4.2.2 Recommended surface facilities

Installation of the following surface facilities, including equipment, is recommended to achieve smooth operation of Shivee Ovoo coal mine at 2 million tons per year capacity;

Table 4.11 Additional Facility List

| Facility & equipment | Number | Initial cost | Note |
|---|---|---|---|
| Workshop & tool | 1 | US$ 1.3 m. | New installation |
| Warehouse | 1 | 0.5 | Expansion |
| Coal stockyard | 1 | 0.8 | New installation |
| (Front end loader) | (1) | (0.4) | 5 $m^3$ |
| (Dozer shovel) | (1) | (0.3) | 250 HP |
| Sizing & loading | 1 | 4.6 | New installation |
| (Crushing plant) | (1) | (0.4) | Crushing & sizing |
| (Conveyer set) | (4) | (2.2) | Hopper & spreader |
| (FEL) | (2) | (0.8) | 5 $m^3$ |
| (Dozer shovel) | (2) | (0.6) | 250 HP |
| Power distribution | 1 | 1.3 | Movable transformer |
| (Emergency generator) | (1) | (0.2) | Diesel generator |
| Communication | 1 | 0.1 | Wireless system |
| Dewatering system | 1 | 4.0 | Well, pump & piping |
| Multi-purpose equipment | 1 set | 3.7 | FEL, bulldozer, truck |
| Coal quality control system | 1 set | 0.2 | Automatic analyzer |
| Other facilities | 1 set | 1.3 | Boiler, office etc. |
| Total | | 17.9 | Excepting Tg-cost |

1) Workshop

Currently a new workshop is under construction, but it is for production capacity of 0.5 million tons of coal per annum. As a dragline system is selected, a number of additional mobile equipment will be minimized. So expansion of the workshop can also minimized. The following garage and workshop is necessary for production capacity of 2 million ton per annum.

Garage (including inspection pit) : 1,200 $m^2$

Workshop (installation of overhead crane) : 1,000 $m^2$

Regarding maintenance, daily inspection and simple maintenance must be implement by mine site, while overhaul and big scale maintenance should be ordered outside companies. Thus, the following general workshop tools must be supplement for maintaining a different type mining equipments such as rear dump truck, shovel, dragline, etc.

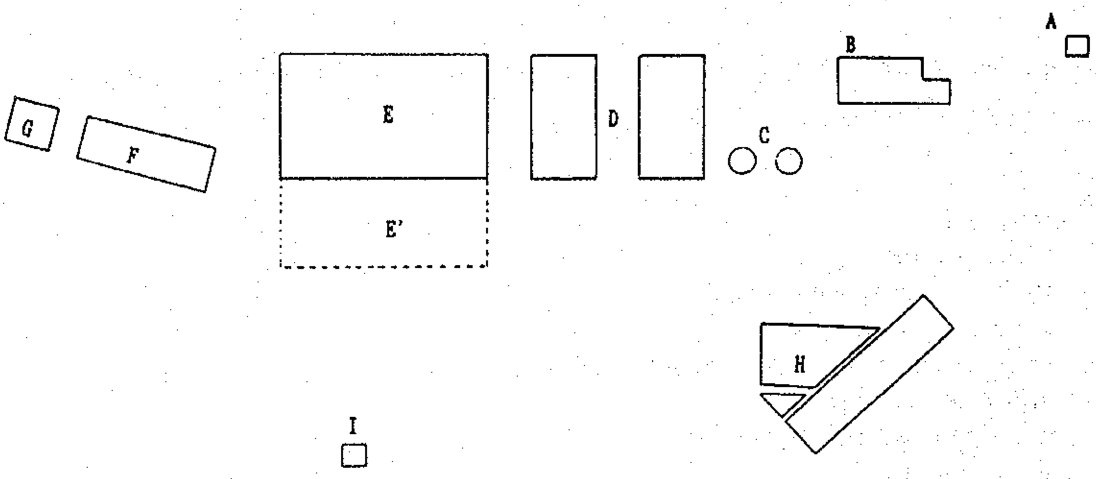
Workshop tools

- Chassis repair tools
- Undercarriage rebuilding tools
- Engine repair tools
  (for diagnostic, repair, test and inspection)
- Transmission repair tools
  (for repair, test and inspection)
- Tire service tools
  (for repair, balancing)
- Hydraulic component service tools
  (for rebuilding, testing)
- Fuel injection service tools
- Electric component repair tools
- General tools
- Machine tools
  (Heat treatment furnace, Small blast furnace, Grinding machine, Welding facilities, Press machine, Shearing machine, Gear shaper, plating facilities, Magnetic prospecting facilities)
- Cable repair tools
- Electric devices repair tools
  (for motor, electric distribution facilities, communication systems)
- Analyzers and measuring instruments
- Metal component analyzer

Training of the maintenance staff is important in order to maximize availability of mining equipment. Establishment of the Training Center is recommended. The following items must be studied for establishment of the center:

- training of the specialists for heavy equipment maintenance
- dispatch of the maintenance specialists in the event of equipment break down at mine site
- purchasing and stock of the common spare parts for mining equipment
- retain and apply the maintenance tool and equipment
- training of the maintenance workers of the mines

Detailed study of this matter will be described in the Master plan.




A : Well
B : Hot water supply system
C : Water tunk
D : Warehouse
E : Workshop
E' : Workshop (expansion)
F : Garage
G : Substation
H : Mine office
I : Sewege pond

Figure 4.9 Proposed Surface Facilities

2) Warehouse

A warehouse is also under construction. Considering the delivery time of the spare parts especially for the equipment imported from the western countries, stock capacity of spare parts must be carefully studied. Up-to-dated computer system will be helpful for management of spare parts. The required warehouse and computer system are as follows;

Warehouse with air conditioner and overhead crane : 400 $m^2$
(for lubrication oil, big parts, small parts)
Stock control system
(Computer, printer, software, etc.) : 1 set

3) Coal stock yard

Most serious problems of coal quality is its high moisture contents. This problem can be solved by dewatering activities or natural drying at the coal stock yard. From the past

experience, it is known that 2 months are enough for natural drying at the stock yard. For this purpose, big scale stock yard will be required. This problem of high moisture contents is only limited in the shallow areas. The deeper the mining area is, the better the coal quality gets.
It was the case at Baganuur coal mine. Regarding the coal stock yard, the following facility and equipment will be required.

Watering system

| | | |
|---|---|---|
| Steel pipe (4 inch) | : | 1,000 m |
| sprinkler | : | 40 sets |
| Front End Loader | : | 1 unit |
| Dozer shovel (250 HP) | : | 1 unit |

4) Sizing and loading

In order to satisfy the requirements of the consumer, the facilities for crushing and sizing are necessary. It is not necessary to built a large crushing and sizing plant, because the size of coal required by the power stations in Ulaanbaatar is 300 mm. Loading capacity of 2 million tons per year is too excessive for the capacity of one unit of 5 $m^3$ electric rope shovel. More integrated loading system will be required for this loading facilities.

Stationary crushing plant:

| | | |
|---|---|---|
| Jaw crusher (800 ton/hour x 400 kW) | : | 1 unit |
| Belt conveyor (36 inch x 800 ton/hour x 30 kW x 50 m) | : | 2 units |
| Conveyor with spreader (36 inch x 800 ton/hour x 200 kw x 400 m) | : | 2 units |
| Conveyor with hopper car (36 inch x 800 ton/hour x 200 kW x 400 m) | : | 2 units |
| Loading silo (capacity of stock : 1,000 ton) | : | 1 unit |
| Electric car puller (90 kW) | : | 1 unit |
| Capacity of puller : 30 freight cars | | |
| Dozer shovel (250 HP) | : | 2 units |
| Front End Loader (5 $m^3$) | : | 2 units |
| Diesel locomotive (1,200 HP) for marshalling freight cars | : | 1 unit |

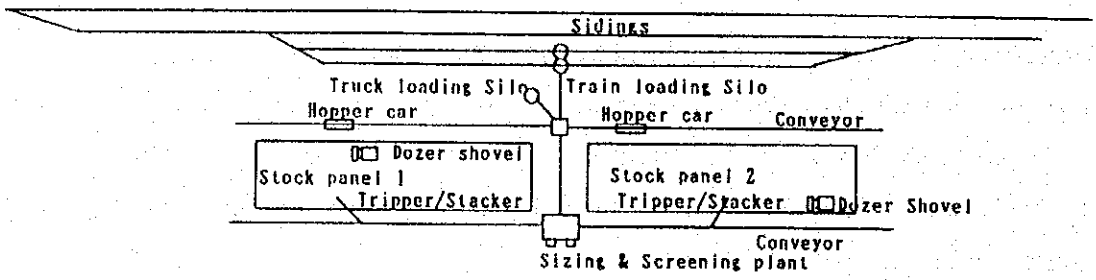



Figure 4.10 Proposed Coal Handling Facilities

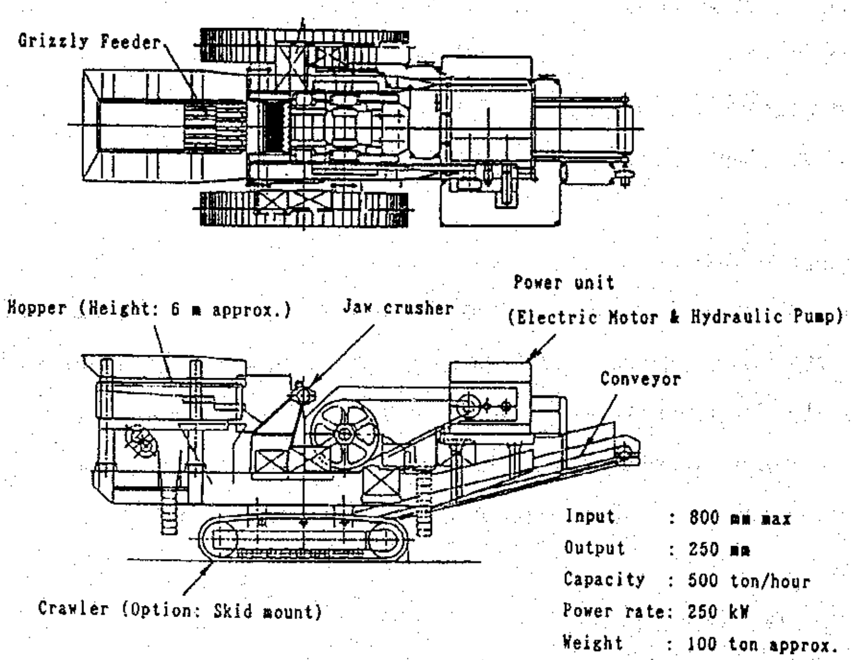



Figure 4.11 Conceptual Design at Mobile Crusher

5) Electric supply

Capacity of the transformer at the mine site is 35/6 KV, 1600 KVA while 3500 KVA transformer is desired. As a dragline system is selected for the renovation plan, power supply system with much bigger capacity will be required. It is recommended to construct a 110/35 KV substation near the mine site. Ideally it is better to remove the 110 KV transmission line which is crossing the mining concession. A 35/6 KV movable transformer is recommended for supply of the electricity to mining equipment. 35/6 KV transformer with 1600 KVA capacity which is currently used for the whole mine will be used for the surface facilities such as mine office, workshop loading facilities and drainage system. This system will be operated at 400 V and be connected to the diesel generator for use on emergency. This circuit will helpful in the event of the electric failure. Even if the power supply were stopped, dewatering and loading activity must be able to continue operations. Mining activities will be forced to stop in the event of the electricity failure, but a large scale coal stock yard will be able to continue the stable coal delivery. There is a plan to introduce a computer network, wireless communication system, internal telephone lines with automatic exchanger and satellite communication system in 1994. The international telephone line is crossing the coal reserves and it is better to remove the telephone line to outside of the mining concession. The removal of power line and the following electric equipments will be required.

| | | |
|---|---|---|
| Removal of power line (220 kV) | : | 48 km |
| (including power lines and pylons) | | |
| Transformer (110/35 kV, 1,000 KVA) | : | 1 unit |
| Movable transformer (35/6kV, 6,300 KVA) | : | 2 units |
| Power line (Aerial cable:36 kV) | : | 12 km |
| Generator for emergency (1,000 KVA x 440 V, diesel) | : | 1 unit |

6) Communication

The following high wireless communication system will be required in order to achieve reliable communication in the mine site.

Power wireless system

| | | |
|---|---|---|
| communication distance | : | 10 km (between office and each equipment) |
| Base station | : | 1 unit |
| (installed in the mine office) | | |
| Movable station | : | 50 units |
| (loaded in every equipment such as shovel and dump truck) | | |

7) Water supply

Water supply system with proper capacity is required. Supply system of hot water for the mining complex will be operated soon.

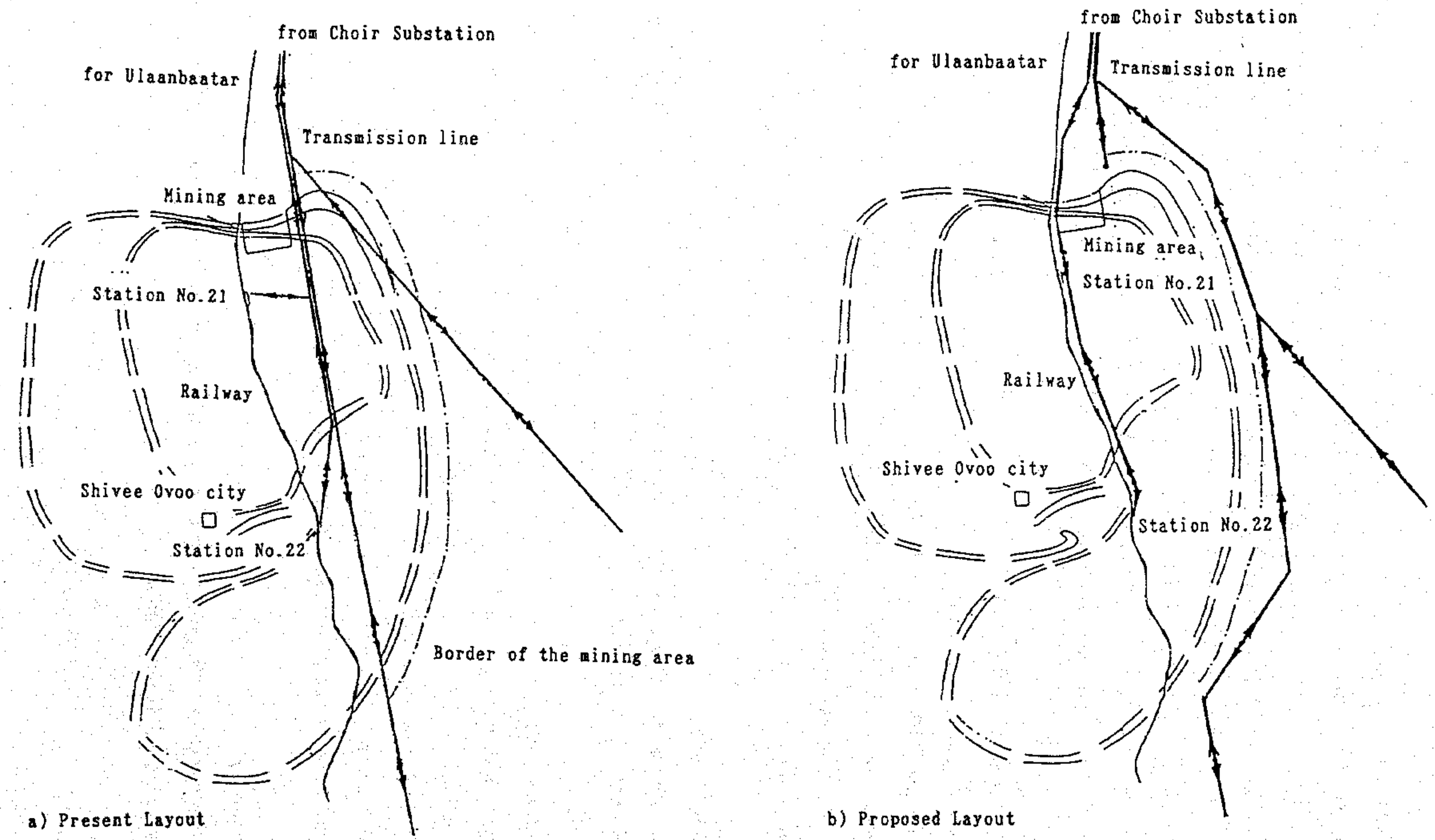



Figure 4.12 Position of Transmission Line

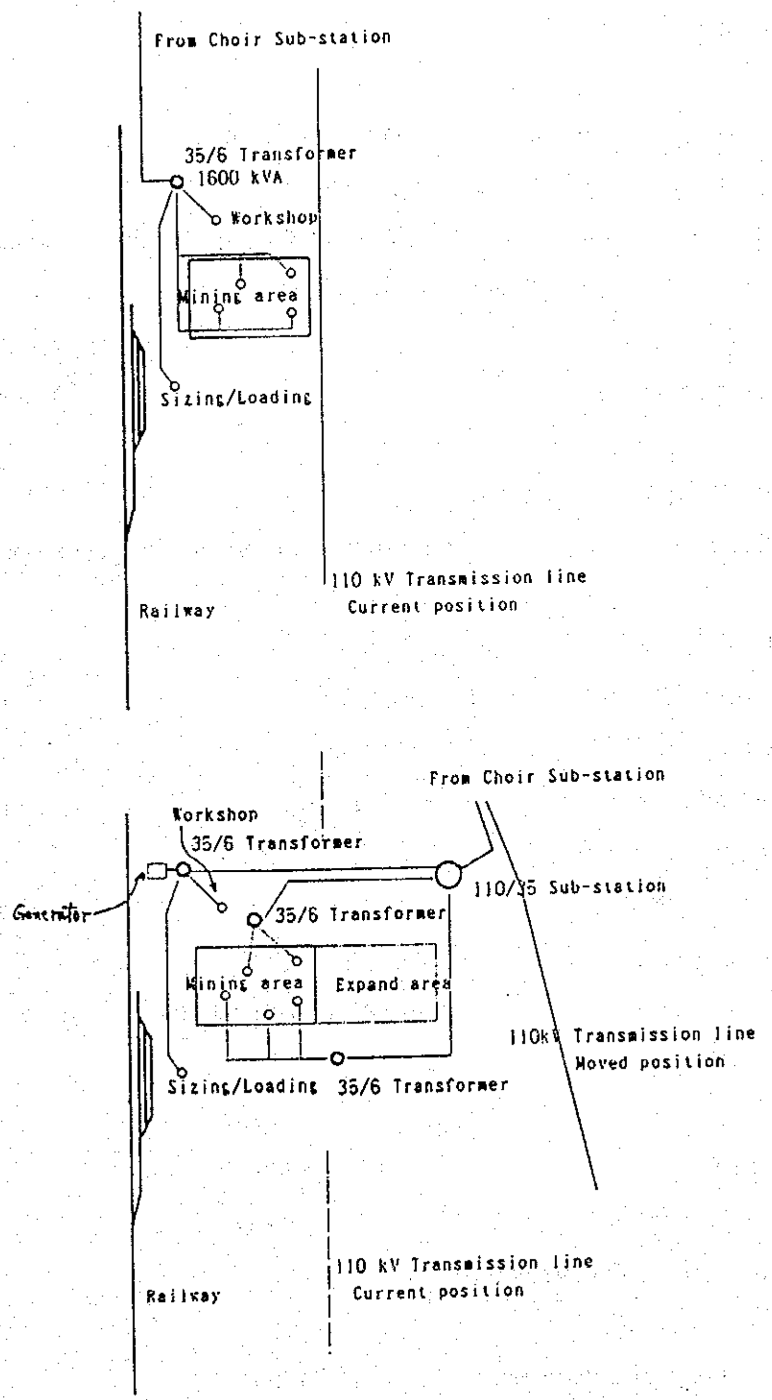



Figure 4.13 Proposed Electric Distribution System

8) Dewatering

The following facilities and equipments will be reinforced to increase production capacity of 2 million ton per year.

| | | |
|---|---|---|
| Dewatering well (diameter : 500 mm, depth : 250m) including the well of monitoring water level | : | 35 wells |
| Electric submersible pump (0.5 $m^3$/min x 250 m x 40 kW) including electric bulb and pumping pipe | : | 30 units |
| Steel pipe (12 inch) | : | 4,000 m |
| Water treatment facilities | : | 1 unit |

9) General purpose equipment

It is recommended to introduce the following equipments for general purpose.

| | | | |
|---|---|---|---|
| Bulldozer (320 HP) | for supporting | : | 2 units |
| Bulldozer (200 HP) | for supporting | : | 2 units |
| Grader (250 HP) | for supporting | : | 2 units |
| Front End Loader (5 $m^3$) | for selective mining | : | 2 units |
| ANFO truck (10 ton) | | : | 1 unit |
| Fuel truck (20 kl) | | : | 1 unit |
| Water truck (20 $m^3$) | | : | 2 units |
| Service truck | for transporting parts and labors | : | 5 units |

10) Others

| | | |
|---|---|---|
| Mine office | : | 1,000 $m^2$ |
| Explosive magazine (for ANFO and detonators) | : | 500 ton |
| Boiler (8 ton/day) | : | 1 set |
| Road maintenance (pavement) | : | 24 km |
| Quality monitoring system | | |
| On-line moisture analyzer | : | 3 sets |
| Equipment for laboratorium (Kinds of equipment are shown in Table 5.2) | : | 1 set |

## 4.3 Study of infrastructure

### 1) Road

Shivee Ovoo and Ulaanbaatar are connected by roads and a railway. Most of the roads are unsealed excepting the main road. In Mongolia, less than one percent of the roads are sealed. In rainy days, the roads become slippery and bumpy. Sealing by the asphalt is the best method, but covering by the gravers is also effective. Interburden of Shivee Ovoo coal mine is a good material for this purpose. In this case, a crushing plant to produce the gravers is required. There are a number of crossings over the railway between Ulaanbaatar and Choir Cities. But there are no bridges between Ulaanbaatar and Choir. Width of the road is wide enough for the current vehicles used for transportation. Almost all of the towns between Ulaanbaatar and Choir Cities have a gas station which is controlled by the oil corporation of Mongolia. Ticket issued by the oil corporation is required for the purchase of petroleum and diesel. A certain amount of these fuels are supplied by Shivee Ovoo coal mine to the regional consumers. Main transportation method used in the district is small trucks. There is a plan to seal the road with the asphalt near Shivee Ovoo coal mine. Total length of the plan is about 24 km.

### 2) Railway

Main railway line which is connected to China and Russia via Ulaanbaatar is crossing through the mining concession. A single-track line is installed and diesel locomotives are hauling freight cars and passenger cars. The track gage of the railway between China and Mongolia is not the same. It is necessary to change the bogies at the station near the border of the country. There are a number of tunnels in China and the dimension of cargos is limited. These problems of transportation must be taken into the considerations when equipment is transported to Mongolia through China. Main consumers of coal produced at Shivee Ovoo coal mine is the power stations in Ulaanbaatar. Most of coal produced at Shivee Ovoo coal mine are transported to Ulaanbaatar by the railway. Capacity of the transportation is still sufficient. Coal demand at Ulaanbaatar is exected to show a slow increase, and so as the total amount of transportation quantity of coal to Ulaanbaatar from the other coal mines. Regarding the capacity of transportation by the railway, the transportation system of coal only from Shivee Ovoo coal mine is not properly studied yet. It is necessary to study on the total capacity of railway transportation in the region. This matter will be described in the Master plan.

3) Communication

Domestic and international calls are available though number of the lines are limited. Facsimile services are already available at the telephone office in Choir City. Services of these communication system are desired to be expanded. International telephone line, which is connected to Beijing and Moscow, is laid in the underground through the mining concession of Shivee Ovoo coal mine.

4) Water supply

The underground mine water is used as an industrial water, and the water is transported by water trucks which are converted from Belaz 540 and Kalaz 256. These trucks are used not only for supply of the water but also for watering the road and fire fighting. There is a fire engine with pump for fire fighting. Potable water is supplied from Shivee Gobi City by 5.5-ton water truck. Distance between Shivee Ovoo City and the mine site is about 17 km. There is a well near Shivee Gobi City and the water is pumped up to the surface. It is possible to bring the water from Choir City by water trucks if required.

5) Electric supply

The electricity supplied to the district is transmitted from the Central Energy System through a high voltage transmission line via Baganuur City. There is a substation at Choir city which delivers the electricity to the district with the low voltage. Demand of the electricity will increase but there are no plans to construct a power station near Shivee Ovoo coal mine so far.

6) Labor force

Population of the Shivee Ovoo area is about 12 thousand. It is considered that recruit of the workers necessary for expansion of production is not so difficult. Training system for new workers is necessary. Infrastructure of the region is not so attractive for the skilled workers and engineers relocating from Ulaanbaatar or other cities. Grade up of the infrastructures is essential for expansion of production.

7) Township

City of Shivee Gobi is located at the south of Choir City. Population of the district is about 12,000. There is a number of uninhabited residences (apartments) in Shivee Gobi City, where the ex-USSR army were used to reside. With minor renovations, it will be possible to live there again. There are schools, hospitals and markets in the district. Potable water is supplied from the well near the city by water trucks. Hot water is supplied from the central hot water supply system. Formerly this system burned crude oil or coal imported from Russia. This system was modified in order to utilize domestic coal. The system is too small to supply the hot water to the city and necessary to construct an additional larger system. The electricity is supplied from the Central Energy System through a high voltage transmission line via Baganuur City. Telecommunication system is available although the capacity is small. International telephone lines are also available through the operators in Ulaanbaatar. A number of television and radio broadcasting services are possible to receive. Generally speaking, the facilities of the Shivee Ovoo City is much better than the standard of other local cities. But it is clear that the standard of Baganuur City is much higher than those of Shivee Ovoo City. In order to employ professional engineers and skilled workers at Shivee Ovoo coal mine, the facilties of the city must be upgraded. With small renovations mentioned before, it is possible to supply the accommodations for new workers necessary for expansion of production.

8) Land

Shivee Ovoo coal mine is located at the foot of the Choir Mountain. Geographical features of the area are almost flat and about 1,200 m above the sea level. There are few trees in the area and the land is a plain. Temperatures of the area vary and it is very cold in the winter season.

## 4.4 Schedule of renovation

(1) Project schedule

Project schedule for renovation is assumed on the basis of the delivery time of equipment, while impact of coal demand is not reflected.

| | |
|---|---|
| Order of spare parts | : End of 1994 |
| Arrival of spare parts | : End of 1995 |
| Funding for capacity-up | : 1995-96 |
| Order of equipment | : End of 1996 |
| Arrival of equipment & field work | : End of 1998 |

(2) Coal production plan

| | |
|---|---|
| 1995 | : 0.6 million tons per year |
| 1996-1998 | : 0.8 |
| 1999 | : 2.0 |

Table 4.12 Required Supporting Equipment for Mine Expansion

| Description | Unit Price US$1000 | Number of unit required | Initial Investment US$1000 | Life years | Cost/y US$1000 | Year to be installed |
|---|---|---|---|---|---|---|
| A. Workshop | | | | | | |
| Garage | 600 | 1 | 600 | 20 | 30 | 1997 |
| Workshop Building | 500 | 1 | 500 | 20 | 25 | 1997 |
| Workshop tools | 255 | 1 | 255 | 6 | 43 | 1998 |
| Total item A | | | 1,355 | | 98 | |
| B. Warehouse | | | | | | |
| Warehouse Building | 500 | 1 | 500 | 20 | 25 | 1997 |
| Computer system | 43 | 1 | 43 | 8 | 5 | 1998 |
| Total item B | | | 543 | | 166 | |
| C. Coal stock yard | | | | | | |
| Watering system | 85 | 1 | 85 | 10 | 9 | 1998 |
| Front End Loader 5 m3 | 408 | 1 | 408 | 8 | 51 | 1998 |
| Dozer shovel 250 HP | 306 | 1 | 306 | 8 | 38 | 1998 |
| Total item C | | | 799 | | 98 | |
| D. Sizing & Loading | | | | | | |
| Crushing plant | 425 | 1 | 425 | 15 | 28 | 1998 |
| Conveyor with hopper car | 425 | 2 | 850 | 10 | 85 | 1998 |
| Conveyor with spreader | 680 | 2 | 1,360 | 10 | 136 | 1998 |
| Siding of the track | 43 | 1 | 43 | 20 | 2 | 1998 |
| Loading silo | 85 | 1 | 85 | 10 | 9 | 1998 |
| Car puller | 43 | 1 | 43 | 10 | 4 | 1998 |
| Dozer shovel 250 HP | 306 | 2 | 612 | 8 | 77 | 1998 |
| Front End Loader 5 m3 | 408 | 2 | 816 | 8 | 102 | 1998 |
| Diesel Locomotive | 470 | 1 | 470 | 8 | 59 | 1998 |
| Total item D | | | 4,704 | | 502 | |
| E. Power distribution | | | | | | |
| Remove Transmission line | 400 | 1 | 400 | 20 | 20 | 1998 |
| Transformer(110/35KV) | 323 | 1 | 323 | 10 | 32 | 1997 |
| Transformer(35/6KV) | 167 | 2 | 334 | 10 | 33 | 1997 |
| Cable | 100 | 1 | 100 | 10 | 10 | 1997 |
| Generator for emergency | 204 | 1 | 204 | 10 | 20 | 1998 |
| Total item E | | | 1,361 | | 115 | |
| F. Communication | | | | | | |
| High power wireless system | 85 | 1 | 85 | 8 | 11 | 1998 |
| Total item F | | | 85 | | 11 | |
| G. Drainage & water supply | | | | | | |
| Drainage system | 4,000 | 1 | 4,000 | 5 | 800 | 1997 |
| Total item G | | | 4,000 | | 800 | |
| H. Supporting equipment | | | | | | |
| Bulldozer 320HP | 476 | 2 | 952 | 8 | 119 | 1998 |
| Bulldozer 200HP | 306 | 2 | 612 | 8 | 77 | 1998 |
| Grader 250HP | 366 | 2 | 732 | 8 | 92 | 1998 |
| Front End Loader 5 m3 | 408 | 2 | 816 | 8 | 102 | 1998 |
| ANFO truck | 170 | 1 | 170 | 8 | 21 | 1998 |
| Fuel Truck | 128 | 1 | 128 | 8 | 16 | 1998 |
| Water truck | 102 | 2 | 204 | 8 | 26 | 1998 |
| Service truck | 51 | 5 | 255 | 8 | 32 | 1998 |
| Total item H | | | 3,869 | | 485 | |
| I. Others | | | | | | |
| Mine office | 500 | 1 | 500 | 30 | 17 | 1997 |
| Explosive magazine | 200 | 1 | 200 | 30 | 7 | 1997 |
| Boiler | 300 | 1 | 300 | 15 | 20 | 1997 |
| Road maintenance | 300 | 1 | 300 | 15 | 20 | 1997 |
| Quality monitoring system | 240 | 1 | 240 | 8 | 30 | 1998 |
| Total item I | | | 1,540 | | 94 | |
| Total item A-I | | | 18,256 | | 2,369 | |
| Local cost | | | 3,651 | | 474 | |
| Grand total | | | 21,907 | | 2,843 | |
| Investment for 20 years | | | | | 56,860 | |
| Production (thousand ton) | 2,000 | | | | | |
| Capital/ton US$/ton | | | | | 1.4 | |

# 5 Study of Quality Control System

## 5.1 Issues of coal quality

### 5.1.1 Coal quality

It was explained by the Department of Energy, Geology and Mining that the actual calorific value of the first 250,000 tons delivered to the power stations in Ulaanbaatar was 2,800 kcal/kg and it has improved to 3,000 kcal/kg in 1993. Estimated calorific value in the feasibility study of the Mining Institute of Mongolia is 3,700 kcal/kg. However, the actual calorific value of coal is far less than the expected value as shown on Table 5.1.

The Mining Institute carries out analysis of coal quality every quarter for monitoring of coal quality delivered to the power stations. In addition to this regular monitoring of coal quality, another function is to resolve the disputes on coal quality between the power stations and coal mines. Claims made by the power stations in Ulaanbaatar are mainly concerned with high total moisture and low calorific value of coal. Lumpy coal is crushed by bucket of electric rope shovel EKG 5A and push dozing by Bulldozers at the mine site. However, it is considered that crushing coal by this method is not sufficient under the production capacity of 2 million tons per year. The oxidized coal exists up to 70 m from the box cut. Although it was not planned to be extracted according to the feasibility study, such coal had to be extracted because the shortage in supply of coal occurred in Mongolia. Coal mined from Seam I and II is separately stocked at the coal stockyard.

### 5.1.2 Issues on quality control of coal

At present, coal supplied to the power plant in Ulaanbaatar has the problems of coal quality such as high total moisture contents, low calorific value and the large size of coal. Coal often froze during transportation in the winter season due to high total moisture contents. The users have been requesting to minimize the fluctuations of coal quality, particularly in total moisture because high moisture contents cause freezing of coal in the railway wagons and plugging of the pipelines at the power stations. As a crushing and screening plant has not been installed at Shivee Ovoo coal mine, bulldozer crushes run of mine coal by push dozing prior to loading coal into the wagons of a unit train. Therefore, the size of coal supplied to the power stations in Ulaanbaatar is not uniform. In order to resolve this problem, management of Shivee Ovoo coal mine prefers to install a small mobile crushing and screening plant, instead of a large stationary crushing and

## Table 5.1 Actual Coal Quality Received by the Power Stations

<Shivee Ovoo>

| NO. 3 | T. M. (ar) | ash (db) | V. M. (daf) | T. S. (db) | C. V. (ar, low) | NO. 4 | T. M. (ar) | ash (db) | V. M. (daf) | T. S. (db) | C. V. (ar, low) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 93-1 | 40. 4 | 17. 6 | 41. 1 | 0. 53 | 2, 552 | | 42. 8 | 14. 2 | 42. 3 | 0. 38 | 2, 468 |
| 2 | 44. 1 | 7. 2 | 42. 9 | 0. 28 | 2, 832 | | 44. 9 | 14. 2 | 40. 9 | 0. 52 | 2, 293 |
| 3 | 36. 9 | 15. 8 | 41. 4 | 0. 39 | 2, 804 | | 37. 2 | 16. 7 | 49. 7 | 0. 51 | 2, 603 |
| 4 | | | | | | | 38. 7 | 10. 0 | 44. 1 | 1. 25 | 3, 070 |
| 5 | | | | | | | 35. 2 | 13. 9 | 43. 9 | 1. 04 | 3, 069 |
| 6 | | | | | | | 36. 6 | 14. 2 | 43. 7 | 0. 95 | 2, 938 |
| 7 | | | | | | | 42. 5 | 9. 4 | 43. 4 | 0. 70 | 2, 779 |
| 8 | 42. 3 | 9. 7 | 44. 2 | 0. 73 | 2, 740 | | 44. 6 | 7. 8 | 43. 5 | 0. 74 | 2, 728 |
| 9 | 43. 5 | 8. 2 | 45. 1 | 0. 73 | 2, 665 | | 41. 8 | 10. 1 | 44. 4 | 0. 95 | 2, 761 |
| 10 | 43. 3 | 8. 0 | 44. 7 | 0. 64 | 2, 816 | | 41. 1 | 11. 7 | 45. 7 | 0. 96 | 2, 668 |
| 11 | 43. 4 | 12. 3 | 45. 4 | 1. 02 | 2, 306 | | 42. 8 | 12. 9 | 47. 8 | 1. 06 | 2, 305 |
| 12 | | | | | | | 43. 7 | 8. 7 | 45. 1 | 1. 04 | 2, 768 |
| Ave. | 41. 5 | 13. 0 | 42. 7 | 0. 57 | 2, 669 | | 41. 0 | 11. 2 | 44. 6 | 0. 93 | 2, 750 |
| 94-1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| 6 | | | | | | | | | | | |
| 7 | | | | | | | 37. 2 | 11. 6 | 46. 3 | 0. 78 | 3, 044 |
| 8 | | | | | | | 44. 6 | 7. 9 | 49. 4 | 0. 95 | 2, 492 |
| Ave. | 0. 0 | 0. 0 | 0. 0 | 0. 00 | 0 | | 40. 7 | 9. 8 | 47. 8 | 0. 86 | 2, 780 |

screening plant installed at Baganuur and Sharyngol coal mines. High total moisture of coal has been delivered to the power station due to delays in dewatering of the groundwater and low calorific value of coal has been caused by mining of the oxidized coal. Spontaneous combustion of coal occurs in the windy season is another problem on control of coal quality.

### 5.2 Recommended quality control system and equipment

It was noted that management must introduce a new thought and system for quality control of coal for operations of Shivee Ovoo coal mine. The factors to be taken into consideration are as follows:

- Proper dewatering of the underground water in the mining area ahead of removal of overburden and mining of coal.
- Proper pumping of surface water at the mining pits ahead of mining of coal.
- Prevention of frozen coal being delivered to the power stations.
- Cease of the oxidized coal being mined.
- Prevention of overburden being sliding down over the exposed coal.
- Introduction of metal detector and magnetic catcher.
- Regular sampling of coal for analysis of coal quality and better communication for forward planning.
- Reinforcement and improvement of the coal drying process for the boilers at the power stations.
- Improvement of coal quality system control at the mine site.

#### 5.2.1 Recommended quality control system

In order to satisfy the requirements of the coal users, management of Shivee Ovoo coal mine has to try their best to improve control of coal quality. It is necessary to reduce surface moisture and ash contents of coal. It is also necessary to control the maximum size of coal. For the purpose of stopping supply of the oxidized coal to the power stations, management has to pay more attention for data of geology and coal analysis obtained from the past exploration program. For more effective usage of total energy, management of the power stations also have to improve effectiveness of the coal combustion systems and management of maintenance.

(1) Control of free moisture contents

High moisture contents of coal is the problems of mining, coal handling and combustion of coal. It is necessary to pay more attention for control of free moisture of coal. Drainage of the ground water from the wells must be improved because this is most effective method to reduce free moisture of coal. Rain water and other surface water which flow into the coal pit must be drained by pumps before excavation. Penetration of water into the seam from the accumulated water over the surface of exposed seam is also another problem. Even though introduction of coal drying at the mine site can reduce free moisture of coal, adoption of this method is not recommended due to economic reasons and spontaneous combustion problem. This tendency is similar to the other lignite coal mines in the world. In case of the mine site drying method is selected, the facilities of drying coal and energy for heat generation are required and it is easy to cause spontaneous combstion during storage and transportation, after drying coal. On the other hand, in case of the drying coal at the power station, waste heat can be utilize for drying. Therefore, the most economic ways to reduce water contents of coal at the mine site are considered to be the drainage of groundwater by wells and natural drying of coal before freight car loading. In order to reduce handling problems in winter season, moisture contents of coal must be monitored carefully. It is recommended to introduce the on-line moisture monitor for the loading facility.

(2) Ash control

Two systems are considered for ash control of coal. One method is a selective mining and the other is coal preparation. Results of coal washability test shows that the washability of Shivee Ovoo coal does not warrant introduction of coal preparation plant. Therefore, investment for the coal preparation plant should not be considered at present. This tendency is common for almost all the lignite mines in the world. Selective mining will enable to reduce ash contents of run of mine coal. This simple method includes cleaning of dirts over the coal surface, removal of partings and prevention of the highwall failures to the coal surface of the seam. It is recommended that the coal surface must be cleaned up by FEL or motor grader operations before excavation. Operators of electric rope shovel have to study the operational skill on digging floor of the seam. Removal of the partings with thickness of 30 cm or more are also recommended.

(3) Control of coal size

Power stations require small size coal while bigger size coal is required by general industries and household usages. Acceptable maximum size of coal at the power station is said to be 300 mm. Currently, much bigger size of coal has been supplied to the power stations and is causing very serious handling problems. If coal is crushed completely to the specifications at the mine site, crushing cost at the power stations can be reduced. However, it encourages spontaneous combustion due to the characteristics of coal and sticking of free moisture during storage and transportation of coal. Crushing of coal at the mine site is high energy consumption works compared with crushing of coal at the power stations. Because crushing at the power stations is free from the electric energy loss during transmission. There are merits of crushing coal into smaller size to satisfy requirements of the power stations. However, it is recommended to crush coal to 300 mm at the mine site in order to avoid the handling problems.

(4) Countermeasures at the power stations

It is ideal to utilize the waste heat of power generation to dry coal ahead of combustion at the power stations. Also, important task is to alter specification of the boilers to match with quality of coal. The way of blending coal must be examined for obtaining proper coal quality through monitoring of coal quality.

### 5.2.2 Recommended equipment

Following equipment and plants must be introduced and reinforced for improved control of coal quality;

Quality control equipment (on-line analyzer)
Crushing and sizing plant
Small size FEL and truck for thin interburden removal
Dewatering system

## 5.3 Expected product quality of Shivee Ovoo coal

Estimated quality of coal products is calculated by a weighing average of the thickness of coal seam and its coal reserves, based on Table 2.2. In order to calculate the estimated quality of coal products, the dilution of upper and lower interburden and parting is considered and the total moisture contracted with power station is used. The conditions of calculation are as follows;

(1) The total thickness of dilution from the upper and lower interburden of each coal seam is assumed to be 10 cm. In order to minimize this dilution, it is necessary to clean up the surface of exposed seam by small equipment and to leave about 30 cm of coal at the bottom

Table 5.2 Recommended Facilities for Laboratory - Shivee Ovoo

| | Name of the item | Specification | Unit | price (1000 US$) |
|---|---|---|---|---|
| 1 | Automatic scale | +-0.001 g | 1 | 8.2 |
| 2 | Jaw Crusher | Crushing size 5 mm | 1 | 15.2 |
| 3 | Brown Crusher | Grain size 0.25 mm | 1 | 13.0 |
| 4 | Cycle mill | -200 mesh | 1 | 11.0 |
| 5 | Ro-Tap Sieve Shaker | 240 rpm, 0-60 min. timer | 1 | 5.6 |
| 6 | Riffle Sampler | Receptable until 60 kg | 1 | 17.8 |
| 7 | Moisture determinator | Max temperature 200 degrees | 1 | 1.8 |
| 8 | Ash determinator | Max temperature 1200 degrees | 1 | 17.7 |
| 9 | VM Analyzer | Max temperature 900 degrees | 1 | 9.3 |
| 10 | Digital Calorimeter | 1000-8000 cal | 1 | 38.2 |
| 11 | Sulfur Analyzor | Max. temperature 1400 degrees | 1 | 23.2 |
| 12 | PH meter | Digital | 1 | 3.1 |
| | Total, Foreign | | | 164.1 |
| | Total, Local cost | | | 32.8 |
| | Grand total | | | 196.9 |

Table 5.3 Recommended Facilities for Laboratory - Mining Institute

| | Name of the item | Specification | Unit | price (1000 US$) |
|---|---|---|---|---|
| 1 | Brown Crusher | Grain size 0.25 mm | 1 | 13.0 |
| 2 | Cycle mill | -200 mesh | 1 | 11.0 |
| 3 | Ro-Tap Sieve Shaker | 240 rpm, 0-60 min. timer | 1 | 5.6 |
| 4 | Riffle Sampler | Receptable until 60 kg | 1 | 17.8 |
| 5 | HGI test machine | 60 rotation, 1 inch balls | 1 | 10.5 |
| 6 | Digital Calorimeter | 1000-8000 cal | 1 | 38.2 |
| 7 | C,H Analyzor | Tube furnace, Max 1350 degrees | 1 | 37.7 |
| 8 | Sulfur Analyzor | Max. temperature 1400 degrees | 1 | 23.2 |
| 9 | Ash melting point tester | Max temperature 1600 degrees | 1 | 39.3 |
| 10 | PH meter | Digital | | |
| | Total, Foreign | | | 196.3 |
| | Total, Local cost | | | 39.3 |
| | Grand total | | | 235.6 |

of seam on the excavation of coal.

(2) Average percentage of dilution from the partings is assumed to be 2%. This percentage is defined as to match the ratio of the thickness of coal and parting which is calculated from a typical geological columnar section (see Figure 2.3).

(3) Total moisture is assumed to be 35%.

(4) The quality of interburden and parting is assumed as follows;

| | | |
|---|---|---|
| Ash | : 70% | (air dry basis) |
| Calorific value | : 1,000 kcal/kg | (air dry basis) |

The results of calculation are shown on Table 5.4 and the details of calculation are shown in Table 5.5.

Table 5.4 Coal Products Quality

| | | As received basis | Air dry basis | Dry basis | Dry ash free basis |
|---|---|---|---|---|---|
| Total Moisture | % | 35.0 | | | |
| Surface Moisture | % | 28.8 | | | |
| Inherent Moisture | % | - | 8.7 | | |
| Ash | % | - | 16.5 | 18.1 | |
| Volatile Matter | % | - | 32.7 | 35.8 | 43.7 |
| Fixed Carbon | % | - | 42.1 | 46.1 | 56.3 |
| Total Sulfur | % | - | 0.60 | 0.66 | 0.80 |
| Calorific Value (HCV) | kcal/kg | 3,580 | 5,030 | 5,509 | 6,725 |
| (LCV) | kcal/kg | 3,212 | 4,756 | | |
| Size | | 0-300mm | | | |

## 5.4 Washability Test

Float and sink analysis for Seams I and II was carried out to investigate the potentiality of coal preparation in Japan. The results obtained from float and sink test of coal samples indicated as follows;

(1) Seam I

In case of the separation of specific gravity at 1.4, product coal of about ash 6% can be produced with theoretical yield with 91%.

## Table 5.5 Calculation Sheet for Expected Product Quality

1. Average coal quality of each seam on table 2.1

| | T.M. (ar) | I.M. (ad) | ash (db) | V.M. (daf) | F.C. | T.S. (db) | C.V. (daf) | C.V. (ar) | ash | C (daf) | H (daf) | N (daf) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 32.5 | 8.3 | 16.9 | 44.0 | | 0.64 | 6,708 | 3,763 | | | 5.48 | |
| II | 33.4 | 9.2 | 15.7 | 42.7 | | 0.69 | 6,779 | 3,675 | | | 5.48 | |
| | | | | | | | (high) | (high) | | | | |

2. To change data (into air dry basis and dry basis) dry basis

| | T.M. (ar) | I.M. (ad) | ash (ad) | V.M. (ad) | F.C. (ad) | T.S. (ad) | C.V. (ad) | C.V. (ar) | ash (db) | C (db) | H (db) | N (db) | S.M. (ar) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 32.5 | 8.3 | 15.5 | 33.5 | 42.7 | 0.59 | 5,112 | 3,763 | 16.9 | | 4.55 | | 26.4 |
| II | 33.4 | 9.2 | 14.3 | 32.7 | 43.8 | 0.63 | 5,189 | 3,806 | 15.7 | | 4.62 | | 26.7 |
| | | | | | | | (high) | (high) | | | | | |

3. Quality of overburden and interburden (air dry basis)

| | I.M. | ash | V.M. | F.C. | T.S. | C.V. |
|---|---|---|---|---|---|---|
| O/B | 10 | 70 | 15 | 5 | 0.6 | 1,000 |

4. Estimated quality of each seam with overburden and interburden

| | T.M. (ar) | I.M. (ad) | ash (ad) | V.M. (ad) | F.C. (ad) | T.S. (ad) | C.V. (ad) | C.V. (ar) | ash (db) | C (db) | H (db) | N (db) | S.M. (ar) | C.V. (ar) | H (ar) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 32.5 | 8.3 | 16.9 | 33.0 | 41.7 | 0.59 | 5,005 | 3,686 | 18.4 | | 4.47 | | 26.4 | 3,328 | 3.0166 |
| II | 33.4 | 9.2 | 15.8 | 32.2 | 42.8 | 0.63 | 5,074 | 3,723 | 17.4 | | 4.53 | | 26.6 | 3,359 | 3.0151 |
| | | | | | | | (high) | (high) | | | | | | (low) | |

5. Estimated average quality of mine

| T.M. (ar) | I.M. (ad) | ash (ad) | V.M. (ad) | F.C. (ad) | T.S. (ad) | C.V. (ad) | C.V. (ar) | ash (db) | C (db) | H (db) | N (db) | S.M. (ar) | C.V. (ar) | H (ar) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32.8 | 8.7 | 16.5 | 32.7 | 42.1 | 0.60 | 5,030 | 3,700 | 18.1 | | 4.49 | | 26.5 | 3,340 | 3.016 |
| 35.0 | 8.7 | 16.5 | 32.7 | 42.1 | 0.60 | 5,030 | 3,580 | 18.1 | | 4.49 | | 28.8 | 3,212 | 2.9185 |
| | | | | | | (high) | (high) | | | | | | (low) | |

6. Thickness of coal, overburden and interburden

| | coal(-0.3m) | O/B | I/B | total |
|---|---|---|---|---|
| I | 15.2 | 0.10 | 0.30 | 0.40 |
| II | 12.2 | 0.10 | 0.24 | 0.34 |

Mixed ratio(2%) 0.02

7. Thickness of each coal seam and coal reserves

| seam | thickness (m) | reserves (m. ton) |
|---|---|---|
| I | 15.5 | 301 |
| II | 12.5 | 173 |

〈Calculation method〉

I. Estimated quality of each seam with overburden and interburden

Estimated quality = (Qc * Tc + Qr * Tr) / (Tc + Tr)
- Qc : quality of coal
- Qr : quality of overburden and interburden
- Tc : Thickness of coal seam
- Tr : Thickness of overburden and interburden

II. Estimated average quality of mine

Estimated average quality = $\sum_{i=1,2}$ Qeqi * Ri / $\sum_{i=1,2}$ Ri
- Qeqi : estimated quality of each seam
- Ri : reserves of each seam
- i : number of seams

(2) Seam II

In case of the separation of specific gravity at 1.45, product coal of about ash 17% can be produced with theoretical yield with 85%.

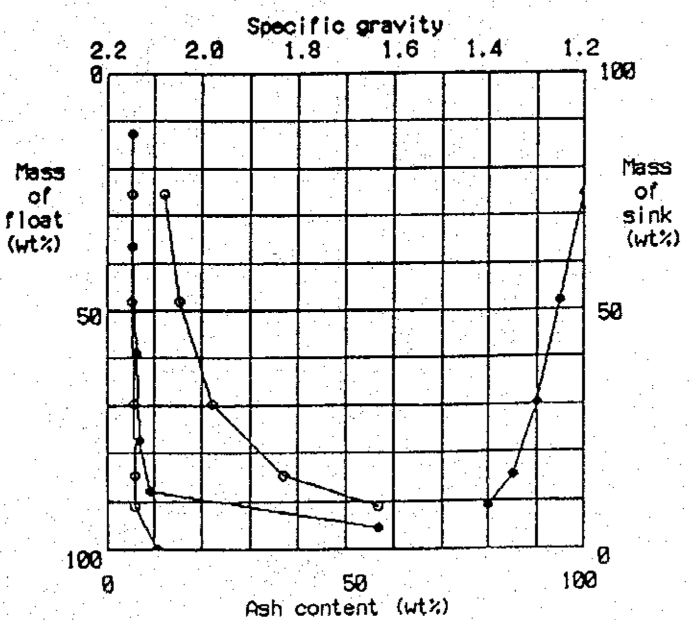
Ash contents of raw coal sample taken from Seams I and II are 11.1% and 22.1% respectively (see Tables 5.6 and 5.7). On the basis of the observed curve, it can be concluded that seam I is relatively easy for the separation of ash while Seam II is rather difficult. However, it has to be stressed that more detailed float and sink tests together with size analysis are required for bulk coal samples to satisfy the requirements of coal quality sought by the users if coal preparation has to be introduced. As a drying method of coal is considered due to high total moisture contents, it is considered to be not advantageous that surface moistures of coal is increased by coal preparation. Because the present problems encountered at the power station is the decreased calorific value due to high total moisture contents of coal, it is not necessary to decrease ash contents by coal preparation of raw coal by judging the specifications of coal quality. Furthermore, there is no such a case that lignite is treated at coal preparation plant in the world. Therefore, the conclusion is that coal preparation plant is absolutely not required at the present stage. If high quality coal is required due to the construction of new power stations in the near future, a further investigation should be carried out for comparison of benefits on high quality coal by coal preparation and construction costs of coal preparation plant.

## Table 5.6 Results of Float and Sink Test (Seam I)

| | | | | | |
|---|---|---|---|---|---|
| Sample | Mongolian Coal | | | | |
| Sample No. | Shivee Ovoo - Seam I. | | | | |
| Size Distribution | 0.5 - 5.0 | Mass (%) | 88.3 | Ash (%) | 11.1 |
| | - 32 mesh (- 500μm | Mass (5) | 19.7 | Ash (5) | 19.1 |
| Date - Sampling | 30th September, 1994 | | | | |
| Date - Analysis | 17th October, 1994 | | | | |

(Moisture Free Basis)

| | | a | | b | c | d | e | f | g | h | i | j |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group No<br>n | Relative Density Fraction | Floats<br>(g) | W<br>(%) | Ash<br>A<br>(%) | Cummulative Mass to the mid Point<br>ΣWn-1+Wn/2 | Quantity of Ash<br>WA | Cummulative Ash<br>ΣWA | Floats Cummulative Mass<br>ΣW | Cummulative Ash<br>ΣWA/ΣW | Total Ash<br>(k)-ΣWA | Sinks Mass<br>100-ΣW | Ash<br>h/i |
| 1 | - 1.20 | 124.5 | 25.63 | 5.24 | 12.8 | 134.33 | 124.33 | 25.63 | 5.24 | 931.46 | 74.37 | 12.52 |
| 2 | 1.20 - 1.25 | 108.4 | 22.32 | 5.53 | 36.8 | 123.39 | 257.73 | 47.94 | 5.38 | 808.06 | 52.06 | 15.52 |
| 3 | 1.25 - 1.30 | 106.5 | 21.93 | 6.30 | 58.9 | 138.22 | 395.94 | 69.87 | 5.67 | 669.85 | 30.13 | 22.23 |
| 4 | 1.30 - 1.35 | 72.3 | 14.88 | 7.09 | 77.3 | 105.53 | 501.47 | 84.75 | 5.92 | 564.32 | 15.25 | 36.99 |
| 5 | 1.35 - 1.40 | 30.9 | 6.35 | 9.13 | 87.9 | 58.03 | 559.50 | 91.10 | 6.14 | 506.29 | 8.90 | 56.89 |
| 6 | + 1.40 | 43.2 | 8.90 | 56.89 | 95.5 | 506.29 | 1065.79 | 100.00 | 10.66 | 0.00 | 0.00 | |
| Total | | 485.9 | 100.00 | | 100.0 | k | | | | | | |

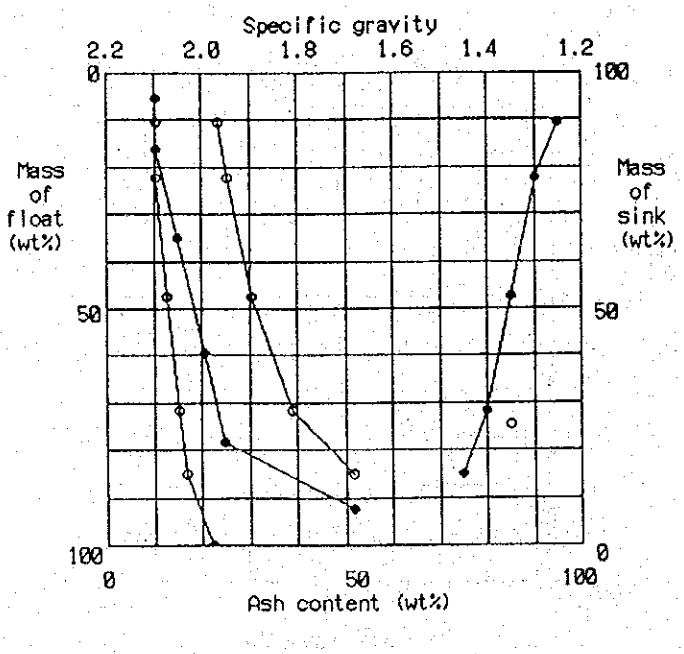


# Table 5.7 Results of Float and Sink Test (Seam II)

| | | | | | |
|---|---|---|---|---|---|
| Sample | Mongolian Coal | | | | |
| Sample No. | Shivee Ovoo - Seam II | | | | |
| Size Distribution | 0.5 - 5.0 | Mass (%) | 81.3 | Ash (%) | 22.1 |
| | - 32 mesh (- 500μm | Mass (5) | 18.7 | Ash (5) | 29.7 |
| Date - Sampling | 30th September, 1994 | | | | |
| Date - Analysis | 17th October, 1994 | | | | |

(Moisture Free Basis)

| | | a | | b | c | d | e | f | g | h | i | j |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group No<br>n | Relative Density Fraction | Floats<br>(g) | <br>W<br>(%) | Ash<br>A<br>(%) | Cummulative Mass to the mid Point<br>ΣWn-1+Wn/2 | Quantity of Ash<br>WA | Cummulative Ash<br>ΣWA | Floats Cummulative Mass<br>ΣW | Cummulative Ash<br>ΣWA/ΣW | Total Ash<br>(k)-ΣWA | Sinks Mass<br>100-ΣW | Ash<br>h/i |
| 1 | - 1.25 | 52.9 | 10.52 | 10.32 | 5.3 | 108.60 | 108.60 | 10.52 | 10.32 | 2100.89 | 89.48 | 23.48 |
| 2 | 1.25 - 1.30 | 58.9 | 11.71 | 10.48 | 16.4 | 122.73 | 231.32 | 22.23 | 10.40 | 1978.16 | 77.77 | 25.44 |
| 3 | 1.30 - 1.35 | 127.3 | 25.31 | 14.91 | 34.9 | 377.53 | 608.85 | 47.55 | 12.81 | 1600.64 | 52.45 | 30.52 |
| 4 | 1.35 - 1.40 | 120.7 | 23.98 | 20.48 | 59.5 | 491.30 | 1100.15 | 71.53 | 15.38 | 1109.34 | 28.47 | 38.97 |
| 5 | 1.40 - 1.45 | 67.3 | 13.37 | 24.69 | 78.2 | 330.19 | 1430.34 | 84.91 | 16.85 | 779.15 | 15.09 | 51.62 |
| 6 | + 1.45 | 75.9 | 15.09 | 51.62 | 92.5 | 779.15 | 2209.49 | 100.00 | 22.09 | 0.00 | 0.00 | |
| Total | | 503.0 | 100.00 | | 100.0 | k | | | | | | |



## 6 Environmental Study

### 6.1 General

The main purpose of Environmental Study for the renovation of Shivee Ovoo coal mine is to preserve a living, natural and social environment. The study was carried out in the Shivee Ovoo openpit mining area and mainly consists of environmental investigation and environmental examination. The work flow of Environmental Study is shown in Figure 6.1 of Chapter I.

Environmental items for openpit coal mine are selected, using matrix method as shown in Table 6.1 of Chapter I based on the existence of influence by the environmental factors of mining activities. The environmental factors consist mainly of stripping of overburden, transportation and piling of spoils, mining of coal, transportation of coal, piling and loading of coal at stockyard, a pumping groundwater, water treatment and drainage, activities at office and other facilities. The environmental items consist finally of air quality, water quality, noise, soil contamination, land, water, soil, fauna and flora, landscape and social conditions including waste, cultural heritage, hazards, resettlement and water right. These the items are just the same with items of field investigation and environmental examination.

The components of environmental examination is to project the environmental impacts which will be caused by increase of the production capacity to two million tons per year, as a result of renovation of mining, and to examine the environmental management and monitoring plan.

### 6.2 Legislation

See Chapter I.

### 6.3 Present conditions in Choir Town

Shivee Ovoo Coal Mine is located in the central part of Govi Sumberel (Aimag) Prefecture, approximately 250 km southeast of Ulaanbaatar and 1,180 to 1,230 m in elevation. Administrative municipality including Shivee Ovoo Coal Mine and survey area is Shivee Govi District in Choir Town as shown Figure in 1.2.

### 6.3.1 Social conditions

(1) Population

The population, number of family, birth rate and population growth rate of Choir Town in 1993 are 11,509, 2,700, 2.3 % and -5.7 % respectively. The rate of population growth before 1992 had shown a tendency to increase.

(2) Education

Educational condition in the town is shown in Table 6.1.

Table 6.1 Educational Condition in Choir Town

| Kind of School | Number | Teachers | Students |
|---|---|---|---|
| 10 years elementary | 5 | 128 | 2,400 |
| ( Boarder | | | 120 ) |

(3) Medical conditions

Medical conditions in the town is shown in Table 6.2.

Table 6.2 Medical Condition in Choir Town

| Medical facility | Number | Beds |
|---|---|---|
| 1. Hospital (Public) | 4 | 150 |
| 2. Sanatorium | 1 | |

(4) Water treatment

Drinking water for Choir townsite is supplied 96 $m^3$/day from water purifying facility, pumping by water wells. Shivee Govi District also has water supply system, pumping by water wells.

Sewage system is set up at Choir townsite and 76 $m^3$/day of sewage water is treated.

(5) Other facilities

Other public facilities in Choir Town are shown in Table 6.3.

Table 6.3 Other Public Facilities

| Public facility | Number | Remarks |
|---|---|---|
| 1. Town office | 1 | |
| 2. Police station | 1 | |
| 3. Post office | 1 | |
| 4. Fire department | 2 | |
| 5. Rail station | 2 | |
| 6. Sports stadium | 1 | |
| 7. Culture center | 1 | |
| 8. Sanitary institute | 1 | |
| 11. Other private facilities | | |
| - Thermal water plant | 1 | |
| - Bank | 3 | Ardyn Bank<br>Hotsh Bank<br>Huduu Ajahui Bank |
| - Hotel | 2 | Zahirgaa Hotel : 20 beds<br>Tumurzaa Hotel : 16 beds |
| - Restaurant | 1 | |
| - Market | 1 | |

(6) Industry

The first industry of the town mainly consists of stock farms, small volume of agriculture and coal mining. Domestic animals including cattle, horse, sheep, goat, camel, etc. are approximately 100,000 heads. The coal mining is the biggest industry in the town and coal production in 1993 was 600,000 tons.

The second industry consists of small scale of bakery, brewery, beverage and cashmere manufacture.

The third industry consists of transportation, railway, hotel, newspaper, restaurant and market.

(7) Land use

Land use in the Choir Town area mainly consists of stock farm, mining area, grass-land, agricultural farm, residential area, etc.

6.3.2 Natural conditions

(1) Water

Rivers in the area except around Mt. Choir are characterized by short water course and usually without surface water, so-called "wadi", because of low precipitation. Small lakes are sporadically distributed at low ground in the area.

(2) Meteorology

The climate of the area belongs to Sub-polar winter dry climate (Dw). Precipitation, average temperature, wind speed and dominant wind direction in the district in 1990 are 293 mm, 0.9℃, 2.8 m/sec and N - NE respectively as shown in Table 6.4 and Figure 6.1.

Table 6.4 Meteorological Data in Choir Town

(1) Precipitation (mm)

| Year : | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | : | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1989 : | 1.2 | 3.4 | 2.6 | 9.7 | 5.5 | 25.4 | 60.2 | 22.2 | 21.0 | 1.4 | 0.7 | 7.2 | : | 160.5 |
| 1990 : | 1.8 | 4.4 | 4.2 | 6.9 | 17.6 | 12.4 | 122.0 | 62.3 | 18.4 | 10.3 | 31.9 | 0.7 | : | 292.9 |

(2) Temperature (°C)

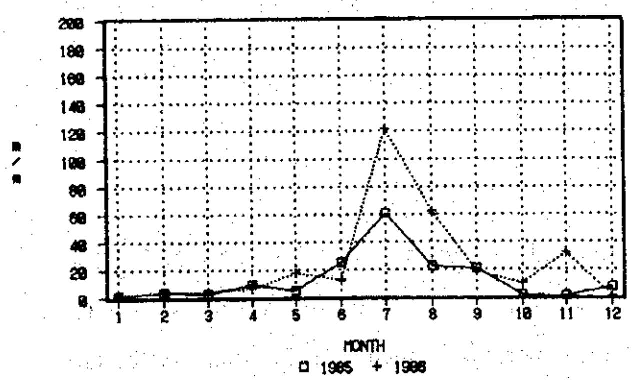
| Year : | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | : | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1989 : | -17.4 | -14.7 | -6.0 | 6.2 | 12.2 | 15.9 | 18.6 | 18.4 | 9.0 | 3.0 | -9.4 | -15.8 | : | 1.6 |
| 1990 : | -22.8 | -14.5 | -2.4 | 1.6 | 11.8 | 15.1 | 18.4 | 15.5 | 9.9 | 6.0 | -10.0 | -17.7 | : | 0.9 |

(3) Wind speed (m/sec)

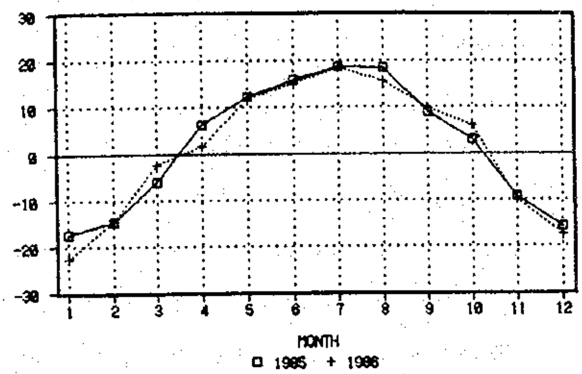
| Year : | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | : | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1989 : | 3.2 | 2.8 | 3.8 | 3.7 | 4.1 | 4.2 | 3.7 | 3.6 | 3.5 | 3.4 | 2.7 | 2.1 | : | 3.4 |
| 1990 : | 2.4 | 2.2 | 2.7 | 5.2 | 3.7 | 3.7 | 3.2 | 2.4 | 3.0 | 1.6 | 2.3 | 1.6 | : | 2.8 |

(4) Wind direction

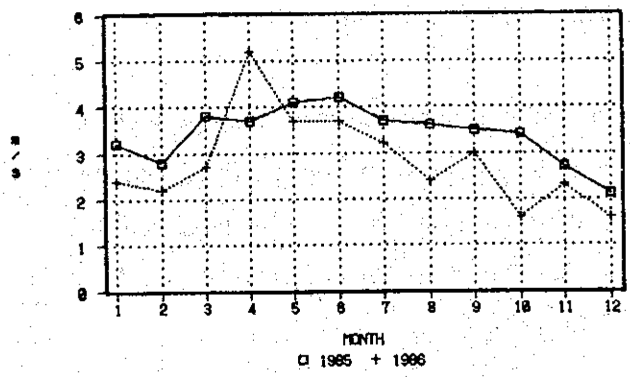
| Year : | NE | E | SE | S | SW | W | NW | N |
|---|---|---|---|---|---|---|---|---|
| 1985 : | 9.7 | 2.5 | 10.5 | 9.1 | 5.8 | 4.0 | 35.9 | 22.5 |
| 1986 : | 12.4 | 2.9 | 9.9 | 10.4 | 3.2 | 3.5 | 30.0 | 27.7 |



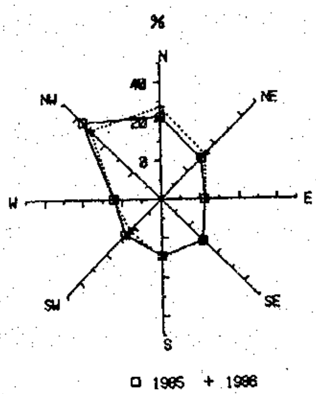

(1) Precipitation




(2) Temperature(° C)




(3) Wind speed




(4) Wind direction

Figure 6.1 Meteorological Condition in Choir Town

### 6.4 Environmental conditions in the survey area

The survey area covers an area of approximately 20 $km^2$ as shown in Figure 6.2. The center of the survey area is Shivee Ovoo Coal Mine.

#### 6.4.1 Living environment (Pollution)

(1) Air quality

Dust, mainly consisting of coal and clay, is generated by dump trucks for coal and spoil transportation at mine roads and blasting at open pits. The dust during warm season is assumably scattered surrounding mine area and influences infinitesimally to flora and fauna including domestic animals.

(2) Water quality

Water quality in the survey area is shown in Tables 6.5 and 6.6 and Figure 6.2.

Groundwater at the mine site is pumped up for the mining operation and pumpage volume ranges from 3,000 to 4,000 $m^3$ per day. The pumped groundwater is discharged into the nearest lake as shown in Figure 6.3. There are some water spring zones in the lake, and the people who live around the lake are drinking water of spring. Water quality of the lake originally corresponds with water spring (Table 6.5 Lake-2).

The pumped groundwater contains relatively much Ca, Cl, $SO_4$, $HCO_3$, Fe and high electric conductivity, 1,826 μS/cm. All of pumped groundwater is drained to the lake, so that the lake is contaminated. Especially, electric conductivity changes from 237 to 1,753 μS/cm and ferric ($Fe^{2+}$) containing 5.0 mg/l in groundwater mostly precipitates iron oxide ( $Fe(OH)_3$ ) by aeration at the drainage channel and lake.

There are several small lakes in and around the mine area. These lakes are contaminated by the drainage from the mine site and domestic animals.

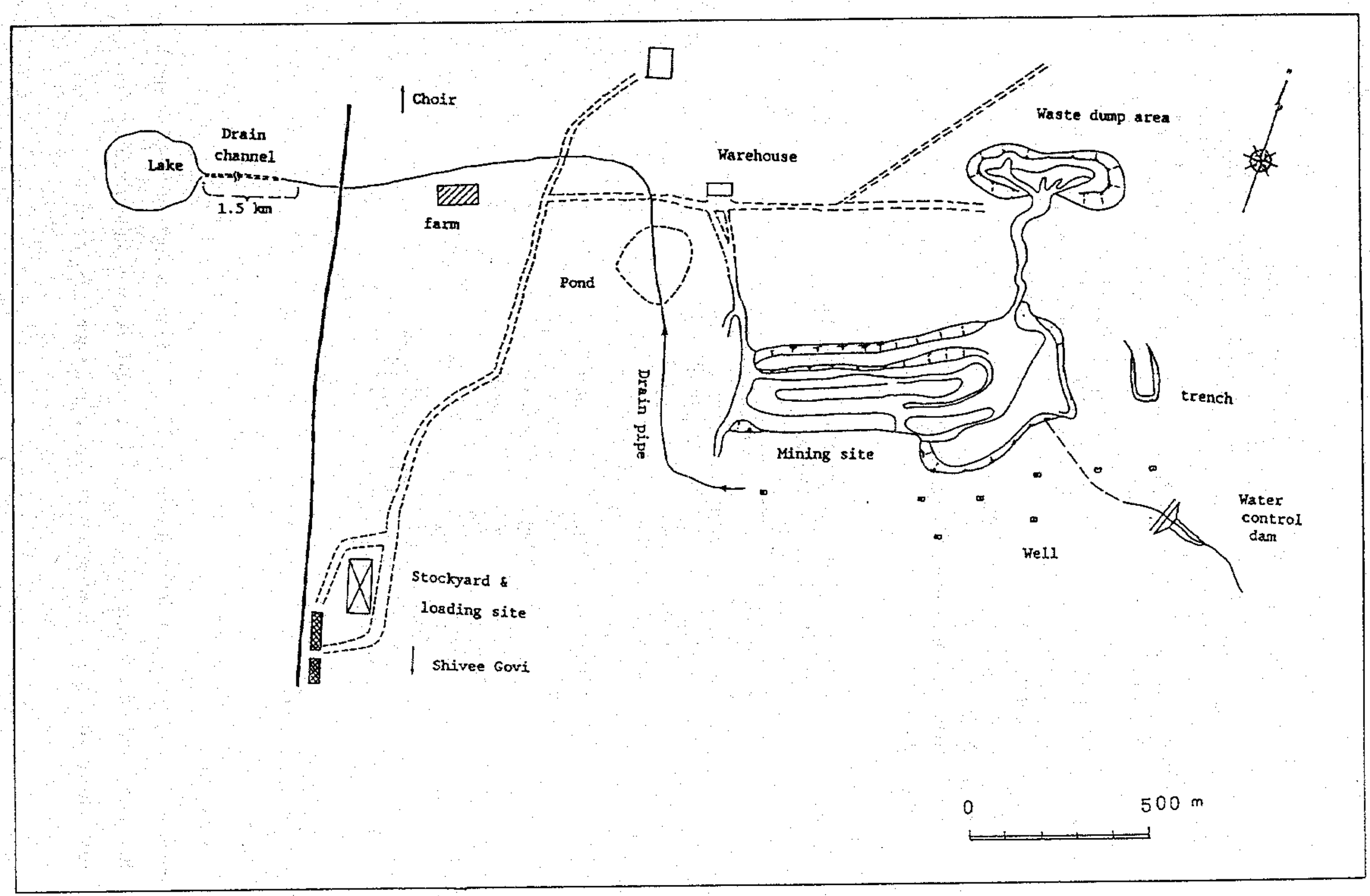



Figure 6.2 Shivee Ovoo Survey Area

Table 6.5 Water Quality in the Survey Area

August,1994

| No. | Location *1 | pH | T.*2 | E.C.*3 | Fe*4 | N*5 |
|---|---|---|---|---|---|---|
| 1 | Groundwater (pumped) | 6.8 | 9.3 | 1,826 | 5.0 | < 0.2 |
| 2 | Seepage at pit | 6.0 | 18.8 | 1,724 | < 0.1 | < 0.2 |
| 3 | Water course - 1 | 6.5 | 17.8 | 1,594 | - | - |
| 4 | Lake - 1 | 7.5 | 20.1 | 1,753 | - | - |
| 5 | Lake - 2 *6 | 7.0 | 23.7 | 237 | < 0.1 | < 0.2 |

*1 : See Figure 6.2.
*2 : Temperature (℃)
*3 : Electric conductivity ( μ S/cm)
*4 : Ferric ($Fe^{2+}$), mg/l
*5 : Nitrogen as ammonium ($NH_4$-N), mg/l
*6 : Water spring

Table 6.6 Water Quality of Groundwater Pumped at Mining Site *1

| Components | Unit | Concentration |
|---|---|---|
| 1. Ca | mg/l | 158.3 |
| 2. Mg | mg/l | 79.0 |
| 3. $Fe^{2+}$ | mg/l | non |
| 4. $Fe^{3+}$ | mg/l | non |
| 5. Na + K | mg/l | 32.7 |
| 6. $NH_4$ | mg/l | non |
| 7. Cl | mg/l | 236.7 |
| 8. $SO_4$ | mg/l | 150.0 |
| 9. $NO_2$ | mg/l | non |
| 10. $NO_3$ | mg/l | non |
| 11. $CO_3$ | mg/l | - |
| 12. $HCO_3$ | mg/l | 366.1 |

source: Shivee Ovoo Coal Mine, 1991
*1 : See Figure 6.2

### 6.4.2 Natural environment

#### (1) Land

##### 1) Topography

The survey area, ranging in elevation from 1,180 to 1,230 m, consists of flat plain and low-hilly land. Coal mine is located in the low-hilly land. A small valley, usually dried up, crosses the mine area from northeast to southwest as shown in Figure 6.2.

2) Geology

The survey area is widely occupied by Tebushin Govi Formation of Cretaceous, composed mainly of sandstone, mudstone, siltstone, limestone and several coal seams. The Cretaceous rocks belong to a part of Choir-Niarga Coal Basin and shows structurally syncline. Present mining area is located northern edge of the syncline.

Coal seams (lignite quality) consist of eight coal seams, namely Seam I to Seam VIII. Coal seams to be mined at present are Seams I, II and V. The dip of coal seam ranges from 4 to 10 degrees to the south. Measured coal reserves and total overburden volume are 484 million tons and 1,691 million BCM respectively.

Aquifer, mainly consisting of sandstone, conglomerate and coal seams, is located between -15.3 m and -260 m deep.

Alluvium deposits, mainly consisting of unconsolidated gravel and sand, are locally found along the dried river.

Waste dump area at mine site is intensively eroded by rain-fall and wind. The surface of slope is incised by innumerable gullies (gully erosion) because of no vegetation. And waste is flowed out and scattered to the surrounding waste dump area. The slope of waste ranges in gradient from 32 to 36 degrees.

(2) Water

1) Surface water

River is not developed and usually dried up because of low precipitation and high infiltration of surface. Several small lakes are sporadically distributed at low ground in the survey area. These lakes are thought to be originally recharged by groundwater and rain-water. The lake (400 m x 600 m wide), which is located near coal mine, has some points of water spring at the bottom of lake. The lake water is used as drinking water for the people living around the lake and domestic animals.

2) Groundwater

The groundwater is relatively rich in the survey area. Groundwater level in the mining area at the beginning of the coal development is confirmed to be-10 to -20 m deep.

Present groundwater level in the mining area is stabilized -45 m in depth by pumpage of nine wells. The capacity of pumpage is 200 $m^3$/hour. At present, ten water wells in the eastern part of the mining area for drawdown up to -130 m deep is drilled according to the new program of pumpage.

(3) Soil

Soil in the survey area mainly consist of chestnut soil. Chestnut soil, ranging in thickness from 15 to 65 cm, is characterized in light brown, precipitation layer of calcium carbonate ($CaCO_3$) and iron oxide. However, iron oxide is presumed to be occurred by oxidation as a result of pumpage.

At present, surface soil is not piled at the outside of mining site in advance for covering up to waste dump areas and mined out areas after land reclamation.

(4) Fauna/flora

Mining and survey area is covered with thin grass.

Mongolia is known to be rich in wildlife resources, and 134 species of mammals, 415 species of birds, 70 species of fish, 9 species of reptiles, 15,000 species of insects and several thousand species of plants are present.

Endangered and threatened species of fauna and flora in Mongolia are listed in Table 6.16 of Chapter I. Biological investigation had not been carried out in and around this area. Therefore, it is necessary to carry out the biological and ecological investigations in the survey area.

The influence of mining activities including extraction of overburden, spoil dumping, waste dump area, water pumping, drainage of waste water, generation of dust and soot, etc., are thought to affect to eco-system around the coal mine.

(5) Landscape

Main landscape in the survey area consists of several lakes, grass field, etc. Alteration of land shape is extensively done at mining site and waste dump areas by mining activities. Waste dump area, which is approximately 30 to 35 m in height, is planned to be used for land reclamation of mined out areas. Rest of waste is planned to reform its land shape and covered by soil and vegetation.

### 6.4.3 Social environment

(1) Wastes

Spoils produce by mining activities from mining sites mainly consist of overburden and interburden of coal seams except topsoil. All of spoils are piled at waste dump areas adjacent mining sites as shown in Figure 6.2. Waste dump areas are planned to reform their land shape and covered by soil and vegetation.

## 6.5 Environmental examination

Present environmental condition in the survey area is integrated in Table 6.7 as well as extraction of several environmental issues. These environmental issues are examined based on the expansion plan of coal mine.

### 6.5.1 Living environment

(1) Air quality

Dust from mine site, especially mine transportation roads, is possible to prevent by sprinkle water on the roads. Therefore, it is necessary to provide several watering trucks based on the extension plan of mining areas and roads.

(2) Water quality

Pumped groundwater at mine site containing much dissolved matter and soluble iron, contaminate to the lake where the people are using for drinking water. It is necessary to take care of draining site and to provide a fresh water for the residents. In addition, it is necessary to extraction of soluble iron from pumped groundwater before drainage.

(3) Others

Soil contamination and noise/vibration pollution are not recognized, but not clear so far. It is necessary to investigate the condition of soil quality and noise level surrounding mine site as well as a monitoring work.

Table 6.7 Environmental Checklist

| Environmental items | Check items | Influence 1 : 2 : 3*1 | Environmental issues | Moni. *2 |
|---|---|---|---|---|
| I. Living environment | | | | |
| 1. Air quality | - Dust from mine site | ○ | Dust | |
| | - Smoke by s. combustion | △ | | |
| 2. Water quality | - Drainage of ground-water | ○ | Fe | + |
| | - Seepage water at pit | △ | | + |
| | - Infiltration water at waste dump areas | ? | | + |
| 3. Soil contamination | - Soil contamination | △ | | + |
| 4. Noise & vibration | - Machinery | △ | | + |
| | - Blasting | △ | | |
| II. Natural environment | | | | |
| 1. Land | - Open pit mining | ○ | Reclamation | |
| | - Waste dump areas | ○ | | |
| | - Slope failure, etc. | ○ | | + |
| 2. Water | - Drawdown of groundwater | ◎ | | + |
| 3. Soil | - Extraction of top soil | ○ | Reuse of soil | |
| | - Soil erosion | △ | | |
| 4. Fauna/flora | - Influence to fauna | △ | Investigation | |
| | - Influence to flora | ○ | Investigation | + |
| | - Decertification | △ | | + |
| 5. Landscape | - Open pit mining | ○ | Reclamation | |
| | - Spoil and waste dump areas | ◎ | Reclamation | |
| III. Social environment | | | | |
| 1. Waste | - Spoil of overburden | ○ | Reclamation, reuse | |
| | - Domestic waste | △ | | |
| 2. Natural monument | - Shivee Ovoo Lake | ◎ | Communication | |
| | - Ovoos | ○ | | |

Note : *1 Influence : 1. ◎ : Major influence, ○: Minor influence
2. △ : Very small to non influence
3. ? : Not clear

*2 Moni. : Monitoring

6.5.2 Natural environment

(1) Land

The waste is used for reclamation of openpits and piled at waste dump areas.

Waste dump areas, which are continuously eroded and scattered by rain-fall and wind, are thought to affect water quality and flora. The slope of dump areas is too steep and there is no vegetation, so that reform and vegetation of slope is required against surface erosion, slope failure,etc.

Standard gradient of stable slope is shown in Table 6.8. Wastes and spoils consist of loose sand and sandy earth, so that the slope of waste dump and reclaimed areas is desirable to set up 1:2.0 in slope gradient, 15 m in maximum height of embankment and 1 m wide berm at each 5 m in height.

Table 6.8 Standard Slope Gradient for Embankment

| Materials | Height | Gradient |
|---|---|---|
| Block (rock) | 10 ~ 20 m | 1:1.8 ~ 1:2.0 |
| Sand | < 10 m | 1:1.8 ~ 1:2.0 |
| Sandy earth | < 5 m | 1:1.5 ~ 1:1.8 |
| | 5 ~ 10 m | 1:1.8 ~ 1:2.0 |
| Sandy earth with gravel | < 5 m | 1:1.5 ~ 1:1.8 |
| | 5 ~ 15 m | 1:1.8 ~ 1:2.0 |
| clay | < 5 m | 1:1.8 ~ 1:2.0 |

Source : Japan Road Association

(2) Water

1) Groundwater

Drawdown of groundwater level is planned up to -130 m deep for mining. Although detailed hydrological data is not available, apparent permeability coefficient is tentatively calculated using actual pumping volume and number of effective water wells as below.

$Q = n \times K \times 2\pi \times H \times L / (\ln L/r)$ : Formula of pumpage

Q : Pumping volume ($m^3$)

K : Permeability coefficient (m/sec)

Average : $8.5 \times 10^{-5}$ m/sec

n : Number of pumping well

H : Difference of head (m)
L : Length of aquifer (m)
r : Radius of well (m)

(Calculation of maximum pumping volume at present)

$Q = 0.05\ m^3/sec$
$H = 45\ m$
$L = 25\ m$
$r = 0.10\ m$
$n = 5$ wells
$Ka = 5.02 \times 10^{-6}\ m/sec$

(Calculation of forecasting pumping volume)

$Ka = 5.02 \times 10^{-6}\ m/sec$ (apparent)
$H = 130\ m$
$L = 50\ m$
$r = 0.10\ m$
$n = 10$ wells
$Qa = 0.330\ m^3/sec = 28{,}503\ m^3/day$
($0.033\ m^3/sec/well$)

As results of calculation of pumpage, the apparent permeability coefficient at present is calculated at $5.02 \times 10^{-6}$ m/sec, which is similar to the apparent permeability coefficient of Baganuur Coal Mine area ($8.65 \times 10^{-6}$ m/sec). The forecasting pumping volume at the next program of pumpage can be calculated at 0.330 $m^3$/sec or 28,503 $m^3$/day.

In addition, radius of influence area of groundwater at the mine area is calculated as below.

$Ra = 3{,}000 \times Sw \times K$ : Formula of Siechardt

Ra : Apparent radius of influence of groundwater (m)
Sw : Drawdown of groundwater (m) : 130 m
K : Permeability coefficient (m/sec)
Apparent : $5.02 \times 10^{-6}$ m/sec

Rp = 873.8 m (apparent)

Apparent radius of influence area of groundwater is calculated at approximately 900 m. Drawdown of groundwater surrounding of the mine site certainly occurs and it might be influenced to surface water including lakes, soil, flora/fauna as a promotion of local decertification, because the area is transition zone between steppe and govi desert zone.

After finish of coal mining as well as pumpage work, reclamation of mining pits will be done. The groundwater will rapidly recover to the primary groundwater level. If the land reclamation is not enforced, large artificial lake will appear in the mining sites.

(3) Soil

Surface soil in the mining area is certainly removed, but it is necessary to pile the topsoil at mining site in order to reuse for replantation of the mined out areas and waste dump areas. The thickness of topsoil is approximately 35 cm in average. It is possible to be obtained topsoil approximately 3,000 $m^3$/ha. Soil lower than -30 cm deep from surface generally contains much Ca and Fe, so that it is better to take topsoil above -30 cm deep.

(4) Fauna/flora

Vegetation in the mining area, which is covered with thin grass, is certainly affected by the alteration of shape.

After mining of coal for the land reclamation of mined out areas and reshape of waste dump areas, replantation for conservation of natural environment should be enforced. Piled up topsoil including much seed of grass can be used for replantation of grass.

(5) Landscape

Mining pits should be reclaimed for landscape. And waste dump areas are necessary to reshape for not only preservation of erosion of slope, slope failure, treatment of waste but also better landscape.

## 6.6 Environmental management plans

Environmental management plans based on the results of examination concerning each environmental item is summarized in Table 6.9.

Table 6.9 Environmental Management Plan

| Items | : Causes and Influences | : Countermeasures |
|---|---|---|
| 1. Air quality | : - Dust by transportation of coal and topsoil | : Sprinkling water by watering trucks |
| 2. Water | : - Water pollution by drainage of groundwater | : Water treatment |
| 3. Land | : - Alteration of land shape by openpit mining and waste dumping | : Reclamation by reusing of spoils and reform of slope of embankment |
| 4. Water | : - Surface water by increased drainage of groundwater water pumped | : Discharged pond |
| 5. Soil | : - Stripping of topsoil by openpit mining | : Piling of topsoil and reuse of topsoil for replantation |
| 6. Fauna/flora | : - Stripping of vegetation by openpit mining and waste dumping | : Replantation at reclaimed and waste dump areas using piled topsoil |
| 7. Landscape | : - Alteration of land shape by openpit mining and waste dumping | : Reclamation and replantation |
| 8. Wastes | : - Occurrence of wastes and waste dump areas | : Reusing for reclamation at mined out areas, reform of slop of embarkment and replantation of surface of wastes |

### 6.6.1 Natural environment

(1) Air quality

Dust occurs mainly from mine roads for transportation of coal and wastes. It is necessary to provide two watering trucks (40 tons capacity) for sprinkling water.

(2) Water quality

Pumped groundwater in the mine site is discharged to the lake where the people living around the lake drink water of the lake. The water drained contains relatively much dissolved matters and soluble iron as drinking water. Therefore, it is necessary to provide a drinking water for the people living around the lake.

### 6.6.2 Natural environment

(1) Land

Openpits will be reclaimed using waste and will be reformed the shape. Waste dump areas should also be reshaped. The slope of reclaimed mined out areas and waste dump areas should be kept stable and be prevented from erosion. The slope of waste dump and reclaimed areas is desirable to have a slope of 1:2.0 in gradient, 15 m in maximum height of embankment and 1 m wide berm at each 5 m high as shown in Figure 6.3.

(2) Water

Pumped groundwater, approximately 28,500 $m^3$/day in future, will be discharged to the lake. The lake will be presumably filled for only 80 days on the condition of non infiltration and evaporation. Therefore , it is necessary to provide an additional settlement pond for discharge.

(3) Soil

Topsoil is important for slope protection and replantation of grass as shown in Figure 6.3, so that it is necessary to strip topsoil prior to the overburden removal.

(4) Fauna and flora

After land reclamation at mined out areas and reshape of waste dump areas, it is necessary to be recovered with the vegetation for ecological condition as well as protection of slope, dust dispersion, landscape, etc. Piled topsoil is suitable for replantation of grass by seeds as shown in Figure 6.3.

(5) Landscape

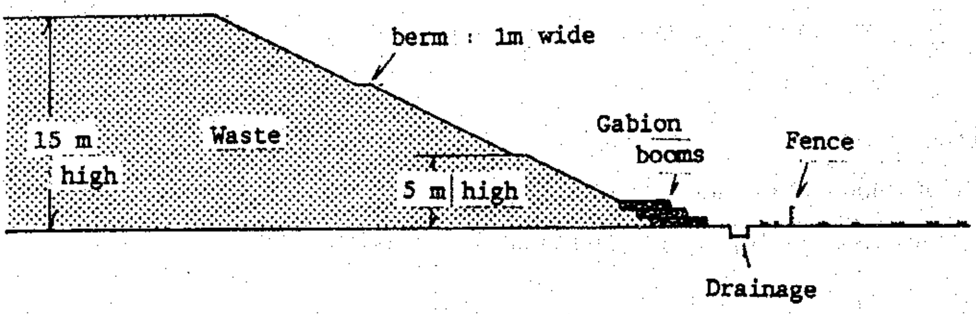
After land reclamation at mined out areas and reshape of waste dump areas, it is necessary to replant seeding of grass for landscape. Piled topsoil is suitable for slope protection and replantation.

### 6.6.3 Social environment

Waste dump areas should be reformed their shape for keeping stable condition, slope protection, drainage system as well as replantation of grass.

## 6.7 Monitoring plan

The monitoring is necessary to follow the change the environmental conditions and examine on the preservation of environment. The components of monitoring are shown in Table 6.10.



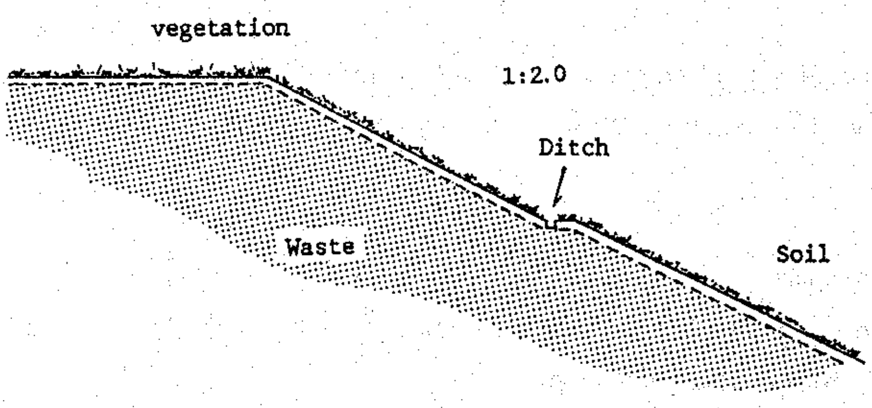




Figure 6.3 Slope of Waste Dump

Table 6.10 Monitoring Plan

| Items | : | Influences | : | Monitoring | |
|---|---|---|---|---|---|
| 1. Air quality | : | - Smoke and dust | : | SPM, dust-fall | : Plantsite, mine site, |
| 2. Water quality | : | - Drainage of sewage and groundwater | : | Main components *1 | : Draining channel, lake, etc. |
| | | -Seepage at pits and dump areas | : | Main components *1 | : Around mine site |
| 3. Water | : | - Drainage of ground-water pumped | : | Outflow, etc. | : Observation |

Note : *1 : Component of analysis : pH, electric conductivity, chemical oxygen demand, suspended solid, total N,Fe, Mn, Cl, K, Ca, Mg, $HCO_3$, $SO_4$

6.7.1 Living environment

(1) Air quality

Monitoring of air quality consists of dust. Components of analysis is suspended particulate matter (SPM) and dust fall. Monitoring points will be located around mine site, stockyard and loading site.

(2) Water quality

Components of water quality of drainage of groundwater and seepage from pits and waste dump areas consists of pH, electric conductivity, chemical oxygen demand, suspended solid, total N, Fe, Mn, Cl, Na, K, Ca, Mg, $HCO_3$, $SO_4$. Monitoring points are designated at drainage channel, lake, drained pond with drained water, mining site and waste dump areas.

6.7.2 Natural environment

(1) Water

Massive pumped groundwater will be drained to the lake. It is necessary to observe the condition of surface water.

6.8 Environmental investigation

It is necessary to conduct detailed environmental investigation in order to understand the environmental conditions in and around the mining area and for planning of concrete measurements for environmental conservation. The components of environmental investigation are listed in Table 6.11.

Table 6.11 Environmental Investigation

| Items | Components | Location |
|---|---|---|
| 1. Air quality | SOx, NOx, SPM, dust-fall | Mining area and its circumstance |
| 2. Water quality | Chemical & physical analyses; components *1 | Rivers, lake, mining area and circumstance |
| 3. Water | Hydrological investigation (Water balance, pumping teat, drilling survey | Lake, rivers |
| 4. Soil | Soil investigation (Soil section, chemical analysis; components *2 | Mining area and its circumstance |
| 5. Fauna/flora | Fauna & flora investigation | Mining area and its circumstance |

Note : *1 : Components : pH, electric conductivity, chemical oxygen demand, suspended solid, total N, Fe, Mn, Cl, Na, K, Ca, Mg, $HCO_3$, $SO_4$

*2 : Components : Pb, Ni, Cu, Mo, Mn, Sn, V, Cr, Cd, Cyanide, Organic P, As, Hg

### 6.9 Cost estimation

Costs for environmental conservation consist of environmental investigation, environmental countermeasures and monitoring works as shown in Table 6.12. The total cost of environmental conservation, excluding the environmental investigation, is estimated to be additional 10 tg. per BCM of total excavation. After finish of mining, the costs for additional environmental conservation, including reclamation, planting and monitoring works should be required.

### 6.10 Conclusions and recommendations

#### 6.10.1 Conclusions

The environmental investigation in the Shivee Ovoo Coal Mine area was carried out for nine environmental items, namely; air quality, water quality, soil contamination, noise/vibration, land, water, soil, fauna/flora and landscape.

Major influences consist of water pollution by the water discharged to the existing lake. Minor influences consist of air pollution, land, fauna/flora and landscape.

Installation of a water treatment system of groundwater is required.

# Table 6.12 Costs of Environmental Conservation

($10^6$ tg.)

| Environmental Items | Components | Rate (%) | Year -1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24-33 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019-2028 | |
| 1. Air quality | Dust | 5 | - | 1.6 | 1.6 | 1.6 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | - | 92.0 |
| 2. Water quality | Water treatment | 10 | - | 3.2 | 3.2 | 3.2 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | - | 183.6 |
| 3. Land | Reclamation | 50 | - | 16.0 | 16.0 | 16.0 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 *1 | 859.4 |
| 4. Water | Drainage | 15 | - | 4.8 | 4.8 | 4.8 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | - | 274.4 |
| 5. Soil | Stockpile | 10 | - | 3.2 | 3.2 | 3.2 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 3.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | - | 183.6 |
| 6. Flora | Planting | 5 | - | 1.6 | 1.6 | 1.6 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 22.0 *2 | 114.0 |
| 7. Monitoring | - | 5 | - | 1.6 | 1.6 | 1.6 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 44.0 *3 | 136.0 |
| 8. Environmental investigation | - | - | 80.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 80.0 |
| 1. A *4 | | | | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 43.7 | 779.7 |
| 2. B *5 | | | | 0.0 | 0.0 | 0.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 55.0 | 65.7 | 1,165.7 |
| Total | | 100 | 80.0 | 32.0 | 32.0 | 32.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 87.0 | 199.4 | 2,025.4 |

*1 : For one year after mined out.
*2 : For five years after mined out.
*3 : For ten years after mined out.
*4 : 10 tg. per BCM of total excavation in cace of A.
*5 : 10 tg. per BCM of total excavation in cace of B.

### 6.10.2 Recommendations

The monitoring plan, consisting of air quality (SPM and dust-fall), water quality (pH, COD, Fe, etc.) and water (drainage of groundwater and Baganuur Lake) in order to preserve the environment in the district during and after mining of coal would be carried out.

In addition, it is recommended to carry out more detailed investigations of air quality, water quality, water, soil and fauna/flora in and around the coal mine area.

# 7 Study of Capital and Operating Costs

Capital and operating costs are studied separately for the project period of 23 years because it is only presumed to be proper for economic evaluation and financial analysis. The capital cost is estimated in accordance with the initial capital cost required for production expansion and the replaced capital cost required by operating life of equipment and facilities. The operating cost is estimated from each equipment in accordance with schedule of production expansion.

## 7.1 Replacement schedule

Result of comparative cost index shows that overburden removal by one new medium size dragline is the most economical option for expansion of the production at Shivee Ovoo coal mine. Table 7.1 shows the replacement schedule of mining equipment for this option - Case 3. Initial capital investment for supporting equipment and facilities is scheduled to be undertaken in the year shown in Table 4.13. Replacement of those equipment and facilities will be periodically required to conform to the operating life of each equipment.

## 7.2 Equipment price and parts cost

For the purpose of estimating and evaluating the capital and operating costs, future cost data are projected from the current cost data and conversion factors. Table 7.2 shows the concept of price and cost structure to be used in this study. Initial investment cost and replace investment cost are included in capital cost. Parts cost, diesel oil, gas and lubricants, electricity, explosives, labour cost, etc. are included in operating cost.

Regarding prices of the existing Russian mining equipment purchased in the past, the prices of those equipment were re-evaluated to the current price level because the registered asset value of those equipment is considered to be still lower than the current price level and the price of Russian made mining equipment is forecasted to increase to 80% level of the modern equipment. Based on the re-evaluated price of those equipment, cost of parts required for existing equipment is projected as shown on Table 7.3.

## Table 7.1 Replacement Schedule of Mining and Supporting Equipment

| | | | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coal production | (million ton) | | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Overburden removal | (million BCM) | | 2.1 | 2.1 | 2.5 | 2.5 | 2.5 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |

| Existing equipment | Unit | Life | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shovel EKG-5A | 4 | 15 | | | | | 1 | 1 | 1 | 1 | | | | | | | | | | | | 1 | 1 | 1 | 1 | | |
| D/T Belaz 548 | 15 | 6 | 4 | 2 | 2 | 7 | | | 4 | 2 | 2 | 7 | | | 4 | 2 | 2 | 7 | | | 4 | 2 | 2 | 7 | | | 4 |
| Bulldozer CAT D8 | 2 | 8 | | | | | | | | 2 | | | | | | | | 2 | | | | | | | | 2 | |
| Bulldozer DET-250 | 2 | 6 | | | | 1 | 1 | | | | | 1 | 1 | | | | | 1 | 1 | | | | | 1 | 1 | | |
| Drill | 2 | 8 | | | 2 | | | | | | | | 2 | | | | | | | | 2 | | | | | | |

Table 7.2 Price and Cost Structures

| Items | Foreign Currency | Local Currency | | CIF Site | |
|---|---|---|---|---|---|
| | Border Price | Taxes | Other Costs | Without Taxes | Total |
| Imported Equipment | 0.8333<br>(1.0000) | 0.1521<br>(0.1825) | 0.0146<br>(0.0175) | 0.8479<br>(1.0175) | 1.0000<br>(1.2000) |
| Imported Parts including explosives | 0.7407<br>(1.00000) | 0.1963<br>(0.2650) | 0.0630<br>(0.0850) | 0.8037<br>(1.0850) | 1.0000<br>(1.3500) |
| Diesel Oil | 0.4726<br>(1.0000) | 0.2578<br>(0.5455) | 0.2696<br>(0.5703) | 0.7422<br>(1.5703) | 1.0000<br>(2.1158) |
| Gasoline & Lubricant | 0.4611<br>(1.0000) | 0.1653<br>(0.3585) | 0.3736<br>(0.8102) | 0.8347<br>(1.8102) | 1.0000<br>(2.1687) |
| Electricity | ——— | 0.0909 | 0.9091 | 0.9091 | 1.0000 |
| M & E Others | ——— | 0.0909 | 0.9091 | 0.9091 | 1.0000 |
| Labor Costs (Salary) | ——— | 0.0700 | 0.9300 | 0.9300 | 1.0000 |
| Royalties & Charges | ——— | T & R | EC | EC | FC |
| * After Tax Expenses | ——— | ——— | 1.0000 | 1.0000 | 1.0000 |

Where,

FC = Royalties and charges for financial cost
Baganuur ——— Revenue×0.03+**(S&W) ×0.048 + Coal(t) ×32.5+TBCM×1.01 Tg
Shivee Ovoo —— Revenue ×0.06+**(S&W) ×0.048 + Coal(t) ×27.0+TBCM×1.01 Tg

EC = Royalties and charges for economic cost
Health insurance, rail car standstill charges, fire fighter & guard, business trip, etc.
Baganuur ——— **(S&W) ×0.048 + Coal(t) ×32.5 Tg
Shivee Ovoo —— **(S&W) ×0.048 + Coal(t) ×27.0 Tg

T&R = Taxes and royalties
Baganuur ——— Revenue ×0.03 +TBCM×1.01 Tg
Shivee Ovoo —— Revenue ×0.06 +TBCM×1.01 Tg

Note: * "After tax expenses" mean the profit distribution procedure in the Mongolian accounting system; however, those are made up of "before tax expenses" and "after tax profits" in the western accounting system. In the analyses, the portion of "before tax expenses" such as bonus, food aid and pension supplement is included in the operating cost.

** (S&W) is short for salary and wage costs.

## Table 7.3 Estimated Equipment Price and Parts Cost for the Existing Equipment

Current parts cost

| Name of the Item | unit | Current Unit price (1000US$) | Required Parts (%) | Parts cost (1000 US$/y) | Total capital (1000US$) | Life (year) | Depreciation Replace Capital (1000US$/y) |
|---|---|---|---|---|---|---|---|
| Shovel 5A | 4 | 676 | 7.80 | 211 | 2,704 | 15 | 180 |
| D/T Belaz | 15 | 80 | 11.00 | 132 | 1,200 | 3 | 400 |
| Bulldozer CAT D8 | 2 | 400 | 14.00 | 112 | 800 | 8 | 100 |
| Bulldozer DET250, 110 | 2 | 90 | 11.00 | 20 | 180 | 6 | 30 |
| Drill 160 | 2 | 200 | 3.00 | 12 | 400 | 8 | 50 |
| Grand total (US$) | | | | 487 | 5,284 | | 760 |
| Local cost (35%) | | | | 170 | | | |
| Local cost (20%) | | | | | 1,057 | | 152 |
| Grand total | | | | 657 | 6,341 | | 912 |

Future parts cost

| Name of the Item | unit | Estimated unit price (1000US$) | Required Parts (%) | Parts cost (1000 US$/y) | Current capital (1000US$) | Life (year) | Depreciation Replace Capital (1000US$/y) |
|---|---|---|---|---|---|---|---|
| Shovel 5A | 4 | 1,514 | 10.00 | 606 | 6,056 | 15 | 404 |
| D/T Belaz | 15 | 304 | 14.00 | 638 | 4,560 | 6 | 760 |
| Bulldozer CAT D8 | 2 | 400 | 14.00 | 112 | 800 | 8 | 100 |
| Bulldozer DET250, 110 | 2 | 320 | 14.00 | 90 | 640 | 6 | 107 |
| Drill 160 | 2 | 448 | 14.00 | 125 | 896 | 8 | 112 |
| Grand total (US$) | | | | 1,571 | 12,952 | | 1,483 |
| Local cost (35%) | | | | 550 | | | |
| Local cost (20%) | | | | | 2,590 | | 297 |
| Grand total | | | | 2,121 | 15,542 | | 1,780 |

Note:
Estimated price of Russian equipment are 80% of modern type equipment.
Estimated future quality of Russian equipment will be closed to western equipment.
Parts for overhaul and daily maintenance are included.
Percents of required parts for Russian equipment are the same as those of the typical western equipment.

## 7.3 Capital and operating cost

### 7.3.1 Capital cost

Initial and replacement capital costs of mining equipment, supporting equipment and facilities are estimated according to the replacement schedule of Section 7.1 and equipment price in Section 7.2 to achieve production expansion to 2 million tons per year. Investment schedule for the renovation project is summarized in Table 7.4.

### 7.3.2 Operating Cost

Operating costs for those equipment and facilities are estimated according to the implementation schedule of production expansion. Base data required for operating cost estimation such as manpower, spare parts, fuels, electricity and consumables for mining equipment are shown in Table 7.5. Those estimations for suppporting equipment are shown in Table 7.6.

In order to estimate the future operating cost, current operating cost data such as explosives, consumables, diesel oil, electricity, etc. are analyzed. Table 7.7 shows the unit operating costs for the existing system. Table 7.8 shows the unit operating costs for additional system. These estimations are mainly based on the budget production plan for 1994 provided by mine, which are shown in Table 7.9. Regarding the salary and wages, variance data are analyzed and shown on Appendix 4.

## 7.4 Foreign currency and local currency

### 7.4.1 Foreign currency portion

Foreign currency portion of capital and operating costs required for 23 years are shown in Table 7.10. Those required for the first three years is US$ 48.7 millions.

### 7.4.2 Local currency portion

Local currency portion of capital and operating costs required for 23 years are shown in Table 7.11. Those required for the first three years is US$ 7.9 millions.

# Table 7.4 Investment Schedule for Renovation Project

## EXISTING EQUIPMENT REPLACEMENT

UNIT:US$ 10*3 (Border Price Basis)

| EQUIPMENT | PRICE | LIFE | UNIT | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | yrs | | | | | | | | | | | | | | | | | | | | | | | | | |
| SHOVEL EKG-5A | 1,514.0 | 15 | 4 | | | 1 | 1 | 1 | 1 | | | | | | | | | | | | 1 | 1 | 1 | 1 | | | 8 |
| (+10%) | 1,665.4 | | | 0.0 | 0.0 | 1,665.4 | 1,665.4 | 1,665.4 | 1,665.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,665.4 | 1,665.4 | 1,665.4 | 1,665.4 | 0.0 | 0.0 | 13,323.2 |
| D/T BELAZ 548 | 304.0 | 6 | 15 | 2 | 7 | | | 4 | 2 | 2 | 7 | | | 4 | 2 | 2 | 7 | | | 4 | 2 | 2 | 7 | | | 4 | 58 |
| (+10%) | 334.4 | | | 668.8 | 2,340.8 | 0.0 | 0.0 | 1,337.6 | 668.8 | 668.8 | 2,340.8 | 0.0 | 0.0 | 1,337.6 | 668.8 | 668.8 | 2,340.8 | 0.0 | 0.0 | 1,337.6 | 668.8 | 668.8 | 2,340.8 | 0.0 | 0.0 | 1,337.6 | 19,395.2 |
| BULL. CAT D8 | 400.0 | 8 | 2 | | | | | | 2 | | | | | | | | 2 | | | | | | | | 2 | | 6 |
| (+10%) | 440.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 880.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 880.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 880.0 | 0.0 | 2,640.0 |
| BULL. DET-250 | 320.0 | 6 | 2 | | 1 | 1 | | | | | 1 | 1 | | | | | 1 | 1 | | | | | 1 | 1 | | | 8 |
| (+10%) | 352.0 | | | 0.0 | 352.0 | 352.0 | 0.0 | 0.0 | 0.0 | 0.0 | 352.0 | 352.0 | 0.0 | 0.0 | 0.0 | 0.0 | 352.0 | 352.0 | 0.0 | 0.0 | 0.0 | 0.0 | 352.0 | 352.0 | 0.0 | 0.0 | 2,816.0 |
| DRILL | 448.0 | 8 | 2 | 2 | | | | | | | | 2 | | | | | | | | 2 | | | | | | | 5 |
| (+10%) | 492.8 | | | 985.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 985.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 985.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2,956.8 |
| ICM is not for contingency but for other equipment. | | LIFE | 15 yrs | 0.0 | 0.0 | 1,665.4 | 1,665.4 | 1,665.4 | 1,665.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,665.4 | 1,665.4 | 1,665.4 | 1,665.4 | 0.0 | 0.0 | 13,323.2 |
| | | | 8 | 985.5 | 0.0 | 0.0 | 0.0 | 0.0 | 880.0 | 0.0 | 0.0 | 985.5 | 0.0 | 0.0 | 0.0 | 0.0 | 880.0 | 0.0 | 0.0 | 985.6 | 0.0 | 0.0 | 0.0 | 0.0 | 880.0 | 0.0 | 5,596.8 |
| | | | 6 | 668.8 | 2,692.8 | 352.0 | 0.0 | 1,337.6 | 668.8 | 668.8 | 2,692.8 | 352.0 | 0.0 | 1,337.6 | 668.8 | 658.8 | 2,692.8 | 352.0 | 0.0 | 1,337.6 | 668.8 | 668.8 | 2,692.8 | 352.0 | 0.0 | 1,337.6 | 22,211.2 |
| | | TOTAL | | 1,654.4 | 2,692.8 | 2,017.4 | 1,665.4 | 3,003.0 | 3,214.2 | 668.8 | 2,692.8 | 1,337.6 | 0.0 | 1,337.6 | 668.8 | 658.8 | 3,572.8 | 352.0 | 0.0 | 2,323.2 | 2,334.2 | 2,334.2 | 4,358.2 | 2,017.4 | 880.0 | 1,337.6 | 41,131.2 |

## ADDITIONAL MINING EQUIPMENT

UNIT:US$ 10*3 (Border Price Basis)

| EQUIPMENT | PRICE | LIFE | UNIT | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | yrs | | | | | | | | | | | | | | | | | | | | | | | | | |
| D/L 29/96 | 16,615.0 | 30 | 1 | | 0.5 | 0.5 | | | | | | | | | | | | | | | | | | | | | 1 |
| | | | | 0.0 | 8,307.5 | 8,307.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16,615.0 |
| BULL. 388 HP | 616.0 | 8 | 1 | | | 1 | | | | | | | | 1 | | | | | | | | 1 | | | | | 3 |
| | | | | 0.0 | 0.0 | 616.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 616.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 616.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,848.0 |
| GRADER 205 KW | 426.0 | 8 | 1 | | | 1 | | | | | | | | 1 | | | | | | | | 1 | | | | | 3 |
| | | | | 0.0 | 0.0 | 426.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 426.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 426.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,278.0 |
| | | LIFE | 30 yrs | 0.0 | 8,307.5 | 8,307.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16,615.0 |
| | | | 8 | 0.0 | 0.0 | 1,042.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,042.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,042.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3,126.0 |
| | | TOTAL | | 0.0 | 8,307.5 | 9,349.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,042.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,042.0 | 0.0 | 0.0 | 0.0 | 0.0 | 19,741.0 |

## ADDITIONAL SUPPORTING EQUIPMENT

UNIT:US$ 10*3 (Border Price Basis)

| LIFE (yrs) | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 0.0 | 700.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 700.0 |
| 20 | 0.0 | 1,600.0 | 443.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,600.0 | 443.0 | 4,085.0 |
| 15 | 0.0 | 600.0 | 425.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 600.0 | 425.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2,050.0 |
| 10 | 0.0 | 757.0 | 2,627.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 757.0 | 2,627.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 757.0 | 2,627.0 | 10,152.0 |
| 8 | 0.0 | 0.0 | 6,849.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6,849.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6,849.0 | 0.0 | 0.0 | 0.0 | 0.0 | 20,547.0 |
| 6 | 0.0 | 0.0 | 255.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 255.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 255.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 255.0 | 0.0 | 0.0 | 1,020.0 |
| 5 | 0.0 | 4,000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4,000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4,000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4,000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4,000.0 | 0.0 | 20,000.0 |
| TOTAL | 0.0 | 7,657.0 | 10,599.0 | 0.0 | 0.0 | 0.0 | 4,000.0 | 0.0 | 255.0 | 0.0 | 6,849.0 | 4,757.0 | 2,627.0 | 0.0 | 255.0 | 0.0 | 4,600.0 | 425.0 | 6,849.0 | 0.0 | 255.0 | 6,357.0 | 3,070.0 | 58,555.0 |

Note : Equipment of each life is shown in Table 4.12.

## Table 7.5 Base Data for Operating Cost Estimation (Case 3)

Manpower

| | Man/unit person | unit | Crew | Total person | Absence Rate | Required person |
|---|---|---|---|---|---|---|
| Dragline 29/96 | 2 | 1 | 3 | 6 | 0.83 | 8 |
| Bulldozer 388 kW | 1 | 1 | 2 | 2 | 0.83 | 3 |
| Grader 205 kW | 1 | 1 | 2 | 2 | 0.83 | 3 |
| Maintenance | | | | 6 | 0.83 | 8 |
| Total | | | | 16 | | 22 |

Spare parts

| | Equipment unit price Border Price 1000 US$ | CIF Site w/o tax 1000 US$ | Parts factor | Parts cost /unit 1000 US$ | Unit | Parts cost total 1000 US$/y |
|---|---|---|---|---|---|---|
| Dragline 29/96 | 16,615 | 18,027 | 0.05 | 901 | 1 | 901 |
| Bulldozer 388 kW | 616 | 668 | 0.05 | 33 | 1 | 33 |
| Grader 205 kW | 426 | 462 | 0.05 | 23 | 1 | 23 |
| Total | | | | | | 957 |

Consumables

| | Equipment unit price Border Price 1000 US$ | CIF Site w/o tax 1000 US$ | Consume factor /hour | Operation hour h/year | Parts cost 1000 US$ | Unit | Parts cost total 1000 US$/y |
|---|---|---|---|---|---|---|---|
| Dragline 29/96 | 16,615 | 18,027 | 0.00001 | 4,236 | 764 | 1 | 764 |
| Bulldozer 388 kW | 616 | 668 | 0.00001 | 4,236 | 28 | 1 | 28 |
| Grader 205 kW | 426 | 462 | 0.00001 | 4,236 | 20 | 1 | 20 |
| Total | | | | | | | 812 |

Overhaul

| | Equipment unit price Border Price 1000 US$ | CIF Site w/o tax 1000 US$ | Parts factor /time | Overhaul Interval year | Life year | Overhaul time /life | Overhaul cost/life 1000 US$ | Overhaul Cost 1000 US$/y | Unit | Overhaul Cost 1000 US$/y |
|---|---|---|---|---|---|---|---|---|---|---|
| Dragline 29/96 | 16,615 | 18,027 | 0.1 | 8 | 30 | 3 | 5,408 | 180 | 1 | 180 |
| Bulldozer 388 kW | 616 | 668 | 0.1 | 2 | 8 | 3 | 200 | 25 | 1 | 25 |
| Grader 205 kW | 426 | 462 | 0.1 | 2 | 8 | 3 | 139 | 17 | 1 | 17 |
| Total | | | | | | | | | | 223 |

Tyre

| | Tyre unit price Border Price 1000 US$ | CIF Site w/o tax 1000 US$ | No. of tyre pcs | Life hour | Operation hour h/year | Consume /year pcs | Unit | Tyre cost 1000 US$/y |
|---|---|---|---|---|---|---|---|---|
| Grader 205 kW | 1.4 | 1.5 | 6 | 4,000 | 4,236 | 6.4 | 1 | 10 |
| Total | | | | | | | | 10 |

Fuel and Lubricant

| | Power kW | Load factor | Operation hour h/year | consume 1000 ltr/y | unit | Total Fuel 1000 ltr/y |
|---|---|---|---|---|---|---|
| Bulldozer 388 kW | 388 | 0.14 | 4,236 | 230 | 1 | 230 |
| Grader 205 kW | 205 | 0.14 | 4,236 | 122 | 1 | 122 |
| Total | | | | | | 352 |

Electricity

| | Power kW | Load factor | Operation hour h/year | kWh/unit 1000 kWh/y | unit | kWh/year 1000 kWh/y |
|---|---|---|---|---|---|---|
| Dragline 29/96 | 2,611 | 0.6 | 4,236 | 6,636 | 1 | 6,636 |

Overhaul

| (short life case) | Equipment unit price Border Price 1000 US$ | CIF Site w/o tax 1000 US$ | Parts factor /time | Overhaul Interval year | Life time year | Overhaul time /life | Overhaul cost/life 1000 US$ | Cost/year 1000 US$/y | Unit | Overhaul cost/year 1000 US$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Dragline 29/96 | 16,615 | 18,027 | 0.1 | 8 | 30 | 3 | 5,408 | 180 | 1 | 180 |
| Bulldozer 388 kW | 616 | 668 | 0.1 | 2 | 6 | 2 | 134 | 22 | 1 | 22 |
| Grader 205 kW | 426 | 462 | 0.1 | 2 | 6 | 2 | 92 | 15 | 1 | 15 |
| Total | | | | | | | | | | 218 |

## Table 7.6 Base Data for Operating Cost Estimation (Supporting Equipment)

Manpower

| | Man/unit person | unit | Crew | Total person | Absence Rate | Required person |
|---|---|---|---|---|---|---|
| Dozer shovel 250 HP | 1 | 3 | 3 | 9 | 0.83 | 11 |
| Bulldozer 320 HP | 1 | 2 | 3 | 6 | 0.83 | 7 |
| Bulldozer 200 HP | 1 | 2 | 3 | 6 | 0.83 | 7 |
| Grader | 1 | 2 | 3 | 6 | 0.83 | 7 |
| FEL 5 m3 | 1 | 5 | 3 | 15 | 0.83 | 18 |
| ANFO truck | 1 | 1 | 3 | 3 | 0.83 | 4 |
| Fuel truck | 1 | 1 | 3 | 3 | 0.83 | 4 |
| Water truck | 1 | 2 | 3 | 6 | 0.83 | 7 |
| Service truck | 1 | 5 | 3 | 15 | 0.83 | 18 |
| Power distribution | 1 | 2 | 3 | 6 | 0.83 | 7 |
| Diesel Locomotive | 2 | 1 | 3 | 6 | 0.83 | 7 |
| Crushing plant | 5 | 1 | 3 | 60 | 0.83 | 72 |
| Maintenance | | | | 30 | 0.83 | 36 |
| Total | | | | 171 | | 205 |

Spare parts

| | Equipment unit price Border Price 1000 US$ | CIF Site w/o tax 1000 US$ | Parts factor | Parts cost /unit 1000 US$ | Unit | Parts cost total 1000 US$/y |
|---|---|---|---|---|---|---|
| Dozer shovel 250 HP | 306 | 332 | 0.05 | 17 | 3 | 51 |
| Bulldozer 320 HP | 476 | 516 | 0.05 | 26 | 2 | 52 |
| Bulldozer 200 HP | 306 | 332 | 0.05 | 17 | 2 | 34 |
| Grader | 366 | 397 | 0.05 | 20 | 2 | 40 |
| FEL 5 m3 | 408 | 443 | 0.05 | 22 | 5 | 110 |
| ANFO truck | 170 | 184 | 0.05 | 9 | 1 | 9 |
| Fuel truck | 128 | 139 | 0.05 | 7 | 1 | 7 |
| Water truck | 102 | 111 | 0.05 | 6 | 2 | 12 |
| Service truck | 51 | 55 | 0.05 | 3 | 5 | 15 |
| Power distribution | 167 | 181 | 0.05 | 9 | 2 | 18 |
| Diesel Locomotive | 470 | 510 | 0.05 | 26 | 1 | 26 |
| Crushing plant | 1,785 | 1,937 | 0.05 | 97 | 1 | 97 |
| Subtotal | | | | | | 471 |
| Others (15%) | | | | | | 71 |
| Total | | | | | | 542 |

Consumables

| | Equipment unit price Border Price 1000 US$ | CIF Site w/o tax 1000 US$ | Consume factor /hour | Operation hour hour/y | Parts cost 1000 US$ | Unit | Parts cost total 1000 US$/y |
|---|---|---|---|---|---|---|---|
| Dozer shovel 250 HP | 306 | 332 | 0.00001 | 4,236 | 14 | 3 | 42 |
| Bulldozer 320 HP | 476 | 516 | 0.00001 | 4,236 | 22 | 2 | 44 |
| Bulldozer 200 HP | 306 | 332 | 0.00001 | 4,236 | 14 | 2 | 28 |
| Grader | 366 | 397 | 0.00001 | 4,236 | 17 | 2 | 34 |
| FEL 5 m3 | 408 | 443 | 0.00001 | 4,236 | 19 | 5 | 95 |
| ANFO truck | 170 | 184 | 0.00001 | 2,824 | 5 | 1 | 5 |
| Fuel truck | 128 | 139 | 0.00001 | 2,824 | 4 | 1 | 4 |
| Water truck | 102 | 111 | 0.00001 | 4,236 | 5 | 2 | 10 |
| Service truck | 51 | 55 | 0.00001 | 4,236 | 2 | 5 | 10 |
| Power distribution | 167 | 181 | 0.00001 | 4,236 | 8 | 2 | 16 |
| Diesel Locomotive | 470 | 510 | 0.00001 | 4,236 | 22 | 1 | 22 |
| Crushing plant | 1,785 | 1,937 | 0.00001 | 4,236 | 82 | 1 | 82 |
| Subtotal | | | | | | | 392 |
| Others (15%) | | | | | | | 59 |
| Total | | | | | | | 451 |

Overhaul

| | Equipment unit price Border Price 1000 US$ | CIF Site w/o tax 1000 US$ | Parts factor /time | Interval year | Life time year | Overhaul time /life | Overhaul cost/life 1000 US$ | Cost/year 1000 US$ | Unit | Overhaul cost 1000 US$/y |
|---|---|---|---|---|---|---|---|---|---|---|
| Dozer shovel 250 HP | 306 | 332 | 0.1 | 2 | 8 | 3 | 100 | 13 | 3 | 38 |
| Bulldozer 320 HP | 476 | 516 | 0.1 | 2 | 8 | 3 | 155 | 19 | 2 | 39 |
| Bulldozer 200 HP | 306 | 332 | 0.1 | 2 | 8 | 3 | 100 | 13 | 2 | 25 |
| Grader | 366 | 397 | 0.1 | 2 | 8 | 3 | 119 | 15 | 2 | 30 |
| FEL 5 m3 | 408 | 443 | 0.1 | 2 | 8 | 3 | 133 | 17 | 5 | 83 |
| ANFO truck | 170 | 184 | 0.1 | 2 | 8 | 3 | 55 | 7 | 1 | 7 |
| Fuel truck | 128 | 139 | 0.1 | 2 | 8 | 3 | 42 | 5 | 1 | 5 |
| Water truck | 102 | 111 | 0.1 | 2 | 8 | 3 | 33 | 4 | 2 | 8 |
| Service truck | 51 | 55 | 0.1 | 2 | 8 | 3 | 17 | 2 | 5 | 11 |
| Power distribution | 167 | 181 | 0.1 | 2 | 8 | 3 | 54 | 7 | 2 | 14 |
| Diesel Locomotive | 470 | 510 | 0.1 | 5 | 15 | 2 | 102 | 7 | 1 | 7 |
| Crushing plant | 1,785 | 1,937 | 0.1 | 4 | 15 | 3 | 581 | 39 | 1 | 39 |
| Subtotal | | | | | | | | | | 304 |
| Others (15%) | | | | | | | | | | 46 |
| Total | | | | | | | | | | 350 |

## Table 7.6 Cont.(1) Base Data for Operating Cost Estimation (Supporting Equipment)

Tyre

| | Tyre unit price Border Price 1000 US$ | CIF Site w/o tax 1000 US$ | No. of tyre | Life hour | Operation hour h/hour | Consume /year pcs | Unit | Tyre cost 1000 US$/y |
|---|---|---|---|---|---|---|---|---|
| Grader | 4.3 | 4.7 | 4 | 4,000 | 4,236 | 4.2 | 3 | 59 |
| FEL 5 m3 | 4.3 | 4.7 | 4 | 4,000 | 4,236 | 4.2 | 5 | 99 |
| ANFO truck | 1.4 | 1.5 | 6 | 4,000 | 4,236 | 6.4 | 1 | 10 |
| Fuel truck | 1.4 | 1.5 | 6 | 4,000 | 4,236 | 6.4 | 1 | 10 |
| Water truck | 1.4 | 1.5 | 6 | 4,000 | 4,236 | 6.4 | 3 | 29 |
| Service truck | 0.9 | 1.0 | 6 | 4,000 | 4,236 | 6.4 | 5 | 32 |
| Total | | | | | | | | 239 |

Fuel and Lubricant

| | Diesel HP | Load factor | Operation hour h/year | consume 1000 ltr/y | unit | Total Fuel 1000 ltr/y |
|---|---|---|---|---|---|---|
| Dozer shovel 250 HP | 250 | 0.11 | 4,236 | 116 | 3 | 348 |
| Bulldozer 320 HP | 320 | 0.15 | 4,236 | 203 | 2 | 406 |
| Bulldozer 200 HP | 200 | 0.15 | 4,236 | 127 | 2 | 254 |
| Grader | 254 | 0.11 | 4,236 | 118 | 3 | 354 |
| FEL 5 m3 | 380 | 0.11 | 4,236 | 177 | 5 | 885 |
| ANFO truck | 200 | 0.06 | 2,824 | 34 | 1 | 34 |
| Fuel truck | 200 | 0.06 | 2,824 | 34 | 1 | 34 |
| Water truck | 400 | 0.06 | 4,236 | 102 | 3 | 306 |
| Service truck | 100 | 0.06 | 4,236 | 25 | 5 | 125 |
| Diesel Locomotive | 1,200 | 0.06 | 2,824 | 203 | 1 | 203 |
| Total | | | | | | 2,949 |

Electricity

| | Power rate kW | Load factor | Operation hour h/year | kWh/unit 1000 kWh/y | unit | kWh/year 1000 kWh/y |
|---|---|---|---|---|---|---|
| Crushing / Loading | 500 | 0.6 | 4,236 | 1,271 | 1 | 1,271 |
| Total | | | | | | 1,271 |

Table 7.7 Unit Operating Cost for Existing System

| | |
|---|---|
| Coal density | 1.21 |
| TBCM | Total Excavation (BCM)<br>= Overburden removal + Coal ÷ Coal density (BCM) |
| Parts<br>Machine parts<br>Consumable parts<br>Tires | 265.1 Tg/TBCM |
| Diesel oil | 0.5550 kg/TBCM @144 Tg/kg |
| Gas & Lub | Diesel oil×0.20 (Gas:Lub = 20:80) |
| Electricity | 3.31 kWh/TBCM @13.2 Tg/kWh<br>@24.53Tg/kWh<br>Escalation from 1995 to 1999: ER = 0.1319434 |
| Explosives | 0.21 kg/TBCM @138 Tg/kg |
| M & E Others | Heat, water, printing & paper, cheap consumables and their depreciation, costs for improvement in working environment and workers' safety, communication, etc.<br>6.0 Tg/TBCM<br>Plus Environment 10.0 Tg/TBCM (Total 16.0Tg/TBCM) |
| Salaries & Wages(S&W)<br>Engineers<br>Adm. Clerks<br>Skilled<br>Unskilled | <br>(Standard Number of Workers)× $860\times10^3$ Tg/y×(Variance Factor)<br>( 〃 )× $385\times10^3$ Tg/y×( 〃 )<br>( 〃 )× $585\times10^3$ Tg/y×( 〃 )<br>( 〃 )× $267\times10^3$ Tg/y×( 〃 ) |
| Social insurance | (S&W)×0.16 |
| Royalties & Charges | Natural resources, land, health insurance, automobile property taxes, rail car standstill charges, fire fighter & guard, business trip, etc.<br>Revenue×0.06<br>+<br>(S&W)×0.048<br>+<br>Coal(t)×27.0 Tg<br>+<br>TBCM×1.01 Tg |
| Adjusted Operating Costs | Operating cost included in "After Tax Expenses" is added to the cost.<br>A × 0.09<br>A = Total operating costs − payable interest − depreciation |

Table 7.8 Unit Operating Cost for Additional System

| | |
|---|---|
| Coal density | 1.21 |
| TBCM | Total Excavation (BCM)<br>= Overburden removal + Coal ÷ Coal density (BCM) |
| Parts<br>Machine parts<br>Consumable parts<br>Tires | 323.9 Tg/TBCM |
| Diesel oil | 0.4982 kg/TBCM @144 Tg/kg |
| Gas & Lub | Diesel oil×0.20 (Gas:Lub = 20:80) |
| Electricity | 1.438kWh/TBCM @13.2 Tg/kWh (1994)<br>@24.53Tg/kWh (1999)<br>Escalation from 1995 to 1999: ER= 0.1319434 |
| Explosives | 0.21 kg/TBCM @138 Tg/kg |
| M & E Others | Heat, water, printing & paper, cheap consumables and their depreciation, costs for improvement in working environment and workers safety communication, etc.<br>20.0 Tg/TBCM<br>Plus Environment 10.0 Tg/TBCM (Total 30.0Tg/TBCM) |
| Salaries & Wages (S&W)<br>Engineers<br>Adm. Clerks<br>Skilled<br>Unskilled | <br>(Standard Number of Workers)× $860\times10^3$ Tg/y×(Variance Factor)<br>( 〃 )× $385\times10^3$ Tg/y×( 〃 )<br>( 〃 )× $585\times10^3$ Tg/y×( 〃 )<br>( 〃 )× $267\times10^3$ Tg/y×( 〃 ) |
| Social insurance | (S&W)×0.16 |
| Royalties & Charges | Natural resources, land, health insurance, automobile property taxes, rail car standstill charges, fire fighter & guard, business trip, etc.<br>Revenue×0.06<br>+<br>(S&W)×0.048<br>+<br>Coal(t)×27.0 Tg<br>+<br>TBCM×1.01 Tg |
| Adjusted Operating Costs | Operating cost included in "After Tax Expenses" is added to the cost.<br>A × 0.05<br>A = Total operating costs − payable interest − depreciation |

Table 7.9 Current Unit Operating Costs (Base Data)

| | 1993 (Actual) | 1994 (Budget) | Used in Study |
|---|---|---|---|
| Coal Production ($10^3$t) | 503 | 650 | |
| Coal (1.21 t/m³)($10^3$BCM) | 415.7 | 537.2 | |
| Overburden ($10^3$BCM) | 1,042.9 | 2,361.0 | |
| TBCM ($10^3$BCM) | 1,458.6 | 2,898.2 | |
| Parts ($10^3$Tg) | | 93,132.0 | Not used |
| (Tg/TBCM) | | * 32.0 | * (35.2) |
| Sub-materials | | | |
| explosives (t) | 343.6 | 597.2 | |
| (kg/TBCM) | 0.236 | 0.206 | 0.21 |
| (Tg/kg) | 108 | 138 | 138 |
| Others ($10^3$Tg) | | 9,265.2 | |
| (Tg/TBCM) | | * 3.2 | |
| Diesel oil (t) | 1,098.3 | 1,609.4 | |
| (kg/TBCM) | 0.753 | 0.555 | 0.555 |
| (Tg/kg) | 110 | 144 | 144 |
| Gas & Lub (% of Diesel) | 25 | 19.8 | 20 |
| Electricity (MWh) | 6,137 | 9,591 | |
| (kWh/TBCM) | 4.27 | 3.31 | 3.31 |
| (Tg/kWh) | 4.4 | 13.2 | 13.2 |
| M & E Other | | | |
| heat | | 7,840.8 | |
| Water | | 152.2 | |
| cheap consumables | | 351.6 | |
| their depreciation | | 175.8 | |
| improvement in environment and safety for workers | | 7,203.1 | |
| printing, paper and communication | | 1,165.0 | |
| Total ($10^3$Tg) | | 16,888.5 | |
| (Tg/TBCM) | | 5.8 | 6.0 |
| environment conservation costs (Tg/TBCM) | | 0 | 10 |
| Royalties and Charges | | | |
| natural resources | | Revenue×0.06 | Revenue×0.06 |
| health insurance | | S&W ×0.048 | S&W ×0.048 |
| land and auto | | 715.5 ×$10^3$Tg | 1.01Tg/TBCM |
| rail car standstill charges ($10^3$Tg) | | 16,944.9 | 27 Tg/coal(t) (rail car standstill charges, fire fighter & guard, business trip, etc.) |
| fire fighter & guard ($10^3$Tg) | | 0 | |
| business trip, etc. ($10^3$Tg) | | 376.2 | |

Table 7.9 Cont.(1) Current Unit Operating Costs (Base Data)

| | 1993 (Actual) | 1994 (Budget) | Used in Study |
|---|---|---|---|
| After tax expenses | | | |
| 1) Cost portion to be treated as "operating cost" (hereafter : Adjusted Operating Costs) | | | |
| • renovation in technological and working conditions<br>• employees training<br>• social development fund<br>— food aid<br>— fuel aid<br>— compensational salary for disabled miners<br>— pension supplement<br>— bonus<br>— compensation for red ink subsidiary | | | → Existing T×0.09<br>Additional Expansion T×0.05 |
| 2) Profit portion nto to be treated as "operating cost" | | | |
| • dividend<br>• debt repayment<br>• social development fund<br>— compensation for red ink subsidiaries<br>— construction costs of miner's apartment houses | | | → 0 |

Table 7.10 Foreign Currency Portion for 23 years

Million US$

| Year | Capital cost *1 | | | Operating cost *2 | | | Yearly Total |
|---|---|---|---|---|---|---|---|
| | Existing | Addition | Total | Existing | Addition | Total | |
| 1996 | 1.7 | 0.0 | 1.7 | 2.1 | 0.0 | 2.1 | 3.8 |
| 1997 | 2.7 | 16.0 | 18.7 | 2.1 | 0.0 | 2.1 | 20.8 |
| 1998 | 2.0 | 20.0 | 22.0 | 2.1 | 0 | 2.1 | 24.1 |
| 1999 | 1.7 | 0.0 | 1.7 | 2.1 | 4.1 | 6.2 | 7.9 |
| 2000 | 3.0 | 0.0 | 3.0 | 2.1 | 4.2 | 6.3 | 9.3 |
| 2001 | 3.2 | 0.0 | 3.2 | 2.1 | 4.2 | 6.3 | 9.5 |
| 2002 | 0.7 | 4.0 | 4.7 | 2.1 | 4.1 | 6.2 | 10.9 |
| 2003 | 2.7 | 0.0 | 2.7 | 2.1 | 4.1 | 6.2 | 8.9 |
| 2004 | 1.3 | 0.3 | 1.6 | 2.1 | 4.1 | 6.2 | 7.8 |
| 2005 | 0.0 | 0.0 | 0.0 | 2.1 | 4.1 | 6.2 | 6.2 |
| 2006 | 1.3 | 7.9 | 9.2 | 2.1 | 4.2 | 6.3 | 15.5 |
| 2007 | 0.7 | 4.7 | 5.4 | 2.1 | 4.2 | 6.3 | 11.7 |
| 2008 | 0.7 | 2.6 | 3.3 | 2.1 | 4.1 | 6.2 | 9.5 |
| 2009 | 3.6 | 0.0 | 3.6 | 2.1 | 4.1 | 6.2 | 9.8 |
| 2010 | 0.3 | 0.3 | 0.6 | 2.1 | 4.2 | 6.3 | 6.9 |
| 2011 | 0.0 | 0.0 | 0.0 | 2.1 | 4.1 | 6.2 | 6.2 |
| 2012 | 2.3 | 4.6 | 6.9 | 2.1 | 4.2 | 6.3 | 13.2 |
| 2013 | 2.3 | 0.4 | 2.7 | 2.1 | 4.2 | 6.3 | 9.0 |
| 2014 | 2.3 | 7.9 | 10.2 | 2.1 | 4.1 | 6.2 | 16.5 |
| 2015 | 4.4 | 0.0 | 4.4 | 2.1 | 4.2 | 6.3 | 10.6 |
| 2016 | 2.0 | 0.3 | 2.3 | 2.1 | 4.1 | 6.2 | 8.5 |
| 2017 | 0.9 | 6.3 | 7.2 | 2.1 | 4.2 | 6.3 | 13.5 |
| 2018 | 1.3 | 3.1 | 4.4 | 2.1 | 4.2 | 6.3 | 10.7 |
| Total | 41.1 | 78.4 | 119.5 | 48.3 | 83.0 | 131.3 | 250.8 |

Note *1 : Necessary capital costs of "existing" are the replacement cost of the existing equipment.

: Necessary capital costs of "addition" include both initial and replacement costs for additional equipment and facilities.

*2 : Operation costs include yearly spare part cost, periodic overhaul cost and imported consumable such as explosives,diesel oil, gasoline and lubricants.

Table 7.11 Local Currency Portion for 23 years

Million US$ as of 1994

| Year | Labor cost | Electricity cost | Others* | Total |
|---|---|---|---|---|
| 1996 | 0.4 | 0.4 | 2.3 | 3.1 |
| 1996 | 0.4 | 0.5 | 1.4 | 2.3 |
| 1998 | 0.4 | 0.5 | 1.6 | 2.5 |
| 1999 | 0.9 | 1.0 | 5.1 | 7.0 |
| 2000 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2001 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2002 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2003 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2004 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2005 | 0.9 | 1.0 | 3.0 | 4.9 |
| 2006 | 0.9 | 1.0 | 3.2 | 5.1 |
| 2007 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2008 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2009 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2010 | 0.9 | 1.0 | 3.0 | 4.9 |
| 2011 | 0.9 | 1.0 | 3.0 | 4.9 |
| 2012 | 0.9 | 1.0 | 3.2 | 5.1 |
| 2013 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2014 | 0.9 | 1.0 | 3.2 | 5.1 |
| 2015 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2016 | 0.9 | 1.0 | 3.1 | 5.0 |
| 2017 | 0.9 | 1.0 | 3.2 | 5.1 |
| 2018 | 0.9 | 1.0 | 3.1 | 5.0 |
| Total | 19.2 | 21.4 | 69.4 | 110.0 |

Note *: Others include domestic producted consumables (M& E others : see Table 7.9), profit distribution (after tax expenses : see Table 7.9), inland cost for imported material (see Table 7.2) and royalties & charges (see Table 7.9).

# 8 Economic and Financial Evaluation

## 8.1 Concept for evaluation

Economic and financial evaluation conducted in this section is based on the concepts of the time value of money with a compound interest rate, which are referred to as "discounted cash flow (DCF) analysis." Methodology and terminology are briefly illustrated in Appendix 5.

The objective of analysis here is to evaluate, from economic and financial standpoints, the conclusions and/or recommendations on various aspects deduced in the foregoing sections such as on mining and environment. The general approach to the analysis conducted here is as follows:

1) Project life studied

1996 to 2018 (23 years)

2) Time value of money

Constant 1994 Togrogs with an exchange rate of 400 Tg/US$

3) Renovation plans prepared for cash flow study

Case 1: Existing operation

The existing mining equipment is fully based on those from the ex-COMECON countries, with which the mine is being developed rapidly by a typical truck and shovel method. The current capacity to excavate overburden and coal (total excavation) is judged to be 3.2 million BCM. This scenario is to maintain the current capacity with replacing of the existing equipment by those from the original ex-COMECON countries. Although, due to rapid development, fundamental facilities such as maintenance shops, stockyard, loading out facilities, etc. have not been fully installed yet, an investment required for their installations is not included in this scenario but an expansion scenario. This scenario, therefore, cannot exactly represent a without-project status.

Current annual excavation profile is as follows;

| | |
|---|---|
| Coal production | $740 \times 10^3$t |
| Total excavation | $3{,}200 \times 10^3$ BCM |
| Stripping ratio | 3.5BCM/t |

Case 2: Expansion

This scenario includes the additional capacity of 5.5 million BCM with a medium-class dragline as well as additional investment for the fundamental facilities and so forth. The equipment and facilities are based on those from the free market western countries. It should be noted that this scenario cannot work independently due to no arrangement of coal minning equipment in the scenario and only works when the current truck and shovel fleets serve as coal minning equipment along with introduction of an overburden-removing dragline.

The annual target of expansion is as follows;

| | |
|---|---|
| Coal production | 1,271×$10^3$t |
| Total excavation | 5,500×$10^3$ BCM |
| Stripping ratio | 3.5BCM/t |

Case 3: Case 1 + Case 2

The combination of the current truck and shovel fleets and the additional dragline can make the project workable effectively.

The annual target of the combined system is as follows;

| | |
|---|---|
| Coal production | 2,011×$10^3$t |
| Total excavation | 8,700×$10^3$ BCM |
| Stripping ratio | 3.5BCM/t |

4) Economic evaluation

Economic analyses by using the DCF method are conducted to evaluate the project from a standpoint of the Mongolian economy as a whole by economic internal rate of return (EIRR) on the total project, which means the cash investment basis. Economic sensitivity analyses are conducted to examine the impact of changes in the base case assumptions.

5) Financial analyses

Financial analyses by using the DCF method are conducted to evaluate the project from a standpoint of an independent coal mine or investors. The value of a project itself is evaluated by financial internal rate of return (FIRR) on the total project, which is on a cash investment basis.

And effects deriving from difference in capital structure (debt/equity) are examined by FIRR on equity, which is on a leverage investment basis. Financial sensitivity analyses are conducted to examine the impact of changes in the base case assumptions by FIRR on the total project and FIRR on equity.

Although a coal marketing study which involves coal supply/demand forecast has to be done prior to conducting this analysis, the coal supply/demand forecast in Mongolia is implemented in Part II stage of the study. Therefore a 100% product of coal from the mine is assumed to be sold mainly to coal fired power stations and other consumers in the analysis here.

## 8.2 Economic evaluation

The renovation project including improvement of the existing system and expansion of production scale for Shivee Ovoo coal mine is analyzed from a standpoint of the Mongolian economy as a whole. Taxes and royalties liable to the mine are all evaluated as "transfer"; then, they are eliminated from economic costs. A trade tax of 10% of sale prices liable to consumers, however, is evaluated as an economic benefit.

### 8.2.1 Analytical criteria

The approach illustrated here is based on the following criteria:

- project financing of 100% debt for foreign currency;
- debt financing costs of 0; and
- no inflation but escalation of electricity from 1994 to 1999,
  escalation rate for electricity 13.2% per annum.

The project financing of 100% debt for foreign currency reflects lack of fund, specially in hard currency, to be injected into the renovation project for the mine. The foreign debt financing is assumed to be a project-untied loan in the analysis here.

The financing sources are assumed to be: firstly, internal financing from retained profits; secondly, loans from international lending agencies for a foreign currency portion of capital investment; and finally, loans from domestic banks which are the sky limit. In the analysis here, the further restrictions are added: all the foreign currency portion of replacement of the existing equipment and additional investment for the years of 1996, 1997 and 1998 is allowed to use foreign loans up to the limitations if none of retained profits; after 1998, only additional investment is allowed to use foreign loans for a shortage after using retained profit. And replacement of the existing and additional equipment is allowed to use only domestic loans after 1998.

A domestic debt financing cost is 10% per month with a repayment period of 6 months; however, it is not an economic cost on the Mongolian economy as a whole but only "transfer" from the mine to domestic banks. Then, a domestic debt financing cost is eliminated from economic costs.

A foreign debt financing cost is 8% per annum with a repayment period of 10 years and repayment beginning the next year after borrowing; due to the assumption of a project-untied loan, the opportunity cost of financing is evaluated as zero.

Inflation, which is defined as persistent rise in the prices of a consumer price index type basket of commodities, goods and services, has not been applied to economic costs and benefits in the analysis here, since inflation equally affects them over the project period. It makes no differences in analytical results between with and without inflation. On the other hand, escalation is defined here as persistent rise in the price of specific commodities, goods or services due to a combination of inflation, supply/demand and other effects such as environmental and engineering changes, which should, if any, be considered in the analyses.

Under the current economic situation in Mongolia, which can be characterized by being in transition from planed economy to free market economy, adjustment escalations have to be required. To the prices of equipment and spare parts which are and will be supplied from the ex-COMECON countries, a rapid adjustment escalation has been applied by using 80% of the current international prices as detailed in 8.2.2 Economic costs. For electricity, however, a smooth changing in five years is assumed. Escalation rate used in the analysis do not include the effect of general inflation.

The current electricity tariff is administrated in the same manner as the pricing of coal by the Mongolian government and the current price level seems insufficient to sustain a normal operation in the power stations, of which equipment and facilities are all imported ones; then, the situation is the same as in the coal mine. Moreover, the electricity supply agency, the Central Energy System (CES), currently delays its payment for coal to the coal mine, which causes the coal mine to borrow a huge amount of working capital to maintain its mine operation and consequently to delay the mine's payment for new equipment and spare parts to the state owned trading company (NUURS Company), which takes responsibility for coal distribution and purchase of imports for the mine.

Since accurate estimation of a power price based on a renovation plan like this study for power plants is beyond the scope of work of the study, it is assumed that a power price levels off at 24.53 Tg/kWh(financial basis), which is 90% of the average 1993 price in the OECD countries, from the current price of 13.2 Tg/kWh (financial basis) within 5 years.

Prices of diesel oil, gasoline, lubricant and explosives are judged to reflect the current international prices; then, any escalation is not applied to those prices in the analysis.

8.2.2 Economic costs

Economic costs are defined as the input of Mongolian national resources for the renovation project and are evaluated in detail hereunder.

In the foregoing cost estimation, duplicate prices for the mining and supporting equipment are used: one for those supplied from the free market western countries which indicates a solid economic price; the other for those from the ex-COMECON countries which is estimated at 80% of the former price against 36% in realty at the moment. Due to economic confusion by the aftermath of the collapse of the ex-COMECON economic block, the current prices of their products are judged to be uncertain and not to reflect their real market prices at the moment. Specific models of equipment such as trucks and bulldozers supplied from the ex-COMECON countries are also estimated to have a six-year working life period and, for the counterpart, to have a eight-year working life period.

Any contingency has not been applied to operating and capital costs since all the estimation is based on the current actual operation and popular mining equipment in addition to the consistent and stable geological setting in the field for the project. The effect of variances in operating and capital costs is assessed as sensitivity analyses.

(1) Conversion factors

Economic costs here are not including primarily visible taxes, royalties and domestic debt interest to be paid and are calculated from financial costs by using conversion factors as presented in the foregoing Table 7.2. The CIF site total on the Table 7.2 except royalties and charges is all financial prices and costs expressed as 1.0000 in which border price, taxes, domestic transportation and other costs are included. The CIF site prices or costs without taxes denote conversion factors; financial costs can be reduced to economic costs at the mine site by multiplying a financial cost by its own conversion factor.

As for the conversion factor of labor costs, only personal income tax (average 7% used) is eliminated from financial labor costs and any opportunity cost of the unskilled labors has not been reflected in the analysis. In Mongolian coal mines, the unskilled are much limited to a small portion of the entire workforce and most of them are regarded as the skilled labors. The renovation project here would not create a large amount of new jobs for the unskilled; therefore, the effect of the unskilled on the project is assumed to be negligible.

Figure 8.1 shows the current tax system and coal price structure in Mongolia.

A standard conversion factor and a shadow exchange rate have not been applied to the analysis.

(2) Operating costs

The operating costs as illustrated in the foregoing section include all mine operating and terminal costs including a railway load out operation as well as the head office administration costs at the mine site. Those operating costs, however, contain a different concept as shown on Table 7.8. Several cost items of tax deductible cost items as recognized in the western accounting conventions are not included in the operating cost.

Those for renovation in technological and working conditions including coal exploration costs, employees training and social development funds including food aid, fuel aid, worker's compensations, pension supplements and bonus payments are not treated as operating costs and are not allowable for tax purposes in Mongolia. These expenses equivalent to operating costs in the western accounting, therefore, have been treated as economic costs in the analysis here.

Other expenditure in profit distributions such as dividend, debt repayment and construction costs for miners' apartment houses are treated as benefits in the same manner as in the West.

(3) Capital costs

The capital costs estimated for all the scenarios are presented in Section 7. Taking into consideration the today's issue of a great amount of trading debts, working capital, required to finance operating costs which are incurred prior to receipt of revenues for the coal produced, is assumed to be equal to three months (25%) of the current year's operating costs in which depreciation and interest payment are not included. The amount of working capital is considered to increase or decrease in any given year.

### 8.2.3 Benefits

Economic benefits are defined as an output from the renovation project and assumed to be only a function of the production of saleable coal from the mine and a sale price including 10% of trade tax at the mine site load out. Any other invisible benefits such as those derived from a ripple effect on other industries caused by coal production activity have not been included, due to, effectively, non existence of such chain relations in the Mongolian economy.

As for the economic price of Shivee Ovoo coal, there is no market price of coal reflecting "willingness to pay" in the country. Individual power plants have a certain degree of freedom in negotiating purchase contracts with the mining organizations after the economic restructuring program started in 1989 by the Mongolian government. The pricing of coal is, however, still under the government control.

Shivee Ovoo coal is classified as lignite by the Russian classification standards; however, it may be classified as sub-bituminous by American Society for Testing and Materials (ASTM) standards. Either way, this type of coal is not traded internationally except between neighboring countries during barter trading of the COMECON era. On the other hand, looking at the function of coal, the essence is its own heating value or a source of electricity which can be seen as tradable.

Now being internationally recognized that caol is the most economical heating source traded today worldwide, an economic price of coal produced by the Mongolian mines, therefore, is considered to be a calorific parity price of hypothetically imported coal from the neighboring countries, which are China and Russia.

China (Datong) and Russia (Neryungri and Kuznetsky) have exported their coal to Japan and their statistics are shown in Tables 8.1 and 8.2 respectively. The average FOB prices of their coal are also presented on Table 8.3 and an overall average FOB price at the Far East port is 0.44 US ¢ /kcal/kg. A railway distance from Neryungri to Nakhodka is 2,580 km and from Kuznetsky to Nakhodka, 6,180 km. On the other hand in China, a railway distance from Datong to Qinhuangdao is only 630 km. In spite of the shorter railway distance from China, Chinese coal is higher in average price than Russian one.

The distances from Neryungri, Kuznetsky and Datong to the Mongolian border and (Ulaanbaatar) are 2,414(2,770)km, 2,684(3,040)km and 366(1,180)km respectively. Regarding a border price, Datong coal seems to be most economical; however, it has difficulty in mass transportation due to a difference in railway gauge between Mongolia and China. Neryungri coal would be sold at almost the same price as at Nakhodka due to nearly equal distance to be transported. A sole beneficiary in terms of transport cost is Kuznetsky coal, which would not be sold at a price less than the current FOB price due to taking advantage of its situation.

As such, the economic price of Mongolian coal is assumed to be a Russian coal average of 0.425 US ¢/kcal/kg. For the Shivee Ovoo coal with 3,580 kcal/kg in long term average, it is assumed to be 6,086.0 Tg/t (gross calorific value basis)*. In the analysis, a Mongolian railway freight cost has been neglected.

* Note: Internationally used is a gross calorific value; however, a net calorific value is usually used for as received coal quality in Mongolia as well as in Russia.

To simplify the analysis, the variability in the heating value (HV) of the coal produced each year and the consequent impact on the pricing relationship is eliminated by assuming a constant as received HV over the life of the project which corresponds to the long term 23 year average HV.

8.2.4 Discounted cash flow analysis

The objective of the DCF analysis is to determine the positive cash flow that accrues to the project and the return on the total project. Procedures several added to the analysis are as follows:

1) The balances of investment/depreciation, remaining net working capital and also mine close reclamation costs are all included in the cash flow at the end of the final year of the project life; and
2) The simplifying assumption is made that all benefits are received and costs are incurred at the end of the year.

A formula for cash flow used in the economic analyses is as follows:

Economic Benefits
− Total operating costs (payable interest = 0, depreciation = 0)
− After tax expenses (adjustment of operating costs)
− Total capital costs
− Increase in working capital
+ *Project liquidation (at the end of the project life)

Cash flow for EIRR on total project

* Project liquidation

= Retained working capital + Equipment salvage - Reclamation costs

By the DCF method, the coal price of each case at a 10% EIRR and also EIRRs at the economic coal value of 6,086.0 Tg/t have been evaluated as follows:

| | Economic Price at a 10% EIRR (Tg/t) | EIRR at 6,086 Tg/t(%) |
|---|---|---|
| Case 1 | 3,290.3 | n.a |
| Case 2 | 4,082.4 | 25.9 |
| Case 3 | 3,727.8 | 67.1 |

The economic prices at a 10% EIRR are higher than the current sale price of 2,200 Tg/t (including a 10% trade tax); however, the project with a 67.1% EIRR at the economic coal price of 6,086

Tg/t is very advantageous in terms of the Mongolian national economy. DCF cash flows and foreign & local currency requirement of Case 3 at a 10% EIRR are shown on Table 8.4. and these of Case 1 and Case 2 are presented in Appendix 4.

### 8.2.5 Sensitivity analysis

The impact of changes in the base case assumptions has been evaluated and the results of the sensitivity analyses are presented on Table 8.5 in terms of EIRR. The changes evaluated at the economic coal value of 6,086.0 Tg/t for the base case are as follows:

- Coal value;
- Foreign exchange rate;
- Capital costs;
- Operating costs; and
- Total excavation with no changes in coal production.

The range of changes is ±20% at every 5% step for all the items. Due to high EIRR, the EIRR of Case 1 is not available in all the items. The impact of changes in coal value is most significant; however, significant changes may be caused only by the hike in the international energy prices. Operating costs, total excavation and capital costs in a descending order are showing relatively big impact on the project. The changes of foreign exchange rates have little impact on the project.

Since the project is highly favorable in economic terms, therefore, serious impacts on the project from these changes will not be anticipated even if those changes should happen.

## 8.3 Financial evaluation

The renovation project (Case 3) including improvement of the existing system (Case 1) and expansion of production scale (Case 2) for Shivee Ovoo coal mine is analyzed from a standpoint of an independent coal mine or investors. Taxes and royalties liable to the mine are all evaluated as financial costs; a trade tax of 10% of sale prices liable to consumers is eliminated from the mine's revenues.

### 8.3.1 Analytical criteria

Since the financial analysis is to be conducted on the same scenario as in the foregoing economic evaluation, only differences in assumption and criteria from those in the economic evaluation are illustrated in detail hereunder.

- project financing of 100% debt, 100% equirety and mixed cases;
- a domestic debt financing cost of 10% per month with a repayment period of 6 months;
- a foreign debt financing cost of 8% with a repayment period of 10 years and repayment beginning the next year after borrowing; and
- no inflation but escalation of electricity and coal sale price from 1994 to 1999,

| | |
|---|---|
| escalation rate for electricity | 13.2% per annum, |
| escalation rates for coal sale price | $(\text{Price in } 1999/2{,}200)^{1/5}-1$. |

A domestic debt financing cost is 10% per month with a repayment period of 6 months; however, due to simplify the assumption that all revenues are received and costs are incurred at the end of the year, interest payment and debt repayment are made altogether the next year after borrowing.

In order to eliminate the effect of general inflation, which is running 8% per month as shown on Table 8.6, the domestic debt financing costs of 10% per month is discounted to 24.6% per annum $[(1.10/1.08)^{12}-1]$. This interest rate discounted here is still too high to last for 23 years of the project life. Then, it is assumed that an interest rate comes to the same rate of 8% as the foreign interest rate assumed, including repayment terms after 2000.

Coal sale price should be adjusted to the catch up escalation of the prices of equipment, spare parts and electricity in order to compensate for their escalations. For smooth transition from the current sale price of 2,200 Tg/t in 1994 to the constant price in real terms in and after 1999, an escalation rate has been given to the computer calculation program as a formula i.e. $(\text{Price in } 1999 \div 2{,}200)^{1/5}$.

In order to assess the effect of variances in foreign debt interest rates and capital structure (debt/equity), in spite of an assumption that project financing is 100% debt, the financial internal rate of return (FIRR) on equity is also evaluated.

### 8.3.2 Financial costs

All the financial costs including operating and capital costs have been calculated by applying the conversion factors to the economic costs. The profit distributions in the Mongolian accounting are treated in the same manner as described in the foregoing economic evaluation. The costs in terms of the western accounting conventions included in the Mongolian profit distribution (after tax expense) are, therefore, treated as costs. Tax calculation, however, is in accordance with the Mongolian taxation regimes.

Currently Mongolia is under a rampant inflation environment, as shown in Tables 8.6, 8.7 and 8.8, which has severely affected the mine management in financial terms, specially on their fixed assets devalued by the inflation. Depreciation of the fixed assets, then, seems to be almost non functional at all. To measure the effect of this situation, revaluation of the fixed assets has been carried out. As a revaluation index, foreign exchange rates are used for the imported fixed assets and general inflation rates are used for the domestic made buildings and structures. Depreciation used in the analysis is based on the fixed assets as of December 1993. The details are shown on Appendix 5 (Table 5.14~ Table 5.16).

### 8.3.3 Revenues

The annual total revenues received by the mine is a function of the production of saleable coal from the mine and a sale price excluding trade tax. To simplify the analysis, the variability in the heating value (HV) of the coal produced each year and the consequent impact on the pricing relationship is eliminated by assuming a constant as received HV over the life of the project which corresponds to the long term 23 year average HV.

A problem here is how much a reasonable coal price should be in Mongolia. Even in the economic analysis, the price to gain 10% of EIRR is 3,727.8 Tg/t (3,388.9 Tg/t without trade tax) in Case 3. Apparently, the current price of 2,200.0 Tg/t (2,000.0 Tg/t) is insufficient to sustain operation in the mine. The reasonable coal sale price, however, should be at least held below the economic value of the Shivee Ovoo coal (6,086.0 Tg/t) and is discussed later in the analyses.

### 8.3.4 Discounted cash flow analysis

(1) General assumptions

The objective of the DCF analysis is to determine the positive cash flow that accrues to the project, the amounts of debt required to finance it and the return on the total project. Procedures several added to the analysis are as follows:

1) The balances of investment/depreciation, remaining net working capital and also mine close reclamation costs are all included in the cash flow at the end of the final year of the project life; and
2) The assumption is simplified so that all revenues are received and costs are incurred at the end of the year.

(2) Cash flow formulae

Formulae for cash flow used in the analyses are as follows:

1) Cash flow for FIRR on total project

Revenue

− Total operating costs (payable interest = 0)

− Tax

− After tax expenses (adjustment of operating costs)

+ Depreciation

− Total capital costs

− Increase in working capital

+ *Project liquidation (at the end of the project life)

Cash flow for FIRR on total project

*Project liquidation

= Retained working capital + Equipment salvage - Reclamation costs

2) Cash flow for FIRR on equity

Revenue

– Total operating costs

– Tax

– After tax expenses (adjustment of operating cost)

+ Depreciation

– Total capital costs

– Increase in working capital

+ Debt

– Debt repayment

+ **Project liquidation (at the end of the project life)

Cash flow for FIRR on equity

** Project Liquidation

= Retained working capital + Equipment salvage - Reclamation costs - Loan unrepaid

(3) Cash flow analyses

By using the DCF method, coal sale prices at an 10% FIRR on the total project and also FIRRs at the economic coal value of 6,086.0 Tg/t (including a 10% trade tax) have been evaluated as follows:

| | Fixed Assets Status | Coal Sale Price at 10% FIRR (Tg/t) | FIRR on Total Project |
|---|---|---|---|
| Case 1 | Not Revalued | 5,323.8 | 19.0 |
| | Revalued | 5,265.3 | 20.5 |
| Case 2 | (No Revaluation) | 6,545.9 | 8.1 |
| Case 3 | Not Revalued | 6,024.4 | 10.3 |
| | Revalued | 5,997.5 | 10.5 |

Note: Since the expansion (Case 2) includes fundamental investment such as workshop, warehouse, stockyard, sizing & loading, etc., part of which should be shared by the