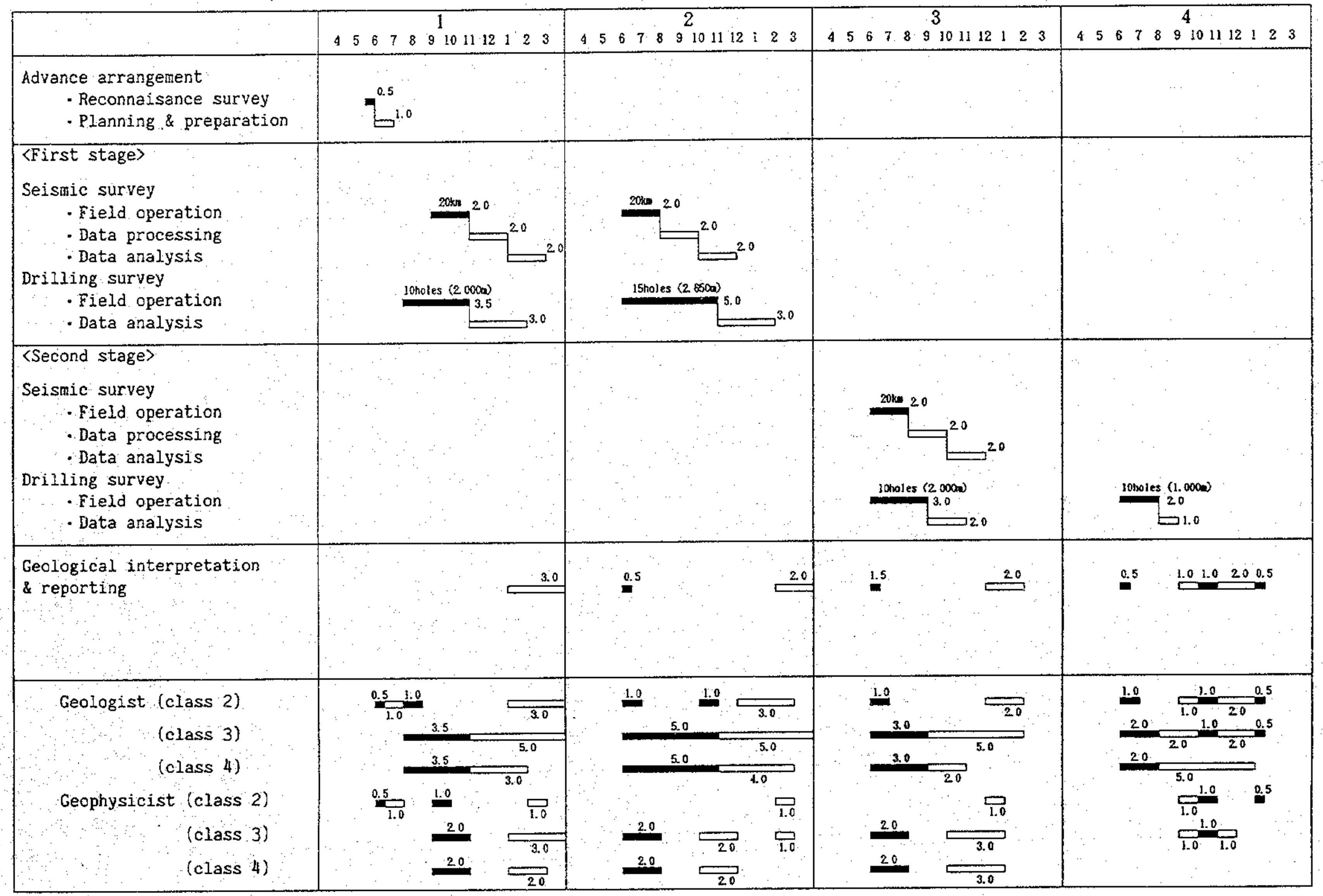


Figure 3.26 Field Survey Plan (1st stage) of Khoot Deposit

Table 3.12 Exploration Schedule of Khoot Deposit



although the preliminary prospecting was carried out in 1986. The field survey plan of the first stage is shown at Figure 3.27, and the tentative exploration schedule is shown at Table 3.13. All exploration activities are as follows:

First stage:

- Seismic survey
  NE lines : 4.0 km x 4 = 16.0 km
  NW lines : 4.5-5.0 km x 4 = 19.0 km
  total : 8 lines, 35 km
- Drilling survey (all coring)
  100 m x 17 = 1,700 m
  200 m x 6 = 1,200 m
  300 m x 2 = 600 m
  total : 25 holes, 3,500 m
  hole interval : 500-1,000 m
- Geophysical logging survey
  total : 25 holes
- Sample analysis
  total : 200 pieces

Second stage:

- Seismic survey
  total : 20 km
- Drilling survey (non coring)
  total : 20 holes, 4,500 m
- Geophysical logging survey
  total : 20 holes

(2) Exploration cost

The exploration cost is composed mainly of the field survey cost such as seismic data acquisition and drilling work and consulting cost for supervision and quality control of field survey, observation of drilled cores, data analysis and interpretation. A basis of both cost depends on the following assumptions.

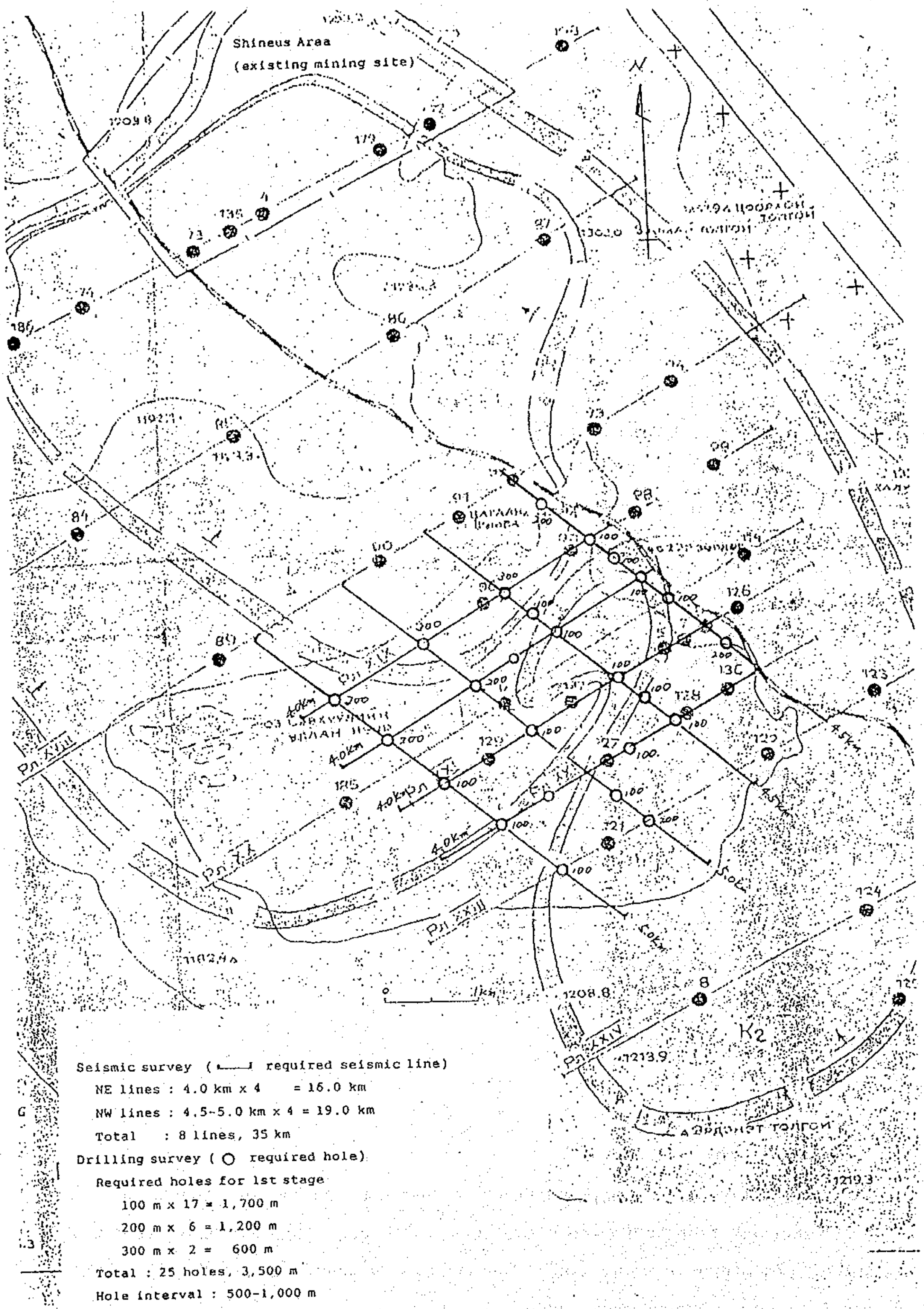
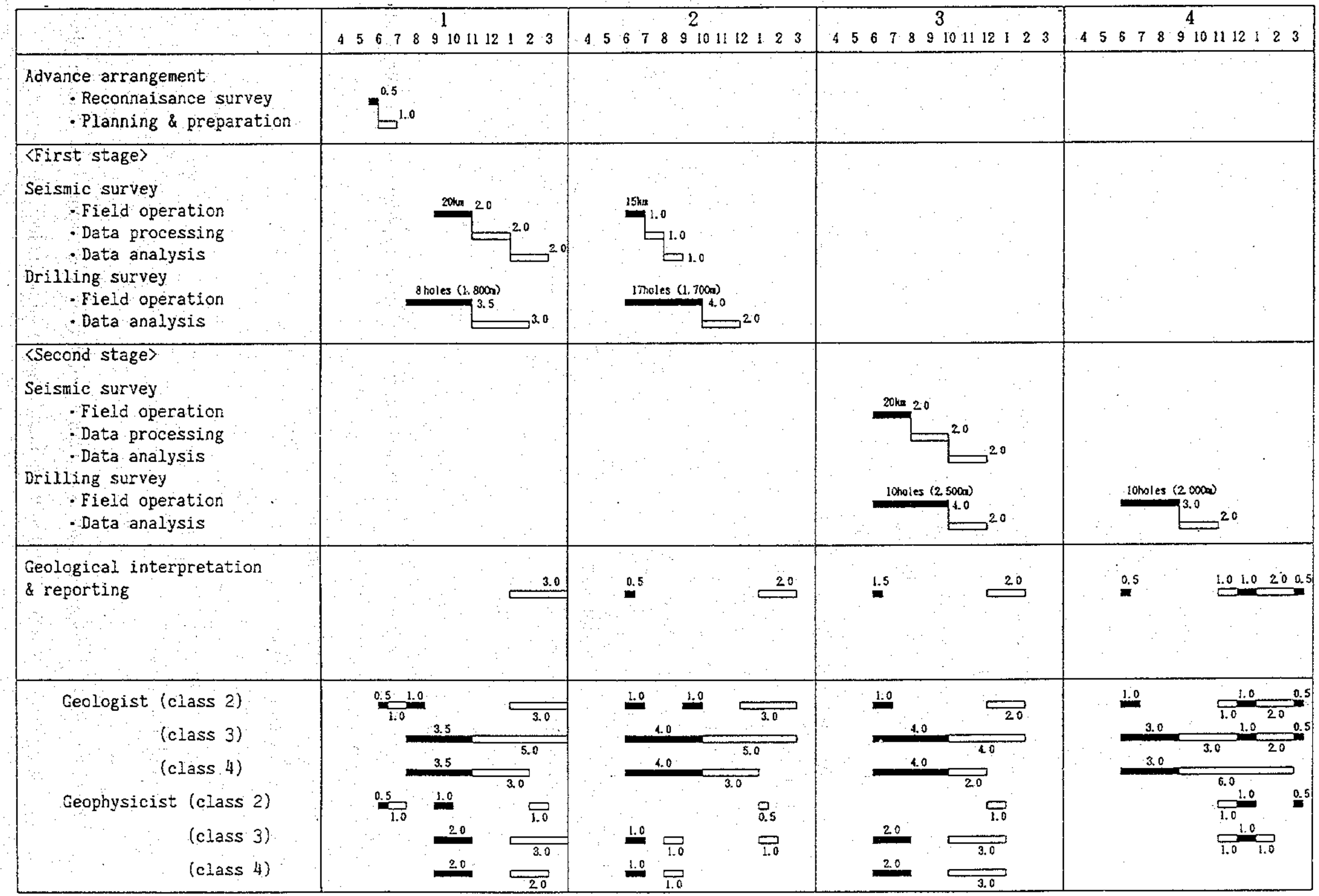


Figure 3.27 Field Survey Plan (1st stage) of Shivee Ovoo Deposit

Table 3.13 Exploration Schedule of Shivee Ovoo Deposit



< Assumption for Cost Estimation >

1) Seismic reflection survey
  - Cost of data acquisition / data processing
    30,000 US$ per kilometer
    including: Rental fee of equipments
      Mobilization/Demobilization
      Personnel expenses
      Accommodation and meals for personnel
      Consumable such as fuel
  - Basic parameters of data acquisition
    Recording system -- 120 channel system
    Receiver point interval -- 5 m
    Vibrator point interval -- 20 m

2) Drilling survey
  - Cost of drilling for coring holes
    50 US$ per meter
  - Cost of drilling for open holes
    20 US$ per meter

3) Geophysical logging survey
   4,000 US$ per hole

4) Analysis of coal sample
   20 US$ per piece

5) Consulting cost

Personnel expenses are estimated based on the tentative exploration schedule with the standard fee of JICA.

  - Organization of the exploration team
    senior geologist (1)
    geologist (2)
    senior geophysicist (1)
    geophysicist (2)

According to the field survey plan and schedule under the master plan level, each exploration cost for the four deposits is roughly estimated as shown at Table 3.14.

Table 3.14 Estimated Cost of Exploration by Each Coal Deposit

	<Shvee Ovoo>	<Khoot>	<Tsaidamnuur>	<Tugrugnuur>
- Period	4 years	4 years	4 years	5 years
- Seismic survey				
length	55 km	60 km	90 km	145 km
cost	$1,650,000	$1,800,000	$2,700,000	$4,350,000
- Drilling survey				
holes	45 holes	45 holes	62 holes	90 holes
length	8,0000 m	7,650 m	11,200 m	14,000 m
cost	$265,500	$292,500	$440,000	$490,000
- Geophysical logging survey				
holes	45 holes	45 holes	62 holes	90 holes
cost	$180,000	$180,000	$248,000	$360,000
- Sample analysis				
pieces	200	150	300	500
cost	$4,000	$3,000	$6,000	$10,000
- Sub-total of survey cost	$2,099,500	$2,275,500	$3,394,000	$5,210,000
- Consulting cost				
man-month	117.0	119.5	146.5	171.50
personnel expenses	$3,205,000	$3,272,000	$3,932,000	$4,610,000
others	$ 469,000	$ 487,000	$554,000	$629,000
- total cost	$3,674,000	$3,759,000	$4,486,000	$5,239,000
- Grand total	$5,773,500	$6,034,500	$7,880,000	$10,449,000

3.3 Infrastructure development plans

3.3.1 Infrastructure

Figure 3.28 and 3.29 show locations of potential coal mines and surrounding infrastructure including railroad, roads, power lines, towns and other mines. All of viable coal mines listed on short list need development of the following infrastructure:

(1) Townships

Due to the remote location of the project, a new town will be developed to provide accommodation for the labor force. It is expected that the population of the town will depend on the total labor force. The town development will commence at the same time as the mine pre-production development, so that accommodation will be available for operational personnel when mine development starts. Location, size of work force, mine life, existing facilities, and company and government policies will influence the magnitude of the residential and community facilities required. Township size is based on the work force requirements and allowance.

The following facilities should be provided for the town;

- Housing : for employees
- Roads
- Services : potable water, power, sewerage, drainage
- Recreation facilities
- Shopping facilities
- Community facilities : town hall, fire station, police, bank, post office
- Commercial facilities
- Medical facilities
- Educational facilities.

Construction costs will consist of three major portions:

- National or local government portion,
- Coal mine portion,
- Private or commercial portion.

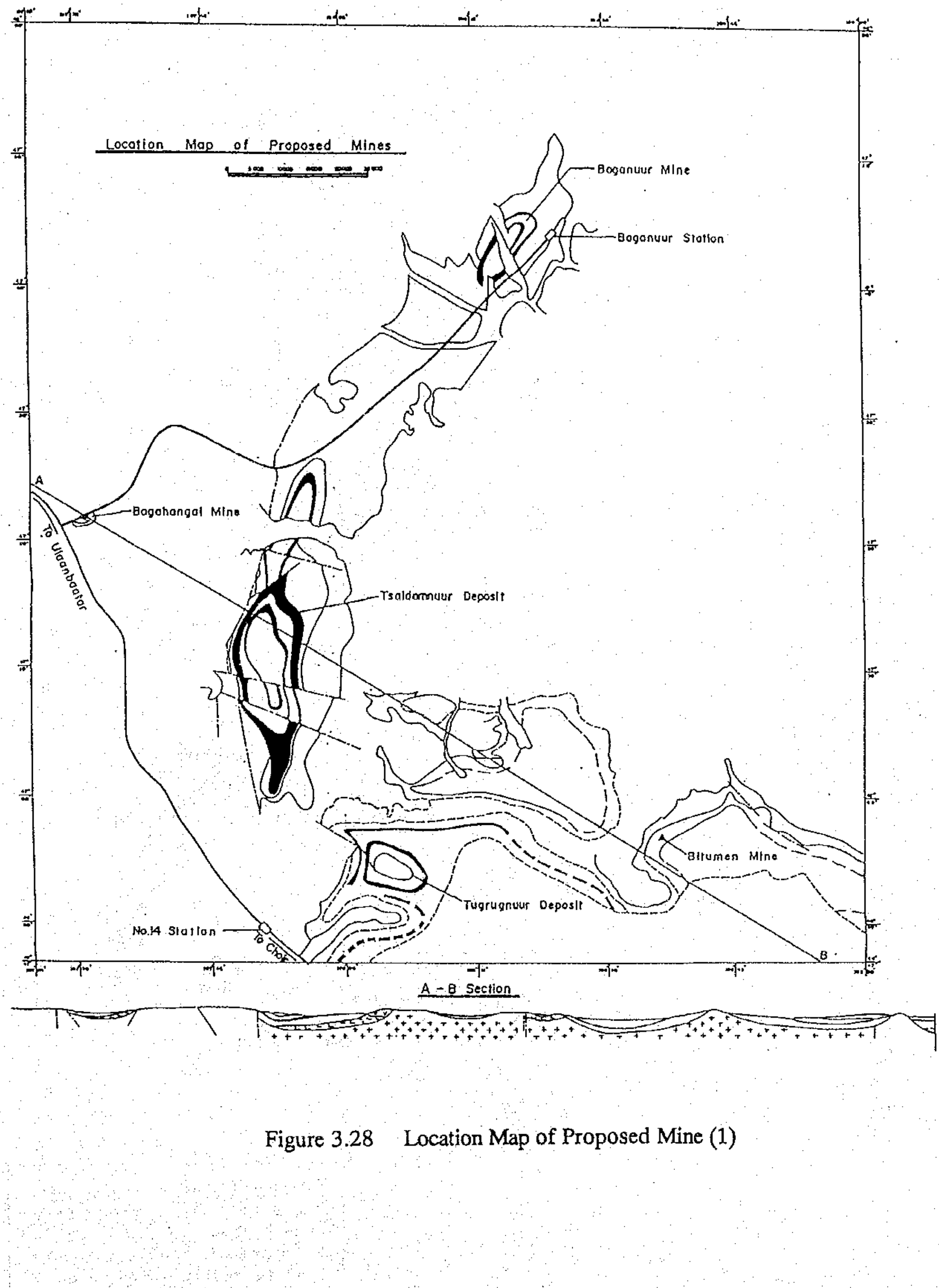


Figure 3.28 Location Map of Proposed Mine (1)

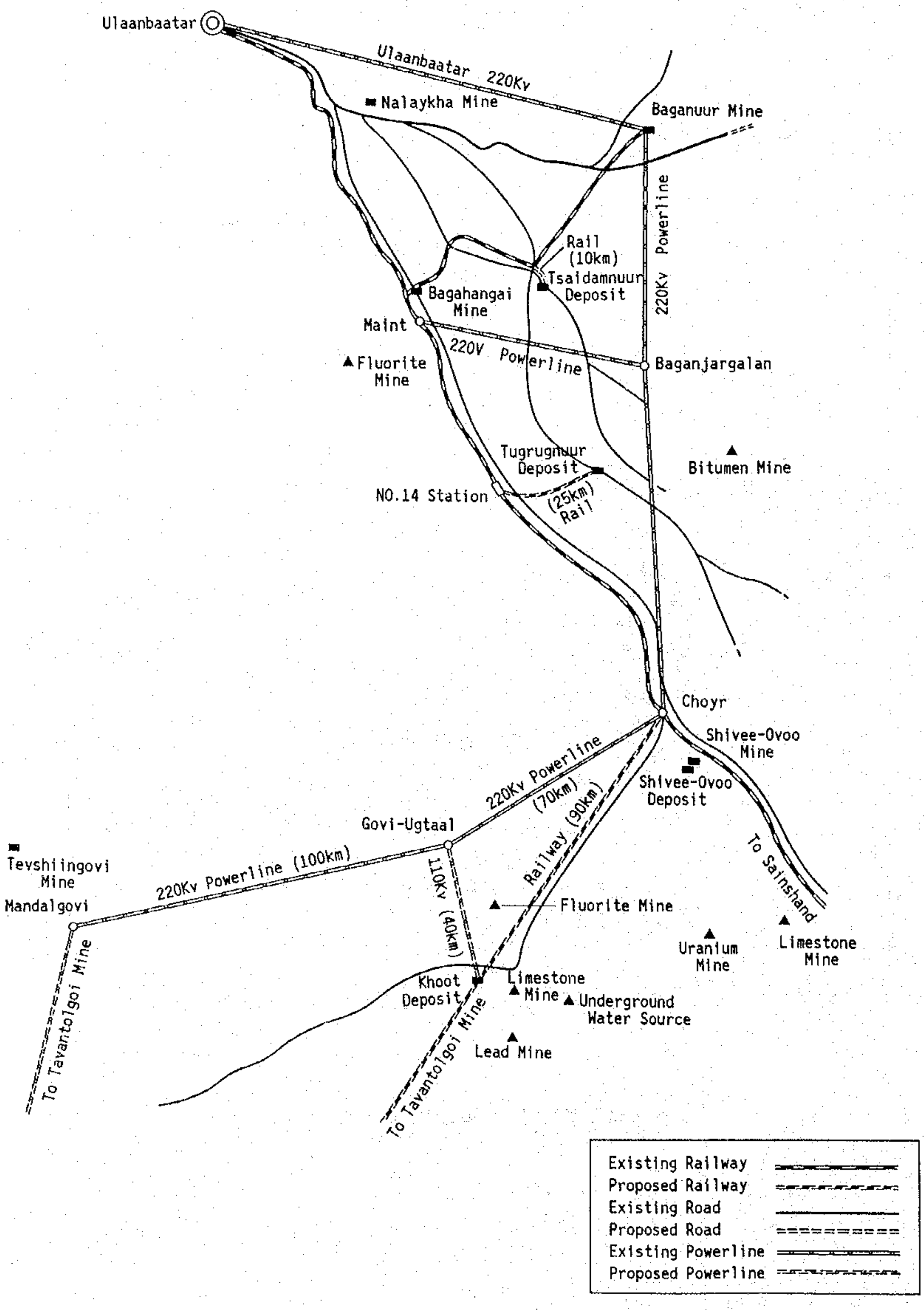


Figure 3.29 Location Map of Proposed Mine (2)

National or local government will be responsible to construct and build fundamental facilities, utilities and services for the community. The coal mining company will be responsible to construct houses for employees. Most of the employees will live in the apartment complex.

From the past experience, the following costs have been estimated for the construction of townships and housings.

Population	1,000	2,000	3,000	4,000	5,000	6,000	7,000	9,000
(Work force)	400	700	1,100	1,400	1,800	2,200	2,500	3,100
Cost estimates (US$ million)								
Government	12.0	18.0	24.0	28.0	32.0	36.0	39.0	45.0
Company	6.0	9.0	12.0	14.0	16.0	18.0	20.0	23.0
Commercial	-	-	-	-	-	-	-	-
Total	18.0	27.0	36.0	42.0	48.0	54.0	59.0	68.0

(2) Transportation and transmission line

Consideration and evaluation of the available transportation is essential. The transportation systems available for consideration include:

- Road
- Railroad.

1) Road

Existing roads in the area provide access to the portion of the property. Some parts of roads will be newly developed or up-graded depending on the location of the project.

2) Railroad

The coal will be transported by trains to consuming cities. A new rail line is to be constructed from the project site to connect with the existing line.

3) Transmission line and communication method

Power is to be obtained from the CES(Central Energy System) through existing transmission line or an extension. It is important to consider any communication both the external and internal services. Telephone, facsimile and mobile radio services may be required for the mine operations.

The following unit costs are used for the estimates:

- Road : US$ 45,000-450,000 (avg. US$ 247,500/km)
- Railroad :
  Track : US$ 450,000-900,000 (avg.US$ 675,000/km)
  Rolling stock : US$ 7,500/million tons. km/year
- Transmission line: US$ 67,500-75,000 (avg. US$ 71,250/km)

Cost estimates

- Road : US$ 247,500/km x 2 km = US$ 495,000
- Railroad :
  Track : US$ 675,000/km x 2 km = US$ 1,350,000
  Rolling stock : Refer to Table 3.15

3) Cost estimation for the development of social infrastructure and mine development : Refer to Table 3.16

3.3.2 Water resources

In operating a coal mine and a mine mouth power plant, potable water and industrial water should be supplied steadily. In planning to construct a mine mouth power plants, there should be water resources around the site, the supply capacity of which should be sustainable for the operation, especially for the cooling water.

Table 3.17 shows explored water resources around the potential mine mouth power plant. In the next stage of coal mine development or the construction of a mine mouth power plant, these exploration results of the water resources should be revalued or more precise survey should be considered according to the scale of the plan.

3.3.3 Training Center

According to the renovation study results of the Baganuur and Shivee Ovoo mines, the issues of these coal mines are pointed out as follows ;

Table 3.15 Cost Estimate for Rolling Stock

(Unit:US$ 1,000)

km / Million tons	10	20	30	40	50	60	70	80	90	100
0.5	38	75	113	150	188	225	263	300	338	375
1.0	75	150	225	300	375	450	525	600	675	750
1.5	113	225	338	450	563	675	788	900	1,013	1,125
2.0	150	300	450	600	750	900	1,050	1,200	1,350	1,500
2.5	188	375	563	750	938	1,125	1,313	1,500	1,688	1,875
3.0	225	450	675	900	1,125	1,350	1,575	1,800	2,025	2,250
3.5	263	525	788	1,050	1,313	1,575	1,838	2,100	2,363	2,625
4.0	300	600	900	1,200	1,500	1,800	2,100	2,400	2,700	3,000

Table 3.16 Cost Estimation for the Development of Social Infrastructure and Mine Development

Costs	Tavantolgoi	Chandgantal	Khoot	Tsaidamnuur	Tugrugnuur	Shivee Ovoo No.2
Social infrastructure						
Railroad						
Length(km)	440	160	90	10	25	0
Costs($000's)	297,000	108,000	60,750	6,750	16,875	0
Road						
Length(km)	* 300	* 160	* 90	10	25	0
Costs($000's)	13,500	7,200	4,050	2,475	6,188	0
Powerline(km)	300	100	40	25	15	0
Costs($000's)	21,375	7,125	2,850	1,780	1,069	0
Township						
Population	2,900	2,500	980	1,300	1,550	1,800
Costs($000's)	23,000	21,000	16,000	17,000	18,000	17,000
Other						
Costs ($000's)	33,188	12,233	6,765	1,100	2,413	0
Total costs	388,063	155,558	90,415	29,105	44,545	17,000

(Note) * upgrade

Above infrastructure plans correspond to coal mine development plans of the short list

Table 3.17 Water Resources around the Potential Mine Mouth Power Plant

	Coal mine name	Under ground								Surface (River)			
		name	Stage and year of exploration	Location (km)	Thickness(m) Aquifer / Depth interval	Geological age and rock type	Production capacity (X 10^3 m3/day)	Life time of exploration (year)	Quality (g/l) and Usage	name	Location (km)	Production capacity (X 10^3 m3/day)	Quality (g/l) and Usage
1	Tsaidamnuur	(n. a.)								Kherlen river	40~50	n. a.	Potable
2	Tugrugnuur	(n. a.)											
3	Khoot	(n. a.)	(n. a.)	15 / 50	(n. a.)	(n. a.)	(n. a.)	(n. a.)	Potable / Industrial	(no exsit)			
4	Baganuur	Baganuur (Alluvial valley of Kherlen river)	Detailed exploration (1976~79)	15 (East)	1.0~36.0 / 13.0~42.0	Q Alluvial	23.3	27	(Na Cl) 0.1~0.2 Potable	Kherlen river	9 (from the well)	n. a.	potable (Service water for city and mine)
5	Shivee Ovoo	Shivee Ovoo	Detailed exploration (1991)	8-40 (South to Choir railway station)	40.9 / 16.0-170.0	K Sedimentary rock	14.4	25	(Na Cl) 0.4~0.7 (South) 1.0~2.0 (North)	Kherlen river	80	n. a.	potable
6	Tavantolgoi	Balgasyn-Ulaanmuur	Detailed exploration (1987)	70 (South Wset)	15.0-70.0 / 1.0-100.0	Q Proluvium K Sedimentary rock	40.2	25	(Na Cl) Av. 0.8 (Potable in the west, Potable and industrial in the east)	Ongi river	210	n. a.	n. a.

(Source: MEGM)

(1) Overburden remove has been delayed mainly due to :

- Low capacity of railway system,which was caused by frequent trouble of whole system and/or equipment itself .
- Lack of spare parts for mining equipment and railway system
- Lack of experts and skilled labors for maintenance

(2) Delay of overburden removal forced to use draglines under unsuitable utilization methods, which has been causing decrease of yearly coal production.

(3) Large scale equipment causes sometimes long time break down due to difficulty of the repair by Mongolian specialists.

(4) Violent economic inflation decreased the present value of prepared spare parts and replacement of equipment.

To resolve above-mentioned issues, development of self-maintenance system by Mongolian is desired. The same kind of issues are also discussed regarding to the maintenance work and supply of spare parts for 25 of local coal mines. Their production capacity is less than 0.2 million t/y respectively. From above-mentioned reasons, the installation of a training center with the following functions is recommended:

(1) Training of operators and mechanics of mining equipment.
(2) Maintenance of major equipment including overhaul function.
(3) Parts center.
(4) Dispatch of maintenance experts from the center to the mine in case of heavy break downs of equipment.

In case that the training center has developed, it is expected that the maintenance technique for large scale mining equipment will be kept in high level, spare parts will be delivered promptly, and preventive maintenance will be advanced resulting in effective mine operation. The detailed plan of the Training Center is discussed in section 7.1.5.

3.4 Comprehensive study on coal development plan

3.4.1 Social impact on viable coal mine development

(1) General

Six deposits have been selected as potential coal mines; Tavantolgoi, Chandgantal, Khoot, Tsaidamnuur, Tugrugnuur and Shivee Ovoo mines.

(2) Tavantolgoi

Tavantolgoi deposit is an unique deposit, which contains coking coal for a blast furnace. The mine development is highly expected for Mongolia. It is of the country's need to produce the coking coal, export it and obtain foreign currencies. The most disadvantageous point is its location. It requires vast investment to develop infrastructure facilities such as railroad, road, transmission line, water supply, township and etc. It is also required to confirm and secure market potential of Tavantolgoi coal, transportation facilities and capability,competitiveness and etc. A transportation route of railroad, Tavantolgoi-Choir-Choybalsan-Tomanko (North Korea), has been researched and reviewed for the development and export of Tavantolgoi coal. There is another possible route to transport the coal directly to China through a new railroad. This area is rich in not only coal but also other mineral resources therefore it will be required to proceed a long-term plan of comprehensive study and development in connection with regional development policy and industrial promotion.

(3) Chandgantal

Chandgantal mine is located 160 km east from the existing railroad. A transmission line is located 100 km southwest of the mine. A 110 kV transmission line will be extended via Choir in the future. Chandgantal deposit should be developed for the coal-fired power plant at mine site instead of shipping the coal to CES area. Electricity generated at the site will be used for the development of western part of Mongolia.

(4) Khoot, Tsaidamnuur, Tugrugnuur and Shivee Ovoo deposits.

These four deposits are located in the same area centering around Choir. Railroads, roads and transmission line are available in the area, and they are connected from the existing ones with short extensions. Choir, Baganuur and Nalaikh are to be strong support for these potential deposits in regard to labor force and their industrial backgrounds. Khoot deposit is located a little bit away from Choir,and the Khoot coal can only be utilized as a substitute for Sharyngol coal. Surrounding areas are rich in mineral resources; fluorite, lead, limestone, uranium and so on. Some are in exploration stages, and others are in development stages. Coal supply and risk will be diversified after the establishment of the new mines. In conclusion, Choir will become one of the mining industry center, following after Erdenet and Baganuur.

3.4.2. Selection of coal mine development projects

From promising areas listed in the short list, Tsaidamnuur and Tugrugnuur could be selected as areas where coal mines could be developed for supplying low calory coal as fuel to the power plants located in Ulaanbaatar in CES, or supplying electricity generated by mine mouth power plant to be built in the future. It is because power lines and railway are constructed near to both two areas and social infrastructure in districts surrounding this two areas is comparatively well-conditioned and large scale with low calory coal mine could be developed in both two areas.

Khoot could be selected as a middle - scale coal mine to supply medium calory coal as the substitution for Sharyngol coal. At the present time, Sharyngol coal mine is the only one which supplies medium calory coal to power plants and boilers in Darkhan and Erdenet. And Sharyngol coal mine is being operated under difficult mining conditions. Annual coal productions of the former two large - scale coal mines and the latter middle - scale coal mine are two million tons and one million tons respectively. Once these three coal mines are developed, the total annual coal production will come up to five million tons. These three coal mine could overcome the forecasted shortage of coal supply in 2010. Table 3.18 shows selected coal development plans.

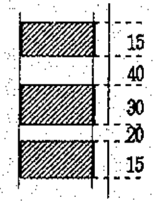
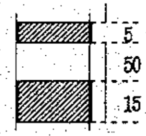
(1) Khoot mine

1) General

Present mining areas in Sharyngol coal mine are deeper than 200 meters and the strip ratios have been increasing year by year. As a minable reserve is limited to 30 million tons, it is supposed to maintain a production level at 1 million tons per annum from now on. And further, mining conditions is getting worse and operating costs have been increasing. It is very fortunate that coal quality of Sharyngol mine is superior to that of Baganuur or Shivee Ovoo mine.

The quality of Sharyngol coal is as below;

Table 3.18 Selected Coal Development Plans

No	Area Name		Coal seam condition: Thickness (m)	Dip (°)	Strike length (km)	Reserves (×10⁶t): Depth (m)	Stripping ratio	Reserves (×10⁶t)	Development plan: Annual Production (×10³t)	Cumurative Coal Production (×10³t)	Strike length (km)	Depth (m)	Total Stripping ratio *	Average overburden removal (×10³m³)	Volume of coal production (×10³m³)	Number of equip. **: Coal mining 5.7m³+46t	Stripping 12m³+80t
1	Khoot	II	7	5	3	65	4.2	20	1,000	20,000	3	34	3.8	3,800	800	1	2
		III	6	5	3	55	4.2	15									
		V	7	2	3	58	4.2	50									
								85								4	13
2	Tsaidamnuur			5	4, 5, 6 } 5	200	2.3	864	2,000	40,000	2	34	3.0	6,000	1,600	1	3
																8	20
3	Tugrugnuur			7	15	88	4.2	288	2,000	40,000	4	47	4.2	8,400	1,600	1	4
																8	27

(Note) * Coal within 10m from surface consists of overburden.
** The upper row is number of shovels and the lower is number of trucks.

Moisture(as received) :	15.0%
Ash(dry):	17.5%
Sulfur(dry) :	0.6%
Volatile Matter(dry ash free) :	41.0%
Calorific value(as received) :	3,900 - 4,200 kcal/kg

On the other hand, the quality of Khoot mine is as below:

Moisture:	13.8%
Ash :	14.5%
Sulfur :	0.7%
Volatile matter :	43.0%
Calorific value :	4,800 kcal/kg

The coal quality of Khoot mine is superior to that of Sharyngol mine, and Khoot coal can be utilized as a substitute for Sharyngol coal. The Khoot deposit is the only potential area to be a substitute for the Sharyngol mine. Therefore, the Khoot deposit should be developed as one of the new development areas.

2) Infrastructure and surrounding mines

A transmission line is already available between Choir and Govi-Ugtaal and this line will be extended toward Mandalgovi and be completed in the summer of 1995. Khoot mine is located 40 km south of Govi-Ugtaal. It is planned that a new transmission line is extended from Mandalgovi to Tavantolgoi in the future. It is also planned that a new spur track of around 90 km is constructed from Choir to Khoot. And further, the railway will be constructed from Khoot to Tavantolgoi in the future.

Uvdokhuduk deposit is located about 40 km south-east of Khoot. This deposit was explored in detail and feasibility reports are now available for development. Coal seams, however contain high sulfur, ranging up to 5 to 7%, proving that it is difficult to utilize the coal for burning. It is very attractive to utilize this source for coal liquefaction in the long term plan.

Surrounding areas of the Khoot deposit are rich in mineral resources; fluorite, lead, limestone, uranium and so on. Some are in exploration stages, and others are in development stages. It has been proved that the underground water source is available around Khoot area. A good potable water source is located at 15 km from the Khoot deposit and an industrial water source is available 50 km from the Khoot deposit. The water yield must provide adequate insurance to satisfy demand of both quantity and quality.

3) Conclusions

- A small coal mine has already been developed since 1993 and produces some thousand tons per annum for local use.
- This area is rich in coal, oil shale, fluorite, limestone, uranium, lead and so on. Therefore, it is very interesting to develop comprehensively all the available mineral resources.
- The Khoot coal is an only source to be utilized as a substitute for Sharyngol coal.
- The Khoot area is capable to contribute to the regional development and industrial promotion in the Choir and Shivee Ovoo areas.
- However, regional infrastructure should be developed in terms of railways, roads, transmission line, communications, water supply, etc.
- Once this area was developed and infrastructure facilities were established, it will be easy to justify a development of the Tavantolgoi project for the next development stage.

(2) Tsaidamnuur mine

1) Infrastructure and surrounding mines

This deposit is located in the south of Baganuur mine. A 110 kV and a 220V transmission line are located in the east and south of the Tsaidamnuur deposit. Two road routes pass through the deposit. Bagahangai coal mine and a fluorite mine are located around the Tsaidamnuur deposit.

2) Conclusion

- Infrastructure facilities are accessible.
- Geological structure and coal quality are very similar to those of Baganuur mine.
- Therefore, it is easy to develop this deposit with a small amount of investment for the infrastructure.

(3) Tugrugnuur mine

1) Infrastructure

This deposit is located 25 km east of the existing railway. Power will be supplied through a 110 kV transmission line which is laid from Baganuur mine to Shivee Ovoo mine via Basganjargalan. 220Vtransmission line is also laid from Maint to Baganjargalan which is one of the regional townships around the deposit.

2) Conclusion

- Geological, mining and infrastructure conditions are similar to those of Tsaidamnuur deposit.
- Like Tsaidamnuur it will be easy to develop this deposit with a small amount of investment for the infrastructure.

(4) Chandgantal

Chandgantal can not be selected. The coal quality of Chandgantal is low and can be used only for the thermal source. The prerequisite to expand existing small - scale coal mine or to develop new large - scale coal mine in Chandgantal is that electricity generated by the mine mouth power plant will be supplied to CES by power line. But in the present condition the distance from the CES power line to Chandgantal is approximately 130 km. And social infrastructure, for example, railway, has not been constructed. In order to consider the development of coal mine in Chandgantal, there has to be the background of basic regional development plan, for example the "Eastern regional economy development plan."

(5) Shivee Ovoo No.2

Shivee Ovoo No.2 can not be selected. In the same coal deposit Shivee Ovoo coal mine is operating. In the near future Shivee Ovoo coal mine will be improved in its surface facilities and expanded in its production. And social infrastructure of surrounding area will be expected to be progressed according to the expansion of Shivee Ovoo coal mine. Moreover, railway is constructed near Shivee Ovoo No.2 area. The mining condition of Shivee Ovoo No.2, however, is very poor. The large - scale coal mine development in Shivee Ovoo No.2 area is impossible because of thin coal seam and short strike length and small geological reserves. In developing Shivee Ovoo No.2 area besides Shivee Ovoo coal mine, too large amount of coal production will be concentrated at one area. It is not recommendable to develop Shivee Ovoo

No.2 area in addition to Shivee Ovoo coal mine in the same coal deposit. The security against shortage of coal supply from one concentrated area must be adopted. The risk of coal supply shortage must be reduced.

(6) Tavantolgoi

Tavantolgoi deposit has tremendous coal reserves. The quality of some seams is classified to coking coal and the other to thermal coal. Many sorts of geological explorations have been conducted by the former Eastern countries.

A feasibility study on development of some area was conducted by the former Soviet Union. It is long cherished by Mongolia to develop this deposit in large scale to produce exports which can gain foreign currency and supply domestic energy source. Tavantolgoi deposit is located in the remote, semi-desert and sparse populated area and is short of infrastructure such as railway, road, power line and water supply, etc. Therefore, it is not expected from the economic standpoint of view to develop this deposit as only coal supply source for domestic power plants in Mongolia. However, if the reliable users in the export market could be found, Tavantolgoi coal mine could get the first priority to be developed. In 7.1.4 the preliminary development plan of Tavantolgoi, one of selected coal mines, is implemented for export use in form of fuel coal, coking coal and electricity.

(7) Development principles

The quality of Khoot coal seams is well superior to those of Baganuur and Shivee Ovoo, and better than Sharyngol coal. The Khoot coal can only be utilized as a substitute for Sharyngol coal. Tsaidamnuur and Tugrugnuur deposits are located between Baganuur and Shivee Ovoo mines. Infrastructure facilities are well established including railways, roads, transmission line, communication systems, water supply, townships and etc. in surrounding areas. Choir will become one of the mining industry center, including not only coal, but also limestone, fluorite, lead, uranium, oil shale and so on. In conclusion, the shortage of around 5 million tons will be supplied from Khoot, Tsaidamnuur and Tugrugnuur. These three mines will be selected for the new development plans.

4 Coal Utilization Plan

4.1 Electric power sector including heating system

4.1.1 Present status

Most of the electric power facilities in Mongolia had been constructed by foreign aid, including preparation of development plan and construction of facilities. China was the first country to aid Mongolia until early 1960s, and U.S.S.R. and the East Europe took it over thereafter. It was around 1987 when Mongolia started its reform of the political and economic systems under the impact of the Perestroika. The stagnant aid from U.S.S.R., however, made demands on electric power supply and heat supply gradually smaller from 1989.

The main power system in Mongolia is operated by the Central Energy System (CES), which supplies electric power and heat to the three largest cities (Ulaanbaatar, Darkhan and Erdenet). It is composed of five interconnected coal fired thermal power plants as shown in the attached sheets in Figure 4.1 and Figure 4.2. Three power plants are located in Ulaanbaatar and the other two power plants are in Darkhan and Erdenet. Details of their functions are described in Table 4.1. In the other area of the country, outside of CES integrated power system, the electric power is normally supplied by diesel generators operated by municipal agencies, although there is one small coal fired power plant outside the CES system which supplies heat and electricity to the city of Choibalsan (24 MW) in the eastern part of the country.

The CES integrated power system is composed of about 1,000 km length of 220 kV line, 2,000 km length of 110 kV transmission line, 35 kV distribution lines and substations as shown in Figures 4.1 and 4.2 above. The system is also interconnected to the Russian power grid by 220 kV transmission line at the north of Darkhan. The CES grid has only one small scale hydro power plant (528kW), and thus electric power is imported from U.S.S.R. at peak load.
Followings are the present status and problems of electric power and heat supply systems.

(1) Electric power supply system

Coal fired thermal power plants are the biggest consumer of coal produced domestically. The largest and newest plant, Ulaanbaatar No. 4, was commissioned in 1991. All the thermal power plants are designed for co-generation of base load electricity as well as for hot water and process steam. All of the power plants are designed by Russian and are in serious and rapidly deteriorating condition because of poor maintenance and shortage of spare parts. There are also

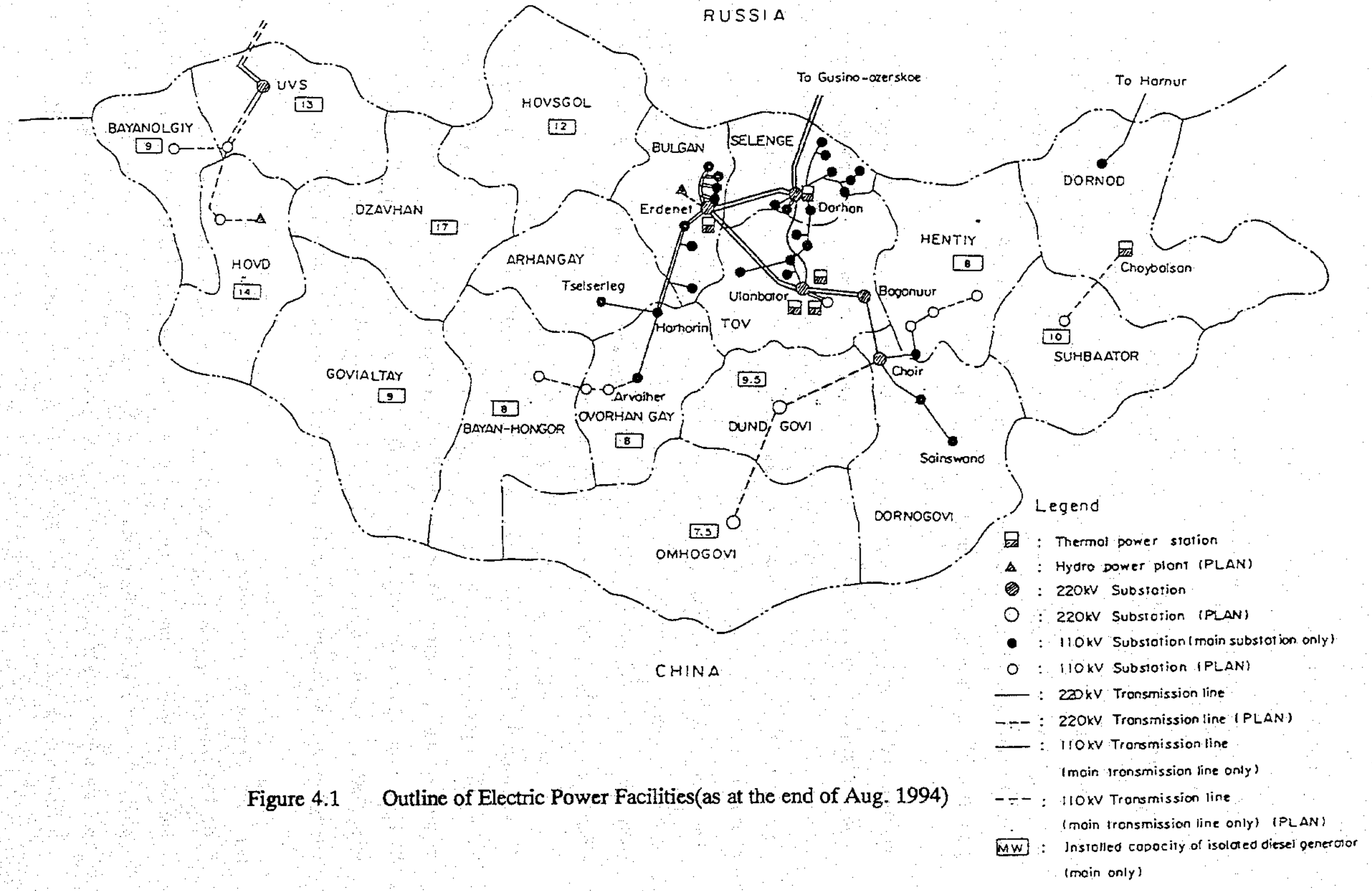


Figure 4.1 Outline of Electric Power Facilities(as at the end of Aug. 1994)

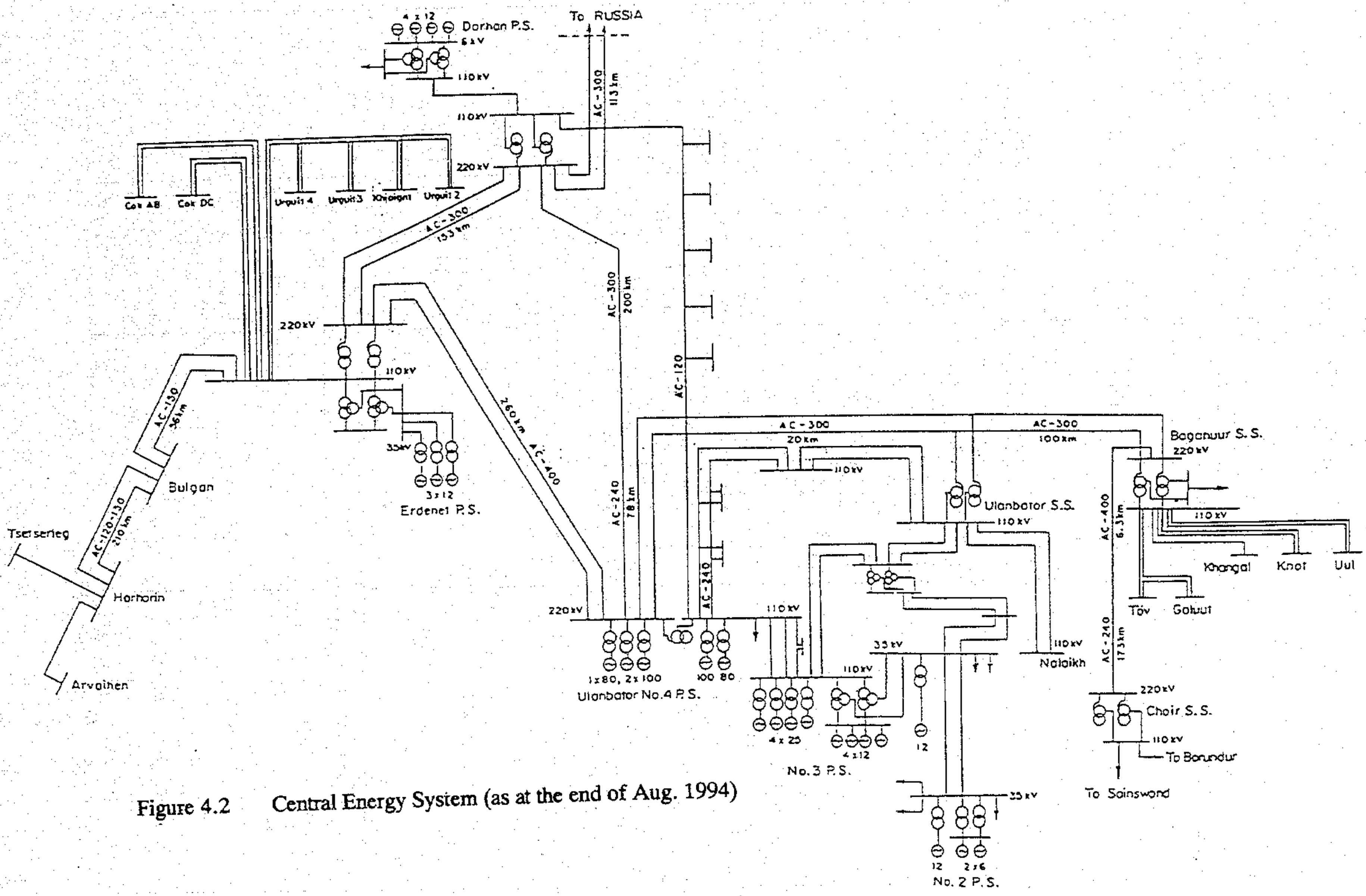


Figure 4.2 Central Energy System (as at the end of Aug. 1994)

Table 4.1 Power Generation and Heat Facilities(1993)

Name of Plant	Boiler: Rating, year of commissioning	Turbine-Generator: Unit No. & capacity	Turbine-Generator: Year of commissioning
Central Power system	(MW)		
Ulaanbaatar No. 2	(1) 35 t/h, 1960 (3) 35 t/h, 1961 (4) 75 t/h, 1969 (5) 75 t/h, 1969	No. 1 6 No. 2 6 No. 3 12	1960-10 1961-12 1978-8
(S-Total)		(24)	
Ulaanbaatar No. 3	(1) 75 t/h, 1968 (2) 75 t/h, 1969 (3) 75 t/h, 1969 (4) 75 t/h, 1969 (5) 75 t/h, 1973 (6) 75 t/h, 1975 (7) 220 t/h, 1976 (8) 220 t/h, 1977 (9) 220 t/h, 1978 (10) 220 t/h, 1979 (11) 220 t/h, 1979 (12) 220 t/h, 1980 (13) 220 t/h, 1981	No. 1 12 No. 2 12 No. 3 12 No. 4 12 No. 5 25 No. 6 25 No. 7 25 No. 8 25	1973-8 1973-12 1974-7 1975-12 1976-12 1977-12 1978-12 1979-12
(S-Total)		(148)	
Ulaanbaatar No. 4	(1) 420 t/h, 1983 (2) 420 t/h, 1984 (3) 420 t/h, 1984 (4) 420 t/h, 1985 (5) 420 t/h, 1986 (6) 420 t/h, 1987 (7) 420 t/h, 1990 (8) 420 t/h, 1991	No. 1 80 No. 2 100 No. 3 100 No. 4 100 No. 5 80 No. 6 80	1983-10 1984-11 1985-12 1986-12 1990-2 1991-12
(S-Total)		(540)	
Erdenet	75 t/h x 9, -	No. 1 12 No. 2 12 No. 3 12	1987 1988 1989
(S-Total)		(36)	
Darhan	75 t/h x 9, -	No. 1 12 No. 2 12 No. 3 12 No. 4 12	1965-10 1966-2 1966-6 1966-12
(S-Total)		(48)	
Total in Central Power System		796 MW	
Isolated System			
Choybalsan		No. 1 6 No. 2 6 No. 3 12 No. 4 12	1969-10 1969-11 1979-12 1982-10
(S-Total)		(36)	
Scattered diesel plants		about 185 MW in total	
Total in Isolated Systems		221 MW	

(Source) MEGM. Aug. 1994

Table 4.2 Installed Diesel Power Station in Mongolia . (In total about 185 MW)

(the end of 1993)

Capacity / Provinces	the unit capacity of diesel power station (MW)													Total generation	Total cap. (MW)
	0.06	0.1	.16	0.2	0.3	0.32	0.4	0.63	0.69	0.8	1.2	1.8	2.5		
Arhangay	14	13						1		7				35	8.4
Bajanulgii	29	18	1			2			8					58	9.9
Bajanhongor	35	10		2		3			5			2		57	12
Bulgan	5	2												7	0.5
Gobi-altay	46	13				2			8			2		71	14
Dornot	17	12		12		4				1			1	47	9.2
Dornogobi	18	6								4			2	30	9.9
Dundgobi	21	16		1		2				6				46	8.5
Zavhan	39	17			3	5				11	4			79	20
Uburhargay	38	4		1	2			2		4				51	7.9
Umnugobi	16	13	3					4		7				43	11
Suhbaatar	16	11				3				8				38	9.4
Selenge															
Tuv	7	2			2									11	1.2
Ubs	35	17		2	2	3			7		4	1	1	72	20
Hovd	18	10				5			5		6			44	14
Hubsugul	32	21				4	2	2	10	1		2		74	19
Hentii	20	7	2			9				8				46	12
Total quantity	406	192	6	18	9	42	2	9	43	57	14	7	4	809	
Total cap. (MW)	24	19	0.9	3.6	2.7	13	0.8	5.7	30	46	16	13	10		185

Note: Army services diesel power stations are not included in the above list.

(Source) MEGM. Aug. 1994

problems with supply and handling of coal. As a result, the available generating capacity is below the installed capacity of the system of 796 MW and the CES is unable to fulfill supply of the present peak demand of 480 MW, and thus power import from Russia is inevitable at peak load.

Existing power plants used for power generation and heat production are located in the cities of Ulaanbaatar, Darkhan and Erdenet, therefore, most of coal consumed at power plants are transported to the cities by railway with cost basis. As results of combustion of low grade coal in cities and poor environmental protection system at power plants, air pollution is affecting life of the publics.

1) Problems on existing boilers

Ulaanbaatar No. 4 power plant is the biggest in the CES having generating capacity of 540 MW and it has about 70% of total generating capacity of the CES.

Specification of boiler (Total 8 units)

Boiler capacity :	420 tons/h
Boiler pressure :	140 kg/cm^{2}g
Steam temperature :	560°C
Designed coal calorific value :	4,000 kcal/kg

Above-mentioned boilers correspond technologically to the boiler product of late 1950s in Japan.

Baganuur coal has been supplied to the power plant ever since the beginning of its operation. Its heating value was about 3,500 kcal/kg, and the value has gradually declined because of poor coal quality control.

Recently, the plant has to inevitably started to combust Shivee Ovoo coal which has less than 3,000 kcal/kg of heating value with more than 30% of moisture, which requires huge amount of drying air.

As results of recent poor coal quality supplied to the plant, boiler pressure dropped from 140 kg/cm^2g to 100 kg/cm^2g and steam temperature also dropped from 560°C to 540°C. Therefore, units are being operated at low efficiency of steam turbine as well. In order to keep stable and safe operation, imported heavy oil is used even though it is costly.

Coal supplied to the power plants contains large lumpy coal, rocks, metals and other foreign materials and these materials cause severe damage to belt conveyer and plug in a hopper.

The causes of problems in operation and maintenance of coal fired thermal power plants are summarized as follows:

- poor maintenance
- lacking spare parts
- low quality of coal including low calorific value (not conform to design value)
- poor facilities of coal handling
- poor ash handling system
- poor environmental facilities

(2) Heat supply system

Heating system during cold season in Mongolia district central heating and hot water is supplied during the period beginning on September 15th and ending on May 15th of the next year. Supply of steam to factories is all year round. Three thermal power plants in the capital city of Ulaanbaatar are supplying electric power and heat.

Steam is being extracted from the intermediate stage of turbine and hot water is supplied through a heat exchanger. Hot water supply pipeline diameter is 800 - 1,200 mm and length of the pipeline laid is about 240 km. Thermal power plants in the city of Erdenet and in the city of Darkhan are also supplying hot water. Conditions to supply hot water to the capital city of Ulaanbaatar are as follows.

- Steam for industry:

Pressure		8 - 13 kg/cm^2
Temperature	Delivery	250 - 300°C
	Return	70°C

- Hot water for heating:

Pressure		0.5 - 1.5 kg/cm^2
Temperature	Delivery	150°C
	Return	70°C

This system is also suffering from poor maintenance and operation similarly to the electric power supply system.

4.1.2 Electric power development plans

(1) Basic direction of future plan

According to our forecast of demand on electric power, peak load (maximum demand) will grow as follows (For MEGM's forecast, see Table 4.3):

	(L)	(H)
2000	518 MW	545 MW
2005	695	787
2010	980	1,239

In order to cope with such growth, firstly, existing coal fired thermal power plants in the CES grid, three in Ulaanbaatar, one each in Darkhan and Erdenet, are required to rehabilitate not only main equipment of boilers and steam turbines but also many auxiliary equipment including coal handling facilities to keep rated generating output and life of the plants.

Egiin hydro power plant (55 MW x 4 = 220 MW) will be developed first and put into operation around in 2000. Egiin will be the first large scale hydro-electric power station in Mongolia and located near the CES grid. The plant is designed to generate the peak power which the CES can not presently satisfy.

The second recommendable construction of mine mouth coal fired power plant will be in either Baganuur or the central and southern areas of the CES. Its reasons are that the central (except Ulaanbaatar) and southern areas have no power plants, and that Baganuur and the other mines in that area have enough reserves of coal and production capacity.

Table 4.3 Power Demand in CES(Actual/Forecast)1985 - 2010

(MW)

Years	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2005	2010
Power consumption						543	565	620	655	685	730	775	930	1082
Peak load	442	530	485	459	464	473	485	530	560	590	630	660	750	872
Reserve power						70	80	90	95	95	100	115	180	210
Installed capacity	509	689	710	796	796	796	796	796	796	796	851	994	1428	1628
Available power	398	539	469	447	400	488	536	606	636	636	691	834	1238	1400
CFPP-2	21	15	11	10	13	13	12	12	12	12	12	0	0	0
CFPP-3	136	102	76	99	83	93	110	110	110	110	110	110	110	90
CFPP-4	195	380	335	321	269	340	360	430	460	460	460	460	430	430
Darhan CFPP	46	24	31	17	19	24	36	36	36	36	36	36	36	24
Erdent CFPP	0	18	16	16	16	18	18	18	18	18	18	18	18	12
New power plant	0	0	0	0	0	0	0	0	0	0	0	100	400	600
Egiin gol HEP	0	0	0	0	0	0	0	0	0	0	55	110	220	220
Choibalsan CFPP	0	0	0	0	0	0	0	0	0	0	0	0	24	24
Excess (power)	0	0	0	0	0	0	0	0	0	0	0	59	308	318
Power shortage	-114	-72	-96	-12	-64	-55	-29	-14	-19	-49	-29	0	0	0

(Source) MEGM. Aug. 1994

The existing CES grid is composed only of coal fired thermal power plants, except interconnected Russian grid. At least one pump storage hydro power plant is,therefor, recommended to put in to operation at around year 2010 to utilize mid-night surplus power which is not able to reduce lower than minimum generating output. It is quite economical because pumped up water will be used at daily and seasonal peak demands.

The expansion of power transmission line in the CES grid including interconnection with Choibalsan coal fired power plant is also planned by the Ministry and the CES. The plan, however, will be carefully implemented because of increment of system losses.

(2) Coal fired power plant

The CES power grid is going to extend to the southern and eastern areas in order to supply electric power to the public and industrial development facilities; such as metal mining, coal mine and other natural resources. In this view point, utilizing coal at mine mouth coal fired power plant is more economical and recommendable than to construct new plant or additional unit in Ulaanbaatar. Followings are points of its strength:

- It is able to avoid coal transportation problems by rail way.
- It is able to minimize coal stock at power plant.
- Easier coal management such as quality control and procurement.
- Avoid too much centralization of power sources in the capital city (Ulaanbaatar).
- Improve system losses due to power supply from Ulaanbaatar to the eastern and southern consumers.
- Minimize environmental problems in Ulaanbaatar.

From the study results of coal development and its supply capability, Baganuur, Shivee Ovoo and Tavantolgoi have high potential to develop mine-mouth power plant.

(3) Mine mouth power plants

A site for coal fired thermal power plant is determined evaluating from the following categories.

- Accessibility to plant site.
- Suitable topographical and geological conditions.
- Availability of sufficient areas for power plant, coal storage and ash disposal.

- Availability of room for future expansion.
- Power system stability.
- Stable availability of sufficient condenser cooling water and no recirculation problems of thermal effluent.
- Availability of good quality and abundant fresh water in the vicinity of the plant site.
- Availability of electric power for construction works.
- Capability to unload and transport heavy machines.
- Availability of construction materials and aggregation.
- Closeness to power consumption areas.
- Little environmental impact caused by plant construction.
- Availability of work force

Based on the evaluation results of candidate sites and cost study, optimum project site and capacity of plant are decided.

However, none of sites satisfy all of the criteria at once. Therefore, the final conclusion must be made by assessing how each problem can be technically solved and at what cost.

Three mine sites of Baganuur, Shivee Ovoo and Tavantolgoi are proposed as candidates of mine mouth coal fired thermal power plant from a study result of coal resources and accessibility from the CES grid for new coal fired power plants.

Coal characteristics of three mines are shown in the following Table 4.4.

Table 4.4 Coal Characteristics of Candidate Mine

	Minable Cap. (MT)	Coal Quality					
		Moisture (are) %	Ash (d) %	Vol. (daf) %	S (d) %	Calorific Value (are) Kcal/kg	Calorific Value (daf) Kcal/kg
(1) Baganuur	515.8	31.0	12.1	44.6	0.4	3,870	7,070
(2) Shivee-Ovoo	564.1	43.6 34.5	17.3 8.7	45.7 44.0	0.9 0.5	2,690 3,610	6,600 6,700
(3) Tavantolgoi	3,500.0	6.9	14.9	32.8	0.8	6,500	7,700 - 8,400

1) Baganuur

A mine in Baganuur city is located 120 km southeast of Ulaanbaatar city and has population of about 12,000. The city was constructed in 1980 in order to develop open cut coal mine to produce 2 million tons of coal at beginning and expanded its production year by year up to 4 million tons at peak.

Most of coal produced at Baganuur mine has been transported to Ulaanbaatar by railway. The coal is used at Ulaanbaatar No. 3 & No. 4 power plants for power generation and heat supply system. The mine mouth power plant in Baganuur is studied by U.S.S.R. and Japan Consulting Institute (JCI) in order to cope with expected increase with demand.
Determination of Baganuur mine as a spot for constructing a new thermal power plant is considered adequate because of the reasons as follows.

(a) Baganuur coal mine is located about 120 km from the capital city of Ulaanbaatar which is the largest consumer of electric power. Proved coal reserve is 567 million tons which is considered abundant.

(b) The mine is producing about 4 million tons of coal a year and equipped with reasonably well organized infrastructure including excavating facilities, road, housing and so on. The mine is well equipped for the increase of coal production.

(c) Two 220 kV transmission lines of 400 MW transmission capacity, which are part of the Central Energy System and interconnection with Ulaanbaatar, are already installed in the city of Baganuur. And thus new transmission line is not required.

(d) A railway was installed through the Baganuur city in 1979. It makes easy transport of plant, equipment and materials needed for the construction of power station from Ulaanbaatar.

(e) Various industrialization projects, including manufacture of children's garment, food, insulators and reinforced concrete are being contemplated in the district. A part of electric power generated by the power station is available for consumption by those industries. Future needs for heat supply within the Baganuur city can be met by making the power station capable of supplying heat in addition to electric power.

(f) If it is constructed in Ulaanbaatar, the power station would need a new railway system for the transport of coal, since existing railway system is not capable of handling coal transportation needed by the power station.

(g) There is a river near the city and its water can be used for cooling system.

2) Shivee Ovoo

Shivee Ovoo coal mine is located 260 km southeast of Ulaanbaatar and about 100 km West of Baganuur coal mine. The mine was developed in 1992 and produced about 0.6 million tons of coal in 1993 and about 564 million tons are minable. Most of coal from the mine are transported to Ulaanbaatar and used at Ulaanbaatar No. 4 power plant.

(a) As the mine is located near the main railway that runs from China to Russia via Ulaanbaatar, produced coal can be transported without much investment.
(b) The mine is also located near 220 kV of power transmission line which is expanding to the Southern of Mongolia.
(c) The mine has huge amount of minable reserve of more than 560 million tons.
(d) However, the coal quality is likely to be combusted at mine mouth.
(e) Cooling water for the power plant is available from the river located not so far from the mine site.

3) Tavantolgoi

Tavantolgoi coal mine is located about 540 km south of Ulaanbaatar and 96 km southeast of Dalanzadgad. The mine has high grade coal and huge amount deposit as shown in the previous Table 4.4. However, the existing production amount is rather small comparing with other two candidate mines and its annual production is only about 100 thousand tons.

Judging from the following points, the priority of Tavantolgoi mine to utilize as mine mouth coal fired power plant is lower than the other two mines and it is recommendable to develop the mine for export purpose.

(a) Location of mine is too far from power demand.
(b) There is no river near the mine to use for plant cooling system and coal washing.
(c) Coal quality is good enough to transport and export

(4) Fludized-Bed Combustion (FBC)

Fludized bed boiler has been developed to use a wide variety of fuels including low grade coal.

In general, there are three ways to burn coal in a boiler on a grate (stoker fired), as an open flame (Pulverized coal fired), or in a fluidized bed. Fluidized bed combustion, theoretically lies between the other two.

In a fludized bed, bed material such as sand or limestone in a fludizing state is heated up to 500 - 600°C by firing auxiliary fuel such as light oil. Coal, which has a maximum particle size of 12 mm or an average particle size of 4 - 6 mm, is then fed into the bed and starts to burn. The auxiliary fuel is then cut off and the bed temperature is maintained at 800 - 850°C. The boiler evaporation section and superheater tubes which are immersed in the bed absorbs the heat and generates steam. Because of the low combustion temperature, the level of NOx emission is lower than that from other combustion methods. Direct desulflurization can also be achieved by introducing limestone ($CaCo_3$) together with the coal. Here, sulfur in the coal reacts with limestone to produce a gypsum ($CaSo_4$) which is eventually taken out of the bed by an overflow. The state of combustion has a similarity to volcanic eruption.

Fludized bed combustion has many advantage compared with conventional pulverized coal fired one (PCF). Advantages of the fluidized bed combustion boiler are as follows:

1) It can burn a wide range of fuels

A wide range of coals can be burned in the same fluidized bed combustor.
PCF: Capable of combusting about ±10% of designed coal calorific value
FBC: Capable of combusting about ±20% of designed coal calorific value

2) It can burn fuels economically in an environmentally acceptable manner

Low level NOx emission and the capability of desulfurization within the bed can eliminate very expensive stack gas treatment equipment.
Total cost of investment and operation for DeNOx and DeSOx, FBC is about 50% of PCF.

3) Large heat transfer co-efficient

The heat transfer co-efficient of the heating surfaces immersed in the bed is extremely high.

Heat transfer ratio
PCF: 49 kcal/m^2.h.°C
FBC: 267 kcal/m^2.h.°C

This feature ensures economy of design with a greatly reduced heat transfer area.
As a result, the construction cost of FBC plant is about 5 to 10% cheaper than PCF.

4) Applicability of FBC in Mongolia

Most of coal in Mongolia has low heating value and wide range, therefore, it is quite recommendable to apply FBC especially at mine mouth power plant.

In the case of FBC, boiler efficiency, operationability and maintainability are almost the same as the pulverized boiler.

In view point of environmental protection, FBC has big advantage comparing with other type of boilers.

(5) Export electric power by HVDC transmission line

Utilizing huge deposit of coal in Mongolia, to generate electric power and to export it to neighbour countries are one of the attractive plans to accelerate economic development of Mongolia.

In general, comparing with the AC transmission, the DC transmission is more suitable for long-distance and large power transmission since the tower can be smaller which reduces the construction cost. Furthermore, since the DC transmission has many merits, like the practicability for system stabilization because of no stability limit on the transmission, ability of quick power control and ability of introducing or connecting large power supply without increasing the short-circuit capacity, the DC transmission is used more popularly.

One of the prospective plans of effective utilization of an abundant coal in Mongolia is to generate electricity at a mine mouth power plant and send it to neighbour countries such as China, Korea and Japan by the DC transmission line. The following technical outline and economic data which are obtained from a model study will indicate the viability of the above-mentioned plans.

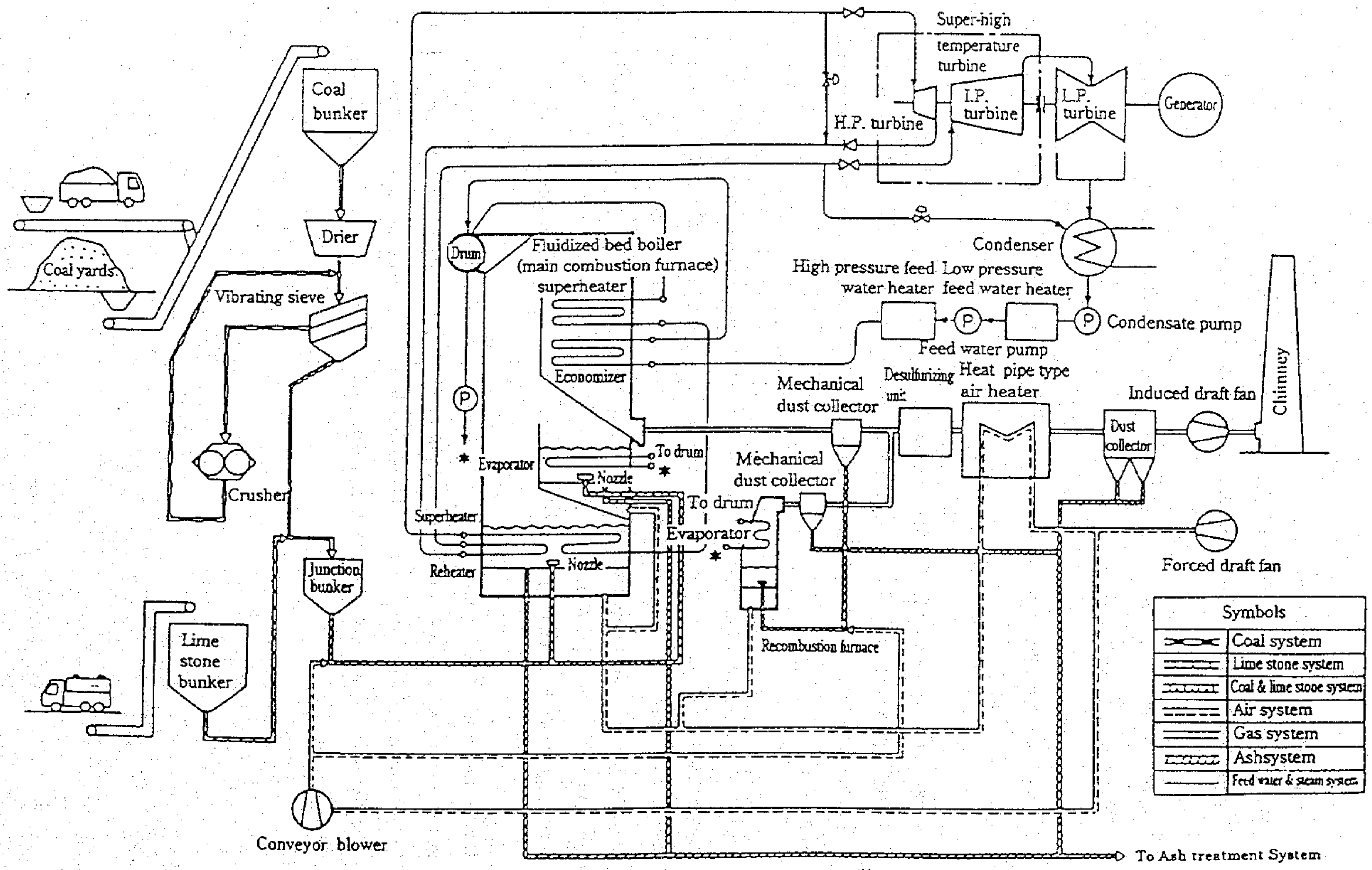
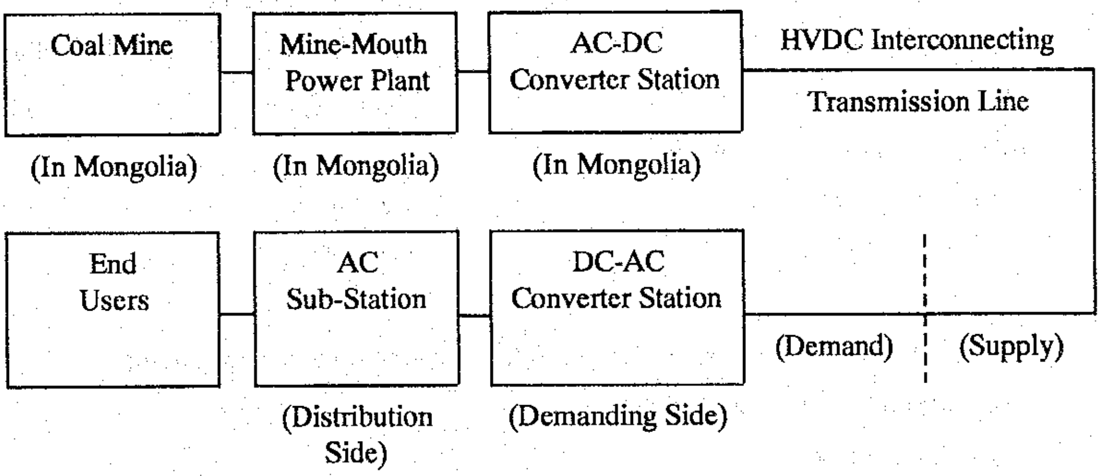


Figure 4.3 Fluidized Bed Combustion

1) Considerable basic development scheme is as follows :



2) Outline of plan is assumed as follows :

(a) Required coal	:	9 M. ton/year
(b) Calorific value	:	6,200 kcal/kg (Tavantolgoi)
(c) Plant factor	:	70%
(d) Heat rate	:	38%
(e) Generator output	:	4,000 MW (500 x 8)
(f) HVDC voltage	:	± 500 kV
(g) Transmission distance	:	1,200 km from Tavantolgoi
(h) Conductor	:	610 mm^2 x 4 x 2
(i) Converter station	:	2 bipolar
(j) Transmission loss	:	11.4
(k) Power plant loss	:	6.5%
(l) Converter station loss	:	1.25 x 2 = 2.5%

Above figures are classified as follows :

Calculated figure	:	(a), (g), (i)
Design data	:	(b), (d), (e), (f), (h)
Assumed figure	:	(c), (j), (k), (l)

3) Estimated and assumed cost data (US$)

(a) Coal price	:	10 dollar/ton
(b) Revenue	:	90 M. dollar/year

(c) Capital cost

Power plant	:	4,000 M. dollar
Converter station	:	400 M. dollar x 2 = 800 M. dollar
HVDC transmission line	:	600 M. dollar

(d) Estimated electricity cost (before tax)

At mine-mouth	:	3.0 cents
At end users	:	3.9 cents

Above calculations were made based on following assumptions and formula.

a) Item (c) Capital cost (US$)

Power plant:

(1,000 \$/kW) x (4,000 x 10^3 kW)

= 4,000 x 10^6 dollar

Converter station :

(100 \$/kW) x (4,000 x 10^3 kW) x 2

= 800 x 10^6 dollar

HVDC transmission line:

(0.5 M.dollar/km) x (1,200 km)

= 600 x 10^6 dollar

b) Service life

Power plant	:	25 years
Converter station	:	30 years
Transmission line	:	50 years

c) Interest: 5(%) for each item

d) Capital recovery factor

Power Plant	:	7.10%
Converter station	:	6.51%
Transmission line	:	5.48%

e) Annual cost ratio

	Power Plant	Converter Station	Transmission Line
Capital cost	7.10(%)	6.51(%)	5.48(%)
Operation &Maintenance	4.90(%)	4.49(%)	2.52(%)
Tax	3.00(%)	3.00(%)	2.00(%)
Total	15.00(%)	14.00(%)	10.00(%)

4.2 Industry and construction sector

4.2.1 Present status of coal utilization

Coal consumption in the sector accounted for 15 percent of the total coal consumption, next to electric power and heat generation sector as shown in 2.1.3. The major consumers are a copper mine in Erdenet, two cement plants in Darkhan and Khutul,brick works in Ulaanbaatar and Darkhan, and Mongolsovtsvetmet ore-dresser in Bor Ondor. In the cement plants, coal is consumed in kilns, while in many other industries including metal mine, coal is utilized as fuel to generate steam and hot water. And in Ulaanbaatar and Darkhan, main factories are placed near to thermal-power stations, which supply steam to the factories. In the construction material industries, the users often face with operationed troubles due to low quality of coal supplied to the factories. Because of low heating value and high ash content in coal, it is difficult to maintain the reuired quality of products in cement and brick factories . There is a steel manufacturing plant in Darkhan, which is installed with an electric furnace to produce steel from scrap iron, and no coal is required at this stage in the factory.

4.2.2 Major coal utilization plan in industries

(1) Mining

In the Erdenet copper mine, the production of copper ore will be increased from 17 million tons in 1993 to 20 to 25 million tons per annum in the period of 1995 to 2000, and coal consumption will increase from 250, 000 tons in 1993 to 550,000 tons per annum in 1997-1998. Currently, only 84,000 tons of domestic coal are supplied to Erdenet, and the rest of 160,000 tons of coal are imported from Russia.

Bor Ondor fluospar mine in Khutul is to increase its capacity to 400,000 tons per annum by 1997. In Ulaan , situated 120 km to the north of Choibalsan City, in Dornod Province, metal mining of lead and zinc with its capacity of 2 million tons per annum, will be developed by around 1998 to 2000. In Tsav in Dornod Province, metal mining for lead and zinc with its capacity of 100,000 tons per annum, will be developed in the period of 2000 to 2003. In Undur Tsagaan, located 170 km from the Baganuur railway station to the east of Henti Province, metal mining of tungsten with its capacity of 5 million tons per annum will be produced by around 2005 to 2008. In addition, the following mine developing plans are considered.

- Boroo gold mine will be developed by 1998, by the joint-venture with Alt Company of Mongolia and the Morrison Qualtz Company, USA
- Bumat gold mine is to be developed by Mongolian Golden Reservation, joint-venture with a

Canadian company, and a production will be commenced in 1998.

In Choibalsan, a uranium refining plant is planned to be constructed, but detailed information is not available yet.

(2) Cement

If the production of existing cement plants be increased to their full capacity, it will reach 700,000 tons per annum, which is said to supply whole domestic requirements in 2000. Some of the new large plants under the plan are those for exports, and the smaller ones are planned for domestic supply. Shivee-Gobi cement plant will be constructed to the capacity of 1.2 million tons per annum in the period of 2000-2005 for export. Also, in Bayanhongor and Hovsgol province the plants of 50,000-200,000 tons per annum are planned to be construct by 2000. Several small sized cement plants, with capacity of 10,000 tons per annum, will be constructed in the periods of 1998-1999.

(3) Steel

A direct reduction plant is planned to be constructed in Darkhan Mini Steel Mill which will have the capacity of 320,000 tons per annum of the sponge iron. Coal used for reductant will be Sharyngol coal, which is classified as lignite type. Coal consumption is one ton coal for one ton sponge iron production, that means coal consumption will be 320,000 tons per annum. Energy consumption is estimated to be 38,400,000 kwh per annum. Iron ore will be carried from Tumurtei iron deposit located 100 km from Darkhan. Tumurtei is a large deposit of approximately 575 million tons ore with comparatively low iron(50 to 60 percent) and high sulfur(up to four percent). Production will start in 1998, according to MTI. Substitution for the imported coal by Erdenet copper mine is expected.

4.3 Agriculture sector

4.3.1 Present status

Coal consumption in agriculture sector increased from 322 thousand ton in 1980 to 517 thousand tons in 1987, and decreased to 62 thousand tons per annum in 1993. This value is equivalent to one percent of total consumption in Mongolia in 1993, and this figure will not be changed for a few years. It is estimated that coal is used in the greenhouses and also for cooking and heating in household of farmers.

4.3.2 Major coal utilization projects

In this stage any specific new major coal demand is not found in this sector. In this stage, energy resources for agriculture are coal, wood, biomass including animal dung. For preservation of forestry, it is recommendable to use coal and coal products instead of wood, and particularly, bio-briquettes will be desirable fuels in the sector.

4.4 Public service and household sector

4.4.1 Present status

As shown in 2.2.4, coal consumption in households from 427 thousand tons in 1980 to the peak of 784 thousand in 1986 and decrease to 209 thousand tons in 1993, these figures value show two to three percent of total consumption in whole requirement in Mongolia..Coal is used as fuel for cooking and heating.

4.4.2 Major coal utilization projects

In houses coal is burned in small stoves or ovens for heating and cooking, and the flue gas is purged out to atmosphere directly without any treatment. Since the chimney of houses are not high, effluent gas is not diluted by air and falling down to the ground level. To reduce emission from flue gas of households', it is recommendable to utilize coal briquettes instead of raw coal burning. Detail of coal briquettes is described in Chapter 7.

4.5 Transportation and communication sector

In the transportation and communication sector , 86,800 tons of coal are consumed in 1993, and this figure is one percent of total demand in Mongolia. Since no steam locomotive is applied in Mongolia, coal is not used for any concrete purpose in transportation and communication, but for cooking and heating at the offices and households of laborers. No specific coal utilization plan is reported in this sector.

4.6 Other new utilization technology

Coal is used only as fuel and not as raw material for creating other kind of fuels at the present in Mongolia. Taking future possibilities into consideration, such kind of usages of coal is worthy of being studied. In this connection, coal briquettes (formed coal), coal gasification and liquefaction are studied in this study.

Coal is often the important source of emission which pollutes air especially in urban areas. In centralized boilers for generating steam and hot water, waste gases can be treated by electrostatic precipitators and flue gas treatment facilities. For small boilers and furnaces and fire places in houses, however, there is no efficient way to treat the gases generated by combustion.Therefore, it is thought appropriate for coal to be pre-treated to cleaner fuel if feasible. One of effective and reliable solutions is considered to be coal briquettes (formed coal) manufactured from coal.

Liquid fuel is the most important energy required especially for vehicles and small size diesel engine-driven power plants in Mongolia. No oil is currently produced and foreseen to be developed at a large scale in the near future in Mongolia. Considering saving foreign currency and the security of supply, it is a desirable way to secure liquid fuel as an alternative to gasoline and gas oil (diesel fuel oil) in the country. Coal liquefaction and gasification is considered to be one of the ways for Mongolia to secure such fuels inside its territory.

4.6.1 Coal briquettes

To use coal as direct fuel in domestic purposes, some problems such as handling loss, smoke generation (smoke and soot) during combustion, and generation of toxic gases including SOx and CO have to be solved. As the most effective solution for above problems, coal briquettes are utilized as fuel in world wide.

In China, 50 million tons of formed coal are produced in 1991, 40 million tons for household and 10 million tons for industries. Total energy consumption in the household is 158 million tons in terms of standard coal. While consumption of coal itself in the household is decreasing gradually after the peak of consumption of 175 million tons in 1988, the share of formed coal increased from 17.8 % in 1985 to 25 % in 1990. According to another information on 32 major cities, 54 % of coal demand is supplied by formed coal.

In Indonesia,the government is now preparing the utilization of smokeless coal briquette.
It is announced in January, 1993, that "Smokeless Coal Briquettes" for households cooking and small-scale industries will be in produced. The purpose of usage of briquettes are, firstly, to reduce kerosene supplying subsidiary; secondly, to protect the forest, and thirdly, to create job and business opportunities among the people. Three counties in West, Central and East Java have been selected to be the locations as pilot projects where the coal briquette will be for cooking in the total household of 6,000 families. PT Bukit Asam Coal Mine will produce coal briquette by using

medium capacity, i.e. about 10,000 tons per annum at mine mouth. The factories having about 1 million tons per annum, will be designed at mine mouth and several locations by PTBA and private companies.

In Bulgaria, one coal briquette factory, having production capacity of 1.5 million tons per annum, has been operated since 1962. The raw material is lignite, which is supplied from a neighboring coal mine, and the lignite is crushed, dried and pressed to briquettes. The briquettes have a caloric value of 4,300 to 4,500 kcal/kg against 1,700 kcal/kg of raw material, lignite. Most of product briquettes are consumed as fuel in the households, and their price is approximately 7 US$ per ton, subsidized by the government, comparing product cost of 20 US$ per ton. These briquettes are not treated for environmental consideration. Sulfur content in the briquettes is two to four percent which is the same as in raw material.

To produce briquettes, there are several processes such as carbonization process, compression process,and so on, and the so called "Bio-Coal" process is the most recommendable process for Mongolia.

Bio-coal is the coal-biomass briquette, formed by high pressure compression, can help decrease troublesome pollutants such as smoke, smell, dust, SO_2, and clinker, which are exhausted by combustion of raw coal. Bio-coal is compound solid fuel of coal and bio-mass of which 15 - 30 % is biomass such as bagasse and desulphurization agent $Ca(OH)_2$ that is added and mixed according to the sulphur content in coal. Compared with the low temperature carbonizing briquettes in conventional smokeless coal technology, this bio-coal method requires a simple process, no complicated operations such as reaction, and no advanced operating technology.

Coal —— Drying —— Grinding ——┐
　　　　　　　　　　　　　　　├ Mixing —— Pressing —— Biocoal
Biomass —— Drying —— Grinding ——┘

The production features are as follows:

- Since bio-coal does not require a carbonizing process, its process is simpler and does not require treatment of by-product such as tar.
- A wide range of coal, from low quality to bituminous coal, can be used. As coal and biomass are treated in a low-temperature zone and processed while moisture remains, and thus flare is

unlikely to occur.

Features of Bio-coal from viewpoint of pollution control and environment are as follows:

i) Smokelessness

Particulate particle emission will decrease one fifth to one tenth comparing with direct coal burning. When Bio-coal contains more than 20 % of biomass, little smoke is visible during combustion.

ii) Desulphurization

Some 70 ~ 80 % of sulphur can be precipitated in ash if 1.5 to 2 $Ca(OH)_2$ is mixed to obtain a Ca/S ratio that corresponds to the sulphur content in the coal.

iii) Energy saving

In comparison with raw coal, coal briquettes is expected to bring around 10 percent of energy efficacy and reduce about 10 percent of handling loss in transportation and storage.

Although Bio-coal has many favorable features as described above, its treatment production cost is quite expensive when compared with that of conventional formed coal and directly burnt raw coal. Initial capital cost of Bio-coal plant is about 170 US$/ton and production cost before tax is about 21.2 US$/ton.

To carry out wide use of coal briquettes, to proceed with pollution control and energy conservation, laws and regulations for environmental and price control and subsidy such as tax exception and reduction must be studied. "Who will pay the cost" is, however, the issue of introduction of briquette utilization in Mongolia. It is recommended to MEGM to implement feasibility studies on production and utilization of coal briquette, selection of biomass, coal compressibility, and both investment and operation cost.

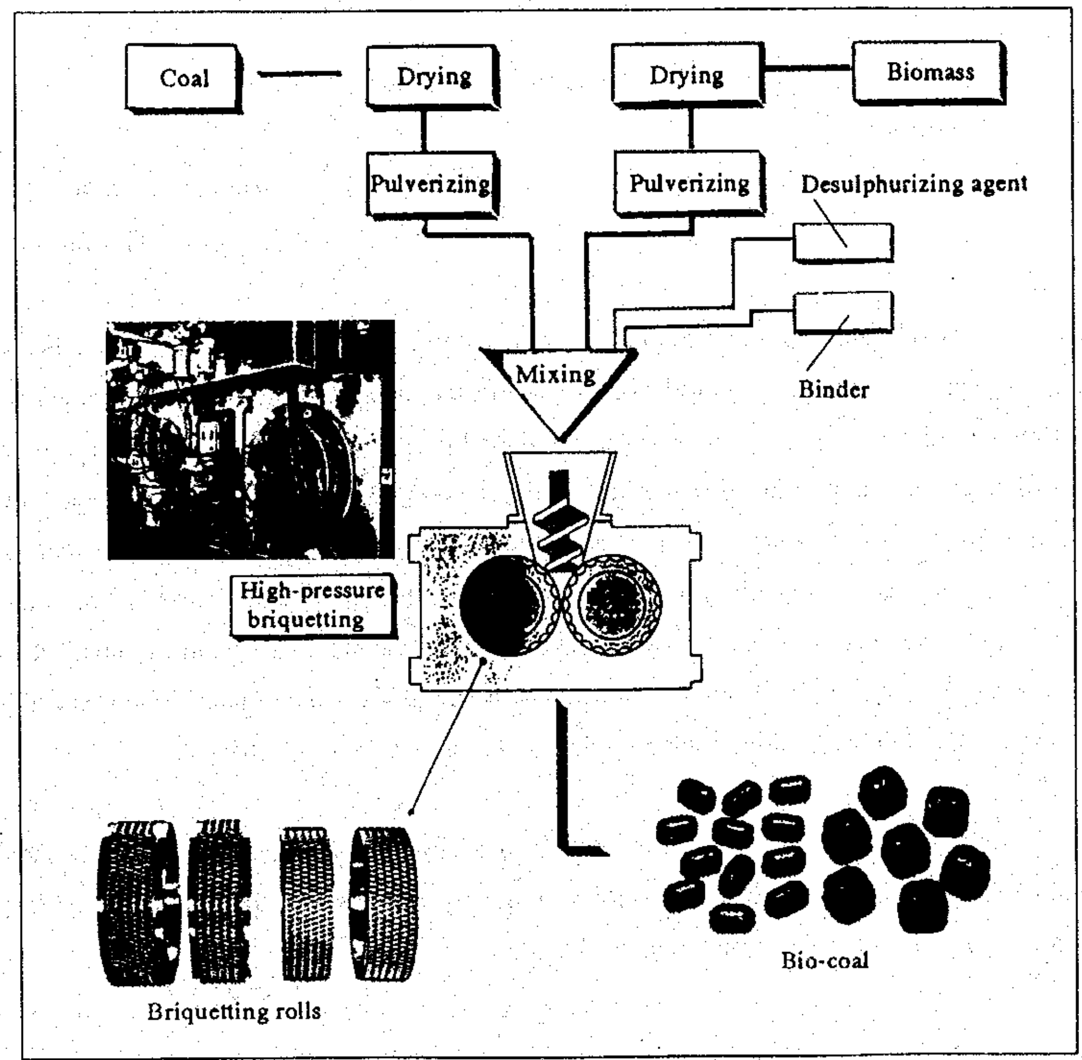


Figure 4.4 Bio-Coal Production Flow
(Source) Japan's Coal Technology, Center for Coal Utilization , Japan,1994

4.6.2 Coal gasification and derivatives

Coal gasification is used for two purposes; production of derivatives and electric power generation.

- Coal — Gasification
  - Co-generation — Electricity, hot water
  - Synthesis
    - Chemicals — Ammonia, Methanol
    - Liquid fuel — Gasoline, Gas oil

Coal is gasified in gasification system to converted it to hydrogen and carbon monoxide rich gas. For power generation, gas is introduced to gas turbine, and steam and hot water is generated by heat recovery of exhaust gas. In so called combined cycle power generation system, the exhaust gas from gas turbine introduced in the heat recovery and power system is also generated by steam turbine. For synthesis of chemicals, the gas is fed to synthesis loop after purification and adjusting component ratio as raw material for synthesis. The process of synthesis itself has been improved already and there are many experiences in the commercial plants. Production of chemicals, mainly ammonia and methanol, has been implemented at the industrial scale in such countries with special economical conditions as China, South Africa, and east European countries.

For the gasification of the coal three different gasification processes are currently large-scale commercial plant operation: Lurgi, fixed-bed type dry ash system, the Koppers-Toptzek(GKT) entrained system, and Texaco, entrained bed system.

Lurgi process has been adopted in several commercial plants. The largest ones, are the three SASOL plants I,II, and III in South Africa.

	Capacity	Product	
SASOL I	10,000 st/d	Liquid fuel	6,000 bpd
SASOL II	25,000 st/d	Synthesis gas	one billion scfd
SASOL III	30,000 st/d	Synthesis gas	one billion scfd & others

Another plant is in China for 1000 ton/d ammonia production and the other one is in USA which produces SNG.

Five plants of Kopper-Totzek(GKT) process plants are known for its operation. Most of these plants produce synthesis gas for ammonia. In some plants methanol is produced with ammonia. Eight Texaco plants are in operation. These plants include two for power plants, three for ammonia plants, and three for chemicals and oxo gas. In addition to these plants, four other plants are under construction in China for fuel gas, ammonia town gas and chemicals.

Production of coal derivatives in Mongolia is not recommended due to the small market and the expensive production cost. The production of liquid fuel using Fischer-Tropsch synthesis has been commercialized in Germany during World War II, and has been carried-out in South Africa which is in special economic conditions.

Development of new technology for coal gasification, co-generation and synthesis to produce gasoline and gas oil are proceeded by the New Energy and Industrial Technology Development Organization (NEDO), Japan, whose objectives are i) energy conservation and environmental control in power generation and ii) supply alternative liquid fuels in gas synthesis.

New technology developed by NEDO are as follows:

a) Pressurized fluidized bed gasification technology for combined cycle power generation
This project aims to develop a technology for low-calorie coal gasification for combined cycle power generation, of which higher heat efficiency than conventional pulverized coal thermal power generation is expected. The process consists of pressurized gasifier, dry type desulphurization and dry-type dust removal system and combined cycle power generation unit. The pilot plant operation with the capacity of 40 t/d gasifier has been completed successfully.

b) Entrained bed coal gasification technology for combined cycle power generation
This project aims to develop high efficiency in comprehensive system of coal gasification of combined cycle power generation. Pulverized coal is gasified by air in entrained bed at high temperature and high pressure to produce low-calorific gas of about 1,000 kcal/Nm^3, and this gas is purified at high temperature in the dry system, and power is generated using the 1,300 degree C class high-efficiency gas turbine and steam turbine under development for low-calorific gas. The pilot plant with capacity of 200 t/d has been constructed, and is under operation from 1991. Expected carbon conversion ratio is higher than 97 %, and expected power generation efficiency at generation terminal will be higher than 43 %.

c) Hydrogen manufacturing technology (Hycoal process)

This is an entrained bed gasification technology designed to obtain hydrogen that will make oxygen react with pulverized coal and medium-calorie gas rich in carbon monoxide. Since the shift reaction of the process can denature carbon oxide and carbon dioxide, highly pure hydrogen can be obtained by separating and purifying in the latter stage of the reaction. The pilot plant with capacity of 50 ton/d coal has been constructed, and is under operation from 1991.

d) Hybrid gasification

This is a technology to produce high-calorie gas with a calorific value of about 5,000 kcal/Nm^3 by making oxygen and steam react with a slurry consisting of coal and heavy oil. The produced gas can be utilized as industrial fuel gas and for city gas to substitute for natural gas (SNG) through methanation. The pilot plant with capacity of 12 ton/d has been operated successfully .

It is reported that the production of synthetic petroleum through coal gasification will be economical when oil price reaches higher than 30 US$/bbl.

According to the recent forecast of oil price by the Institute of Energy Economics, Japan, the oil price will reach to 30 US$/bbl by around 2010. Therefore, industrialization of coal gasification in Mongolia can not be recommended for the time being.

It is recommended for MEGM to evaluate coal characteristics for gasification by installing a small-scale test facilities in the relevant institute.

4.6.3 Coal direct liquefaction

Coal direct liquefaction is used for production of gasoline and gas oil. With coal direct liquefaction process, coal is pulverized first and slurry is prepared by mixing this coal with solvent. The slurry is fed into reactor section with hydrogen, having pressure of 100 to 300 atm. and 400 to 480 degree C, and decomposed product oil is separated and purified in the purification section. There is no industrial scale of production in the world at the present time.

Development of new technology for coal direct liquefaction is proceeded by New Energy and Industrial Technology Development Organization (NEDO), Japan. One is brown coal liquefaction pilot plant test operation in Australia, the other one is bituminous coal liquefaction pilot plant in

Japan. The brown coal liquefaction pilot plant had been constructed in Morwell city with capacity of 50 t/d, corresponding to liquefied oil production of 150 bbl/d. This pilot plant consists of coal pretreating section, slurry preheating section, primary hydrogenation section and the secondary hydrogenation section. Finally, about three barrels of liquified coal oil can be produced from one ton of dry brown coal. The plant has been completed is test operation successfully in 1992. The bituminous coal liquefaction pilot plant had been constructed in Kashima, Ibaragi Prefecture, Japan, and now is under test operation. The plant capacity is 150 t/d coal and target recovery ratio is 54 % per weight, 630 liter/t. It is expected to complete of the coal liquefaction technology by the year of 2000 - 2010.

Coal ——— Liquefaction ——┬— Crude gasoline ——— Hydrotreating ——— Gasoline
　　　　　　　　　　　　　└— Crude gas oil ——— Hydrotreating ——— Gas oil

Liquefied oil , such as crude gasoline and crude gas oil, shall be purified including hydrogenation for purification.

In accordance with the NEDO's report, the production of synthetic petroleum through direct coal liquefaction will be economical when oil price reaches higher than 30 US$/bbl in around 2010.

It is recommended for MEGM to evaluate coal characteristics for direct liquefaction by installing a small-scale test facility in the relevant institute.

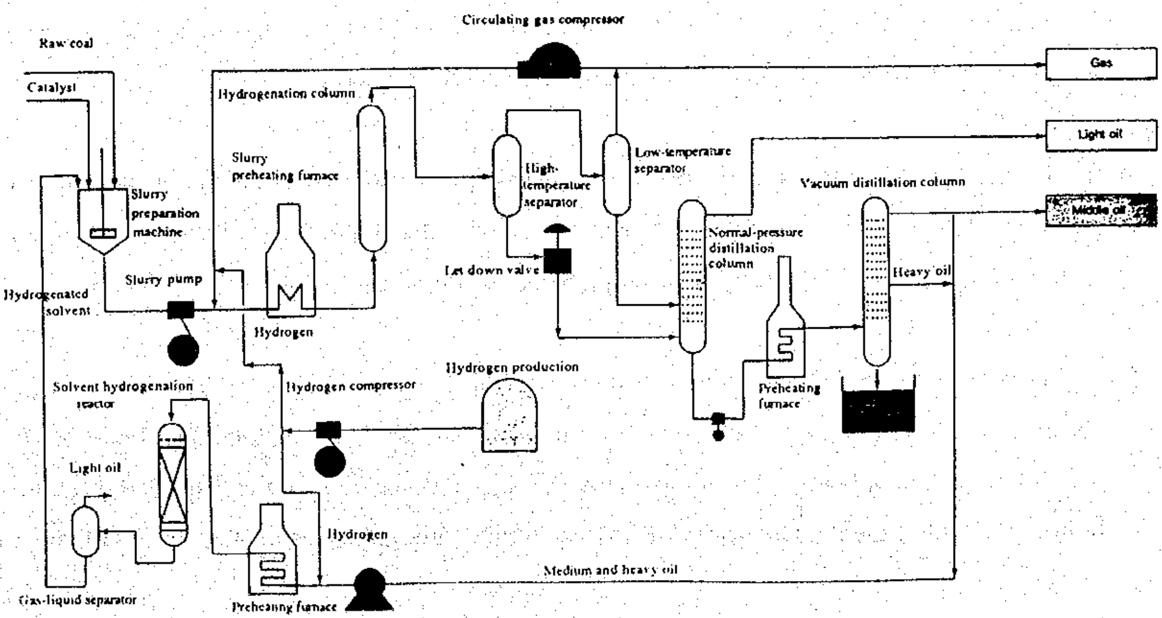


Figure 4.5 Coal Liquefaction Process Flow

5 Energy Conservation Plan for Coal-related Facilities

5.1 Present status of thermal efficiency in coal utilization

First of all, it must be noted that frequent electricity failure and scheduled power cut in Mongolia are causing too much losses of not only energy itself but also many materials and time in whole sectors of Mongolia. Coal utilization facilities can be classified into three groups from the point of view of energy conservation: coal conservation facilities(coal fires power and thermal plant), indirect coal utilization facilities(electricity and heat) and direct coal utilization facilities(boiler and stove). Energy conservation plan will be studied for each group in this section.

5.1.1 Coal conversion and supply facilities (power plant)

As shown in Table 2.6, 77 % of consumed coal is converted into electricity, steam and hot water by large and middle size of boilers. Actual thermal efficiency of such boilers is 80 to 85 %, and it is low compared with 90 % of the state-of-art because they are designed by the former Soviet Union without any energy saving concept. In addition, the internal use of electricity is very high at the present time. It increased from 18.3 % to 26 % of the gross electricity production between 1989 and 1992 in No. 3 power plant in Ulaanbaatar, according to ADB report. The design value for internal use of electricity is 18-19 %. The biggest internal consumers of electricity are the coal mills of 17 %, district heating pumps of 17 %, feed water pumps of 15 %, primary air fans of 12 %, and ID fans of 12 %. The high internal consumption of electricity is primarily due to:

- Inferior quality of coal resulted from the design which takes longer running time with the mills.
- Leakage of air into the boilers causes higher flow of the flue gas, and thus the fans have to work at a higher load and speed than what is originally designed for.

ADB also reported that heat loss in hot water distribution system and utilization system is very huge, about 50 % of delivered energy. In accordance with the above report, the energy situation in Mongolian production and distribution system can be summarized as follows.

(1) Energy balance in district heating system (hot water)

As shown below, losses in radiation water leakages are 20 % of the total supplied hot water, and 80 % are supplied to buildings. However, the utilization of the supplied heat to the buildings is inefficient. The value of losses in the building is estimated 36 % of the total supplied heat to the building, therefore useful heat in the buildings is only 51 % of the total heat.

Item	
Radiation(thermal) losses, piping system	5 %
Water leakages in primary and secondary heating system	5
Leakages in hot tap water distribution	10
Building losses	29
Heat useful in the building	51
Total	100

(2) Steam system

As shown below, steam losses during distribution are 44 %, and only 56 % of steam are supplied to industries, according to the ADB report.

Item	
Radiation (thermal) losses, piping system	19 %
Other losses, including leakages, metering losses,etc.	25
Supplied to industries	56
Total	100

(3) Electricity system

As shown below, losses including station internal use are 35 %, and 65 % of generated electricity is supplied to the consumers. And losses shown in the table are only the technical losses that could be verified by calculations and, to same extent, by measurements. None of technical losses assumed to be on the level of two to four percent. These are included in the supply to the consumers.

Item	
In station internal use	25 %
Transmission and distribution losses(technical)	10
Supplied to consumers	65
Total	100

(4) Energy balance

For example, the energy balance of Ulaanbaatar No.3 Power Plant is as follows:

Item	
Boiler losses	20 %
Other losses, including leakages, etc.	5
Electricity	16
Steam	16
District heating	43
Total	100

Energy balance of Ulaanbaatar No. 3 Power Plant and connected energy distribution systems are shown as below.

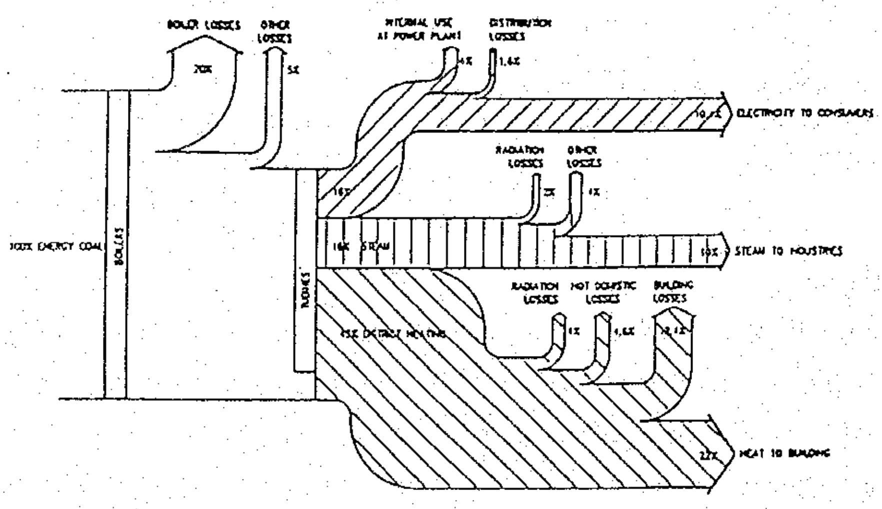


Figure 5. 1 Energy Balance of Ulaanbaatar No.3 Plant and connected Energy Distribution Systems

(Source) Mongolian Energy Audit Efficiency and Conservation Study T.A.(Final Report)

The figure shows that due to inefficiencies in the transmission and distribution, only approximately 42 % of fuel energy input is finally distributed as power, steam and hot water to the consumers.