8.2 Economic evaluation

- In order to evaluate Shivee Ovoo renovation project from Mongolian economy as a whole, taxes, royalties and debt financing costs are all eliminated from the economic costs.
- Economic value of Shivee Ovoo coal with 3,580 kcal/kg is evaluated to be 6,086 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 cost (payable interest = 0, depreciation = 0)
  - After tax expense (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 (Economic Internal Rate of Return)

Economic evaluation of each case

- EIRR on the total project of Case 3 is as high as 67.1% at the economic coal value of 6,086 Tg/t.
- Coal price to gain 10% EIRR is 3,728 Tg/t and is cheaper than 4,743 Tg/t of Baganuur coal.

	Economic price at 10% EIRR(Tg/t)	EIRR at 6,086 Tg/t(%)
Case 1	3,290	∞
Case 2 *1	4,082	25.9
Case 3	3,728	67.1

Note *1: All capital cost of the surface facilities is included in Case 2.

- Above results prove that the renovation project is advantageous in terms of Mongolian economy and has a sufficient economic feasibility.
- ±20% changes in conditions will not give a serious impact on the feasibility.

Table 14 Economic Sensitive Analysis (Case 3)

unit: EIRR %

Condition Changing rate	Price	Capital cost	Operating cost	Excavation volume (no change in coal)	(S/R)
1.2	∞	43.8	48.3	48.9	(4.4)
1.1	∞	52.7	56.4	56.8	(3.9)
Base	67.1	67.1	67.1	67.1	(3.5)
0.9	44.1	135.4	84.1	83.0	(3.1)
0.8	29.7	∞	∞	∞	(2.6)

8.3 Financial analysis

- In order to evaluate economics of the renovation project in view of Shivee Ovoo coal mine, several criteria are added as follows:
  - Domestic debt financing cost : 10 %/month with a repayment of 6 months
  - Foreign debt financing cost : 8 %/year with a repayment of 10 years

- Formula for cash flow used in the financial analyses is as follows:
  - Cash flow for FIRR on the total project(Financial Internal Rate of Return)
    + Revenue
    - Total operating cost (payable interest = 0)
    - Tax
    - After tax expense (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 cost
    - Tax
    - After tax expense (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 evaluation of each case

- FIRR on the total project of Case 3 is 10.5% at the economic coal value of 6,086 Tg/t, which is a critical value in view of investors.

	Financial price at 10% FIRR(Tg/t)	FIRR at 6,086 Tg/t(%)
Case 1	5,265	20.5
Case 2 *1	6,546	8.1
Case 3	5,998	10.5

Note *1: All capital cost of the surface facilities is included in Case 2.

- Sale price (financial coal price) to realize 10% FIRR on the total project is 6,000 Tg/t and as high as 160% of the economic coal price (3,728 Tg/t).
- Results of the above-mentioned analyses shows that the project is critically viable at the sale price of economic value of 6,086 Tg/t under current taxation regimes.
- To improve the financial feasibility of Shivee Ovoo coal mine as well as to decrease the coal sale price from the level of the economic value of 6,086 Tg/t,introduction of low cost loan and/or amendment of Mongolian taxation rates will be necessary.

  Note: For reference, the effect of tax exemption in case of renovation of Baganuur coal mine is shown on Table 19 of Chapter I.

Effect of leverage

- Table 15 illustrates that introduction of low cost loan can improve FIRR on equity.

  However, higher than 95% of debt/equity ratio can hardly recommended due to the large amount of loan unrepaid at the end of the project life.

Table 15 Relation between FIRR, Debt/Equity and Interest Rate

Debt	Equity	Foreign loan interest rate (%)				
(%)	(%)	1	2	5	8	10
0	100	10.5	10.5	10.5	10.5	10.5
50	50	14.6	14.3	13.4	12.6	12.1
80	20	24.9	23.6	20.1	17.5	6.6
95*1	5	∞	∞	∞	(unrepaid)	(unrepaid)

Note *1: FIRR on equity is higher than 100, while, in the range of more than 95% dept/equity ratio, financial unsoundness is unfabourably increased by the amount of loan unrepaid.

Financial sensitivity analysis

- Impact of changes in coal sale price were evaluated by the amount of loan unrepaid.

  The reasonable lowest sale price of Shivee Ovoo coal under assumed financial conditions (debt/equity = 80/20) is differed by foreign loan interest rate from 5,180 Tg/t at 2% to 5,430 Tg/t at 8%.

- Impact of changes in base case assumptions was evaluated in regard of FIRR on the total project and FIRR on equity.

  In the case of 80% debt at 6,086 Tg/t, FIRR on equity is 23.6% which is shifted from an original 10.5% resulting from leverage, ±20% of changes in assumed conditions will not gives a serious impact on the financial feasibility.

Table 16 Financial Sensitive Analysis
(80% debt with 2% foreign loan at 6,086 Tg/t)

Condition Changing rate	Capital cost	Operating cost	Excavation volume (no change in coal)	(S/R)
1.2	15.0	10.8	11.1	(4.4)
1.1	18.6	16.4	16.6	(3.9)
Base(1.0)	23.6	23.6	23.6	(3.5)
0.9	31.3	33.1	32.7	(3.1)
0.8	42.6	45.4	44.4	(2.6)

9 Conclusions and Recommendation

Issues of present Shivee Ovoo coal mine

- Coal quality is sometimes out of specification in terms of moisture content,calorific value and contamination of rocks and metallic materials.
- Dump truck cannot work at expected efficiency due to:
  - Lack of spare parts due to shortage of the fund
  - Lack of maintenance facilities

Recommended mining system for renovation

- After technical and economic evaluation, one medium-size dragline with supporting equipment was selected.
- Fundamental surface facilities were also planned.

Environmental impact

- No limitation on the renovation project was not recognized in all environmental aspects.
- To prevent from precipitation in the river of Fe exhausted from groundwater, a water treatment system of groundwater drainage is planned and included in investment.

Major equipment and facilities

- Major equipment is as follows:

Equipment	Existing	Expansion	Major services
Dragline	0	1	Overburden removal
Shovel	4	0	Excavation(overburden & coal)
Truck	15	0	Transportation(overburden & coal)
Bulldozer	4	1	Supporting and multi-services
Grader	0	1	Road maintenance

Note: Above equipment consists of different types and capacities.

- Most of the surface facilities are not yet installed at the present time, and therefore, urgent installation is required.

Coal quality control system

- At present, Shivee Ovoo coal is sent to users without quality inspection. Current complained coal qualities are as follows:

	Unit	September/1993	October/1993	Request/power plant
Total moisture(a,d)	%	41.8	41.4	less 36
Calorific value(a,r)	kcal/kg	2,761	2,637	more 3,000
Size of coal	mm	(some coal> 300)		less 300

Capital and operating costs

- Capital and operating costs for 23 years (1996-2018) of the project period,which consist of initial cost and replacement cost, are as follows:

	Capacity (mil.t/y)	Capital cost (mil.US$)	Operating cost (mil.US$)
Rehabilitation of existing system	0.7	43	97
Expansion of the capacity	1.3	82	139
Total	2.0	125	236

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

	Capital cost (mil.US$)	Operating cost (mil.US$)
Rehabilitation of existing system	6.4	6.3
Expansion of the capacity	35.9	0
Total	42.3	6.3

Results of economic evaluation

- Economic evaluation proves that the renovation project of Shivee Ovoo coal mine is highly advantageous in terms of national economy.
- EIRR, which represents the point of view of Mongolian economy, is as high as 67.1% at the economic coal value of 6,086 Tg/t, and the coal prices at 10% of EIRR shown below are significantly low compared with the economic coal value.

	Coal production (m.t/y)	Economic coal price at 10% EIRR (Tg/t coal)	EIRR at 6,086 Tg/t (%)
Rehabilitation	0.7	3,290	∞
Expansion	1.3	4,082	25.9
Whole system	2.0	3,728	67.1

- ±20% changes in conditions will not give a serious impact on the feasibility.

Results of financial analysis

- Under severe Mongolian taxation system, the renovation project of Shivee Ovoo coal mine is critical in the financial feasibility.
- FIRR on the total project (debt/equity = 0/100), which represents the investor's point of view, is a critical level of 10.5% at the economic coal value of 6,086 Tg/t.
- Sale price (financial coal price) to gain 10% FIRR on the total project is 6,000 Tg/t and as high as 160% of the economic coal price of 3,728 Tg/t, which illustrates the heavy taxation regimes in Mongolia.

	Coal production (m.t/y)	Financial coal price at 10% FIRR (Tg/t coal)	FIRR at 6,086 Tg/t (%)
Rehabilitation	0.7	5,265	20.5
Expansion	1.3	6,546	8.1
Whole system	2.0	5,998	10.5

- ±20% changes in conditions gives a serious impact on the financial feasibility.
- To improve the financial feasibility of Shivee Ovoo coal mine as well as to decrease the coal sale price from the level of 6,086 Tg/t, introduction of low cost loan and/or amendment of the current taxation rates will be necessary.

  Note: Effect of tax exemption is shown on Table 8.12 of Chapter I.

- Relationships among FIRR, debt/equity ratio and foreign loan interest rate indicate that:
  - Introduction of low interest rate loans can improve FIRR on equity.
  - When the interest rate is high, more than 95% debt/equity ratio causes financial unsoundness due to the large amount of loan unrepaid.

Desired financial conditions for renovation

- Desired financial conditions for the renovation project of Shivee Ovoo coal mine that can be concluded from above-mentioned results of financial analysis 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
  - Tax reduction:

    Import tax for equipment and spare parts

    Trade tax for equipment and spare parts
- If the Mongolian government plans to promote the privatization, it is recommended to create the similar conditions in effect described above.

Improvement of management system

- Improvement of management system in the following sections is recommended:
  - Maintenance section:

    The section that takes the responsibility for the maintenance of equipment including stock of spare parts.

    Development of maintenance capability is the top urgent subject of a new maintenance section.
  - Coal quality control section:

    The section that takes actions in resolving coal quality troubles and hold good communication with the coal users on coal quality issues.
  - Environmental section:

    The section that preserves the environment through implementation of the monitoring plan and the proposed countermeasures.
  - Coal sales section:

    The section that sells the product, negotiates the price, manages the claims from users and prepares the sales plan in short and long term.

Part II Master Plan Study

1 Introduction

- In Mongolia, no oil is produced at present time and all of petroleum products are imported.
- While, Mongolia has an abundant coal resources and is producing 5.6 million t/y of coal as fuel for electricity and heat generation mainly.
- Coal is expected to be the most important primary energy resources in the foreseeable future, even if oil resources could be discovered by the extensive oil exploration work.
- Objective of Part II is to formulate the effective coal development and utilization plan for a long term.
- Study team of Part II visited Mongolia in August and December of 1994(each 4 weeks) and June and September of 1995(2 weeks), and prepared this Final Report.
- Highlight of the Final Report is "Conceptual action plan" including the master plans for coal development and utilization.

2 Coal Supply and Demand Forecast

2.1 Present status of energy supply and demand

2.1.1 Economic activities at present and in the past

- Mongolia is in transition from centrally-planned economy to market economy.
- Until 1989, economic growth was high, around 6%/y in Net Material Product(NMP), due to well integrated economic activities with the former Soviet.
- At present, Mongolia is suffered from the recession and a high inflation rate, however, several economic indicators show the start of the recovery from 1994.
- NMP is mostly supported by mineral mining industry and stock raising sectors.

2.1.2 Trend of energy supply and demand

- Coal is the main primary energy in Mongolia in the past and at present.
- Share of imported petroleum products has increased since 1985.
- Trend of primary energy consumption, including non-commercial energies, is as follows:

Table 1 Estimated Primary Energy Requirements in Mongolia

1,000t/y coal of 7,000 kcal/kg

	1970	1975	1980	1985	1990
Coal	1,060	1,450	2,380	2,950	3,370
Petroleum	360	520	740	1,080	1,710
Wood & biomass	190	280	260	360	250
Total	1,600	2,260	3,410	4,400	5,350

- Amount of the primary energy supply and the final energy consumption are as follows:

Table 2 Estimated Energy Balance in Mongolia

as of 1990, 1,000t/y coal of 7,000kcal/kg

	Coal	Wood & biomass	Petroleum products	Electricity	Heat	Total
Primary energy supply						
Production	3,630	240	-	-	-	3,870
Import	40	-	1,120	30	-	1,190
Total supply	3,670	240	1,120	30	-	5,060
Export	-240	0	-	10	-	-250
Stock change	- 60	10	750	-	-	700
Domestic supply	3,380	250	1,870	20	-	5,520
Energy conversion						
Electricity & heat	-2,200	-	-150	410	720	-1,210
Own consumption	-0	-0	-10	-110	-	-120
Final energy consumption						
Industry	510	30	510	220	n,a	n,a
Transportation	60	0	800	20	n,a	n,a
Agriculture	80	30	240	20	n,a	n,a
Public/household	340	130	20	40	n,a	n,a
Other uses	200	40	150	30	n,a	n,a
Total	1,180	230	1,710	330	720	4,190

- Figure 1 illustrates the relationship between primary energy consumption and NMP, which presents the clear correlation between two indicators.

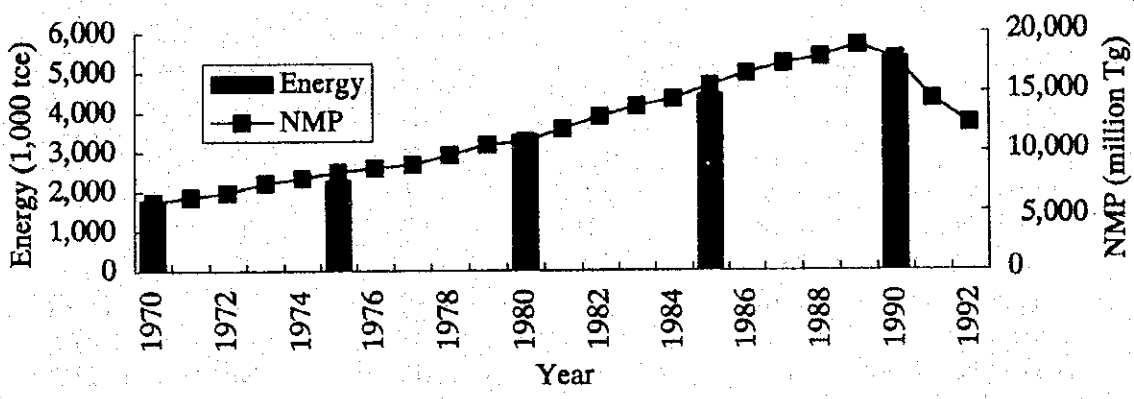


Figure 1 Relationship between Primary Energy and NMP

2.1.3 Trend of coal supply and demand

- Coal demand recorded its peak of 7.6 million t/y in 1988, and has decreased to about 5 million t/y due to the recession as well as a hike in the coal price.
- Export of coal is negligibly small due to low coal quality or lack of infrastructure for export.
- Biggest consumer of coal is electricity and heat generation which consumed 4.0 million t/y (77% of total coal). The share of industry/construction is 15%.
- Central Energy System (CES) area accounted for 88% of total coal demand of Mongolia in 1990, and Ulaanbaatar had the largest share of 79%.
- Following show coal consumption in Mongolia by sector in 1993

as of 1993, 1,000t/y

Electricity Heat	Industry Construction	Transportation Communication	Agriculture	Public Household	Others	Total
4,050	730	90	60	210	120	5,260

- Following show supply and demand balance of coal.

Table 3 Coal Consumption and Supply in 1993

as of 1993, 1,000t/y

	Sharyngol	Baganuur	Shivee Ovoo	Local mines	Total
Ulaanbaatar	630	2,540	380	10	3,560
(Power plants)	(610)	(2,190)	(320)	0	(3,120)
Darkhan	260	20	0	0	290
(Power plant)	(210)	(0)	(0)	(0)	(210)
Erdenet	210	80	10	10	310
(Power plant)	(130)	(80)	(10)	(0)	(210)
Other local areas	20	150	50	870	1,090
Mine consumption	60	80	10	60	210
Total	1,180	2,870	450	940	5,450

2.2 Activities of consumption sectors: Demand potential on coal

2.2.1 Electric power sector

- Electric power generation and supply in Mongolia is divided into two systems, CES and the out of CES.
- CES is the integrated power system and composed of five interconnected coal fired thermal power plants, about 1,000 km length of 220 kV and 2,000 km length of 110 kV transmission lines, and distribution lines.

Table 4 Generation and Boiler Capacity by Power Plant

Name of power plant	Generation capacity(MW)	Boiler capacity(t/h)
Ulaanbaatar No.2	24	220
Ulaanbaatar No.3	148	1,950
Ulaanbaatar No.4	540	2,940
Darkhan	48	750
Erdenet	36	450
Total	796	6,240

- CES area accounted for 90% of the total electric power generation of Mongolia in 1992. The peak power is imported from Russia due to no hydropower plants.
- Trend of electricity consumption by sector is as follows:

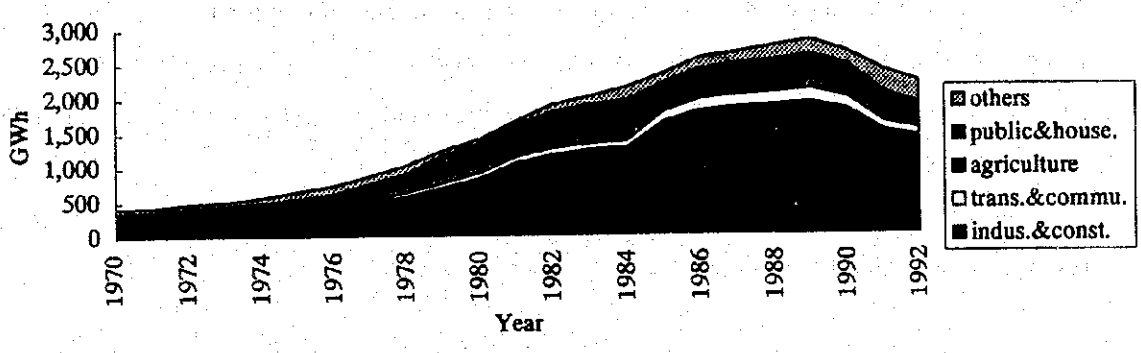


Figure 2 Trend of Electricity Consumption by Sector

- Out of CES is composed of about 800 of the independent small power systems, located in each local town, with diesel power plants of total capacity of 190 MW.

  Note: Choibalsan plant, 24 MW, is only one coal fired plant in the out of CES
- Out of CES accounted for 11% of the total electric power generation of Mongolia in 1992.
- There is no medium and large scale hydropower plant in CES at present time, however, Egiin hydropower plant of 220 MW(55 MWx4), located near the CES grid, is planned to put into CES around in 2000.
- In this study, among electricity development projects in the CES area, the first priority will be given to Egiin hydropower plant due to its expected favorable impact on the economic activities such as indigenous construction material manufactures and construction firms as well as the employment of workers.
- Electricity demand of CES will show 5-6 %/y of the growth rate after the recovery from the present recession.
- Electricity demand of the out of CES will be affected greatly by the rural electrification policy of the Government.
- Possibility of electricity export to China, Korea, Japan and other countries by HVDC transmission line should be pursued as one of options of effective coal use.
- Electric power and heat generation in CES will keep the position of the biggest consumer of coal in the future, even if indigenous oil is produced.

2.2.2 Mining, industry and construction sector

- Mongolia has the abundant mineral resources such as copper, molybdenum, lead and zinc, and those mining will play an important role in the industry development plans.
- Most of minerals are produced by the joint ventures with Russia and other former socialist countries, and exported without processing highly.
- National Development Board projects to increase the production in the sub-sectors of metal processing and building materials with extremely high speed:

Table 5 Forecast of Production in Mining/Industry Sector in Mongolia

billion Tg.

	1993	1994	2000	2005	2010	2010/1994
Electricity/heat	33	48	74	91	127	2.7
Coal	12	18	21	23	38	2.1
Mining	70	72	119	161	167	2.3
Metal processing	0.3	4.2	24	57	136	32.4
Building materials	3.2	3.2	40	62	78	24.4
Food processing	29	52	92	104	115	2.2
Light industry	20	44	134	199	208	4.7
Others	5.4	26	19	27	38	1.5
Total industry	173	267	523	723	907	3.4
(% of 1994)	(65)	(100)	(196)	(271)	(340)	

- Erdenet copper mine, with the record of 350 thousand tons of concentrated copper in 1990, consumes about 250 thousand tons of coal.
- It is expected that the coal demand in the industry sector will be greatly increased when some of the projected plans are materialized in the near future.

2.2.3 Agriculture sector

- Coal consumption in the agriculture sector increased from 322 thousand tons in 1980 to the peak of 517 in 1987. In 1993 it was only 62 thousand tons, however, such a sudden decrease may suggest any error or a change of the data system.
- Major coal consumption in the agriculture sector is estimated to be household use of farmers.
- National Development Board projects to increase the production in the agriculture sector through development of agro-industrial projects, as follows:

billion Tg.

	1993	1994	2000	2005	2010	2010/1994
Agriculture	91	118	125	135	140	1.2

- According to the growth rate of the production in Tug., the expansion of the coal consumption will be small.

2.2.4 Public service and household sector

- Coal consumption in the sector increased from 427 thousand tons in 1980 to the peak of 784 in 1986. In 1993 it was only 209 thousand tons, however, such a sudden decrease may suggest any error or a change of the data system.
- Major coal consumption in the sector is cooking and heating.
- Residents in the ger around large cities will be urged to use coal for cooking and heating due to shortage of biomass fuels, animal dung and wood, althrough the increase of coal consumption is estimated to be small.
- Use of briquette in the ger is recommended to minimize air pollution such as smell, smog and dust.

2.2.5 Transportation/communication

- Coal consumption in the transportation/communication sector increased from 42 thousand tons in 1980 to the peak of 114 in 1990.
- Coal is not used for drawing rail cars in Mongol, therefore, it is estimated that most of the coal of the sector is used for heating of the building and partially for cooking and heating in the household.
- Coal consumption in the sector cannot be expected to increase in the future.

2.2.6 Exportation

- Coal produced in existing coal mines is low calorific coal which is not suitable for export and a large amount of export cannot be expected in the future.
- Coking coal of Tavantolgoi is one of potential coal resources for export, but development of the transportation facilities in Mongolia and China will be the bottleneck of Tavantolgoi coal development.

2.3 Supply capability on coal

2.3.1 Present status of coal mining activities

- Coal mines in Mongolia are classified into two types, three large-scale coal mines with large mining equipment for supply to CES's power plants and 24 of the small-scale coal mines for

supply to rural residents.

- There are many coal deposits in Mongolia, while infrastructure for coal transportation is undeveloped. Therefore, the coal consumed in rural area is supplied by developing a small-scale coal mine near the demand site.
- Details of coal mining activities are reported in Section 3.1.3 and Attached Table 12.

2.3.2 Development plans of existing coal mines

- Development plans of existing major coal mines are scheduled as follows:
  - Baganuur coal mine : Capacity expansion from 3.7 million t/y to 6.0 (see the report of Part I)
  - Shivee Ovoo coal mine : Capacity expansion from 0.6 million t/y to 2.0 (see the report of Part I)
  - Sharyngol coal mine : No capacity expansion (0.8 million t/y)
  - Ulaan Ovoo coal mine : Under construction with 0.55 million t/y
    The coal quality is equivalent to that of Sharyngol coal.

  Note: Time schedule of each expansion plan will be studied in this Part II (Section 8).
- Development plans of the small rural coal mines are not clarified, however, the increase of the production will be easily implemented by extension of operating hours.

2.3.3 Coal transportation

- In the CES area, coal is transported by the railway system, while by the truck in the out of CES.
- In 1991, the coal transportation volume by railway was 4.9 million t/y and had the largest share of 69% in total transportation volume of commodities.
- Present railway capacity between Ulaanbaatar and Bagahangai is about 8.5 million t/y and can be increased by i) rehabilitation of the existing railway ii) installation of new passing loops and iii) modification to the double track line.
- As far as the expansion plan of existing coal mines in CES is concerned, the construction of a new line will not be required.

2.4 Forecast of coal demand

- Forecast of the coal demand is made individually for the CES area and the out of CES due to different consumption patterns and economic data availability.

- Forecast of the coal demand in CES area is made for each sector by making regression analyses.
- Coal demand in the out of CES area is the estimated value by MGEM due to no available economic and trend data.
- Impact of oil development in Mongolia was out of consideration in this study because such important oil would not be used as substitutive fuel for coal.

2.4.1 Coal demand in power/heat sector in CES

- Forecast of the electricity demand in CES area was studied by an econometric method. The model was built by regression analysis of the past trends on the relation between NMP and the electricity consumption.
- Development of Mongolian economy in long term will be characterized by following three steps:
  - (i) First step(about 3 years) : Economic disruption is stabilized.
  - (ii) Second step(3-5 years) : Economy starts the mild recovery.
  - (iii) Third step(10 years-more): Economy is in the stage of the new growth.

  Hence, following two cases were assumed as the base for coal demand forecast.

  High case : Fast achievement of above-mentioned economic development steps.

  Low case : Slow achievement of above-mentioned economic development steps.
- Growth rate of NMP estimated on the basis of the above-mentioned cases of economic development is as follows:

	1993	1994	1995-1996	1997-2000	2001-2005	2006-2010
High case	-3.3	2.5	3.5	4.5	5.0	6.0
Low case	-3.3	2.5	3.0	3.5	4.0	4.5

- Electricity demand (gross consumption), generator output (gross generation) and the coal consumption in the CES area were forecasted for "High case" and "Low case" as follows:

  Hence,

  *1 : Auxiliary power rate = 20%, Transmission loss = 10%,

  *2 : Energy conversion rate = 35% (heat rate : kcal/kWh = 2,450),

  Calorific value of coal = 7,000 kcal/kg

Table 6 Forecast of Power Demand and Required Coal in CES area

	1993	2000	2005	2010
High case				
Gross consumption(GWh)	1,780	2,240	3,230	5,080
Industry	1,170	1,520	2,340	3,970
Transportation	90	130	180	220
Agriculture	50	80	100	120
Household	280	350	410	490
Others	190	160	200	260
Gross generation(GWh)*1	2,610	3,110	4,480	7,050
Coal consumption(1,000 t)*2	880	1,090	1,570	2,470
Low case				
Gross consumption(GWh)	1,780	2,130	2,850	4,020
Industry	1,170	1,430	2,020	3,030
Transportation	90	130	160	200
Agriculture	50	80	90	110
Household	280	340	390	460
Others	190	150	180	230
Gross generation(GWh)*1	2,610	2,950	3,960	5,580
Coal consumption(1,000 t)*2	880	1,030	1,380	1,950

- Coal demand for heat supply in the CES area was forecasted on the basis that;

  (i) Heat recovery from the electric power generator will start from 2005.

  (ii) Effective heat recovery from the generator as the average of the year will be 16% of the theoretical maximum.

Table 7 Coal Demand for Heat Supply in Power Plants

		1993	2000	2005	2010
High case					
Estimated heat demand	(mil. Gcal)	4.3	5.0	6.5	8.3
Heat supply by recovery	(mil. Gcal)		0	0.9	2.8
Heat supply by heat boiler	(mil. Gcal)		5.0	5.6	5.5
Coal for heat boiler *1	(1,000t)	790	910	1,010	980
Low case					
Estimated heat demand	(mil. Gcal)	4.3	4.3	5.5	6.9
Heat supply by recovery	(mil. Gcal)		0	0.8	2.2
Heat supply by heat boiler	(mil. Gcal)		4.3	4.7	4.7
Coal for heat boiler *1	(1,000t)	790	770	850	840

Note *1: Calorific value of coal = 7,000 kcal/kg

2.4.2 Coal demand in mining, industry and other sectors in CES

- Forecast of coal demand in mining and industry sector was studied by the same method as 2.4.1 above. Furthermore, taking the demand potential studied in Section 2.2 into

consideration, additional demands by development of Erdenet copper mine and unspecified big projects were provided.

- For other sectors, econometric method was not applied because there was no relation among past trends of NMP and coal consumption. Historical coal demand in each sector was fluctuated frequently without reasonable reasons. In this study, each demand was estimated in relation with the population growth based on the data before the economic disruption.
- According to the above-mentioned methods, coal demand of industry and other sectors in the CES area were forecasted as follows(1,000 ton):

Table 8 Coal Demand Forecast by Sector in CES area

	1993	2000	2005	2010
Industry				
High case	560	1,690	2,230	2,910
Low case	560	1,650	2,130	2,690
Transportation	40	40	50	50
Agriculture	250	290	320	360
Household	350	420	460	510
Others	320	380	420	470

2.4.3 Summary of the coal demand forecast

- Following is the summary of the coal demand in Mongolia. A master plan for coal supply, hereafter, will be studied only for the demand in the CES area.

Table 9 Forecast of Coal Demand in Mongolia

1,000 t/y

		1993	2000	2005	2010
In CES	High case	4,800	6,800	8,600	11,200
	Low case	-	6,400	7,900	9,700
Out of CES area		700	2,100	2,500	2,500
Export		0	400	400	400
Total	High case	5,600	9,300	11,600	14,100
	Low case	-	8,900	10,800	12,600

2.5 Required coal supply amount

2.5.1 Margin on production capacity

- Actual coal demand shows typical seasonable fluctuation as follows, however, such a change will be responded by changing the working volume for stripping and coal excavation.

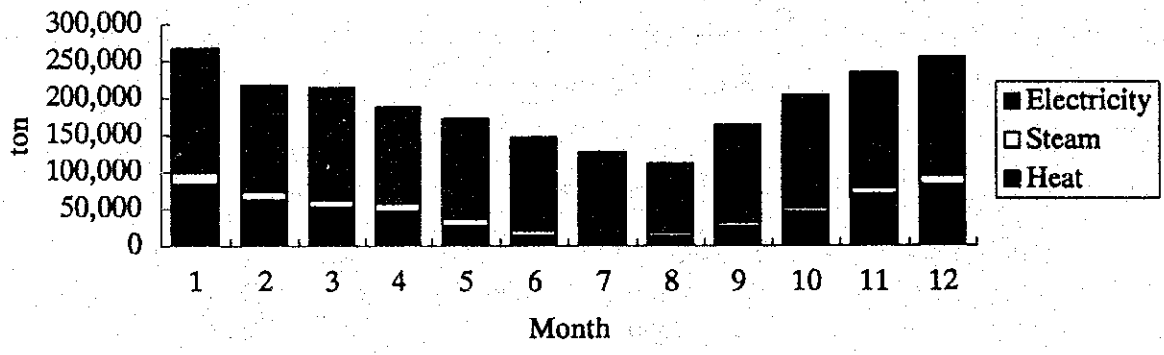


Figure 3 Coal consumption in the Ulaanbaatar Power Plants in 1993

- Security of coal supply needs the user's stock of coal corresponding to about 15 days' consumption against coal production and transportation troubles.
- In addition to the user's stock, a margin in the production capacity will be required to cover the production loss that may be caused by a trouble of a coal mine.
- It is concluded that the necessary margin to be held in total capacity of coal mines inside the CES area is around 10% of the production capacity of the largest coal mine. 400-600 thousand t/y of the margin is calculated when a trouble of Baganuur coal mine is assumed.

2.5.2 Required capacity for new coal mines

- Following show total required production capacity for new coal mines corresponding to High case/Low case of demand forecast.

Table 10 Total Required Production Capacity for New Coal Mines

1,000 t/y of 3,500 kcal/kg

	High case			Low case		
	2000	2005	2010	2000	2005	2010
Total required capacity	7,300	9,300	11,900	6,800	8,400	10,400
Demand in CES area	6,800	8,600	11,200	6,400	7,900	9,700
Margin in capacity	500	600	700	500	500	700
Capacity of existing mines *1	7,300	9,300	9,700	6,800	8,400	9,700
Required for new coal mines	0	0	2,200	0	0	700

Note *1:Expansion of Shivee Ovoo and Baganuur and new development of Ulaan Ovoo are included.

- When Baganuur coal mine is increased to 6.0 million t/y, any new coal mine is not required until around 2008.
- Best choice for the future development plans should be studied in accordance with the preliminary economic comparison between the expansion plans of Baganuur and Shivee Ovoo coal mines and the new development plans which would be studied in Section 3.

3 Coal Development Plan

3.1 Review of coal resources

3.1.1 Outline of coal resources

- Mongolia is one of the prominent countries having large coal resources in the world. The total geological coal reserves is estimated at 150 billion tons.
- Most of coals are subbituminous coal-lignite in the East and bituminous coal in the West.
- There are 27 coal deposits as shown on Attached Figure 4.

3.1.2 Major coal deposits

- Major information of coal deposits is summarized on Attached Table 11.
- There are 27 existing coal mines: 17 out of them are being mined by MEGM, 2 by local governments and 8 by private sectors.
- Seven coal deposits inside CES are particularly prospective for expansion of existing coal mines or development of new coal mines.
- Tavantolgoi deposit is prospective for export of coking coal, although there is no infrastructure.

3.1.3 Mining conditions and equipment of existing coal mines

- Attached Table 12 illustrates the outline of each coal mine owned by MEGM, including coal quality, mining conditions, existing mining machines and the estimated production capacity, which are obtained by hearing.
- Simplified estimation method of the actual production capacity of each coal mine, taking mining conditions and equipment data into consideration, is developed and used in this Section.

3.2 Coal mine development plans

3.2.1 Selection of potential coal deposits

- 14 of the potential coal deposits were selected, as shown on Attached Table 13 (Long list), based on the following examination criteria:
  - (i) Larger coal reserves more than 100 million tons
  - (ii) Simple geological structure and shallow occurrences
  - (iii) Sufficient coal quality for potential use

3.2.2 Required surface facilities for potential coal deposits

- All of potential coal deposits are located in remote areas, and therefore, the construction of typical service facilities is required; such as workshop and warehouse with enough spare parts and consumable.
- Coal quality control system such as dewatering and crushing/sizing facilities, and coal quality analyzers.
- Hospital, school and other public facilities must be prepared, although such infrastructure is usually installed by the Government.

3.2.3 Conceptual plan of viable coal mines

- Among potential coal deposits listed on Table 13 (Long list), viable coal mines were selected based on the following examination criteria of developing conditions:
  - (i) Produced coal can be transferred by the existing railway or can be used by a mine mouth power plant.
  - (ii) Minable coal reserves which are calculated on the criteria of 200m as the maximum mining depth or 4.2 as the maximum stripping ratio are evaluated to be suitable for commercial development.

- Conceptual plans of the viable coal mines are developed based on the simplified estimation method(see Section 3.1.3) and following conditions.
  (i) Shovel(12 m^3) and truck(80 ton) system is applied to stripping.
  (ii) Maximum mining depth is 200m or equivalent depth to 4.2 of the average stripping ratio.
  (iii) Capital cost consists of mining equipment, general purpose machines and service facilities. Infrastructure is not included.
  (iv) Operating cost is estimated based on the unit operating cost of US$ 1.43/BCM in Baganuur coal mine which is obtained by the study of Part I.

- Attached Table 14 (Short list) shows the outline of the viable coal mines and the results of the conceptual design.
- Khoot coal mine is inferior in coal reserves and mining conditions but superior in coal quality. Therefore, it is selected as the substitutive coal mine for Sharyngol.
- Ulaan Ovoo coal mine, which is under construction, will supply the substitutive coal for Sharyngol

3.2.4 Required exploration plans

- Four of the selected viable coal mines, excepting Tavantolgoi and Chandgantal, need additional exploration activities prior to the feasibility study for commercial development due to lack of detailed geological data.
- High-resolution seismic reflection survey as well as the conventional drilling survey are recommended.
- All exploration activities for one coal mine will take about 4 years.
- Rough estimation of cost exploration activities including the field work, analysis and evaluation are as follows:

Table 15 Estimated Cost of Exploration by Each Coal Deposit

	Tugrugnuur	Tsaidamnuur	Khoot	Shivee Ovoo
Seismic survey				
Line length(km)	145	90	60	55
Conventional survey				
Holes	90	62	45	45
Length(km)	14	11	8	8
Total exploration cost (million US$)	11	8	6	6

3.3 Infrastructure development plans

3.3.1 Infrastructure

- Five coal mines, excepting Tavantolgoi, are located inside the CES area. Therefore, necessary investment for infrastructures can be minimized.
- Additional infrastructures are transportation and transmission lines, utility facilities and township that includes a hospital and a school.
- Capital costs for the infrastructures above-mentioned are estimated in magnitude of order as follows:

Table 16 Cost Estimation for the Development of Social Infrastructure

million US$

	Tugrug-nuur	Tsaidam-nuur	Khoot	Shivee Ovoo	Tavan-tolgoi	Chanda-ganta
Railway*1	17	7	61	0	300	110
Road	6	2	4	0	14	7
Transmission line	1	2	3	0	21	7
Township	18	17	16	17	23	21
Others	2	1	7	0	33	12
Total	44	29	90	17	388	156

Note *1: When coal is used by a mine mouth power plant only, railway may be unnecessary.

3.3.2 Training Center

- According to the renovation study of Part I, the issues of existing coal mines are pointed out as follows:
  - (i) Lack of spare parts for mining equipment and railway system
  - (ii) Lack of experts and skilled laborers for maintenance
  - (iii) Large scale equipment causes sometimes long time break down due to difficulty of the repair by Mongolian specialists
- There are 25 coal mines in Mongolia which are difficult to have their own workshop and maintenance specialists.
- To resolve above-mentioned issues, the installation of a training center with the following functions is proposed:
  - (i) Training of operators and mechanicians of mining equipment
  - (ii) Dispatch of maintenance experts to the mine in case of break downs
  - (iii) Stock and delivery of common spare parts

3.4 Comprehensive study on coal development plans

3.4.1 Social impact of viable coal mine development

- Development of Tavantolgoi coal mine which can produce coking coal is expected to contribute to earning hard currency.
- Development of other viable coal mines will contribute to providing cheap fuel.

3.4.2 Selection of coal mine development projects

- To supply 4 million t/y(high case) of the required coal amount for new coal mines(see 2.5.2), prospective coal mines are selected as candidates for development projects.
- As mentioned in 3.2.3, Khoot coal mine should be selected as the substitutive coal mine for Sharyngol.
- Tugrugnuur and Tsaidamnuur are selected due to good geological conditions and preferable location equipped with infrastructure.
- Choir will be surrounded by many coal mines in the near future; Baganuur, Shivee Ovoo, Khoot, Tsaidamnuur and Tugrugnuur. The area is also rich in other mineral resources such as oil shale, limestone, fluorite, uranium and etc. Therefore, Choir will become one of the mining industry centers in Mongolia.

4 Coal Utilization Plan

4.1 Electric power sector including heating system

4.1.1 Present status of coal utilization

- Present status of electric power sector and the coal demand forecast are reported in 2.2.1 and 2.4.1. Electricity generation is the biggest consumer of coal.
- Coal is used at pulverized coal fired power plants which are designed by former Soviet. Old power plants constructed around 1961-1965 are still working.
- Many problems of coal fired power plants in operation and maintenance are caused by following reasons:
  - (i) Poor maintenance and lack of spare parts
  - (ii) Low quality of coal, including delivery of off-specification coal

(iii) Unsuitable structure of existing boilers to the present coal quality
(Poor coal pre-treating and ash handling facilities)

- There is no hydropower plant.
- Present power plants of CES have enough margin in the generation capacity, nevertheless the peak power is imported from Russia.
- Electricity in the out of CES is supplied mostly by diesel engine generators installed at the demand site.

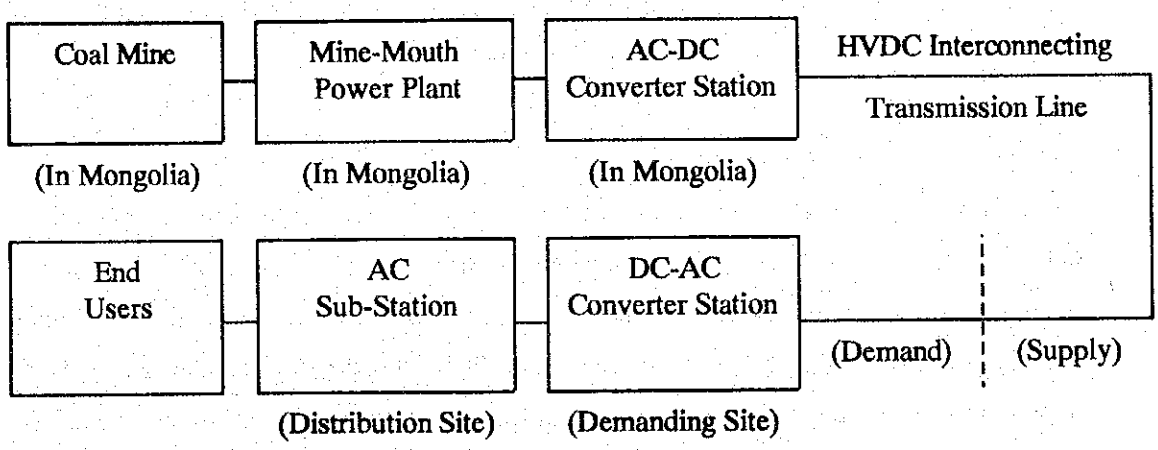
4.1.2 Electric power development plans

- According to the forecast for electric power demand, the peak power(maximum demand:MW) at 65% of load factor will grow as follows:

Table 17 Peak Load based on Power Demand Forecast

	High case	Low case
1993	470	470
2000	550	520
2005	790	700
2010	1,240	980

- As the first priority for construction among new plans, it is assumed that Egiin hydropower plant of 220 MW which is designed for the peak power is put into the operation around 2000.
- Second priority will be given to a mine-mouth coal fired power plant at the mine site such as Baganuur, Shivee Ovoo and Tsaidamnuur around 2005. A mine-mouth coal power plant has following advantages:
  (i) Coal transportation(railway) and stockpile can be minimized.
  (ii) Environmental problems can be minimized.
- Fluidized bed boiler is favorable for the low grade coal which will be supplied from the coal mines near the CES area, because it can burn such low grade coals in an environmentally acceptable manner.
- To generate electric power at mine mouth and to export it to neighboring countries such as China, Korea and Japan by HVDC (high voltage direct current) transmission line seems to be an attractive plan to support Mongolian economy. The following technical outline and economic data obtained from a model study indicates the viability of the plan.
  • Considerable basic development scheme is as follows:



• Outline of the plan is follows:

Generator output : 4,000 MW(500x8)

Coal consumption : 9 million t/y of 6,200 kcal/kg(fuel coal)

HVDC voltage : ±500kV

Transmission distance: 1,200 km from Tavantolgoi mine

Capital cost

Power plant : 4,000 million US$

Converter station: 800

HVDC line : 600

Estimated electricity cost(before tax)

At mine-mouth : 3.0 cents

At end users : 3.9

Note: Above costs are based on 10 US$/t of coal and 70% of plant factor.

- It is recommended to implement the feasibility study of the mine-mouth coal fired power plant, including application of the fluidized bed boiler and export of electricity by HVDC transmission line.

4.2 Mining, industry and construction sector

4.2.1 Present status of coal utilization

- Coal is used for heating of process materials as well as heating of buildings of coal and metal mines and manufacturing industries such as cement, brick, steel, etc.

- Because the calorific value of the most present coal is lower than the design value of the plants, many users are willing to use higher calorific coal.

4.2.2 Major coal utilization plans in industries

- Expansion of some metal mines (copper, lead, zinc, etc) such as Erdenet copper mine, Bor-Odor fluorite mine and Tsav lead and zinc mine is scheduled in around 2000.
- In addition, the development of some new metal mines such as Boro gold mine and Bumat gold mine is planned to start the operation in around 2000. Furthermore, some unspecified metal mining and processing projects, including an uranium refining project, may be expected after 2000.
- Expansion of building material plants such as cement and brick is planned to start the operation in around 2000. Some large scale plants for export market and several small scale plants of 10,000 t/y for local market are being studied.
- Development of a sponge iron project which uses Tumurtei iron deposit is being planned by Darkhan Steel Mill.
- Substitution for the imported coal by Erdenet copper mine is expected.
- Coal utilization for production of chemicals and synthetic fuel can not be expected in the near future from the point of view of economics of Mongolia. (see Section 4.6)
- Other typical coal utilization could be expected to expand in accordance with development of Mongolian economy.

4.3 Agriculture sector

- It is estimated that coal is used for heating of greenhouses and also for cocking and heating in household of farmers.
- Any specified coal utilization plan could not be found in this sector.

4.4 Public service and household sector

- Coal is used for cocking and heating.
- Any specified coal utilization plan is not reported in this sector.

4.5 Transportation and communication sector

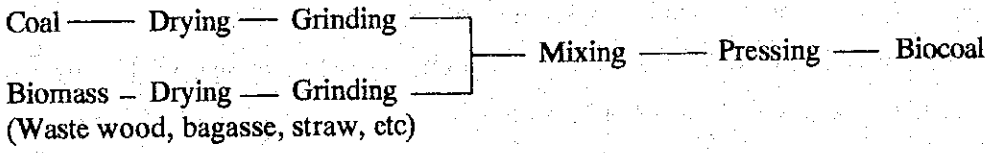
- Coal is not used for any concrete purpose of transportation and communication, but for coocking and heating at household of laborers.

- Any specified coal utilization plan is not reported in this sector.

4.6 New utilization technology

4.6.1 Coal briquette

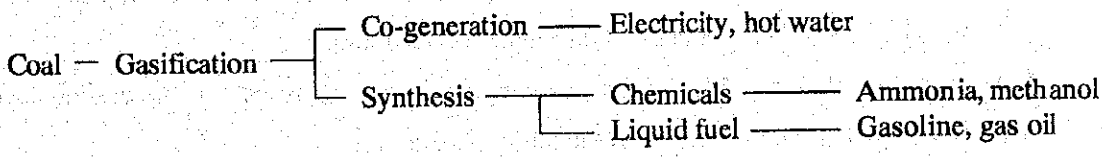
- Coal briquette is used world-widely to modify the handling and combustion characteristics of raw coal.
- Coal-biomass briquette named "Biocoal" is suitable technology for producing briquette from low quality coal in Mongolia. It can help decrease troublesome pollutants such as smoke, smell,dust, SO_2 and clinker which are exhausted by combustion of raw coal.



- Initial capital cost of Biocoal plant is about 170 US$/t and the approximate production cost before tax is 21 US$/t including the costs of coal and biomass at 10 US$/t.
- "Who will pay the cost" is the issue of introduction of briquette utilization into Mongolia.
- It is recommended for MEGM to implement the feasibility study for production and utilization of coal briquettes.

4.6.2 Coal gasification and derivatives

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



- Production of chemicals, mainly ammonia and methanol, has been implemented at the industrial scale in such countries with special economic conditions as China, South Africa and East European countries. For gasification of coal, fixed bed process(Lurgi) and entrained flow process (Koppers-Totzek, Texaco) are mainly applied.
- Production of coal derivatives in Mongolia is not recommended due to the small market and the expensive production cost.

- Production of gasoline and gas oil using Fisher-Tropsch synthesis has been carried out in South Africa which had special economic conditions.
- Development of new technology for coal gasification, co-generation, and gas synthesis to produce gasoline and gas oil are proceeded by NEDO, Japan, which objectives are i) energy conservation and environmental control in electricity generation and ii) supply of alternative liquid fuels in gas synthesis.
- It is reported that the production of synthetic petroleum through coal gasification will be economical when oil price reaches higher than 30 US$/bbl.
- According to the recent forecast of oil price by the Institute of Energy Economics,Japan, the oil price will reach to 30 US$/bbl around 2010. Therefore, industrialization of coal gasification in Mongolia can not be recommended for the time being.
- It is recommended for MEGM to evaluate coal characteristics for gasification by installing a small scale test facility in the relevant institute.

4.6.3 Coal direct liquefaction

- Coal direct liquefaction is used for production of gasoline and gas oil. There is no industrial scale of production in the world at present time.
- Development of new technology for coal direct liquefaction is proceeded by NEDO,Japan. NEDO has finished the pilot plant test of lignite installing the semi-industrial scale plant in Australia.

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

- It is reported that the production of synthetic petroleum through coal direct liquefaction will be economical when oil price reaches higher than 30 US$/bbl.
- It is recommended for MEGM to evaluate coal characteristics for direct liquefaction by installing a small scale test facility in the relevant institute.

5 Energy Conservation Plan for Coal-related Facilities

5.1 Present status of thermal efficiency in coal utilization

- First of all, it must be noted that frequent electricity failure and scheduled power cut in Mongolia are causing too much losses of not only energy itself but also many materials and time in whole sectors of Mongolia.
  In this Section, however, such losses are excepted from the study expecting early modification of power supply situation.
- Coal utilization facilities can be classified into three groups for energy conservation: (i) coal conversion facilities (coal fired power and thermal plant), (ii) direct coal utilization facilities (boiler and stove) and (iii) indirect coal utilization facilities (electricity and thermal).
  Energy conservation plan will be studied for each group in this section.

5.1.1 Coal conversion facilities(power plant)

- As shown in Section 2.1.3, 77% of the consumed coal is converted into electricity, steam and hot water by large- and middle-size boilers.
- Actual thermal efficiency of such boilers is 80-85%, and is low compared with 90% of the state-of-art because they are designed by the former Soviet without any energy conservation concepts.
- ADB reported that heat loss in hot water distribution and utilization system is huge, about 50% of the delivered energy.

5.1.2 Direct coal utilization facilities(coal burning)

- Industry sector
  - As shown in Section 2.1.3, industry sector consumed 14% of coal.
  - Efficiency of coal use in industry sector is around 60% and is comparatively low because most of the facilities are designed and operated without any energy conservation concepts.
- Public and household sector
  - As shown in Section 2.1.3, public and household sector consumed 4% of coal.
  - Actual efficiency of coal use in the sector is not available, but it is estimated to be very low as the efficiency of small boilers and ovens is low, 20-30%.

- Other sectors
  - Coal consumption of other sectors is 2% of the total and used in almost the same fields as in public and household sector for heating and coocking.
  - Present efficiency of coal use in other sector is estimated to be the same level as in public and household sector, because coal is used for heating and cooking.

5.1.3 Indirect coal utilization facilities(electricity and heat)

- Industry sector
  - As shown in Figure 2, 67% of produced electricity is consumed in industry sector.
  - Share of industry sector will be in the same range, 60-70%, though actual data of the share in thermal energy consumption are not available,
  - Efficiency of electricity use and thermal energy use in industry sector is not available, but it is estimated to be comparatively low because most of industrial facilities were designed by the former Soviet without any energy conservation concepts.
- Other sectors
  - Electricity in other sectors accounted for 33% of the total. It is used for miscellaneous purposes as usual, including heating of buildings and homes in the out of the hot water supply area.
  - Present efficiency of electricity and thermal energy use in other sectors is not available, but it is estimated to be very low due to neither energy-saving effort nor energy control device.

5.2 Technical potential of energy(coal) conservation

- Technical analysis on possibility of energy-saving on existing facilities is not included, because such an analysis is out of the scope of the study.

5.2.1 Coal saving in conversion facilities

- Electric power plant
  - It is planned to repair and modify the power plants in the CES before 2000, and therefore, it is sure that energy conservation measures would be applied in the course of renovation by 2000, utilizing the most modern technology.
  - As mentioned in Section 4.1.2, a mine-mouth coal fired power plant will be constructed at

coal mining site around 2005. Such a new power plant would be designed to secure high energy efficiency, 35% of gross generation efficiency, applying new technology.

- Application of a more efficient power generation system such as combined cycle co-generation system will not be industrialized until the hike of oil price.

- Heat supply system
  - Coal-saving devices for the large boiler will be implemented by 2000 in the same schedule as the power plant.
  - Heat loss of the hot water distribution system must be minimized by renovation of the system, which includes installation of the flow meter in each consumer.
  - According to the ADB report, present heat loss reach about 50% of the delivered heat and it could be decreased to 30% at least by renovation of facilities and energy-saving efforts by users.
- Taking renovation above into consideration, the effect of energy-saving in power sector was included in the coal demand forecast described in Section 2.4.

  Note: 35% of gross conversion efficiency as the average of recent coal fired power plants in Japan was used for estimation.

5.2.2 Coal saving in direct coal utilization(coal burning)

- Present and desirable thermal efficiencies of the medium size boiler and the typical ovens are estimated as follows:

	Present	Desirable efficiency
Industrial boiler/heater	60	88-92
Household ovens	50	60-65

- Rather high amount of energy-saving in the out of power sector will be achieved by energy saving effort which is promoted by price control of the Government,however, saving measures by modification of facilities will need rather long period due to lack of the capital fund.
- Taking uncertainty of expected energy conservation of boilers above into consideration, the effect of energy conservation in coal direct use, excepting power plants, was not included in the coal demand forecast described in Section 2.4.

5.2.3 Coal conservation in indirect coal utilization (electricity and heat)

- Best and faster method for electricity-saving is the price control by the Government, while the profit by price control policy must be used for subsidy of capital fund for energy-saving.
- Electricity saving and thermal energy conservation in industry sector can be achieved mostly by modification of the equipment and sometimes the whole plant and therefore will need a long period.
- Taking uncertainty of expected energy conservation by electricity and heat users into consideration, the effect of energy conservation in indirect coal use was not included in the coal demand forecast described in Section 2.4.

5.2.4 Other energy(coal) conservation potential

- Converting oil to coal
  - In Mongolia, petroleum products are used mainly in three fields (i) Gasoline and diesel oil for cars and machines, (ii) Diesel oil for electricity generation in rural areas and (iii) Fuel oil for controlling the coal fired boilers.
  - Amount of the petroleum consumption for (i) and (ii) is about 2 million tce/y (1990) and it will be difficult to convert it to coal in technical and economic point of view.
  - Amount of fuel oil consumption for (iii) is about 4% of coal consumption of power plants, 130 thousand t/y of coal(3,500 kcal/kg) or 50,000 t/y of oil, however, it will be minimized by repair and modification of existing boilers before 2000.
- Upgrading of coal quality
  - Typical upgrading process of coal by washing is not recommendable for the coal in CES area because most coal is rather low grade coal and application of washing process is uneconomical procedure for such a low grade coal.
  - Upgrading of coking coal in Tavantolgoi will be implemented for export.
  - Briquetting of lignite is recommendable upgrading method which could decrease air pollutants and increase thermal efficiency of small boilers and stoves.
- Utilization of flammable wastes
  - It is sure that an effective utilization of flammable wastes is already implemented as fuel for household use in Mongolia, and therefore, it is unnecessary to introduce a large-scale waste disposal combustion boiler.

5.3 Policy and procedure for promotion of energy conservation

- Basic policy measures for promoting energy conservation are as follows:

(i) Guidance and inducement	:	Campaign for energy conservation
		Establishment of standard energy efficiency
		Education by Energy Conservation Center
(ii) Incentives	:	Price control for each fuel
		Tax control for energy saving devices
		Financial assist for energy saving devices
(iii) Compulsory	:	Restriction of car driving
		Closing petrol station on holiday

- Tax control and financial assistance of (ii) above-mentioned are effective measures for energy conservation in industry sectors.
- Above all, the most effective policy measures for whole sectors is the price increase including tax control for each fuel by the Government.
  However, the profit caused by price increase must be used for support of low income people as well as funds for tax control and low-interest loans.

5.4 Energy conservation plan

- First of all, repair and modification of existing power plants should be proceeded immediately to avoid electricity failure and scheduled power cut.
- Second, in view of constraint on funds for modernization of industrial process and facility, including energy saving measures, the Government must support the supply of the required funds by reviewing the tax system to industry sector and supplying low-cost loans.
  Before entering this action, it is required for the Government to resolve the issues regarding to the unpreferable credit and debt system which the enterprises in Mongolian suffer from.
- Third, increase of energy price up to the international level should be studied paying particular attention to its impact on people's lives.

6 Environmental Protection Plan for Coal-related Facilities

6.1 Present state of air pollution

6.1.1 Pollutants exhausted from coal-related facilities

- Coal fired power plant
  - Three coal fired power plants are in operation in Ulaanbaatar, generating 90% of national product. They consume 2.9 million t/y of coal.
  - No.3 power plant is installed with scrubbers and No.4 with electrostatic precipitators, however, neither desulfurization nor denitration facility is installed in any plant.
- Miscellaneous boilers
  - Total number of 222 units of large to small boilers are installed in offices and industrial facilities. They consume 0.4 million t/y of coal.
  - These boilers are not equipped with any flue gas treatment device like filter.
- Stoves in gers
  - Almost half(300 thousand) of inhabitants in Ulaanbaatar live in gers of about 53,000 located at the suburbs. They consume 4-5 tons of coal and approximately 4 m^3 of firewood per ger per year.
  - These stoves have stacks with 3-4 meter high and are regarded as one of major causes of air pollution, particularly in the crowded area with gers.
- Air pollutants exhausted in Ulaanbaatar are estimated for 1993 as follows:

Table 18 Estimation of Air Pollutants Exhausted in Ulaanbaatar

	Coal		Estimated present emission			
	Consumption (thousand ton)	Sulfur content (wt%)	SO_2	NO_2 (thousand t/y)	Dust	Benzpyrene (kg/y)
Power plant	2,900	0.74	42	36	86	14
Boilers	400	0.76	5	3	23	17
Stoves	260	0.76	2	1	10	161
Total	3,560		49	39	119	192

Note: Amount of air pollutants are calculated on the basis of coal quality above and supposed emission factors which are referred from Japanese documents.

- Share of power plants in SO_2, NO_2 emission volume are the highest and these of miscellaneous boilers and stoves are negligibly small, while 92% of Benzpyrene is exhausted from boilers and stoves. It is estimated that Benzpyrene concentration is hazardously high in the crowded area

with gers.

6.1.2 Emission of coal-fired pollutants

- SO_2, NO_2 concentration
  - Ministry of Environment of Mongolia measured SO_2 and NO_2 concentration at three fixed stations in Ulaanbaatar and acquired for 1990-94 as shown bellow:

Table 19 SO_2 and NO_2 Concentration at Three Fixed Stations

		mg/m^3
	SO_2	NO_2
Maximum in each 1990-94	0.03-0.25	0.111-0.401
Average in each 1990-94	0.004-0.013	0.025-0.115
Environmental standard(daily)	0.05	0.04
(hourly)	0.5	0.085

  - Annual average of SO_2 concentration stayed below the environmental standard of 0.05 mg/m^3 each year, on the contrary, the maximum concentration sometimes went over the standard.
  - Annual average of NO_2 concentration sometimes went over the standard.The maximum was exceeding the standard many times.
- Dust concentration
  - Total suspended particulate(dust) was observed by a high-volume air sampler at Ulaanbaatar in February 1995.
  - It was found that the daily concentration exceeded the standard of 0.15 mg/m^3 for 81 days, in total, out of 104 days of the whole measurement period.
  - Maximum value observed was 1.17 mg/m^3, which suggests that Benzpyrene may be also exceeding.

6.2 Estimated emissions of pollutants from coal-related facilities

- Although coal consumption is estimated to increase approximately 60% from 1993 to 2010, the results of the simplified simulation indicate that the increases of the ground-level concentrations of SO_2 and NO_2 emitted from each of No.3 and No.4 power plants are rather small at 10-15%.
- Dust emitted from power plants gives small influence on the ground-level concentration due to

the installed dust removal facilities.

Dust emissions from stoves in gers will not be decreased in the future.

6.3 Technical potential for air pollution control

- Sources and pollutants necessary to be controlled in Ulaanbaatar are low-height emission sources such as household stoves and small-to-medium size boilers.
- Estimated effects of bio-briquette in reduction rate of pollutant emissions are 70% for dust and benzpyrene and 75% for SO_2.

6.4 Environmental protection plan

- Potential demand of bio-briquette is estimated to be approximately 100 thousand t/y, when 50% of gers in Ulaanbaatar introduce the briquette for their gers.
- Required investment for production of 100 thousand t/y of the briquette is about US$ 17 million.

The issue of introduction of the briquette into gers is who can pay the production cost without raw materials of US$ 2.7/ton-briquette.

7 Preliminary Study on Selected Plans

7.1 Coal development plans

- Location and relevant infrastructure of selected coal mines are shown on Attached Figure 5.
- Preliminary economic evaluation is implemented on the following criteria:
  - Project life : 23 years (from 1996 to 2018)
  - Time value of money : Constant 1994 Tg with 400 Tg/US$
  - Project financing : 100% equity
  - Price and the life span of equipment: Same as Part I
  - Operating unit cost : Same as Part I (1.43 US$/BCM)
  - Inflation : No inflation

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

Cash flow for EIRR on total project =

Benefit - total capital cost - total operating cost - increase in working capital

- Formula for the approximate production cost is as follows:

  Approximate production cost =

  (total capital cost + total operation cost) ÷ total production volume

  Hence, tax, royalty and interest are not included in the cost.

7.1.1 Tsaidamnuur

- Proposed mining plan and the equipment and facility list with the capital cost are shown on Table 7.1 of the text.
- Details of plan
  - Production capacity : 2.0 million t/y
  - Coal quality : Lignite with characteristics of 3,700 kcal/kg (as received) and 0.4-0.7 wt% of sulfur content, which is almost the same as Baganuur coal
  - Minable reserves : 860 million tons at mining depth of 200m with stripping ratio of 2.3
  - Mining equipment : One fleet for coal and three fleets for stripping
  - Surface facilities : One set of service facilities must be constructed
  - Infrastructure : Railway(10 km), transmission line(10 km) and township must be constructed
  - Coal use and users : Fuel of power plants in the CES area
- Implementation schedule
  - First priority to the implementation order among selected plans will be given to Tsaidamnuur in view of huge reserves and favored location as well as estimated low mining cost, however, the recommended timing of development is varied from 2003 to 2008 in competition with Baganuur expansion project.
- Estimated manpower is 480 as total.
- Capital investment is as follows:

	Mining equipment	Surface facilities	Total
Investment cost for 23 years	108 mil.US$	48	156
Initial investment	44	27	71

- Cash flow study for EIRR on total project shows that the coal price to gain 10% EIRR is 11.1 US$/t(4,444 Tg/t).

- Approximate production cost without tax, royalty and interest is 9.4 US$/t.

7.1.2 Tugrugnuur

- Proposed mining plan and the equipment and facility list with the capital cost are shown on Table 7.3 of the text.
- Details of plan
  - Production capacity : 2.0 million t/y
  - Coal quality : Lignite with characteristics of 3,700 kcal/kg (as received) and 0.8 wt% of sulfur content, which is almost the same as Baganuur coal
  - Minable reserves : 290 million tons at mining depth of 90m with stripping ratio of 4.2
  - Mining equipment : One fleet for coal and four fleets for stripping
  - Surface facilities : One set of service facilities must be constructed
  - Infrastructure : Railway(25 km), transmission line(10 km) and township must be constructed
  - Coal use and users : Fuel of power plants in the CES area
- Implementation schedule
  - Second priority to the implementation order among selected plans will be given to Tugrugnuur in view of the mining cost.
- Estimated manpower is 570 as total.
- Capital investment is as follows:

	Mining equipment	Surface facilities	Total
Capital cost for 23 year	136 mil.US$	50	186
Initial capital cost	56	28	84

- Cash flow study for EIRR on total project shows that the coal price to gain 10% EIRR is 13.9 US$/t(5,547 Tg/t).
- Approximate production cost without tax, royalty and interest is 11.8 US$/t.

7.1.3 Khoot

- Proposed mining plan and the equipment and facility list with the capital cost are shown on Table 7.5 of the text.
- Details of plan
  - Production capacity : 1.0 million t/y
  - Coal quality : Lignite with rather high calorific value of 4,800 kcal/kg (as received) and 0.7 wt% of sulfur content, which is almost the same characteristics as Sharyngol
  - Minable reserves : 85 million ton at mining depth of 65m with stripping ratio of 4.2
  - Mining equipment : One fleet for coal and two fleets for stripping are required
  - Surface facilities : One set of service facilities must be constructed
  - Infrastructure : Railway(90 km), transmission line(40 km) and township must be constructed
  - Coal use and users : Users of Sharyngol coal in the CES area such as cement,brick and steel
- Implementation schedule
  - Start of operation must be decided by two conditions:
    (i) Cost competition with Sharyngol coal mine
    (ii) Production capacity of Sharyngol coal mine in production of high calorific coal
- Estimated manpower is 360 persons as total.
- Capital investment is as follows:

	Mining equipment	Surface facilities	Total
Investment cost for 23 years	72 mil. US$	38	109
Initial investment	29	22	52

- Cash flow study for EIRR on total project shows that the coal price to gain 10% EIRR is 14.7 US$/t(5,892 Tg/t).
- Approximate production cost without tax, royalty and interest is rather high at 12.1 US$/t, while, the approximate calorific cost of 2.9 US$/$10^3$kcal.ton is cheap and almost same as those of Shivee Ovoo(2.7) and Tsaidamnuur(2.9).

7.1.4 Tavantolgoi

- Proposed mining plan and the equipment and facility list with the capital cost are shown on Table 7.7 of the text.
- Details of plan
  - Production capacity : 11.0 million t/y (fuel coal 10.2, coking coal 0.8)
  - Coal quality : Bituminous coal with characteristics of 6,500 kcal/kg (as received) and 0.8 wt% of sulfur content.
  - Minable reserves : 1,400 million tons at mining depth of 200m with stripping ratio of 4.4.
  - Mining equipment : 5 fleets for coal and 20 fleets for stripping
  - Surface facilities : One set of service facilities must be constructed
  - Infrastructure : Railway(440km), transmission line(300km) and township must be constructed
  - Coal use and users : Fuel for mine-mouth power plants to be constructed in Tavantolgoi in the future
- Implementation schedule can not be decided due to no information of the export demand of electric power and coking coal.
- Estimated manpower is 3,200 as total.
- Capital investment is as follows:

	Mining equipment	Surface facilities	Total
Investment cost for 23 years	670 mil.US$	145	815
Initial investment	280	86	366

- Cash flow study is not implemented due to no information on demand, price, etc.

7.1.5 Training center

- Corresponding to the basic plan of the training center proposed in Section 3.3.2, the preliminary study was implemented, getting information of the Construction Machinery Training Center which is established in Pakistan by the grant aid of Japanese government.
- Function(i): Training of operators and mechanics
  - Training courses : Operator, mechanic-1(engine) and mechanic-2(chassis)

- Contents of training : Practical training in operation and maintenance
- Training equipment : Shovel, dump truck, bulldozer and dragline, etc.
  Driving simulator system of above machines.
  Workshop for assembly of engine, transmission, etc.
- Instructors : 5

- Function(ii): Expert services for maintenance
  - Available experts : 10 engineers and 30 mechanic/electricians.
  - Fields of services : Repair and overhaul of shovel, dump truck, bulldozer, dragline, etc.
  - Available area : Whole Mongolia, including private companies.
- Function(iii): Spare parts service
  - Fields of services : Common spare parts of shovel, dump truck, bulldozer dragline, etc.
  - Equipment and tools : Necessary ones for maintenance at the field.
  - Number of staffs : 50

- Outline of necessary capital cost and operating cost are as follows:
  - Investment required :

Buildings	3.0 mil.US$
Facilities and equipment	6.2
Total	9.2

  - Annual operating cost : 0.4 mil.US$/y
- As an idea of the training center is in the conceptual stage, implementation of the detailed feasibility study in future is recommended.

7.2 Coal utilization plan

7.2.1 Baganuur mine mouth power plant

- Baganuur mine mouth power plant is recommended as the next new power development plan in view of following advantages:
  (i) Transportation of 4-5 million t/y of coal to Ulaanbaatar power plants by only one railway is an expensive and unsteady plan.
  (ii) Additional power plant in Ulaanbaatar is not preferable to prevent air pollution.
  (iii) There are enough coal reserves and industrial water resources in the site.

- Conceptual design of the power plant is as follows:
  - Pulverized coal fired boiler: Two units of 470 t/h at 135 kg/cm^2 and 543℃
  - Steam turbine generator : Two units of 100 MW at 13.8 kV
  - Coal consumption : 1.2 million t/y
  - Project schedule : 55 month for design, construction and tests.
- Capital cost, including insurance, supervisors and engineering consultant, is 410 million US$.

7.2.2 Briquette

- As mentioned in 4.6.1, coal-biomass briquette can help decrease troublesome pollutants and increase thermal efficiency in use.
- Followings illustrate the outline of the industrial production plan of Biocoal.
  - Production capacity recommendable: 38 thousand t/y(5 t/h)
  - Raw materials consumption

    Raw lignite : 0.75 ton coal/ton product
    Biomass(straw or dung) : 0.25 ton coal/ton product
    Lime : 0.02 ton coal/ton product
  - Major equipment

    Raw biomass feed system (feeder, crusher, dryer, hopper) : one train
    Raw coal feed system (feeder, crusher, dryer, hopper) : one train
    Mixer and Roll-press : each one
    Miscellaneous equipment(belt conveyor, bag filter,etc)
  - Capital cost : 6.5 million US$
  - Estimated approximate production cost(before tax)

    Capital cost : 8.5 US$/t
    Operating cost : 12.7
    Total : 21.2

    Note: Above cost is based on 10 $/t of lignite and biomass.

8 Conceptual Study of Action Plan

8.1 Master plan for coal development

(1) Priority among coal development projects

- Increase in coal production will be carried out by the priority order among five development plans, two of expansion and three of new development, as shown on the Table below.
- Comparisons in technical characteristics and results of preliminary economic evaluation of the five coal development projects are as follows:

Table 20 Comparison of Technical and Economic Features

	Unit	Baganuur Expansion	Shivee Ovoo Expansion	Tsaidam-nuur New	Tugrug-nuur New	Khoot New
Proved reserves	mil.t	567	550	864	288	85
Stripping ratio	BCM/t	4.2	3.5	3.0	4.2	3.8
Heating value(ar)	kcal/kg	3,250	3,250	3,250	3,250	4,350
Designed capacity	mil.t/y	2.3	1.4	2.0	2.0	1.0
Initial investment	mil.US$	51.6	36.5	70.8	84.5	51.7
Existing infrastructure		Yes	Yes	No	No	No
Total production	mil.t	47	25	40	40	20
Total sales amount	mil.US$	510	260	440	560	300
Total investment	mil.US$	130	80	160	190	110
Total operating cost	mil.US$	340	140	220	290	130
Coal price(10% EIRR)	Tg/t	4,339	4,070	4,444	5,547	5,892
Production cost *1	US$/t	9.9	8.6	9.4	11.8	12.1
Calorific cost	US$/10^{3}kcal.t	3.1	2.7	2.9	3.6	2.8
Priority order		2	1*3	2	4	*2

Note *1: Approximate production cost =
(total capital cost + total operating cost) ÷ total production volume

*2: Priority order was not decided due to industrial use

*3: Expansion of Shivee Ovoo mine provides with advantages such as:
- Expansion of the infrastructure is easy technically and economically
- Required investment cost for the expansion is low
- Geological and mining conditions are comparatively favorable etc.

and in accordance with these advantages the order to expand this mine in priority is first.

- Priority between expansion of Baganuur and new development of Tsaidamnuur makes no difference, though Baganuur is slightly superior due to the existing ready-to-use infrastructure.
- Although the proved reserves in Khoot is rather small in volume, its mining cost is possibly cheaper than that of Sharyngol. Priority order depends on the mining cost of Sharyngol coal

mine.

(2) Implementation schedule of each development project

- In order to meet the required capacity in Section 2.5.2, commencement of the individual projects is settled as below with the said priority order.

Table 21 Implementation Schedule of Coal Development Projects

		1996-2000	2001-2005	2006-2010
Required capacity	mil.ton	1.3	1.7	2.5
Shivee Ovoo	mil.ton	1.4	-	-
Baganuur	mil.ton		2.3	-
Tsaidamnuur	mil.ton			2.0

Note *1: Timing of Khoot depends on the mining cost of Sharyngol coal mine.
*2: Export contracts of coking coal and electricity are required to start Tavantolgoi coal mine development, though the timing is unpredictable.
*3: In this implementation schedule it is foreseen that the Ulaan Ovoo mine will be opened by 2000 and have the capacity of 550,000 t/y.

(3) Required total capital cost and operating cost

- Overall funds required to implement the master plan are as follows:

Table 22 Investment and Operating Cost for Coal Mine Development

		1996-2000	2001-2005	2006-2010
Total investment	mil.US$	37	64	116
Total operating cost	mil.US$	21	108	152
Total required fund	mil.US$	57	173	267

Note: *1 In 1996-2000 the total required fund for expansion of Shivee Ovoo mine is 57 mUS$.
In 2001-2005 the total required fund for expansion Baganuur mine is 126 mUS$.
The loyalty and taxes are excluded in these costs.
*2 In order to expand the capacity of existing coal mines, it is essential to renovate some equipments and improve the living conditions at the mine sites, costs for which are included in the above-mentioned investment.

(4) Cash flow and required fund raising amount

- Cash flow in the master plan at the time the coal of each project is sold at the price of 10% EIRR is shown below.

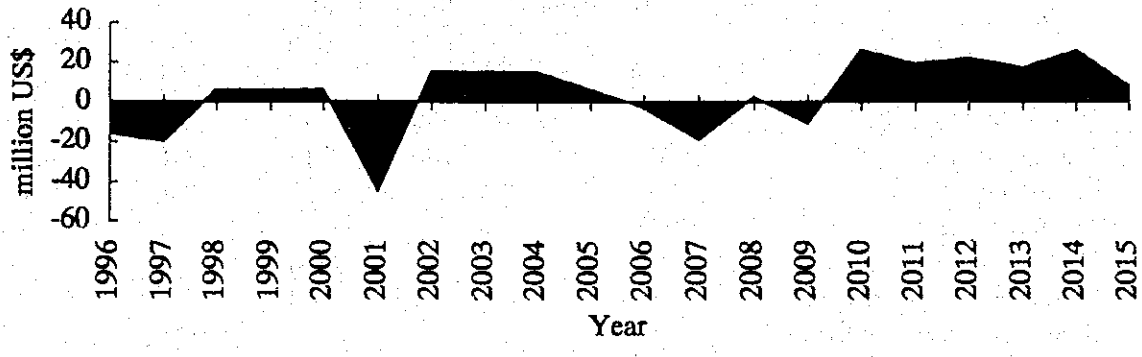


Figure 6 Total Net Cash Flow in the Master Plan

- Total net cash flow in the Master Plan is as follows:

Table 23 Total Net Cash Flow in the Master Plan (mil. US$)

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cash flow	-16	-20	6	6	6	-45	15	15	15	6
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cash flow	-3	-19	2	-11	26	19	22	17	26	8

Note: Rehabilitation costs of the existing mines are not included.

8.2 Master plan for coal utilization

(1) Electric power development plans

1) Development schedule and capacity

- Electric power master plan consists of the development plans for CES as discussed in Section 4 and that for export.
  - First priority is given to Egiin hydro power plant designed for the peak load, and is planned to start from 1999.
  - Second priority is given to a mine-mouth coal fired power plant.

Table 24 Electric Power Development Plan

		1993	2000	2005	2010	After 2011
Electricity demand in CES	mil.MWh	2.6	3.1	4.5	7.1	n,a
Peak demand in CES *1	MW	460	550	790	1,240	n,a
Required total capacity*2	MW	(790)	780	1,130	1,770	n,a
Required new capacity	MW	-	0	350	990	n,a
Development plan	MW					
(Egiin hydro power)			(55)	(165)		
Mine-mouth coal fired(A)				200		
Mine-mouth coal fired(B & C)					200+200	
Mine-mouth coal fired(D)					200	500MWx8

Note *1: Demand when its load factor is at 65%.
*2: Capacity when its plant factor is at 70%.

2) Required capital cost and operating cost

- Overall funds required to implement the master plan are as follows:

		1996-2000	2001-2005	2006-2010
Total required funds	mil. US$	0	320	1,040

Note: Tax is excluded in these costs considering them as the government costs.

3) Required fund arising amount

- To raise funds for new coal fired power plants is unnecessary until 2000 due to no development project.

(2) Briquette and other use

1) Briquette development plan

- As discussed in Section 6.4 and 7.2.2, production of briquette and use in gers are advised in order to prevent air pollution and to promote energy conservation. Potential demand of briquette will reach about 100,000 t/y.
- Capital cost of a briquette plant of 40,000 t/y is about 6.5 million US$. Required total capital cost for 100,000 t/y is about 17 million US$, although the steps and time schedule of development is hardly predictable.
- "Who will pay the cost" is the biggest issue of introduction of briquette use into the ger group near large cities.

2) Other use plans

- Coal use plans in other uses are hardly estimated, and therefore, the fund raising for other coal

uses cannot be included in the master plan.

8.3 Policy and incentive for coal development and utilization

(1) Policy for price

- Pricing policies of the key energies form a base for economic policy. Prices are decided by the government in the present Mongolia as both coal and electric power plants are owned by the government.
- Although they are to be supplied as cheap as possible, it is impossible to operate with financial soundness under the current prices given.
- It is desired to consider the following range in price control.
  - Bottom price: the level to gain reasonable profit for reinvestment

    Coal price at 10% EIRR ; 4,743 Tg/t in case of Baganuur coal
  - Ceiling price: the coal economic value in Mongolia

    Economic value of Baganuur coal ; 6,057 Tg/t at 3,560 kcal/kg GHV
- When privatization of the coal mines is implemented, having an example of the renovation plan of Baganuur coal mine studied in Part I, a suitable coal price can be realized by reallocating the profit given to the government by the severe taxation system.

(2) Effect of tax reduction and exemption and low cost loan

- In case of the renovation project of Baganuur coal mine, the following amendment of the current Mongolian taxation system is effective to gain 10% FIRR at the economic coal value of 6,057 Tg/t.

	Tax reduction and exemption	FIRR on total project *1	NPV at 10% discount rate *2
	(Present situation after assets reevaluation)	0.9%	-30,730 mil.Tg
1	Increase of tax exemption item in operating cost	2.3	-25,530
2	Tax exemption for equipment and spare parts: Import tax;7.5-15% to 0, Trade tax;10% to 0	7.8	- 6,680
3	Coal trade tax redistribution: 5% to the coal mine	10.0	+ 120

Note *1: FIRR on total project is the case of full self-funds (debt/equity=0/100).
*2: 10% FIRR is critical in the financial soundness of the project.

- For further improvement of the financial soundness, supply of low cost loan will be effective. Multiplicative effects with tax reduction and foreign loan of 2% interest rate at the economic coal value of 6,057 Tg/t are as follows:

	Tax reduction and exemption	FIRR on equity for debt/equity of 50/50	80/20
	(Present situation after assets reevaluation)	0.8%	0.9%
1	Increase of tax exemption item in operating cost	1.4	n,a
2	Tax exemption for equipment and spare parts: Import tax;7.5-15% to 0, Trade tax;10% to 0	9.7	(16.1)
3	Coal trade tax redistribution: 5% to the coal mine	(13.7)	(32.2)

Note: Tax reduction and exemption is unnecessary for ( ) due to high FIRR.

- In this way, the price can be reduced to the ceiling price of 6,057 Tg/t, and further, close to the bottom price of 4,743 Tg/t.

8.4 Institutional arrangement

- In spite of the settlement of "Mongolian privatization program" introduced in May 1991, the energy industries are full or majority of undertaking by the government to provide cheap energies.
- Following rationalization will be required.
  - Transfer the competence of the central government office to sites, define management responsibilities in each and promote rapid actions.
  - Establish and strengthen the financial control section in order to change the operation control system from planned economy to market economy.
  - Establish a training center for maintenance services as well as human resources development.
- It seems preferable to change these state-own companies into private companies in the long-run in order to activate them, however, such privatization should be carried out after getting know-how of the management in market economy.