No. 6

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF ENERGY, GEOLOGY AND MINING (MEGM)
MONGOLIA

STUDY
ON
COMPREHENSIVE COAL DEVELOPMENT
AND UTILIZATION
IN
MONGOLIA

FINAL REPORT
SUMMARY

NOVEMBER 1995

THE INSTITUTE OF ENERGY ECONOMICS, JAPAN (IEEJ)

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PREFACE

In response to a request from the Government of the Mongolia, the Government of Japan decided to conduct the Study on Comprehensive Coal Development and Utilization in Mongolia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Takehiko Sato of the Institute of Energy Economics, Japan (IEEJ) and organized by IEEJ to Mongolia seven times from November 1993 to September 1995.

The team held discussions with the officials concerned of the Government of Mongolia, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the plan and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Mongolia for their close cooperation throughout the study.

November 1995

Kimio Fujita

President

Japan International Cooperation Agency

November 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita,

Letter of Transmittal

We are pleased to submit to you the study report on Comprehensive Coal Development and Utilization in Mongolia. The report contains the advice and suggestions of authorities concerned of the Government of Japan and your Agency as well as the formulation of the above mentioned project. Also included are comments made by the Ministry of Energy, Geology, and Mining of Mongolia during technical discussions on the draft report which were held in Ulaanbaatar. The study is divided into two Parts:

Part I : Feasibility study for the renovation of two coal mines
Part II: Master plan study for the coal development and utilization and preliminary action plan

Baganuur coal mine and Shivee Ovoo coal mine were selected as "two coal mines" to be studied in Part I by both study teams in accordance with the procedure of Scope of Work.

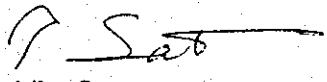
This report presents the results of the Study, which has been implemented since November 1993 in cooperation with the Ministry of Energy, Geology and Mining as the Counterpart, and consists of three separate volumes, the summary (110 pages), Part I (the renovation plans:650 pages) and Part II(the master plan:430 pages) of the main texts.

Part I reports the renovation plan of Baganuur coal mine (Chapter I) and Shivee Ovoo coal mine (Chapter II). Each Chapter includes;coal resources; present mining status; renovation plan; capital and operating costs;financial and economic analysis; and conclusion.
Part II reports the master plan and the preliminary action plans, and includes: coal demand and supply forecast; coal development and utilization plan; conceptual study of the selected plans; and conceptual "Action Plan"

In view of the urgency of renovation of coal mines in Mongolia, we recommend that Mongolian government implements the renovation plans of Baganuur coal mine and Shivee ovoo coal mine in accordance with the coal development master plan.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, and the Ministry of International Trade and Industry. We also wish to express our deep gratitude to the Ministry of Energy, Geology, and Mining of Mongolia, the JOCV Ulaanbaatar office, and the Embassy of Japan in Ulaanbaatar for the close cooperation and assistance extended to us during our investigation and study.

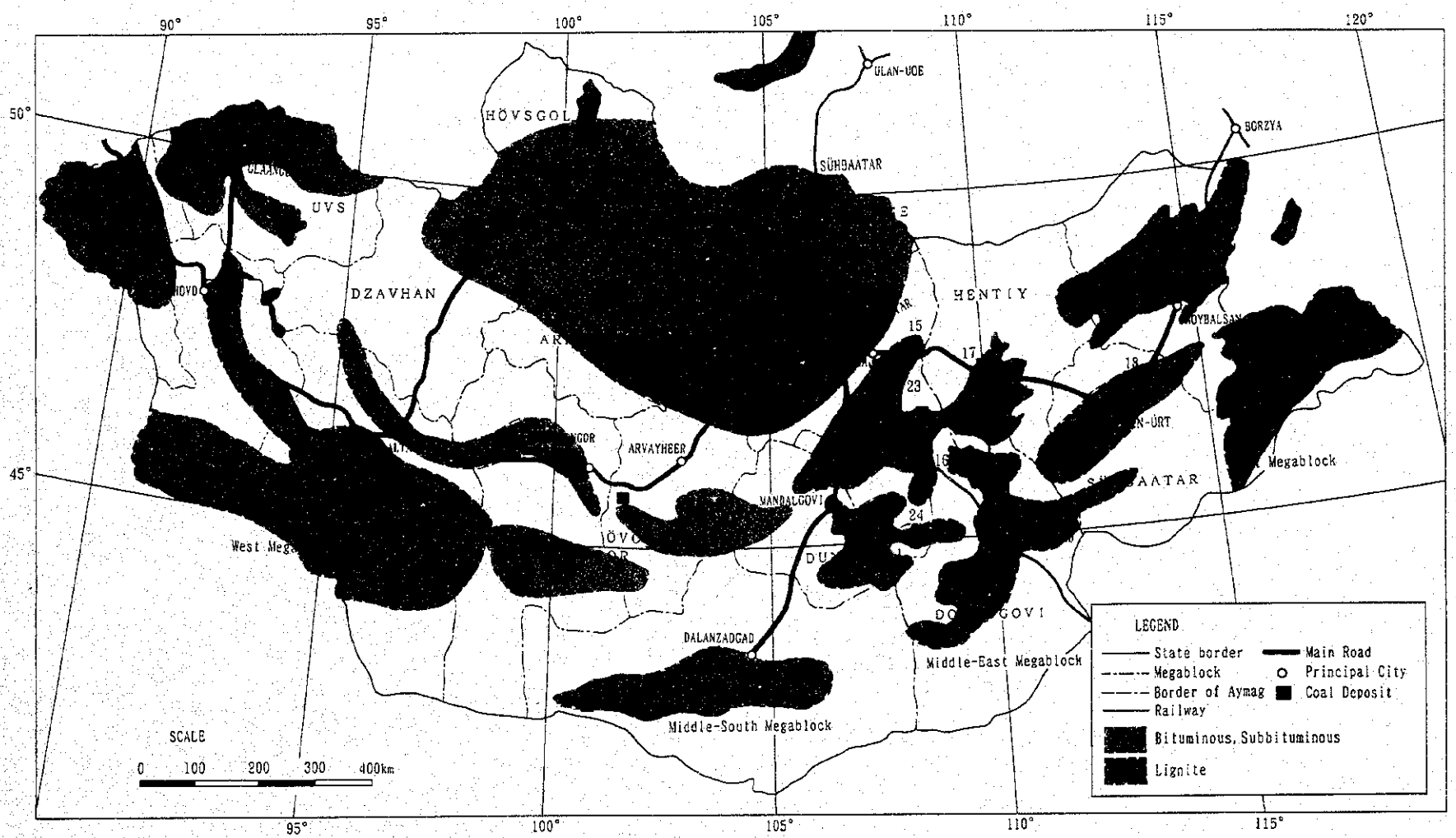
Very truly yours,



Takehiko Sato

Team Leader
The Study on Comprehensive Coal
Development and Utilization in Mongolia

Coal Resouces in Mongolia

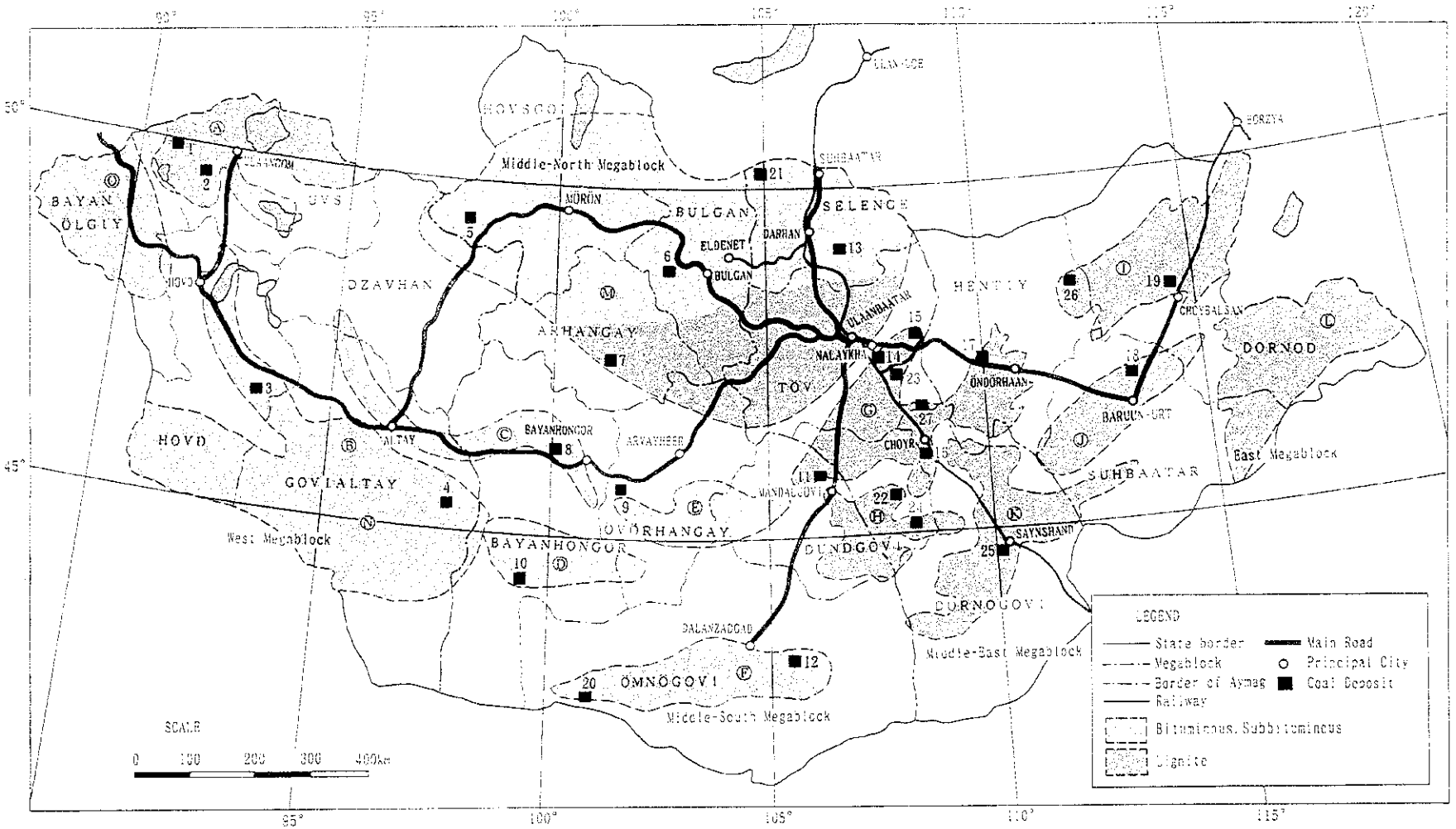


Names of basins
- Ⓐ:Kharkhiraa (C)
- Ⓑ:Mongol Altay (C)
- Ⓒ:South Khangay (P)
- Ⓓ:Big Bogdyn (J)
- Ⓔ:Ongiyngol (J)
- Ⓕ:South Govi (P)
- Ⓖ:Choir-Niarga (K)
- Ⓗ:Middle Govi (K)
- Ⓘ:Choybalsan (K)
- Ⓙ:Sukhe Bator (K)
- Ⓚ:East Govi (K)
- Ⓛ:Tamtsak (K)
- Ⓜ:Orkhon-Selenge (J)
- Ⓝ:Altay-Chandmani (C)
- Ⓞ:Bayan-Ulegei (C)

* C-Carboniferous, P-Permian, J-Jurassic, K-Cretaceous

Names of deposits
1 Nuursthotgor Deposit
2 Khartarvagatai Deposit
3 Khusheet Deposit
4 Zeegt Deposit
5 Mogoingol Deposit
6 Salhan-Ovoo Deposit
7 Bayantsagaan Deposit
8 Uburchuluut Deposit
9 Bayanteeg Deposit
10 Shinjinst Deposit
11 Tevshiingovi Deposit
12 Tavantologoi Deposit
13 Sharyngol Deposit
14 Nalaykha Deposit
15 Baganuur Deposit
16 Shivee-Ovoo Deposit
17 Chandagantal Deposit
18 Talbulag Deposit
19 Aduunchuluun Deposit
20 Narynsohait Deposit
21 Ulaan-Ovoo Deposit
22 Khoot Deposit
23 Tsaidamnuur Deposit
24 Ovdok-Huduk Deposit
25 Sainshand Deposit
26 Hulstnuur Deposit
27 Tugrugnuur Deposit

Coal Resources in Mongolia



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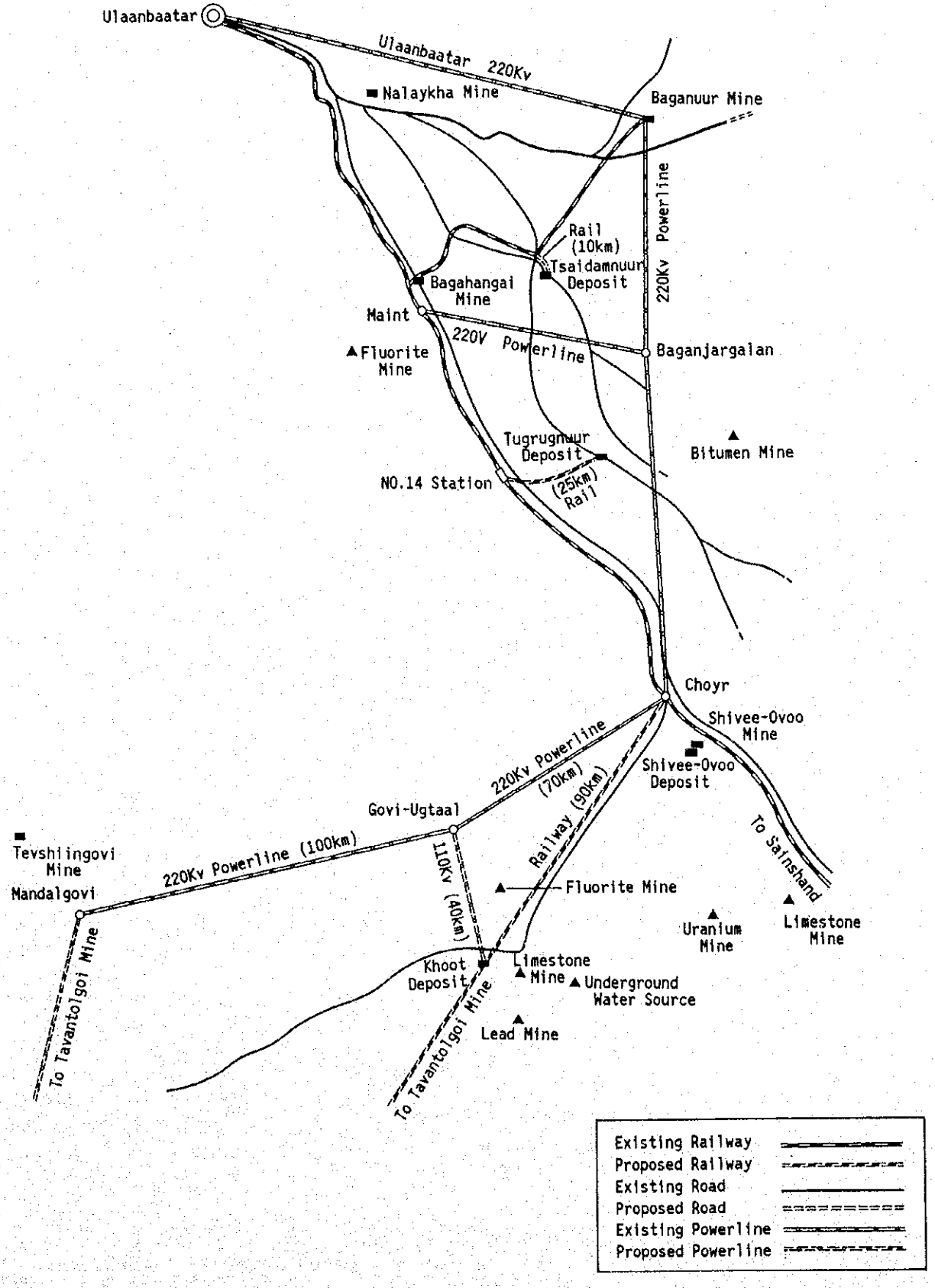


Location Map of Coal Mines

STUDY ON COMPREHENSIVE COAL DEVELOPMENT AND UTILIZATION IN MONGOLIA

FINAL REPORT

Table of Contents

Table of Contents

List of Tables

PART I Renovation Study

CHAPTER I Renovation Study of Baganuur Coal Mine

CHAPTER II Renovation Study of Shivee Ovoo Coal Mine

PART II Master Plan Study

List of Figures

PART I Renovation Study

CHAPTER I Renovation Study of Baganuur Coal Mine

CHAPTER II Renovation Study of Shivee Ovoo Coal Mine

PART II Master Plan Study

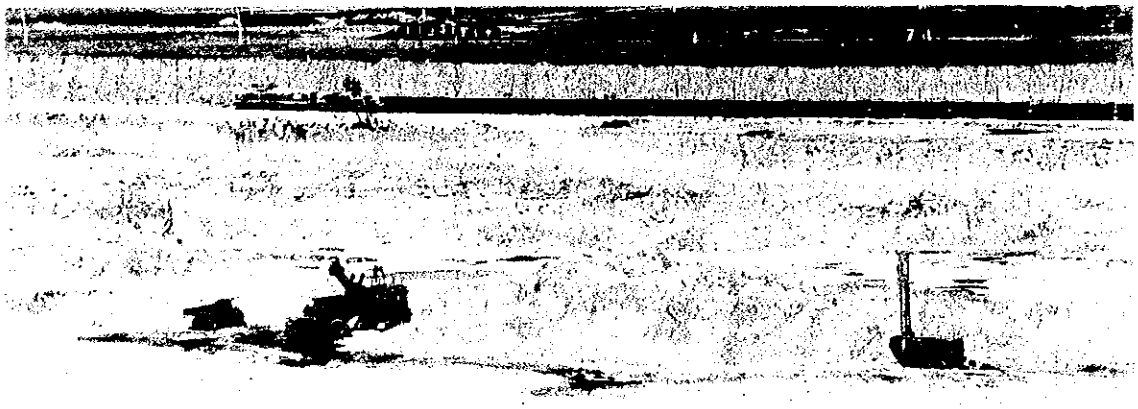
Abbreviations

AD,ad	: Air Dried Basis
ADB	: Asian Development Bank
AR,ar	: As Received Basis
ASTM	: American Society for Testing and Materials
atm.	: Atmosphere(s)
bbl	: Barrel
BCM	: Bank Cubic Meter
BWE	: Bucket Wheel Excavator
CES	: Central Energy System
CIF	: Cost, Insurance and Freight
COMECON	: Communist Economic Conference
D/L	: Dragline
D/T	: Dump Truck
DB,db	: Dry Basis
DAF,daf	: Dry Ash Free
dB(A)	: Decibel in Scale A
DCF	: Discounted Cash Flow
E.C.	: Electric Conductivity
EIRR	: Economic Internal Rate of Return
F/S	: Feasibility Study
FBC	: Fluidized Bed Combustion
FEL	: Front End Loader
FIRR	: Financial Internal Rate of Return
FLIR	: Foreign Loan Interested Rate
FOB	: Free on Board
Gcal	: Giga-caloric
GDP	: Gross Domestic Product
GHV	: Gross Heating Value
GWh	: Giga-watt-hour(s)
ha	: Hectare(s)
HCV	: Higher Calorific Value
HHV	: Higher Heating Value
HP	: Horsepower
HV	: Heating Value
HVDC	: High Voltage Direct Current

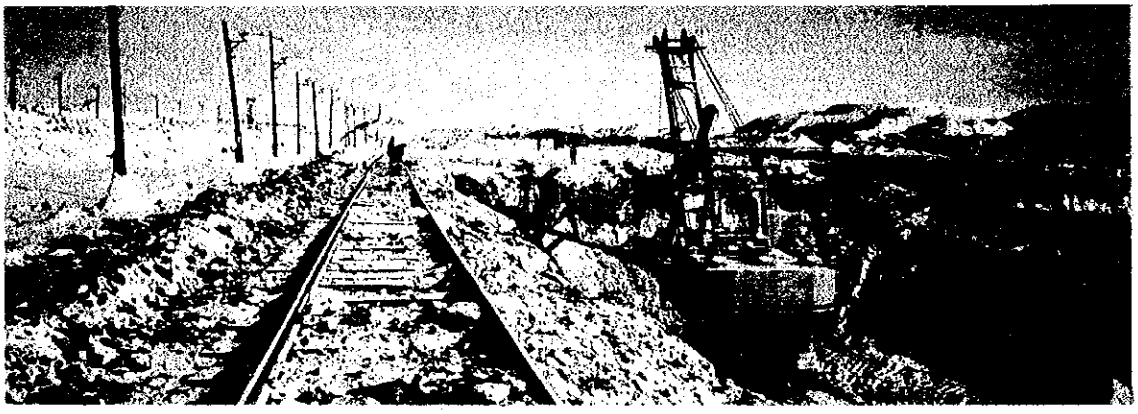
Hz.	: Hertz
IEEJ	: The Institute of Energy Economics, Japan
INPS	: Institute of National Project for the former Soviet Union
IRR	: Internal Rate of Return
JCI	: Japan Consultant Institute
JICA	: Japan International Cooperation Agency
JIS	: Japanese Industrial Standards
KV,kV	: Kilo-volt
KVA,kVA	: Kilo-volt-ampere
kW	: Kilo-watt(s)
kWh	: Kilo-watt-hour(s)
LCV	: Lower Calorific Value
LHV	: Lower Heating Value
m.,mil.	: Million
MCR	: Maximum Continuous Rating
MEGM	: Ministry of Energy, Geology and Mining of Mongolia
MJ	: Mega-joule
MTI	: Ministry of Trade and Industry of Mongolia
MW	: Mega-watt(s)
NDB	: The National Development Board
NEDO	: New Energy and Industrial Technology Development Organization
NMP	: Net Material Product
NPV	: Net Present Value
ODA	: Official Development Assistance
OECD	: Organization for Economic Co-operation and Development
PCF	: Pulverized Coal Fired
ppb.	: Parts per Billion
rpm	: Revolutions per Minute
S.L.	: Sea Level
SNG	: Substitute Natural Gas
SPM	: Suspended Particulate Matter
SS	: Suspended Solid
TBCM	: Total Bank Cubic Meter
TCE,tce	: Ton Coal Equivalent
Tg, tg	: Tugrug(s)
TSP	: Total Suspended Particulates
UNCED	: U. N. Conference on Environment and Development

PART I Renovation Study

CHAPTER I Renovation Study of Baganuur Coal Mine



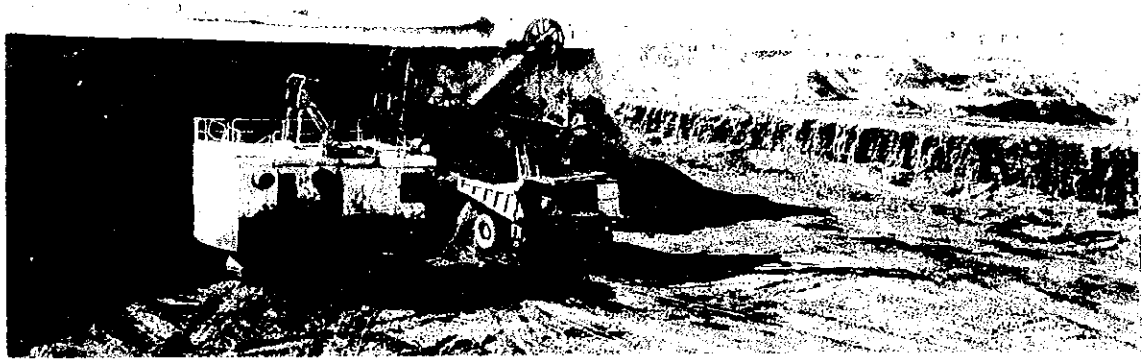
Removal of Overburden by Shovel/Railway and Shovel/Truck System



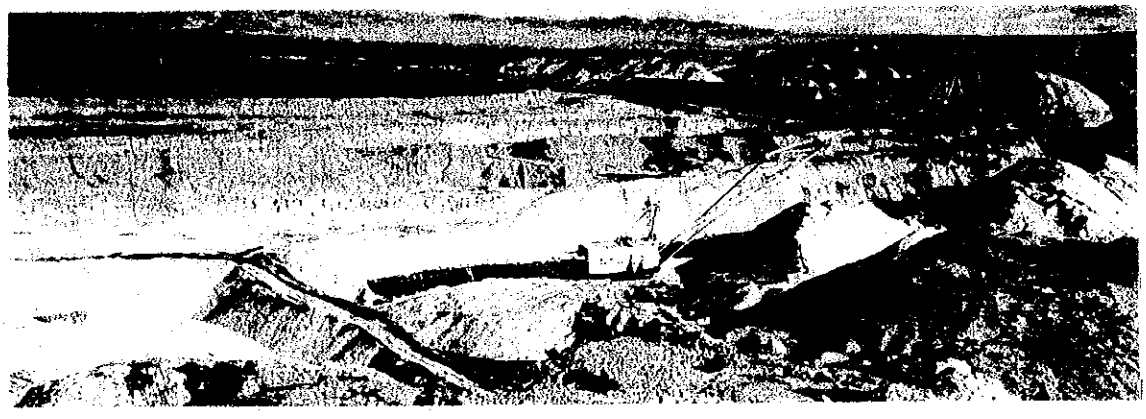
Removal of Overburden by Shovel/Railway System

Transportation of Overburden by Railway System

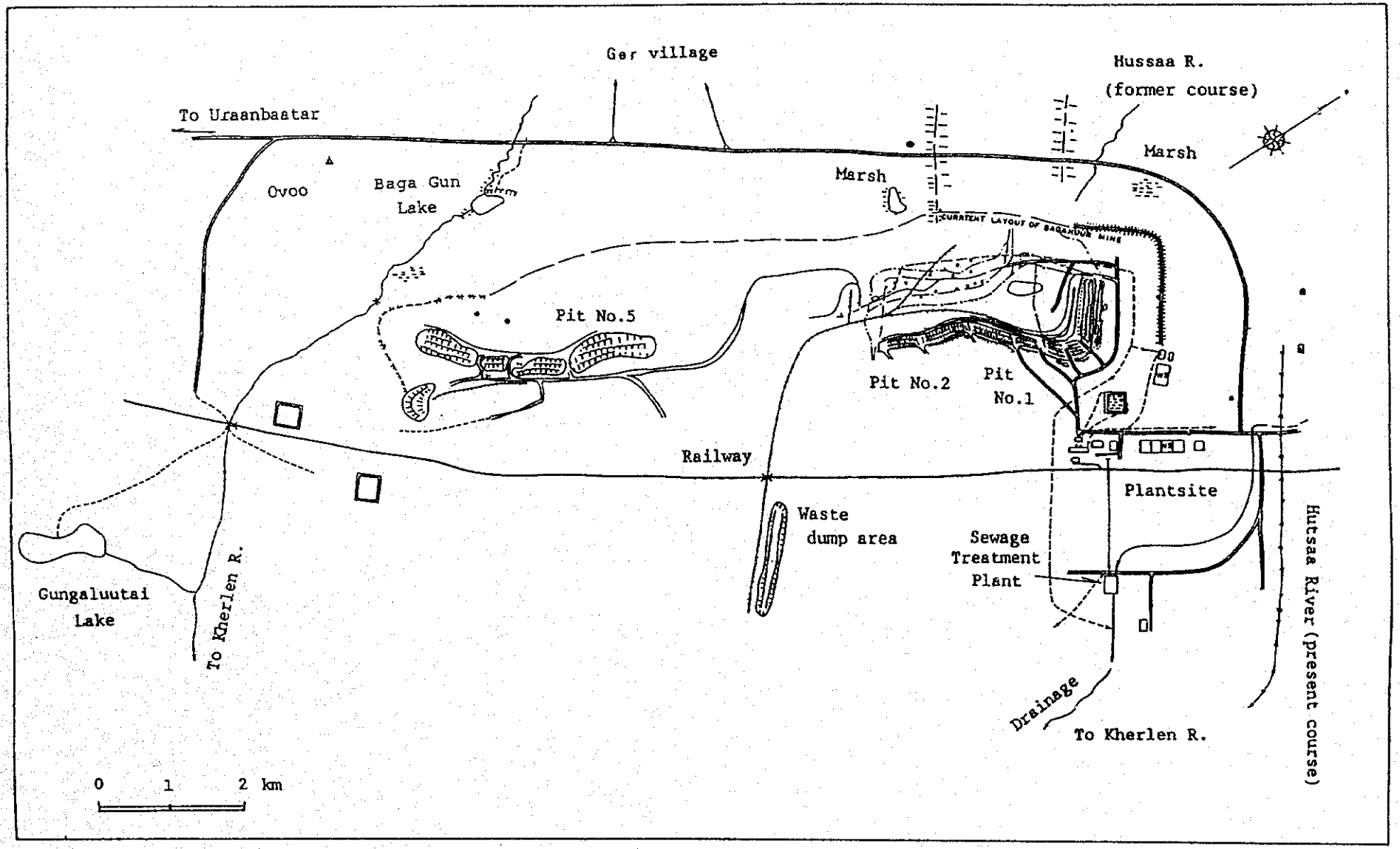
Dumping Overburden from Wagons at Overburden Dump



Removal of Overburden by Shovel/Truck System



Removal of Overburden by Dragline



Baganuur Coal Mine

CHAPTER I Renovation Study of Baganuur Coal Mine

1 Introduction

- Baganuur coal mine is located in 110 km east of Ulaanbaatar and 1,350 m above the sea level.
- Lignite with about 3,600 kcal/kg (LHV) is excavated by an open cut method and mostly consumed at Ulaanbaatar power plants.
- Baganuur coal mine which was designed by the former Soviet Union at 6 million t/y of coal can produce 3-4 million t/y only due to delay of overburden removal.
- Target of renovation is to achieve the coal production of 6 million t/y, improving the defects in the existing Baganuur coal mine.

2 Coal Resources

Reserves

- Proved coal reserves are 560 million tons.
- Coal deposit is 4.5 km width and 12.0 km length within about 200m depth.

Table 1 Proved Coal Reserves

Name of coal seam	Proved reserves (million ton)	Stripping ratio (BCM of soil/ton of coal)
3	53	2.1
2a	246	4.2
2	268	4.8
Total	567	4.3

Quality

- Typical coal quality is featured by high moisture and ash contents.

Table 2 Quality of Reserved Coal

Item	Unit	Average value*1
Total moisture (as received)	%	33.3
Inherent moisture (air dry)	%	11.2
Ash (dry basis)	%	14.9
Calorific value (as received)	kcal/kg	3,616 (LHV)
(air dry)	kcal/kg	4,810 (LHV)
Total sulfur (dry basis)	%	0.73

Note *1 : This shows the average of several sample data obtained from the seam 3, 2a and 2. The reliability of data was confirmed by the both sides.

3 Present Status of Baganuur Coal Mine

3.1 Present mining status

Present mining system

- Overburden is removed by dragline, electric rope shovel and electric railway system, and shovel and dump truck system.

  Coal is excavated by shovel and dump truck.

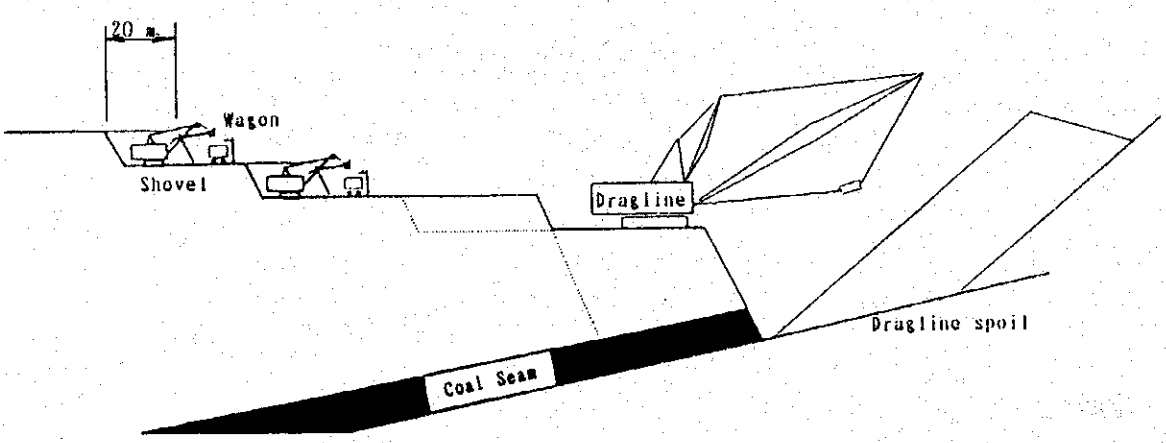


Fig. 1 Present Overburden Removal System

- In 1990, whole equipment designed to produce 6 million t/y of coal was delivered from the former Soviet Union, however, replacement of deteriorated equipment has been delayed due to financial difficulty.

Surface facilities

- Surface facilities such as workshop, warehouse, sizing and loading are well equipped, however, more effective use of the facilities is desired.

Production

- Total of coal production and corresponding overburden removal has been increasing while it was only 55 % of the designed capacity in 1993.

Table 3 Comparison of Coal and Overburden Excavation

Year	Coal production (m.t/y)		Overburden removal (m.BCM/y)		Total (m.BCM/y)	
	Designed	Actual	Designed	Actual	Designed	Actual
1983	1.0	0.7	2.2	3.2	3.0	3.7
1986	2.0	3.2	4.4	6.0	6.0	8.5
1989	3.0	3.8	10.2	8.1	12.5	11.1
1992	6.0	3.4	15.0	9.7	19.7	12.4
1993	6.0	2.9	17.0	9.7	21.7	11.9

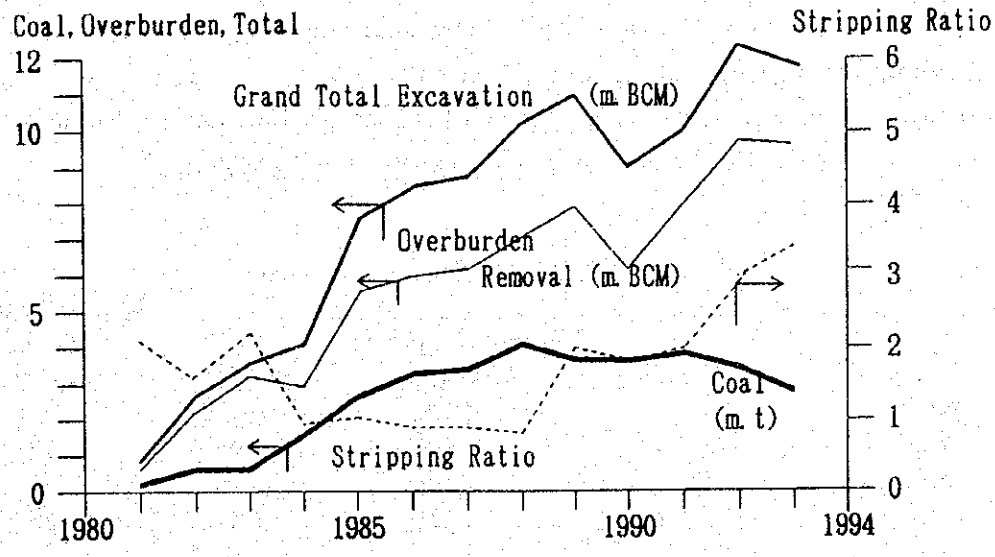


Fig.2 Actual Excavation Trend of Baganuur Coal Mine

Employee

- Total employees were 1,730 in 1993, of which 460 were for production, 290 for railway and 280 for maintenance.

3.2 Issues of present Baganuur coal mine

- Overburden removal has been delayed mainly due to:
  - Low capacity of railway system, which was caused by frequent troubles of whole system and/or individual equipment.
  - Lack of spare parts due to short of the funds.
  - Lack of experts for maintenance due to repatriation of foreign engineers.
- Delay of overburden removal forced to use draglines under unsuitable utilization methods, which has been causing decrease of yearly coal production from the seam 2a due to a cave-in of dumped soil onto seam 2a.
- Large scale equipment sometimes causes long time break down due to difficulty of the repair by Mongolian specialist.
- Violent economic inflation decreased the present value of funds prepared for spare parts and replacement of equipment.

3.3 Evaluation of production capacity of existing coal mine

Operating efficiency

- Analyses of operation data show that the operating efficiency of each mining equipment is rather lower than the desired efficiency (Table 4).
  Efficiency of the locomotive (railway system) is specially low, and the fact indicates that the railway system is a fundamental defect of the existing mining system.

Table 4 Efficiency of Mining Equipment

%, as of 1992

Equipment	Existing equipment Availability	Utilization	Efficiency	Desired Efficiency
Dragline	74-90	67-93	61-78	77
Electric shovel	65-94	58-82	49-76	72
Locomotive	50	56	28	51
Truck	77	85	67	68

Improvement

- Analyses of operation data show that 11.9 million BCM/y of current mining capacity can be increased to 17.3 m.BCM/y through improvement of equipment efficiency, the improved capacity (17.3 m.BCM/y), however, is still lower than the designed capacity (21.7 m.BCM/y).

Table 5 Capacity of Existing Coal Mine

million BCM/y

	Designed value	Current/actual	Improved/estimated
Dragline	4.7+Rehandle	5.5+Rehandle	7.7+Rehandle *1
Shovel/railway	12.3	2.0	3.6 *2
Shovel/truck	4.7	4.4	6.0
(Coal)	(4.7)	(2.2)	(3.1)
(Overburden)	(0.0)	(2.2)	(2.9)
Total	21.7	11.9	17.3 *3

Note *1 : Addition of 0.8 m.BCM/y can be expected by the decrease of the rehandling volume, when new shovels/trucks are equipped.

*2 : Addition of 0.4 m.BCM/y can be expected by equipping new FELs.

*3 : 18.5 m.BCM/y of the total capacity can be expected, when new additional equipment is equipped.

Spare parts

- To achieve above-mentioned improvement regarding the existing coal mine, 16 million US$/y of foreign currency is required for procurement of spare parts.

4 Renovation Study of Baganuur Coal Mine

4.1 Study of effective mining system

Basis for economics comparison

- Tax, interest and royalty are not included in the cost comparison studies.
- Following energy prices are used in the cost comparison studies:

Diesel oil	: International price (169 US$/t) x 1.1
Gasoline	: International price (186 US$/t) x 1.1
Coal	: International price (15.7 US$/t) x 0.7
Electricity	: International price (0.062 US$/kwh) x 0.9

Note: ( ) shows prices (FOB) as of the end of 1993

Economics of the existing mining system

- Present mining system and equipment have some advantages in technical and economic aspects in Mongolia, particularly in performances in cold conditions and less consumption of petroleum products as driving energy.

Table 6 Comparison of Economics Indexes

Cost index	unit	Existing system			New system
Mining system		Railway	Others	Total	Shovel/truck
Base(capacity)	m.BCM/y	3.6	13.7	17.3	12.6
Operation cost	m.US$/y	6.4	20.4	26.8	15.0
Spare parts		(4.6)	(12.5)	(17.1)	(8.5)
Consumables		(1.0)	(5.8)	(6.8)	(5.9)
Labor etc.		(0.8)	(2.1)	(2.9)	(0.6)
Capital cost *1	m.US$/y	6.4	12.6	19.0	7.8
Equipment		(6.4)	(12.6)	(19.0)	(7.8)
Total cost	m.US$/y	12.8	33.0	45.8	22.8
Cost index	$/BCM				
Before life span *2		1.8	1.4	1.5	-
With replacement *3		3.6	2.4	2.6	1.8

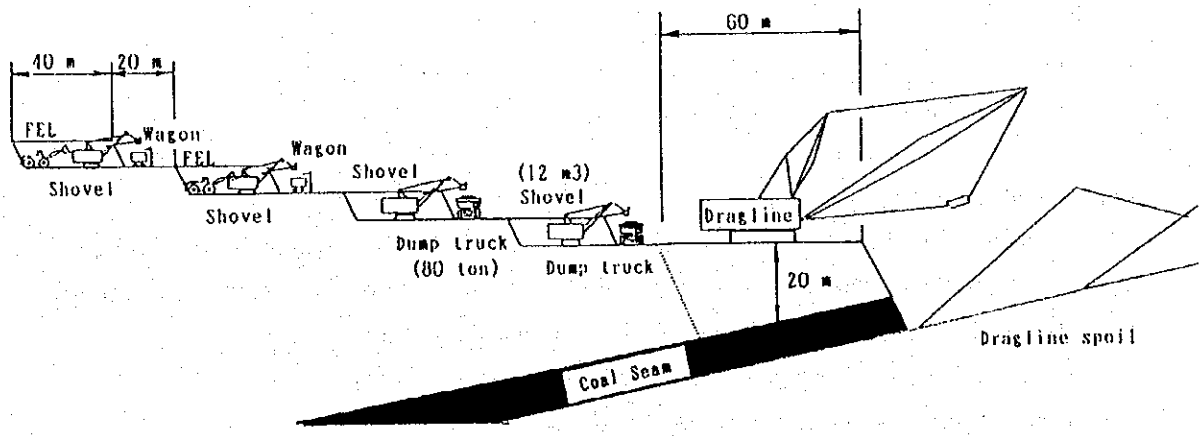
Note *1 : Tax, interest and royalty are not included in the figures.
*2 : Cost index before replacement of the existing equipment.
Replacement cost is not included in cost index.
*3 : Cost index includes a periodic replacement of equipment

- Above economics comparison study between existing systems and new mining system shows that:
  - Immediate replacement of the railway system with other types of equipment is not economical. However, it should be replaced with a new shovel and truck system after the operation life.
  - Replacement of existing equipment with the Russian-type equipment after the operation life may be uneconomical, if the price is increased.

Overall mining system

- Overall mining system was reviewed and the following basic mining system was selected for renovation, taking issues of overburden removal into consideration:

Overburden removal of shallow zone : Existing shovel/railway and FEL(up to 1997)
Existing shovel/new truck after 1998
Overburden removal of middle zone : New additional system
Overburden removal of bottom zone : Existing dragline
Coal excavation : Existing and new shovel and truck



Note: Railway system will be replaced with new trucks after around 1998.

Fig.3 Proposed Overburden Removal System

Economics of new mining systems

- Comparison study was implemented to select the new additional mining system to be used for overburden removal at middle zone.

  Case A : Fleets of 8 m^3 shovel and 50 ton dump truck

  B : Fleets of 12 m^3 shovel and 80 ton dump truck

  C : Fleets of 16 m^3 shovel and 120 ton dump truck

  D : Bucket wheel excavator and conveyer

- Case B was chosen due to the lowest cost index as shown in Table 7 and the lowest cost for the maintenance facilities.

Table 7 Comparison Study of New Systems

		Existing	Additional system			
	Unit	Improved	Case A	Case B	Case C	Case D
Existing capacity	m.BCM/y	17.3	-	-	-	
Additional capacity	m.BCM/y	-	12.6	12.6	12.6	12.6
Number of fleets *1		-	4	3	2	2
Initial capital *2	m.US$	-	62	54	42	112
Operating cost *2	m.US$/y	26.8	17.3	15.0	15.9	18.9
Spare parts		(17.1)	(9.9)	(8.5)	(9.5)	(11.9)
Consumables		(6.8)	(6.6)	(5.9)	(5.9)	(6.5)
Labor etc.		(2.9)	(0.8)	(0.6)	(0.5)	(0.5)
Capital cost *2	m.US$/y	19.0	9.0	7.8	6.9	14.6
Equipment		(19.0)	(9.0)	(7.8)	(6.9)	(14.6)
Total cost *2	m.US$/y	45.8	26.3	22.8	23.0	33.5
Mining cost index	$/BCM	2.6	2.1	1.8	1.8	2.7

Note *1 : Fleets were planned based on the most modern equipment.

*2 : Tax, interest and royalty are not included.

Change of coal recovery ratio

- Design philosophy of Baganuur coal mine was reviewed. Principal change of design basis is to increase coal recovery ratio for the purpose of effective utilization of Baganuur coal resources.
- Following three cases were compared to select the optimum recovery ratio.

  Case 1 : Present mining plan (up to 170m from the surface)

  Case 2 : Medium depth of the case 1 and case 3

  Case 3 : Maximum mining depth (up to 200m from the surface)

Table 8 Comparison Study of Economics of Coal Recovery Ratio

	unit	Case 1	Case 2	Case 3
Depth of mining	m	170	190	200
Minable coal	m.ton	260	400	480
Coal recovery ratio	%	54	83	base*1
Total coal production	m.ton/y	6	6	6
Life of mine	years	43	67	80
Required total capacity	m.BCM/y	24	27	30
by existing system		(17.3)	(17.3)	(17.3)
by additional system		(6.7)	(9.7)	(12.6)
Stripping ratio(average)	BCM/ton	3.2	3.7	4.2
Additional shovel/truck*2	fleet	1.6	2.3	3
Initial cost of <*2> *3	m.US$	29	41	54
Total operating cost *3	m.US$/y	31.6	35.0	38.3
Existing system		(23.9)	(23.9)	(23.9)
Additional system		(7.7)	(11.1)	(14.4)
Total capital cost *3	m.US$/y	26.4	28.4	30.3
Existing system		(21.9)	(21.9)	(21.9)
Additional system		(4.5)	(6.5)	(8.4)
Total cost *3	m.US$/y	58.0	63.4	68.6
Coal cost index*4	US$/ton	9.7	10.6	11.4

Note *1 :About 85% of measured coal reserves. Deeper than 200m zone is excluded due to no geological data.

*2 :Fleet of Case B in Table 7 is adopted for each case, therefore, number of fleets is not an integral.

*3 :These include both costs of existing system and additional ones. Tax, interest, royalty and surface facilities are not included.

*4 :Total cost is divided by 6 m.t/y of coal.

- Case 3 is selected because Case 3 shows an acceptable increase in the coal cost index, while the large volume of additional coal production is available.
- Stripping ratio to be used in the study of renovation is 4.2 (average).

4.2 Recommended mining equipment and facilities

Recommended mining equipment

- In accordance with the revised design basis above-mentioned, the new additional equipment is recommended as shown on Table 9.
- Life of equipment depends on the equipment quality, utilization circumstances and maintenance methods. Therefore, two cases, "Short-life case" and "Long-life case" are assumed. Expected life depends on the selected manufacturers and adopted utilization and maintenance methods in Mongolia.

Table 9 Additional Equipment List

Equipment	Required number	Life (years)		Unit price (m.US$)*2	Major use
		S*1	L*1		
12 m^3 shovel	3	15	21	4.0	Overburden removal
80 ton dump truck	27	6	8	0.8	Ditto
40 ton coal truck	14	6	8	0.4	Coal transport
10 m^3 FEL	3	6	8	0.9	Overburden removal
Bulldozer 400 HP	11	6	8	0.5	Multi-purpose
Grader 254 HP	3	6	8	0.4	Road maintenance

Note *1 : "S" is short-life case and "L" is long-life case.
*2 : All costs and fees for manufacturing, packing, transportation, field assembly and training are included in unit price.

Recommended facilities

- Installation of following surface facilities, including supporting equipment, is recommended to achieve 6 million t/y of coal production with a smooth and effective operation:

Table 10 Additional Facility List

Facility & equipment	Number	Initial cost	Note
Workshop & tools	1	US$ 0.9 m.	Expansion & repair
Warehouse	1	0.3	Expansion
Coal stockyard at Pit 2&5	2	1.1	New installation
(Dozer shovel)	(3)	(0.9)	250 HP
Sizing & loading at Pit 2&5	2	3.7	New installation
(Crushing plant)	(2)	(1.1)	Crushing/sizing
(Conveyer set)	(2)	(0.9)	Hopper/spreader
(Dozer shovel)	(4)	(1.1)	250 HP
Power distribution	1	1.2	Movable transformer
(Emergency generator)	(2)	(0.4)	Diesel generator
Communication	1	0.1	Wireless system
Dewatering system	1	4.0	Well, pump & piping
Multi-purpose equipment	1 set	4.3	FEL,bulldozer,truck
Coal quality control system	1 set	0.2	Automatic analyzer
Total		15.8	Excepting Tg-cost

4.3 Schedule of renovation

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.

Project schedule

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 1997

Coal production plan

1995	: 3.5 million t/y
1996,1997	: 4.0 million t/y
1998	: 5.0 million t/y
1999	: 6.0 million t/y

5 Quality Control System

5.1 Issues of coal quality

- At present, volumes of Baganuur coal are sent to users without crushing and quality inspection.
- High moisture content causes freezing in railway wagon and plugging of pipeline at the power plants.
- Sometimes, thin interburden were excavated and mixed into coal, resulting in lowered calorific value of the product coal.
- User are requesting to minimize the change of coal quality, particularly in moisture content.

5.2 Recommended quality control system and equipment

- Management must introduce "thought on quality control" into Baganuur coal mine.
- Following equipment and plants must be introduced and reinforced:
  Quality control equipment (on line analyzer)
  Crushing and sizing plant
  Small scale FEL and truck for thin parting removal
  Dewatering system

Note: Installation of a coal drying plant at the mine site is desirable, however, such a plan is abandoned because dried lignite may cause spontaneous combustion during storage and transportation. It is recommended to install a coal drying plant at users' side.

5.3 Expected average quality of product coal

- Following quality will be achieved by introduction of above-mentioned quality control system;

Table 11 Expected Quality of Product Coal

Item		Unit	Estimated value
Total moisture	(as received)	%	35.0
Surface moisture	(as received)	%	26.8
Inherent moisture	(air dry)	%	11.2
Ash	(air dry)	%	17.0
Volatile matter	(air dry)	%	31.8
Fixed carbon	(air dry)	%	40.0
Total sulfur	(air dry)	%	0.63
Calorific value	(air dry)	kcal/kg	4,868 (GHV), 4,620 (LHV)
Calorific value	(as received)	kcal/kg	3,563 (GHV), 3,221 (LHV)

6 Environmental Study

- Environmental impact of renovation of Baganuur coal mine was studied in nine environmental items such as air, water, soil, noise/vibration and fauna/flora.
- Any limitation on renovation for 6 million t/y was not recognized in all environmental aspects.
- Major environmental issues are precipitation of Fe by drainage of groundwater and possibility of drawdown of the water level of Baga Gun Lake.
- Expansion of the existing water treatment system of groundwater drainage and a change of the water flow route of Hutsaa River into Baga Gun Lake are proposed to resolve above-mentioned issues.
- Monitoring and more detail investigations are recommended in order to preserve the environment of Baganuur coal mine.

7 Capital and Operating Cost

7.1 Replacement schedule of mining equipment

- As discussed in 4.1, followings are expected to be the most effective renovation plan of Baganuur coal mine:
  - Existing railway system should be replaced with the most modern and large scale shovel and truck system after the operation life.
  - Other existing equipment will be replaced with the same type of equipment, assuming that the parts of the used equipment can be used as spare parts for the new equipment.
- To evaluate the above-mentioned basic options, three kinds of replacement plans are developed for further detailed economic study.

  Case A: Railway system to be used through the project life (23 years)

  Case B: Railway system to be changed into a shovel and truck system in 1998, when the full scale operation begins.

  Case C: Railway system to be changed into a shovel and truck system in 2002, when major equipment of the railway system reaches to the life.

7.2 Capital and operating cost

- Capital and operating costs for the three cases are estimated for 23 years (1996-2018) of the project period in accordance with the replacement schedule of each equipment and the estimated international level of unit prices.

Note 1: Duration of 23 years is presumed only for the purpose of economic evaluation and financial analysis.

2: Price level of the existing equipment type, which is imported mainly from ex-COMECON, is estimated to be 80% of the recent modern equipment in this study, although the level is low at the present time.

Table 12 Capital and Operating Costs by Case

Million US$

	Case A	Case B	Case C
Capital cost			
for rehabilitation	400	326	340
for expansion	135	135	135
Total	535	461	475
Operating cost			
for rehabilitation	754	716	723
for expansion	334	334	334
Total	1,088	1,050	1,057
Total cost for renovation	1,623	1,511	1,532

Foreign currency portion

- Foreign currency portion of capital and operating costs required for Case B during 23 years is shown on Table 13.
- Foreign currency required for capital cost during the first three years is US$ 130 million.
- Foreign currency required for operating cost during the first three years is US$ 63 million.

Table 13 Foreign Currency Portion for 23 Years
Case B: Without railway from 1998

Million US$

Year	Capital cost			Operation cost*3			Yearly
	Existing*1	Addition*2	Total	Existing	Addition	Total	Total
1996	15.5	0	15.5	19.5	0	19.5	35.0
7	30.4	0	30.4	19.5	0	19.5	49.9
8	33.7	50.6	84.3	18.6	5.3	23.9	108.2
9	3.5	0	3.5	19.2	10.5	29.7	33.2
2000	17.3	0	17.3	19.2	10.5	29.7	47.0
1	7.8	0	7.8	19.2	10.5	29.7	37.5
2	2.0	0.4	2.4	19.2	10.5	29.7	32.1
3	6.0	0	6.0	19.3	10.5	29.8	35.8
2004-2008	73.7	37.5	112.2	96.3	52.5	148.8	260.0
2009-2013	60.5	1.0	61.5	96.3	52.5	148.8	210.3
2014-2018	61.2	38.8	100.0	96.2	52.5	148.7	248.7
Total	311.6	128.3	439.9	442.2	215.3	657.8	1,097.7

Note *1 : Necessary capital costs of "existing" are the replacement cost of the existing equipment and calculated on the basis of short-life and 80% of unit prices (see Table 9). Taxes in Mongolia are not included.

*2 : Necessary capital costs of "addition" include both initial and replacement costs for additional equipment and facilities and calculated on the basis of long-life and 100% of unit prices.

*3 : Operating costs include yearly spare part cost, periodic overhaul cost and imported consumables such as explosives, diesel oil, gasoline and lubricants.

Local currency portion

- Local currency is required mainly for labor cost and electricity cost.

Table 14 Local Currency Portion for 23 Years
Case B: Without railway from 1998
Million US$ as of 1994

	Labor cost	Electricity cost	Other cost	Total
1996	2.6	1.8	16.3	20.7
1997	2.6	2.0	7.7	12.2
1998	2.6	2.4	13.0	18.0
1999-2018	56.0	64.0	243.3	363.4
Total	63.8	70.2	280.3	414.3

Note: Other cost includes domestically produced consumables, after tax expense listed in

profit distribution (adjustment of operating cost).

8 Economic Evaluation and Financial Analysis

8.1 General approach

- Major concern for renovation of Baganuur coal mine is the impact of the replacement of the railway system as discussed in 4.1 (Table 6).
- For the purpose of economic evaluation and financial analysis of the renovation project, the cash flows are prepared for the following three renovation programs;

  Case A: Rehabilitation (18.5 m.BCM/y) and expansion (11.4 m.BCM/y) using the existing railway system through the project life.

  Case B: Rehabilitation and expansion changing the existing railway system (abandoned) into a new shovel and truck system in 1998.

  Case C: Rehabilitation and expansion changing the existing railway system into a new shovel and truck system in 2002. Its major equipment of the railway system will reach to the life span.

- Followings are used for the studies:
  - Project life : 23 years (from 1996 to 2018)
  - Time value of money : Constant 1994 Tg with 400 Tg/US$
  - Project financing : 100% debt～ 100% equity(case study)
  - Foreign debt financing : Project untied loan
  - Price and the life span of equipment (see Table 9 and 11)
    - Existing type of equipment : 80% of international prices and short-life case
    - New additional equipment : 100% of international prices and long-life case
  - Inflation : No inflation

- Table 15 shows the concept of recent price and cost structure in Mongolia used in the economic and financial evaluation.

Table 15 Price and Cost Structure

	Foreign currency	Local currency		CIF Site	
Item	Border Price	Taxes	Other Cost	Without Taxes	Total
Imported equipment	0.8333	0.1521	0.0146	0.8479	1.000
	(1.0000)	(0.1825)	(0.0175)	(1.0175)	(1.200)
Imported parts	0.7407	0.1963	0.0630	0.8037	1.000
including explosives	(1.0000)	(0.2650)	(0.0850)	(1.0850)	(1.350)
Diesel oil	0.4726	0.2578	0.2696	0.7422	1.000
	(1.0000)	(0.5455)	(0.5703)	(1.5703)	(2.116)

8.2 Economic evaluation

- In order to evaluate Baganuur renovation project from Mongolian economy as a whole, taxes, royalties and debt financing costs are all eliminated from the economic costs.
- Economic value of Baganuur coal with 3,563 kcal/kg is evaluated to be 6,057 Tg/t as a calorific parity border price of the import substitute from Russia.
- Formula for cash flow used in the economic analyses is as follows:

  + 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 (retained working capital, equipment salvage etc.)
  = Cash flow for EIRR on total project

Selection of the base case for economic evaluation

- Three scenarios above-mentioned were compared with one another by using the coal prices calculated at 10% of economic internal rate of return (EIRR).

Table 16 Economic Coal Prices with/without Railway System

	Coal production (m.t/y)	Total excavation (m.BCM/y)	Economic coal price (Tg/t coal) Case A	Case B	Case C
Rehabilitation	3.7	18.5	5,257	4,916	4,971
Expansion	2.3	11.4	4,370	4,370	4,370
Whole system	6.0	29.9	4,977	4,743	4,781

- Difference in price, specially, between Case B and Case C is almost nil.

Although economic priority will be mainly affected by the assumed equipment price made in ex-COMECON, "Case B:without-railway from 1998" is selected as the base case for economic evaluation.

Economic evaluation of the base case

- EIRR of Case B is as high as 97% at the economic value of 6,057 Tg/t.

	EIRR
Rehabilitation of existing system abandoning railway in 1998	∞
Expansion from 3.7 m.t/y to 6.0 m.t/y in 1988	36.6%
Renovation combined (Case B)	97.0%

- Coal price of 4,743 Tg/t at 10% of EIRR (Table 15) is significantly low compared with the economic value of 6,057 Tg/t.
- EIRR of 97% at the economic value and the price of 4,743 Tg/t at 10% of EIRR are evaluated to be sufficient for the economic feasibility of the project.

Economic sensitivity analyses

- Impact of changes in the base case assumptions was evaluated at the economic coal value of 6,057 Tg/t.

Table 17 Economic Sensitivity Analysis (Case B)

unit: EIRR %

Conditions Changing rate	Price	Capital cost	Operating cost	Excavation volume (no change in coal)	(S/R)
1.2	∞	39.3	28.9	30.0	(5.2)
1.1	∞	53.9	45.9	46.9	(4.7)
Base	97.0	97.0	97.0	97.0	(4.2)
0.9	31.5	∞	∞	∞	(3.7)
0.8	12.3	∞	∞	∞	(3.2)

- Impact of changes in coal value is most significant, however, such a change may be caused only by the change of the international energy price.
- ±20% changes in conditions such as capital cost, operating cost and stripping ratio will not give a serious impact on the feasibility of the project.

8.3 Financial analysis

- In order to evaluate economics of the renovation project in view of Baganuur coal mine or investor, several criteria are added as follows:
  - Domestic debt financing cost : 10 %/month with a repayment period of 6 months
  - Foreign debt financing cost : 8 %/year with a repayment period of 10 years
- Formula for cash flow used in the financial analyses is as follows:
  - Cash flow for FIRR on total project (debt/equity = 0/100)

    + 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 (retained working capital, equipment salvage, etc)

    = Cash flow for FIRR on total project

  - Cash flow for FIRR on equity

    + Revenue
    - Total operating costs
    - Tax
    - After tax expenses (adjustment of operating costs)
    + Depreciation
    - Total capital costs
    - Increase in working capital
    + Debt
    - Debt payment
    + Project liquidation (retained working capital, equipment salvage, etc)

    = Cash flow for FIRR on equity

Financial analysis

- Three scenarios above-mentioned were compared with one another by using the coal prices calculated at 10% of FIRR on total project.

Table 18 Financial Coal Prices with/without Railway System

	Coal production (m.t/y)	Total excavation (m.BCM/y)	Financial coal price (Tg/t coal) Case A	Case B	Case C
Rehabilitation	3.7	18.5	8,675	7,923	8,061
Expansion	2.3	11.4	6,696	6,696	6,696
Whole system	6.0	29.9	7,980	7,493	7,586

- Comparing the financial coal price (7,493 Tg/t) with the economic coal price (4,743 Tg/t) at 10% EIRR in Case B, the financial price is 160% of the economic price.
- FIRR on total project of Case B is as low as 0.9% at the economic value of 6,057 Tg/t, and the project is not financially feasible.

	FIRR
Rehabilitation of existing system abandoning railway in 1998	(-1.7)%
Expansion from 3.7 m.t/y to 6.0 m.t/y in 1988	5.6
Renovation combined (Case B)	0.9

- Under the current taxation regimes in Mongolia, the project cannot be viable as concluded by low FIRR of 0.9% at the economic coal value of 6,057 Tg/t and the high coal price of 7,493 Tg/t required to gain 10% of FIRR.

  Fig.4 shows the current taxation system and the coal price structure in Mongolia.

- To improve the financial feasibility of Baganuur coal mine as well as to decrease the coal sale price from the level of the economic value of 6,057 Tg/t, amendment of Mongolian taxation rates including tax exemption will be necessary, which will result as a profit redistribution from the Government to the coal mine.

Effect of tax exemption

- Regarding tax exemption, the most possible steps so as to gain 10% of FIRR on the total project in Case B at the economic coal value of 6,057 Tg/t are examined as presented below.

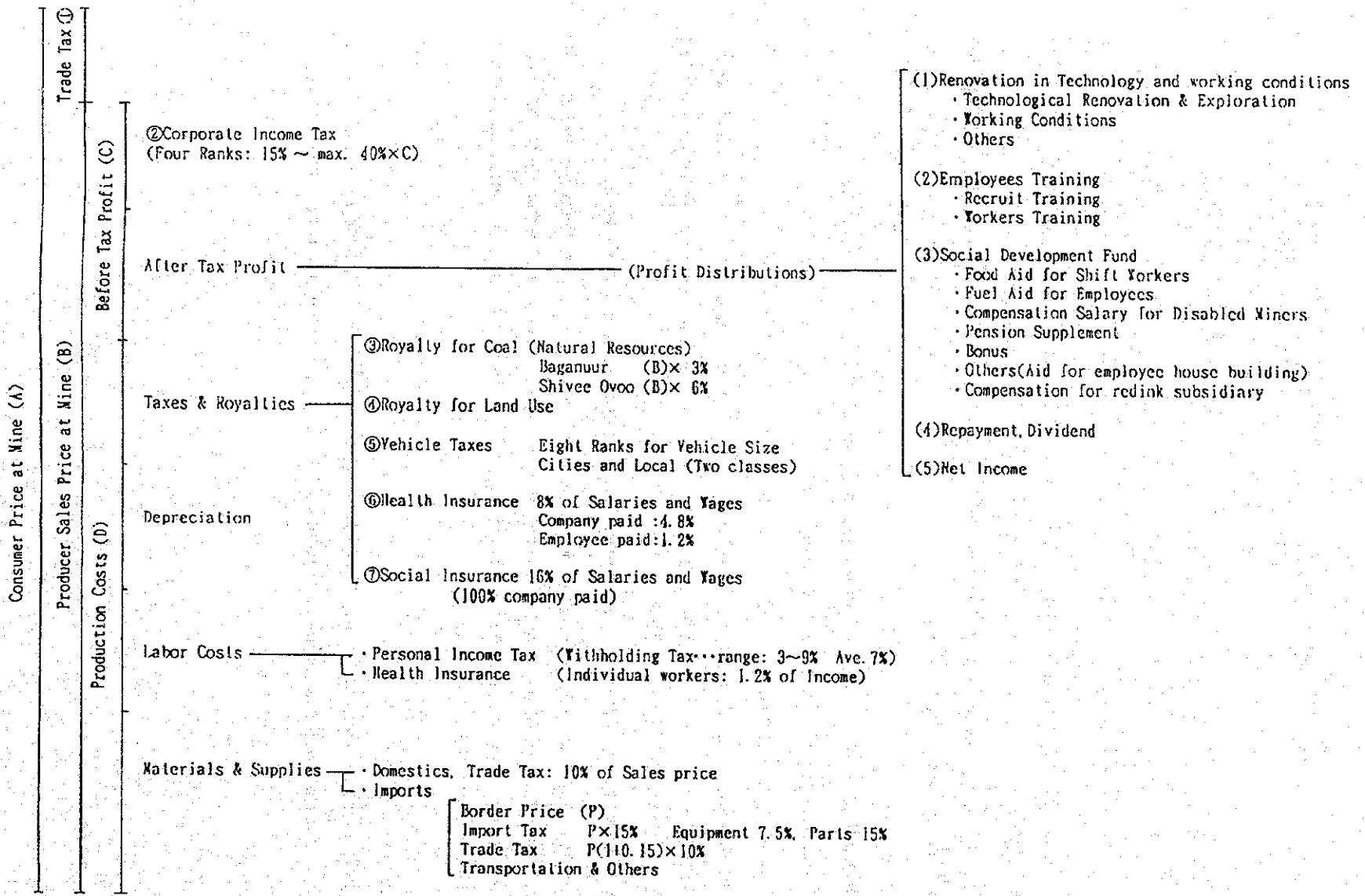


Fig. 4 Tax System and Coal Price Structure

Table 19 Tax Exemption Steps for Case B

Tax items and exemption step	FIRR on total project	NPV at 10% discount rate (10^6Tg)
1 Current tax regimes	0.6%	-32,420
2 Assets revaluation	0.9	-30,730
3 Carry-over of gross operation loss	0.6	-29,630
4 Increase of tax exemption item in operating cost	2.3	-25,530
5 Reduction of tax rate for equipment: Import tax of 7.5% to 0, Trade tax of 10% to 5%	2.9	-22,080
6 Reduction of tax rate for spare parts: Import tax of 15% to 0, Trade tax of 10% to 5%	6.1	-11,470
7 Tax exemption for equipment and spare parts: Trade tax of 5% to 0	7.8	- 6,680
8 Coal trade tax redistribution: 5% to the coal mine	10.0	+ 120

- Above Table 19 shows that 10% of FIRR on the total project (debt/equity = 0/100) is critical at 6,057 Tg/t, even if tax exemptions above are implemented.
  For further improvement of the financial feasibility, low cost loan will be necessary.

Effect of leverage

- In order to assess the effects of leverage, relationships among FIRR, debt/equity ratio, foreign loan interest rate and corresponding tax exemption steps necessary to gain the required FIRR (more than 8%) on equity at 6,057 Tg/t was examined.
- Table 20 is the relationships in case of 2% of foreign loan interest rate.
  It shows that the high debt/equity ratio with low interest rate loans can decrease the necessary tax exemption step.
  Note: The high debt/equity ratio with high interest rate loans needs more tax exemption steps to prevent from unrepaid loans.

Table 20 Relationship between Leverage and Tax Exemption Steps
(Case B at 6,057 Tg/t with 2% of foreign loan)

Tax items and exemption steps	FIRR for debt/equity of 50/50	70/30	80/20
1 Current tax regimes	0.4%	0.4	0.9
2 Assets revaluation	0.8	0.8	1.1
3 Carry-over of gross operation loss	1.2	1.2	1.1
4 Increase of tax exemption item in operating cost	1.4	n,a	n,a
5 Reduction of tax rate for equipment: Import tax of 7.5% to 0, Trade tax of 10% to 5%	2.8	0.9	n,a
6 Reduction of tax rate for spare parts: Import tax of 15% to 0, Trade tax of 10% to 5%	7.4	9.0	10.6
7 Tax exemption for equipment and spare parts: Trade tax of 5% to 0	9.7	(12.5)	(16.1)
8 Coal trade tax redistribution: 5% to the coal mine	(13.7)	(19.5)	(32.2)

Note: ( ) means that the corresponding tax exemption step is not necessary due to the high financial feasibility of the project.

Desired financial conditions for renovation

- Above-mentioned examinations indicate that the desired financial conditions for renovation project of Baganuur coal mine are as follows:
  - Project financing of 80% debt and 20% equity
  - Foreign loan of low interest rate
  - Fixed assets revaluation
  - Tax deductible of accumulated operation loss
  - After tax expenses into tax exemption
  - Import tax of 0% for equipment and spare parts
  - Trade tax of 5% for equipment and spare parts
  - Redistribution of coal trade tax of 5% to the coal mine

Financial sensitivity analysis

- Impact of changes in coal sale price was evaluated by the amount of loan unrepaid at the end of the project life.
  The reasonable lowest sale price of Baganuur coal under above-mentioned financial conditions and without loan unrepaid is slightly differed by a foreign loan interest rate from 5,900 Tg/t at 2% to 6,068 Tg/t at 8%.
- Impact of changes in other assumptions was evaluated in Case B under above- mentioned

financial conditions in regard of FIRR on the total project and FIRR on equity.

Table 21 Financial Sensitivity Analysis
(Case B: 80% debt with 2% foreign loan at 6,057 Tg/t)

unit: FIRR on equity %

Conditions Changing rate	Capital cost	Operating cost	Excavation volume (no change in coal)	(S/R)
1.2	9.3	n,a	n,a	(5.2)
1.1	13.7	7.5	7.8	(4.7)
Base	20.3	20.3	20.3	(4.2)
0.9	32.3	64.1	60.5	(3.7)
0.8	59.5	∞	∞	(3.2)

- ±20% of changes in capital cost, operating cost and stripping ratio give a serious impact on the financial feasibility of the project.

9 Conclusions and Recommendation

Issues of present Baganuur coal mine

- In 1990, whole equipment designed for 6 million t/y coal was delivered, however, the total excavation volume of coal and overburden was 55% of the designed capacity in 1993.
- Above issues were caused mainly by:
  - Low achievement of the railway system due to frequent troubles
  - Lack of spare parts due to shortage of the funds
  - Lack of experts for maintenance due to repatriation of foreign engineers.

Recommended mining system for renovation

- After detailed technical and economic evaluation, Case B was selected as the most economical system for renovation, which consists of:
  - Abandonment of the existing railway system and introduction of a new truck and shovel system in 1998.
  - Introduction of the additional trucks and shovels for the production scale expansion to 6 million t/y.

Environmental impact

- No environmental limitation on renovation for 6 million t/y was recognized in all environmental aspects.
- Expansion of the existing water treatment system to prevent from precipitation of Fe in groundwater and other environmental measures are included in the renovation project.

Capital and operating cost

- Capital and operating cost of Case B for 23 years (1996-2018) are as follows:

	Capacity (mil.t/y)	Capital cost (mil.US$)	Operating cost (mil.US$)
Rehabilitation of existing system	3.7	326	716
Expansion of the capacity	2.3	135	334
Total	6.0	461	1,050
(Unit cost: US$/t.coal)	-	3.46	7.88

- Foreign currency portion of the above-mentioned capital and operating cost for the first 3 years (1996-1998) is as follows:

	Capacity (mil.t/y)	Capital cost (mil.US$)	Operating cost (mil.US$)
Rehabilitation of existing system	3.7	79	58
Expansion of the capacity	2.3	51	5
Total	6.0	130	63

Results of economic evaluation

- Economic analyses indicate that renovation of Baganuur coal mine is highly advantageous in terms of national economy.
- EIRR, which represents the point of view of Mongolian economy as a whole, is high as 97% at the economic coal value of 6,057 Tg/t.
- Coal price to gain 10% EIRR is 4,743 Tg/t which is significantly low compared with the economic coal value of 6,057 Tg/t.
- ±20% changes in conditions such as coal price, capital cost, operating cost and stripping ratio will not give a serious impact on the project.

Results of financial evaluation

- Under severe Mongolian taxation regimes, the renovation project of Baganuur coal mine is not financially viable.
- FIRR on the total project, which represents the investor's point of view, is as low as 0.9% at the economic coal value of 6,057 Tg/t.
- Coal price to gain 10% FIRR on the total project (debt/equity = 0/100) is 7,598 Tg/t which is extremely high compared with the economic value of 6,057 Tg/t.
- ±20% of changes in capital cost, operating cost and stripping ratio gives a serious impact on the financial feasibility of the project.

Improvement of financial feasibility

- Since the renovation is highly advantageous in terms of national economy, following amendments of the current Mongolian taxation regimes recommended:
  - Trade tax exemption for equipment and spare parts: from 10% to 0
  - Import tax exemption for equipment and spare parts: from 7.5/15% to 0
  - Increase of tax exemption items in operating cost
  - Redistribution of coal trade tax: 5% to Baganuur coal mine
- Even after above is applied tax exemption, 10% of FIRR on the total project (100% equity) is critical at the economic coal value of 6,057 Tg/t.
  Introduction of low cost loan together with tax exemption will be effective for further improvement of financial feasibility.
- For example, in case of 80% debt with foreign loan of 2% interest rate, the coal sale price of 5,900 Tg/t will give 15% of FIRR on equity which is a reasonable value for the fundamental industries.

Desired financial conditions for renovation

- Desired financial conditions for the renovation of Baganuur coal mine that can be concluded from above-mentioned results of evaluations are follows:
  - Project financing of 80% debt and 20% equity
  - Foreign loan of low interest rate
  - Fixed assets revaluation
  - Tax deductible of accumulated operation loss
  - After tax expenses into tax exemption
  - Import tax of 0% for equipment and spare parts

- Trade tax of 5% for equipment and spare parts
- Redistribution of coal trade tax of 5% to the coal mine

- If Mongolian government plans to promote the privatization, it is recommended to create the similar conditions in effect described above.

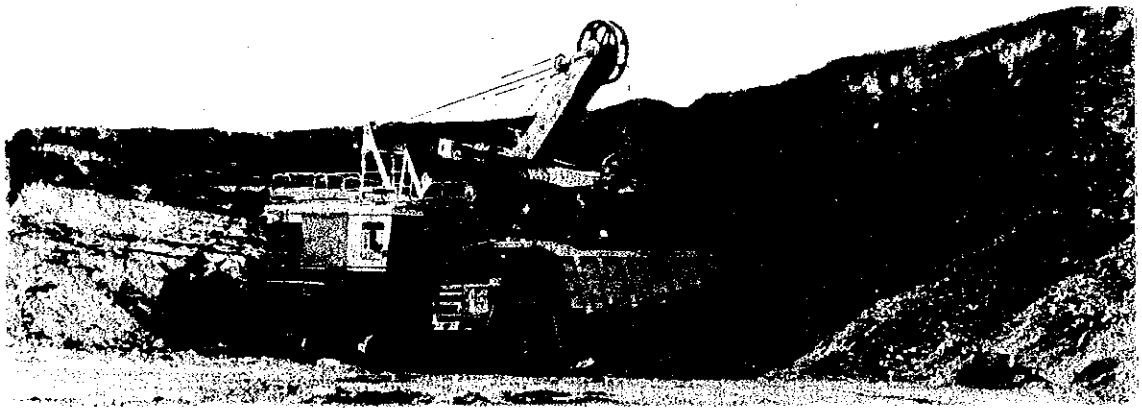
Improvement of management

- Improvement of the management system in the following section is recommended:
  - Maintenance section:
    To take the responsibility for the maintenance of equipment and facilities including preparation and stock of spare parts, and to develop maintenance capability as soon as possible.
  - Coal quality control section:
    To resolve coal quality troubles such as low calorific value, high moisture content, and rock and metallic obstacles in coal as well as to hold better communication with the coal users on coal quality issues.
  - Environmental section:
    To preserve the environment through implementation of the monitoring plan and expansion of the existing groundwater treatment system.
  - Coal sales section:
    To sale the coal, to negotiate the price, to manage the claims and to prepare the sales plan in the short and long term.

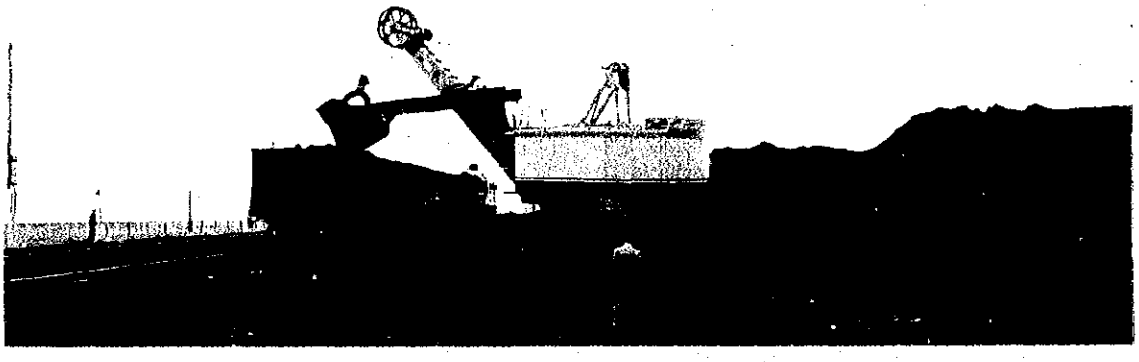
PART I Renovation Study

CHAPTER II Renovation Study of Shivee Ovoo Coal Mine

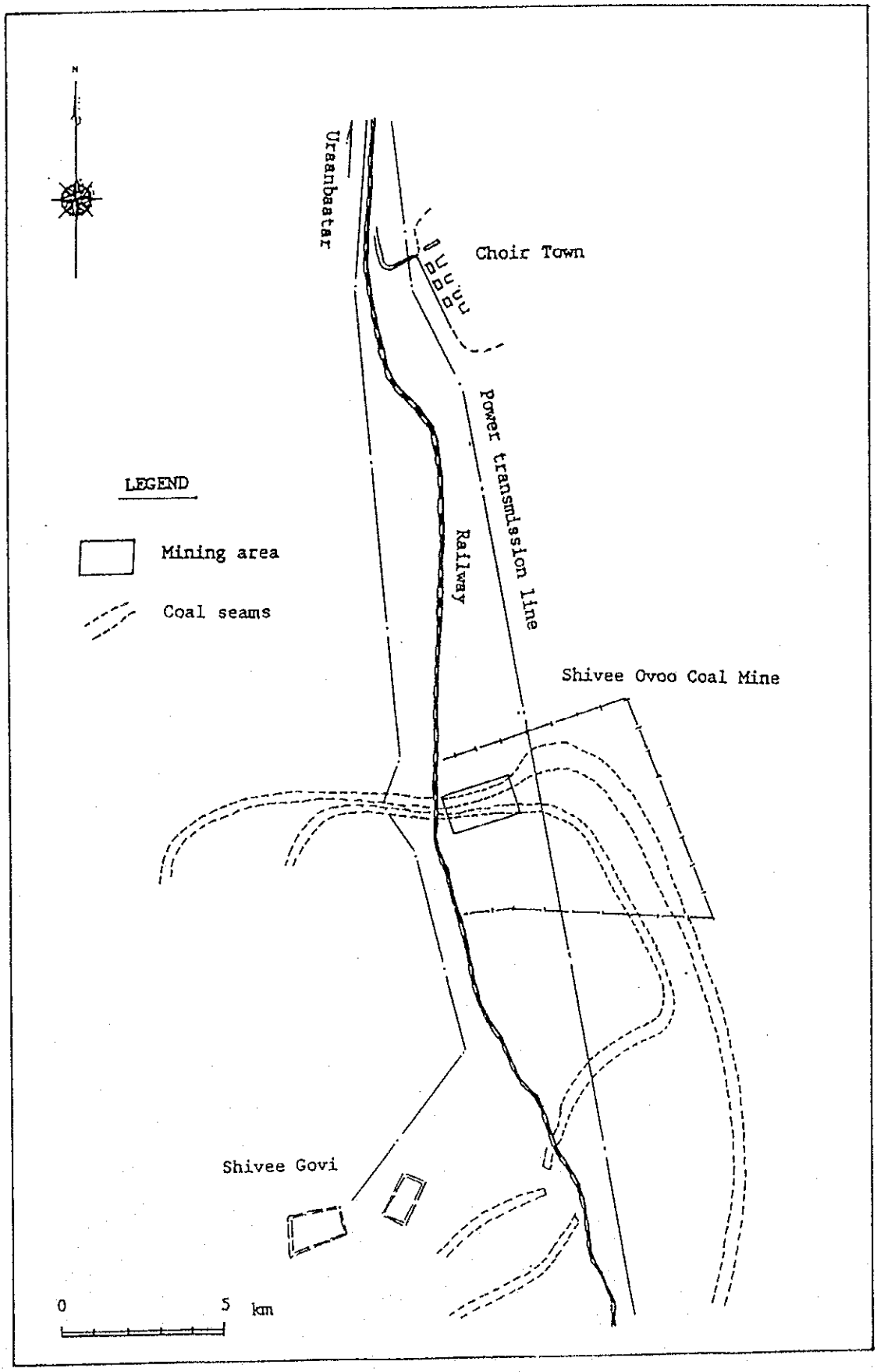
General View of Shivee Ovoo Coal Mine



Overburden Stripping by Shovel and Truck



Coal Stockyard and Train Loading



Location of Shivee Ovoo Coal Mine

CHAPTER II Renovation Study of Shivee Ovoo Coal Mine

1 Introduction

- Shivee Ovoo coal mine is located in 260 km southeast of Ulaanbaatar and 1,200 m above sea the level.
- Lignite with about 3,700 kcal/kg (GHV) is excavated by an open cut method and mostly consumed at Ulaanbaatar power plants.
- Shivee Ovoo mine was designed by the Mining Institute of Mongolia, started in 1992, and produced 0.5 million t/y of coal in 1993.
- Target of renovation is to achieve the coal production of 2 million t/y, improving the defects in the existing Shivee Ovoo coal mine.

2 Coal Resources

Reserves

- Proved coal reserves are 600 million tons.
- Space of the deposit is 24.4 km^2 and the depth is within about 250 m.

Table 1 Proved Coal Reserves

Name of coal seam	Proved reserves (million ton)	Stripping ratio (BCM of soil/ton of coal)
I & II	550	n,a
V	45	n,a
Total	600	about 3.5

Quality

- Typical coal quality is featured by high moisture content.

Table 2 Quality of Reserved Coal

		unit	Average*1
Total moisture	(as received)	%	31.8
Inherent moisture	(air dry)	%	8.4
Ash	(dry basis)	%	16.4
Calorific value	(as received)	kcal/kg	3,776(GHV) *2
	(air dry)	kcal/kg	5,070(GHV) *3
Total sulfur	(dry ash free)	%	0.75

Note *1 :This shows the average of several sample data obtained from Seam I, II and V. The reliability of data was confirmed by the both sides.

*2 :Calorific value of coal reserved near the surface is only 2800 kcal/kg (LHV).

*3 :Estimated from moisture content. Gross Heating Value (GHV) is used in Shivee Ovoo coal mine, while LHV is used in other areas in Mongolia.

3 Present Status of Shivee Ovoo Coal Mine

3.1 Present mining status

Present mining system

- Overburden is removed by electric rope shovel (5 m^3 bucket) and 40 ton dump truck system. Neither dragline nor shovel and railway system are adopted to Shivee Ovoo coal mine.
  Coal is produced by shovels and trucks.
- In 1993, the mining capacity was expanded by some of additional equipment. On the other hand, repair of equipment was not effective due to lack of spare parts, workshops and maintenance specialists.

Infrastructure

- Necessary surface facilities such as boiler, crushing and loading plant, workshop, warehouse and quality control system have not been equipped.
  Repair of dump trucks is implemented in the open-air in winter.

Production

- Since 1992, the oxidized coal near the surface, where mining conditions were very favorable, especially in low stripping ratio of 1.9, has been firstly mined because the urgent start of coal production was required.
- In 1993, the actual total excavated volume of coal and overburden of 1.6 million BCM/y

was less than the planned volume (1.9 m.BCM/y) due to delay of arrival of some additional equipment.

Table 3 Comparison of Coal and Overburden Excavation

Year	Coal production (m.t)		Overburden removal (m.BCM/y)		Total excavation (m.BCM/y)	
	Planned	Actual	Planned	Actual	Planned	Actual
1992	0.3	0.14	n,a	0.7	n,a	0.8
1993	0.5	0.59	1.5	1.1	1.9	1.6

Employee

- Total employees were 260 in 1993, of which 110 were for production and 90 for maintenance.

3.2 Issues of present Shivee Ovoo coal mine

- Moisture content is too high and the coal is sent to users without moisture control due to:
  - Delay of dewatering work, resulting in high water level at the mining site
  - Lack of drying facility
  - Lack of moisture management system and inspection equipment
- Calorific value is too low in comparison with sales contracts due to:
  - Mining of the oxidized coal near the surface because the production is easy (stripping ratio : 1.9).
  - High moisture content in coal
- Dump truck cannot work at high efficiency due to difficulty of repair (lack of spare parts, workshop and maintenance specialist)
- Violent economic inflation decreased the present value of funds prepared for spare parts and replacement of equipment.

3.3 Evaluation of production capacity of existing coal mine

Operating efficiency

- Analyses of operation data show that the operating efficiency (85%) of electric shovel is high enough compared with that of the modern type, while that (58%) of dump truck is a little low due to frequent mechanical troubles.

Table 4 Efficiency of Mining Equipment

%, as of 1992

Equipment	Existing equipment Availability	Utilization	Efficiency	Desired Efficiency
Electric shovel	n,a	n,a	85	72
Dump truck	n,a	n,a	58	68

Note :Efficiency of the existing equipment is very high due to new equipment and the flexible mining system.

Improvement

- Results of the analyses show that the production capacity of existing mining equipment can be expected to be about 3.2 m.BCM/y at the end of 1993, providing that above-mentione maintenance issues are resolved.

Table 5 Capacity of Existing Coal Mine

million BCM/y, as of 1993

	Planned value	Current/actual	Improved/estimated
Shovel/truck	1.9	1.6 *1	3.2
(Coal)	(0.41)	(0.49)	(0.9-0.6)
(Overburden)	(1.5)	(1.1)	(2.3-2.6)

Note *1 : Some of new additional equipment were not delivered in time.

Coal production capacity

- Improved coal production capacity is varied by the required stripping ratio.

  In case of the present miming location near the coal outcrop, it is about 1.2 million t/y at stripping ratio of 1.9, while it is 0.8 million t/y at the entire average stripping ratio of 3.5.

- To increase the calorific value as soon as possible, a new pit toward the fresh coal zone must be developed, and therefore, the estimated coal production capacity of existing equipment is assumed to be about 0.8 million t/y.

Spare parts and workshop

- To achieve above-mentioned improvement, 1.4 million US$/y of foreign currency is required for procurement of spare parts and workshop tools.

4 Renovation Study of Shivee Ovoo Coal Mine

4.1 Study of effective mining system

Basis for economics comparison

- Tax, interest and royalty are not included in the cost comparison studies.

- Following energy prices are used in the cost comparison studies:

Diesel oil	:	International price (169 US$/t) x 1.1
Gasoline	:	International price (186 US$/t) x 1.1
Coal	:	International price (15.7 US$/t) x 0.7
Electricity	:	International price (0.062 US$/kWh) x 0.9

Note : ( ) shows prices (FOB) as of the end of 1993

Overall mining system

- Overall mining system was reviewed and the followings were selected for renovation, taking expected flexibility for overburden removal into account:

Overburden removal	: New additional system
Interburden removal	: Existing shovel and truck
Coal excavation	: Existing shovel and truck

Economics of new mining systems

- Comparison study was implemented to select the new additional mining system to be used for overburden removal.

Case I : 5 m^3 shovel and 40 ton dump truck

II : 10 m^3 front end loader and 80 ton dump truck

III : One of dragline with 29 m^3 backet

IV : Two of dragline with 20 m^3 backet

- Case III was selected due to the lowest cost index.

Table 6 Comparison Study of New Systems

		Existing	Additional system			
	Unit	Improved	CaseI	CaseII	CaseIII	CaseIV
Existing excavating capacity	m.BCM/y	3.2				
Additional capacity required	m.BCM/y		5.5	5.5	5.5	5.5
Required number of fleets *1			4	2	1	2
Additional initial capital *2	m.US$		6.8	8.2	17.7	26.1
Operating cost *2	m.US$/y	3.0	5.1	4.7	3.5	5.5
Spare parts		(1.5)	(1.9)	(1.6)	(2.7)	(4.0)
Consumables		(1.1)	(3.0)	(3.0)	(0.8)	(1.4)
Labor etc.		(0.4)	(0.2)	(0.1)	(0.0)	(0.1)
Capital cost *2	m.US$/y	1.4	1.7	1.6	0.9	1.3
Equipment		(1.4)	(1.7)	(1.6)	(0.9)	(1.3)
Total cost *2	m.US$/y	4.4	6.8	6.3	4.4	6.8
Mining cost index	$/BCM	1.4	1.2	1.1	0.8	1.2

Note *1 : Fleets were planned based on the most modern equipment.

*2 : Tax, interest, royalty and surface facilities are not included.

4.2 Recommended mining equipment and facilities

Design basis

- Design philosophy of Shivee Ovoo coal mine was reviewed, however, any necessity of change of the design basis was not found.
  Coal recovery ratio in the original mining design is 100%.
- Stripping ratio to be used in the study of renovation is 3.5 (average).
- Additional equipment is one dragline with the excavating capacity of 5.5 million BCM/y.

Recommended mining equipment

- New additional equipment is shown on Table 7.
- Life of equipment depends on the equipment quality effected by a manufacture, and operating circumstances and maintenance methods effected by users. Therefore, 2 cases, "Short-life case" and "Long-life case" are assumed. Actual life would be decided by above-mentioned conditions in Mongolia.

Table 7 Additional Equipment List

Equipment	Required number	Life (years)		Unit price (m.US$)*2	Major use
		S*1	L*1		
29 m³ Dragline	1	30	30	16.6	Overburden removal
Bulldozer 388 kW	1	6	8	0.6	Support
Grader 205 kW	1	6	8	0.4	Road maintenance

Note *1 : "S" is short-life case and "L" is long-life case.

*2 :All costs and fees for manufacturing, packing, transportation, field assembly and training are included in unit price.

Fig.1 Dragline with 96m Boom and 29 m³ Bucket

Recommended surface facilities

- Installation of the surface facilities, including supporting equipment, is recommended to achieve 2 million t/y with a smooth and effective operation as shown on Table 8.

Table 8 Additional Facility List

Facility & equipment	Number	Initial cost	Note
Workshop & tools	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

4.3 Schedule of renovation

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.

Project schedule

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

Coal production plan

1995	: 0.6 million t/y
1996-1998	: 0.8 million t/y
1999	: 2.0 million t/y

5 Quality Control System

5.1 Issues of coal quality

- At present, there is no coal quality management section in Shivee Ovoo coal mine and whole Shivee Ovoo coal is sent to users without quality inspection.
- Issues of the coal quality are the low calorific value, the high moisture content and the large size of coal block.

Table 9 Current Coal Quality in Complaints

Unit		Sep.1993	Oct.1993	Request/power plant
Total moisture(a,d)	%	41.8	41.4	less36
Calorific value(a.r)	kcal/kg	2,761	2,637	more3,000
Size of coal block	mm	(some blocks>300)		less300

Note: Low calorific value is caused by the high moisture content together with production of oxidized coal near the outcrop.

- Users are requesting to minimize the change of coal quality, particularly in moisture content. High moisture content causes plugging of pipeline resulting in emergency shut down of the power plant.

5.2 Recommended quality control system and equipment

- Management of Shivee Ovoo coal mine must introduce the concept of "management for coal quality control" into whole managers, staffs, and labors.
  Oxidized coal should never be shipped to users.
- Following equipment and facilities must be installed for improvement of coal quality:
  - Quality control equipment (on-line analyzer) : Quality management
  - Dewatering system : Moisture
  - Crushing and sizing plant : Coal size
  - Small scale FEL and truck for thin interburden removal : Ash

Note 1: Installation of coal drying system at Shivee Ovoo coal mine is desirable,however, dried lignite may cause spontaneous combustion during storage and transportation. Therefore, installation of the coal drying system at the coal user side is recommended.

2: Washability test was carried out to investigate the effect of ash removal from coal. The results show that Seam I is relatively easy while Seam II is rather difficult. In conclusion,

selected coal mining is recommendable to decrease ash content rather than installation of a coal washing plant.

5.3 Expected product quality of Shivee Ovoo coal

- Following quality will be achieved by introduction of above-mentioned quality control system;

Table 10 Expected Quality of Product Coal

Item		Unit	Estimated value
Total moisture	(as received)	%	35.0
Surface moisture	(as received)	%	28.8
Inherent moisture	(air dry)	%	8.7
Ash	(air dry)	%	16.5
Volatile matter	(air dry)	%	32.7
Fixed carbon	(air dry)	%	42.1
Total sulfur	(air dry)	%	0.6
Calorific value	(air dry)	kcal/kg	5,030 (GHV), 4,756 (LHV)
	(as received)	kcal/kg	3,580 (GHV), 3,212 (LHV)

6 Environmental Study

- Environmental impact of renovation of Shivee Ovoo coal mine was studied in nine environmental items such as air, water, soil, noise/vibration and fauna/flora.
- Any limitation on renovation for 2 million t/y was not recognized in all environmental aspects.
- Installation of a water treatment system of groundwater is required.

7 Capital and Operating Cost

- Capital and operating costs were estimated for 23 years (1996-2018) of the project life in accordance with the replacement schedule of each equipment and the estimated unit prices of the international level.

Table 11 Capital and Operating Cost

million US$

	Capital cost	Operating cost	Total
Existing improvement	43	97	140
Expansion	82	139	221
Total for renovation	125	236	361

Note 1: Duration of 23 years is presumed only for the purpose of economic evaluation and

financial analysis.

2: Price level of the existing equipment type, which is imported mainly from (ex-COMECON, is estimated to be 80% of the recent modern equipment in this study, although the level is low at the present time.

Foreign currency portion

- Foreign currency portion of capital and operating costs required during 23 years is shown on Table 11.
- Foreign currency required for capital cost during the first three years is US$ 42 million.
- Foreign currency required for operating cost during the first three years is US$ 6 million.

Table 12 Foreign Currency Portion for 23 Years

Million US$

Year	Capital cost			Operating cost*3			Yearly
	Existing*1	Addition*2	Total	Existing	Addition	Total	Total
1996	1.7	0	1.7	2.1	0	2.1	3.8
7	2.7	16.0	18.7	2.1	0	2.1	20.8
8	2.0	20.0	22.0	2.1	0	2.1	24.1
9	1.7	0	1.7	2.1	4.1	6.2	7.9
2000	3.0	0	3.0	2.1	4.2	6.3	9.3
1	3.2	0	3.2	2.1	4.2	6.3	9.5
2	0.7	4.0	4.7	2.1	4.1	6.2	10.9
3	2.7	0	2.7	2.1	4.1	6.2	8.9
2004-2008	4.0	15.5	19.5	10.5	20.7	31.2	50.7
2009-2013	8.5	5.3	13.8	10.5	20.8	31.3	45.1
2014-2018	10.9	17.6	28.5	10.5	20.8	31.3	59.8
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. Taxes in Mongolia are not included.

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

*3:Operating costs include yearly spare part cost, periodic overhaul cost and imported consumables such as explosives, diesel oil, and lubricants.

Local currency portion

- Local currency is required mainly for labor cost and electricity cost.

Table 13 Local Currency Portion for 23 Years

Million US$ as of 1994

	Labor cost	Electricity cost	Others	Total
1996	0.4	0.4	2.3	3.1
1997	0.4	0.5	1.4	2.3
1998	0.4	0.5	1.6	2.5
1999-2018	18.0	20.0	64.1	102.1
Total	19.2	21.4	69.4	110.0

8 Economic Evaluation and Financial Analysis

8.1 General approach

- Renovation plan of Shivee Ovoo coal mine is rather simple in comparison with that of Baganuur coal mine. Only one case is evaluated.
- For the purpose of economic evaluation and financial evaluation of the renovation project, the cash flows are prepared for the following three renovation programs:

  Case1: Existing operation with the total excavation capacity of 3.2 million BCM/y using existing equipment type designed by ex-COMECON countries.

  Case2: Expansion of 5.5 million BCM/y using medium-class dragline as well as fundamental surface facilities.

  Case3: Whole renovation project consisting of Case 1 and Case 2.

- Following criteria, which are the same as in Chapter I, are used for the studies:

  - Project life : 23 years (from 1996 to 2018)
  - Time value of money : Constant 1994 Tg with 400 Tg/US$
  - Project financing : 100% debt ~100% loan
  - Foreign debt financing : Project untied loan
  - Price and the life span of equipment
    - Existing type of equipment : 80% of international prices and short-life case
    - New additional equipment :100% and long-life case
  - Inflation : No inflation

  Note: Regarding the recent Price and cost structure in Mongolia, refer to Table 15 of Chapter I.