output of Sharyngol mine will be reduced from 1 to 0.8 million tons per annum due to rising production cost because of deterioration of mining condition. After 2000, coal production capacity of Sharyngol mine might drop still more. MEGM is examining the rehabilitation of two mines (refer to Part 1 study) so that they will be able to get a stable coal supply.

- Baganuur coal mine

  This project is to increase the production capacity from around 3.7 to 6 million tons per annum while to improve productivity of existing mining equipments and facilities.
- Shivee Ovoo coal mine

  This project is to increase the production capacity from 0.6 to 2 million tons per annum.

These projects are described in detail in Part I of this study.

Present development plans are mentioned as above. Namely, if all projects are carried out, total production capacities for demand in the CES area are 8.8 million tons (6 million of Baganuur, 2 million of Shivee Ovoo, and 0.8 million of Sharyngol). However, it is necessary to examine economical new coal development plan for the future demand and it should be noted that it is likely to develop the new mine of high quality coal as alternative sources of Sharyngol coal mine that has the possibility of reducing production capacity. Besides, rural region has a big problem that isolated location from mine site causes high transportation cost of coal. Thus, it is preferable that the local government will aggressively support exploration and development of potential coal deposits.

Note: There is Ulaan Ovoo coal deposit at 120km west to Shaamar station. The product coal with calorific value of 4,300kcal/k is substitutive for Sharyngol coal. At present it is already under construction by Erdenet copper mine for their consumption on the scale of 550 thousand ton/year. Therefore, Ulaan Ovoo coal mine is not involved in the new coal development plans in this study.

2.3.3 Coal transportation

(1) Present status of transportation system

In Mongolia, the ton-km of freight transported by the railway is much higher than that of transported by roads. The share of air and the waterway is extremely small. Long distance transportation of both passengers and freights have been largely relied upon the railway because of lack of well maintained roads. The road network in Mongolia has not yet been developed. The records of passenger and freight traffic volume by transportation mode are shown on Table 2.13. The total traffic volume has increased until 1989, and has started to decrease from that time.

Table 2.13 Freight and Passenger Transportation Volume by Type

Item	Unit	1987	1988	1989	1990	1991
Freight traffic						
Road	mil. ton-km	2,099.1	2,162.2	2,097.9	1,771.7	1,362.5
Railway	mil. ton-km	6,179.9	6,241.1	5,956.1	5,085.9	3,012.6
Air	mil. ton-km	8.1	10.6	9.9	7.8	4.1
Waterway	mil. ton-km	5.2	4.9	5.0	4.9	1.7
Total	mil. ton-km	8,292.3	8,418.8	8,068.9	6,870.3	4,380.9
Passenger traffic						
Road	mil. passenger-km	838.6	923.4	957.0	n.a.	913.4
Railway	mil. passenger-km	486.5	531.0	578.6	570.0	596.3
Air	mil. passenger-km	367.7	532.4	567.3	n.a.	448.4
Total	mil. passenger-km	1,692.8	1,986.8	2,102.9	n.a.	1,958.1

(Source) Mongolian Railway, and National Development Board

1) Railway

The transportation volume of freight from 1987 to 1991 is shown in Table 2.14. Total transportation volume fell down sharply from 1989. Especially, import and export from/to Russia and passing through traffic decreased, although decrease of the domestic traffic is not so sharp. Table 2.15 shows the domestic traffic volume by commodity. In spite of decrease of the total domestic volume, coal keeps the volume. At present, the majority of domestic traffic volume is occupied by coal. Therefore, increase of coal demand in the future is very important subject to the transportation capacity. The Mongolian railway network consists of a trunk line linking from Russia to China, short lines branched from the trunk line and a separated line located in the northeast area and several branch lines. The distance of each line is as follows:

Table 2.14 Past Transportation Volume of Freight

(Unit:1,000 ton)

	1987	1988	1989	1990	1991
Export					
to Russia	2,306.3	2,787.7	2,823.0	2,659.2	1,564.5
to China	33.4	41.4	50.3	94.2	142.3
Import					
from Russia	3,697.4	3,697.3	3,000.9	2,190.0	1,200.0
from China	13.9	11.8	18.8	19.8	81.2
Passing through	1,549.2	1,353.8	1,268.0	978.3	168.6
Domestic	9,152.3	9,958.4	9,687.0	8,575.6	7,113.2
Total	16,752.5	17,850.4	16,848.0	14,517.1	10,269.8

(Source) Mongolian Railway

Table 2.15 Domestic Traffic Volume by Commodity

(Unit:1,000 ton)

	1987	1988	1989	1990	1991
Coal	5,023.0	5,342.2	5,073.7	4,830.0	4,910.0
Oil products	29.3	21.5	43.8	32.3	26.3
Iron & steel	73.8	85.3	55.9	25.3	23.1
Machines	45.4	34.6	14.6	11.3	9.6
Building materials	2,564.7	3,148.5	3,301.4	2,693.9	1,414.5
Wheat products	67.1	89.4	91.5	66.0	45.5
Raw foods	21.6	15.5	11.3	10.3	6.9
Livestock	14.5	10.0	9.9	9.3	8.9
Wool & furs	10.2	10.0	9.0	7.4	5.1
Fluorite	3.8	78.6	77.9	105.5	104.4
Chemical products	4.2	6.0	3.6	10.6	2.1
Fertilizer	0.0	0.0	0.0	0.0	0.9
Foods	29.1	47.9	49.9	39.7	24.9
woods	299.7	268.1	221.2	151.9	101.2
Timber	599.6	474.2	441.0	375.9	258.5
Nonferrous metals	0.4	1.3	0.6	0.3	0.7
Others	365.9	325.3	285.8	205.9	170.5
Total	9,152.3	9,958.4	9,691.1	8,575.6	7,113.1

(Source) Mongolian Railway

Trunk line			
Sukhbaatar	-	Zamyn-uud	1,111 km
Branch line			
Darkhan-II	-	Sharyngol	63 km
Salkhit	-	Erdenet	164 km
Tolgoit	-	Songino	20 km
Honkhor	-	Nalaikh	14 km
Bagahanbai	-	Baganuur	94 km
Airag	-	Bor-ondor	60 km
Sainshand	-	Zuunbayan	50 km
Separated line			
Ereentsav	-	Bayan-tumen	237 km
Total			1,813 km

The lines are of single track except the double track section between Darkhan-I and Darkhan-II. The track gauge is 1,524 mm which is the same as that of Russian railway. Therefore, the trains can be operated directly into Russian railway. It can not be operated into Chinese railway without changing their bogies in Zamyn-uud station of a boundary. The track gauge of Chinese railway is a standard gauge of 1,435 mm. In order to improve the efficiency of reshipment, Mongolian government is carrying the improvement plan of the reshipment facilities by foreign aid.

As the mentioned section 2.3.2, MEGM has the plan to increase the production capacity of Shivee Ovoo and Baganuur in order to correspond with the future demand of coal in the CES area. An annual output of eight million tons will be produced from these mines by the year 2000, if the MEGM plan is accomplished on schedule. Most of coal from these two mines will be consumed in Ulaanbaatar, which will be transported by railway.

The current train diagram of freight is shown in Figure 2.5. The diagram is applied to all the year round. The diagram shows the maximum number of freight trains to be operated. The number of trains will be reduced according to the traffic volumes predicted day by day. The number of freight trains to be operated from Bagahangai to Ulaanbaatar will be nine trains at the maximum per day according to the diagram. Table 2.16 shows the actual number of freight trains per day from 1986 to 1991 in Mongolian Railway.

The distance, ruling gradient, travelling time of freight and passenger trains and permissible hauling tonnage between stations on the trunk line are shown on Table 2.17. The maximum

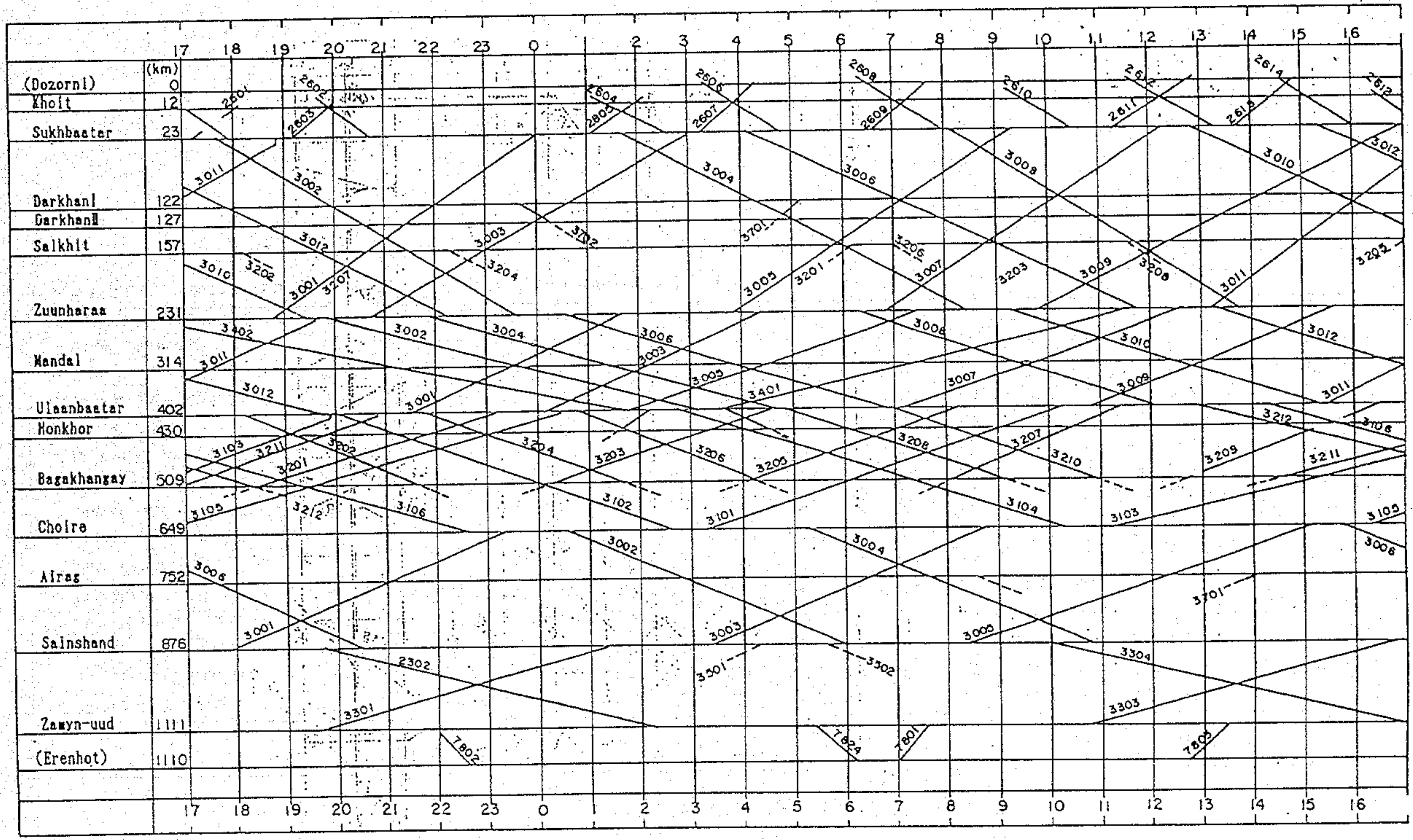

Figure 2.5 Scheduled freight train operation diagram (all the year round)

(Source) OECF, The Railway Transport Capacity Reinforcement Project in Mongolia, Feb. 1993

Table 2.16 Number of Freight Trains per Day

Section	1986			1987			1988			1989			1990			1991		
	UP	DN	Total	UP	DN	Total	UP	DN	Total	UP	DN	Total	UP	DN	Total	UP	DN	Total
1 (Dozomi) - Sukhbaatar	5.7	3.1	8.8	5.0	3.3	8.3	4.7	3.8	8.5	4.5	3.5	8.0	2.0	1.9	3.9	1.5	0.8	2.3
2 Sukhbaatar - Zuun-Haraa	4.7	4.4	9.1	4.4	4.3	8.7	4.3	4.0	8.3	4.0	3.7	7.7	3.8	3.6	7.4	3.4	3.2	6.6
3 Darkhan-I - Zuun-Haraa	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.2	1.0	2.2
4 Zuun-Haraa - Ulaanbaatar	6.0	6.0	12.0	5.9	5.9	11.8	5.7	5.7	11.4	5.0	5.0	10.0	4.5	4.5	9.0	4.3	4.3	8.6
5 Ulaanbaatar - Choir	**4.0**	**4.4**	**8.4**	**4.1**	**4.2**	**8.3**	**4.1**	**4.5**	**8.6**	**4.1**	**4.4**	**8.5**	**4.0**	**4.5**	**8.5**	**3.9**	**4.5**	**8.4**
6 Choir - Sainshand	1.8	2.1	3.9	1.9	1.9	3.8	1.8	1.8	3.6	1.8	1.8	3.6	1.7	1.8	3.5	1.7	1.8	3.5
7 Sainshand - Zamyn-Uud	1.1	1.1	2.2	1.1	1.1	2.2	1.1	1.1	2.2	1.1	1.1	2.2	1.1	1.1	2.2	1.1	1.2	2.3
8 Ulaanbaatar - Bagahangai	**2.5**	**2.9**	**5.4**	**2.6**	**2.7**	**5.3**	**2.6**	**3.0**	**5.6**	**2.6**	**2.9**	**5.5**	**2.5**	**3.0**	**5.5**	**2.4**	**2.9**	**5.3**
9 Zamyn-Uud - (Erenhot)	2.9	0.8	3.7	2.9	0.8	3.7	2.0	0.7	2.7	1.9	0.8	2.7	1.4	0.8	2.2	0.6	0.2	0.8
10 Darkhan-I - Sharyngol	2.0	2.0	4.0	2.0	2.0	4.0	2.0	2.0	4.0	2.0	2.0	4.0	2.0	2.0	4.0	1.8	1.9	3.7
11 Salkhit - Erdenet	2.5	2.5	5.0	2.5	2.5	5.0	2.5	2.5	5.0	2.5	2.5	5.0	2.5	2.5	5.0	2.3	2.9	5.2
12 Bagahangai - Baganuur	2.5	2.9	5.4	2.6	2.7	5.3	2.6	2.9	5.5	2.6	2.9	5.5	2.5	3.0	5.5	2.4	2.9	5.3
13 Honkhor - Nalaikh	2.0	2.0	4.0	2.0	2.0	4.0	2.0	2.0	4.0	2.0	2.0	4.0	2.0	2.0	4.0	1.6	1.7	3.3
14 Airag - Borundur	n.a.	n.a.	n.a.	n.a.	n.a.	0.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.1	1.1	2.2
15 Sainshand - Zuun-Bayan	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.1	1.1	2.2

(Source) OECF, The Railway Transport Capacity Reinforcement Project in Mongolia, Feb. 1993

Table 2.17 Hauling capacity and traveling time

	Distance (km)		Traveling time (minutes)				Ruling gradient (‰)		Hauling Capacity (tonnes)			
			Passenger Train		Freight Train		North→South		South Bound		North Bounds	
	Between Stations	Accumulated	South Bound	North Bounds	South Bound	North Bounds						
Ulaanbaatar												
Amgalan	10	412	13	10	16	11	-	9				
Tuul	7	419	10	9	16	8	-8	8				
Honkhor	11	430	15	11	26	11		9	2,600		2,650	
Bayan	20	450	25	23	47	22		9				
Hoolt	18	468	24	20	46	20	-9	9				
Tsagaanyar	9	477	11	13	17	18	-9	-				
Hangay	20	497	20	28	20	55	-9	-	2,650			
Bagakhangay	12	509	12	16	13	24	-9					
Maanyt	12	521	11	13	12	17	-9		4,500			
Naranelgen	52	573	44	50	51	66	6	-9	3,700	2,600		2,600
Lun	51	624	47	50	60	64	-9	9	2,600		2,600	
Choir	25	649	28	29	33	36	9	-9				
Shivee Ovoo	22	671	18	24	28	35	9	-9				
Shivee gobi	12	684	15	16	16	17	-9	8				
Oloon ovoot	34	718	33	35	38	53	-9	9				
Airag	34	752	33	34	36	55	-9	9				
Ulaan ovoo	66	818	62	62	69	71	-9	9				
Sainshand	58	876	58	55	70	71	-9	9				
Orgon	63	939	58	49	90	90	-9	9				
Ulaan-uul	47	986	49	53	60	58	-9	9				
Auchny gol	60	1,046	57	60	100	81	-9.2	9				
Zamyn-uud	65	1,111	69	70	82	95	-9	9		2,000	2,000	
Erenhot	5	1,116					-9	6.7				

(Source) OECF, The Railway Transport Capacity Reinforcement Project in Mongolia, Feb. 1993

gradient is 18.5 ‰ on the section between Tolgoit and Emeelt, and the hauling capacity on the section is limited to 1,500 tons, and the formation of freight trains is limited to 50 wagons or 200 axles. On the other hand, the gradient on the section between Bagahangai and Ulaanbaatar is 9 ‰ and the hauling capacity on the section is limited to 2,600 tons. Judging from the above, the maximum annual freight traffic volume from Bagahangai to Ulaanbaatar is calculated as follows:

2,600 tons/train x 365 days x 9 trains/day = 8,541,000 tons/year

The present transport capacity of coal will not be able to correspond to the increased future coal demand. Moreover, a large fluctuation in the annual coal consumption makes this problem difficult. That is, the coal demand in winter inevitably increases because power plants supply not only electric power but also hot water and steam. The Mongolian Railway requires 330 to 350 wagons in winter though 60 to 70 wagons are required in summer, which is approx. five times more than those in summer. Moreover, coal cannot be stored for a long time because coal easily causes spontaneous combustion due to its property. Though the numbers of required locomotives and wagons can be replenished according to the consumption of coal, replenishment of them is limited. A basic measure to increase transport capacity is to extend tracks and invest in railway facilities, which requires a enormous amount of fund. Therefore, it is necessary to accurately grasp the future transport amount and make a transport schedule suitable for the coal demand structure, that is, prepare train constitution and train diagrams more perfectly. The Mongolian Railway mainly uses single tracks except main stations and some intersection tracks (signal stations).

To increase transport capacity, it is necessary to increase the transport unit of a train or the number of trains. The following three methods are considered to increase the number of trains.

- Speedup of trains
  Railways in Mongolia are considerably deteriorated, and there are many curves (between Honkhor and Bayan) and the speed is limited. By maintaining and straightening these tracks, the operating speed is improved and eventually the operating frequency increases.
- Construction of new passing loops
  Transport capacity will be increased by, for example, constructing new passing loops at

the middle of the range between Honkhor and Bayan with the maximum inter-station distance.

- Change from single track to double track

  Transport capacity of a double track will be three times or more when it is compared to that of a single track. In particular, train speed can be improved because unnecessary waiting time due to passing each other in a single track section is eliminated.

It is estimated that the coal demand in the CES area in 2010 reaches approx. 11 million tons in high case. Except Sharyngol coal mine, this amount of coal will be produced in the south of Ulaanbaatar and consumed in the north of Ulaanbaatar. Even if power plants are constructed at mine mouths in the future, approx. 10 million tons of coal will be transported by railways. The transport amount of coal occupies 70% of the total transport amount at present. If the percentage is kept in the future, the future railroad transport capacity requires 1.5 times of the present capacity. Though concrete plan must be studied in detail, this report proposes the steps of railway facilities preparing for increase of coal demand in the future.

- Increase of the numbers of locomotives and wagons
- Speedup of trains by maintaining and straightening existing railway facilities
- Construction of signal station between stations with a long distance
- Local change of single track to double track

2) Road

Mongolian State Road Corporation is responsible for the plan, construction, and maintenance of the road. Mongolian roadway is composed of state road of 9,700 km, local road of 39,600 km , and internal road connecting small villages and farms of 150,000 km with total length of 199,300 km and the paved road is only less than 1 % of total length. It is difficult to pave the road because they have to import asphalt.

The transportation volume by vehicles in 1991 is as follows:

Table 2.18 Transportation Volume by Vehicles in 1991

Item	(Unit:1,000 ton)
Coal	1,131.5
Machines	204.7
Building materials	14,771.9
Wheat products	530.5
Fuels	278.6
Livestock foods	264.8
Water	635.8
Foods	363.3
Woods	328.1
Fluorite	168.2
Others	7,522.6
Total	26,200.0

From Table 2.18, we can see that the amount of coal occupies only less than 5% of its total traffic volume. In 1991, total coal production of local mines, except Aduunchuluun which is located near the railway, is about 1.2 million tons. It seems that the coal which is transported by trucks will be consumed by users in local area.

2.4 Forecast of coal demand

The forecast of coal demand is made for two areas, one of which is the CES area and another is area outside the CES. Although there are some constraints for the forecast, coal demand in the CES area can be forecasted relatively easily by using available data and information. However, it is very difficult to forecast coal demand outside the CES. The reason is that the demand forecast outside the CES is made by the process engineering method (a kind of build-up system). It is so because the future demand of rural area will depend on the local policy and new projects. In collecting the information, a lot of time and manpower is required in this study. If the forecast is made by an econometric method, it is necessary to get some economic data in the local area. However, there is no economic data by region. Therefore, JICA team inevitably uses the demand forecast outside the CES that was estimated by MEGM (Ministry of Energy, Geology, and Mining) in Mongolia. On the other hand, the forecast of coal demand in the CES area is made for each of such fields as power and heat generation, industry/construction, transportation/ communication, agriculture, communal housing, and others.

Exploration of oil fields is going to be undertaken in the south-east of Mongolia. Even if new oil field is discovered, it can not be considered that the oil production directly affects the coal demand in the future. Because domestic oil should be taken the place of imported oil products and should not be consumed in the power plant as fuel. Further, such oil is valuable resources in order to get foreign currency.

2.4.1 Power and heat generation sector in the CES

(1) Forecast of power supply

1) Methodology of forecasting

An econometric method is used for the forecast of power demand by sector, mainly because it is not necessary to collect a wide variety of data in the model. In this study, a mathematical model is built by making regression analyses on the relationship past trends of NMP and by-sector power consumption. In order to forecast the power demand, a model (a system of simultaneous equations) resulting from the analyses above is used in making scenario-by-scenario calculation. The following shows simultaneous equations by regression analyses:

- Power demand are classified by industry/construction, transportation/communication, agriculture, public service/household, and others.
- Data observation year is from 1980 to 1992.
- Power demand of each sectors is calculated as a function of NMP.
- Mathematical model is built by regression analysis

(a) Power demand of industry/construction sector (DI)

Log(DI) = -3.7151 + 0.6401 x Log(NMP) + 0.6699 x Log(DI(-1))

(-1.96) (2.24) (5.47) -------------------------- T-value

R-squared = 0.985

Durbin-Watson rate = 1.297

Standard Error = 0.098

(b) Power demand of transportation/communication sector(DT)

DT = -836.7 + 94.8 x Log(NMP) + 0.435 x Log(DT(-1))

(-3.82) (3.87) (3.22) ----------------------------------- T-value

R-squared = 0.943

Durbin-Watson rate = 1.292

Standard Error = 15.277

(c) Power demand of agriculture sector (DA)

Log(DA) = -0.6249 + 0.1805 x Log(NMP) + 0.7536 x Log(DA(-1))

(-0.27) (0.57) (4.02) ------------------------T-value

R-squared = 0.863

Durbin-Watson rate = 0.965

Standard Error = 0.210

(d) Power demand of public service/household (DH)

Log(DH) = -0.1885 + 0.1395 x Log(NMP) + 0.8063 x Log(DH(-1))

(-0.14) (0.64) (5.38) ------------------------T-value

R-squared = 0.914

Durbin-Watson rate = 1.680

Standard Error = 0.146

(e) Power demand of other sector (DO)

Log(DO) = -1.8013 + 0.3203 x Log(NMP) + 0.7630 x Log(DO(-1))

(-1.03) (1.36) (4.55) ------------------------T-value

R-squared = 0.759

Durbin-Watson rate = 2.279

Standard Error = 0.270

2) Forecast of NMP growth

(a) Steps of economic development in Mongolia

Mongolian economy has been and will be developed according to the following three steps:

a) In the short term (about three years) ------- Economic disruptions to be tranquilized (or settled) and economy to be stabilized.

b) In the middle term (about 3 - 5 years) ---- Economy to be transformed into a market-oriented one.

c) In the long term (ten years and longer) --- Economy to be put on the road of a middle and long term growth.

The first step has been realized (1990 - 1994). Mongolian economy is now on the second step and is proceeding to the first stage of the middle and long term growth road.

(b) In general, the basic methodology for a developing country to grow (and become self - reliant) is as follows:

a) In the beginning, foreign saving (ODA and foreign direct investment) needs to be introduced to finance the investment and the international trade deficit of the country ;
b) Then, as the national income increases, the domestic saving should be led to increase so that the dependency of investment on foreign saving may decrease and the trade balance may improve ;
c) Finally, as the national income and the domestic propensity to save further rise, the domestic saving and the trade surplus will become large enough to repay loans from abroad.

Mongolian economy is in the process a) above (1994-1997). Table 2.19 shows that foreign financing is playing a big role in resource availability for the period above, and that energy, transport and telecommunication (which are the parts of the infrastructures, not industries) are main "resource users".

Table 2.19 Public Investment Program, 1994-97

	1994	1995	1996	1997
	as percent of GDP			
Resources availability	23.8	22.1	20.4	21.0
Government savings	2.9	3.9	4.9	6.0
Foreign financing	22.3	18.7	15.5	15.0
Other domestic financing *	-1.4	-0.5	0.0	0.0
	in US$ millions			
Resource use	140.5	157.0	155.0	173.2
Directly productive projects **	33.8	20.6	7.6	24.0
Energy	45.2	39.7	50.0	49.3
Transport	43.9	65.9	60.8	70.0
Telecommunication	0.0	16.4	29.2	22.6
Other	17.6	14.4	7.4	7.3

(Note) * Includes borrowing by the public sector and internal savings of state-owned enterprises.
** Investment in manufacturing, agricultural, on-lending to the private sector.
(Source) World Bank

(c) Leading industries in the future

In the processes b) and c), some leading industries will grow and contribute to expanded economic activities and exports. They will be agro-based industries (including food processing and cashmere), tourism, and mining, especially from the viewpoint of expanded exports or accumulation of foreign currencies. At the same time, building materials including cement and brick and metal processing may lead industries mainly for domestic markets, as mentioned already in section 2.2.2.

(d) Scenarios for NMP growth

Based upon considerations above-mentioned, following scenarios of NMP growth are supposed.

The scenarios are High and Low growth rates. High scenario means that the formation and implementation of policy for the Mongolian economy will be proceeded favorably. To the contrary, the policy formation and implementation are not supposed to proceed as scheduled or planned in Low scenario.

Followings are the rates of NMP growth supposed in both scenarios;

	High	Low
1993	-3.25	-3.25
1994	2.50	2.50
1995-1996	3.50	3.00
1997-2000	4.50	3.50
2001-2005	5.00	4.00
2006-2010	6.00	4.50

3) Future electric power demand

Table 2.20 and 2.21 show high and low case of the power demand forecast by sector in the CES area from 1993 to 2010. Gross thermal generation is calculated from final power demand in consideration of auxiliary power rate and transmission and distribution losses. In this report, auxiliary power rate is estimated to be 20% and transmission and distribution loss 10% according to past trend. In the low case, 2,768.0 GWh recorded in 1992 is likely to rise to 2,952.6 GWh by 2000 (up 0.8 % per year), 3,957 GWh by 2005 (up 6.0% per

Table 2.20 Power Demand Forecast - CES Area

High Case

NMP Growth Rate (%)	1994	1995-1996	1997-2000	2001-2005	2006-2010
	2.5	3.50	4.50	5.00	6.00

Year	Demand (GWh)					Total	Trans.	Net output	Auxiliary	Gross output	NMP	Growth
	Industry	Transport	Agriculture	Household	Others	(GWh)	loss (%)	(GWh)	power (%)	(GWh)	(Million Tg)	rate (%)
1992	1,238.6	88.5	38.6	270.0	290.6	1,926.3	12.9	2,211.6	20.1	2,768.0	12,343.3	
1993	1,170.5	92.2	45.7	280.1	189.9	1,778.3	14.4	2,077.5	20.4	2,609.9	11,942.1	-3.25
1994	1,144.9	96.1	52.2	289.5	155.4	1,738.0	10.0	1,931.1	20.0	2,413.9	12,240.7	2.50
1995	1,153.1	101.0	58.1	298.7	143.0	1,754.0	10.0	1,948.9	20.0	2,436.1	12,669.1	3.50
1996	1,184.5	106.5	63.3	307.8	139.6	1,801.7	10.0	2,001.9	20.0	2,502.4	13,112.5	3.50
1997	1,240.5	113.0	68.1	317.3	141.1	1,880.0	10.0	2,088.9	20.0	2,611.1	13,702.6	4.50
1998	1,316.0	120.0	72.5	327.2	145.0	1,980.8	10.0	2,200.8	20.0	2,751.1	14,319.2	4.50
1999	1,408.3	127.3	76.6	337.5	150.3	2,100.0	10.0	2,333.3	20.0	2,916.7	14,963.5	4.50
2000	1,515.8	134.6	80.5	348.1	156.5	2,235.6	10.0	2,484.0	20.0	3,105.0	15,636.9	4.50
2001	1,642.9	142.4	84.3	359.4	163.8	2,392.8	10.0	2,658.7	20.0	3,323.3	16,418.7	5.00
2002	1,789.0	150.5	88.1	371.2	171.7	2,570.5	10.0	2,856.1	20.0	3,570.1	17,239.7	5.00
2003	1,954.1	158.6	91.8	383.7	180.2	2,768.5	10.0	3,076.1	20.0	3,845.1	18,101.7	5.00
2004	2,138.9	166.8	95.6	396.7	189.3	2,987.3	10.0	3,319.3	20.0	4,149.1	19,006.7	5.00
2005	2,344.5	175.0	99.4	410.3	198.9	3,228.1	10.0	3,586.8	20.0	4,483.5	19,957.1	5.00
2006	2,588.0	184.1	103.5	425.1	210.0	3,510.6	10.0	3,900.6	20.0	4,875.8	21,154.5	6.00
2007	2,870.1	193.5	107.8	440.9	222.3	3,834.6	10.0	4,260.7	20.0	5,325.9	22,423.8	6.00
2008	3,193.0	203.2	112.3	457.9	235.5	4,201.9	10.0	4,668.8	20.0	5,836.0	23,769.2	6.00
2009	3,559.7	212.9	117.1	475.8	249.8	4,615.4	10.0	5,128.2	20.0	6,410.2	25,195.3	6.00
2010	3,974.2	222.7	122.1	494.8	264.9	5,078.8	10.0	5,643.1	20.0	7,053.9	26,707.1	6.00
Growth(%) (1993-2010)	7.46	5.33	5.95	3.40	1.98	6.37		6.05		6.02	4.85	

Table 2.21 Power Demand Forecast - CES Area

Low Case	1994	1995-1996	1997-2000	2001-2005	2006-2010
NMP Growth Rate (%)	2.5	3.00	3.50	4.00	4.50

Year	Demand (GWh)					Total	Trans.	Net output	Auxiliary	Gross output	NMP	Growth
	Industry	Transport	Agriculture	Household	Others	(GWh)	loss (%)	(GWh)	power (%)	(GWh)	(Million Tg)	rate (%)
1992	1,238.6	88.5	38.6	270.0	290.6	1,926.3	12.9	2,211.6	20.1	2,768.0	12,343.3	
1993	1,170.5	92.2	45.7	280.1	189.9	1,778.3	14.4	2,077.5	20.4	2,609.9	11,942.1	-3.25
1994	1,144.9	96.1	52.2	289.5	155.4	1,738.0	10.0	1,931.1	20.0	2,413.9	12,240.7	2.50
1995	1,149.6	100.6	58.0	298.5	142.7	1,749.3	10.0	1,943.7	20.0	2,429.6	12,607.9	3.00
1996	1,174.7	105.4	63.1	307.2	138.8	1,789.3	10.0	1,988.1	20.0	2,485.1	12,986.1	3.00
1997	1,218.5	110.7	67.7	316.0	139.3	1,852.2	10.0	2,057.9	20.0	2,572.4	13,440.6	3.50
1998	1,276.5	116.3	71.8	324.8	142.0	1,931.4	10.0	2,146.0	20.0	2,682.4	13,911.0	3.50
1999	1,346.2	122.0	75.6	333.7	145.9	2,023.3	10.0	2,248.1	20.0	2,810.1	14,397.9	3.50
2000	1,426.0	127.7	79.0	342.6	150.5	2,125.9	10.0	2,362.1	20.0	2,952.6	14,901.9	3.50
2001	1,519.9	134.0	82.3	352.0	155.9	2,244.0	10.0	2,493.3	20.0	3,116.6	15,497.9	4.00
2002	1,626.5	140.4	85.4	361.6	161.9	2,375.8	10.0	2,639.8	20.0	3,299.8	16,117.8	4.00
2003	1,745.3	146.9	88.5	371.7	168.3	2,520.7	10.0	2,800.8	20.0	3,501.0	16,762.6	4.00
2004	1,876.3	153.5	91.5	382.0	175.1	2,678.4	10.0	2,976.0	20.0	3,720.0	17,433.1	4.00
2005	2,019.5	160.1	94.6	392.7	182.1	2,849.0	10.0	3,165.6	20.0	3,957.0	18,130.4	4.00
2006	2,182.2	167.1	97.7	404.1	190.0	3,041.1	10.0	3,379.0	20.0	4,223.7	18,946.3	4.50
2007	2,364.1	174.3	100.9	416.0	198.4	3,253.8	10.0	3,615.3	20.0	4,519.2	19,798.8	4.50
2008	2,565.7	181.7	104.2	428.5	207.4	3,487.5	10.0	3,875.0	20.0	4,843.7	20,689.8	4.50
2009	2,787.7	189.1	107.7	441.5	216.8	3,742.7	10.0	4,158.6	20.0	5,198.2	21,620.8	4.50
2010	3,031.3	196.4	111.2	455.1	226.7	4,020.7	10.0	4,467.5	20.0	5,584.4	22,593.8	4.50
Growth (%) (1993-2010)	5.76	4.55	5.37	2.90	1.05	4.92		4.61		4.58	3.82	

year), and reach 5,584.4 GWh by 2010 (up 7.1% per year), representing 2.0 times of the 1992 record. On the other hand, in the high case, gross thermal generation in the CES is likely to rise to 3,105.0 GWh by 2000 (up 1.4 % per year), 4,483.5 GWh by 2005 (up 7.6 % per year), and reach 7,053.9 GWh by 2010 (up 9.5 % per year), representing 2.5 times of the 1992 record.

(2) Forecast of heat supply

Future heat supply forecasts two categories which are residential and non-residential uses. Heat supply defines the volume of heat (steam and hot water) which is generated in and sent out of power plants in the CES. Table 2.22 shows the heat supply forecast in Ulaanbaatar, Darkhan, and Erdenet. In forecasting heat supply for residential use, two factors---(i) population and (ii) heat supply per one thousand of population----are used. Population in Ulaanbaatar, Darkhan, and Erdenet is supposed to grow in the following rate:

	(% per year)
1993~2000	1.75
2001~2005	2.00
2006~2010	2.00

With regard to heat supply per one thousand of population, two cases are considered (high and low cases). In high case, heat supply per one thousand of population in the cities is supposed to decline by 10% from 1993 to 2000 mainly because the income of household is foreseen to recover not so as it can increase heat consumption in the sector. However, heat supply per one thousand of population will increase by more than 30% from 2001 to 2005 and by around 10% from 2006 to 2010, reflecting the recovered and expanded activities of economy.

In low case, the recovery of household income is supposed to be much slower than in the high case, and therefore, heat supply per one thousand of population is foreseen to decline by 20% from 1993 to 2000, after that it will increase by around 20% from 2001 to 2005 and by 20% from 2006 to 2010.

In forecasting heat supply for non-residential use (in the industry and other sectors), the two factors of (i) the number of customers and (ii) heat supply per one customer are used.

Table 2.22 Heat Supply Forecast in the Three Cities

	1993	2000		2005		2010	
		High case	Low case	High case	Low case	High case	Low case
<Residential>							
Ulaanbaatar							
Population (1,000 people)	598.6	675.9	675.9	746.2	746.2	823.9	823.9
Growth rate (%)		1.75	1.75	2	2	2	2
Heat supply/1,000 people	2.6	2.4	2.08	3.12	2.6	3.38	3.12
Total heat supply (1,000Gcal)	1,556	1,622	1,406	2,328	1,940	2,785	2,571
Darkhan							
Population (1,000 people)	93	105.0	105.0	115.9	115.9	128.0	128.0
Growth rate (%)		1.75	1.75	2	2	2	2
Heat supply/1,000 people	1	0.9	0.8	1.2	1	1.3	1.2
Total heat supply (1,000Gcal)	93	95	84	139	116	166	154
Erdenet							
Population (1,000 people)	64.5	72.8	72.8	80.4	80.4	88.8	88.8
Growth rate (%)		1.75	1.75	2	2	2	2
Heat supply/1,000 people	3	2.7	2.4	3.6	3	3.9	3.6
Total heat supply (1,000Gcal)	194	197	175	289	241	346	320
<Non-Residential>							
Ulaanbaatar							
Customers	2135	2215.5	2215.5	2277.1	2277.1	2334.6	2334.6
Growth rate (%)		0.53	0.53	0.55	0.55	0.5	0.5
Heat supply/customer	0.9	1.08	0.9	1.26	1.08	1.62	1.26
Total heat supply (1,000Gcal)	1,922	2,393	1,994	2,869	2,459	3,782	2,942
Darkhan							
Customers	234	242.8	242.8	249.6	249.6	255.9	255.9
Growth rate (%)		0.53	0.53	0.55	0.55	0.5	0.5
Heat supply/customer	1.6	1.92	1.6	2.24	1.92	2.88	2.24
Total heat supply (1,000Gcal)	374	466	389	559	479	737	573
Erdenet							
Customers	90	93.4	93.4	96.0	96.0	98.4	98.4
Growth rate (%)		0.53	0.53	0.55	0.55	0.5	0.5
Heat supply/customer	2.6	3.12	2.6	3.64	3.12	4.68	3.64
Total heat supply (1,000Gcal)	234	291	243	349	299	461	358
Ground total	4,373	5,064	4,290	6,534	5,535	8,277	6,917

Considering the growth rate in the past, the number of customers in the three cities is supposed to increase at the following rates:

	(% per year)
1993~2000	0.53
2001~2005	0.55
2006~2010	0.50

Heat supply per one customer is supposed to increase by 20% from 1993 to 2000, by about 17% from 2001 to 2005, and by about 30% from 2006 to 2010 in the high case. In the low case, heat supply per one customer is supposed to be maintained from 1993 to 2000, but to increase by 20% from 2001 to 2005 and by about 17% from 2006 to 2010.

Each growth rate of heat supply per one customer in both the high and low case reflects the recovery of economic activities in industry and other sectors, which are the main users of steam and hot water in the non-residential sectors. In addition, the reason for the growth rate of heat supply per one customer will be higher than that per one thousand of population as mentioned above is that economic activities in the non-residential sectors are foreseen to recover at faster rates than incomes in the residential sector.

(3) Coal demand for power plants

Coal demand for power plants is calculated based upon power and heat production in the future. In forecasting, 35% of gross thermal efficiency (heat rate = 2,450 kcal/kWh) and 80% of boiler efficiency are supposed. These efficiencies were estimated from the actual data of power plants. After 2005, the calculation of coal demand is considered heat recovery from the thermal boiler. However, heat recovery ratio* will be very low because of daily and annual load fluctuations. Table 2.23 shows the required coal amount for the power plants in the CES area. In the coal demand forecast, it is not considered the impact of Egiin hydropower because even the generation of 220 MW of the hydropower corresponds to only 337 thousand ton per year of coal (availability factor is 25%).

(Note) * : Heat recovery ratio from thermal boiler in 2010 is assumed as following:

In this study, it is supposed that power generating efficiency is 35 % and the rest of 65 %

Table 2.23 Coal Demand for Power Plants in the CES Area

		2000		2005		2010	
		High case	Low case	High case	Low case	High case	Low case
Gross thermal generation	1000kWh	3,105,000	2,952,639	4,483,472	3,956,944	7,053,889	5,584,306
(convert to calorie the above)	Gcal	7,607,250	7,233,965	10,984,507	9,694,514	17,282,028	13,681,549
Auxiliary power rate	%	20	20	20	20	20	20
Transmission loss	%	10	10	10	10	10	10
Net thermal generation	1000kWh	2,484,000	2,362,111	3,586,778	3,165,556	5,643,111	4,467,444
Final power consumption	1000kWh	2,235,600	2,125,900	3,228,100	2,849,000	5,078,800	4,020,700
Coal for power (7,000kcal/kg)	ton	1,086,750	1,033,424	1,569,215	1,384,931	2,468,861	1,954,507
Heat recovery from thermal boiler	Gcal	0	0	892,491	787,679	2,808,330	2,223,252
Heat demand	Gcal	5,064,000	4,290,000	6,534,000	5,535,000	8,277,000	6,917,000
Heat generation from heat boiler	Gcal	5,064,000	4,290,000	5,641,509	4,747,321	5,468,670	4,693,748
Coal for heat boiler (7,000kcal/kg)	ton	904,286	766,071	1,007,412	847,736	976,548	838,169
Required energy to heat boiler	Gcal	6,330,000	5,362,500	7,051,886	5,934,151	6,835,838	5,867,185
Total coal amount (7,000kcal/kg)	ton	1,991,036	1,799,495	2,576,628	2,232,666	3,445,409	2,792,676
Total coal amount (3,500kcal/kg)	ton	3,982,071	3,598,990	5,153,255	4,465,333	6,890,819	5,585,353

Heat rate (35%)	kcal/kWh	2450	
Boiler effeciency	%	80	
Heat recovery from thermal boiler	2000;	0%	
	2005;	8%	(65% × 25% × 50%)
	2010;	16%	(65% × 25%)

is energy loss. Supposed recoverable energy is a half of the 65% of energy loss considering daily load swing, moreover, annual recoverable energy is a half of daily recoverable energy considering annual load swing.

Annual recoverable energy = 65% x 50% x 50% = 16%

Beside, recoverable energy in 2005 is supposed a half of recoverable energy in 2010 so that exhaust heat recovery system will be installed only 50% of the total.

2.4.2 Coal demand of industry and construction sector

The coal demand forecast of industry/construction sector was also estimated by the model that was built by making regression analyses on the relationship between past trends of the NMP and coal consumption of the sector, because the coal consumption correlated with the NMP growth. The result by the model was made a total coal demand at nationwide level, so, JICA team assumed that coal demand of the sector in the CES area has 80% of the total.

2.4.3 Coal demand of other sectors

As regard to other sectors (transportation/communication, agriculture, service/household, and others), an econometric model can not be used for the forecast because there are no relationship among past trend of the coal consumption and the NMP growth. The historical coal consumption of these sectors rose and downed irrelevantly to the NMP growth. As the reason, it is considered that a statistical method of coal consumption in these sectors sometimes changed in the past. In Mongolia, it seems that coal demand of these sectors is consumed by the people who are engaged in the sectors as heating. So, in this study, these demand forecasts are increased in the population growth rate in the future and used based on the data before the economic disruption. JICA team assumes that the demand of these sectors in the CES has 50% of the total demand. Table 2.24 shows coal demand forecast by the models by sector in Mongolia and Table 2.25 shows coal demand by the models in the CES area, except electricity and heat sector.

2.4.4 Total demand forecast

After 2000, this copper mine plans to consume 550 thousand tons of coal that are supplied from Ulaan Ovoo coal mine that will start to operate after a few years. This model, however, can not forecast the development plan of new coal utilization projects. Mongolia is a developing country. In industry sector, some new projects will be carried out in the future. It is why JICA team added 300 thousand tons in 2000, 600 thousand tons in 2005, and 900 thousand tons in 2010 to the coal

Table 2.24 Coal Demand Forecast in Mongol by Models

		1995-1996	1997-2000	2001-2005	2006-2010
NMP growth rate (%)	High case	3.50	4.50	5.00	6.00
	Low case	3.00	3.50	4.00	4.50
		1993-2000		2001-2010	1993-2000
Population growth rate (%)		1.75		2.00	1.75

(Unit: 1,000 ton)

Year	Coal Demand					
	Industry/Construction		Transport	Agriculture	Residential	Others
	High case	Low case	Communication			
1993	734.6	734.6	75.0	517.0	737.0	676.8
1994	802.8	802.8	76.3	526.0	749.9	688.6
1995	843.2	840.1	77.6	535.3	763.0	700.7
1996	877.0	869.5	79.0	544.6	776.4	713.0
1997	916.6	901.0	80.4	554.2	790.0	725.4
1998	959.3	933.8	81.8	563.8	803.8	738.1
1999	1004.2	967.9	83.2	573.7	817.9	751.0
2000	1051.4	1003.3	84.7	583.8	832.2	764.2
2001	1104.9	1043.8	86.4	595.4	848.8	779.5
2002	1162.2	1087.1	88.1	607.3	865.8	795.1
2003	1222.7	1132.3	89.9	619.5	883.1	811.0
2004	1286.5	1179.6	91.7	631.9	900.8	827.2
2005	1353.7	1228.8	93.5	644.5	918.8	843.7
2006	1434.9	1285.0	95.4	657.4	937.2	860.6
2007	1523.9	1344.9	97.3	670.6	955.9	877.8
2008	1619.1	1407.9	99.2	684.0	975.0	895.4
2009	1720.5	1474.1	101.2	697.6	994.5	913.3
2010	1828.2	1543.3	103.2	711.6	1,014.4	931.5
Growth (%)	5.28	4.17	1.91	1.91	1.91	1.91

Table 2.25 Coal Demand Forecast in the CES Area by Models

		1995-1996	1997-2000	2001-2005	2006-2010
NMP growth rate (%)	High case	3.50	4.50	5.00	6.00
	Low case	3.00	3.50	4.00	4.50
		1993-2000		2001-2010	1993-2000
Population growth rate (%)		1.75		2.00	1.75

(Unit: 1,000 ton)

Year	Coal Demand					
	Industry/Construction		Transport Communication	Agriculture	Residential	Others
	High case	Low case				
1993	587.7	587.7	37.5	258.5	368.5	338.4
1994	642.2	642.2	38.2	263.0	374.9	344.3
1995	674.6	672.0	38.8	267.6	381.5	350.3
1996	701.6	695.6	39.5	272.3	388.2	356.5
1997	733.3	720.8	40.2	277.1	395.0	362.7
1998	767.4	747.1	40.9	281.9	401.9	369.1
1999	803.4	774.3	41.6	286.9	408.9	375.5
2000	841.1	802.6	42.3	291.9	416.1	382.1
2001	883.9	835.1	43.2	297.7	424.4	389.7
2002	929.7	869.6	44.1	303.7	432.9	397.5
2003	978.2	905.9	44.9	309.7	441.5	405.5
2004	1,029.2	943.7	45.8	315.9	450.4	413.6
2005	1,083.0	983.1	46.7	322.3	459.4	421.9
2006	1,147.9	1,028.0	47.7	328.7	468.6	430.3
2007	1,219.1	1,075.9	48.6	335.3	477.9	438.9
2008	1,295.3	1,126.4	49.6	342.0	487.5	447.7
2009	1,376.4	1,179.2	50.6	348.8	497.3	456.6
2010	1,462.6	1,234.6	51.6	355.8	507.2	465.8
Growth (%)	5.28	4.17	1.91	1.91	1.91	1.91

demand forecast by the models (Table 2.24, 2.25), taking these new projects into consideration. These amount of coal also include the demand of Darkhan steel plant in the future.

Table 2.26 and Figures 2.6 and 2.7 show the total demand forecast in Mongolia. Coal demand will increase from 5.56 million tons in 1993 to 8.87~9.30 million tons in 2000, 10.76~11.55 million tons in 2005, and 12.56~14.09 million tons in 2010. In 1993, Erdenet copper mine consumed 250 thousand of coal.

2.5 Required tonnage for coal supply storage

2.5.1 Stock at demand side

Conceptually, it will not be jeopardized by supplying required amount of coal, if coal has a margin of supplying capacity. However, it is preferable to secure coal supply for any unforeseeable trouble or discontinuation likely to happen at power and heat generation. In Japan, it is engaged to provide approx. 45 days of coal stocks at each power plant for security purpose, since Japanese consumers are largely dependent upon imported coal. In a practical sense, making allowance of 45 days could be deemed to be sufficient for reshuffling existing coal contractor to another suppliers.

For Mongolia, it is proposed in the report that the consumer side should have a stock of coal equivalent to approx. 15 days operation for the above reason. In the case of Mongolia, the following are considered as unstable factors for coal supply.

- Railway accident
- Failure of mining equipment in coal mine
- Temporary stop of mining due to a natural disaster such as heavy rain

(1) Problem on coal storage

It is understood that most of the Mongolian coal is lignite and it is difficult to store for a long time. That is, lignite with a low carbonization has high moisture content, a lot of volatile matter, and a high oxygen content compared to bituminous and anthracite. In general, when volatile matter and oxygen are enriched in their content and carbonization is low, the absorption of oxygen increases and oxidation is progressed. In the case of coal with high moisture content, oxidation is also progressed rapidly because cracks occur into the coal lumps when moisture evaporates and thereby the surface area to be oxidized increases. Therefore, coal such

Table 2.26 Overall Forecast of Coal Demand in Mongolia

(Unit: 1,000 ton)

	1993	2000		2005		2010	
		High	Low	High	Low	High	Low
CES area							
Power plants	3,336	3,982	3,599	5,153	4,465	6,891	5,585
Industry * & Construction	307	841	803	1,083	983	1,463	1,235
Transport & Communication	35	42	42	47	47	52	52
Agriculture	245	292	292	322	322	356	356
Service & Household	349	416	416	459	459	507	507
Others	320	382	382	422	422	466	466
Erdenet copper	250	550	550	550	550	550	550
Unspecified Projects	-	300	300	600	600	900	900
CES total	4,842	6,806	6,384	8,636	7,848	11,184	9,650
Outside CES area **	722	2,090	2,090	2,510	2,510	2,510	2,510
Export		400	400	400	400	400	400
Total	5,564	9,296	8,874	11,546	10,758	14,094	12,560

(Note) 1993 is estimated.

Demand of outside CES area and export uses the demand forecast of MGEM.

(Source) JICA study team estimate

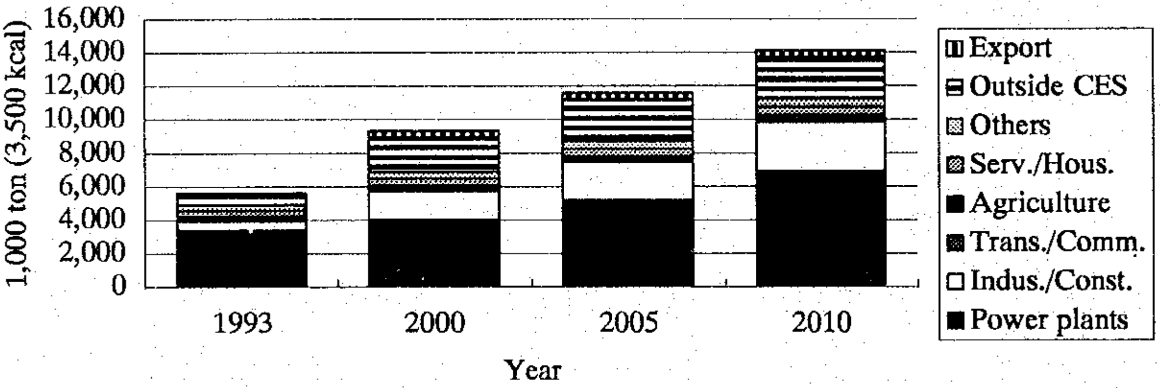

Figure 2.6 Coal Demand Forecast in Mongolia (High Case)

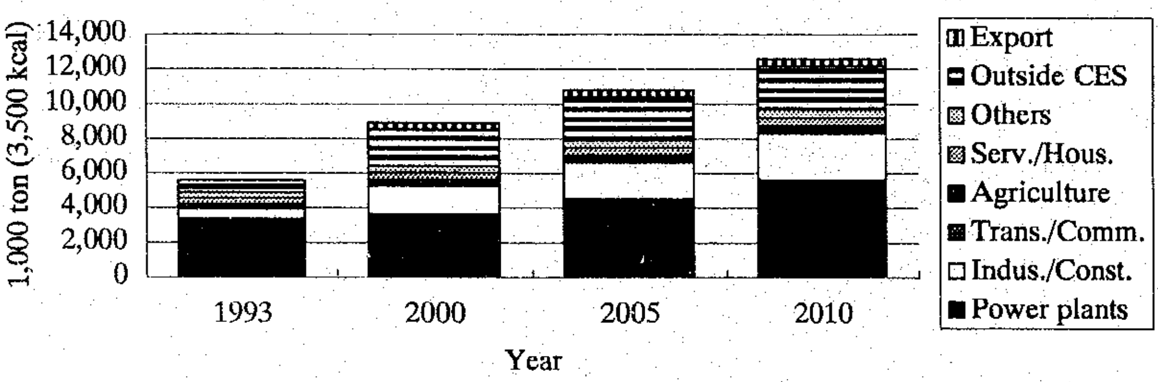

Figure 2.7 Coal Demand Forecast in Mongolia (Low Case)

as lignite with a low carbonization easily causes spontaneous combustion and it is difficult to store the coal for a long time.

Spontaneous combustion depends on the state of stored coal and meteorological conditions. In the case of lignite, spontaneous combustion is likely to occur within one week to ten days after stocked at surface stockyard. Spontaneous combustion greatly relates to the following factors.

- Coal quality
- Height of stock pile
- Size of coal
- Position of stock pile
- Rotation of stock pile
- Coal storage method

The oxidation rate of coal decreases for higher-quality coal. The worst stockpile is mixture of pulverized coal and lump coal with different sizes. Lumpy coal gives air passages to pulverized coal with a high possibility of spontaneous combustion. A temperature rise due to oxidation progresses an oxidation rate. Roughly speaking, the oxidation rate increases twofold whenever the temperature rises by 10 °C.

(2) Preventive measures of spontaneous-combustion

This report proposes the preventive measures of spontaneous combustion as follows;

- It is safe and effective to prevent inflow of air by applying rolling compaction to each coal layer or hardening the slope of a stock pile by a bulldozer or front-end loader. It is preferable that the slope of stock pile has an inclination of 30° or less.
- To pile up coal, stack the coal from a position with a small height (1 to 2 m) in order to avoid separation of coal with different lump sizes.
- In summer, store coal on a cloudy day or when temperature lowers in early morning or evening in order to avoid sunlight.
- Insert a pipe into a stock pile so that temperature and produced gas can be measured.
- When temperature rises, re-pile up coal in the stock pile. For this purpose, prepare another place to where coal can be transferred.

By taking these measures, it is possible to store lignite by preventing spontaneous combustion for a little longer period. However, duration of stocks depends on the quality of coal, condition of the coal storage yard, and weather. Therefore, it is necessary to enhance measurement such as temperature, carbon monoxide measurement and monitor the sign of the combustion prior to begin in earnest.

2.5.2 Problem of seasonal demand

Demand difference between summer and winter is one of other problems to be taken account by coal suppliers. In general, though there is no significant difference of power supply between summer and winter, there is a considerably large difference of supply of hot water and steam between summer and winter. Figure 2.8 shows the amounts of electric power, steam, and hot water supplied from three power plants in Ulaanbaatar in terms of electric energy for each month, which is described in the report on the study of energy efficiency and energy saving in Mongolia performed by MEGM. Figure 2.9 shows the coal consumption of each month (3,500 kcal/kg) calculated in accordance with the graph in Figure 2.8 (the conversion factor is based on the data of power plants in the Mongolian energy statistics). As described above, the coal consumption of a power plant greatly differs in seasons. Particularly, the consumption in winter reaches two times of the consumption in summer. By considering the above fact, it is preferable that coal suppliers will carry out stripping operation in summer when coal demand decreases and will prepare for winter when coal demand increases.

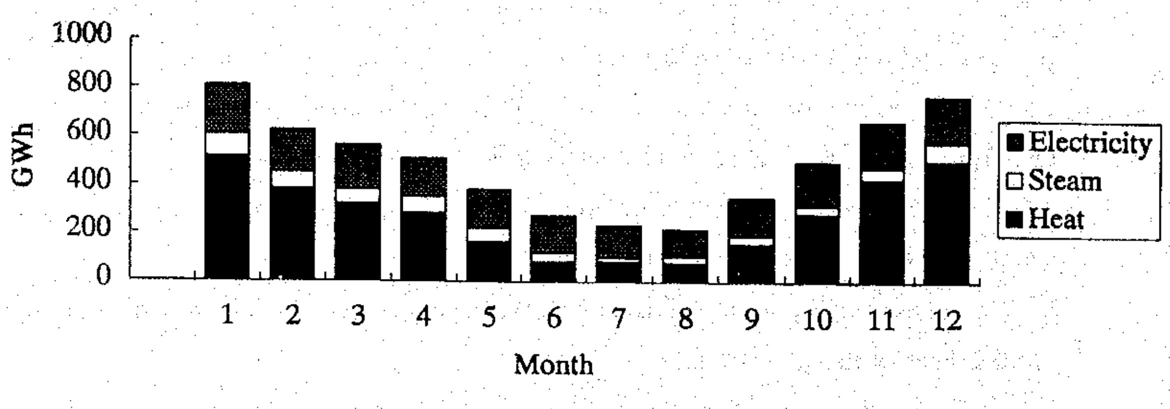

Figure 2.8 Enrgy Production from the Ulaanbaatar Power Plants in 1993

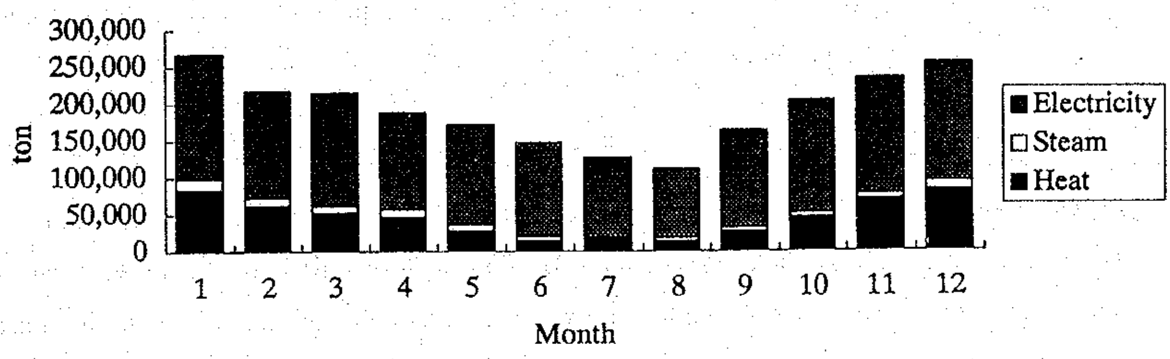

Figure 2.9 Coal Consumption in the Ulaanbaatar Power Plants in 1993

2.5.3 Margin on production capacity

At present, more or less 70% of production coal in Mongolia is consumed for power generation and heat supply industry. This JICA study also estimates that the particular percentage will not be drastically changed in the future. No doubt, it is extremely important to stably supply coal to the power plants from socio and economic point of view. In Mongolia, all power plants use domestic coal. Since security system is not established yet, immediate import coal from Russia or China if mine accident or a like should happened, will be difficult and change of supply sources of foreign coal will be urged to increase cost. To correspond to the decrease of coal to be supplied, it is preferable that coal mines have a production capacity slightly larger than the whole demand in Mongolia. According to a demand forecast in the CES area, the coal demand in 2010 reaches approx. 11 million tons in high case. For Mongolia, the worst case in which coal supply may decrease is the stop of coal supply due to an accident in Baganuur coal mine which accounts for 50% of Mongolian coal production or more. To determine the allowance of coal amount, it is assumed as the basis of assessment that Baganuur coal mine stops for one month. This is why coal production is rarely stopped for one month or more in other countries except a special case such as a strike. Moreover, each coal mine is made to implement the advanced overburden removal for two to three months for an emergency same as other countries do. To avoid stop of supply in the emergency, each coal mine can use trucks for overburden removal as a coal-mining truck tentatively. It cannot be considered that the above long-term production stop will happen so often in a year. In this study, when it is assumed that the overburden removal delayed during an emergency is taken back in one year using margin on production capacity and the stripping ratio of other coal mines is three, it is calculated that margin on supply capacity of approx. 450 thousand tons is to be added on the gross demand of coal when the production capacity of Baganuur coal mine is 3.7 million tons and an additional supply capacity of approx. 700 thousand tons is necessary when that of Baganuur coal mine is six million tons.

2.5.4 Required coal amount for new coal mines

Decentralization of energy supply sources is one of the subjects to secure stable supply of energy. The fact that half of the whole coal demand or more in Mongolia depends on one coal mine represents that other coal mines shoulder a large burden if a trouble of mining or transport occurs.

In the renovation plan of Baganuur coal mine in Part I of this study, the profitability of production increase of Baganuur coal mine is not still confirmed compared with another new coal development plans. Therefore, exploration and development of other prospective deposits are considered as a problem to be studied for profitability, diversification of risks, and local advancement. In this section, it is considered as one of options that the production scale of Baganuur coal mine is the 3.7 million tons level. The following are tabled as options for studying the development period and production scale of a new coal mine.

- 6 million tons of Baganuur coal mine
- 3.7 million tons of Baganuur coal mine

In addition to the above two options, the future demand forecast includes high and low cases which are summarized respectively (Tables 2.27~2.30). As the production capacity of Baganuur mine is 3.7 million tons in high case, new coal mines should be developed in 2001. In low case and six million capacity of Baganuur, new coal mines should be developed in 2009. In addition, it should be noted to develop the new mine of high quality coal as alternative sources of Sharyngol coal. Coal development plans after chapter 3 are carried out based on above required development capacity.

Table 2.27 Required Coal Amount in the CES Area - High Case (Capacity of Baganuur is 6 million tons)

(Unit: 1,000 ton)

	1993	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Required coal amount												
Demand in CES	4,842	6,806	7,172	7,538	7,904	8,270	8,636	9,146	9,655	10,165	10,674	11,184
Margin capacity		450	460	490	540	580	630	700	700	700	700	700
Total	4,842	7,256	7,632	8,028	8,444	8,850	9,266	9,846	10,355	10,865	11,374	11,884
Supply capacity												
Nalaikh	42	0	0	0	0	0	0	0	0	0	0	0
Baganuur	2,848	4,000	4,100	4,350	4,800	5,200	5,600	6,000	6,000	6,000	6,000	6,000
Shivee ovoo	603	1,600	1,900	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Sharyngol	1,183	800	800	800	800	800	800	800	800	800	800	800
Saikhan ovoo	3	20	20	20	20	20	20	21	22	23	24	25
Bayanteeg	108	200	204	208	212	216	220	220	220	220	220	220
Chandgantal	55	70	72	74	76	78	80	80	80	80	80	80
Ulaan ovoo	0	550	550	550	550	550	550	550	550	550	550	550
Others	21	24	24	25	25	26	26	27	28	28	29	29
New mines	0	0	0	0	0	0	0	200	700	1,200	1,700	2,200
Total	4,863	7,264	7,670	8,027	8,483	8,890	9,296	9,898	10,400	10,901	11,403	11,904

(Note) Others are Uburchuluut and Hangay

(Source) JICA study

Table 2.28 Required Coal Amount in the CES Area - Low Case (Capacity of Baganuur is 6 million tons)

(Unit: 1,000 ton)

	1993	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Required coal amount												
Demand in CES	4,842	6,384	6,677	6,970	7,262	7,555	7,848	8,208	8,569	8,929	9,290	9,650
Margin capacity		450	450	450	450	490	540	580	630	700	700	700
Total	4,842	6,834	7,127	7,420	7,712	8,045	8,388	8,788	9,199	9,629	9,990	10,350
Supply capacity												
Nalaikh	42	0	0	0	0	0	0	0	0	0	0	0
Baganuur	2,848	4,000	4,000	4,000	4,050	4,400	4,700	5,100	5,500	5,950	6,000	6,000
Shivee ovoo	603	1,200	1,460	1,750	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Sharyngol	1,183	800	800	800	800	800	800	800	800	800	800	800
Saikhan ovoo	3	20	20	20	20	20	20	21	22	23	24	25
Bayanteeg	108	200	204	208	212	216	220	220	220	220	220	220
Chandgantal	55	70	72	74	76	78	80	80	80	80	80	80
Ulaan ovoo	0	550	550	550	550	550	550	550	550	550	550	550
Others	21	24	24	25	25	26	26	27	28	28	29	29
New mines	0	0	0	0	0	0	0	0	0	0	300	700
Total	4,863	6,864	7,130	7,427	7,733	8,090	8,396	8,798	9,200	9,651	10,003	10,404

(Note) Others are Uburchuluut and Hangay

(Source) JICA study

Table 2.29 Required Coal Amount in the CES Area - High Case (Capacity of Baganuur is 3.7 million tons)

(Unit: 1,000 ton)

	1993	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Required coal amount												
Demand in CES	4,842	6,806	7,172	7,538	7,904	8,270	8,636	9,146	9,655	10,165	10,674	11,184
Margin capacity		420	420	420	420	420	420	420	420	420	420	420
Total	4,842	7,226	7,592	7,958	8,324	8,690	9,056	9,566	10,075	10,585	11,094	11,604
Supply capacity												
Nalaikh	42	0	0	0	0	0	0	0	0	0	0	0
Baganuur	2,848	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Shivee ovoo	603	1,900	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Sharyngol	1,183	800	800	800	800	800	800	800	800	800	800	800
Saikhan ovoo	3	20	20	20	20	20	20	21	22	23	24	25
Bayanteeg	108	200	204	208	212	216	220	220	220	220	220	220
Chandgantal	55	70	72	74	76	78	80	80	80	80	80	80
Ulaan ovoo	0	550	550	550	550	550	550	550	550	550	550	550
Others	21	24	24	25	25	26	26	27	28	28	29	29
New mines	0	0	250	600	1,000	1,300	1,700	2,200	2,700	3,300	3,700	4,200
Total	4,863	7,264	7,620	7,977	8,383	8,690	9,096	9,598	10,100	10,701	11,103	11,604

(Note) Others are Uburchuluut and Hangay

(Source) JICA study

Table 2.30 Required Coal Amount in the CES Area - Low Case (Capacity of Baganuur is 3.7 million tons)

(Unit: 1,000 ton)

	1993	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Required coal amount												
Demand in CES	4,842	6,384	6,677	6,970	7,262	7,555	7,848	8,208	8,569	8,929	9,290	9,650
Margin capacity		420	420	420	420	420	420	420	420	420	420	420
Total	4,842	6,804	7,097	7,390	7,682	7,975	8,268	8,628	8,989	9,349	9,710	10,070
Supply capacity												
Nalaikh	42	0	0	0	0	0	0	0	0	0	0	0
Baganuur	2,848	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Shivee ovoo	603	1,500	1,800	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Sharyngol	1,183	800	800	800	800	800	800	800	800	800	800	800
Saikhan ovoo	3	20	20	20	20	20	20	21	22	23	24	25
Bayanteeg	108	200	204	208	212	216	220	220	220	220	220	220
Chandgantal	55	70	72	74	76	78	80	80	80	80	80	80
Ulaan ovoo	0	550	550	550	550	550	550	550	550	550	550	550
Others	21	24	24	25	25	26	26	27	28	28	29	29
New mines	0	0	0	50	300	600	900	1,300	1,600	2,000	2,350	2,700
Total	4,863	6,864	7,170	7,427	7,683	7,990	8,296	8,698	9,000	9,401	9,753	10,104

(Note) Others are Uburchuluut and Hangay

(Source) JICA study

3 Coal Development Plan

3.1 Review of coal resources in Mongolia

3.1.1 Outline of coal resources

Mongolia is one of the prominent countries having large resources of coal in the world. Coal is found in a total of 15 large-scale coal-bearing basins (regions) as shown in Figure 3.1. These distributed limits of basins are presumably based on the similarities of each coal deposits and/or coal occurrences in terms of geological peculiarities such as major geotectonic structures, stratigraphical and paleogeographical features, and degree of coalification. In the basins, about two hundred ore deposits and occurrences are known from the whole country. According to the last report by the Department of Geology in 1993, the total geological coal reserves is estimated at 152.2 billion tons in the whole country.

Generation of coal accumulations on the territory of Mongolia occurred during the Carboniferous, Permian, Jurassic and Cretaceous ages, which differ from each other in conditions of coal-bearing deposit, degree of coalification and coal quality. In the process of their formation, the coal-bearing deposits migrated from west to east in ascending order. The most intensive accumulation of coal took place during the Middle-Upper Carboniferous, Upper Permian and Lower Cretaceous times.

All the coal deposits formed under continental environment in areas of intramontane troughs of varying sizes. In terms of geotectonic structure, these deposits are subdivided into two major groups : orogenic and young platform areas. The first group includes all Carboniferous, Permian and Jurassic deposits, and shows usually a rather complex folded pattern representing frequently graben-syncline broken into blocks. The second group comprises the Cretaceous deposits of eastern Mongolia, and is found at low grounds in present geographical features.

With regard to the degree of coalification, the Carboniferous and Permian coals belong to bituminous to subbituminous coals of the medium grade. The Jurassic coals are subbituminous or transitional (to lignites) coals. The Cretaceous ones mostly belong to lignites of the low degree in coalification and partially to transitional (to subbituminous) coals. The classification of coal ranks in Mongolia, USA, and Japan is summarized at Table 3.1.

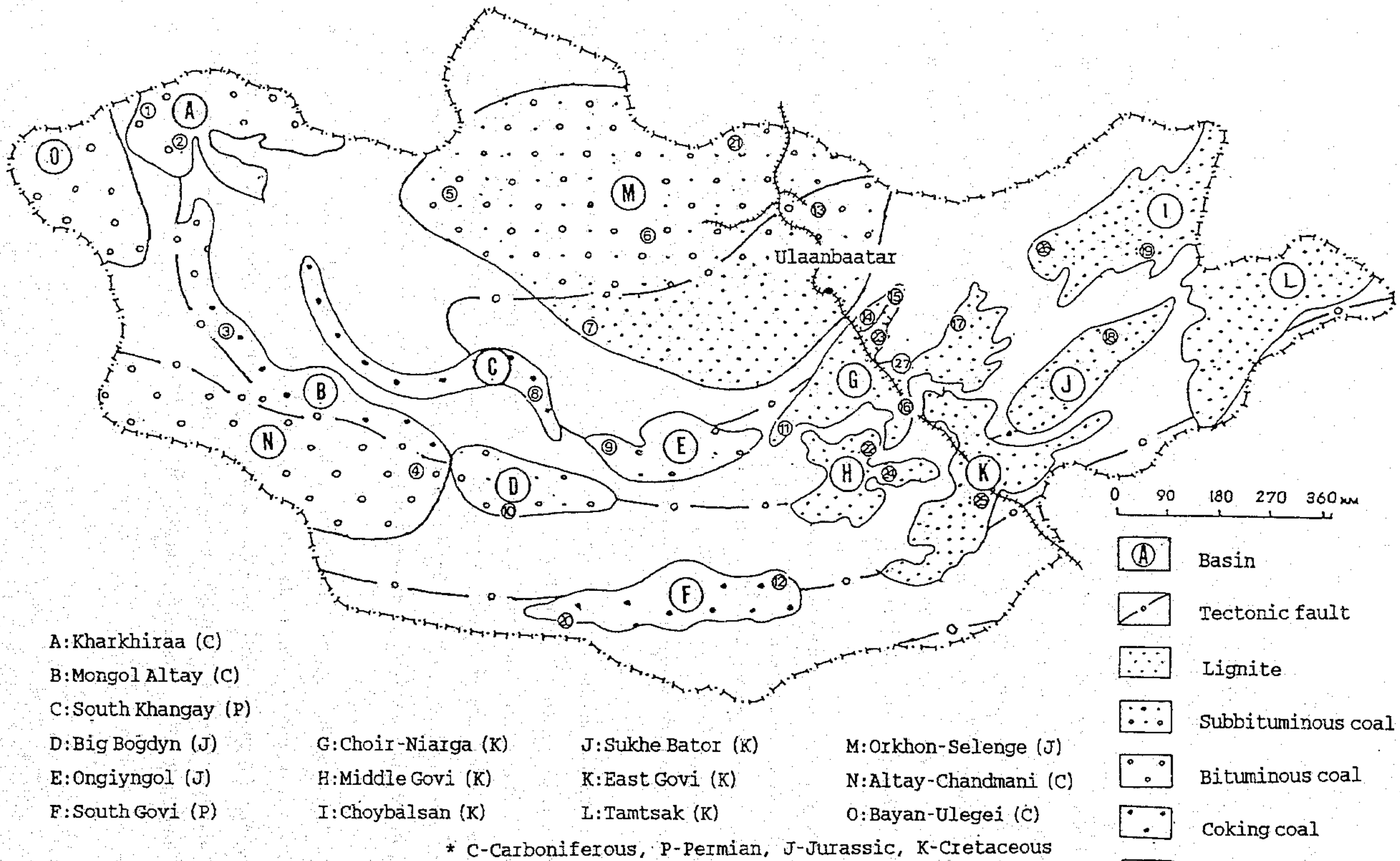

Figure 3.1 Distribution Map of Large-scale Coal-bearing Basins

Table 3.1 Classification of Coal Ranks

Rank: Mongolia	Rank: U.S.A (ASTM)	Rank: Japan (JIS)	Ro %	Vol.M. (daf) %	Carbon (daf) %	Bed Moiture %	Cal.Value kcal/kg (Btu/kg)	Applicability of Different Rank Parameters
	Peat		0.2	68, 64	60	75		
B 1	Lignite	Lignite F	0.3	60, 56		35	4,000 (7,200)	bed moisture (af); calorific value (daf)
B 2	SB C	F	0.4	52				
B 3~D	SB B	E		48	71	25	5,500 (9,900)	
	SB A	E	0.5					
D~G	HV C	SB	0.6	44	77	8-10	7,000 (12,600)	carbon (daf)
G J	HV B	D	0.7	40				
J	HV A	C	0.8, 0.9, 1.0	36, 32				
K~K J	M V	Bit. B	1.2, 1.4	28, 24	87		8,650 (15,500)	volatile matter (daf)
O C	L V	B	1.6	20				Ro
T	Semi Anthracite	Anth. A 2	1.8, 2.0	16, 12				
A	Anthracite	A 1	3.0, 4.0	8, 4	91		8,650 (15,500)	hydrogen (daf)
A	Meta-A	A 1						