Ministry of Mining

Mongolia

Mongolia

Master Plan Study for Coal Development and Utilization

November 2013

Japan International Cooperation Agency (JICA)

Japan Coal Energy Center

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Reference Materials

Abbreviations

ADB	Asian Development Bank
APERC	Asia Pacific Energy Research Center
BOT	Build Operate Transfer
BREE	Bureau of Resources and Energy Economics
CBM	Coalbed Methane
CCS	Carbon Capture and Storage
CCT	Clean Coal Technology
CHP	Combined Heat & Power
COG	Coke Oven Gas
COM	Coal Oil Mixture
CWM	Coal Water Mixture
DME	Dimethyl Ether
DOR	Department of Road
EIA	Energy Information Administration
FIFTA	Foreign Investment and Foreign Trade Agency
GDP	Gross Domestic Product
GTZ	German Technical Assistance Agency
HGP	Herlen Gobi Pipeline Project
HOB	Heat Only Boiler
IEA	International Energy Agency
IEEJ	The Institute of Energy Economics, Japan
IEO	International Energy Outlook
IGCC	Integrated Gasification Combined Cycle
IGFC	Integrated Gasification Fuel Cell
IMF	International Monetary Fund
JCC	Joint Coordinating Committee
JCOAL	Japan Coal Energy Center
JICA	Japan International Cooperation Agency
LPG	Liquefied Petroleum Gas
MCA	Millennium Challenge Account-Mongolia
MMRE	Ministry of Mineral Resources and Energy
MNS	Mongolian National Standards
MRAM	Mineral Resources Authority of Mongolia
MTG	Methanol to Gasoline
MTZ	Mongolian Railway State Owned Shareholding
NAQ	National Air Quality
NEB	National Energy Board

OGP	Orhon-Gobi Pipeline Project
OJT	On the Job Training
RAM	Railway Authority of Mongolia
toe	Ton of oil equivalent
UBC	Upgraded Brown Coal
USC	Ultra Super-Critical
WB	World Bank
WEC	World energy Council
WEO	World Energy Outlook

Chapter 1 Introduction

1.1 Background of the study

Mongolia is abundant in mineral resources such as gold, copper, coal, uranium, and rare earth metals. Existence of 80 types of mineral resources, 1,000 ore deposits, and 8,000 mineral resources has been confirmed until now..Mining industries accounted for 10% of Mongolia's GDP in 2002, but grew to 22% by 2011 and accounted for 83% of exports. The mining industry is currently the most important industry in Mongolia.

So far, in Mongolia, coal is mainly used as an energy source for domestic purposes. But, development of the Tavan Tolgoi coal mine (the largest underdeveloped coal mine, which is the largest in the world with about 6.4 billion tons of deposits) in south Gobi area is poised to start, and in the next few years, an expansion of 50 million tons of foreign export is predicted. Particularly, the coking coal export is also predicted. Furthermore, the planning for resources development projects, including coal mine development, is also underway. The environment surrounding the coal sector of Mongolia has undergone a rapid change in the past several years and infrastructure development projects in the surrounding areas (railway, road, electric power, etc.) have been released. The "coal program" of the Mongolian government including a future coal development policy and a coal utilization policy was planned in 2007; but, it is yet to be implemented and formulation of mid- and long-range plan including an export strategy has been called for.

In such a situation, the Mongolian government requested the creation of a "Master Plan Study for Coal Development and Utilization" in the mid- and long-term period for the synthetic development and utilization of coal. In response, JICA held discussions for the confirmation of the contents of the request made in July 2011. It was confirmed that the Ministry of Mineral Resource and Energy is demanding creation of master plan to review the contents of the "Study on comprehensive coal development and utilization in Mongolia", which JICA conducted in 1995. Later, the Record of Discussion was signed in March 2012 after a detailed planning study in December 2011.

1.1.1 Outline of Mongolia

Mongolia is a landlocked country sandwiched between Russia and China, with a total area of 1,565,600 km^2, which is about 4.2 times the area of Japan. About 65% of the area is grassland called as steppe, the southern part of the country is desert (Gobi Desert), which constitutes 15% of total area, and the northern part mainly consists of mountains and forests, which constitute 12% of the total area.

The use of coal for primary energy was high, a feature of the energy balance of Mongolia. According to the data[1] in 2009, coal accounted for 72.9% of primary energy consumption. With significant development in the transportation sector, the amount of oil consumption is on the rise. Presently, the coal dependence rate in Mongolia is decreasing but the estimated percent of coal as the primary energy in the year 2030 is 59.8%, which is still high. Therefore, it can be said that the position of coal as the main energy source in the country will remain unchanged.

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1 IEA Statistics & Balance, http://www.iea.org/stats/pdf_graphs/MNTPES.pdf

The usage of coal is 80% for electricity and heat supply (Combined Heat & Power, CHP), 9% for residential fuel, and 11% for industrial and other uses. In particular, supply of heat is very important and all main power plants are CHP systems. Annually, about 60% of coal is consumed for electric power and 40% for heat generation in plant. 80% of coal for heat generation is consumed in winter (mid-September to mid-May).

The coal resources of Mongolia are reserved in 15 main sedimentary basin and more than about 320 places of coal deposits are confirmed. The total amount of coal resources of Mongolia is 165 billion tons of which about 70% is lignite. Coal production of Mongolia in 2011 was about 33 million tons from which about 6.2 million tons was consumed internally and about 26 million tons was exported. The export of Mongolia has been increasing rapidly since 2003, and a major part of it is coking coal for China. The forecasting for coal demand in China shows an average increase of 1.2% per year from 2008 to 2035. It has been predicted that it will amount to about 2.8 billion tons in 2035, and it is expected that Chinese coal import from Mongolia will increase further from now on.

In recent years, the development project of a large-scale coal mine has been underway in Mongolia, and development of coking coal, especially in a south Gobi district, has attracted global attention. The Mongolian government placed the Tavan Tolgoi coal deposit in the south Gobi as a "strategically important deposits", and is advancing the development plan with governmental guidance. The mining area held by the Mongolian government is divided into WEST TSANKHI and EAST TSANKHI area. Erdenes Tavan Tolgoi (ETT), which is a state-owned firm, had taken up mining of EAST TSANKHI area. However, it was announced in December 2010 that it was decided to choose the developer in WEST TSANKHI through international bidding. Each tender applicant and the Mongolia government will negotiate, and finally a successful bidder will be decided. Development of the WEST TSANKHI area with 0.6 billion tons of resources will be started.

According to the 1997 Minerals Law of Mongolia, the mining area was more open for foreign applicants than domestic applicants for receiving favorable tax measures. Therefore, there were opinions that, in some areas, there would be no benefit to government due to the removal of precious resources out of the country, which would in turn harm national interests. From such a background, the Minerals Law was amended, which guaranteed that national interest was upholded with the resource development. In addition to that, environment preservation mechanism has been introduced in recent years, which is one of the main concerns of every country. It is expected that it will lead to the development of domestic resources from now on.

1.1.2 Present condition of industry and economic growth of Mongolia

A general economic condition of Mongolia is shown in Table 1-1. The key industry includes agriculture, stock raising forestry and mining. In agriculture and stock raising forestry, cashmere, wool, leather, fur, wood, furniture, etc. are the mainstream industry. In mining, molybdenum, copper, and coal are produced in large scale, while the development of gold, silver, tin, tungsten, lead, oil shell, oil, etc. is expected.

Prior to 2008, the Mongolian economy, which relies heavily on mineral resource exports, had been making steady progress due to the influence of price increases in world mineral resource markets.

However, due to price increases in grain and petroleum products and steep price drops for resources and raw cashmere wool caused by the global recession, Mongolia's economy slowed greatly. Since copper price was high until the global recession occurred, there was not much fall in economic growth rate of Mongolia in 2008 (at 8.9%), but it fell to 1.3% in 2009.

Through IMF fiscal programs and governmental policies of fiscal tightening based on these programs, the recovery of the economy of the largest importer of Mongolian exports, China, and increases in resource prices, the Mongolian economy rebounded quickly, with a growth rate of 6.3% in 2010 and 17.26% in 2011.

Meanwhile, using increases in estimated income due to increases in mineral resource prices, the Mongolian government established the Human Development Fund, and is restarting a policy to distribute MNT 1.5 million to each Mongolian citizen and a decision to raise the salaries of government workers by 30% starting in October 2010. Fortunately, there was financial surplus due to the rise of the mineral resources prices in 2010. However, if the mineral resources price falls, it leads to anxiousness about the possibility of seriously damaging the macro-economy of Mongolia again.

The following are thought to be the most important issues for the Mongolian economy going forward. In recent years, Mongolian economy has been greatly influenced by change of mineral resources prices including copper. In order to aim for stable economic growth from now on with a steady progress in mineral resources development, the construction of economic structure, which is only independent of mineral resources, is called for. The following are the main issues raised in the Mongolian economy:

1) Promoting development in the mineral resources field, such as copper and gold ore deposit, and coal deposits
2) Counter measure of poverty, reducing the gap of wealth and poverty
3) Maintenance of an infrastructure
4) Reduction of the regional gap by community development
5) Measures against environmental destruction

Table 1-1 General economic condition of Mongolia

Main industry	Mining Stock farming Distribution industry Light industry	Major trade items	(1) Export Mineral resources (coal, copper ore, fluorite) crude oil Stock farming products (cashmere, leather) (2) Import Oil fuel Automobile Type of machinery and equipment Convenience goods medical supplies
Each GDP	8,557.6 million US dollar (Year 2011, World Bank)		
GDP per capita	2,562 million US dollar (Year 2011, World Bank)		
Economic growth	17.3% (Year 2011, NSC)		
Inflation rate	10.2% (Year 2011, NSC)		
Unemployment rate	approx. 7.7% (Year 2011, NSC)	Foreign reserves	2,273.9 million dollar (Year 2011, NSC)
Total trade	11,415.9 million US dollar (Year 2011, NSC) (Income & Expenditure ： -2,568.3 million US dollar) (1) Export 4,817.5 million dollar (2) Import 6,598.4 million dollar	Major trading partners	(1) Export (Year 2011, NSC) China, Russia, Canada, Italy, South Korea (2) Import (Year 2011, NSC) China, Russia, the United States, Japan, South Korea
		Currency	Tugrik (MNT)
		Exchange rate	1 U.S. dollar = 1,265.46 (Year 2011 year average, NSC)
		National Budget for the year 2011	Income & Expenditure Approximately $ 1 million (Year 2011, NSC) Annual expenditure About 4 trillion 79.2 billion Tugrik (U.S. $ 3,786.8 million)

Source: Ministry of Foreign Affairs of Japan website as of August 2012

1.2 Purpose of study

This study aims at formulating development and utilization master plan of Mongolia, which is targeted for the year 2025. Particularly, the coal supply and demand assumption in Northeast Asia (potential export market of Mongolia, which includes Northeast Asia focusing on Japan, China, South Korea, and Russia), which gazed at export diversification of coal, is considered. After examining the possible use of arrangement and analysis of the existing information, coal utilization technology of the clean coal technology related to Mongolian coal development, a coal exploitation master plan is drawn up.

1.3 Flow of study

Fig. 1-1 shows the study flow on the master plan for coal development and utilization.

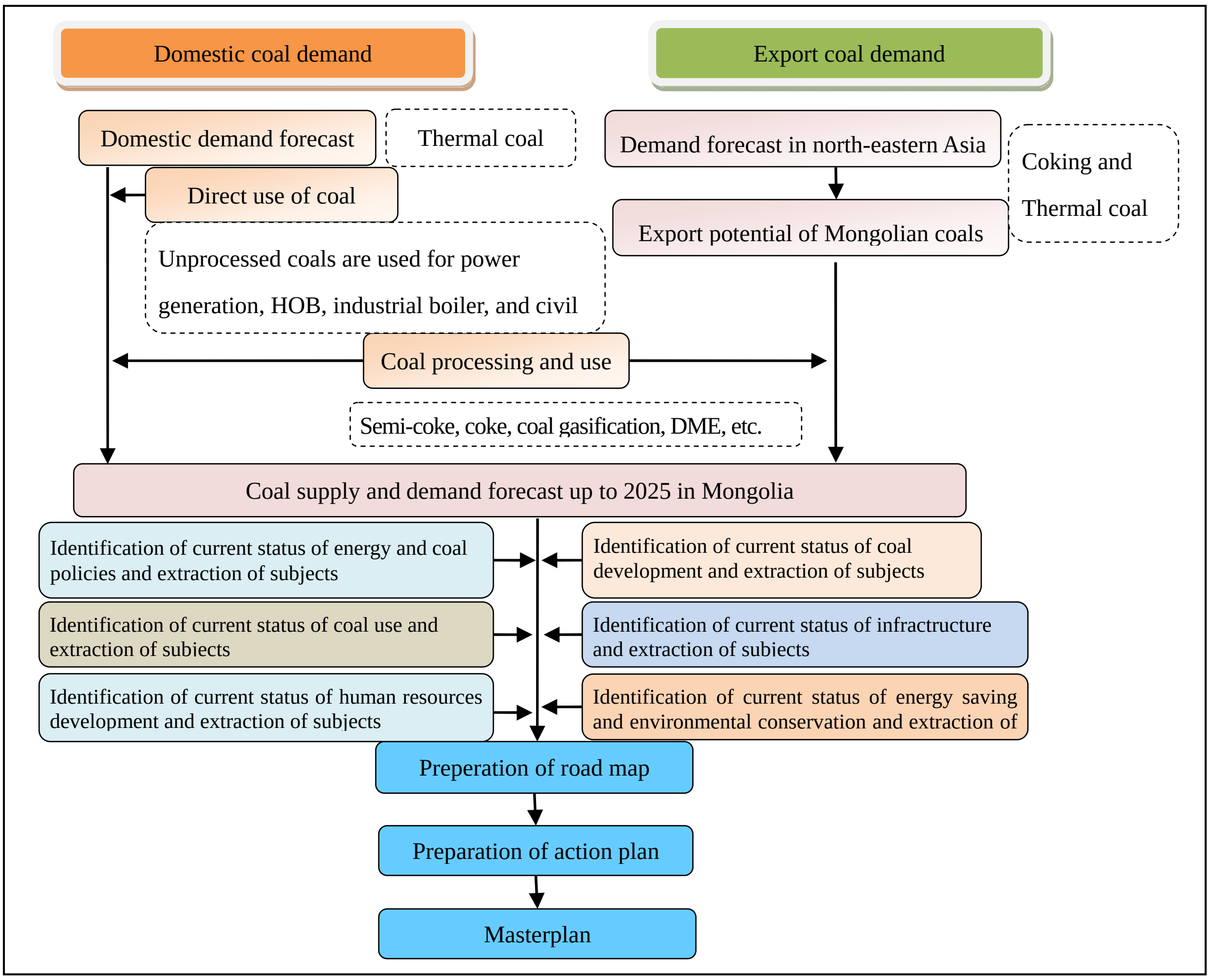


Fig. 1-1 Study flow on the coal development & utilization master plan

1.4 Study system

1.4.1 Counterpart mechanism

A counterpart team that appointed persons in charge focusing on JCC (Joint Coordinating Committee) members' sector shall be established, and close sharing of planning and analysis of data/materials (including technology transfers for each sector) with other related organizations shall be performed.

A reorganization of ministries and government offices took place as a result of the general election held on June 28, 2012 after the launch of this project. Fig. 1-2 and Fig. 1-3 denote the counterpart agencies under the former and current administrations, respectively.

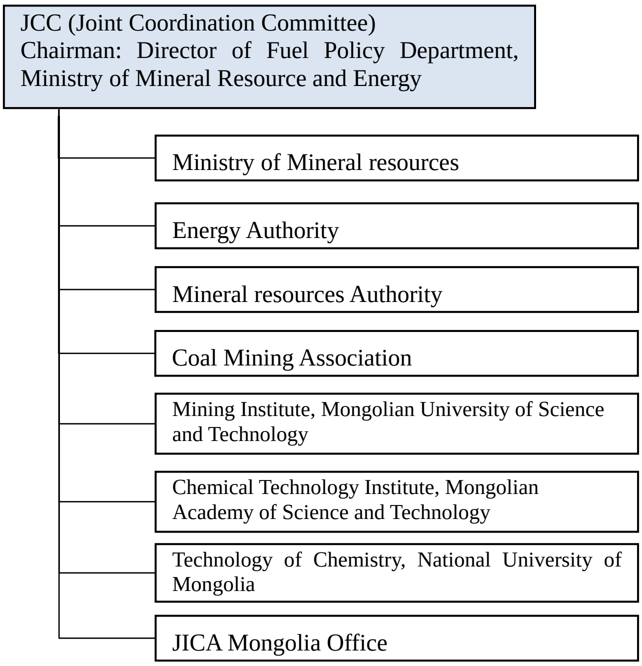


Fig. 1-2 JCC members of the Ex-Government

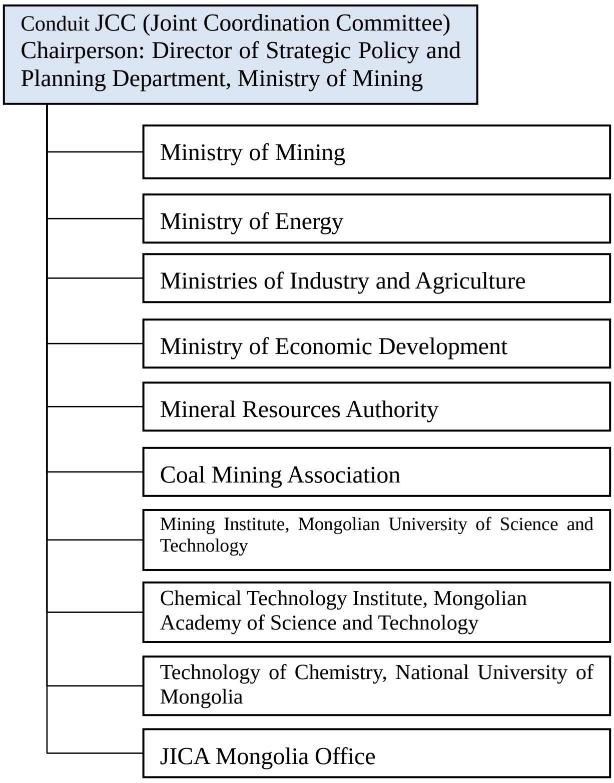


Fig. 1-3 JCC members of the New Government

1.4.2 Old and New Government organizations

(1) Old organization

The colored section in Fig. 1-4 indicates the counterpart to this project under the former administration.

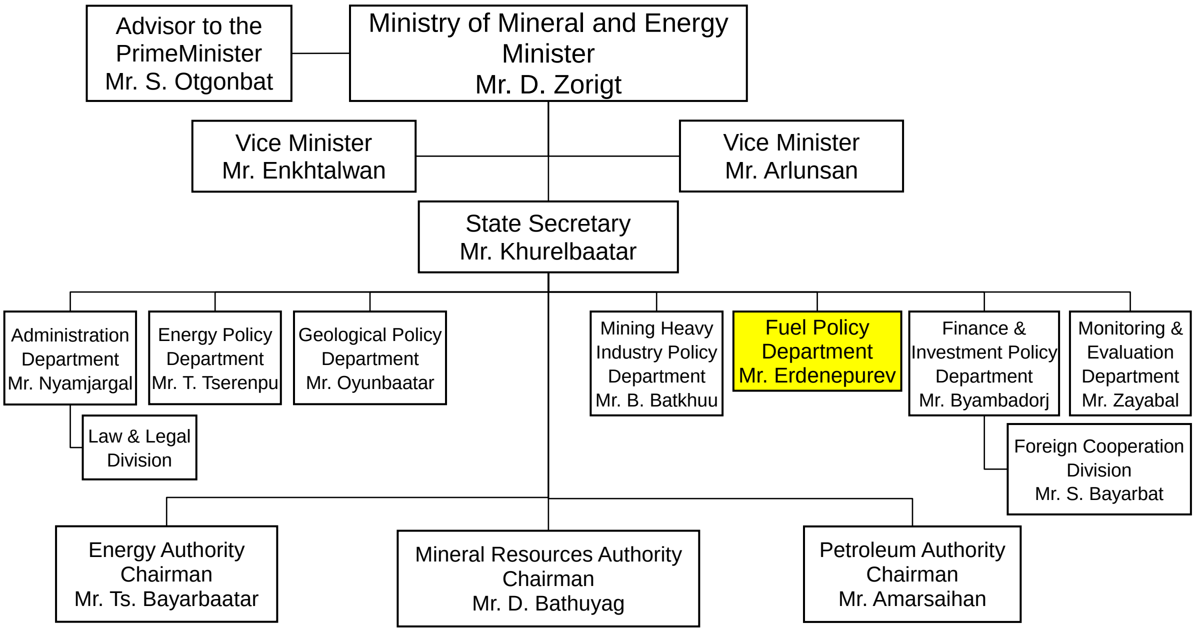


Fig. 1-4 Organization of the Ministry of Natural Resources and Energy upto August 2012

(2) New organization

Fig. 1-5 is an organizational chart for the Ministry of Mining, the counterpart of the new administration.

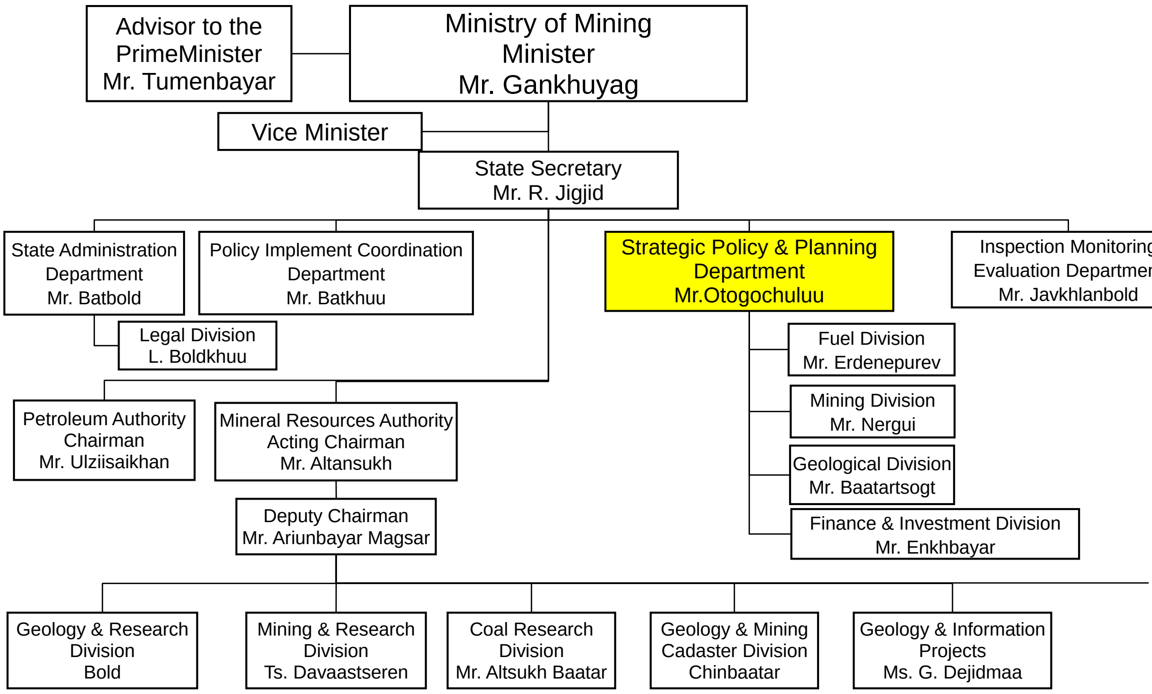


Fig. 1-5 Ministry of Mining organization from September 2012

1.4.3 Structure and allotment of study group

(1) Composition of study group

The Master Plan Study is composed of the following four teams:

(a) Future outlook team of coal supply and demand, such as Northeast Asia
(b) Future development planning team and current analysis of coal development
(c) Possible use of coal utilization technology team
(d) Energy saving and environmental protection planning team in coal-related facilities

(2) Work allotment

Table 1-2 and Table 1-3 show the work allotment of each member on the study.

Table 1-2 Work allotment (1)

Name	In charge	Work content
Hajime Endo	Project management	· Project management · Summary of master plan for coal development and utilization · Summary of action plan
Masafumi Uehara	Coal development/sub summary	· Overall assistance · Making master plan for coal development and utilization (coal supply and demand, coal development, economic infrastructure) · Scrutiny of an action plan (coal supply and demand, coal development, economic infrastructure)
Koji Morita	Economy and market analysis 1	· Future analysis of coal supply and demand (coal market) in Northeast Asia (Overall, in charge of the coal supply country) − Supply capacity of the major coal-producing countries − Possibility of entry into the market of Northeast Asia Mongolia coal · Analysis of potential coal supply of existing mines in Mongolia · Study of future supply of coal by Mongolia
Atsuo Sagawa	Economy and market analysis 2	· Future analysis of coal supply and demand (coal market) in Northeast Asia (In charge of the coal consuming countries) − coal demand forecast of China, South Korea, Taiwan, and Japan (Coal demand modeling) − Coal demand forecast of various southeast Asian countries, India · Analysis of the world energy supply and demand · Analysis of future trends in the world coal demand and price
Eiji Yamashita	Coal development plan 1	· Review of coal-related legislation & policy in Mongolia · Analysis and proposal on development of coal mine and economic infrastructure in Mongolia · Study of coal development project
Kosuke Tanaka	Coal development plan 2	· Review of coal information in Mongolia (coal deposit &, reserves) · Review of coal mine development plan
Koichi Koizumi	Coal development plan 3	· Information gathering and analysis on status of coal production and development plan · Study and proposals on legislation related to coal production

Table 1-3 Work allotment (2)

Name	In charge	Work content
Yasushi Kawamura	Coal utilization plan 1	· Overview of coal utilization in the world · Review of legislation and policy on coal utilization · Proposal on development and utilization of coal (coal environmental policy, utilization policies coal) · Study of the possibility of using Clean Coal Technology (CCT) · DME technology
Shuntaro Koyama	Coal utilization plan 2	· Study of the possibility of using CCT · Coal gasification and power generation technology · Proposal on human resource development, education and OJT training of CCT
Nobuhiro Koyanagi	CCT/gasification 1	· Study of the possibility of using CCT · Analysis of coal preparation technology and study on the possibility of its improvement in Mongolia
Takashi Nakamura	CCT/gasification 2	· Economic evaluation study of applicability (briquettes, coke, gasification, DME) of Mongolia that targets in 2005
Toshihiko Yamada	CCT/gasification 3	· Analysis of current situation of coal utilization and study on the possibility of its improvement in industrial sector in Mongolia
Shigenobu Takada	CCT/gasification 4	· Analysis of current situation of coal utilization and study on the possibility of its improvement in industrial sector in Mongolia
Junichi Kamada	CCT/gasification 5	· Workshop in Mongolia · Implementation of Training programs focused on coal utilization technology in Japan
Yasuhiro Konno	CCT/gasification 6	· Analysis of current situation of coal utilization and study on the possibility of its improvement in power sector in Mongolia
Chang Jing	CCT/Gasification 7	· Information-gathering of CCT
Norio Ishihara	Related infrastructure plan 1	· Analysis of existing data related to the infrastructure development of coal and proposal on development of economic infrastructure
Hanji Koga	Related infrastructure plan 2	· Collection and analysis of the existing data related to infrastructure for coal development (transportation for domestic demand, railway and road)
Haruo Inoue	Environmental and Social Considerations 1	· Study and evaluation of environmental impact if the master plan is put into action · Analysis of current situation of activities on energy conservation & environmental protection in the World/ Mongolia · Study of the plan for energy conservation and environmental protection in Mongolia with the target year at 2025
Shinji Tomita	Environmental and Social Considerations 2	· Review of laws and policy on energy conservation and environmental protection · Analysis of current situation on technology related to energy conservation and environmental protection and study of application of the new technology

1.5 Study schedule

Fig. 1-6 shows the overall schedule of the study.

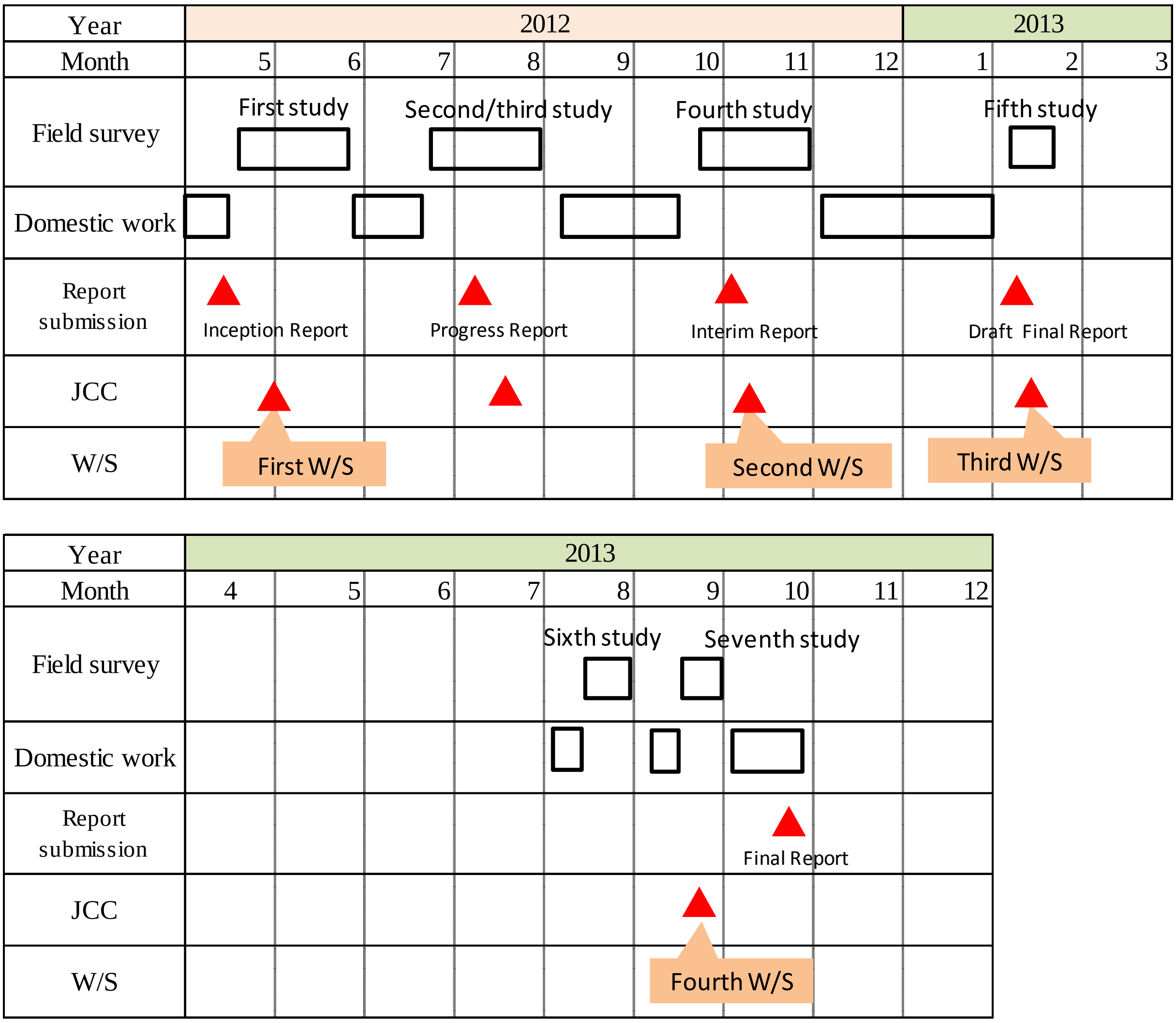


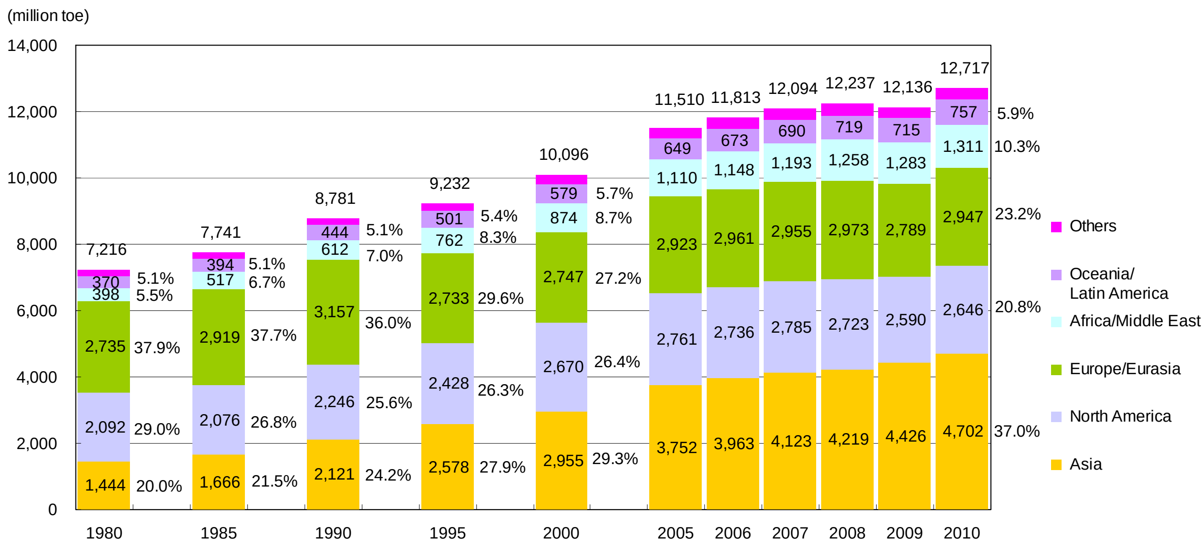
Fig. 1-6 Study schedule

Chapter 2 Coal Supply-Demand Forecasts for Major Supplier Countries and Northeast Asia, Etc.

2.1 Analysis of present global energy supply-demand situation[2]

2.1.1 Global energy supply and demand

World primary energy consumption[3], as shown in Fig. 2-1, had been soaring until 2008, but in 2009, its consumption decreased by 102 million toe (ton oil equivalent) from the preceding year to 12,136 million toe under the influence of global recession. In 2010, however, primary energy consumption increased substantially to 12,717 million toe due to economic recovery, increasing by 582 million toe from the year before. Looking at share by region, energy consumption increased in every region, in particular, significant increase was found in Asia[4] (up 276 million toe year-over-year) and Europe/Eurasia[5] (up 159 million toe year-over-year). Regarding changes in share by region, Europe/Eurasia gained the largest share of 37.9% in 1980, followed by North America with 29.0%, and Asia with as low as 20.0%. In and after 1997, however, Asia came to gain the largest share and, in 2010, Asia expanded its share to 37.0% while Europe/Eurasia and North America decreased their share to 23.2% and 20.8%, respectively.



Note: Others represent fuel for international aviation and marine bunkers.

Source: Prepared by JICA study team based on the "Energy Balance of OECD/Non-OECD Countries 2012" of IEA

Fig. 2-1 World Primary Energy Consumption by Region

Looking at global energy consumption by source, oil gains the largest share, followed by coal as

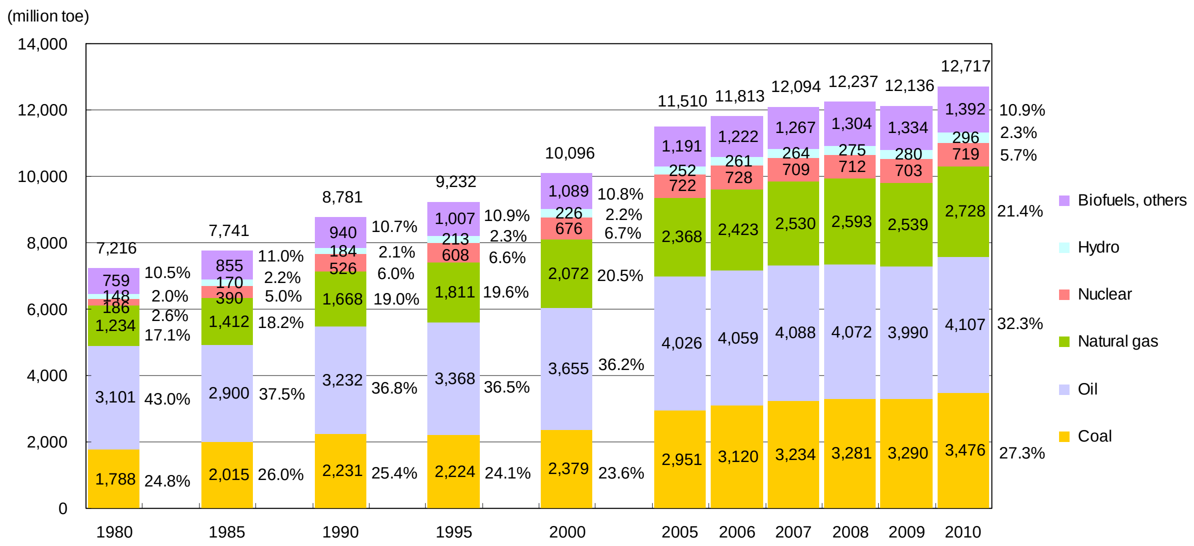
[2] Based on the data released by IEA in 2012 (Energy Balance of OECD/Non-OECD Countries 2012).

[3] IEA presents amounts of domestic supply by taking import/export volumes, etc. into consideration along with domestic production of each country. Here, such a domestic supply amount is regarded as consumption.

[4] Asia region except the Middle Eastern countries to the west of Iran and Afghanistan and the Central Asian countries that belonged to the former Soviet Union.

[5] Region including the European countries and the Central Asian countries that belonged to the former Soviet Union.

shown in Fig. 2-2. As for the growth of energy consumption by source between 2000 and 2010, coal grew at an annual rate of 3.9% which is the highest among all fossil energy sources, followed by natural gas with 2.8%, and then by oil with 1.2%. Looking at share by source, oil, coal and natural gas accounted for 36.2%, 23.6% and 20.5%, respectively in 2000, and 32.3%, 27.3%, and 21.4%, respectively, in 2010. Namely, during that period, oil recorded a 3.9-percentage point decrease in share while coal and natural gas expanded their shares by 3.8 and 0.9 points of percentage, respectively.



Source: Prepared by JICA study team based on the “Energy Balance of OECD/Non-OECD Countries 2012” of IEA

Fig. 2-2 World Primary Energy Consumption by Source

Next, characteristics of primary energy supply and demand by major region (Asia, North America, Europe/Eurasia, and others[6]) are sorted out.

Fig. 2-3 indicates that, in Asia, coal plays a leading part in supply-demand composition of energy. As for fossil energy, consumption of any kind exceeds its production, preventing consumption from being satisfied with internal production alone to inevitably depend upon imports from outside. In particular, dependence on oil imports is greater than other regions. As far as coal and natural gas are concerned, production within the region is large and, therefore, its dependence on imports from outside is scarce.

North America is the largest consumer of oil and cannot satisfy its consumption with internal production, inevitably depending upon imports to make up for shortfall. Coal production exceeds coal consumption in North America, and the United States and Canada are regarded as coal-exporting countries. Production and consumption of natural gas are roughly balanced within the region.

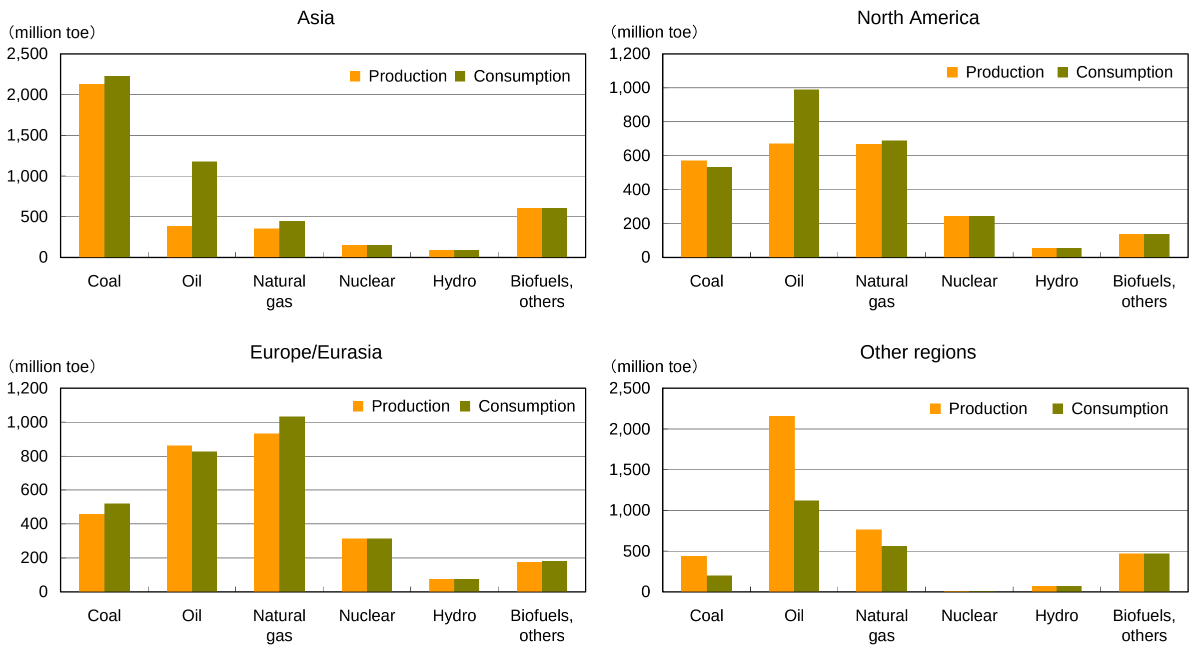
In Europe/Eurasia, unlike in Asia and North America, production and consumption of oil are roughly balanced since the former Soviet Union and other oil producing countries are included. Despite that the former Soviet Union, Germany, Poland, etc. are rich in coal, and the former Soviet Union and the North Sea’s coastal countries, etc., are rich in natural gas, their consumption exceeds their production in the

6 Region including Africa, the Middle East and Oceania (excluding Asia, North America, and Europe/Eurasia).

region as a whole, requiring imports from outside.

As for other regions, since Australia which is a leading coal exporter (and also exports natural gas) and oil/gas-producing countries in Middle East and Africa are included, production of fossil energy exceeds its consumption and these countries bear the role of supplying it to regions that depend upon imports for fossil energy like Asia, North America, and Europe/Eurasia.

"Biofuels, others" tend to be consumed more in developing countries in Asia, Africa, etc. since firewood, wastes, and other types of fuel account for 90% or more of "biofuels, others".

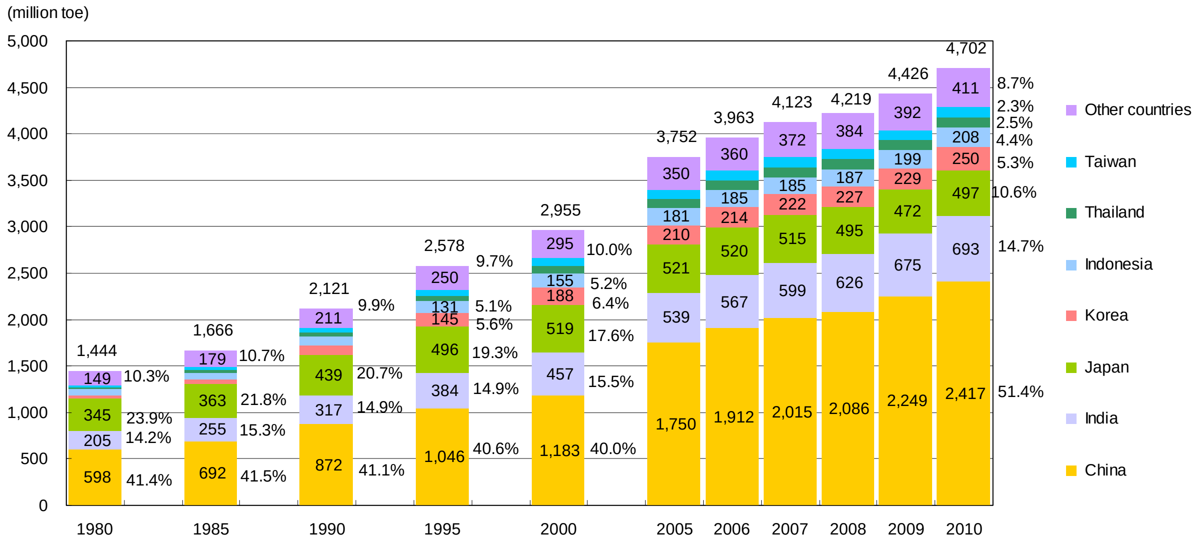


Source: Prepared by JICA study team based on the "Energy Balance of OECD/Non-OECD Countries 2012" of IEA

Fig. 2-3 2010 Supply-Demand Composition of Primary Energy by Region

2.1.2 Energy Supply and Demand in Asia

Whole Asian primary energy consumption steadily increased even in 2009 of global recession and the amount consumed in 2010 reached 4,702 million toe. Looking at Asian primary energy consumption by country/region in 2010, energy consumption increased in countries like China (up 168 million toe year-over-year), Japan (up 25 million toe year-over-year), South Korea (up 21 million toe year-over-year), and India (up 17 million toe year-over-year) as shown in Fig. 2-4. Looking at changes in share by country/region between 1980 and 2010, China, gaining the largest share, expanded it by 10.0 percentage points from 41.4% in 1980 to 51.4% in 2010. India's share remained between 14% and 16% during that period. Japan brought down its share by 13.3 percentage points during that period to mark 10.6% in 2010.

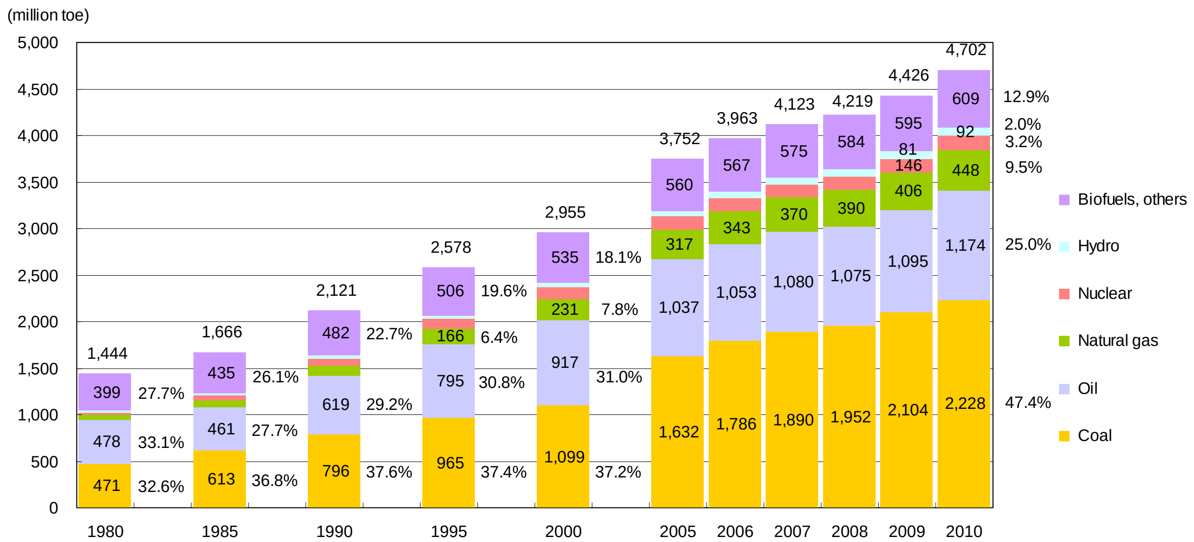


Note: Top 7 Asian energy consuming countries/regions in 2010

Source: Prepared by JICA study team based on the "Energy Balance of OECD/Non-OECD Countries 2012" of IEA

Fig. 2-4 Primary Energy Consumption by Country in Asia

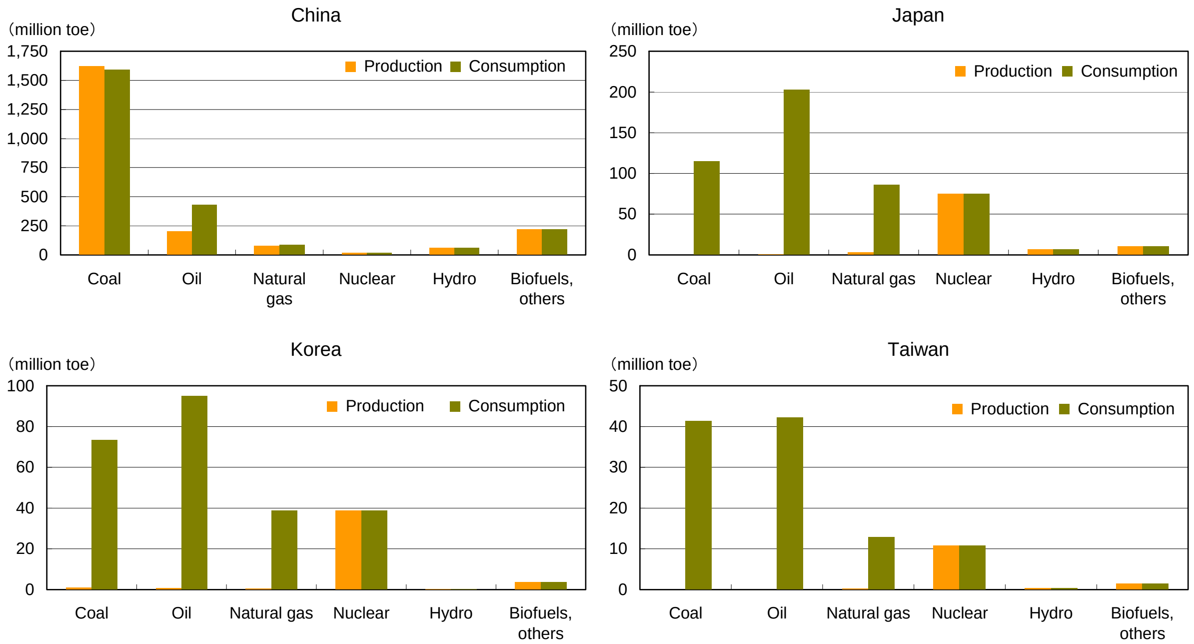
Looking at energy consumption by source in Asia, it is found that coal has the largest share as shown in Fig. 2-5. As for the growth between 2000 and 2010, coal grew at annual rate of 7.3% which is the highest among all fossil energy sources, followed by natural gas with 6.9%, and oil with 2.5%. Looking at share, coal, oil, and natural gas accounted for 37.2%, 31.0%, and 7.8%, respectively in 2000, and 47.4%, 25.0%, and 9.5%, respectively, in 2010. Namely, during that period, oil marked a 6.1-percentage point decrease in share while coal and natural gas expanded their shares by 10.2 and 1.7 points of percentage, respectively.



Source: Prepared by JICA study team based on the "Energy Balance of OECD/Non-OECD Countries 2012" of IEA

Fig. 2-5 Primary Energy Consumption by Source in Asia

Fig. 2-6 shows the supply-demand composition of primary energy in 2010 in China, Japan, South Korea, and Taiwan composing the northeast Asia coal market. As far as coal is concerned, only China can satisfy its consumption by its domestic production, while Japan, South Korea, and Taiwan, which are difficult to develop new mines in their countries because of higher production costs, depend upon imports from overseas for most of coal consumption. Japan, South Korea, and Taiwan also depend upon imports for other fossil energy (oil and natural gas).

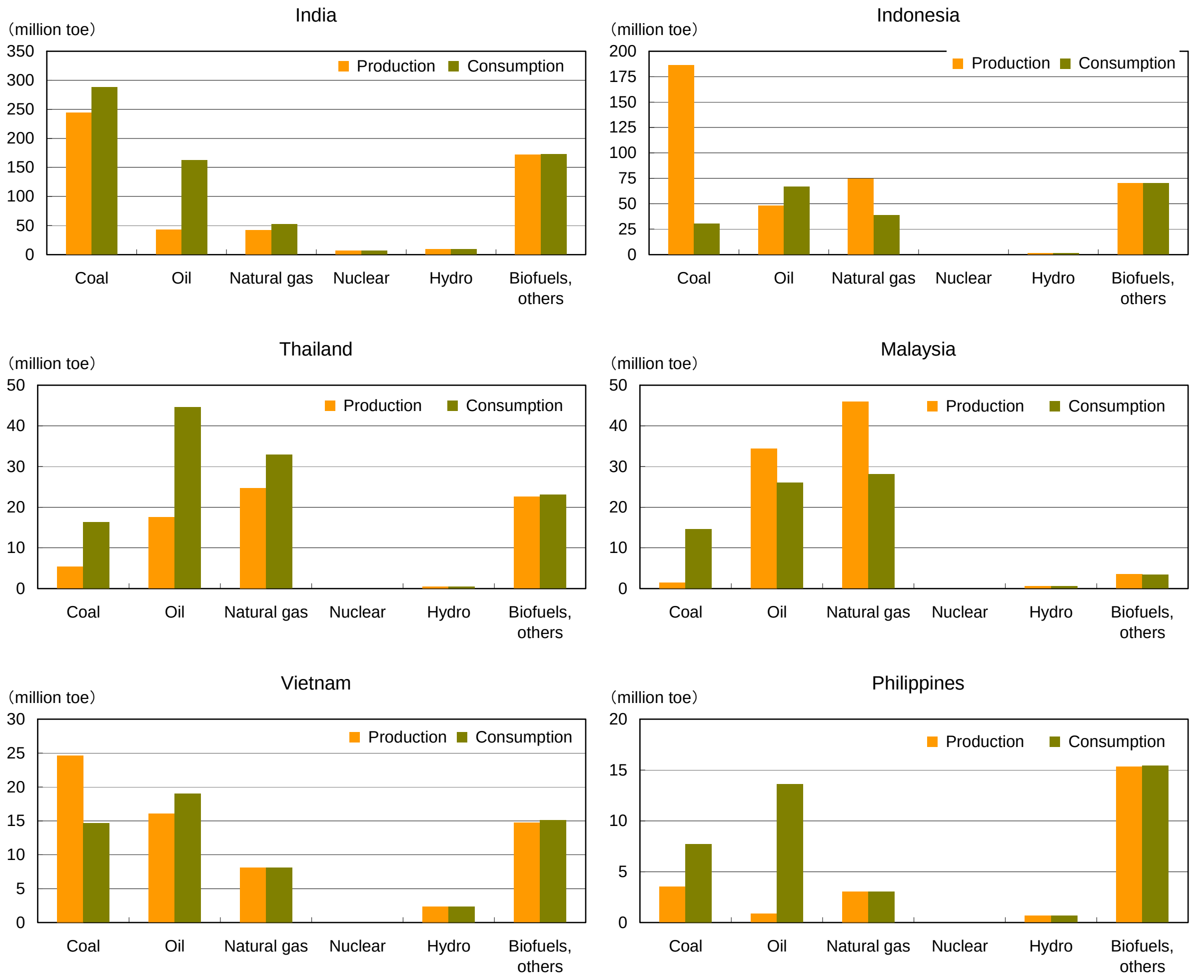


Source: Prepared by JICA study team based on the “Energy Balance of OECD/Non-OECD Countries 2012” of IEA

Fig. 2-6 2010 Supply-Demand Composition of Primary Energy in Four Northeast Asian Countries

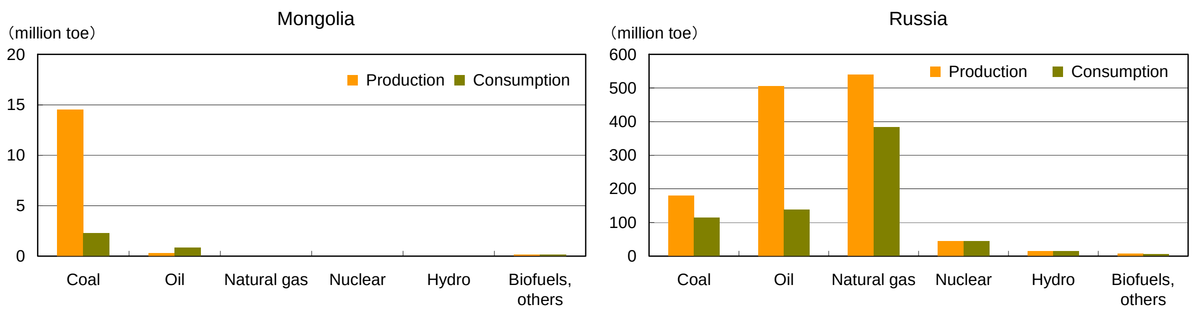
Fig. 2-7 shows the supply-demand composition of primary energy in 2010 in major Asian countries excluding four northeast Asian countries. Regarding coal, with production far surpassing consumption in Indonesia and Vietnam, both countries are key coal exporters in Asia. Indonesia exports not only coal but also natural gas yet the country is an importer of oil. In Vietnam, production and consumption of natural gas are roughly balanced while oil consumption exceeds oil production. Remaining India, Thailand, Malaysia, and the Philippines produce coal domestically but cannot cover their consumption, thus depending upon imports from overseas to make up for shortfall. India and Thailand also import oil and natural gas since domestic production cannot solely be sufficient. Malaysia exports oil and natural gas while in the Philippines, production and consumption of natural gas are balanced though large quantities of oil are imported. In five countries other than Malaysia, the fuel classified as “biofuels, others” including firewood and wastes constitutes a large part of primary energy.

Fig. 2-8 shows the supply-demand composition of primary energy in Mongolia and Russia in 2010. Coal production in Mongolia and Russia exceeds their coal consumption, and both countries are regarded as coal exporting countries. Although Mongolia’s coal exports are only nascent, Russia’s exports are, as mentioned later, on the largest scale after those of India and Australia. Russia exports not only coal but also oil and natural gas.



Source: Prepared by JICA study team based on the "Energy Balance of Non-OECD Countries 2012" of IEA

Fig. 2-7 2010 Supply-Demand Composition of Primary Energy in Major Asian Countries Excluding Four Northeast Asian Countries



Source: Prepared by JICA study team based on the "Energy Balance of Non-OECD Countries 2012" of IEA

Fig. 2-8 2010 Supply-Demand Composition of Primary Energy in Mongolia and Russia

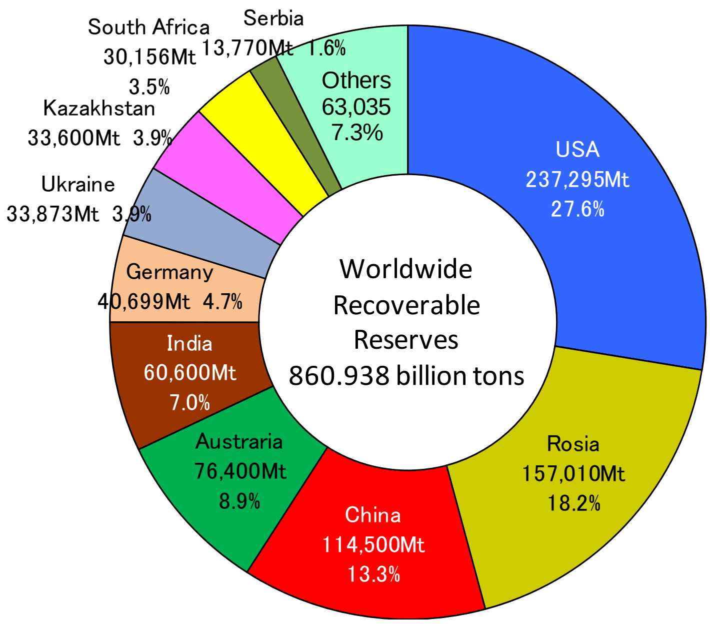
2.2 Future trend analysis of world coal supply-demand and price

2.2.1 World coal reserves

Worldwide, the recoverable reserve of coal is 860.9 billion tons approximately, of which the bituminous[7] coal (soft coal) and the anthracite coal (hard coal) constitute about 404.7 billion tons, and the subbituminous coal and lignite (brown coal) constitute about 456.1 billion tons.

Fig. 2-9 shows the amount of recoverable reserves of coal for different countries worldwide. The global abundance and the lack of regional bias can be cited as the major advantages of coal compared to petroleum and natural gas. Furthermore, Asian and Oceanic regions like China, Australia, Indonesia, etc., are major producers of coal, which is very significant from Japan's perspective.

Although, the worldwide coal reserves are summarized by WEC, Mongolia was the first country to make a report of coal reserves in 2010. According to this data, the total recoverable coal reserve in Mongolia is 2.52 billion tons (1.17 billion of anthracite and bituminous coal, and 1.35 billion tons of lignite).



Reference: WEC 2010 Survey of Energy Resources

Fig. 2-9 Worldwide Recoverable Reserves

2.2.2 Present situation of coal supply and demand[8]

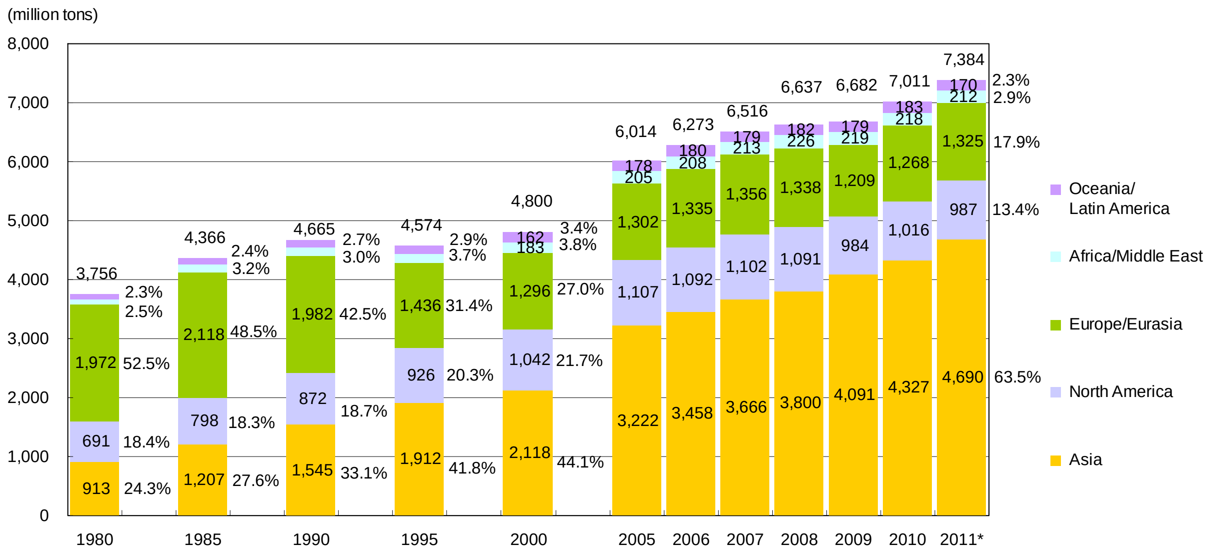
(1) Coal consumption

World coal consumption including that of lignite, as shown in Fig. 2-10, slowed its growth in the 1990s, but in the 2000s, its consumption has been soaring to reach 7,384 million tons in 2011. A decrease in consumption at the beginning of the 1990s is attributable to slower coal consumption in the former Soviet Union while the consumption decrease in and after 1997 may well be caused by slowing

[7] In coal classification, there are some classifications (by usage; coking coal and steam coal, by coal rank; lignite, subbituminous coal, bituminous coal, anthracite coal.) In this report, coal rank classification is used.

[8] Based on the data released by IEA in 2012 (Coal Information 2012).

consumption in China and Europe. Since 2000, coal consumption has increased in Asian countries, mainly in China. Overview of consumption by region from the 1980s shows that consumption has grown substantially in Asia, on the other hand, in Europe/the former Soviet Union and North America, it tends to decrease.

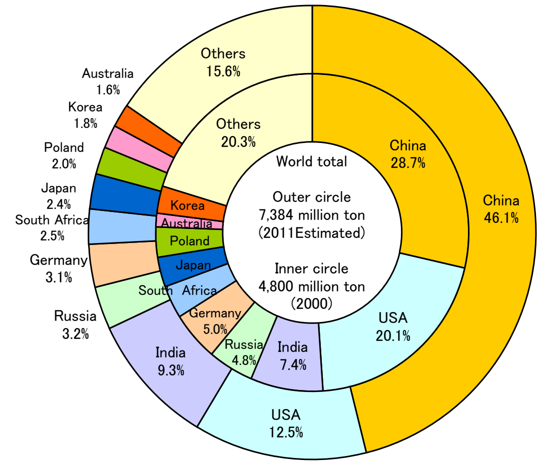


Note: * Data for 2011 is estimated.

Source: Prepared by ICA study team based on the "Coal Information 2012" of IEA

Fig. 2-10 World Coal Consumption

Looking at coal consumption by country in 2011, China, the United States, and India consumed 3,404 million tons (46.1% of total consumption), 925 million tons (12.5%, the same), 687 million tons (9.3%, the same), respectively, as shown in Fig. 2-11, and these three countries alone account for nearly 70% of total consumption. Comparison of coal consumption of 2011 with that of 2000 for top 10 coal consuming countries in the world shows that China made the largest amount of consumption increase. The amount of increase grew during that period at an annual rate of 8.6% in China, 6.1% in India, and 5.6% in South Korea. On the other hand, in the United States, Germany, and Australia, a decrease was witnessed. In 2011, Asia consumed 4,690 million tons of coal, which accounted for 63.5% of world coal consumption. Compared with 2000, coal consumption increased by 2,572 million tons and its ratio to global consumption increased by 19.4 percentage points during that period.



(million tons)

	1990	2000	2011 Estimated
China	1,051	1,378	3,404
USA	816	966	925
India	221	357	687
Russia	374	230	235
Germany	451	239	230
South Africa	125	157	183
Japan	115	153	175
Poland	188	143	146
Korea	45	72	130
Australia	95	128	120
Others	1,185	977	1,149
World total	4,665	4,800	7,384
Asian total	1,545 (33.1%)	2,118 (44.1%)	4,690 (63.5%)

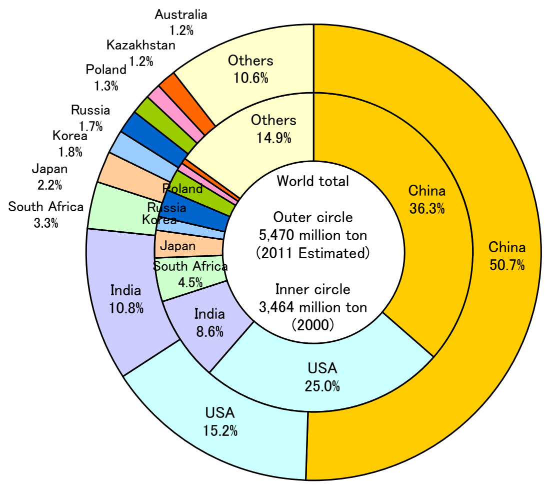
Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-11 Top 10 Coal Consuming Countries

Top 10 steam coal (including anthracite) and coking coal consuming countries are shown in Fig. 2-12 and Fig. 2-13, respectively.

As for steam coal consumption in 2011, China reached 2,772 million tons (50.7% of world steam coal consumption), the United States, 832 million tons (15.2%, the same), and India, 591 million tons (10.8%, the same), and consumption by these three countries alone account for three fourth or more of total consumption. China made outstanding increase in amount by growing at an annual rate of 7.4% during 2000-2011, far surpassing the world average of 4.2%.

Steam coal consumption in Asia in 2011 reached 3,837 million tons, accounting for 70.1% of world steam coal consumption. Compared with 2000, such consumption increased to as much as 2,006 million tons, its ratio to global consumption increased by 17.3 percentage points.



(million tons)

	1990	2000	2011 Estimated
China	971	1,259	2,772
USA	702	866	832
India	166	296	591
South Africa	119	155	179
Japan	50	96	122
Korea	33	52	98
Russia	186	98	92
Poland	102	70	72
Kazakhstan	56	31	66
Australia	6	23	65
Others	563	517	582
World total	2,955	3,464	5,470
Asian total	1,304 (44.1%)	1,831 (52.9%)	3,837 (70.1%)

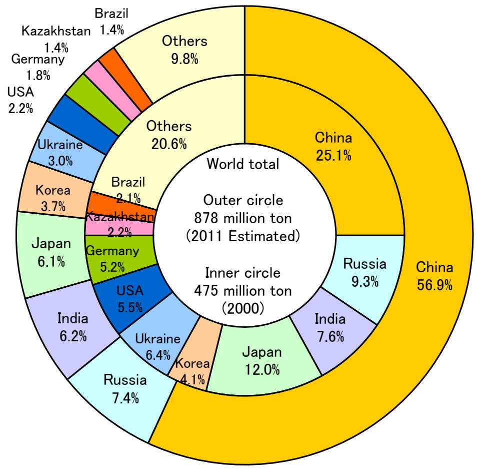
Note: Steam coal includes anthracite.

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-12 Top 10 Steam Coal Consuming Countries

China's consumption of coking coal also overwhelms that of other countries. China's coking coal consumption in 2011 reached 500 million tons (56.9% of world coking coal consumption), which was followed by Russia, 65 million tons (7.4%, the same), India, 55 million tons (6.2%, the same), and Japan, 54 million tons (6.1%, the same). Between 2000 and 2011, Russia, India, and South Korea, aside from China, increased coking coal consumption by more than 10 million tons while it tended to decrease in the United States and European countries.

In 2011, Asia consumed 647 million tons of coking coal, which accounted for 73.7% of world coal consumption. Compared with 2000, its increase in amount reached 409 million tons and its ratio to global coking coal consumption increased by as much as 23.6 percentage points.



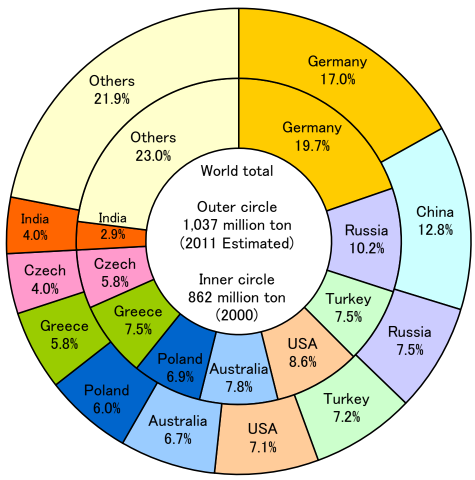
(million tons)

	1990	2000	2011 Estimated
China	80	119	500
Russia	54	44	65
India	39	36	55
Japan	65	57	54
Korea	12	19	32
Ukraine	55	31	27
USA	35	26	19
Germany	42	24	16
Kazakhstan	30	10	12
Brazil	10	10	12
Others	132	98	86
World total	555	475	878
Asian total	207 (37.2%)	238 (50.1%)	647 (73.7%)

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-13 Top 10 Coking Coal Consuming Countries

Consumption of lignite in 2011 is 1,037 million tons, and each of eight countries of Germany, China, Russia, Turkey, the United States, Australia, Poland, and Greece consumes more than 50 million tons as shown in Fig. 2-14.



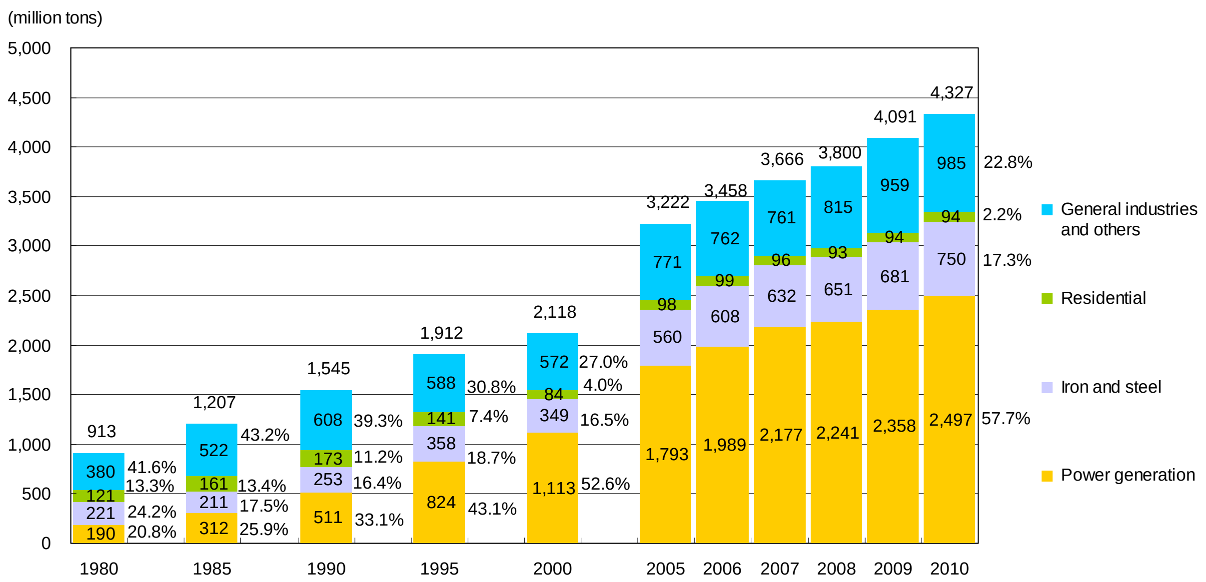
(million tons)

	1990	2000	2011 Estimated
Germany	364	170	176
China	0	0	133
Russia	134	88	78
Turkey	46	64	74
USA	79	74	74
Australia	46	67	70
Poland	67	59	63
Greece	52	65	60
Czech	72	50	42
India	15	25	41
Others	280	198	227
World total	1,155	862	1,037
Asian total	34 (3.0%)	49 (5.6%)	206 (19.8%)

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-14 Top 10 Lignite Consuming Countries

Coal consumption growth in Asia was sluggish between late in the 1990s and early in the 2000s. However, it expanded by 4.7 times from 913 million tons in 1980 to 4,327 million tons in 2010 along with increasing demand for power generation as shown in Fig. 2-15. Coal consumption for power generation rapidly expanded by 2.7 times from 190 million tons in 1980 to reach 511 million tons in 1990 due to incessant construction of coal thermal power plants. After that, coal consumption for power generation still continued to increase to reach even 2,497 million tons in 2010. The ratio of consumption for power generation to total coal consumption expanded from 20.8% in 1980 to 57.7% in 2010. On the other hand, consumption for iron and steel production increased from 221 million tons in 1980 to as much as 750 million tons in 2010 while its ratio to total consumption dropped from 24.2% in 1980 to 17.3%. Consumption for other purpose (such as for general industries) gained the largest share in 1980, reaching 380 million tons which accounted for 41.6% of total consumption. After that, consumption went up even to 985 million tons in 2010 while repeating ups and downs but its ratio to total consumption dropped even to 22.8%. Residential use consumption decreased from its peak of 181 million tons in 1988 to 94 million tons in 2010 and its ratio to total consumption decreased from 12.7% in 1988 to 2.2% in 2010.



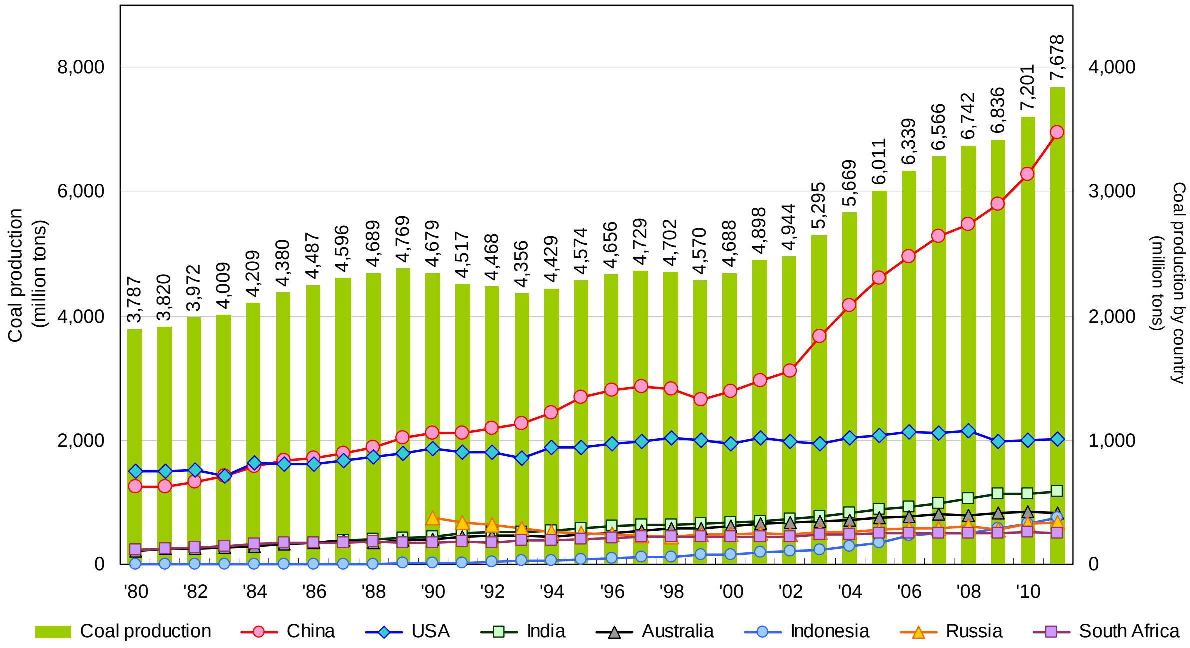
Note: Consumption for power generation includes private power generation/heat supply purposes. Consumption for iron and steel production includes those diverted into coke and blast furnace gas.

Source: Prepared by JICA study team based on the "Energy Statistics of OECD/Non-OECD Countries 2012" and the "Coal Information 2012" of IEA

Fig. 2-15 Coal Consumption by Sector in Asia

(2) Coal production

According to overview of world coal production including lignite, global production dipped, as shown in Fig. 2-16, at the beginning of the 1990s when consumption shrank mainly in the former Soviet Union and late in the 1990s when demand declined in China and Europe. However, it turned to increase again in and after 2000 and 7,678 million tons of coal was produced in 2011. Looking at production by major country, production growth in China in and after 2002 is something remarkable. The United States is the second largest coal producer after China and its production has remained on the level of around 1 billion tons since 1997 while India as well as coal exporters such as Australia and Indonesia are steadily expanding coal production. Russia increased coal production again in 1999 after some years of decline because of its economic recovery and has since maintained an increasing tendency. South Africa has maintained its slight increasing tendency.

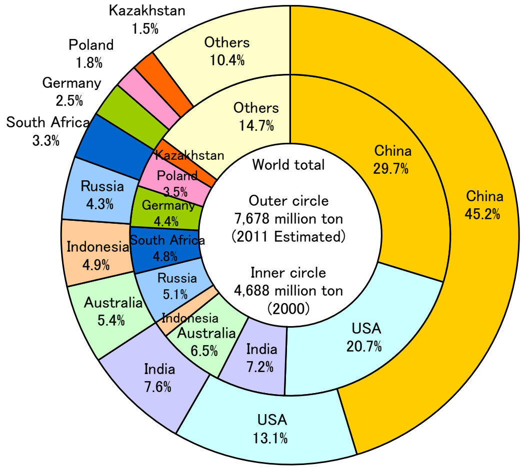


Note: Data for 2011 is estimated.

Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-16 World Coal Production

Looking at coal production by country in 2011, it is found that China and the United States alone account for 58.3% of total coal production, followed by India, Australia, Indonesia, Russia, and South Africa in that order as shown in Fig. 2-17. Compared with 2000, global production increased by 2,990 million tons and all top 10 coal producing countries except Germany and Poland increased coal production. Coal production in Asia in 2011was 4,584 million tons (59.7% of total production), most of which attributed to China, India, and Indonesia, and three countries alone account for 96.7% of production in the Asia region. Compared with 2000, production in China, India, and Indonesia has grown remarkably and, particularly, Indonesia is rapidly boosting its production in and after 1990 as a coal-exporting country of Asia.



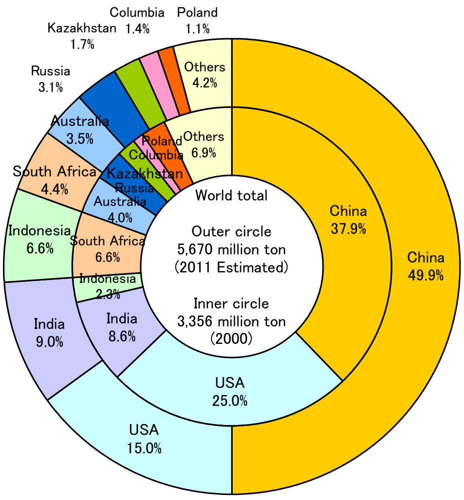
(million tons)

	1990	2000	2011 Estimated
China	1,051	1,394	3,471
USA	934	972	1,004
India	225	336	586
Australia	205	307	414
Indonesia	10	79	376
Russia	372	240	334
South Africa	175	224	253
Germany	434	205	189
Poland	215	163	139
Kazakhstan	131	77	117
Others	927	691	795
World total	4,679	4,688	7,678
Asian total	1,387 (29.6%)	1,891 (40.3%)	4,584 (59.7%)

Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-17 Top 10 Coal Producing Countries

Steam coal production (including anthracite) in 2011 is 5,670 million tons, accounting for 73.8% of total coal production as shown in Fig. 2-18. China bears nearly half of steam coal production, followed by the United States, India, Indonesia, South Africa, Australia, and Russia in that order and top 3 countries alone cover 73.9% of steam coal production. Among top 10 countries, it is only Poland that showed decline in production from 2000. In 2011, Asia produced steam coal of 3,812 million tons, accounting for 67.2% of total steam coal production, up 16.7 percentage points from 2000.



(million tons)

	1990	2000	2011 Estimated
China	965	1,271	2,831
USA	760	840	849
India	175	289	509
Indonesia	10	79	374
South Africa	165	221	250
Australia	94	136	199
Russia	152	102	178
Kazakhstan	98	64	98
Columbia	20	36	80
Poland	119	86	65
Others	380	233	237
World total	2,939	3,356	5,670
Asian total	1,228 (41.8%)	1,697 (50.5%)	3,812 (67.2%)

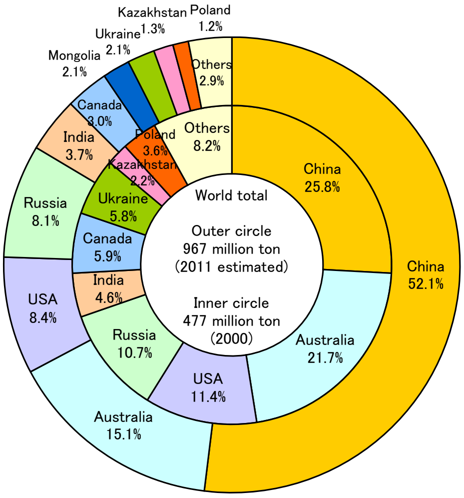
Note: Steam coal includes anthracite.

Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-18 Top 10 Steam Coal Producing Countries

Coking coal production in 2011 is 967 million tons. As shown in Fig. 2-19, China is the largest producer as in the case of steam coal, bearing half or more of coking coal production, followed by Australia, the United States, Russia, India, and Canada in that order. Two countries of China and

Australia alone cover 67.2% of production. Coking coal production in Asia in 2011 is 562 million tons, accounting for 58.1% of world coking coal production, up 25.8 percentage points from 2000.



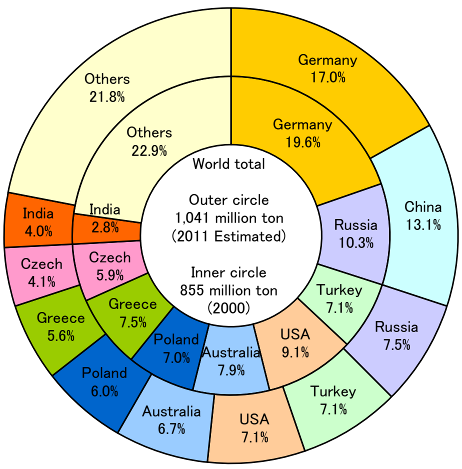
(million tons)

	1990	2000	2011 Estimated
China	86	123	504
Australia	65	104	146
USA	93	54	82
Russia	85	51	79
India	36	22	35
Canada	28	28	29
Mongolia	0	0	20
Ukraine	62	28	20
Kazakhstan	30	11	13
Poland	29	17	11
Others	86	39	28
World total	600	477	967
Asian total	124 (20.7%)	146 (30.6%)	562 (58.1%)

Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-19 Top 10 Coking Coal Producing Countries

Lignite production in 2011 is 1,041 million tons and producing countries include Germany, China, Russia, Turkey, and the United States (see Fig. 2-20).



(million tons)

	1990	2000	2011 Estimated
Germany	357	168	177
China	0	0	136
Russia	134	88	78
Turkey	44	61	74
USA	80	78	73
Australia	46	67	70
Poland	68	59	63
Greece	52	64	59
Czech	79	50	43
India	14	24	41
Others	265	195	227
World total	1,140	855	1,041
Asian total	34 (3.0%)	48 (5.7%)	210 (20.2%)

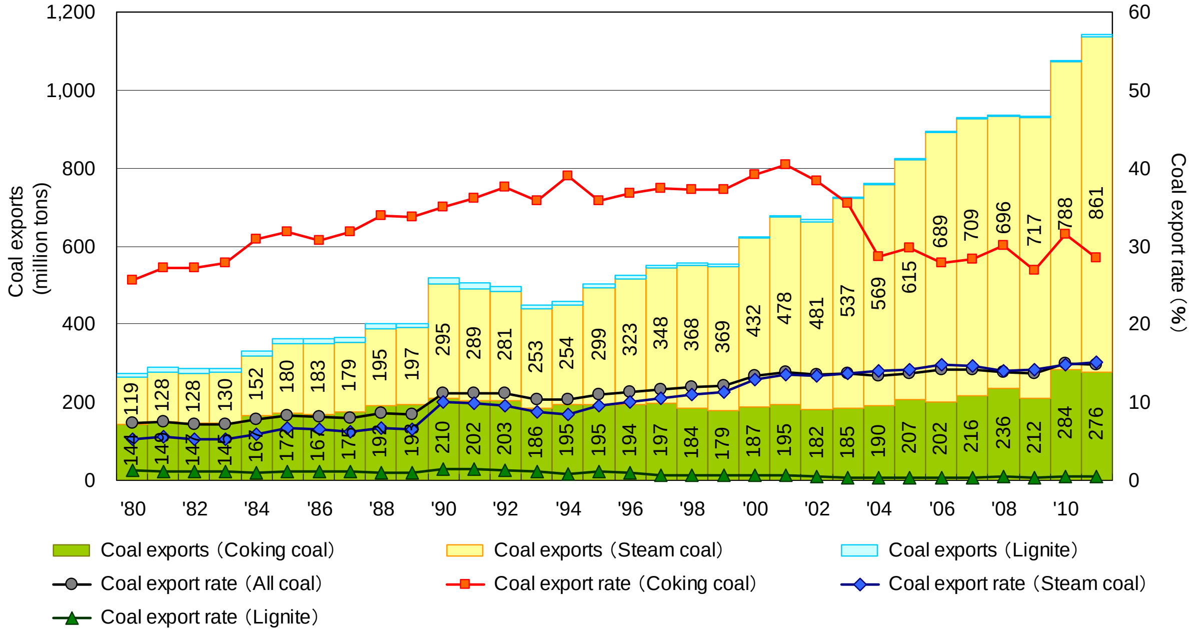
Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-20 Top 10 Lignite Producing Countries

(3) Coal trade

World coal trade volume (here, coal export volume including lignite) has, as shown in Fig. 2-21, increased along with increasing demand for steam coal consumed mainly as fuel for power generation. But the amount of coal used as traded commodity is smaller, compared with its production and the ratio of trade volume to production (export rate) is only 14.9% in 2011. Looking at it by coal type, coking coal, steam coal (including anthracite), and lignite accounted for 28.5%, 15.2%, 0.5%, respectively.

Steam coal, coking coal, and lignite accounted for 75.4%, 24.2%, only 0.4% of world coal trade volume, respectively.



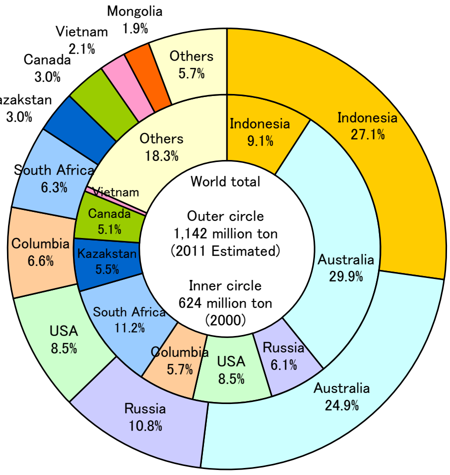
Note: Data for 2011 is estimated. Steam coal includes anthracite.
Data for China's export in 2005 is corrected with reference to the "Coal Information 2011" since China's export volume of steam coal (other bituminous coal) in 2005 given in the "Coal Information 2012" is apparently too small.
The export rate of coal was calculated from the following equation:
Coal export rate (%) = Coal export volume / Coal production (%)

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-21 Coal Trade Volume

World coal export volume in 2011 is 1,142 million tons as shown in Fig. 2-23, and the largest exporting country is Indonesia that recorded export volume of over 300 million tons. Australia was ranked second, followed by Russia, the United States, Columbia, and South Africa in that order and top 6 countries solely cover 80 percent or more of world export volume.

Looking at coal export volume of major coal exporting countries (top 10 coal exporting countries), it is found that Australia had overwhelmed others until early in the 2000s as shown in Fig. 2-23. In recent years, Indonesia has expanded its export volume remarkably, recording a larger export volume than Australia in 2011. In Australia, coal production became sluggish because of torrential rains in the State of Queensland, with declining output due to coal miners' strikes etc. combined, resulting in export volume decline in 2011 from the previous year. Russia reduced its coal export volume by half in the 1990s but, in and after 1999, showed its increasing tendency again. The United States decreased its export volume early in the 2000s but, in 2007 and then in 2008, increased its export volume. Despite its export volume turned to decrease again in 2009, export volume increased in and after 2010.



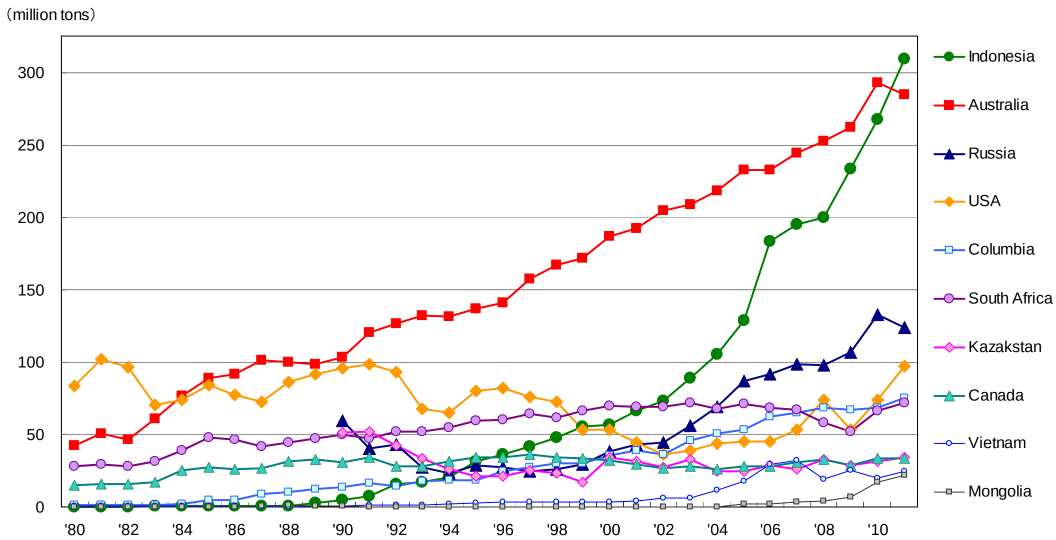
(million tons)

	1990	2000	2011 Estimated
Indonesia	4.7	56.8	309.5
Australia	103.4	187.0	284.5
Russia	59.2	38.3	123.7
USA	96.0	53.1	97.3
Columbia	13.5	35.4	75.5
South Africa	49.9	69.9	71.7
Kazakstan	51.5	34.4	34.0
Canada	31.0	32.1	33.7
Vietnam	0.8	3.3	24.4
Mongolia	0.5	0.0	22.1
Others	109.6	114.2	65.5
World total	520.0	624.4	1,142.0
Asian total	23.9 (4.6%)	117.0 (18.7%)	384.0 (33.6%)

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-22 Top 10 Coal Exporting Countries

Columbia decreased its export volume from the previous year in 2009, but it turned to increase again in and after 2010. South Africa has also increased its export volume in recent years. China sharply increased coal export in and after 2000 to be the world second-largest coal exporting country between 2001 and 2003 but, in and after 2004, decreased its export volume substantially, and descended from the top 10 position in 2011 with its export volume of 13.4 million tons (11th place).



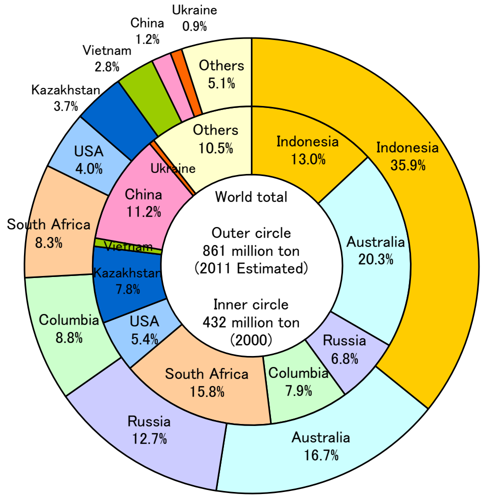
Note: Data for 2011 is estimated.

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-23 Coal Export Volume of Top 10 Coal Exporting Countries

World steam coal (including anthracite) and coking coal export volumes in 2011 are 861 million tons of the former and 276 million tons of the latter. Looking at export volumes by exporting countries for steam coal, the largest steam coal exporting country is Indonesia, which accounts for 35.9% of world steam coal export volume, followed by Australia, Russia, Columbia, and South Africa in that order with

16.7%, 12.7%, 8.8%, and 8.3%, respectively (Fig. 2-24). As for coking coal export volume, Australia was ranked the first, accounting for 50.9%, followed by the United States, Canada, and Mongolia in that order with 22.9%, 10.0%, and 7.3%, respectively. In recent years, Mongolia has expanded coking coal exports to China, recording export volume of 20 million tons in 2011 (Fig. 2-25).



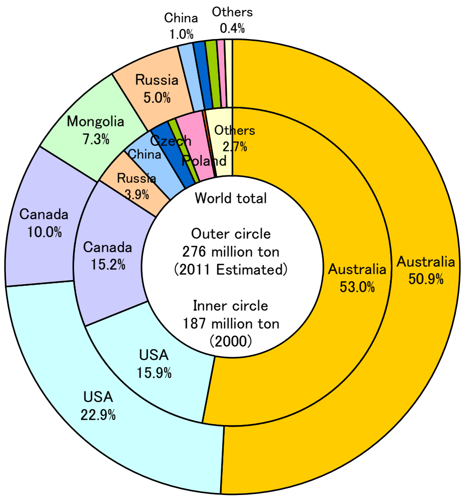
(million tons)

	1990	2000	2011 Estimated
Indonesia	4.6	56.2	308.9
Australia	45.6	87.8	144.1
Russia	24.5	29.4	109.4
Columbia	12.6	34.2	75.4
South Africa	46.3	68.2	71.6
USA	38.3	23.2	34.1
Kazakhstan	51.5	33.9	31.8
Vietnam	0.8	3.3	24.4
China	13.8	48.6	10.6
Ukraine	14.4	2.3	7.5
Others	42.3	45.5	43.6
World total	294.7	432.5	861.2
Asian total	19.9 (6.7%)	109.1 (25.2%)	360.0 (41.8%)

Note: Steam coal includes anthracite.

Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-24 Top 10 Steam Coal Exporting Countries



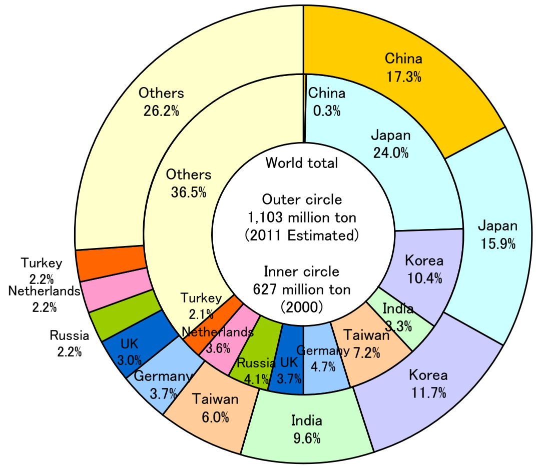
(million tons)

	1990	2000	2011 Estimated
Australia	57.8	99.2	140.5
USA	57.6	29.8	63.1
Canada	26.9	28.4	27.7
Mongolia	0.0	0.0	20.0
Russia	31.6	7.3	13.8
China	3.5	6.5	2.9
Czech	4.5	3.4	2.5
New Zealand	0.3	1.6	2.1
Poland	11.2	5.3	1.7
Indonesia	0.0	0.6	0.6
Others	16.4	5.0	1.2
World total	209.7	187.0	276.0
Asian total	3.5 (1.7%)	7.7 (4.1%)	23.6 (8.5%)

Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-25 Top 10 Coking Coal Exporting Countries

Looking at coal trade volume from the side of importing countries, the largest importing country in 2011 is China, which recorded 191 million tons (17.3% of world import volume) to top the list for the first time, surpassing 175 million tons (15.9%, the same) of Japan. It was followed by South Korea with 129 million tons (11.7%, the same), India with 106 million tons (9.6%, the same), and Taiwan with 66 million tons (6.0%, the same) in that order. The combined import volume of four northeast Asian countries (China, Japan, South Korea and Taiwan) is 561 million tons, which exceed half of total coal import volume. India is the world third-largest coal producer but, in recent years, remarkably increases coal imports (Fig. 2-26).



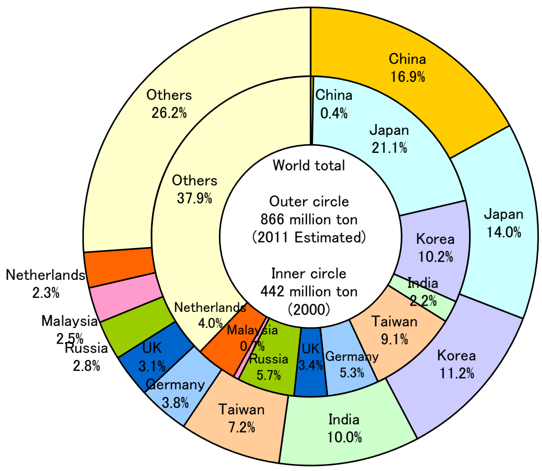
(million tons)

	1990	2000	2011 Estimated
China	2.0	2.2	190.5
Japan	106.9	150.3	175.4
Korea	23.7	64.9	129.2
India	6.0	20.9	105.7
Taiwan	18.5	45.4	66.3
Germany	15.7	29.7	41.3
UK	14.8	23.4	32.6
Russia	53.2	25.5	24.5
Netherlands	17.5	22.6	24.5
Turkey	5.6	13.0	23.8
Others	246.5	228.9	289.3
World total	510.5	627.0	1,103.1
Asian total	175.2 (34.3%)	306.4 (48.9%)	735.3 (66.7%)

Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-26 Top 10 Coal Importing Countries

World steam coal (including anthracite) and coking coal import volumes in 2011 are 866 million tons of the former and 229 million tons of the latter. As for steam coal, China is the largest importer, taking on 16.9% of world steam coal import volume, followed by Japan with 14.0%, South Korea with 11.2%, India with 10.0%, and Taiwan with 7.2% in that order (Fig. 2-27). With regard to coking coal, Japan takes on 23.5%, topping the list, followed by China, South Korea, and India with 16.7%, 14.1%, and 8.5%, respectively (Fig. 2-28).



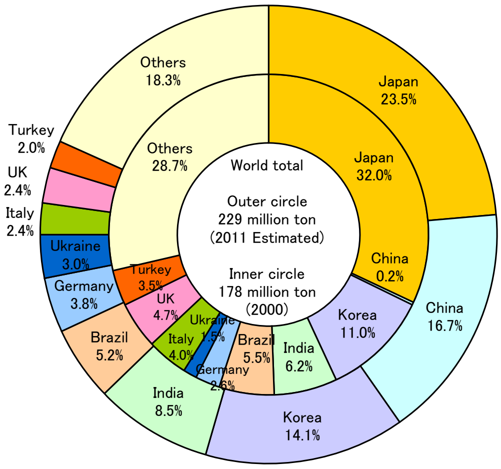
(million tons)

	1990	2000	2011 Estimated
China	1.8	1.8	146.4
Japan	42.0	93.3	121.5
Korea	12.4	45.3	96.9
India	0.2	9.9	86.4
Taiwan	14.3	40.3	62.5
Germany	11.9	23.3	32.5
UK	6.2	15.0	27.1
Russia	53.2	25.3	23.8
Malaysia	2.3	3.1	21.5
Netherlands	12.8	17.7	20.1
Others	165.3	167.5	226.7
World total	322.3	442.4	865.5
Asian total	85.1 (26.4%)	212.0 (47.9%)	581.2 (67.2%)

Note: Steam coal includes anthracite.

Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-27 Top 10 Steam Coal Importing Countries



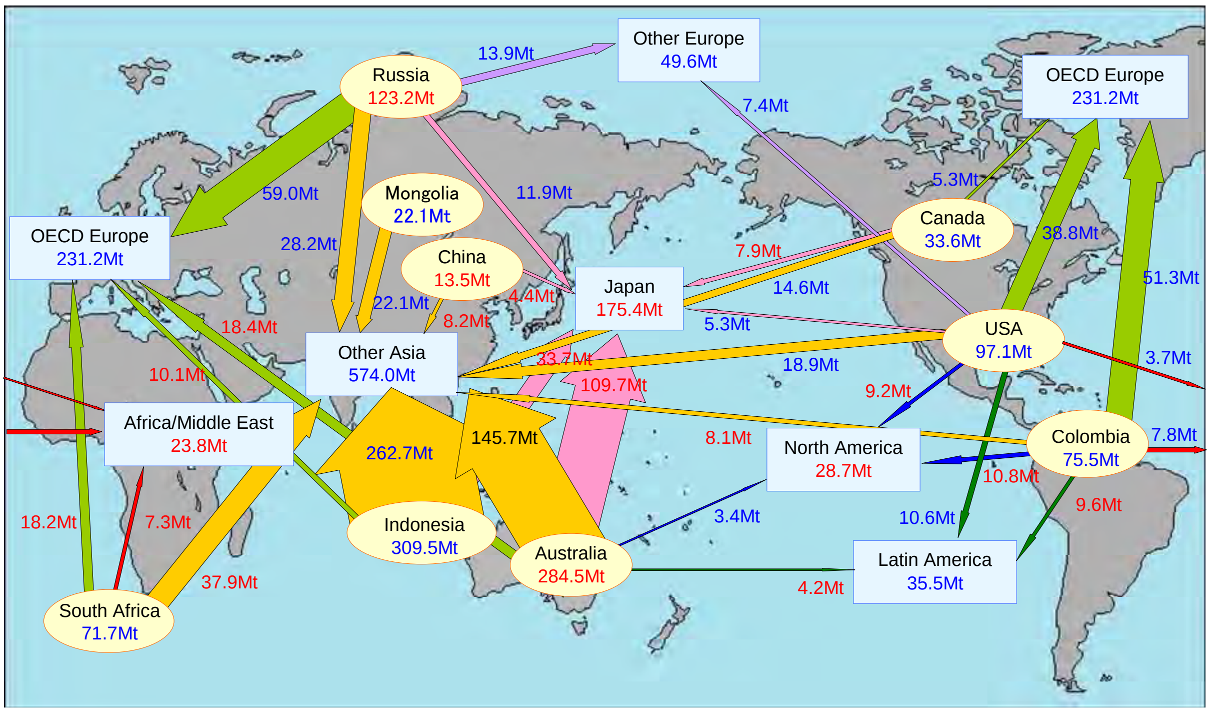
(million tons)

	1990	2000	2011 Estimated
Japan	64.9	57.1	53.8
China	0.3	0.3	38.3
Korea	11.3	19.6	32.2
India	5.9	11.1	19.3
Brazil	10.1	9.8	12.0
Germany	1.7	4.6	8.8
Ukraine	0.0	2.8	7.0
Italy	8.6	7.2	5.6
UK	8.6	8.5	5.5
Turkey	3.7	6.2	4.6
Others	56.0	51.2	41.8
World total	171.2	178.3	228.8
Asian total	90.1 (52.6%)	94.3 (52.9%)	148.2 (64.8%)

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-28 Top 10 Coking Coal Importing Countries

World coal trade situation excluding lignite (Coal Flow) is shown in Fig. 2-29. Coal forms a flow toward Asia region (particularly, four northeast Asian countries) and another toward Europe region, developing the Pacific and the Atlantic markets.



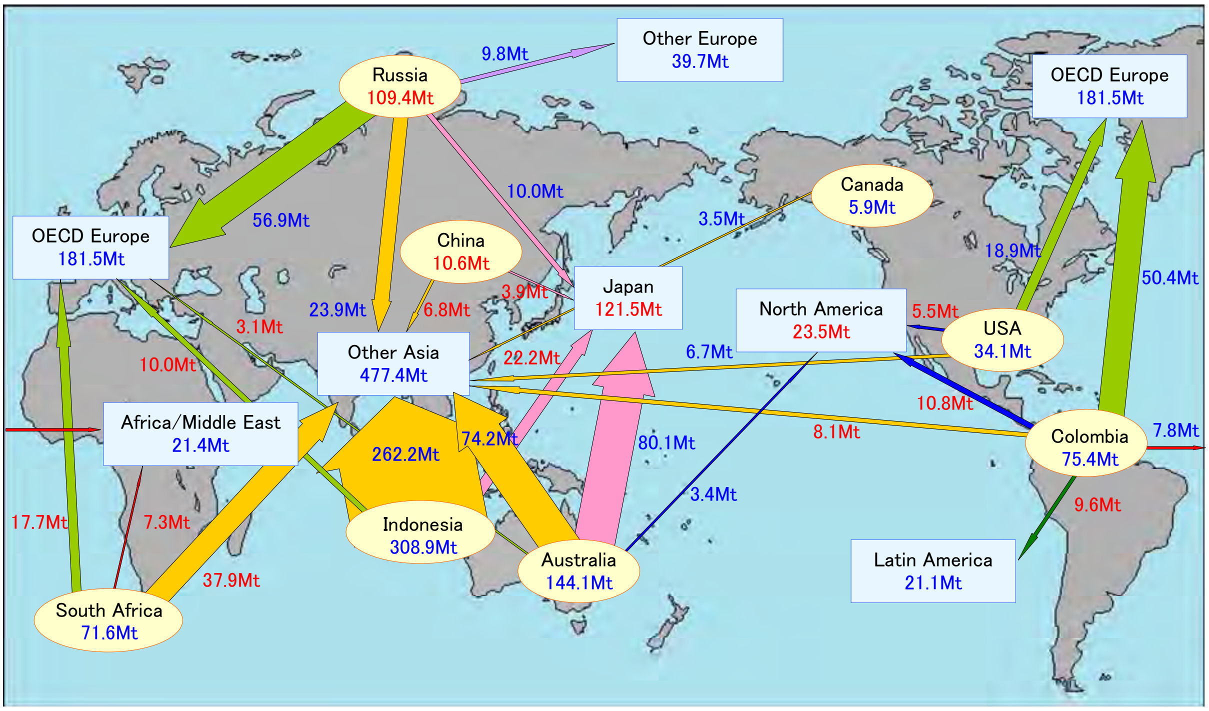
Note: Figures of exporting countries (shown by ellipse) in the above chart represent the total exports of each country, and those of importing countries and areas (shown by square) represent the total imports of each country. This figure contains no flow of less than 3 million tons. Blue-letter figures represent amounts increased from the previous year while red-letter ones represent amounts decreased from the previous year. "North America" on the importer side includes Mexico. China as importer is included "Other Asia" on the importer side.

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-29 World Coal Trade (Excluding Lignite, 2011 estimated)

Next, coal flows in 2011 are illustrated separately for steam and coking coal. Regarding each of Japan, South Korea, and Taiwan as major Asian coal consumers plus China and India whose import volume has been substantially increasing in recent years, the volume of steam and coking coal imports from major coal exporting countries in 2011 is block-diagrammed and tabled.

Fig. 2-30 shows the coal flows of steam coal in 2011, and Fig. 2-31 shows the steam coal imports from major coal exporting countries to Japan, South Korea, Taiwan, China, and India in 2011. Indonesia exports the largest quantities of steam coal to Asia. According to Fig. 2-30, the sum total of Indonesian steam coal exports to Japan and other Asian countries exceeds 280 million tons. As mentioned later, however, part of PCI coal, which should otherwise be normally categorized as coking coal, may have been handled as steam coal in Indonesian export statistics.

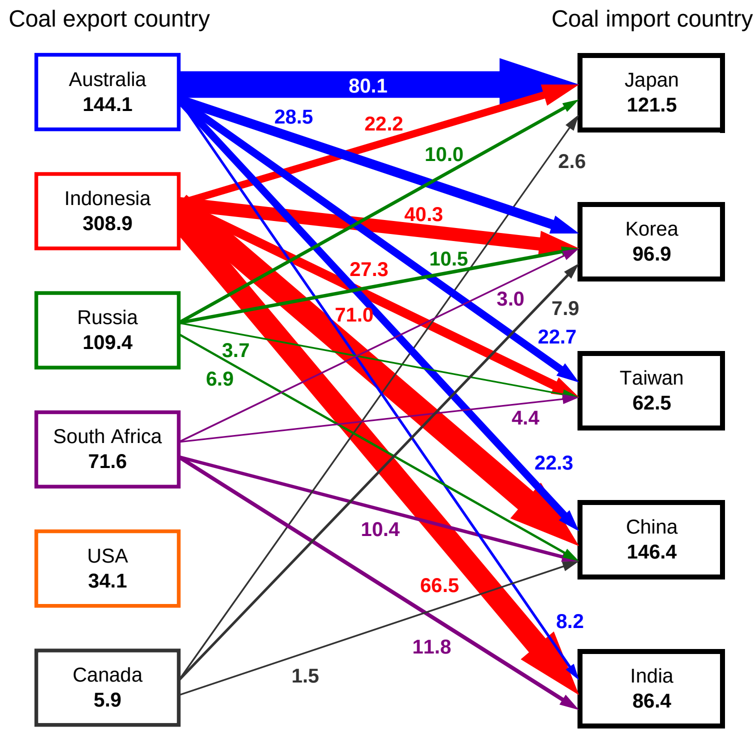


Note: Steam coal includes anthracite. Figures of exporting countries (shown by ellipse) in the above chart represent the total exports of each country, and those of importing countries and areas (shown by square) represent the total imports of each country. This figure contains no flow of less than 3 million tons. Blue-letter figures represent amounts increased from the previous year while red-letter ones represent amounts decreased from the previous year. “North America” on the importer side includes Mexico. China as importer is included “Other Asia” on the importer side.

Source: Prepared by JICA study team based on the “Coal Information 2012” of IEA

Fig. 2-30 World Trade of Steam Coal (2011 Estimated)

As shown in Fig. 2-31, steam coal exports of Australia amount to 144 million tons, and the imports of the five countries total 162 million tons. This is considered to be due to the difference between coal kinds used for export statistics in Australia and import statistics in the five countries. In short, it is considered that coal exported as coking coal in Australian export statistics is imported into importing countries as steam coal. China imports 33 million tons or more of steam coal from other exporting countries (Fig. 2-31), of which 22 million tons are imported from Vietnam.



(million tons)

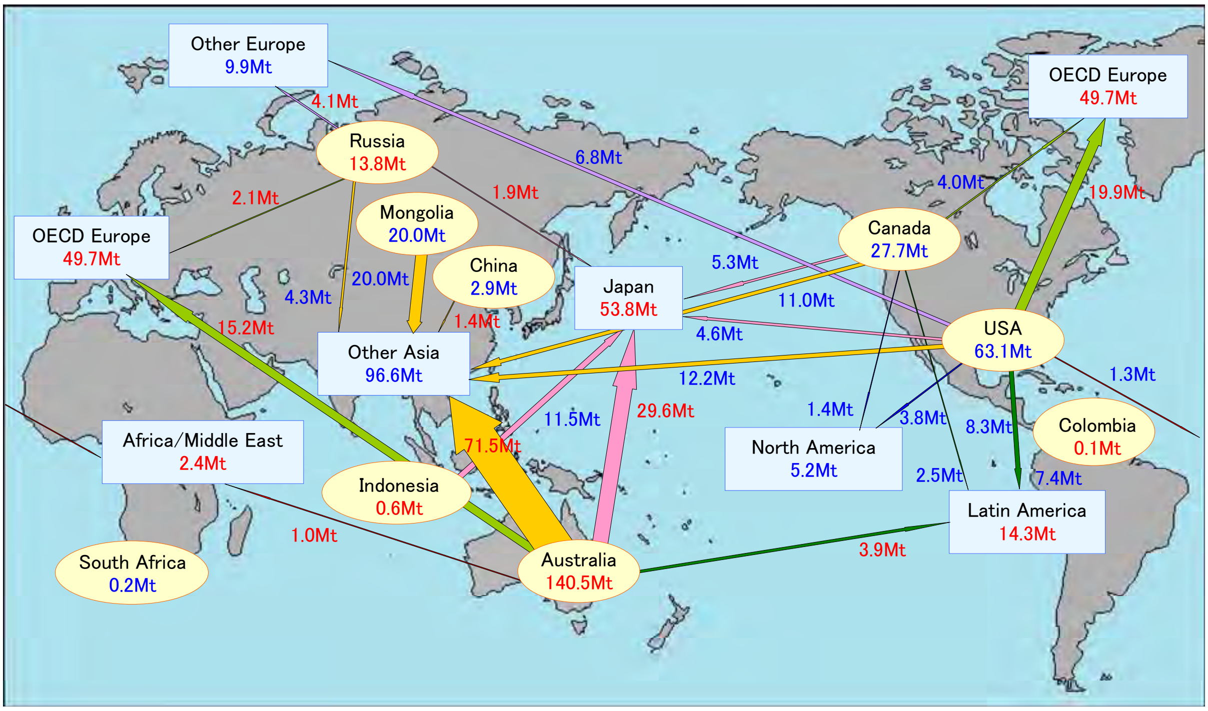
		Import					
		Japan	Korea	Taiwan	China	India	Total
Export	Australia	80.15	28.47	22.68	22.26	8.21	161.75
	Indonesia	22.19	40.28	27.32	71.02	65.51	226.31
	Russia	10.00	10.48	3.72	6.92	0.53	31.63
	South Africa	0.70	3.03	4.41	10.40	11.80	30.34
	USA	0.67	0.85	—	0.86	0.37	2.76
	Canada	2.60	7.94	0.93	1.46	—	12.93
	Others	5.23	5.86	3.45	33.45	0.00	47.99
Total imports		121.54	96.92	62.50	146.36	86.40	513.72

Note: Steam coal includes anthracite coal. Figures of exporting countries in the above chart represent the total exports of each country, and those of importing countries represent the total imports of each country. The chart does not include the flow of less than 1 million tons. Figures in the table are based on the import statistics, with Import Total representing a total of the 5 countries' figures.

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-31 Asian Trade of Steam Coal (2011 Estimated)

Like in the case of steam coal, Fig. 2-32 shows the coal flows of coking coal in 2011 and Fig. 2-33 shows the coking coal imports from major coal exporting countries to Japan, South Korea, Taiwan, China, and India in 2011. Although Australia exports the largest quantities of coking coal to Asia, imports from the Unites States and Canada are also indispensable. Fig. 2-32 and Fig. 2-33 show that Indonesian exports of coking coal amount to only 600 thousand tons; however, the import volume of coking coal to Japan from Indonesia is 11.5 million tons. This is considered to be because the volume of coking coal imported into Japan includes part of PCI coal possibly handled as steam coal in Indonesian export statistics.

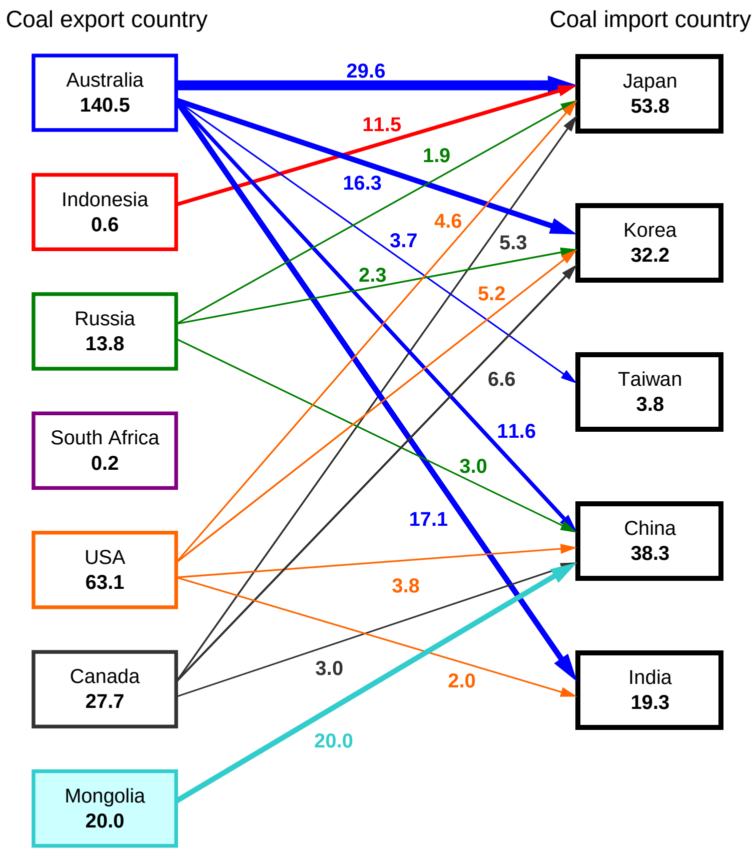


Note: Figures of exporting countries (shown by ellipse) in the above chart represent the total exports of each country, and those of importing countries and areas (shown by square) represent the total imports of each country. This figure contains no flow of less than 1 million tons. Blue-letter figures represent amounts increased from the previous year while red-letter ones represent amounts decreased from the previous year. "North America" on the importer side includes Mexico. China as importer is included "Other Asia" on the importer side.

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

Fig. 2-32 World Trade of Coking Coal (2011 Estimated)

As shown in Fig. 2-33, China imported 16 million tons or more of coking coal from other exporting countries in 2011, most of which is considered to be imported from Mongolia (while referenced "Coal Information 2012" issued by IEA does not specify the volume of coking coal imported from Mongolia to China, it regards coking coal exports from Mongolia in 2011 as 20 million tons).



(million tons)

		Import					
		Japan	Korea	Taiwan	China	India	Total
Export	Australia	29.57	16.28	3.69	11.55	17.11	78.20
	Indonesia	11.50	—	—	0.57	—	12.07
	Russia	1.93	2.26	—	2.98	0.00	7.16
	South Africa	—	—	—	—	—	0.00
	USA	4.59	5.21	—	3.76	2.04	15.60
	Canada	5.33	6.56	0.13	2.97	0.08	15.07
	Others	0.92	1.92	0.00	16.43	0.10	19.37
Total imports		53.84	32.23	3.82	38.25	19.34	147.48

Note: Figures of exporting countries in the above chart represent the total exports of each country, and those of importing countries represent the total imports of each country. The chart does not include the flow of less than 1 million tons. Figures in the table are based on the import statistics, with Import Total representing a total of the 5 countries' figures. Figures of coal flow (trade volume) are based on table, but the figure of exports from Mongolia is represented 20.0 million tons, as almost all of exports from Mongolia is exported to China.

Source: Prepared by JICA study team based on the "Coal Information 2012" of IEA

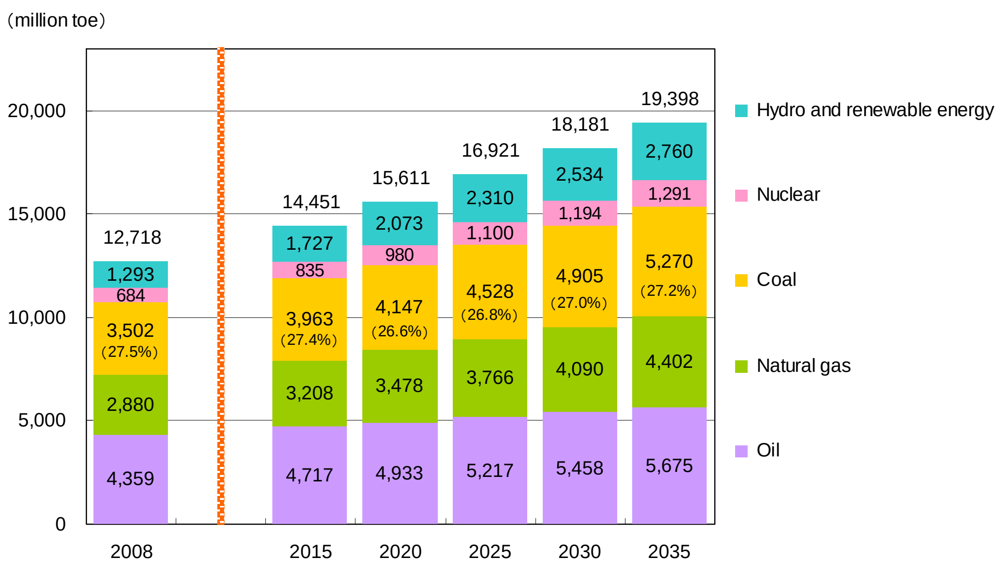
Fig. 2-33 Asian Trade of Coking Coal (2011 Estimated)

2.2.3 Coal Supply and Demand Outlook

Reference case outlooks reported by major world organizations (U.S. Department of Energy/EIA, International Energy Agency (IEA), and the Institute of Energy Economics, Japan (IEEJ)) are summarized.

(1) Outlook of the US Department of Energy/EIA

According to the "International Energy Outlook 2011 (IEO2011)" released by the US Department of Energy/EIA in September, 2011, world primary energy consumption in Reference case is, as shown in Fig. 2-34, expected to grow at an annual rate of 1.6% between 2008 and 2035 from 12.72 billion toe in 2008 to 19.40 billion toe in 2035. The annual average rate of growth by energy during the same period for coal, natural gas, and oil will be 1.5%, 1.6%, and 1.0%, respectively. Coal's share of total energy consumption is assumed to remain almost unchanged from 27.5% in 2008 to 27.2% in 2035.



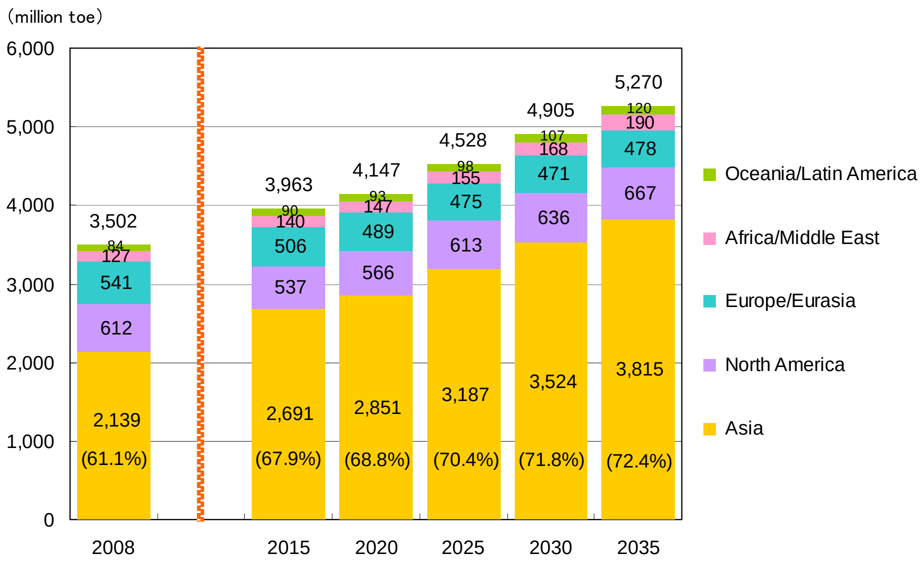
Note: Percentage denotes coal's share of primary energy consumption.

Source: Prepared by JICA study team based on the "International Energy Outlook 2011" of EIA

Fig. 2-34 World Primary Energy Consumption Outlook (IEO2011, Reference case)

Looking at coal consumption outlook for Reference case by region, coal consumption is expected to increase during the period between 2008 and 2035 in regions other than Europe/Eurasia. Among them, the growth in Asia during the same period is assumed to be high with an annual rate of 2.2% and it is expected that coal consumption in Asia region will increase from 2,139 million toe in 2008 to 3,815 million toe in 2035. During that period, global coal consumption is anticipated to grow by 1,768 million toe and the amount of increase in Asia is likely to reach its 90% or more, 1,676 million toe (Fig. 2-35). As for shares of world coal consumption by region, Asia's share is expected to expand from 61.1% in 2008 to 72.4% in 2035.

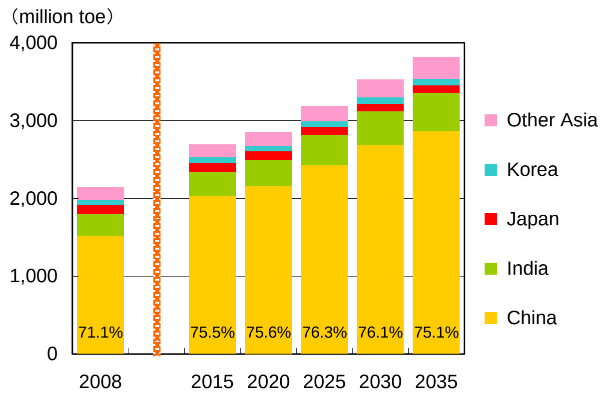
IEO2011 assumes that annual non-OECD Asian countries' economic growth rate between 2008 and 2035 will be 5.3% (global annual growth rate will be 3.4%) for Reference case. Looking at Reference case by countries, it is expected that coal consumption will, as shown in Fig. 2-36, increase in every of all countries except Japan, with the significant increase in China and India. China's coal consumption will increase from 1,521 million toe in 2008 to 2,864 million toe in 2035, with the annual growth rate during that period assumed to be 2.4%. Coal Consumption in India is expected to grow at an annual rate of 2.2% between 2008 and 2035 to reach 491 million toe in 2035. Coal consumption in South Korea is expected to increase at an annual rate of 1.0% to reach 86 million toe in 2035 while that in Japan is assumed to decrease by 24 million toe from 2008 to reach 96 million toe. As for Other Asia (non-OECD Asia) region excluding these four countries, coal consumption is expected to increase by some 119 million toe during that period (at an annual growth rate of 2.1%) to reach 277 million toe in 2035.



Note: Percentage denotes Asia's share of world consumption.

Source: Prepared by JICA study team based on the "International Energy Outlook 2011" of EIA

Fig. 2-35 World Coal Consumption Outlook by Region (IEO2011, Reference case)



(million toe)

	2008		2015	2020	2025	2030	2035
China	1,521		2,033	2,156	2,430	2,683	2,864
India	274		311	342	387	435	491
Japan	120		116	110	105	100	96
Korea	66		66	66	70	77	86
Other Asia	158		165	177	194	228	277
Total	2,139		2,691	2,851	3,187	3,524	3,815

Note: Percentage denotes China's share of Asia's coal consumption.

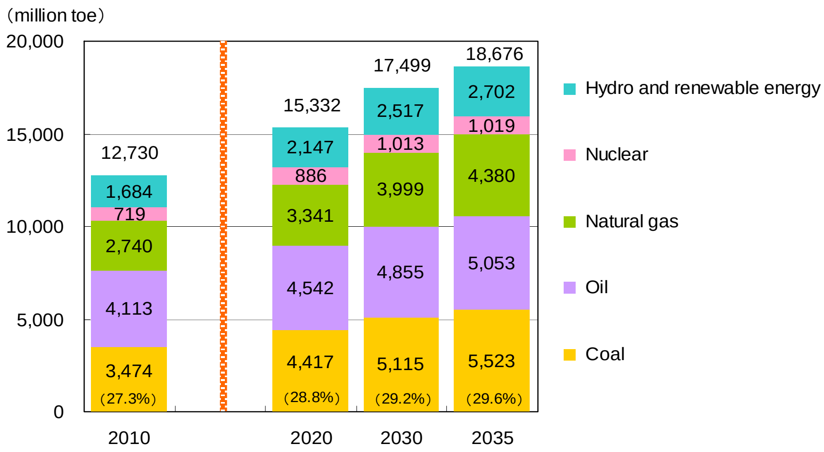
Source: Prepared by JICA study team based on the "International Energy Outlook 2011" of EIA

Fig. 2-36 Coal Consumption Outlook by Country in Asia (IEO2011, Reference case)

(2) Outlook of the International Energy Agency (IEA)

The "World Energy Outlook 2012 (WEO2012)" released by IEA in November, 2012 shows "New Energy Policy Scenario" and "450ppm Scenario" in which measures to reduce greenhouse gas are taken into consideration and "Existing Energy Policy Scenario." Here, for comparison with EIA's prediction, "Existing Energy Policy Scenario"-based outlooks are summarized.

World primary energy consumption based on "Existing Energy Policy Scenario" is expected, as shown in Fig. 2-37, to grow at an annual rate of 1.5% between 2010 and 2035 to increase from 12.73 billion toe in 2010 to 18.68 billion toe in 2035. The annual average rate of growth by energy for coal, natural gas, and oil during the same period will be 1.9%, 1.9%, and 0.8%, respectively. Coal's share of total energy consumption is expected to increase, though slightly, from 27.3% in 2010 to 29.6% in 2035.

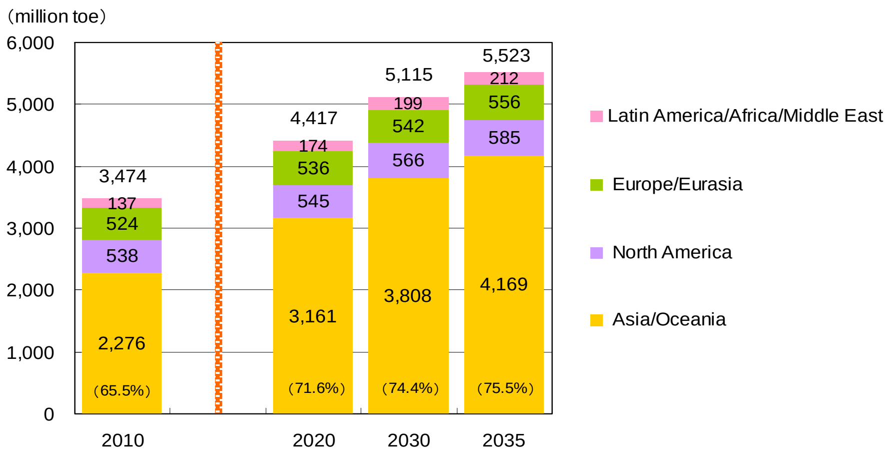


Note: Percentage denotes coal's share of primary energy consumption.

Source: Prepared by JICA study team based on the "World Energy Outlook 2012" of IEA

Fig. 2-37 World Primary Energy Consumption Outlook
(WEO2012, Existing Energy Policy Scenario)

Looking at coal consumption by region, it is expected that it will increase in every region between 2010 and 2035 as shown in Fig. 2-38. The amount of increase as well as the growth rate during that period is assumed to be small for both North America and Europe/Eurasia at 47 million toe for the formers and 33 million toe for the latter's amount of increase while the annual growth rate is expected to be 0.3% for North America and 0.2% for Europe/Eurasia. On the other hand, the growth in Asia/Oceania during that period is assumed to be high at annual 2.5% and coal consumption in the same region is expected to increase by 1,894 million toe from 2,276 million toe in 2010 to 4,169 million ton in 2035. Since the amount of increase in world coal consumption during the same period is 2,048 million toe, Asia/Oceania's amount of increase comes to account for a little over its 90%. With respect to the share of world coal consumption, Asia/Oceania are expected to expand its share from 65.5% in 2010 to 75.5% in 2035. Coal consumption in Asia will continue to expand in the future and the expansion of world coal consumption comes to be almost entirely borne by this region.



Note: Percentage denotes Asia/Oceania's share of world consumption.

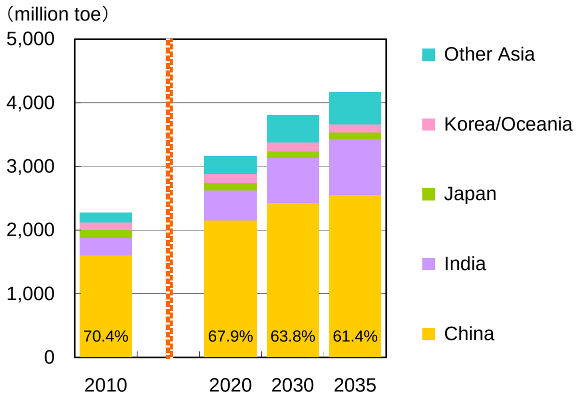
Source: Prepared by JICA study team based on the "World Energy Outlook 2012" of IEA

Fig. 2-38 World Coal Consumption Outlook by Region
(WEO2012, Existing Energy Policy Scenario)

WEO2012 assumes that annual economic growth rate of non-OECD Asian countries between 2010 and 2035 will be 5.5% (global annual growth rate will be 3.5%). Looking at forecasts for coal consumption by country in Asia/Oceania, as shown in Fig. 2-39, China and India are to mark a remarkable increase. Coal consumption of China is expected to grow at an annual rate of 1.9% from 1,602 million toe in 2010 to 2,561 million toe in 2035. India's coal consumption is assumed to grow at an annual rate of 4.6% between 2010 and 2035 to increase from 283 million toe in 2010 to 862 million toe in 2035. In this outlook, China's coal consumption in 2035 is smaller, but on the other hand, India's consumption is larger, than in EIA's outlook. Japan is assumed to maintain some 107 million toe of consumption toward 2035. It is anticipated that coal consumption in other Asia (non-OECD Asia) region excluding these three countries and Korea/Oceania will grow at an annual rate of 5.0% from 150 million toe in 2010 toward 2035 to increase to 506 million toe in 2035. The amount of increase in global coal consumption during that period is expected to be 1,894 million toe, with China, India, and other Asia will take on 51%, 31%, and 19% of such an amount, respectively.

(3) Outlook of the Institute of Energy Economics, Japan (IEEJ)

According to the "Asia/World Energy Outlook 2012 (IEEJ2012)" released by the Institute of Energy Economics, Japan in November, 2012, world primary energy consumption in Reference case is expected, as shown in Fig. 2-40, to grow at an annual rate of 1.6% between 2010 and 2035 to increase from 11.74 billion toe in 2010 to 17.52 billion toe in 2035. The annual average rate of growth by energy for coal, natural gas, and oil will be 1.4%, 2.0%, and 1.2%, respectively, anticipating higher rate of natural gas. Coal's share of total energy consumption is expected to undergo a change from 29.6% in 2010 to27.8% in 2035 with oil's share expected to shrink from 35.0% in 2010 to 31.8% in 2035, while natural gas will expand its share from 23.2% in 2010 to 25.50% in 2035.



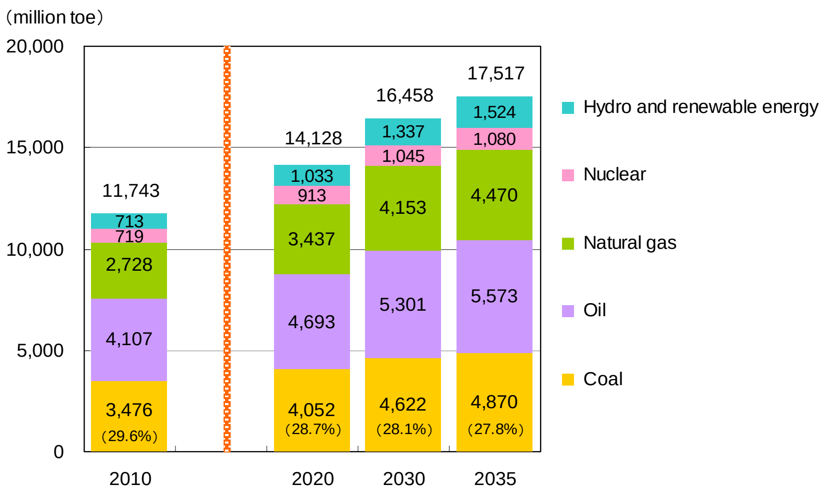
(million toe)

	2010		2020	2030	2035
China	1,602		2,148	2,429	2,561
India	283		478	701	862
Japan	115		112	109	107
Korea/Oceania	126		146	145	134
Other Asia	150		278	424	506
Total	2,276		3,161	3,808	4,169

Note: Percentage denotes China's share of Asia's coal consumption. Korea/Oceania is the sum total of South Korea, Australia, and New Zealand.

Source: Prepared by JICA study team based on the "World Energy Outlook 2012" of IEA

Fig. 2-39 Coal Consumption Outlook by Country in Asia (WEO2012, Existing Energy Policy Scenario)

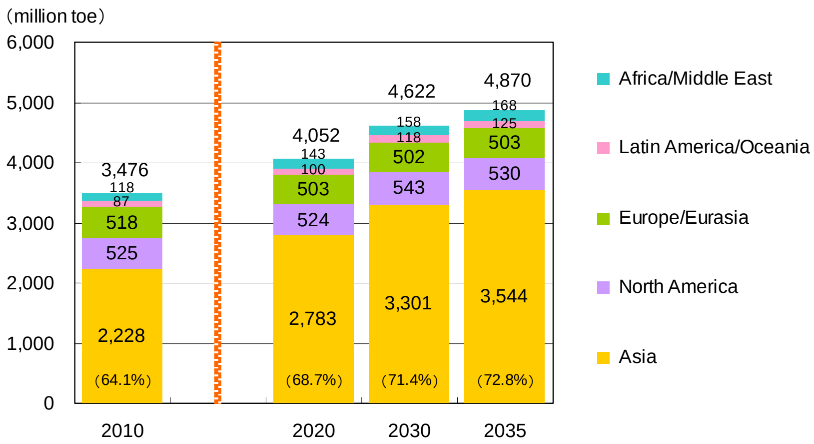


Note: Percentage denotes coal's share of primary energy consumption.

Source: Prepared by JICA study team based on the "Asia/World Energy Outlook 2012" of IEEJ

Fig. 2-40 World Primary Energy Consumption Outlook (IEEJ2012, Reference case)

Although the role of coal as primary energy is also expected, like by EIA and IEA, not to abate in the future, IEEJ predicts that, compared with 2010, coal's share of energy consumption will decrease slightly in 2035. Looking at coal consumption by region, it is expected, as shown in Fig. 2-41, to increase in the region except Europe/Eurasia between 2010 and 2035. It is expected that coal consumption in Europe/Eurasia will tend to decrease from the peak to be reached late in the 2010s. On the other hand, Asia's annual growth rate of 1.9% during that period will be the highest of all five regions in the world and coal consumption in this region is expected to increase by 1,317 million toe from 2,228 million toe in 2010 to 3,544 million toe in 2035. Since the amount of increase in world coal consumption during the same period is likely to be 1,394 million toe, Asia's amount of increase comes to account for its 94%. This resulted in the prediction that Asian coal consumption's share of the world total coal consumption would expand from 64.1% in 2010 to 72.8% in 2035.

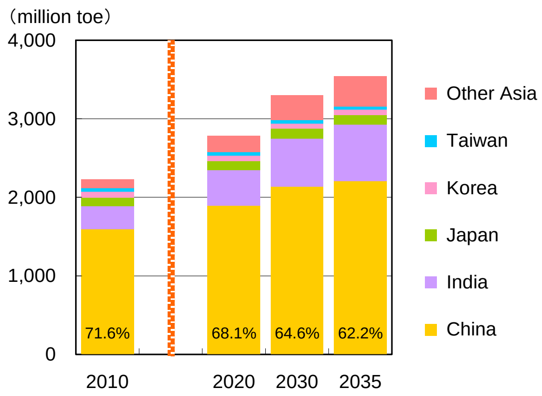


Note: Percentage denotes China's share of Asia's coal consumption.

Source: Prepared by JICA study team based on the "Asia/World Energy Outlook 2012" of IEEJ

Fig. 2-41 World Coal Consumption Outlook by Region (IEEJ2012, Reference case)

IEEJ2012 assumes that annual economic growth rate of Asian countries excluding Japan from 2010 to 2035 will be 5.2% (global annual growth rate will be 2.9%). Looking at the coal consumption outlook by country in Asia, it is found that the increase in China and India is large as shown in Fig. 2-42. China's coal consumption in particular is expected to increase from 1,595 million toe in 2010 to 2,205 million toe in 2035, at annual growth rate of 1.3% during that period. India's coal consumption is assumed to grow at an annual rate of 3.7% between 2010 and 2035 to increase from 288 million toe in 2010 to 721 million toe in 2035. In South Korea, and Taiwan, coal consumption is expected to increase from late in the 2010s to the 2020s, and then turning downward. Coal consumption in 2035 will be 67 million toe in South Korea, and 39 million toe in Taiwan. Coal consumption in other Asia (non-OECD Asian countries) is assumed to grow at higher annual rate of 5.0% which is higher than India toward 2035 from 114 million toe in 2010, increasing to 388 million toe in 2035. The amount of increase in whole Asian coal consumption during that period is likely to be 1,317 million toe, assuming 46% of such increment is attributable to China, 33% to India, and then 21% to other Asian countries. IEEJ2012, like WEO2012 of IEA, anticipates larger expansion of India's coal consumption than IEO2011 does.



(million toe)

	2010		2020	2030	2035
China	1,595		1,896	2,134	2,205
India	288		447	618	721
Japan	115		117	121	124
Korea	73		72	69	67
Taiwan	41		44	42	39
Other Asia	114		206	317	388
Total	2,228		2,783	3,301	3,544

Note: Percentage denotes China's share of world consumption.

Source: Prepared by JICA study team based on the "Asia/World Energy Outlook 2012" of IEEJ

Fig. 2-42 Coal Consumption Outlook by Country in Asia (IEEJ2012, Reference case)

(4) Coal consumption outlook comparison

Comparison of coal consumption outlooks given in IEO2011 of EIA, WEO2012 of IEA, and IEEJ2012 of IEEJ finds that, in Reference case, energy consumption increases toward 2035 as shown in Table 2-1, not abating the role of coal in energy consumption. Slight difference is, however, found in coal's share of energy consumption. Toward 2035, EIA expects coal to have the same level of share (some 27%) as current level while IEA anticipates that the share will become larger, though only a little, than current level. On the other hand, IEEJ predicts that the share will decrease, though only a little.

World coal consumption in 2035 is expected by IEA to be 5,523 million toe or the largest in three outlooks, expectation by EIA is 5,270 million toe, and expectation by IEEJ is 4,870 million toe, allegedly increasing by as much as 1.4 billion toe through 2.0 billion toe from the present level. All outlooks agree in the prediction that the growth of coal consumption in Asia will be the largest, allowing Asia to tract the increase in world coal consumption.

The predicted Asia's largest coal consumption in 2035 is 4,169 million toe expected by IEA (though including consumption in Australia and New Zealand) while EIA's expectation is 3,815 million toe and IEEJ's expectation is 3,544 million toe, assuming that Asia accounts for 72% through 76% of world coal consumption. Although the expansion of coal consumption in Asia owes most to China, expansion of coal consumption in India and other Asian countries (excluding China, India, Japan, and South Korea) cannot also be overlooked. As for outlook for coal consumption in China in 2035, 2,864 million toe expected by EIA is the largest, followed by 2,561 million toe expected by IEA, with the smallest 2,205 million toe expected by IEEJ. Similarly, with respect to India, IEA's prediction is the largest at 862 million toe, followed by 721 million toe expected by IEEJ, with the smallest 491 million toe expected by EIA. It is inferred that such difference is mainly due to each organization's different concept of coal consumption in China and India, particularly, in the power sector from another.

Table 2-1 Coal Consumption Outlook Comparison

		2008	2010		2020	2030	2035
a. Primary energy consumption of world (million toe)	EIA	12,718	―		15,611	18,181	19,398
	IEA	―	12,730		15,332	17,499	18,676
	IEEJ	―	11,743		14,128	16,458	17,517
b. Coal consumption of world (million toe)	EIA	3,502	―		4,147	4,905	5,270
	IEA	―	3,474		4,417	5,115	5,523
	IEEJ	―	3,476		4,052	4,622	4,870
c. Ratio of coal (b/a)	EIA	27.5%	―		26.6%	27.0%	27.2%
	IEA	―	27.3%		28.8%	29.2%	29.6%
	IEEJ	―	29.6%		28.7%	28.1%	27.8%
d. Coal consumption of Asia (million toe)	EIA	2,139	―		2,851	3,524	3,815
	IEA*	―	2,276		3,161	3,808	4,169
	IEEJ	―	2,228		2,783	3,301	3,544
e. Asian coal consumption ratio (d/b)	EIA	61.1%	―		68.8%	71.8%	72.4%
	IEA*	―	65.5%		71.6%	74.4%	75.5%
	IEEJ	―	64.1%		68.7%	71.4%	72.8%
f. Coal consumption of China (million toe)	EIA	1,521 (71.1%)	―		2,156 (75.6%)	2,683 (76.1%)	2,864 (75.1%)
	IEA	―	1,602 (70.4%)		2,148 (67.9%)	2,429 (63.8%)	2,561 (61.4%)
	IEEJ	―	1,595 (71.6%)		1,896 (68.1%)	2,134 (64.6%)	2,205 (62.2%)
g. Coal consumption of India (million toe)	EIA	274 (12.8%)	―		342 (12.0%)	435 (12.4%)	491 (12.9%)
	IEA	―	283 (12.5%)		478 (15.1%)	701 (18.4%)	862 (20.7%)
	IEEJ	―	288 (12.9%)		447 (16.1%)	618 (18.7%)	721 (20.3%)

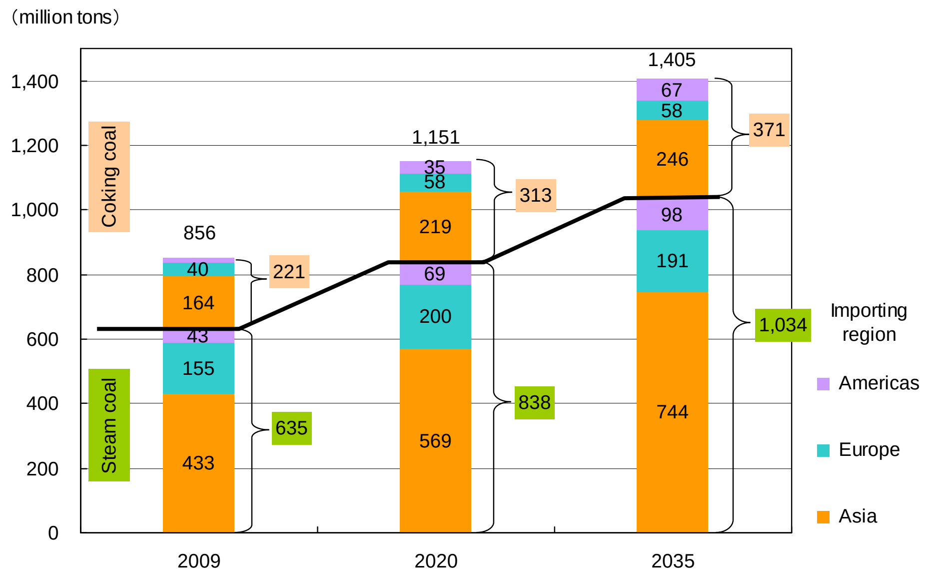
Note: EIA (IEO2011) gives values based on Reference case, IEA (WEO2012) gives values based on Existing Energy Policy Scenario, and IEEJ (IEEJ2012) gives values based on Reference case.
As for IEA*, coal consumption in Asia/Oceania including Australia and New Zealand is provided.
Coal consumptions in China and India presented with % in parentheses represent each country's share of Asia's coal consumption.

Source: Prepared by JICA study team based on the "International Energy Outlook 2011" of EIA, the "World Energy Outlook 2012" of IEA, and the "Asia/World Energy Outlook 2012" of IEEJ

(5) Coal trade outlook

According to IEO2011 of EIA, world coal trade is expected, as shown in Fig. 2-43, to grow at an annual rate of 1.9% between 2009 and 2035 to increase from 856 million tons in 2009 to 1,405 million tons in 2035. Among the 549 million ton-increase to be reached in 2035, steam coal bears 399 million tons, which accounts for 73% of the total increment. Meanwhile, the ratio of Asia's coal trade volume to the world coal trade is assumed to expand, though slightly, from 69.6% in 2009 to 70.5% in 2035.

Steam coal trade volume will increase toward 2035 not only in Asia and the Americas (South/North Americas) but also in Europe (including the former Soviet Union, the Mediterranean Sea-front Africa, and others) but 78% of the increment is attributed to Asia. Asia's steam coal trade volume is expected to increase by 312 million tons from 433 million tons in 2009 to 744 million tons in 2035. On the other hand, coking coal trade volume is also assumed to increase in every region toward 2035. Coking coal trade volume is expected to increase during that period by 82 million, 50 million, and 18 million tons in the Asia, the Americas, and the Europe region, respectively.



Note: Steam coal includes anthracite.

Source: Prepared by JICA study team based on the "International Energy Outlook 2011" of EIA

Fig. 2-43 World Coal Trade Outlook (IEO2011, Reference case)

Looking at the outlook for exports to Asia from major exporting countries, as shown in Table 2-2, the volume of exports from Australia increases from 250 million tons in 2009 to 466 million tons in 2035 and the ratio of Australia to the entire Asia-bound trade volume increase by 5.1 percentage points from 41.9% in 2009 to 47.0% in 2035. The export volume of Indonesia that is the second largest exporting country after Australia in 2009 is expected to increase by some 100 million tons during the same period to reach 313 million tons in 2035 but it is anticipated that, in and after 2016, the Asia-bound export volume will hit its ceiling at around 300 million tons. Coal exports from China are expected to remain on the level of 20 million tons in the future against a background of growing domestic demand. As for other exporting countries, the volume of exports from the former Soviet Union region is expected to increase by 1.3 times from 26 million tons in 2009 to 35 million tons in 2035 and the volume of exports from South Africa, etc., is expected to increase by 2.9 times from 25 million tons in 2009 to 74 million tons in 2035. Furthermore, exports from the South America region which exported nearly no coal to Asia in 2009 are expected to increase to 17 million tons in 2035. In the meantime, Canada and Vietnam are assumed to decrease the volume of coal exports to Asia toward 2035 in the future.

Table 2-2 Coal Export Outlook by Main Exporting Country

(million tons)

Exporting country	2009			2020			2035		
	Steam	Coking	Total	Steam	Coking	Total	Steam	Coking	Total
Australia	132	118	250	165	145	310	299	166	466
USA	1	5	6	7	22	29	11	17	28
Southern Africa	25	0	25	41	7	48	61	13	74
Former Soviet Union	22	4	26	20	8	28	25	10	35
Poland	0	0	0	0	0	0	0	0	0
Canada	6	16	22	0	17	17	0	20	20
China	22	1	22	25	1	26	25	1	26
South America	0	0	0	0	0	0	17	0	17
Vietnam	27	0	27	14	0	14	11	0	11
Indonesia	199	19	218	297	19	316	294	19	313
Total	433	164	596	569	219	789	744	246	990

Note: Steam: Steam coal, Coking: Coking coal. Steam coal includes anthracite.
The volume of exports from Indonesia in 2009 includes the following volume (approximate figure) of exports from other regions: Some 3.9 million tons of steam coal, some 1.5 million tons of coking coal, some 5.4 million tons in total

Source: Prepared by JICA study team based on the "International Energy Outlook 2011" of EIA

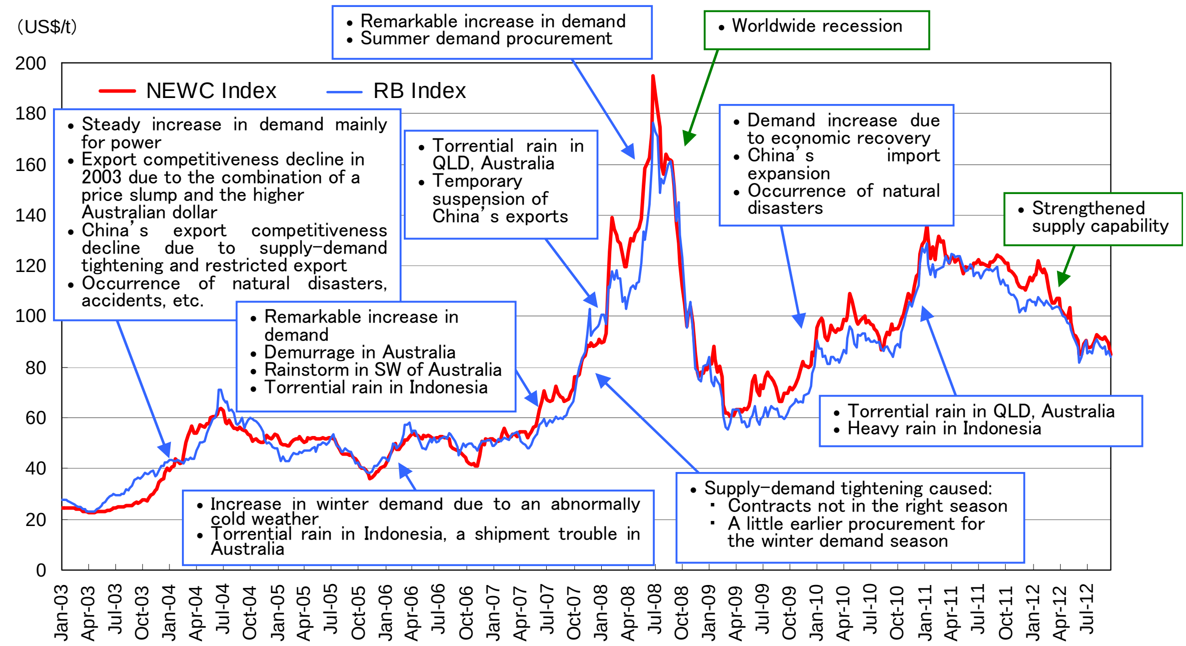
2.2.4 Present state of and outlook for coal price

The present major price indices of steam coal include those cited below. For reference, transitions of NEWC Index and RB Index of globalCOAL are shown in Fig. 2-44.

- NEWC Index (FOB price of steam coal shipped from Newcastle Port, Australia) : globalCOAL
- RB Index (FOB price of steam coal shipped from Richards Bay Port, South Africa) : globalCOAL
- API4 (FOB price of steam coal shipped from Richards Bay Port, South Africa) : Argus/McCloskey
- API6 (FOB price of steam coal shipped from Newcastle Port, Australia) : Argus/McCloskey
- NEX Spot Index (FOB price of steam coal shipped from Newcastle Port, Australia) : Energy Publishing Inc

When coal is actually purchased, a contract is signed such as with reference to the above price index and a coal purchase contract can be roughly divided into a long-term contract and a spot contract. Power companies of countries that depend upon imports for nearly 100% of coal supply such as Japan, South Korea, and Taiwan procure 70% or more of consumption under long-term contract (including one-year contract) due to the stability and continuity of coal supply. In steam coal trades other than for power generation, a one-year contract or a spot contract under which the price is determined each time is common. Steel companies also emphasize more stable and consecutive supply to make coke and execute a long-term contract more frequently than power companies. Table 2-3 shows by-contract type characteristics in Japan.

Coking coal is, as shown in Table 2-3, hardly procured under a spot contract but mainly negotiated for transactions between a shipper and a consumer. Coking coal has so far had no price index similar to that of steam coal and Coking coal price has been determined an annual agreement price through the negotiation between shippers and steel companies. Since FY2010, at the request of BMA and other shippers, long-term contract-based prices have been reexamined every quarter for coking coal.



Source: Prepared by JICA study team based on the data contained in the Web site of globalCOAL

Fig. 2-44 NEWC Index and RB Index of globalCOAL

Table 2-3 Type of Coal Purchase Contract in Power and Steel Sectors of Japan

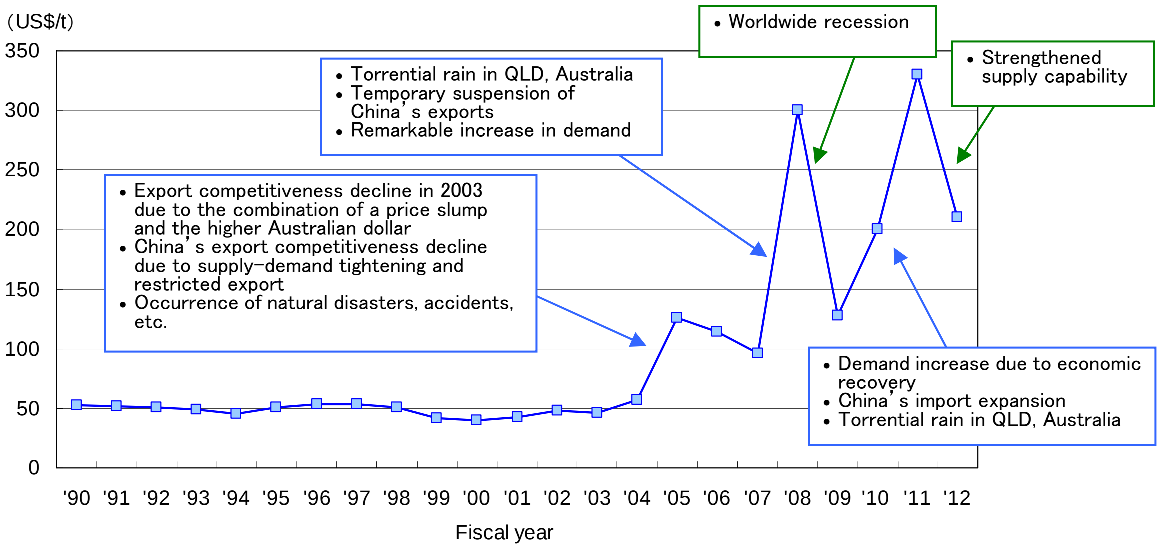
	Long-term contract*	Spot contract
Power	70 to 90%	10 to 30%
Steel	95 to 100%	0 to 5%
Merit	Secured contract volume	Highly flexible to a change in demand
Demerit	Less flexible to a change in demand	High risk of securing volume

Note: Long-term contracts generally mean three- or more-year ones but, here, include less than three-year contracts.

Source: Prepared by JICA study team based on various materials

Reviewing coking coal price, since steel demand dipped substantially in and after fall of 2008 under the influence of worldwide recession, demand for coking coal decreased, resulting in a significant drop of FY2009's coking coal price as shown in Fig. 2-45. After that, the coking coal price rose due to increase of demand in 2010 and rose sharply to over 300 US$/ton due to heavy rainfall since November 2010. But the coking coal price have been falling since in August 2011, as coking coal supply have caught up demand in late 2011 and, the increase of coking coal demand have slowed down in 2012.

With regard to coking coal, Energy Publishing started showing its price indices in 2010 and Argus also did so in 2012. Fig. 2-46 shows Energy Publishing's coking coal price indices as an example.

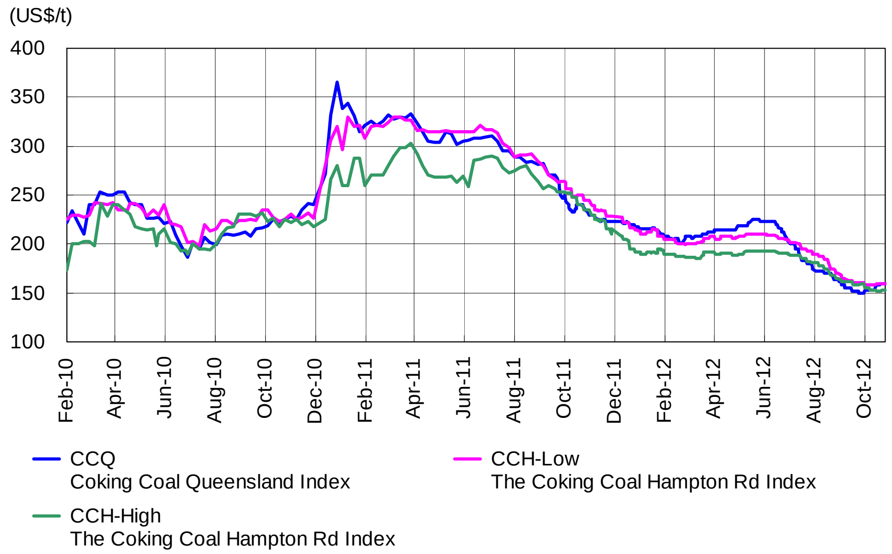


Note: Up to FY2009, Goonyella coal price is used, for FY2010, Peak Downs/Saraji coal price, and for FY2011 and FY2012, German Creek/Hail Creek coal price.

Source: Prepared by JICA study team based on the "Coal 2005" of Energy Publishing up to FY2005 and various data in and after FY2006

Fig. 2-45 FOB Japan-Bound Australian Coking Coal

(Heavy Coking Coal) Price(at the Time of Annual Revision (April))



Note: CCQ: Spot price index of steam coal produced in QLD, Australia
CCH-Low: Spot price index of low-volatile steam coal shipped from Hampton Rd (coal export terminal), US East Coast
CCH-High: Spot price index of high-volatile steam coal shipped from Hampton Rd (coal export terminal), US East Coast

Source: Prepared by JICA study team based on the information contained in the web site of Energy Publishing Inc.

Fig. 2-46 Energy Publishing's FOB Coking Coal Price Indices

Coal prices are those determined by the supply and demand situation at that time, it is difficult to predict future price specifically. Import prices of steam coal contained in the "Asia/World Energy Outlook 2011" of IEEJ (Table 2-4) are shown here.

Table 2-4 Energy Price Outlook (CIFP of Japanese Imports)

		2000	2011	2020	2030	2035
Crude oil	Real price	35	109	115	122	125
$/bbl	Nominal price	28	109	137	177	201
LNG	Real price	303	762	753	739	729
$/t	Nominal price	244	762	899	1,076	1,173
Steam coal	Real price	44	138	136	139	143
$/t	Nominal price	35	138	163	203	230

Note: Japanese CIF prices. Real prices are 2011's. Calculated, using an annual inflation rate of 2%.

Source: The "Asia/World Energy Outlook 2012" of IEEJ

2.3 Outlook for coal supply and demand such as in Northeast Asia and analysis of future Northeast Asia coal market

Coal demand in the Asia region including Northeast Asia has rapidly increased and is also expected to expand in the future along with economic development. In this part, coal demand of Northeast Asian countries (Japan, South Korea, and Taiwan) including China that is a major export market of Mongolian coal and that of India and Southeast Asian countries is projected and, at the same time, supply potentials of major coal supplier countries are reviewed to have a look over of the Northeast Asia coal market in 2025.

2.3.1 Coal demand

(1) Coal demand prediction method and conditions

It is necessary in this demand prediction to analyze the market condition (supply-demand situation) of coking coal separately from that of steam coal since the mainstay of coal exported from Mongolia is coking coal. Coal demand forecast is, therefore, made for steam coal and coking coal separately. The "Asia/World Energy Outlook" reported each year by The Institute of Energy Economics, Japan is consulted in predicting supply and demand of coal. And there are many demand prediction tools but, here, the "Simple E" software developed by IEEJ independently is used.

(a) Countries (regions) to be covered

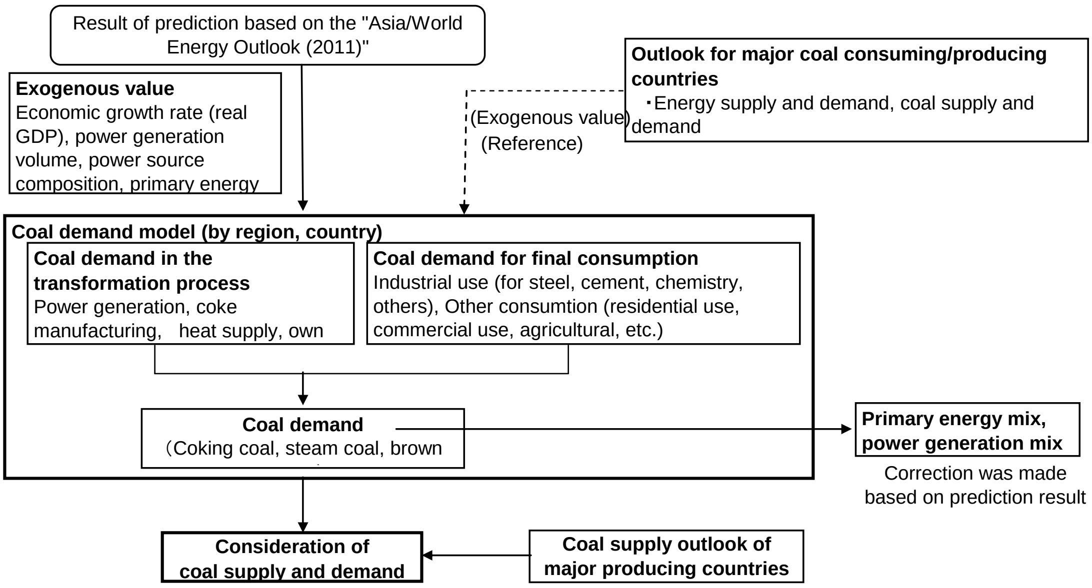
Countries covered are as follows:

Major Northeast Asian countries/regions： China, Japan, Hong Kong, Taiwan, South Korea

Southeast Asia, etc.： Indonesia, India, Malaysia, the Philippines, Thailand, Vietnam

(b) Basic structure of a model

Fig. 2-47 shows the basic structure of a coal demand model. From the result of "Asia/World Energy Outlook," the economic growth rate, power generation volume, power generation composition and primary energy demand are imparted to the coal demand model as exogenous values to make a forecast with reference to the outlook released by the relevant countries. Coal demand is divided such as into power generation and coke manufacturing purposes in the transformation process and, for final consumption, into industrial (steel, cement, and other), primary industry, residential use, etc. for by-coal type prediction.



Source: JICA study team

Fig. 2-47 Structure of a Model

(c) Preconditions for prediction

Precondition for prediction is as follows. Any information or data obtained concerning the outlook for each country (region), etc. are not simply taken into consideration but also expressed numerically, to be substituted for the model as exogenous values for certain countries:

1) Time series data

IEA data (1980 through 2010) to be used

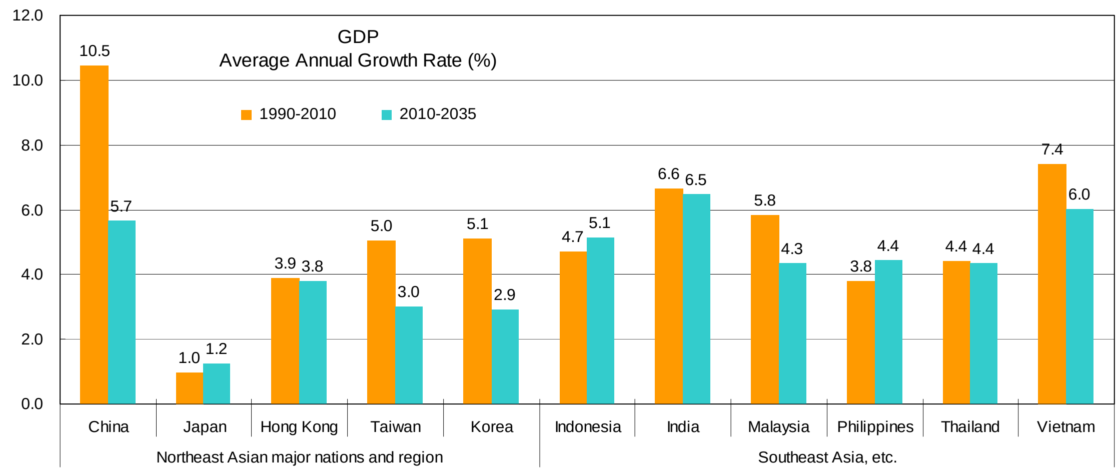
2) Period of prediction

This survey targets 2025 but, for subsequent demand situation analysis to identify coal demand in 2025, prediction is made until 2035 with 2010 as the reference year.

3) Economic growth

Economic growth rates used in this prediction are those contained in the "Asia/World Energy Outlook 2012" reported by the Institute of Energy Economics, Japan in November, 2012[9], which are shown in Fig. 2-48.

[9] Established on the basis of predictions by international organizations including the Asian Development Bank, economic development programs announced by national (regional) governments, and national (regional) potential economic growth rates.



Source: Prepared by JICA study team based on The "Asia/World Energy Outlook 2012" of IEEJ

Fig. 2-48 Economic Growth Rate

4) Power generation volume and its composition

Since consumption in the power sector accounts for a large percentage of demand for steam coal, power generation volume and its composition are key determinants of steam coal demand. Power generation volume and its composition used in this prediction are basically those predicted in the "Asia/World Energy Outlook 2012."

(2) Coal demand in Asia

The prediction result of coal demand and imports in Asia including Northeast Asia (total of 11 countries covered by this survey) is as follows (Table 2-5 and Fig. 2-49):

Coal demand grows by 2.3% annually between 2010 and 2025 to increase 1.4 times from 4,311 million tons in 2010 to 6,096 million tons in 2025.

Looking at coal demand by coal type, coking coal decreases though slightly from 584 million tons in 2010 to 606 million tons in 2025. India is likely to expand its crude steel production while such production in other crude steel producers, namely, in Japan, South Korea, and Taiwan, remains almost unchanged and demand for coking coal will decrease if the progress of technology is considered. Moreover, concerning the largest crude steel producer, China, production has rapidly expanded so far but, from now on, entering the transition stage of an industrial structure from secondary to tertiary industry, crude steel production is assumed to show no increase and coking coal demand is also likely to decrease slightly. Regarding imports of coking coal, despite a little decrease in demand, the import volume is assumed to increase. This assumed increase in import volume is due to the assumption that imports will expand in India where demand for coking coal is to increase along with expansion of crude steel production in the future as well as that cheaper coking coal will come into China, where coking coal is deemed as a scarce resource, from Mongolia and other overseas markets.

Steam coal demand is also increasing in Southeast Asian countries, mainly in China and India, as fuel for power generation, though there is no fast growth like that previously achieved by China. Demand for steam coal grows at an annual rate of 2.6% from 3,670 million tons in 2010 to 5,411 million tons in 2025.

The import volume also increases along with expansion of demand. Imports expand, particularly, in coal resources-poor Southeast Asian countries (Malaysia, Thailand, Vietnam[10], and the Philippines) as well as in India.

Table 2-5 Outlook for Coal Demand and Coal Import in Asia (11 countries covered by this study)

(kT) (%)

		1980	2000	2010	2020	2025	2030	2035	10/00	25/10	35/25
Demand		880,831	2,160,973	4,310,977	5,547,585	6,095,926	6,677,136	7,229,777	7.2	2.3	1.7
	Coking coal	157,712	237,378	583,994	626,664	605,810	583,825	585,709	9.4	0.2	-0.3
	Steam coal	715,986	1,880,201	3,670,136	4,849,572	5,411,197	6,006,651	6,547,527	6.9	2.6	1.9
	Lignite	7,133	43,395	56,848	71,349	78,919	86,660	96,542	2.7	2.2	2.0
Import		81,220	303,962	669,163	916,043	1,048,182	1,188,832	1,361,236	8.2	3.0	2.6
	Coking coal	68,277	93,356	145,676	186,787	206,987	226,206	251,425	4.6	2.4	2.0
	Steam coal	12,943	210,606	523,487	729,256	841,194	962,627	1,109,811	9.5	3.2	2.8
	Lignite	0	0	0	0	0	0	0			

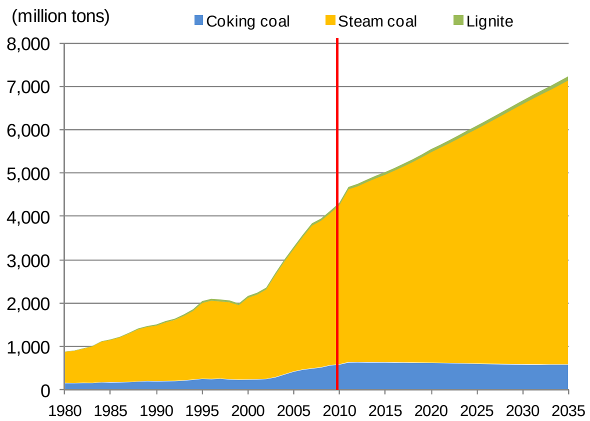
(Reference: ton of oil equivalent)

(kTOE) (%)

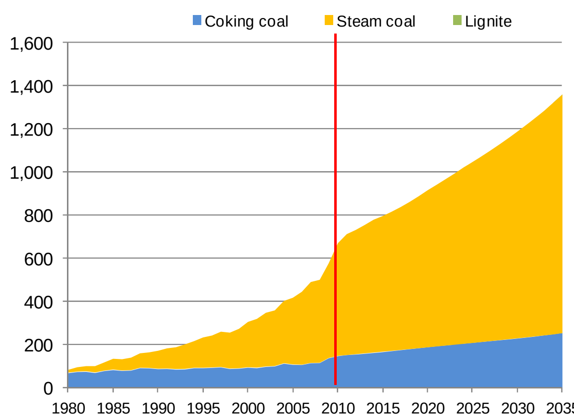
		1980	2000	2010	2020	2025	2030	2035	10/00	25/10	35/25
Demand		427,057	1,045,977	2,150,805	2,777,578	3,047,973	3,335,374	3,608,534	7.5	2.4	1.7
	Coking coal	103,906	153,641	375,417	402,623	389,366	375,362	376,598	9.3	0.2	-0.3
	Steam coal	321,597	881,521	1,761,778	2,357,509	2,639,526	2,939,282	3,209,072	7.2	2.7	2.0
	Lignite	1,554	10,815	13,610	17,445	19,081	20,730	22,864	2.3	2.3	1.8
Import		57,118	190,076	419,174	567,168	645,848	729,493	830,619	8.2	2.9	2.5
	Coking coal	49,761	61,896	94,079	119,290	131,976	144,198	160,187	4.3	2.3	2.0
	Steam coal	7,357	128,180	325,095	447,878	513,872	585,295	670,432	9.8	3.1	2.7
	Lignite	0	0	0	0	0	0	0			

Source: JICA study team

＜Coal Demand＞



＜Coal Imports (Coal Market)＞



Source: JICA study team

Fig. 2-49 Outlook for Coal Demand and Coal Import in Asia (11 countries covered by this study)

Prediction results of demand in the Northeast Asia market as a major market for Mongolian coal and in the Southeast Asia market including India are shown in Table 2-6, Table 2-7, Fig. 2-50, and Fig. 2-51.

[10] Vietnam is a coal (anthracite)-exporting country and anthracite is abundantly distributed in its northern part but, since it cannot keep up with demand for power generation-purpose coal, coal thermal with imported coal is under planning mainly in its southern part.

Coal demand of Northeast Asia increases at an annual rate of 1.9% from 2010 to 2025 and coal demand in 2025 reaches 4,660 million tons 1.3 times as large as that in 2010. On the other hand, rapid future expansion of coal supply and demand of India/Southeast Asia is expected, it will almost double at an annual rate of 4.2% from 776 million tons in 2010 to reach1, 436 million tons in 2025. Looking at demand by coal type, coking coal increases at an annual rate of 5.4% and steam coal increases at an annual rate of, 4.2% toward 2025, allowing demand for both in 2025 to reach 115 million tons and 1,242 million tons respectively. The increment in coking coal is attributable to India and steam coal demand increases in all Southeast Asian countries covered including India for power generation purposes.

In 2025, Northeast Asia will import 635 million tons of coal and India/Southeast Asia will import 414 million tons, but compared with Northeast Asia's increment of 99 million tons, Indian/Southeast Asia will increase its coal import by 280 million tons. Looking at import volume increase by coal type up to 2025, coking coal increases by 22 million tons and steam coal increase by 78 million tons in the Northeast Asia market. This is compared with 39 million tons of coking coal and 240 million tons of steam coal in the Indian/Southeast Asia market.

Table 2-6 Outlook for Coal Demand and Coal Import in Northeast Asia

(kT) (%)

		1980	2000	2010	2020	2025	2030	2035	10/00	25/10	35/25
Demand		775,929	1,734,553	3,534,669	4,360,117	4,660,245	4,973,283	5,213,925	7.4	1.9	1.1
	Coking coal	142,271	202,597	532,016	534,684	491,239	444,758	417,346	10.1	-0.5	-1.6
	Steam coal	633,658	1,531,956	3,002,653	3,825,433	4,169,006	4,528,525	4,796,580	7.0	2.2	1.4
	Lignite	0	0	0	0	0	0	0			
Import		80,232	268,880	535,157	616,110	634,593	652,376	668,691	7.1	1.1	0.5
	Coking coal	67,727	82,153	126,137	144,258	147,983	148,823	150,863	4.4	1.1	0.2
	Steam coal	12,505	186,727	409,020	471,852	486,610	503,553	517,828	8.2	1.2	0.6
	Lignite	0	0	0	0	0	0	0			

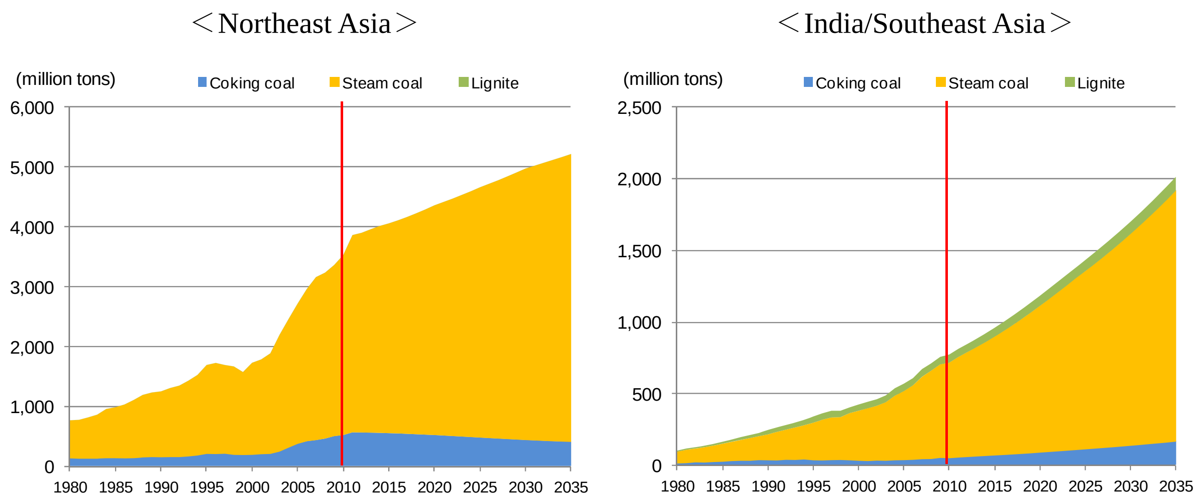
Source: JICA study team

Table 2-7 Outlook for Coal Demand and Coal Import in India/Southeast Asia

(kT) (%)

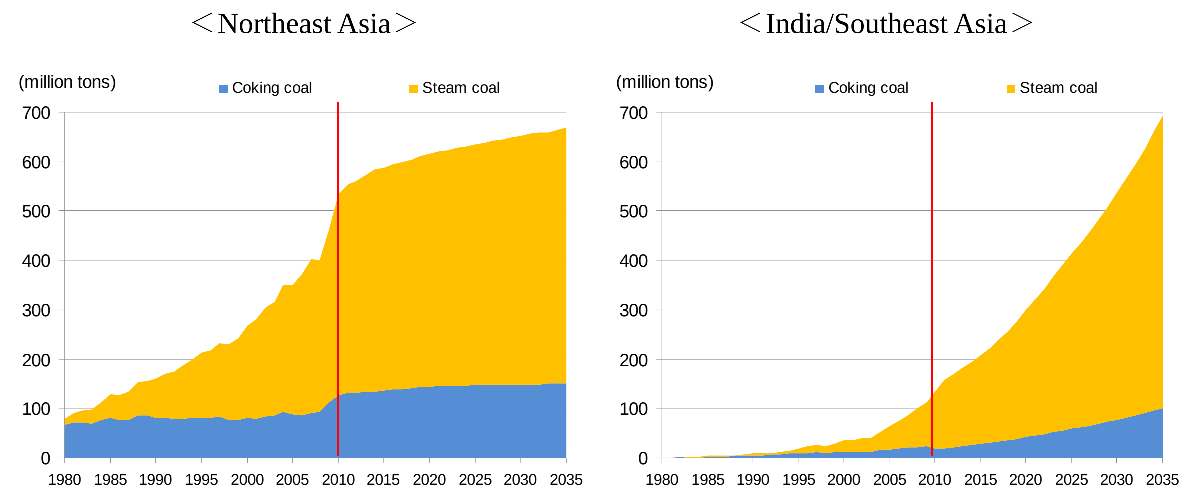
		1980	2000	2010	2020	2025	2030	2035	10/00	25/10	35/25
Demand		104,902	426,421	776,309	1,187,468	1,435,681	1,703,853	2,015,852	6.2	4.2	3.5
	Coking coal	15,441	34,781	51,978	91,979	114,571	139,067	168,363	4.1	5.4	3.9
	Steam coal	82,328	348,245	667,483	1,024,139	1,242,191	1,478,126	1,750,947	6.7	4.2	3.5
	Lignite	7,133	43,395	56,848	71,349	78,919	86,660	96,542	2.7	2.2	2.0
Import		988	35,082	134,006	299,933	413,588	536,456	692,545	14.3	7.8	5.3
	Coking coal	550	11,203	19,539	42,529	59,004	77,383	100,562	5.7	7.6	5.5
	Steam coal	438	23,879	114,467	257,404	354,584	459,073	591,983	17.0	7.8	5.3
	Lignite	0	0	0	0	0	0	0			

Source: JICA study team



Source: JICA study team

Fig. 2-50 Comparison of Demand between Northeast Asia and India/Southeast Asia



Source: JICA study team

Fig. 2-51 Comparison of Import Volume between Northeast Asia and India/Southeast Asia

The following prediction result for India and China which have much coal demand and have a big impact on Asia coal market is described. The demand and imports for coking coal in China is analyzed in some cases, as coking coal market in China is important for coking coal exports of Mongolia.

(3) Coal demand in India

The primary energy demand in India will increase due to a substantial growth of economy as well as with increasing population in the future. India currently depends upon coal for about half of its primary energy consumption, and a similar ratio is expected in 2025. At present, coal accounts for nearly 70% of the total amount of power generated. In the future, much of steam coal will be used for power generation purposes, and its demand will increase in industries such as cement sector. The demand for steam coal will increase at an annual rate of 3.9% toward 2025 to reach 942 million tons, an increase of 1.7 times from 2010. On the other hand, the demand for coking coal will also increase as the economic growth will boost the steel demand. It will increase at an annual rate of 5.4% toward 2025 to reach 115 million tons, an increase of 2.2 times from 2010.

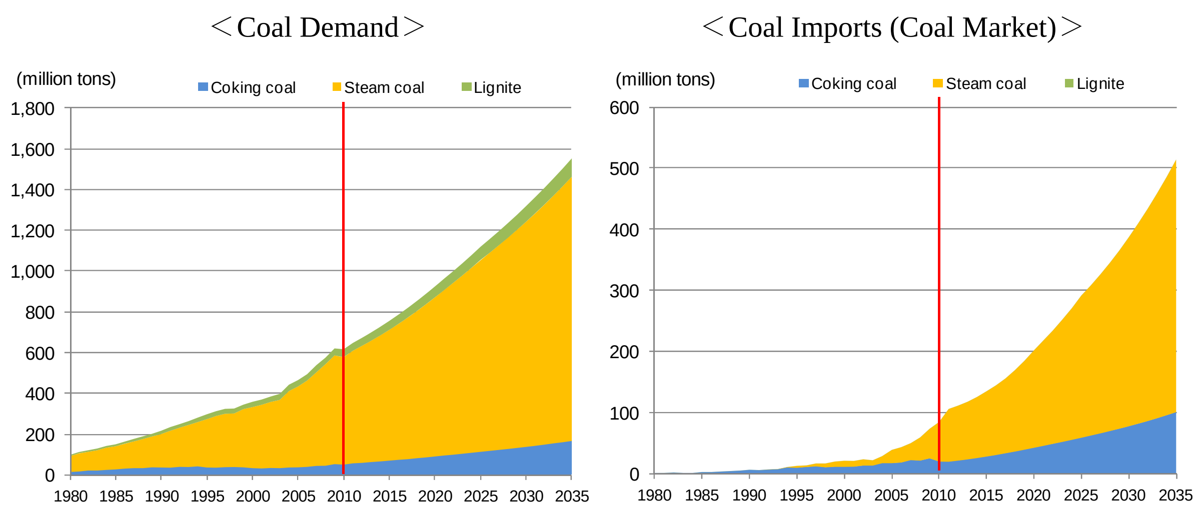
While India has abundant reserves of coal, India cannot cover the demands with only domestic production since the quality is poor due to high ash contents and the development of domestic coal has been so slow. This results in the increase in the volume of imports with growing demand. The volume of imported coal will become much larger in both of coking and steam coal, and 59 million tons of coking coal and 233 million tons of steam coal will be imported in 2025.

Table 2-8 Outlook for Coal Demand and Coal Import in India

(kT) (%)

		1980	2000	2010	2020	2025	2030	2035	10/00	25/10	35/25
Demand		99,189	359,928	618,207	927,482	1,121,335	1,321,166	1,555,128	5.6	4.0	3.3
	Coking coal	15,441	34,641	51,923	91,924	114,516	139,012	168,308	4.1	5.4	3.9
	Steam coal	78,064	299,479	527,478	781,982	941,938	1,105,669	1,296,577	5.8	3.9	3.2
	Lignite	5,685	25,809	38,807	53,575	64,881	76,485	90,243			
Import		550	20,930	84,562	201,825	291,496	386,845	514,173	15.0	8.6	5.8
	Coking coal	550	11,063	19,484	42,474	58,949	77,327	100,506	5.8	7.7	5.5
	Steam coal	0	9,867	65,078	159,351	232,547	309,518	413,667	20.8	8.9	5.9
	Lignite	0	0	0	0	0	0	0			

Source: JICA study team



Source: JICA study team

Fig. 2-52 Outlook for Coal Demand and Coal Import in India

(4) Steam coal demand in China

At present, China depends upon coal for about three fourth of its primary energy consumption, and coal will remain a key source of energy toward 2025.

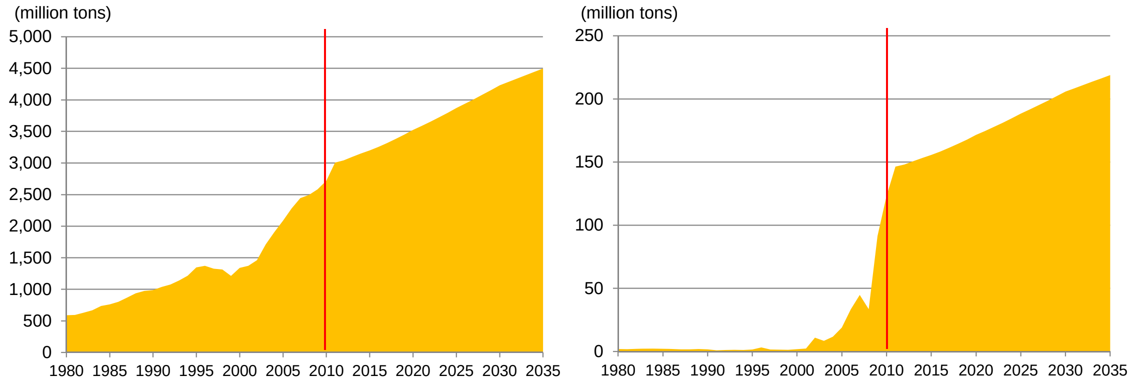
As the economy will gradually slow down, the growth of steam coal demand for industrial sector will decline and steam coal demand for power generation purposes will not increase rapidly like in the 2000's due to a future decline in the growth of power demand. Steam coal demand will grow at an annual rate of 2.4% from 2010 to 2025. The steam coal demand in 2025 will be 3,870 million tons, an increase of 1.4 times from 2010.

Table 2-9 Outlook for Steam Coal Demand and Steam Coal Import in China

(kT) (%)

	1980	2000	2010	2020	2025	2030	2035	10/00	25/10	35/25
Demand	589,038	1,340,165	2,720,805	3,523,356	3,869,778	4,230,665	4,497,620	7.3	2.4	1.5
Imports	1,990	1,839	122,942	171,455	188,312	205,874	218,864	52.2	2.9	1.5

Source: JICA study team



Source: JICA study team

Fig. 2-53 Outlook for Steam Coal Demand and Steam Coal Import in China

(5) Coking coal demand in China[11]

Crude steel production volume has rapidly increased in 2000s, however it has been continued being said that the production hits the ceiling at some future and it has reached the production at the present. Steel industry has been facing overproduction (excess capacity) due to the economic slowdown in 2012, and the problem of inefficient facilities such as outmoded iron works and small-scale still mills is also serious. The government has been promoting measures for energy conservation such as financial assistance to those companies which have cooperated with the closure of aging facilities. Considering the above situation, this prediction mentioned the above is estimated based on the premise of "the crude steel production will not grow but decrease in the future". Here, we estimated the demand for coking coal assuming two other cases than the one presumed in this prediction that." The following three cases are assumed to analyze coking coal demand in China.

Case 1: The production will decrease after peaking in 2011.

Case 2: The production will remain flat in and after 2011.

Case 3: The production will decrease in and after 2021.

The result of prediction is shown in Table 2-10. Since specific energy consumption will be improved because of energy conservation and the closure of outmoded steel mills, coking coal demand will decrease from 5,840 million tons in 2011 to 4,840 million tons in 2025 in Case 1. Crude steel production

[11] In this study, IEA data is used as time-series data. However, JICA team reviews expectation results for regarding the China consultant's (北京亜能時代諮詢有限公司) data is actual data in this section. This reason is to carry out analyzing so that it is closer to reality due to use the China reporting data because most of Mongolian coking coal exports are for China and China coking coal market is to be export market of Mongolian coking coal in the future.

will remain flat in Case 2, but coking coal demand will slightly decrease to 5,620 million tons in 2025 because of the improvement of specific energy consumption by energy conservation and closure of outmoded steel mills. Coking coal demand of Case 3 will increase to 7,020 million tons in 2020 and decrease to 6,610 million tons in 2025.

The analysis for coking coal imports is described in the section of 2.4.2 in detail. Here, the result of prediction is shown in Table 2-10. The volume of imports for coking coal in 2025 will be around same as 2011 in Case 1, increase by more than 10 million tons from 2011 in Case 2, and increase by around 25 million tons in Case 3.

Table 2-10 Outlook for Coking Coal Demand and Coking Coal Import in China

(kT)

		2006	2010	2011	2015	2020	2025	2030	2035
Crude steel production									
	Case 1	422,660	626,959	689,655	673,921	640,892	579,315	510,432	473,281
	Case 2	422,660	626,959	689,655	689,655	689,655	689,655	689,655	689,655
	Case 3	422,660	626,959	689,655	746,288	776,514	738,457	702,266	667,848
Coking coal demand									
	Case 1	408,130	527,100	583,930	565,913	534,663	483,795	429,648	398,889
	Case 2	408,130	527,100	583,930	577,481	569,808	561,724	553,632	545,442
	Case 3	408,130	527,100	583,930	651,812	701,692	660,754	622,497	586,669
Coking coal import									
	Case 1	4,662	47,269	44,658	56,591	53,466	45,961	38,668	31,911
	Case 2	4,662	47,269	44,658	57,748	56,981	56,172	55,363	54,544
	Case 3	4,662	47,269	44,658	67,788	76,484	69,379	62,872	56,907

Note: Actual data of demand and imposts for coking coal is based on the data provided Chinese consultant (“北京亜能時代諮詢有限公司”).

Source: JICA study team

(6) Coal demand by main coal-consuming country (region)

The Outlook of demand and imports for coking coal and steam coal by country surveyed are shown in Table 2-10 and Table 2-11 for reference.

Table 2-11 Outlook for Coking Coal Demand and Coking Coal Import by main country of Asia

Demand (million tons) (%)

	2010	2020	2025	2030	2035	25/10	35/25
China	527.1	534.7	483.8	429.6	398.9	-0.4	-2.0
India	51.9	91.9	114.5	139.0	168.3	4.8	4.0
Japan	57.0	56.8	55.9	55.0	54.1	0.4	-0.3
Korea	27.2	28.0	27.8	27.2	26.3	1.8	-0.5
Taiwan	5.4	6.7	6.5	6.4	6.3	4.1	-0.4
Indonesia	0.1	0.1	0.1	0.1	0.1	-1.5	0.0
Malaysia	0.0	0.0	0.0	0.0	0.0	-	-
Philippines	0.0	0.0	0.0	0.0	0.0	-	-
Thailand	0.0	0.0	0.0	0.0	0.0	-	-
Vietnam	0.0	0.0	0.0	0.0	0.0	-	-
Hongkong	0.0	0.0	0.0	0.0	0.0	-	-

Imports (million tons) (%)

	2010	2020	2025	2030	2035	25/10	35/25
China	47.3	53.5	46.0	38.7	31.9	3.4	1.1
India	19.5	42.5	58.9	77.3	100.5	5.5	5.6
Japan	57.7	56.8	55.9	55.0	54.1	0.5	-0.3
Korea	28.2	28.0	27.8	27.2	26.3	2.0	-0.5
Taiwan	5.5	6.7	6.5	6.4	6.3	3.2	-0.4
Indonesia	0.1	0.1	0.1	0.1	0.1	-1.4	0.0
Malaysia	0.0	0.0	0.0	0.0	0.0	-	-
Philippines	0.0	0.0	0.0	0.0	0.0	-	-
Thailand	0.0	0.0	0.0	0.0	0.0	-	-
Vietnam	0.0	0.0	0.0	0.0	0.0	-	-
Hongkong	0.0	0.0	0.0	0.0	0.0	-	-

Note: The values for demand and imports in China is used the values of Case 1 in Table 2-10.
Source: JICA study team

Table 2-12 Outlook for Steam Coal Demand and Steam Coal Import by main country of Asia

Demand (million tons) (%)

	2010	2020	2025	2030	2035	25/10	35/25
China	2,720.8	3,523.4	3,869.8	4,230.7	4,497.6	2.4	1.5
India	527.5	782.0	941.9	1,105.7	1,296.6	3.9	3.2
Japan	123.5	142.7	142.3	142.0	148.9	0.9	0.5
Korea	84.9	89.3	87.4	86.1	84.4	0.2	-0.3
Taiwan	63.0	70.8	72.3	74.9	76.0	0.9	0.5
Indonesia	59.9	95.5	120.1	150.8	189.7	4.7	4.7
Malaysia	23.4	42.2	49.5	56.4	62.9	5.1	2.4
Philippines	13.3	18.5	21.8	25.6	29.7	3.3	3.1
Thailand	17.1	25.8	31.2	35.6	40.4	4.1	2.6
Vietnam	26.1	60.2	77.7	104.1	131.7	7.5	5.4
Hongkong	10.3	13.2	13.7	13.9	13.6	1.9	-0.1

Imports (million tons) (%)

	2010	2020	2025	2030	2035	25/10	35/25
China	122.9	171.5	188.3	205.9	218.9	2.9	1.5
India	65.1	159.4	232.5	309.5	413.7	8.9	5.9
Japan	127.7	142.2	142.1	142.0	148.9	0.7	0.5
Korea	85.4	88.2	86.7	85.9	84.4	0.1	-0.3
Taiwan	57.6	70.8	72.3	74.9	76.0	1.5	0.5
Indonesia	0.0	0.0	0.0	0.0	0.0	-	-
Malaysia	20.7	39.9	47.2	54.1	60.6	5.6	2.5
Philippines	11.0	14.4	17.0	20.0	23.7	3.0	3.3
Thailand	16.8	25.8	31.2	35.6	40.4	4.2	2.6
Vietnam	0.9	17.9	26.6	39.9	53.7	25.5	7.2
Hongkong	10.3	13.2	13.7	13.9	13.6	1.9	-0.1

Source: JICA study team

2.3.2 Coal supply

(1) Coal export potentials of major coal supplier countries

Australia, Indonesia, Russia, the United States, Canada, South Africa, China, etc. may be cited as coal producing courtiers which supply (export) coal to Northeast Asia coal markets, and, regarding coking coal, Mozambique can be further added as a new exporting country. The following summarizes coal export potentials of these coal supplier countries:

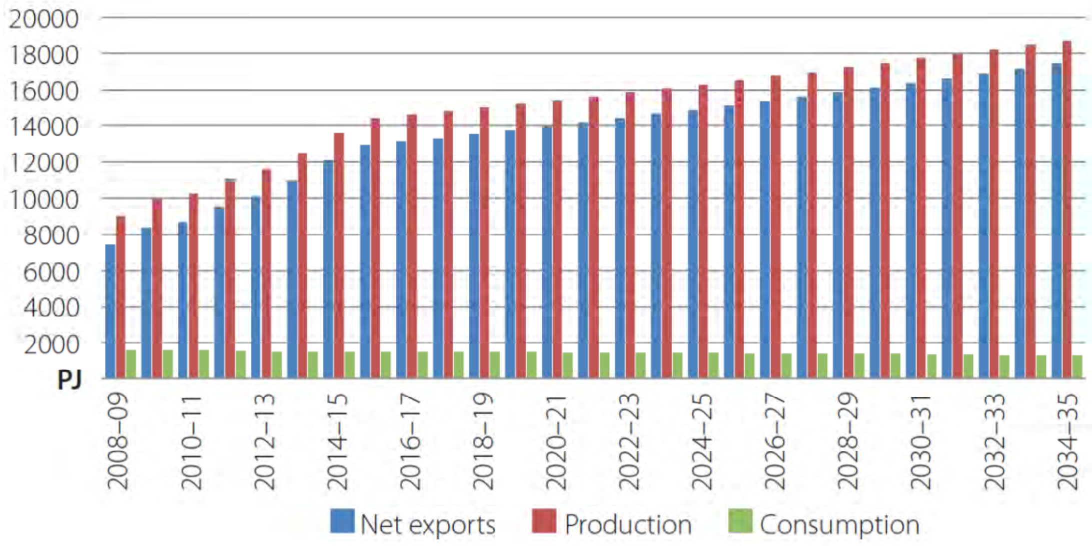
(a) Australia

According to the "Australian energy projections to 2034–35" released by the Bureau of Resources and Energy Economics (BREE), a research body of the commonwealth of Australia, in December, 2011, production of black coal (bituminous coal of both steam and coking coal, etc.) is expected to increase at an annual rate of 2.8% from 300 million tons (9,004 petajoules) in FY2008/09 to 623 million tons in FY2034/35 (18,676 petajoules) as shown in Table 2-13 and Fig. 2-54. Since domestic coal demand is expected to become lower than that at present in the future, the export volume should increase along with expansion of production. Construction of infrastructure for coal development and coal exports is promoted in the State of New South Wales and the State of Queensland, and it is expected that the volume of coal exports will continue to expand at an annual rate of 3.3% toward FY2034/35 from 247 million tons (7,411 petajoules) to reach 581 million tons (17,415 petajoules) (black coal alone).

Table 2-13 Australian Coal Supply and Demand Outlook

		2008/09		2019/20		2034/35	
		(million tons)	(PJ)	(million tons)	(PJ)	(million tons)	(PJ)
Production	Black Coal	300	(9,004)	506	(15,185)	623	(18,676)
	Brown Coal	66	(647)	66	(647)	29	(281)
		366	(9,651)	572	(15,832)	651	(18,957)
Domesiti Consamption	Black Coal	53	(1,593)	49	(1,460)	42	(1,260)
	Brown Coal	66	(647)	66	(647)	29	(281)
		119	(2,240)	115	(2,107)	71	(1,541)
Exports	Black Coal	247	(7,411)	458	(13,725)	581	(17,415)
	Brown Coal	0	(0)	0	(0)	0	(0)
		247	(7,411)	458	(13,725)	581	(17,415)

Source: Prepared by JICA study team based on the "Australian energy projections to 2034–35, December 2011" of BREE



Source: The "Australian energy projections to 2034–35, December 2011" of BREE

Fig. 2-54 Australian Black Coal Supply and Demand Outlook

In the "Resources and Energy Major Projects, October 2012" made public by BREE on its own Web site in November, 2012, 45 projects to expand existing coal mines (18 under construction[12]) and 55 new development projects (5, the same), totaling 100 projects (23, the same), are listed up (Table 2-14). If coal supply capacity that can be added by such coal production increase projects listed up here in and after 2012 is cumulated, Australia can add 640 million tons of coal supply capacity in total in 2017, of which steam coal is 450 million tons and 190 million tons is coking coal (Table 2-15). BREE says that 348 million tons of coal (coal product except lignite) was actually produced in 2011 and simple addition of this value to added coal supply capacity gives 990 million tons as of 2017. BREE expects coal production (coal product except lignite) in 2019/20 to be 506 million tons and, if production increase projects shown in the "Resources and Energy Major Projects, October 2012" are implemented smoothly, it seems that supply capacity will be sufficient enough to satisfy the expected value even if some of existing mines are closed due to coal reserve depletion. Since coal production can be expanded as mentioned above, it is assumed quite possible to achieve the outlook for 2019/20 coal exports. According to BREE, Australia exported 281 million tons of coal in 2011, of which 148 million tons or its 53% was steam coal and 133 million tons or its 47% was coking coal.[13] This means that, if the above ratio is applied the forecast for amount of export shown in Table 2-13, as shown in Table 2-16, the volume of steam coal exports swells to 241 million tons in 2019/20 and to 305 million tons in 2034/35, while the volume of coking coal exports goes up to 217 million tons in 2019/20 and to 275 million tons in 2034/35.

[12] Including the committed projects and the completed projects.
[13] BREE's Web site-contained information "Resources and Energy Statistics, December Quarter 2011"

Table 2-14 Number of Australian Coal Projects

	NSW	QLD	West Australia	Total
Expansion	22 (10)	23 (8)	0 (0)	45 (18)
New Project	8 (1)	46 (4)	1 (0)	55 (5)
Total	30 (11)	69 (12)	1 (0)	100 (23)

Note: The figures in parentheses are the number of projects under construction (including the committed projects and the completed projects).

Source: Prepared by JICA study team based on the "Resources and Energy Major Projects, October 2012"of BREE

Table 2-15 Australian Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015	2016	2017+
NSW		12.0	15.6	34.5	21.5	8.1	30.9
	Steam Coal	9.0	8.0	26.1	16.0	1.6	26.0
	Coking Coal	3.0	7.6	8.4	5.5	6.5	4.9
QLD		7.5	33.7	108.0	158.1	38.9	165.6
	Steam Coal	1.7	5.0	78.8	144.3	7.0	122.2
	Coking Coal	5.8	28.7	29.3	13.8	31.9	43.4
West Australia		0.0	0.0	2.5	0.0	0.0	0.0
	Steam Coal	0.0	0.0	2.5	0.0	0.0	0.0
	Coking Coal	-	-	-	-	-	-
Total		19.5	49.3	145.0	179.6	47.0	196.5
	Steam Coal	10.7	13.0	107.4	160.3	8.6	148.2
	Coking Coal	8.8	36.3	37.7	19.3	38.4	48.3
Cumulative Total		19.5	68.8	213.8	393.4	440.4	636.9
	Steam Coal	10.7	23.7	131.1	291.4	300.0	448.2
	Coking Coal	8.8	45.1	82.8	102.1	140.5	188.7

Source: Prepared by JICA study team based on the "Resources and Energy Major Projects, October 2012" of BREE

Table 2-16 Australia's By-Coal Type Coal Exports Outlook

(million tons)

		2011 Actual	2019/20	2034/35
Exports	Steam Coal	148	241	305
	Coking Coal	133	217	275
		281	458	581

Note: Actual values are based on BREE statistics.

Source: Prepared by JICA study team based on the "Resources and Energy Statistics, December Quarter 2011"of BREE and Table 2-13

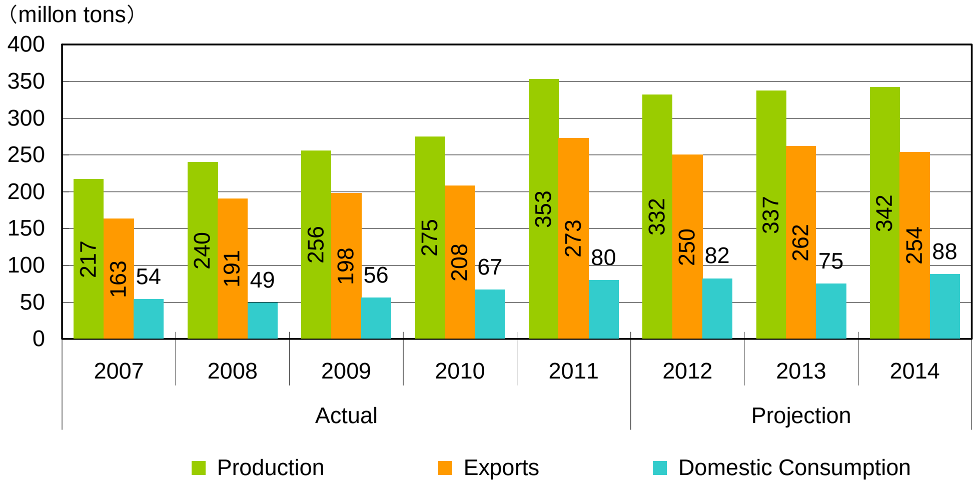
(b) Indonesia

According to the presentation[14] made by Mr. Wibowo, Directorate General of Mineral and Coal, the Ministry of Energy and Mineral Resources, at the "Clean Coal Day in Japan 2012 International Symposium" held on September 4 and 5, 2012, as shown in Fig. 2-55, in the medium run, both production volume and export volume of coal fail to maintain such expansion as was achieved before and hit their ceilings. And according to the presentation[15] made by Mr. Kamandanu from the

[14] The "Coal Policy and The New Mining Law No. 4/2009 in Indonesia"
[15] The "Indonesian Coal Mining Outlook"

Indonesian Coal Mining Association at the IEA workshop "Coal Market's Outlook" held in China on April 14, 2011, as shown in Fig. 2-56, it is expected that, in the long term, coal production will continue to expand. It is, however, assumed that since domestic coal demand is expected to increase, exports will remain in the range from 240 million tons to 260 million tons and fail to maintain such expansion as was achieved before.

Table 2-17 shows a compilation[16] of projects for production increase at existing coal mines and new coal mine development cited in an information magazine[17] of 2011 and 2012, indicating that the supply capacity that can be added between 2012 and 2014 reaches 121 million tons (107 million tons of steam coal and 14 million tons of coking coal). As shown in Fig. 2-55, in the medium run, since no increase in coal production is expected between 2011 and 2014, 121 million tons of supply capacity to be added becomes reserve supply capacity as is. In other words, Indonesia comes to have some 100 million tons-worth reserve coal export capacity.



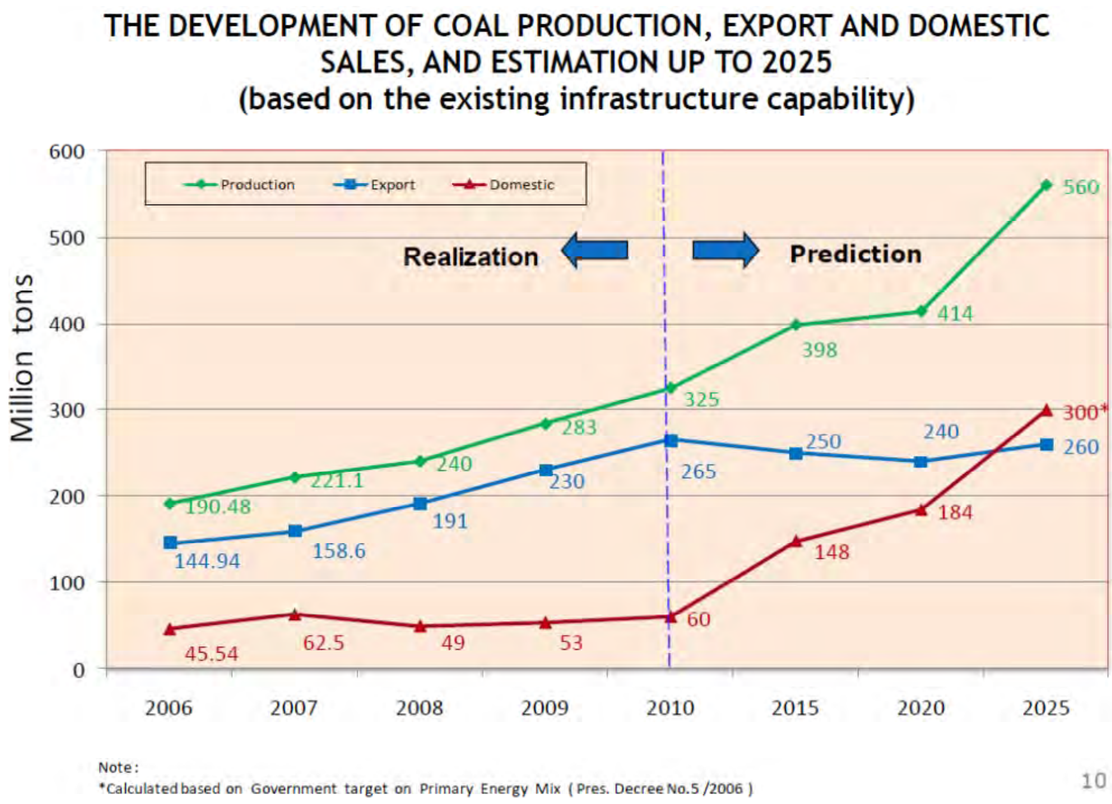
(million tons)

	Actual					Projection		
	2007	2008	2009	2010	2011	2012	2013	2014
Production	217	240	256	275	353	332	337	342
Exports	163	191	198	208	273	250	262	254
Domestic Consumption	54	49	56	67	80	82	75	88

Source: Prepared by JICA study team based on lecture materials of the "Clean Coal Day in Japan 2012 International Symposium" held on September 4, 2012

Fig. 2-55 Indonesian Medium-Term Coal Supply and Demand Outlook

[16] Does not cover all of Indonesia's projects for production increase and new development.
[17] TEX Report (released by The TEX Report Ltd., http://www.texreport.co.jp/xenglish/index.html)



Source: Lecture materials of IEA workshop "Coal Market's Outlook" held on April 14, 2011

Fig. 2-56 Indonesian Long-Term Coal Supply and Demand Outlook

Table 2-17 Indonesia's Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015	2016	2017-
Total		33.8	45.0	42.0	13.5	3.0	6.0
	Steam Coal	29.3	35.5	42.0	0.0	0.0	6.0
	Coking Coal	4.5	9.5	0.0	13.5	3.0	0.0
Cumulative Total		33.8	78.8	120.8	134.3	137.3	143.3
	Steam Coal	29.3	64.8	106.8	106.8	106.8	112.8
	Coking Coal	4.5	14.0	14.0	27.5	30.5	30.5

Note: Does not cover all of Indonesia's projects for production increase at existing coal mines and new coal mine development.

Source: Prepared by JICA study team

With regard to the breakdown of outlook for coal exports, in Indonesia, coking coal demand for domestic use is scarce and it is assumed that coking coal supply capacity to be added will be all applied to exports. Therefore, although Indonesia exported about 1 to 2 million tons of coking coal in the 2000s[18], it becomes possible to expand this to around 20 million tons in 2015. Assuming that coking coal supply capacity to be added is entirely applied to exports, by-coal type outlook for coal exports prepared in line with long-term coal supply and demand outlook (Fig. 2-56) will be as shown in Table 2-18.

[18] The "Coal Information 2012" of IEA

Table 2-18 Indonesia's By-Coal Type Coal Exports Outlook

（million tons）

		2011 Actual	2015	2020	2025
Exports	Steam Coal	272	230	220	240
	Coking Coal	1	20	20	20
		273	250	240	260

Note: Actual values are based on Fig. 2-55.

Source: Prepared by JICA study team

(c) Russia

"The long-term program of development of coal industry of Russia up to 2030" released by the Ministry of Energy of Russia in 2012 foresees coal production and exports as shown in Table 2-19 and Table 2-20. In 2030, coal production is assumed to reach as much as maximum 430 million tons and the export volume is expected to increase 170 million tons. Looking at coal export for 5 years from 2007 to 2010, steam coal accounted for 85% to 90% of Russia's coal export volume. In the future, the export volume will increase in both steam coal and coking coal. Coking coal ratio of total coal exports will increase to 26%.

Table 2-19 Russia's Coal Production/Exports Outlook

（million tons）

		Actual	Projection		
		2008	2015	2020	2030
Production	Steam Coal	257.9	250.6	251.4	277.4
	Coking Coal	65.1	104.4	128.6	152.6
		323.0	355.0	380.0	430.0

Source: Prepared by JICA study team based on "The long-term program of development of coal industry of Russia up to 2030" of the Ministry of Energy of Russia

Table 2-20 Russia's By-Coal Type Coal Exports Outlook

（million tons）

		Actual				Projection			
		2007	2008	2009	2010	2015	2020	2025	2030
Exports	Steam Coal	88.6	87.6	94.1	98.4	115.0	115.0	115.0	125.0
	Coking Coal	10.0	13.6	13.3	18.0	25.0	35.0	40.0	45.0
		98.6	101.2	107.4	116.4	140.0	150.0	155.0	170.0

Source: Prepared by JICA study team based on "The long-term program of development of coal industry of Russia up to 2030" of the Ministry of Energy of Russia

In Russia, Mechel (Russia's major resources and energy company) promotes Elga projects in Sakha Republic and, if this project is in progress as planned, Elga projects production capacity may possibly be raised to 30 million tons per year (20 million tons of steam coal and 10 million ton of coking coal) in 2014. Other than the above, several coking coal development projects are under planning in Tuva Republic and, further in Kemerovo Oblast, Chukot Autonomous Area, etc. in East Siberia, exploitation of undeveloped coal concession areas is under way. Because of the above facts, it seems quite possible to achieve the coal production outlook shown in Table 2-20.

(d) The United States

According to the "Annual Energy Outlook 2012" released by the U.S. Department of Energy's Energy Information Administration (EIA) in June, 2012, as shown in Table 2-21, the United States' coal production is expected to expand from 992 million tons (863 million tons of steam coal, 83 million tons of coking coal, and 64 million tons of lignite) in 2011 to 1,099 million tons (913 million tons of steam coal, 89 million tons of coking coal, and 97 million tons of lignite) in 2035. Production decreases toward 2015 to 900 million tons and then gradually increases at an annual rate of 1.0% toward 2035.

On the other hand, coal export volume is assumed to remain in the range between 86 million tons and 100 million tons up to 2023, but, in and after 2024, comes to exceed 100 million tons and, toward 2035, maintain a trend of increase until coal export volume increases to 117 million tons in 2035.

Table 2-21 The United State's Coal Supply-Demand Outlook

(million tons)

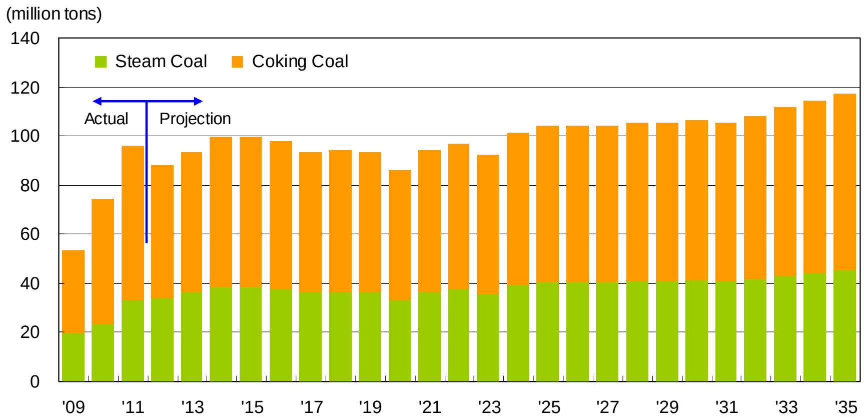
		Actual			Projection				
		2009	2010	2011	2015	2020	2025	2030	2035
Production		975.2	983.7	991.8	901.1	938.0	1,014.1	1,057.6	1,099.3
	Steam Coal	862.8	843.9	844.8	747.3	787.3	842.6	880.5	913.1
	Coking Coal	46.6	68.9	83.0	86.5	80.1	88.2	86.8	89.1
	Lignite	65.8	71.0	64.0	67.3	70.6	83.3	90.3	97.1
Exports		53.5	74.4	96.2	99.8	86.2	104.3	106.1	117.0
Imports		19.1	16.3	11.8	13.6	25.4	39.9	29.9	32.7
Domesiti Consamption		904.5	953.5	942.6	829.2	890.9	964.3	997.0	1,031.5

Source: Prepared by JICA study team based on the "Annual Energy Outlook 2012" of EIA

In the United State, following tightening of environmental regulations on newly built coal thermal power plants and a decline in demand for power generation-purpose coal due to the Shale Gas Revolution, Peabody Energy Corporation, Arch Coal Inc., Consol Energy Inc., and other leading coal producers have started to decrease domestic production, temporarily close or abandon less profitable coal mines, naturally reducing production for the time being. These coal producing companies, however, aiming at exportation to Asia where coal demand is likely to expand in the future, plan to apply their reserve production capacity derived from a decline in production for domestic use to Asia-bound exports. In the meantime, some producer companies also daringly have reduced production due to a price slump but they retain reserve capacity to expand exports once the market conditions recover.

Looking at actual export results for most recent 5 years between 2007 and 2011, steam coal accounted for 39% of the United States' coal export volume and coking coal, 61%[19]. The coal exports outlook shown Table 2-21 is sorted out by coal-type by using the above ratios and shown in Fig. 2-57.

[19] Calculated by JICA study team based on the US trade statistics placed such as on TEX Report (released by The TEX Report Ltd.).



Source: Prepared by JICA study team based on the “Canada's Energy Future: Energy supply and demand projections to 2035” of NEB.

Fig. 2-57 United States’ By-Coal Type Coal Exports Outlook

(e) Canada

According to the “Canada's Energy Future: Energy supply and demand projections to 2035 (CEF2035)” released by Canada’s National Energy Board (NEB) in November, 2011, as shown in Table 2-22, Canada’s coal production is expected to expand from 67.8 million tons (37.6 million tons of steam coal and 30.1 million tons of coking coal) to 94.7 million tons (43.1 million tons of steam coal and 51.6 million tons of coking coal) in 2035. The peak production volume is 99.3 million tons in 2020 (53.5 million tons of steam coal and 45.8 million tons of coking coal) and, after that, gradually decreases toward 2035.

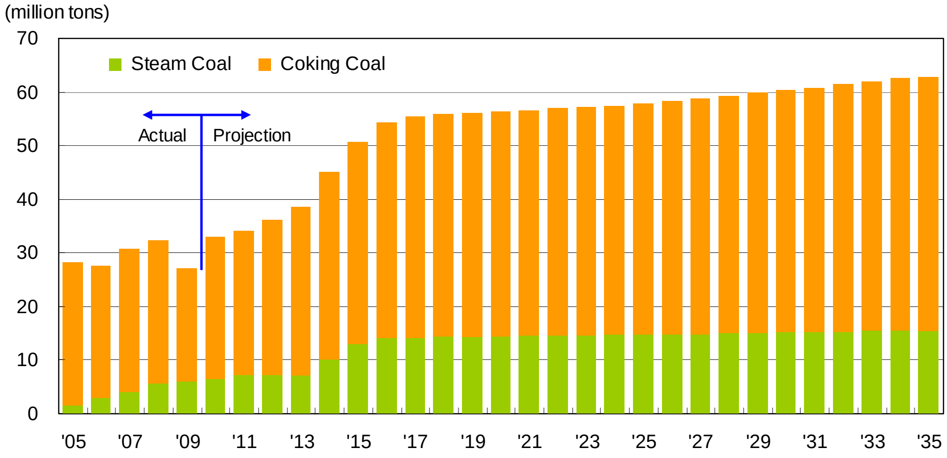
Table 2-22 Canada’s Coal Supply and Demand Outlook

(million tons)

		Actual		Projection					
		2008	2009	2010	2015	2020	2025	2030	2035
Production		67.8	62.8	78.3	92.7	99.3	95.3	95.7	94.7
	Steam Coal	37.6	38.4	48.3	51.2	53.5	48.4	46.6	43.1
	Coking Coal	30.1	24.4	30.0	41.5	45.8	46.9	49.0	51.6
Exports		32.2	27.1	32.9	50.9	56.3	57.7	60.3	63.0
	Steam Coal	5.7	6.0	6.5	13.1	14.4	14.8	15.2	15.5
	Coking Coal	26.5	21.1	26.4	37.7	41.9	43.0	45.1	47.4
Imports		20.5	12.7	12.5	7.2	7.3	6.5	5.4	5.5
	Steam Coal	17.3	10.5	10.9	5.2	5.1	4.3	3.2	3.2
	Coking Coal	3.3	2.2	1.6	2.1	2.2	2.2	2.2	2.3
Domesiti Consamption		58.4	55.5	57.9	49.1	50.3	44.0	40.8	37.2
	Steam Coal	51.4	50.0	52.7	43.2	44.2	38.0	34.7	30.8
	Coking Coal	7.0	5.5	5.2	5.9	6.1	6.0	6.1	6.4

Source: Prepared by JICA study team based on the “Canada's Energy Future: Energy supply and demand projections to 2035” of NEB.

On the other hand, export volumes of both steam coal and coking coal are, as shown in Fig. 2-58, expected to keep soaring without dropping but, in and after 2017, the growth of exports will slow down. Although until 2005, coking coal accounted for 90% of coal export volume, the share of coking coal is expected to gradually shrink to less than 80% in 2014.



Source: Prepared by JICA study team based on the "Canada's Energy Future: Energy supply and demand projections to 2035" of NEB.

Fig. 2-58 Canada's By-Coal Type Coal Exports Outlook

Table 2-23 shows a compilation[20] of projects for production increase at existing coal mines and new coal mine development cited in an information magazine[21] of 2011 and 2012, indicating that the supply capacity that can be added between 2012 and 2018 reaches 35 million tons (12 million tons of steam coal and 23 million tons of coking coal). This means that since 67 million tons of coal was actually produced in 2011, supply capacity will exceed 100 million tons in 2018, assuming that production will not drop due to coal mine closure etc. If projects compiled in Table 2-23 are implemented as planned, volumes predicted by the coal exports outlook shown in CEF2035 (Table 2-22, Fig. 2-58) also become feasible.

Table 2-23 Canada's Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015	2016	2017	2018
Total		1.7	4.8	3.2	16.5	1.6	0.0	7.0
	Steam Coal	0.0	0.1	0.0	5.0	0.0	0.0	7.0
	Coking Coal	1.7	4.7	3.2	11.5	1.6	0.0	0.0
Cumulative Total		1.7	6.5	9.7	26.2	27.8	27.8	34.8
	Steam Coal	0.0	0.1	0.1	5.1	5.1	5.1	12.1
	Coking Coal	1.7	6.4	9.6	21.1	22.7	22.7	22.7

Note: Does not cover all of Canada's projects for production increase at existing coal mines and new coal mine development.

Source: Prepared by JICA study team

(f) South Africa/Mozambique

Regarding South Africa and Mozambique, nothing like coal supply-demand outlook released such as by a government agency is available but coal supply capacity that can be added is identified from projects for production increase at existing coal mines and new coal mine development contained in

[20] Does not cover all of Canada's projects for production increase and new development.

[21] TEX Report（released by The TEX Report Ltd.）

an information magazine to infer the volume of coal that can be exported.

First, with regard to South Africa, a compilation[22] of 6 new coal mine development projects placed on an information magazine[23] of 2011 and 2012 is shown in Table 2-24. In and after 2012, supply capacity that can be added by 2015 is 19 million tons (18 million tons of steam coal and 1 million tons of coking coal). Since coal production in 2011 is 253 million tons[24], supply capacity expands to as much as about 270 million tons in 2015, assuming that production will not drop due to coal mine closure etc. As for added coal supply capacity, it is assumed that coking coal will be entirely applied to exports and, 80% of steam coal will be applied to exports. But steam coal supply capacity of 10 million tons to be added in 2014 is excluded because it is for domestic use. Table 2-25 shows coal export volume outlook based on this assumption.

Table 2-24 South Africa's Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015
Total		0.8	6.2	12.1	0.0
	Steam Coal	0.8	5.2	12.1	0.0
	Coking Coal	0.0	1.0	0.0	0.0
Cumulative Total		0.8	6.9	19.0	19.0
	Steam Coal	0.8	5.9	18.0	18.0
	Coking Coal	0.0	1.0	1.0	1.0

Note: Does not cover all of South Africa's projects for production increase at existing coal mines and new coal mine development.

Source: Prepared by JICA study team.

Table 2-25 South Africa's By-Coal Type Coal Exports Outlook

(million tons)

		Actual					Projection			
		2007	2008	2009	2010	2011*	2012	2013	2014	2015
Exports	Steam Coal	66.1	56.6	51.4	65.6	71.6	72.2	76.3	78.0	78.0
	Coking Coal	0.9	1.3	0.6	0.8	0.2	0.2	1.2	1.2	1.2
		67.0	57.9	52.0	66.4	71.7	72.3	77.4	79.1	79.1

Note: Actual values are based on "Coal Information 2012" of IEA and 2011 values are prospective.

Source: Prepared by JICA study team

Next, as for Mozambique, a compilation[25] of 5 new coal mine development projects placed on an information magazine[26] of 2011 and 2012 is shown in Table 2-26. Supply capacity that can be added between 2012 and 2015 is 44 million tons (14 million tons of steam coal and 30 million tons of coking coal). Since, according to the "Coal Information 2012" released by IEA, coal production in 2011 is below 0.1 million tons, supply capacity of 44 million tons that can be added by 2015 remains as is the amount that can be produced. Assuming that added coal supply capacity will be entirely applied to

22 Does not cover all of South Africa's projects for production increase and new development.
23 TEX Report (released by The TEX Report Ltd.)
24 The "Coal Information 2012"of IEA
25 Does not cover all of Mozambique's projects for production increase and new development.
26 TEX Report (released by The TEX Report Ltd.)

coking coal and 70% of steam coal will be applied to exports, coal exports outlook will be as shown in Table 2-27.

Table 2-26 Mozambique's Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015
Total		6.3	10.5	17.4	9.6
	Steam Coal	1.9	3.1	3.4	5.2
	Coking Coal	4.3	7.5	13.9	4.4
Cumulative Total		6.3	16.8	34.1	43.7
	Steam Coal	1.9	5.0	8.4	13.6
	Coking Coal	4.3	11.8	25.7	30.1

Note: Does not cover all of Mozambique's projects for production increase at existing coal mines and new coal mine development.

Source: Prepared by JICA study team.

Table 2-27 Mozambique's By-Coal Type Coal Exports Outlook

(million tons)

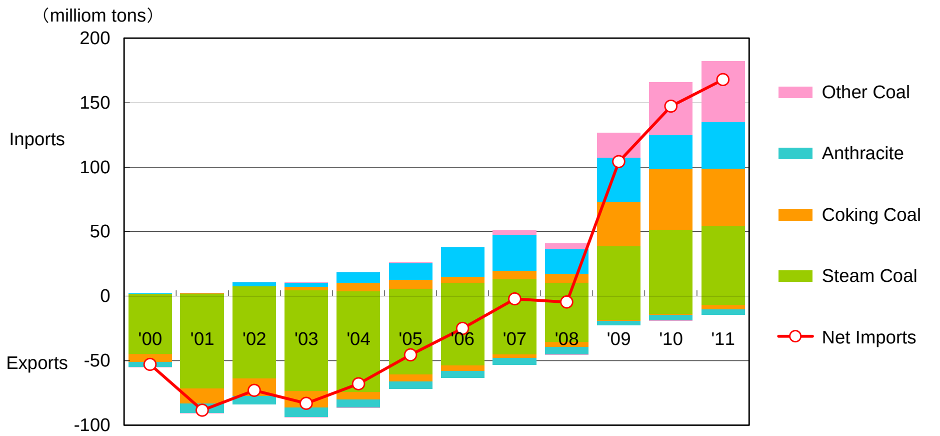
		Actual					Projection			
		2007	2008	2009	2010	2011*	2012	2013	2014	2015
Exports	Steam Coal	0.02	0.03	0.03	0.03	0.01	1.3	3.5	5.9	9.5
	Coking Coal	0.00	0.00	0.00	0.00	0.00	4.3	11.8	25.7	30.1
		0.02	0.03	0.03	0.03	0.01	5.7	15.3	31.6	39.7

Note: Actual values are based on the "Coal Information 2012" of IEA and 2011 values are prospective.

Source: Prepared by JICA study team

(g) China

According to Chinese foreign trade statistics (China Customs Statistics), China's coal export volume from 2001 to 2004 exceeded 80 million tons as shown in Fig. 2-59 and, during that period, China was ranked second in the world behind Australia in terms of coal exports in 2001, 2002, and 2003. But, in and after 2004, it reduced export volume in order to meet the expansion of domestic coal demand and, in 2009, turned from a net exporter into a net importer. Export volume is unlikely to recover to the previous level but will probably, without dropping to zero, go up and down, depending upon the market situation, from the present export volume of some 15 million tons as the reference. As far as coking coal is concerned, however, export volume may possibly become zero.



(milliom yons)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Imports	Steam Coal	1.6	1.8	7.6	4.6	3.8	5.6	10.5	13.3	10.3	38.6	51.3	54.3
	Coking Coal	0.3	0.3	0.3	2.6	6.8	7.2	4.7	6.2	6.9	34.5	47.3	44.7
	Anthracite	0.2	0.4	2.8	3.4	7.8	12.8	22.6	28.4	19.4	34.4	26.5	36.1
	Other Coal	0.0	0.0	0.1	0.1	0.2	0.5	0.4	3.1	4.3	19.2	41.2	47.3
		2.1	2.5	10.8	10.8	18.6	26.1	38.2	51.0	40.8	126.6	166.2	182.4
Exports	Steam Coal	-44.6	-71.6	-63.9	-73.3	-74.5	-60.8	-53.7	-45.3	-35.8	-18.5	-13.6	-6.7
	Coking Coal	-6.5	-11.5	-13.3	-13.1	-5.7	-5.3	-4.4	-2.5	-3.5	-0.6	-1.1	-3.6
	Anthracite	-3.9	-7.7	-6.6	-7.4	-6.4	-5.6	-5.2	-5.3	-6.1	-3.2	-4.3	-4.2
	Other Coal	-0.1	-0.2	0.0	-0.1	-0.1	0.0	-0.1	-0.1	-0.1	0.0	-0.1	0.0
		-55.0	-90.9	-83.9	-93.9	-86.6	-71.7	-63.3	-53.2	-45.4	-22.4	-19.0	-14.5
Net Imports		-52.9	-88.5	-73.1	-83.2	-68.0	-45.6	-25.1	-2.2	-4.6	104.2	147.2	167.9

Source: Prepared by JICA study team based on China customs statistics placed such as on TEX Report (released by The TEX Report Ltd.)

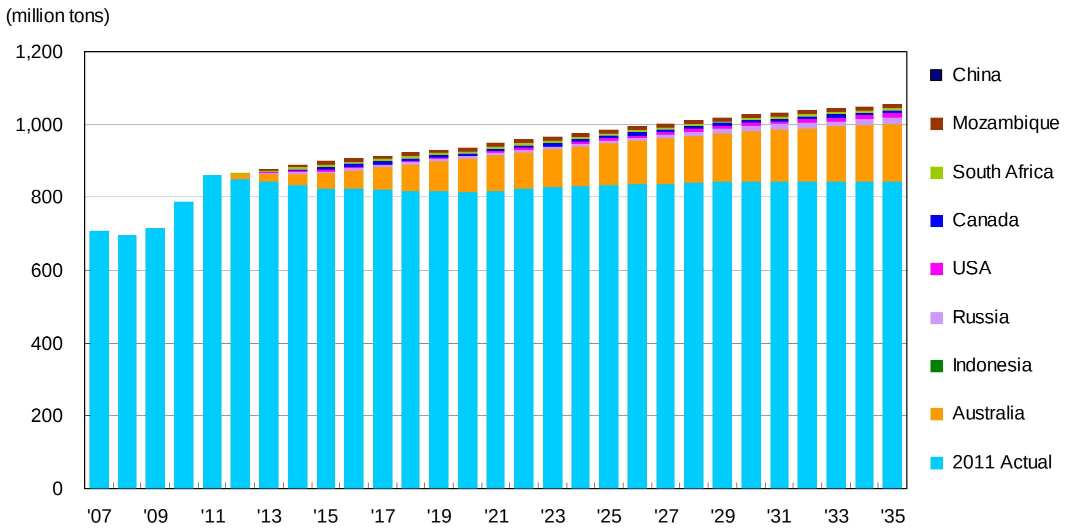
Fig. 2-59 Transition of China's Actual By-Coal Type Coal Export/Import Results

(2) Coal export potential of countries surveyed

Fig. 2-60 and Fig. 2-61 illustrate, separately for steam coal and coking coal, outlook for coal exports of 8 countries surveyed by cumulating it on 2011 world export volume.

Fig. 2-60 shows outlook for steam coal export volume which will be pushed up by countries surveyed from the base year of 2011. Indonesia (Table 2-18) is expected to reduce its export volume of steam coal in comparison with the 2011 level in the future due to growing domestic demand, and such a decrement is shown in Fig. 2-60 by lowering the 2011 baseline. As shown earlier, China maintains the present level of export volume but does not contribute to the expansion of export volume. It is Australia that most greatly contributes to the expansion of export volume, presumably bearing 75 % of the increment. 8 countries surveyed can alone cumulate steam coal export volume by 180 million tons between 2011 and 2035. Among others than countries surveyed, Colombia will hopefully increase its steam coal production.

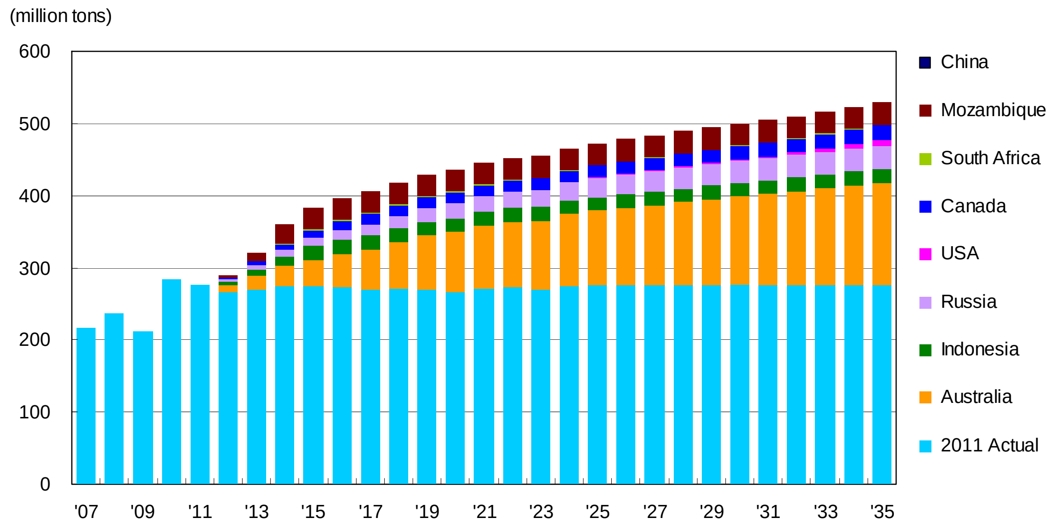
Fig. 2-61 shows outlook for coking coal export volume which will be pushed up by countries surveyed, like that of steam coal. The United States (Fig. 2-57) is expected to decrease its coking coal export volume between 2012 and 2024 to the level lower than that of 2011 and Fig. 2-61 expresses the amount of decrease by lowering the base line of 2011. It is Australia that most greatly contributes to the expansion of export volume but Canada, Mozambique, and Indonesia are also important exporting countries. It is considered that Russia will reduce its export volume of coking coal to Europe and increase the export to Asia, contributing to a global increase in export volume. As for coking coal as well, China maintains the present level of export volume but does not contribute to export volume expansion. 8 countries surveyed can alone cumulate 250 million tons of coking coal export volume between 2011 and 2035.



Note: Actual values up to 2011 are based on the "Coal Information 2012"of IEA. Among the 8 countries surveyed, Indonesia is expected to reduce its export volume from the 2011 level in and after 2012. Such volumes were deducted in respective years from the export volume in 2011 as the baseline year.

Source: Prepared by JICA study team

Fig. 2-60 Outlook for Steam Coal Export Volume Pushed Up by Countries Surveyed (1)



Note: Actual values up to 2011 are based on the "Coal Information 2012"of IEA. Among 8 countries surveyed, however, the United States is expected to bring its export volumes down between 2012 and 2024 below the 2011 level and these volumes were subtracted each year from export volume of 2011 taken as the baseline year.

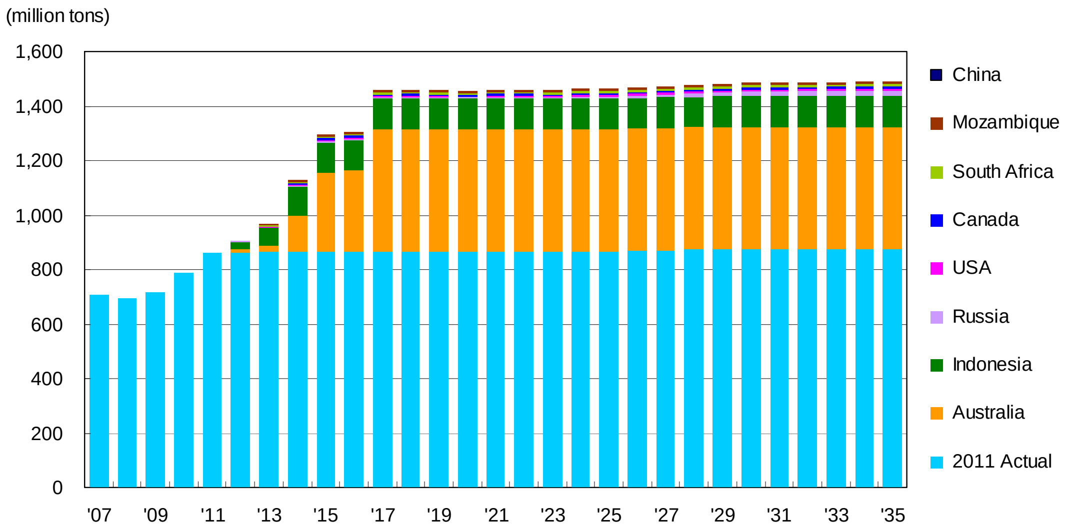
Source: Prepared by JICA study team.

Fig. 2-61 Outlook for Coking Coal Export Volume Pushed Up by Countries Surveyed (1)

Fig. 2-62 (steam coal) and Fig. 2-63 (coking coal) are based on an assumption that for Australia and Indonesia, the figures shown in their plans for increasing coal production (Australia: Table 2-15;

Indonesia: Table 2-15) are totally allocated to exports, instead of using the coal export outlooks used for Fig. 2-60 and Fig. 2-61.

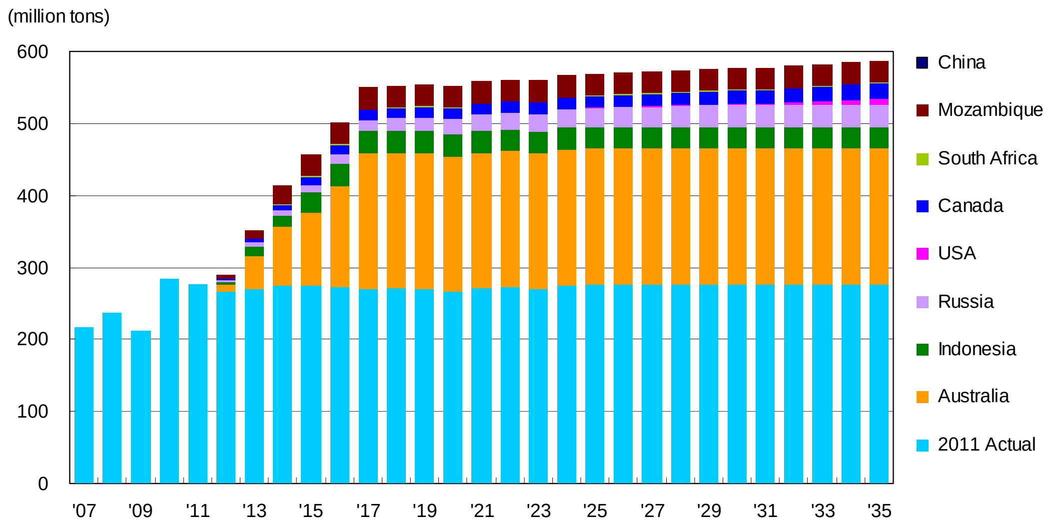
Regarding steam coal, as shown in Fig. 2-62, it is anticipated that its export volume will increase by 600 million tons than the 2011 level and world steam coal export volume will reach 1.46 billion tons as of 2017. Similarly, with regard to coking coal, as shown in Fig. 2-63, it is anticipated that its export volume will increase by 270 million tons than the 2011 level and world coking coal export volume will exceed 540 million tons as of 2017.



Note: Actual values up to 2011 are based on the "Coal Information 2012"of IEA.

Source: Prepared by JICA study team.

Fig. 2-62 Outlook for Steam Coal Export Volume Pushed Up by Countries Surveyed (2)



Note: Actual values up to 2011 are based on the "Coal Information 2012"of IEA. Among 8 countries surveyed, however, the United States is expected to bring its export volumes down between 2012 and 2024 below the 2011 level and these volumes were subtracted each year from export volume of 2011 taken as the baseline year.

Source: Prepared by JICA study team.

Fig. 2-63 Outlook for Coking Coal Export Volume Pushed Up by Countries Surveyed (2)

2.4 Mongolia Coal Supply and Demand Figures and Projections for Export Potential

2.4.1 Coal Supply and Demand Figures

Table 2-28 shows figures for coal supply and demand in Mongolia, summarized using statistical materials published annually by the Mongolian government. Number ⑦[27], which indicates coal use in Mongolia, refers to consumption volume for HOB used for heat, electricity, and hot water supply at power plants, industrial boilers, and coal used for heat and cooking by private and public businesses and the transport sector. Recent years have also seen a boom in the production of house coke, which is processed form of coal.

Table 2-28 Coal supply and demand

Item	2008	2009	2010	2011	2012
① Resources-Total (②+③+⑥ = ⑦+⑰+⑱+⑲)	10,453.7	14,883.5	26,506.1	34,903.9	34,140.9
② Stock at the beginning of the year	381.3	441.2	1,344.0	2,874.1	4,214.5
③ Produced (④+⑤)	10,071.9	14,442.1	25,161.9	32,029.7	29,926.1
④ State owned mining company	6,674.2	7,186.7	10,459.5	12,090.3	10,335.6
⑤ Private sector's mining company	3,397.7	7,255.4	14,702.4	19,939.4	19,590.5
⑥ Import	0.5	0.2	0.2	0.1	0.3
⑦ Consumption-Total (⑧+⑨)	5,843.2	6,426.2	6,905.8	6,815.3	7,381.3
⑧ Consumed by thermal power stations	4,849.9	5,077.9	5,533.2	5,410.1	5,800.9
⑨ Distributed to establishments and households for fuel purpose (⑩+⑪+⑫+⑬+⑯)	993.3	1,348.3	1,372.6	1,405.2	1,580.4
⑩ Industry & construction	190.1	226.3	179.6	221.9	336.6
⑪ Transport & communication	41.3	41.2	49.5	52.5	42.2
⑫ Agriculture	7.2	13.6	10.0	8.9	3.7
⑬ Communal housing (⑭+⑮)	580.6	598.2	614.9	641.3	637.0
⑭ Household	406.6	596.5	612.3	639.7	626.0
⑮ Others	174.0	1.7	2.6	1.6	11.0
⑯ Others	174.1	469.0	518.6	480.6	560.9
⑰ Manufacturing				2,578.1	3,813.3
⑱ Export	4,169.3	7,113.2	16,726.2	21,296.0	20,915.5
⑲ Stock at the end of the year	441.2	1,344.0	2,874.1	4,214.5	2,030.7

Source: Organized by the JICA survey team based on the Mongolian Statistical Yearbook, 2012

It is thought that how to handle the quantity of washed coal has a problem in this. In Table 2-28, ⑰ indicates ROM produced from coal mines that was transported to a coal preparation plant, furthermore, since the clean coal produced at coal preparation plants is included in ⑱. This causes not only the amount of clean coal is recorded in double, but also the amount of waste to be disposed after coal preparation is not clear. It will be a problem if the preparation capacity increases in the future. Fig. 2-64 provides an image of the above situation. Each number shows a number in Table 2-28.

[27] Number ① to ⑲ are represented to explain by JICA team, thus there are not in original data.

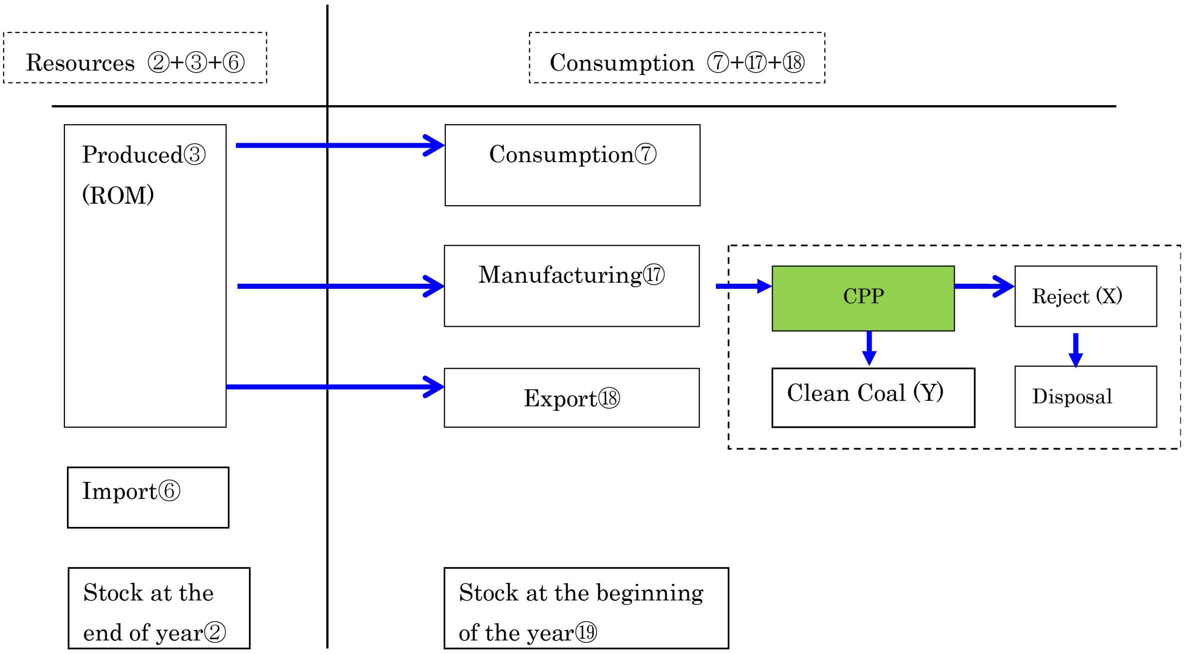


Fig. 2-64 Coal Supply and Demand Table Revisions (draft)

As an amendment, we suggest to revise the overall style of Table 2-28 from simplification of handling quantity, description of production of coal in raw coal base, and the division of Table 2-28 between the productions and the consumptions.

2.4.2 Projections for Export Potential

Due to its current economic infrastructure, it is unavoidable that China is the main recipient of Mongolian coal exports. An evaluation of raw coal demand volumes in China is discussed in 2.3.1 (5) but here we will examine this in detail and summarized Mongolia's export potential.

The examination method is as the follows.

(a) Coking coal demand is predicted by a crude steel production prediction of China.

(b) Prediction of coking coal import of China

(c) In the coking coal import, prediction of the ratio that the Mongolia occupies

(1) Coking coal

(a) Raw coal production and import volumes for China

In examining the potential for exports to China, vital factors for consideration are China's domestic production capacity and Chinese policies related to raw coal. Table 2-29 shows actual production capacity figures created using data created by China. As for coal policy, in 2007 the National Development and Reform Commission published the "11th 5-Year Development Plan for the Coal Industry", which outlines coal industry development policies, goals, major missions, and policy measures for the given timeframe. Also in 2007, the National Development and Reform Commission published "Coal Industry Policies", in which it clarifies policies for support, restrictions, and prohibited matters in an effort to clearly define development goals for the coal industry as well as protective measures to ensure the realization of those goals. On October 10, 2011, the State Council published a revised version of the "People's Republic of China Temporary Statute on Resource Taxes", through which the resource tax rate on other coal types is maintained at 0.3 to 5 yuan/ton while the tax rate on raw coal was increased from 8 yuan/ton (US$1.28) to between 8 and 20 yuan/ton (US$3.2). This suggests a government policy trend toward limited development of raw coal as it becomes a scarce resource.

Table 2-29 summarizes the coking coal demand from a crude steel production prediction for Table 2-10.

Table 2-29 Past Raw Coal Production and Import Volumes in China

	2006	2007	2008	2009	2010	2011
Coking coal demand of clean coal	408,130	446,880	439,740	485,870	527,100	583,930
Domestic production of clean coal	408,650	428,540	436,960	445,770	482,980	565,250
Barance	−520	18,340	2,780	40,100	44,120	18,680
Coking coal import	4,662	6,219	6,857	34,423	47,269	44,658
Ratio of import amount	1.1%	1.4%	1.6%	7.1%	9.0%	7.6%

Source: China Coal Resource Network

(b) Coking coal import of China

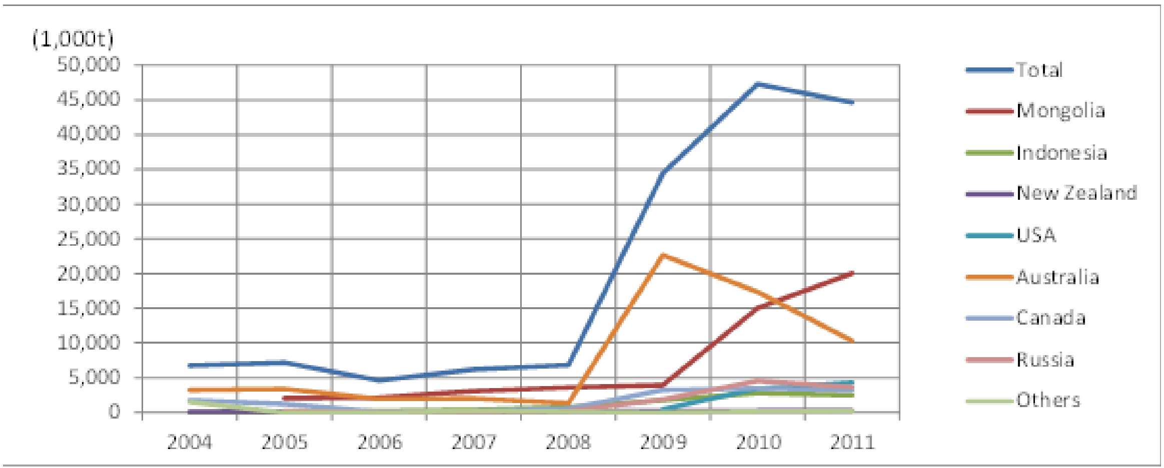
Table 2-30 shows the results of coking coal import of China by 2011. According to Fig. 2-65, which illustrates Table 2-30, China has imported coking coal positively since 2009.

Table 2-30 Chinese Raw Coal Imports by Country

(1,000t)

	2004	2005	2006	2007	2008	2009	2010	2011
Total demand of coking coal	NA	NA	408,130	446,880	439,740	485,870	527,100	583,930
Total of import coking coal	6,758	7,194	4,662	6,219	6,857	34,423	47,269	44,658
Mongolia		2,078	2,154	3,119	3,634	3,980	15,048	20,039
Indonesia	37	0.166	249	420	763	1,814	2,817	2,523
New Zealand	119	170	113	60	186	243	304	284
USA						512	3,477	4,334
Australia	3,248	3,435	1,963	2,033	1,352	22,652	17,386	10,326
Canada	1,815	1,228	146	223	559	3,260	3,504	3,223
Russia		281	32	60	214	1,901	4,558	3,684
Others	1,539	2	5	304	149	61	175	245

Source: Chinese consultant “北京亜能時代諮詢有限公司”



Source: Created by JICA survey team based on data from Chinese consultant "北京亜能時代諮詢有限公司"

Fig. 2-65 Chinese Raw Coal Imports by Country

(c) Chinese raw coal import projections

Table 2-31 shows import projects based on coking coal demand indicated in Table 2-12. As actual data from 2009 through 2011 is limited, it is difficult to predict imported coal volume in relation to coking coal demand but estimates were made using the ratios shown in Table 2-30. Details are as follows.

- Case 1: The ratio was lowered due to a decline in coking coal demand, which would cause China to consider maintaining current coal ore production volumes.
- Case 2: Ratio set at 10% because domestic demand will be virtually stagnant from 2015 onward.
- Case 3: Domestic demand will increase through 2020 and much of that increased demand will be address through imports so the ratio is increased initially and then decreased to reflect the eventual decline in demand.

Table 2-31 Ratio of imported raw coal reflected in Chinese raw coal demand

	2011	2015	2020	2025	2030	2035
Case 1	7.6%	10.0%	10.0%	9.5%	9.0%	8.0%
Case 2	7.6%	10.0%	10.0%	10.0%	10.0%	10.0%
Case 3	7.6%	10.0%	10.9%	10.5%	10.1%	9.7%

Source: JICA survey team

(d) Coking coal export potential to China

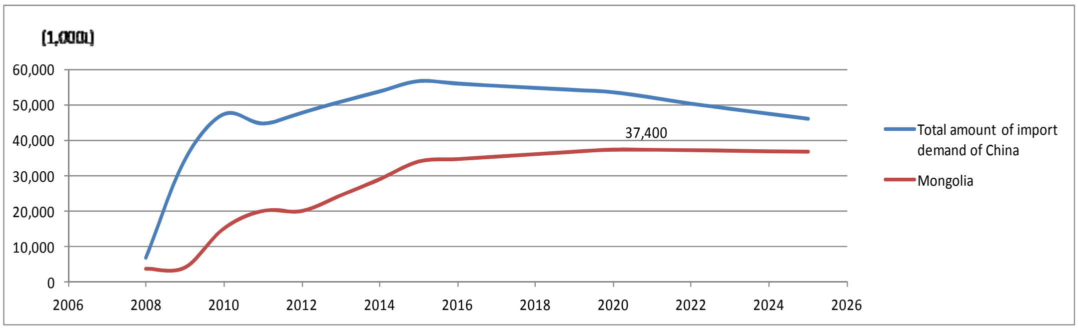
Table 2-32 shows the potential of coking coal export of Mongolia based on the import coking coal ratio of Table 2-31. Maximum export is that Case 1 becomes 38 million tons in 2015, Case 2 becomes 45million ton in 2025and Case 3 becomes the 54 million ton in 2020.

But all these numbers show the demand with the quantity of clean coal base after washing ROM. When you export as ROM, the numbers will be increased approximately 30%. In that case, naturally the sales price will fall than clean coal, too.

Table 2-32 Mongolia's Potential for Exports to China based on each Case(1000t/year)

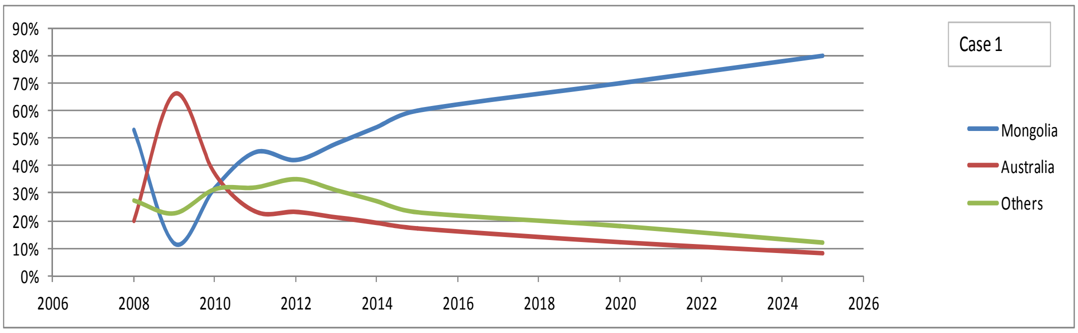
		2010	2011	2012	2013	2014	2015	2020	2025
Case 1	Total of import coking coal of China	47,269	44,658	47,700	50,800	53,700	58,635	44,318	38,096
	Potensial of export coking coal of Mongolia	15,048	20,039	20,000	24,400	29,000	34,000	37,400	36,800
	% of Mongolian coal in total	32%	45%	42%	48%	54%	60%	70%	80%
Case 2	Total of import coking coal of China	47,269	44,658	47,700	51,100	54,400	57,700	57,000	56,200
	Potensial of export coking coal of Mongolia	15,048	20,039	20,100	24,500	29,400	34,600	39,900	44,900
	% of Mongolian coal in total	32%	45%	42%	48%	54%	70%	70%	80%
Case 3	Total of import coking coal of China	47,269	44,658	48,300	54,600	61,200	67,800	76,500	69,400
	Potensial of export coking coal of Mongolia	15,048	20,039	20,300	26,200	33,100	40,700	53,500	48,600
	% of Mongolian coal in total	32%	45%	42%	48%	54%	60%	70%	70%

In addition, the import quantity of China and the export of Mongolia and the Chinese import distribution ratio of each country in each case show in from Fig. 2-66 to Fig. 2-71.



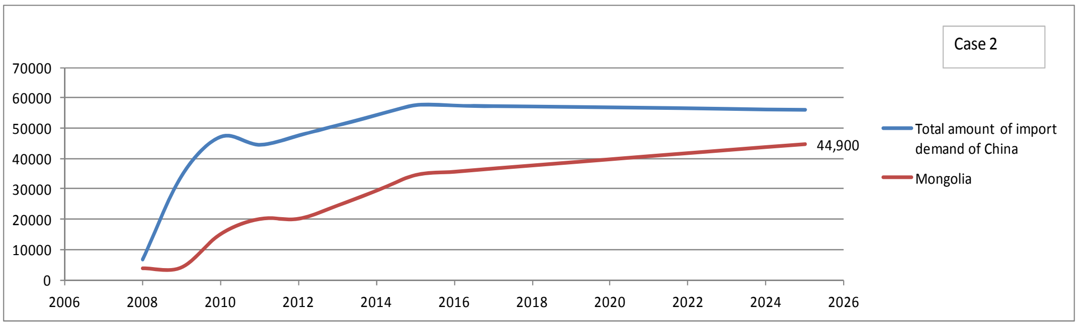
Source: JICA survey team

Fig. 2-66 Chinese Raw Coal Import Projections And Projected Export Volume for Mongolia (Case 1)



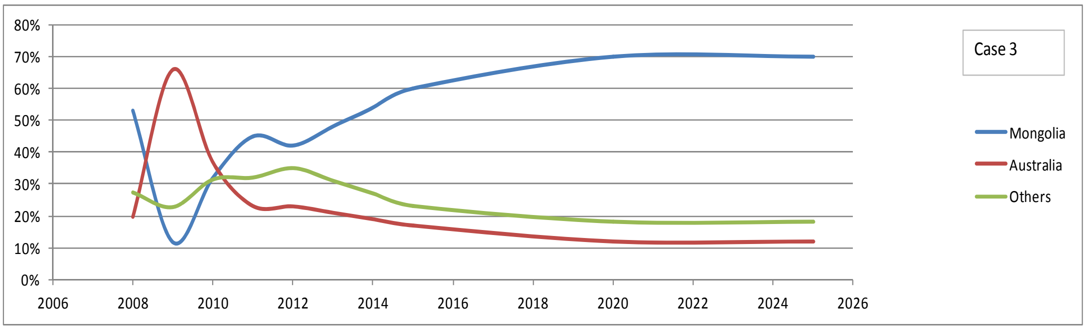
Source: JICA survey team

Fig. 2-67 Chinese Raw Coal Import Ratio (Case 1)



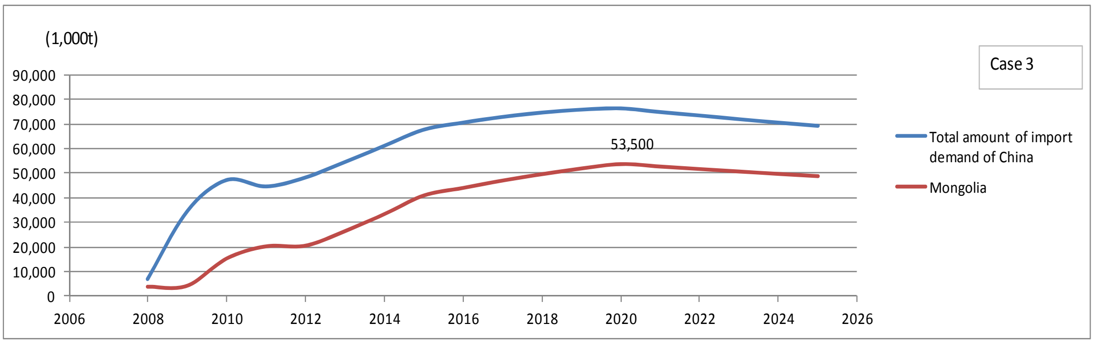
Source: JICA survey team

Fig. 2-68 Chinese Raw Coal Import Projections And Projected Export Volume for Mongolia (Case 2)



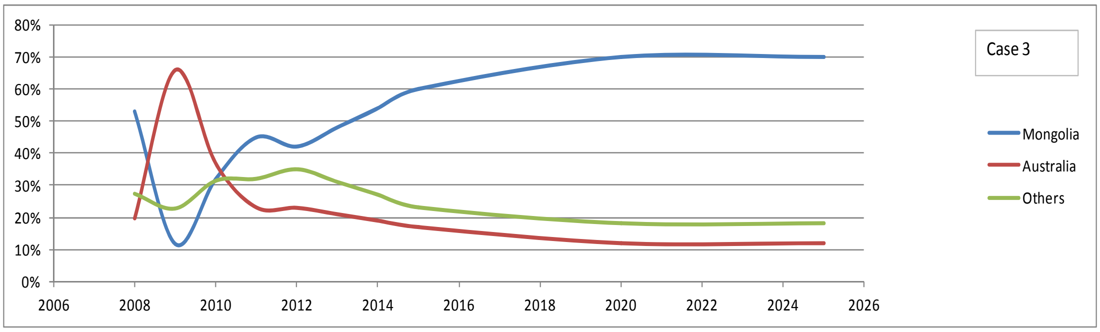
Source: JICA survey team

Fig. 2-69 Chinese Raw Coal Import Ratio (Case 2)



Source: JICA survey team

Fig. 2-70 Chinese Raw Coal Import Projections And Projected Export Volume for Mongolia (Case 3)



Source: JICA survey team

Fig. 2-71 Chinese Raw Coal Import Ratio (Case 3)

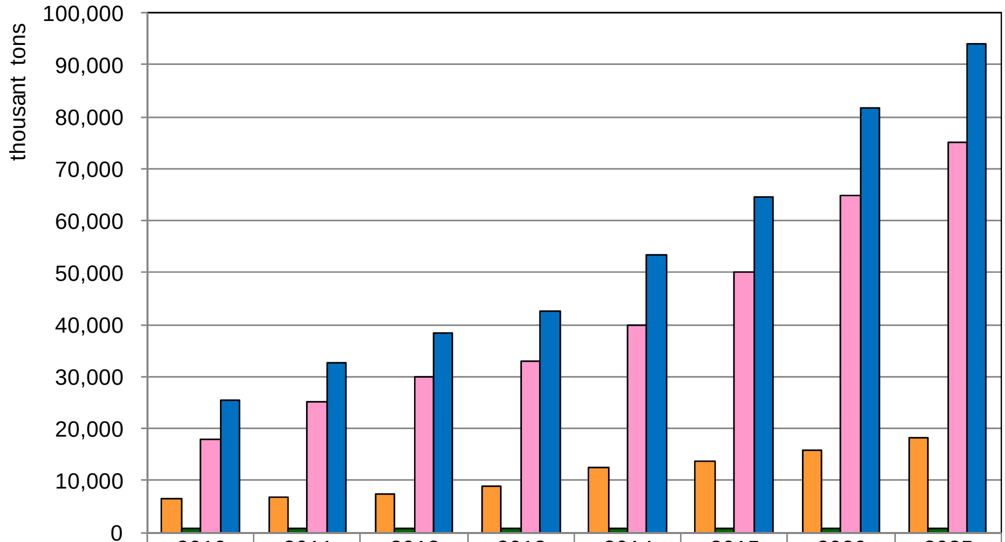
(2) Export Potential for Thermal coal

Thermal coal, the intermediary product produced after the coal preparation process for coking coal, seen little demand right now and thus it is discarded at mining site. Details are discussed in 4.1.5 (2) but here we evaluated the potential for exports of this product.

While there is demand in the Northwestern regions of China, with the current state of Mongolia's infrastructure and current coal prices, export expenses are too high to allow Mongolia to be competitive. As such, improvements in current conditions could result in potential for exports but at present this is not at a level where it can be included in export volume.

(3) Coal Supply Projections Prior to Survey

Fig. 2-72 shows coal production, consumption, and export projections through 2025 based on a report by Mongolia's MRAM in 2009. It was export of 75million tone expectation in 2,025 years, but, as for the result of this investigation, it is with 37.4 - 53.5million tons between until 2025 as showed in Table 2-32. Evaluation results are provided in Chapter 6.



	2010	2011	2012	2013	2014	2015	2020	2025
Domestic usage (Central area)	6,546	6,828.7	7,526.5	8,813.9	12,525	13,742.6	15,709	18,110.5
Domestic usage (Local area)	798	806	814	822	830	838	878	900
Export	18,000	25,000	30,000	33,000	40,000	50,000	65,000	75,000
Total	25,344	32,634.7	38,340.5	42,635.9	53,355	64,580.6	81,587	94,010.5

Reference: MRAM

Fig. 2-72 Coal production, consumption, and export in Mongolia

Chapter 3 Coal Development Analysis and Development Projects

3.1 Review of laws and policies of Mongolia relevant to coal

3.1.1 New Minerals Law

According to the Minerals Law of Mongolia (1997), mining area is open to both national and foreign applicants, along with tax advantages. Therefore, the problem has arisen in Mongolia that in some areas, there would be no benefit to the government due to the removal of precious resources out of the country, which would then harm national interests. Thus, the law was amended in July, 2006 in the Mongolian Parliament with the expectation that it would lead to resource development and environmental protection without affecting the national interests.

The main points of the 2006 Amended Minerals Law is as follows. Also in 2011, royalty stipulation was modified.

(1) Overview of Amendments in 2006

(a) Ownership of mining rights (Article 5) (newly introduced regulation)

The State may participate up to 50% jointly with or may own up to 34% of the shares of the investment made by a license holder in the extraction of strategically important mineral deposits.
Strategically important deposits are defined as "deposits that may have a potential impact on national security, economic and social development of the country at the national and regional levels (Article 4.1.10).

Moreover, the legal person can sell off 10% or more of its shares on the Mongolian Stock Exchange.

(b) Licensee[28] qualification (Article 12 (exploration rights) and Article 21 (mining rights))

"The right of exploration" is applicable to any exploration license holder, while anybody without license can be explored on the surface in case of non-mining activities. He is not involved in any mining activities in the exploration licensed area.

Table 3-1 Comparison between New and Old Licensee Qualifications

New	Old
Right of Exploration & Mining: Corporations established under the domestic law and have a tax-payment track record	Right of Exploration: Citizens, foreigners, or corporations Right of Mining: Corporation established under the domestic law

(c) Validity period of the license (Article 14 & 16 (Exploration Rights) and Article 20 & Article 22 (Mining Rights))

Table 3-2 compares the new and old laws on the validity period of the license.

28 Licensee means both exploration right and exploitation right

Table 3-2 Comparison between New and Old License Validity Periods

New	Old
Right of Exploration: Maximum 9 years (3 years at the beginning + 3 years of extension x 2)	Right of Exploration: Maximum 7 years (3 years at the beginning + 3 years of extension x 2)
Right of Mining: Maximum 70 Years (30 years at the beginning + 20 years of extension x 2)	Right of Mining: Maximum 100 Years (60 years at the beginning + 40 years of extension)

(d) Investment Agreement (Article 24)

This refers to an agreement between the government and the investing company on the investment terms and conditions. Since resource development requires an immense investment, the agreement, which is valid irrespective of changes in tax rates, concludes on investments beyond a fixed scale in the first five years of its development, with the purpose of attracting foreign investments by stabilizing the investment environment.

Table 3-3 compares the new and the old Investment Agreements. This shows terms of agreement on investment amount of first five years.

Table 3-3 Comparison between the New and Old Investment Agreements

New	Old
Investment Agreement 5 year investment of over US$ 50 million 15 year investment of over US$ 100 million 30 year investment of over US$ 300 million	Stability Agreement 10 year investment of over US$ 2 millions 15 year investment of over US$ 20 millions

(e) Mining Tax (Article 33)

New regulations were established outlining the requirement to apply a certain amount of funds towards exploration annually (Article 33). This provision was not outlined in the original Minerals Law drafted in 1997. An overview of mining taxes and minimum exploration expenditures are shown in Table 3-4. Prior to the revisions, rights of mining area could be retained simply by paying mining taxes but following the revisions, annual exploration reports are now mandatory and failure to conduct mining exploration equating to minimum expenditure levels will result in the suspension of mining rights. This enables the government to prevent the acquisition of mining rights for resell purposes.

Table 3-4 Mining Tax and the Minimum Exploration Costs

Mining Tax	Minimum Exploration Costs
Right of Exploration: per 1 hectare (ha) First Year →0.1 US$ Second Year →0.2 US$ Third Year →0.3 US$ 4th ~6th Year →1.0 US$ 7th ~ 9th Year→1.5 US$ (If explored for 9 years, 8.1 US$ per ha)	per 1ha 1st – 3rd Year→0.5U$ 4th ~ 6th Year →1.0 US$ 7th ~ 9th Year →1.5 US$ (If explored for 9 years, 9.0 US$ per ha)
Right of Mining: 15.0 US$/year per ha (Coal is 5.0 US$/year per ha)	

Thereby, the acquisition of right to resell (as provided in the earlier version) will be avoided.

(f) The Upper Limit of Foreign Employment (Article 39) (Provisions newly introduced)

Earlier, the law stated that "a license owner employs only Mongolian for exploration and mining". However, the new revisions state that "foreign workers must not exceed 10%" of the total number of employees under the license holder.

(g) Environmental protection obligations (Article 33 and 36, Article 57 (Penalties))

According to the newly introduced obligations, the license holder must draw up an environmental protection plan, submit it to the government, and observe it.

However, when laws with respect to environmental protection are violated, the exploration and mining activities of the license holder is suspended for two months and a complaint is registered. Moreover, if the mining license holder causes serious damage to the environment, the license would be revoked and no license shall be issued for the next 20 years.

(h) Information Supply (Article 44) (Newly introduced provisions)

The license holder must release information related to the production and sales of mineral resources, i.e., results of the exploration work, for the general citizens of the country (According to the Penalty Provisions (Article 57), the highest penalty for breach of this law is 1 million Tg)

(2) Royalty Amendments (2011)

(a) 2006 Revision (Article 47)

Table 3-5 shows the before and after for royalties as revised in 2006.

Table 3-5 Royalties Before and after Revision

New	Old
5% of sales value of mineral resources (2.5% for coal for domestic fuel use and widely available mineral resources)	2.5% of sales value of mineral resources (7.5% for gold)

(b) 2011 Revision

The following is a summary of the royalty laws that were newly revised in 2011.

- Those with special development rights pay mineral resource use royalties to national and regional budgets calculated based on the sales value of all types of products used, products sold/extracted from mining areas, or products transported for the purpose of being sold.
- Usage royalties for coal and mineral resources sold in Mongolia shall be equivalent to 2.5% of the sales price of either the product used, sold/extracted from the relevant mining area, or transported for the purpose of being sold.
- In the legal revision of December 23, 2011, in the rule of mineral resources royalties, "widely available mineral resources" was changed to "coal," and this is to be observed starting on January 1st, 2013.
- The minimum usage royalties for other mineral resources excluding those stipulated in Article 47 Paragraph 3 of this law are equivalent to 5.0% of the sales price of either the product used, sold/extracted from the relevant mining area, or transported for the purpose of being sold.

In addition to the above, those that reflect the ratio that corresponds to the market value standard of the product in question (see Article 47, Paragraph 5, Table 3-6 of this law) are charged as mineral resource use royalties.

Table 3-6 Coal related Royalty Addition Ratio

Product	Unit	Standard product	Market price level (USD)	Additional rate for the basal rate based on the product processing steps		
				Raw coal	Clean coal	Finished product
Raw coal	Ton	Coal	0–25	1.00		
			25–50	1.00		
			50–75	2.00		
			75–100	3.00		
			100–125	4.00		
			125 or more	5.00		
Coal after dry and wet sorting	Ton	Coal	0–100		0.00	
			100–130		1.00	
			130–160		1.50	
			160–190		2.00	
			190–210		2.50	
Semi-coke, coke	Ton	Carbon fuel	0–160			0.00
			160–190			0.50
			190–210			1.00
			210–240			1.50
			240–270			2.00
			270 or more			2.50

3.1.2 Basic Concepts of Rural Development

As created based on “The State regulates the economy of the country with a view to ensure the nation’s economic security, the development of all modes of production, and social development of the population” as stated in the Constitution of Mongolia, the Concept for Region-Specific Development of Mongolia describes as follows:

- State organizations that plan region-specific development methods to achieve balanced development throughout the entire country via these regions
- Economic framework for preparing an environment that is favorable to the economy, society, culture, urban development, and external cooperation

In Resolution #57 of 2001 of the Mongolian Parliament, confirmed as Basic Concepts of Rural Development that the grounds for defining the policies and actions for creating political measures and systems for supporting provincial and regional development through methods that achieve unification in upgrading regional areas and cities with above points.

Additionally, according to Mongolian government news from April 2012[29], national program of the regional development was submitted to Parliament, where the approval decision draft was approved. The main details are as follows:

- The first phase of the program is to be implemented between 2012 and 2015, and shall double regional real household income and halve poverty
- Through this program, the influence of natural environment, climate, raw material prices, and exchange rate fluctuations that have an effect on welfare of nomadic people shall decrease. The program will create an environment where regional citizens can equally receive fundamental social services, ensure continuous supply of electricity to all sums (similar to counties), a selection of large scale villages (bags), and other settlements so that it is possible for residents to receive telecommunications services.
- Each village will have autonomous power to handle finances, which makes it possible to ensure annual revenues and allows approval and execution of annual expenditure and fundraising based on participation of the residents.

The above goals are being implemented as part of the program.

3.1.3 Policies of Mining Development

Policies concerning the mineral resources development field in Mongolia include the Comprehensive National Development Policy in 2008, which covers the goal and the basic policy of the mineral field development, and the Mongolia’s Policy for National Security in 2010, which covers national security. In 2013, a draft of the new State Policy on Mineral Sector Development is planned to be discussed in the

[29] Mongolian government news is put on the “State and cabinet information” as weekly news

deliberations at the Diet that will start in September 2013, after obtaining the approval from the Government, to implement the above policies, which specify the priority of development according to the guidelines of the policies and the amendment of laws and regulations, based on the mineral field and the medium- to long-term program. The policies cover the mineral resources as a whole, and are not specialized in the coal resource.

The proposed outline of the new mineral field development policies are as follows.

<Background of the policies>

Establishment of polices and creations of regulations that take account of the following points are required.

- Domestic and international economic trends, economic competitiveness of Mongolia, expectations of people in Mongolia in the mineral field, use of revenue in the mineral field for the purpose of economic diversification, adding value on products, effective investment, reduction in the transportation and logistics cos.

<Outline of basic principle of the policies>

Amendment of legislative environment and establishment of program within a framework of the policies

- Setting of specific legislative environments concerning exploration and development of minerals
- Regular estimation and understanding of the international economy and the domestic market trend, and establishment of short-, medium- and long-term plans
- Regular implementation of the comprehensive research of mineral deposits and the classification and evaluation of products, and establishment and implementation of short-, medium- and long-term programs
- Support of the strategies of refinement industries, a responsible mining strategy and the strategic evaluation system of social economy and environment, and establishment of legislative environment concerning these issues
- Establishment of legislative environment to make rules on the relationship between the introduction of resource evaluation system and the economic benefit

<Outcomes expected to be achieved as a result of implementation of the policies>

The following outcomes are expected as a result of the implementation of the policies.

- Mineral resources will be dug using technologies to reduce environmental burden and an appropriate amount of production will be ensured with the application of upgraded level of mineral concentration. As a result, the increase and diversification of products that have added values complying with the international standards.
- Large-scale mining, processing and infrastructure project may increase state revenues of Mongolia and enable Mongolia to build a fund that makes it possible invest other economic sectors sufficiently
- Activities in the mineral resources field must be conducted according to the laws and be transparent and open to Mongolian people.

3.1.4 Investment Policy

(1) Foreign Investment Policy

With the advancement of political and economic regimes in 1990s that promotes the foreign direct investment policy, economic foreign openings, job creation, technology transfer, etc. have also improved. The policy helps creating an organization that deals in foreign investments – the Foreign Investment Adjustment Registrar.

Foreign investment methods are the most important aspect of the Foreign Investment Law, 1991. However, in order to encapsulate subsequent economic affairs, this Law was revised in 1993, 1998, and 2002. The last revision was in May 29, 2008.

Deregulation is important in a Foreign Investment Promotion policy, and a foreign investment is possible only if it abides by the Municipal Laws in all fields. In more than 25% of the investment (tangible and intangible) is based on foreign capital, the project is deemed to be a foreign capitalization and registration with the Foreign Investment Adjustment Registrar is required. With foreign investments, companies are free to transfer revenue, dividends, and asset inventory amounts to their home country. According to the law, a company can either be an incorporated (open or joint stock company) or a limited company (closed or limited liability company). The minimum capital required to form an incorporated company is 10,000,000 Tg and for a limited company, it is 1,000,000 Tg. This also applies to Foreign Investment Adjustment Registrar for the establishment of a liaison office. Establishment permission of an office serves as extension for every two years after the initial three years. The minimum required capital for foreign funding was raised from 10,000 to 100,000 USD on May 29, 2008.

With regard to investment in the mining industry or capital companies, it is possible to enter into a stability pact with the government. Doing this guarantees the freezing of taxes such as corporate taxes, etc. for 10, 15, or 30 years. And, according to Foreign Investment Law, foreign corporations have to give priority to employing Mongolian nationals. So, if they employ foreigners, they have to have special qualifications or skills, which requires permission from the Ministry of Social Welfare and Labor.

(2) Laws governing Foreign Investments in Strategic Industries

This law was approved in the Parliament on May 17, 2012, and was enforced on the same day. This law manages the investments of a person or a third party, including foreign investors, in businesses in the strategic fields, which is concerned with national security and interests. A strategic industry meets the basic needs of the population, maintains the independence and normal functioning of the economy, generates national revenue, and ensures national security. In April, 2012, it was announced that the Chinese aluminum major company Chalco would acquire the stocks of South Gobi Resources in which the Ivanhoe Mines of Canada owns a maximum of 60%. With the shift in management rights of South Gobi Resources to Chalco, the Mongolian Government would cease to make any benefits from the company. Thus, the Government suspended all mining rights and licenses of South Gobi Sands, including the Ovoot Tolgoi coal mine - a strategic mine of the country.

When a person or a third party, including foreign investors, own a portion or interests of a corporation set up in a country, it is necessary to obtain the approval of the Government of the host country. In addition, foreign direct investments in excess of 49% or in excess of 100 billion Tg in an entity operating in a sector of strategic importance, requires approval from the Mongolian Government. In other cases, the Government judges the propriety of recognition. An agreement to be recognized is described as follows:

- The agreement which acquires the right to acquire 1/3 or more of the stocks of the company operating in the strategic fields
- The agreement which gives the board of directors the right to select representatives of the company, which does business in the strategic field
- The agreement which uses veto against the resolution of the decision making body of the company, which does business in the strategic field
- The agreement which gives the right to determine business operations and its policies for a company operating in the strategic field
- International Agreement that may establish monopoly of a market by the purchase or sale of mineral resources and its products in a domestic mineral-resources market
- The agreement which may affect the market and price of a mining export of a country directly or indirectly
- Specialty of the company operating in the strategic field
- The agreement which eventually sets a contract of the ratio of investments/ownership of the company

After that, this amended law concerning foreign investment was approved by the Diet on April 19, 2013. Under Article 4.7 of the Investment Act that was enforced in May 2012, the approval of the Diet was required when a foreign investor acquired interest exceeding 100 billion Tg and 49% in a strategically important sector. However, in the draft of the amended law, part of Article 4.7 was revised as follows: the approval of the Diet is required only when a state-owned company other than those of Mongolia obtains 49% or more interest in a Mongolian company, but the conditions for obtaining the approval of the Diet and the amount set at 100 billion Tg were eliminated from the requirement in case of acquisition by foreign companies. Acquisition of interest other than the above requires the approval of the Government. With the amendment of the investment law, we can expect that the environment of investment by foreign countries will be improved and accordingly so will be economic growth.

3.1.5 Coal Program

While the coal program was considered in the Ministry of Mineral Resources and Energy in 2007, it has not been released in the form as approved by the Diet. The coal program includes the coal management policy, the coal environment policy and the coal use policy, the contents of which are important in understanding the current situation of Mongolia. Some parts of the program have been already implemented in the form of legislation. Summary of the contents is provided in the reference material 1.1.1.

3.1.6 National Guidelines on "Coal Field Development"

In this study, the summary of the national policy concerning the coal field development contains a more specified plan for coal development and use compared to the above mentioned coal program, according to the interview with the officers of the former Ministry of Mineral Resources and Energy (currently the Ministry of Mining). Simplified version of the entire policy is provided in the reference material 1.1.2. With regard to the policies concerning the coal field, The Mineral Resources Field Development Policy mentioned in the above section 3.1.3 is scheduled to be presented to the Diet in 2013. Therefore, specific national guidelines on the coal field development are considered to be discussed after the establishment of the policy.

3.1.7 Contents of big projects conducted on a priority basis which was announced by Mongolian government.

Priority projects outlined by the previous administration are noted in 1.1.3 of References. This includes details on projects related to coal use. While it is unclear how far these will be implemented under the new government, this provides a general understanding of the direction in which the country is heading.

3.1.8 Taxes Associated with the Production and Sales of Coal

(1) Current State of the Tax System

Currently, various taxes are levied on coal mining individually from different ministries, with a total over approximately 20 different types. In the Mongolian system, in addition to paying taxes that all enterprises pay, taxes exist for coal companies that must be paid on top of this. All coal mining companies are obliged to pay the required taxes, which are about 60% of net earnings or about 40% of all incomes.

Table 3-7 describes the current status of tax and fees related to coal mines, as identified in this study and Table 3-8 describes the surtax concerning a mineral resources commission.

Table 3-7 List of Tax and Fees related to Coal Mines

	Tax	Content	Remark
1	Income Tax	30 billion Tg is less than 10% 30 billion Tg is more than 25%	
2	Social Security Tax of Employee	13% of Salary	
3	Employment Insurance	5% of Salary	
4	Surtax	Raw Coal: 5% is 1 ~ 5% standard + α Clean Coal: 5% is 1 ~ 3% standard + α	+α (for details, see Table 3-8)takes into account export, domestic consumption, and coal market price
5	Value Added Tax	10%	It is set to 10% of the product's (gasoline, etc.) purchase price.
6	Property Tax	2% of real estate valuation	
7	Automobile Transportation Tax		The heavy industrial machines of a coal mine are taxed according to their engine's size.
8	Duty	5%	
9	Air Pollution Tax	1,000 Tg/t	
10	Land Usage Tax		The tax rates for the office and space for concentrating coal.
11	License Fee	5+β US$ / year per 1 ha	Some amount of Exploration expenses shall be used in line with regulation
12	Water Usage Tax	30 Tg ~ 100 Tg per 1 ton raw coal	It differs with the usage (e.g., domestic and industrial use) of water.
13	Tax Related Quarantine		
14	Tax Related Environmental Protection		
15	Royalty		When acquiring mining rights, various royalties are required for undertaking the necessary procedures.
	Commission	Content	Remark
16	Mineral Resources Commission	5%	2.5% of sale for domestic
17	Social Insurance Fee	11-13%	
18	Charge Customs Procedures	1,500 Tg per ton export coal	
19	Water Usage Fess		
20	Tax Payment Fee		

Source: A Japan International Cooperation Agency (JICA) edits the data of Ministry of Mineral Resource and Energy (MMRE).

Table 3-8 Surtax Concerning a Mineral Resources Commission

Coal Washing		Raw Coal	
0 – 100	0%	0 – 25	0%
100 – 130	1%	25 – 50	1%
130 – 160	1.5%	50 – 75	2%
160 – 190	2%	75 – 100	3%
190 – 210	2.5%	100 – 125	4%
more than 210	3%	more than 125	5%

Source: MMRE

(2) Tax Issues

1) Problems

Taxes on current coal mining companies involve taxes levied individually by various state organizations, in addition to regular taxes paid by Mongolian corporations. Mongolia lacks a unified tax system, whereby if a ministry has low tax revenue, it may suddenly raise tax rates.

Of these taxes, taxes levied per ton of coal are common based on coal market price, and the market price of coal set by the government becomes important. The Government has determined the export price of coal for the circulation index in China as reference. This price is quite higher than the market price with which coal mines actually trade, and there are twice as many differences in a coal producer.

Moreover, the tax paid to a country is not fully utilized in the development of towns and villages around the coal mine. As tax money is not adequately provided to regional areas by the government, many peripheral citizens are extremely upset by coal mining development due to harm to nomadic herding, environmental pollution, etc., and there are cases where mining companies pay money directly to local administrations.

2) Issues and Recommendation

(i) It is necessary to clarify taxes or charges levied on current coal mining companies and reconfigure the tax system into one that is more efficient.

- Specialist from third-nation audit corporation to check the taxes system between coal mining company and Government.
- Prepare the place of exchange of opinions of the Government, National Coal Association, and private enterprises.

(ii) Rationalization of China’s market price and selling price is advanced.

- Improving an international system for exporting to China by the Ministry of Foreign Affairs /Trade.
- To grasp the information control thoroughly as a country and a market trend.

(iii) Although national or local tax payment concerning a coal mining company is distributed by central government or local government respectively, it clarifies about the purpose for spending.

3.2 The Situation of the Existing Coal Mine and New Coal Mine Plan

3.2.1 Summary

Abundant coal resources[30], of 165 billion t, are widely available in the country, which are located underground at sedimentary basin of 15. The country underwent a big change from the 1990s, i.e., from being a socialist to democratic country. Coal development also underwent change with the establishment of mineral resources legal revision in 1997 and mineral resources in 2006, etc. Although the coal production of the country was increasing every year, it did not exceed 10 million t till 2008. Although almost all the production was for domestic supplies, the coal production from a joint corporation Qinhua-MAK Naryn Sukhait coal mine with MAK and Chinese group started in 2003, coal export from the south Gobi area to the China side came into existence, and gradually, the coal output of the country increased to 33 million t in 2011.

Presently, the coal mines are progressing in the whole country, as shown in Table 3-9 and Fig. 3-1. In addition, Table 3-9 indicates the existing coal mines and links them with the number of the positions in Fig. 3-1.

In south Gobi near China border, many coal mines were developed where good coking coal was produced and exported to China. The typical coal mines with high coal outputs were Erdenes Tavan Tolgoi, UHG (Ukhaa Khudag), Naryn Sukhait, Ovoot Tolgoi, and Qinhua-MAK Naryn Sukhait, which accounted for a total production of about 20 million tons in 2011. It is expected that the large-scale coal mines other than those in the south Gobi area, such as, Khushuut coal mine of Khovd prefecture, will develop rapidly. The new coal mine plan, such as, the Erdenes Tavan Tolgoi coal mine in West Tsankhi, is also progressing and the coal production for export has increased.

On the other hand, the coal mine production for domestic electric power is also increasing every year. A Fifth Thermal Power Plant plan for Ulaanbaatar was proposed in 2012 for which coal will be supplied from the Baganuur and Shivee-Ovoo Coal Mines. These are likely to produce about 4.8 million tons in total in 2011. The Ulaan Ovoo coal mine supplies coal to the Erdenet and Darhan coal-fired power plants. The Aduunchuluun coal mine supplies coal to the Choibalsan coal-fired power plant. The production quantity is expected to increase from now on by improving the capacity of the plant, equipments, and starting coal-associated business, such as, a cement plant in the surrounding area.

Moreover, small-scale coal mines provide noncommercial coal to the heat-only boilers (HOB) located in the outskirts of the district. Although the current production capacity of a district coal mine is about 100,000–300,000 tons per year, if the infrastructure improves, there will be an increase in production as the coal mines have enough deposits. The present coal miners are seeking places for exports in order to increase their volume of sales.

30 Resources: Existing amount of discovered coal

Table 3-9 Mongolia Coal Mine Summary List

No.	Deposit name	Section name	Company name	Licence	Province	Soum	Production (thousand tons)			Moisture %		Ash%	S %	Caloric value kcal/kg		Carbon content%
							2009	2010	2011	War	Wad	Ad	St	Qdaf	Qar	C
1	**Aduunchuluun**		Mongolyn Alt Co.,LTD	14892A	Dornod	Bayantumen	-	-	-	45.2	9.4	16.7	1.12	6,484		66.8
			Nainga Co.,LTD	1364A	Dornod	Bayantumen	314.10	350.10	344.67							
			Aduunchuluun JSC	1389A	Dornod	Bayantumen										
2	**Ailbayan**	Dornogobi-4	COAL CO.,LTD	16865A	Dornogobi	Khuvsgul,Mandah	-	0.00	43.35	4.8		23.1	0.80	8,215		77.4
3	**Alag-Undur**		Minyu Shi Shi Co.,ltd	15122A	Dornogobi	Saikhandulaan	-	-	-		2.6	36.9	0.38	7,738		95.4
4	**Alagtogoo**	Eastdalan, Dalan	JLDB Co.,ltd	11281A	Dornogobi	Dalanjargalan	0.00	129.00	0.00	3.8	2.1	26.1	1.37	7,456		80.8
		Dalangiin section	Chingisiin har alt Co.,ltd	12515A, 12435A	Dornogobi	Dalanjargalan	41.50	27.60	5.68	7.3	2.1	33.5	1.46	7,560	4,243	80.8
		Jargalantyn section	Mongolyn Alt Co.,LTD	11932A	Dornogobi	Dalanjargalan	-	-	-	3.9		21.7	1.70	7,750	4,900	79.1
		Eldeviin section	Mongolyn Alt Co.,LTD	2545A, 12463A	Dornogobi	Dalanjargalan	511.17	358.16	454.80	12.8		19.1	1.08		4,903	80.8
		Zuundalan, Dalan	MCJT Co.,ltd	14492A	Dornogobi	Dalanjargalan	-	-	-		1.0	37.7	0.56	8,330	4,080	88.5
		Alag tolgoi	Mongolyn Alt Co.,LTD	716A	Dornogobi	Dalanjargalan	-	-	-	7.3	2.1	26.1	1.37	7,560	4,243	80.1
		Alag tolgoi	Powerland Co.,ltd	9517A, 13132A	Dornogobi	Dalanjargalan	-	-	-	7.3	3.5	28.9	1.31	7,720	5,430	78.2
5	**Alagtsahir**		Shanshi mejo Co.,ltd	12669A	Bayanhongor	Bayantsagaan	-	-	-							
6	**Baganuur**		Baganuur JSC	1371A 13630A 13631A	Ulaanbaatar	Baganuur	3,050.00	3,394.70	3,253.30	33.3	11.1	14.9	0.73	6,780	3,616	72.3
7	**Banzatkhairhan**		Gurvan zam Co.,ltd	16861A	Umnugobi	Noyon	-	-	-	5.9	0.4		0.61	8,442		
8	**Baruungalt**	Zaamryn Eh area	Antracite Co.,ltd	4773A	Tuv	Zaamar	4.00	-	-							
9	**Baruundalan1**		Lovonco Co.,ltd	15161A	Dornogobi	Dalanjargalan	-	-	-		3.1	17.6	0.67	7,330		
10	**Baruunnaran**		Hangad exploration	14493A	Umnugobi	Kahnhongor, Tsogttsetsii, Bayan-Ovoo	-	-	-	4.8	0.6-3.1	18.3-30.4	0.65-1.27	8,006-8,332		
11	**Baruun noyon-1**	North	Tsagaan uvuljuu Co.ltd	17162A	Umnugobi	Noyon	-	-	-	2.0		23.5	0.40	6,840		
12	**Bayan Us**		"PIRAN Co.ltd	15616A	Dornod	Mamad	-	-	-							
13	**Bayanjargalan**		"Zanadu Coal Mongolia" XXK	16871A	Tuv	Bayanjargalan	-	-	-	36.1		13.6	0.43			
14	**Bayantes**	Gashuut tolgoi	"South govi coal trans" XXK	17038A	Umnugobi	Gurvantes	-	-	-							
15	**Bayanteeg**		"Baynteeg XK	367A	Uvurkahngai	Nariin teel	37.64	47.03	55.30	5.2		22.6	1.01	7,239	5,570	
16	**Bayantsagaan**		"Erdenetsagaan"co.,ltd	223A	Arkahngai	Ihtamir	0.36	-	-							
17	**Bayantsogt**		"Cidaquangai"Co.,ltd	17105A	Sukhbaatar	Erdenetsagaan	-	-	-							

Table 3-9 Mongolia Coal Mine Summary List (continued)

No.	Deposit name	Section name	Company name	Licence	Province	Soum	Production (thousand tons) 2009	2010	2011	Moisture % War	Wad	Ash% Ad	S % St	Caloric value kcal/kg Qdaf	Qar	Carbon content% C
18	**Bayantsogt-1**		Border security team No.0119	3959A	Sukhbaatar	Erdenetsagaan	-	-	-	36.0	11.2	18.9	1.79	6,590		
			"Erdeniin olz Co.,ltd	12297A	Sukhbaatar	Erdenetsagaan	46.80	50.10	141.30							
			Andyn ilch Co.ltd	12307A	Sukhbaatar	Erdenetsagaan										
19	**Byrgastaingol**		"Datsan trade Co.,ltd" "uurhai" Co.,ltd	3752A, 3767A, 11924A	Uvs	Tarialan	-	-	-							
20	**Javkhlant**		"Huldyn nuurs"Co.,ltd	10871A 14987A 16703A	Tuv	Jargalant	-	-	-		3.7	38.8	0.52		4,453	
21	**Jilchigbulag**		"Mon Ajnai"Co.,ltd	1361A	Khuvsgul	Burentogtokh	13.76	17.10	-		1.8	25.2	0.93	6,755		
22	**Zangat Uul**		"Javkhlant ord"Co.,ltd	16952A	Umnugobi	Gurvantes	-	-	-	12.7		22.7	0.70	6,065		
23	**Zeegt**		"Gobi Coal & energy"Co.,ltd	905A, 11965A, 14217A	Gobi Altai	Chandmani	3.97	5.00	5.20	13.5		22.9	0.23		3,507	
24	**Maanit**		"Mandal Altai" group	6387A	Gobi Altai	Tugrug	14.90	-	-							
25	**Mandah nuur**		"Ih gobi energy"Co.,ltd	17196A	Dornogobi	Mandakh	-	-	-	13.9	3.6	34.8	0.51	7,493		
26	**Manlai**		"Shine Longda"Co.,ltd	16806A	Umnugobi	Manlai	-	-	-	7.7	0.6	19.4	0.61	8,445		75.0
27	**Mogoin gol**		"Mogoin gol"Co.,ltd	384A	Khuvsgul	Tsetserleg	14.00	30.00	23.00	6.5		19.8	0.90		6,990	75.2
28	**Myangan**		"Erdes Uvs" Co.,ltd	1025A	Uvs	Tarialan	2.70	2.90	4.50							
29	**Nalaih**		35pc's mining license		Ulaanbaatar	Nalaih				24.3		11.8	2.23	6,716	4,089	
30	**Naryn suhait**	Tuv, EAST	"Mongolyn alt" Co.,ltd	5458A 12225A 12226A 227A 6852A 15630A	Umnugobi	Gurvantes	1,438.30	5,072.20	5,282.91	2.0-4.0		7.0-19.8	0.25-0.46		6800-7400	83.8
		Ovoot tolgoi	"South Govi Sand's" Co.,ltd	12726A	Umnugobi	Gurvantes	1,327.57	2,308.66	4,574.70							
		Khuren tolgoi	"Qinhua-MAK-Nariin sukhait" Co.,ltd	5459A	Umnugobi	Gurvantes	744.40	1,823.65	1,776.10							
		Sumber	"South Govi Sand's" Co.,ltd	16869A	Umnugobi	Gurvantes	-	-	-							
31	**Nomhonbor**	Togoottalbai	"Ontre gold" Co.,ltd	15603A	Umnugobi	Bayan-Ovoo	-	-	-							
32	**Nuursthotgor**		"Khotgor shanaga" Co.,ltd	3508A, 14865A	Uvs	Bukhmurun	-	-	-	2.9	1.8	22.9	0.34	7,412		83.1
			"MCJT" Co.,ltd	12474A	Uvs	Bukhmurun	-	-	-							
			"Mentuyu" Co.,ltd	2763A	Uvs	Bukhmurun	-	-	-							
			"Erchim" Co.,ltd	5696A	Uvs	Bukhmurun	10.67	17.10	-							
			"Hotgor"JSC	1441A	Uvs	Bukhmurun	45.90	55.30	74.70							
			"Hotgor"JSC	14442A	Uvs	Bukhmurun	-	-	-							
33	**Ovoot**	Mogoin gol	"Hurgatai hairhan" Co.,ltd	17098A	Khuvsgul	Tsetserleg	-	-	-		0.5	16.3	1.37	8,219		98.9
34	**Olonbulag**		"Mo En Ko" Co.,ltd	2913A	Khovd	Ueynch	-	-	-							

Table 3-9 Mongolia Coal Mine Summary List (continued)

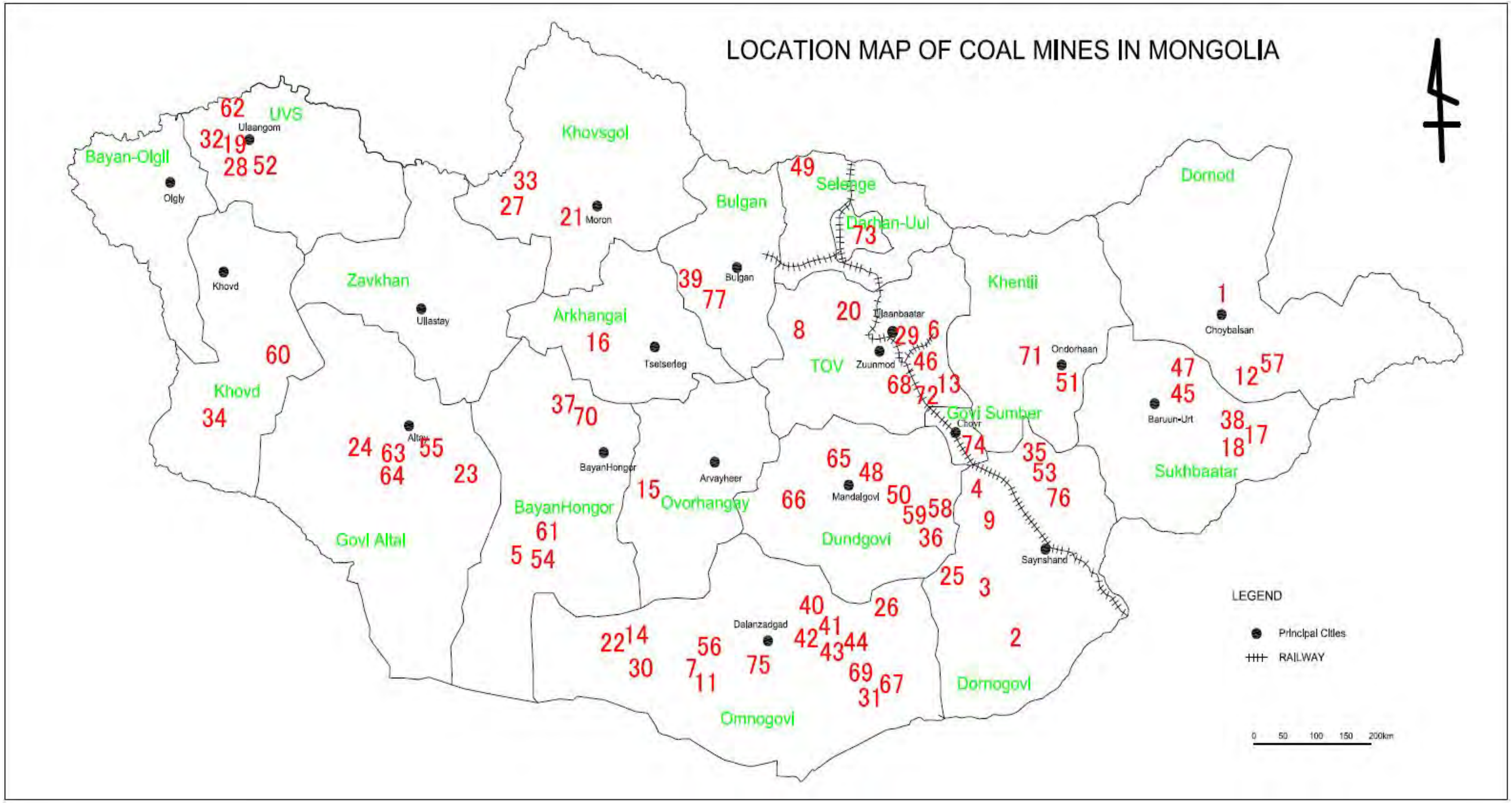
No.	Deposit name	Section name	Company name	Licence	Province	Soum	Production (thousand tons)			Moisture %		Ash%	S %	Caloric value kcal/kg		Carbon content%
							2009	2010	2011	War	Wad	Ad	St	Qdaf	Qar	C
35	**Olongiin uhaa**		Shim Aminaa	17112A	Dornogobi	Ih het	-	-	-		11.0-12.5	18.7	1.18	6,320		66.2
36	**Uvdughudag Ih Ulaan nuur**		"Talyn shigtgee" Co.,ltd	17013A	Dundgobi	Undurshil	-	-	-	36.2	7.8	13.9	2.70	6,277	3,069	
37	**Ubur chuluut/Muhar**		"Bayalag ord"Co.,ltd	222A	Bayanhongor	Galuut	16.50	22.10	23.30							
38	**Sain huuvur**		"Badmaarag khash" Co.,ltd	16679A	Sukhbaatar	Erdenetsagaan	-	-	-	5.4		21.7	0.60	6,810		
39	**Saihna-Ovoo**		"SMI" Co.,ltd	2366A 11985A	Bulgan	Saikhan	-	-	-	14.0		20.0	0.50	7,800		
40	**Siirestein hudag**		"Broad"Co.,ltd	14840A	Umnugobi	Tsogttsetsii	-	-	-		1.5	21.1	0.92		6,220	
41	**Tavantolgoi 2713**	Davharga 10	"Tavantolgoi" LGSC	287A 11945A	Umnugobi	Tsogttsetsii	2,722.50	5,205.40	6,239.80	5.3	1.0	20.3	0.90		7,790	
42	**Tavantolgoi**	Tsankhiin East, Borteeg East	"Erdenes Tavan tolgoi" SHC	11943A license is issue of all, West-north part , To the west-south part 11954A, North, east, south part 11955A, for west part 11956 A-east part	Umnugobi	Tsogttsetsii	-		898.60		0.4-0.7	17.0-25.6	0.90	8145-8503		87.4-88.9
43	**Tavantolgoi**	Tsankhiin east, Borteegiin north, Uhaahudagiin west	"Erdenes Tavan tolgoi" SHC	16881A 16882A	Umnugobi	Tsogttsetsii	-	-	-		1.0	18.2-27.9	0.95	8,479		84.7-88.0
44	**Tavantolgoi**	Uhaa hudag	"Energy resource's" Co.,ltd	11952A	Umnugobi	Tsogttsetsii	1,840.94	3,932.00	7,077.10		0.8	23.2	0.66	8,126		82-89
45	**Talbulag-2**		"Talyn gal"JSC	14563A	Sukhbaatar	Sukhbaatar	43.40	45.00	49.50		11.5	12.1	1.37	6,412		
			"Engui tal" Co.,ltd	14209A	Sukhbaatar	Sukhbaatar	0.20	-	5.84							
			"Tsegeen Uuden" Co.,ltd	12466A	Sukhbaatar	Sukhbaatar	-	-	-							
46	**Tugrugnuur**	West-south	"Neichou"Co.,ltd	15124A	Tuv	Bayan	-	-	-	34.5	8.7	15.3	0.46		2,805	73.0
		Tahilt	"Tugrug nuuryn energy" Co.,ltd	228A, 13553A, 13533A 15429A	Tuv	Bayan	-	0.00	17.86		6.0	17.3	1.18	5,838		73.0
		Tugrugiin section	"Tugrug tal" Co.,ltd	15581A, 17173A	Tuv	Bayan, Bayanjargalan	-	-	-	30.9	7.1	13.8	0.84	6,201	3,533	58.6
		Khovil	"Petrocoal" Co.,ltd	9097A, 12475A	Tuv	Bayan	14.60	11.20	54.10							
				12377X	Tuv	Bayan, Bayanjargalan	-	-	-							
		Dovtsog	"Tsircon mine"Co.,ltd	6452A 13146A	Tuv	Bayan	-	-	-							

Table 3-9 Mongolia Coal Mine Summary List (continued)

No.	Deposit name	Section name	Company name	Licence	Province	Soum	Production (thousand tons)			Moisture %		Ash%	S %	Caloric value kcal/kg		Carbon content%
							2009	2010	2011	War	Wad	Ad	St	Qdaf	Qar	C
47	**Tuhum**		"NBMU" Co.,ltd	16975A	Sukhbaatar	Sukhbaatar	-	-	-	13.8	6.5	10.5-12.6	0.32	7,296		
48	**Tevshinn gobi**		"Tevshiin gobi"JSC	1390A	Dundgobi	Saintsagaan	12.00	15.00	15.50	30.5	11.2	20.9	0.65	6,450	3,452	63.1
			"Mogul energy" Co.,ltd	16854A	Dundgobi	Saintsagaan	-	-	-							
			"Tevshiin nuurs" Co.,ltd	10874A	Dundgobi	Saintsagaan	-	-	-							
49	**Ulaan-Ovoo**		"Red hill Mongolia" Co.,ltd	1231A, 14657A	Selenge	Tushig	0.99	70.68	205.20	17.3		10.0-15.0	0.67	7,025-7,513	5,045	
50	**Unsthudag**		"Bilegt hairkhan"Co.,ltd	14911A	Dundgobi	Gurvansaikhan	-	-	-		16.0-38.3	6.0-31.6		6,618		
51	**Havtgai**		"Dornyn nuurs"Co.,ltd	4872A	Khentii	Bayanhutag	-	-	-	17.0		10.6	0.92	6,919	4,767	
52	**Hartarvagatai**		"Khartarvagatai" JSC	1366A 9950A 9951A 11923A	Uvs	Tarialan	-	70.00	53.70	3.9		20.9	0.71	7,446	5,569	
53	**Hashaat hudag**		"Mongol ross tsvetmet" Co.,ltd	158A	Dornogobi	Ih het	-	-	-	35.4		11.0	0.40	6,450	3,548	
54	**Khotgor**		"Gobi Coal 7 energy" Co.,ltd	12728A 17057A 17060A 17061A 17062A	Bayanhongor	Shine jinst	0.52	0.44	0.72			18.0	0.58	8,306		
55	**Huvbulag**		"Mandal Altai" Co.,ltd	17121A	Gobi Altai	Delger	-	-	-	5.9		18.5	0.74		5,400	
56	**Huvguun**	North	"Alag tevsh" Co.,ltd	16971A	Umnugobi	Noyon	-	-	-	8.4		36.0	0.52			
57	**Huut**	Tamsag Depress South	"Buman-Olz" Co.,ltd	13500A	Dornod	Matad	1.59	11.89	16.97	38.6	12.0	10.0	1.11	6,285	3,074	
58	**Huutiin honhor**	Eedemt	"Gan Ilch" Co.,ltd	7944A, 12401A, 12199A	Dundgobi	Bayanjargalan	-	-	-	18.7		20.1	0.89	6,324		
59	**Huutiin honhor**	Zuun hoit hesgiin har tevshinn talbai	"Big Mogul Coal & energy" Co.,ltd	7944A 14715A	Dundgobi	Bayanjargalan	33.17	-	-	12.5	6.5	19.1	1.49	6,767		
60	**Khushuut**		"Mo En Ko" Co.,ltd	1414A 1640A. 4322A. 11887A. 11888A. 11889A 11890A 6525A. 15289A	Khovd	Darvi	-	397.50	806.92	5.0	1.3	15.5	0.51	7,192		90.6
61	**Huurai tal**		"Terra mining"Co.,ltd	17073A	Bayanhongor	Shine jinst	-	-	-							
62	**Huden**		"Nordlint" Co.,ltd, "Khuden" Co.,ltd	841A, 11617A	Uvs	Davst	-	-	-							
63	**Hurengol**	Hujirtyn bulag West	"Hunnu Gobi-Altai" Co.,ltd	5043A 15403A	Gobi Altai	Tugrug	-	-	-	5.0	1.3	27.2	0.55		6,814	
64	**Khurengol**	Hujirtyn bulgiin section	"Hunnu Gobi-Altai" Co.,ltd	1715A 5097A	Gobi Altai	Tugrug	-	-	-							

Table 3-9 Mongolia Coal Mine Summary List (continued)

No.	Deposit name	Section name	Company name	Licence	Province	Soum	Production (thousand tons)			Moisture %		Ash%	S %	Caloric value kcal/kg		Carbon content%
							2009	2010	2011	War	Wad	Ad	St	Qdaf	Qar	C
65	**Huren Uul**		"Talyn ilch" Co.,ltd	16938A	Suk, Dundgobi	Bayandelger, Tuvshinshiree, Delgereh	-	-	-		5.7	10.0	1.14	6,808		
66	**Tsagaan Ovoo**	Elgen gobi	"Khan deej" Co.,ltd	859A	Dundgobi	Erdenedalai	-	-	-	5.2	2.7	17.5	0.93	7,558		76.6
67	**Tsagaan tolgoi**		"South gobi sand's"	15041A	Umnugobi	Nomgon	-	-	-	10.8	2.8	39.3	0.66	8,030	5,366	
68	**Tsadam nuur**	East-North section	"Peebody coal resourse" Co.,ltd	3066A	Tuv	Bayanjargalan	-	-	-	27.5		8.5-25.9	1.93	6,334		
				7863A	Tuv	Bayanjargalan	-	-	-							
		East-South section	"Tenri petro chemicals" Co.,ltd	15090A	Tuv	Bayan	-	-	-	32.2		27.1	1.19		3,995	
			"Tsetsens mining" Co.,ltd	6453A, 17188A, 17187A	Tuv	Bayan	-	-	-			12.7-45.0	0.28-2.18			
69	**Tsant Uul**		"Munh noyon suvraga" Co.,ltd	16872A	Umnugobi	Bayan-Ovoo	-	-		5.4		25.7	0.36	7,404	5,198	71.4
70	**Tsahir hadag**		"Magnet Import" Co.,ltd	12653A	Bayanhongor	Galuut	-	-	-							
71	**Chamdgan tal/Tsaidam nuur**		"Berkh-Uul JSC	4590A	Khentii	Murun	2.00	17.18	28.75	40.9	12.2	11.7	0.92	6,552		
			"Chandgana coal" Co.,ltd	10126A, 16767A	Khentii	Murun	21.00	5.00	-							
			"Tephis mining" Co.,ltd	10144X, 9720X	Khentii	Murun	-	-	-							
72	**Shanagan**	South section	"JLDB" Co.,ltd	16990A	Tuv	Bayanjargalan	-	-	-		7.9	36.9	0.49		4,785	
73	**Sharyn gol**	Shaazgait, Sharyn gol	"Sharyn gol" JSC	1498A	Darkhan-Uul	Sharyn gol	420.40	428.50	375.20	15.0	4.0	20.6	0.89	7,158		75.6
74	**Shivee-Oboo/Sumber**	Shine Us	"Shivee-ovoo" JSC, "Erdenes MGL" SHC,	901A, 13312A 13313A 13311A	Gobisumber	Shiveegobi	1,403.20	1,767.15	1,586.30	42.0	7.9	15.2	0.78	6,635		70.0
75	**Erdenebulag**	Khuren del	"Bold Forward" Co.,ltd	4478A, 11919A	Umnugobi	Khurmen	53.30	3.76	23.00		1.1	19.0	1.03	7,217-7,910		74.7
		Khuren del-1	"Junhaovei ye" Co.,ltd	17007A	Umnugobi	Khurmen	-	-	-		1.4	22.9	1.01	7,643		75.0
		Baga Argalant /West section/	"Altan erdene gazar" Co.,ltd	15582A	Umnugobi	Khurmen	-	-	-		1.9	9.3	0.49	6,976		
		Tasarhai	"Mon lai khad" Co.,ltd	15600A	Umnugobi	Khurmen	-	-	-		1.4	14.2-26.0	0.80	7,217-7,916		74.1
76	**Erdenetsogt**		"Sheerez stone" Co.,ltd	16686A	Dornogobi	Altanshiree	-	-	-	33.6	10.5	16.4	1.26	6,209	3,366	
			"ECM" Co.,ltd	17078A	Dornogobi	Altanshiree	-	-	-	39.4	13.5	20.0	1.56	6,332	2,943	
			"Cinotym" Co.,ltd	16958A 16959A	Dornogobi	Altanshiree	-	-	-		9.0	27.0	1.70	6,828		
77	**Ereen**	North-South section	Ilchit metal" Co.,ltd	8766A	Bulgan	Saikhan	57.60	37.73		4.4		16.6	0.88	7,237	6,785	
			"Peebody polo resources	14228A	Bulgan	Saikhan	43.09	-	-							



Source: JICA Study Team Creation

Fig. 3-1 Mongolia Coal Mine Location Map

3.2.2 South Gobi

(1) Existing Mines

(a) Erdenes Tavan Tolgoi Coal Mine (EAST TSANKHI) (Fig. 3-1 No.42)

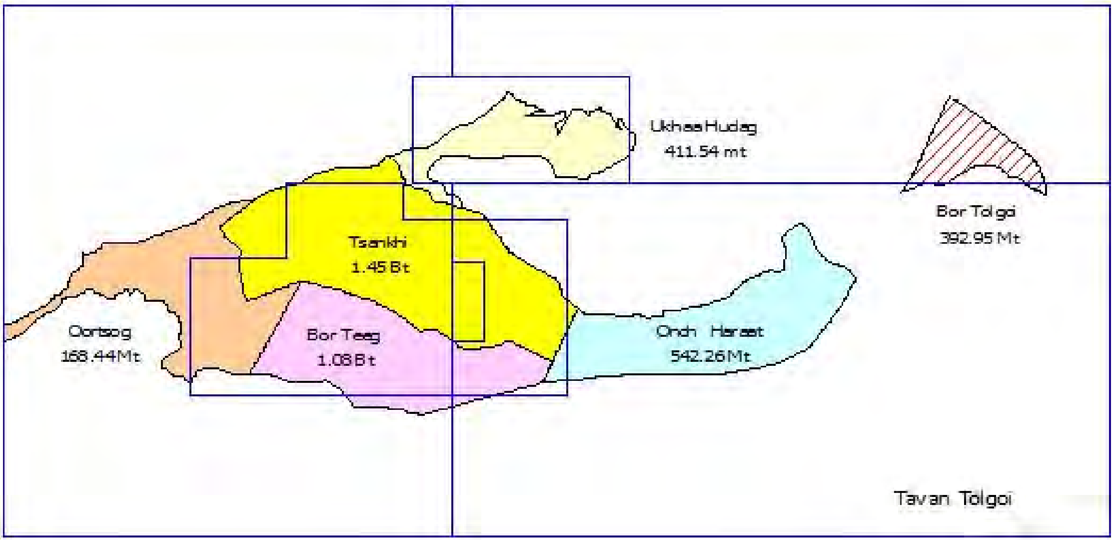
	Content	Remark
Place	It is located in a place (240 km from the Chinese border; 540 km of Ulaanbaatar city; and 90 km from Dalanzadgad) in Ömnögovi province.	
Mining Area	Mining area owns 68,522 ha (96% of total 71,000 ha). Tavan Tolgoi is specified as the strategic coal deposit. There are six mining areas: Tsankhi, Bor Teeg, Oortsog, Onch Haraat, Bor Tolgoi, and Ukhaa Hudag.	The Tsankhi mining area is divided into East Tsankhi and West Tsankhi. Although there is a coal mine, which is in operation with the interest of 51% of the local government besides Erdenes-TT and 49% of private enterprises, Small Tavan Tolgoi is called and it distinguishes from the mining area under new development.
Reserve	2.5 Billion tons (Tsankhi Mining Area)	
Management Structure	100% state-owned enterprises under the company Erdenes-MGL	

Fig. 3-2 shows the mining area of East Tsankhi, Fig. 3-3 shows a coal mining pit, and Fig. 3-4 shows the map of mining area of Tavan Tolgoi. At present, Erdenes-TT is operating in East Tsankhi: its production was about 1 million tons in 2011; about 2.5 million tons in 2012, and 20 million tons by 2017. The mineral income is planned for about 100 years. Seventy percent of it is coking coal; while exploiting the present No. 4 layer (planned value of 18–25 m of layer pressure, and 3.5–3.9 m^3/t/30-year of stripping ratio). Depth of pit is 85 m under the ground. About 7,000 kcal/kg No. 3 layer and the No. 0 layer are endowing under a No. 4 layer. Now, the whole quantity is exported as raw coal to China.

Coal preparation plant has been planned, which will be constructed in 2013 or 2014. The 300 MW capacity plant will come up in an Erdenes-TT coal mine. also in 300 MW plant and the Oyu Tolgoi mine (copper and gold) under present development, and it generates by the steaming coal from an Erdenes TT coal mine.

Fig. 3-2 East Tsankhi Mining Area

Fig. 3-3 Mining Pit in Erdenes TT Coal Mine



Source: JICA Study Team Creation

Fig. 3-4 Tavan Tolgoi Mining Area Location Map

(b) UHG (Ukhaa Khudag) Coal Mine (Fig. 3-1 No.44)

	Content	Remark
Place	It is in the Tsogttsetsii village of Ömnögovi province, and adjoins a Tavan Tolgoi coal mine.	
Mining Area	Mining area is 2,962 ha; mining area number 11952A	
Reserve	Resources 141 million tons (coking coal) and 67 million tons (steaming coal)	
Management Structure	Holders of mining company Energy Resources system (Energy Resources LLC)	Mining rights registered on August 29, 2006

In April 2009 Mining is started by contract mining (contractor: Leighton Asia LLC) from the month. Stripping was started from August, 2008, 2009 annual production was started. The amount of resources has been surveyed at 206 million tons (coking coal) and 288 million tons (fuel coal) in 2011. In 2009, it produced 1.8 million tons; in 2010, 3.8 million tons; 7.2 million tons in 2011, and 8.6 million tons in 2012. In 2013, it will be 12 million tons, and will reach 15 million tons production by 2031. For 2014 and afterwards (a total of 435 million tons is projected). A No. 4 layer with the coking coal characteristic is under mining now. Fig. 3-5 shows the photograph of a coal mining pit.

Energy Resources LLC is responsible for mining UHG coal deposits and it has nine subsidiaries including coal transportation company, coal-fired power generation company, coal preparation facility company, etc. This mine coal is carried to the 245 km away China border in the paved road for exclusive use (the coal transportation company of Energy Resources possession (Coal Road LLC) and Trans Gobi take charge). The company (Ukhaa Khudag Power Plant LLC), which takes charge of coal-fired power generation, 20% of the amount of raw coal except a part being used at six MW x three sets (Fig. 3-6) of the mine mouth coal fired power plant which Energy Resources owns; the steaming coal which will occur also a year in 200-300 million tons is discarded by the Botha dump, while not being utilized by it.

Coal with 23% of ash contents and 5,960kcal/kg of calorific value is burned at the feed rate of 15t/hour, otherwise unused coal is dumped at waste yard.

The company (Enrestechnology LLC) takes charge of a coal preparation facility; it collaborated with Sedgman Limited of Australia for construction of two Coal Handling and Preparation Plant (Fig. 3-7) of 5 million tons/year capacity at a cost of 20 million Australian dollars. Although the third module has not yet been built in the end of 2012, the trial run is to be take place in the first quarter of year 2013, and the full operation with capacity of 15 million tons/year is to take place in the second quarter (details of a coal preparation plant is mentioned in 4.1.5). Energy Resources raised 719,400,000 shares in capital on October 13, 2010, and registered a 20% gain on the whole in the Hong Kong stock exchange.

Fig. 3-5 Mining Pit in UHG Coal Mine

Fig. 3-6 Generation Companies Adjacent

Fig. 3-7 Coal Preparation Plant

(c) MAK Naryn Sukhait Coal Mine (Fig. 3-1 No.30)

	Content	Remark
Place	It is located in Gurvantes village of Ömnögovi province, 50 km north of Shiveekhuren border checkpoint with China, 296 km west of Dalanzadgad.	
Mining Area	Block number is 5458A, 131 ha area	
Reserve	229,000,000 t	Currently under investigation at 350 m depth
Management Structure	Mongolyn Alt Corporation Inc. ("MAK" or later) 100% owned	Mining right registration date is a 2003/02/25, and a mining right authority is MAK.

Investigation was carried out in 1991 for this ore deposit, and the coal bed of nine sheets, which has an inclination of 46–55° was discovered. The No.1 and No.5 coal bed is for earnings. The No.5 layer is exploited now. No.5 coal bed is 53.3 m thick, sulfur content is 1% or less, ash is 5–30.3%, moisture is 1.6–2.8%, calorific value is 6,435–6,935 kcal/kg. Analysis values for finished coal are sulfur content of 0.37-0.9%, ash content of 4.18%-7.44%, water content of 5.8-11.5%, volatile matter content of 33.34-36.46%, and a calorific value of 6,354-7,217 kcal/kg. Moreover, the coal from this mine also has the characteristics of coking coal; the button index (CSN) which shows a coking property is 4–6.

This coal mine started stripping in December 2007 and began exporting coal in May 2008. Have six areas and the total plot is 1666.9 ha. In 2011, 5,280,000 tons was produced, most of it is exported to China (it is for local HOB about 500 tons). In the future, the maximum possible export amount will be 14 million tons, depending on demand. Fig. 3-8 shows the photograph of a coal mining pit.

An Excavator and the shovel of an operation heavy industrial machine are a total of 19 sets, dumping are 38 sets and there are six drilling machines. Through a 35-kV power line, the required electric power shall be purchased from China, shall be 6 kV in a substation, and is supplying electricity. Shipment, a purchase contractor's track (90–100 t) loads directly by working face, tariff procedure is performed in the hall, and it is then carried to the China border. The total coal produced is exporting to China, except concentrating coal. The customs clearance equipment and track parking lot coal storage for custom houses were built recently; construction of the coal preparation plant of 7 million tons capacity per year is scheduled to be completed in 2014. It has been planned to build coal storage for concentrated coal 32 km away from preparation plant, which will transported on a conveyor belt.

Fig. 3-8 Mining Pit in MAK Naryn Sukhait Coal Mine

(d) Ovoot Tolgoi Coal mine (Fig. 3-1 No.30)

	Content	Remark
Place	Located at the southwest end of Ömnögovi province, 320 km southwest of Dalanzadgad, 45 km north from the Chinese border.	
Mining Area	A mining area number is 12726A and area is 98.1 km^2.	
Reserve	Approximately 87,000,000 tons	
Management Structure	SouthGobi Energy Resources	

The ore deposit of this coal mine is the same as that of a Naryn Sukhait coal mine; it has a comparatively complicated geological feature, coal is produced with semi coke in three kinds (low ash, inside ash, high ash). In 2011, 3,800,000 tons was produced and all of were exported to China. In future, production capacity of 8 million tons per year is possible. Production in excess of 10 million tons according to equipment expansion is also possible. It seems that it does not produce more on management. Fig. 3-9 shows the complete view of a coal mining face.

SouthGobi is building a road (45 km) up to the China border with the BOT method returned to the country after 20 years. As this area has little water, which may not progress further, concentrating coal undergoes dry gravity separation.

Fig. 3-9 Panoramic View of Mining Pit in Ovoot Tolgoi Coal Mine

(e) Qinhua-MAK Naryn Sukhait Coal Mine (Fig. 3-1 No.30)

	Content	Remark
Place	This coal mine is located in 3.5 km west of the MAK Naryn Sukhait coal mine.	
Mining Area	WEST MINE: (mining-area number: 5459A; area: 70 ha; mining right registration date 2003/02/25) and 2 km southeast. EAST MINE: (mining area number: 227 A; area: 91 ha; mining right registration date 1995/10/08).	Three licenses are acquired; it will be MAK about two licenses in 2007, remaining one is exploited as Qinhua-MAK. Mining area at present (August, 2012) is 70 ha.
Reserve	The deposit in 2003 was 7,200,000 tons; and was 28 million tons in 2011.	
Management Structure	Qinhua-MAK-Naryn Sukhait LLC	Joint corporation of the Mongolia group (Qinhua) and MAK (50 opposite 50)

In 2011, 1,700,000 tons was produced with the noncommercial use being about 500 tons, most of which was exported to China. A total of 11 million t will be produced by 2011. For a period of 10 years starting from 2012, 20 million tons is expected to be produced. In the future, if raw coal is regulated by law, the MAK coal cleaning factory (planned for 2014) will be used and export is planned.

Coal property is thermal coal; it is a raw coal base and has 6,000–7,000 kcal/kg calorific values, 0.6–0.8% of sulfur content, 22–24% moisture, 20–25% ash, 30–35% volatile matter content. The stripping ratio is 2.5–3.0 m^3/t.

Fig. 3-10 shows coal mining face panorama view. The company employs 170 people, of which 160 people are Mongolian. In the Excavator, 12 sets (1.2 m^3 capacity Komatsu make 3 set, 5.5 m^3 Komatsu make 1 set, 3.5 m^3 Hitachi make 5 set, product made from 4.5 m^3 CAT 3 set) and six 100 tons of tracks are working. For coal, trucks from China visit coal mines directly to load up., the customs formalities are carried at the gate of MAK.

Fig. 3-10 Panoramic View of Mining Pit in Qinhua-MAK Naryn Sukhait Coal Mine

(f) Baruun Naran Coal Mine (Fig. 3-1 No.10)

	Content	Remark
Place	It is in Omnigovi province, located 30 km from UHG coal mine.	
Mining Area		
Reserve		
Management Structure	Energy Resources LLC	

This mine has produced on February 2012 and produced 822,000 tons in 2012. The produced coal is transported to the UHG coal mine, and it is exported after concentrating coal there. During an investigation in 2010, quantity of deposits for coking coal was about 282 million tons. It is estimated to be 7 million tons per year in future, and expected to mine for 20 years.

(2) Planned New Mines

(a) Erdenes Tavan Tolgoi Coal Mine (WEST TSANKHI) (Fig. 3-1 No.43)

	Content	Remark
Place	It is in the sogttsetsii village of Ömnögovi province, and adjoins UHG (Ukhaa Khudag) coal mine.	
Mining Area	Mining area number is 11956 A and mining area is 5,603 ha; mining right registration date is 2006/08/29.	2006/07: One of the Mining Areas Specified as "Strategic Ore Deposit (Strategically Important Deposits)" by Revision Mineral Resources Method (Minerals Law)
Reserve	The amount of resources is 0.6 billion tons	
Management Structure	Erdenes MGL Company	

In the West Tsankhi area of Tavan Tolgoi, guidance of the bid was released in December 2010 and 15 companies tendered their bids. The companies and unions, which tendered a bid are shown inTable 3-10. In March 2011 Mongolian Cabinet announced six shortlisted companies. In July 2011, development rights percentage of this mine area resulted from international bid were announced: China Shenhua Energy 40%; U.S. Peabody Energy 24%; remaining 36% was announced as a collaboration of Korea Resources of national policy resources development of national Russia railway and South Korea, it was presupposed that it will be a temporary announcement later.

The new government will be inaugurated in July 2012; it seemed that a successful bidding company would be selected by the end of the year but has not been announced by November 2013.

Table 3-10 List of Companies That Have Bid and Association

		Mongolia	China	Japan	Russia	Korea	India	Australia	USA	Brazil	EU
1	Shihua Energy Mitsui Co		○	○							
2	Mongolian Alt Group	○									
3	Arcelor Mttal SA										○
4	I-tai group	○	○								
5	Peabody Energy								○		
6	En plus				○						
7	Fortescue metals group							○			
8	Vale									○	
9	Russian Railway Corp(2 firms) JV Group（Sumitomo Co. Itochu Co.Sojitz、Marubeni） Korec(Korean consortiam of 9firms)			○	○	○					
10	Mesco Steel LTD						○				
11	International Coal Ventures LTD						○				
12	Mongolian auto road joint consortium	○									
13	Xtrata group							○			
14	Erdos Chenlong group		○								
15	Signum Industrial corp	○									

A coloring box is six companies which remained in the short list.

Source: Investigations, such as an advancement in the overseas charcoal development in the 2012 fiscal year

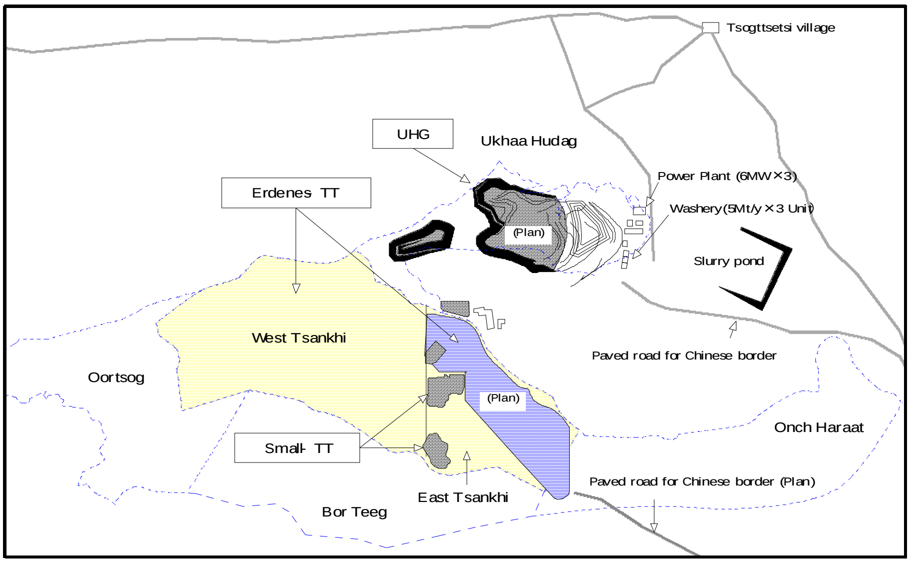


Fig. 3-11 Tavan Tologoi Coal Mine Location Map

Source: JICA Study Team Creation

(b) Tsant Uul (Fig. 3-1 No.69)

	Content	Remark
Place	It is located in Bayan Ovoo village of Ömnögovi province, 40 km to the south of Tavan Tolgoi coalfield, 236 km to the Chinese border.	
Mining Area	Investigation mining area is 69,255.64 ha; mining rights to Mo'nxnoyon suvarga; mining area registration date April 25, 2002.	
Reserve	Resources are 90 million tons (34 million tons of accessible reserve, 27 million tons of presumed resources, 29 million tons of possible reserve).	In order to decide resources, drilling test of 187 hole (28,029 m) was carried out in February, 2011.
Management Structure	Hunnu Coal has 90% rights of the mining area.	A chance of purchasing from Banpu of Thailand and starting production in 2012

The mine operator is Hunnu Coal Co., which holds 90% of exploration license rights in the mining area. Hunnu obtained the exploration license in July 2011. This exploration license grants two 20-year extension options to the initial 30-year license period for a total of 70 years of mine operating rights. Hunnu was purchased from Banpu in Thailand and looks set to start production in 2012. Planned production scale is 1.5M to 3M tons annually.

Thus far, they have dug 20 test holes (total excavation length: 3,654m) and have confirmed strike direction continuity exceeding 4km. There are eight separate coal beds with thickness ranging from 0.5 to 25.22m. Seams 1, 2, and 3 are thick with a total thickness of 59m. Coal bed covering is thin, with coal beds confirmed at 7.8m below surface level.

Coal quality is as follows: caloric value - 7,008 to 7,455kcal/kg, water content is 3.99 to 6.51%, ash content is 17.51 to 19.01%, volatile element content is 22.02 o 42.44%, and sulfur content is 0.28 to 0.65%.

(c) Soumber Coal Project (Fig.3-1 No.30)

SouthGobi Resources has planned Soumber Coal Project as its next coal mine development. The field is located 45 km north side of the Chinese border and about 20 km east of Ovoot Tolgoi coal mine. Large scale investigation by drilling was conducted in 2011. Calorific values range from 5,000–7,800 kcal and the estimated resource of bituminous coal is 137 million tons. Commencement of coal production has not yet been decided. It might depend upon the situation of the Chinese economy.

3.2.3 East Gobi

(1) Existing Mines

There is no operating coal mine in the area now.

(2) Planning New Mines

(a) Unst Khudag Project (Fig.3-1 No.50)

This project is located in Gurvansaikhan village of Dornogovi province, and is located 180 km southwest from Choyr town. A mining area has the digging area 1 and the exploration mining area 2. As for the coal bed, the thickness of those with ten sheets and a coal bed inclines twice on 47.9 m and the north at the maximum in all. The ore deposit is divided in the fault of a NE-SW system. Drilling of 258 holes (22,655 m) has been completed, and F/S and the environmental influence survey are also completed. The endowment depth of the coal bed is comparatively shallow, and the stripping ratio is below 3 m^3/t. It has estimated resources of 324 million tons (18,850,000 tons of accessible reserve; 207,400,000 tons of presumed resources; 98 million tons of possible reserve) up to 140 m under the surface of the earth. It is an implementation plan about F/S towards the mine month power station construction.

The mining area situation of Unst Khudag is shown in Table 3-11, and specification is shown in Table 3-12.

Table 3-11 Mining Situation of Unst Khudag Project

Mine Number	Area	Mine Area (ha)	Mine Right Holder	Registration Date
14911A	Digging Area	1,638.94	Gobikhurakh	2009/5/18
13544X	Digging Area	29,573.99	Gobikhurakh	2008/4/15
14907X	Digging Area	28,191.38	Gobikhurakh	2008/4/15

Source: Investigations, such as an advancement in the overseas charcoal development in the 2010 fiscal year

Table 3-12 Coal Specification of Unst KhudagCoal

Ad Base

Item	Unit	Average
Total Moisture	%	30.8～33.8
Inherent Moisture	%	20.0～22.3
Ash	%	10.6～15.8
Volatile Portions	%	32.1～33.6
Total Sulfur	%	1.04～1.22
Calorific Value	kcal/kg	4,346～4,578

Source: Investigations, such as an advancement in the overseas charcoal development in the 2010 fiscal year

3.2.4 Ulaanbaatar Peripheral

(1) Existing Coal Mine

(a) Baganuur Coal Mine (Fig. 3-1, No. 6)

	Content	Remark
Place	It is located in 110 km east from Ulaanbaatar city.	
Mining Area	Mine number is 1371A and 3631A.	
Reserve	Resources are 599,800,000 tons; 2009 Recoverable Reserves in Year Time are 231,200,000.	
Management Structure	Baganuur Joint Stock Company	75% of the shares are owned by the State, 25% is owned by private

The old Soviet Union developed the coal deposits of Baganuur from 1975 to 1978, and coal production was started in 1978. The produced coal is sent to the coal-fired power plant, which is mainly in Ulaanbaatar.

The coal bed of this ore deposit presented syncline structure, and is prolonged north-eastward. The spread of ore deposit is 15 km in length, and 8 km (the pit sizes in a mining area are 12 km x 4 km) in width. The coal bed has an 8–10° inclination on the south; the inclination increases going westwards and becomes 15–20°. Moreover, although it is almost level in the center, the inclination increases rapidly in the fault neighborhood and three. Main faults are checked. Among these, two faults are located on the south of one deposit, and another is located in the central part. The fall of a fault is 40–50 m. The coal bed has five layers and is two from a low rank. The coal bed of eye watch serves as a candidate for mining.

Coal quality shows a value of 40% in the highest place, although ash is 12–17%. Moisture is 31.8–35.9% and calorific value is 2,783–3,615 kcal/kg. At 20–25 m depth, the calorific value even falls to 2,000 kcal/kg due to weathering.

The actual production in 2010–2011 and future planning of production are shown in Table 3-13. The production is scheduled to increase to 300,000 tons after construction of the dry distillation factory in 2013 in the 2nd plant. Moreover, it is under construction with collaboration of South Korean Hyondon, Baganuur, and the production of 500,000 tons will be increased, 1 million tons is planned by the transportation schedule commencing from 2016 onwards in the Ulaanbaatar 5th plant that will be planed construction. Coal output of 5.5 million tons is scheduled for 2020, which will increase debris from its current 15 million m^3 - 16 million m^3 to 20 million m^3.

Table 3-13 Actual Production in 2010 and 2011 and Future Production Plan

1000 tons	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Coal Production	3330	3100	3200	3500	4000	4000	4500	4500	4500	4500	5500

Source: A JICA investigating commission edits from Baganuur coal mine hearing investigation.

Moreover, the following enterprises are also advanced in this coal mine.

- Tie up with South Korean Hyondon and use of 500,000 tons of raw coal per year as semi-coke.
- Coal preparation plant: as for the processing capacity of the coal preparation plant, although it

is 1 million tons per year in pre F/S, the design fund and operation funds are problematic.

- It is going through financial difficulties although there is also a plan for coal gasification in a combined cycle power generation place (IGCC).
- 270 MW gas power generation in collaboration with the South Korean Knowledge Economy Ministry and Trade and Industry of South Korea will construct a semi-coking plant: 3 million tons pre-treatment plant, 1 million tons of semi-coke export (use of tar and gas).
- MCS(s) have been requested and the investigation stage is underway about the proposal of gasification and liquefaction, and land reservation.
- Effective use of a coal mine byproducts: after oxidization, charcoal becomes manure, which is contained in the surface portion. High quality construction materials, such as, brick, Brock, and road material are made from stripping (sand containing 75% of silica). It is (3.2-4 million m^3 per year) about groundwater. It is used for the object for boilers and offices.

(b) Shivee Ovoo Coal Mine (Fig. 3-1, No.74)

	Content	Remark
Place	Located 20 km southeast from Choyr town in Govisumber province	
Mining Area	Mining number is 901A	Mining area is 91 ha, mining rights were registered at Shivee-Ovoo on December 30, 1997.
Reserve	Abundance confirmed 0.6 Billion tons	
Management Structure	Erdenes MGL 90%, Private shareholders 10%	

This coal mine started open cut mining in 1990, and a major portion of the produced coal is supplied to the coal-fired power plant of Ulaanbaatar.

The accessible reserve of coal is 0.6 billion tons. As for the area of the ore deposit, endowment of the coal bed is checked to 24.4 km^2 and a depth of 250 m. It has eight coal beds endowment. The thickness of the coal bed is the sum total of four layers, averaging of 50.4 m; the inclination of the coal bed is 6–10°, and presents a syncline structure. A 5 m^3 electromotive excavator and a conveyor are used for coal mining. It progresses to 12 m in the northeast direction, and the stripping ratio is 4 m^3/t.

Every year, it produces 1,700,000 tons of clean coal. The Fifth Thermal Power Plant has been planned, which will get 70% of its coal requirement from Shivee-Ovoo coal mine.

This coal mine has two 100 t/h capacity driers, which crush raw coal to the size of below 30 mm. Moisture is sent to a drier, and few (less than 38%) are sent to coal storage by a belt as they are. It is necessary to supply kg in 3,200 kcal/to plant. If it is less than this standard, this coal mine receives a penalty whether a fine is paid and is refused.

(c) Eldev Coal Mine (Fig. 3-1 No.4)

	Content	Remark
Place	It is located in Dalanjargalan district of Dornogovi province, 21 km east from Olon Ovoot town, 40 km southeast of Choir town.	
Mining Area	Mining Number is 901A	Mining Area is 19 ha
Reserve		
Management Structure	Mongolyn Alt Mak Corporation	Registered on 1997/07/31

This coal mine produces 500,000 tons of coal per year for domestic use. This coal mine has a dig end schedule in 2014, although it is dependent on deliberation with three coal mines of surrounding license possession and its up time may be prolonged. It produces 54,000 tons of semi-coke per year. MAK is examining gasification/liquefaction experiment equipment presently, programs usage of lignite of the 100 km away Khoot coal mine after this coal mine digging will be finished.

This coal mine commenced mining from 2002, stripping ratio is 3.5 m^3/t, and the coal bed has a charcoal length of 3–4 m. Many stripping are advanced to a warm period with little demand, and coal is mined and shipped in the winter season. A coal ingredient is measured at an analysis room, 4,800 kcal–5,800 kcal/kg, volatile matter content is 20% or less, sulfur content is usually 0.7–0.9%. A dry distillation factory’s construction will start in June 2010. Commencement of commercial operation will be from March 2011 up to a period of one year and will stop in March, 2012. It has 75,000 t/year of ability, 115,000 t of coal is required.

3.2.5 North

(1) Existing Mines

(a) Ulaan Ovoo Coal Mine (Fig. 3-1 No.49)

	Content	Remark
Place	It is located in the Tushig district of Selenge province; it is 193 km northwest from Darhan city, 149 km from the border checkpoint Altanbulag with Russia, 12 km from Mongolian-Russian border port Zelter.	
Mining Area	Mining number is 1231A, 5895X	
Reserve	The present recoverable reserves are estimated at 80 million tons, and deposits are estimated at 200 million tons.	
Management Structure	Redhill company has 100% ownership	

In the Sharyn Gol layer, the coal bed consists of seven sheets. Main coal beds are of two layers: Mod Coal Seam and Gol Coal Seam. Mod Coal Seam layer is 2.0–7.5 m thick; in the southwest area, thickening of it was carried out and it has branched in towards west. Gol Coal Seam layer is 29.8–63.9 m thick in the northern half.

Canada Redhill has 100% ownership and coal production started in November 2011. It has produced 400,000 tons raw coal for Darkhan plant or Erdenet plant till now. As a mid- and long-term production plan, 1 million t will be planned in 2012, at F/S, it is 3 million t by 2020, 5 million t, the production is due to be increased with 6 million t.Fig. 3-12 shows a coal mine cover shot.

The calorific value of coal property is 5,100 kcal/kg at sub bituminous coal, stripping ratio is the maximum and is a 7 m^3/t grade. It is 1.8 m^3/t at present. Oil pressure backhoe will be three sets (CAT, 3.4–3.5 m^3 bucket capacity), and equipment has become eight stripping tracks (50 t).

Fig. 3-12 Panoramic View of Mining Pit in Ulaan Ovoo Coal Mine

(b) Sharyn Gol Coal Mine (Fig. 3-1 No.73)

	Content	Remark
Place	It is located 45 km southeast of Darkhan city.	
Mining Area	Company mineral rights, Sharyngol JSC Company	Mining area 1,827.9 ha; registered on April 20, 1999
Reserve	0.1 billion tons	
Management Structure	It was privatized in 2003. U.S. investment company Firebird Global Master Fund holds 54.42% of stocks.	

It was discovered in the 1930s, developed in 1962, and mining commenced in 1965. Coal deposits belong to inside and the second-half Jura system. It exists between the large-scale faults of northeast and southwest. The syncline structure of having an axis of the northeast-southwest direction is presented. It has an inclination of 10–28° in the west side and 8–12° in the east side. The coal bed consists of 10 layers, among these the recoverable reserves of Sharyn gol of the Velican layer are based on this as a candidate for mining. It was decided with 100 million tons. The mining length of Velican is 4.1–34.1 m, and average thickness is 19.1 m. As for the Velican layer, the fall is cut at the coal mining place by some faults below 10 m.

Coal from this coal mine is transported by railway and the track. The main users are Erdenet and Darkhan coal-fired power plants.

Mining is performed with three sets of drag lines, six sets of shovels, two bull dozers, and eight sets of damp trucks. Fig. 3-13 shows the situation of a coal mining pit. The calorific value of coal is 3900–4100 kcal/kg, and the stripping ratio is 6 m^3/t. As opposed to 2,500,000 t/year of design production capacity, in recent years, geological conditions and economic efficiency have increased it to 700,000 t/year. Track record for 2011 was 12–140,000 tons per plant, although a little less than 90,000 tons and volume of sales is decreasing for general. A cement plant at Darkhan, iron mill, dry distillation factories, etc. and one million tons production per year is planned for 2013. The new area where production increase is planned will be 20-year mining period, the stripping ratio is 6–8 m^3/t, coal property is sub-bituminous coal. Resources are of JORC[31] standard and are 371 million tons; the recoverable reserves by the standards of the country are said to be 190 million tons.

Source: Sharyn Gol Annual Report 2007

Fig. 3-13 Mining Pit in Sharyn Gol Coal Mine

(c) Ereen Coal Mine(Fig. 3-1 No.77)

	Content	Remark
Place	Location 3 by car to the west of Erdenet City, Bulgan Prefecture	
Mining Area		
Reserve	500-600k tons (annual production 60k tons, planned for 8 years of operation)	Mining surface area 65ha
Management Structure	Mongolian private company Ilchit Metal Co. holds 100%	

This coal mine supplies coal mainly for each village's HOB in Bulgan province and Arhangay province, copper refining plant (10,000t/year), and power plant (30,000t/year) in Erdenet. When both Baganuur and Shivee Ovoo's coal qualities are not suited, this coal usually use for conditioning the calorific value in power plant. This coal mine produced coal 32,000t in 2003. Until now, production

31 JORC is Australian regulation about definition of resources and reserves. JORC (1999) consists of 51 articles, defines details of qualified person (allowed to evaluate and report resources and reserves), exploration results, mineral resources, and mineral reserves.

amount was 60,000t/year at a maximum. This mine has produced 265,000t over the last nine years. In 2011, this mine produced 40,000t, and is planning to supply 63,000t in 2012. There are 18 employees. This mine only conducts stripping from June to August, then start producing coal in September until next May.

The calorific value of coal property is 5,200-8,200 kcal/kg, volatile matter content is about 40%, sulfur content is about 0.5%, moisture content is about 7%, and ash content is about 10%, therefore coal quality is high level. These coal properties were examinated at Mining Institute and Academy of Science. There is a coal seam at 48m from surface, and thickness is 4-8 m. The strip ratio is 9.8-11 m^3/t. Mining machinery are made in Hyundai, operated run on diesel. There are 2sets of excavator (2.8-3.8 m^3 capacity), one bull dozers, 8 trucks for strip (20 t capacity), and 4 trucks for mining coal (50-80 t capacity). After finishing mining the current spot in 6 or 8 years, plan to start mining the south mining area where owner has mining right. Therefore, boring exploration has been conducting.

Fig. 3-14 Mining Pit in Ereen Coal Mine

3.2.6 West

(1) Existing Mines

(a) Hartarvagatai Coal Mine (Fig. 3-1 No.52)

	Content	Remark
Place	It is located about 105 km south of Ulaangom city; it is at a distance of about 3.5 hours by car.	
Mining Area		
Reserve	Reserve production ratio is 25 million tons. Geological deposits are about 200 million tons.	
Management Structure	Fuel and Thermal Group management	

This coal mine supplies coal mainly as an object for heating in winter. Operation was started in the 1970s. The present production scale is about 70,000 tons per year. From September to May and June, it will apply and operate in June; the remaining time is for coal mining preparation, and only stripping is carried out. As coal mining face will be in high ground at an altitude of 2,400 m and winter will be 40°

below the freezing point or less, machines capable of operating 45° below the freezing point are used.

The calorific value of coal is 6,100–6,500 kcal, stripping ratio is 0.5–0.6 t/t, reserve production ratio is 25 million tons, and inferred reserves are about 200 million tons. The mesh is applied to three sizes for the mined coal at present. Concentrating coal technology is given further. Fig. 3-15 shows the mining face panoramic view of this coal mine.

Although the thickness of the coal bed is 65 m or more by drilling, this is because the investigation depth of drilling was about 65–70 m. In future, a long picture is drilled, it seems that reserve production ratio increases.

Mining equipment, the excavator (bucket capacity 1–1.5 m^3/t) of CAT is three sets, a bulldozer is 3–4 sets, in the track, the capacity of 40–50 t is performed for both stripping conveyance with five sets and coal transport. If prospective coal output is in demand, every year 1 million tons is possible.

Fig. 3-15 Panoramic View of Mining Pit in Hartarvagatai Coal Mine

(b) Khotgor Coal Mine (Fig. 3-1 No.54)

	Content	Remark
Place	It is located about 110 km southwest of Ulaangom city of UVS province; it is in the distance of about 4.5 hours by car.It is necessary to pass a peak with an altitude of 2,500 m on the way.	
Mining Area		
Reserve	12.2 million tons	former Soviet Union in 1963
Management Structure		

Coal supply is mainly targeted at ordinary homes as an object for heating in winter. Since its operation started in 1963, 3,700,000–4,000,000 tons have been produced until now. The quantity of production in 2011 was about 74,000 tons. It applies and is in operation from October–February. The block coal with big size is sold for noncommercial use, small coal is stored in order to concentrate coal in the future. The remaining time is used for coal mining preparation, and only stripping is carried out.

Several years earlier, the production scale was about 40,000–50,000 tons per year. But, since the use of wood for fuel purposes was forbidden, the quantity of production of coal has increased gradually. The selling price of coal is 22,800 Tg/t. A small plant was built in Minehead for the purpose of supplying electric power to the neighboring village. But, since the power purchase price from Russia was cheap, its operation was stopped in one year.

The calorific value of coal is 6,000–7,000 kcal, stripping ratio is 2.0 m^3/t, reserve production ratio is 12,200,000 tons (thing at the time of 1963 the sudden Soviet Union), There are five layers of coal beds in all, each being about 12–15 m thick in the 2.5–3.0 m sum total. Fig. 3-16 shows the mining face complete view of this coal mine.

Mining equipment, four sets of excavator PM200 (bucket capacity 1 m^3/t) of Komatsu, three sets of bulldozer, the capacity of 20–25 tons of a track is those with eight sets (made in China), both stripping conveyance and coal transport are performed.

Fig. 3-16 Panoramic View of Mining Pit in Khotgor Coal Mine

(c) Khushuut Coal Mine (Fig. 3-1 No.60)

	Content	Remark
Place	It is located in Khovd province, 210 km south of Khovd city, 310 km northeast from a Baytag border checkpoint.	
Mining Area	Mining Area: 1414A, 1640A, 4322A, 6525A, 11887A, 11888A, 11889A, 11890A Mining Exploration: 11515A	Digging areas are eight mining areas, An investigation mining area is one mining area. Mining area is 800 ha.
Reserve	Recoverable reserves are 87,500,000 tons.	
Management Structure	MEC (Mongolian Energy Company, MoEnCo)	

In the Khushuut coal mine, mining is performed on a small scale in 1967. Coal was supplied for domestic purposes to the neighboring villages and towns on a small scale. MEC (Mongolian Energy Company, it is referred to also as MoEnCo) bought the mining area rights and interests currently distributed from each company, additional investigation was started in 2007 after mineral resources legal revision. This coal mine started activity in 2007.

MEC is listed on the stock exchange of Hong Kong (search by the access code 276 is possible).The coal bed of 29 layers endowed this coal mine to Khushuut coal bed of midterm. Main coal beds are B layer and C layer. The layer thickness of B layer is 10–16 m, the layer thickness of C layer is 25–30 m. Between the layers of B layer and C layer, it is 15–25 m. Geological structure, it inclines north and it consists of a north-south sync line structure mostly.

Mining area is 800 ha, calorific value is 7,000 kcal/kg coking coal, and recoverable reserves are 87,500,000 tons. The area of open cut mining has coal crush equipment and small power generation equipment by 600 ha. Leighton started mining in 2010 and manages two pits (Fig. 3-17 is the No.1 pit, and Fig. 3-18 is the No.2 pit) now. It will prepare for large-scale mining from now on, and three pits are under preparation, which will be unified later. The present mining capacity is 1,800,000 tons; 10,469 tons was produced in 2010; 806,920 tons was produced in 2011. In 2012, a production of 1,500,000 tons is targeted. Currently (August 2012), about 174,000 tons is shipped for export, and 72,000 tons is sold. In future, three million tons of raw coal will be produced by Phase 1; in Phase 2, coal is concentrated in 1,800,000 tons after raw coal, the schedule which concentrates coal in 3 million tons after 5 million tons of production by Phase 3. However, time is unknown on the problem of water development investigation.

The stripping ratio is 4.0 m^3/t, there are many faults and scissors in the geological structure. Although 75% per/ton is coal, it is thought by the place that it is unstable and concentrating coal is required.

All coal is exported to China by road. A 311 km asphalt-paved road upto the China border is under construction. The Customs and Tariff Bureau personnel reside by service on each point of a customhouse for 24 hours. It contracts with five transportation companies, a 60–100 tons track is carrying out 170 set operations (loading to 80 tons of substance). A platform scale, the personal house, office of worker, and a gate have been set up at their company.

Fig. 3-17 Khushuut Coal Mine No.1 Pit

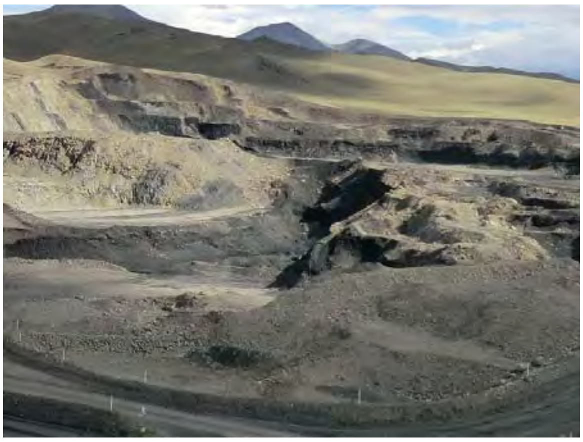


Fig. 3-18 Khushuut Coal MineNo.2 Pit

3.2.7 East

(1) Existing Mines

(a) Aduunchuluun Coal Mine (Fig. 3-1 No.1)

	Content	Remark
Place	It is located 660 km east of Ulaanbaatar, 5 km north of the Choibalsan, a center of Dornod province.	
Mining Area		Mining area is registered by 92 ha on October 29, 1998.
Reserve	Resources are 400 million tons, the deposits of the present mining domain are 243 million tons.	
Management Structure	Aduunchuluun Company	

In this coal mine, the Tobishin Gobi Coal bed continues for 6–7 km northwestward, a sync line showing a structural spread of about 5–6° inclines towards the central part. In this coal bed of ore deposit, thickness gets decreased in the direction of north from south, and depending on a place, it might disappear completely.

At the southern part of the ore deposit, charcoal layer thickness is be 52.2 m. The coal bed is embedded at a depth of 2.5–79.0 m from the surface of the earth.

Inside a pit, mining was performed since 1954. Open cut mining was started in 1969. Fig. 3-19 shows the mining face complete view of this coal mine. Annual production capacity, although 600,000 tons, has changed and come down to 300,000 tons in recent years (the 2011 track record 370,000 tons). With future prospective, the Choibalsan coal-fired power plant will be extended to 136 kW from 36 kW in 2–3 years; The production is due to be increased 2015 onwards to 1,500,000 tons per year. The calorific value of the produced coal is 3,000–4,000 (3,300 average) kcal /kg, moisture content is 38–40%, volatile matter content is 45%. Coal is mainly supplied to the Choibalsan coal-fired power plant.

Mining is performed by capacity of three electric excavator of 4.6–5 m^3, the stripping ratio is 2.0 m^3/t. An operation track is 22 tons freight, stripping is nine sets, ten objects are used for coal; it carries directly to the electricity generation place.

This coal mine aims at export of semi-coke and upgradation of lignite so as to use the byproduct fuel for operating heavy industrial machines. Investigation has been requested from Chinese companies in this regard.

Fig. 3-19 Panoramic View of Mining Pit in Aduunchuluun Coal Mine View

3.2.8 South

(1) Existing Mines

(a) Khub Bullag coal mine (Fig. 3-1 No.55)

	Content	Remark
Place	It is located in eastern Gobi-Altai province, north latitude 46°12'10", east longitude 97°17'51", 90 km east of Altai city, it is in the distance of about 2 hours by car.	
Management Structure	Mandal-Altai Co.	Mongolian private company

In this coal mine, the coal bed is gently inclining. Topsoil accounts for about 1 m to 1.5 m from the surface, while coal beds in a layer beneath that at about 10 m (with a dirt band of around 1 m in between), making it ideal conditions for mining. Fig. 3-20 shows the mining face complete view of this coal mine. Mining will commence from 2011 (there were no royalties, it was unauthorized and royalties got down signs when ground was carrying out). From September 2012, production (only winter production schedule) will start. Five tracks and three excavators are in use.

As a sale place, Mandal-Altai, a noncommercial use, is a hit in five neighboring companies. A track conveys the coal to the boilers of Altai city. In case of noncommercial use, it comes by a private track to stack directly. Coal is sold at 25,000 Tg/t.

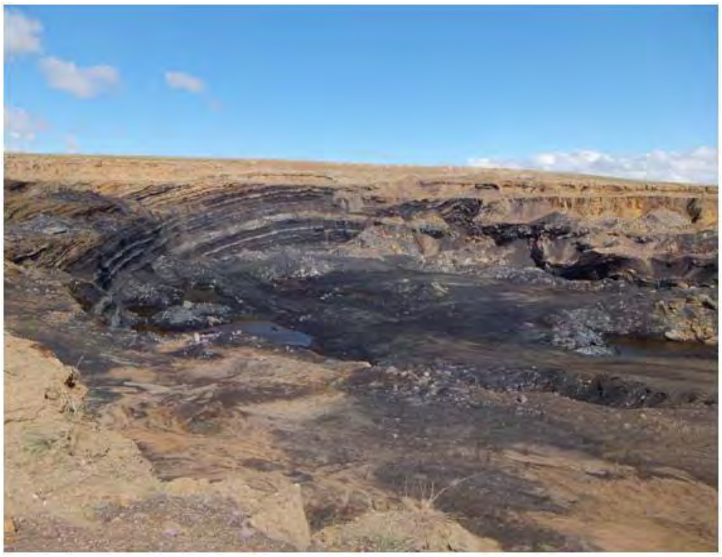


Fig. 3-20 Panoramic View of Mining Pit in Khub Bullag Coal Mine

(2) Development of New Coal Mines

(a) Maanit Coal Mine (Fig. 3-1 No.24)

	Content	Remark
Place	It is located in the western Gobi-Altai province, north latitude 45°47'21" and east longitude 94°43'11", about 150 km southwest of Altai city. It is in the distance of about 4 hours by car.	
Management Structure	Mandal-Altai Co.	Mongolian private company

It was mechanized in 2006. Production for 2011 was 35,000 tons (September–May). As an object for heating 90% of Altai city, 25,000 tons is supplied to HOB, and the noncommercial use is purchased from remaining 10,000 tons. Calorific value is 8,000 kcal/kg, ash is 25%. Mandal-Altai is carrying out new investigation in 2012, and it has not carried out the present production. Plans to export coking coal to China in the future are under investigation (August, 2012).

Coal is embedded at a depth of 28–110 m, coking coal exists near 82 m. However, with the trench by backhoe, a coal bed has much folding. Since there is also an inclination and there is also much middle, it seems that it needs to concentrate coal after mining.

(b) Huren Gol Coal Mine (Fig. 3-1 No.31)

	Content	Remark
Place	It is located in western Gobi-Altai province, north latitude 45°46'58" and east longitude 95°13'53", about 150 km southwest of Altai city. It is in the distance of about 4 hours by car.	
Management Structure	Hunnu Coal Co.	

At present (August, 2012), enforcement of the coal production is not carried out; Hunnu Coal is carrying out geological investigation and a drilling survey. Drilling investigation with a depth of 300 m or more is carried out, twelve rigs are used. Drilling was done in 220 holes (the interval of 300 m, an average of 300 m depth). Deposits were investigated from September last year, development F/S is due to be performed, and coal production is planned in about three years.

This coal mine has an inclination of the coal bed of sync line and antic line in both directions of 45° or more. It is in the state which does not almost have scissors in the coal bed up to 4 m–80 m. In a place with sufficient coal property, 7,000 kcal/kg weak coking coal exists.

3.2.9 Mine Production Planning Issues and Recommendations

(1) Challenges And Recommendations for Export Coal Mine Plan

(a) Future Plans

1) Expectation of Future Plans by Mongolian Government

As per this clause, by 2025, a great portion of the produced raw coal will be exported.

Table 3-14 is prediction of the amount of coal export by 2025 by a MRAM coal inquiry section. According to this, coal export increases to an upward rise, the amount will be 75 million tons in 2025, which will be an increase by 2.5 times in 2012.

On the other hand, the result which Mongolian National Coal Association investigated is Table 3-15 In addition, this clause aims at the coal mine from which coals are exported on a large scale. Working on a theory that if all coal extracted from the mines was exported, it would work out to be about 54 million tons annually by 2025. However, this investigation result does not include plans for export production at major mines, so further investigation is needed in the future.

Table 3-16 is a list of projected production capacity for export coal ore in 2025 based on data collected by the JICA survey team based on interviews at local coal mines, relevant reference materials, and websites. Furthermore, highlighted mires indicate the values have been estimated by the JICA survey team based on interviews because detail production capacity could not be ascertained as of December 2012.

According to this, if the coal mine of a project stage is also included, it turns out that the production capacity in 2025 amounts to a total of 91 million tons.

Table 3-14 Export Volume Estimation (MRAM)

Export	2010	2011	2012	2013	2014	2015	2020	2025
1,000t/y	18,000	25,000	30,000	33,000	40,000	50,000	65,000	75,000

Source: MRAM

Table 3-15 Future Coal Export Plan (Mongolian Coal Association Estimation)

No.	Lisence owner	Coal producing forecast/ thous.y/y (ave.)		
		2013 – 2015	2016 - 2020	2021 - 2025
1	Erdenes Tavan Tolgoi	11,333 - 12,000	19,000	20,000
2	MAK-Nariin Sukhait	13,000	14,000	14,000
3	Energy Resources LLC	17,994	14,970	14,971
4	Southgobi Sands LLC	6,667	5,000	5,000
5	Qinhua-MAK	666	666	-
	Total	49,660 - 50,327	53,636	53,971

Source: A JICA investigating commission edits the data which Mongolian National Coal Association created.

Table 3-16 Export coal ore anticipation production capacity

Mine Name	Forecast of production in 2025 (1,000 t)		Remarks
	ROM	Clean Coal	
Erdenes Tavan Tolgoi (East Tsankhi)	20,000	14,000	Under planning of CHP
UHG (Ukhaa Khudag)	15,000	11,000	15Mt CHP
MAK Naryn Sukhait	14,000	5,000	Under planning of CHP (7Mt)
Ovoot Tolgoi	8,000		Dry CHP
Baruun Naran	7,000		
Tavan Tolgoi (West Tsankhi)	20,000	14,000	Presumed plan of CHP
Tasnt Uul PJ	2,000		
Soumber Coal PJ	5,000		
Khushuut	5,000		Presumed dry CHP
Maanit	2,000		
Huren Gol	3,000		
Total	101,000	44,000	

Source: JICA Study Team Creation

2) Expectation of Future Plans by JICA study team

The data above indicates that even if coal export volume continues to rise in the future, the production capacity for coal ore for export purposes is still sufficient. However, as was discussed in Chapter 2 during the presentation of survey results by the survey team, while the coal import volume of China, which would be the export destination for Mongolian coal, may continue trend upwards, we project that a decline in the economy will result in import volume to level off at 40M to 50M tons by 2025. As such, there is a strong possibility that planning export production that includes mines still in the project phase as outlined in Table 3-16 could result in over-production and a lack of buyers, which would see coal piling up at the production sites. It is important that demand from the main buyer, China, be considered throughout the development of mines for export coal ore.

(b) Challenges and Recommendations for Coal Production Activities

As mentioned above, although it is expected that the export-oriented amount of coal production will increase from now on, some factors need to be mentioned:

(i) For current coal mining companies, they have various taxes over 40% of total incomes that accompany coal development, which is an obligation shared by private companies as well, but there are complaints regarding government's support for the private companies. For example, it is pointed out that private companies are fully responsible for maintenance and expansion of roads and bridges used for exportation, and some coal mines where the private companies pay facility costs such as gates for exportation, etc. Deep cooperation between public companies and government ready for coal development is necessary.

(ii) Since China is mostly an export destination, the exports will be greatly influenced by the Chinese business. In a certain coal mine, export is stopped and production is stopped when the selling price of coal is falling. The trials in which a new sale place and the selling price are not dropped are needed. For instance, market price could be become competitive due to find second export destination.

(iii) Although, under free economy, control of price competition is difficult, there is room for investigation about the bailout package of the country, which lowers the production cost.

(iv) Improved relations with residents are subjects. When furthering development, protests may be received from the residents who are nomadizing and living inside the mining area. Thus, development may not progress smoothly. It is necessary to ensure that the peripheral people are satisfied with the tax, which the coal mining company pays for the living environment, and fully obtain the residents' understanding.

(v) To ensure the stability of a workforce required for coal mine development, work must begin immediately on urban development that provides worker families with a pleasant and long-term living environment. This will provide stability for workers, allowing them to focus on mining labor and make it possible to ensure not only work safety but also to master continued technologies. The inclusion of an urbanization concept is a requirement for the mine development plan.

(2) Issues and Recommendations for Mining Plan of Coal Mine for Domestic Consumption

(a) Future Plans

As per this clause, by 2025, planning of production in coal mines, which supply a great portion of their produced coal to domestic plant and HOB is considered.

Table 3-17 shows the coal demand forecast in the domestic plant and HOB. Local plant and coal demand forecasting of HOB are shown. Demand's increase by 2025 depends the construction of the 5th plant. It is predicted that twice the amount of coal in 2011 will be consumed.

On the other hand, Table 3-18 shows plan of production of coal mines for domestic plant by 2025. The Baganuur coal mine currently supplies to Ulaanbaatar plant; Sivee Ovoo coal mine and Sharyn gol coal mine currently supply to Darkhan plant or Erdenet plant; Redhill Mongolia (Ulaan Ovoo coal mine) and Aduunchuluun coal mine currently supply to the Choibalsan plant. If this is seen, it will follow on the 5th plant operation of Ulaanbaatar, Baganuur coal mine. Although production of the Sivee Ovoo coal mine is scheduled to increase till 2025, it seems that the production increase plan that other coal mines are big is not considered.

Plant in 2025 from Table 3-17 Ulaanbaatar in the city and the coal demand[32] of HOB are about 9.5 million tons, it is a Baganuur coal mine in 2025 from Table 3-18, the amount of coal production of a Sivee Ovoo coal mine is about 10 million t, it turns out that it is planning of production which can provide demand. Moreover, planning of production, which exceeds demand forecasting in another province occurs. Although it seems that the production increase plan of coal mine for domestic power generation progresses, a subject as shown by the following clause also occurs.

(b) Production Planning Issues and Recommendations

(i) Among the coal mines, which supply coal for power generation for domestic use, the prime coal mines are Baganuur coal mine and Sivee Ovoo coal mine. Both these coal mines are national coal mines in which the country has more than half the stock. For this reason, there is a field, which cannot set up minehead price[33] freely. If Baganuur coal mine sets a high selling price, it leads to price increase of electricity bill, selling price[34]: has set to 20,500 Tg/t at a low price to minehead price 22.000 Tg/t by government. The Shivee Ovoo coal mine is also in a similar situation, and because it is necessary for coal being sent to power plants to clear calorific value standards, it is bringing in drying equipment to the coal mine. In the future, support from the state and increase of sales prices through coal upgrade technologies, etc., are important.

(ii) Moreover, both coal mines are saddled with the long-term loan of mining equipments introduced late in the 1990s. It has become a burden on the management. Capital investment is required in order to carry out a production increase plan. How to raise this fund is still a subject of investigation.

[32] Number 1, 2, 3, 8, 9, and 10 in Table 3-17 are coal demand of Ulaanbaatar.

[33] The price mined 1 ton of raw coal

[34] The price sold 1 ton of coal to sale destination

Table 3-17 Domestic Plant (Including HOB) Coal Demand Forecasting

Nos.	PPT Name	2011	2012	2013	2014	2015	2016	2017	2018
1	No2 PPT	202	425	650	650	650	650	650	650
2	No3 PPT	1,100	1,104	1,126	1,149	1,172	1,178	1,184	1,189
3	No4PPT	2,966	3,133	3,511	3,723	3,723	3,723	3,723	3,723
4	Darkhan PPT	380	420	598	600	600	610	620	625
5	Erdenet PPT	275	308	308	308	407	410	407	407
6	Dornod PPT	370	398	450	500	894	930	940	948
7	Dalanzadgad PPT	37	46	49	53	56	53	57	60
8	Baganuur HOB	66	69	72	75	78	83	88	92
9	Nalaih HOB	60	52	44	43	46	46	49	49
	Total	**5,456**	**5,955**	**6,613**	**6,888**	**7,626**	**7,682**	**7,717**	**7,744**
10	No5 PPT					1,830	1,830	1,830	1,830
11	Telmen PPT			170	170	170	170	210	210
	Total(Thous.ton)			**170**	**170**	**2,000**	**2,000**	**2,040**	**2,040**
	Grand total	**5,456**	**5,955**	**6,783**	**7,058**	**9,626**	**9,682**	**9,757**	**9,784**
Nos.	PPT Name	2019	2020	2021	2022	2023	2024	2025	
1	No2 PPT	650	650	650	650	650	650	650	
2	No3 PPT	1,195	1,201	1,203	1,204	1,205	1,206	1,207	
3	No4PPT	3,723	3,723	3,723	3,723	3,723	3,723	3,723	
4	Darkhan PPT	630	630	630	631	631	630	630	
5	Erdenet PPT	407	407	407	407	407	407	407	
6	Dornod PPT	950	955	958	960	965	968	970	
7	Dalanzadgad PPT	64	68	72	75	79	83	87	
8	Baganuur HOB	97	102	107	111	116	121	126	
9	Nalaih HOB	53	54	54	60	60	60	62	
	Total	**7,769**	**7,790**	**7,804**	**7,821**	**7,836**	**7,851**	**7,864**	
10	No5 PPT	1,830	3,620	3,620	3,620	3,620	3,620	3,620	
11	Telmen PPT	210	210	210	210	210	210	210	
	Total(Thous.ton)	**2,040**	**3,830**	**3,830**	**3,830**	**3,830**	**3,830**	**3,830**	
	Grand total	**9,809**	**11,620**	**11,634**	**11,651**	**11,666**	**11,681**	**11,694**	

Source: MRAM

Table 3-18 Forward Planning Of the Coal Mine for Domestic Plant

No.	Lisence owner	Coal producing forecast/thous.t/y(ave.)		
		2013 - 2015	2016 - 2020	2021 - 2025
1	Baganuur JSC	4,667	5,200	5,600
2	Shivee-Ovoo JSC	1,800	3,739	4,480
3	Sharyn gol JSC	300 - 1,000	1,000 - 1,500	1,500 - 1,000
4	Aduunchuluun JSC	817	1,000	200
5	Red hill mongolia	340	1,224	1,224
	Total	7,924-8,624	12,163-12,663	12,504-13,004

Source: JICA study team edits the data which Mongolian National Coal Association created.

(3) The Subject and Proposal of the Coal Mine Plan for Noncommercial Uses

(a) Future Plans

By this clause, planning of production of the coal mine, which supplies the produced coal as a noncommercial use is considered by 2025.

Table 3-19 shows noncommercial coal demand forecasting by 2025. If this is seen, noncommercial coal demand will result in about 4.2 million tons in 2025. From the planning of coal mines for noncommercial uses in Table 3-20, when 2014 is removed, it turns out that it is likely to produce the amount of coal which covers the amount demanded by 2025. However, if noncommercial coal production is set to 2025, far exceeding an amount demanded will be predicted. It is necessary to opt for planning of production, thinking future demand trends as important. (Table 3-19 will need to be investigated from now on)

Table 3-19 Coal Demand Estimation for the Commercial

1,000 ton/year	2013	2014	2015	2020	2025
Central area	279	3,578	2,091	1,380	3,306
Local area	822	830	838	878	900
Total	1,101	4,408	2,929	2,258	4,206

Source: JICA study team edits MRAM data.

Table 3-20 Plan For the Future of The Coal Mine For The Commercial

No.	Lisence owner	Coal producing forecast/thous.t/y(ave.)		
		2013 - 2015	2016 - 2020	2021 - 2025
11	Khangad exploration LLC	333 -1,000	600 - 1,000	1,000 - 2,000
15	Gobi coal and energy	1,000	-	5,000
16	Buman olz	333	333	-
18	Bold Fo Ar Da	766	920	500
19	Chingisiin khar alt LLC	767	85	85
25	Khar tarvagatai	70 - 100	100 - 200	200 - 1,000
26	Khotgor	117	90	130
	Total	3,386-4083	2,128-2,628	6,915-8,715

Source: JICA study team edits the data which Mongolian National Coal Association created.

(b) Production Planning Issues and Recommendations

(i) As the big subject of the coal mine for noncommercial uses, a transport infrastructure is mentioned. There is also a coal mine, which has conveyed the unpaved mountain path to the main towns by tracks over one way 4 to 5 hours. Although there are quite many reserves, in some coal mines which are less than 100,000 tons annual output, the subject of a transport infrastructure is being examined. Finding a new sale place including export is called for.

(ii) Although small-scale coal mine development is progressing in rural areas, various problems have arisen. In rural area, mine sales raw coal cheap. Thus there are some issues of environmental protection and technology acquisition related on exploitation due to not afford the expense of doing those. Actually, in the central coal mine of 100,000~300,000 tons of coal production, about 20,000–30,000 small-scale coal mine is stopped. Class is set up for every area, coal is concentrated there, if necessary, coal processing, such as semi coke, has to be performed. It is done in the coal mine, which is also considered as nomad’s pasturage.

Under the sell price setup corresponding to it, the organization whose environmental program is possible is taken, and peripheral people's fueling problem should be solved.

(iii) In Mongolia, there are a lot of cases that mine company employ foreign contractors for coal exploitation. Thus, Mongolian job security is emergency issue. There are many young men who have lost their jobs even though they had the qualification of an engineer from a university in Mongolia. On the other hand, the following is considered.

- Reeducation, which makes an organization like a vocational school and suits business
- Propose a required subject from a private sector to educational facilities.
- qualified person institution

Additionally, among these illegal miners (called "ninjas[35]") are a number of young people with great amounts of practical mining experience, and it is very effective to change their thinking through reeducation, train specialists through qualifications systems, and offer a secure, steady income.

[35] illegal miners are called "ninjas" in Mongolia

3.3 Economic Infrastructure Development Plan

3.3.1 Summary of Survey Plan of Economic Infrastructure plan

(1) Survey Methods and Results

The railway, the road, and the air route can be chosen as the means of transport in a country. Among these, the road and railway are commonly used. for coal transportation. In this country, when the supply for the power plant is from interior areas, coal transportation uses railway. In recent years, with large-scale export-oriented coal development progress in newly developed zones, maintenance of the railway has not caught up to the speed of coal development. Therefore, in interior places where road construction is preferentially carried on, followed by railway construction.

Based on the plans and data on the transportation, transport means matching to coal development by 2025 are reviewed. Coal production, consumption and export by 2025 are predicted by MRAM as shown in Fig. 2-72. This prediction was verified, by means of referring to the preparation plan of the facilities of the railway and road, and check up the validity of transportation plan.

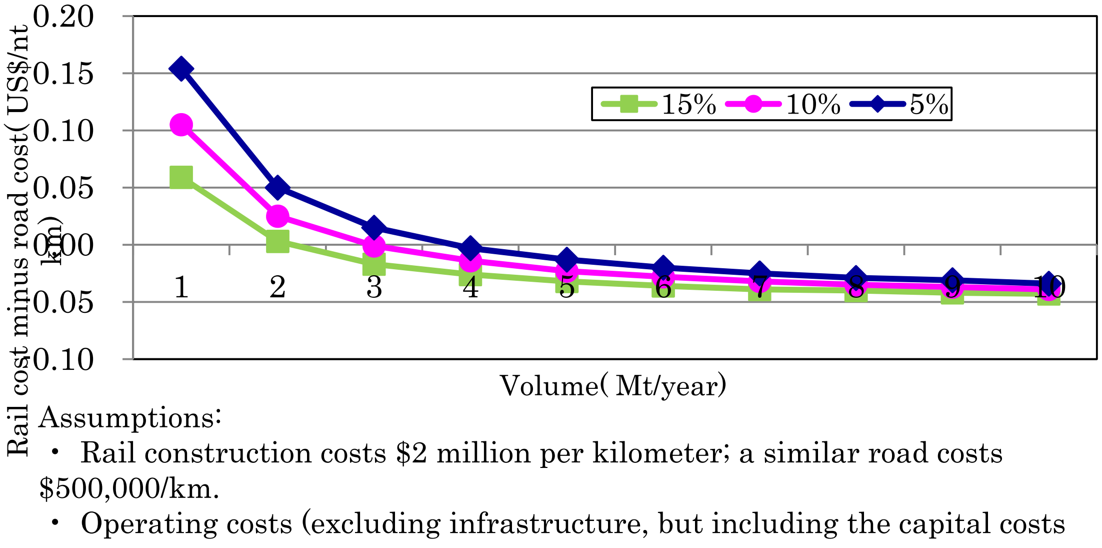
According to Fig. 2-72, the amount of domestic coal consumption in 2025 will be about three times in comparison with that of 2010, while export volume in 2025 will increase by about four times to 75 million tons, and domestic consumption in urban and local districts will be 19 million tons in 2025. As those figures were projected in 2010 reflecting the Chinese buoyant economy, it shall be reviewed. Referring to Fig.6-1 in Chapter 6, export and domestic consumption quantity are projected as max. 53.5 million tons and 14.4 million tons respectively, totaling max.64.4 million tons in 2020, where the slowing of Chinese economy in 2012 reflects. Those figures are used herein for reviewing the future transport capacity.

To verify the future transport capacity, it is required to gather the breakout of export volume by coal mine as well as coal supply plan by coal mine equivalent to coal consumption of 19 million tons in 2025. The validity of the aforesaid export volume of 53.5 million tons in view of transportation, is examined mainly from railway maintenance information, while 14.4 million tons per year, which is domestic coal demand, was similarly examined not only from a network of railways but also from the maintenance information on a domestic road network. New railway construction plan is significantly associated with the amount of coal exports, while a road construction program deeply associated with new mining development.

For domestic coal transportation infrastructure, road construction could commence earlier than that of railway due to shorter constriction period and lower costs than those of railway. The necessity of traffic increases in connection with production rise leads to entertaining more efficient and mass-transportation methods such as railway

The World Bank studied break-even points for railway and road to assess which transportation method would be more economical. The outcome of turning point analysis is shown in Fig. 3-21. Accordingly, it is supposed that the rail traffic is more economical in case that 2 to 4 million tons or more coal is transported in each year. Since the pre-conditions in this case are likely to be a possible setup, it is assumed that this would be used as a criterion of judgment of the breakeven point over the road and rail transportation in this paper.

However, in case of the rail construction on international routes, it might be not given approval to construction, taking account into the national security or the state policy. Thus, it shall be noted that transportation methods are not determined only by its economic efficiency.



Source: Southern Mongolian Infrastructure Strategy, World Bank, 2011

Fig. 3-21 Cost Comparison of Rail and Road

(2) Reference Materials

Until now, many investigations have been conducted by various overseas organizations, reporting about the railway and road of the country. Since the state policy is changing from moment to moment, the 3-year-old report has not yet matched the current state policy in many cases. Therefore, the report on the railway and road released in 2010 and later is chiefly quoted.

With reference to the distribution of water resources, being indispensable in coal mine development, decided to refer to the report of 2009 is referred to since only few reports on the water resources were available for.

Eight research reports as per below are chiefly referred to this study. The proposition for the optimized transport infrastructure maintenance is made from the results of study on those reports and other data this time.

- "The Study on transport infrastructure for the Asia Pacific region, concerning the coal resource development in the South Gobi (Tavantolgoi coalfield)", February, 2012, New Energy and Industrial Technology Development Organization (it is henceforth called as "NEDO 2012 report")
- "The Detailed Planning Survey on the Coal Development Master Plan", December, 2011. JICA/Japan Coal Energy Center (it is henceforth called as "JICA2011 report")
- "The State of Coal Development in Mongolia and the Export Potential and its impact on the Asia Pacific Coal Market, March, 2011, New Energy and Industrial Technology Development Organization (it is henceforth called as "NEDO2011 report")

- “Southern Mongolian Infrastructure Strategy”, World Bank, 2011 (It is henceforth called as “WB2011 report”).
- “New Railway Infrastructure Project”, October 04, 2010, Mongolian Railway (It is henceforth called as “MR2010 report”).
- “Current and future prospects of the Mongolian electricity sector”, Ministry of Mineral Resources and Energy (It is henceforth called as “MMRE2012 report”).
- “Strategies for energy development and the current status of nuclear energy program in Mongolia”, Tudev TSERENPUREV MMER, 2011 (It is henceforth called as “MMER2011 report”).
- “Final Draft Report of the Groundwater Assessment in the Gobi Region”, January 25, 2009, World Bank (It is henceforth called as “WB2009 report”).

3.3.2 Current State and Issues of Domestic Infrastructure

(1) Railway

(a) Current State of the Railway

The country’s arterial railway is a north-south route of Sukhbaatar-Uraanbaater-ZamiinUud,. Connecting to Russia, Ulan-Ude of the Siberian railway in the north line; while southern route, from Ereen to China. In the north-eastern, there is a route that goes between Choibalsan-Ereensav, connecting to the Siberian railway. Besides, these routes are also used for cargo shipments other than ore. The railway distance and annual transportation capacity is shown in Table 3-21. In addition, there exist branch lines that connects an arterial railway to a mine, another branch line to the copper mine (Erdenet) of Ulaanbaatar north, a branch line from Sharyngol coal mine, as well as from Baganuur coal mine, etc. The total extension of the railway is 1,810 km. It is represented in black color in Fig. 3-23, and the existing train lines are also showed in it.

Table 3-21 Transport Capacity of the Existing Railway

Railway Section (Domestic)	Railway Distance (km)	Annual Transportation Capacity (One Million tons)
Suhkbaatar-Ulaanbaatar-ZamiinUud	1,108	20
Chiobalsan-Ereensav	238	6

Source: Railway Authority of Mongolia (RAM）

The rail traffic track record of 2010 is shown in Fig. 3-22. Although, the transit commodities (for Russia China) occupied many domestic cargoes in 2005; in 2010, the amount of domestic cargos changed at around 8 million tons, rising about 9%. The amount of imported cargo was around 34%, the amount of transit cargos being reduced by half, and export cargo drastically increasing to 2.1 times. Besides, the total cargo transports exceeded to about 18 million tons, rising around 8%.

Transporting coal by railway from the Zamyn-Uud to China has been ceased since 2007 to the requirements from China, although iron ore can been exported to China at this stage.

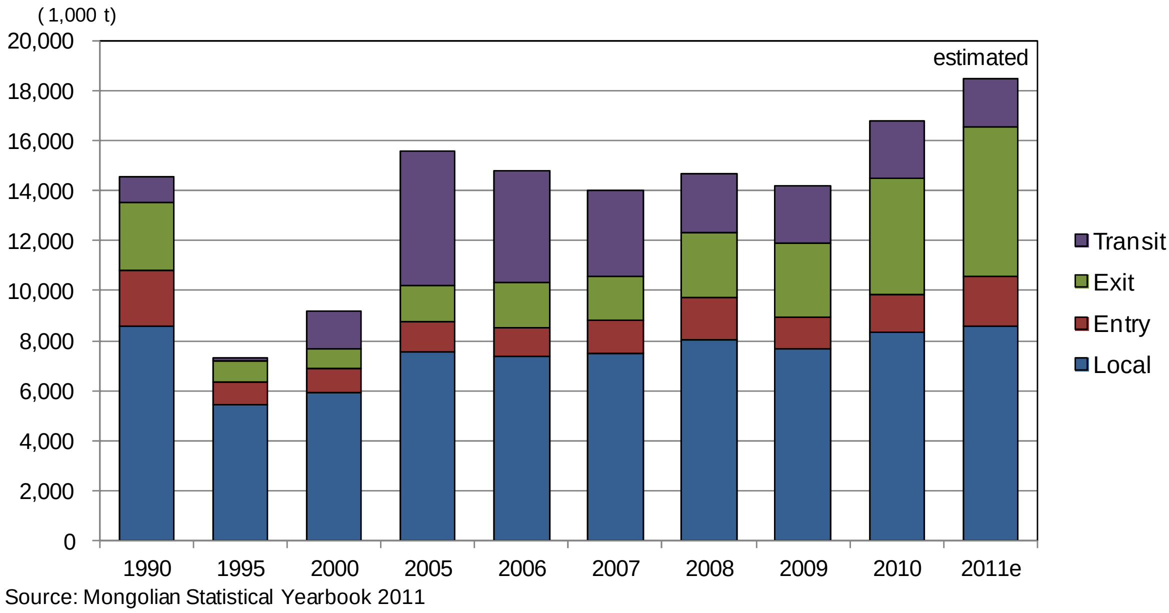


Fig. 3-22 Railway Transport Performance

Different rail gauge is adopted in China and Russia. The country has adopted the rail gauge of Russia standard. Rail gauge and axle load of China and Russia is specified in Table 3-22.

Table 3-22 Trajectory Comparison of Countries

Country	Gauge (mm)	Axle load (ton)
Russia and Mongolia	1,520	23.5
China	1,435	23

Source: NEDO2012 report processing

To export cargos from Mongolia to China, with, trans-shipment between freight cargo and freight cargos is needed due to the difference in rail gauge.

(b) Railway Plan

On the basis of railway plan decided by the country parliament in June, 2010, State Owned Mongolian Railway Company (henceforth referred to as "MTZ") divided railway network with total distance of 1,800 km into the stages of Phase I – Phase III. Among these, railway planned in the Phase I and Phase II is of high importance and to be built by 2015. The new railway construction plans by Phase II and during Phase I to III are shown in Table 3-23 and Fig. 3-23 respectively. According to the new construction plan in Phase I and Phase II, it is supposed that the new and existing railway can convey about 66 million tons of coal per year by 2020. On the other hand, regarding the financing required for it, railway construction funds are to be raised from the Mongolia Development Bank to MTZ, investment by cash from SPC (Special Purpose Company), and/or the investment from the country's mining contractors or an investors, etc. In fact, it was directed that the planning should be entrusted a third party company. The amount of capital investment concerning the railway construction of these series was estimated at about US$ 4–5 billion.

Table 3-23 Mongolian Railway Construction Plan (2010)

Route		Distance km	Annual transportation amount（million tons）	note
Phase Ⅰ	Tavantolgoi-Sainshand	468	24.7	(1)
	Sainshand-Khuut	450	15.7	
	Khuut-Choibalsan	155	0.5	
Phase Ⅱ	Khuut-Numrag	380	15.2	
	Sainshand-Zamyn-Uud		1.0	
	Sainshand-Sukhbaatar		8.0	
	Tavantolgoi-Gashuun Sukhait	267	18.1	(2)
	Nariinsukhait-Shiveekhuren	46	23.2	(3)
Total		1,766	66.0	Export total(1)+(2)+(3)

Source: RAM

Source: Edited article in the Railway Authority of Mongolia

Fig. 3-23 Mongolian Railway Construction Plan (2010)

Table 3-24 shows the railway construction plan of 2010. The result of Feasibility Study, concerning a new line building program, was received and modified in 2011. Mentioned below are the five points regarding the main changes in 2010 or later.

- Carrying-out Phase I and Phase II, simultaneously, among the priorities of a railway construction plan.
- The fund procurement is to be the B.O.T. System (Build Operate Transfer).
- Conducting the construction to be started in 2012, in each route, is in three routes shown in

Table 3-24.

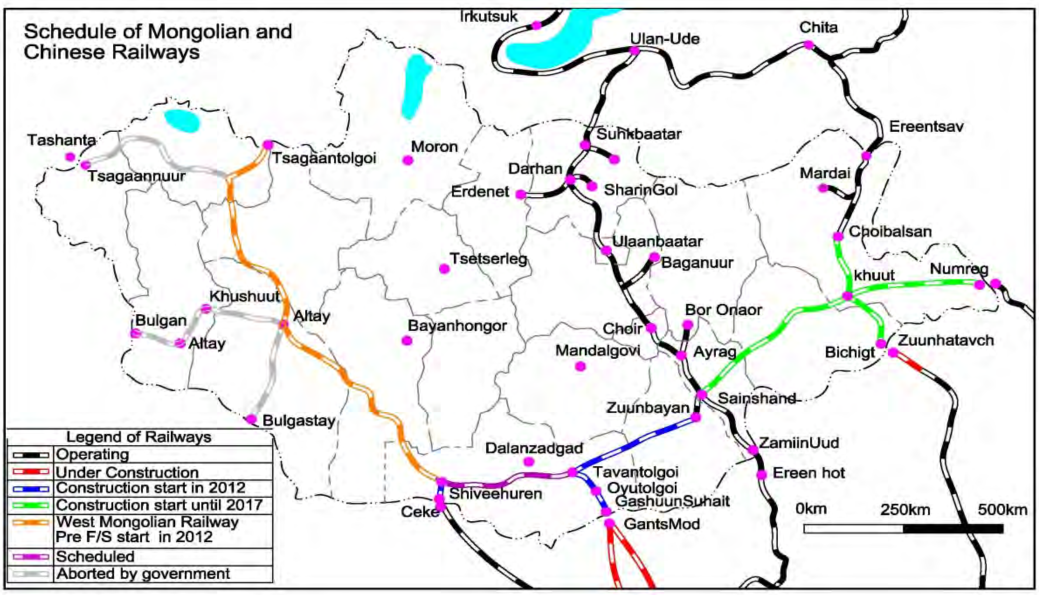
- F/S of the route that connected China border to the inside, and west part of the country that was being made into Phase III to Russia.
- The west and south-west route would not be constructed, which passes China through the railways of Phase III on a national security level, instead railway would be converted into the road.

Table 3-24 Three Lines of the Start of Construction in 2012

Route	Distance (km)	Annual transportation amount (Million Ton)	Construction Method	construction Period
Tavantolgoi-Sainshand	468	Bold tumur eruu Gol (50%) Russian Railways (50%)	B.O,T,	2.5 year
Tavantolgoi-Gashuun Sukhait	267	ER (100%)	B.O,T,	
Nariinsukhait-Shiveekhuren	46	MAK (100%)	B.O,T,	
Total	781			

Source: RAM

The route of the examined railway of the country, as well as the extent of the first three lines is shown in Fig. 3-24. The red colored line in the figure represents the railway lines from China side under construction. According to the Railway Authority of Mongolia (henceforth abbreviated as "RAM"), it is likely to be completed earlier than the line to be constructed by Mongolia.



Source: JICA study team edits the information from RAM

Fig. 3-24 Schedule of Mongolian and Chinese Railways (2011)

The B.O.T. system brings the business proprietor profits of 0.45 cents/km-t during running railway. On the other hand, the state will acquire 51% of the railway rights without compensation after 21 years. This financing system became a completely different from the system reported in the MR2010 report. Even in B.O.T system, the Mongolia Development Bank is in the mainstream in funding for construction, while private sectors such as commercial bank (a foreign bank is also included) also contributes to funding for B.O.T. system.

Moreover, the Boldtumur Eruu Gol presented in Table 3-24 is, a Chinese steel corporation, which is an iron ore mining company in the northern Mongolia. The company has a track record for constructing the railway for carrying iron ore. The company takes charge of the part of west half of railway construction started in 2012. Due to the construction by the B.O.T. system, it was possible to consider and shorten sharply the time necessary for completing the work in 2.5 years, while it was initially assumed to be around five years. Therefore, the completion is being planned by the end of 2014.

However, as of November 2012, this B.O.T. system had been discarded. It was decided that MTZ would begin construction of a new railroad. The policies regarding capital procurement is also reverting to the original method. In other words, procurement of required capital will involve funding from Mongolia's development banks to MTZ, investments of cash and land by SPCs (Special Purpose Company), and broad-based solicitations for direct investments from exploration companies and investors in Mongolia, and will consign the drafting of proposals to a third-party company. The construction contractor in Table 3-24 will be MTZ. The only change to the five aforesaid issues changed in 2010 was the elimination of the B.O.T system. There were no other changes.

The construction or reinforcement of each line shown in Table 3-25, is likely to be made within this three route construction time.

Table 3-25 A Future Railway Construction Plan and Reinforcement Plan

Route/Interval	Summary
Sainshand－Choibalsan	Contractor(s) for construction is to be decided by the end of 2012. The construction span will be five years.
ZamiinUud－EreenHot	Although there exists a railway, Mongolian and China sides shall reinforce existing facilities for coal export and import.
Khuut-Bichgt	USD 3.5 million was given for F/S expense from the World Bank. Investigation budget is likely to be one-by-one from now on. In 2012, it will bid for this F/S on the 31st in August. The plan is posted on the World Bank homepage.
Western train (Tsagaantolgoi-Altay-Shiveekhuren)	USD 3.2 million was given as F/S expense from the World Bank. Pre-F/S is due to be carried out from 2013. The construction is scheduled five years later.

Source: RAM & World Bank Homepage

The government can catch up delay of planned railway construction by simultaneously commencing Phase I and Phase II.

The railway in the western brings merits both Russia and Mongolia by this construction in the future.

Firstly, such railway makes it possible to convey the coal from Russia to China effectively. The examination of this route, however, was requested from Russia.

At the same time, Mongolia is also able to decrease the amount of export coal from the Southern Gobi region to China, and it can maintain the amount of its own precious resources as well as the amount of resources supplied to non-Chinese markets.

Pre-F/S will be scheduled to carry out this line from 2013.

A construction funds plan becomes easy by introducing the B.O.T. system, and the railway construction plan is being accelerated as well. On the other hand, in order to restrict the number of railway facilities from the viewpoint of national security to China border, the following three railway lines plan will be replaced by a road construction (refer to RAM information and Fig. 3-24).

Western halves between Tsagaantolgoi-Tsagannuur

Between Altay-Bulgan

Between Altay-Bulgastay

<Challenge>

- From the viewpoint of coal resource distribution on geopolitics, the coal export industries mainly concentrate on South Gobi area. Since I Baotou Inner Mongolian Autonomous Region is a large steel producing district, there is also the huge demand of coking coal. It cannot be denied that to export coal from South Gobi area to China is of highest profit ratio for both sides of Mongolia. In future, the coal export from South Gobi is done directly through exist transportation road and new construction railway until a railway towards the east is connected to Sainshand.

<Recommendation>

- Until railway routes build up which enable to export coal to countries other than China, the economy of Mongolia will be greatly influenced by the Chinese economy, to have two or more export alternative routes is to stabilize its domestic economy and to lead to the direction of development.
- It is necessary to continuously move ahead on the maintenance of multiple export routes. It is important issues to secure not only export route in Mongolia, but also transportation routes in China and Russia, as well as shipment seaport. To realize this, the negotiation both by the governments and private sectors among Mongolia, China and Russia will be required.

While export volume in 2025 is projected to be at maximum 53.5M tons annually (Fig. 6-1), the timing at which this is achieved is likely to be when both routes the Tavantologoi-Gasuun Sukhait and the Nariin Sukhait-Shivee Khhren routes have been opened around 2020.

As noted above, the demolish of the B.O.T. System resulted in the inability to take advantage of the public sector so effort on the part of MTZ, the construction contractor, will be required in order to meet construction deadlines.

(2) Road

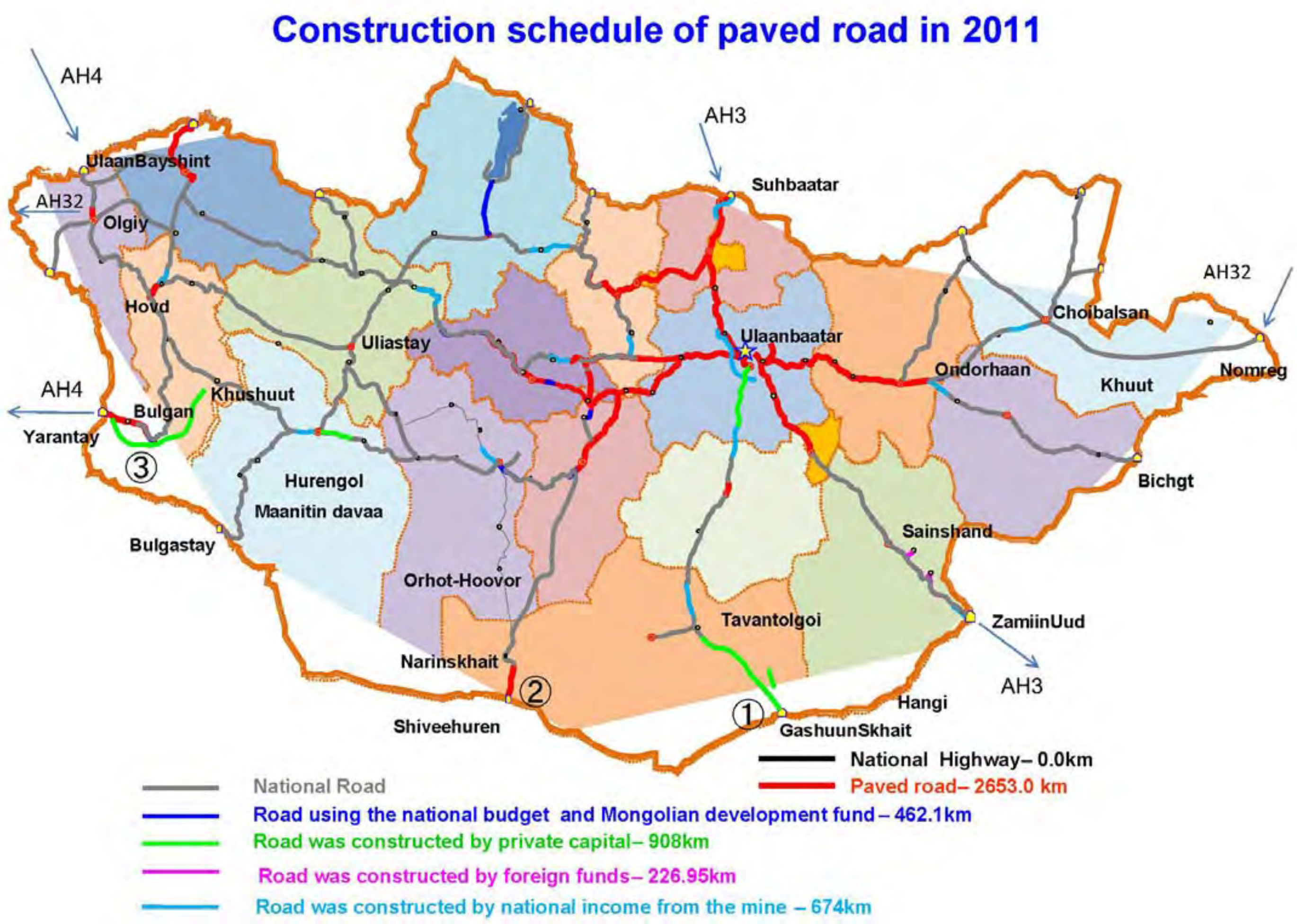
(a) Current State of the Road

The road map made in 2011 by Department of Road, Ministry of Road, Transport, and Tourism of Mongolia (hereinafter referred to DOR) of, and the road map planned in 2021–2030 is shown in Fig. 3-25 and Fig. 3-26. The national road pavement distance is shown in Fig. 3-25 in red color; it accounts for less than 10% of the whole, about 2,600 km. The section currently paved road is radiating from Ulaanbaatar, while most of the roads in rural areas are unpaved.

The paved arterial road (1,041 km) runs along the railway through the north towards Russia and south towards China. The south road of pavement is 604 km to Choir; while the road about 437 km towards the south has been constructed for pavement. According to the government, the road policy in 2008–2020 was set forth in 2006, and then it was reviewed in 2007.

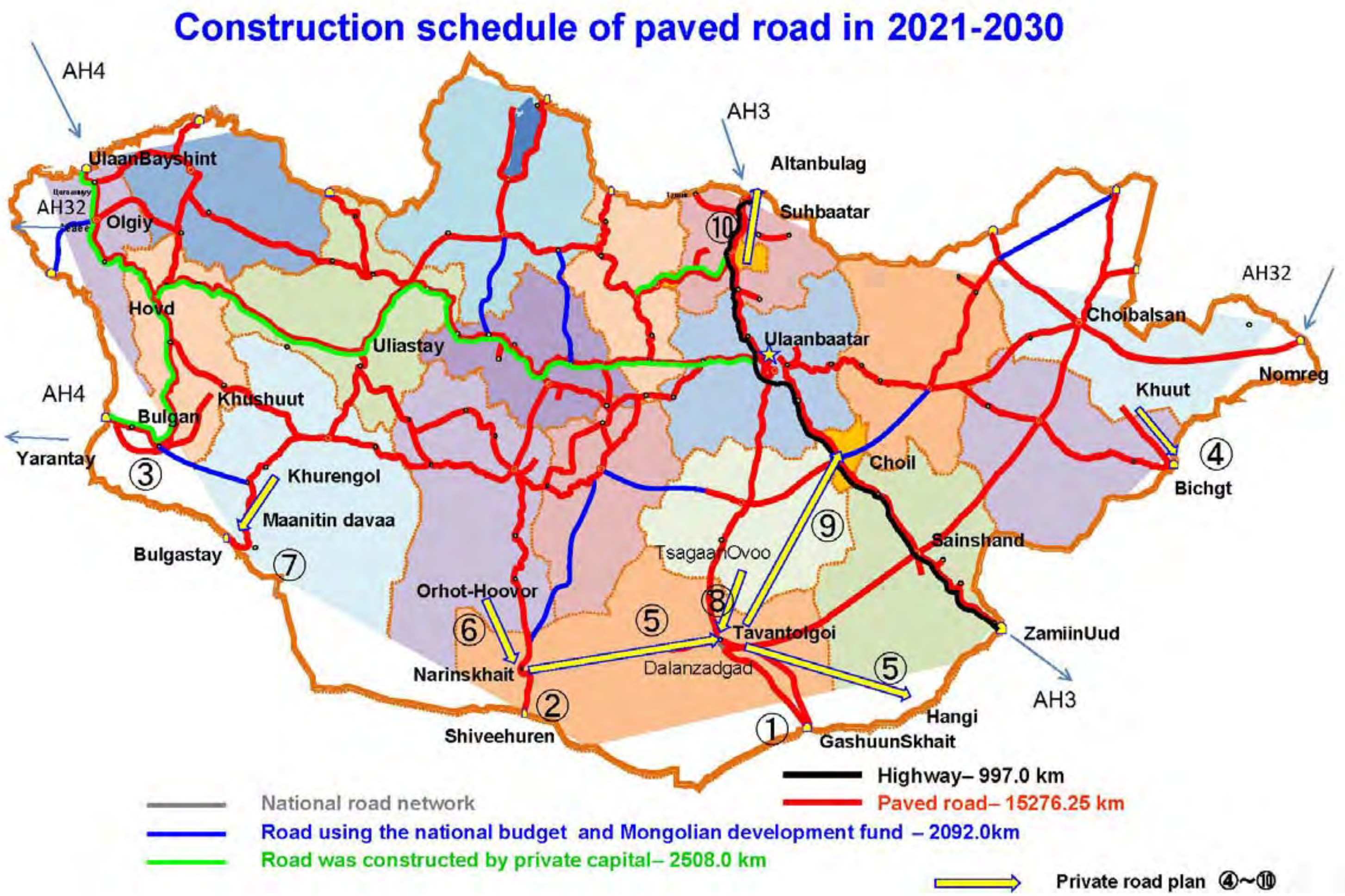
On the other hand, a change in the road standard was also made. In 2011, new standard MNS6872 for coal transportation road was added to the existing standard MNS4598.

The differences between both standard are shown in Table 3-26.



Source: DOR

Fig. 3-25 Construction schedule of paved road in 2011



Source: DOR

Fig. 3-26 Construction schedule of paved road in 2021–2030

Table 3-26 Comparison of Standard Road MNS6872 and MNS4598

Standard	Specification
MNS4598 (Conventional Standard)	Maximum Weight < 44 tons
MNS6872 (New Standard)	Maximum Weight < 129 tons

Source: DOR

MNS6872 is a new standard for transporting coal efficiently and enabling mass transportation. The coal export road, under construction in 2011, is in compliance with the conventional standard, MNS4598 presented in the Table 3-26. The road to be in compliance with new standard, MNS6872 is likely to increase from now onwards.

(b) Road Plan

The existing road and construction plan are summarized below.

According to the jurisdictional road segmentation, roads in Mongolia are segmented into Asian Highway as an international road, national highway, local highway and private road. Among these, an international road and a national highway are managed by DOR.

The Asian Highway comprises of three planned routes, such as AH3, AH4, and AH32, shown in Fig. 3-25. AH3 is a route between Irkutsk, Russia and Beijing, while AH32 is a route between Olgiy, Mongolia and Uladivostok, Russia. The present states of those international roads are outlined in Table 3-27.

Table 3-27 Progress of Asian Highway

Road Name	Planned Road Distance (km)	Distance completed (km)	Section to be completed by 2013	Section to be completed by 2017	Section suspending completion timing
AH3	1,000	700	300 km around Sainshand	Sainshand-ZamiinUud	
AH4	741	Approx 140		Total route	
AH32	2,500	Approx 1200	(1) Ulaanbaatar-Choibalsan		(1) The east of Choibalsan
			(2) Ulaambaatar-Uliastay		(2) The West of Uliastyay

Source: DOR

According to DOR in 2013, the route of AH3 between Sainshand-Zamiin Uud is scheduled to complete earliest among three routes. The arterial road of Mongolia, running along the railway from Suhkbaatar through Ulaanbaatar to Zamiin Uud, turns into all the paved roads, and its function as the arterial road is substantially improved. In Fig. 3-26, this road is classified as a highway after 2021, and thus, its function is expected to increase further. AH4 is due to be completed by 2017. AH32 is to be built from east to west with distance of 2,500 km, road between the major cities is due to be paved by

2013. The east of Choibalsan and the west of Uliastay are unlikely to be opened by 2025 due to the problem of budgetary constraints.

On the other hand, construction program of the national highway is as followed. Although many unpaved roads still exist as of 2011 (Fig. 3-25), national highway is scheduled to be paved in entire interval by 2020 (DOR information). In recent years, the number of road construction by B.O.T. system is increasing over the country. Taking a look at Fig. 3-25 and Fig. 3-26, road marked as ① and ③ in Fig. 3-25 being privately constructed in 2011 will become the national highways in 2021 and later as per shown in Fig. 3-26. These were constructed by the B.O.T. system for coal transportation, and then it will be national highways after 10 years from construction. From now on, road will be constructed on the premise of the B.O.T. system.

DOR is due to construct 42 ore-transportation roads by a B.O.T. system, of which 23 roads are exclusively for coal. Most of coal roads radiate outward the Tavan tolgoi and Nariinsukhait, and the road that extends south-west further from the coal mines of the south-western country, and goes to the China border. Besides, road connects minor coal mines to arterial routes.

1) Coal Transportation Road for Export

The coal export roads are set up in three routes, as shown in Fig. 3-25. From among these, the routes (1) and (3) shown in Fig. 3-25 were constructed by the B.O.T. system. Besides, all over the Fig. 3-26, they are expressed in red color, representing the national highway in 2021 and onwards. The route (2) is the road constructed by Qinhua-MAK, who also constructed the customhouse and owed the maintenance expense related to infrastructure, and thus this company receives a right of tax exemption on coal trade (DOR information). The information about three coal transportation routes is summarized in Table 3-28. The number of (1), (2) and (3) in the table match to the number in Fig. 3-25.

Table 3-28 Coal Export Road Overview

No.	Route	Distance (km)	Remark
(1)	Tavantolgoi－Gashuunskhait	Approx 120	The road, which ER constructed by the B.O.T. system on a 10 year contract with the government. It will be returned to the country, after 10 years, in 2022. It will be used after 10 years, as a national highway for transporting coal.
(2)	Nariinskhait-Shiveehuren	45	The national highway used at three companies (QinhuaMAK, SGS, and MAK). Since, QinhuaMAK constructed, the company received the tax break with a time limit. The company's burden in construction of road includes also the electric wire construction along the road, a customhouse institution, etc.
(3)	Khushuut-Bulgan	325	The road constructed by the B.O.T. system, which connects the Khushuut coal mine in the Mongolian western part with the town Bulgan at the westernmost end. It was started to be used in 2011 for the export from Bulgan to China. However, it will be returned to the country in 2021.

Source: DOR

At present, 23 roads including 3 routes mentioned above are due to be constructed for coal export. In addition to those three routes, other seven routes (4) to (10) shown in Table 3-29 and Fig. 3-26, totaling 10. Each road connects coal mines to export way. Not only export way to China from Tavantolgoi and Nariinskhait, but also the routes which connect coal mines to transportation roads in the northern area of the country, and routes connecting main cities.

Table 3-29 Planned Coal Export Road

No.	Route	Remark
(1)	Khuut – Bichgt (177km)	The road from Khuut coal mine to Bichgt. Coal mines are also located along the railway.
(2)	Nariinskhait – Dalanzadgad –Tavantolgoi - Hangi (770km)	It has become a trial between Tavantolgoi-Hangi (340 km) because of the bid trouble. Therefore, the opening of traffic schedule in 2014 is undecided. The transportation programming way of coal or iron ore was due to be connected after the completion of this route, is obliged to reconsider its plan.
(3)	Orhot-hoovo - Nariinskhait (150km)	The road from a coal mine located in the north of about 150km to Nariinskhait,
(4)	Maanitin and Hurengol-Bulgastay(150km)	The road, which carries the coal from two coal mines of Govi-Altay province to Bulgastay of the China border.
(5)	TsagaanOvoo - Dalanzadgad	The road to which Dalanzadgad is connected from TsagaanOvoo coal mine. Construction work is not yet started.
(6)	Tavantolgoi - Choil(385km)	The route is not determined.
(7)	Ulaantolgoi - Dalhan - Altanbulag (132km)	The route is not determined.

Source: DOR

2) Coal Transportation Road for Domestic Demand

The coal transportation routes are linked to the areas under coal mining development. In order to transport capacity equivalent to the 19 million tons for domestic demands in 2025, it is necessary to investigate the future production plan of the coal mines at each province. The present state of main coal mines, and production prediction, are shown in Table 3-30. Coal mine location is referred to Fig. 3-1.

Table 3-30 The Production and the Transportation at coal Mines in 2025

Mine Name	Production volume in 2011 (1000 tons)	The amount of estimated production in 2025 (1000 tons)	Transportation	Purpose, Remarks, etc.
Aduunchuluun	350	1,500	Vehicle	A railway to Choibalsan is due to be constructed, for the production increase of the electric power supply for railways. The distance to plant is 6 km, chance of coming out and becoming truck line at the present condition for a certain reason.
Baganuur	3,395	5,500	Existing Railway	The coal supply starts for the 5th plant (30% of a total amount). Since the existing railway capability is 2 million tons per year, transport capacity reinforcement is thus unnecessary.
Shiveeovoo	1,807	4,500	Existing Railway	The coal supply starts to the 5th plant (70% of a total amount). Correspondence by the transport capacity of the existing railway is possible.
Ulan-Ovoo	47	3,000	Vehicle	It is in the position of 20 km to Russia, and considers Russia export in the future. However, road development, power line installation, since maintenance of all economic infrastructures, such as, a customhouse and a stay place, is demanded, an export start is undecided.
SharinGol	422	700	Existing Railway	The production is increased for the neighboring industries. Correspondence by the transport capacity of the existing railway is possible.
Total	6,021	15,200		

Source: Each Coal Mine

The total coal production of the main coal mines for domestic use in 2025 is projected at 15.2 million tons. In addition, total production volume will be increased, taking account into production from small-scaled coal mines as well. It is possible to supply coal to the domestic market where the coal consumption volume is projected less than 19 million tons predicted by MRAM up to the year 2025.

Coal mines that need to replace transportation methods from road to railway in the future due to production increase is only Ulan-Ovoo coal mine. Regarding this coal mine, it needs to discuss the possibility of railway construction at the stage when coal production plan of 3million tons comes to be realized. The administration of road has been transferred in November 2012 from DOR to the Ministry of Road and Transport. In view of road construction and management, B.O.T. method is applied, thus the road administration policy would not be changed much.

(3) Security of Power and Water associated with Coal Development

(a) Review of Power Development Plan Associated with Coal Development

In MMRE2011 report, the electric power supply and the demand by 2030 is discussed. The electric power demand prediction is described in details in Chapter 4 of this report. Here, the outlined is the demand anticipation and the electric supply plan of Gobi area, which needs to correspond to the increase of electricity demand by the future mining development. New coal fired power plants, etc., are to be constructed in the Southern Gobi area to meet the increased demand for electricity. The coal fired power plant construction program over the country is shown in Table 3-31. In Table 3-32, the main electric power supply points from the Tavantolgoi plant are shown. Moreover, the electric power supply and the demand by 2025 of South Gobi area are shown in Table 3-33. The locations of those plants are shown in Fig. 3-27. Plant construction corresponds to the increased demand of Ulaanbaatar, the electric power supply to the Sainshand industrial complex, aiming at supply in the mines of South Gobi area. From these tables, it can be assumed that about 600 MW[36] of demand in 2025 is thought to be for Tavan tolgoi plant. The Supply status quo to the increased demand by coal development in South Gobi area is put in place.

Table 3-31 New Coal Fired Power Plant

Power plant name	MW
Mongol Gol CHP	60
Ulaanbaatar CHP	830
Shuren HPP	300
Ukhaa Khudag CHP	18
Oyu tolgoi CHP	420
Tavantolgoi CHP	360
Shivee-Ovoo CHP	500
Total	2,488

MMRE2011 Report

Table 3-32 Main Demands for the Power

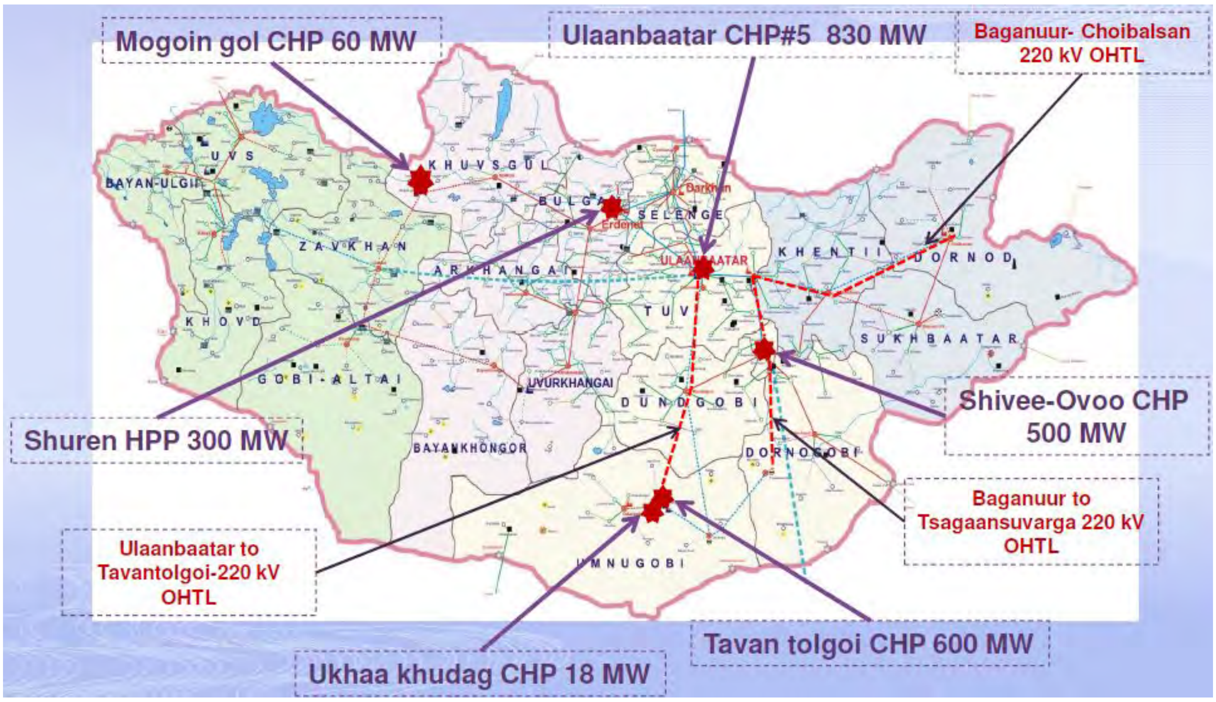
Tavantolgoi power plant		
Mine name	Coal bed	MW
Oyutolgoi	Cupper	200-310
Tavantolgoi	Coal	100-250
Tsagaan Suvarga		50
Total		350-610

Table 3-33 Power Demand Estimate in South Gobi

Year	2012	2015	2020	2025
Electric generating capacity（MW）	48.5	260	498	607

Source: Presentation Materials MRAM 2012

[36] As of November, 2013, there are two power plant projects at the Tavantolgoi that are composed of Tavantolgoi CHP and Oyutolgoi CHP shown in Table3.31.



Source: MMRE2012 Report

Fig. 3-27 Planned Power Plant Location Map

(b) Review of the Water Resource Security for Coal Development

1) Supply and Demand of Water Resources

It is known that Mongolia has very little precipitation. The precipitation of Gobi area is about 50–150 mm per year. In the WB2009 report, study on securing water resources in coal development in Gobi area is reported. Although it is necessary to discuss the water resources of the country's whole region, water resources are now under survey by the state and thus there exists little investigation data. Since the detailed data is confidential, it was the view of Water Authority that these data is hard to be open to the public. Therefore, it cannot be discussed with the water resources over the country. Using WB2009 report on water resources in the South Gobi where water supply is to be tight, the state of water resources in South Gobi summarized herein. In Mongolia, the common water resources in the country are groundwater, river water, lake water and glacier water, of which only groundwater is available in the Gobi areas with little precipitation. The main water use in Mongolia is for drinking, livestock, irrigation, mines, industrial and power plant.

In the WB2009 report, the trial calculation is conducted, where the available groundwater supplies of Gobi area's three provinces (Dunggobi, Dornogobi, Umnogobi), and the amount of supply for the mine development are compared.

According to the report, if the groundwater resource of Gobi area is estimated severely, the amount of water resources confirmed at this stage will be finished up around 2020.

2) Measures against Securing Water Resources in Gobi Area

In the UHG coal mine of Energy Resources, water is obtained from the underground water in

Naimantiin Khundii, transported through pipe line about 30 km away from the coal mine.

In order not to drain the water resources of Gobi, supplying water to the Gobi area through pipeline, from two rivers in the northern areas of Mongolia, is examined by the state. It is called Orhon-Gobi Pipeline Project (OGP) and Herlen Gobi Pipeline Project (HGP), respectively. Each outline is shown in Table 3-34 and Fig. 3-28.

Table 3-34 Pipeline Project Overview

Project Name	Water Quantity (ℓ/sec)	Transportation Distance (km)	Urban Transit	Current Status*
OGP	2,500	740	Tavantolgoi	F/S Underway
			Oyu tolgoi	
			Mandarugobi	
			Dalanzadgad	
HGP	1,500	540		Investigation not started

Source: WB2009 Report, *World Bank Home Page

Source: WB2009 Report

Fig. 3-28 Orhon-Gobi and Herlen Gobi Project Location Map

The demand of water in South Gobi area in 2020 is estimated to be around 518,000 m^3/day (6,000 l/sec). It assumes to supply 4,000 L/sec, which amounts to about 66% on the pipeline. The water supply plan in 2020 to be ready to run ready is shown in Table 3-35.

Table 3-35 The Water Electric Supply Plan in 2020

No.	Water User	Estimated Demand	Source Demand	
		Source	surfase	Underground
Energy and mining Industry				
1	Shivee-Ovoo	616	467	149
2	Tsuagaan Suvarga	604	300	304
3	Oyu-Tolgoi	1,060	360	700
4	Tavan Tolgoi	951	486	465
	Subtotal	3,231	1,613	1,618
Urban Water Supply				
5	Mandalgobi	50	50	0
6	Dalanzadgad	70	60	10
7	Choir	40	40	0
8	Sainshand	85	65	20
9	Zamiin-Uud	50	50	0
10	Soum center and rural	104	52	52
	Subtotal	399	317	82
Agriculture and Enviroment				
11	Livestock	200	100	100
12	Agriculture	1,750	1,750	0
13	Environment	300	100	200
	Subtotal	2,250	1,950	300
Others				
14	others	120	120	0
Total		6,000	4,000	2,000

Source: WB2009 Report

It is believed that by carrying out this plan, the mining operation can be conducted while preventing the drainage of groundwater.

The only problems are to realize the plan and its costs. In recent years, regarding the OGP plan, there are certain oppositions from the residents nearby the river, etc., although investigation is progressing with Japan's cooperation. Whereas, regarding the HGP plan, it is unlikely that it is a stage to conduct investigation. Moreover, although the outline of a pipeline's cost is not clear yet, it is however expected to be more expensive than the method of pumping up and purifying groundwater.

Although each mining company has secured underground water supplies, coal mines may find the difficulty in water use, that is, immediately shift from underground water to water through a pipeline in case that the cost difference is large. Especially, as the possibility of political restriction for the amount of underground water being used especially in South Gobi, aiming at the prospective underground water supplies preservation in South Gobi area is also considered, all interested parties and person concerned should consider a smooth transition.

3.3.3 The Case Study concerning Coal Export

(1) Survey Results

The following five routes were examined concerning the transportation costs. Besides, the clause "(2) Particulars" explains the details about route planning, etc.

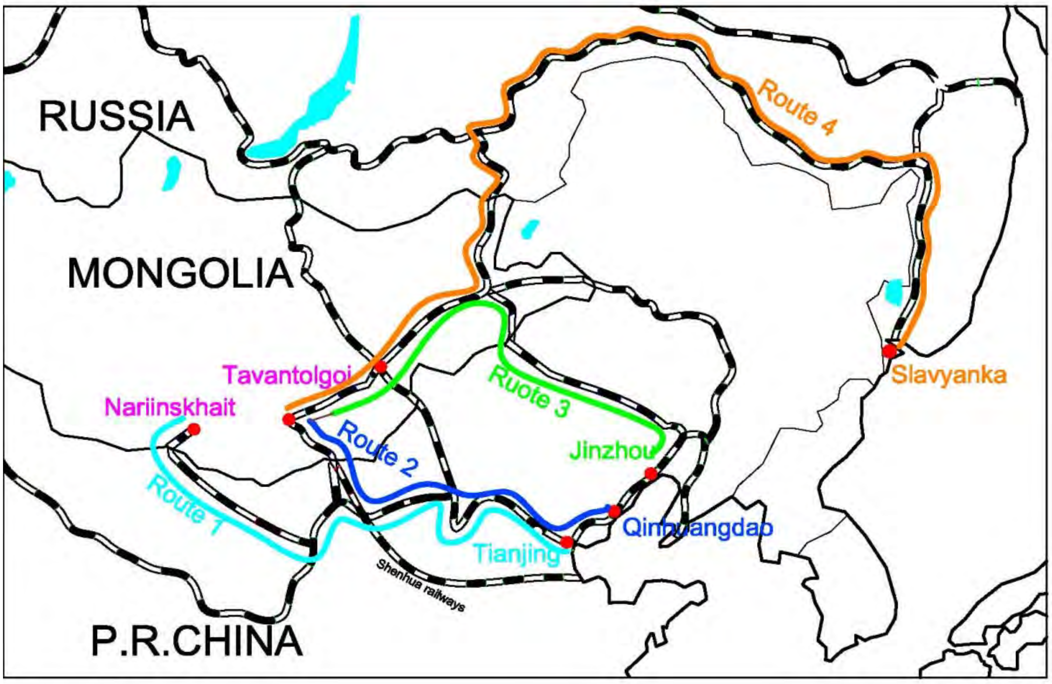
- Route 1 Nariinskhait →Shiveehuren →Huang hua
- Route 2 Tavantolgoi→Gashuunsukhait→Tianjin
- Route 3 Tavantolgoi→Gashuunsukhait→Qinhuangdao
- Route 4 Tavantolgoi→Bichgt→Jinzhou
- Route 5 Tavantolgoi→Sukhbaatar→Slavyanka

The five routes and port position are indicated in Fig. 3-29 and transport expenses based on an evaluation of each export route are shown in Table 3-36. Figures in the table F.O.B projected amounts for each port based on the WB2011 report and the NEDO2012 report with adjustments made to reflect the results of evaluations conducted thus far.

The following three points are prerequisites.

- It is assumed that the use of the railway is the cheapest method of transport. Concerning to the Chinese route from the South Gobi region to China's Ceke, Ganqimaoto, it is to be used and that no transshipment will take place and that the Chinese side will extend the railway to Shiveekhuren, Gashuunskhait.
- Through Chinese route, 10M tons of coal is to be exported annually while 9M tons of coal per annum is to be exported through Russian route, taking account into transport capacity of each railway.

These route expense calculations are meant to serve as reference values for expense comparison.



Source: JCOAL Document

Fig. 3-29 Coal Export Routes China And Russia

Table 3-36 List Of Transport Costs By Route (Reference)

Route 1			Route 2			Route 3		
Action	Action Place	USD/t	Action	Action Place	USD/t	Action	Action Place	USD/t
FOR	Nariin Sukhait	125.00	FOR	Tavantolgoi	125.00	FOR	Tavantolgoi	125.00
Railway 45km	Shiveehuren	1.66	Railway 267km	Gashuun Sukhait	9.61	Railway 267km	Gashuun Sukhait	9.61
Transport Cargo to Cargo	Shiveehuren	0.00	Transport Cargo to Cargo	Gashuun Sukhait	0.00	Transport Cargo to Cargo	Gashuun Sukhait	0.00
Export Commission		2.41	Export Commission		2.41	Export Commission		2.41
Import Commission		0.94	Import Commission		0.94	Import Commission		0.94
Railway 2,011km	Shiveehuren	19.82	Railway 1,355km	Gashuun Sukhait	13.93	Railway 1,539km	Gashuun Sukhait	15.58
Port Charge	Huanghua	33.75	Port Charge	Tianjin	33.75	Port Charge	Qinhuandao	33.75
FOB Total USD/t		183.58	FOB Total USD/t		185.64	FOB Total USD/t		187.29

Route 4			Route 5		
Action	Action Place	USD/t	Action	Action Place	USD/t
FOR	Tavantolgoi	125.00	FOR	Tavantolgoi	125.00
Railway 1,118km	Bichigt (SS+KH)	40.25	Railway 1,310km*	Sukhbaatar	47.16
Transport Cargo to Cargo	Bichigt (SS+KH)	3.00	Transport Cargo to Cargo	Sukhbaatar	0.00
Export Commission		2.41	Rent Cargo		8.50
Import Commission		0.94			
Railway 1,070km	Bichigt	11.37	Railway4,180km*	Sukhbaatar	41.95
Port Charge	Jinzhou	33.75	Port Charge	Slavyanka	23.00
FOB Total USD/ton		216.72	FOB Total USD/ton		245.61

SS=Sainshan:KH=Khuut
*=Not Authorizad

Source: NEDO2012 Report, WB2011 Report, JCOAL Document

Setting conditions in Table 3-36

1) Coal Price

Supposed that US$125/ton is the selling price at mine for washed coking coal in 2012 (the price information is from MRAM).

2) Rail Fare

Domestic line adopts US$0.036/ton km, according to the WB2011 report. The China line adopts the fare shown in Table 3-40. In Russia, the discounted fare is adopted according to the NEDO2011 report.

3) Tariff

Export and import duties are not applicable in Russia. However, the rental rates of a freight cargo are incurred. On the other hand, import charge mentioned in Fig. 3-33 are adopted by China.

4) Port Dues

China was represented with the usage fee of Tianjin port. On the other hand, about the port usage fee of Russia, Suravyyanka Port, the port charge of the Navotka Port was substituted at Russian Transport Infrastructure (2009 Coal Trans Russia).

5)Transshipment fees

As it is likely that the NariinskhaitCeke and Tavantolgoi-Gantsmod routes plan for the use of China-side tracks, it is assumed that transshipment will not take place. In addition, as the routes to Russia also use Russia tracks, there will be no transshipment. Transshipment would take place on the Tavantolgoi-Sainshand-Bichigt-Jinjiou routes, where a transshipment fee of US$3 would be incurred.

Although 52% of the discounted fare is taken into account, Russian route is more expensive (Table 3-36) at FOB price than those at any port in China. It judges only with the transportation cost and expenses, selection by the railway and port in China is not conducted; however, the position on the geopolitics of the country is taken into consideration. Moreover, in order to change the economic affairs and coal market with pliability, it is required to use the railway and port of Russia, simultaneously. In fact, this study was cost comparison at the time of conveying coal by a carload (bulk).

(2) Detailed Exposition

(a) Examination of the Export Routes

Among the reports, which were investigated and could be obtained, three reports, i.e., NEDO2011, NEDO2012, and WB2011, were referred to so far. The contents of the main item quoted when considering export planning out of these reports, are as follows.

- US$200 million/km of the railway installation expense and trial calculation of the railway fare concerning some routes about (WB2011 report).
- The report about the present condition of each port in each train line in China and Russia (NEDO2012 report).

The outcome of these report and the routes towards the each port, are comparatively studied and examined from view points of rail transport capacity. Items to be examined, are transport capacity of an air route, port-loading and unloading ability is an export aggregate total cost. The position of the railway, which may be able to export from a country, and the port of an outline, is shown in Fig. 3-30. The route examination result of each country is as follows.

1) China

A new train lines are under construction in China; the route between southern China up to Ceke located at the national border near Shiveehuren were completed.. Two routes towards the Gashuunsukhait border are under construction, and a route between ZuunHatavch and Bichgt has not yet commenced to construct. According to the NEDO2012 report, a domestic route in China is supposed to be constructed by the completion of constructing the new railway in Mongolia. In the existing route to ZamiinUud or Ereenhot, the transport capacity of China every year is 10 million tons.

By this railway route, coal transportation other than by truck has been forbidden by China although no explanation of the stoppage coal loaded train has not been made by China. According to RAM information, coal is transshipped from rail cargo to truck at the warehouse in ZamiinUud This system is likely to work out for increase the quantity of coal transport, unless the concrete reinforcement plan of rail traffic capability is delineated. Therefore, at the present stage, it is judged that this route will not contribute immensely to the coal export by 2025. Coal export through this route is assumed to be a maximum of 1 million tons.

In conclusion, coal export to China in future is to be without trouble once new planned railway lines are constructed. except the route via ZamiinUud.

2) Russia

There are two Russian routes that will serve as export routes: the Trans Siberian Railways and the Baikal-Amur Mainline, which branches off from the Trans Siberian Railways at Tyshet. According to RAM, surplus capacity for coal shipments on the Russian routes is 8million tons annually. As such, it is assumed in this study that 8 million tons of coal could be exported via these routes. As for the Baikal-Amur Mainline in the north, once the Kuznetsovskiy tunnel located in the northwest is completed in 2013, transport capacity will increase from 12 million tons to 35 million tons. According to RAM, construction of this tunnel is proceeding on schedule and is not expected to cause any trouble for coal transports from Mongolia. However, as the comprehensive development program for this region calls for 52 million tons of transport of goods other than coal (NEDO2012 Report), it is assumed that coal could not be transported through the Baikal-Amur Mainline. As such, this route is excluded from planned routes through 2025 in this report. As for the other route, Trans Siberian Railways, it has been reported that exports from Mongolia will not be a problem (NEDO2012 Report). According to RAM, there is nothing that would prohibit the use of the Trans Siberian Railways for 8 million tons annually, thus the Trans Siberian Railways is selected as a target route in this report.

Slavyanka Port is selected for coal shipment since the Russian government is proceeding with the development of that port for export port. Transport costs are 41.95USD/ton with a discounted rate of 52% from standard rate.

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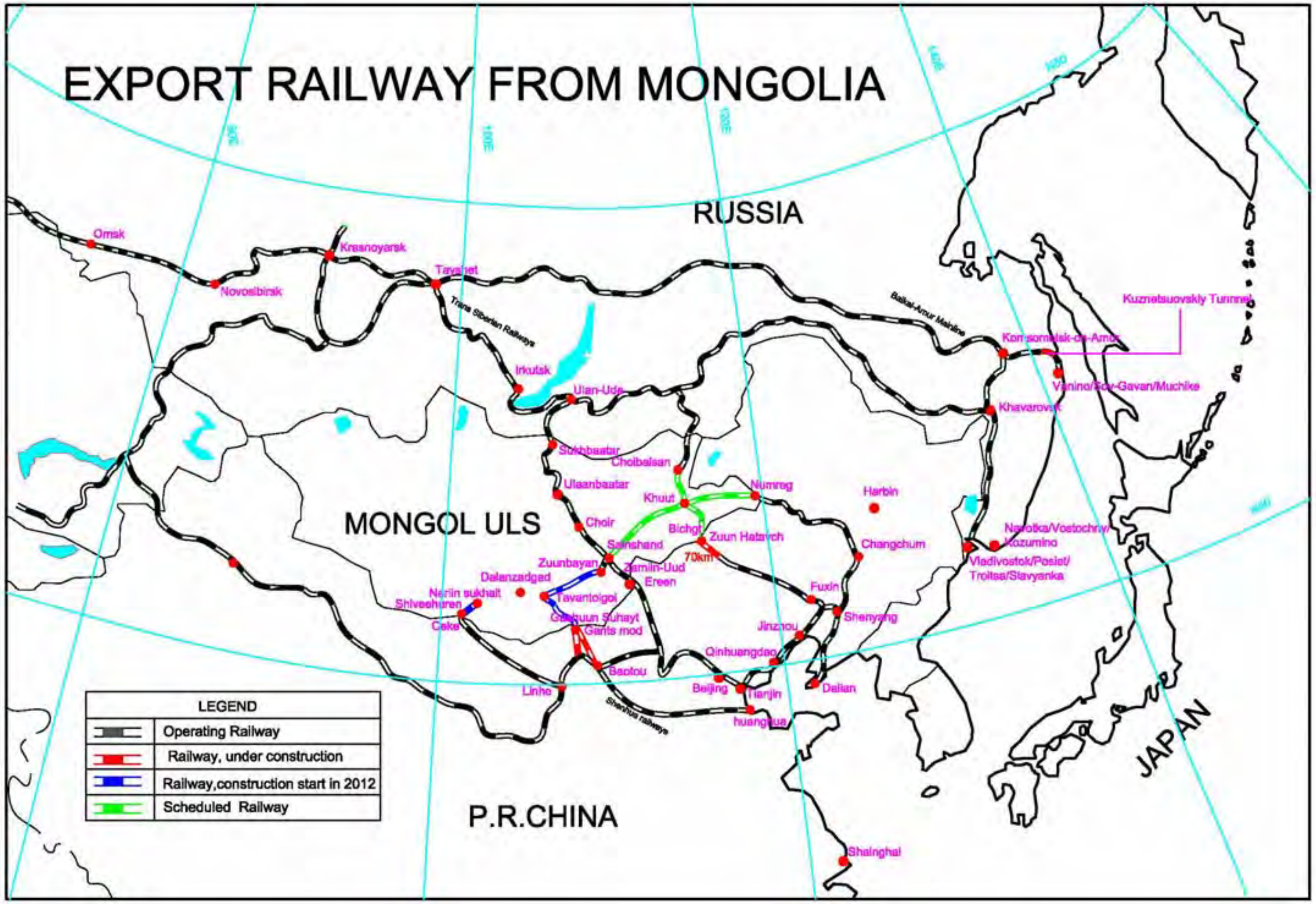


Source: JCOAL Document

Fig. 3-30 Export Railway of Mongolia

3) With Respect to Port Facilities

In the NEDO2012 report, ports in Russia and China is detailed taking account into coal export from Mongolia. The ports studied include 14 ports such as;

Russia : Vanino Port of Khavarovsk district, Sov-Ganvan Port, Muchike Port, Vladivostok Port of southern part, Nakhodka Port, Posiet Port, Troitsa Port, Slavyyanka Port, Vostochny Pport, and Kozumino Port

China : Tianjin Port, Qinhuangdao Port, and Dalian Port.

For those port, the following issue are mainly studied.

- Actual performance and record of coal export in the past
- Present coal export capability and extension plan
- The state of connection with the existing railway
- Ice-free port
- Environmental Issues

The port positions are shown in Fig. 3-31.

Source: NESO2012 report, edited by JCOAL.

Fig. 3-31 Russia and China Loading Port

Regarding these 14 ports, the above-mentioned five items were uniquely point-trated and evaluated. Score 2 at maximum are given to each item, with a total of 10 possible points, in order to prevent as much as possible subjectivity of the investigators. Consequently, the one that has higher score served as an evaluation that it was a good port. The result is shown in Table 3-37.

Table 3-37 Port Evaluation Table

Country・Place・Harbor			Export	Potential of export and development	Combination of exist railway	Open harbor	Non-environmental problem	Total
RUSSIA	SOUTH	POSIET	0	1	1	2	2	6
		TROITSA	0	1	2	2	0	5
		SLAVYYANKA	0	2	1	2	2	7
		VLADIVOSTOK	0	0	2	2	0	4
		NAKHODKA	0	2	2	2	2	8
		VOSTCHNY	2	2	1	2	2	9
		KOZUMINO	0	2	2	2	2	8
	NORTH	SOV-GAVANI	1	2	2	0	2	7
		VANINO	0	0	2	2	0	4
		MUCHIKE	2	2	2	1	2	9
CHINA		TIANJING	2	2	2	2	2	10
		QUINHUANDAO	2	2	2	2	2	10
		TONSYAN	2	2	2	2	2	10
		DALIEN	0	0	2	2	0	4
		JINCHOU	Not mention					

Source: NEDO2012 report is edited.

The main examination results about port facilities are mentioned below.

- Dalian is excluded from desirable port, since is close to the city area, and it is anxious about an environmental problem. The other port in China listed are thought to be convenient to export about 10 million tons.
- Given that coal export is assumed to be 9 million per year, many ports are needed to newly expand facilities. The WB2011 report is not examining the port of Khavarovsk district (northern part) among the ports in Russia. According to the RAM information, three ports of the Khavarovsk district may freeze during winters. On the other hand, according to the NEDO2012 report, Muchike Port was made into a port free from ice, and both of these are contradictory as well. Here, it judges, including the possibility of a problem in the transport capacity of WB2011 report, and above mentioned Baikal-Amur Mainline, it was evaluated that three ports of the Khavarovsk district are unsuitable for exporting. On the other hand, based on the RAM information, the port, which was discussed by Mongolia with Russia, is the Slavyyanka Port. Although, the evaluation of this port is low, as shown in Table 3-37. However, it is inquiring to improve the port and its circumference in the future.

Accordingly, four ports out of 14 ports are listed up as shown in Table 3-38.

Table 3-38 Port Consideration

Port Name	Country Name	Remark
Tianjin	China	Using the railway from Baotou to Sienhua, which goes via Tavantolgoi to GashuunSukhait, is most efficient. There is a notion that 15 to 25 million tons rail traffic per year will be secured as an object for coal country in the free trade zone of Tianjin.
Tangshan	China	Port facilities with the loading capacity of 50 million tons/ year were built in 2008. The second facilities is under construction. The target for long term is of 100 million tons/year, while the final target is of 200 million tons/year, Exceeding the loading capacity of Qinhuandao.
Jinzhou	China	According to the RAM information, the country government is negotiating with China about the route of Khuut-Zuunhatavch-Fuxin-Jinzhou port. This route passes through the country's inside, about 500 km or more from Tavantolgoi, but does not pass through the inside of China(route 7 in Fig. 3-32). Therefore, it is thought that the transportation cost contributes mostly to the country.
Qinhuangdao	China	A coal export track record is abundant, and can export about 10 million tons of coal easily.
Slavvyanka	Russia	It is conceiving of RAM, negotiating with the Russian government, about fixing this port and connecting the railway branch line, along with converting it into the port of 12 million tons scale. Although, it is a port, which is extensible, according to the information in Table 3-37, the coal stacks are inexperienced in appearance and branch line use, as well as their evaluation is low port, noting that the connection with the main line has some difficulty.

Source: JICA Team Study Creation

(b) Setting the Volume Transport

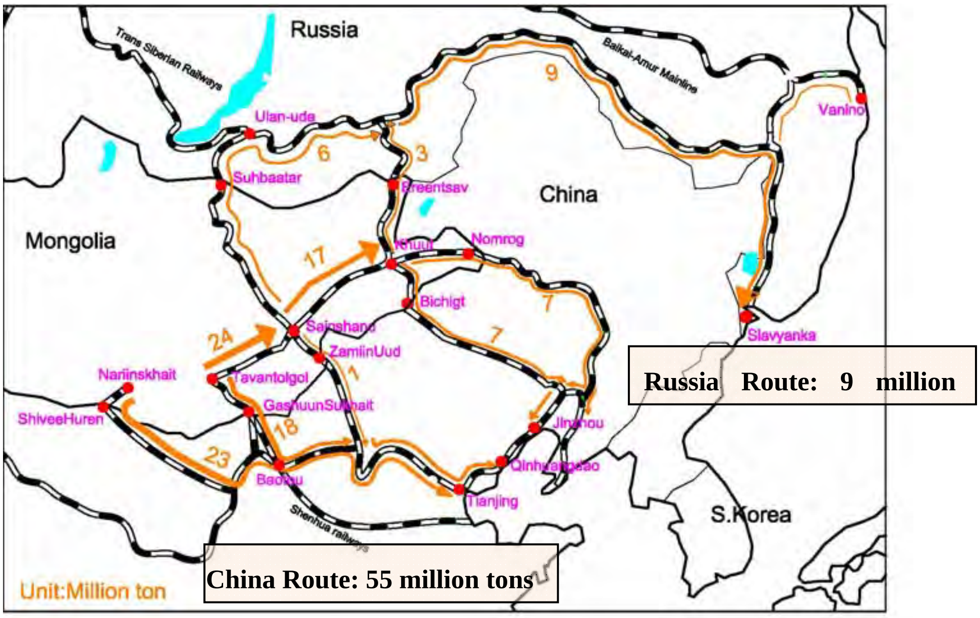
In Table 3-23, transport capacity of rail is 18 million tons/year on the Tavantorgoi-Gashuunskhait route and 23million tons/year on the Nariinskhait－Shiveehuren route. Conversely, the NEDO2012 Report projects that future coal excavation volume from the main mines in Tavantolgoi and Nariinskhait will exceed 55million tons annually. As such, coal export in 2025 from Gashuunskhait and Shiveehuren is assumed at 41million tons/year, which is the upper limit for transport capacity (transport capacity of 23+18 million tons based on Table 3-23). Also, the 12.5million tons derived by subtracting 41million tons from the maximum export volume of 53.5million tons is treated as export volume to be exported through Russia and ports in China. This figure of 12.5million tons/year is within the scope of the 24.7 million tons/year transport capacity for the Tavantolgoi - Sainshand route noted in Table 3-23. It is interred potential of transport are 55 million tons on China route and 9 million tons on Russia route in Table 3-39 and Fig. 3-32.

Maximum export volume in 2025 will be 53.5million tons and since the rail-based transport capacity for the Russian and Chinese routes shown in Table 3-39 is 64million tons, transport capacity is sufficient.

Table 3-39 Annual Export Route and Amount

Route	Annual Export Volume (Million tons)
Tavantolgoi → Gashuunskhait	18.1
Tavantolgoi → Khuut → Bichigt (Numrug)	14.0
Tavantolgoi → Sainshand → Suhkbaatar → Slavyyanka	6.0
Nariinskhait → Shiveehuren	23.2
Khuut→ Choibalsan	3.0
Total	64.3

Source: NEDO2011 Report, NEDO2012 Report



Source: JICA study team edited the information from MRAM.

Fig. 3-32 Amount of Available Rail Transport

(c) Breakdown of Export Cost

1)Rail Fare

a) Domestic

The new railway fare has been under consideration and not open to the public. Thus, in this report, railway fare used in WB2011 report is used. Based on the calculation, the construction cost per km is US$1,800,000 (WB2009), on conditions of 20 years refund, calculated as 15% of the discount rate, the price according to the haul distance is set to this. Specifically, it is considered as US$0.036/ton km.

b) China

The railway costs are the unit price data as of 2011 by the National Development and Reform Commission and Department of Railway, posted on the committee homepage. It is shown in Table 3-40.

Table 3-40 China Railways Department Freight 2011

Exchange rate: 7.17RMB/US$

Item	Base Price 1 (USD/t)	Base Price 2 (USD/t)
Coal	1.75011233	0.00898625

Source: Mongolian Railway internet information, 2011 #579

The concrete calculation method is as follows.

Cost of Transport = Base Price 1 + Base Price 2 × Transportation Distance

c) Russia

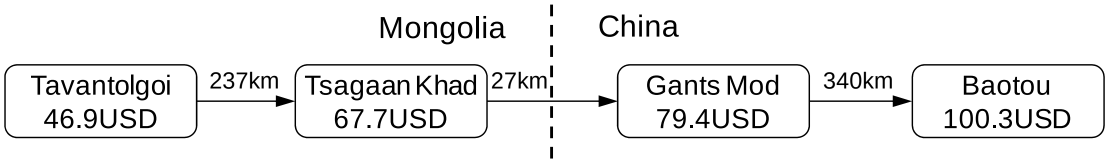
According to the WB2011 report, the fare that passed through Russia was calculated. The result, in order that the distance may reach four times, as compared with the Chinese route, the amount of money will also be about 1.8 times. Therefore, it was concluded that for the competitive power reservation, the price negotiation of future Mongolia and Russia were expected. Then, the contents showed from Russian railway to Ulaanbaatar railway, the charges were discounted about 62% on the condition that a Russian railway and a port should be used (NEDO2011 report). This, although the Russian route is about four times the haul distance of China route, the transportation cost to Vladivostok via Nausky from Sukhbaatar of the existing railway, is US$3.5–US$4.5 per ton higher than that of transport whithin China. As opposed to the handicap in which Russia has long haul distance, it seemed that almost the same amount of money, as the unit price, which passed through China by making the unit price cheap, was scheduled to be used. In order to verify whether it was possible to use this price by this report, the view of RAM about this discount excursion fare was taken into account as follows;

- Russian Railways is a 50% shareholder of Ulaanbaatar Railways. It is in a position to make proposals to the company regarding operations. There are the following two demands instead of discounting fares:
  - Participation by Russian companies in railway facility construction.
  - Get coal trade rights and have the right to export to other countries.

Because RAM has not at present decided whether it will accept the requests from Russia, fare prices within Russia still have special conditions, but this report uses the actual discounted price of US$31.9/ton. This is due to the big spread occurring at a charge, without the discount as compared with the China course. Moreover, Mongolia will negotiate with Russia from now onwards, expecting to derive advantageous conditions.

2) Customs Fees

According to the data from Mongolian Coal Association, an export duties are not imposed on the exporters; in fact, the title and the other costs, which are known as customs fee, need to be paid as well. Moreover, import charges are imposed on the importers. A series of expenses are the sum total, and each is US$1.125/ton (MGT 1,500), whereas in China it is US$0.94/ton. When a tax is imposed by the export duty, from being a future subject, the customs fee is used. Incidentally, this US$1.125/ton (MGT 1,500) has a domestic unified price, before it differed from the MGT 1,500–3,000 for every customhouse. The details about the translated data of the language are shown in Fig. 3-33.



	USD
Handling charge	1.0
Transportation charge	18.0
Road charge	1.5
Reduced charge	0.3
Total	20.8

	USD
Handling charge	2.0
Transportation charge	7.0
Reduced charge	0.2
Commission of Tariff	2.5
Total	11.7

	USD
Import tax and commission	0.9
Handling charge	0.7
Transportation charge	16.4
Storage charge	2.9
Total	20.9

Export cost	USD
Custom commissions	1.125
Custom clearance	0.030
Certificate of origin	0.030
Environment protection fee	0.040
Sterilization charge	0.040
Transportation Management fee	0.080
Sealing fee	0.020
Total	1.365

China Import cost	USD
Disinfection fee	0.05
China transportation management and clearance	0.07
Quarantine fee	0.12
Pre-entry fee	0.05
Weighing cost	0.07
Port construction	0.29
New channel construction fee	0.29
Total	0.94

Source: Mongolian Coal Association (translated by JICA team)

Fig. 3-33 Commissions of Export/Import

3) Cost for Trans-shipment

The rail gauge of China differs from that of Mongolia, thus on the Chinese border, trans-shipment is definitely needed. According to the RAM, China's trans-shipment expense is about US$3/ton. On the contrary, since the Russia rail gauge is same as of Mongolia, trans-shipment at the border is unnecessary. However, since Russia carries out on the condition that transportation by the engine and freight cargo of its own country is performed on shore transportation, while exporting across the Russian border from the country, it is necessary to use the engine and freight cargo, which suits Russian standard on the Trans Siberian Railways whole line. If a freight cargo is rented from Russia, the usage fee for a Mongolian freight cargo or locomotive is charged. On the other hand, when a freight cargo is built by the country, based on the specification by which the standard of Russia is met, use of this freight cargo is thus approved. Hence, it was assumed that the freight cargo rental charge (US$90/freight cargo) in Russia was compressible. In main enumeration, it computes from the freight cargo construction expenses uniquely. Usage fees for these Mongolian-made freight cargos were calculated to be about US$60/day. Because one of these freight cargos can hold 71t, it is possible to calculate the price per ton per day with the following formula.

US$60/day / 71t = US$0.85/day per ton

The US$0.85/day and t by these our original calculation are used. Moreover, the average round-trip days of Tavantolgoi-Slavyyanka Port was calculated to be around 10 days. Thus, the freight cargo fee for one round trip in Slavyyanka Port is US$0.85/day, and for 10 days round trip, it will be US$8.5/ton.

On the other hand, since the usage fee of an engine and a driver is 5,000 tons, carried on a line vehicle, its unit price per ton was cheap. Besides, even when it was compared with other export examples, it was judged that there was no need for any expense appropriation.

4) Export Tax Costs and Cargo Handling

a) Russia

According to the Russian Transport Infrastructure (2009 Coal Trans Russia), port loading and unloading expenses are high as compared with a foreign country. For the Vanino port, it is US$6.5/ton; for Vostochny Port, it is US$10.5/ton; and for Nakhotka port, it is US$13/ton. Since, it is indicated that the general price in the port of a foreign country is US$2–4/ton; it becomes about 2.5 times the usual expenses for port loading and unloading. Here, it is considered that the port usage fees for the Slavyanka Port after maintenance are Nakhotka Port and the same amount, it appropriates as US$13/ton. US$10/ton is expenses, as well as the Nakhotka Port is needed for this, and it is set to a sum total of US$23/ton.

b) China

The port loading and unloading expenses in China and customhouse charge becomes the following amount of money or rate. Here, it is the Jinzhou Port after improving the Tianjin Port; however, it is regarded as the Qinhuangdao Port and the same amount, and calculates.

Tianjin Port

- Port Charge of US$10/ton
- Export Tax at 10%
- Export License (E/L) Commission of US$10/ton
- Other Taxes (Tax, and other costs of exchange) at 1%

where, if the selling price of the cooking coal is set to US$125/ton of the present price, the export aggregate total cost of per ton in this case will be as follows.

US$10 + US$125 × 0.1 + US$10 + US$125 × 0.01 = US$33.75/t

(3) Russia-based route transport example[37]

There is a recent trial of coal transported from Russia to Japan. Based on that, total transport expenses from Tavantolgoi to Russia's far-east port were approximately US$120/t (excludes cost of coal; fare on Siberian rail was 52% off). This is almost identical to the Tavantolgoi-Port of Slavvyanka fare indicated in Table 3-36 (fare on Siberian rail was 52% off). It should be noted that there are cases of full transport costs where the preferred fare of 52% off for Siberian rail is removed. In those cases, the rate is US$ 166/ton, referring to JCOAL's data .

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37 Source related price which is used here is JCOAL data.

3.3.4 Results of the Container Transport Survey

The expense in case of a container transports processed coal, such as coke etc., refers to the case of container from Ulaanbaatar via the Tianjin port in China is packed from. In addition, when examining this case, the data (Apr, 2012)[38] of BPI were referred to.

With container transport, because container size and load types differ for rail transport and all-route road transport, the conditions were set with the 20-foot container, and the conditions are as follows:

(a) Setting conditions for container transport:

Container Specifications: 20-Feet Container

Content loaded, Weight: packed Coke 10 tons

Means of Transport: Use whole line railway (However, transport to a warehouse truck).

Transport Section: Ulaanbaatar-China Tianjin Port

Tariff Cost: Not included

Transportation distance (estimated): Ulaanbaatar-Zamiin uud, 710 km; Zamiin uud-China Erenhot, 14 km; Erenhot-Tianjin, 990 km

(b) Container Export Cost

The expense concerning the container traffic to China Tianjin under these conditions is summarized in Table 3-41.

Table 3-41 20-Foot Container Export Cost

Expense Items	Expense (US $)	Number of Days Required (Maximum)
Export Paperwork	145	28
Customs Procedures	60	2
Terminal, Used Port, Procedures	130	2
Transshipment, Transportation (Railways)	1,930	14
Total	2,265	46

Source: BPI report 2012

In case that a 40-foot container is used, in cost comparison with the 20-foot container, expenses other than "Transport/Transship," are the same as those shown in Table 3-41. The transport/transship expense for a 40-foot container is to be 1.4-1.5 times that of the 20-foot container by taking into consideration other examples. Setting the condition at 1.4 times that for the 20-foot container, transport/transship for the 40-foot container becomes US$2,702 (US$1,930 x 1.4), and with the other expenses included, the total is US$3,037/container.

38 Mongolia Business Plus Initiative Project "Preliminary estimates of the staggering costs of inefficient trade regulation in Mongolia".

In case that transportation by truck instead of railway is performed between ZamiUud-Tianjin, the expense per one container is US$600–800 added to the above costs.

3.3.5 Other Coal Transportation

The means of coal transport of currently examined in South Gobi, other than the rail way and road, is also examined.

(1) Belt Conveyor

As belt conveyors are unmanned powered equipment, these facilities typically are used for lengths of 50km or less. With the discarding of the B.O.T. System, MAK Co. constructed a belt conveyor between Shiveekhuren and Ceke. It appears that they also are considering constructing a conveyor between Nariinskhait and Shiveekhuren. The company evaluated equipment with specifications for cold-weather terrain produced by a Canadian company. According to the company, transport costs including amortization expenses would be 30% lower than the total costs for transporting over the same distance via trucks. As such, this is thought to be an effective means of transport for distances below 50km.

Transport rates between Nariinskhait and Ceke for each transport method based on our own independent estimates are shown in Table 3-42. This shows that for Case 1, transport costs between Nariinskhait and Ceke are 1.66USD when using railways for all zones. Case 2 and Case 3 presume that the Chinese side will construct railroad in the 20km zone from the Chinese border to the Mongolian side. Case 2 is based on belt conveyor transport between Nariinskhait and Shiveekhuren while Case 3 is based on truck-based transport. The transport costs for each are 1.73USD and 5.68USD respectively. Costs via the belt conveyor system are equivalent to rail-based transport but that transport capacity will not be available during repair periods thus will not provide the same capacity as railroad transport. As such, when considering both price and transport volume, rail-based transport is the means of transport that is cheapest and allows for greatest transport volume.

Table 3-42 Transport Costs between Nariinskhait and Ceke for Each Method of Transport

Transport Nariinsukhait → Ceke							
Case No.	Transport by	Transport Section					Total (USD)
1	Railway	Nariinsukhait Railway	→ 1.66 46 km	Shibeekhuren	→	Ceke Railway	1.66
2	Conveyorbelt + Railway	Nariinsukhait Conveyorbelt	→ 1.55 30 km	20km point from border Railway	→ 0.18 20 km	Ceke	1.73
3	Track + Railway	Nariinsukhait Track	→ 5.50 30 km	Shibeekhuren Railway	→ 0.18 20 km	Ceke	5.68

Source: JCOAL materials

(2) Pipeline

A transport method by pipeline was developed in the United States in the 1990s. Water is used to float coal, traveling through the pipe. Approximately 100km of pipeline is operated in Nevada. This method has been improved in recent year to the point where it can withstand cold terrain temperature as low as -60°C, which has improved transport efficiency. There are reports that transport using this technology is nearly the same as with rail transport (E-Trans Co. website). However, when we inquired with various sites regarding the incorporation of this technology in Mongolia, we could not find any organization that had considered employing this transport system due to the fact that securing water resources in the Gobi region is not easy.

3.3.6 The Subject and Proposal about an Economic Infrastructure

The economic infrastructure, at the present condition, of the country, although the plan of the subject and future has been considered, the proposal and subject point based on these results are summarized below.

(i) Transport infrastructure- building facilitates to the development of mining activities. Introduction of B.O.T. into transportation infrastructure with private enterprises' participation and private capital leads to shortening the periods for procurement of railway construction expenses and the lead time up to operation. B.O.T for railway construction, however, has been repealed, and thus it is concerned for railway construction to be slowed down. Meanwhile, road construction is to be accelerated due to the introduction of B.O.T. From the environmental points of view, drastic economical infrastructure development extensively influences the environment. Thus, the government needs to control the pace of resources development, taking account into the proceeding of development plans in line with government policy.

(ii) When road is constructed by private enterprises, it is recommended to take consideration in unequal conditions among the large-scaled mining enterprises and small-scale ones; that is, road construction , installment of power lines and other relevant infrastructure is relatively easier for the well-funded enterprises while it is heavy strain on smaller enterprises. Small- and medium-scaled coal mines located near the national boundary with Russia do not have sufficient infrastructure, which leads them to having nowhere in sight to export coal to Russia. It is needed for the government to administratively support such small- and medium- scaled enterprises so as to serve as function for developing industries.

(iii) To secure water sources is critical issue for development of mineral and coal resources, especially for Gobi districts with very low- rainfall. The survey of water sources and the quantity of water reserves shall be conducted extensively over the areas as well as the surrounding areas of development. The government approval to the usage of the water resources verified by such survey is desired to be actively given to the mining enterprises unless water sources are expected to be depleted in the short term.

3.4 New Technologies of Coal Development

3.4.1 CBM

An overview of CBM is provided in 1.3.1 of reference at the end of this report but here we discuss the potential for application in Mongolia and relevant problems.

Various foreign countries are in the commercialization phase and in Mongolia as well there is future potential for this technology. Ideal conditions for coal beds for CBM development include a broad, thick dispersal of coal with a high volume of gas adsorption and that the coal bed is permeable so that gas is able to flow freely. Regarding the first condition, the generation of methane gas in coal is greatest with bituminous coal. As the rate of adsorption increases with the rate of bituminization, coal with a more advanced rate of bituminization (bituminous coal to anthracite coal) is more beneficial. Also, the progression of bituminization results in the development of cleats (fracture for gas transport), which form favorable cleat networks. However, as the burial depth gets deeper, i.e., as geological pressure increases, cleat width decreases and the rate of permeability declines. As such, represented quantitatively, coal beds with an appropriate rate of bituminization (high rate of gas adsorption) and wide open spaces while also having favorable permeability are optimal for CBM development. In reality, thus far the depth of coal beds suitable for CBM development has been at most roughly 1,000m. At coal beds of depths beyond this, the low rate of permeability becomes a bottleneck for development.

The following are requirements for CBM development.

(i) It is economically beneficial if the location at which excavated coal bed gas will be consumes is physically close to the development site.

(ii) Reserve volume appraisals using excavation boring are vital and the appraisal of adsorption rate is particularly vital.

3.4.2 Underground Gasification

An overview of underground gasification is provided in 1.3.2 of reference at the end of this report but here we discuss the potential for application in Mongolia and relevant problems.

This technology used to gasify coal in deep beds, thin layers, coal beds with large quantities of ash or sulfur, and other coal beds that are not economically viable, turning the coal into a collectable and turning previously unusable coal beds into usable resources. Recent years have seen the technology garner attention to an extent not seen since its intense development during the 1930s by the former Soviet Union. However, while the technology has reached the point of feasible application in various foreign countries, there are few examples of successful commercialization, suggesting that it is a technology with many hurdles facing commercialization.

Risk factors are outlined below.

(i) The concept of UCG is simple but controlling reactions and production a gas with consistent quality is difficult with face with various geological conditions and coal quality.

(ii) Failure to select the proper coal bed conditions or conduct UCG under less than optimal management conditions could result in causing two environmental risk factors: groundwater contamination and surface depression.

Chapter 4 Potential of Coal Utilization Technology

4.1 Current status of coal utilization in Mongolia and improvement possibility consideration

4.1.1 Coal-fired power plant

There are eight coal-fired power plants across Mongolia and they use coal produced in Mongolia only. Total capacity for coal-powered thermal power plants at the time of our survey was 888.7MW. A list is provided in Table 4-1. In the table, excluding the No. 8 UHG mine base power plant, all coal-powered thermal power plants have supply electricity as well as hot water for heating in residential districts and steam for manufacturing plants.

The power supply system in Mongolia consists of three systems: Central Energy System (CES), Eastern Energy System (EES) and Western Energy System (WES). The CES is a system which supplies power and heat (hot water, steam) to the capital, Ulaanbaatar, and the suburban cities of Darkhan and Erdenet, and about 95% of Mongolia's facility capacity of coal-fired power plants is concentrated. The No.2, No.3 and No.4 Ulaanbaatar power plants established in Ulaanbaatar occupy 90% of the facility capacity of the coal-fired power plants in the CES system. Therefore, site research for the master plan at this time is targeted on the No.2, No.3 and No.4 Ulaanbaatar power plants.

Table 4-1 Coal-fired Power Plants List

No	System	Coal-fired power plant	Facility capacity (MW)	Single capacity (MW)x units	Year started
1	CES	No.2 Ulaanbaatar	21.5	6×1、3.5×1、12×1	1961,1969
2		No.3 Ulaanbaatar	148	12×4、25＊Note 1×4	1973～1979
3		No.4 Ulaanbaatar	580	80×1、100×5＊Note 2	1983～1991
4		Darkhan	48	12×4	1965
5		Erdenet	28.8	12×2、8.4×2	1987～1989
	CES subtotal		826.3		
6	EES	Dornod	36	6×2、12×2	1969, 1980, 1982
7	Independent system	Dalanzadgad	8.4	3×2, 2.4×1	2000,2012
8		UHG, ER.Co.	18	6×3	2011
	Total		888.7		

Source: Mongolia Power Statistics 2011 edited by JICA study team

*Note 1: Source shows four units of turbine with 22MW. The table above shows four units of turbine with 25MW determined by segment search results.

*Note 2: Source shows four units of turbine with 100MW. The table above shows five units after confirmation that their capacities have been enhanced in 2009.

(1) Coal-fired power plant operational performance (2011)

According to the power energy percentages per power source type in 2011: coal-fired 92.7% (4450 GWh), hydraulic 1.1% (56.2 GWh), diesel 0.42% (20.2 GWh) and imports 5.8% (278 GWh); coal-fired power occupies most of the percentage.

Annual power generation, net supplied power, heat supplied and coal used of the coal-fired power plant are shown in Table 4-2.

Heat from the power plant is used to supply hot water to houses and steam to factories. The lowest winter temperature in Mongolia falls to -40°C or lower and the cold lasts longer so that heat supply for heating systems is one of the most important roles for power plants. Total annual volume of coal used is 5 million tons.

Table 4-2 Annual Power Generation, Net Supplied Power, Heat Supplied, Coal Used in 2011

No	Power plant	Power generation GWh	Net Supplied Power GWh	Heat supplied 1000 Gcal	Hot water 1000 Gcal	Steam 1000 Gcal	Average coal calorific value kcal/kg	Coal used 1000 ton
1	No.2 Ulaanbaatar	125.8	106.6	164.1	149.3	14.8	3454	191.5
2	No.3 Ulaanbaatar	685.6	540.8	1847.8	1570.6	277.2	3479	1067.5
3	No.4 Ulaanbaatar	3101.5	2690.8	3128.8	3003.2	125.6	3295	2899.7
4	Darkhan	266.2	216.5	453.6	443.0	10.6	3645	351.9
5	Erdenet	134.6	106.0	521.7	491.0	30.7	4085	222.4
	CES subtotal	4313.8	3660.6	6116.1	5657.1	458.9	3406	4733.0
6	Dornod	115.8	94.3	187.5	187.5	—	2524	270.6
7	Dalanzadgad	20.7	15.5	17.8	17.8	—	4945	39.4
	Total	4450.3	3770.4	6321.4	5862.4	458.9	3371	5043.0

Source: Mongolia Power Statistics 2011 edited by JICA study team

(2) CES system: Shift of operation performance from 2005 to 2011

Shift of operational performance of 5 power plants in CES system in the last seven years from 2005 to 2011 is shown in Table 4-3.

Table 4-3 Shift of Power Generation, Net Supplied Power, Heat Supplied

No	Item	2005	2006	2007	2008	2009	2010	2011
1	Power generation GWh	3320.4	34433.3	3594.1	3874.1	3874.2	4127.1	4313.8
2	Net supplied power GWh	2718.4	2832.4	3002.0	3249.8	3259.5	3482.5	3660.6
3	Internal power Consumption %	18.13	17.5	16.47	16.11	15.87	15.62	15.14
4	Heat supplied 1000 Gcal	5393.8	5344.7	5532.8	5781.0	5957.7	6018.2	6116.1
5	Hot water 1000 Gcal	5046.1	4986.5	5121.4	5359.1	5537.0	5620.7	5657.1
6	Steam 1000 Gcal	347.7	358.2	411.4	422.0	420.7	397.5	459.0

Source: Mongolia Power Statistics 2011 edited by JICA study team

Power generation and net supplied power in 2011 compared to 2010 increased by 4.5% and 5.1%, respectively. The heat supplied increased by 1.6% and the rate of steam for factories is larger than hot water. The power consumption within the power plants has been decreasing year by year and there are solid efforts for improved efficiency. Shift of energy efficiency in power plant is shown in Table 4-4.

Table 4-4 Shift of Energy Efficiency in Power Plant (Unit: %)

No	Power plant	2005	2006	2007	2008	2009	2010	2011
1	No.2 Ulaanbaatar	27.2	26.1	23.3	21.4	21.0	21.0	21.2
2	No.3 Ulaanbaatar	29.8	33.9	34.2	37.2	38.6	37.9	37.8
3	No.4 Ulaanbaatar	35.7	36.7	39.3	40.3	40.1	39.2	40.3
4	Darkhan	29.7	29.8	28.1	28.0	28.5	28.1	28.0
5	Erdenet	34.0	39.0	41.9	40.3	40.8	43.3	40.5

Source: Mongolia Power Statistics 2011 edited by JICA study team

These plants are a cogeneration type and the energy efficiency of the power plants is the ratio of energy output with power and heat to the energy input of boiler fuels. Average energy efficiency of cogeneration type power plants is about 50% to 80% but the actual values are as not good, and are about 20% to 40%. The cause of this lower efficiency is considered to be lower heat efficiency of boilers or turbines, excessive internal power consumption and larger loss of heat cycle. The No3 and No.4 Ulaanbaatar plants and Erdenet plant have some efficiency improvements but the efficiency of No.2 Ulaanbaatar plant has been decreasing as it is getting older.

In Mongolia, the standard coal consumption ratio is used as the thermal efficiency index for thermal power plants. Table 4-5 and Table 4-6 show transitions in standard coal consumption efficiency for power generation and for heat supply. The standard coal calorific value (low) used for calculating the coal consumption efficiency is 7000 kcal/kg.

Table 4-5 Shift of Coal Consumption Rate for Power Generation (Unit: g/kWh)

No	Power plant	2005	2006	2007	2008	2009	2010	2011
1	No.2 Ulaanbaatar	654.1	679.5	644.3	622.3	610.0	588.4	591.3
2	No.3 Ulaanbaatar	443.5	418.5	393.5	381.2	359.3	357.3	363.7
3	No.4 Ulaanbaatar	349.5	336.8	316.9	306.2	307.2	314.2	305.1
4	Darkhan	413.1	421.9	438.4	438.5	434.1	438.0	431.8
5	Erdenet	328.9	324.9	314.2	315.1	309.8	328.7	315.6
6	CES total	378.4	366.7	347.9	336.8	332.6	336.8	329.8

Source: Mongolia Power Statistics 2011

Table 4-6 Shift of Coal Consumption Rate for Heat Supply (Unit: kg/Gcal)

No	Power plant	2005	2006	2007	2008	2009	2010	2011
1	No.2 Ulaanbaatar	189.0	201.0	200.8	197.5	195.1	193.5	192.6
2	No.3 Ulaanbaatar	187.3	182.3	182.9	178.4	177.8	177.8	179.7
3	No.4 Ulaanbaatar	180.4	177.0	173.6	175.4	175.3	175.2	174.4
4	Darkhan	192.1	195.4	203.2	196.3	197.0	197.5	196.7
5	Erdenet	178.0	179.2	168.1	177.2	174.4	180.6	184.8
6	CES total	183.3	180.8	178.5	178.6	178.1	178.6	179.0

Source: Mongolia Power Statistics 2011

The shift of internal power consumption rate is shown in Table 4-7.

These values are calculated from an equation "(Generated power – Net supplied power) / (Generated power)" and as no consideration has been made to the power required for heat supply, the internal power consumption rate is apparently lower than that of power generation-only plants. As these plants are cogeneration types and the plants have different supply ratios between power and heat, relative merits among the plants cannot be simply compared. The internal power consumption rate of these power plants has been improving yearly.

Table 4-7 Shift of Internal Power Consumption Rate (Unit: %)

No	Power plant	2005	2006	2007	2008	2009	2010	2011
1	No.2 Ulaanbaatar	17.01	17.15	16.4	16.21	16.35	16.07	15.31
2	No.3 Ulaanbaatar	23.74	22.75	21.03	20.68	20.54	20.76	21.13
3	No.4 Ulaanbaatar	16.4	15.78	14.8	14.44	14.09	13.84	13.24
4	Darkhan	18.39	18.65	18.5	18.89	19.47	19.18	18.66
5	Erdenet	22.98	22.93	22.8	21.37	21.59	21.57	21.24
6	CES total	18.13	17.5	16.47	16.11	15.87	15.62	15.14

Source: Mongolia Power Statistics 2011 edited by JICA study team

Number of equipment outages of power plants in 2010 and 2011 classified by accidents and others is shown in Table 4-8. Numbers of accident outages in the power plants are very high so that cause investigation and recurrence prevention are important issues. It is necessary to improve facilities reliability and secure stable operations.

Table 4-8 Number of Boiler and Turbine Outages (2010, 2011)

No	Power plant	Equipment	2010			2011		
			Accident	Others	Total	Accident	Others	Total
1	No.2 Ulaanbaatar	Boiler	66	7	73	68	6	74
		Turbine	31	4	35	35	4	39
2	No.3 Ulaanbaatar	Boiler	81	27	108	78	31	109
		Turbine	45	13	58	33	8	41
3	No.4 Ulaanbaatar	Boiler	47	26	73	43	19	62
		Turbine	36	22	58	34	13	47
4	Darkhan	Boiler	69	11	80	43	12	55
		Turbine	28	9	37	35	9	44
5	Erdenet	Boiler	8	18	26	19	7	26
		Turbine	9	0	9	13	1	14

Source: Mongolia Power Statistics 2011 edited by JICA study team

The Plant Load Factor (PLF; Percentage of Annual generated power output as against Rated power output of generator in calendar period 8760 hours) of each power plant is shown in Table 4-9. In the source, rated output of the No.3 power plant is calculated as 136MW and the No.4 power plant for 560MW but the values in the following table are from the source document. If the values of Table 4-9 are used for the rated output, the PLF will be worse. The PLF of each power plant is as not good as about 50% to 60% and resulted in showing room for improvement.

Table 4-9 Shift of Plant Load Factor (PLF) (Unit: %)

No	Power plant	2005	2006	2007	2008	2009	2010	2011
1	No.2 Ulaanbaatar	58	60	62	63	64	66	67
2	No.3 Ulaanbaatar	48	48	49	56	55	56	58
3	No.4 Ulaanbaatar	48	50	53	57	57	60	63
4	Darkhan	58	60	62	60	58	61	63
5	Erdenet	55	56	56	57	57	53	53

Source: Mongolia Power Statistics 2011 edited by JICA study team

Outline of facilities, current operation status and future issues of No.2, No.3 and No.4 (Fig. 4-1) Ulaanbaatar power plants are described as follows.

Fourth power plant Second power plant Third power plant

Fig. 4-1 Distant View of Power Plants

(3) No.2 Ulaanbaatar Power Plant

No.2 Ulaanbaatar power plant, located in the north west of Ulaanbaatar, started operating in 1961 with three 35tons/hour boiler units and two 6,000kW condensing steam turbines for a total of 12MW output. In 1969, two 75tons/hour boiler units and a 12,000kW turbine were added to make the total at 24MW output. After that, one 35tons/hour boiler unit was removed and one 6,000kW condensing steam turbine was modified to become a 3,500kW back-pressure turbine.

Current capacity of the plant consists of two 35tons/hour and two 75tons/hour boilers at total steam evaporation 220tons/hour, one 6,000kW and one 12,000kW condensing steam turbines and one 3,500kW back-pressure steam turbine for a total of 21.5MW output, resulting in an annual power output from 105 GWh to 110 GWh.

This power plant also employs hot water supply facilities for supplying steam to adjacent factories. The heat quantity supplied is 15 Gcal/h. The temperature of hot water is designed at 135°C and return temperature is at 70°C. The available period of heat supply is from September 15 through May 15 (8 months) and no heat is supplied in the summer.

This plant uses Baganuur coal (about 200 thousand tons per year). The number of employees is 260.

Modification for one 75tons/hour boiler was started in 2011 for semicoke manufacturing and the boiler was in operation under adjustment at the time of research in 2012. The steam evaporation and steam conditions at boiler output were not changed after the modification so that no change is made to power capacity and heat supply capacity.

Fig. 4-2 Full View of Power Plant, Chimney: 120m (The 80m-chimney at left is not used)

(a) Outline of facilities and current operation status

1) Major boiler and turbine specifications are shown in Table 4-10 and Table 4-11.
Cross-section of steam turbine (Model: PT-12-35/10) is shown Fig. 4-3.

Table 4-10 Major Boiler Specifications

No	Item	Unit	#1, #3	#4, #5
1	Boiler type		TC-35-39	BKZ-75-39
2	Manufacturer		China/Shanghai	Former Soviet Union BKZ
3	Number of units	Unit	2	2
4	Rated steam flow	tons/hour	35	75
5	Steam pressure at superheater outlet	kgf/cm2	39	39
6	Steam temperature at superheater outlet	°C	440	440
7	Combustion system		Changed from Stoker combustion to fixed-bed system	Pulverized coal combustion
8	Dust collector		Cyclone Separator	Cyclone Separator ＋ Wet Scrubber
9	Desulfurizer, denitration system		None	None
10	Ash handling system		Mixed with water, disposal to Ash Pond	

Source: Edited by JICA study team after site research

Table 4-11 Major Turbine Specifications

No	Item	Unit	#1	#2	#3
1	Turbine type		AK-6-35	P-4-35	PT-12-35/10
			Condensing steam	Back-pressure	Condensing steam
2	Manufacturer		China	China	Former Soviet Union
3	Rated output	kW	6,000	3,500	12,000
4	Main steam pressure	kgf/cm2	35	35	35
5	Main steam temperature	°C	435	435	435
6	Designed main steam flow rate	tons/hour	30	30	109

Source: Edited by JICA study team after site research

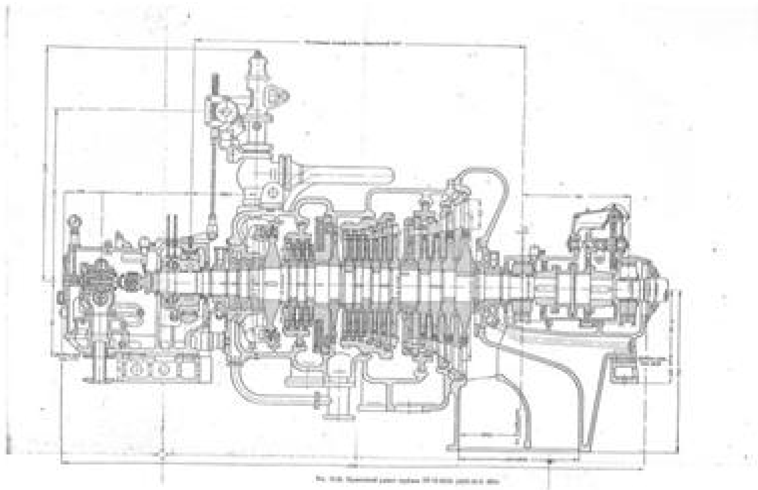


Fig. 4-3 Cross-section of 12,000MW Steam Turbine (Model: PT-12-35/10)

2) Facilities status

This power plant is already 50 years old after constructed in the 1960's and boiler facilities, turbine facilities and controllers on the site have been rather organized but their aging is apparent.

Field monitor and control panels are located in the front of steam turbine, full-time operators are operating, a segment operating room is located in the front of boiler unit, and there is no central operations room for monitoring across boilers and turbines. Part of the segment monitor panel has computer displays and operation monitoring system seems to have been updated. The main steam pipes, boiler feed-water pipes and industrial steam pipes are the common header pipeline system and pipes from boilers and turbines that are connected to the common header pipeline so this system is not one piece of equipment for each unit.

Boiler #2 has already been decommissioned and removed and a new 35 tons/hour boiler is scheduled for this space. However, no plan to install new turbine facilities has been set.

Boiler #5 has been modified for semicoke manufacturing and is in operations under adjustment.

3) Operation status

The operation status of equipment is shown in Table 4-12 and Table 4-13.

Plant Availability Factor (AVF) is a percentage of annual facilities operation hours to the annual calendar hours (8760hrs.). As furnace #5 is a semicoke manufacturing furnace and modification started in 2011, the AVF is lower than the others.

In Table 4-12 shows future plans (2015 to 2025) for annual operation hours (availability factor), coal consumption and heat supply which shows a future plan of these facilities intended by power plant.

Table 4-12 Boiler Facilities Operation Statuses

No	Item		#1	#3	#4	#5	Power plant total
1	Year service started		1961	1961	1969	1961	
2	Rated steam flow (tons/hour)		35	35	75	75	220
3	Accumulated operation time (hrs)		146,864	128,189	243,274	232,372	
4	Annual operation time (hrs)	2008	4,210	3,746	4,949	6,369	
4	Annual operation time (hrs)	2011	5,058	4,912	6,872	3,060	
5	Future planned operation time (hrs)	2015	5,800	5,800	6,200	6,200	
5	Future planned operation time (hrs)	2020	6,000	6,000	6,500	6,500	
5	Future planned operation time (hrs)	2025	6,100	6,100	6,700	6,700	
6	Plant Availability Factor AVF (%)	2008	48.0	42.8	56.5	72.7	
6	Plant Availability Factor AVF (%)	2011	57,7	56.1	78.4	34.9	
7	Coal consumed (ton/y)	2008	29,003	19,184	61,794	71,750	181,731
7	Coal consumed (ton/y)	2011	38,474	31,094	84,115	36,677	190,360
8	Future planned coal consumption (ton/y)	2015	39,000	32,000	62,000	75,000	208,000
8	Future planned coal consumption (ton/y)	2020	39,000	32,000	62,000	75,000	208,000
8	Future planned coal consumption (ton/y)	2025	39,000	32,000	62,000	75,000	208,000
9	Heat supplied*Note 1 (Gcal/y)	2008	89,110	63,992	206,394	234,186	593,682
9	Heat supplied*Note 1 (Gcal/y)	2011	106,426	85,181	258.,136	112,612	562,355
10	Future planned heat supply*Note 1 (Gcal/y)	2015	120,000	86,000	250,000	240,000	696,000
10	Future planned heat supply*Note 1 (Gcal/y)	2020	120,000	86,000	250,000	240,000	696,000
10	Future planned heat supply*Note 1 (Gcal/y)	2025	120,000	86,000	250,000	240,000	696,000
11	Boiler efficiency (%)		80	80	89	89	
12	Number of unplanned outages (times)	2008	1	1	2	3	
12	Number of unplanned outages (times)	2009	2	2	0	3	
12	Number of unplanned outages (times)	2010	0	3	5	1	
12	Number of unplanned outages (times)	2011	2	2	0	2	

Source: Documents from second power plant and segment search edited by JICA study team

*Note 1: This heat supplied is heat from boiler evaporation and not heat supplied to the regions.

Turbine facilities operation statuses are shown in Table 4-13.

No. 1 and No. 3 turbines are operated at a nearly consistent load during both day and night.

The plant availability factor and plant load factor for turbine #2 are significantly lower than the other turbines. This was explained as being the result of the turbine being modified from having been a condensing turbine to becoming a back-pressure turbine causing lower economy efficiency with any extraction steam stoppage allowing for only three months operation within the winter. The number of unplanned outages of the turbines is larger than the boilers.

Table 4-13 Turbine Facilities Operation Statuses

No	Item		#1	#2	#3	Power plant total
1	Year service started		1961	1961	1969	
2	Rated output (kW)		6,000	3,500	12,000	21,500
3	Accumulated operation time (hrs)		73,718	31,147	84,262	
4	Annual operation time (hrs)	2008	6,837	459	7,963	
		2011	7,395	991	8,033	
5	Future planned operation time (hrs)	2015	7,500	1,500	8,000	
		2020	7,800	2,000	8,000	
		2025	8,000	3,000	8,000	
6	Plant Availability Factor AVF (%)	2008	78.0	5.2	90.9	
		2011	84.4	11.3	91.7	
7	Power output (MWh)	2008	38,353.9	945.9	80,138.0	119,437.8
		2011	39,492.2	2,643.9	83,607.7	125,833.8
8	Future planned power output (MWh)	2015	43,000	3,000	84,000	130,000
		2020	43,000	3,000	84,000	130,000
		2025	43,000	3,000	84,000	130,000
9	Plant load factor PLF (%)	2008	73.0	3.1	76.2	
		2011	75.1	8.6	79.5	
10	Number of unplanned outages (times)/time (hrs)	2008	8／39	—	14／400	
		2009	8／84	—	14／486	
		2010	7／44	—	12／75	
		2011	5／60	—	11／53	

Source: Documents from second power plant and segment search edited by JICA study team

4) Periodical overhaul inspection, repair status

Periodical overhaul inspection for boiler and turbine facilities has been conducted once every three to four years by stopping the facilities for two to three months. Repairs have been conducted when facilities were stopped once a year in July for about 20 days.

(b) Semicoke furnace status

According to ADB documents (May 2011, Ulaanbaatar Low Carbon Energy Supply Project Using a Public-Private Partnership Model: F/S Report), the No.2 power plant was planned to be decommissioned in 2005 but is still running as no new power/heat supply facilities have been built. It is reported that there is a need to implement some urgent measures to improve the efficiency and environmental load. Construction of No.5 power plant has been scheduled. The general manager of the power plant has a desire to succeed with a new project, semicoke manufacturing and briquette manufacturing for employment and survival of employees of the second power plant before starting operation of the No.5 power plant.

See Clause 4.1.4 for details of semicoke manufacturing in the second power plant.

(c) Future plan

Opinions about future power plant plans heard from the general manager of the power plant are as follows:

- A plan to add one 35 tons/hour boiler is in progress. This is a plan which will complete the construction by the end of 2013 and will accept international bidding. No turbine/generator facilities will be newly added.
- Boiler #5 was modified to become a semicoke manufacturing furnace and is operating under adjustment and the fourth boiler is planned to be modified with Russian technology. Starting operating boiler #4 will increase the annual net supplied output of the second power plant from 110 to 160 GWh
- At first, we planned to modify all the boilers in the No.2 power plant for semicoke manufacturing but we are working on the two boiler units (#4 and #5) that will be the first to be complete.

(4) The Third Ulaanbaatar power plant

The Third (No.3) power plant (Fig. 4-4) established in the vicinity of center of Ulaanbaatar, located a little to the west, is a national company which started construction in 1966. Its #1 boiler started supplying heat to the capital city in 1968 and started generation in 1973, employs power facilities making up about 18% of the CES system and a cogeneration power plant which supplies about 30% of heat to Ulaanbaatar having about 40 years history from construction.

Power facilities are separated into mainly two buildings and called the intermediate pressure system and high pressure system. Entire power facilities have capacities of boiler evaporation at 1990 tons/hour, output at 148 MW and heat supplied at 1102 Gcal/h.

Steam supply for factories covers 40% of Ulaanbaatar, at about 100 points. In the summer, the No.4 power plant supplies steam allowing for lowering loads on the No.3 power plant. Intermediate pressure system stops running from July 1 through September 1.

This plant uses Baganuur coal (about 1 million tons a year) and the number of employees is 960.

Fig. 4-4 Full View of Power Plant

Left: Intermediate pressure system building (Chimney: 100m),

Right: High pressure system building (Chimney: 150m)

(a) Outline of facilities and operation status

1) Power plant facilities configuration

Power plant facilities configuration is as follows and the main specifications of boilers and turbines are shown in Table 4-14 and Table 4-15, and cross-sectional view of steam turbine is shown Fig. 4-5.

Intermediate pressure system: boiler: 75tons/hour x 6 units, turbine: 12MW × 4 units

High pressure system: 220tons/hour × 7 units, turbine: 25MW × 4 units

Table 4-14 Major Boiler Specifications

No	Item	Unit	Intermediate pressure system	High pressure system
1	Boiler type		BKZ-75-39-FB	BKZ-220-1004C
			Indoor, mono-tube natural circulation, balanced draft system	
2	Manufacturer		Former Soviet Union BKZ	Former Soviet Union BKZ
3	Number of units	Unit	6	7
4	Rated steam flow	tons/hour	75	220
5	Drum pressure	kgf/cm2	44	112
6	Steam pressure at superheater outlet	kgf/cm2	39	100
7	Steam temperature at superheater outlet	°C	440	540
8	Feed-water temperature	°C	145	215
9	Cal consumption	tons/hour	16	35
10	Exhaust gas temperature	°C	128	130
11	Coal burner		3 units in front	Paired 2 faces x 3 units
12	Coal pulverizer		Horizontal ball mill (1 unit/furnace)	Horizontal ball mill (2 units/furnace)
13	Combustion system		Pulverized coal combustion #3, #4: Fluidized bed*Note 1	Pulverized coal combustion
14	Dust collector		Cyclone Separator ＋ Wet Scrubber	
15	Desulfurizer, denitration system		None	None
16	Ash handling system		Mixed with water, disposal to Ash Pond	

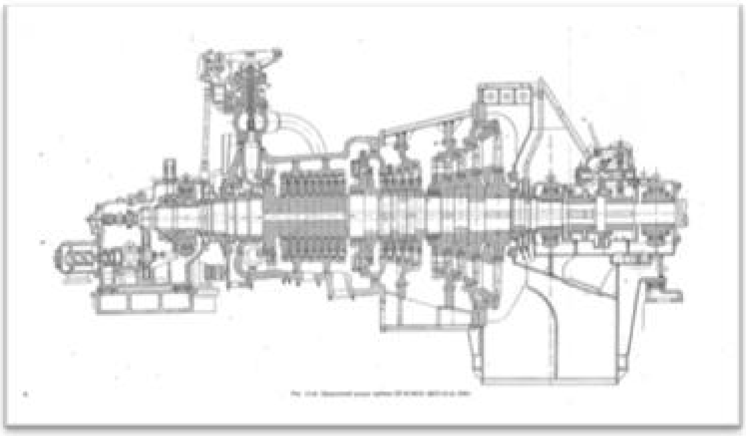
Source: Third power plant brochure and site research, edited by JICA study team

*Note 1: #3 and #4 furnaces were modified to fluidized bed type in 2000 to 2003 (China manufacturer)

Table 4-15 Major Turbine Specifications

No	Item	Unit	Intermediate pressure system	High pressure system
1	Turbine type		PT-12-35/10M	PT-25-90/10M
			Non-reheat, single cylinder-single exhaust-condensing system	
2	Manufacturer		Former Soviet Union KTZ	Former Soviet Union KTZ
3	Number of units	Unit	4	4
4	Rated output	kW	12,000	25,000
5	Main steam pressure	kgf/cm2	35	90
6	Main steam temperature	°C	435	535
7	Vacuum at condenser	%	91	91
8	Industrial steam pressure	kgf/cm2	8－13	8－13
9	Steam pressure for heating water	kgf/cm2	0.7－2.5	0.7－2.5

Source: Third power plant brochure and documents, edited by JICA study team



Source: Third power plant documents

Fig. 4-5 High Pressure System, Cross-sectional View of Steam Turbine (25MW)
(Model: PT-25-90/10M)

2) Status of Facilities

The main steam pipes, boiler feed-water pipes and industrial steam pipes for both intermediate and high pressure systems are the common pipeline system and pipes from boilers and turbines are connected to the common pipeline so this system is not independence system of equipment for each unit. This common pipeline system was an old Japanese design in an era with lower reliability but it plays an important role of supplying hot water and steam to regions in Mongolia so that this system is designed to value flexibility in operations.

Both turbines and boilers of the intermediate pressure system do not have an organized central operations room, the segment control panel is located near equipment, a full-time operator is operating and the 40-year old design policy remains unchanged. Most operation monitoring systems and controllers of the intermediate pressure system do not seem to have been updated and they seem to be old.

The high pressure system has two central operations rooms. Operation monitoring panels and controllers for boilers #7 through #10 and turbines #5, #6 are located in central operations room #1 and operation monitoring panels and controllers for boilers #11 through #13 and turbines #7, #8 are located in the central operations room #2. Full-time operators are monitoring operations in the rooms. Part of the boiler controllers of the operators rooms have been modified by using investment funds from the Asian Development Bank.

Both of intermediate and high pressure systems facilities are 30 to 40 years old and older than the others.

3) Operation Status

The operation status of equipment based on the answers is shown in Table 4-16 to Table 4-18. Intermediate pressure system, boiler facilities operation statuses are shown in Table 4-16.

Typical operation of this power plant involves running at best load where the daytime power load is nearly uniform while during the winters the three intermediate pressure system turbines and the four high pressure system turbines (total seven units) are run at full power with one intermediate system (12MW) serving as backup. This is the maximum power output of the plant (136MW). Boilers' evaporations have room to supply electricity and heat. As no demand for heating is present in the summer, the entire intermediate pressure system equipments are stopped from July 1 through September 1 to operate two high pressure system turbines only (25MW).

Heat supply to the region is designed so that during external temperatures of -39°C and lower, water feed volume is 6875t/h, hot water supply temperature is 135°C, and the return warm water temperature is 70°C. When the external temperature is higher, water feed temperature is 100°C and the return water temperature is 53°C.

Table 4-16 Intermediate Pressure System, Boiler Facilities Operation Statuses

No	Item		#1	#2	#3	#4	#5	#6
1	Date service started		1968/12/1	1969/1/30	1969/10/29	1969/11/30	1973/12/13	1975/1/1
2	Accumulated operation time (hrs)		189,565	202,331	155,716	168,913	193,745	170,248
3	Annual operation time (hrs)	2008	5.323	6,812	4,409	2,278	6,462	3,238
		2011	5,345	5,458	2,363	3,205	4,912	5,618
4	Plant Availability Factor*Note 1 AVF (%)	2008	73.2	93.7	60.6	31.3	88.9	44.5
		2011	73.5	75.1	32.5	44.1	67.5	77.3
5	Coal consumed (tons/year)	2008	60,809	84,469	59,709	34,755	69,104	41,678
		2011	65,085	68,066	30,618	42,096	63,310	72,730
6	Boiler efficiency (%)		88.1	88.8	89.2	87.5	88.4	88.0
7	Number of unplanned outages (times)	2008	14	7	14	8	8	7
		2009	4	5	11	10	9	8
		2010	10	6	9	7	5	9
		2011	10	9	7	10	5	7

Source: Third power plant documents, edited by JICA study team

*Note 1: calculation by setting 10 months as annual calendar time

Plant Availability Factor (AVF) is the percentage of annual facilities operation time less the annual calendar time. As entire operations of intermediate pressure system equipments operate during summer without needing heat supply (from July 1 through September 1, factory steam is supplied from the No.4 power plant during this period) and are stopped for inspection&repair, calculation by setting 10 months as annual calendar time with a consideration for this period resulted in the values of the table above. The AVFs for fluidized bed type boilers #3 and #4 are lower than the others.

The number of unplanned outages for any of the boilers is larger and one of them stops once a month. This seems to be from aged equipment with less reliability.

High pressure system and boiler facilities operation statuses are shown in Table 4-17. The AVF for high pressure system boiler facilities is lower than the others. This seems to be from longer planned stop time in the summer, but this must be considered. However, the number of unplanned outages is larger so this operation status is never good. Boiler #9 has been stopped due to failure since 1999.

Table 4-17 High Pressure System, Boiler Facilities Operation Statuses

No	Item		#7	#8	#9	#10	#11	#12	#13
1	Date service started		‘76/12/30	‘77/11/4	‘78/12/20	‘79/6/30	‘76/12/30	‘80/9/19	‘81/12/26
2	Accumulated operation time (hrs)		109,096	106,766	65,645	111,906	104,378	99,516	107,003
3	Annual operation time (hrs)	2008	4,371	5,592	0	1,461	3,655	3,271	3,328
		2011	5,216	6,504	0	3,677	3,737	1,876	4,344
4	Plant Availability Factor AVF (%)	2008	49.9	63.8	0	66.7	41.7	37.3	38.0
		2011	59.5	74.2	0	42.0	42.6	21.4	49.6
5	Coal consumed (tons/year)	2008	122,376	156,976	0	71,365	102,568	89,877	100,198
		2011	151,153	176,852	0	109,492	109,140	55,452	123,590
6	Boiler efficiency (%)		90.4	90.9	—	89.1	90.9	89.0	91.2
7	Number of unplanned outages (times)	2008	12	11	—	8	13	10	9
		2009	10	7	—	9	7	8	8
		2010	7	9	—	10	9	12	15
		2011	15	13	—	6	6	6	10

Source: Third power plant documents, edited by JICA study team

The supplied heat shown in Table 4-18 is a value obtained from turbine extraction system.

The AVF and PLF for the intermediate pressure system (#1 through #4) are calculated by setting 10 months as annual calendar time. Current operational pattern for high pressure system turbines (#5 through #8) in the summer is two units running and two units stopped. The AVF and PLF for units with planned-outages appear to be lower. The number of unplanned stoppages is smaller than that of boilers.

Table 4-18 Intermediate and High Pressure Systems, Turbine Facilities Operation Statuses

No	Item		#1	#2	#3	#4	#5	#6	#7	#8
1	Date service started		‘73/12/1	‘74/1/1	‘74/5/1	‘75/12/1	‘77/1/28	‘77/11/4	‘78/12/31	‘79/6/30
2	Accumulated operation time (hrs)		199,856	178,005	200,651	173,897	170,610	182,745	174,520	168,954
3	Annual operation time (hrs)	2008	4,503	3,986	7,188	5,462	5,977	3,919	5,891	6,154
		2011	3,788	3,597	6,543	5,112	6,985	6,562	4,201	6,405
4	Plant Availability Factor*Note1 AVF (%)	2008	61.9	54.8	98.8	75.1	68.2	44.7	67.2	70.2
		2011	52.1	49.5	90.0	70.3	79.7	74.9	48.0	73.1
5	Power output (MWh)	2008	41,793.5	33,514	70,988	49,247	135,985	840,088	120,150	127,791
		2011	35,309	32,989.2	63,733.8	49,126	152,159	137,782	84,444	130,021
6	Plant load factor PLF (%)	2008	47.9	38.4	81.3	56.4	62.1	38.4	54.9	58.4
		2011	40.5	37.8	73.0	56.3	69.5	62.9	38.6	59.4
7	Heat supplied (turbine extraction) (1000 Gcal/y)	2008	—Note2	—	—	—	94.4	165.8	76.8	36.4
		2011	—	—	—	—	169	186.3	228.1	167.4
8	Turbine efficiency (%)		42	42	42	42	42	42	42	42
9	Number of unplanned outages (times)	2008	9	11	9	15	11	7	10	3
		2009	3	3	9	7	6	5	7	7
		2010	7	12	4	7	8	8	6	6
		2011	3	4	2	3	9	4	9	7

Source: Third power plant documents, edited by JICA study team

Note1: calculation by setting 10 months as annual calendar time

Note2: Heat is also supplied from the intermediate turbine extraction line but the system has no gauge so measurements are not taken.

4) Periodical overhaul inspection, repair status

Power plants perform major repairs (periodical overhaul inspection) every four years, intermediate repairs every two years and minor repairs every year. Minor repairs are done on boilers every three months.

In the summer, as entire intermediate pressure system facilities will be stopped and will not supply heat, overhaul inspections, repairs and modifications are allowed in this period. The high pressure system also has room to operate equipment during summer so overhaul inspection and repair can be performed in this period. As operational patterns of power plants are fixed, the plants have time to perform planned repairs and updates for equipment and parts. Periodical overhaul inspection status is shown in Table 4-19.

Table 4-19 Periodical overhaul inspection status (OH：Overhaul)

No	Fiscal year	Intermediate pressure system		High pressure system	
		Boiler facilities	Turbine facilities	Boiler facilities	Turbine facilities
1	2007				#5: OH
2	2008		#2: OH Generator rotor replaced		#6: OH
3	2009		#3: OH Generator rotor replaced		—
4	2010	#2 : OH	#4: OH Generator rotor replaced		#8: OH
5	2011	#5 : OH Tube partially retraced	#1: OH Generator rotor replaced	#11&#12: Tube replaced	#7: OH Turbine rotor replaced
6	2012	#3 :Tube 100% replaced #6 : OH	#2: OH	#10&#13 furnaces Tube 100% replaced	#5: OH

Source: Third power plant documents, edited by JICA study team

In the segment research in August 2012, the power output was about 40MW, the entire intermediate pressure system facility was stopped and boilers #8 and #12 and turbines #6 and #7 of high pressure system were running. Turbine #5 was undergoing an overhaul inspection and turbine #8 was in standby as a spare.

Boiler #3 (fluidized bed) of the intermediate pressure system was undergoing major repairs, boilers #10 and #13 of high pressure system were also undergoing major repairs, and large numbers of tubes and pressure-resistant parts were stacked outside the power plant.

During our on-site evaluation in November 2012, the No. 5 turbine backup unit and other intermediate and high pressure system turbines were all in operation. Power output was 100MW at night and 102MW during the day, indicated that the plant was operating at uniform output. Fig. 4-6 shows boilers / turbines periodical overhaul inspection status in 2012.

#13 boiler: 100% tube relocated
Tubes dismantled and located outdoor

#5 turbine rotor in overhaul inspection
Updated in 1995, overhaul inspection in 2007

Fig. 4-6 Boilers/Turbines Periodical Overhaul Inspection Status in 2012

5) Equipment performance tests

Boilers and turbines are subjected to performance tests (thermal efficiency confirmation test) before and after regular overhaul inspections. Performance test results are used to confirm that operating and equipment problems are being identified and managed.

(b) Issues and improvement offer

Current issues, necessary improvement items and measures considered by the power plants are summarized in Table 4-20 and Table 4-21.

Table 4-20 Issues and Measures of Intermediate Pressure System Facilities

No.	Facilities	Issue (Improvement)	Measures
1	Main turbine	It has reached the designed lifetime and its intermediate/high pressure diaphragms are deformed. Thermal efficiency has decreased and steam consumption has increased due to worn seals/rotor blades and extended clearances.	Replace diaphragms, rotors and seals in stages. Update with state-of-the-art turbines is desired other than repair but it depends on national policy.
2	Main air ejector	Thickness of heat exchanger is decreased to increase air leaks. Vacuum of condenser is low.	Consider whether to update entire equipments.
3	Condenser	Old functions and capabilities. Cooling capacity is decreased especially in summer and it is hard to secure stable power.	Consider modification to condenser with Russian technologies. A plan to move the condenser from a high pressure system to an intermediate pressure system is under consideration.
4	#1, #2, #5, #6 boilers	Leaks often occur in tubes. Boiler furnace pipes were replaced 11 to 13 years ago without a problem for 10 years but they tend to burst. They explained the cause is reduced thickness due to wear and material texture.	Considering the operation time, deteriorated material may be due to abnormal stress or abnormal rises of temperature, but no investigation has been made yet.
5	Ball mill	Internal liners and mill balls are extremely worn, their performance is decreased and un-combusted material is increased in the ash. They made all kinds of efforts, such as drying the coal, but capacity is insufficient.	A ceramic plate is attached to the ceiling of the mill but it fell due to heavy vibration. Thermal spraying is attempted but it requires internal repair with the mill stopped after operations for 40 to 45 days. Consider updating the ball mill to a hammer type mill.
6	#3, #4 boilers (fluidized bed)	They were modified to fluidized bed type which does not require any mill. Power saving without mill power is expected but it requires a higher head to fluidize medium and power consumption for FDF increased resulting in no difference between both methods. Fluidized bed type has easier operation but Tubes have worn and often burst.	Change #1 boiler to fluidized bed type.
7	Boiler control		Update to computer-controlled one.

Source: Field research results edited by JICA study team

Table 4-21 Issues and Measures of High Pressure System Facilities

No.	Facilities	Issue (Improvement)	Measures
1	Main turbine	As it will reach the designed lifetime, intermediate/high pressure diaphragms and rotors must be replaced and seals must be updated in stages.	Research/consider whether to replace with state-of-the-art turbines or increase capacity to 50 to 60 MW power turbines, and update them in stages.
2	Main air ejector Starting air ejector	Thickness of heat exchanger is decreased to increase air leaks. Vacuum of condenser is low.	Update entire equipments.
3	Condenser	Old functions and capabilities. Cooling capacity is decreased especially in summer and it is hard to secure stable power.	Consider to update it with a new condenser with improved capacity.
4	High pressure feed water heater Low pressure feed water heater	They are old after operations of more than 30 years and heat transmission tubes are worn (the heat transmission tubes have steel pipes with spiral shape and are different from Japanese design with a construction hard to take measures against leaks).	A Japanese high pressure feed water heater was considered for introduction but they explained they want to reuse older facilities.
5	Hot water heat exchanger	It is old same as feed-water heater.	It is required to update to a heat exchanger with new design.
6	Cooling tower	Cooling area is shorter by about $500m^2$. (current: $1200m^2$, 1 unit)	Whether to increase the cooling are in 2013 or construct a new cooling tower is under consideration. (It depends on national policy and budget)
7	Boilers	Tube leaks occur at boilers often. Wall Soot Blower (wall type ash blower) always fails. Economizer of boiler #12 is damaged. Boiler #9 has been stopped since 1995.	100% replacements of tubes of boilers #10 and #13 are in progress. Update boiler #9 (*Note 1)
8	Ball mill	Internal liners and mill balls are extremely worn and their performance is decreased. Replacements require considerable expense.	Consider to change or update the model of ball mill.
9	FDF, IDF		Consider to use rotation-controlled FDF and IDF.

Source: Field research results edited by JICA study team

*Note 1: Boiler #9 has been stopped since 1995 but it is expected to have a budget in fiscal 2013 for maintenance and restart due to power condition allowing operation in 2014.

The intermediate pressure system turbine went online in the early 1970s and has been in operation for nearly 40 years. In addition to the turbine, the control equipment and operation monitoring board also are very old facilities. It is best to aim for another several years of stable operation and then decommission the facility without conducting any major facility renovations.

In order to continue operating, the high pressure system facilities, including the turbines, will require an upgrade to facilities with the latest technology and improvements to power generation capacity and heat supply capacity also are required.

(c) Future plan

There was a plan to construct the No. 5 power plant current in the planning phase on the bare land to the west of the No. 3 power plant and then decommission the intermediate pressure systems. However, the construction site for the No. 5 power plant has been changed to a site east of Ulaanbaatar. The No. 3 power plant is close to central Ulaanbaatar and plays a vital role in the provision of electricity and heat. Increases to electricity and heat demand must be addressed through the maintenance and management of decaying facilities and improvements to facilities. The No. 3 power plant is considering a plan for constructing a 50MW facility and upgrading the No. 9 boiler.

Separately, there also is a plan underway to construct a new 250Gcal/h HOB facility to the east of the city.

(5) No.4 Ulaanbaatar power plant

The No.4 power plant is the largest Mongolian cogeneration plant of which #1 with 80MW started operating in October 1983. The current capacity of the plant is output 580MW and heat capacity of 1185 Gcal/h. This plant is an important backbone power plant, covering about 70% the of Central Energy System (CES) power around Ulaanbaatar and about 65% of heat demand from the Mongolian capital.

This plant started after being constructed using the former Soviet Union’s technologies in 1979 but Russian engineers left the plant in 1991 due to the collapse of the Soviet Union and parts supplies stopped. Investment and technical support started from the Japanese government after that and the boiler’s auxiliary machinery and measurement/control system were updated. Senior volunteer staff sent from JICA at the plant and are supporting it.

Management of the power plant was changed to a national company in which the government owns 100% of shares in 2001. The Ministry of Mining holds 41%, the State Property Committee holds 23% and the Ministry of Finance holds 20% of shares.

The plant’s employees as of end of 2011 total 1508, comprising 279 engineers and, broken down by gender, 1,115 men and 393 women. The power plant ancillary facilities include maintenance and repair machinery factories, chemical analysis facilities, hospitals and welfare facilities.

Business values in fiscal 2011:

- Income breakdown: Power 81.1%, heat: 17.8%, steam 1%
- Expenditure breakdown: Fuel cost 55.1%, depreciation cost 23.3%, repair and spare cost 3.4%, payment 10.4%
- Social security/health insurance: 1.4%, others 6.4%

Baganuur coal (#1 through #4 boilers) and Shivee Ovoo coal (#5 through #8 boilers) are used and annual coal consumption is about 3 million tons.

(a) Outline of facilities and operation status

Since the #1 turbine 80MW started in 1983, the power facility's capacity became 380MW (80 MW x 1 unit, 100 MW x 3 units) in 1987, with 160 MW (80 MW x 2 units) added from 1990 to 1991 resulting in output of 540 MW and heat capacity 1,185Gcal/h. Technical and financial support from the Japanese government from 1992 onward allowed boiler repair work, changing the coal pulverizer to a direct combustion system and vertical mill and updating the boiler measurement control system.

Turbines #5 and #6 were modified in 2007 and 2009 to increase output by 20MW from 80MW to 100MW. Present power plant facilities consist of eight boilers and six turbines, and the output is 580MW with heat capacity of 1,185Gcal/h.

They conduct demand-driven based operations where they lower the power load at night and increase the power load during the daytime. During the winter, one boiler is set as a backup and the other seven boilers and six turbines are all in operation.

Fig. 4-7 Miniature Power Plant Model   Chimney: 250m

Fig. 4-8 Full View of Fourth Power Plant from Boiler Building Side (Picture taken from second power plant, pipes in the foreground are for factory steam)

Operations of the power plant are intensively monitored from the central control/operations room. Operation monitoring panels and controllers for boilers #1 through #4 and turbines #1 through #3 are located in the central control room #1 and operation monitoring panels and controllers for boilers #5 through #8 and turbines #4 through #6 are located in the central control room #2. Full-time operators are monitoring the operations in the rooms.

Part of the financial support from the Japanese government allowed for an update of the boiler measurement control system at the same time as boiler repair work was being carried out. The performance of the turbine monitoring system improved over existing analog/local monitoring to become independent remote monitoring by the power plant. Operation monitoring Panel for #1 to #3 turbines and #1 to #4 are shown Fig. 4-9 and Fig. 4-10 respectively.

Fig. 4-9 Operation Monitoring Panel for Turbine #1 to #3

Fig. 4-10 Operation Monitoring Control Panel for Boiler #1 tio #4

(The right side is the control panel related to heat supply)

1) Main specifications for boilers and turbines

Major boiler specifications, cross-sectional view of boiler, coal property, major turbine specifications, and cross-sectional view of steam turbine are shown in Table 4-22, Fig. 4-11, Table 4-23, Table 4-24, and Fig. 4-12 respectively.

Table 4-22 Major Boiler Specifications

No	Item	Unit	#1 to #8 furnace
1	Boiler type		BKZ-420-140-10C
			Indoor, radiated mono-tube natural circulation
2	Manufacturer		Former Soviet Union BKZ
3	Number of units	Unit	8
4	Rated steam flow	tons/hour	420
5	Steam pressure at superheater outlet	kgf/cm2	140
6	Steam temperature at superheater outlet	°C	560
7	Feed-water temperature	°C	260
8	Fuel consumption	tons/hour	75～80
9	Draft system		Balanced draft system, FDF x 2 units, IDF x 2 units
10	Coal burner		Corner firing, 4 lines x 3 stages
11	Coal pulverizer		Vertical mill, 4 units/furnace
12	Combustion system		Direct combustion system
13	Dust collector		Electrical
14	Desulfurizer, denitration system		None
15	Ash handling system		Mixed with water, disposal to Ash Pond

Source: Fourth power plant brochure and site research, edited by JICA study team

Source: Obtained from fourth power plant

Fig. 4-11 Cross-sectional View of Boiler (Model: BKZ-420-140-10C)

Left: Side view, Right: Front view

Table 4-23 Coal Property

No	Description	Unit	Baganuur	Shivee Ovoo
1	Proximate analysis(As received)			
2	Total moisture	%	30～40	37～44
3	Inherent moisture	%	4～13	3～12
4	Ash content	%	12～27	12～18
5	Volatile matter	%	39～45	36～48
6	Fixed carbon	%	30～40	28～36
7	Ultimate analysis(Dry ash free basis)			
8	C：Carbon	%	73.2	72.89
9	H：Hydrogen	%	4.7	4.19
10	N：Nitrogen	%	0.9	0.93
11	O：Oxygen	%	20.6	21.38
12	S：Sulfur	%	0.4～0.8	0.6～0.9
13	Caloric value(As received)			
14	Lower heating value (LHV)	kcal/kg	3,000	2,700
15	High heating value (HHV)	kcal/kg	3,800	3,400
16	Grind ability (hardness)	HGI	30～50	62～66
17	Ash fusion temperature			
18	Initial deformation point	°C	1,175	1,326
19	Softening point	°C	1,130	1,318
20	Flow point	°C	1,260	1,331

Source: Obtained from fourth power plant

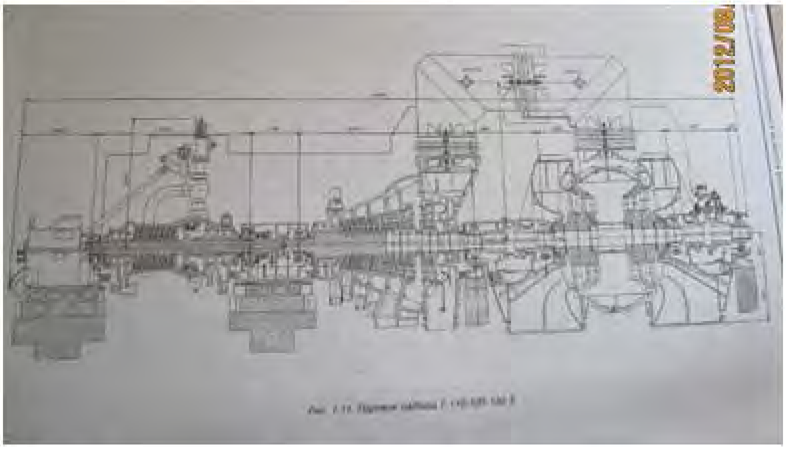
#1 through #4 boilers use Baganuur coal and #5 through #8 boilers Shivee Ovoo coal.

Table 4-24 Major Turbine Specifications

No	Item	Unit	#1	#5, #6	#2, #3, #4
1	Turbine type		PT-80-100	PT-80-100	T-100-130
			Non-reheat, dual cylinder-single flow exhaust-condensing system		Triple cylinder-dual flow exhaust-condensing system
2	Manufacturer		Former Soviet Union	Former Soviet Union	Former Soviet Union
3	Number of units	Unit	1	2	3
4	Rated output	kW	80,000	100,000＊Note1	100,000
5	Main steam pressure	kgf/cm2	130	130	130
6	Main steam temperature	°C	555	555	555
7	Main steam flow rate	tons/hour	470	485	485
8	Vacuum at condenser	%	92	92	92
9	Cooling water temperature	°C	20	20	20
10	Heat supplied (extraction)	Gcal/h	220	220	175
11	Process steam pressure	kgf/cm2	13±3	13±3	—

Source: Fourth power plant brochure and documents, edited by JICA study team

*Note 1: Turbine rotor was modified in 2007 and 2009 and the capacity was enhanced from 80MW to 100MW.



Source: Obtained from fourth power plant

Fig. 4-12 Cross-sectional View of Steam Turbine (100MW) (Model: T-100-130)

Supplying hot water to Ulaanbaatar uses turbine extraction as its heat source. Only low-pressure extraction is used for heating water in the summer but it is necessary to raise the water temperature up to 135 degree in the winter higher than that in the summer. Hot water heated by low-pressure extraction is reheated by extraction at 13kgf/cm2 from 80MW unit for supply to the city (100MW does not have process steam lines at 13 kgf/cm2).

Boiler steam is not sent directly but via heat exchanger (evaporator) to the factories (The third power plant sends boiler steam directly to the factories).

2) Operation status

The operation status of equipment based on the answers is shown in Table 4-25 and Table 4-26.

Annual coal consumption in 2011 is Baganuur coal at 1,260,669t, Shivee Ovoo coal at 1,639,016t, total 2,899,685t.

Table 4-25 Boiler Facilities Operation Status

No	Item		#1	#2	#3	#4	#5	#6	#7	#8
1	Year service started		1983	1984	1984	1985	1986	1987	1990	1991
2	Accumulated operation time (hrs)		128,692	136,973	124,065	115,826	107,760	106,614	86,848	104,683
3	Annual operation time (hrs)	2008	6,807	3,407	5,914	1,999	5,612	4,280	7,051	4,431
		2011	4,839	5,637	3,017	5,952	4,953	5,869	4,550	7,004
4	Plant Availability Factor AVF (%)	2008	77.7	38.9	59.3	22.8	64.1	48.9	80.5	50.6
		2011	55.2	64.3	34.4	67.9	43.4	67.0	51.9	80.0
5	Coal consumed (tons/year)	2008	394,260	209,639	378,435	122,498	424,296	305,625	480,482	301,727
		2011	296,443	351,408	192,791	420,026	339,018	457,149	322,630	520,220
6	Heat supplied*Note 1 (Gcal/y)	2008	1259824	668184	1203167	382356	1191508	855687	1383806	875312
		2011	969398	1164199	644516	1335663	1042268	1258306	915901	1447629
7	Boiler efficiency (%)		91.89	91.28	91.30	—	91.30	—	91.51	91.40
8	Measured environmental values Operation Data in 2011	Dust mg/Nm3	0.037	0.029	0.048	0.035	0.044	0.036	0.027	0.009
		SOx (ppm)	255.61	241.73	236.18	264.04	290.81	417.33	459.05	406.32
		NOx (ppm)	579.69	594.33	362.45	523.9	579.11	534.49	656.28	635.57

Source: Fourth power plant documents edited by JICA study team

*Note 1: Heat supplied shows heat from boiler evaporation, not heat supplied to regions.

Table 4-26 Turbine Facilities Operation Statuses

No	Item		#1	#2	#3	#4	#5	#6
1	Date service started		1983.10.18	1984.11.26	1985.12.27	1986.12.31	1990.1.22	1991.12.29
2	Accumulated operation time (hrs)		145,045	180,371	169,493	160,417	77,334	99,287
3	Annual operation time (hrs)	2008	6,310	7,848	6,986	5,120	7,803	3,250
		2011	4,416	8,130	6,103	8,013	6,471	6,923
4	Plant Availability Factor AVF (%)	2008	72.0	89.6	79.7	58.4	89.1	37.1
		2011	50.4	92.8	69.7	91.5	73.9	79.0
5	Power output (MWh)	2008	331,574	673,404	593,896	413,768	523,681	158,016
		2011	280,849	776,653	474,238	683,456	410,031	476,315
6	Plant load factor PLF (%)	2008	47.3	76.9	67.8	47.2	59.8	18.0
		2011	40.0	88.7	54.1	78.0	46.8	54.3
7	Heat supplied (turbine extraction) (Gcal/y)	2008	640,991	674,112	562,898	475,231	533,298	354,067
		2011	488,278	720,329	402,759	561,560	511,871	548,920
8	Turbine efficiency (%)	2011	33.42	34.12	34.61	34.1	—	28.71
9	Accident outages (No. of times) *Note 1	2008	11	2	6	5	2	3
		2009	2	10	3	3	3	1
		2010	9	4	9	3	1	5
		2011	3	2	2	4	1	1

Source: Fourth power plant documents edited by JICA study team

*Note 1: This figure is the same as the response received from the No. 4 power plant. It only indicates stoppages due to accidents.

Table 4-27 shows the shift of actual power plant operations in the past seven years, from 2005 to 2011.

Power output has increased by about 1.4 times and heat supplied by more than 1.1 times in the six years from 2005, but the average number of operating units for both boilers and turbines is less than five units and the boiler AVF is about 50%. The AVF for turbines has been increasing yearly but is low in 2011 at 61%. Power output is always being generated at 50 to 60% loads only even though the capacity is 580MW.

The No.4 power plant had achieved 578MW loads for two days at the demand peak of winter in 2011 and it was the largest load ever.

There have been many cases of both the boiler and turbine being out of operation. In 2011, the boiler was out of operation 62 times and the turbine was down 49 times. While compared to recent years the number of outages has declined, they still see roughly 10 outages per unit, per year. Statistical management of accident reports is based on per-division bases with accidents caused by human error being subject to fines against the supervisor and the person responsible. These fines are published. The

Technology Inspections Division in charge of managing this system holds monthly activity report meetings.

Among accident causes, the number of accidents due to human error have declined and it likely they are seeing the benefits of operator training.

Table 4-27 Shift of Power Plants Operation Statuses

No	Item	2005	2006	2007	2008	2009	2010	2011
1	Power Output (GWh)	2,260.8	2,348.7	2,486	2,694.4	2,711.3	2,940.5	3,101.5
2	Net supplied power (GWh)	1,889.1	1,978.1	2,117.5	2,305.2	2,329.4	2,533.5	2,690.8
3	Internal power consumption (%)	16.44	15.78	14.82	14.44	14.09	13.84	13.24
4	Heat supplied (1000 Gcal)	2,783.6	2,759.8	2,873.1	2,942.3	3,052.5	3,106.5	3,128.8
5	Coal consumed (1000 t)	2,503.9	2,434.3	2,497.3	2,616.9	2,635.9	2,880	2,899.7
6	Heavy oil used (t)	2,808	1,897	1,687	2,196	1,645	1,366	1,096
	Boilers							
7	Steam generated (1000 t)	12,215.5	12,279.6	12,580.4	13,235/9	13,489.3	14,515.2	
8	Number of operating units (unit)	4.18	4.17	4.32	4.42	4.47	4.76	
9	Average load (tons/hour)	336	336	334	341	344	348	
10	AVF (%)	41.73	41.72	42.98	44.85	45.83	49.32	
11	Number of outages (times)	134	126	96	110	94	84	62
12	Outages by human error (times)	5	14	5	4	4	2	3
	Turbines							
13	Number of operating units (unit)	3.8	3.86	4.1	4.25	4.31	4.58	
14	Average load (MW)	259.51	268.11	285.39	306.73	309.51	335.68	354.05
15	AVF % Electrical *Note 1	48.06	49.65	52.85	56.8	57.32	62.16	61.04
	AVF % Hot water	33.65	31.55	32.29	31.13	30.5	30.36	
16	Number of outages (times)	112	76	99	96	76	74	49
17	Outages by human error (times)	14	5	11	10	4	4	1

Source: Fourth power plant documents edited by JICA study team

*Note 1: Electrical AVF is calculated assuming power plant output is 540MW. Calculation for 2011 uses 580MW.

3) Periodical overhaul inspection, repair status

The power plant conducts regular overhaul inspections once every four years. They were in the process of conducting the overhaul inspection on the No. 5 turbine during our site visit in 2011. Equipment performance confirmation tests - Performance tests (thermal efficiency performance tests) for boilers and turbines are conducted before and after the regular overhaul.

4) Equipments performance tests

Performance tests (thermal efficiency performance tests) are conducted for boilers and turbines before a periodical overhaul inspection.

(b) Issues and improvement proposals

Current issues, necessary improvement items and measures considered by the power plants are summarized in Table 4-28.

Table 4-28 Issues and Measures of Power Plant Facilities

No	Facilities	Issue (Improvement)	Measures
1	Boiler	Have a hard time to handle clinker. Ash processing Preventative maintenance for boilers	Dry ash handing system is under consideration. Introduce RBM (Risk based maintenance) method in Japan
2	Turbine	Securing rated power Desired to improve turbine controller. Oil leak at 5th bearing shaft of #2 to #4 turbines	Change to EHG (Electro-hydraulic Governor) and use DCS (Digital Control System) for controller.
3	Condenser	Aging, decreased function due to dirty cooling pipes	Install cooling pipe cleaning system.
4	High pressure feed water heater Low pressure feed water heater	Aging, worn heat transmission tube.	Improvement or replacement to a new heater is required.
5	Hot water heat exchanger	Aging	Desire to update to a new heat exchanger.
6	Hot water feeding pump	Measure to increased demand for heat supply is required.	Added a pump in 2011 (It was completed in the summer of 2012).
7	Cooling tower	Insufficient cooling tower capacity	Added a cooling tower in 2011.

Source: Field research results edited by JICA study team

(c) Future plans

Concerning power growth, projection data for 2015 through 2025 indicates a growth rate of 5%/year. This is because the countries power demand is increasing at a rate of 5-7%/year.

No. 4 power plant is the backbone power plant for electricity and heat supply in Mongolia. Their facilities improvement and renovation plan is well underway as they step up measures to improve deteriorating facilities, improve output, and improve reliability. The first priority is facility operational stability and the second priority is the improvement of performance efficiency.

a) Construction plan for 100MW steam turbine

They are planning to add a 100MW turbine and on November 13 a contract was signed with the company URAL Turbine in Russia. This is the same manufacturer that constructed the turbine in the existing facility. Completion is planned for November 2014. They also will need to add a 50t/h - 70t/h boiler but there is no plan in place regarding the boiler.

We examined the plan schematics for the new turbine. The design calls for the same system used in the existing turbines No. 2 - No. 4, specifications for an external casing. The internal casing, rotor blades, seal, and rotor have all been improved. Rather than using the latest technology, improvements have been made to existing facilities and it is likely they took compatibility with existing facilities into consideration.

b) Measures for reducing power in plant

A plan is underway to use an inverter in order to reduce auxiliary equipment power and apparently they are considering getting estimates from Japan and one other company. Of the eight boiler water supply pumps, two would be converted to inverters. They have begun evaluating boiler FDF (Forced Draft Fan) and IDF (Induced Draft Fun). We see that they are taking concrete steps regarding issues indicated during diagnoses conducted by the Japan side.

c) Environmental measures

An electrostatic precipitator (ESP) has been installed. Desulfurization and denitration is expensive and at present there are no plans for installation. Environmental measurements of exhaust gas shows that levels were within Mongolian standards.

(6) Human resource development system of power plants and future issues

1) State of power plant human resources development system

During the on-site surveys of power plants No. 2, No. 3, and No. 4, we saw that the power plant human resource development system had been improved through training at a training center overseen by the Energy Bureau. The education center is an organization that falls under Mongolia's Energy Ministry Energy Development Center. Established in 1964, it has a 50-year history. Since 1998, the center has received support from Germany's GTZ to run a project that cultivates instructors of power plant technology related to energy. The center has conducted dedicated training for 35 engineers. Within the center are multiple practice facilities installed through the abovementioned support. The facilities are used as a way to experience real-world facilities and have elevated the efficacy human resource development. Currently, the center has 11 instructors who conduct engineer and general training courses in electricity, power transmission, welding and other elementary training and retraining as well as courses for engineers preparing for internships overseas. From what we saw during on-site surveys, content of power plant human resources varied somewhat between power plants. A summary is provided in Table 4-29.

Table 4-29 Human Resource Development System for Power Plants

No	Item	Description
1	Target for human resource development	Employees are classified as engineers or regular employees. Engineers are university graduates and regular employees are technical school graduates or compulsory education graduates.
2	Education for engineers	Education for engineers is held as a re-education session for two to three weeks in a college every five years. Engineers will become a Selected Engineer after 15 years and an Advisor Engineer after 20 years. The advisor engineers must take a test given by the Ministry of Energy. Project-based overseas training is held for engineers. At the No. 4 power plant, future managerial candidates are selected from among the engineers and are enrolled in intern courses at the university where they are taught business management.
3	Education for regular employees	The education center of the Ministry of Energy conducts training for regular employees. The education is consists of 4.5 days or 2-month courses in spring, summer and winter. The course covers a wide variety of classes such as operator training/assembly for welding/boilers. After the training, tests will be conducted and the results reflected in payment.
4	Education for newcomers	After introductory education for newcomers held for a week as one-to-one internal generation education, training following the power plant-specific program for 4.5 to 6 months will be held. Newcomers must take a test after the training is completed and if they pass, they will be treated as an independent engineer. Employees who train newcomers will be paid for motivation to improve education effects. The human resources department has a teacher (engineer) who provides advice to the newcomers once a week.

The fourth power plant, which has been continuously supported by JICA and in which senior volunteers reside until now, expects support associated with human resource development as shown in Table 4-30 from Japan.

Table 4-30 Issues and Measures for Power Plant Facilities

No	Item	Description
1	Need for experts in residence such as JICA's senior volunteers	The fourth power plant was established in 1973 and introduced power plant facilities made by Russia in 1983 to start operating. The facility uses technologies from the 1960's and 70's and is very old. Russian engineers resided here until the 1990's but they all went back home so that Mongolians operate them now. Due to outdated technologies, overseas latest technologies must be introduced. Under these circumstances, Japan is the country which first supported the power plants and they were able to update control rooms with yen loans. Russian, Chinese, Germany, Korean and Australian as well as Japanese technologies have been introduced and they expect to introduce facilities from these countries in the future. They told us that Japanese senior volunteers helped them with effective work so that they asked JICA for continued help in the future.
2	Necessity of new technology introduction/training in Japan, held by WS	Two to three engineers participate in training held by JICA in Japan every year. As the education center of the Ministry of energy is used for regular employees, training in Japan is necessary in the future.

There were plans at the 4th power plant to apply Japan's superior CCT technology in JICA-supported power plant facilities training but we did not get the sense that human resources development was being conducted in order to maintain and expand this CCT technology with power plant engineers and general workers. As noted above, power plant engineer and general worker development in Mongolia is based on an education center that falls under the umbrella of the Energy Ministry and began with the cultivation of instructors through support from other countries. Any future transplanting of Japan's CCT technology to Mongolia will have to begin with an instructor development project at the education center. The education center has expressed a desire to welcome Japan's CCT technology.

Also, particularly important in relation to the transplanting of CCT technology are subjects related to power plant O&M (Operation & Maintenance). In Japan, there are several plants that, through appropriate O&M, have maintained initial power plant efficiency even after 40 years. Human resource development related to maintenance and management is vital for Mongolia's power plants.

4.1.2 HOBs and industrial boilers

HOBs (Heat Only Boilers) in Mongolia were historically introduced to schools and hospitals as heat supplying facilities. HOBs are classified in two types: hot water supplies and steam supplies, and most of HOBs are boilers supplying hot water[39], “Air pollution competency enhancement project for Ulaanbaatar, Mongolia”). This document shows about 130,000 tons/year of coal is consumed by HOBs and factories in Ulaanbaatar, and it is only about 3% of coal consumption in the second, third and fourth Ulaanbaatar power plants. In contrast, emission per unit coal of air pollutants: smoke dust (PM_{10}; smoke dust smaller than 10 micron), sulfur dioxide (SO_2) and carbon monoxide (CO), are larger than that of boilers in the power plants. The emissions per unit coal of air pollutants, obtained from emission measurements in the boilers of the fourth power plant (Mongolia’s major power plant) and HOBs in Ulaanbaatar, are shown in Table 4-31.

Table 4-31 Emission Factor of Air Pollutants

Power plant/HOB	Emission factor (Pollutant emitted/Coal consumed) (kg/t)				
	TPS (entire smoke dust)	PM10	SOx	NOx	CO
Fourth power plant	2.90	1.89	2.20	3.90	0
HOB	32.88	21.37	6.96	1.69	72.89

Source: JICA/SUURI-KEIKAKU Report (June 2012), “Air pollution competency enhancement project for Ulaanbaatar, Mongolia”

For Table 4-31, HOBs have large emissions of air pollutants except for NO_x. NO_x emissions from HOBs are so low because of their lower combustion temperature and this results in larger CO generation.

[39] Source: JICA/SUURI-KEIKAKU Report from June 2012

(1) HOBs and industrial boilers in Ulaanbaatar

The 72nd school HOB of ANU Service and industrial boiler in MCS's beer factory were visited for status research of HOBs and industrial boilers in Ulaanbaatar.

(a) 72nd school of ANU Service

The pictures taken at the 72nd school of ANU Service are shown in Fig. 4-13 and Fig. 4-14.

1) Main HOB and dust collector

Started operating: 2006

Model: EKOEFEKT—600 (manufactured in Hungary)

Capacity: 600 KW

Pressure: 0.2 MPa

Temperature: 90 °C

2) Pumping system

Manufacturer: manufactured in China

Designed pressure: 1 MPa

Fig. 4-13 Main HOB and Dust Collector

Fig. 4-14 Pumping System

(b) Example of industrial boiler

Pictures of a boiler located in MCS's beer factory are shown in Fig. 4-15 and Fig. 4-16. Boiler specifications are as follows:

Manufacturer: Manufactured in China

Started operating: 2007

Evaporation: 4 tons/hour

Steam pressure: 1.25 MPa

Steam temperature: saturated

Steam generated is used in the factory as well as used to create hot water at 40°C to 70°C for heating. Economizer and dust collector are attached to the output of the boiler.

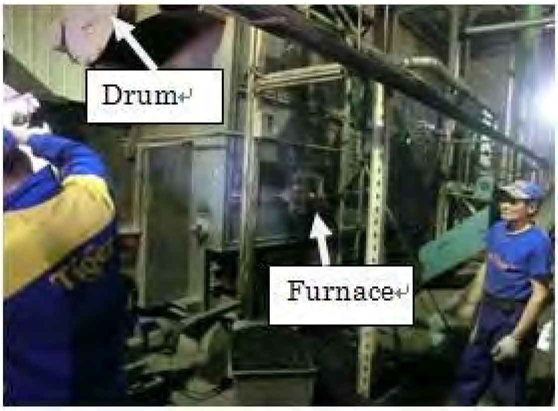


Fig. 4-15 Side View of Industrial Boiler **Fig. 4-16 Rear View of IndustrialBoiler**

(2) Schematic flow diagram of HOBs and industrial boilers

System outlines for the HOBs and industrial boilers researched are shown in Fig. 4-17 and Fig. 4-18. Boiler operation is performed by operators supplying coal manually and it combusts on the fixed grate. An induced draft fan is installed at the outlet of the boiler to make combustion chamber in negative pressure and it introduces combustion air to the chamber and exhausts combustion gas from the chimney. A cyclone separator is installed to remove smoke dust included in the emission gas but there is no gas seal system used for exhausting smoke dust collected leading to re-collection of ash when collected ash is exhausted outside the system during operation.

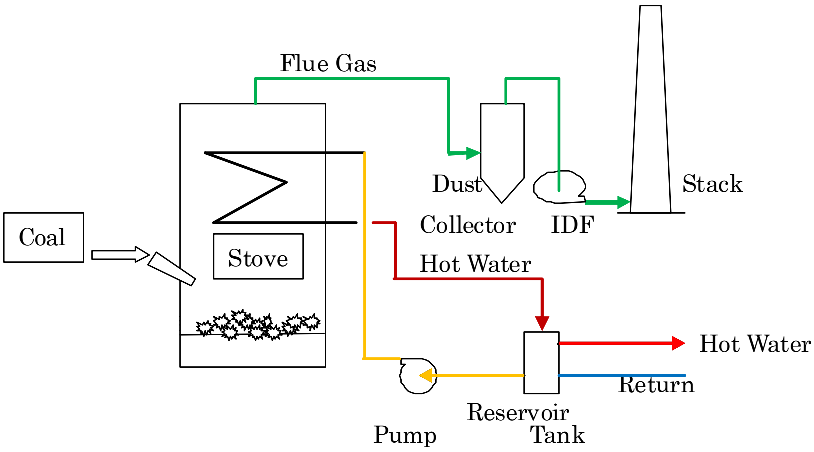


Fig. 4-17 HOB Heat Supply System (Example)

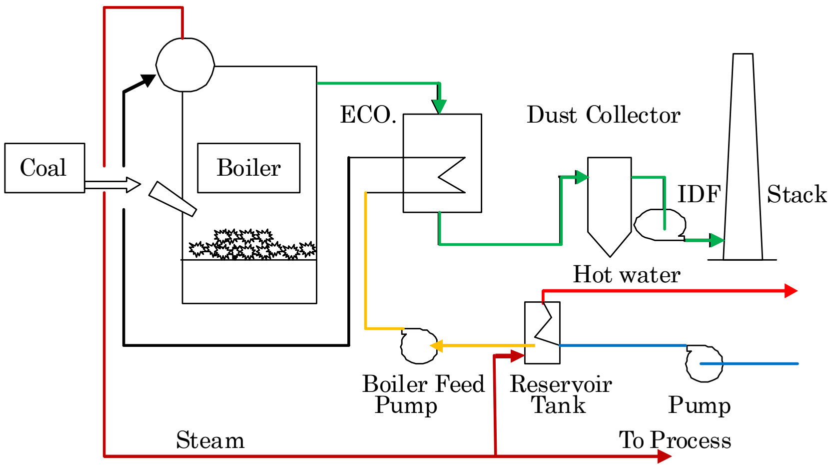


Fig. 4-18 Industrial Boiler Heat Supply System (Example)

(3) Operation data and HOB thermal efficiency

Oxygen content in the flue gas at HOB outlet in Ulaanbaatar, measured by SUURI-KEIKAKU Co., LTD in 2011, is around 12% to 18% and this is too high compared to the power boiler in 3% to 5%. The average HOB thermal efficiency in Aimag Central Heating System is expected to be about 30% to 40%[40] and this is considered to be due to low HOB thermal efficiency and larger heat loss at supply pipes. This report assumes the heat loss at supply pipes is in 15% to 20% and the HOB thermal efficiency can be about 45% to 60% by setting the heat loss at supply pipes in "0".

(4) Improvement Proposals

Generally thermal efficiency of HOB can be defined as follows.

$\eta_B = (1-(L_1+L_2+L_3+L_4+L_5+L_6)/H_h)*100$ %

Here η_B: Thermal efficiency (%)

L_1: Dry gas loss (kJ/kg coal)

L_2: Heat loss due to H2 combustion in coal(kJ/kg coal)

L_3: Heat loss due to H_2O in coal (kJ/kg coal)

L_4: Heat loss due to H_2O in combustion air (kJ/kg coal)L_5:CO loss due to insufficient combustion (kJ/kg of coal)

L_6: Unburned loss (kJ/kg coal)

L_7: Radiation loss (kJ/kg coal)

L_8: Other loss (kJ/kg coal) H_h: Calorific value of coal (kJ/kg coal)

For the improvement of thermal efficiency, the heat losses consisted of L_1 to L_8 of specified in section must be reduced. Major losses are L_1, L_2 and L_3 and they are influenced by HOB outlet gas temperature and O_2 content in flue gas. Fig 4-19 shows a sample calculation for brown coal with 35 % H_2O in coal and 3500 kcal/kg coal in calorific valve.

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[40] Source: ADBTA No. 7619-MON "Updating Energy Sector Development Plan," June 30, 2012

To reduce the dry loss and improve the thermal efficiency, combustion air flow should be appropriately adjusted corresponding to the coal flow rate. As being reduced air flow rate, the gas temperature raises and combustive circumstance might be improved but, in contrast, it leads to increase CO generation in flue gas and unburned materials accompanied with ash, therefore the adequate O_2 content in the flue gas must be kept and also it must be not to exceed the temperature limit depending on the HOB construction. To achieve stable operation at an adequate O_2 content, air volume commensurate with supplied coal must be provided. This requires automatic coal supply facilities and system with automatic combustion air adjustment.

Heat-transfer surface of HOB effectively must absorb the heat from the flue gas as much as possible for improved heat efficiency. Fig. 4-19 shows the relationship between the HOB outlet gas temperature and heat loss when operated with O_2 content at 12% 15% and 18% in the combustion gas. To lower the HOB outlet gas temperature as much as possible and improve efficiency, the heat-transfer surface is required to keep clean by hammering, jet water washing etc.,. If predetermined performance cannot be achieved with these methods, the heat-transfer surface area must be increased (increasing the heat-transfer surface area of economizer is also accepted for boilers) or an air preheater installed at the HOB outlet.

The combustion system on the fixed grate should be modified to stoker type or fluidized bed type to improve the combustive performance.

We recommend employing a seal mechanism such as a rotary valve or double damper at the bottom hopper of combustion ash collecting cyclone separator to be able to discharge ash during operation.

Air pollution measures such as De-NOx, De-SOx for smaller HOBs may be technically and economically difficult but some measures for the improvement of combustive performance can be achievable with a small investment and save a coal cost.

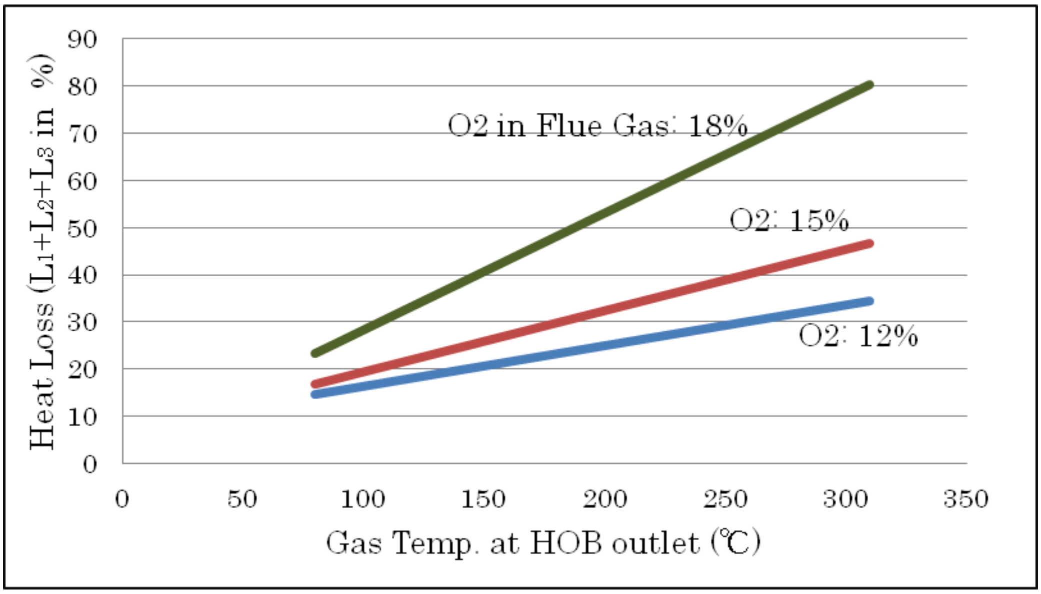

Fig. 4-19 HOB Outlet Gas Temperature and Heat Loss

(5) Future vision for heat supply

(a) HOB

As the coal fired HOBs will be required to install the De-Nox and De-Sox equipment in near future but it seems not to be easy to develop them from the economical point of view. Therefore we recommend to change the fuel from coal to so-called clean fuels like gas or kerosene but it is also difficult at the present due to its cost in Mongolia Briquettes are not clean fuel but better than coal and economical production method of them are required to develop immediately .

(b) Heat supply from power facilities

This is a heat supply system utilizing steam with lower energy level after having worked in the turbine of power plant. It is especially effective to improve the heat efficiency of the entire plant due to recover the latent heat of the steam. Heat has been supplied to the condominiums such as schools, hospitals, etc., in Ulaanbaatar from the second, third and fourth power plants but coverage of heat supply should be extended in collaboration with city plans for condominium construction plan to be able to use in wide. We recommend the heat supply net work system as in Fig. 4-20.

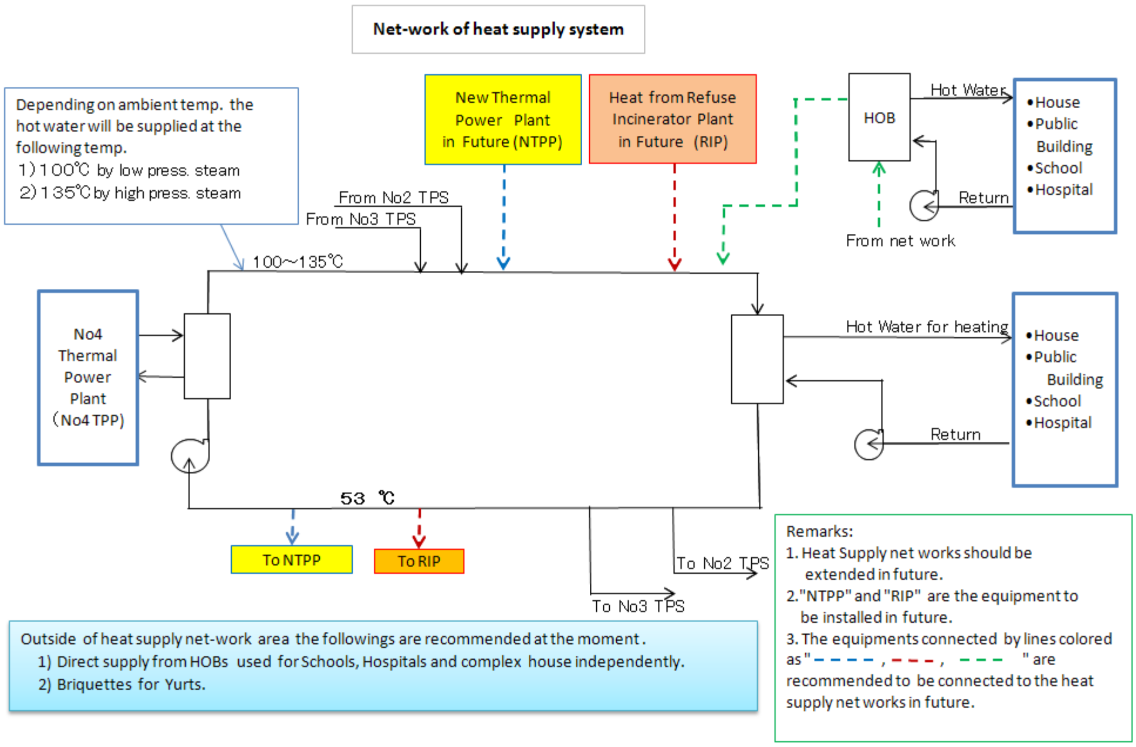

Fig. 4-20 Heat Supply Network

(c) Effective use of waste

Municipal waste has increased closely in connection with economic growth and their rates in developing countries are especially rapid. The amount of waste in Asian nations is expected to increase by 10%[41]. The amount of municipal waste generated in Ulaanbaatar is around 1500 to 1800 t/d (450 to 500kt/y), and is disposed by landfill in three places (west landfill (Narangiin enger), east landfill (Tsagaan dawaa), and south landfill (Moringiin dawaa) of Ulaanbaatar). The waste treatment plant is under construction at the east landfill and will complete in 2013. The waste generated will be separated to combustible, incombustible and recycle materials and combustible materials will be incinerated but the heat generated by combustion of them will not be recovered. The calorific value of waste also requires future research but it is expected to be about half of the lignite and the heat energy of waste might correspond to be in half of the coal used by HOBs in Ulaanbaatar in 2011. Under the city plan, we offer facilities with waste incinerators and an exhaust heat recovery boiler that collects incineration exhaust heat for condominium blocks expected to generate a large amount of daily waste, thus allowing for heat supply to condominiums and neighboring areas.

This proposal is included in the "26 projects for priority implementation by the cabinet" (see References, 1.1.3) so we expect continued evaluations by the Mongolian government.

4.1.3 Civilian/Public Businesses/Transport Sector[42]

(1) Overview

Among civilians, public businesses, and the transport sector, in locations where there are no power plants or supply of hot water from HOB, coal is the primary energy source for heating homes and offices, with residents using coal to fuel heating and cooking stoves.

Urban areas, particularly Ulaanbaatar, are seeing annual increases in concentrations of nomadic herdsmen. These herdsmen typically used stoves that burned horse and cow manure as fuel and are using these same stoves to burn coal. This results in incomplete combustion that has in turn led to increased air pollution problems over recent years. One factor causing this pollution is related to geographical characteristics of Ulaanbaatar. Ulaanbaatar is located in a basin along the River Tuul and is surrounded on both sides by mountainous terrain. In winters, when there is little wind, residents light their stoves in the mornings and incomplete combustion causes the release of coal dust and exhaust gases that sit stagnant in the air. This situation is similar to the London smog[43] that produced significant losses in 1952 and, similarly, health issues are being reported.

During the same period, air pollution problems resulting from coal burning for residential purposes were also seen throughout Europe and in Japan and prompted the development of a semi-coke referred to as house coke. However, it was during this same period that it became economically possible for these countries to transition to oil as a fuel source, which improved air pollution problems on a scale much

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41 Source: “Research for Estimate and Future Forecast of Global Waste Amount,” Masaru Tanaka, Research Institute of Solid Waste Management Engineering, 2011.

42 The category of “Civilan/Public Business/Transport Sector” is from the statistical data in Table 2-72. As all usage is for cooking and heating, they are combined and represented here.

43 London is known for thick fog in the winters but during the late 19th century, a industrial revolution and the use of coal fuel resulted in smoke produced from burning coal being mixed with the fog. This sediment came to be known as smog, which cause various health problems including respiratory ailments. In particular, the smog in 1952 was notably horrible as it led to eye soreness, throat pain, nasal irritation and coughing. In the week following this smog, numerous people we hospitalized for lung inflammation and heart problems, resulting in 4,000 more deaths than a typical winter. The majority of these victims were elderly and young children. In the following weeks another 8,000 deaths, or a total of 12,000 deaths, were attributed to the smog.

greater than what was possible with coal. Conversely, in the case of Mongolia, the country is dependent on exports for fossil fuels other than coal and with coal being consumed primarily by those in lower income classes, the major issue facing Mongolia is, with extreme winters where temperatures reach -15 °C to -40 °C, finding ways to burn low-cost coal cleanly.

In response, the country and city established air pollution taxes (1,000Tg/t) corresponding to coal consumption volume and through foreign funds and other financial backing are working to widen the use of house coke and other new fuels and stoves that are discussed below. From Table 4-32, we see that in 2010, there were 161,000 ger and single-dwelling residences and annual coal consumption among these residences was 668,000 tons, with HOB annual consumption reaching 134,000 tons[44]. Conversely, the supply of house coke during the winter period from 2012 to 2013 was at most 80,000 tons, representing approximately 10% of consumption. Also, 90,000 new stoves were being used in the 161,000 residences, representing a 56% rate of dissemination.

Table 4-32 Population/No. of households per hollow[45] in yurt district during 2010

Hallow (area name)	Ger area						
	Ger homes		Building homes		No. of ger stoves and wall stoves		
	Households	Population	Households	Population	Ger[46]	Wall[47]	Total
Bayangol	5,921	24,088	6,174	22,546	6,045	6,304	12,349
Bayanzurkh	22,582	86,954	21,548	85,898	23,056	22,000	45,056
Sukhbaatar	7,776	32,966	11,590	44,769	7,940	11,834	19,774
Songinokhairhan	19,700	86,687	21,731	97,457	20,114	22,187	42,301
Chingeltei	7,189	32,522	18,244	84,100	7,340	18,627	25,467
Khan Uul	6,428	23,019	12,236	45,922	6,563	12,493	19,056
Total	69,596	286,236	91,523	380,692	71,058	93,445	164,003

Source: Per hollow population data: City Office Statistics Bureau 2009 to which is added the average rate of population increase from 2000 to 2007 of 4.9%.

Stove volume: City statistical data, World Bank Ger Area Heating

(2)Status of new fuels

(a) Overview

Currently, the Mongolian government and Ulaanbaatar are working to promote the following fuels as new fuel alternatives to coal. In particular, there is a focus on promoting semi-coke and semi-coke briquettes commonly known as house coke[48]. New fuel categories are indicated in Table 4-33 while

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44 Excerpt from JICA project "Ulaanbaatar, Mongolia Air Pollution Response Enhancement Project. Project progress report (No. 3)" (Numerical plan), P21, 27-28.

45 Hallow is the common name in Mongolian for an area name in Ulaanbaatar.

46 Ger stove is a heater installed in a Ger.

47 Wall stove is a heater installed in houses which provide heating of a house effectively. The exhaust smoke is passing through the inside of the wall.

48 It is easily confusing that the house coke sounds similar to the semi-coke in Mongolia. However, the house coke defines it as a generic name of the carbonization coal fuel to use at home.

Table 4-34 indicates new fuel sales performance and supply plans.

Table 4-33 New fuel categories

Category name based on Mongolia National Standards	Common name	Remarks
Compressed sawdust		Called "ogatan" in Japan, it is used as a fire starter.
Compressed coal	Coal briquettes	Formed from coal dust, gas emissions properties are nearly identical to coal when burned.
Semi-coke smokeless compressed fuel	Semi-coke (House coke)	Coal subjected to low-temperature carbonization. No briquette processing means low-cost production.
	Semi-coke briquettes (House coke)	Formed by machine pressing the coal dust produced during low-temperature carbonization of coal.

Source: Category names referenced from Mongolia National Standards (MNS 5679:2011, MNS 5679-1:2011). Other created by JICAL survey team.

Table 4-34 State of new fuel sales and plans

Name of Manufacturer	Production capacity (t)	Supply volume (t)
Wooden Briquette		
Warm Energy		800
Dulaan Agaar		1,200
golden Blasé		500
Khairkhan buyant		800
Wooden briquette plant		2,500
Tara		680
Tenote		1,000
MNNBD		400
Semi-cokes		
MAK	75,000	6,000
Semi-cokes Briquette		
Sharin Gol Energy	15,000	5,000
No.2 TPS	100,000	0
Total		18,880

Source: Ministry of Mining Strategic policy and planning department at MONGOLIA – JAPAN GOVERNMENT AND PRIVATE SECTOR 6th FORUM, 2013

(b)House coke

1) Overview of semi-coke

Coal and semi-coke briquette burn tests using existing stoves used in Mongolia validate that volumes of coal dust produced are reduced by 1/3[49]. The reason for this is because semi-coke is produced through low-temperature carbonization at 500 to 600°C, which reduces the level of volatile elements

49 NEDO FY2006 International coal use policy project report "Clean Coal Ecology Validation and Promotion Project (FS) Mongolia Coal Improvement and Fuel Technology Survey Project".

typically found in coal, which in turn reduces the level of coal dust produced as a result of incomplete combustion when used in conventional stoves. Conversely, the remaining volatile portion impacts combustibility thus Mongolian standards outline 18% or less (daf base). Table 4-35 and Table 4-36 indicate Mongolian standards for new fuels. (Certain aspects of analytical base are unclear thus further research is required.) As of 2012, only MAK Co. is producing semi-coke. Details concerning MAK Co. production plants are discussed in 4.1.4(a).

The particle size of semi coke of MAK is +20 mm. A part of them are used by MAK, another part of them is sold for other companies as material for semi-coke briquette.

Pre-carbonization raw coal is shown in Fig. 4-21 and Pre-sorted semi-coke is shown in Fig. 4-22.

Fig. 4-21 Pre-carbonization raw coal

Fig. 4-22 Pre-sorted semi-coke

Table 4-35 Mongolian standards for new fuels

Fuel name	Total moisture	Sulfur content (ad)	Volatility (daf)	Ash content (ad)	Heat value (gar)	Size	Strength[50]
Compressed coal	Less than 15%	Less than 1.0%	-	Less than 38%	Above 3,800kca/kg	-	Above 80%
Smokeless compressed semi-coke	Less than 10%	Less than 1.0%	Less than 18%	Less than 38%	Above 4,500 kcal/kg	Above 40 mm	Above 85%
Compressed sawdust	Less than 10%	-	-	Less than 5%	Above 4,000 kcal/kg	-	Above 80%

Source: MNS 5679:2011

Table 4-36 Mongolian standards for semi-coke

Fuel name	Total moisture	Sulfur content (ad)	Volatility (daf)	Ash content (ad)	Heat value (gar)
Coal semi-coke	Less than 20%	Less than 0.8%	Less than 18%	Less than 25%	Above 4,800kcal/kg

Source: MNS 5679:2011

50 "Drop tests" are performed to confirm the durability of a compressed fuel. Five or six sample pieces are taken from the product and dropped from a height of 1.5m onto a stone or hard floor surface. Pieces larger than 25mm are collected from the dropped sample product and measured.

2) Semi-coke briquettes

Semi-coke briquettes are formed by combining pulverized semi-coke with a binding agent and then using a machine to shape them. With a carbonization oven, coal must be crushed to a size below 5mm and then freeze dried, thus requiring the molding process. With portable carbonization ovens, pieces above 20mm in size can be shipped as semi-coke but pulverized coal smaller than 20mm displays poor combustibility in stoves and thus this also requires the molding process.

Companies manufacturing semi-coke briquettes include Sharyn Gol Energy (SE Co.) and UOOM Co. and the No. 2 power plant is currently under construction. Fig. 4-23 shows SE Co. Semi-coke briquettes and Fig. 4-24 shows 30kg bags.

Fig. 4-23 SE Co. Semi-coke briquettes

Fig. 4-24 30kg bags

(c) Compressed sawdust

Sawdust produced during the production of construction wood is compressed and becomes biomass fuel. When burned independently, existing stoves do not present air pollution problems but heat value is inferior compared to house coke and in general, compressed sawdust is used as a starter material for coal stoves. Fig. 4-25 shows compressed sawdust products.

Fig. 4-25 Compressed sawdust

(3) State of stove improvements

(a) Conventional vs. new model stoves

Conventional stoves are designed for herdsmen to burn dried scat from livestock. In Japan, these are called “maki stoves”. They are not appropriate for the complete combustion of coal. Fig. 4-26 shows a ger stove used for both heating and cooking. During winters, to maintain continuous heating fires are lit in the morning and coal is added throughout the day. When cooking, the top lid is removed and a pot is placed on top. Not only is black smoke containing coal dust emitted as exhaust gas produced by incomplete combustion that occurs in the stove, but also CO and coal dust are released inside the ger when stove flames are fanned, which can lead to health problems.

Fig. 4-27 shows a stove used in a single-dwelling home. These are also referred to as "wall stoves" because they are designed so that exhaust is passed through the walls to heat all rooms in the structure. These stoves are constructed identically to ger stoves and are producing the same air and home pollution problems.

Fig. 4-26 Conventional gel stove

Fig. 4-27 Typical residential stove

(b) State of new model stove dissemination

Stove improvements and the introduction of new model stoves is occurring through proposals, research, awareness, and promotion activities by the World Bank and many other overseas donors. Particularly contributing to the dissemination of new model stoves is the Clean Air project that is part of the MCA (Millennium Challenge Account-Mongolia); a fund working with a budget of US$47.2 million. By the end of the project in 2013, they plan to replace old stoves with 97,000 new model stoves manufactured in Turkey. As of 2012, replacement of some 90,000 stoves was already exchanged. Fig. 4-28 and Fig. 4-29 show examples of new model stoves. Reviews of these stoves are currently being conducted.

Fig. 4-28 New model stove (Turkey)

Fig. 4-29 New model stove

(4) State and local dissemination support policies

As part of their air pollution countermeasure strategy, Ulaanbaatar city is using tax revenues and foreign funds to support the dissemination of house coke and new model stoves.

(a) House coke

Fig. 4-30 explains an example of sales prices, revenue, and subsidy amounts for house coke. In the figure, the green arrow indicates the flow of materials while the blue arrow indicates payments. Black numbers indicate amounts from 2011 and red numbers indicate projected amounts for 2012. Consumer house coke pricing is nearly equivalent to current market prices for coal.

As such, Ulaanbaatar city is bearing nearly 40% of the manufacturer's distribution price.

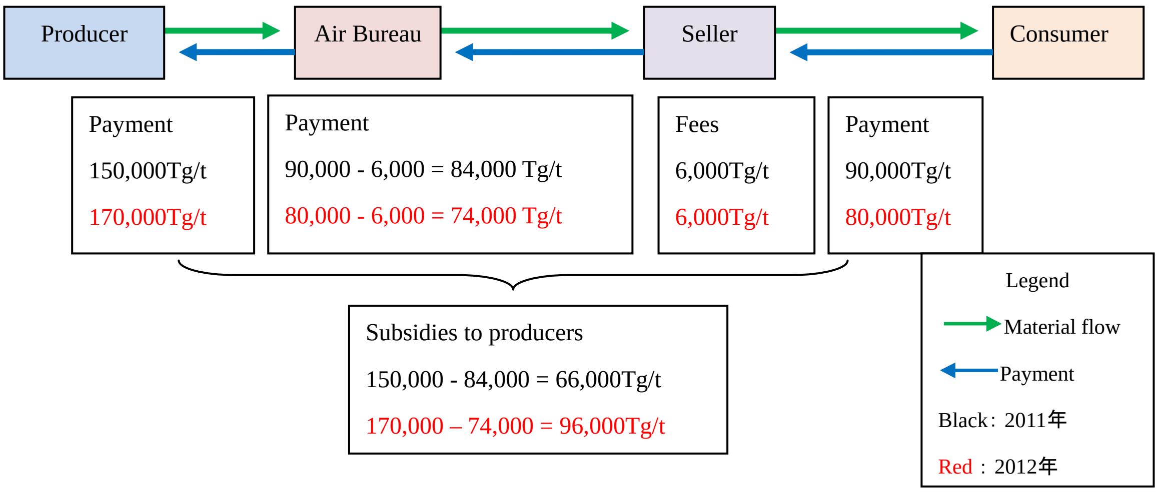


Fig. 4-30 Details of house coke flow and production costs

(b) New model stoves

New model stoves for ger are priced at 25,000Tg while stoves for single-family homes are priced at 50,000Tg. (The actual price of the stoves is nearly 10 times these prices so it is assumed that significant subsidies are being provided but, as some portion comes from the MCA fund, it is unclear actually how much in subsidies comes from air pollution taxes.)

(5) Issues

(i) House coke and new stove efficacy validation

The city has designated the Bayangol area as a house coke usage area and other areas have been designated as areas for installation of new stoves as a way to promote use. Although demand of coal in the Bayangol area is approximately 50,000 t, the amount of supply of new fuel, such as house coke, is 20,000t or less, and the amount of supply to the area was insufficient in 2012. Moreover, in the whole Ulaanbaater city, demand of coal is about 600,000 t and the most important thing for the country and the city is the design of policy to spread the house coke.

(ii) In order to give the private producer of house coke incentives, they should set up the subsidy corresponding to a manufacturing cost.

In chapter 4.3.6 (6) shows the demand of semi-coke in 2025. The use of semi-coke is effectual for atmospheric problems in the medium and short term, but it’s not enough as an answer. The new fuel produced from coal gasification is promising as a post-semi-coke, but there are some problems of how to proceed to realize it.

4.1.4 State of house coke production

(1) MAK Co.

Explanation of MAK Co. carbonization plant, which produces semi-coke (Fig. 4-31) and is located near the Eldev mine.

(a) Overview

- Construction started in June 2010, operations launched in March 2011. Shutdown in March 2012 after 1 year of operation.
- There are three carbonization ovens, each measuring 3m in diameter and 11m in height. Carbonization capacity is 3.5 to 4.5t/hr for annual performance of 75,000t, which requires 120,000t of coal.
- Last year production was 65,000t with 11,000t in inventory and sales of 54,000t.
- Semi-coke production produces tar and gas. Tar is sold to China and gas is reused at the plant.
- Semi-coke is packed in 30kg bags and shipped to Ulaanbaatar. Primarily used for heating purposes in the Ger area.
- Raw goal is grouped using sifters ranging from 20 to 100mm. Coal dust smaller than 20mm is used at the limestone plant or packed into coal sold to the power plant.
- +20mm is 40%, -20mm is 60%. Semi-coke smaller than 20mm that is not destined for cement plants and other non-residential use is sold to the Ulaanbaatar city briquette plant.

(b) Process

Mounds of coal blocks are transported to the supply hopper of the semi-coke oven via a conveyor. Manipulating the supply hopper switch valve injects coal into the semi-coke oven. Fig. 4-32 shows carbonizer coal insertion shoot. The semi-coke oven uses air-based partial combustion to increase oven temperature to above 800ºC. Fig. 4-33 shows carbonizer intermediate firing. This heat carbonizes the coal and turns it into semi-coke. Semi-coke is dropped into a water tank at the bottom of the oven and cooled. The semi-coke is then removed from the cooling tank and transported outside. Semi-coke oven gas generated during semi-coke production is extracted from the top of the oven and cooled via a water rinse tower. This is where tar is separated from the gas. Coke oven gas is treated as follows.

1) reused as fuel for the semi-coke oven
2) heat source for coal drying
3) remainder is sold

Furthermore, the temperature of the semi-coke oven gas outlet reaches 200 to 300ºC with pressure between 0.5 and 1.5 kPa. Fig. 4-34 shows semicokes before screen.

(c) Facilities/operations

- The facilities in the plant were manufactured in China. The building was built by the Mongolians but fixtures and facilities come from China.
- Specialty training occurred over a period of two months during which time operation was learned from Chinese specialists. From there, MAK has conducted its own training.
- There are 55 plant employees (15-18 per shift) working in 12-hour shifts to achieve 24-hour operation. MAK handles trouble response and maintenance internally.
- MAK Co. semi-coke production technology know-how has grown and they are applying that experience to consider gasification and diesel production, etc.
- The most important elements of creating good-quality coke are coal quality and engineering prowess (know-how).
- Semi-coke quality evaluations are conducted internally with reports being issued to the National Air Quality Office.
- Injected coal returns 50 to 60% semi-coke and 4% tar.
- They currently have 250 to 300t of tar remaining (approximately 10% of total). Ulaanbaatar is researching utilization technology.
- They are paying due attention to environmental problems and currently there are no issues concerning smell, dust, or noise. Drainage is also circulated and the company practices tree planting.
- CO measurement gauges are on site. They also have ordered individual samplers. Apparently there have been reports of dizziness during work thus it is problem to work at this environmental.

Coke oven gas composition is indicated in Table 4-37.

Table 4-37 MAK Co. Carbonization oven COG[51] composition (vol%)

CO2	CmHn	O2	CO	H2	CH4	N2
2.8	0.2	0.2	28.4	13.6	6.6	48.2

Source: Carbonization oven data referenced and organized by JICA survey group.

- N_2 and O_2 come from the air. Oxygen density is low and they are operating at a very low air/coal ratio.
- CO_2 is produced during coal firing. H_2, CO, and CH_4 are produced during carbonization (heat dissipation reaction). H_2 density is low, CO density is high, and C_mH_n is smaller compared to gas from the dedicated coke oven. From this, we see that operating parameters are based on the firing side.
- Sustained oven temperature – 200 to 300ºC.
- Propane used for oven ignition.
- The coke production process for iron and steel, the coke and tar yields are 72% and 18%, respectively. Compared to these figures, yields from this plant are low. Putting it another way, the coke oven gas yield is high. Observation suggests that the reason for this is due to the fact that while a dedicate coke oven is heated externally, this plant partially burns coal (internal heating), thus coke yield is low and gas yield is high.

(d) Issues

- As Erdev Coal Mine owned by Mak LL is nearly close due to depletion of coal resources, manufacturing of semi coke is under consideration. Company has a plan to combine oil shale project at Khoot coal mine and new semi coke project at new factory.
- The reasons for the low amount of semi−coke supply to Ulaanbaatar, i.e. 6,000 tons, in 2012 are the production cost and the issue of tar disposal. How to store tar has become a problem since China stopped to receive it.

Fig. 4-31 Carbonizer full view

Fig. 4-32 Carbonizer coal insertion shoot

51 COG refers to coke oven gas (COG) generated from a coke oven.

Fig. 4-33 Carbonizer intermediate firing

Fig. 4-34 Semicokes before screen

(2) Sharyn Gol Co.

(a) Overview

- The semi-coke briquette plant has been operating since 2011. There is one carbonization oven that processes 6t/h of raw coal to produce 3.5t/h of carbonized coal (Fig. 4-35). The carbonization oven manufacturer is Jiko Heavy Industries Corporation, located in the city of Taiyuan in Shanxi, China (Fig. 4-36). SE Co. focuses on the manufacture of semi-coke briquette from the beginning and has consistently the technologies of carbonization oven and the process of briquette is different from MAK.

(b) Process

- Carbonization temperatures range from 500 to 650ºC and carbonization gas and tar are produced as byproducts at a rate of 2,000 to 3,000Nm^3/h and 3 to 5%, respectively. Tar is separated via electrical precipitation and then stored. Currently evaluating whether to export to China or manufacture high value-added chemical products. Carbonized gas from which tar has been removed is dehumidified and run through a dry desulphurization process using ferric oxide. A portion of the refined gas (500Nm^3/h) is used for the drying of carbonized coal and the rest is dispersed via combustion. Carbonized coal is turned into briquettes via a briquette machine (capacity: 8t/h) to which is added a binder made from starch (3 to 4%) and NaOH solution and then dried at 150 to 250ºC until water content reaches approximately 5%. The briquettes are then packed into 20kg bundles and shipped. Three types of raw coal are used: Sharyn Gol coal, Baganuur coal, and Eldev coal (MAK Co.) and carbonization times differ depending on the type of coal. Baganuur coal has the highest gas content. (Gas 40%, coke 60%.) Fig. 4-37 shows carbonization process.

(c) Construction and Operation

- In 2012, briquettes totaling 2,000t/y were sold to the National Air Quality Office. They are planning to sell 5,000t/y this year. The price is 170,000Tg/t ($125/t) and the sale contract has already been concluded.
- Compared to carbonized coal, molding into briquettes provides high durability and thus the

product is less likely to crack during transport and briquettes are easier to burn during actual use. Conversely, the starch used as a binder (1MTg/t) is costly and increases the costs of the briquettes. To offset this, they are considering the plant facilities able to produce starch from potatoes.

- Approaches to environmental problems include the use emitted gas as fuel, thus they are planning the construction of a 3MW generator. They already have executed a purchasing agreement for gas engine generators. There are no complaints from surrounding residents to the plant concerning odor. Tar is being stored in an underground tank. Inspectors come from the city office once every three months. They issue monitoring results reports to the city office.

(d) Future plan and Issues

- Management consulting staff has been dispatched from the Japan branch of EBRD[52] to provide managerial guidance to SE. The construction of two places foundry coke plant of 300 thousand ton scale is currently under consideration. This coke oven is a non-recovery type; originally German technology now held by China and Australia. Gas and tar byproducts are reduced and thus the oven is easy on the environment. COG is planning to generate power using a gas engine (power capacity: 3MW).
- Tests are being conducted regarding the production of coke from coking coal (7,000 to 8,000kcal/kg) from the Mogollin Gol mine owned by SE Co.
- The manufacture of semi-coke in winter is discontinued because of freezing of tar. Maximal production capacity in consideration of it is 15,000 ton per year.

Fig. 4-35 13m diameter carbonizer

Fig. 4-36 Name plate

52 EBRD: European Bank for Reconstruction and Development

Fig. 4-37 Carbonization process

(3) No. 2 Power Plant

(a) Overview

At the No. 2 power plant, they are planning to refit existing boilers to semi-coke manufacturing specifications in order to produce semi-coke and make semi-coke briquettes at a newly constructed facility. At present, retrofitting work on the first boiler has been completed and they are conducting test runs.

Retrofitting only involved converting the bottom ash collector of the existing boiler to a fluidized bed carbonization oven. Carbonization gas is combusted on the spot by the boiler flame to serve as a heat source for steam. Including the fact that air is used for the carbonization process, it is a method matches the boiler’s functionality. Fluidized bed ovens use a brick construction, meaning facility construction costs are likely to be low. Carbonization gas contains tar, phenol and other substances that require environmental measures but as they are completely combusted by the boiler, exhaust gas is the same as any normal boiler and thus as a coke production oven it does provide superb environmental friendliness.

1) Construction background

The background to establish semi-coke briquette plant in second power plant shows Mongolian policy of promoting semi-coke.

- 2007: Plan proposed
- 2009: Bidding for semi-coke briquette production plant announced
- April 2010: International consortium of Mongolia and Russia’s Siberia Thermo Co. win bid.
- November 2010: Basic specifications set. Semi-coke production volume set at 210,000t/year.
- March 2011: Construction begins.
- April 2012: Starting trial operation Coke oven test run. Eight test runs thus far. Two boiler

steam production trials. The briquette production plant for turning semi-coke into briquettes is 80% complete.

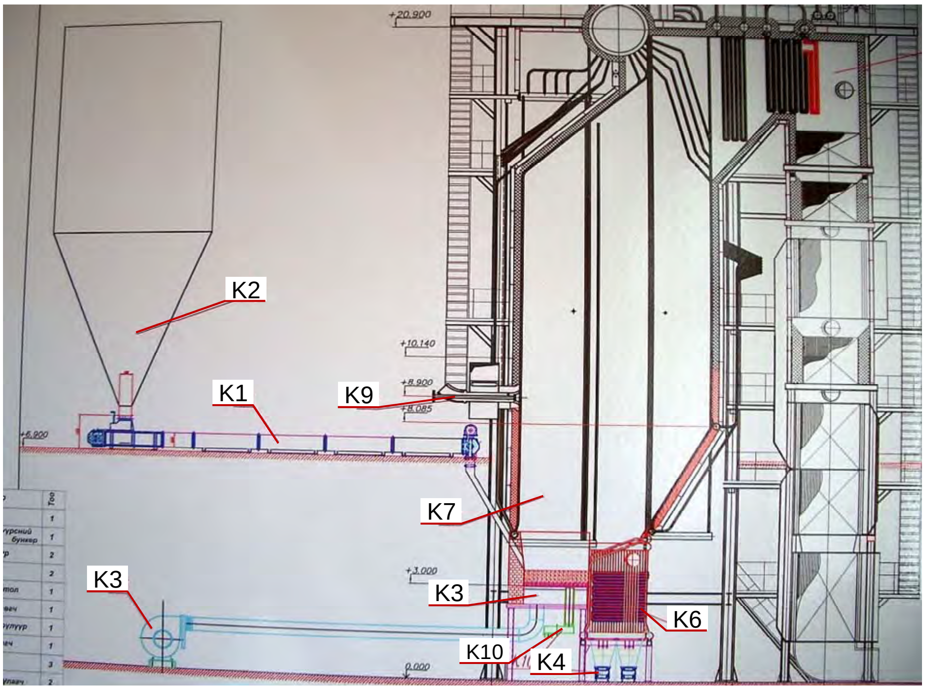
- March 2013: Because of adjustment to semi-coke oven, products have not been shipped yet.

2) Reference: Semi-coke oven construction overview

- This plant is designed with the concept to produce 210,000 tons of semicoke per year without changing the amount of vapor generation, accordingly the generated electric energy, of the existing boiler. The amount of coal supply is 200,000 tons per year using the existing power generation facilities, and 400,000 tons per year for electricity and coke collectively.
- Since the amount of vapor equivalent to the existing boiler is generated with the modified boiler and coke are produced at the same time, they conducted burning of existing powdered coal and carbonization gas generated in the process of producing coke in the boiler.
- The bottom of furnace of the existing boiler was modified to coke furnace.
- Carbonization technology: Russia's Siberia Thermo Co.
- Carbonization method: Fluidized bed method, partial air oxidation method[53]
- Semi-coke production volume: 8 to 10t/h, coal consumption volume: approximately twice the semi-coke production volume.

Fig. 4-38 shows the retrofitting diagram for the existing boiler. The red portion inside the diagram indicates the retrofitted portion.

[53]Estimated by JICA survey group based on diagrams, explanations, and deliberation.



K1: coal conveyor, K2: coal hopper, K3: air blower, K4: semi-coke receiving conveyor, K6: semi-coke cooling heat transfer, K7: air tower (boiler furnace), K9: existing coal powder burner, K10: coke oven object extractor

Fig. 4-38 Semi-coke oven

(b) Semi-coke production process

- Coal bits (Baganuur coal) are crushed to a particle diameter of 0 to 15mm. It is likely they will use the existing mill for this process but particle diameter for powder coal boilers is normally on average 0.1mm thus it is likely they have changed the crusher parameters of the mill to produce a rougher grain particle size.
- Crushed coal is collected in the hopper (K2) and from there travels on the conveyor (K1) and is injected into the carbonization oven. (Fig. 4-39)
- The carbonization oven is thought to be a fluidized bed with partial air oxidation system. Air is taken in from below the dispersal plate to partially oxidize coal that is moved around (firing in a state of insufficient air, a form of gasification). Volatile elements are emitted from the coal. These volatile elements together with a portion of the carbonized coal (semi-coke) are ignited in the air, which causes the temperature to rise. The temperature reaches 700ºC. Semi-coke collects in a dam built at the end of the fluidized bed and enters the heat exchanger for cooling.
- Heat transfer pipes, through which runs cold water, are built into the heat exchanger. Here, the 700ºC semi-coke is cooled to a certain extent. The heat exchanger is thought to be a moving bed type. Semi-coke exiting the heat exchanger is sprayed with water and probably cooled to near room temperature. This coke is transported on a conveyor to the briquette production plant.
- Carbonization gas produced in the fluidized bed works to increase boiler temperature. Heat is transferred to the boiler's heat transfer piping to produce steam.
- Semi-coke quality was approximately 5,900kal/kg during test runs. During the briquette production

process, semi-coke is crushed, ash is added to adjust the calorie level, and a liquid glass adhesive agent is added. Their goal for product calorific value is approximately 4,500kcal/kg.

Fig. 4-39 Coal shoot

(c) Construction and operation

- The cost for modifying boiler is 20 billion Tg (approximately 1.3 billion yen including facilities for manufacturing briquet).
- The operation system is consisted of 4 shifts of three persons per shift for carbonization furnace (boiler) and totally 46 persons for briqquet.
- The Government has wholly funded the manufacturing facilities of briquetting (14 million US$) and promoted the project. However, the adjustment operation has been delayed until present. While the facilities were scheduled to complete in August 2011, only one system of briquet line had completed as of September 2012 and the remaining part is scheduled to complete in March 2013.
- With regard to the quality of semicoke, the semicoke has less residual volatile substances and presents a problem with ignition performance. There is a bubbling-type fluid bed in the lower part of boiler, presenting a problem of unstable combustion in the upper furnace. Reduction combustion is implemented in the fluid bed and air is introduced for complete combustion from the burner before modification, which has not succeeded in ensuring safety operation. If the amount of fluidized air is increased, fine powders in the bed will scatter without being burned. If the amount of fluidized air is decreased, there will be a problem of increased bed temperature. Its performance depends on the quality of coal supplied. They consider some kind of management such as sieving supplied coal is necessary.
- The modification of No.4 furnace will start after the modification and operation of No.5 furnace have become complete.

(d) Issues

(i) There is an issue of whether or not fluidized bed operation and management can be done properly. As this is the first attempt at such a project, significant time is likely required before stable operation can be achieved. In particular, temperature control is vital. Temperatures too high will produce ash clinkers that will prevent fluidity and cause operations to stop. Sufficient learning during the test run period is important.

(ii) Using coal powder necessitates that briquettes be formed thus costs must be evaluated carefully. There is the method of carbonizing lump coal and selling that as semi-coke but this would produce coke of a size that could be used as in stoves. As such, a comparison of semi-coke and semi-coke briquettes will be required at some point in the future.

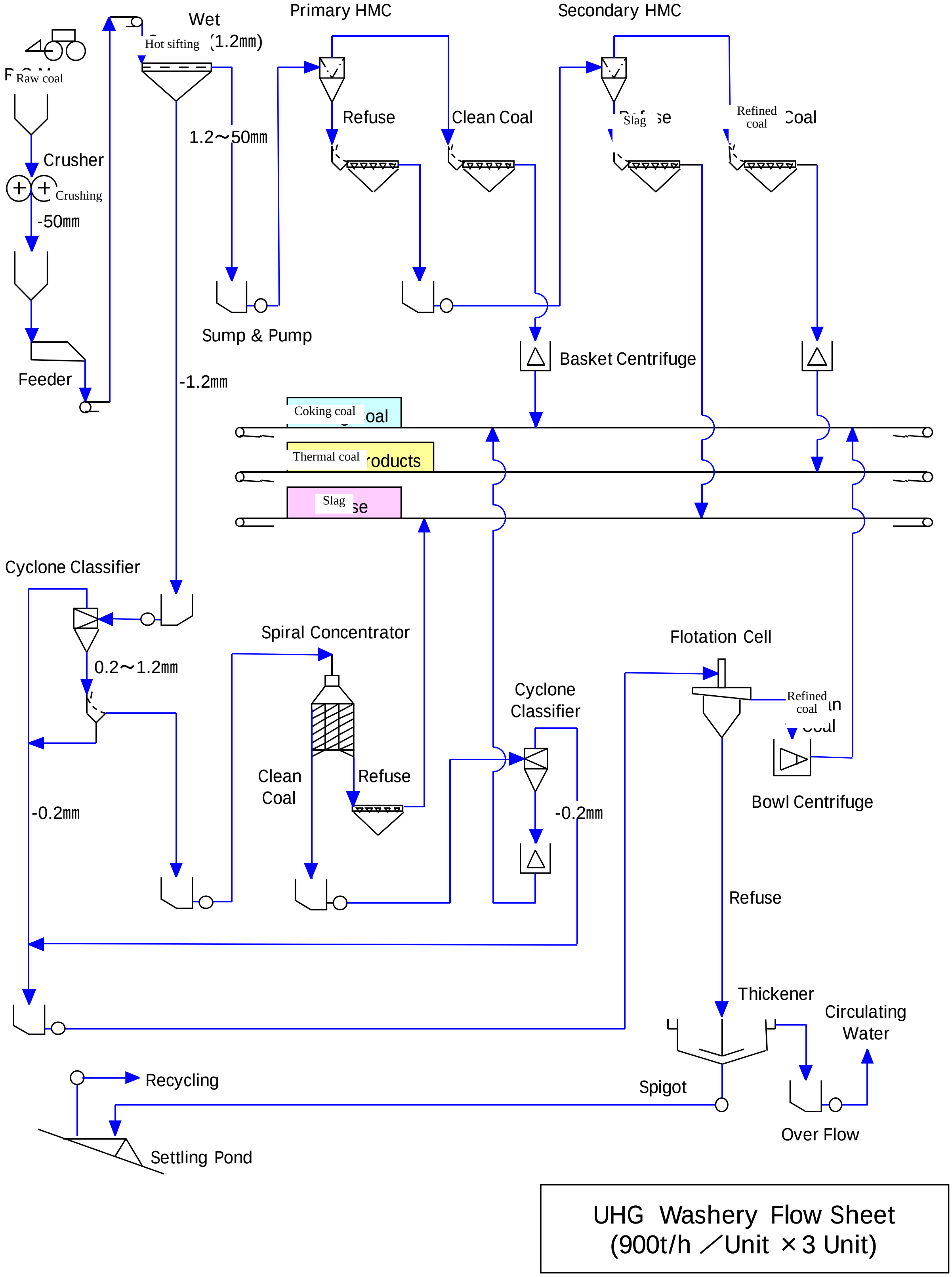
(iii) Semi-coke production at the No. 2 power plant is a national project. The biggest problem facing the new administration is the quick resolution of issues and the achievement of initial production goals. The JICA survey team had the request from the Mongolian government regarding support of semi-coke production on the No. 2 power plant.

4.1.5 Analysis of current coal preparation technology and evaluation of improvement potential

(1) Current state of coal preparation plant

(a) UHG (Ukuhaa Khudag) mine

The UHG mine preparation plant (see Fig. 3-7) is the country's first large-scale preparation plant. The coal preparation company Enrestechnology Co., which is owned by Energy Resources Co., manages coal preparation while the Australian company Sedgman acts as a contractor in charge of transport and expansion construction. The preparation facilities were constructed by Sedgman and have a raw coal processing capacity of 5Mt/year (900t/hour) x two units. Additionally, they currently are building another unit that is planned for completion at the end of this year. As a result, the processing capacity became 15 million tons per year (2,700 tons per hour). A flow sheet is shown in Fig. 4-40.



Source: Created by JICA survey team based on materials obtained from the UHG mine.

Fig. 4-40 Coal Preparation Flow Sheet

Raw coal crushed to pieces less than 50mm is screened by 1.2 mm wet type screen. Raw coal ranging in size from 1.2 to 50mm is separated into three categories - coking coal, middling coal, and reject – via a primary dense-medium cyclone and a secondary dense medium cyclone (Fig. 4-41). Average ash content is 20% in raw coal, 10.5% in coking coal, 16 to 20% in middling coal, and 30 to 40% in reject. Coking coal yield is approximately 70%, making it good raw coal for coal preparation.

Thermal coal is 20% in amount of raw coal; produced 2-3 million tons per year. Part of them is discarded to reject yard except for utilizing by Energy Resources Co.

Raw coal which is smaller than 1.2mm is sorted at 0.2mm groupings using a cyclone. Groups from 0.2 to 1.2mm are feed to spiral (Fig. 4-42) while groups smaller than 0.2mm are feed to floater (Fig. 4-43) for coking coal production. Coking coal smaller than 1.2mm is mixed with coking coal of sizes from 1.2 to 50mm and transported to coal yard.

Fig. 4-41 Dense-medium cyclone

Fig. 4-42 Spiral

Fig. 4-43 Flotator (Jameson Cell)

Coking coal is transported along a dedicated sifting road to the Chinese border 245km away (the coal transport company Transgobi, owned by Energy Resources, handles transport).

With the exception of amounts used at the power plant (6MW x 3) owned by Energy Resources, some 20% of raw coal volume, thermal coal generated at a volume of 2M to 3Mt/year, is discarded as unusable coal at a dump site.

Assuming raw coal moisture of 0% and average product moisture of 5%, processing 15Mt/year (2,700t/hour) of raw coal requires a supplemental water supply of 135m^3/hour. This supplemental water is being drawn from a well that lies 20km from the preparation plant. In total there are 12 wells and currently six wells are being operated to supply 350 to 400m^3/hour to the preparation plant and the power generator. There also is a plan to dig a new well in a location 50km from the plant.

(b) Erdenes Tavan Tolgoi (TT) mine

Refer to 3.6.2 for an overview of the mine.

Erdenes-TT Co. is planning to construct a coal preparation plant with a raw coal acceptance capacity of 15Mt/year and this plan has been included in the TT Project ("26 Priority Projects") created by the government. The Erdenes-TT design group (located in Ulaanbaatar) already has completed the FS. As for water for coal preparation, they are surveying water sources located 65 to 70km southwest of the *Baragashi Inorannuru* mine.

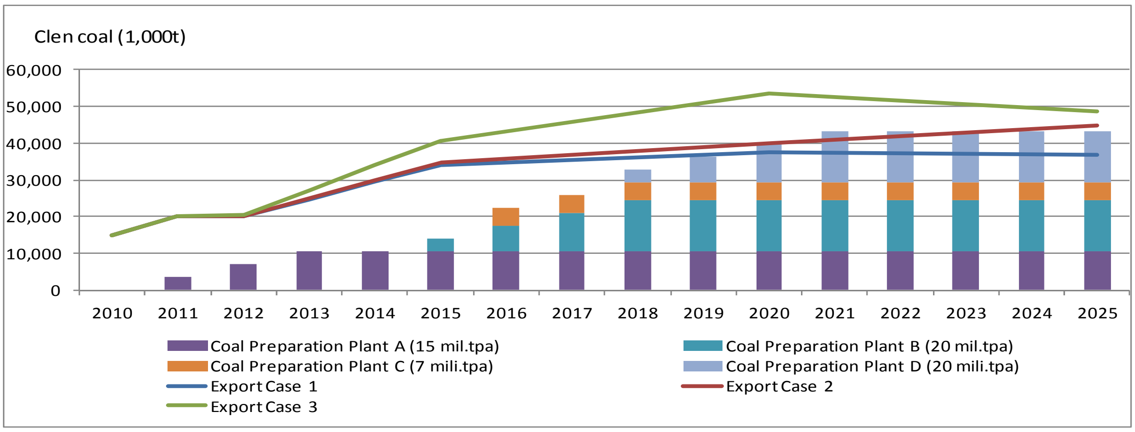
(2) Coal preparation plant Plan

Table 4-38 indicates coal preparation plant construction status through 2025. In 2021, coal preparation capacity for the four plants A - D will be 6.2M tons/year. Assuming a refined coal yield ratio of 70%, Clean Coal production volume will reach 4.34M tons/year. Also, Fig. 4-44 is a bar graph showing Clean Coal production volumes following processing at the preparation plant. The plotted line in the figure shows export volume based on Mongolia's raw coal export potential evaluated in Chapter 2. 4.2. Raw coal export potential is projected in Case 3 of Case 1 - 3 and is based on raw coal demand volumes in China. Case 1 is based on a decline in Chinese demand for raw coal, Case 2 is based on virtually stagnant demand, and Case 3 is based on an increase in demand. With Case 1 and Case 2, raw coal export demand volume can be fully supplied via Clean Coal produced in Mongolia. For Case 3, Clean Coal volumes would be insufficient so it would require exporting raw coal and conducting coal preparation in China to produce Clean Coal.

Table 4-38 Expectation of Constructing Coal Preparation Plant

Coal Preparation Plant	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2025
Plant A(15 Mtpa)	5,000	10,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Plant B(20 Mtpa)					5,000	10,000	15,000	20,000	20,000	20,000	20,000	20,000
Plant C(7 Mtpa)						7,000	7,000	7,000	7,000	7,000	7,000	7,000
Plant D(20Mtpa)								5,000	10,000	15,000	20,000	20,000
Total throughput capacity	5,000	10,000	15,000	15,000	20,000	32,000	37,000	47,000	52,000	57,000	62,000	62,000
Clean coal	3,500	7,000	10,500	10,500	14,000	22,400	25,900	32,900	36,400	39,900	43,400	43,400

Source: JICA study team



Source: JICA study team

Fig. 4-44 Expectation of Coking Coal Export and Production from Coal Preparation Plant

(3)Issues and response measures

(a) Quality management

(i) UHG coal preparation plant is managed by an Australian contractor but there is question as to whether or not operating results evaluations are being conducted for the Mongolians and whether or not requirements are being issued to the contractor. A strategy is needed that involves analyzing what volume of coal from among discarded thermal coal (middling, intermediate product) and reject could be converted to coking coal in order to increase the yield ratio for coking coal.

(ii) Construction of this plant started in 2008 and thus the Mongolians' experience operating the facility is still limited. Going forward they will need to develop Mongolian plant managers capable of understanding all aspects from operations to analysis and demand management.

(b) Expanding use of intermediate product

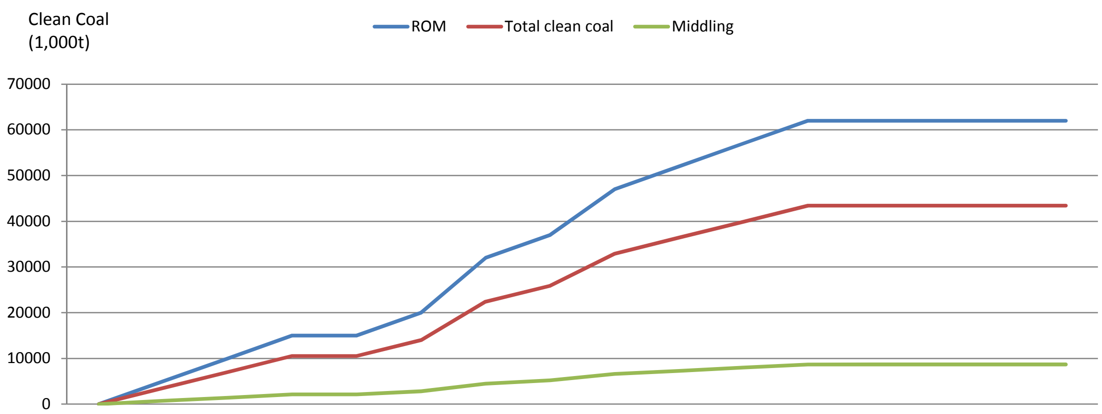
(i) At the UHG mine coal preparation plant, with the exception of amounts used at the power plant (18MW) owned by Energy Resources, some 20% of raw coal volume, intermediate product generated at a volume of 3Mt/year, is discarded as unusable coal at a dump site. As the volume of intermediate product will most certainly increase, they are facing the issue of how to utilize this intermediate product.

This 18MW power plant covers demand for the village Tsogttsetsii, the UHG preparation plant and mining camp, and does not have surplus to provide any further supply so the country is planning to construct a 300MW power generator as part of its TT Project. FS is currently underway. Power generated here would be supplied to the Erdenes-TT coal preparation plant, electric excavator, mining camp, and residential area as well as provide power to the city of Dalanzadgad and connect to the central grid to transmit power to the Oyutolgoi copper mines. However, a 300MW power plant would only be able to utilize 1.5M tons of intermediate product a year, which is barely half of the intermediate product produced at the UHG coal preparation plant. Furthermore, once the Erdenes-TT coal preparation plant (15Mt/year) becomes operational, an additional 3Mt/year of intermediate product will be produced.

In the government plan through to 2025, they are planning to build a 300MW power plant to create a system providing a total of 600MW of power. Though the plan calls for 600MW, the amount of intermediate product that could actually be utilized would be no more than 3Mt/year, which would mean no more than half of the 6Mt/year of intermediate product produced by the UHG and Eredenes-TT preparation plants could be utilized.

The Mongolian government’s plan for the future involves moving away from the simple exporting of excavated raw coal toward the exporting of value added product. The first step in increasing the added value of coal is coal preparation. When planning operations in coke and other coal chemical industries, or when planning advanced CCT, the first requirement is coal preparation that provides “stable quality, low ash, low sulfur” coal. Producing coal (primary product) with the quality required for these applications will always result in the production of intermediate product (secondary product) as a byproduct.

Fig. 4-45 shows projected levels of intermediate product produced from coal for export purposes based on projections for coal preparation plants in operation by 2025. Intermediate product production volumes[54] are projected as follows: 2015 - 2.8M tons, 2020 - 8M tons, 2025 - 8.7M tons.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
ROM	0	5,000	10,000	15,000	15,000	20,000	32,000	37,000	47,000	52,000	57,000	62,000	62,000	62,000	62,000	62,000
Total clean coal	0	3,500	7,000	10,500	10,500	14,000	22,400	25,900	32,900	36,400	39,900	43,400	43,400	43,400	43,400	43,400
Middling	0	700	1,400	2,100	2,100	2,800	4,480	5,180	6,580	7,280	7,980	8,680	8,680	8,680	8,680	8,680

Source: Expected by JICA study team basis on MRAM data

Fig. 4-45 Expectation of producing Intermediate Products

(c)Development of dry coal preparation system

In Mongolia, it is difficult to secure the water resources required for coal preparation. At the Khushuut mine owned by the Mongolian Energy Company (MEC)., there is much sediment thus the preparation

[54] According to MRAM data, the yield ratio of a middling was assumed to be 20% (That of a coking coal was assumed to be 70%).

process is vital but due to local pressure they are unable to even survey for water sources. Required is the development of dry coal preparation technology and other methods that do not use water like the fluidized bed dry-wash method of coal preparation being developed in Japan.

4.2 Installation of future coal utilization techniques in Mongolia

4.2.1 Outline of global coal use

Separating coal utilization for CCT, each overview are shown follow. Details of technology are described in references.

- Coal preparation
- Efficient utilization
- Flue-gas treatment/gas cleaning
- Effective coal ash utilization
- CO_2 separation/collection
- Coal transformation
- Fundamental technologies

This section describes the outline of the technologies above.

(a) Coal preparation

Coal preparation is a first CCT step which processes coal mined into “Constant quality/Low-ash/Low-sulfur” product coal and an inevitable process for efficient coal utilization.

China has been researching the latest coal preparation technologies but the coal cleaning process has not been sufficiently applied to general coal yet. India currently delivers coal with 40% to 50% of ash into power plant without any coal cleaning after transportation more than 1,000km. Widespread use of coal cleaning is mandatory for China, India and Mongolia aiming at higher coal utilization.

(b) Efficient utilization

“Energy saving/Resource saving” have been required for efficient utilization based on combustion technology, gasification technology, iron application technology and cement application technology. As described later, coal is the most common fuel used by power plants. Coal is a key area for recent global environmental issues and various high efficiency generation technologies have been put into practical use. These technologies are evaluated with many parameters such as efficiency, reliability, safety, economic efficient and environmental friendliness. When a high efficiency and high performance technology are introduced into a developing country, the parameter of “Technology proficiency” is also important so that evaluation for this parameter is mandatory for Mongolia. The next segment which uses coal after generation is iron industry. Many power-saving efforts such as reduced coke rate[55] have been taken for years. Prior to update of coke ovens with average age at 30 years, Japan has developed “SCOPE21,” an innovative next generation coke manufacturing technology, which is flexible to expand useable coal resources, best in environmental measures, power-saving and productivity in Japan.

(c) Flue-gas treatment/gas cleaning

Flue-gas treatment and gas cleaning are based on desulfurization, denitration and dust removal

[55] Amount of coke to produce one ton of pig iron

technologies. Japan has been advanced in these technologies which are exported overseas. Whether a technology is accepted depends on the relationship with environmental regulations but a simplified method is used if the regulations are not so strict. These regulations will inevitably be introduced to the countries and in regions where regulations are comparatively weak, selection of technologies will become more important.

(d) Effective coal ash utilization

Fields for which coal ash is effectively used are: cement segment occupying 60% of entire use (largest), civil engineering segment for lightweight boards and base course materials at 14%, construction segment for aggregates at 3% (Japan, 2010). Cement production has tended toward reduced use in recent years so that it is difficult to expect significantly increased production in the future in Mongolia. Therefore, expanded use by other segments becomes an important issue to cope with future increased coal ash and it is expected coal ash will be used as civil engineering material.

(e) CO_2 separation/collection

CO_2 separation technology has wide variety and many technologies are being developed or implemented. CO_2 separation/collection technologies were originally established in the oil and chemical industries. As a concept "plan of reduce CO_2 emission" has derived from recent global environmental problems, CO_2 density, separation energy (power) and separation efficiency are called for separation technology. This resulted in developing technologies which improve the performances of existing absorbing liquid, absorbing and recycling methods.

(f) Coal transformation

Coal transformation is to convert coal to clean gas, liquid or a solid to be used as clean fuel and typically consists of gasification technology, direct liquefaction technology, ash removal technology and reforming technology. Development of direct liquefaction technology was started mainly by the United States and Japan after the oil crises in the 1970's but it has not been commercialized yet. China is the only country that has started commercial plants.

(g) Basic technology of coal utilization

Research into basic coal utilization technology included the coal characteristics and gasification properties during coal gasification, environmental properties, highly reliable gasification furnace designs, and scientific and engineering research into the dynamics of micro-elements found in coal. Results are being gained from precision gasification reaction models and ash control theories, and this research will be a powerful tool in the rapid commercialization of coal conversion technology.

(2) Global movement of coal utilization technology

Various coal application technologies were organized as above. These technologies are not used independently or individually but used always as a combination of upstream (coal mining) and downstream (final product manufacturing). Use process of coal is called Coal Flow, and technologies and their respective processes in the flow are shown in Fig. 4-46. This figure shows that multiple technologies are used for a process. These technologies are different in maturity: one within development, another at commercial level. If Mongolia is to introduce a new technology as described above, it is important to examine the maturity and economic efficiency to choose one from technologies with the same purpose.

This section describes global coal use segments (sectors). According to IEA statistics, the use segments are classified as follows:

<Primary fuel> Power generation
Gas manufacturing
Transformation as solid fuel (briquette, coke, blast furnace coal)
Transformation as liquid fuel* (liquid fuel manufacturing)
*Other transformation

<Final use> Industry
Transportation
Residential
Commercial/public

Table 4-39 shows that segments using the most coal are the electric power segment and then the iron-related segment (iron-making). In OECD countries, the electric power segment is at 82% (largest) and then the iron-related segment is at 8%. In China, which mostly uses coal, the electric power segment is at 54% and then the iron-related segment at 17%, and in India at second place, the electric power segment at 69% and then the iron-related segment at 9%. In any of these countries, the electric power segment and the iron-related segment occupy 70 to 90% for coal. Remarkable item with smaller volume in Table 4-39 is residential coal use. Residential use in OECD countries, China and India are respectively 1.6%, 3.2% and 1.0%. This means that Mongolia uses more coal at 5.7% (2008). They directly burn coal for heating and cooking in yurts and this causes pollution problems in Ulaanbaatar. Countermeasures to the problems are an important theme for the master coal use plan. Table 4-39 shows that coal used for chemicals for China and other transformation for South Africa is gasification use. China manufactures ammonia, methanol and DME, and South Africa manufactures synthetic petroleum during the coal gasification process. Both countries are the only countries in the world which set the coal gasification as a major national technology in a segment. As shown above, the electric power segment and iron-related segment are two major coal markets globally.

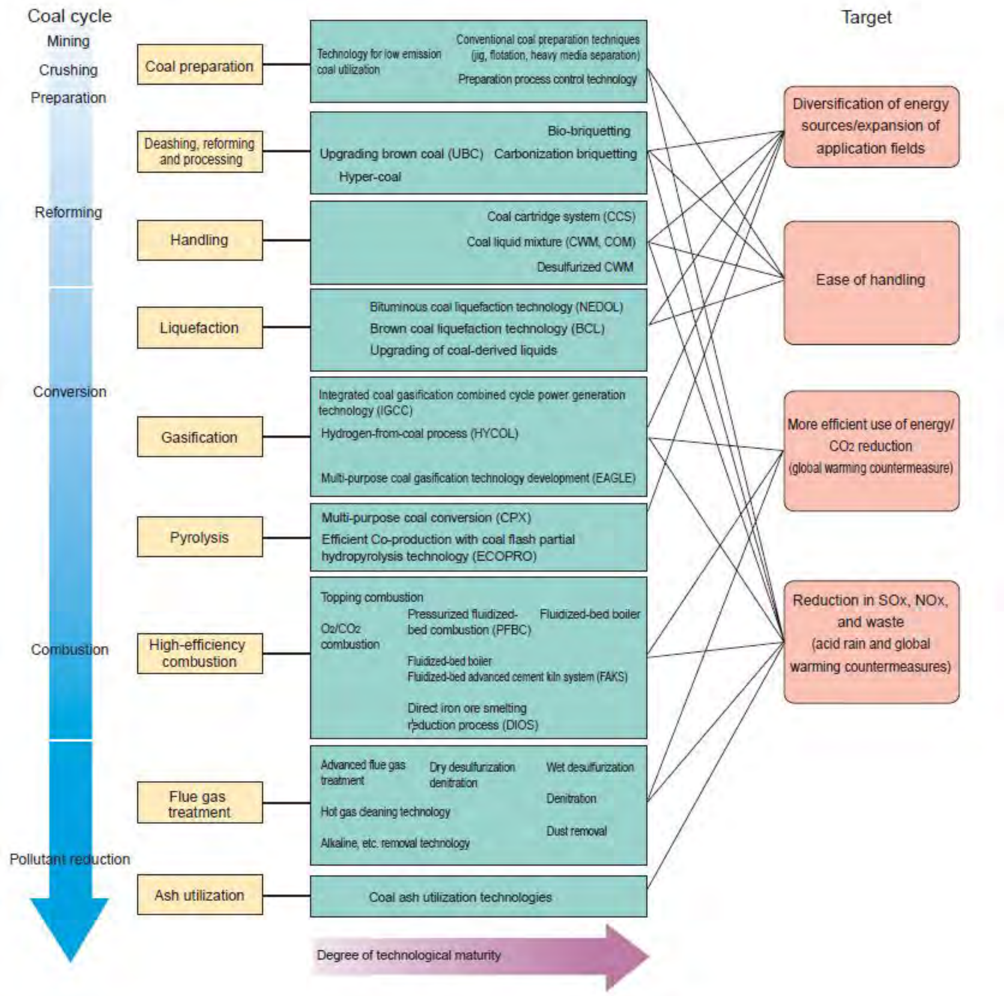


Fig. 4-46 Coal Use Processes and CCT (Clean Coal Technology)

Table 4-39 World Coal Use Segments

	OECD Total	China	India	Russia	Aouth Africa
Primary Supply	**1,476.1**	**2,168.0**	**407.7**	**136.1**	**140.5**
Total electricity&Heat	1,208.8	1,166.0	283.3	92.0	84.1
Main activity producers	1,172.2	1,155.0	248.0	65.4	80.7
Autoproducers	36.6	11.0	35.3	26.6	3.4
Gas works	2.9	4.8	0.0	-	3.1
Coal Transformation	66.3	150.9	13.2	19.9	1.9
Patent Fuel/BKB* plants	0.5	2.8	0.2	0.0	-
Coke Ovens	10.1	30.3	5.0	11.0	1.3
Blast furnace inputs	56.7	117.8	8.0	8.9	0.6
Other transformation**	1.0	-		-	26.0
Final consumption	**164.0**	**738.8**	**106.0**	**26.1**	**25.0**
Industry	129.2	577.7	70.6	19.3	12.8
Iron & steel	47.0	220.8	23.9	16.6	5.3
Chemicals	14.8	60.3	2.5	0.8	1.4
Non-metallic minetals	23.7	174.1	9.9	1.2	0.8
Paper,pulp&print	9.6	17.0	2.1	0.0	0.1
Transport	0.1	4.5	-	-	-
Other***	31.8	111.2	35.3	6.5	10.6
Comm& pub services	6.7	14.7	5.1	3.6	3.4
Residential	23.1	70.3	9.2 4.1	2.7	6.8
Non-energy use	2.9	45.4	-	0.2	1.6

* BKS; Brown Coal Briqueetes

** Liquifaction and non-specifiled transformation processes

*** Includes commertial and public services, agriculture, and residential

Source: IEA Statistics & Balance, http://www.iea.org/stats/pdf_graphs/MNTPES.pdf

4.2.2 View of coal utilization techniques installing

(1) Fundamental Policy of coal utilization techniques installing

Mongolia's fundamental policies with its plans for the development and use of goal learned during this survey are as follows. Mongolia aims to use assets procured through resource exports to establish a strategy for self-sufficient national energy based on coal as they seek to quickly establish energy security for Mongolia. The government is confident that it will have the support of the people regarding coal development and the establishment of coal usage technology for this purpose.

Conversely, there are many within government and private ranks who feel the country should process coal to affix added value and export it. However, since their national industrial infrastructure is lagging, we got the impression that it is still too early for such policies. In detail, the first matter facing the country is the issue of incorporating coal usage technology that meets domestic demand. As such, they should look to take steps toward being an industrial nation through the establishment of a technological environment, the acquisition of technology, and the development of human resources.

As Mongolia has a small population, domestic demand is low and it is projected that domestic production costs for processed coal products using coal utilization technology would exceed the cost of imported products. However, paying into the Mongolian population through the contracting of domestic manufacturing companies will provide greater benefits and lead to industry growth when compared to making payments to foreign countries for their products. In the future, when increased domestic production exceeds demand, the remainder can be sold have export products.

(2) Vision of coal utilization techniques installing

It is important to satisfy the view on master plan that a vision of coal utilization techniques installing for developing countries is needed to view differently for developed countries. Bellow, marshal our ideas as a reference the study which World Bank conducted.

It is important to evaluate contributory and priority in coal utilization techniques installing. In World Bank study, three points: demand, advance of industry and policy were adduced as contributory in Mongolia, added to evaluate these intensions (Table 4-40)[56]. Also this study pointed that if policy has legal force, priority will be decreased because of without needs or industry power. This industry power means the industry which has core curtain techniques or progress level of industry system. This system means that engineering company having such technique, maker of such equipment, user, and organization or business operator selling and distributing productions etc. how these were developed. In the field were not developed about them, hasty industrialize will cause a large risk because technical development or installing need to take a step-by-step approach. In Mongolia, coal gasification technique falls into this. However, if the contributory can develop that field in future, the installing will be forwarded positively on a step-by-step approach.

[56] World Bank Report,Clean Coal, Lignite Mining and Power Development Options Study in Mongolia-Draft Report-September 23, 2008

Table 4-40 Evaluation of Coal Usage Technology Implementation Sectors and Priority Levels[1)]

Sector		Incentives			
		Demand	Industrial power	Policy	Overall
Upgraded coal		A	C	B	B
Heat generation		B	A	B	B
Power generation		A	A	A	A
Gas production		C	- - -	C	C
Chemicals production		- - -	- - -	A	C
Liquid fuel production		C	- - -	B	C
Rating	A	Large	Substantial	Strong	Significant
	B	Medium	Moderate	Moderate	Moderate
	C	Little	Little	Weak	Weak
	- - -	Negligible	Negligible	Negligible	Negligible

For this survey, we targeted "electricity", "heat supply", "transportation", "steel", "chemicals", and "city gas" as six potential sectors for coal use and where Mongolia should concentrate its efforts. We also evaluated the potential for non-coal fuels (alternative fuels) in each sector as well as the usage technology on which the country should focus. The results are indicated in Table 4-41.

Table 4-41 Target Sectors for Coal Usage, Energy Resources, and Usage Technology in 2025

main　partical use　trial operation　prematurity

Field \ Resources		Coal: Direct Use	Coal: Changeover Use	Oil	Others: LPG	Others: Waste Product	Others: Wind Power	Others: Solar	Others: Water Power
Power		CHP						Solar Power	
Heat	Industry	CHP							
	Communal Facility	CHP	HOB			Stoker oven			
	House	CHP	House-Coke						
Car Fuel			Gasification GTL	Refined oil					
Industry Fuel			Gasification GTL	Refined oil					
Iron Manufacture		Coke oven							
Chemical Goods			Gasification MTO	Chemical Synthesis					
City Gas			Gasification SNG						

The power sector will continue to debate on how to use resources other than coal. However, Mongolia is a coal country and for the time being it should continue to focus on coal-based thermal power plants, which have the longest history of success in the country. Converted coal use, in other words, for the reasons noted below (b), gasification-based power generation is something that is still too early for Mongolia to consider. Hydro power plants are being used in areas not connected to the thermal power plant system and produce approximately 3.7MW. Currently, there is a concept being floated for a 300MW Hydro power plant in Shuren[57]. In general, as water resources are sparse, this is considered a power source for limited regions.

Currently, Mongolia's heat supply is largely divided into the following categories:

(1) Large-scale, wide area supply via CHP plants

(2) Supply to large-scale facilities via HOB

(3) Supply to individual homes using house coke

Mongolia needs to work to improve thermal efficiency, improve user convenience, and environmental impact as they look to 2025. A new thermal coal power plant needs to be at the core of a CHP method for large-scale, wide area distribution. However, considering the need for a significant increase in electricity demand and power generation efficiency and, as was analyzed in Section 4.4.3, considering that future heat demand is not expected to grow on the same pace as electricity demand, they should consider reducing the heat supply load placed by improvement of efficiency on CHP power plants. More specifically the power generation will be increased by the reduction of heating steam for heat supply and making the low pressure turbine steam increase without increasing of boiler load in future. Conversely, as was indicated in 4.1.2, one aspect of city trash processing in Ulaanbaatar could be heat supply using trash incinerators. Considering their economical nature, heat supply to ger homes will continue to remain dependent on house coke for some time. Production facilities need to be expanded. As the country's economic state improves, in terms of convenience and environmental impact as well they need to consider liquid fuels (gas) for gers. LPG is now being used in hotels and other large-scale facilities. They need to complete a delivery base for receiving imports but as it involves a simple system based on gas tanks and transport vehicles, an acceptance base would be a simple facility (converged piping and valves). As such, LPG should be expanded to use in apartments and residential areas. LPG can also serve to supply areas with no electricity or heat services.

Fuel used in the transport sector is currently gasoline and diesel imported from Russia. While there has been an increase in the number of LPG vehicles, in terms of volume (thermal volume) this still represents less than 1% of petroleum products. The advance of motorization has led to increased demand for petroleum products. Currently, there is a plan to construct a 44,000 bbl/d refinery in Darkhan City[58]. Annually, it would produce approximately 1M tons of gasoline and diesel. When added with current import volumes, this is sufficient for meeting 2020 demand volumes (refer Fig. 4-81). Future demand for petroleum products will warrant the construction of a second refinery. Currently, they are evaluating the production of a liquid fuel based on coal gasification but, for the reasons noted below in Section 4.2.3(3), we believe it is too early for this. The coal gasification technology needs to progress

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[57] Bayarbaatar.Ts.,Right Generation Structure of Integrated Energy System of Mongolia,Mongolia

[58] Marubeni News release,September,29,2010

gradually so that by 2025, they will have gained experience by operating small-scale gasification facilities.

Petroleum (diesel fuel) is used for industrial fuel. Similar to above, future increases in demand will be met through a mixture of imported products and domestically refined products.

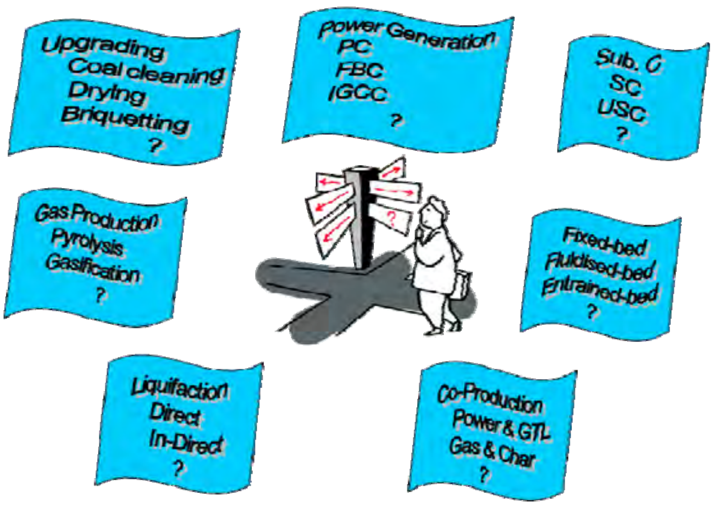
Sectors with potential for coal use include a gasification-based chemical product production system, which is a major industry in China. The framework to use the coal for chemical industry is not ready for because the chemical industry has non- fully developed in Mongolia.

If, for example, there were to attempt to manufacture base products like ethylene, from a commercial standpoint such efforts should be based on a matured petroleum chemical industry. The buildup of either coal chemical or petroleum industries will require careful market analysis and research into commercialization.

The production of synthetic natural gas (SNG) through coal gasification would first require the transplanting of gasification technology into Mongolia. Bringing natural gas to Mongolia will be a major theme in the future and basic evaluations are being conducted concerning the potential for CBM, power generation, and residential uses[59].

(3) Evaluation of installing techniques

There are various types of coal utilization technologies (Fig. 4-47). There are multiple methods for coal preprocessing (quality improvement), incineration, gasification, liquefaction, and joint production. It is vital that new implementation of these techniques be proceeded by an evaluation of which techniques are most suited to the country.



Source: World Bank Report,Clean Coal, Lignite Mining and Power Development Options Study in Mongolia-Draft Report-September 23, 2008

Fig. 4-47 Types of Coal Utilization Technique

[59] Mongolian Nature & Environment Consortium, Methane Recovery and Utilization Opportunities,Ulaanbaatar,2009

Factors to evaluate when considering bringing coal utilization techniques to a developing country include: i) shape of the country's industry and energy conditions, ii) technology assessment, and iii) project feasibility (Fig. 4-48). During the creation of this Master Plan, we considered the following factors concerning the evaluation of techniques.

Source: World Bank Report,Clean Coal, Lignite Mining and Power Development Options Study in Mongolia-Draft Report-September 23, 2008

Fig. 4-48 Coal utilization technology assessment factors

(a) Fuel Adaptability

Regular coal, the major type found in Mongolia, is a low quality coal with a large water content. As such, incorporation of overseas technology installing will require adaptation to the coal quality. Normally, crushed coal boilers use coal with a maximum water content of 35% so it would be beneficial for new power plants to have drying facilities.

In general, fluidized bed boilers are said to be geared towards low quality coal and there is a long record of past performance but operational management of fluidized bed boilers requires significant experience and incorporation of such facilities would require the establishment of a training program as well.

(b) Maturity and Difficulties in Usage

Technology constantly evolves and there are types of CCT that are currently under development or being validated. Though performance is excellent, there is little history as a commercial product and since there is a risk involving not knowing annual operating rates, this is not something that should be implemented immediately. Even if efficiency is low, they should focus on using highly reliable machines and facilities in order to ensure ease of operating management and facility maintenance and inspections.

Even with globally established technologies or with something that is a first-time experience for Mongolia, they will need to be careful when incorporating technology. The longer it takes to conduct test runs in order to master a new technology, the longer production is delayed and the more negative impact is had on business revenue.

There are few examples of evaluating "level of maturity and ease of implementation" when considering factors for technology assessments. Table 4-42 shows an excerpt from the results of a World Bank analysis of technology implementation in Mongolia. For example, compared to subcritical or supercritical power plants, ultra supercritical power generation requires a higher level of training. Also, IGCC requires special education and experience for successful use during the demonstration stage.

With coal gasification plants, entrained-bed systems have reached commercial viability but use requires special training. This analysis also includes temperatures and pressure for each process. As temperatures and pressures increase, the difficulty of use also increases. These specifications also present new problems in terms of safety management and thus future implementation of pressurized facilities in Mongolia will require the establishment of safety regulations. These analysis results are from 2008 so each technique may have evolved somewhat but it still should be referenced as a comprehensive assessment of coal utilization technologies.

We have discussed that the incorporation of coal gasification technology into Mongolia must be done carefully. Below, we explain a case study that will serve as reference regarding the issue of maturity of technology and the difficulty of operation and management. Among gasification technologies (Reference 1.3.4 for details), the GE/Texaco method is historically one of the most established methods and is used in China, Japan, and the United States. The biggest user of this method in the United States is Eastman Co. Methanol and acetic acid are produced from coal gasification gas and those are used as raw materials for the production of plastics, film, and resins. They boast an incredibly high rate of annual operating time at 98% and they credit "people" as the greatest driving force behind this high performance[60]. This means that they have numerous personnel with vast experience. An analysis of this situation is shown in Source：Hrivnak.S., Fine Tuning to Improve Availability and Reliability of Coal Based gasification, Gasification Technologies Conference 2001,Oct.2001

Fig. 4-49. This figure shows the level of experience and time required for operation and maintenance.

60 Hrivnak.S., Fine Tuning to Improve Availabilitu and Reliability of Coal Based gasification,Gasification Technologies Conference 2001,Oct.2001

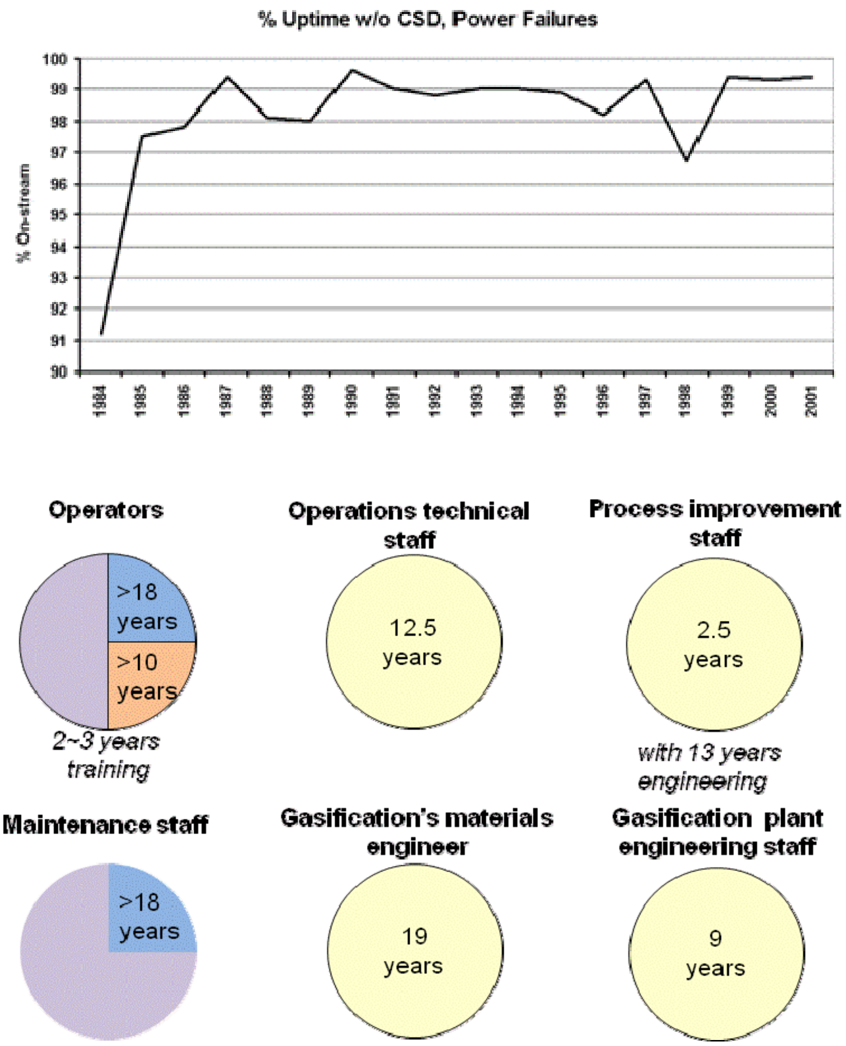
Table 4-42 Coal utilization technology assessment - Excerpt -

Sector	Technology		Features		Matuarity of Technology [1)]				Difficulty In Usage 2)		
			P(MPa)	T(℃)	P	D	C		E	M	H
Upgrading Coal Production	Preparation (Cleaning)	Wasing	0.1	25			○	Completely proven. More by use of		○	
		Dry Separation	0.1	25			○	Completely proven			
	Evaporating Drying	Slurry Dewatering	0.1	150~200	○			Under development			
		Steam Tubular Dryer	0.1	110~140			○	Most industrial scale use	○		
		Steam Fluidised-bed	0.1	150	○			Under development			
	Non-evaporative Drying	Mechnical Thermal	~6	150~180	○						
		Hydrothermal	8~20	275~325							
		High Pressure	3~4	240		○		Proven but specific		○	
	Low Temperatur Pyrolysis (Coking)	Rotary Kiln	0.1	450~700		○		Proven in small scale	○		
		Fruidised-bed	0.1	300~700		○		Proven in small scale	○		
	High Temp.	Coke Oven	0.1	900<				Completely proven			
	Briquetting or Pelletizing	Mixer Agglomeration	0.1	25					○		
		Disk Pelletiser	0.1	25					○		
		Roall Press	0.1	25					○		
		Extruction	0.1	28~65					○		
Electric Power Generation	Fluidised-bed Combustion -FBC-	Bubbling FBC -BFBC-	*Boiler* 0.1 *Steam* 16.625.1	*Boiler* 800~900 *Steam* 566/593			○	Proven at small scale (<350MW)		○	
		Circulating FBC -CFBC-	*Boiler* 0.1 *Steam* 4~25.1	*Boile* r 800~900 *Steam* 545/545			○	Proven as relatively small scale (<330MW)		○	
		Pressurized FBC -PFBC-	*Boiler* 1~2 *Steam* 16.6~25.1	*Boiler* 900 *Steam* 566			○	Substantially Proven			○
	Purverised Coal Combustion	Sub Critical	*Steam* <24	Steam 566			○	Completely proven	○		
		SuperCritical	*Steam* 24	*Steam* 566-593			○	Completely proven		○	
		Ultra Super Critical	*Steam* 24	*Steam* 593<			○	Substantially		○	
	Integrated Gasification Combined Cycle -IGCC-	Fix-bed	*Gasifier* 2~3 *Steam* 10	*Gasifier* 600~1200 *Steam* 538		○		*Not proven *Less available than PCC *Operating experience is somewhat specialised			○
		Fluidsed-bed	*Gasifier* 2~3 *Steam* 10	*Gasifier* 850~950 *Steam* 538		○					○
		Entrained-bed	*Gasifier* 2~4 *Steam* 10	*Gasifier* 1200~1600 *Steam* 538		○					○
Town Gas Production	Gasification	Fixed-bed	*Gasifier* 3	*Gasifier* 600~1200			○	Completely proven, but limitative			○
		Fluidsed-bed	*Gasifier* 1.6	*Gasifier* 800~900		○		Proven			
		Entrained-bed	*Gasifier* 2~3	*Gasifier* 1200~1600							
Chemicals Production	Pyrolysis	Entrained-bed	*Gasifier* 0.1~1	*Gasifier* 600~900	○			Under development			○
	Gasification	Atomspheric Fixed-bed	*Gasifier* 0.1	*Gasifier* 1200	○			Completely proven	○		
		Pressurised Fixed-bed	*Gasifier* 3	*Gasifier* 600~1200				Completely proven, but limitative			○
		Fluidised-bed	*Gasifier* 1.6	*Gasifier* 850~950		○		Demonstration completed			○
		Entrained-bed	*Gasifier* 2~3	*Gasifier* 1200~1600			○	Completely proven			○
Liquid Fuel Production	In direct Liquefaction	Fixed-bed	*Gasifier* 3	*Gasifier* 600~1200			○	Completely proven, but limitative			○
	Direct Liquefaction	SRC-2	*Liq. reactor* 14	*Liq. reactor* 460	○			Long so far			○
		EDS	17	450	○						○
		H-Coal	20	450	○						○
		New IG	30	480	○						○
		BCL	15	450/360	○						○
		NEDOL	17	450	○						○
		Shenhua	14	460							○

1)【Maturity of Technology】P: Pilot plant stage, D: Demonstration stage, C: Commercial stage

2)【Difficulties in Usage】E: Ease to O&M, M : Moderate to O&M, H : Need special education and Experiences

Source: Evaluation Criteria, World Bank Report, Clean Coal, Lignite Mining and Power Development Options Study in Mongolia-Draft Report-September 23, 2008



Source: Hrivnak.S., Fine Tuning to Improve Availability and Reliability of Coal Based gasification, Gasification Technologies Conference 2001,Oct.2001

Fig. 4-49 O&M team at US Eastman's gasification plant

(c) Coal utilization technology R&D experience

The above related to technology difficult of use but when assessing the incorporation of a technology, it is important to consider whether or not the country has experience and history applying that technology. In general, significant time is required to master coal utilization technologies. As shown in Fig. 4-50, mature technology in Mongolia is power generation technology. Additionally, they also have been studying the production and preparation of house coke in recent years.

Moving forward, improved efficiency of crushed coal power generation will be vital and ideally, Mongolia should switch from current subcritical to critical facilities. However, there is a dramatically technological leap between subcritical and ultra supercritical, thus mastery would require study and training. The incorporation of coal gasification technology would require the elements shown in Fig. 4-50. Learning these elements will require time and effort. They should begin by first working with small-scale test facilities.

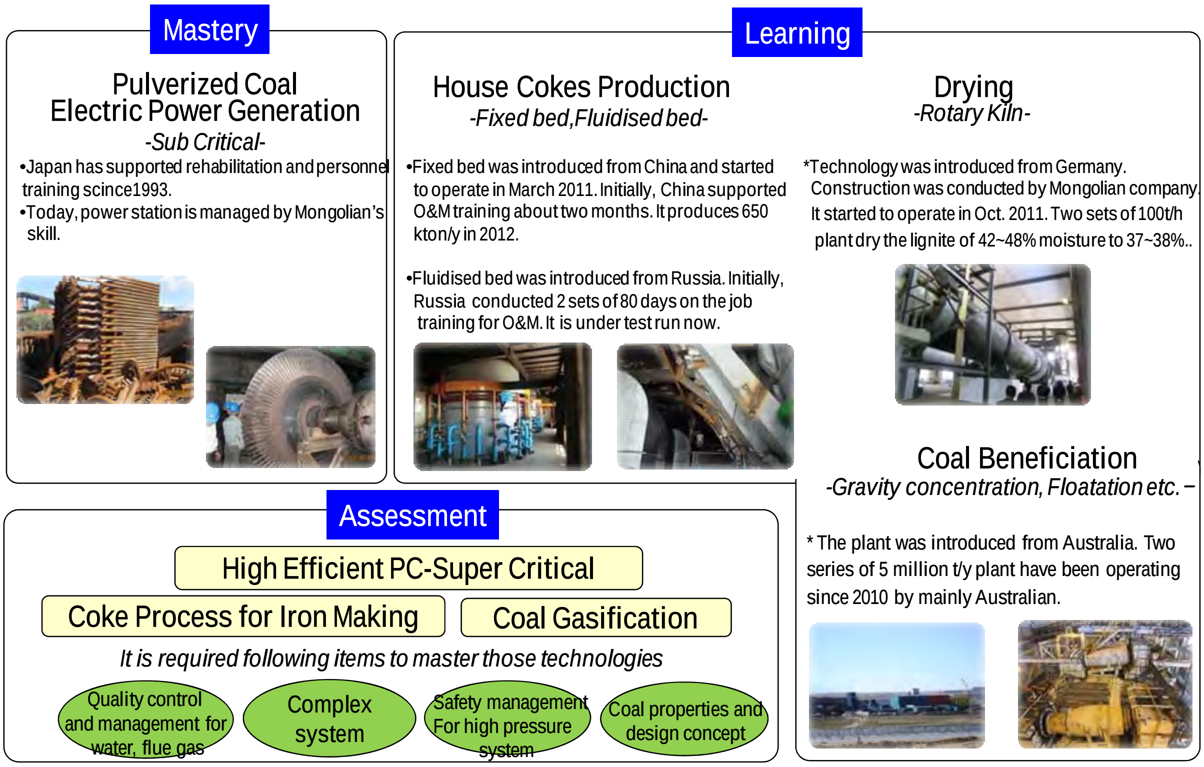


Fig. 4-50 Process of incorporating coal technology in Mongolia

(d) Environment

There are also various technologies for removing environmental pollutants. Major substances produced a power plant using large volumes of coal are as follows:

i) Sulfur compounds

ii) Nitrogen compounds

iii) Smoke and dust

In each case, what kind of removal technology is implemented will depend on trends in environmental regulations. Table 4-43 shows elimination standards for current and new power plants. Currently, the main No. 4 power plant is equipped with an electrical dust collector but is not equipped with desulfurization or denitration facilities. The plant is satisfying allowed values for SO_2, NOx, and dust (Section 5.3.2). Allowed values for new facilities are most strict that for existing facilities.

Table 4-43 Maximum allowed environmental pollutants from power plants

Substance	Current: MNS5919-2008		New power plants :MNS6298-2011	
	Conditions*	Concentration	Conditions**	Concentration
CO (mg/m^3)	Coal supply capacity 221～420ton/h	180	Population density 10～1000 persons/km^2	180
	Coal supply capacity 76～220ton/h	300	Population density less than 10 persons /km^2	300
SO_2 (mg/m^3)	Coal supply capacity221～420ton/h	1,200	Population density 10～1000 persons /km^2	400
	Coal supply capacity 76～220ton/h	1,485	Population density less than 10 persons /km^2	600
Soot dust (mg/m^3)	Coal supply capacity221～420ton/h	200	Population density 10～1000 persons /km^2	50
	Coal supply capacity 76～220ton/h	10,800	Population density less than 10 persons /km^2	200
NOx (mg/m^3)	Coal supply capacity 221～420ton/h	715	$V_{daf}<10\%$	1,100
	Coal supply capacity 76～220ton/h	1100	$10\%\leq V_{daf}\leq 20\%$	650
			$20\%<V_{daf}$	450

*No. 3 power plant: 210ton/h, No.4 power plant: 525ton/h **Ulaanbaatar 254 people/km^2

Table 4-44 shows an example of environmental technology application in Mongolian power plants conducted by the World Bank. Here, the following two technologies are indicated as options.

A: Crushed coal boiler power generation method (Sub Critical PC)

Desulfurization technology: Dry desulfurization

Denitration technology: Internal combustion (two-stage process combustion)

Dust removal technology: Electric dust collector (removal rate 99%<)

B: Fluidized bed boiler method (CFBC)

Desulfurization technology: Internal desulfurization

Denitration technology: Internal combustion (secondary air, long retention times)

Dust removal technology: Electric dust collector (removal rate 99%<)

This would make it possible to achieve SO_2 of 1000mg/Nm^3, NOx of 400 or 510mg/Nm^3, and dust of 50mg/Nm^3. However, this survey was conducted in 2007 and new power plant guidelines had not yet been released. SOx was set at 1000mg/Nm^3 based on guidelines used in Asia and by the World Bank at the time. Today, regulated values for new power plants in the above Table 4-43 are set at 400mg/Nm^3, thus the results of the 2007 report need to be reevaluated.

As at present the No. 4 power plant is meeting regulated levels without desulfurization equipment, we can presume that SOx levels are currently at least below 1200mg/Nm^3. To bring this level down to below 400mg/Nm^3 would require technology that achieves desulfurization of at least 70%. This is easily achievable using the dry desulfurization method noted above. This method is referred to as simple desulfurization and facilities expenses are cheap. Details are provided in Reference 1.3.8.

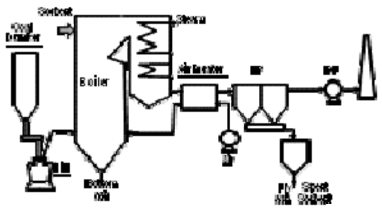
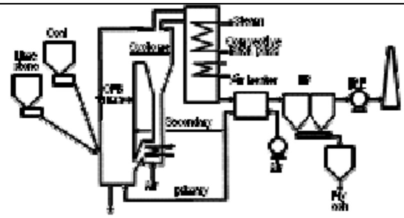
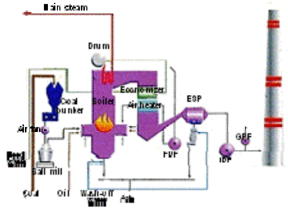
For denitration, regulations differ depending on the level of coal volatile components. As shown in

Table 4-23, typical coal likely to be used moving forward is Baganuur coal and Shivee-Ovoo coal, which have volatile component rates of 36 to 48%, which if applied to the above NOx regulated values, means that 450mg/Nm^3 is the allowed level. As at present the No. 4 power plant is meeting regulated levels without denitration equipment, we can presume that NOx levels are currently at least below 715mg/Nm^3. To bring this level down to below 450mg/Nm^3 would require technology that achieves denitration of at least 40%. As seen in the World Bank survey, at this level improvements can be achieved via a two-stage process combustion method. Or, internal non-catalyst denitration via ammonia insertion is also possible (Reference 1.3.8).

Dust tolerance levels of 50mg/Nm^3 can be achieved using an electric dust collector. It should be noted that dust collection efficacy at the No. 4 power plant is 98.9% but based on the electric dust collection method properties indicated in Reference 1.3.8, this can be improved to a rate of above 99.9%.

CO concentration regulations are the same for both existing and new power plants. At present, they are meeting requirements so no special technology is needed. If new boilers will use coal, something not used in the past, then carefully attention will be given and evaluations of combustion conditions and other measures will take place.

Table 4-44 Overview of power plant environmental facility specifications (as of 2007)

Options			Sub-Critical PC	CFBC	cf: Thermal Power Plant #4
Schematic Flow sheet					
Capacity		(MW)	500	500	540
Main Steam Conditions	Pressure	(MPa)	16.5	16.5	16.5
	Temp.	(deg.C)	538	538	538
Environmental Protection	DeSOx	(%)	Dry desulphurization process:80%	In-bed desulphurization process:80%	Not equipped
	DeNOx		Combustion improvement (Direct combustion system)	Combustion control (2^{nd} Air injection, long residence time)	Combustion Improvement (Direct combustion)
	Dust	(%)	ESP:99<	ESP:99<	ESP: 93~95
Emission	SOx	(ppm	350 (=1000 mg/Nm^3)	350 (=1000 mg/Nm^3)	700~900
	NOx	(ppm)	245 (=510 mg/Nm^3)	240 (=400 mg/Nm^3)	340~390
	Dust	(mg/Nm^3)	50	50	N/A
Plant Load factor		%	80	80	56
Power Generation Efficiency	Gross	(%)			49.6[5)]
	Net	(%)	34.8	34.8	42.3[6)]
	AUX	(%)			14.8
Advantage			Mastery easy due to the experience of existing power plants	Lignite adeptly (High combustion In-bed DeSOx	
Disadvantage			Higher DeSOx cost O&M inexperienced DeSOx plant	Mastery difficulties duo to rack of fluidized-bed reactor. Lack of large-scale inexperience	

(e) Law Regulation

To ensure the safe and smooth development of new operations in Mongolia such as coal new utilization, LPG development, and the launching of fuel refineries, the country will need to establish new laws and regulations. Normally, coal gasification facilities are operated at high pressures (1MPa and higher). Produced gases such as CO, H_2, and CH_4 are both flammable and toxic. As such, safety regulations related to facility design, construction, and operation are vital. The house coke production methods we examined typically involved either coal pyrolysis or partial oxidation (gasification), which produces the above types of flammable gases. At the plants we surveyed, safety measures such as gas leak warning systems and portable gas detectors were in place. The current plants operate a normal pressure but if in the future they are to transition to applied pressure and high pressure facilities, these safety measures will need to be enhanced on all levels and strict compliance will have to be enforced. Today, LPG is used as vehicle fuel and as fuel in restaurants. LPG loading facilities and filling stations for LPG vehicles and gas tanks are governed by dangerous material handling laws but we have heard that the framework for regulations is an old one from the former Soviet Union. Future expansion of use to residences will require regulations to ensure safe handling by the general public. Also, expansion of LPG will also require a reevaluation of current rules regarding transport routes and times. As refineries planned for construction in the future will handle numerous dangerous substances, fire prevention laws, high-pressure gas safety laws, and labor health and safety laws will apply.

Table R-12 in Reference 1.4.3 shows major safety regulations related to the above that are applied in Japan. These regulations apply to not only safety at applicable facilities, but also require considerations be given to the safety of the surrounding areas. New facilities will also need to fulfill these requirements. Also, operation of these facilities requires the placement of persons with qualifications that ensure compliance with these laws. Mongolia will need to establish these laws as well as create a system for educating and training qualified individuals.

(f) Cost

This JICA survey did not go so far as to evaluate the business plans for each project. However, we thought this Master Plan would need to indicate guidelines in terms of required capital. Table 4-45 shows examples of construction costs for coal-related facilities that have been completed, are in planning, or are in FS in countries around the world. Needless to say, expenses disclosed in various documentation will not be figures based on any type of uniform standard. As such, we made various corrections and estimations using the methods noted in the table. Even when in the same sector, facility expenses vary by country of manufacture, technology method, facility scale, and major product produced. For this survey, we applied the following approach ((i) to (iv))when estimating standard costs.

(i) Costs for power facilities will vary depending on steam conditions and the boiler furnace system. Compared to systems from other countries, per output costs (US$/kw) are very inexpensive for Chinese systems. For example, a supercritical (SC) thermal system is 40% cheaper than a US system. For CHP plants, the latest available data is the evaluation results for the No. 5 power plant in Ulaanbaatar, Mongolia conducted by the Asian Development Bank (ADB). That price was 1196 US$/kw.

(ii) Coal gasification facilities are most operated in China. As with power generation facilities, they are very inexpensive compared to US systems. Recent data includes estimates conducted by Japan's NEDO in 2011. This involves producing synthetic gasoline (MTG:Methanol-To-Gasoline) and DME from Mongolian lignite at a rate of 589,000 tons/year. The cost of this facility was said to be 916,000 US$/t/d.

(iii) For coal indirect liquefaction facilities, South Africa boasts the only commercial success. Operation of a direct liquefaction facility has begun in China. This cost is conducted.

(iv) The costs of other related facilities is also included. Costs for the Ulaanbaatar No. 4 power plant rehabilitation project enabled through Japanese support were US$ 120M. Also, construction costs for a petroleum refinery are set at US$ 600 - 800M. A simple comparison of per barrel costs (US$/bbl/d) shows this to be approximately 1/4 that of coal indirect liquefaction. The target costs for liquid fuel from coal gasification and oil prices are compared later in Fig. 4-59 but it can only be said that even though lignite may be cheaper than petroleum, gasification will lead to higher costs.

Table 4-45 Construction cost examples for coal utilization facilities and related energy facilities

Category	Technology	Country	Status	Coal & Product Capacity							Cost				Note
				Input Coal		Electricity	Solid	Gas	Liquid						
			2012	(ton/d)	(kton/y)	(netMW)	(kton/y)	(mNm^3/y)	(kton/y)	(bbl/d)	(Million US$)	(US$/unit)		year	
Power Plant	Sub C	China	In operation	4,745		600					580	967	($/kW)	1995	JICA ODA
		USA	S	4,745		550					1,098	1,996	($/kW)	2007	Bittminous
	SC	USA	In operation			600					1,265	2,108	($/kW)	2008	
		Chian	In operation			2,000					1,394	697	($/kW)	2004	華能国際
		Mongolia	Plane			600					350	583	($/kW)	2010	Tavantolgoi
	USC	USA	S	5,959		550					1,323	2,405	($/kW)	2007	Sub Bitminous
		China	In operation			1,200					750	625	($/kW)	2006	遼寧華電
	(PC)	Indonesia	Start			945					818	866	($/kW)	2011	Lontar
		Indonesia				700					706	1,008	($/kW)	2012	China EPC,Awar-Awar
		Phillipine				600					696	1,160	($/kW)	2012	China EPC,Mariveles
		Thailand				1,800					2,016	1,120	($/kW)	2012	China EPC,Hongsa
	IGCC	USA	Construction			632					2,350	3,795	($/kW)	2008	Indiana coal
		China	In operation	2,097		250					362	1,447	($/kW)	2009	
	CFB-SC	USA	S	6,111		550					1,296	2,357	($/kW)	2007	Sub Bitminous
	(CFB)	Botswana				600					1,164	1,940	($/kW)	2012	China EPC
	FBC-SC	Slovak	In operation			300					829	2,762	($/kW)	2008	
CHP Plant		China	In operation			600					375	625	($/kW)	2006	山東黄台
		Russia	In operation			103					287	2,791	($/kW)	2008	
		Germany	In operation			200					593	2,966	($/kW)	2008	
		Mongolia	FS		856	450					538	1,196	($/kW)	2011	CHP5,Phase-1,703 MWth
Gasification Plant	SNG	USA	In operation					1,573			2,100	441	($/Nm^3/d)	1984	Dakota Gas Co.
		China	Construction	28,800				4,000			3,432	283	($/Nm^3/d)	2009	大唐国際赤峰
	Fetilizer	China	In operation				240				96	132,013	($/t/d)	2000	Luzhai,ODA
	Methanol	China	Construction						1,819		760	137,897	($/t/d)	2008	Anhui
	Methanol	USA	FS	6,600		66			1,482		1,102	245,369	($/t/d)	2006	Illinois coal
	DME	China	Plan						1,000		757	249,810	($/t/d)	2006	
	MTO	China	In operation	10,500					1,800		2,057	377,117	($/t/d)	2004	Shenhua
	MTP	China	In operation	9,000					1,670		2,196	433,940	($/t/d)	2005	大唐
	MTG	USA	FS	22,900		145			1,968	50,000	3,940	660,797	($/t/d)	2009	
	MTG/DME	Mongolia	Pre.FS		2,080				589		1,621	916,457	($/t/d)	2011	S-O coal
Liquifaction Plant	InDirect	Sasol 2+3	In operation		4,500					144,000	8,046	55,875	($/bbl/d)	1978	Mk-4*40
		USA	FS	26,700		472				50,000	4,880	97,600	($/bbl/d)	2008	
	Direct	Shenhua	In operation		3.45				1,070	24,000	1,815	75,625	($/bbl/d)	2004	
		China	FS							80,000	5,000	62,500	($/bbl/d)	2005	
		USA	FS							80,000	8,000	100,000	($/bbl/d)	2005	
Housecokes Plant	FBC	Mongolia					120				15	40,441	($/ton/d)	2011	
	FB	Mongolia													
Coke Plant	Coke Oven (	China	Stop				600				83	45,450	($/ton/d)	2002	9MWe
	SCOPE21	Japan	Plan	4,140			1,000				394	129,894	($/ton/d)	2008	
Coal Washing Plant		Mongolia	In operation		10,000						17	1,714	($/kton/y)	2008	
Waste Boiler Plant	Stoker	Taiwan	In operation	1,250							155	124,098	(US$/t/d)	2002	Taiwan EPC
		Singapol	In operation									98,843	(US$/t/d)	2001	Japan EPC
		Indonesia	In operation									111,157	(US$/t/d)	2001	Japan EPC
		Korea	In operation									169,835	(US$/t/d)	2001	Japan EPC
		USA	In operation									107,438	(US$/t/d)	2002	USA
Refinary		Mongolia	FS						1,690	44,000	600	13,636	($/bbl/d)	2010	Diesel;1000kton,Gasoline63
				Specification											
Infrastructure	Apartment	UB city	Plan	100,000 household, railway,road,general construction infrastru							588			2009	
	Coal Mine	Baganur & Shivee-Ovoo	Completed	2,200 kton/y production capacity increase Mining machines,coal handling plant,auxiliary equipment,spair parts, etc.							126	57	($/ton/y)	1997~1998	JICA ODA etc.
Rehabilitation	Power Plant	#3	Completed								40			1993~1996	ADB
		#4	Completed								129			1992~2000	Japan

Created by JICA survey team based on reference literature 1) - 31)

1) JICA ODA Project Survery report,http://www.jica.go.jp/english/our_work/evaluation/oda_loan/post/2003/pdf/2-07_full.pdf

2)*DOE Report No.DOE/NETL-2010/1397,Cost and PerformanceBaseline for Fossil EnergyPlantsVolume 1: Bituminous Coal and Natural Gas to lectricity-Revision 2,Nov.,2010*

3) *IEA/NEA Report,Projectred Costs of Generting Electricity-2010 edition*

4) *http://cftn.cn/news/cftn_1/20[20121026]_613.html*

5) *Ganbaatar.B.,Current statuse of prospects for energy rsources and infrastructure development of South Gobi in Mongolia*

6) *DOE Report No.DOE/NETL-2011/1463,Cost and PerformanceBaseline for Fossil EnergyPlantsVolume 3b: Low Rank Coal to Electricity: Combustion Cases, March 2011*

7) *Coal Asia,March.23-Apriul23.,2012*

8) *http://www.cneec.com.cn/Achivements/Achievements/Energy/Thermopower*

9)*Sears.R.,Duke Energy Indiana Edwardsport IGCC Project Updata,Projects ,2008 Gasification Technologies Conference,Washington D.C.,Oct.,2008*

10) *Zhaofeng,X.,Economics evaluation of an IGCC cogeneration power plant with CCS for application in China,Energy Procedia 4,2011*

11) *DOE Report No.DOE/NETL-2011/1463,Cost and Performance Baseline for Fossil Energy Plants Volume 3b: Low Rank Coal to Electricity: Combustion Cases,March 2011*

12) *IEA/NEA Report,Projectred Costs of Generting Electricity-2010 edition*

13) *http://cftn.cn/news/cftn_1/20[20121026]_613.html*

14) *ADB Feasibility Report TA No.7502-MON,Mopngolia:Ulaanbaatar Low Carbon Energy Supply Project Using a Public^Private Partnership Model,Oct.,2011*

15)*Sterm.F.,Duke Dakota gasification Company ,2008 Gasification Technologies Conference,Washington D.C.,Jun.,2006*

16)*JCOAL mahazine,No.94,2012.3.28*

17)*Praxair Co.,Huayi-Praxair Partnership in Integrated Coal to Chemicals Project,Gasificayion Technology Conference,Oct.,2008,Wsshington DC*

18)*Aycock.J.,Chemicals and Power Co-production by Gasification of Illinois Coal,2006 Gasificaiton Technologies Conference,Oct.,2006*

19)*http://www.greencarcongress.com/2006/12/lutianhua_group.html*

20)*JCOAL mahazine,No.77,2011.6.15*

21)*USNRC,Liquid Transportation Fuels from Coal and BiomassTECHNOLOGICAL STATUS, COSTS, AND ENVIRONMENTAL IMPACTS,2009*

22)*Sasol,Sasol 50Yeras of Inovation*

23)*http://www.csclc.com.cn/ens/cpyfw/youpin/2010-12-21/320.shtml*

24)*Sichinga.J.,Enabling a Coal to Liquids Industry in the US,Sasol Synfuels International 2nd, Oct.,2006*

25)*JICA Survay2012*

26)*JCOAL Report,2007*

27)*JCOALSuvay 2010*

28)*Aoyama.T.,http://www.yc.tcu.ac.jp/~kiyou/no5/P654-059.pdf*

29)*Marubeni News release,September,29,2010*

30)*http://www.mad-mongolia.com/news/mongolia-news/mongolian-government-maintains-that-apartment-prices-will-decrease-5530/*

31)*JICA http://www.mofa.go.jp/mofaj/gaiko/oda/jisse*

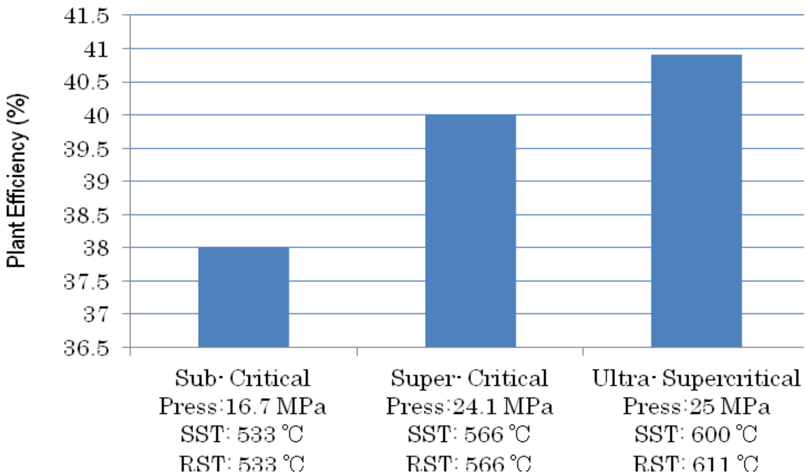
Notes:
1) Denotations related to costs in the materials were assigned names such as construction costs, project costs, total budget, etc. Figures for project costs and total budget are shown.
2) For construction of a power plant, typically the scope calculated as fixed expenses (used to calculate electricity charges) is the total of "construction costs" and "costs related to construction". Costs related to construction includes i) personnel expenses during construction period, ii) initial fuel and parts costs, iii) owner's liability share. In the table, figures related to construction within China frequently site "EPC cost" and thus it was considered that "costs related to construction" have not been included. Having analyzed US examples, we found these costs to be 20% of "construction costs".
3) Construction costs change each year. There were few documents that indicated in which year calculations were made. When the construction start date is known, that date was used. If unknown, we estimated the year based on the date of publication for the documents (Year noted on Table).
4) Amounts are indicated in US$. When amounts were noted in various currencies, we converted using the US$ exchange rate for that year.

4.2.3 Potential for incorporation of coal utilization technology and risk analysis

(1) Power generation technology

(a) Concerning efficiency

Mongolia's thermal power plants are subcritical pressure steam power plants that do not utilize reheaters. Currently in Japan, Europe, America, China, etc., USC (Ultra Super-Critical) power plant facilities have become common. Steam conditions and power plant efficiency are indicated in Fig. 4-51.



SST: Super-heater Steam Temperature

RST: Re-heater Steam temperature

Source: Created by JICA survey team based on Indonesia Power - JCOAL Workshop 2012 materials.

Fig. 4-51 Steam conditions and power efficiency (examples)

Compared to subcritical pressure facilities, USC and US (Super-Critical) plants are more complicated in terms of operations, maintenance, and management and typically are utilized in large-scale power plants with large capacities. In general, it is thought that the merits of USC are not gained in facilities below 350MW. Currently in Mongolia, total power generation capacity for all facilities in approximately 860MW and, as a measure against the effects an unplanned shutdown would have on the grid, per facility capacity is limited to around 100MW. However, in the future as Mongolia's economy grows and total power generation capacity for all facilities exceeds 3000MW, they will be able to employ a 350MW SC. Conversely, currently power plants in Mongolia are already suffering from deterioration and some are close to replacement timing. As such, sufficient evaluation is needed concerning future power needs to determine what kinds of facilities will be required. The No. 5 power plant currently planned for construction will have subcritical pressure turbines with a capacity of 150MW to ensure capacity for future expansions of power facilities. As part of plans to increase steam pressure parameters and improve efficiency, they are planning to use more advanced control technology, including a DCS (Distributed Control System) system that employs reheating cycles and a one boiler per turbine configuration as well as using steam from the turbine as a heat supply. As this is a subcritical pressure facility, there are no dramatic technological leaps being made but learning operating techniques, implementing maintenance and inspections, and securing parts will be relatively easy, which is appropriate for current conditions in Mongolia. Ideally, facilities currently in operation that are suffering from deterioration will be gradually updated to power generation facilities that employ up-to-date technologies such as subcritical pressure and reheating cycles. It is after that point that they are likely to consider the application of SC and USC technology based on growing power demand in the country.

(b) Power plant air pollution

As pollution prevention equipment, the Ulaanbaatar No. 2, 3, and 4 power generators are equipped with electrical dust collectors or venturi scrubbers but black smoke rises through the stacks and removal appears insufficient and there is a need for additional equipment such as increased numbers of electrical dust collectors or back filters. No measures are in place to address SOx or NOx. As for desulphurization, all the power plants use a central stack for multiple boilers so it would be economically efficient to employ a system where desulphurization equipment is installed in one or two turbines and then connected via a smoke pathway. Regarding denitration, eventually they will need denitration facilities that inject ammonia through a catalyser but for now they should move to install a low NOx burner or two-phase combustion method. Fig. 4-52 shows EU air pollution standards. Pollution is a problem that impacts not only the country in question but also neighboring nations as well so Mongolia must give consideration to global standards but first they must proceed with measures that work toward the "Actual Standards" indicated in Figure.

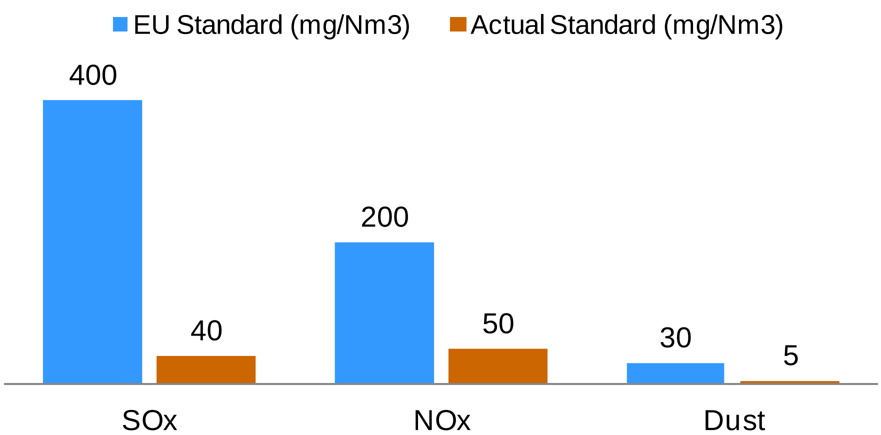


Fig. 4-52 EU air pollution standards

(c) Improving power transmission efficiency

There are no transmission system which can cover whole land in Mongolia, there are three separated system composed CES (Central Energy System), EES (Eastern Energy System) and WES (Western energy System). CES is 98% of overall electricity energy and supply energy to Ulaanbaatar and main city on suburbs. EES supplies electricity energy to Choibalsan and villages of eastern area.WES has no power plant, thus import electricity energy from Russia. With the exception of these systems there is independent electricity distribution network such as Dalanzadgad. Changes of electric power transmission and distribution losses on each system are shown in Table 4-46.

Table 4-46 Changes of Electric power transmission and distribution losses (%)

No	Name	2005	2006	2007	2008	2009	2010	2011
1	CES	19.8	18.4	17.4	16.8	17.7	17.3	16.6
2	EES	16.6	9.0	7.6	8.0	10.1	8.7	9.4
3	WES	12.2	11.5	10.1	12.0	12.4	11.8	10.8
4	Dalanzadgad	32.8	27.0	26.3	27.2	22.6	24.1	23.5

Source: JICA team based on Mongolian Energy Statistics 2011

Although the rate of electric-power-distribution loss shows the fall tendency, there is room for an improvement. For the efficiency improvement of a power supply, the rate of consumed power inside and the rate of electric-power-distribution loss needs to be decreased.
(Table 4-7 shows the transition of the rate of electric-power-distribution loss.) The proposal of the remedy of these is shown below.

1) Reducing internal power

- Replace auxiliary equipment such as ventilators, pumps, mills, etc. with high-efficiency equipment and control via an inverter. Regulate the number of units to ensure maximum power efficiency throughout the entire plant.
- Conduct the control of unit So that overall plant would be maximum efficiency for energy demand.
- Unscheduled stops occur frequently. Fuel and power normally not required are consumed during a plant stoppage and during plant reboot. Maintenance management is required in order to minimize unscheduled shutdowns.

2) Improving power transmission

- Plan a structure that networks power transmission systems throughout the control to optimize converters, breakers, and power transmission pressure and modernize the power transmission system. Furthermore, planned facilities upgrades are required for distribution facilities including power poles, power lines, and converters.
- There also is a need to build power plants in adequate locations in order to limit power transmission

distance as much as possible.

As mentioned above about the improvement of efficiency, Fig. 4-53 shows the example estimated effects of proceeding of these efficiencies. This figure shows coal demand which is estimated on actual efficiency by efficiency on electric power and heat production and coal demand which cover annual demand of electric and heat at the condition of approved efficiency in this figure. As a result, 1,320,000 t of coal can be saved by improvement in efficiency in 2025.

As a result, 1,320,000 t of coal can be saved by improvement in efficiency in 2025.

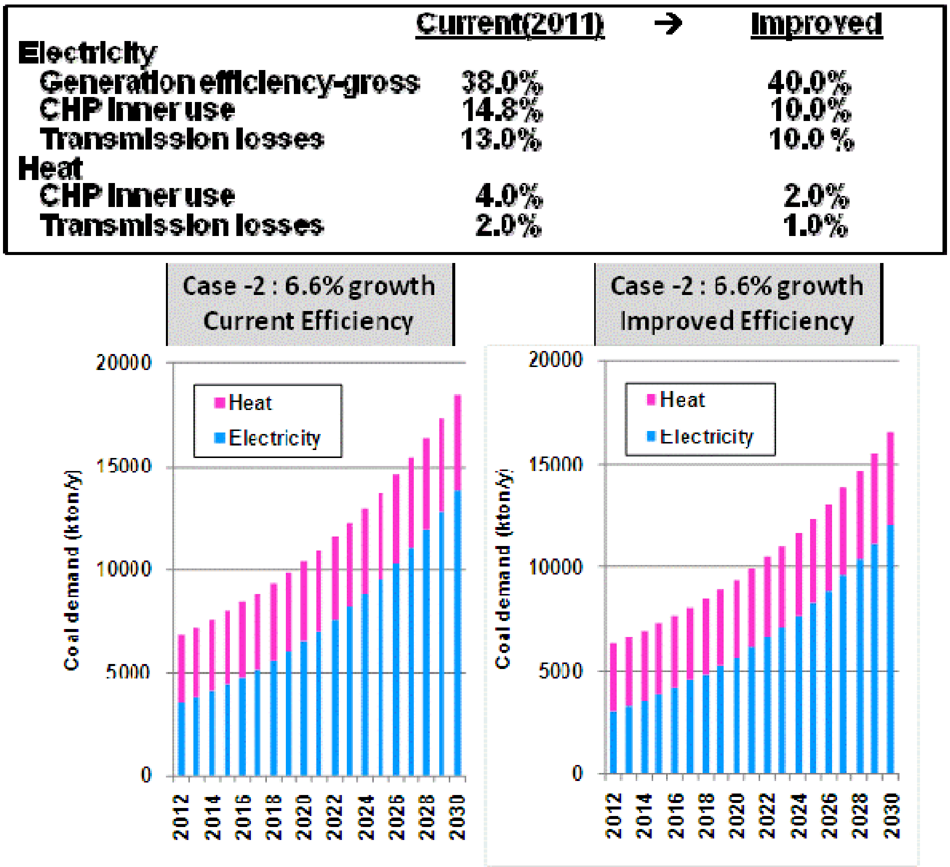


Fig. 4-53 Coal consumption reduction effect through power plant efficiency improvements

(2) Producing House Coke and Activated Coal

As part of air pollution prevention measures in Ulaanbaatar, Mongolia is aggressively promoting the dissemination of house coke as a replacement to raw coal but they are behind schedule. Details and issues are noted in 4.1.4 but here, we discuss future plans and the production of activated coal as an application of that technology.

(a) House Coke

Currently, house coke is produced in three locations. Semi-coke manufacturing technology can be looked upon as the first step toward the future of the coal processing industry in Mongolia. Among coal carbonizing technologies, this method is called low-temperature carbonizing. While there are many issues such as the use of the COG and low-temperature tar produced during carbonizing but not only can this be used as a vehicle for expanding research fields in the coal chemical sector, but this will lead to the development of researchers and technicians. A current technical issue is the reduction of costs. As it is nearly 2-3 times more expenses that current coal prices, there is the issue of how to lower pricing.

There are two markets of house coke on the market: semi-coke used as is as a fuel source and semi-coke shaped into briquettes and used as fuel. Which is better can be left up to the users but in terms of costs, semi-coke is 20%-30% cheaper. If they both provide the same performance, the most economical method would be to use rough semi-coke as is as a fuel and at the same time form crushed semi-coke into briquettes for easier combustion. Another issue with briquettes is the need for a cheap, effective binder.

Demand volume for house coke will be determined by the number of Ger and single-family homes[61] in Ulaanbaatar. Details regarding demand are noted in 4.4.3 (6) but they should seek to immediately meet 75% of total demand, approximately 600,000 tons. Based on current projections, demand will be met around 2018 but in order to speed this up for the meanwhile they should consider imports as well.

(b) Activated Coal

Consumption volumes of activate coal in Mongolia is still a few thousand tons but as Mongolia becomes more industrialized, it is undoubtedly to become a vital fuel due to its lower environmental impact. Details for activated coal are discussed in References but coal is an important raw material for activated coal. Globally speaking, activated coal using coal as a raw material includes bituminous coal and lignite, meaning there are strong prospects for Mongolia, which has vast lignite resources.

Activated Coal production methods are similar to semi-coke production. The addition of steam activation facilities will convert a plant into an activated coal facility. In terms of technology, Mongolia has the advantage of being able to apply its semi-coke production technology. If in the future they are able to produce activated coal, considering potential pricing, Mongolia will be able to export in containers to other countries.

(3) Coal gasification technology

(a) Coal gasification technology fields of application and state of worldwide implementation

Coal gasification technology is being applied in the following fields (Fig. 4-54)

- Power plants (Integrated Gasification Combined Cycle: IGCC)
- Liquid fuel manufacturing
- Chemical product synthesis
- Synthetic natural gas (SNG) manufacturing

With IGCC (Integrated Gasification Combined Cycle), coal clean gas is used as gas turbine fuel. Liquid fuels include methanol, DME (Di-Methyl Ether), and F-T (Fischer-Tropsh) synthetic oil. These

[61] In this content, it is assumed that all stand alone houses in Mongolia use coal for heat energy. In the fact there are a small minority of houses which does not use coal.

are manufactured through a CO and H_2 synthesis reaction. Chemical products include methanol induction products (olefin, propylene, MTBE, DME, acetate), ammonia, etc. These are used as base materials for the creation of plastics, adhesives, and resins. SNG (synthetic natural gas) is a gas primarily comprised of CH_4 that is synthesized from CO and H_2. It is used as city gas.

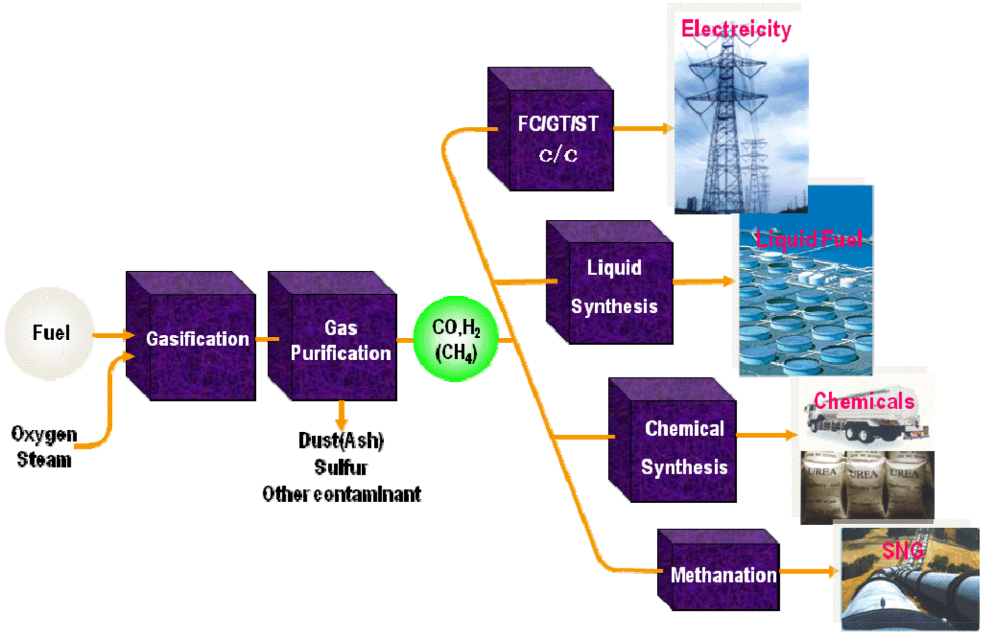
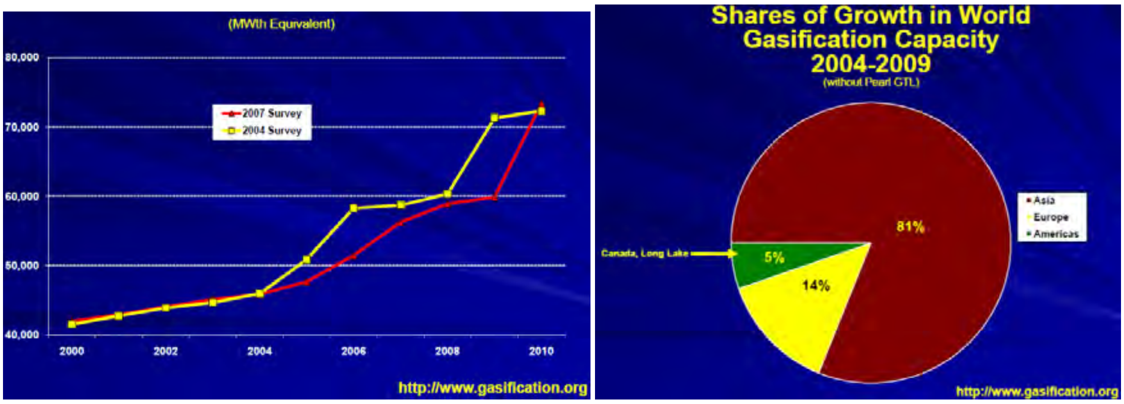


Fig. 4-54 Coal gasification process and products

Fig. 4-55 shows worldwide gasification facility capacity (MWth). In 2007, global capacity was approximately 56,000MWth. This is the equivalent of 19 plants of 1,000MWh-coal-furnace power plant. Looking at capacity by country, based on statistics from 2004 through 2010, 53% in Asia, 35% in Africa/Middle East, 9% in Europe, and 3% in America. Broken down by application, 43% for chemical products, 30% for liquid fuels, 11% for electricity, 6% for gas, and 2% for other applications. Specifically, chemical product manufacturing in China and liquid fuel production (F-T fuel) in South Africa represent the majority of use. Today, outside of these two countries there are no examples of gasification technology supporting a single industry (chemical industry, fuel manufacturing) in that country. Power generation (IGCC) has been researched and developed over many years with massive funding being invested in R&D but in terms of degree of maturity and rate of dissemination, it cannot compare to coal furnace power generation technology. In the 1990's 250 to 350MW plants were built as validation sites in Holland, Spain, and America (two sites). All gasification ovens all utilize air fluidization bed systems but the gasification methods (licenser) were all different. Each project ran into various problems three to four years into their test runs and were unable to achieve rated operation. Recently they appear to be operating commercially. From 2003 to 2004, there were many concepts discussed in America related to a 600MW class commercial IGCC unit but all have been delayed indefinitely. This is due to the uncertainty of tax breaks and subsidies as well as the skyrocketing of facility costs in recent years.

In Japan, the first oil shock served as the catalyst for a national project. Two projects were progressed in parallel: a multi-purpose furnace that uses air as a gasification agent for use in the manufacturing of

IGFC (Integrated Gasification Fuel Cell), IGCC, H_2, and chemical products, and a dedicated IGCC furnace that used air. At present (as of 2011), pilot plant testing has been completed for an air-blown gasification furnace. Currently, testing is being conducted on the separation and recovery of CO2 from gasification gas. Validation testing for the air-blown gasification furnace will be conducted using a 250MW IGCC system and the program has shown superior results far beyond what was achieved under the aforementioned four programs in Europe and America.



Source: Haute, T.,World Gasification Industry: Status, Trends & Drivers,Gasification, Workshop,June ,2010

Fig. 4-55 Global gasification facility capacity

(b) Coal consumption volumes during liquid fuel production in Mongolia

Currently, Mongolia is considering the production of liquid fuel via coal gasification. As is explained below, there are significant hurdles facing the incorporation of coal gasification in Mongolia but we calculated how much coal might be required annually if, hypothetically, the country did product liquid fuel. Adequate liquid fuels include:

- Alternatives to gasoline
- Alternatives to diesel fuel

These are equivalent to MTG (Methanol to Gasoline Fuel) and DME, respectively. An overview of the production process is shown in Fig. 4-56. During the gasification process, powdered coal is gasified using air. The gasification oven used is a high-temperature model (approx. 1,800K). Gasification results in the generation of CO and H_2. Generated gas contains minute amounts of sulfur compounds, nitrogen compounds, and dust impurities so these are removed during the gas refinement process. From there, methanol fuel is produced using a methanol synthesis process.

This methanol is used as a base material for the synthesizing of MTG and DME. Referencing studies conducted by NEDO in 2011, we find that material balance when using Shivee-Ovoo coal as a base material is as shown in Fig. 4-56.

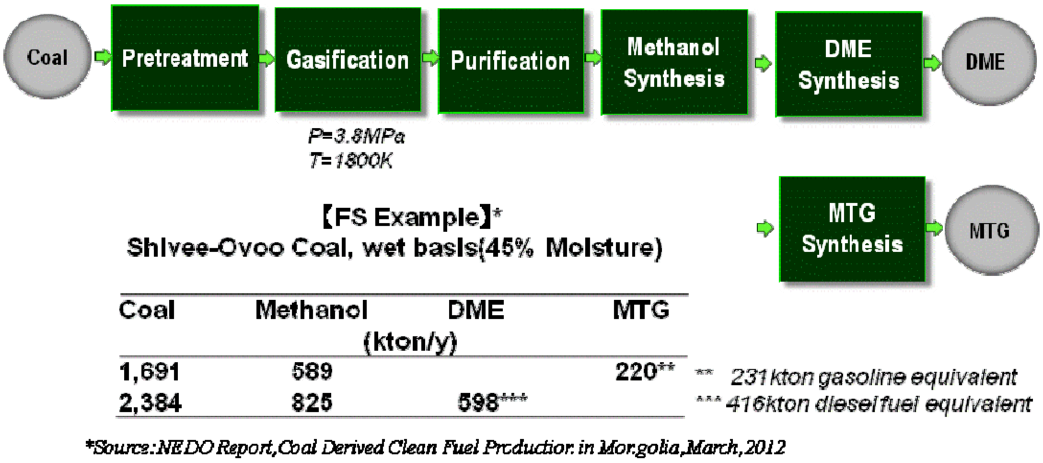


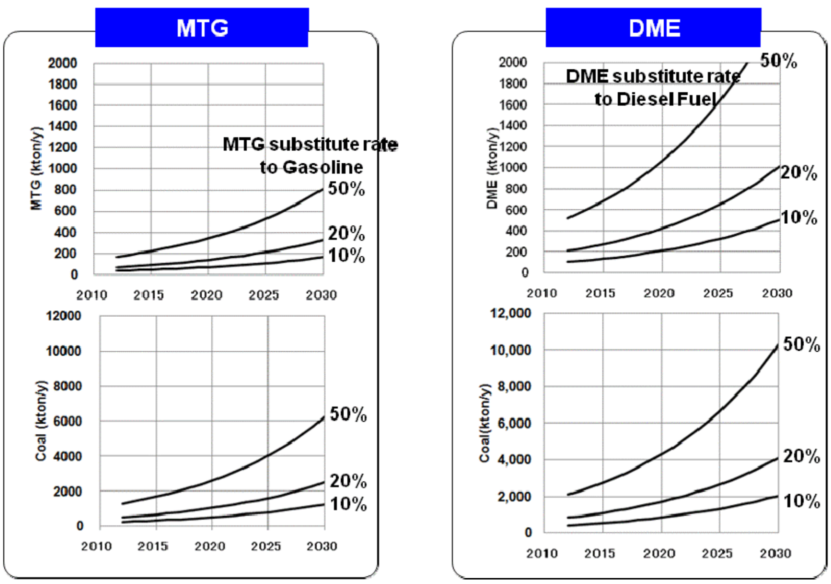
Fig. 4-56 MTG & DME production process using coal gasification and production volume test calculations

Fig. 4-57 shows the alternative fuel production volume and the volume of coal required to achieve such production when a portion of the oil demand projected in 4.3.3(5) is met using a coal gasification-based alternative fuel. MTG and DME volumes are set to production volumes that produce the equivalent calorific value of gasoline and diesel fuel, respectively. The demand volume for petroleum is the Case-2 scenario. The substitution rates (%) shown in the graphs refer to the percentage of annual gasoline and diesel fuel demand volume that can be substituted using synthetic fuels. For example, to substitute 10% in 2025 would produce the following:

MTG 105,000t/year: coal consumption of 810,000t/year

DME 330,000t/year: coal consumption of 1.33Mt/year

As the rate of substitution increases, the volume of fuel produced and the volume of coal consumed will increase proportionately.



Source: Swedish Trade Council Beijing Office, Private Sector

Fig. 4-57 Coal volume required for production of synthetic fuel

(c) Coal gasification technology implementation risk analysis

Issues facing the incorporation of coal gasification plants in Mongolia include follows:

(i) Price competitiveness with existing petroleum products and coal gasification-based clean fuels from China.

(ii) Acquisition of project funding (capital) sufficient for a national budget-level order

(iii) CCT implementation and mastership

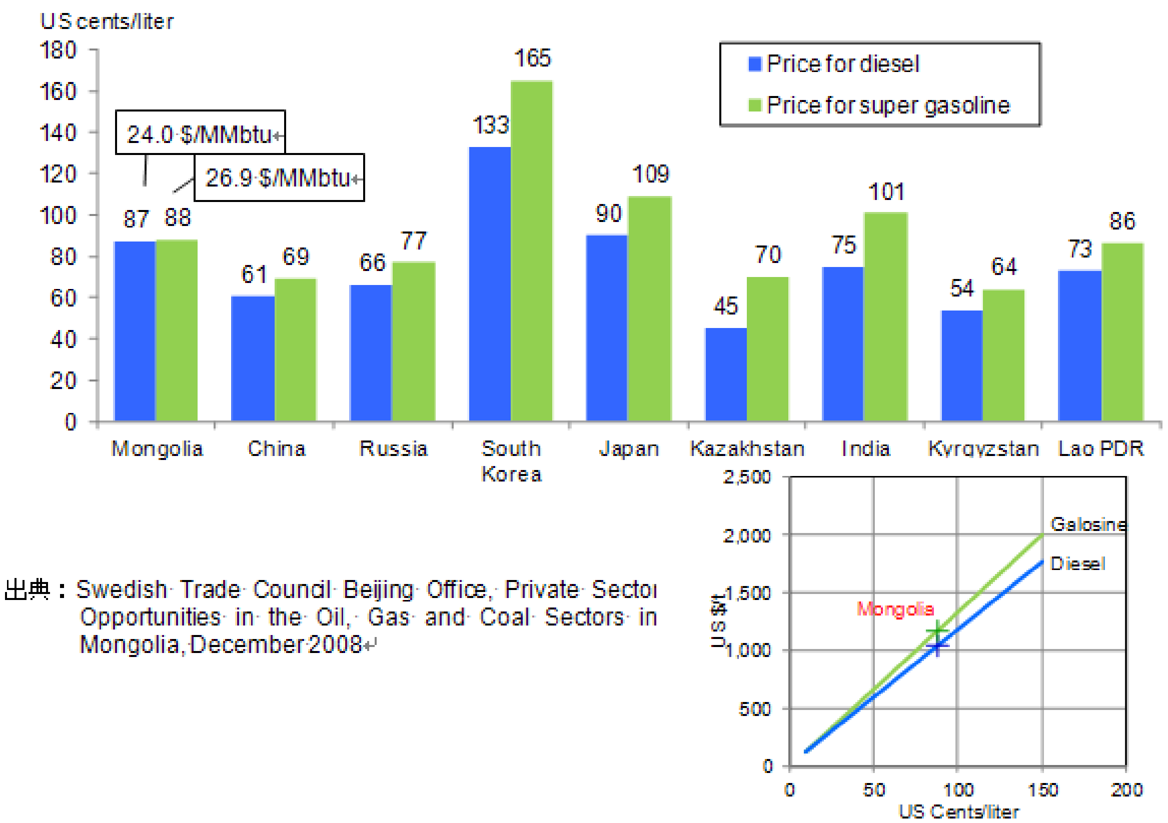
Detail of issue a) will be presented here.

Potential competitors when producing liquid fuels based on coal gasification in Mongolia are likely to be:

A. Current petroleum products

B. Coal gasification products manufactured in China.

Fig. 4-58 shows gasoline and diesel prices in various countries. Prices in Mongolia are 87 to 88 US cents/liter. This is cheaper than Japan or Korea but higher than China and Russian. The class of people using vehicles in Mongolia (primarily Ulaanbaatar) are relatively affluent classes but the question is how to provide the improverished with low-cost clean fuel. When gasoline and diesel prices are indicated in $/t, they are $1100/t and $1240/t respectively. These prices are thought to include taxes. While the tax rate is unknown, if for example the Japanese rate of 30 to 50% is used, gasoline and diesel are $600/t and $870/t respectively.



Source: Swedish Trade Council Beijing Office, Private Sector Opportunities in the Oil, Gas and Coal Sectors in Mongolia, December, 2008

Fig. 4-58 Gasoline and diesel fuel prices

Mongolia also has crude oil reserves so it is assumed that eventually domestic production will occur but prior to that, Mongolia will remain dependent on crude oil import risk. Marubeni and Toyo Engineering project that 44,000bbl/d in crude oil will be used to produce 1Mt/year in diesel fuel, 630,000t/year in gasoline, and 60,000t/year in jet fuel[62]. Construction-related contract amounts total $600M USD. They are considering acquiring crude oil from Irkutsk, Russia and Kazakhstan. Volume will be equivalent to 76% of the 2.22M tons in demand projected for 2020 (discussed below in 4.3.3), which will be sufficient to meeting the majority of oil demand as of 2020.

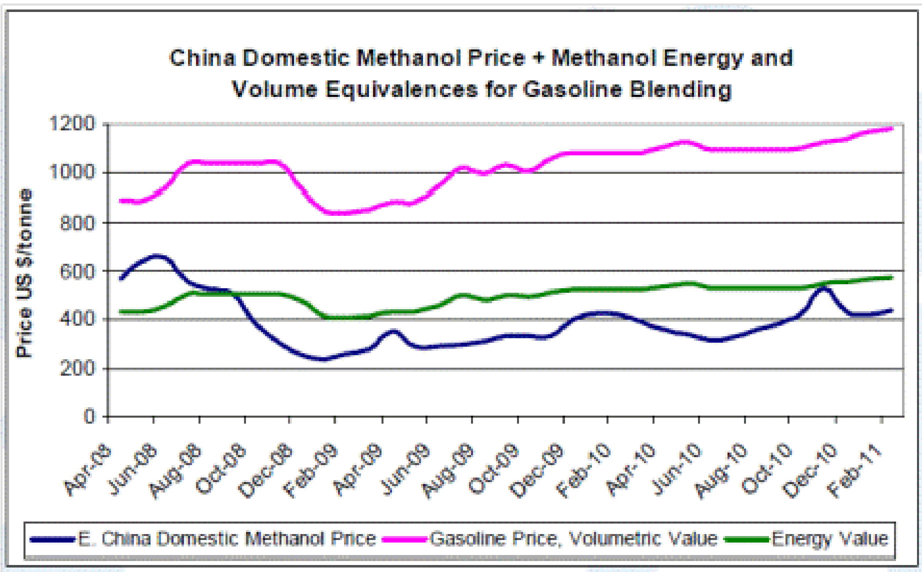
Conversely, methanol and DME, both coal-based clean fuels, are being produced in mass amounts in China. Coal gasification-based products in Mongolia would have to focus on competitiveness with import products from China. Fig. 4-59 and Fig. 4-60 show prices for similar products in China[63][64]. Methanol prices are influenced greatly by international market trends and thus fluctuate dramatically. China is facing a production surplus of DME in recent years thus prices have been in a decline. Recent prices in China are as follows. It is likely that these would be target prices for products produced in Mongolia

Methanol: US$ 320 to 520/t (2010 - 2011)

DME: US$ 420 to 480/t (since 2009)

LPG: US$ 600 to 800/t (since 2009)

Gasoline: US$ 1100 (2010)



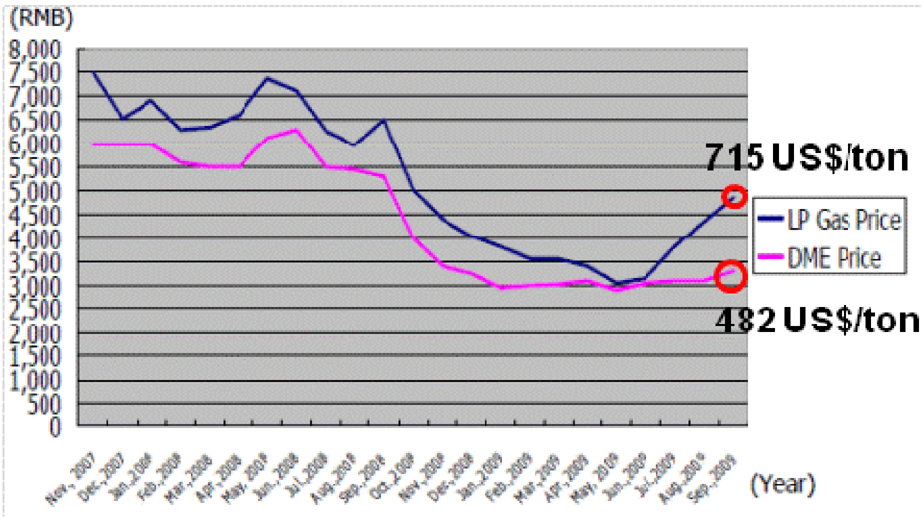
Source: Floren.J., Global Opportunities for Methanol Blending and DME, March 10, 2011

Fig. 4-59 Methanol & gasoline prices in China

62 http://www.marubeni.co.jp/news/2010/100929.html

63 Floren.J.,Global Opportunities for Methanol Blending and DME,March 10, 2011

64 Mikita.Y., Dimethyl Ether (DME) and the trend of Bio DME production in China,2009 Joint Task 40/ERIA workshop, October 29, 2009

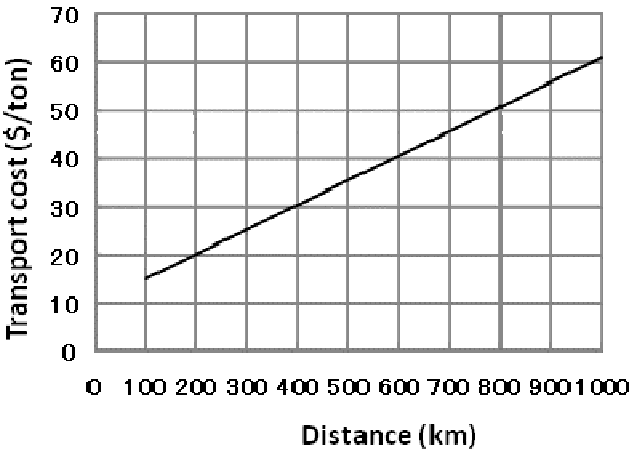


Source: Mikita.Y, Global., DME and The Trend of Bio DME Production in China, Oct. 29, 2009

Fig. 4-60 LPG & DME prices in China

Importing liquid fuels from China would mean adding transport costs to the price of the product. Fig. 4-61 shows costs for transporting LPG via truck in China. Transport from a coal gasification plant in China Inner Mongolia to Ulaanbaatar would mean of distance of roughly 1,000km and cost approximately $60/t. In other words, even if product prices in Mongolia were higher than those of Chinese products, that difference would need to be kept below $60/t.

Source;Larson.D., DME from Coal as a Household Cooking Fuel in China, Energy for Sustainable Development, Vol.8, No.3, Sept.2004



Source: Larson.D.,DME from Coal as a Household Cooking Fuel in China, Energy for sustainable Development, Vol.3, No.3, Sert. 2004

Fig. 4-61 LPG truck transport costs in China

Fig. 4-62 shows energy prices[65] in Mongolia. In order to make the price of coal gasification-based liquid fuel equivalent to today's low-cost energy including coal, coke, and hot water, prices would need to be set to between $200 and 300/t, which is approximately 50% of the abovementioned Chinese products. As production at these prices would prove impossible in Mongolia, offering coal gasification-based products to low-income residents would require some form of government subsidies.

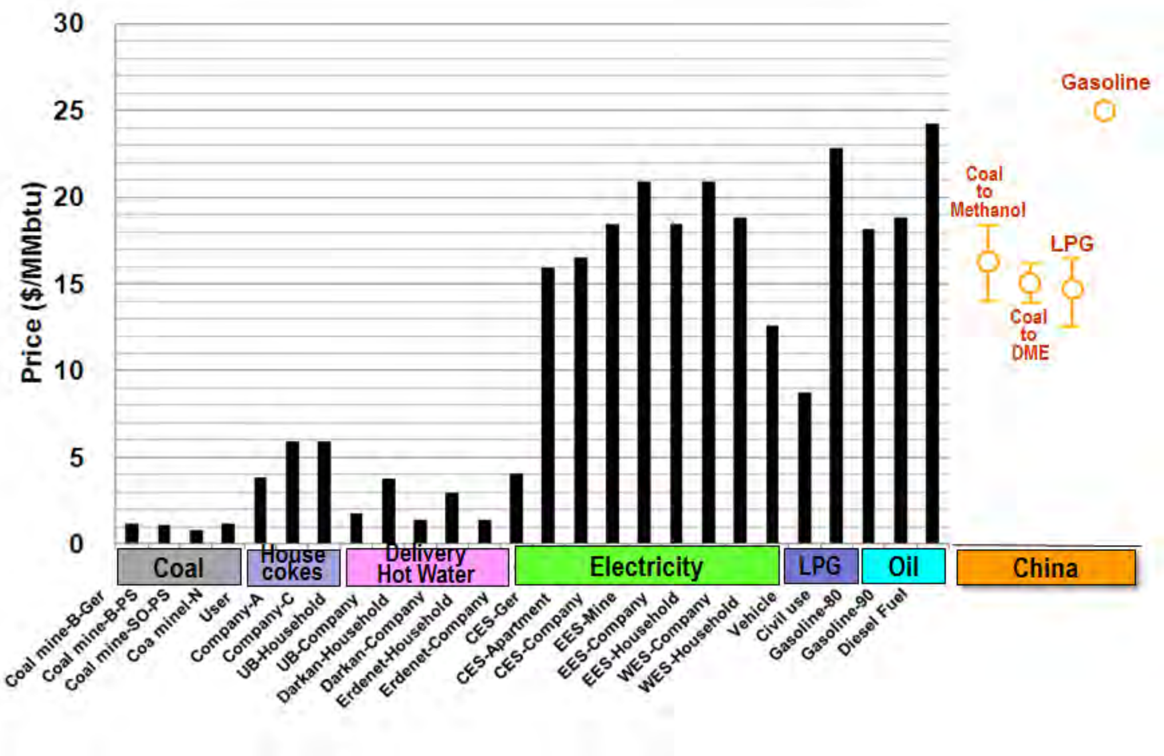


Fig. 4-62 Energy prices in Mongolia

(4) Sainshand industrial complex master plan

To develop heavy industries in Mongolia, a master plan to construct Sainshand industrial complex was approved by Mongolian government in June 2012. Figure 4-63 shows that Sainshand is the prefectural capital city of Dornogovi prefecture, which is located east of Gobi Desert and with a population of about 20,000. A Mongolian longitudinal railway connecting Russia and China was built and a railway network from Tavan tolgoi (a large coal mine) to Sainshand has also been planned for expecting a future heavy industry hub. This plan is also positioned as one of "Contents of big projects conducted on a priority basis which was announced by Mongolian government" which was announced by the Mongolian government in 2009.(References 1.1.3)

[65] The World Bank Report, Clean Coal, Lignite Mining and Power Development Options Study in Mongolia, June, 2008

Source: NDIC (National Development and Innovation Committee)

Fig. 4-63 Location of Sainshand

This master plan was created by Bechtel in the United States with a request from the Mongolia NDIC and includes six businesses at the basic research stage, but finally narrowed down to the four businesses of coke, refining copper, iron pellets and cement. Table 4-47 shows the product scale and technology outline of each business.

The basic research step included iron-making businesses: DRI (Direct Reduction Iron) and HBI (Hot Briquetted Iron) for overseas sales. However, as iron demand in Mongolia is small at 350 thousand tons/year in 2010 and final iron products were planned to be aggregated to Darkhan, they were deleted at the final research step. Furthermore, in relation to the omission, a coal gasification plant which manufactures DRI reducing gas was also deleted. Coal consumption at the basic research step was 7.6 million tons/year for coking coal and 4 million tons/year for thermal coal. However, DRI and coal gasification plants and coal fired power generation facilities were deleted to result in consuming only 2.9 million tons/year of coking coal for coke manufacturing.

This master plan includes infrastructure development such as water supply, railways, roads, power supply, regional heating system, air separator, communications and security, and public facilities such as houses, shopping center, schools, libraries, hospitals, leisure facilities, public offices, police stations, fire stations and post offices, excluding the four businesses above. Fig. 4-64 shows positional relationship in the industrial complex.

Table 4-47 Outline of Major Businesses in Sainshand Industrial Complex

Business	Product scale		Technology outline
	Basic research step	Final research step	
Coke factory	2 million tons/year	2 million tons/year	・Consumes 2.9 million tons/year of raw coal from Tavan Tolgoi ・Exports coke for iron-making ・Uses technology from Uhde (Germany)
Copper refinery	0.3 million tons/year	0.45 million tons/year	・Consumes 1.5 million tons/year of copper ore for 450 thousand tons/year of refined copper ・Refined copper for exports, sulfuric acid (for manufacturing fertilizer) as by-product ・Uses technology from Outotec (Finland)
Iron-making factory (pellets)	4.5 million tons/year	4.5 million tons/year	・Consumes 4.5 million tons/year of iron ore ・Pellets for direct reduction (DRI) material, or for exports ・Uses technology from KOBELCO (Japan)
Cement factory	1 million tons/year	1 million tons/year	・Consumes 1.3 million tons/year of lime stone ・Cement for domestic use and export for China ・Uses technology from F.L.Smidth (United States)
Iron-making factory (DRI /HBI)	2.5 million tons/year	(omission)	・Consumes 3.625 million tons/year of iron and steel pellets ・Material for domestic and foreign electric furnaces ・Uses technology from Midrex (United States)
Coal gasification plant	1.5 million tons/year	(omission)	・Consumes 1.3 million tons/year of coal ・Coal gasification is used for reduction of DRI manufacturing ・Uses technology from SES (United States)

Source: NDIC (National Development and Innovation Committee) documents edited by JICA study team

Source: NDIC

Fig. 4-64 Site Plan for Sainshand Industrial Complex

The site contains four neighboring businesses in a heavy industry area and another site to the east is planned as a future light industrial complex. For example, copper currently is powdered for shipment to China but it has been considered to ship the copper as copper wire by melting or casting method and iron pellets by processing them into reinforcing bars or rails in the future.

According to Bechtel, total investment for the industrial complex is estimated 9.36 billion dollars. Details are shown in Table 4-48. Construction costs for the four businesses are 5.32 billion dollars and infrastructure and public facilities costs are 4.04 billion dollars. Private investments occupy 60% and government investments occupy 40% of the total investment. A Sainshand project management department is planned for establishment in Mongolian government, showing the master plan and preparing for bidding on the land plan and infrastructure plan. The four businesses uses private investment only and the Mongolian government expects to choose companies with international bidding which desire to start their factory construction businesses with their own capital. For a coke business example, the Mongolian government is considering investments from a coke consumer such as Thyssen Krupp in Germany, which has its own coke ovens, ironworks and products with marketing and quality assurance. The Mongolian government is also considering investments by government and private sectors (PPP system) for infrastructure and public facilities so that the level of investments from the private sector seems to be a key issue to realize this business. The schedule is targeting completion in 2018 as it requires about 80 months from approval of the master plan even if it were with good progress.

Table 4-48 Investment Scale for Industrial Complex

Business, facilities	Investment (USD)	
	Private sector	Government
Coke factory	2.27 billion	-
Copper refinery	2.35 billion	-
Cement factory	380 million	-
Iron-making factory (pellets)	320 million	-
Public facilities	-	2.75 billion
Infrastructure (railways, roads)	-	600 million
Community	310 million	380 million
Subtotal	5.63 billion	3.73 billion
Total	9.36 billion	

Source: NDIC (National Development and Innovation Committee)

Issues for realizing Sainshand master plan are described as follows.

(i) As coke businesses have little iron or steel demand in Mongolia, most iron-making coke is used for export. With no actual iron-making coke business achievement in Mongolia, construction and operation of coke ovens and products shipments are entrusted entirely to foreign iron and steel companies as investors. The level of competitive advantage in Sainshand coke businesses including quality and cost found by these foreign iron and steel companies is an issue to realize the businesses.

(ii) Companies holding coke in China, India, Germany, Japan, Korea or other countries become candidates to run the businesses. As coke manufacturing technologies have been advancing including energy saving countermeasures (1) low-price materials compounding technique, (2) high-level use of coke oven gas and tar, (3) coke dry quenching (CDQ), the key is to especially improve economic efficiency of (1) and (2) described above in the location in Mongolia.

(iii) It is important for refined copper and iron pellets to develop foreign markets by improving quality, cost and added value, and for cement to develop a domestic market.

(iv) As the industrial complex uses an average of 12 million tons of water, an immediate water supply is prioritized as well as future water resources must be researched.

(v) Improved productivity, energy saving and environmental characteristics by sharing energy, by-products, waste materials and water among businesses and industrial complex

(vi) Human resource development for Mongolian engineers and business managers involved in this business

(vii) Smooth and timely support by the Mongolian government

4.3 Energy demand predictions through 2025 in Mongolia

4.3.1 Survey methods

Fig. 4-65 indicates survey methods for predicting energy demands in Mongolia. The following are vital indicators.

- Current state of Mongolia's energy demands
- Industrial sectors consuming main resources (coal and petroleum) and volume of consumption
- Future energy demand projects and consumption sectors
- Projections on future necessary coal volume

As such, we conducted interviewed with the local relevant agencies indicated in Fig. 4-65 and gather various data and materials. The incorporation of new coal technology in Mongolia will require information and knowledge related to these characteristics and actual conditions. To address this we utilized the information databases held by JCOAL.

As will be noted later, future energy and coal demand volume was predicted using a simple volume measurement model formula that references recent growth rates and GDP projections.

Furthermore, data from the 2011 edition of the Mongolia statistical yearbook was used in projections but in case that 2011 data is unclear analysis is based on data from 2010 or 2009.

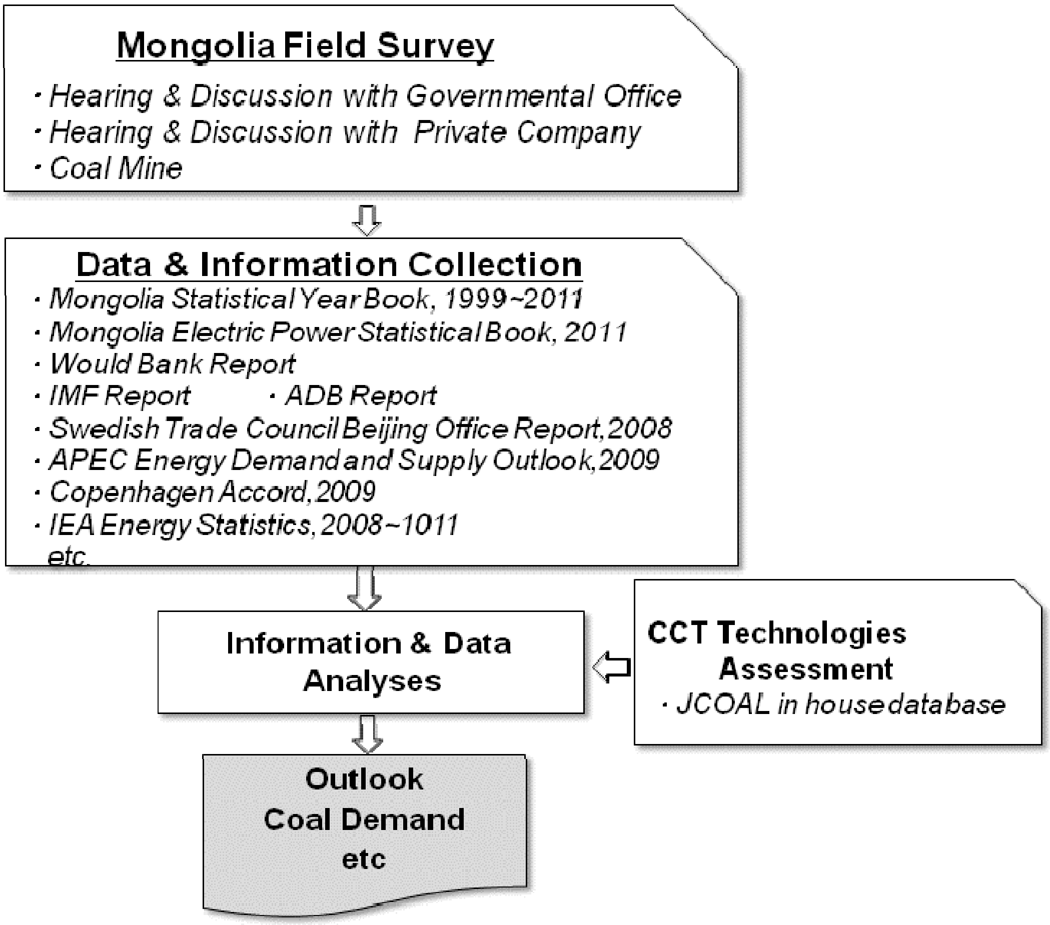
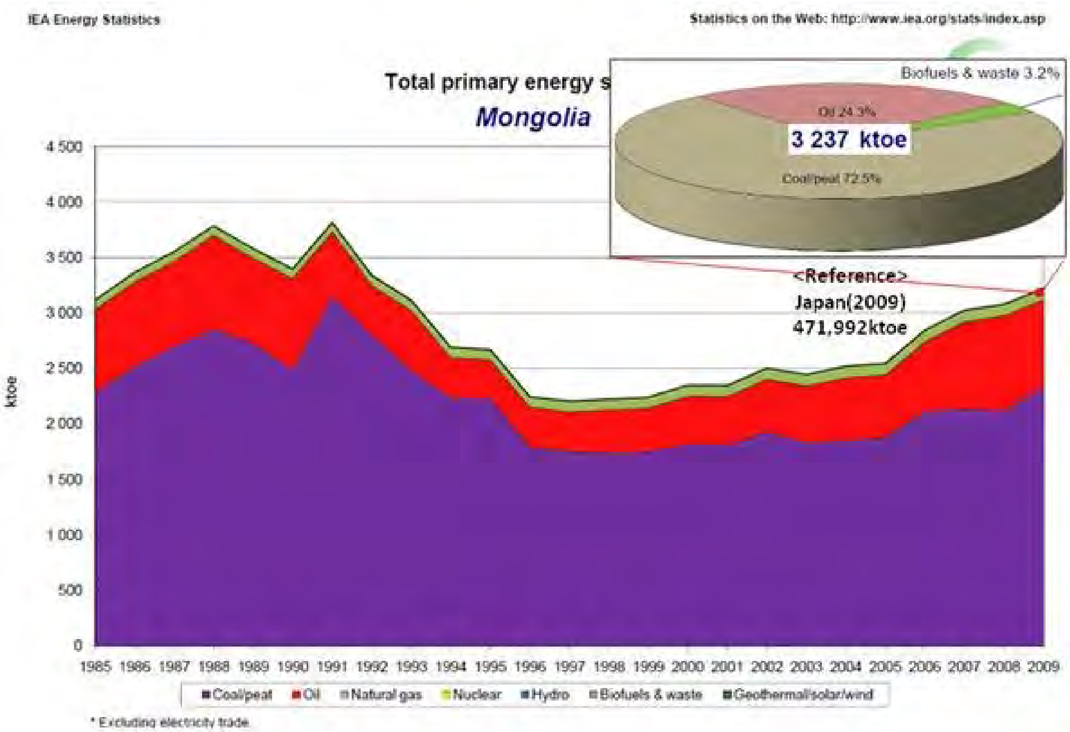


Fig. 4-65 Survey methods

4.3.2 State of energy demand and applications for coal

(1) Primary energies

Fig. 4-66 shows primary energy supply in Mongolia. After the fall of the former Soviet Union, Mongolia chose a path of independence but energy consumption volumes declined dramatically as a result of economic decline in 1991. Since then consumption has gradually recovered and in 2009 grew to 86% of 1991 levels. Their main energy resource is coal, representing 72.5% of all primary energies. Following coal is petroleum (petroleum products) at 24.3%. All coal is produced domestically and all petroleum products are imported from Russia. There is a gradual trend towards an increase in petroleum products over recent years but in general, Mongolia is a coal-based country.



Source: IEA Statistics & Balance

Fig. 4-66 Fluctuations in primary energy supply

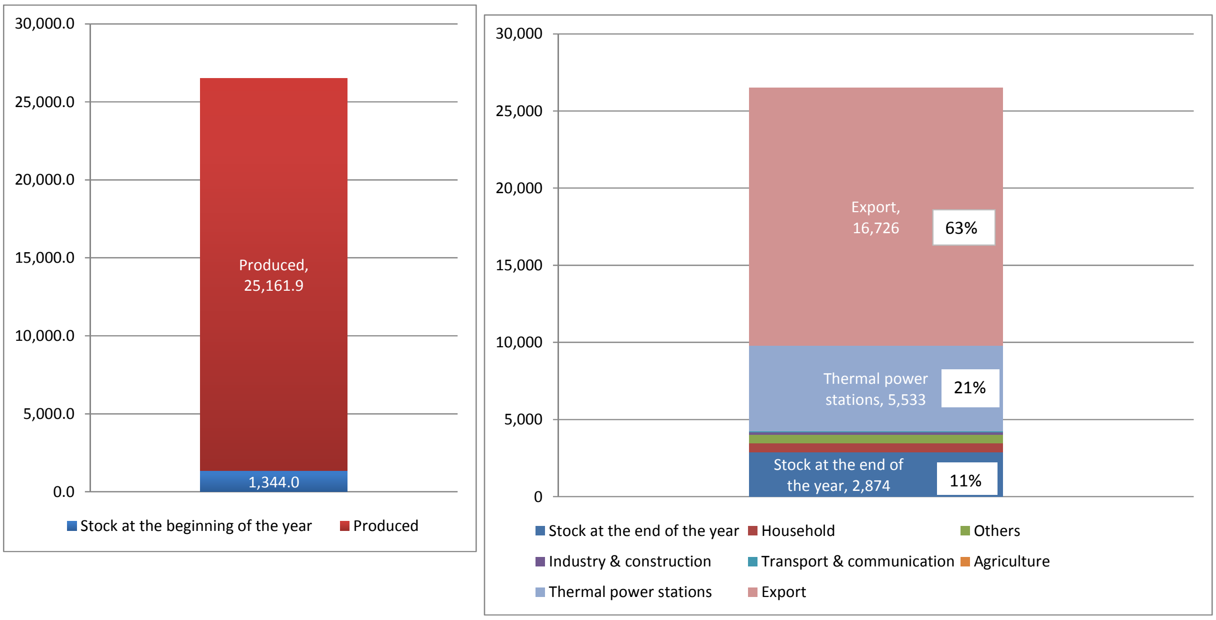
(2) Coal use

Fig. 4-67shows coal supply and consumption volumes. In 2010, 26.56M tons were produced. Of this, 62.9% was exported. Export volumes have increased dramatically since 2010. Fig. 4-68 shows domestic consumption. Excluding stocked amounts, in 2010 consumption was 9.89M tons. Power plant CHP (Combined Heat and Power) production accounts for the vast majority of consumption at 80%. 8.8% is residential consumption and the remaining 13.4% is consumed by industrial and other sectors. The final form of consumption is power, home heating, cooking heat, coke and other fuels, etc. Within CHP, 3.32M tons of coal was used for power generation. Heat production use total 2.79M tons but of this amount, CHP-related heat is 79% and residential heating is 19%. Coal for residential use is consumed as coal for "heating" and coal for "cooking". In Mongolia, coal remains the heat source for this purpose.

Furthermore, based on Mongolia statistics, industry refers to the following sectors (% - percentage of production value)[66].

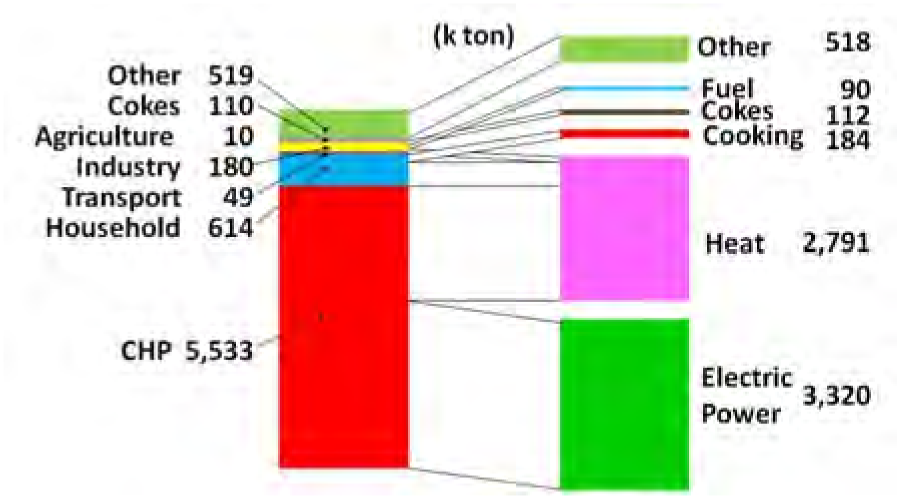
- Mining (mining, quarries) 71%
- Manufacturing (food and beverages, textiles, metals) 21%
- Other 8%

[66] National Statistical Office of Mongolia, Mongolia Statistical Yearbook 1999~2011



Source: National Statistical Office of Mongolia, Mongolia Statistical Yearbook 2011

Fig. 4-67 Coal supply and consumption volumes



Source: Created by JICA survey team based on National Statistical Office of Mongolia, Mongolia Statistical Yearbook 2010,2011 IEA Statistics &Balances, http://www.iea.org/stats/coaldata.asp?COUNTRY_CODE=MN

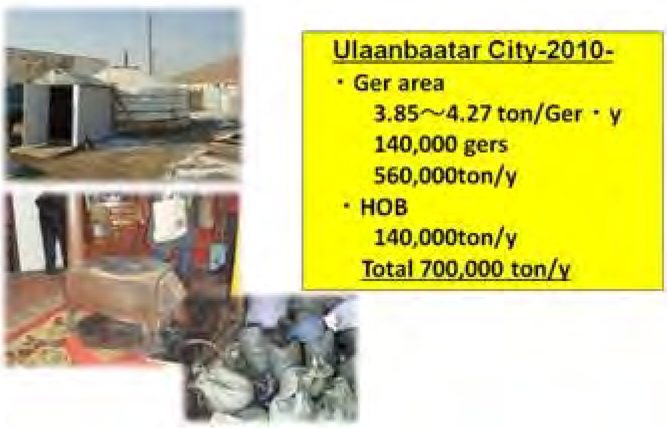
Fig. 4-68 Domestic coal use

Fig. 4-69 shows the state of residential-se coal in Ulaanbaatar. Ger are common forms of residential housing in Mongolia. Of the 252,000 homes in Ulaanbaatar, Gar make of 56% of those home and people living in those homes make up 66% of the city's population, or approximately 660,000 people. These people use 3.85 to 4.27 tons of coal per household, per year[67][68]. The use of coal in cooking and heating stoves is one of the causes of air pollution affecting the city and in response policies have been

67 Mongol News 2009/9/18,http://sky.geocities.jp/hairhanchildren/news.htm

68 JICA/Mathematical Plan Report, Ulaanbaatar, Mongolia Air Pollution Response Enhancement Project, June 2012

implemented to convert people to the use of coke. These trends and related future developments are one of the themes of this research.



Source: Private communication from Energy Resources LLC., November 21, 2011 Mongol News 2009/9/18,http://sky.geocities.jp/hairhanchildren/news.htm

JICA/Mathematic Programming Report, Ulaanbaatar, Mongolia Air Pollution Response Reinforcement Project June 2012

Fig. 4-69 Coal for residential use in Ulaanbaatar

(3) Petroleum use

Fig. 4-70 shows petroleum product consumption. In 2009, annual consumption of petroleum products totaled 760,000 tons. As reference, daily consumption of petroleum products in Japan during 2008 was 590,000 tons. The majority of petroleum products are represented by gasoline and diesel. Usage breaks down to gasoline being used for automobiles while diesel fuel is consumed in various sectors. In this survey, we attempted to research per product consumption for each sector. However, while energy statistics for Mongolia[69] indicate per product consumption, those statistics are not categorized by sector. Furthermore, during on-site surveys we visited the Petroleum Bureau to request this information but were not provided a response. As such, for this survey we referred to IEA energy statistics[70], which indicate sector-based data, and estimated per sector product consumption. IEA statistics indicated total volume as 757,000 tons wile Mongolian government statistics indicated this as 761,000 tons, thus discrepancies were noted. For these calculations, we used the Mongolian statistic of 761,000 tons. This resulted in data indicating that for diesel, 53% was used for automobiles, 27% for industry, 11% for power generation, and 8% for agriculture. As can be seen, diesel is consumed in various sectors and it is expected that demand will grow in the future.

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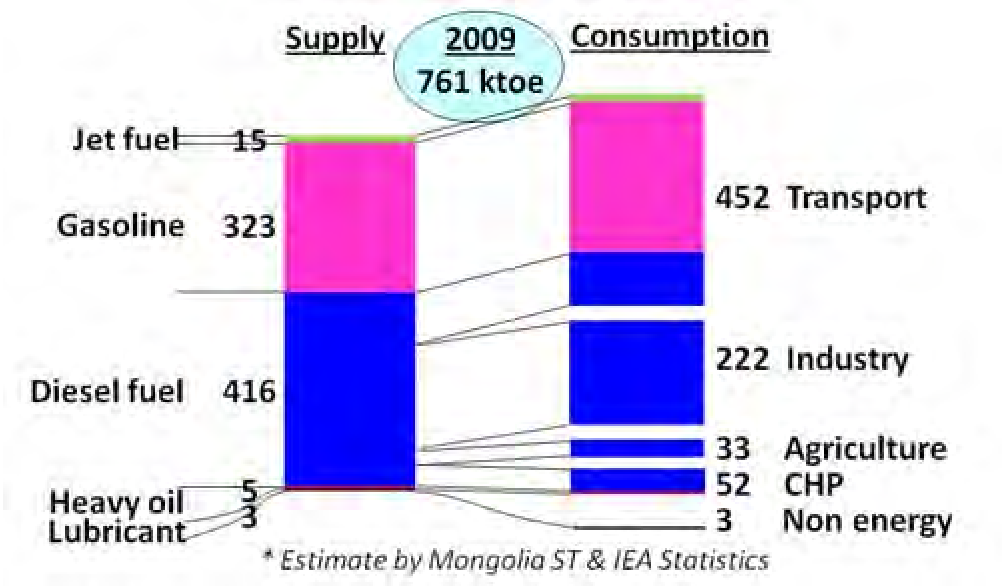
69 National Statistical Office of Mongolia, Mongolia Statistical Yearbook 1999~2011

70 IEA Statistics & Balance, http://www.iea.org/stats/pdf_graphs/MNTPES.pdf



Source: Created by JICA survey team based on IEA Statistics & Balance,http://www.iea.org/stats/pdf_graphs/MNTPES.pdf
National Statistical Office of Mongolia, Mongolia Statistical Yearbook 2009

Fig. 4-70 Petroleum use

(4) Other energy and their uses

LPG is another form of energy that is being used. All LPG is being imported from Russia. As shown in Table 4-49, 5000 to 6000 tons is being consumed annually for home and automobile use. LGP is sold by private companies. In 2004, a portion of restaurants converted to using LPG and by 2010 the majority of restaurants had converted to LPG. Ulaanbaatar is planning to have all taxis and buses convert to LPG vehicles. In areas without hot water, LPG also is used as fuel for gas boilers. Use of LGP appears to be spreading gradually to rural areas.

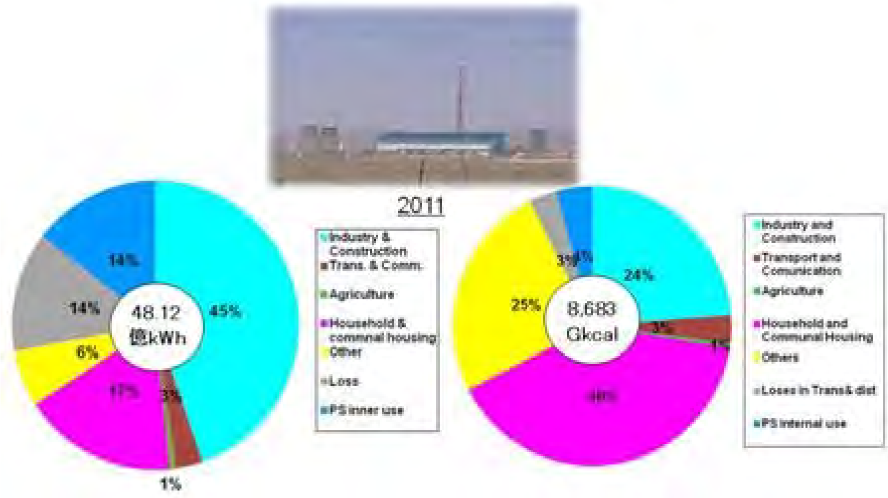
Table 4-49 LGP applications and consumption volumes

Year	Consumption (t/year)	LPG vehicles	Homes/restaurants using LPG
2004	2200		
2005	3500		
2006	4500	450	
2007	6000		Approx. 20000 (Ulaanbaatar 12000)
2008		Approx. 1000	Approx. 20000 (Ulaanbaatar 12000)
2010			
2012	8000		

Source: Swedish Trade Council Beijing Office, Private Sector Opportunities in the Oil, Gas and Coal Sectors in Mongolia, December, 2008

(5) Power and heat consumption

Fig. 4-71 shows power and heat demand sectors from 2011. There are eight CHP plants in Mongolia. Of these, four are located in Ulaanbaatar. Of those, the No. 4 plant is the largest, supplying 70% and 50% of Mongolia’s total power and heat, respectively. Among power consumption sectors, industry and construction represent the largest consumers followed by housing. For heat, housing represents the largest consumer. Power demand is slightly greater in the winter than in the summer but heat demand is significantly greater in the winter. As such, securing heat demand during the winter is key to Mongolia's energy supply and demand. Therefore, it is important to secure the heat supply in winter.



Source: National Statistical Office of Mongolia, Mongolia Statistical Yearbook 2011

Fig. 4-71 Sector-based power and heat consumption

In conclusion, the state of Mongolia’s energy consumption can be summarized as follows.

For primary energy, Mongolia is a coal-consuming nation where 72.5% of need is met using coal while 24.3% is addressed through imported petroleum products. 80% of coal is used for power and heat production while 8.8% is used in homes. Residential use consists of heating and cooking purposes. Policies are in place working to covert residential use from coal to coke. Automobile gasoline represents 42.4% of petroleum products while 54.7% is diesel used for vehicles and industrial purposes. Additionally, 8000t/year of LPG is being imported for use in vehicles and large-scale facilities such as restaurants.

As such, when predicting future coal demand we predicted how much demand there would be in the following sectors.

- Power generation
- Heat production
- Resident coke production
- Automotive liquid fuels
- Industrial liquid fuels

Next, we estimated the amount of coal required to fulfill all or part of this demand. The following shows predictions for energy and coal demand in 2025.

4.3.3 Energy demand projections through 2025

(1) Method of projecting demand

In this research, the following method was used to project energy and coal demand through 2025.

$E = P \times E_{capita}$ ---(1)

Here,

E : X year energy demand volume

P : X year population

E_{capita} : X year per capita energy consumption

X year population P was estimated using a linear approximate equation for population changes from 2000 through 2011.

$P = aX + b$ ---(2)

Here,

X : Number of calendar years a, b : Coefficient of approximate expression

Two estimation methods were used for X year per capita energy consumption E_{capita}.

[Case 1]

Estimated using a linear approximate equation for actual population changes from 2005 through 2011.

$E_{capita} = \alpha X + \beta$ ---(3)

α, β: Coefficient of approximate expression

[Case 2]

Estimated based on per capita GDP growth rate assumed value and energy value of elasticity.

$E_{capita} = E_{capita\text{-}0} \times (\gamma \times \delta)^{(X-X_0)}$ --(4)

Here,

$E_{capita\text{-}0}$: Base year X_0 の E_{capita} actual value

γ : Per capital actual GDP_{capita} growth rate

δ : energy value of elasticity

X_0 : Base year -2011

Predictions of automotive fuel were based on the number of automobiles, not energy consumption.

$E_{vehicle} = P \times V_{capita} \times F_{vehicle}$

--(1)’

Here,

V_{capita} : X year per capita number of cars owned

$F_{vehicle}$: Per vehicle consumption

The method of estimating V_{capita} is the same as the above. We used the Case 1 method of "a linear approximate equation based on growth for the most recent 6 years" and the Case 2 method of "GDP growth rate and elasticity." 2011 actual figures were used for $F_{vehicle}$.

Fig. 4-72 shows prediction results. The curved line indicates the results from this survey, which are based on the following formula.

P =36,321×X – 70,248,900 ---(5)

A comparison of these results with results from another agency is indicated in Table 4-50. We found that the values estimated using the above formula (5) are almost identical to results issued by the Mongolian government and the UN Medium Case.

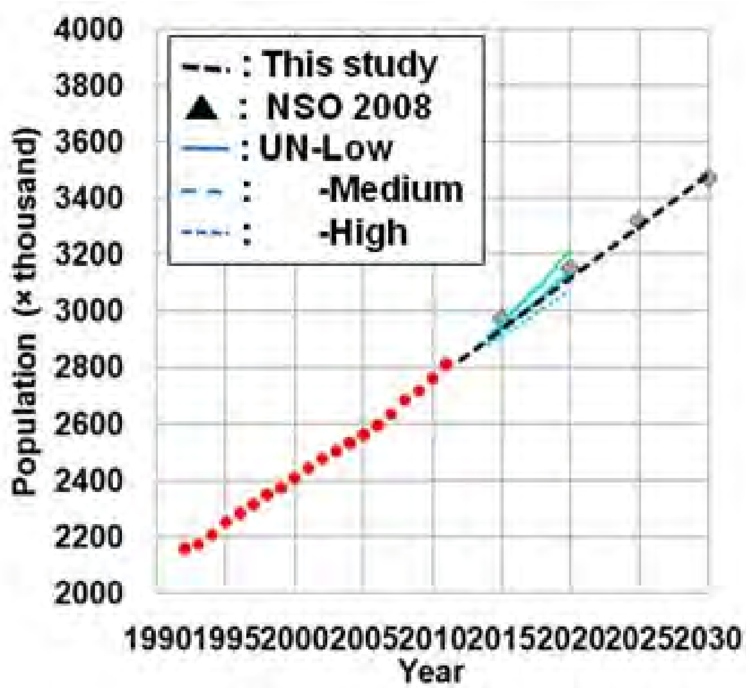


Fig. 4-72 Population predictions

Table 4-50 Comparison of population predictions

(Unit: 1000 people)

Year	This report	Mongolia[71]	UN[72]		
			Low	Medium	High
2015	2938	2973	2912	2936	2960
2020	3119	3154	3084	3143	3216
2025	3301	3320			
2030	3483	3475			

Fig. 4-73 shows projections from various agencies concerning actual per capital GDP growth rate. The red plot indicates actual figures through 2011. While figures differ with each organization, high-level growth exceeding 10% is expected by 2015. This is thought to be because of assumptions that resource exports from copper mines and coal mine development will see dramatic increases. However, from 2015 onward, both the IMF and the Asian Development Bank (ADB) predict that this will fall below 10%. The Mongolia government is assuming both a base case and a copper mine development

[71] Swedish Trade Council Beijing Office, Private Sector Opportunities in the Oil, Gas and Coal Sectors in Mongolia, December, 2008

[72] ADB report,Updating Energy Sector Development Plan-Interium report,June,2012

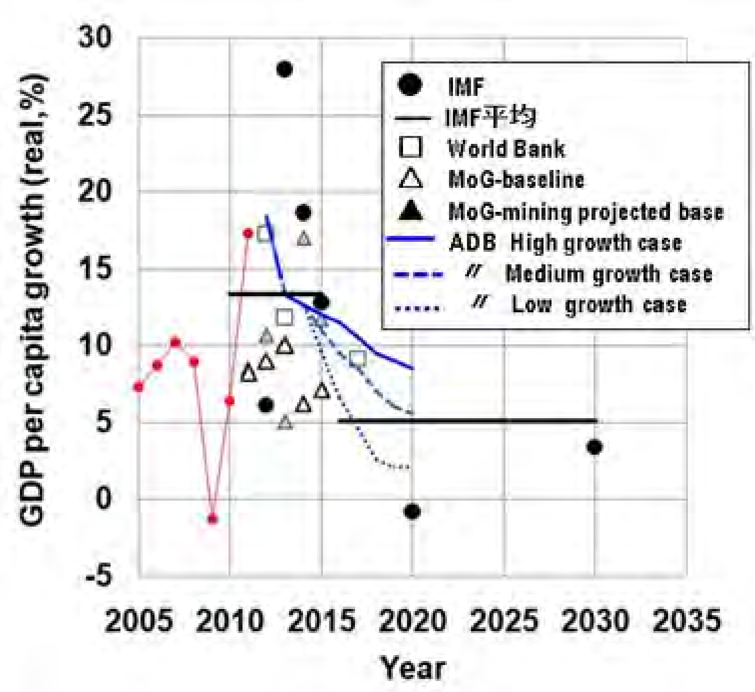
case[73].

This survey does not debate the adequacy of various GDP figure, but instead predicts energy demand volume by setting a certain value for GDP. In estimating demand through 2025, we assume the high growth rate seen through 2015 will not continue and thus decided to establish the Mongolian government's baseline value and the mean value.

Assumed per capita GDP growth rate (actual) γ=7.9%

This 7.9% is relatively close to the IMF's weighted mean[Note)] for 2010 through 2030 of 7.4% and the ADB 2020 Medium/High intermediate value of 7.1%.

Note) Weighted mean $(\sum\gamma_i \times n_i)/(\sum n_i)$, γ_i : per capital GDP growth rate, n_i: number of years to reach γi



Source: ADB report, Updating Energy Sector Development Plan-Interim report, June, 2012

Jargalsaikan. G., Overview of Mongolian Economy Impact of the Global Economics Crisis, Europe-Mongolia Investor's Forum, London, Dec., 2009

IMF Report, World Economic Outlook-Growth Resuming, Dangers Remain, April, 2012

IMF Country Report No. 10/166, Mongolia: Joint IMF/World Bank Debt Sustainability Analysis Under the Debt Sustainability Framework for Low-Income Countries, June, 2010

Fig. 4-73 Projected real per capital growth rate

(2) Demand projection prerequisites

Table 4-51 indicates per capita GDP and energy value of elasticity using demand productions. In Case 1, the abovementioned formula (3) is used (based on changes for most recent six-year period) but with this method actual annual growth rate changes depending on the year. The <annual mean value> shown in the table is the mean value for growth rates for each from 2012 through 2025 calculated using the

[73] Jargalsaikan.G., Overview of Mongolian Economy Impact of the Global Economics Crisis,Europe-Mongolia Investor's Forum,London,Dec.,2009

following formula.

$$\text{Annual mean} = \frac{\sum_{i=2006}^{2011}\{(E_{i+1} - E_i\}/E_i}{(2011 - 2006)}$$

Here,

Ei : i year per capita energy consumption

The growth rate in Case 1, for example, was coal 2.0%, power 2.6%, and heat 0.3%. Diesel growth rate was significant while heat growth rate was low. These and other characteristics were noted.

Conversely, in Case 2, as was noted above the per capita GDP growth rate was set to 7.9%. The elasticity value for energy from 2005 to 2011 was as shown in the table. From 2012 onward, we calculated the elasticity value as the mean value from years 2005 through 2011. However, actual diesel consumption volume and the number of cars owned were 1, which is a significant value. If, for example, 2012 and beyond is calculated using this value of elasticity, diesel consumption volumes and vehicle ownership become extremely high values in 2025. Thus, we set the elasticity value to 1 for both of these elements.

Using the above value of elasticity to examine growth rates in Case 2, coal was 4.9%, power was 6.6%, and heat was 0.6%. In all cases, values are higher than in Case 1 and, of course, these changes are seen as differences in energy consumption and coal demand volume.

Table 4-51 Values using demand predictions

Item		Per capita growth rate (%)		Energy elasticity(-)	
		Case 1 <Annual mean>	Case 2 <Set value>	2005~2011 <Annual mean>	2012~2025 <Set value>
GDP-real-			7.9		
Coal	Power	1.4		0.40	
	Residential, public	2.1		0.65	
	Total	2.0	4.9	0.62	0.62
Petroleum	Gasoline	0.8	1.7	0.21	0.21
	Diesel	5.8	7.9	2.98	1.0
	Total	4.1	7.9	1.60	1.0
Power	Industry / construction	2.8		0.96	
	Residential	2.7		0.93	
	Total	2.6	6.6	0.84	0.84
Heat	Industry / construction	-3.4		-0.63	
	Residential	0.0		0.02	
	Total	0.3	0.6	0.08	0.08
Vehicles	Personal	6.0		3.48	
	Other	6.0		3.49	
	Total	6.0	7.9	3.49	1

(3) Power demand predictions

Fig. 4-73 shows the results of power demand projects. Here, power demand volume refers to: Power demand volume: consumption volume + volume used in power plant + transfer loss.

In order words, this refers to the total power volume that needs to be produced by the power plant. Actual volume in 2011 total is 4812GWh. In Case 1, this grew to 7,454GWh in 2025. In specific sectors, growth in industry and construction was largest followed by homes and public facilities.

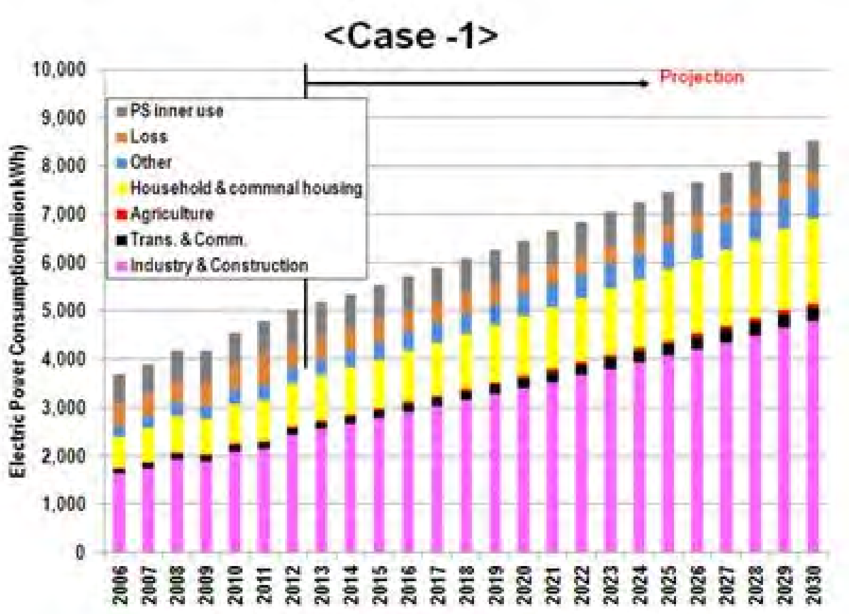


Fig. 4-74 Power demand predictions – Case 1

Fig. 4-75 shows future capacity requirements of power plants. The figure summarizes the following prediction results.

- Analysis results from this survey: Case 1, Case-2: two cases - power growth rate 3.4% and 6.6%
- predictions of Mongolia Power Department power plant construction plant by Mongolia Energy Policy Department
- Asian Development Bank (ADB) predictions[74]

As shown in Table 4-50, the Case 2 power growth rate of 6.6% is based on a GDP growth rate of 7.9%. However, as we referenced a case with a lower power growth rate, we also indicated the power growth rate of 3.4% based on the actual GDP growth rate of 4% between 2006 and 2011.

Power plant capacity was calculate using the following formula.

Power plant capacity (MW) = power demand (MWh) x 1000/(365 x 24 x annual load rate L) … (6)

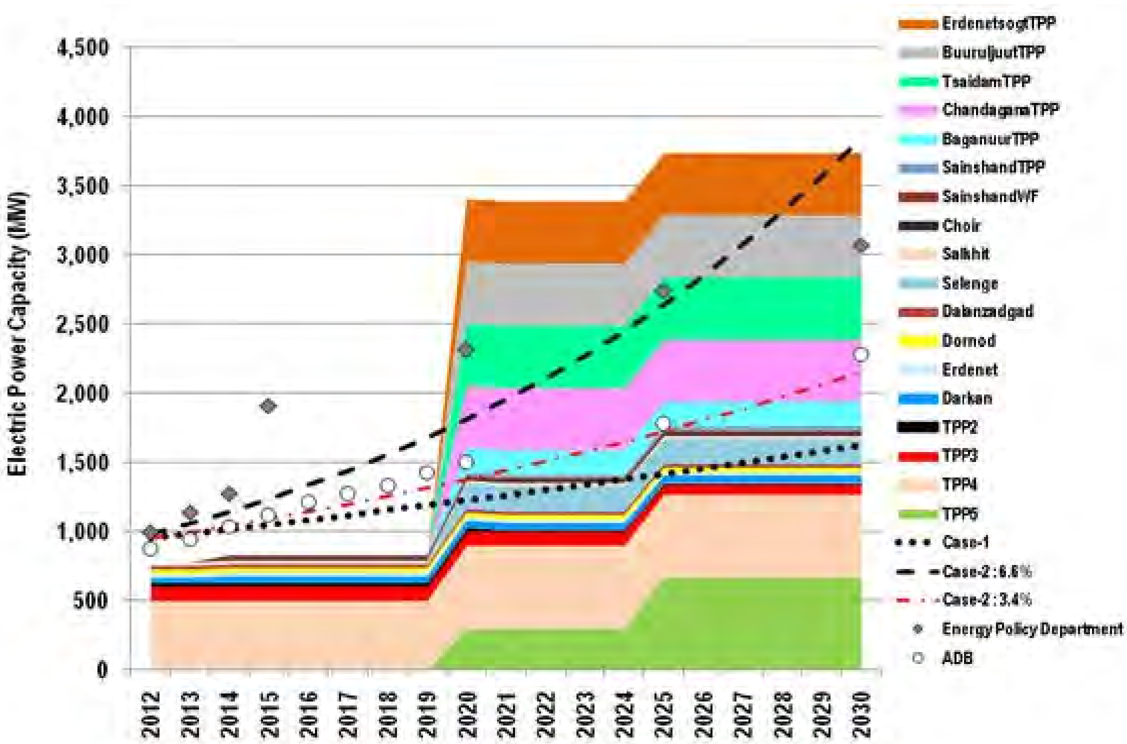
Plant load factor (PLF) = annual total power capacity (MWh)/(max facility capacity (MW) x 365 x 24/1000) … (7)

Plant load factor refers the rate gained by comparing the actual volume produced through the year against the theoretical maximum if the plant operated at maximum capacity for an entire year (8760 hours). Actual performance for No. 2, No. 3, and No. 4 power plants during 2011 was on average 0.60[75]. For calculations in this survey, PLF = 0.6.

74 ADB report,Updating Energy Sector Development Plan-Interium report,June,2012

75 Mongolia Electricity Statistical Year Book-2011

The following is gained from Figure 4-75.



Source: ADB report,Updating Energy Sector Development Plan-Interim report,June,2012

Mongolia Energy Policy Department

Created by JICA survey team based on Mineral Resources Authority data.

Fig. 4-75 Predictions for required power plant capacity

A. Power plant capacity for 2025 was estimated in the following way. The influence of power growth rate is significant.

Power growth%	Power capacity
2.7%	1418 MW
3.4%	1726MW
6.6%	2643MW

B. Projections by the Mongolia Energy Policy Department call for the immediate construction of approximately 600MW in 2014 followed by an additional increase of nearly 1000MW of the next 15 years. Projections for 2025 are similar to the Case 2 result of 6.6% in this survey.

C. Asian Development Bank (ADB) projections are close to the 3.4% result from Case 2 of this survey.

D. The power plant construction plan drafted by the Mongolia Power Department calls for a jump to nearly 2700 MW by 2020. Conversely, the plan through 2020 only calls for the construction of the No. 5 power plant.

E. From the above, it is apparent that the power plant construction plan is asymptotical with projections for growing demand.

As noted above, calculations in this survey assume a mean annual rate of 6.6% for power demand growth from 2012 through 2025, thus creating an exponential growth trend but as shown in Figure 4-75, setting the GDP growth for each year produces a power demand prediction curve that is not continuous. The Energy Policy Department predictions (◆in figure) display this type of trend. Considering data from this survey and the Power Department are nearly identical for 2025, it is likely that Mongolia assumed average growth in the range of 6.6%.

Based on the above observations, we can identify the following issues concerning the present power plant plan.

- Significant power shortage by 2019 and exceeded supply capacity from 2020 through 2030. Mongolia needs a plan that is adequate for projected demand.

For example, Fig. 4-76 shows an example of a power plant plan that is adequate for demand assuming a growth rate of 6.6%. For this figure, it is assumed supplying would be tight; construction on the No. 5 power plant needs to begin immediately.

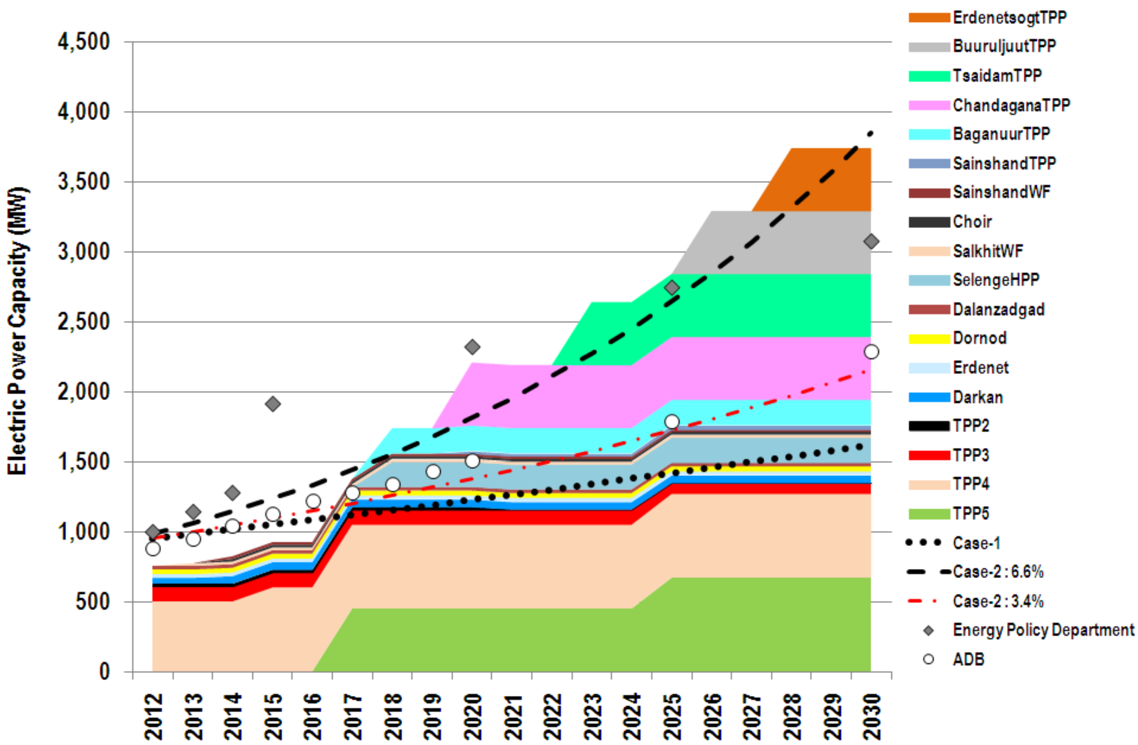


Fig. 4-76 Power plant construction plan adequate for demand

Furthermore, the Power Department's plan assumes operation of the No. 4 power plant through 2030. This power plant was constructed between 1981 and 1991, and up to this point a significant number of revisions, improvements, and repairs have been made. By 2025, the plant will be a deteriorating facility that will have been in operation for 40 years since its construction. Thus, they must prepare for the likelihood that the No. 4 power plant will require replacement by 2025.

(4) Heat demand predictions

Fig. 4-77 shows heat demand prediction results.

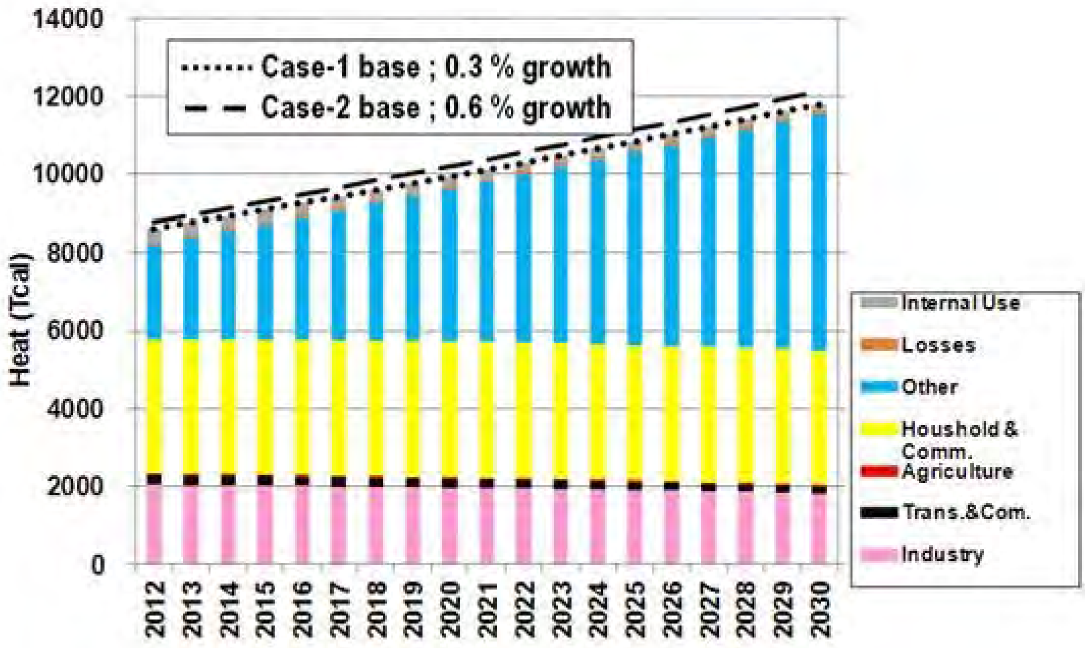


Fig. 4-77 Heat demand predictions

In Case 1 and 2, growth rates are 0.3% and 0.6% respectively. As the rates were low in both cases, predicted values did not result in significant differences.

	Growth%	2025 heat demand
Case 1	0.3%	10,957 Tcal
Case 2	0.6%	11,136 Tcal

Sector-based demand projections are characterized by little increases in housing and public facilities while industry will experience a decline.

(5) Oil demand predictions

Fig. 4-78 shows demand prediction results for the number of vehicles owned. Case 2 showed greater growth with approximately 690,000 vehicles by 2020, 1.06M by 2025, and 1.64M by 2030.

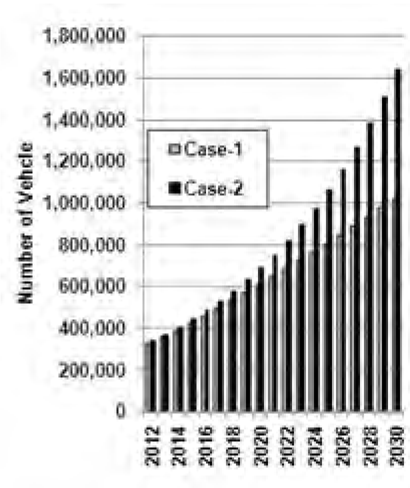


Fig. 4-78 Vehicle increase projections

Fig. 4-79 shows demand predictions for petroleum (petroleum products). Gasoline is used for personal vehicles while diesel is used for other vehicles (buses, taxis, trucks, etc.) and for commercial purposes.

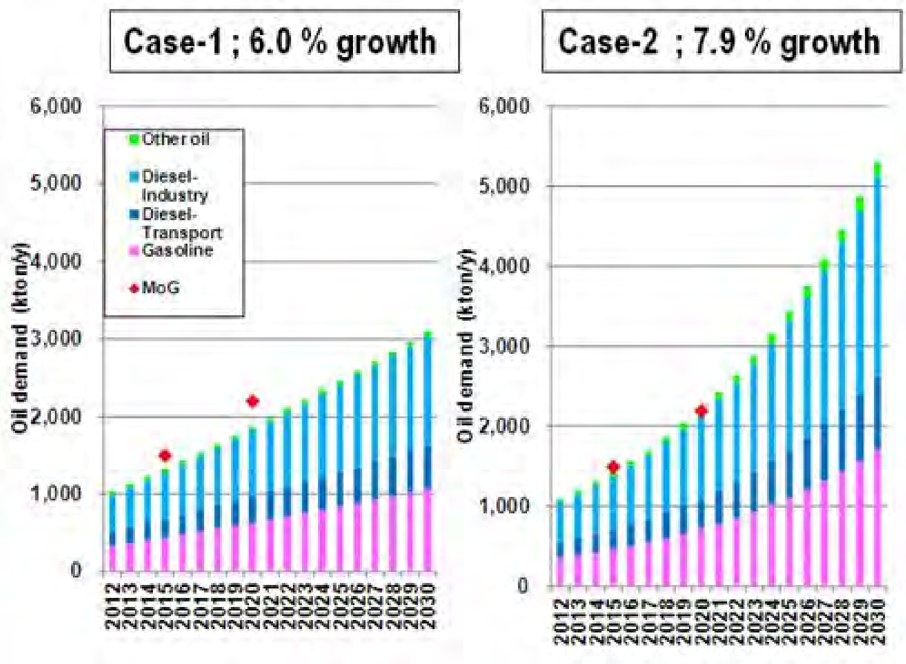


Fig. 4-79 Petroleum demand predictions

We see significant growth for gasoline and commercially used diesel. Petroleum demand volume in 2025 for Case 1 and Case 2 are as follows.

	Petroleum demand volume (1000t/year)		
Year	Case-1	Case-2	Petroleum Bureau
2015	1,328	1,430	1,500
2020	1,865	2,220	2,200
2025	2,455	3,436	

Case 2 results are close to the results of interviews held with the Petroleum Bureau in February 2012 and it is likely they are assuming a growth rate of around 7.9%. However, as seen in the previous figure, in Case 1 and Case 2, predictions for vehicles owned in 2020 differ dramatically. In predictions for Case 2, there will be approximately one vehicle for every three people by 2025 with this ratio growing to 2:1 by 2030. The 2030 per capital vehicle ownership rate would be equivalent to countries in present day Europe.

(6) House coke demand predictions

Currently, policies are being promoted to replace coal used in Ger with house coke in order to limit air pollution in urban areas. Table 4-52 shows the results of projections[76] for increases in Ger and projections for house coke demand.

The following conditions were applied when projecting house coke demand volumes.

(i) Calculated based on figures from the Mongolia Bureau of Statistics' predictions that the population of Ulaanbaatar will increase from 2010 through 2020 at a rate of 4.5% annually and from 2020 to 2030 at a rate of 2.6% annually.
(ii) Increases in Ulaanbaatar residences was estimated based on statistical documents for actual figures from through 2011.
(iii) For (3), Ulaanbaatar's new apartment plan, a project concept for 100,000 residences, was assumed for post-2015. While the amounts of coal used in Ger and single-family houses differs, we set this at 4t annually per household.
(iv) House coke usage volume is set at 70% of raw coal usage volume.
(v) Assumed 0.6t of house coke could be produced from 1t of coal.

Our prediction result shows in Table 4-52; in addition to be needed to revise with overseeing future record.

The above projections are merely for reference and they will need to be reevaluated in comparison to actual figures. From Table 4-52, we see that by 2016 some 600,000 tons of house coke will be required if the apartment construction and relocation plan is implemented according to schedule. As such, they must quickly seek to establish house coke production plants.

76 Guttikunda.S., Urban Air Pollution Analysis for Ulaanbaatar, June 2007

Table 4-52 Ger increase projections and house coke demand volume

Year	Mongolia		Ulaanbaatar												
								Case 1: If the new apartment was built as a planned					Case 2: No new apartment		
	Population	Increasing number	Population	Increasing number	No. of house-holds	Ratio of family	No. of house-holds of ger & house	New apart-ment	Remaining No. of households of ger & house	Coal	House cokes	Coal for house cokes	Coal	House cokes	Coal for house cokes
	(1,000 people)	(1,000 people)	(1,000 people)	(1,000 people)	(1,000 unit)	(person /unit)	(1,000 unit)	(unit)	(1,000 unit)	(1,000 t)	(1,000 t)	(1,000 t)	(1,000 t)	(1,000 t)	(1,000 t)
2006	2,595		994		227	4.4	133		133						
2007	2,635	40	1,031	37	235	4.4	138		138						
2008	2,684	48	1,072	41	252	4.3	149		149						
2009	2,716	33	1,112	41	273	4.1	162		162						
2010	2,761	45	1,152	39	294	3.9	176		176	704	493	821	704	493	821
2011	2,811	50	1,201	50	307	3.9	186		186	744	521	868	744	521	868
2012	2,829	18	1,253	52	321	3.9	194		194	777	544	907	777	544	907
2013	2,865	36	1,305	52	335	3.9	203		203	812	569	948	812	569	948
2014	2,901	36	1,357	52	348	3.9	212		212	847	593	988	847	593	988
2015	2,938	36	1,409	52	361	3.9	220	10	210	842	589	982	882	617	1,029
2016	2,974	36	1,461	52	384	3.8	236	20	216	863	604	1,006	943	660	1,100
2017	3,010	36	1,513	52	398	3.8	245	30	215	858	601	1,001	978	685	1,141
2018	3,047	36	1,565	52	412	3.8	254	40	214	854	598	996	1,014	710	1,183
2019	3,083	36	1,617	52	426	3.8	262	50	212	850	595	991	1,050	735	1,225
2020	3,119	36	1,669	52	439	3.8	271	60	211	846	592	987	1,086	760	1,267
2021	3,156	36	1,712	43	463	3.7	287	70	217	867	607	1,012	1,147	803	1,338
2022	3,192	36	1,756	43	475	3.7	294	80	214	858	601	1,001	1,178	825	1,374
2023	3,228	36	1,799	43	486	3.7	302	90	212	849	594	990	1,209	846	1,410
2024	3,265	36	1,843	43	498	3.7	310	100	210	839	587	979	1,239	867	1,446
2025	3,301	36	1,886	43	510	3.7	317	110	207	830	581	968	1,270	889	1,481

Source: JICA study team

(7) Demand predictions for energy in industry and other sectors

Fig. 4-80 shows energy, in other words coal demand predictions for industry, construction, transport, communications, and agriculture. In 2025, Case 1 estimates 370,000 tons. Case 2 predicts growth rate of 4.9% and 650,000 tons.

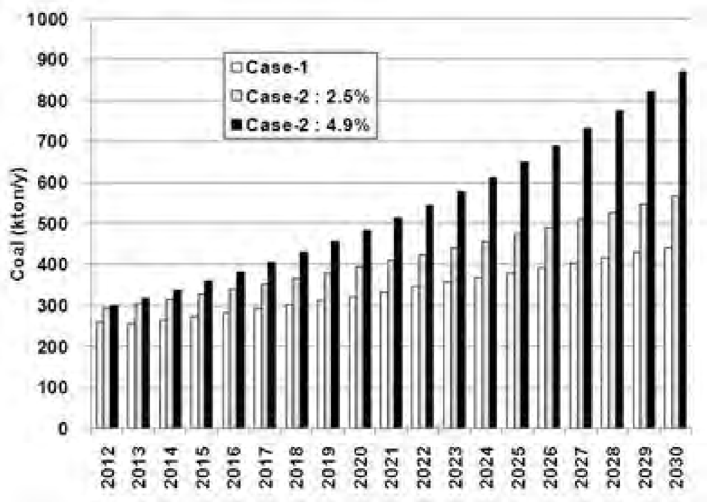


Fig. 4-80 Coal demand predictions for industry and other sectors

4.3.4 Projections for domestic coal demand through 2025

We calculated future coal demand volume for sectors currently consuming coal. The results are shown in Fig. 4-81 and Table 4-53 Domestic Coal demand volume for 2025. Target sectors were as follows:

- Power
- Heat production
- Industry and other sectors
  - a) Growth rate for coal use in Mongolia from 2005 to 2011 as standard: 2005 to 2011 growth based
  - b) Per capital GDP growth rate of 7.9% and coal growth elasticity value as standard: Growth rate of 4.9%

Here, reference value (coal only) is not an analysis of energy consuming sectors and their aggregate values as was done in Case 1 and Case 2. This value is the coal demand volume estimated based on coal consumption growth rates in Mongolia from 2005 through 2011.

When converting the energy volumes calculated above into coal volumes, we used the following figures. These figures are based on actual power plant performance during 2011.

- Coal calorific value: 3300kcal/kg
- Overall power generation efficiency: 38%
- Heat (produced) efficiency: 80%

Note) Mongolia Power Statistics 2011, P 42, P43. Weighted mean value for actual performance from 6 power plants.

The result with Case 2 was projected demand of 14.4M tons in 2025 (the reference value was 15.6M tons). According to predictions by the Mineral Resources Agency of Mongolia (MRAM) Coal Survey Division demand will be 18.1M tons by 2025, which was greater than the volume predicted in this survey. This difference could be attributed to the fact that the scope of sectors covered in this survey is narrow compared to MRAM, which was likely to have covered a broader scale of sectors and applications. For example, it is likely they take into account the production of liquid fuels using coal gasification. Furthermore, Case 2 sets the per capita GDP growth rate at 7.9% while it is possible

MRAM is assuming a higher GDP growth rate. On this matter, there is need to conduct further research and compare results prior to the final report.

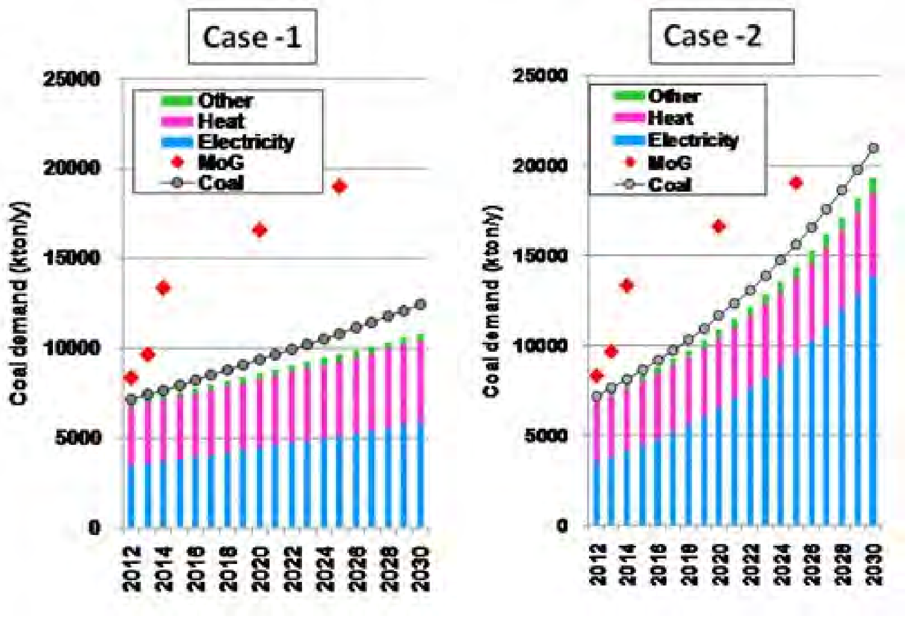


Fig. 4-81 Coal demand predictions

Table 4-53 Domestic Coal demand volume for 2025

(Unit: 1000t/year)

	Case 1	Case 1.5: 2.5%	Case 2: 4.9%	Reference		MRAM data
				2005-2011 Result	Rate of increase:	
2008	5,843	5,843	5,843			
2009	6,426	6,426	6,426			
2010	6,906	6,906	6,906			
2011	6,815	6,815	6,815			
2012	7,000	7,000	7,200			
2013	7,200	7,300	7,500			
2014	7,400	7,500	7,900			
2015	7,500	7,800	8,300	8,000	8,600	13,700
2016	7,700	8,000	8,800			
2017	7,900	8,300	9,300			
2018	8,100	8,500	9,800			
2019	8,300	8,800	10,300			
2020	8,600	9,100	10,900	9,300	11,600	15,700
2021	8,800	9,400	11,500			
2022	9,000	9,700	12,100			
2023	9,200	10,100	12,800			
2024	9,400	10,400	13,600			
2025	9,600	10,700	14,400	10,800	15,600	18100

Note: Case 1: Energy demand projections based on straight-line approximations using actual figures for 2005 - 2011

Case 1.5: 2005 - 2011 coal usage volume actual figures projected using straight-line approximation

Case 2: Energy demand projections are based on per capita growth rate of 4.9% and energy elasticity value of 0.62

Chapter 5 Environmental Protection Plan at Coal-related Facilities

5.1 State of environmental protection in the world and in Mongolia

5.1.1 Environment protection relating to development and operations of coal mines

(1) Environmental protection relating to development and operations of coal mines in the world

With coal mining development, untouched lands are excavated and this can have various effects on the environment. The effects on the environment include the followings:

(a) Impact on air

The impact on air includes noise created by mining equipment, soil and coal dust scattering from excavation, scattering of gases contained in coal, and scattering of gases exhausted from mining equipment.

(b) Global warming

Carbon dioxide exhausted from equipmnet during operations and methane gas contained in coal seams are greenhouse effect gases that are a major cause of global warming.

(c) Impact on land and soil

Natural landforms are greatly changed through exploitation. Also, removed soil can be polluted by heavy metals.

(d) Impact on surface water and underground water

Excavation can produce acidic wastewater, which can give negative impact on the local ecosystem. Also, excavation can cut off natural underground water paths.

(e) Impact on vegetation

Cutting off vegetation for excavation purposes results in the loss of vegetation . Also, dust produced during excavation can impact the growth of vegetation.

(f) Impact on people

Noise, equipment vibration, inhaling dust, etc. can give negative impact on the health of workers and surrounding residents. Inhaling large volumes of dust can cause pneumoconiosis and other lung ailments.

These are problems faced by all coal-producing countries around the world and each of the countries has implemented a variety of measures. In advanced countries, strict regulations are already in place. In Japan, the Mine Safety Act and the Coal Mining Safety Regulations require that mining licensees implement environmental measures.

In NSW and Queensland, the two largest coal-producing states in Australia, mining laws and environmental protection laws have been in place for each state. As an example of environmental measures, the reclamation of opencut mining sites is shown in Fig. 5-1 and Fig. 5-2. For opencut mining sites, the sites are reclaimed by levelling and by vegetation. Coal mining companies are attemping to return the site to as close as its original state prior to mining began. Fig. 5-2 shows the same location of Fig. 5-1 after its reclamation. The land has been reclaimed to the state where it is difficult to notice that mining was actually conducted.

Source: oresomeresources.com

Fig. 5-1 Mined area

Source: oresomeresources.com

Fig. 5-2 After reclamation

Similar to Australia, the United States also has mining laws and environmental protection laws set at the federal and state levels. States and county governments, and environmental protection organizations conduct strict monitoring of not only mining development but also the transport infrastructure. Appropriate environmental impact assessments are required in order to satisfy those related parties in proceeding with mining development.

Developing countries as well have been establishing laws in recent years. In China, the Mineral Resources Act, the Mineral Resources Act Enforcement Regulation, the Environmental Production Act, the Environmental Impact Assessment Act, the Air Pollution Prevention Act, and the Water Pollution Prevention Act require reductions in the environmental burden caused by mining activities. Currently, revisions to the Environmental Protection Act are discussed in order to make the regulations stricter.

Indonesia regulates the mining activities by the Mineral and Coal Mining Law. Companies must submit an environmental impact assessment when applying for mining concessions, and regulations also require restoration of water resources and mining sites. Additionally, a number of ministerial decrees have been issued on protection of water, air, and noise pollution. However, in reality measures are not being implemented fully and for example, in Indonesia and Vietnam there have been cases of acidic wastewater flowing from coal mines into rivers and negatively impacting the surrounding environment (Fig. 5-3). Indonesia has recently begun implementing measures including use of top soils and water treatment as methods limiting the production of acidic water.

Fig. 5-3 Acidic wastewater from an Indonesian mine

Environmental issues related to mining operations include problems related to within the mines or the surrounding environment as well as issues with greenhouse effect gases that impact an wide region. Mining development without any harms to the environment is virtually impossible but mining operations must put forth the effort to reduce environmental burden to the smallest levels possible. These efforts are seen in countries throughout the world.

(2) Environmental protection relating to the use of coal

The report titled "Clean Coal Technology in Japan" issued by JCOAL in 2007 is referenced to provide an overview of activities in the world concerning environmental protection in the coal utilization and, in particular, the efforts of Japan, which imports and uses large volumes of coal while implementing advanced environmental protection efforts. The developed countries other than Japan have been making efforts similar to those implemented in Japan in relation to environmental protection in the coal utilization. In developing countries, there is a tendency of increased coal use in association with as the growth of energy demands and environmental protection is an important issue when using coal, thus clean coal technology is being introduced.

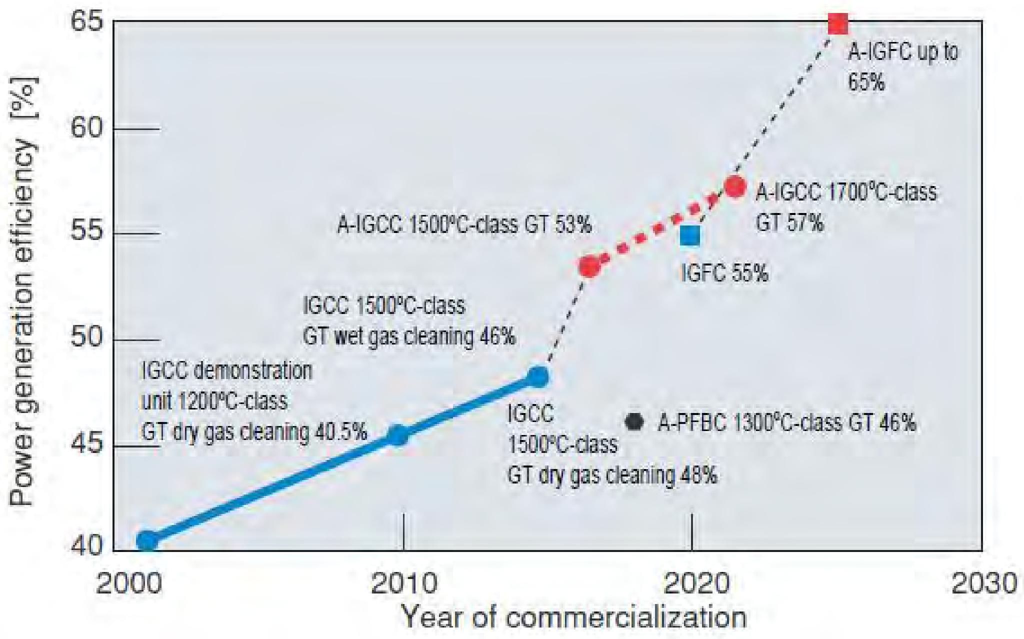
(a) Efforts for reduction of CO_2 emission

The Kyoto Protocols came into effect in February 2005 and during the period between 2008 and 2012, Japan is required to reduce greenhouse effect gases (carbon dioxide, methane, nitrous oxide, Hydro chlorofluorocarbon) by 6% compared to 1990 emission levels.

As one of the countries in the world with the most advanced coal utilization technology (clean coal technology), Japan conducts the following efforts to reduce emissions of CO_2, a gas having the largest effect among the greenhouse gas.

1) Reduction of CO_2 emissions through increased efficiency in the power sector

To increase power plant efficiency, the development of various technologies such as IGCC (Integrated Coal Gasification Combined Cycle) and IGFC (Integrated Coal Gasification Fuel Cell Combined Cycle) are progressing. Fig. 5-4 shows projection of improvement of power generation efficiency.

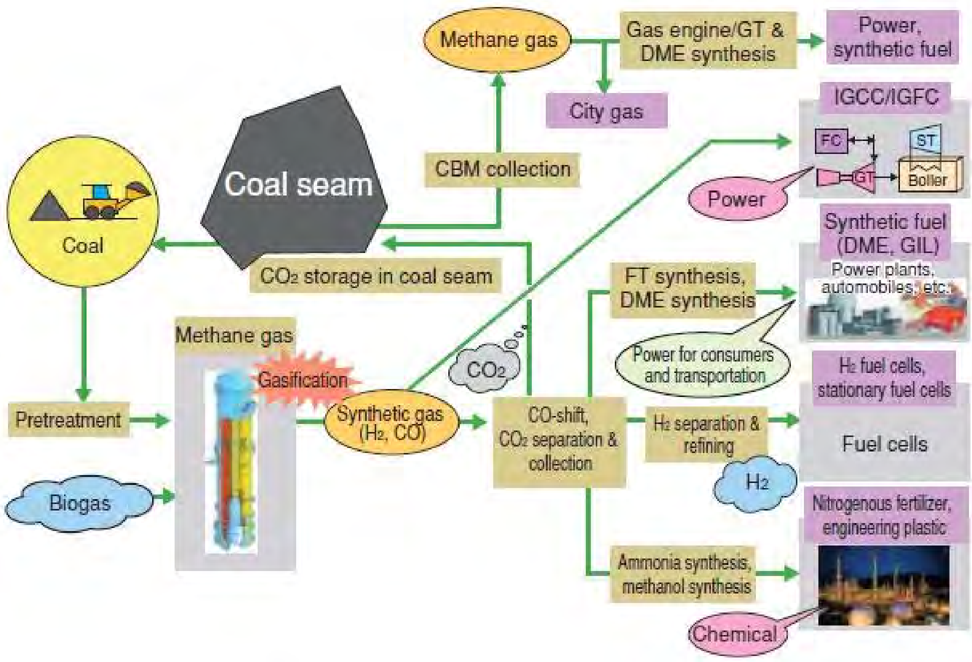


Source: "Clean Coal Technology in Japan"

Fig. 5-4 Projection of improvement of power generation efficiency

2) Controlling CO_2 emissions produced during direct combustion in raw material sectors using carbon constituents contained in coal.

Using the synthetic gases produced during coal gasification, it is possible to manufacture a variety of chemical raw materials. The development of these types of coal utilization technologies can be used to control CO_2 emissions. Fig. 5-5 shows co-production.

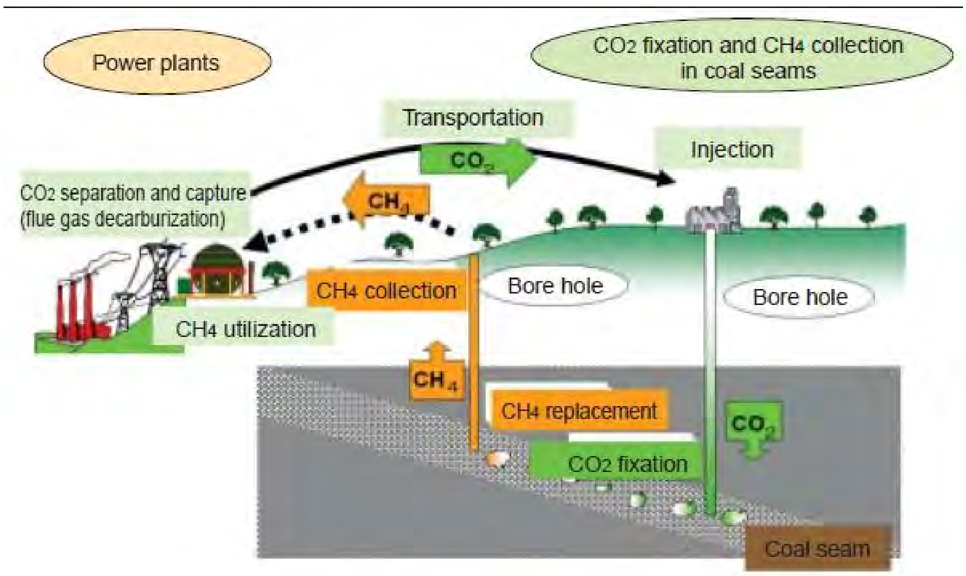


Source: "Clean Coal Technology in Japan"

Fig. 5-5 Co-production

3) Separation and collection of CO_2 contained in exhaust gases for sequestration and storage into underground

First, chemical and physical methods are used to separate and collect CO_2 contained in exhaust gases. This is then transported via pipeline or vessel to be relocated and stored in underground water-bearing layers, coal seams, or in the sea. Fig. 5-6 shows CO_2 sequestration and storage.

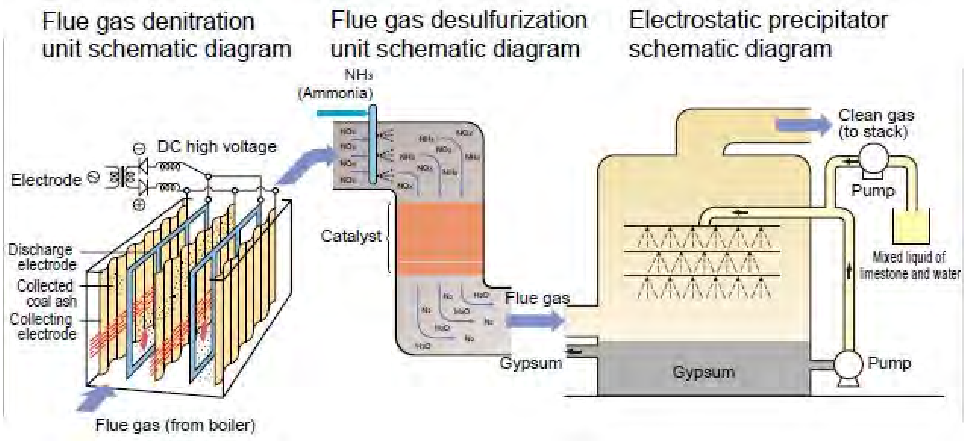


Source: "Clean Coal Technology in Japan"

Fig. 5-6 CO_2 sequestration and storage

(a) Flue-gas treatment technology

Technology development is advancing to reduce emissions and remove dust, sulfur, and nitrous compounds by processing the flue-gas produced from coal combustion or by contriving combustion methods. Fig. 5-7 shows flue-gas treatment technologies.



Source: "Clean Coal Technology in Japan "

Fig. 5-7 Flue-gas treatment technologies

4) Electric dust collectors

When flue-gases containing dust and smoke are passed between two electrodes with a high-voltage electric charge, the dust become negatively charged and is attracted to the positive electrode. Dust gathered to the electrode is then dropped by a regular beating into a dust collector. This principle is the same as papers and rubbish adhered by static electricity due to friction.

5) Flue-gas desulfurization device

Limestone is crushed to powder to make a compound mixed with water (limestone slurry). When this slurry is sprayed onto flue-gas containing sulfur compound, the sulfur compound in the flue-gas reacts with the limestone to form calcium sulfite. This calcium sulfite is then used to react with oxygen to create calcium sulfate for removal.

6)Flue-gas denitration device

Flue-gas containing nitrogen compounds is sprayed with ammonia and passed through a metallic catalyst (a material that facilitates a chemical reaction). The nitrogen compounds in the flue-gas react by the catalyst to decompose into nitrogen and water. Fig. 5-8 shows denitration reaction formula.

Reaction formulae

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

(Nitrogen monoxide) (Ammonia) (Nitrogen gas))

$$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$$

(Nitrogen dioxide) (Nitrogen gas)

Source: ”Clean Coal Technology in Japan”

Fig. 5-8 Denitration reaction formula

(b) Coal preparation technology

The reduction of sulfur compounds associated with coal use is vital to environmental protection and coal preparation is one of the environmental protection technologies that enable removal of ash and pyrite particles, the source of sulfur compounds, prior to use of the coal. Fig. 5-9 shows floatation machine (left) and heavy medium cyclone (right).

Source: ”Clean Coal Technology in Japan”

Fig. 5-9 Floatation machine (left) and heavy medium cyclone (right)

(c)Recovery and dewatering technology for sludge coal

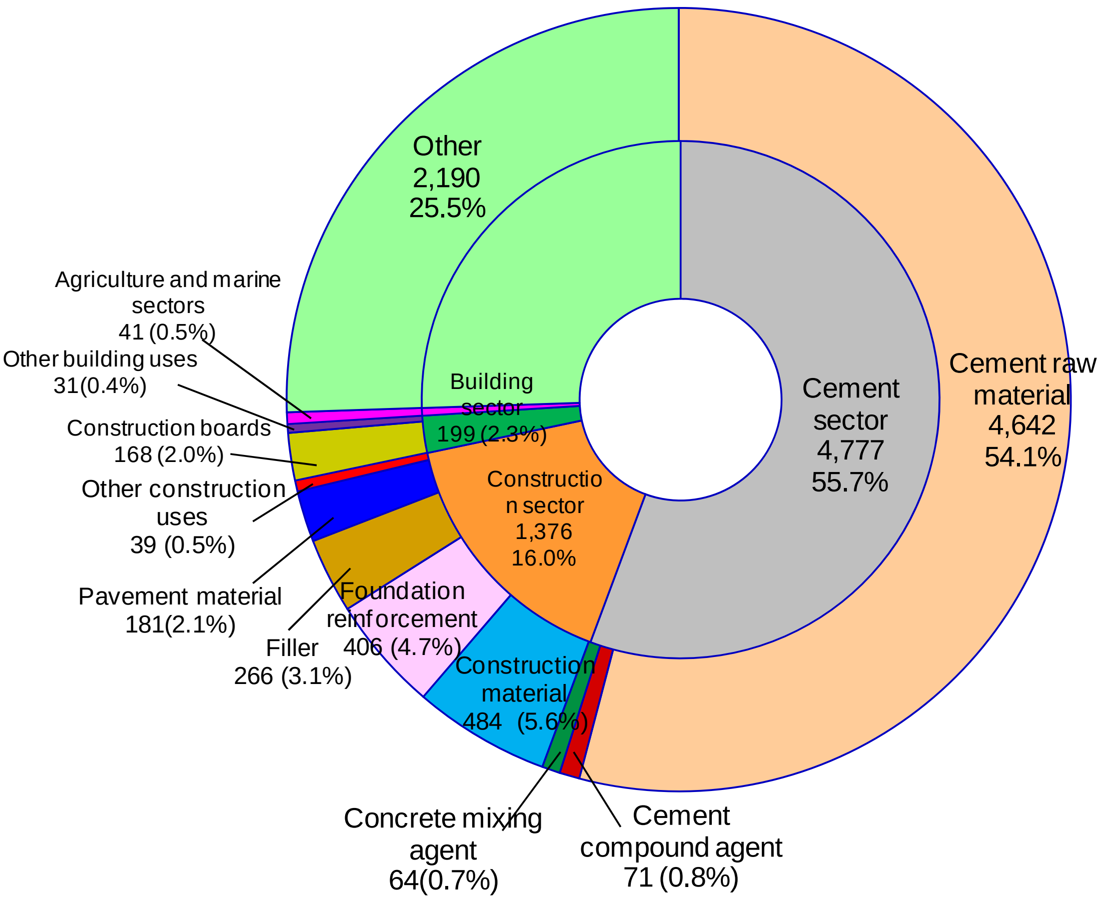
Since water discharged after coal preparation contains pulverized coal, is the water could cause environmental problems if discharged into rivers. For this reason, development of high-efficiency sludge coal recovery and dewatering technology is in progress even from the viewpoint of effective use of resources. Fig. 5-10 shows thickener (right) and dewatering device (left).

Source: "Clean Coal Technology in Japan"

Fig. 5-10 Thickener (right) and dewatering device (left)

(d) Effective utilization technology of coal ash

Ash produced during coal combustion can be used effectively as a raw material for cement and is being evaluated for utilization for various other purposes. Fig. 5-11 shows results of effective use of coal ash in JFY2010 (total utilized volume: 8,583,000 tons).



Source: JCOAL Report on coal ash national survey (February 2012)

Fig. 5-11 Coal ash utilization in Japan

(3) Environmental standards of the World Health Organization (WHO)

With respect to air quality, WHO has listed four pollutants which affect human health over a long period and provided guidelines for each of them[77]. These items are: particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2).

(a) Particulate matter (PM)

Of the four pollutants, PM have the worst effect on human health. Exposure to PM over an extended time increases the risk of inducing cardiovascular and respiratory diseases as well as lung cancer.

When measuring air quality, normally, PM_{10} is measured. PM_{10} generates mainly from dust from construction activities and roads, or mechanical processes such as wind. $PM_{2.5}$, on the other hand, generates mainly during the combustion of fossil fuels and biomass.

With respect to PM, WHO has set the guidelines in Table 5-1 below. WHO uses the conversion rate of $PM_{2.5}/PM_{10}$ ratio of 0.5 for calculation of the value of $PM_{2.5}$. In developing countries, this ratio is typically 0.5.

Table 5-1 WHO Guidelines – Particulate Matter

$PM_{2.5}$	Annual average: 10 $\mu g/m^3$
	24-hour average: 25 $\mu g/m^3$
PM_{10}	Annual average: 20 $\mu g/m^3$
	24-hour average 50 $\mu g/m^3$

In 2008, the World Bank carried out a survey by measuring PM_{10} in cities around the world[78]. The Annual average of PM_{10} in Ulaanbaatar was 279 $\mu g/m^3$,showing that the city ranked the second worst air pollution in the world.

(b) Ozone (O_3)

Ozone is a major component of photochemical smog. Ozone occurs by the reaction of sunlight, NOx and other volatile organic compounds. As ozone increases, the deterioration of pulmonary functions, respiratory failure and bronchitis could occur. Table 5-2 shows WHO gaidelines - Ozone.

Table 5-2 WHO Guidelines - Ozone

O_3	8-hour average: 100 $\mu g/m^3$

(c) Nitrogen dioxide (NO_2)

It is known, based on the results of past experiments, that an exposure to NO_2 in a concentration exceeding 200 $\mu g/m^3$ has adverse effects on health. In the long term, increases in NO_2 concentration may lead to the worsening of bronchitis or the lower pulmonary functions of asthma suffer.

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77 WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global update 2005

78 The World Bank, Air Pollution in Ulaanbaatar Initial Assessment of Current Situation and Effects of Abatement Measures Discussion Paper, December 2009

The major sources of NO_2 emissions from human activities are the combustion process in heating, power generation and automobile engines. Table 5-3 shows WHO guidelines - NO_2.

Table 5-3 WHO Guidelines – NO_2

NO_2	Annual average: 40 μg/m^3
	8-hour average: 200 μg/m^3

(d) Sulfur dioxide (SO_2)

It is known from the results of past investigations that an asthma patient would display changes in pulmonary functions and respiratory symptoms when the person stays in an SO_2 concentration of 500 μg/m^3 for 10 minutes.

The major sources of the SO_2 emissions from human activities are the combustion of sulfur-containing fossil fuels used in heating, power generation and automobile. SO_2 is a colorless gas with a strong odor. Table 5-4 shows WHO guidelines - SO_2.

Table 5-4 WHO Guidelines - SO_2

SO_2	24-hour average: 20 μg/m^3
	10-munite average: 500 μg/m^3

5.1.2 Current state of environmental protection in Mongolia

(1) Environmental assessments of the development of new coal mines and construction of coal-related facilities

In many countries, resource development or plant construction requires an environmental impact assessment (EIA) to be conducted. The EIA contents required in Mongolia for the development of new coal mines or construction of coal-fired power plants, coal-related plants, or facilities using coal including hot water supply facilities are described as follows:

(a) Environmental impact assessment regarding the development of new coal mines

1) Information required for an EIA report

In Mongolia, acquisition of a mining license is required for a holder of an exploration license to develop a coal mine. Prior to applying for a mining license, the developer must conduct an EIA study. In accordance with the Natural Environment Assessment Law, the EIA report must include the following:

- Environmental baseline data and indices;
- Project and technology alternatives;
- Recommendations for minimizing and mitigating measures as well as eliminating potential and significant adverse impacts;
- Analysis and calculation of the extent and distribution of adverse impact and its consequences;
- Assessment of accidents and risks;

- Environmental protection plan;
- Environmental monitoring program;
- Opinions of local residents and council representatives of the district (*soum*) and sections (*bagh*) in the proposed project site;
- Other issues relating to the cultural strata of the project site and the special nature of the project; and
- Proposed rehabilitation plan

The following information also must be attached to an EIA report:

- Request for a comprehensive evaluation by the affected residents and relevant agencies;
- Feasibility study report on the project;
- Overview of the project;
- Project site;
- Map of the project environment;
- Copy of a land use permit or leasing contract;
- Copy of a State Registration Certificate for a foreign corporation;
- Exploration work report
- Project drawings;
- Copy of an exploration license;
- Relevant addresses and telephone numbers

2) Approval process of an EIA report

According to the Minerals Law of Mongolia, an EIA report must be submitted to the Ministry of Nature, Environment and Tourism (the “Environment Ministry”), the Governor of the province (*aimag*), chief administrators of the district and section, the General Agency for Specialized Inspection and the Provincial environmental inspection agency.

The EIA report submitted to the Environment Ministry is to be examined in detail by the Assessment Committee set up within the Ministry. The Committee makes comments on the report and issues an improvement order, as well as ordering any additional investigation as necessary. Approval of the EIA report is given by the Ministry based on the recommendations of the Committee.

On the other hand, while the Law of Mongolia on Environment Impact Assessments mandated that only three copies of the EIA report need be prepared, one each for the Environment Ministry, the developer, and the entity who prepared the EIA report, the Environment Impact Assessment Law was revised on May 17, 2012 and it is now required that four copies of the EIA report be created. Under these revisions, one copy must be submitted to the Environment Bureau of the province in which the development project will be located. However, the provisions covering the EIA report are inconsistent between the Minerals Law and the Environment Impact Assessment Law.

3) Relationship between EIA and a mining license

When an exploration license holder is to proceed with development of a coal mine, he first must apply to the Mineral Resources Authority of Mongolia (MRAM), the Ministry of Mineral Resources and Energy for a mining license. The application requires the following documentation:

- Official certificate of the applicant and the business entity;
- Certificate of tax payments in Mongolia (from the relevant tax office);
- Copy of a State Registration Certificate for a foreign corporation;
- 2 copies of a map showing mining site and other regional and local drawings, and a map showing the coordinates;
- Receipt for the payment of fees;
- Minutes of the meeting of the State Minerals Council which accepted and approved the exploration work report, and the decision of the Government agency; Maps of the area of the mineral reserve map contained in the exploration work report for which a special permit is requested for a mining license (scale: M1:1,000, M1:5,000, M1:10,000).
- Document verifying full compliance with the environmental protection plan during the exploration work;
- Assessment of natural environment (comprehensive assessment)
- Original copy of an exploration permit (attached); and
- In case that the proposed area is located within the exploration area conducted by state budget funding, the name of the organization which approved the exploration

As the first step in coal mine development, an exploration license holder must first submit the results of the coal reserves study to the State Minerals Council via MRAM. Once the State Minerals Council approves these results, a mining license is granted by the Ministry of Mineral Resources and Energy together with an order to carry out a General Environmental Impact Assessment (GEIA). The mining license holder must complete the GEIA within two weeks and the mining Feasibility Study at the same time, and submit both reports. The GEIA report is evaluated by the Ministry of Nature, Environment and Tourism, and when it approves the GEIA, it will order the submission of a Detailed Environmental Impact Assessment (DEIA) within a specified period. The mining license holder carries out the DEIA in accordance with the order, and submits the DEIA report to the Ministry. Upon approval by the Ministry, coal mine development may be started.

(b) EIA for construction of coal-related facilities

1) Information required for an environmental impact assessment

An EIA is required for the construction of a coal-related facility with annual consumption of coal exceeding 50 tons. An EIA report relating to a coal-related facility should contain the following information:

- Environmental baseline data and indices;
- Project and technology alternatives;
- Recommendations for minimizing and mitigating measures as well as eliminating potential and significant adverse impacts;
- Analysis and calculation of the extent and distribution of adverse impact and its consequences;

- Assessment of accidents and risks;
- Environmental protection plan;
- Environmental monitoring program;
- Opinions of local residents and council representatives of district (*soum*) and sections (*bagh*) in the proposed project site;
- Other issues relating to the cultural strata of the project site and the special nature of the project; and
- Proposed rehabilitation plan

The following information also must be attached to an EIA report:

- Request for comprehensive evaluation by the affected residents and relevant agencies;
- Feasibility study report of the project;
- Overview of the project;
- Project site;
- Map of the project environment;
- Copy of a land use permit or leasing contract;
- Copy of a State Registration Certificate for a foreign corporation

2) Approval process of EIA report

According to the Law on Environmental Impact Assessment, an EIA report shall be submitted to the Ministry of Nature, Environment and Tourism.

The EIA report submitted to the Environment Ministry will be examined in detail by the Assessment Committee within the Ministry. The Committee makes comments on the report and issues an improvement order, as well as ordering an additional investigation as necessary. Approval of the EIA report is given by the Ministry based on the recommendations of the Committee.

(2) Approval and inspection process of environmental protection plan prepared annually by a coal mine

(a) Annual operations plan and report on results

All coal mines operating in Mongolia, regardless of whether they are state-owned or privately-owned, must prepare an annual operations plan, including a production and export plan for the subsequent year, and submit it to the MRAM, the Ministry of Mineral Resources and Energy between September 1 and September 30 each year. The operations plan includes an environmental protection plan. The operational plans of a coal mine are to be approved by the MRAM.

Each coal mine is further required to submit a report on the operations for the previous year to the MRAM, the Ministry of Mineral Resources and Energy by February 15.

(b) Annual environmental protection plan of a coal mine

As stated above, an annual environmental protection plan is included in the coal mine operations plan. Each coal mine must submit its environmental protection plan for the year to the Environment Ministry and other relevant authorities (e.g. General Agency for Specialized Inspection, provincial inspection agency, governors of province, district and section) by February 15. The environmental protection plan is to be approved by the Environment Ministry.

Each coal mine is further required to submit a report on its environmental protection activities for the previous year to the Environment Ministry by February 15.

(c) Inspection process for an environmental protection plan of a coal mine

Normally, the officers of the provincial environmental bureau and inspectors or environmental inspectors from the provincial inspection office carry out an inspection of a coal mine with respect to the approved environmental protection plan to confirm that the coal mine is performing environmental protection as planned. An environmental protection inspection group consisting of the inspectors, provincial governor, the district administrator and coal mine personnel discuss the state of environmental protection. The group prepares and submits its report to the Environment Ministry.

The inspectors of the General Agency for Specialized Inspection and the provincial inspection agency have the power to suspend the operations of coal mines. When the inspectors of the General Agency for Specialized Inspection or the provincial inspection agency have determined that the coal mine is not practicing environmental protection according to its environmental protection plan, an order will be issued first to instruct the coal mine to carry out its obligations, and, if the instructions are not carried out within two weeks, the inspectors may issue an order to suspend the operations of the mine.

(3) Environmental protection in closing a coal mine

The Minerals Law and General Law concerning the environment were revised on May 17, 2012. Under the previous laws, regulations and procedures related to closure of a coal mine were managed by the General Agency for Specialized Inspection but as of May 17, 2012, this rule became invalid. The regulations and the related documents in relation to the procedures on mine closure were sent from the General Agency for Specialized Inspection to the Environment Ministry, but within the Environment Ministry the documents on mine closure have not been well-organized. The documents sent by the General Agency for Specialized Inspection to the Environment Ministry on includes the guidelines on mine closure but the Environment Ministry plans to conduct a review of the mine closure guidelines and, if necessary, create new mine closure guidelines.

The Environment Impact Assessment Law was revised on May 17 and the provisions concerning mine closure have now been included in this law. A mining license holder must submit its mine closure plan to the Ministry of Mining two years prior to the planned mine closure. The mine closure plan is sent from the Mining Ministry to the Environment Ministry, and instructions and opinions regarding the mine closure plans are issued directly from the Environment Ministry and the provincial Environment Bureau to the mine. However, in accordance with the revised Environment Impact Assessment Law, detailed provisions regarding mine closure will be specified in the regulations to be drafted at a later date.

The General Agency for Specialized Inspection created the "Regulations concerning the Temporary and Permanent Closure of a Mine" as Ordinance No. 309, dated August 21, 2003. A translation of those regulations is provided as the reference materials in Chapter 8.

(4) Environmental standards on air quality, power plants and HOBs, monitoring, reporting to inspection agencies and inspections in Mongolia

The environmental standards on air quality as well as the environmental standards for power plants and HOBs in Mongolia are included as the reference materials in Chapter 8.

(a) Monitoring of power plants/HOBs

1) Ulaanbaatar No. 2 Power Plant

The components being monitored by the Ulaanbaatar No. 2 Power Plant include NOx, SOx, and CO in the flue-gas and temperatures of flue-gas, soil contamination at a fly ash pond and the water quality of water wells used for sprinkling at the ash pond. The situation of fly ash scattering from the ash pond is independently inspected by the Air Quality Agency of the Capital City, as well as by JICA under the "Project for the reinforcement of the air pollution control capability of Ulaanbaatar, Mongolia." The National Air Quality Office and the Central Environmental Monitoring Laboratory, both under the National Agency for Meteorology, also jointly measure SOx, NOx, O_2 and CO concentrations once or twice every year at the No. 2 Power Plant.

2) Ulaanbaatar No. 3 Power Plant

The Ulaanbaatar No. 3 Power Plant has not been measuring the concentrations of the components of its flue-gas so far. Starting this year, the plant is measuring NOx, SOx, CO and O_2 concentrations regularly. Water quality in the ash pond is also regularly measured.

3) Ulaanbaatar No. 4 Power Plant

The components monitored at the Ulaanbaatar No. 4 Power Plant are NOx, SOx, CO and soot dust. Concentrations of CO_2, O_2 and ash composition are also monitored as operational control data. In addition, soil contamination is measured at several points on the plant premises.

4) Monitoring of HOBs

According to the Environment Ministry and Air Quality Agency of the Capital City, there are approximately 1,000 HOBs and two or three industrial coal-fired boilers operating in the city of Ulaanbaatar. By the Air Quality Law, coal-related facilities such as HOBs are required to report the monitoring results to the National Air Quality Office of the National Agency for Meteorology. Basically, however, no flue-gas monitoring is taking place except at state-owned HOBs.

The Air Quality Agency of the Capital City, however, is measuring the concentrations of flue-gas from HOBs in cooperation with JICA under JICA's "Project for the reinforcement of the air pollution control capability of Ulaanbaatar, Mongolia." The National Air Quality Office also goes off for measurements when requested by the General Agency for Specialized Inspection or an HOB-equipped factory. As, however, the cost of the measurements by the National Air Quality Office is borne by the party who requested the measurements, such requests for measurements are limited from foreign-owned private sector factories, because the state-owned factories are in budgetary constraints.

5) Monitoring at carbonization plants

The MAK carbonization plant monitors concentrations of H, CO, CO_2, SO_2, methane, ethane, organic carbon, aromatic carbon and dust as well as noise levels around the plant. Quality of drinking water and household water are also analyzed. Air quality analysis is carried out once every three years.

Only water and air qualities are required to be reported to the state. Other components are treated as internal monitoring control items.

MAK submits to the Environmental Ministry every year its environmental protection plan as well as an environmental monitoring and the results of the analysis program on the carbonization plant , but no personnel from the Ministry have ever visited the plant. The plant has never submitted a report to the General Agency for Specialized Inspection.

6) Monitoring at Gers

There are some 190,000 Gers and simple housing structures in Ulaanbaatar and use of coal in these homes is said to be a major cause of the serious air pollution in Ulaanbaatar during the winter months. However, no monitorings has been conducted forflue-gas from coal stoves used in Ger.

7) Reporting to and inspection by regulatory agencies

Each of the power plants prepares and submit their respective environmental protection plan to the Environment Ministry every year and performance reports by February 15 of the following year. Power plants are required to carry out its monitoring roughly once every month, and to report the monitoring results for the year to the Environment Ministry by December 15.

While HOBs are required to submit their monitoring reports, , only about the 100 state-owned HOBs out of the approximately 1,000 HOB, accounting for roughly 10% of all HOBs, are reporting to the Environment Ministry.

Facilities which use coal, such as coal-fired power plants and HOBs, are required by the Air Quality Law to submit measurement data once every month to the National Air Quality Office of the National Agency for Meteorology. Presently, only two power plants, Ulaanbaatar No. 3 and No. 4 Power Plants, are reporting regularly to the National Air Quality Office. The Ulaanbaatar No. 2 Power Plant has not submitted its reports of measurement data.

As mentioned in the description of the current state of monitoring, the HOBs have not reported their measurement data to the National Air Quality Office.

Inspection of power plants is carried out by the General Agency for Specialized Inspection every several years. In the case of No.2 Power Plant, the inspections were carried out in 2001, 2007 and 2010. At the time of an inspection, the General Agency for Specialized Inspection sends out a document outlining the inspection policy. The 2010 inspection focused on budgeting, expenditures, transportation, health management and equipment relevant to environmental protection. Based on the results of such inspection. Power plants are to develop and submit a document of necessary corrective measures to the General Agency for Specialized Inspection.

5.2 Review of relevant laws and policies

5.2.1 List of coal-related environmental laws and policies of Mongolia

Table 5-5 lists the laws and standards which have been identified so far.

Table 5-5 Coal-related environmental laws and standards of Mongolia

Name	Effective date
Minerals Law	July 8, 2006
Air Quality Law	June 24, 2010
Law on Air Pollution Levies	June 24, 2010
Law on Alleviation of Air Pollution in the Capital	February 10, 2011
Law on Environmental Protection	March 30, 1995
Law on Environmental Impact Assessment	January 22, 1998
Water Law	April 22, 2004
Regulations for Revisions of Water Fees (Government Regulation No. 351 of Mongolia)	November 25, 2009
Order of the Minister of Nature, Environment and Tourism: Approval of the revisions of regulations – Regulations for the Preparation, Checking, Acceptance and Approval of Environmental Protection Plans, Environmental Monitoring Programs and Reports	February 16, 2011
MNS 3342 Requirements for Protection of Groundwater from Contamination	1982
MNS 4585 Environmental Standards on Air Quality	2007
MNS 5041 Specifications for hot water boilers below 100kW	2001
MNS 5043 Specifications for heating boilers between 0.10MW and 3.15MW	2001
MNS 5045 Technical specifications for hot water boiler using solid fuels	2001
MNS 5216-1 Technical specifications for household stoves	2011
MNS 5457 Standards for Flue-Gas Emissions from HOBs and Stoves used in Gers (CO, SO_2, NO_x, Ash)	2005
MNS 5885 Tolerance Range of Concentration of Air Pollutants - Technical Requirements	2008
MNS 5915 Classification of Land Disturbed by Mining Activities	2008
MNS 5916 Requirements for Determining Fertile Soil Removal and Its Temporary Storage During Earth Excavation	2008
MNS 5917 Reclamation of Land Disturbed by Mining Activities - General Technical Requirements	2008
MNS 5918 Re-vegetation of Disturbed Land – Technical Requirements	2008
MNS 5679 Coal briquettes – Technical Requirements	2011
MNS 6063 Air Quality – Tolerable Concentration of Air Pollutants in Public Areas	2010
MNS 6148 Water Quality – Concentration of Pollutants in Groundwater	2010

Although the list is not exhaustive, the Mongolian government is said to have been working on a review and integration of 36 environment-related laws and the number of laws has been reduced to 14 to 15. The survey on the laws will continue. The MNS stands for the Mongolian National Standards. In the environmental area, the MNS provides standards for allowable emission limits for the air pollutants, such as SOx, NOx and PM, as well as the requirements for rehabilitation of mine sites disturbed by mining activities and acceptable values of groundwater pollutants. The details of the environmental standards are included as the reference materials in Chapter 8.

5.2.2 Contents of major coal-related environmental laws and policies

(1) Laws an regulations on development and operations of coal mines

(a) Minerals Law

Article 35 “General obligations of a license holder” provides for a mining license holder to submit an environmental impact assessment and environmental protection plan.

Articles 37 through 40 contain descriptions of the obligations regarding environmental protection.

- The exploration license holder must prepare an environmental protection plan within 30 days following the receipt of an exploration license. The plan requires the approval of the General Agency for Specialized Inspection and the governors of the province, district and section. Likewise, the license holder must submit reports on the plan to each of the agency and governors of the local governments.
- The exploration license holder must deposit funds equal to 50% of the budgets necessary for its environmental protection in that year.
- The mining license holder must carry out an environmental impact assessment, develop an environmental protection plan, and submit both to the Environment Ministry. Immediately after the approval, the license holder must deliver a copy of these documents to the governor of the province, district and section as well as the local specialized inspection agency in the area where the mine is located. This requirement is applicable to both state-owned and privately-owned coal mines.
- The implementation of the environmental protection plan and preparation of the report are mandatory for mining license holders. The plan and report must be submitted to the Environment Ministry as well as the governor of the province, district and section and the local office of the specialized inspection agency.
- In the event an exploration license holder seeks an extension of his license, he must revise their environmental protection plan. If a mining license holder seeks an extension of his mining license, he must revise their environmental protection plan and environmental impact assessment. They must obtain approval from the relevant agencies.

In addition, Article 45 provides for closure of a mine

- A mining license holder must notify the General Agency for Specialized Inspection of the closure of a mine at least one year before such closure, and implement measures necessary for the protection of the environment.

(b) Law on Environmental Protection

The Parliament (Great Khural) or the government formulate and take leadership for the policy for the protection of natural environment and appropriate use of natural resources and restoration. Polluters will be subject to a penalty or other appropriate actions.

In order to monitor the destruction of the environment by coal development, the General Agency for Specialized Inspection (and its local agencies) and the Environment Ministry (and its local agencies) carry out the inspectional operation jointly. The inspectors of the General Agency for Specialized

Inspection have strong powers, and are authorized to take action, including suspension of operations, if there has been gross negligence during the operations of the mine.

Indices for the determination of adverse effects on the environment are also set forth and prescribed by the MNS.

(c) Regulations for Revisions of Water Fees (Government Regulation No. 351 of Mongolia)

A team of the Water Resources Authority carried out a study from 2007 to 2009 for the purpose of surveying the use of water across Mongolia. Government Regulation 351 was enacted in response to the proposal by the survey team to formulate a water usage fee system for elimination of wasted water use. As a result, mine operators are subject to the payment of water usage fees under these regulations.

In the coal mine development, water usage fees listed in Table 5-6 are charged in both exploration and mining phases.

Table 5-6 Water usage fees in coal mine development

	Fees (Tg/m^3)	
	Surface water	Groundwater
Coal extraction	100	150
Coal exploration, drilling	50	100

Source: Water Resources Authority

(2) Laws and regulations on coal utilization

(a) Air Quality Law

This law provides for general matters to prevent air pollution, andstipulates the establishment of National Air Quality Office by Article 8 as a specialized agency carrying out the comprehension and inspection of air pollution. The law also expressly provides for the levying of penalties on air polluters. These penalties are paid to the Clear Air Fund which is used for the implementation of measures to protect the environment.

(b) Law on Air Pollution Levies

This law provides for the amount of levies to be paid in respect of air pollution. At present, the amounts are determined on the basis of the weight of each type of polluting fuels rather than the volume of pollutant emissions. For coal, producers are levied at a rate of 1 to 2 Tg per ton.

When pollutants are removed from coal and the coal is made into a fuel which meets certain standards, the levy is waived for the amount which reflects the portion of the volume of the manufactured fuel.

(c) Law on Mitigation of Air Pollution in the Capital

Air pollution due to the burning of raw coal is the biggest problem in Ulaanbaatar, the capital of Mongolia. The government is discouraging the use of raw coal and promoting the use of alternative energy sources, such as electricity, geothermal power, household cokes and gaseous fuels.

The Environment Ministry and the Mayor of Ulaanbaatar announce annually the severely polluted areas which are designated for air quality improvements. The burning of raw coal is prohibited in these air quality improvement areas.

(d) Regulations for Revisions of Water usage fees (Government Regulation No. 351 of Mongolia)

Similar to coal development, water usage fees are incurred for the water used in power generation. At present, fees for the water usage for the production of energy and electricity are 10 Tg/m^3 for surface water and 30 Tg/m^3 for groundwater.

5.3 Review on the status of technology for environmental protection in Mongolia

To ascertain current efforts as well as future measures and plans in Mongolia concerning environmental issues facing the upstream sectors (mining/transport) and downstream sectors that use coal, the details of interviews and surveys conducted at the relevant facilities as well as their responses received are compiled.

5.3.1 Current state of environmental protection in the upstream isectors (coal mines and transportation)

For the upstream sectors, the state of environmental protection efforts at seven mines - Baganuur, Shivee Ovoo, Erdev, Sharyngol, UHG, Erdeness Tavan Tolgoi, and MAK Naryn Sukhait - are summarized for each issue below in Table 5-7.

State of environmental protection in the upstream sectors

1) Groundwater
2) Wastewater and discharge from mining operations
3) Reclamation of excavation sites
4) Scattering of dust and coal dust
5) Noise
6) Environmental issues in transport sector
7) Disposal of refuse generated during operations
8) Health examinations for employees
9) Complaints from surrounding residents and nomads
10) Environmental protection inspections
11) Mine visits by provincial inspectors
12) Instructions by inspectors

Table 5-7 State of Coal Mine Environmental Protection Efforts at Seven Mines

Mine name	Baganuur	Shivee Ovoo	Erdev	Sharyngol	UHG	Erdeness Tavan Tolgoi	MAK Naryn Sukhait
Ground water	Extracting 3.2 - 4M m^3 of groundwater annually. A small portion is used for boilers and offices. Also uses for restoration of Bagaguv Lake. There is a future plan to clean groundwater and use it for water and greenhouses in the Baganuur region.		One well dug for water supply for employees. Drinking water purchased from the district well.	Pit bottom is 216m from the surface. 600,000m^3 of groundwater is drawn annually and stored in 2 reserve lakes and run into the river after treatment for impurities. Water quality tests are conducted once a year.	Drawing groundwater from wells 250-400m deep. Water supply and usage volume managed via Telemeter system. Installed equipment allows for 95% water reuse. Polluted water from daily use is treated at a treatment facility.	Analysis is conducted quarterly on water used in the mine and mine groundwater is analyzed monthly. To secure water for a coal preparation plant planned for 2013 or 2014, FS has been conducted regarding drawing water from a site 70km apart and transporting it via pipeline.	Analysis is conducted quarterly on water used in the mine and mine groundwater is analyzed monthly.
Waste water and discharge from mining operations	No waste water problems. There is a treatment facility for polluted water. Treated water is run into Bagaguv Lake		Water in the mine and rain water is kept in a reserve pond. There is a wastewater treatment facility. Treated water is used to spray roads and for reclamation and watering of plants.		Wastewater in the mine is treated at a treatment facility. Treated water is measured regularly to ensure treatment standards are being met.	Wastewater from the mine is treated at a 2-stage water treatment facility.	In 2010, a wastewater treatment facility was constructed in the mine village. In 2011, sewer water treatment facilities were built in the mine village and the workshop. Also, water treatment facilities installed in the vehicle repair and car wash facility.

Table. 5-7 State of Coal Mine Environmental Protection Efforts at Seven Mines (continued)

Mine name	Baganuur	Shivee Ovoo	Erdev	Sharyngol	UHG	Erdeness Tavan Tolgoi	MAK Naryn Sukhait
Reclamation of excavation sites	Excavated sites are filled and resurfaced with fertile soils and vegetation is planted. Mine has reclaimed 120.5ha since 1999. As a long-term plan, the "Baganuur Mine Technical Reclamation Plan" was prepared in 2007. The long-term plan is reviewed every five years.	Problem is that rainfall is limited and plants will not grow.	Reclamation work is implemented in accordance with the standards. Excavated sites are filled and resurfaced with fertile soils and original vegetation is planted. 30,000 trees were planted over 20ha in 2011. German technology to insert water retention agents at the roots is adopted.	Reclamation of 5ha per year has been conducted. No vegetation is planted.	Top soils are stored separately prior to mining and then reused for reclamation after excavation. Trees are planted. 22,000 trees ranging over 18 different types are being planted to test for the optimal trees for the site.	Reclamation works have not yet started as the mining operations commenced recently. Currently removing and storing top soils are conducted according to the standards for future use in reclamation.	Excavated top soils are used for reclamation purposes.
Scattering of dust and coal dust	Scattering of dust is limited and within tolerance levels on good weather days. Watering is conducted to supress scattering of dust where soils were relaid.	Significant scattering of dust and coal dust by sandstorms.	Vehicle speed limits are in place to minimize dust scattering on roads and roads are sprayed with water regularly.		The greatest environmental problem at the mine is dust. Spraying water is conducted to suppress dust scattering. 18m fences are installed to weaken wind impact. Dust monitoring is conducted at 5 sites within the mine and at 5 sites located 6km from the mine.	Dust samples are collected at 5 locations for analysis. Dust analyzers are ordered for monitoring purposes. As soon as the equipment arrives, monitoring will start at those 5 locations.	As the Gobi climate is dry, dust scattering is quite common. Measures are taken to suppress dust produced from mining operations by paving roads with gravel and spraying water. Covering sheets are used on coal transport trucks so dust scattering is relatively limited.

Table. 5-7 State of Coal Mine Environmental Protection Efforts at Seven Mines (continued)

Mine name	Baganuur	Shivee Ovoo	Erdev	Sharyngol	UHG	Erdeness Tavan Tolgoi	MAK Naryn Sukhait
Noise	Noise standards are 85 decibels but the coal loading site is 101-104 decibels, 95 decibels around the crusher, 91-92 decibels at dump trucks, and 103 decibels at the mining equipment.		Regular measurements of noise are conducted at work sites.		Mining equipment and vehicles are inspected regularly. Noises are monitored every month.	Noise monitoring devices have been ordered. monitoring will start as soon as the devices arrive.	There are noises from trucks operating around the mine. There is no otherimpact from noise.
Environmental issues in transport sector	Significant dusts occur during coal transport.		None in particular	As coal is transported by rail, there are no environmental problems in transport.	A 245km paved road has been constructed to the Chinese border for exporting coal. To reduce traffic accidents during transport, roads are equipped with signals and markers. A driving instructor conducts retraining for drivers every 6 months.	Trucking coal on unpaved roads generate dust problems. Currently, coal trucks are using the paved road constructed by ER Co. Tolls of 400,000tg/truck (US$ 300/truck, ¥24,000/truck) are paid to ER. Coal loading volume to a truck is limited to less than 65 tons. Erdeness TT and Small TT Co. have a plan to build a new paved road jointly.	A 56km paved road has been built from the mine to the border at Shiveekhuren inspection site. This paved road is used by empty trucks. Trucks loaded with coal run on unpaved roads. 200-250 trucks are operating daily, which are generating dusts on the unpaved roads.

Table. 5-7 State of Coal Mine Environmental Protection Efforts at Seven Mines (continued)

Name of Mine	Baganuur	Shivee Ovoo	Erdev	Sharyngol	UHG	Erdeness Tavan Tolgoi	MAK Naryn Sukhait
Disposal of refuse produced during operations	Scrap metals are stored at a designated place. Other wastes are taken to the refuse collection site and disposed in landfill by bulldozers.		Daily refuse and operations-related refuse are separated and incinerated or buried in landfill. Rubble, scrap metals and refuse oil generated by the operations are recycled and tires are used as fences.		Refuse is separated and recyclable types such as metal, wood or plastic are stored at designated collection sites. A 3R+R (Reduce, Recycle, Reuse + Respect) system has been introduced.	Currently, refuse is carried to the district refuse site, or incinerated at the site. Refuse oil is taken away by a contractor under a contract. Refuse from heavy equipment will be disposed of at the refuse incineration plant in the future.	Refuse generated during the mining operations is separated and disposed under the regulations for refuse disposal and recycling. For example, scrap metals are disposed at a designated place and tires are used as fences to improve the environment.
Health examinations for employees	All employees working at the mines have health examinations regularly twice per year.		All employees working at the mines have health examinations regularly.		All employees working at the mines have a health examination once per year.	All employees working at the mines have a health examination once per year.	All employees working at the mines have a health examination once per year.
Complaints from surrounding residents and nomads	No complaints in particular.		No complaints in particular.		Nothing in particular.	No complaints in particular. Individual talks were held with three nomad families living in the mining license area; the families were paid compensation and moved to outside of the mining license area. Accordingly, mine has no issues with nomads.	No complaints in particular. Measures were taken each time when a request was made to protect springs and plants facing extinction in the Gobi region.

Table. 5-7 State of Coal Mine Environmental Protection Efforts at Seven Mines (continued)

Name of Mine	Baganuur	Shivee Ovoo	Erdev	Sharyngol	UHG	Erdeness Tavan Tolgoi	MAK Naryn Sukhait
Environmental protection inspections							
Mine visit by provincial inspectors	Inspectors visit the mine twice a year (in summer and winter) and meet with the mine manager, an administration director, a production supervisor and so on.	Inspectors make visits to the mines without advance notice.	Inspectors visit the mine three to five times a year, and meet with the mine manager, the chief engineer, a personnel administration engineer, an ecological expert and so on.		Inspectors visit the mine five to six times a year from spring to winter, and meet with the mine manager, an environment officer and an occupational health and safety officer.	Inspectors visit the mine in March and April and meet with the mine manager, a natural environment officer and an occupational health and safety officer.	Inspectors visit the mine three to five times a year. When they visit, they meet with the mine manager, the chief engineer and a natural environment officer.
Instructons by inspectors	No instructions in particular.		There are no major points for improvement from the inspectors at present.	Early implementation of the annual 5ha back-filling plan as an environmental measure has been requested. Implementation of environmental reclamation FS as a long-term measure has been requested.	Inspections are conducted based on a checklist and if non-compliance is identified, take corrective measures based on directions given by the inspectors and submit a report on the matter.	There are no major points for improvement from the inspectors at present.	Use of the coal transportation road was suspended from April 13 to May 12 2012 by an order of the inspectors because the road did not meet the usage requirements. After taking measures for use of the road by the coal mine, the inspectors re-inspected it and allowed re-use of the road .

5.3.2 Current state of environmental protection in the downstream sectors

For the downstream sectors, the state of environmental protection efforts at six coal utilization facilities - Ulaanbaatar No. 2 Power Plant, Ulaanbaatar No. 3 Power Plant, Ulaanbaatar No. 4 Power Plant, industrial coal boiler (MCS beer plant), MAK carbonization plant, and Sharyngol Energy carbonization plant - are summarized for each issue below in Table 5-8.

1) Problems of dust, SOx and NOx scattered from smoke stacks
2) Problems of spontaneous heating (ignition) and dust scattering at coal storage yards
3) Coal ash disposal
4) Groundwater-related issues (extraction, pollution, water reuse)
5) Soil pollution
6) Disposal of refuse produced during operations
7) Health examinations for employees
8) Complaints from surrounding residents
9) Reports to the relevant government agencies and instructions from inspectors

Table 5-9 shows instructions of the general agency for specialized inspection and the corrective measures implemented and Table 5-10 shows performance report on the 2011 environmental protection plan.

Table 5-8 Status of Coal Utilization Facility Environmental Protection Efforts

Coal using facility	Ulaanbaatar No. 2 Power Plant	Ulaanbaatar No. 3 Power Plant	Ulaanbaatar No. 4 Power Plant	Industrial coal boiler (MCS beer factory)	MAK carbonization plant	Sharyngol Energy carbonization plant
Production/ comsumption status	200,000 tons of Baganuur coal is consumed annually.	1,000,000 tons of Baganuur coal is consumed annually.	3,000,000 tons of coal is consumed annually, being 50% Baganuur coal and 50% Shivee-Ovoo coal.	The plant has been operating since 2007 and uses 2,000 tons of Nalaikh coal annually.	The carbonization plant was commissioned in March 2011. 92,700 tons of Erdev coal produced at their own Erdev coal mine is consumed annually. Semi-coke production volume for 2011 was 33,700 tons of 20-100mm size and 22,500 tons of 0-20mm size for a total of 56,200 tons. 21,000 tons of semi-coke was sold in 2011.	The carbonization briquette plant was commissioned in 2011. Three types of raw coal are used: Sharyngol, Baganuur and Erdev (MAK). Briquette sales to the Air Quality Agency of the Capital City were 2,000 tons in 2011; sales of 5,000 tons are expected in 2012.
Problems of dust, SOx and NOx scattered from smoke stacks	Smoke dust is emitted from the stacks but has not been measured.	Measurements are made including SOx and NOx, but technology to minimize their emissions has not been introduced. Smoke dust emissions are not measured.	NOx, SOx, CO2, CO and other harmful gases / fly ash have been measured since 2010. Desulfurization devices and other such equipment are not installed. Electric dust collectors are installed and the dust collection rate in 2011 was 98.9%. A request was made to the Air Quality Agency of the Capital City in February 2009 for measurements of pollutants in flue-gas. Measured levels were lower than the standards in MNS5919:2008, and had little impact on the air quality of the city of Ulaanbaatar.	The company is not conducting environmental monitoring.	Sulfur gas and hydrogen disulfide separated in the semi-coke carbonization process are absorbed by the absorbent installed in the desulfurization tower. Because the maximum temperature of the desulfurization tower is 600℃, NOx and nitric oxides are dissolved to within the acceptable standards. Gas monitoring equipment is used to measure the composition of the plant gas emissions.	Monitoring is conducted at the plant.

Table 5-8 Status of Coal Utilization Facility Environmental Protection Efforts (continued)

Coal using facility	Ulaanbaatar No. 2 Power Plant	Ulaanbaatar No. 3 Power Plant	Ulaanbaatar No. 4 Power Plant	Industrial coal boiler (MCS beer factory)	MAK carbonization plant	Sharyngol Energy carbonizationplant
Problems of spontaneous heating (ignition) and dust scattering at coal storage area	Heavy coal dust scattering occurs in spring and autumn. Coal is unloaded from the coal wagons by hand, causing coal dust.	Heavy coal dust scattering occurs in spring and autumn.	Coal dust is scattered southwards from the power plant. 200 nursery trees were planted to the east of the coal storage yard to prevent coal dust scattering.	Because there is no coal storage yard, coal is consumed without being stored for a long time. Imperfect combustion does not occur. Coal dust is generated when unloading from the trucks.	Spontaneous heating does not occur in the coal storage area. Coal stored in the coal storage area is supplied to the carbonization plant within a short period of time.	
Coal ash disposal	22,500-36,000m^3 of coal ash is discarded annually into the ash pond. In the dry weather, water dries off causing coal ash to scatter, drawing complaints from surrounding residents. A sprinkler system is installed to prevent coal ash scattering.	12,000-13,000 tons of coal ash is discarded annually into the ash pond. When the ash pond becomes full, its surface is covered with soils and trees are planted to help protect the environment. 3,000 willows have been planted over the 11 ha No. 3 ash pond after it became full. Sprinkler systems have also been installed. The quality of the water in the ash ponds is tested every two weeks.	280,000-300,000 tons of coal ash is generated annually; 10,000 tons is sold to a construction company, the rest is discarded as a state of slurry into No. 5 ash pond (1,400,000m^3 capacity) , 3 kilometers from the power plant. No. 3 and No. 4 ash ponds, which are fully filled wish coal ash, are covered with soils to prevent coal ash scattering, and 1,000 trees were planted on them over 2009 to 2011.	500m^3 of coal ash is generated annually, and is discarded into the refuse areas from the ash storage area.Ash is sometimes sold to local people. The sale price is 20,000 Tg/t.		

Table 5-8 Status of Coal Utilization Facility Environmental Protection Efforts (continued)

Coal using facility	Ulaanbaatar No. 2 Power Plant	Ulaanbaatar No. 3 Power Plant	Ulaanbaatar No. 4 Power Plant	Industrial coal boiler (MCS beer factory)	MAK carbonization plant	Sharyngol Energy carbonization plant
Groundwater-related issues (extraction, pollution, water reuse)	2,000,000 tons of groundwater is used annually. There is no facilities to reuse the water in the ash pond; the water is not reused.	In 2011, 9,644,563 tons of groundwater was pumped up from 18 groundwater wells and consumed.	10,000,000 tons of groundwater is pumped up and used from 12 wells 17-23 kilometers distant from the power plant.		The biggest environmental problem in the mine is dust; sprinkling water is conducted to suppress dust. An 18-meter high fence is in place to reduce the wind strength. Dust is monitored in five places inside the mining license area, and in five locations outside the six kilometers distant from the mine.	
Soil pollution	Every year soil testing is carried out downwind of the ash pond. There are no problems in particular.	12,500 m^3 of land east of the fence of the power plant has been prepared as a car park for the reclamation purpose to reduce the contaminated soil area.	Soil pollution was measured at several places inside the power plant premises. Pollution is considered from fuel oil used at the power plant , but it is not a major problem. The ash pond has a monitoring hole from which soil samples are taken and analyzed every month. There are no problems on this. .			
Disposal of refuse generated during operations	Refuse is collected and carried to the refuse collection area. Scrap metals are taken to and sold at a place where purchasers want to receive.	Refuse is collected and taken to the refuse collection area. Scrap metals are taken to and sold at a place where purchasers want to receive.	Daily wastes occur but are disposed of at the designated refuse dump.	Refuse is discarded at the refuse dump.	Refuse generated at the plant is taken to the refuse dump.	

Table 5-8 Status of Coal Utilization Facility Environmental Protection Efforts (continued)

Coal using facility	Ulaanbaatar No. 2 Power Plant	Ulaanbaatar No. 3 Power Plant	Ulaanbaatar No. 4 Power Plant	Industrial coal boiler (MCS beer factory)	MAK carbonization plant	Sharyngol Energy carbonization plant
Health examinations for employees	All employees working at the power plant have health examinations regularly.	All employees working at the power plant have health examinations regularly.	All employees working at the power plant have health examinations regularly.	All employees have health examination once per year.	All employees have health examination once per year.	
Complaints from surrounding residents	When coal ash is scattered by strong winds, surrounding residents complain . Requests also come from No. 4 power plant for measures to be taken against coal dust scattering.	No complaints.	No complaints in particular.	Nothing in particular.	Nothing in particular.	Nothing in particular.
Reports to the relevant government authorities and instructions from inspectors	Directions following an inspection by the General Agency for Specialized Inspection in 2007 and the report on measures taken at No. 2 power plant in response are attached as a table. (Table 5-9)	Directions have been given as to natural environmental problems. A report on the 2011environmental protection plan is attached. (Table 5-10)	The inspectors checked our performance on the 2011 environmental protection plan, and made no major instructions for improvement.	No reports have been submitted to the Ministry of Nature, Environment and Tourism, the General Agency for Specialized Inspection, or the Air Quality Agency of the Capital City. Inspectors from the Geneal Agency for Specialized Inspection visited before, but there were no particular instructions made. An expert comes from the Air Quality Agency once a year to measure the flue-gas.	Reports are submitted every year to the Ministry of Nature, Environment and Tourism on the environmental protection plan and on the environmental monitoring / analysis programs. No reports have been submitted to the General Agency for Specialized Inspection.	Environmental monitoring results are submitted to the municipal government. An inspector from the municipal government visits the plant every three months.

Table 5-9 Instructions of the General Agency for Specialized Inspection and the corrective measures implemented

April 23, 2007

No	Instructions	Implemented measures
1	To implement the measures according to the environmental assessment, environmental protection plan and environmental standards	By changing the automatic ash discharging systems of the boilers No. 1 and No. 3 to BTSU-M model battery-operated systems, in the utilization rate increased by 82 to 92%.
2	To regularly control the pollutants contained in the flue-gas according to the environmental inspection plan.	Inspected the gas emitted from the ash discharging system of the boilers.
3	To prepare instruments on site to take measurements of theflue-gas regularly.	Purchased a portable Greenline measuring instrument and h is used.
4	To collect and test water samples taken from the water reservoir to check contamination of groundwater by the water from the ash pond.	Excavated three 10m-deep water reservoirs in front of the ash pond. Water level is 6.7 to 7 m. Volume of water is 1.2 L/C.
5	To have tests carried out by the environmental inspection laboratory once every 3 months.	The tests have been carried out at the Central Environmental Inspection Laboratory once every 3 months.
6	To submit a report on the measures taken to implement the environmental protection plan semi-annually to the Environmental Protection Division of the General Agency for Specialized Inspection.	The reports has been submitted semi-annually.
7	To improve and operate the device to reduce dust in coal transporter.	The parts in the coal transporter were replaced in 2006 at a cost of 6,428,200 Tg.
8	To put the crane installed in the coal storage yard into operation.	Chinese experts were invited for the improvement work of the falicities in 2006 and the crane was put in operation continuously. The cost was 6,428,200 Tg.
9	To introduce clean technology. To implement a project if possible to recycle ash and other waste for sale.	Participated in a bid called by the Ulaanbaatar city to construct a thermal power plant using smokeless fuels.
10	To clean out the ash in the ash pond, and re-use the water from the ash pond to save water.	Designed a water sprinkler system for the ash pond and had it built by Us-Erdene.

Source: Ulaanbaatar No. 2 Power Plant

Table 5-10 Performance report on the 2011 Environmental Protection Plan

2012.01.15

No	Actions to be implemented	Timing	Person in charge	Results
A. Organization and guidance:				
1	To lay obligations and responsibilities of the duty on the Environmental Protection Committee of the power plant.	Regularly	Chair of the Environmental Protection Committee	Implemented.
2	Toaudit policies and business schedules of the projects undertaken by various offices and departments in respect of the environmental protection.	Quarterly	Environmental Protection Committee	Audit of the Medium-Pressure Boiler Dept., High-Pressure Boiler Dept. and Chemicals Dept.
3	To hold seminars on environmental protection; To have engineers and officers in-charge participate in the seminars.	2011	Engineering and Machinery Management Depts.	Attended all six seminars.
4	To develop a project plan for examination of the feasibility of adapting superior technologies to the conditions required by the plant for mitigation of adverse impact on natural environment.	2011	Engineering and Machinery Mannagement Depts.	Two projects by the Ministry of the Environment and JICA of Japan are implemented.
B. Reduction of air pollution:				
5	To set accurate combustion standards for the boilers and control the boilers on a regular basis to meet the standards.	Regularly	Boiler Standards Control Office	Implemented.
6	To measure and record the flue-gas and air pollutants emitted from the power plant to confirm that they are at acceptable levels.	Quarterly	Boiler Standards Control Office	Purchased a new mobile TESTO measuring instrument; Measuring activities implemented
7	To inspect and check theflue-gas monitoring systems for Boilers No.1 to No.7 as scheduled for their proper operation, and record the results; Operate the systems based on the results.	Regularly	Boiler Standards Control Office, High-Pressure Boiler Dept.	Not implemented.
8	To compile a report of the results of the measurement of the flue-gas and air pollutants to confirm that they are at acceptable levels, and submit it to the Air Quality Agency of the Capital City.	Quarterly	Machinery Management Dept., Boiler Standards Control Office	Submitted to the Air Quality Agency of the Capital City every month.
9	To check the ash discharging systems; To check their usage on a regular basis to ensure their proper operation.	Regularly	Medium-Pressure Boiler Dept., High-Pressure Boiler Dept.	Implemented.
10	To inspect the storage and usage of chemicals used by the power plant for technical reasons, and submit a report to the relevant agencies	Regularly	Chemicals Dept., Machinery Management Dept.	Reports are submitted every month to the Emergency Control Bureau and the specialized inspection bureau of the city and the section.
C. Water usage and protection from wastewater:				
11	To request the Water Authority to prepare	Second	Machinery	Done.

	information on water usage in 2011.	quarter	Management Dept.	
12	To carry out the measurement of groundwater for the water supply to the power plant.	Quarterly	High-Pressure Turbine Dept.	Well No. 10 uses the measuring device installed by the Land Ecology Institute.
13	To implement necessary measures as to production technology on a regular basis to reduce leakage of steam and hot water.	Regularly	Production Dept., various Departments	Carried out every month.
14	To check leakage of water from the cooling system of the power plant for water conservation.	Regularly	Medium-Pressure Turbine Dept., High-Pressure Turbine Dept.	Controlled on a regular basis.
15	To collect samples from the ash ponds and water reservoirs twice per month, test them and record the results.	Twice per month	Machinery Management Dept.	Measured at the chemical lab twice per month.
D. Soil contamination				
16	To prohibit littering and cutting of trees and willows around the power plant to improve the area and develop it into a botanical garden.	Regularly	Vice President Ch. Battulga and various Departments	Implemented.
17	To make full use of the sprinkler systems to nurture trees and willows planted in the old ash ponds as part of the biological rehabilitation work.	2011	High-Pressure Boiler Dept.	Willows planted have grown up to 1m tall; Sprinkler systems are utilized.
18	To check the ash ponds on a regular basis.	Regularly	Machinery Management Dept., Medium-Pressure Boiler Dept., High-Pressure Boiler Dept.	Checked regularly.
19	To cover the surface of the fully-filled ash ponds with soil.	2011	Environmental Protection Committee	Done on May 6, 2011.
	Performance rate			**94.7%.**

Source: Ulaanbaatar No. 3 Power Plant

(2) HOB

The Ulaanbaatar city rail repair plant has five stoves built in 1998 and one Mongolian manufactured stove built in 2006. While they have been consuming 7,600 tons of coal annually (from Baganuur and Shivee-Ovoo coal mines), two new stoves made in China are under construction since August, 2012 to replace the five old 1998 Chinese-made stoves. The new stoves have been in operation since October but as of November, the heating water temperature has not achieved the planned temperatures and thus adjustments are required. The installed Chinese stoves are equipped with dust collectors but the stove built in 2006 does not have a dust collector. Coal scattering is common at the coal storage site. Experts from the Air Quality Agency of the Capital City and JICA have been visiting the plant two to three times since December, 2011 for measurements of the flue-gas.

The HOB in the Shar Khad Mental Hospital consumes 1,100 tons of the Nalaikh coal annually. Ash is being stored for use in the construction of the planned new building. In May, 2011, inspectors and experts in sanitation and infectious diseases for the Bayanzurkh section visited the hospital to assess the volume of coal dust emitted from the chimney and discuss the issues of employees' health and sanitation. The HOBs are in operation from September 15 to May 15.

Neither of the facilities carries out any environmental monitoring or submits reports to the relevant national and city agencies. They have received no complaints from local residents, and their employees undergo medical examination once a year.

5.3.3 Social considerations to nomads

(1) Impact of development and operations of coal mines on nomads

An interview survey for the nomadic people living in the South Gobi coalfield region was carried out by visiting their Gers. The most serious problem identified by all nomads living near coal transport roads is that coal transportation by trucks using unpaved roads for export to China is adversely affecting their nomadic life. As Fig. 5-1 indicates, the trucks running along dry unpaved roads generate significant dust and noise which destroy the grass for livestock. There was a witness account that the dust was affecting the health of the livestock as the animals had to feed on dust-covered grass (their dung turns black). There are 1,300 to 1,500 coal trucks in operation near the Mongolia-China border. The construction of numerous trucking roads has destroyed pastures. In order to counter the problem, the Mongolian government has had Energy Resources LLC build a 245-km paved road from its coal mine to the border. In addition, the government requires the trucks carrying coal for export to use the earth-filled roads when they use unpaved ones.

Fig. 5-12 Truck running through unpaved road

(Almost no pasture remains)

The nomads also voiced their concern that the level of groundwater, which was important for their livelihood as well as for their livestock, had gone down as a result of the effect of coal mining operations in the area. Coal mines in the South Gobi coalfield, however, pump up their water from groundwater veins 100 to 400 meters deep while the nomads take the groundwater from a level much closer to the surface, so the groundwater veins used by coal mines and normads are different. According to the source at the Water Resource Authority, 75% of the recent fall in the groundwater levels is attributable to desertification, and was almost unaffected by the mining development. Fig.5-13 is a photograph of a well which is used by the nomads.

Fig. 5-13 Well used by nomads

In addition, some of the nomads are apparently barred from entering the areas they had used to put their animals for grazing because their summer or winter camping areas have become covered by mining licenses. One of the nomads interviewed complained that he had had a permit allowing him to use the area for 60 years but the coal mine or the village mayor paid no attention to his requests. Coal mines occasionally pay lump-sum compensations (about 2 million Tg) to the nomads who have lost their migration areas but the amount is not sufficient according to the nomads.

(2) Requests from the nomads for coal mine development and operations

The most pressing request from the nomads in respect of the development and operations of coal mines is to have the road to be used for transporting coal paved. Paving will result in the solving of the dust problem, the prevention of the pasture from being covered by dust, a reduction of the area where the pastured have disappeared, and a reduction of noise.

The nomads voiced concerns that their nomadic life is in danger due to the coal mine development from which they are not receiving any benefit. The nomads, however, are not necessarily against the mine developments, including coal mines, so long as there are no detrimental impacts on them.

The nomads wish that coal mine development companies would build new water wells so that they could secure water for themselves and their livestock in cases that their migration area are affected by the coal mine development. An opinion was voiced that it was no problem to change the migration areas so long as there is a proper compensation package.

5.4 Issues and recommendation on environmental protection

5.4.1 Area for development and operations of coal mines

The most serious environmental issue relating to coal mine operations is the trucking of coal from the South Gobi coalfield for export to China using unpaved roads. In the dry climate of the South Gobi region, many trucks running on the unpaved roads are creating massive amounts of dust which cover the pastures for the nomads and their livestock. In addition, the traffic of trucks through the pastures causes the disappearance of the pastures and also generates the issue of noise.

Our interview survey of the nomads indicated that the dust from unpaved roads was recognized to be the biggest environmental problem. From the viewpoint of the social considerations to the nomads, it is desirable that in the case of a new coal mine development includes a plan to transport coal by trucks, permission to commence coal extraction be given at least after confirmation is received that construction of paved roads from the mine to the destination point is completed.

In the case of small coal mines lacking in funds for road paving, the state should build a paved road the cost of which may be paid back through a long-term toll on the road.

5.4.2 Coal utilization area

In Mongolia, air pollution arising from combustion of coal, raw coal in particular, by household stoves in Gers and simple houses and by HOBs, and the health problems that is accompanied by the air pollution problem in Ulaanbaatar and other urban areas is a major issue. In particular, particulate matters have the potential to cause serious diseases by accumulating in the human body over a time. Measures against the particulate matters are the most critical.

(1) Measures for Gers

Since 2011, testing using house cokes has been conducted at Gers and simple housed in the Bayangol district of Ulaanbaatar. The house cokes from MAK Co. and the house cokes (briquettes) from Sharyngol Energy Co. are supplied. From interviews at a simple house in the Bayangol district, burning house cokes even with an old-type stove produces almost no smell or smoke and they expressed their strong intentions that they never want k to use raw coal again. As such, promotion of converting from raw coal to house cokes in Ger communities should be implemented as soon as possible to reduce air pollution and promote healthy living.

In the short to medium term, it is desirable to implement a total ban on raw coal burning within 3-5 year over the entire Ulaanbaatar area whose air pollution is a serious problem and promote a total shift to house cokes.

In view of this, it is desirable to facilitate a production system that ensures supply of house cokes to all Gers and simple houses in the Ulaanbaatar area as well as a solid political strategy of the government to support an expanded use of house cokes.

In the long run, it is desirable that the areas of Ulaanbaatar should be limited where coal stoves in Ger and simple houses are allowed to use, and that the government should speed up the implementation of its plan to relocate the residents of the Gers and simple houses near the central area of Ulaanbaatar to apartment complexes. Since it is considered that there are some residents who resist changing their Ger-based lifestyle, it is desirable to develop a policy obliging such people to use fuel other than coal or electricity to provide them with the option to continue their Ger-based lifestyle.

(2) Measures for HOBs

There are some 1,000 HOBs in Ulaanbaatar, but except comparatively new HOBs, older HOBs are not equipped with dust collectors. Smokes emitted from old HOBs without dust collectors are one of the factors causing air pollution in Ulaanbaatar.

As a short-term measure, the mandatory installation of dust collectors is recommended for the existing HOBs and HOBs under construction as well as those for which applications for construction will be submitted in the next five years.

As for medium and long terms, with the target of completion by 2025, it is recommended to build a hot water supply system using large-scale coal-fired boilers with the mandatory use of clean coal technology, increasing in size and consolidating the HOBs, in the future urban planning of Ulaanbaatar in particular.

5.4.3 Development of laws and policies

It is laudable that efforts for improvement have been continued with a number of laws and standards enacted in order to protect the natural environment. Our survey, however, found certain cases in which these standards were not met. A violation of law may cause, for example, the General Agency for Specialized Inspection to issue an order to suspend the operations but the criteria for such actions are not clear. It might be beneficial to give local agencies a certain power in order for them to respond promptly.

While the EIA requirement is also stipulated by law, many at work sites complained of the complexity of the procedures which demanded their time and labor. There are about 100 firms certified by the government to carry out EIAs, but not all of them share the same approach to the assessment. Although it is important for the assessment to be carried out without fail, taking too much time may interfere with the operations. This may lead to holding back of investment by businesses. The methodology should be considered to make the evaluation faster and more certain, such as, for example, a review of assessment items, a reduction of time spent on each step of the procedures, and the consolidation of evaluation processes carried out by both the central, provincial and local governments so as to reduce the time.

Under current laws, the responsibilities and obligations on mining license owners for mine closure are not necessarily clearly specified. As significant funding is required for necessary reclamation works and other environmental protection measures after mine closure, the mining license holders should be required to make an annual deposit for reclamation reserves to the relevant authorities once the mine starts coal production and sales for the entire period of the mining operations.

Coal developments require a large area of land. It is considered that issues on the land used by the nomads will continue to arise often. Provisions should be made for the ownership rights and at the same time considerations should be given to protect the livelihood of the nomads to the extent possible.

5.4.4 Issues on the nomad

The nomads live by a unit of small-scale extended families consisting of one to several households. They travel regularly from place to place so that their livestock will not exhaust grass in the pastures. Each extended family unit has its exclusive pastures, such as summer and winter camps, which they move to and from regularly. They travel between summer and winter camps according to the season as well as the conditions of their livestock through a somewhat established route.

However, there are some cases where the areas the nomads travel through have become parts of the mining license area for coal mine development, so they cannot go to the camps they intends to travel to.

It is recommended that, if the area of a new coal mine development overlaps with the migration area of the nomads, the developer shall be obliged to compensate these nomads who use the area as their camp ground. The development of the "Guidelines for compensation to the nomads" is particularly recommended to establish the transparent and fair process of consensus-building in tripartite negotiations between the Mongolian government, developer and the nomads to provide compensation to the nomads. Further, the guidelines for compensation should include allocation of an alternative land to the nomads and, if there is no water well in the alternative land, the requirement for the drilling of new water wells by the developer at its own expense.

Chapter 6 Coal Development and Utilization Master Plan, Action Plan, and Recommendations

In this chapter, based on the survey results presented in Chapter 2 through Chapter 5 we provide a Master Plan consisting of the summarization of the points that will serve as reference for coal policy to be implemented by Mongolia through 2025.

6.1 Master plan of coal development

6.1.1Coal Demand Projections through 2025

Prior to discussing the Master Plan for coal development and utilization, we will summarize projections for coal demand in Mongolia, which is the underlying presumption for the Master Plan.

Table 6-1 shown a breakdown of domestic coal demand projections in Case 1 and Case 2 while export potential projections are broken down in Case 1 through Case 3. A summary of coal demand projections based on these cases is shown in Table 6-2 through Table 6-4 and Figure 6-1 is a graphical representation of that data.

Specifically, coal export potential was projected using raw coal demand projections for China based on the percentage of China's overseas import volume. Furthermore, the percentage of that import volume that would be represented by Mongolian raw coal is projected based on price.

Table. 6-1 Domestic demand and export potential projections for each case

	Case 1	Case 1.5	Case 2
Domestic demand projections	From energy demand projections based on straight-line approximation of 2005 - 2011 actual volume	Projected using straight-line approximation of actual coal use volume for 2005 to 2011	From energy demand projections, projected based on per capita GDP growth rate of 4.9% and energy elasticity value of 0.62.
	Case 1	Case 2	Case 3
Export potential projections	Chinese raw steel production will peak in 2011 and then decline.	Chinese raw steel production will remain the same from 2011.	Chinese raw steel production will increase through 2020 and then decline.

Among the cases shown in Table 6-1, we assume the most realistic case and case with the highest potential is Case 2 for domestic demand and Case 2 for export potential. Results based on that assumption are shown in Table 6-4. This shows that in 2025, domestic demand will be 14.4M tons and export potential will be 44.9M tons for a total demand of 59.3M tons. However, as the export potential demand volume is based on refined coal that has gone through coal preparation, we must assume a raw coal volume that is approximately 130% compared to those figures.

Also, as shown in Figure 6-1, in all cases the demand volume through 2025 is at least 46.4M tons and at most 64.4M tons. This is a maximum 30M tons less than the demand volume indicated in 2010 MRAM projections of 94M tons by 2025.

Table. 6-2 Evaluation results of Mongolian domestic coal demand (Case 1) and export coal (Case 1 - 3)

	Domestic Case 1	Export Case 1	Total	Export Case 2	Total	Export Case 3	Total
2008	5,843	3,634	9,477	3,634	9,477	3,634	9,477
2009	6,426	3,980	10,406	3,980	10,406	3,980	10,406
2010	6,906	15,048	21,954	15,048	21,954	15,048	21,954
2011	6,815	20,039	26,854	20,039	26,854	20,039	26,854
2012	7,000	20,000	27,000	20,100	27,100	20,300	27,300
2015	7,500	34,000	41,500	34,600	42,100	40,700	48,200
2020	8,600	37,400	46,000	39,900	48,500	53,500	62,100
2025	9,600	36,800	46,400	44,900	54,500	48,600	58,200

Source: JICA survey team

Table. 6-3 Evaluation results of Mongolian domestic coal demand (Case 1.5) and export coal (Case 1 - 3)

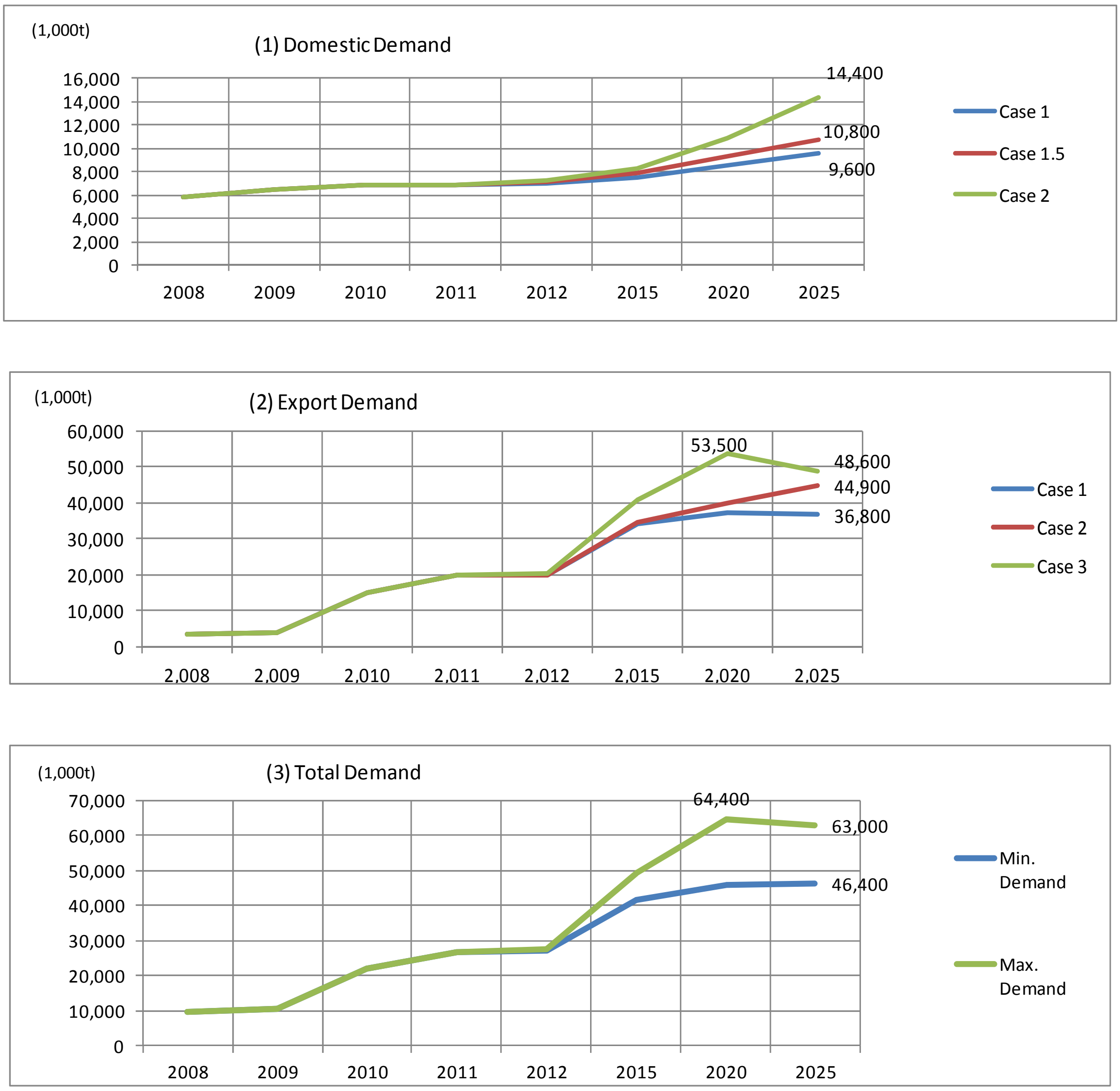
	Domestic Case 1.5	Export Case 1	Total	Export Case 2	Total	Export Case 3	Total
2008	5,843	3,634	9,477	3,634	9,477	3,634	9,477
2009	6,426	3,980	10,406	3,980	10,406	3,980	10,406
2010	6,906	15,048	21,954	15,048	21,954	15,048	21,954
2011	6,815	20,039	26,854	20,039	26,854	20,039	26,854
2012	7,100	20,000	27,100	20,100	27,200	20,300	27,400
2015	7,900	34,000	41,900	34,600	42,500	40,700	48,600
2020	9,300	37,400	46,700	39,900	49,200	53,500	62,800
2025	10,800	36,800	47,600	44,900	55,700	48,600	59,400

Source: JICA survey team

Table. 6-4 Evaluation results of Mongolian domestic coal demand (Case 2) and export coal (Case 1 - 3)

	Domestic Case 2	Export Case 1	Total	Export Case 2	Total	Export Case 3	Total
2008	5,843	3,634	9,477	3,634	9,477	3,634	9,477
2009	6,426	3,980	10,406	3,980	10,406	3,980	10,406
2010	6,906	15,048	21,954	15,048	21,954	15,048	21,954
2011	6,815	20,039	26,854	20,039	26,854	20,039	26,854
2012	7,200	20,000	27,200	20,100	27,300	20,300	27,500
2015	8,300	34,000	42,300	34,600	42,900	40,700	49,000
2020	10,900	37,400	48,300	39,900	50,800	53,500	64,400
2025	14,400	36,800	51,200	44,900	59,300	48,600	63,000

Source: JICA survey team



Source: JICA survey team

Fig. 6-1 Domestic demand, export demand, and total demand volumes

In evaluating production plans at domestic mines to determine whether or not supply volume could meet the total demand indicated in Figure 6-1, we determined that supply could be met based on current plans.

Table 6-5 indicates the results of our survey of operations. In particular, demand projections for exports to China are based on post-preparation refined coal, figures for Mongolia's export volume are divided into refined coal and raw coal. Case 2 in Figure 6-1(2) indicates 44.9M tons so, based on Table 6-5, almost the entire demand volume can be achieved with refined coal. Also, Case 3 assumes extended growth in exports with a maximum of 56M tons but in this case remaining demand could be fulfilled using raw coal so there are no problems with supply.

Table. 6-5 Export coal projected production capacity

Mine Name	Forecast of production in 2025 (1,000t)		Remarks
	ROM	Clean Coal	
Erdenes Tavan Tolgoi (EAST TSANKHI)	20,000	14,000	Under planning CHP of
UHG （Ukuhaa Khudag）	15,000	11,000	15mt CHP
MAK Naryn Sukhait	14,000	5,000	Under planning CHP of 7mt CHP
Ovoot Tolgoi	8,000		Dry CHP
Baruun Naran	7,000		
Tavan Tolgoi (WEST TSANKHI)	20,000	14,000	Presumed plane of CHP
Tasnt Uul PJ	2,000		
SOUMBER COAL PJ	5,000		
Khushuut	5,000		Presumed dry CHP
Maanit	2,000		
Huren gol	3,000		
Total	101,000	44,000	

Source: JICA survey team

6.1.2 Master plan of coal development

Mongolia has abundant many kinds of resources and pushes forward economic development by the resources export due to small domestic demand. Mongolia buries high quality cooking coal also enormously. The increase of export is expected continuously and the coal development with it will increase rapidly.

We predicted possible amount of coal export and domestic demand of Mongolia around a northeast coal supply and demand trend of Asia. As a result, we assume that domestic and export demand will became min.46 million t and up to max.64.4million t, foreseeing 2025. Our target is to achieve this figures that how Mongolian people will enjoy a benefit of exploitation of resources and how there should be the coal development that minimized an environmental problem.

The master plan of the coal development is drawn up including proposal and the item of action plan and schedule after we investigated and examined the Mongolian coal development status and economic infrastructure situation and arranged issues including a prediction in the future,

Master Plan of Coal Development

Target: Coal development aims at obtaining a coal supply and demand of max. 64.4million t by 2025, to allow the Mongolian people to enjoy the benefit of such coal development and minimize the environmental impact

The Coal management policies

- Tax system issues related to coal production and sales
  - Review of coal tax system by export agency,
  - Establishment of a representative organization for private mining companies that can negotiate with the government,
  - Gain the understanding of the public through public relations and edification activities.
- Establishment of local communities for mine workers
  - Include residential environment development conditions in the mining development approval process,
  - Establish and implement urban planning
- Coal engineer development, employment security, and guarantee of status
  - Establishment of coal engineering accreditation system and specialty schools
- Mines for domestic demand

  Create government organization to serve as central administrative organization for coal operations in order to achieve quick evaluation and implementation of measures.

Coal environmental policies

- Organization of laws and policies related to environmental preservation
  - Improvement for environmental conservation-related legislation, policy connection, the transparency
- Issues concerning nomads
  - To pave the transportation road and the maintenance of laws and review of the existing system for the coexistence of coal mine development and nomads.

Coal export policies

- Mongolian investment climate
  - The stability of the investment climate for foreign country
- Problem of export coal prices
  - Establishment of "Coal Export Price Survey Council" (provisional name),
  - Establishment of "3rd Country Coal Export Evaluation Council" (provisional name),
  - Reevaluation of coal tax system and evaluate fees, etc.

Economic infrastructure development plan

- Tax revision related to transport for large and small business of coal mine
- Incorporate water recycling technology

6.1.3 Coal development master plan, action plan, and recommendations

(1) Coal management policies

(a)Tax system issues related to coal production and sales

1)There is a need to reevaluate the taxes currently being paid by mining companies and create a more efficient tax system. To achieve this, the opinions of mining companies should be evaluated by an overseas auditing firm and opportunities for exchanges of opinion between the government and private companies should be established (3.1.6) [79].

2)Currently, export coal mining operations are taxed at over 40% in related to coal exploration and the country's private companies have voiced their dissatisfaction (3.2.9) and the public is not seeing the benefits of coal exports (2.1.6). To resolve these problems, private mining companies should form a "representative organization" that can negotiate officially with the government.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Review of coal tax system by export agency	→	→	
(2) Establishment of a representative organization for private mining companies that can negotiate with the government.	→		
(3) Gain the understanding of the public through PR and edification activities.	→	→	

(b)Establishment of local communities for mine workers

1)Policies are needed that help establish communities for miners and their families in areas near the mine development site. This would establish a stable environment in which workers could concentrate of mining operations. Not only would this ensure the safety of workers, but also help establish a technical foundation (3.2.9). To achieve this, immediate work should begin towards the urbanization of large-scale mining development areas that gives consideration to providing a pleasant, long-term living environment for worker families. This also should contribute to constraining population growth in U/B City.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Include residential environment development conditions in the mining development approval process.	→		
(2) Establish and implement urban planning	→	→	

79 ( ) numbers indicate section reference number within the report.

(c)Coal engineer development, employment security, and guarantee of status

1)In Mongolia, there are many young people without work despite holding university degrees in engineering. Among illegal miners are many young people with significant mining experience but they are not settled (3.2.9). From the understanding that engineers are part of a country's assets, public and private organizations must support the creation of specialty schools and the reeducation of workers. This will result in the development of specialist engineers through an accreditation system and help stabilize employment through guarantees of stable income.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Establishment of coal engineering accreditation system and specialty schools	→	→	

(d)Mines for domestic demand

1)Regarding the problem of setting coal prices that support stable operations of mines providing coal for power supply, the experience of private companies should be applied to the management of coal mines in order to streamline management. Also, the use of coal upgrading technology to prevent declines in sales prices as well as government support will be vital. (3.2.9).

2)Facilities investment plans for the purpose of increasing production at coal mines providing coal for power supply involve differing policies between government-run and private coal mines but the country needs a centralized organization to manage all coal activities (3.2.9).

3)In rural areas, small-scale mines have reached a state of over-exploration and such operations are causing various problems related to environmental preservation and exploration technology (3.2.9). Small-scale rural minds need to be organized and reestablished at medium-sized mining operations producing 100-300k tons of coal for each region in order to achieve a high level of efficiency. Establish adequate coal prices and incorporating a system that gives consideration to nomads and environmental preservation in order to resolve the problem is fuel supply for surrounding residents.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Create government organization to serve as central administrative organization for coal operations in order to achieve quick evaluation and implementation of measures.	→		

(2)Coal environmental policies

(a)Organization of laws and policies related to environmental preservation

1)During our on-site reviews, we saw examples of natural environment standards not being fulfilled. There are cases where a cease of operations order is issued by the National Special Audit Bureau in response to legal violations but the standards for such measures are unclear (5.4.3). As immediate measures are required, appropriate authority should be allocated to local agencies as well. There is a need to achieve increased transparency of standards.

2)Environmental impact assessments are outlined by law but we received many on-site opinions indicating that the assessment procedures are complicated and requiring a lot of work (5.4.3). The country should reevaluate assessment criteria, reduce the time required for various procedures, and decrease required times by consolidating the assessment procedures required by prefectures and villages in addition to the central government in order to create a system that ensures quick and accurate assessments.

3)Based on current laws, the liabilities and obligations that must be fulfilled by a mining rights owner during the decommissioning of a mine are not necessarily clear (5.4.3). Restoration work required after the decommissioning of a mine, including environmental preservation actions, requires significant capital. It would be preferable to have laws requiring the mining rights owner to submit proof of annual reserves to an agency managed by the government in order to ensure that environment restoration funds are secured in advance.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Establishment of relevant laws by the supervising government bureau	→		

(b)Issues concerning nomads

1)The greatest problem related to mining operations is the use of truck transport via unpaved roads in order to export coal from the South Gobi mine to China (5.4.1) If truck transport will be used in new coal exploration plans, at the very least approval for the start of mining operations should be pursuant to confirmation of paved roads from the mine to the truck transport target site. For small-scale mines, the government could consider developing paved roads and then collecting tolls.

2)There are cases where nomads living within a mining district raise objections to mine exploration and development is not able to progress smoothly (3.2.9). Taxes paid by mining companies could be used to provide nomads in the area surrounding the mining region with a satisfactory living environment in order to gain the understanding of nomads.

3)Massive land is required for mine development and problems related to land used by nomads will continue to occur (5.4.3). In addition to establishing ownership rights, measures need to be implement to protect the livelihoods of nomads as much as possible.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Establishment of relevant laws by the supervising government bureau	→		
(2) Review existing policies by supervisory agencies so that residents at risk of harm and residents potentially at risk are provided with direct relief.	→	→	

(3) Coal export policies

(a)Mongolian investment environment

It is not a thing denying participation such as enforcement of the regulation of the foreign capital, the rights and interests acquisition of the country for the strategic goods, but in the case of the investment from the foreign country, the stability of the investment environments is very important.

(b)Problem of export coal prices

1)In relation to Chinese market prices and adjusting Mongolian sales prices, agencies related to foreign policy must establish an international framework for exports to China and revise pricing (3.1.6) Also, the country must reinforce its information management and market trend assessment capabilities in order to evaluate export pricing management.

2)As almost all exports are to China, exports are greatly influenced by the Chinese economy. The country requires a strategy and economic infrastructure to support exports to other countries. If coal prices rise in the future, then possibilities will arise. Also, national support policies to bring down production costs are required.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Establish "Coal Export Price Survey Council" (provisional name)	→		
(2) Establish "3rd Country Coal Export Evaluation Council" (provisional name)	→		
(3) Must reevaluate coal tax system and evaluate fees, etc.	→	→	

(4)Economic infrastructure development plan

1)The Mongolian economy is greatly influenced by the Chinese economy. In order to stabilize and expand the domestic economy, Mongolia must establish multiple export routes (3.2.2). Additionally, not only must they secure domestic export routes, but it is also vital that they secure land transport routes through China and Russia as well as a port for loading and unloading. As such, Mongolia will need to conduct negotiations with governments and private companies in China and Russia.

2)With the elimination of the B.O.T. system for railway construction, there is concern that construction will be delayed but, conversely, general roadway construction will be accelerated by the B.O.T. system. The development and expansion of infrastructure is greatly related to problems of environmental impact and attempts to achieve both sometimes results in opposing cases (3.3.2) In order for the government to achieve development planning in line with funding policies and decrease environmental impact, they will need to control the speed of resource development.

3)Concerning the private development of roads, it will prove difficult for small to medium-scale mines to grow if they are levied with the same conditions as large-scale mines (3.3.2). To establish the support of small to medium-scale businesses as a key to future industrial development, the government must make radical revisions to tax systems related to transport for large businesses and small to medium-scale businesses.

4)Securing water resources is vital to resource development. In particular, securing water resources in the Gobi region, where annual rainfall is extremely low, is a critical issue (3.3.2). Measures, including securing water resources through surveys of underground water resources or long-distance transport of necessary volumes, are required. They also must incorporate water recycling technology.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Incorporate water recycling technology	→		

6.2 Master plan of Coal utilization

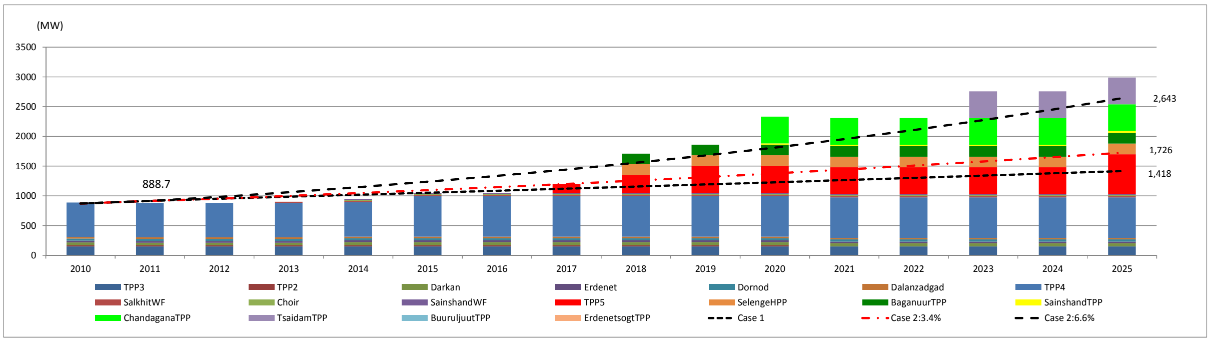
6.2.1Current status of coal utilization in Mongolia and forecast

(1) Forecast of electricity demand and power station construction plan

Table 4-1shows an electricity demand prediction and the power station plan of each case.

Table 6-1 Forecast of power capacity in 2025 by Case 1 to Case 3

Case	Power growth	Power capacity
Case 1	2.7%	1418 MW
Case 2 (GDP growth: 4%)	3.4%	1726MW
Case 3 (GDP growth: 6.6%)	6.6%	2643MW



Source: JICA study team

Fig. 6-2 Forecast of electricity demand and power station construction plan

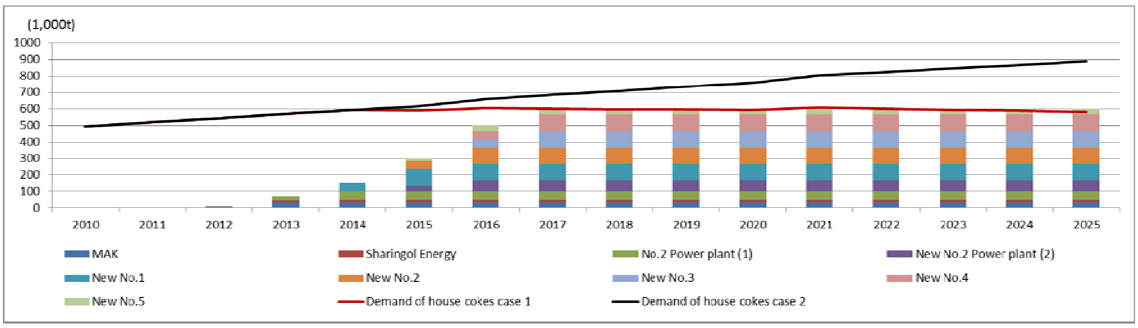
(2) The forecast of householder cokes demand

Table 4-2 shows the forecast of householder cokes demand. Total 600,000t of householder cokes will be required in 2015 when a new apartment plan is implemented. Fig. 4-2 shows construction plan of householder cokes plant.

Table 6-2Ger increase projections and household cokes demand

Year	Mongolia		Ulaanbaatar			Case 1			Case 2
	Population (1,000 people)	Increasing number (1,000 people)	Population (1,000 people)	No. of households (1,000 unit)	No. of households of ger & house (1,000 unit)	New Apartment (1,000unit)	Remaining No. of households of ger & house (1,000 unit)	House cokes (1,000t)	House cokes (1,000t)
2010	2,761	45	1,152	294	176		176	493	493
2011	2,811	50	1,201	307	186		186	521	521
2015	2,938	36	1,409	361	220	10	210	589	617
2020	3,119	36	1,669	439	271	60	211	592	760
2025	3,301	36	1,886	510	317	110	207	581	889

Source: JICA study team



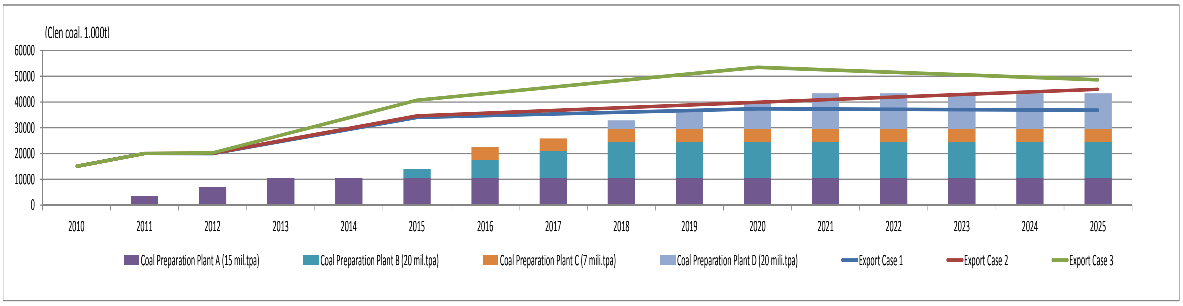
Source: JICA study team

Fig. 6-3 The forecast of householder cokes demand and construction plan of householder cokes plant

(3)Forecast of construction plan of coal preparation plants

Fig. 4-3 shows the forecast of construction plan of coal preparation plants and amount of export coal to china.

Case 1	The case of decrease of Chinese demand of coking coal from 2011 at the peak
Case 2	The same level in Chinese demand of coking coal after 2011
Case 3	Chinese demand of coking coal until 2021 increase then decrease

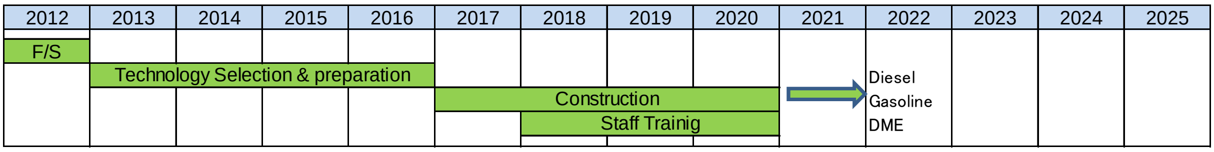


Source: JICA study team

Fig. 6-4 Forecast of construction plan of coal preparation plant

(4) Forecast of construction plan of coal gasification and liquefaction

Fig. 4-4 shows the construction plan of coal gasification and liquefaction using 3 to 4million tons of coal by a Mongolian private company after completion of F/S. There are two more companies planning a construction plan of coal gasification.

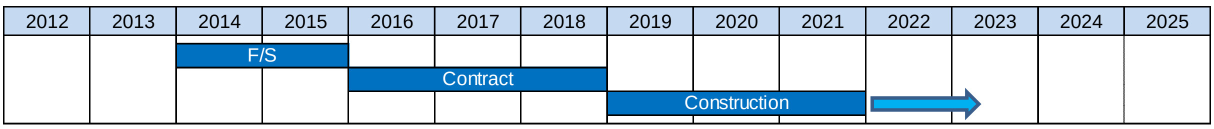


Source: JICA study team

Fig. 6-5 The construction plan of coal gasification and liquefaction

(5) Forecast of construction plan of metallurgical cocks

Fig. 4-5 shows the construction plan of metallurgical cocks of 300,000 tons by a Mongolian private company. All products will be exported to designated consumers.



Source: JICA study team

Fig. 6-6 The construction plan of metallurgical cocks

6.2.2Master plan of coal utilization

Coal is not only a source of energy but also may become high-value-added product through processing. Mongolia has much interest in establishing a new industry utilizing coal. In developing a master plan for the coal use, we first understood and projected the coal use of Mongolia. As a result, when prospecting to 2025, we decided the following concept for the master plan: it should provide recommendations and items of the action plan focusing on electric power generation, heat production and coal use technologies fields in Mongolia toward the establishment of energy security of Mongolia. Our targets were to establish a self-sufficient system for energy as soon as possible in Mongolia and to export processed coal products in line with the level of maturity of industrial base to be achieved through accumulation of coal processing technologies in Mongolia.

The master plan of the coal utilization shows the proposal, the item of an action plan and action schedule to achieve.

Master Plan of Coal Utilization

Target: Establishment of the Mongolian energy self-sufficiency system using abundant coal resources and construction of the industrial base for exports of the coal processing product.

Coal policies for introduction of coal utilization

- Tax exemptions for imported equipment
- Loan guarantees for large scale financing
- Stability agreement
- Staff training

Power sector

- Improving efficiency of existing CHP
- Replacement of No. 4 power plant
- Early launch of construction of No. 5 power plant
- Construction of new power plants linked to power demand
- Exporting electricity
- Establish a training simulator

Heat production sector

- CHP plant efficiency improvements and increased HOB efficiency
  - Short-term improvement plans for HOB efficiency improvements,
  - Large-scale centralization of HOB,
  - Examination of HOB using blended fuel of municipal waste and coal
- The reinforcement of household cokes facilities
  - Supply 600k tons for winter in 2018,
  - Reevaluate grant program,
  - "Household cokes Production Evaluation Workgroup (provisional name)"
- Processing of tar and phenol-laced waste water produced by private companies producing household cokes
- Production of coal-based synthetic liquid fuels
  - Cultivate engineers through a collaborative effort by government, businesses, and universities

Coal utilization technology sector

- Coke for steel production
- Activated carbon production

Coal preparation technology

- Development coal preparation engineers
- Use of middling product after washing
- Practical application of dry coal preparation technology

6.2.3Action plan, recommendations and schedule

(1) Coal utilization policies for introduction of coal utilization

(a)Tax exemptions for imported equipment/facilities

As transportation cost to Mongolia is very expensive, so all imported equipment/facilities cost become costly and damage economic viability of capital-intensive projects. From Mongolian government perspective it is better to tax profitable projects after their start of operation, otherwise high up-front tax burden will discourage investment into capital intensive sector such as coal gasification.

(b) Loan guarantees for large scale financing

Developing countries like Mongolia are regarded as high risk country for financing. So, financial institutions require high degree of guarantees which may not be available for domestic companies. That is why Government of Mongolia can step in by providing government guarantees to support viable and important projects.

(c) Stability agreement

Huge up-front capital investment into coal gasification will result in long-term repay period. So investors receive returns long after their initial investments. In order to encourage investment, Mongolian government also has to ensure that investors receive their expected returns.

(d) Staff training

Coal utilization such as coal gasification plants will employ many highly skilled engineers, operators. It is good chance to promote employment with sustainable salaries. So educating needed staff at universities, colleges are necessary.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Tax exemptions for imported equipment/facilities	→		
(2) Loan guarantees for large scale financing	→		
(3)Stability agreement	→		
(4)Staff training	———	→	

(2)Power sector]: Improve CHP efficiency and stable implementation of new power plant plans

(a)Improving efficiency of existing CHP

Since 1993, the No. 3 and No. 4 power plants in Ulaanbaatar have received continuous renovations in terms of both hardware and software. However, during this survey we found need for further improvements (Section 4.3.1). Continued rehabilitation of these facilities is required in order to ease the power shortages facing Ulaanbaatar.

(b)Replacement of the No. 4 power plant

As noted above, the No. 4 power plant has received numerous improvements and renovations since its construction between 1983 and 1991. However, by 2025, the facility will be a deteriorated thermal power plant that is over 40 years old. As such, they will need to replace this facility with a new power plant. If that happens, the facility should be a 600MW supercritical large-scale facility equipped with both desulphurization and denitration facilities.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Rehabilitation of No. 3 and No. 4 power plants		→	→
(2) Replacement of No. 4 power plant			→

(c)Early launch of construction for No. 5 power plant

The power shortages facing Ulaanbaatar have been pointed out for years and thus construction of the No. 5 power plant currently under consideration should be accelerated. To meet 2015 demands, they will initially need 450MW but from 2025 onward, an additional 300MW will be required. The power plant system can be a subcritical system, which Mongolia has significant experience, and should equipped with both desulphurization and denitration facilities.

(d)Construction of new power plants that is linked to power demand

The country needs 5-6 300 to 450MW class power plants to meet power demands in 2025 (see Fig. 6-2). As indicated in Section 4.3.5, if constructing a power plant in Southern Gobi, intermediary product produced during coal preparation can be used as fuel. The construction of these facilities must be linked with demand and progressed without fail. As noted above, specifications should include both desulphurization and denitration facilities.

(e)Exporting power

When considering export potential, issues including whether or not a long-term sales agreement needed to recover power plant facilities investments is possible and the energy security policies of the target country. Countries with long histories of exporting power should be evaluated in order to reduce risks. A system of meeting domestic demand and exporting surplus is ideal.

(f)Establish a training simulator targeting the latest pulverized coal thermal power plants.

This will help ensure smooth operation of future thermal power plants.

(3)Heat production sector:

(a)CHP plant efficiency improvements and increased HOB efficiency

Air pollution in cities resulting from coal combustion and the growing damage to health are serious problems. Measures to address these problems include the expanded use of house cokeand

HOB improvements, both discussed below. As noted in detail in 4.3.2, as a medium-term solution, particularly in relation to the U/B urban planning policies, is the large-scale centralization of HOB as a way to create a hot water provision system based on large-scale coal boilers with CCT requirements. Another vital environmental policy will be the mixed combustion of city trash and coal as a way to improve energy efficiency with HOB centralization.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Short-term improvement plans for HOB efficiency improvements (4.3.2)	→		
(2) Large-scale centralization of HOB		→	→

(b)Improvements to house coke facilities

Demand volumes does correlate to apartment housing construction plans but during the winter periods of 2017-2018, they should aim to achieve supply volume of 600k tons annually. Also, to promote the aggressive and continuous production of house coke by private companies, a system of funding should be reevaluated. Mongolia should also maintain the awareness that house coke holds a vital position in the country's plans for the accumulation of technology for a coal processing industry and the development of future engineers.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Supply 600k tons for winter 2018	→	→	
(2) Reevaluate grant program	→		

(c)Processing of tar and phenol-laced waste water produced by private companies (4.3.4)

Conduct collaborative evaluation by government, businesses, and universities regarding the development of technology for processing methods that suit Mongolia. Evaluations of these processing methods should be incorporated into evaluations of new house coke production facilities. Propose establishment of a "House Coke Production Evaluation Workgroup (provisional name)" and include matters from 28) above.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) "House Coke Production Evaluation Workgroup (provisional name)"	→		
(2) Measures for processing of tar and phenol-laced waste water produced by private companies	→		

(4)Production of coal-based synthetic liquid fuels

In Mongolia, which has vast coal resources but few other fossil fuel resources on a large scale, the production of coal-based synthetic liquid fuels is both promising and necessary to the country's future. However, as at present the country does not have the required production environment, the technology risks are significant. The problem is how to reduce these risks. Case studies led by private companies and in line with domestic demand should be implemented and the country must align this technology as necessary to the country's future and support its realization. Projects through a collaborative effort by government, businesses, and universities should be implemented in order to provide support and cultivate engineers. While it would depend on private company trends but operation of the country's first commercial plant could occur in 2020.

Private company gasification projects should education and training plans for gasification facilities, machinery, safe operation laws, overcoming malfunctions, maintenance and inspection procedures. This will aid in the smooth launch of facilities and ensure rapid trouble response.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Production of coal-based synthetic liquid fuels		→	→
(2) Cultivate engineers through a collaborative effort by government, businesses, and universities	→	→	→

(5)Coal utilization technology sector]

(a)Coke for steel production

Based on the fundamental plan for self-sufficiency, the production of coke for export purposes when there is no demand for coke for steel production poses large risks in terms of ensuring coke quality and importer demand as well as environmental risks. This is not the case where coke is produced in Mongolia for the purpose of being exported to foreign companies that will use the coke in their own country. In other words, there are cases where it will be economically advantageous to have coke produced in Mongolia, transported to their home country, and then use that coke in their home country.

(b)Activated carbon production

One of the next coal utilization from a semi-coke production technology is to produce an activated carbon. They are imported now, and its consumption will increase as environmental pollution measures materials continuously. Lignite coal is widely used on world markets as the raw material for activated coal. The activated carbon production in Mongolia is promising from a self-sufficient policy. The basic investigations should be carried out, such as marketability, grade of its quality required in Mongolia, trial product by Mongolian lignite and so on.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Basic investigation and F/S	→		
(2) Construction of commercial plant		→	

(6)Coal preparation technology]

(a)Development coal preparation engineers

Coal preparation plants are facilities that tie directly to the coal sale profits so the country needs to develop specialist able to evaluate coal preparation technology from a third-party standpoint. It would be ideal to cultivate Mongolians who learn the technology and can serve as plant directors in order to ensure quality management and operational management (4.3.5). The cultivation of coal preparation engineers should involve the development of educational curriculum that uses local coal preparation plants.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Establish coal preparation engineer development system and create educational curriculum	→		
(2) Conduct coal preparation education	→	→	→

(b)Use of intermediary product produced using coal preparation

Based on coal preparation construction plans, the volume of intermediary product will be: 2.8M tons in 2015, 8M tons in 2020, and 8.7M tons in 2025. It is vital that they evaluate heat supply facilities and coal thermal power plants that utilize this product as part of their coal urban city planning. There is potential as an energy export but there are problems related to infrastructure and coal prices.

(c)Practical dry coal preparation technology

As a coal technology in regions with limited water resources and for providing superior options in terms of environmental measures, dry coal preparation technology is vital. At existing facilities, the precision of coal preparation is low and it will be difficult to achieve levels equivalent to raw coal exports. Mongolia already has optimal conditions for implementing this technology. If use of this technology can be made practical, the technology can be exported to regions with low water resources in other countries.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) Dry coal preparation validation facilities	→		
(2) Construction of commercial plant	→	→	

1) Activated coal

Currently imported as a coal utilization method based on semi coke production technology, consumption of activated carbon will increase as further measures toward environmental preservation fall into place. Lignite coal is widely used on world markets as the raw material for activated coal. The production of activated coal also is promising in terms on Mongolia's self-sufficiency policies. What level of quality can be attained in activated coal production should be evaluated quickly through marketability surveys and other key research.

Action plan	Short term (2015)	Intermediate (2020)	Long term (2025)
(1) F/S for activated coal production	→		
(2) Construction of commercial plant		→	

Chapter 7 JCC Meetings and Workshops

7.1 JCC meeting summery

(1) First JCC meeting

Summary of discussion held at first JCC meeting is showed below. First meeting was held as kick-off meeting, inception report was presented.

SUMMERY OF DISCUSSION HELD

1.1 The fuel policy department is now making a draft of a fresh paper of coal policy contained master plan of coal development in cooperation with Mongolian Coal Association (MCA) and other sectors. Cooperation with MCA and opinions from government and private sectors will be essential to carry out the JICA master plan.

1.2 JCC will strongly support to successfully hold The 1st Work Shop on 31st of May, 2012 and all necessary arrangement should be worked out with MCA.

1.3 The JICA master plan should be stressed on the importance of coal resources as energy security in Mongolia and necessity of environment conservation to utilize coal.

1.4 In the JICA master plan, infrastructure of transportation, taxation, market prices trend of coal product will be important to be covered.

1.5 There are many power station projects and some of them are working toward exporting electricity. The domestic coal demand and supply should be included this situation and catch up with private sectors' circumstance .

1.6 Planning and policy of coal development is a critical issue at present. License holders of coal are mining like a wild rabbit. The proposal to this situation will be expected in the JICA master plan.

1.7 In the JICA master plan, a coal development and utilizing plan at each area of future coal mine in Mongolia shall be included as well as present coal mines. And proposal of what kind of up-grading coal is required to each area will be expected.

(2) Second JCC meeting

Summary of discussion held at second JCC meeting is showed below. Progress report was presented at second meeting.

SUMMERY OF DISCUSSION HELD

2.1 It is expected to well reflect the proposition and requests from JCC member's organizations on this project associated with mutual cooperative framework.

- JICA Team: . Acknowledged

2.2 In this project, depending on the results of survey on the types of the processed coal products, those distribution and prices, the-most-advantageously exportable commodities from Mongolia shall be selected. For example, one of them will be evaluation report of potential of semi-cokes.

- JICA Team: Acknowledged.

2.3 It is desirable to conduct economic research to compare the competitiveness between Mongolian and Russian coal.

- JICA Team: AS JICA team is not allowed in this project to visit Russian and conduct on-site survey, it is only said that it would be checked up how deep it could be done, using the existing and obtainable data and documents.

2.4 Which are original sources of data for Nos.2, 3 and 4 power plants up to year 2030?
Are these power plants going on up to 2030?

- JICA Team: Those are based on the data given to JICA team before. It is going to revise those data on the basis of survey from now on.

2.5 Are the figures for railway transportation reflected from coal market?

-JICA Team: These figures indicate the railway transportation capability respectively. Coal market conditions do not reflect on those figures.

2.6 Figures on the coal production indicate washed coal products? Nowadays, coal after washing is recommended to export. The possibilities of exporting liquefied brown coal are seeking for. Do you have any ideas of this?

- JICA Team: In general, quantity of coal production is expressed in raw coal basis.

Washing process differs from coal to coal in terms of its characteristics. Referring to quantity of washed coal, quantity of unsalable middling doesn't appear on the statistics figures. Thus, the quantity of coal production is based on raw coal even in other countries. Suitable coal washing process of each coal quality would be specified in the report.

Challenges for coal liquefaction are in demand and price. Better is commercial product not always able to be sold. Which the best products from coal in Mongolia are will be examined in short, middle and long term in the report.

2.7 Market for thermal coal is expected to be cultivated. As it is desirable to sell middlings after washing coking coal in Mongolia as thermal coal, its market and utilization are expected to be learned.
- JICA Team: Acknowledged.

2.8 It is desirable to check up the most profitable market for Mongolia by researching worldwide coal demand.
- JICA Team: Acknowledged.

2.9 Are Korea and Japan wish to buy coal from Mongolia? If so, what the quality of the coal would be required by them? According to some study, approximately 100 million could be exported from Mongolia.
- JICA Team: Acknowledged.

2.10 Mongolian coal prices attend to downslide with competition among the coal suppliers, also reflecting global coal price weakening and quantitative restriction of coal production. Avoiding coal price drop is thought to restrict quantity of coal export, and there might be also other measures against it. Prevention measures against price competition are also required to be mentioned in The Master Plan.
- JICA Team: It can be said that even good stuff is unable to be sold with high price. In other word, coal with higher price is not being sold even if restriction to saleable coal quantity is introduced. The fundamental issues of control of price competitiveness will be described in the report.

2.11 It is required to study on new transport system instead of railway and road. Although economic efficiency was given to importance in the past time, symbiosis with nature, in other words, prevention of pollution is also needed nowadays. Transport system shall be considered, by which environment influence on the surrounding areas along the transport track shall be as less as possible. Even so, economic efficiency and technology is required for new transport system, such as a belt conveyor and a pipeline.
- JICA Team: Acknowledged.

2.12 Mining Institute researched clean energy in 2009. Clean energy, such as underground coal gasification, is expected to be introduced in next generation. In this project, clean energy would be surveyed and make a proposition in the report.
- JICA Team: Acknowledged.

2.13 Proposition for human resources development and skill-up and research equipment in the organizations associated with research study is desired in this project.

- JICA Team: Acknowledged.

2.14 Important issues on coal utilization are to study on coal utilization based on Mongolian identity and its economic efficiency. In this project, it is recommended to study on “Mid-term Development Plan”, which was open to public in 2011, and also related international treaties which Mongolia has acceded to.

- JICA Team: Acknowledged.

2.15 Coal utilization is interesting to us. It is expected for the experts to report on processed coal products. Hous cokes is needed for counter measure to reduce air pollution in winter season. Research on mating with the needs for consumer of semi cokes shall be conducted. Although it is said that stuff with higher price is hard to be sold, even if high technology is applied to produce stuff, it is considered that high technology will be applied to produce the stuff in Sainshand Industrial Park. Our university does not grudge cooperation with study on the product competitiveness and human resources development.

- JICA Team: House cokes business is considered to last 10 years. After that, coal gasification instead of house cokes would be proposed for countermeasures again air pollution. Manufacturing cokes in Sainshand would be studied in this Master Plan, going over the study conducted by USA’s consultant. Our views on this issue will be reported in this Master Plan.

2.16 It could be said that ADB interim report on transition of energy demand and supply does not much serve as useful reference. Reports on regional demand and supply of electricity are recommended to be gathered for your reference. Referring to such regional reports, study on coal development in response to needs for districts would be recommended.

- JICA Team: Acknowledged. Requested are such reports for JICA Team.

2.17 We will try to collect such reports and pass it on to you, while reports on nuclear power are tried to collect as well. Comments and information raised in the JCC are expected to be reflected on The Master Plan. Otherwise, official paper, mentioning the reasons why it could not be embraced for The Master Plan, shall be required for.

-JICA Team: Acknowledged.

(3) Third JCC meeting

Summary of discussion held at third JCC meeting is showed below. Interim report was presented at second meeting.

<u>SUMMERY OF DISCUSSION HELD</u>

3.1 (SUNDUI)

(1) In slide 25, 18MW power station of UHG is not included. The scale is not very big, but transmits electricity to Dalanzadgad and the nearby town.
(ENDO): Acknowledged

(2) In slide 34, the middling is a very big environmental problem and the issue must solve it. Because there does not become very much the middling consumption even if 600MW power station will be constructed in future. It is necessary to examine various usages. I want the suggestion that is concrete recommendation about the middling. For example, I want to examine the gasification and liquefaction. There is many energy coal there too and please instruct it about these usage.
(ENDO): Acknowledged.

(3)About slide 44, the government takes the policy to do an electric bill to half by night time about the house where does not burn coal and only electricity uses for from 21:00 to 6:00 in a gel area about Environmental Suggestion ③. I want you to investigate it if you did not examine it.
(ENDO): Acknowledged.

3.2 （BAYANMUNKH）

(1) About slide 8, do you investigate the export to the Asian market of the Mongolian coking coal?

(ENDO): We are investigating it how a supply for China turns out. We intend to put a result by the final report.

(SAGAWA): It is demand for coking coal and it is thought that China reaches the limit in the future. I consider that India will increase in future. Japan and Korea will be the same level as the present conditions. The overall demand in Asia is not prolonged than these greatly so much.
Because domestic coking coal is very valuable resources in China, China thinks that demand is at the uppermost limit, and the import may increase. It is up to a price where China will buy coking coal from. Mongolia has big advantageous situation from the point of CIF (arrival base price of China).

(2) About slide 11, as Mongolian export figures were not shown in the figure. Please put it in the figure in the report.
(ENDO): Acknowledged.

3.3 (AVID)

(1) About slide 39, Growth of the coal demand may not match the number of power stations built newly in future. I want you to investigate it well.

(KOYAMA): Acknowledged. At first I predict the electricity demand and I calculate quantity of the coal necessary to bring about the electricity based on efficiency. I will review the efficiency of the power station once again and want to calculate it again.

(2) Is there any policy that Mongolia can export energy coal in the Asian market such as Japan and Korea, if infrastructure improves?

(ENDO): I hear it is unprofitable in our investigation due to too low demand price of China. We examined the transportation cost of 60-90 US$/ton, for example, through China. Therefore, it is thought that cost becomes very higher because present FOB price of energy coal is about 85 US$/ton. Regarding export to the third country, it is the important problem how you build cheap infrastructure.

(3) I suppose that Mongolian energy coal can export to China only.

(ENDO): I think so. However, it is necessary to investigate it in detail why a private company does not sell it even in China.

(4) About slide 46, it is written about coal mine development in the future by proposal 7, but I think coal development is done enough and is it possible to state that coal development should not be carried out in future?

(ENDO): It is necessary to gather various opinions, but to develop coal is not a bad thing. It is necessary to consider it and solve the problem so that a problem does not happen on the occasion of development.

(KOYAMA): I ask you to teach one. For example, there are the number of approximately 15 million tons for our prospect and 18 million tons for government prospect of Mongolian coal production in slide 40 in 2025. Do you think that this number can be achieved in existing coal mines?

(AVID) I think that for quantity of demand for prediction can cope by the increase in production of the existing coal mine in 2025.

3.4 （ENKHTUYA）

Do you consider the demand for Mongolian local villages in energy demands prediction?

(KOYAMA): I do it. The local demand quantity enters all the prediction numerical value now because I predict it based on electricity, coal and semi-coke used in Mongolia. About the prediction, I will consider a population growth prediction in the future. So, I consider the whole land of Mongolia.

3.5 （SUNDUI）

I think that it becomes a better prediction if you include the demand prediction according to the area, such as each village, prefecture or district.

(KOYAMA): Since I think that it is a purpose to investigate macroscopically about the making of this master plan, I want to think about what I examine according to an area.

3.6 （JARGALSAIKHAN）

(1) You calculate the deposits of each coal mine with Table 3-9 in page 90 of the report, but I want the table which includes both a company name and a coal mine name (coalfield name), because there is some item is a coal mine name and some item is a company name.
For example, it is easy to be revealed that four companies are shown in Narlin Sukhait because four companies operate a coal mine in the Narlin Sukhait coalfield. And please write the overall deposits of Mongolia in total.

(2) I doubt how reliable the source of the data such as coal mines in Table 3-16 of page 116 is.

(3) I want you to put the information of a new coal mine in Table 3-15.

(4) In each coal mine investigation, I want you to list it if there is a coal mine intending to export coal to Russia.

(5) I want you to make clear Khogor in Table 3-20 because there are two places.

(6) I want you to put the information of the mine mouth power station in Shivee Ovoo.

(7) Energy Association makes the development master plan according to the area in Mongolia. As they are making the plan about the power station, I want you to hear a story from the organization.

(8) The report divides it into three groups of the coal mine for export coal mine, coal mine for domestic power stations and districts. But is there any information about deposits and the amount of production of the coal mine for power stations, stripping ratio and mining plan?

(9) In this report, do you investigate a fund of the facilities update in the coal mine for domestic power stations and for districts?

(ENDO): It will be difficult to get this information about each coal mine in slide 16. I want to go for hearing to you if you have data.

（JARGALSAIKHAN）

Because I cannot show the F/S report of the private enterprise by obligation of keeping secrecy, please ask them the Mineral Resources Agency. Or regarding the large-scale coal company, at you can get information at their office in Ulaanbaatar.

3.7 （ALTSUKH）

I will arrange that MRAM will supply this information. There is a name of power plant developing in the future. Like this, I think that it should be gathered up about a coal mine name and mining plan. For example, I hope that you can show a prediction of coal production in Tavan Tolgoi, such as some prediction in 2012, some prediction in 2020 and so on.

(ENDO): The study team of coal development will stay next week. And they will visit MRAM and please look after them.

(MORITA as a comment from study team)

Mongolia can produce much coking coal, but has a problem to be able to sell it to only China. This is a serious problem, and we have to think about a solution. However, this is the way of thinking of the thing and there is the coking coal consumption in slide 4. China uses 57% among the consumption of coking coal of 878 million tons. Even if Mongolia does not transport it to third country, Mongolia is to have the world's largest market in the neighboring country. If Mongolia has already produced high quality coking coal and says that Mongolia sells in the prices that are lower than the coking coal price of Australia, China will buy it with pleasure. It is important how it can supply coking coal at a stable price and stable quantity for long period.

3.8 (ENKHASARUUL)

(1) It is written that the semi-coke quality is with less than 0.8% of sulfur in Interim report. I think it is a little bit high. This is about the same in raw coal. I think that sulfur may fall down if raw coal is distillated.

(ENDO): This is in a Mongolian standard. We suggested that sulfur content should be low. In addition, the sulfur content does not decrease even if they make distillation. There is a method to blend limestone at briquetting process to reduce sulfur at the time of the combustion.

(2) I think that SNG or electricity is convincing for a semi-coke alternative fuel. If it is Japan, there is the cheap turn in order of kerosene, gas, electricity, but I think that it is reversed in our country. Because a price is important, please examine this based on it. In addition, about processing of the coal, there is a plan about producing metallurgical coke in Sain Shand, but there is little information about liquefaction, the gasification. When a factory will be built, there will be an inquiry to the university about upbringings of a talented person working there.

(ENDO): We carry out hearing it about the coal sophisticated processing from the companies. I want to put it together about the personnel training and collect information.

(KOYAMA): I don't know whether an electric bill is cheap. I examined contents in slide 37 to examine it. I want you to think this to be the real price that conducted a local investigation in Mongolia. The price of the electricity in the report refers to Yearbook of the electricity. We recognize that the electricity is quite more expensive than house coke and heat. I am considering how I should go based on burden on consumer's ability. We may have to examine the rate of consumers finally pay a little more.

7.2 Workshops

(1) First Workshop

The workshop was organized under the title of "Coal Utilization Technology and its Applicability to Mongolia" as part of a study of a master plan for the development and use of coal in Mongolia for the purposes of outlining the survey in an inception report, and promoting Japan's coal utilization technology and the clean coal technology (CCT) for the effective use of coal and the protection of environment in Mongolia.

The Government of Mongolia is currently working to harmonize industrial development through the effective utilization of its coal resources and environmental protection. In the area of welfare of households, the government is reviewing various approaches, such as a change of fuels to coke with which smoke emissions from combustion can be controlled, wide-spread adoption of altered stove models, and the effective use of dimethyl ether (DME) in coke oven gas (COG), which is a byproduct of the coke production process, and coal liquefaction in the coal-chemical industry. With the rapid growth of export of metallurgical coal from Tavan Tolgoi and other regions, the government is also considering the exporting of high value-added products, such as coke, rather than raw coal. In the light of the above, experts from various fields in Japan gave lectures and exchanged opinions and ideas with the participants in respect of such topics in particular as the principles of the CCT as well as technologies for coal dressing, coke production, briquette manufacturing, coal gasification and DME production.

(a) Outline of the workshop

Date:May 31, 2012 (9:00 – 16:00)

Place:Blue Sky Hotel, Conference Hall (3rd floor), Ulaanbaatar

Participants: 69 (Mongolia – 46; Japan – 23 including interpreter)

Prominent Mongolian participants:

The participants included government and industry leaders, such as the representative of the government coal policy administration, including Mr. Erdenepurev (Director of Fuel Policy Agency) and Mr. B. Altsukh (Senior officer, Fuel Policy Agency), as well as researchers and academics. Private sector participants included Mr. Naran (Executive Director, Mongolian Coal Association), Mr. Munkhtur Togochi (Director, Residential Gas, ER), and Mr. Zoljargal Jargalsaikhan (Research Manager, MAK).

Japanese participants:

On the Japanese side, the participants included Mr. Suenori Isogai (Manager), Mr. Junichi Arai (Planner/Researcher) and Mr. E. Ankhtsetseg (Project management staff) from JICA Mongolian Office,); and the JCOAL Survey Team of 10 including Mr. Endo the Leader and Mr. Uehara the Deputy Leader. In addition, 6 dispatched experts and 4 interpreters and support staff were also present.

Workshop Agenda

9:00-9:15	Opening Opening address: A. Erdenepurev, Director, Fuel Policy Bureau, Ministry of Mineral Resources, Mongolia Suenori Isogai, Manager, JICA Mongolian Office Chair: T. Naran, President, Mongolian Coal Association
9:15-9:40	Outline of the study on a master plan for the coal development and utilization in Mongolia Hajime Endo, Leader, JICA Survey Mission
9:40-10:10	Principles of clean coal technology (CCT) (Introduction to coal utilization technology in Japan) Hironobu Oshima, Director, Project Development, JICA
10:10-10:20	Q&A
10:20-10:50	Coke production technology (Current production technology and its applicability to Mongolia) Lecturer: Koji Hanaoka, Manager, Ironmaking Technology, JFE Steel
11:15-11:45	Briquette manufacturing technology (Current production technology and its applicability to Mongolia) Lecturer: Masahiro Maeda, Managing Director and General Manager, Steel Business Division, Keihan Co., Ltd.
11:45-11:55	Q&A
11:55-12:25	Coal gasification (Current gasification technology and the applicability to Mongolia) Lecturer: Koichi Sakamoto, Manager, IGCC Gasification Project Office, Mitsubishi Heavy Industries, Ltd.
12:25-12:35	Q&A
12:35-14:00	Lunch
14:00-14:30	Coal dressing technology (Presentation on dressing technologies for general coal and metallurgical coal, and their applicability to Mongolia) Lecturer: Nagata Engineering
14:30-14:40	Q&A
14:40-15:10	DME production technology (Current production technology and its applicability to Mongolia) Lecturer: Nikki
15:10-15:40	Q&A (on DME and all other lectures)
15:40-15:50	Closing address: Representative of the Ministry of Mineral Resources of Mongolia

(b) Opening remarks by the organizer

In his opening address, Mr. Erdenepurev, Director of the Fuel Policy Agency, announced that JCOAL had started a survey for the development of a master plan for coal development and utilization in Mongolia. Mr. Isogai, Manager of JICA office, also remarked on the master plan development that, while the JICA would assist the development of the master plan for Mongolia's coal development and utilization, the plan should be formed not for the interest of JICA and the Mongolian government but for the benefit of the private sector people who actually work in the field.

The workshop opened following remarks by Mr. Naran, Executive Director of the Mongolian Coal Association, who presided over the workshop, stating that he expected all in attendance would actively participate and exchange opinions and ideas during the workshop in order to uphold the importance of human resource development as Mongolia looked to adopt the latest technologies to increase the added values of its coal rather than just extracting and transporting it.

After the conclusion of the workshop, Mr. B. Altsukh, Senior Officer at the Fuel Policy Agency, recalled how the proposals in the coal master plan developed by JICA in the 1990s led to the materialization of the Baganuur and Shivee-Ovoo coal mines projects with yen-loans and contributed to coal development in Mongolia. He emphasized the importance of the effective utilization of coal, citing that the coal development in Mongolia was entering a new era with coal production increasing from 6 million tons at the time of the previous master plan development to 30 million tons today, and urged the Coal Association, businesses involved with coal, government agencies as well as coal experts to work together so that the new master plan would be a better one.

Lastly, Mr. Erdenepurev congratulated that the workshop was very meaningful and had substance. He stated that the purpose of the new master plan was not just to produce a paper but enact measures with the aim of taking on the challenges of the future to develop actual businesses. Whereas the government used to play a much bigger role in the old days, it is the private sector that is at the helm today, and therefore its opinion should be reflected strongly in the master plan. The government will present its opinions, plans and proposals from the point of view of public policy. Mr. Erdenepurev closed the workshop by pledging that the government agencies, including the Fuel Policy Agency and MRAM, would provide information in addition to the knowledge imparted during the workshop, and cooperate with the master plan development by taking on joint responsibility.

(c) Outcomes of the workshop

As the workshop presented many lectures in a limited time frame, it was not possible to answer all the questions during Q&A periods which were only 10 minutes long after each lecture and 20 minutes after the completion of all the lectures. Many of the questions, however, focused specifically on how to implement the technologies presented in the lectures, and brisk exchange of opinions and ideas ensued.

Thirty-eight participants returned the questionnaire distributed during the workshop. Duration of lectures was rated “A – Appropriate” by 36, and “B – Short” by two who commented that (1) not enough time to cover the subject; the workshop should be organized more efficiently by providing sub-sessions under each of the agenda for example, and (2) the Q&A periods were too short. The topics for lectures were rated “A – Appropriate” by 37 out of the 38 who participated in the questionnaire.

In respect of the question regarding the Japanese coal technologies that Mongolia should adopt, the responses, such as “any one of them can be the first as all are important” and “all projects are feasible and will be implemented after an investigation and feasibility study as economy will determine the significance of a project," seem to represent the views of the Mongolian participants as a whole. Fig. 7-1 and Fig. 7-2 below graphically present the results of the questionnaire by the number of responses to each question (multiple answers for some).

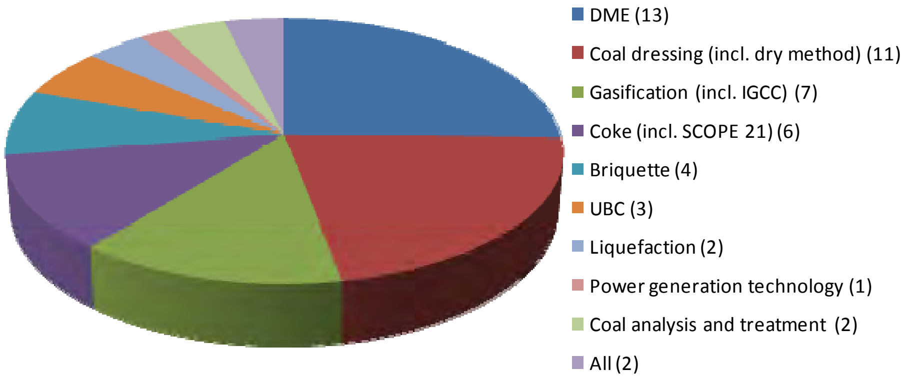


Fig. 7-1 Technologies which Mongolia should adopt

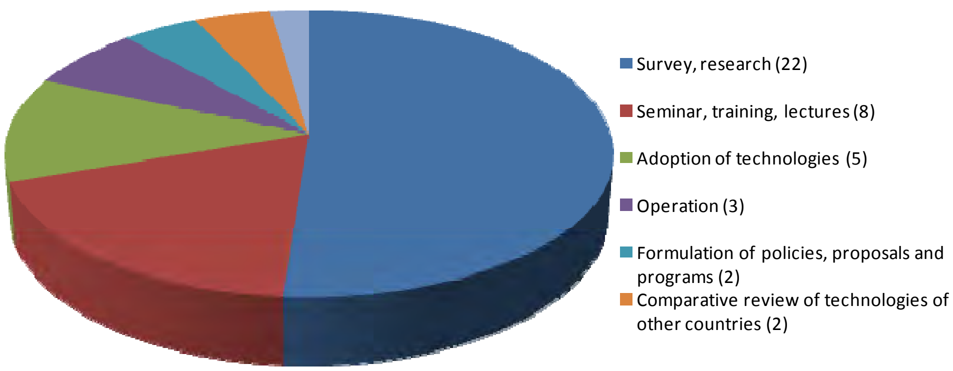


Fig. 7-2 Use of the inforamtion gained from workshop

The overall the workshop was given high rating. The participants commented: The workshop was fun and provided a great deal of information in a short time offering new ideas and technologies; The seminar was meaningful and useful for not only the coal industry but also the fields of fuel and energy, and the workshop helped the participants to gain a wide range of knowledge of coal and DME.

Fig. 7-3 Group photograph after the workshop

7.3 Training in Japan

At the first field workshop, the Japanese experts travelled to Mongolia and gave lectures on the principles of CCT and other technologies which might well be adopted by Mongolia in the future, including those for coal dressing, coke production, briquette manufacturing and gasification. In order to ensure a better understanding of these technologies, we invited the Mongolia government policymakers and coal experts from the private sector, research institutions and universities, a total of 20 in two groups, to further lectures and site visits.

Mongolia has had a general election and a government shuffle is likely to be completed by sometime in September. Accordingly, we held consultation meeting between JICA's Mongolian office and its Mongolian counterparts on August 8 and 9, and obtained the approval of the JICA Mongolian office and the Fuel Policy Agency of the Ministry of Mineral Resources to hold the training sessions on the November 5-14 period for the first group of 10, and on November 19-29 period for the second group of 10.

At present, the local JICA office and the Fuel Policy Agency are selecting candidates to attend the training sessions which are scheduled as follows:

Training schedule for Group 1(draft)

Group 1 (10)

Training Schedule					Subjects	Place	Instructor	(Transportation)	Lodging
11/5	Mon				Arrive in Japan: 08:10 Ulaanbaatar → 17:20 Narita		-	OM301 OZ106	Tokyo
11/6	Tue	AM	09:00-10:00	2h	Orientation	JICA Tokyo International Center	JICA		Tokyo
			11:00-12:00	1h	Lecture: ① Principles of CCT		JCOAL		
		PM	13:00-16:00	3h	Ditto				
11/7	Wed	AM	10:00-12:00	2h	Lecture: ② Coke production technology	JFE Ogishima Ironworks	JFE	Rent-a-cars	Kisarazu
		PM	13:00-15:00	2h	Visit: ① Coke production facility				
			15:30-17:30	2h	[Travel] Tokyo → Kisarazu				
11/8	Thu	AM	09:00-12:00	3h	Lecture: ③ Coal analysis technology	Idemitsu Coal and Environment Laboratory	Idemitsu	Rent-a-cars	Yokohama
		PM	13:00-15:00	2h	Visit: ② Coal combustion test facility Bulk terminal				
			15:30-17:30	2h	[Travel] Kisarazu → Yokohama				
11/9	Fri	AM	09:00-12:00	3h	Visit: ③ Two-stage gasifier pilot plant	IHI Yokohama Works	IHI	Rent-a-cars	Tokyo
		PM	13:00-15:00	2h	Visit: ④ USC coal-fired thermal power plant	JPOWER Isogo plant	JPOWER		
			15:30-17:30	2h	[Travel] Yokohama → Tokyo				
11/10	Sat				(Day off)	-			Tokyo
11/11	Sun		09:10-14:14	5h	[Travel] Tokyo → Fukuoka	-		Nozomi 19	Fukuoka
11/12	Mon	AM	09:00-10:00	1h	Lecture: ④ Briquette manufacturing technology	Keihan Shime Laboratory	Keihan	Rent-a-cars	Kokura
			10:00-11:00	1h	Visit: ⑤ Briquette manufacturing facility				
		PM	13:30-15:30	2h	Visit: ⑥ Environmental protection activities	Kitakyushu Ecotown	City of Kitakyushu		
			16:00-17:00	1h	Visit: ⑦ Coal dressing technology (dry processor)	Nagata Engineering	Nagata		
11/13	Tue	AM	9:00-10:35	1.5h	[Travel] Kitakyushu → Haneda			SFJ76	Tokyo
		PM	13:00-15:00	2h	General seminar	JICA Tokyo International Center	JCOAL		
			15:00-16:00	1h	Discussion				
11/14	Wed				Return to Mongolia: 9:00 Narita → 16:10 Ulaanbaatar		-	OZ107 OM302	-

Training schedule for Group 2 (draft)

Group 2 (10)

Training Schedule					Subjects	Place	Instructor	(Transportation)	Lodging
11/19	Mon				Arrive in Japan: 08:10 Ulaanbaatar → 17:20 Narita		-	OM301 OZ106	Tokyo
11/20	Tue	AM	09:00-10:00	2h	Orientation	JICA Tokyo International Center	JICA		Tokyo
			11:00-12:00	1h	Lecture: ① Principles of CCT		JCOAL		
		PM	13:00-16:00	3h	Ditto				
11/21	Wed	AM	10:00-12:00	2h	Lecture: ② Coke production technology	JFE Ogishima Ironworks	JFE	Rent-a-cars	Tokyo
		PM	13:00-15:00	2h	Visit: ① Coke production facility				
11/22	Thu	AM	09:00-12:00	3h	Lecture: ③ Coal analysis technology	Idemitsu Coal and Environment Laboratory	Idemitsu	Rent-a-cars	Tokyo
		PM	13:00-15:00	2h	Visit: ② Coal combustion test facility Bulk terminal				
11/23	Fri				(Day off)	-			Tokyo
11/24	Sat				(Day off)	-			Tokyo
11/25	Sun		09:10-14:14	5h	[Travel] Tokyo → Fukuoka	-		Nozomi 19	Fukuoka
11/26	Mon	AM	09:00-10:00	1h	Lecture: ④ Briquette manufacturing technology	Keihan Shime Laboratory	Keihan	Rent-a-cars	Kokura
			10:00-11:00	1h	Visit: ③ Briquette manufacturing facility				
		PM	13:30-15:30	2h	Visit: ④ Environmental protection activities	Kitakyushu Ecotown	City of Kitakyushu		
			16:00-17:00	1h	Visit: ⑤ Coal dressing technology (dry processor)	Nagata Engineering	Nagata		
11/27	Tue	AM	9:00-10:35	1.5h	[Travel] Kitakyushu → Haneda			SFJ76	Tokyo
		PM	13:00-15:00	2h	Visit: ⑥ Two-stage gasifier pilot plant	IHI Yokohama Works	IHI	Rent-a-cars	
			15:00-16:00	1h	Visit: ⑦ USC coal-fired thermal power plant	JPOWER Isogo plant	JPOWER		
11/28	Wed	AM	10:00-12:00	2h	General seminar	JICA Tokyo International Center	JCOAL		Tokyo
		PM	13:00-14:00	1h	Discussion				
11/29	Thu				Return to Mongolia: 9:00 Narita → 16:10 Ulaanbaatar		-	OZ107 OM302	-

Reference Materials

1.1 Government policies related to Mongolian coal

1.1.1 Coal programs

(1) Coal Management Policy

- Use coal effectively from a macro point of view and cope with energy supply and demand.
- Strengthen the policies related to the supply of surface-coal from the viewpoint of energy security.
- Gradually raise the price of domestic coal in both public and private sector coal mines. This is aimed at price liberalization in the future.
- Promote investments in coal mines. Problems in each coal mine can be resolved by preferential treatment disposal of debts.
- Build an energy system and secure fuel stability.
- Promote concentrated coal and encourage export of processed coal. Set up the floor price of exported coal.
- Activate coal deposits investigation and aim at increasing coal deposits.
- Strengthen geological surveys that specify the quantity of coal bed methane (CBM).
- Improve the new system of registration and information on coal resources.
- The comprehensive policy of energy resources of a country secures fuel and energy safety, reflecting a mineral resource and an energy method.
- A state carries out the management exercise of important deposit development, which is significant to the state.
- A state takes the required measures when price adjustment on a policy is required in the coal selling price. The Government is also equally responsible. It cooperates with the Ministry of Justice and a financial prefecture in this case. Since a huge fund is required to build a coal processing factory, the environment of the legislation, which includes both internal and external investments, finances, and taxation administration, is also improved.
- Provide preferential treatment with respect to the taxation system regarding the manufacturing and development of coal gas combustion, electric generating facilities, coal liquefaction, and half-Caux Kos fuel.
- Build and develop the infrastructures of the coking coal-ore deposits of Tavan Tolgoi.

(2) Coal Environmental Policy

- This policy improves the laws and regulations related to the environment of the coal gasification gas-fueling field, taking into consideration the gas fueling program by the Government.
- Develop clean coal technology and promote its introduction.
- In order to reduce the air pollution in Ulaanbaatar, promote the use of coal in the form of coke fuel, which is carbonized coal. This fuel is free from raw coal and is being supplied to a gel area from 2010 onwards.
- Offer support to low income citizens in a gel area with respect to coke fuel, ecology clean fuel, and gas utilization.
- Use clean coal technology in the construction of coal gas plants and CBM. Production of coke, coal

chemistry, and smokeless briquette is advanced preferentially. Maintenance of the law and taxation system improves investments and financial environment.

(3) Coal Policy Usage

- Promote the coal liquefaction technology and the technology (dry distillation) used to heat coal. This may help build a coking study factory in the future. Use the by-products extracted from a coal processing process.
- Build and develop the infrastructures of the coking coal-ore deposits of Tavan Tolgoi.
- Use concentrated coal and promote improved quality or upgraded version of coal.
- Collect methane in a coal bed to produce dim ethyl ether (DME).
- Support internal and external investments towards coal processing technology.
- Gasification of coal, gas production, and promotion of research on use of coal water mixture (CWM)
- Manage energy resources and fuel problems comprehensively.
- Improve the facilities for research and the coal center of coal chemistry with equipments related to coal processing, gasification technologies, and liquefaction techniques. Strive for improvement in talented and capable people.
- Examine coke fuel as the new electric power and heat source for Ulaanbaatar city. Choose a manufacturing facility, which is close to the coal production area, e.g., the Choir-Nyalga area was choosed where the infrastructure building was ready to use.
- Introduction of technologies and equipments that produces coal gas and carries out electric power use, and encouragement of environment friendly technology.
- Advance the market research of coal and promote concentrating coal, coke processing, and its exports. Also, increase the coal transportation capability for that is made to increase.
- Gasify coal and manufacture DME to methanol, and ethanol. A new type of energy resources, such as hydrogen fuel cells, is also considered.
- Consider the industrial complex construction, which utilized the coal of the Tavan Tolgoi ore deposits and which has a coking plant, a coal chemistry factory, a coal-fired power plant, etc.
- Exploit the heat sources for heating of a colony etc. The thermal energy generated in gasification and coal processing process of coal is improved. The network which supplies CBM is improved.

1.1.2 National Policies related to “Coal Sector Development”

(1) With Respect to the Management and Operation of Coal Resources

- For Mongolia, coal is a strategic mineral resource, and resources are managed and run by the state.
- Coal fields expected to be profitable will be given priority for development, but environmental conservation and restoration must also be considered.
- In each economic region of Mongolia, the amount of coal deposits is calculated. Development periods and usage purposes (domestic use, for export, for coke, etc.) will be decided after considering the properties and qualities of that region’s coal resources.

- For coal resource development, coal mine development systems, equipment, environmental technologies, and the latest technologies being used in advanced nations will be brought in to use the resources efficiently.
- Geological surveys will be performed, and mineral resource deposit size assessment standards will be established as law.
- Some of the income from coal mining will be used in domestic surveys, such as geological surveys, investigations, creation of geological maps, detailed surveys/investigations, etc., and Mongolia will pursue a policy to increase national funding related to coal resources.
- Explorations and surveys will be performed either with national or private funds, and conditions will sometimes be set for private funding.
- Geological surveys and mining of deposits will be handled separately. Regulations will stipulate that public and private enterprises and businesses are to be awarded geological survey or deposit mining rights through bidding. For this, it is necessary to create a business environment and legislation where the initial step involves bidding by Mongolian enterprises/businesses, and if there are no domestic enterprises/business that meet the bidding requirements, international bidding will be performed.
- There are points in Mongolian mineral resource presenting/reporting standards that do not meet international standards. Current Russian standards will be revised, and with cooperation with CRIRSCO (Committee for Mineral Reserves International Reporting Standards), reporting standards for Mongolian geological survey results and mineral resource deposit sizes will be designed and implemented that take into consideration circumstances unique to Mongolia.
- When performing geological surveys, exploration, or analysis, programs categorized by precision of exploration will be decided and promulgated in the central government and then performed.

(2) With Respect to Environmental Protection and Restoration

- Regarding site restoration of abandoned coal mines, new laws will be made or the current laws will be changed/revised to stipulate how to introduce and implement methods used in advanced nations into Mongolia.
- Details will be stipulated about implementation methods and deadlines for environmental conservation issues in coal mining feasibility and mine planning.
- An "environmental restoration fund" will be established for the purpose of ensuring future financing necessary for activities involving environmental conservation, restoration, and relief of damage incurred from the mining industry, and the business of accumulating capital for the fund will be managed/run by the central government.
- The coal mine owner will bear the responsibility of accumulating prepayments during the period of excavation for future financing of necessary actions such as site restoration of abandoned mines, environmental conservation, eliminating other mine pollution caused by the coal mining industry, long-term restoration, conservation, etc.
- In the case that the coal mine operator transfers an amount of money equivalent to that necessary to

close the mine to the nationally-run fund for the department in charge of this work, the mine where mining has stopped shall be returned to the central government. It will be decided that it is more reasonable for restoration work to be done through contract with specialist organizations/companies.

- National development policies, and short- and mid-term environmental programs that are suitable to the policies, will be created and implemented. Specialized cooperation with domestic and international organizations will be received when creating these programs.
- Regions or locations that are destroyed or harmed through the influence of coal mining activities will be recorded and evaluated, and restoration techniques will be investigated taking into account properties of the location in question, such as land surface and water resources, etc.
- In order to increase the quality and efficiency of restorations, cooperation will be receieved from scholars, researchers, and environmental ecology specialists in the form of post-restoration monitoring, etc. Financial and legal support for the personnel involved in this work will be managed and run by the government.
- Audits/observations on the status of conformation to conservation, restoration, and technical standards in currently operating mines will be done not only by government organizations, but a system/mechanism will be introduced and implemented so that specialist non-governmental organizations, specialist groups related to sector in question, and local people can participate.

(3) With Respect to the Adjustment of Investment

- Policies and appropriate proportions of domestic/foreign investments in the coal sector will be developed properly. For ownership of and investment in large-scale coal deposits, regulations will be made that are easy for citizens to understand.
- Problems with (large) scale coal deposit ownership and investment will be made public in as much a capacity as is possible when decided on by the state, and will be done in a transparent and easy-to-understand way.
- Regarding ownership of large-scale coal deposits, to avoid monopolies by a small number of people, investment financing from securities markets will be given priority.
- Regarding domestic/foreign investment in the coal sector, current national regulations that provide equal chances will be maintained. In order to increase the abilities of enterprises, organizations, and the people to the level of an advanced nation in a short period, the state will give as much support as possible in all aspects in accordance with the law.
- In order to support domestic enterprises active in the coal sector, changes will not be made for long periods to the tax system and business-related legislation.
- In industrial processes such as exploration, research, mining, and simple coal cleaning that can be done single-handedly by domestic companies, it will be understood that foreign investment is not always necessary.
- In areas yet undeveloped in Mongolia, such as coke/chemical industry and coal/chemical industry that use the latest processing techniques, such as coal thermal decomposition and nanotech, focus

will be on giving priority to foreign investments, equipment, and specialists.

- For investors in the coal sector and developing the necessary infrastructure, legal and managerial preferential treatment will be developed on the whole in a short period, and, among the countries of the world, priority will be given to close cooperation between the coal sector and Asian/European countries for mutual benefit.

(4) Development in the Field of Coal Based on Market Principles

- Direct involvement of the state in prices of coal for power generation and prices of coal for export will stop, and integrated, global-level rules will be put in place where the price structuring process is set based on free market principle factors, such as product demand, supply amount, cost, domestic and foreign market prices, quality, market, management level, etc.
- The current laws where sale of mining products is performed by a coal deposit license holder will be revised, and laws will be drawn up where this can be done by specialized companies skilled at international business in domestic and foreign markets.
- In order that transactions in domestic and international markets with actual goods and with futures for both coal and products produced using coal, preparations will be done that prioritize building a business environment and administrative laws that set up an international coal exchange in Mongolia.
- Regarding enforcement of laws in the coal sector, state regulations will be improved so that they become equivalent to other mining sectors, and civilian participation and the active participation of civilian specialist associations, non-governmental organizations, etc., will be promoted.
- State participation in strategic coal deposits will be done by state-owned enterprises. These enterprises will fulfill a beneficial environment through transparent and public practices, and business practices and financial systems that conform to international rules will be introduced.
- When developing strategic coal deposits, adjustments will be made using policies that decrease possible financial risk to the national budget.

(5) For the Supply of Fuel to the Power Industry

- Exploration, mining, and treatment of coal for electricity generation and natural gas, which is closely-linked to coal, will be given special focus, and specific work and plans will be proposed and implemented by the government.
- The potential for constructing fuel production factories that have a low environmental impact, are highly reliable, can be run safely, and involve the latest technologies will be investigated and introduced. Especially in city areas where population density is high, clean coal technologies will be nationalized so that coal processed to be of good quality and safe to the health of people and the environment can be supplied, and state policies will support the construction of fuel factories that meet international standards.
- Not just energy coal, but for all other fuels, a transport and distribution system will be constructed that has a high economic effect and is appropriate for the needs of Mongolia.

- Long-term special plans will be drawn up and implemented to regulate and develop the deposit amounts, mining, sale, and consumption of energy coal.
- New laws will be proposed, deliberated, and adjusted with regard to the mining and processing under the management of the state of a fixed amount of energy coal for the purpose of maintaining the economic stability of Mongolia.

(6) For Exports

- Coal will be made to match overall regulations for international business and product sales, then exported.
- The goal will be to hand off coal for export not at the coal mine or national borders, but to export coal under the conditions of hand off on the end users' railways, coal depots, and warehouses as often as possible.
- Policies will be made to limit export of raw coal, support export of coal reformulated through coal cleaning, etc., or commercialized coal, and increase these coal amounts as well as the number of export licenses.
- Mechanisms will be prepared for selecting comprehensive policies for tariffs and prices for export coal by introducing a bidding system at commodity exchanges.
- It is necessary to integrate factors in coal export, such as market, quantity, quality, price, etc., with factors in petroleum product import. Policies will be made to further increase the competitive power of domestic companies that operate in the coal sales business by increasing the customs clearance capacity of border gates and checkpoints for export of coal and coal products, and by upgrading transport infrastructure.
- Strategies and programs will be drawn up for developing coal export, and introduce economic mechanisms such as insurance compensation, tax systems, and financing that actively support exports and are already being used in advanced nations.

(7) Advanced with Respect to Coal Processing (Processing)

- Active progress will be made with manufacturing eco-friendly and clean briquettes, petroleum products, coke chemical and coal chemical products, coal mine methane, CBM, coal gasification, and construction of power plants that use clean coal technology. An appropriate economic, legal, tax, and financial environment will be prepared that allows for reliable recovery of investment costs.
- Policies will be made for securing coal-derived fuel, commercialization, etc., and newly set up and make active state specialist organizations to perform monitoring of related surveys and ideas.
- Introduction of the latest modern techniques will be intended for advanced processing of coal, a comprehensively divided center will be established for analysis, surveying, and verification factories, and domestic and foreign experts and scholars will actively be brought into these activities. Special ideas and programs will be drawn up for using methane gas collected from coal mines as a green energy source and for specifying methane and shale gas deposit amounts and

execute these ideas.

(8) Development for SMEs (Small medium enterprises)

- Coal development will be performed that aims for sustainable development, and in order to support economic development, etc., workplaces will be promoted that utilize modern machinery and technologies and measures will be taken that will quickly increase the incomes of the general populace.
- Regarding large-scale operations in the area of coal, detailed programs and projects will be drawn up and implemented for establishing and developing small- and medium-sized Mongolian enterprises that utilize the latest technologies and machinery. An environment will be made which cultivates and develops small- and medium-sized enterprises that focus on mining machinery services in this field.

(9) Terms of Human Resource Development

- Attractive loans will be implemented from state funds and free collaboration for cultivating specialists in the areas of geology, mining, and manufacturing necessary in the coal sector. Scholarships, aid, and other financial resource from the Mongolian government and from other countries will be used to implement activities that follow detailed policies and measures for cultivating personnel.
- A system will be set up and implemented that has on-the-job and off-the-job training in order to cultivate specialists, engineers, and technical personnel that majored in advanced coal processing and learned advanced technical and knowledge-based skills in domestic and foreign universities. Comprehensive support from the state will be given for activities to receive training from international organizations and coal enterprises, companies, etc., in advanced nations.
- Abilities of occupational and specialist coal groups and associations will be developed, and through these organizations, cultivate/develop personnel and train specialists.
- The central government will work to support and make comprehensive measures to cultivate business specialists and lawyers that possess the advanced knowledge and skills to participate in domestic/foreign and international legal and judicial activities, and are able to carry out international negotiations/contracts, surveying/auditing, and solve deliberations and frictions not just in the coal sector, but also in general mining industries.
- As a duty of government, an organizational system will be developed for surveying and researching industry development, technology, domestic markets, international markets, the domestic and global economies, etc., while also rationally organizing a system for cultivating and developing the personnel that handle this surveying/research, and putting in place conditions for participating in non-governmental organizations and sector industry groups and associations in these activities.

1.1.3 Contents of big projects conducted on a priority basis which was announced by Mongolian government.

No.	Project name	Project overview	Ministry in charge	Supervising WG member
	Prioritization policy -1 Development of mineral resource mine exploration and mining sector, creation of foudnation for heavy industry			
1	Oyu Tolgoi Project	Ore separation site. 35M tons annually (100k tons/day) Create a facility able to process ore. Also, expland to capacity of 58M tons annually (150k tons/day). Dig at open-air and underground sites. Planning to mine using block method at open-air sites.	Mineral Resources/Energy Ministry	Mongolian government and Aivanhoe Mine's Co.
2	Tavan Tolgoi Project	Mine coal at 20M tons annually. Coal separation capacity is 15M tons annually. Will serve as foundation for future coke and chemical industries. Regular coal to be supplied to power plants with remainder going to coke plant.		Erdenes MGL Co.
3	Copper dissolution project	Process copper conc at plant. Manufacture 70K tons of cathode copper annual at plant.		G.Batkhuu, Mineral Resources & Energy Ministry Heavy Industries Bureau Chief
4	Steel plant complex project	Dissolve 2M tons of steel annually to manufacture steel plates, rails, and large-scale metal objects.		
5	Coke/chemical industry project	Project for coke production for the purpose of developing the coke and chemical indsutries. Chemical processing plant for gas, bitumen, and other chemical substances separated during coke heating.		D.Tsevelmaa, Mineral Resources & Energy MinistryFuel Policy Bureau Chief
6	Petroleum refinery project	Selects technology for processing oil domestically and outline production capacity. Plant technology will look to comply with international standargs.		A.Purev, Mineral Resources & Energy Ministry, Fuel Policy Bureau worker
7	Coal/chemical plant project	Creation of plant for manufacturing DME and other chemical products based on coal ore. Will incorporate clean coal technology.		
8	Construction materials plant project	Produce 1M tons annually at the cement plant in Sainshand, 30-50k tons annual at the cement plant at Bayankhongol, 50k tons at the cement plant in the village of Daishil in Gobi Altai, and 30k tons annually at the cement plant in Undelhaan, Hentey. Construction steel product plant: 2M tons of steel products annually, ceramics lab plant: 50M products annually. Also to product insulation and build a block plant.	Road, Transport, Construction, and Urban Development Ministry	A.Gansukh, Deputy Minister of Road, Transport, Construction, and Urban Development Ministry M.Ulaankhuuhen, Road, Transport, Construction, and Urban Development Ministry, Construction, Housing, and Public Facilities Bureau worker
	Prioritization policy –3 Related to the development of infrastructure facilities			
9	Tavan Tolgio power plant project	400MW thermal power plant. Connect to central power grid. Air cooled system, ash to be dry-removed. Plant with advanced technology for low water consumption.	Mineral Resources/Energy Ministry	T.Tserenpurev, Mineral Resources & Energy Ministry, Energy Policy Bureau Chief
10	New railroad project	Railroad infrastructure development in Gashuunshai, Tavan Tolgoi region, railroad infrastructure development in Nalynshai Svellen region, railroad infrastructure development in Sugaan Subaragaans Bayan Sainshand region	Road, Transport, Construction, and Urban Development Ministry	A.Gansukh, Deputy Minister of Road, Transport, Construction, and Urban Development Ministry T.Batbold, Railroad Bureau Chief
11	Project to meet Gobi region water needs with water from the Olhaan River	Project will supply 2500L/second of water to resolve water problems in the Gobi region.	Natural Environment/Tourism Ministry	D.Dorjsuren, Marine Resources, National Committee Chairman
12	Ulaanbaatar city road development project	Renovate current 350,0 kilometers of paved road and utilities. 212 kilometers of paved road and utilities to be layed in Ulanbaataar city	Road, Transport, Construction, and Urban Development Ministry	
13	Road development project for Altanbrag, Ulanbaatar, Zamyn	990 kilometer highway construction project in Altanbrag, Ulanbaatar, Zamyn regions.		
14	No. 5 Power plant project	Project to supply heat and electricity in Ulanbaataar	Mineral Resources/Energy Ministry	B.Erdenebileg, Energy Bureau, Project Manager Tel: 341371
15	Project for creating electricity from garbage and biomass	Plant for separating 1000 tons of water/day 250 tons/day of organic waste and biomass to be process into combustion fuel.	Natural Environment/Tourism Ministry	D.Enkhbat, Natural Environment/Tourism Ministry

1.2 New coal development technology

1.2.1 CBM (Coalbed Methane)

(1) CBM trends

In recent years, as concerns grow over consistently high crude oil and gas prices, and the constraints of future energy supply and demand, progress in the fields of petroleum and gasoline development technology have led to significant attention being given to "non-traditional" petroleum and gas resources that, up to this point, had been seen as too difficult to recover. And as environmental awareness grows, especially considering certain countries in Europe already have implemented a system of environment taxes, a system that is expected to be expanded moving forward, the worldwide need for energy with a low environmental impact is greater than ever, as is the hope being placed on the demand and development of these "non-traditional" gas resources.

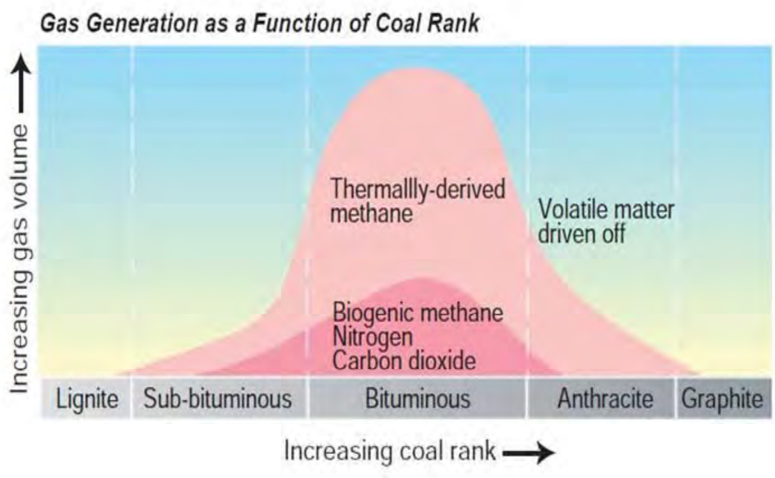
Among these non-traditional resources, Coalbed Methane (CBM), a bountiful resource that exists in the layers between coal beds, had garnered much interest as a promising gas resource.

At present, commercial production of CBM takes place in the United States, Canada, and Australia, where CBM already has begun to build a major footprint within the gas markets. For example, CBM production during 2006 in the United States was approximately 1.8Tcf, which equates to 10% of total natural gas production. In Australia, and particularly in Queensland where the CBM sector is concentrated, currently nearly 50% of gas supplied in the state is based on CBM production. Furthermore, spurred by the rise in international gas prices, since last year several CBM-LNG projects have been announced. These projects calls for CBM produced in Queensland to be transported via pipeline to the eastern port city of Gladstone, where it will be liquefied and turned into LNG gas. Currently, negotiations are underway in hopes of turning these six projects into a reality. On a global scale as well conditions affecting CBM have changed dynamically and it is almost certain that the presence of CBM on energy markets will continue to grow larger.

(2) Characteristics of CBM

(a) CBM production and storage mechanisms

CBM methane gas is produced primarily as a result of the process of coal heat maturation (dehydration and degasification). As shown in Figure R-1, the majority of gas is produced during the bituminous coal phase. Also, which it is in small amounts, methane originating from organic materials is produced during the initial stages of bituminization as well. Coal has a structure consisting of minute porous spaces (empty spaces). The majority of methane gas produced exists on the surface of those porous spaces, adsorbed onto the coal through van der Waals force at the molecular level. In this way, CBM differs greatly from traditional natural gas beds where gas is compressed and stored within porous spaces between reserve bed layers. While methane gas that is not adsorbed onto the cleats (called open air gas) does exist, this accounts for little more than a small percentage of all methane and even during reserve volume appraisals it is common for appraisals to consider only adsorbed gas and free air gas is usually ignored. Furthermore, as shown in Figure R-2, gas absorption volumes as known to increase in relation to the progression of bituminization, thus under equivalent temperature and pressure conditions, anthracite coal will contain the maximum volume of absorbed gas. With CBM, this adsorption volume appraisal is vital during reserve volume estimates.



Source : Schlumberger

Fig. R-1 Coal Rank and Gas Production Volume

Fig. R-2 Correlation between Coal Rank and Methane Gas Absorption Capacity

(b) Gas composition

The major component of CBM is methane (CH_4) as per its name. In general, CBM is comprised of over 90% methane. Additionally, CBM also contains a percentage of ethane (C_2H_6) and other hydrocarbons and carbon dioxides that are heavier than methane. In other words, while CBM is classified as a "non-traditional" gas resource, the actual components of the gas bear no major differences when compared to gases produced from traditional natural gas fields. In fact, as carbon dioxides and other impurities are normally found at minute levels, handling is relatively easy and allows for simple gas processing facilities.

Flow mechanism

As noted above, the majority of CBM is absorbed into the surface of coal. During production, the following process is used to deliver the gas to production wells.

- Coal bed pressure reduction (or methane partial pressure reduction) used to separate methane from coal surface
- Separated methane is dispersed through a network of porous spaces via a concentration gradient, causing it to travel to the cleat
- Pressure differences within the cleat network cause the gas to travel and flow into a well.

Gas flow based on pressure differences within the clear is the same as with traditional gas fields. This is something that can be expressed using Darcy's Law but the separate of gas from the coal surface and the concentrated dispersal of separated gas are phenomena not seen in traditional gas fields. As such, compared to traditional gas fields, CBM is thought to present a more complicated flow mechanism.

(c) Production behavior and production capacity

Coal beds can be divided into "dry types" and "wet types". Gas production behavior in dry coal beds is largely similar to that of traditional gas fields but at wet coal beds, which represents that large majority of coal beds, CBM presents production behavior that differs greatly compared to traditional natural gases.

At dry beds, gas is absorbed into the coal surface at a level that is represents the maximum absorption level of the coal (saturation) and free air gas occupies the space within the cleat so from the initial stages there is no water present within the cleat. Immediately following the launch of production, separation of gas from the coal surface begins and gas can be produced at a high rate. The coal from the Horseshoe Canyon bed (upper cretaceous) in Alberta, Canada is a well-known dry type coal bed.

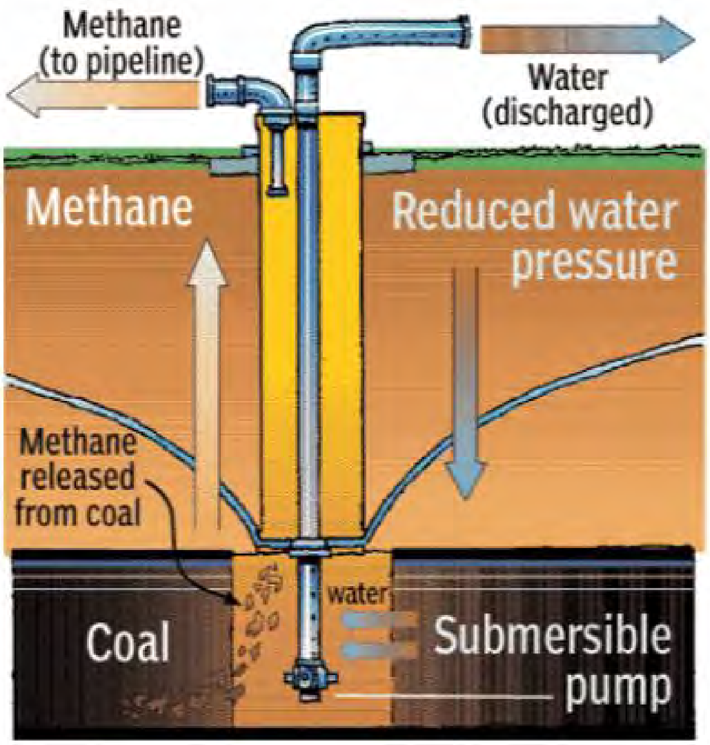
Conversely, with wet types, coal surface gas absorption rates are not at their maximum levels (not saturated) and at the initial stages the cleat is filled with water. Removing gas from the surface of the coal bed requires dewatering the cleat and then lowering pressure until the coal bed is saturated. As such, we see a unique production profile wherein the gradual decline of marine production, which is at its peak in the initial stages, will result in the increased production of gas.

Regarding the production capacity of CBM well gas, while there are some wells that compare favorably with traditional gas well (production route: daily production of 10MMscf and higher), in general production is low at 1/10 to 1/1000 that of traditional wells, meaning that a large number of production wells is required to ensure economic viability. Also, that productivity will vary greatly with each well is also a known characteristic of CBM. This is thought to be due localized variances in permeability caused by differences in cleat development levels as well as differences in cleat width.

(d) Coal beds suitable for exploration

Ideal conditions of coals beds suitable for CBM exploration include having a thick and wide dispersal of coal with a large gas absorption rate as well as having a high rate of permeation and that the gas flows well. Concerning the first condition, methane gas production volume from coal is greatest with bituminous coal, and because absorption capacity increases as the bituminization process progresses, coal that is further along in the bituminization process (bituminous to anthracite coal) provides better yield. Furthermore, while cleat development progresses in correlation to bituminization and thus form a more beneficial cleat network, bituminization progresses in correlation to increases in burial depth, in other words the increase of geopressure, thus the decrease in cleat width will result in a decrease in permeability. To state this qualitatively, coal beds suitable for CBM exploration are those that have wide areas of open space containing coal with favorable bituminization (larger gas absorption rate) and have favorable permeability.

In reality, the depth of coal beds that have been targeted for CBM exploration have been limited to roughly 1,000m but for coal beds below that depth the rate of permeation is considered a bottleneck for exploration. Figure R-3 shows the CBM production flow.



Source: created by JICA survey team

Fig. R-3 CBM Production Flow

1.2.2 Underground coal gasification

(1) Overview

Underground coal gasification (UCG) technology involves converting coal found in underground coal beds into CH_4, CO, CO_2, H_2, and other mid-to-low calorie gases. Produced gas can be used as fuel at power plants or as a chemical raw material. Since experiments with UCG began in the former Soviet Union in the 1930's tests have been conducted around the world. Various gasification methods have been developed and the technology has reached a point to where it is almost ready for practical application. With UCG, two or more boreholes are drilled in the direction of the coal bead and the boreholes are linked via natural or induced permeation routes. After igniting the coal, air, oxygen, steam, water, etc. are injected into one borehole to induce the continued gasification of the coal. The basic gasification reaction is the same as that which would occur above ground. The quality of the produced gas depends on the pressure and temperature achieved during the UCG process. At low temperatures and high pressure, a large amount of CH_4 is produced, causing a high gas calorific value. At low temperatures and low pressure, a large amount of CO_2 is produced, which lowers the calorific value. The calorific value of the gas can be increased through the injection of oxygen. Also, it is possible to increase the hydrogen content level by adjusting the volume of injected gas, water, and the process pressure.

Coal in underground deep and shallow layer coal beds, in coal beds with large ratios of ash or sulfur, and in other underground coal stores where coal production is not economically viable can be gasified underground, and then collected and used as gas, making once unusable coal reserves usable and contributing to the stabilization of energy supply and demand.

As a result, as the rich resources of deep layer coal beds can be recovered as gas, this gas can be used as a natural gas alternative energy source, used in power plants, and used as a raw material in chemical manufacturing, thus creating possibilities for the effective utilization of untapped resources.

Base technology includes (1) directional borehole drilling methods, (2) gasification route setup methods, (3) temperature and environmental impact monitoring, and (4) technology for environmental protection including prevention of groundwater pollution.

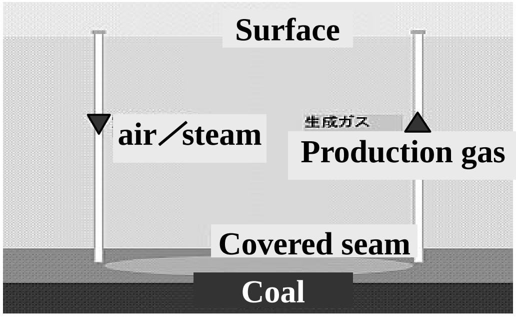
(2) Development history of UCG technology

After concentrated development efforts in the former Soviet Union during the 1930's, in the 1950's this expanded to industrial-scale UCG operations for shallow layer coal beds. In 1966, UCG gas production reached its annual peak at 2.5 billion m^3. The fundamental UCG technology was established in the former Soviet Union. In Europe during the 1970's and 1980's, deep layer coal bed tests were conducting while in the United States UCG tests were conducted on shallow layer coal beds. In particular, the United States would go on to conduct vigorous UCG testing and, through the development of Controlled Retracting Injection Point (CRIP) technology, which uses directional drilling to achieve horizontal boreholes and relocate ignition sites, succeed in the production of a high calorie gas (above $10MJ/m^3$). In China, beginning in the 1980's the China University of Mining and Technology and the China National Coal Group began collaborating on the development of underground gasification methods suitable for use in China. A long-distance route, two-phase method developed at the China University of Mining and Technology whereby the coal tunnel is vacuum sealed and a gasification furnace is setup is already in use at a number of coal mines.

(3) Overview of UCG technology

(a) Linking

UCG is simple technology but with changing geological conditions and changes in the state of the coal, it is difficult to control reactions and produce gas of a consistent quality. As is shown in Figure R-4, the basic structure consists of two boreholes with one used for injecting an oxidizing agent and the other used for collected produced gas.



Source: created by JCOAL

Fig. R-4 Basic structure of UCG

The most important factor to consider when discussing UCG is the establishment of links between the injection and production routes. Coal beds have many cracks and break lines, which serve as natural routes. In recent years, advancements in directional drilling technology has made it possible to link routes by crossing injection boreholes and production boreholes at desired locations within the coal bed and in past testing, research into this linking method has driven the development UCG technology.

(b) Methods

There are primarily three methods. The first method is based on the technology development in the former Soviet Union. This method relies on a pair of perpendicular boreholes to open a path within the coal bed (refer to Figure 8-4). Utilizing natural routes existing within the coal bed, these natural routes are expanded and, when necessary, a link is formed between the injection borehole and the production borehole. This method was tested successfully in Chinchilla, Australia and there are reports that commercialized FS based on this method is underway in India, Pakistan, Canada, and Australia. The second method is the Chinese method whereby an artificial tunnel created within the coal bed is used and a borehole is drilled to link the surface with the tunnel. During this process, they alternate between injecting air and steam into the tunnel. The third method was tested in Europe and the United States. This method uses petroleum and natural gas production technology to drill a dedicated borehole on the edge of the coal bed. This method employs transitioning injection points known as CRIP. For coal beds beyond a depth of 1,000m, it also is possible to perforate the gasification borehole. At greater depths, implementation of this method provides advantages in terms of air hole development, energy output and environmental benefits, and from the perspective that it is possible to maintain CO_2 reserves at a supercritical state.

(c) Environmental management

When UCG is not managed under optimal conditions, the process can present two environmental risk factors in the form of ground water pollution and surface depression. During tests at Hoe Creek in the United States, improper site selection and excessive reactor pressure resulted in ground water being polluted by benzene and volatile organic carbons. Conversely, tests at Chinchilla validated that it is management of groundwater pollution risks can be managed by using surrounding void pressure to further decrease reactor pressure. Under such conditions, risks related to the danger of groundwater pollution can be greatly reduced when water flows from the wall rock into the UCG air hole and the flow of pollutants into the surrounding water-bearing stratum is constrained. When conducted at similar depths, the occurrence of surface depression is similar to surface depression seen with long-wall coal mining, which is one type of underground mining method. As such, many countermeasures can be learned from underground mining technology.

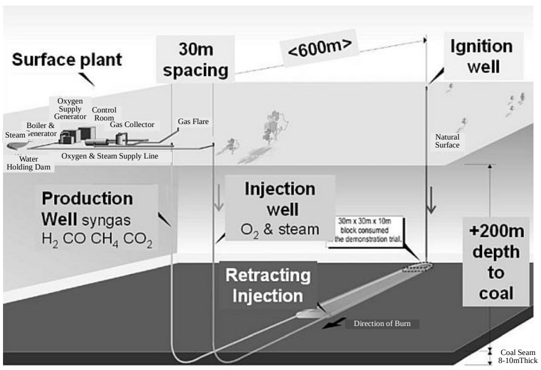
(4) Current state of UCG

(a) Chinchilla tests

Chinchilla tests (Reactor 1) were conducted between 1997 and 2003, and this remains the largest UCG project undertaken by any western country. Canadian company Ergo Energy Technology developed UCG technology through an agreement with Australia's Link Energy. Gas production began in December 1999 and shutdown in April 2003. During the test period they perforated nine wells and produced synthetic gas equivalent to 70MWe at a maximum rate of 80,000Nm^3/h from a coal bed with a depth of 140m and a thickness of 10m. Consuming nearly 35,000t of coal, they produced over 80 million Nm^3 of 300°C, 5.0MJ/Nm^3 gas. Since October 2008, they have been conducting UCG tests on Reactor 3, which is in the region adjacent to Reactor 1. The goal of Reactor 3 is the application of the Fischer-Tropsch (FT) method to produce diesel from synthetic gas.

(b) Bloodwood Creek tests

Carbon Energy conducted UCG tests in an area near Chinchilla. Their goal was to produce stable synthetic gas as well as validate and correct the models and algorithms used for UCG control. Beginning in October 2008, they conducted UCG tests over a period of 100 days using one panel. These tests were designed based on the success seen at the Rocky Mountain tests conducted in the United States (refer to Figure R-5). Trial overview: Coal consumption rate: 80 to 90t/d → 150t/d, goal: determine parameters required to produce energy equivalent to 1PJ annually (natural gas equivalent of 28 million m^3), panel: 600m (length) x 30m (width: space between two wells) x 9m (coal bed thickness), oxygen and steam consumption volume: 70t/d, boiler capacity 70t/d.



Source: created by JCOAL

Fig. R-5 Well design concept diagram

1.3 Overview of World Coal Application Technology

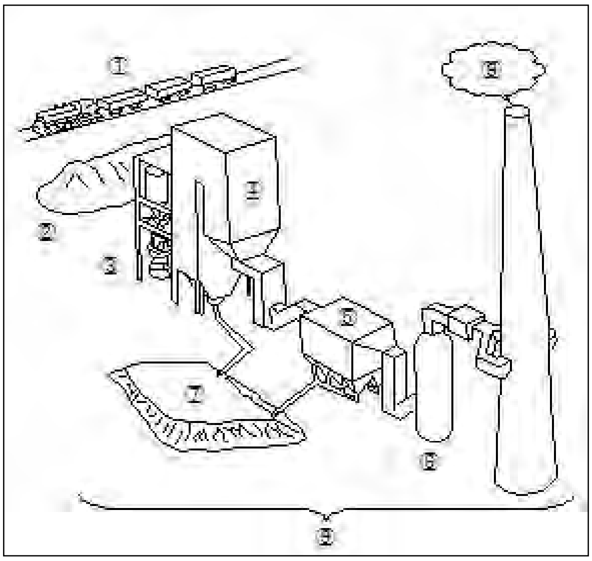
1.3.1 Coal Preparation Technologies

(1) What is Coal Preparation?

In addition to organic coal, inorganic minerals (ash) are included in extracted coal (raw coal). Coal preparation is the process of reducing the mineral content so that it has quality (size, moisture content, ash, calorific value, and sulfur content) to suit the purpose so that coal with high added value (commercial coal) can be obtained from raw coal. The coal preparation process has the separating process as its center, with associated processes such as crushing, screening and dewatering.

(2) Advantages of Coal Preparation

By preparing the coal, useless minerals (ash) are removed, and coal with more "constant quality, low ash, and low sulfur" is provided to users such as power plants. Benefits arise as a result, such as 1) decreased volume of transportation, 2) decreased volume of coal stockyard, 3) decreased pulverizing mill load, 4) less trouble with ash, 5) decreased dust collector load, 6) decreased exhaust gas desulfurizer load, 7) decreased ash disposal amount, 8) decreased atmospheric pollution, 9) improved power generation efficiency as an overall result (see Fig. R-6). Additionally, when there is a plan to introduce higher level of clean coal technology (CCT), providing coal with constant quality, low ash and low sulfur content is a prerequisite. Coal preparation is the first step of CCT.



Source: JICA Study team

Fig. R-6 Benefits of Coal Preparation at a Power Plant

(3) Principles of Coal Preparation

(a) Gravity Concentration Process

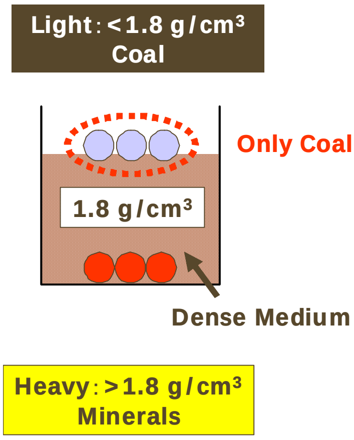
The minerals mixed in extracted coal are mainly sandstone and shale, and also small amounts of pyrites. The specific gravity of sandstone and shale is 2.5, and the specific gravity of pyrite is 5.0, while the specific gravity of organic coal is about 1.4 with small differences depending on the type of coal.

Gravity concentration is a separation process that exploits differences in specific gravity, and is the separation process most often used at coal preparation plants.

One gravity concentration process is a method that uses a dense medium. This is called "dense medium separation". For example, feed raw coal in a dense medium with specific gravity 1.8, particles lighter than specific gravity 1.8 will float, and those heavier than 1.8 will sink. Since the particles that float are coal and the particles that sink are minerals, they can be collected separately (see Fig. R-7). As for the dense medium, slurry of magnetite (specific gravity: 5.0) particles suspended in water is used. When this principle is applied with real machinery, it is a simple matter to recover the particles that float, but the problem is how to continuously recover particles that sink, and for which various mechanisms have been devised. Among commercial separator machinery there are the dense medium bath, and the dense medium cyclone.

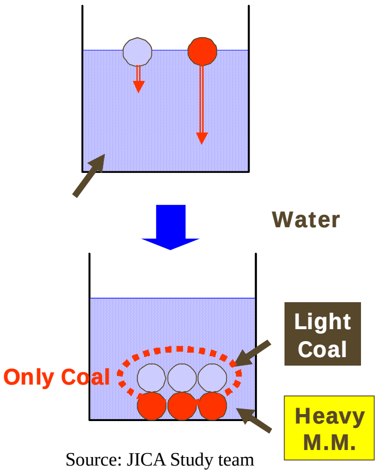
In addition, there is also a gravity concentration process that exploits the difference in falling velocity of coal particles and mineral particles in water. Three forces are at work on the particles falling in water: gravity in the downward direction, buoyancy in the upward direction and viscous resistance in the upward direction. The particles sink while slowly increasing the falling velocity, the resistance of water increases and at some point in time, particles sink at a constant velocity. Since the larger the specific gravity of particle, the faster the falling velocity, mineral particles with high specific gravity quickly settle stratifying on the bottom, while coal with a low specific gravity slowly settles and stratifies on the top. If the stratified top and bottom portions are collected separately, the two can be separated (see Fig. R-8). Furthermore, because the law “the larger the particle diameter, the faster the falling velocity” is also true, accuracy of separation is affected by the size range of raw coal. When this principle is applied to actual machinery, the problems are how to continuously collect top layer and bottom layer separately, and how to detect the position of the boundary between the two, and for which various mechanisms have been devised. Jigs are included in the commercial separator machinery for such purposes.

There is a gravity concentration process exploiting water flow for small particles with diameter around 1mm. Mineral particles with large specific gravity will not be washed away in the stream of water and will remain, while coal particles with small specific gravity will be washed away in the stream of water. By separately collecting the particles that remained and the particles that washed away, the two can be separated (see Fig. R-9). Accuracy of separation is not high, but equipment costs and running costs are inexpensive. Furthermore, the principle is the same as the pans used for panning gold. Commercial separators include the spiral concentrator and shaking table.



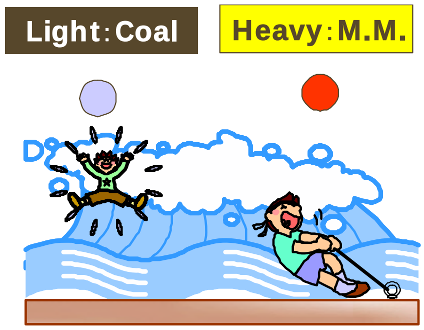
Source: JICA Study team

Fig. R-7　Dense Medium



Source: JICA Study team

Fig. R-8　Falling Velocity



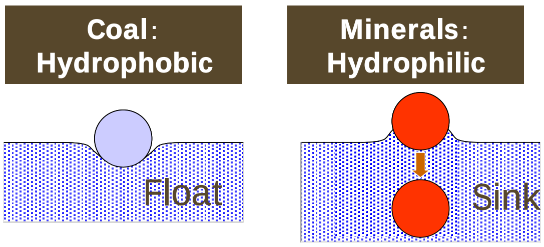
Source: JICA Study team

Fig. R-9　Water Stream

(b) Flotation Process

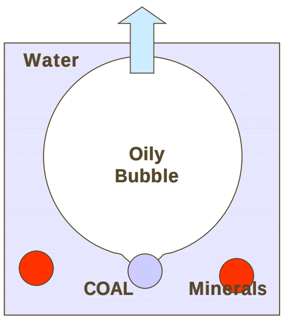
The separation accuracy of the gravity concentration process decreases as the size of particles to become smaller, and separation is impossible when particle diameter is less than 0.5mm. For such fine raw coal which is difficult for gravity concentration, the "flotation process " is used.

This is a separation process that exploits the fact that the surface of coal particles is hydrophobic while in contrast the surface of mineral particles is hydrophilic (see Fig. R-10). Oily bubbles are produced in slurry of fine raw coal, while the hydrophobic coal adheres to the rising oily bubbles, the hydrophilic mineral particles do not adhere to the oily bubbles and remain in the slurry, and the two are separated (see Fig. R-11).



Source: JICA Study team

Fig. R-10　Difference in Surface Properties

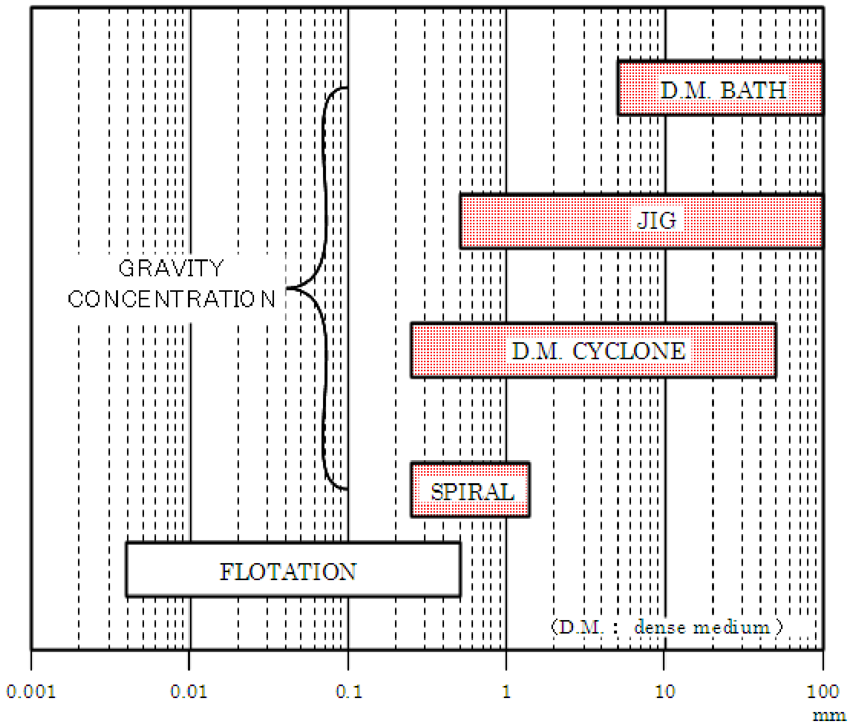


Source: JICA Study team

Fig. R-11　Flotation Process

(4) Coal Cleaning Devices

Typical coal cleaning devices in commercial use are shown in Fig. R-12. The horizontal axis in the figure shows target particle diameter. The most economical separators are selected considering separation accuracy and other conditions in addition to particle diameter.



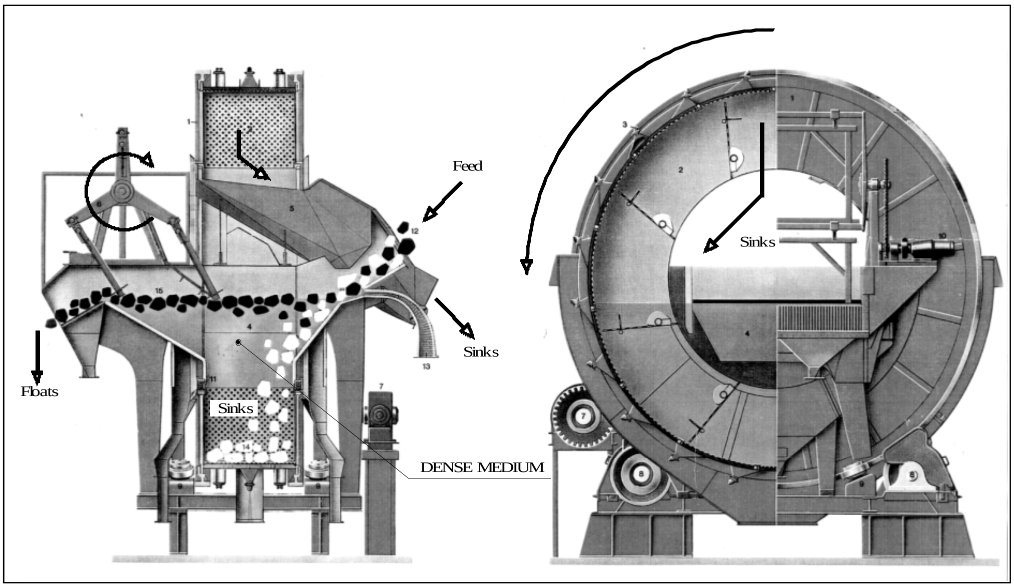
Source: JICA Study team

Fig. R-12 Coal Cleaning Devices

(a) Dense Medium Bath

A gravity concentrator used to separate lumps of raw coal with size range of 40-50mm or larger, as named it consists of dense medium put into a bath.

Fig 8-13 is a schematic diagram of a dense medium bath. Here, raw coal is fed into a bath holding dense medium with specific gravity 1.8. Particles lighter than specific gravity 1.8 float to the surface, particles heavier than specific gravity 1.8 sink, achieving gravity concentration. When such gravity concentration is performed continuously the floats can easily be recovered with a scraper, but continuous recovery of the sinks requires consideration. Methods for continuous recovery of the sinks are divided into drum (cylinder) type, cone type, and trough type. Fig. R-13 is a drum type dense medium bath. The floats are scraped out with rotating paddles. On the other hand, sinks settled to the bottom of the vertically installed drum are lifted upward by lifters together with the rotation of the drum, and ultimately dropped in a waste outlet. Chutes are ready and waiting where the sinks are dropped so that they are moved out of the machine.



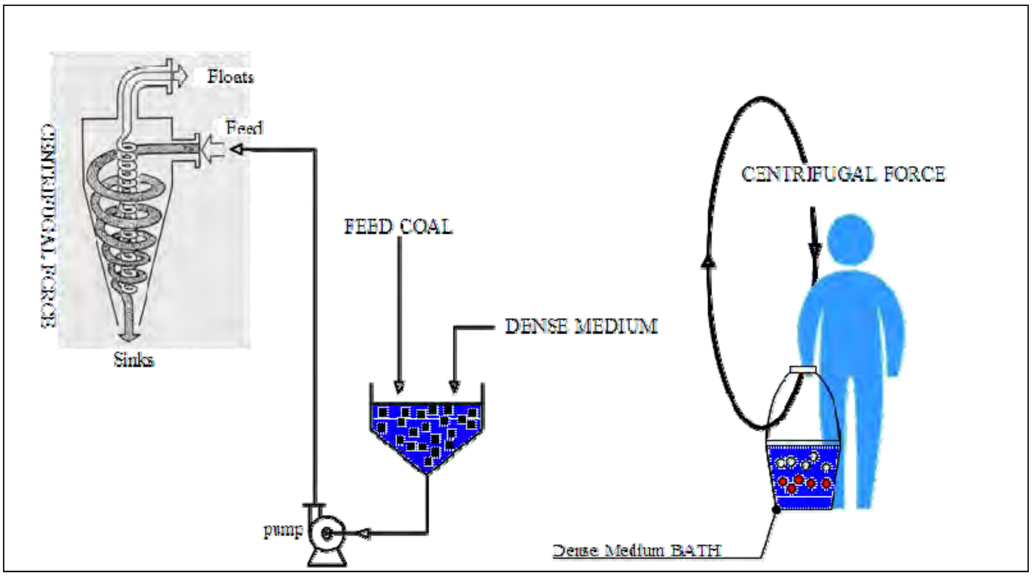
Source: JICA Study team

Fig. R-13 Dense Medium Bath

(b) Dense Medium Cyclone

This is also a separator that uses a dense medium, and the separation principles are the same as the previously discussed dense medium bath. The point of difference is that the dense medium cyclone has a processing target particle around 50mm or less, which is finer than the dense medium bath. As the processing target particles become finer, factors other than specific gravity such as viscosity and flow of the dense medium control the movement of the raw coal particles, rendering accurate gravity concentration difficult. At that point the dense medium cyclone emphasizes factors of particle's specific gravity acting with centrifugal force on raw coal particles.

Fig. R-14 shows a schematic diagram of the dense medium cyclone. The bucket being held on the right is assumed to be the dense medium bath. The centrifugal force acting on the raw coal particles going around and around in the bucket is the separation with the dense medium cyclone. Actually, the mixture of raw coal and dense medium is pressured in the direction of the tangential line of the cyclone body, producing rotational motion, and centrifugal force is obtained from that.

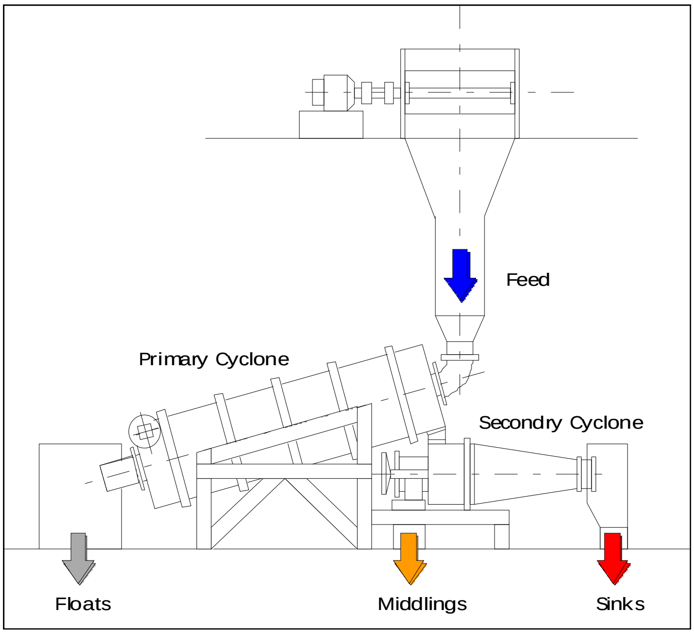


Source: JICA Study team

Fig. R-14 Dense Medium Cyclone

In recent years, the dense medium cyclone has been enlarged, with great improvement in processing capacity. The conventional dense medium cyclone has a diameter of 700mm, and processing capacity of about 70t/hr, and since the capacity of a single machine is small, it is necessary to line up several machines for large scale processing. However, at present, large cyclones have appeared with diameter of 1,300mm and processing capacity over 500t/hr.

In China, machines called "no pressure 3-products dense medium cyclone” are becoming common (see Fig. R-15). It is a cyclone that yields three products where sinks of the primary cyclone (cylindrical shape) are re-separated as the raw coal of the secondary cyclone. Efforts are made with the feed hopper so that the raw coal supplied to the primary cyclone is supplied at its own weight (the raw coal supply is not pressured by a pump hence the name "no pressure"). Also, omitting the process to remove fine particles of 0.5mm or less from the raw coal before feeding the coal, has achieved great cost reduction. The dense medium cyclone with increased processing capacity and size range of feed particle has enabled lower costs in the areas of equipment investment and operations and, accompanying the developments of antifriction material and automation technology for controlling dense medium specific gravity, is in use at many coal preparation plants.

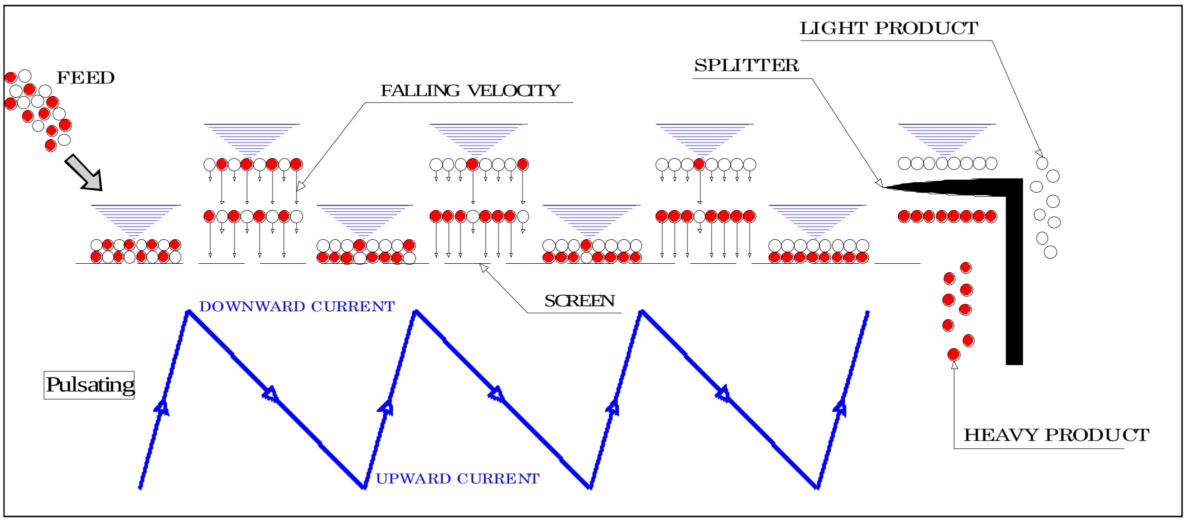


Source: JICA Study team

Fig. R-15　Non-pressure 3-Products Dense Medium Cyclone

(c) Jig

The jig is a gravity concentrator used to separate raw coal of about 100mm or less.　Water is used here, no dense medium is used at all. Fig. R-16 shows the separation process of the jig.



Source: JICA Study team

Fig. R-16　Jigging Process

(i)　A vessel with a punching screen is filled with water, and the water is moved up and down.

(ii)　Raw coal is fed from the left side (●coal, ●minerals).

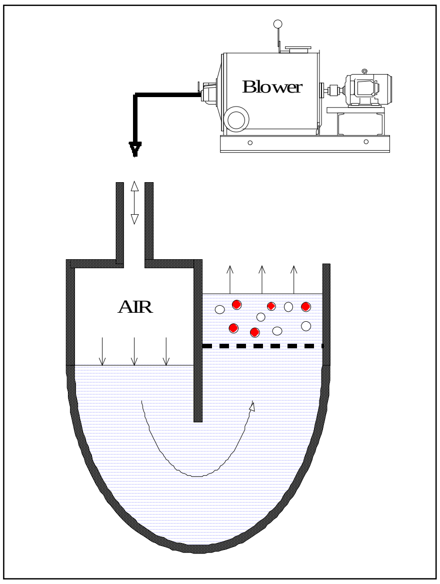
(iii)　Raw coal is carried up together with water, and reaches the highest point then sinks.

(iv) Particles with a large specific gravity have a larger falling velocity than particles with a small specific gravity, and therefore sink rapidly, particles with a large specific gravity (●minerals) stratify on the punching screen, and particles with a small specific gravity (●coal) stratify on them.

(v) Again, they are carried up with the water, and sink. When they reach the punching screen, almost all of the particles stratify on the punching screen are ● minerals, and almost all of the particles stratify on them are ●coal.

(vi) Again, they are carried up with the water, and sink. When they reach the punching screen, all of the particles that stratify on the punching screen are ●minerals, and all of the particles that stratify on them are ●coal.

(vii) When next carried up together with the water, the two layers are separated with a splitter, and divided into ●coal and● minerals.



Source: JICA Study team

Fig. R-17 Baum Jig

Fig. R-18 shows a type of machine called a Baum jig. Structurally, the U-shaped body on one side is the air chamber and the other side is the separation chamber, water is raised and lowered by putting air in and out of the air chamber (the up and down motion of the water is called pulsation). Increasing the area of the separation chamber will increase processing capacity, but irregularities will occur in the vertical water stream thus adversely affecting separation.

The BATAC jig[80] is an improvement with the air chamber installed directly under the punching screen, and with vertical streams equal in the lateral direction, it has achieved a processing capacity greater than 500t/hr.

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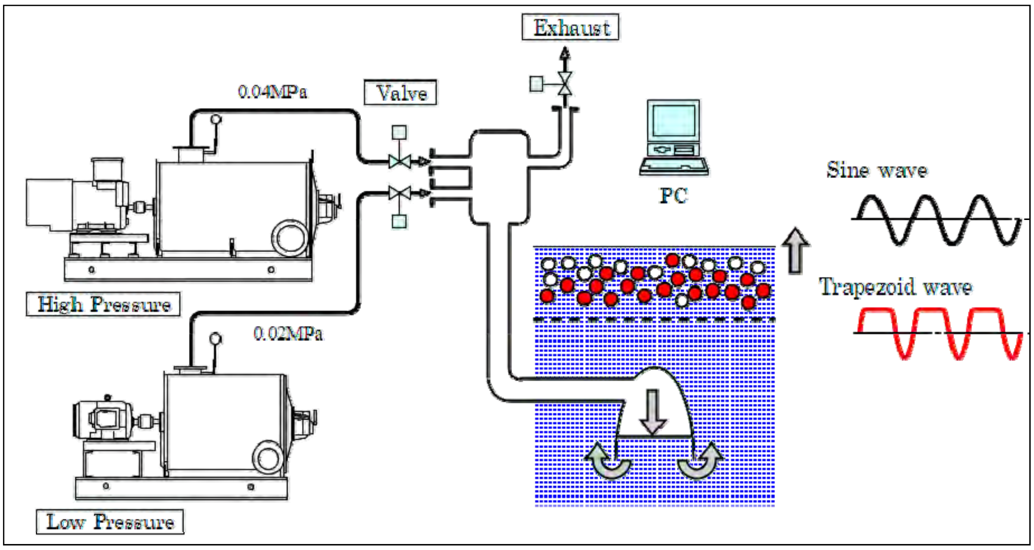
[80] At the 2nd International Coal Preparation Conference at Essen in 1954, Prof. Takakuwa at Hokkaido Univ. introduced the TACUB jig (Takakuwa Air Chamber Under Bed) with the air chamber installed directly under the screen. Then, the BATAC jig (BAum+TACub) combining the strengths of both the Baum jig and the TACUB jig was developed by SKB Co. in West Germany, which was introduced in coal preparation plants everywhere.

Whichever Baum jig, TACUB jig or BATAC jig, the pulse source is merely a low pressure air blower, and the waveform is a sine wave. In contrast, the VARI-WAVE jig[81] uses two types of air, high and low pressure blowers for its pulse source, and the pulse waveform is trapezoidal. Fig. R-18 shows a schematic diagram of the VARI-WAVE jig. Furthermore, the valve that introduces air from the high and low pressure blower into the air chamber is computer controlled, enabling setting to an arbitrary waveform.

To gravity separate the particles inside the jig it is necessary to loosen up particles from each other. In particular, when the raw coal particles are heavy (when ash content of raw coal is high), particles are not loosened sufficiently with the weak sine wave of the up flow speed. If the raw coal particles will not be loosened, even if free fall of particles is repeated, it is difficult to separate and stratify coal particles and mineral particles. The VARI-WAVE jig uses its high-pressure blower for this, and gives the coal particles an up flow that is enough to scatter particle clusters.

Additionally, differences in falling velocity caused by differences in particle specific gravity occur at a fraction of the time when the stream changes from up-flow to down-flow. In the case of the VARI-WAVE jig, because, due to the effect of the low pressure blower, wave height is maintained for a while even after wave height has reached the maximum point, free falling time becomes longer improving separation accuracy.

Thus the VARI-WAVE jig demonstrates high performance in both separation accuracy and processing capacity compared to common jigs and has been introduced in many coal preparation plants [82].



Source: JICA Study team

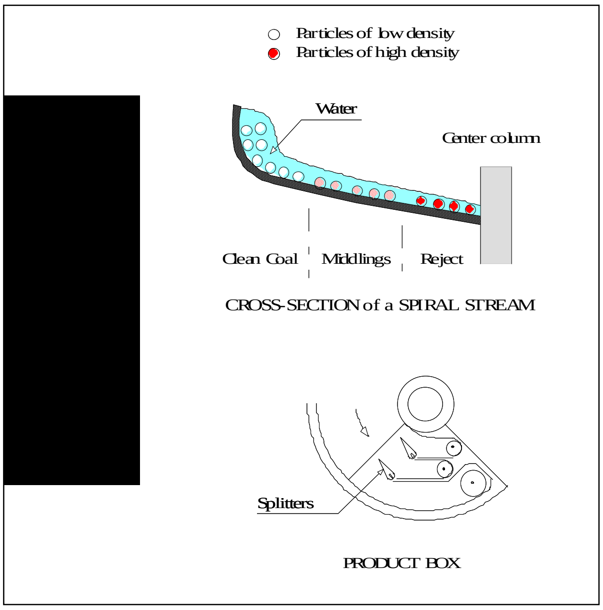
Fig. R-18 Schematic Diagram of VARI-WAVE Jig

[81] Commercially developed by Japan Coal Energy Center and Nagata Engineering Co. Ltd.

[82] In Japan, in operation at the Kushiro coal mine, Miike Coal Preparation Plant, and the Ikeshima Coal Preparation Plant. Abroad, in China at the Panjian Coal Preparation Plant, in Vietnam at the Cua Ong Coal Preparation Plant, in Indonesia at the Ombilin Coal Preparation Plant, and in India at the Angul Coal Preparation Plant.

(d) Spiral Concentrator

The spiral is a gravity concentrator that separates small particles around 1mm using a water current. The principle is the same as the pan used in panning gold. Fig. R-19 shows a schematic diagram of the spiral. In the figure, a raw coal and water slurry mixture is supplied from the top of the spiral shaped chute shown on the left. The slurry descends while going around the spiral chute, and produces an effect like the rotation in panning gold. The result, as shown on the right of the figure, is that particles with heavy specific gravity are left in the center of the spiral, while particles with light specific gravity follow the current at the outer edges of the spiral. A splitter is installed at the terminus of the spiral, and products are separated and recovered according to distance from the center of the spiral.



Source: JICA Study team

Fig. R-19 Spiral Schematic Diagram

(e) Flotation Cell

The flotation cell is used to separate fine raw coal smaller than particle diameter 0.5mm, the two are separated by exploiting the differences in particle surface characteristics where coal is hydrophobic (lipophilic) and minerals are hydrophilic (lipophobic). Because the fine raw coal is produced as a product under the wet process screen (desliming screen), it is in the form of slurry. When oily bubbles are produced in the slurry, the hydrophobic (lipophilic) coal adheres to the bubbles and floats up (Froth). On the other hand, the hydrophilic (lipophobic) mineral particles do not adhere to the oily bubbles and remain in the slurry (Tailings) and the two are separated (see Fig. R-20). To make the oily bubbles, a frothing agent (such as pine oil), and a collecting agent (such as light oil) to enhance the lipophilic characteristics of

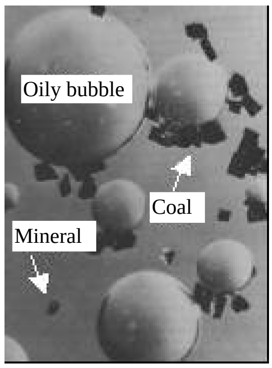
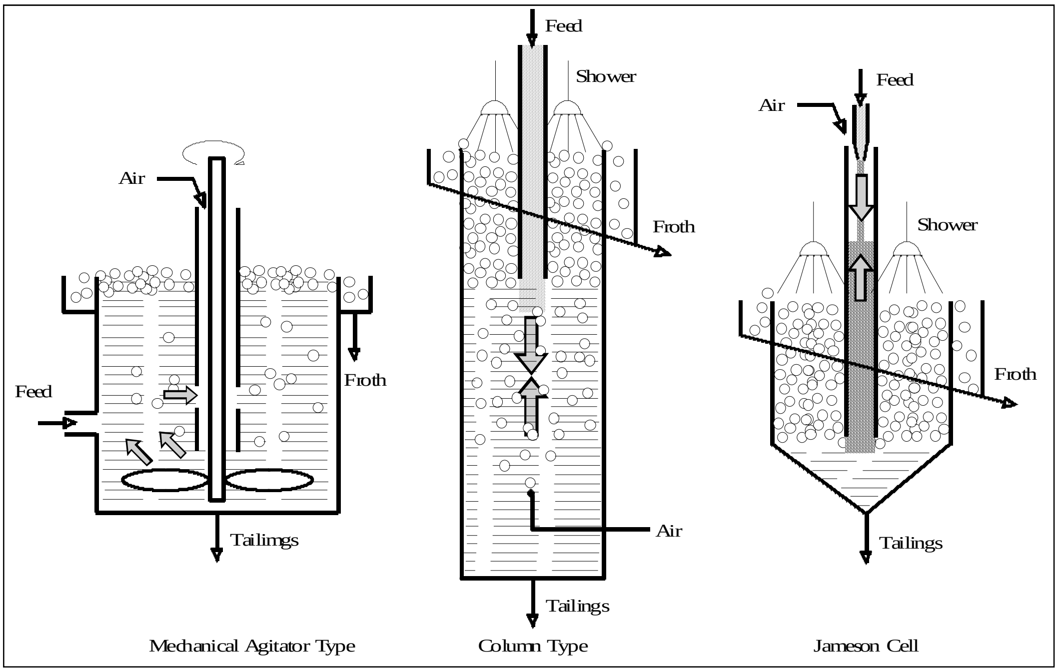


Fig. R-20 Adhesion

coal, are added to the slurry.

Fig. R-21 shows schematic diagrams of various flotation cells. The mechanical agitator in the figure on the left is structured such that, a shaft that turns agitator vanes is in a hollow pipe, and by means of the turning agitator vanes, inside the pipe is negatively pressured, sucking in air used to produce the bubbles.

Coal particles adhered to the bubbles begins to float up and is recovered. Therefore in order to increase the recovery rate of the coal particles, it is necessary to increase the chance of the coal particles and bubbles encountering each other. In a mechanical flotation cell, the coal particles and the bubbles both move in the direction of rotation of the agitator vanes, and they cannot have much chance. The column flotation cell and the Jameson cell take that into consideration. The column flotation cell produces fine bubbles, and the bubbles and the coal particles move in opposed flow to increase the chance of encounter. In the Jameson cell, the slurry is fed with a high-pressure nozzle to produce fine bubbles by causing the severe turbulence in the pipes, and to increase the chance of encounter.

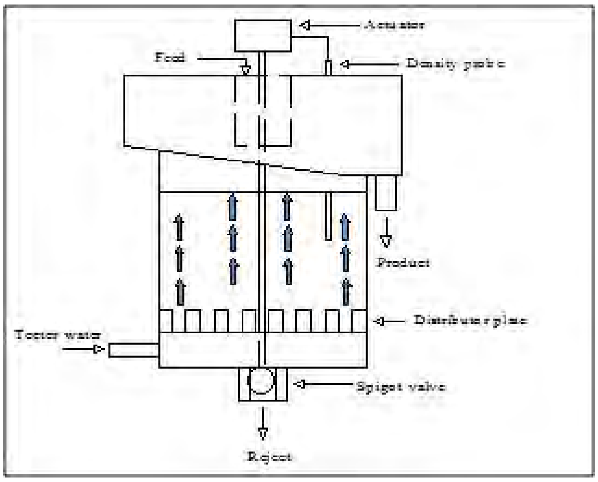


Source: JICA Study team

Fig. R-21 Various Flotation Cells

(f) TBS (Teetered Bed Separator)

The TBS (Teetered Bed Separator) is a separator that has emerged for separating small particles around diameter 1mm (see Fig. R-22). As discussed under wet gravity separators, in water, the falling velocity of light specific gravity particles (coal) is smaller than high specific gravity particles (tailings). Therefore the principle is that if the light specific gravity particles are given a lift stream above the falling velocity, the coal will overflow and the tailings will sink and both will separate. Separation accuracy is higher than the spiral concentrator.



Source: JICA Study team

Fig. R-22　TBS (Teetered Bed Separator)

(8) Dry Separators

The separators discussed thus far, both gravity concentration and flotation, have been wet separators, in contrast, dry separators are gravity separators that use no water at all. This separator is indispensable for coal preparation in regions with sparse water resources, regions where water freezes in winter, and in regions where there are minerals that absorb water and become slime. Dry separators, as a matter of course, do not require processes such as dewatering and waste water treatment, the process is simple compared to wet separation, and construction and operation costs are low.

The dry separator spreading in China is a domestically produced. It is being exported to Vietnam (Fig. R-23), Indonesia, Mongolia, etc. This dry separator is a machine that achieves gravity concentration by means of compound effects of buoyancy with a mixed medium of air and fine particles contained in raw coal, and separation by means of a dry shaking table. It requires that the raw coal particles supplied have a diameter of 0-80mm, and the raw coal moisture of less than 7% (however almost no raw coal of 6mm or below is separated). It is difficult to say that separation accuracy is high.

Fig. R-23　Compound Dry Separator (Vietnam)

Fig. R-24 is the “ALLAIR jig”, an American made dry jig. To loosen coal particle clusters, a fixed quantity of air, and to give particle clusters vertical motion, pulsed air, is blown in from under the screen holding the raw coal. The screen is shaking, and moves particle clusters towards the outlet.

While repeating the pulsation of raw coal particles, they are stratified by specific gravity, and at the splitter of the terminus, light specific gravity product and heavy specific gravity product are separated. Particle diameter of the feed raw coal is 1-50mm. There is no problem if the moisture content of the raw coal does not cause blockage of the chute.

Separation accuracy of these dry separators is low, but because construction cost and operation cost are also low, it is useful as a machine to complement the wet separation by performing processes such as de-shaling of raw coal.

On the other hand, the fluidized bed dry separator creates a fluid with constant specific gravity with sand as a fluid medium, and it is a machine with high separation accuracy performing gravity concentration in the same way as the wet process separation already discussed. It has already been commercially developed in Japan's natural resource recycling field with estimates of great demand in the future. Fig. R-25 is a fluidized bed dry separator jointly developed by Okayama University and Nagata Engineering Co., Ltd., and it is a machine used to separate and recover vinyl chloride from pulverized plastic. Other than this, various fluidized bed separators have been commercially developed for various purposes such as a separator for steel and aluminum, but none has reached the stage of commercial development for the coal sector. In China, too, fluidized bed systems to separate coal are under research, but are still in the research phase and have not reached commercial development.

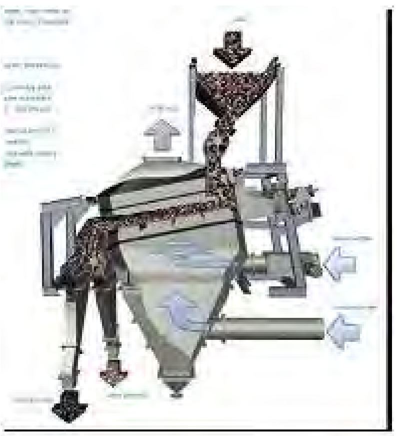


Fig. R-24 allair jig

Fig. R-25 Fluidized Bed Dry Separator

(5) Summary of Separation Machinery

Coal Cleaning Devices discussed thus far are summarized in Table R-1.

Table. R-1 Summarizing Coal Cleaning Devices

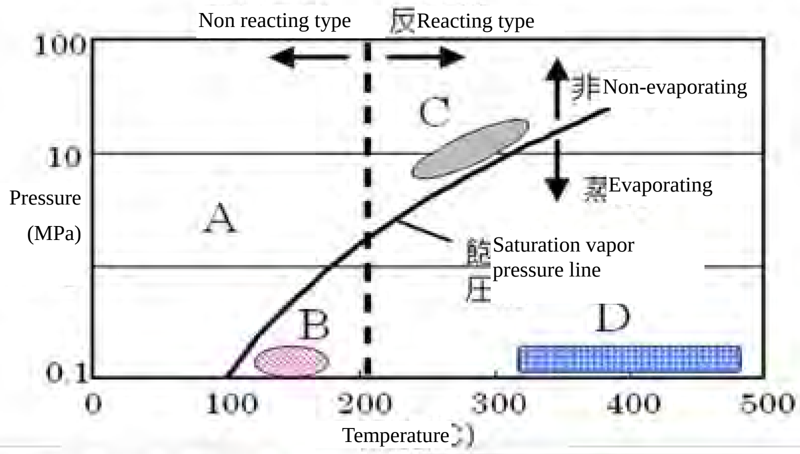
	Dense Medium Bath	Dense Medium Cyclone	Jig	Spiral Concentrator	TBS	Flotation Cell
Particle Diameter	50mm or more	50-0.5mm	100-0.5mm	about 1mm	about 1mm	0.5mm or less
Separation Accuracy	High	High	Medium	Low	>Spiral	Depends on coal type
Separation Cost	Medium	High	Medium	Low	Low	High

Source: JICA Study team

1.3.2 Upgrading and Processing Technologies

This section discusses upgrading processes for coal (low rank coal). Almost half of the world coal reserves are low rank coal such as lignite. There is much low rank coal in reserve, but thermal output is low due to high water content, and because spontaneous combustion occurs when desiccated, it is not widely used compared to high grade coal such as bituminous coal, and at present its use is limited to use in power generation in the producing areas. However, among the low rank coals, there are some that also compare favorably to bituminous coal in low ash content and low sulfur content, if they can be converted to high thermal output by means of upgrading processes there are possibilities that they can be used with economic conditions. For this reason, technologies are progressing to overcome the weak points, low thermal output and low transportation and reserve performance due to spontaneous combustion, through dewatering and upgrading of low rank coal.

Dewatering methods can be generally categorized as "mechanical dewatering", "evaporation methods" and "non-evaporation methods", but in mechanical dewatering with presses etc., it is not suitable as an upgrading method since there is no surface modification, and therefore the water content is reabsorbed after dewatering. Evaporation methods remove water by evaporating it, and non-evaporation methods are methods to remove water while still in the liquid state. Fig. R-26 shows the interrelationship between these technologies. In addition, typical upgrading technologies are discussed later.



Group	Evaporation	Reaction	Example of Process
A	×	×	Pressurized dewatering
B	○	×	UBC, tubular dryer, vapor fluidized bed
C	×	○	Fleissner, hot water processing, KFUEL+
D	○	○	ENCOAL SYNCOAL KFUEL

Source: Prepared by JICA Research Group

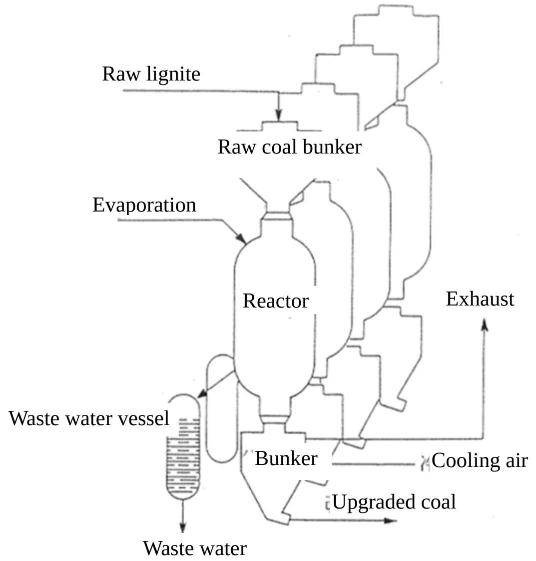
Fig. R-26 Condition Map for Coal Upgrading Process

(1) Fleissner

The Fleissner process was developed by the Austrian Fleissner in 1927. Its principle became the basis for all non-evaporation methods, and it is a process that has long been implemented in Europe.

The process is a method to remove water content while still liquid using saturated water vapor for drying, and the reason to use saturated water vapor is to avoid evaporation which requires a large amount of latent heat of evaporation. For that purpose, in order to press out capillary water, the coal requires shrinking with heat, and to avoid expansion after cooling, the generation of tar is necessary to the extent that it will not re-expand. The processing conditions are temperature 220-240ºC, pressure 30-35kgf/cm2, processing time about 160 minutes.

Because it is a non-evaporation method, energy expenditure is small about 240-380kcal/kg-H2O. Additionally, it has advantages that thermal output of the dry coal base increases through decarbonization, partial desalination of the soluble sodium content is possible, and spontaneous combustion is suppressed by the upgrading. On the other hand, since batch operation and heat exchange with solids under high pressure is fundamental, there are operational drawbacks, and scaling up capacity and equipment costs are disadvantages. Equipment costs are high because it is a high temperature, high pressure process, and because waste water contains large amounts of organic matter, waste water processing is a great burden and a disadvantage. Fig R-27 shows the Fleissner Process.

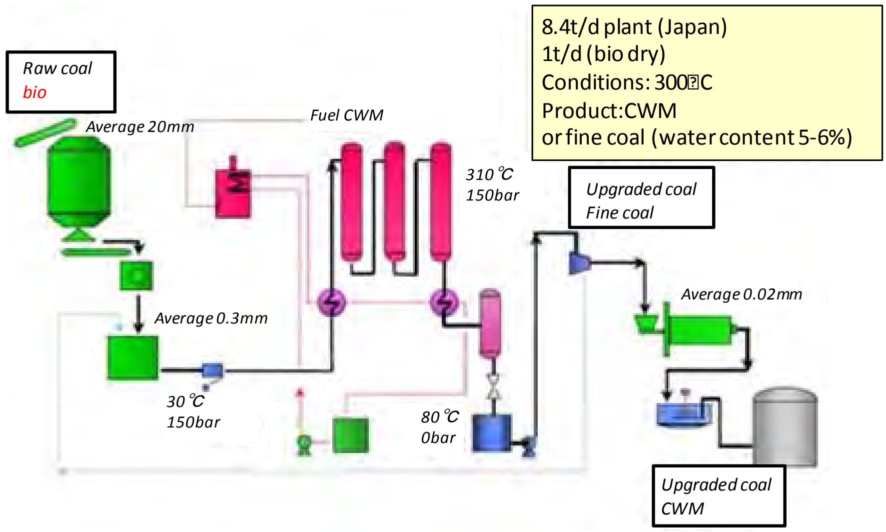


Source: Institute of Applied Energy Upgrading Technologies for Low-rank Coal Page 28 (March, 1997)

Fig. R-27 Scheme of Fleissner Upgrading Process (from IEA Coal Research, 1990)

(2) HWD

The basic principles are the same as the Fleissner process, but the process uses water slurry to economically perform the pressurization operation under high pressure. As a characteristic, the energy costs are relatively small because the slurry supply system enables a continuous process and the dewatering system is in hot water. Disadvantages include high pressure (100-140kgf/cm2g) and because the product becomes a water slurry, dewatering and waste water are problems. According to research results with a 90kg/h pilot plant at the University of North Dakota Energy and Mineral Research Center (UNDEMRC), CWM with a coal density 51-60% is manufactured from Texas and North Dakota lignite, and that with a coal density of 56-64% is manufactured from Wyoming sub-bituminous coal. Fig. R-28 shows the HWD process.

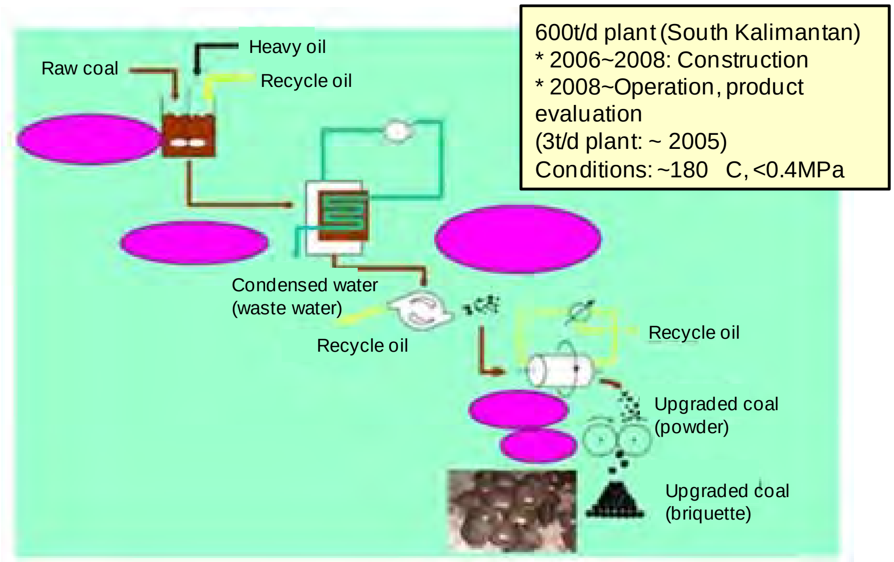


Source: Prepared by JICA Research Group

Fig. R-28 Schematic Chart of the HWD Upgrading Process

(3) UBC

This process applies the slurry dewatering technology of the Brown Coal Liquefaction process (BLC process), and consists of three processes 1) slurry preparation and dewatering process, 2) solid-liquid separation and oil recovery process, 3) the molding process. Fig. R-29 shows the UBC process.



Source: From Japan 2005 Coal Technologies Symposium "On Development of Low-rank Coal Upgrading Technologies (UBC)" (Shigehisa Takuo, Director)

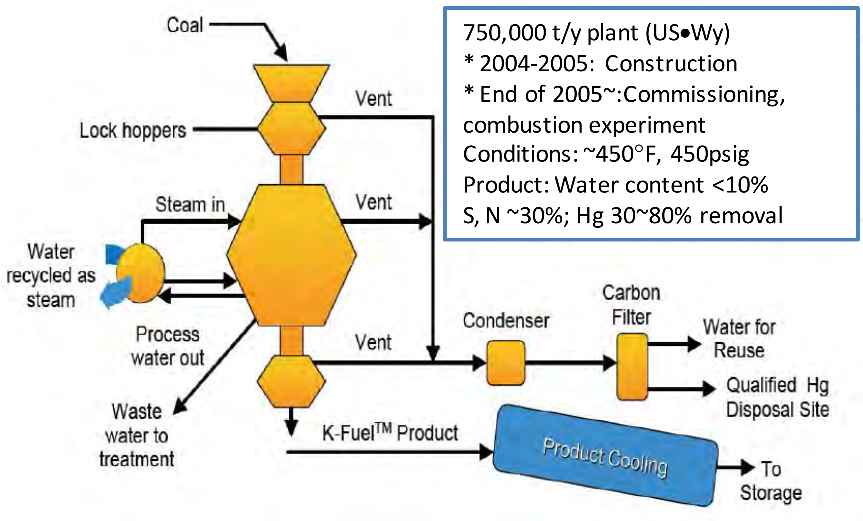
Fig. R-29 Schematic of UBC Upgrading Process

In the slurry preparation and dewatering process, pulverized high-moisture low-rank coal and recycle oil (usually petroleum based light oil) are mixed, heated in a shell and tube-type evaporator with a small amount of heavy oil (asphalt, etc.) added, and then water is evaporated and recovered. This water vapor is pressurized with a compressor and sent to the shell side of the evaporator, and by re-using it as a heat source, the energy costs of the dewatering process are greatly reduced. Also, since low-rank coal has a structure with many pores, when the water in them is removed in the evaporation process, a small amount of the added heavy oil is effectively adsorbed onto the pore surface and suppresses spontaneous combustion. In particular, the heavy oil produces water repellence, and acts to prevent reabsorption of water and accumulation of the heat of wetting. In the solid-liquid separation and oil recovery process, solid-liquid separation is performed on dewatered slurry and recycle oil is recovered in a decanter, and then remaining recycle oil in the pores of the upgraded coal is also recovered with a steam tubular dryer. Upgraded coal obtained with the UBC process is still granular, and needs a molding process in order to transport it. Usually binder less briquetting of the upgraded coal is possible, and it can easily be molded with a double roll briquette machine.

Thermal output of the upgraded coal depending on the type of coal can be improved to about 6,500kcal/kg, and spontaneous combustion can also be suppressed. Additionally, it has been confirmed that handling ability and recrushing of the briquetted upgraded coal is the same as regular bituminous coal. In particular, when upgraded coal is burned, it has good combustibility, even under low NOx burning conditions, virtually no uncombusted portions are exhausted, and it has been confirmed that it has excellent fuel characteristics.

(4) K-Fuel

The K-Fuel process was developed on the basis of the Koppleman process, a non-evaporation type of hot water dewatering method, and after making many improvements on the process, a 750,000t/yr scale plant (based on raw coal, 500,000t/yr based on finished product) was built and operates in the suburbs of Gillette, Wyoming. Fig. R-30 shows the process.



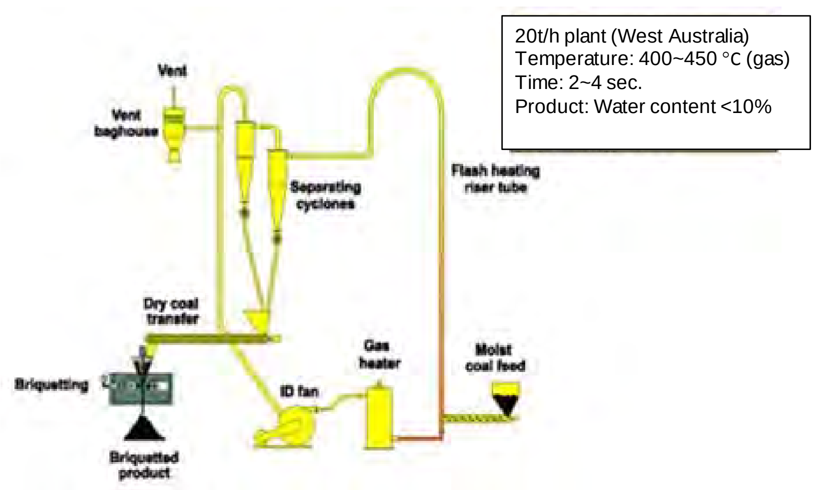
Source: Prepared by JICA Research Group from JCOAL WORLD COAL REPORT vol. 1

Fig. R-30 Schematic Diagram of K-Fuel Upgrading Process

Because, in the past it was a semi-batch method to process lump coal under pressure in two stages at 260ºC and 430ºC, large scale and continuous processing were difficult to achieve, but these drawbacks were solved by relaxing the operation conditions to 1 stage with 240 ºC, 34kgf/cm2, in addition to using the Lurgi Mark-IV gasifier, which has been proven in Sasol (described in Reference 1.1.5 Liquefaction Technology), in a dewatering system. When sub-bituminous coal from the Powder River coal fields in Wyoming are upgraded, thermal output is increased from 8,000-8,800 Btu/lb to 10,500-11,500 Btu/lb, and water content is reduced from 30% to 7%. However, because processing is by high temperature steam there is a lot of waste water, and because organic matter in the coal dissolves and mixes in the waste water, waste water treatment is a problem. On the other hand, through the decomposition of coal with high temperature processing, a characteristic is that about 30-80% of the mercury in coal is removed, which is an issue in coal use in the U.S.

(5) BCB

The BCB process has a simple configuration where coal pulverized to a few mm or less is quickly dewatered in gas heated to about 400ºC with a lot of water vapor, and briquetted. Fig. R-31 shows the BCB upgrading process. Because gas in the flash tube is mostly water vapor evaporated from the coal, there is little oxygen concentration, and almost no oxidation of the coal occurs. Since the inside of thecoal recovered in the cyclone after dewatering is filled with water vapor, when compressed into briquettes, water vapor inside the particles and between the particles condenses and gas pressure goes down, transmitting the force of the pressure to the particles effectively and collapsing pores inside theparticles so that rapid cohering occurs to form briquettes. Therefore binders are unnecessary during briquetting, and production is considered possible by increasing briquetting speed. Also, becausebriquettes are refined by shear and compression forces given between rollers by means of differentiating the speed of each roller of the double roll briquette machine, the porosity of pores is decreased by more than 50%, there are said to be no problems with strength and spontaneous combustion. Although the water content is about 7-10% after upgrading, since dewatering time in the flash tube is short, there is tendency for product coal to have a lot of water content if coal with a lot of water content is fed, thus it can be said to be suitable for sub-bituminous coal. Also because upgrading conditions are relaxed, there is little change in characteristics of the coal such as volatile matter.

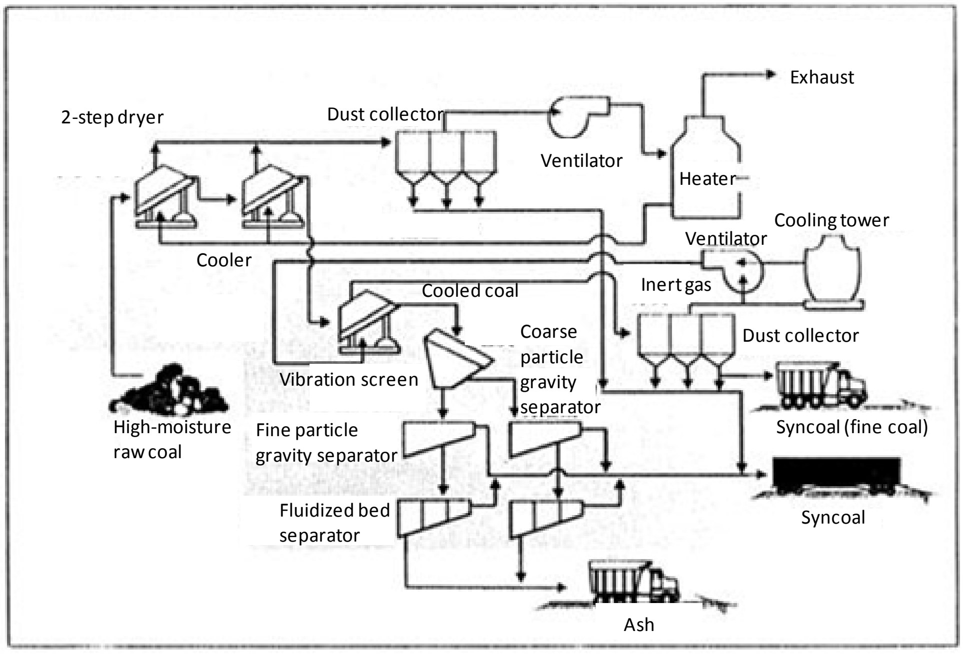


Source: Prepared by JICA Research Group

Fig. R-31 Schematic of BCB Upgrading Process

(6) Syncoal

The Syncoal process is the second method belonging to evaporation methods. The process uses a vibrating fluidized bed (VFB) in three steps, the first step is removal of adherent moisture, the second step is removal of capillary water (at about 300ºC) and performing decarboxylation, and the third step is vibration classification of pyrites (iron pyrites) to decrease sulfur content. Fig. R-32 shows the Syncoal upgrading process. Rosebud coal is suitable for the process because it has about 0.9% sulfur content, relatively high as PRB coal, but 50% is inorganic sulfur pyrites. Thermal output of the product is about 6,700kcal/kg, and sulfur content is 0.3%.

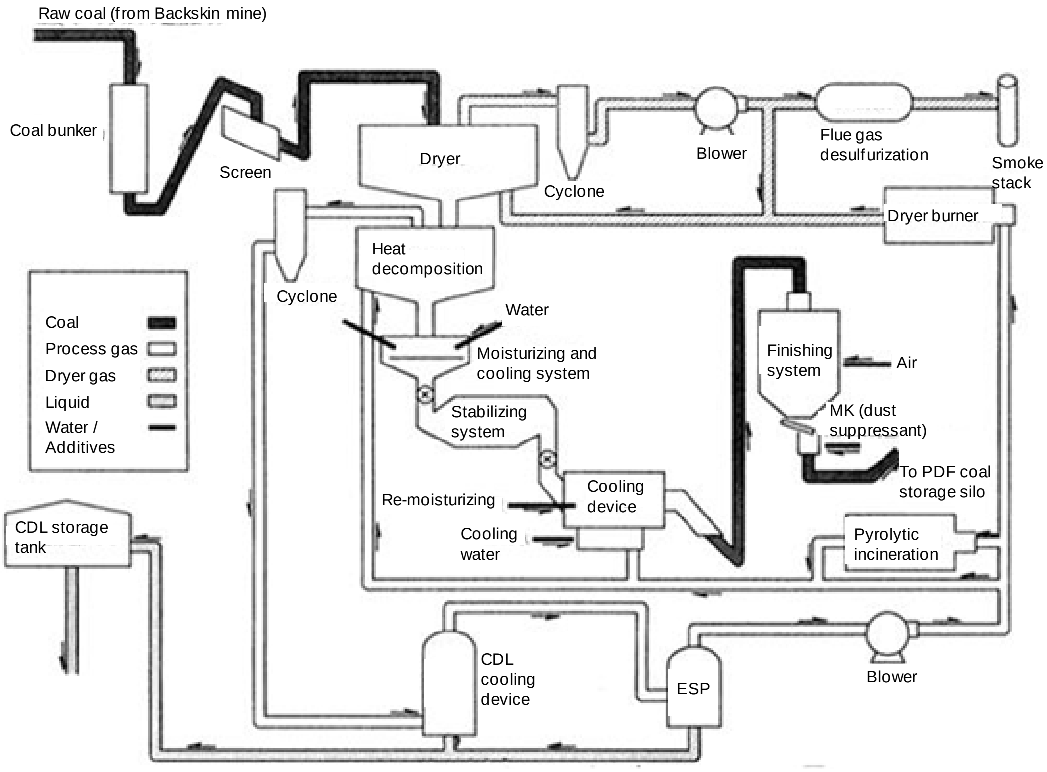


Source: Prepared by JICA Research Group

Fig. R-32 Schematic of the Syncoal Upgrading Process

(7) Encoal

The Encoal process is the third method belonging to evaporation methods. Fig. R-33 shows the process flow. The process utilizes rotary disk type grates (a system where coal is spread on top of the rotary disk, and hot gas is blown in through holes opened in the disk and it is dried or heat decomposed) in two steps; in the first step coal is dried, and in the second step it undergoes mild heat decomposition (around 540ºC) to dewater and remove organic sulfur. From 1t of raw coal, about 500kg of upgraded coal and 80kg of heavy oil are obtained. Gas is also produced by thermal decomposition, but it is consumed as the heat source for drying and thermal decomposition. After the upgraded coal obtained is cooled, it is moisturized and surface oxidized and becomes stable coal in three processes, stabilization, moisturizing and finishing. When the product coal is shipped, it is sprayed and coated with a dust suppressant called MK. Water content of the product coal is 8%, thermal output is 6,300kcal/kg, sulfur content is 0.5%. The heavy oil is sold as low sulfur No.6 oil (equivalent to C heavy oil).



Source: Prepared by JICA Research Group

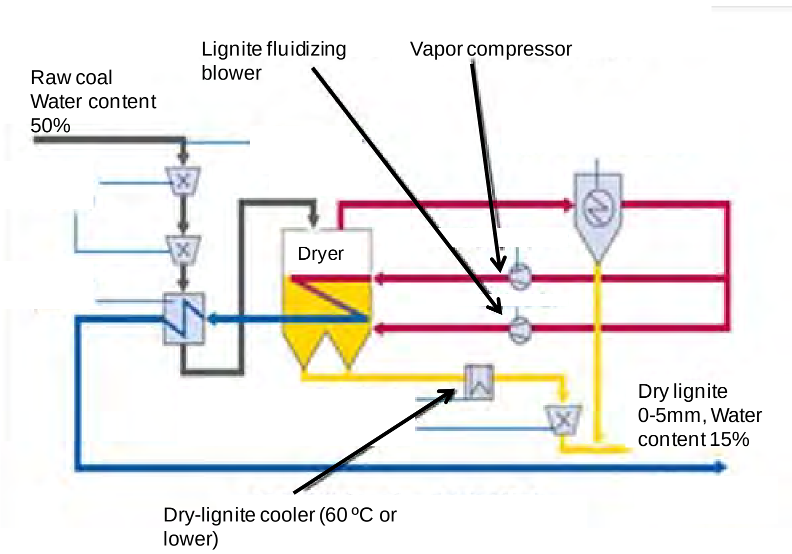
Fig. R-33 Schematic of the Encoal Upgrading Process

Both the foregoing Syncoal process and this Encoal process have the main objective of enabling the use of the large amounts of low sulfur, sub-bituminous coal present in the western U.S. without modification of existing bituminous coal fired boilers to support regulations on SOx emissions according to a revision of the Clean Air Act, together with lowering shipping costs. Neither process recovers the latent heat of evaporation, and the yield calculated from coal for coke making and the attributes of the product (not including invested electrical energy) is no more than about 85% but, because the minehead price of about $5/t is very cheap, there is not much effect economically.

Both the Syncoal and Encoal processes underwent significant equipment modifications because both processes confronted the problems with spontaneous combustion and coal dust exceeding the expectations in research on the laboratory scale when operations first started. Because water was sprayed on the product coal to suppress spontaneous combustion, the water content of the product coal was higher than initially planned, but with success in stabilizing the product.

(8) WTA

This is a drying technology developed by Rheinbraun Co., and is a fluidized drying system by water vapor supplied from the bottom of the dewatering device by means of a vapor fluidized-bed dryer. To reduce the externally supplied heat, evaporated water vapor is pressurized with the aim of increasing temperature, and self-regeneration. The process is shown in Fig. R-34. Construction of the 1st block on a commercial scale was completed at Niederaussen Power Plant (in the future 4 blocks were expected to be full capacity). It is in development with the goal of being a large-scale facility for large capacity lignite fired boilers.



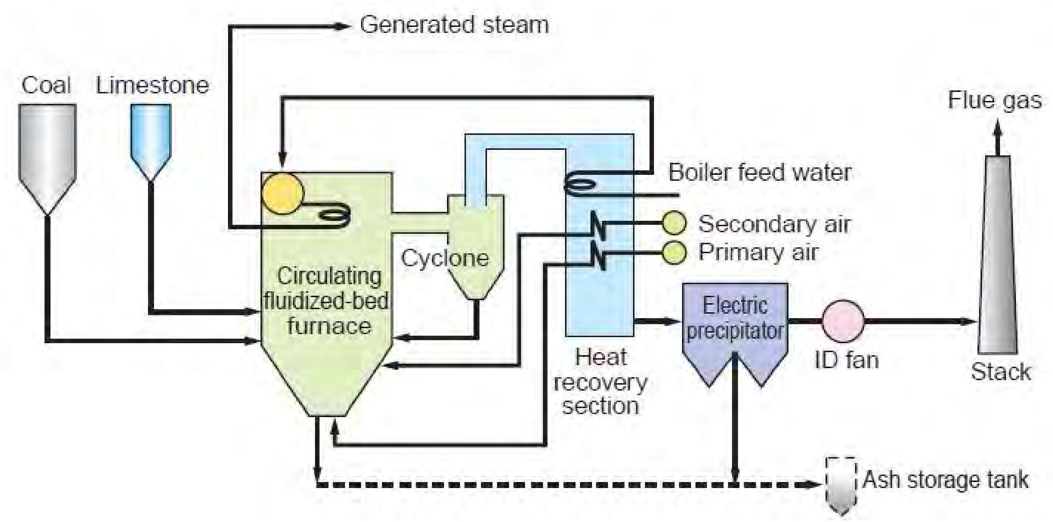
Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-34 Schematic of WTA Upgrading Process

1.3.3 Combustion Technologies

(1) CFBC

Circulating normal pressure fluidized bed boiler (CFBC) generally consists of the boiler itself and a high temperature cyclone, gas velocity inside the furnace is fast at 4-8m/s, large diameter fluid medium and char in the exhaust gas are captured and returned to the boiler body by the high temperature cyclone. By means of the circulation, the bed height is maintained and denitrification efficiency is improved. Typical process flow for the CFBC is shown in Fig. R-35.



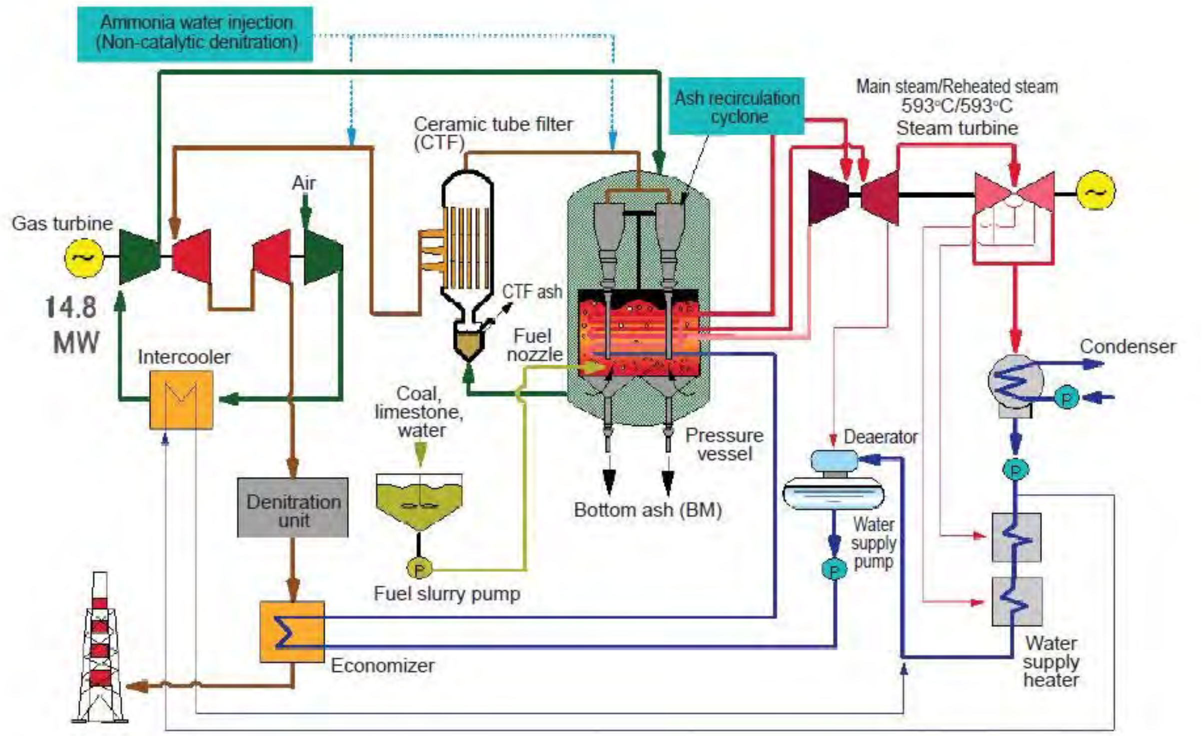
Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-35 CFBC Process Flow

CFBC demonstrates the following characteristics. In contrast to power generation boilers of the past, which could only be supported by fossil fuels such as high-rank coal, oil, gas, etc., it is compatible with a wide range of fuels since low-rank coal, biomass, sludge, waste plastic, waste tires etc, can be used as fuel. Discharge of environmental pollutants NOx and SOx can be significantly reduced without addition of special environmental facilities. In the case of a fluidized bed boiler, desulfurization is desulfurization inside a furnace using limestone as a fluidized medium. Regarding denitrification, thermal NOx generation (temperature dependent NOx generation) can be suppressed with a circulating fluidized bed boiler because the combustion temperature inside the furnace is low, 850-900ºC, compared to that of a boiler burning pulverized coal 1,400-1,500ºC. Also, by means of two stage combustion, reduction combustion on the fluidized bed and oxidation combustion on the freeboard, lower NOx can be aimed for. In particular, uncombusted carbon is captured by the high temperature cyclone installed at the boiler outlet, and returned to the boiler by circulation, heightening the effect of denitrification. Therefore, pollution is low. Due to the improvement in combustion time with the circulating fluidized bed system, high combustion efficiency is obtained. Independent desulfurization, denitrification and fuel pulverizing facilities are not necessary. Thus, there is economy of space, and maintenance is also easy, with few parts that can break down.

(2) PFBC

PFBC (pressurized fluidized bed combustion technology) is a combined cycle power generation system that combines turbines turned by steam created by burning coal in a fluidized bed boiler inside the pressure vessel, with gas turbines turned by the combustion gas. Fig. R-36 shows the bubbling type PFBC process flow. The characteristics of PFBC are high efficiency, space economy and desulfurization inside the furnace. Compared to past power generation systems, thermal efficiency is high and the fuel used can be reduced. Also, the fluidized bed boiler does not require any exhaust smoke desulfurization system in the downstream of the boiler because the SOx produced when coal is burned is desulfurized inside the furnace using powdered limestone that has a desulfurizing function. Additional characteristics are that the amount of NOx produced is small, and CO2 discharge can be reduced.



Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-36 Bubbling Type PFBC Process Flow (71MWe-PFBC plant, owned by J-POWER)

(3) IGCC

Integrated gasification combined cycle power generation is a generation system that uses gasified coal. Prospects for the use of combined cycle generation (a power generation method combining gas turbine and steam turbine) are higher generation efficiency than burning pulverized coal in the past (about 48-50% at the transmitting end). Thus it is possible to use coal for power generation with the same CO2 discharge as burning oil. See section 1.1.4 for details on each gasification technology.

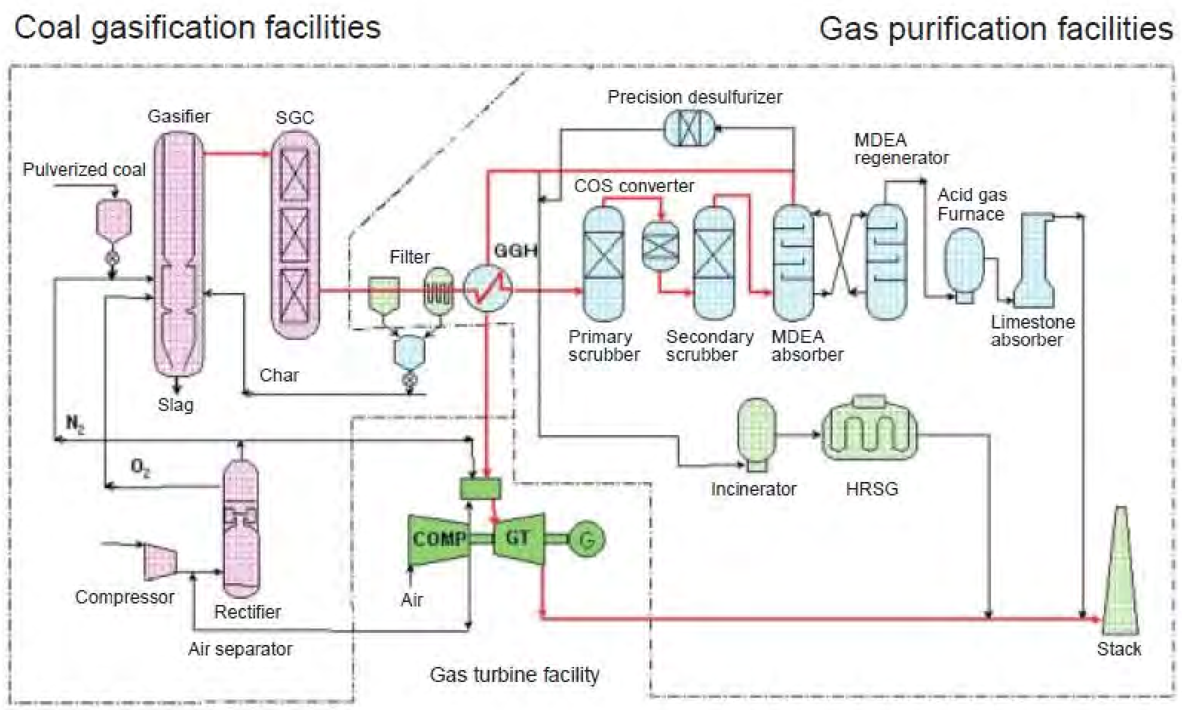
1.3.4 Gasification Technologies

(1) Entrained Flow Gasifier

(a) Hitachi/Electric Power Development

EAGLE (multi-purpose coal gas manufacturing technology) has objectives aiming for reduction of the environmental load, particularly reducing the volume of greenhouse gases produced, it utilizes an oxygen-blown one-chamber two-stage spiral-flow gasification method, and can be applied to a broad range of applications such as for chemical raw materials, hydrogen manufacture, synthetic liquid fuel, and electrical power.

In the EAGLE project, operational research was performed for a pilot plant processing coal on a scale of 150t/d. Fig. R-37 shows an outline of flow for the pilot test equipment, and Table R-2 shows specifications of major equipment. Test equipment consists of coal pre-processing equipment, coal gasification equipment, air separation equipment, gas refining equipment, waste water treatment equipment, generated gas combustion equipment, gas turbine equipment, and others.



Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-37　Outline Flow of Pilot Test Equipment

Table. R-2　EAGLE Project Major Equipment Specifications

Item	Specifications
Coal gasifier	Oxygen-blown, single-chamber, two-stage swirling-flow entrained bed gasifier
Coal processing capacity	150t/d (6.3t/hr)
Gasification temperature	1,200-1,600℃
Gasification pressure	2.5MPa
Gas refinery	Wet chemical absorption type
Absorbing solution	Methyl diethanolamine (MDEA)
Processing capacity	Approx. 14,800 m^3N/h
Sulfur recovery unit	Wet limestone-gypsum method

Item	Specifications
Air separation system	Pressurized cryogenic separation type
Air pressure	1.09MPa
Air processing capacity	Approx. 27,500m^3N/hr
Oxygen production	Approx. 4.600m^3N/hr
Oxygen purity	95%
Gas turbine	Open simple-cycle, single-shaft type
Output	8,000kW

Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

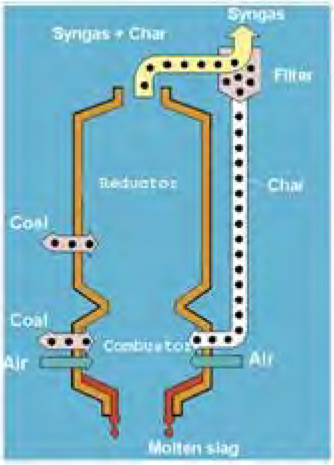
EAGLE can be utilized in an integrated gasification combined cycle system (IGCC) that combines gas turbine power generation equipment and steam turbine power generation equipment, and also in an integrated coal gasification fuel cell combined cycle system (IGFC).

(b) Mitsubishi Heavy Industries

The gasifier of Mitsubishi Heavy Industries (MHI) was utilized in a 250-MWIGCC proving system of Clean Coal Power R&D Co., and has the following characteristics:

- Dry supply system, suitable for low ranking coal with a lot of water content
- Two stage supply
- Continuous operation system

- Air supply
- Membrane waterwall
- Waste liquid processing requirements are minimal



Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

Fig. R-38　MHI Type Gasifier

(c) Shell

The Shell coal gasifier (SCGP) is shown in Fig. R-39 (max about 40 atmospheres). The SCGP gasifier features a water cooled membrane wall the same as membrane walls used on coal boilers in the past. There are four horizontal burners in the center of the gasifier vessel. Slag discharges from the slag tap at the bottom of the vessel. Generated gases flow to the top. Generated gases are rapidly cooled to about 1000ºC.

Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

Fig. R-39　Shell (SCGP) Type Gasifier

In 2008, Shell operated 26 plants, and produced 2,800 MWth of synthetic gas. –In China it is used a great deal in chemical product manufacturing. It has the following characteristics:

- Dry supply (after coal is pulverized and dried, it is supplied to the gasifier)
- Oxygen supply
- Waterwall heat exchange inside the gasifier
- Suitable for a variety of fuels from pet coke to low-rank coal
- Low flexibility for turndowns
- Waste liquid processing requirements are minimal

(d) GE

GE Energy gasification process was originally developed by Texaco in the 1950s, and GE acquired the technology from Chevron-Texaco in 2004. The characteristic of this process is the use of a coal/water slurry. As shown in Fig. R-40, synthetic gases and slag discharge from the bottom of the gasifier.

Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

Fig. R-40 GE Type Gasifier

There are two options (quench, radiant) for heat recovery from the GE Energy process. In the quench system, the synthesis gases and slag are force immersed in a water bath, then the slag congeals and the synthesis gases are cooled. Slag is removed at the lock hopper from the bottom of the quench section. With the radiant system, the heat recovery of synthesis gases and slag is performed in a radiant-type boiler. The GE Energy gasifier has the following characteristics:

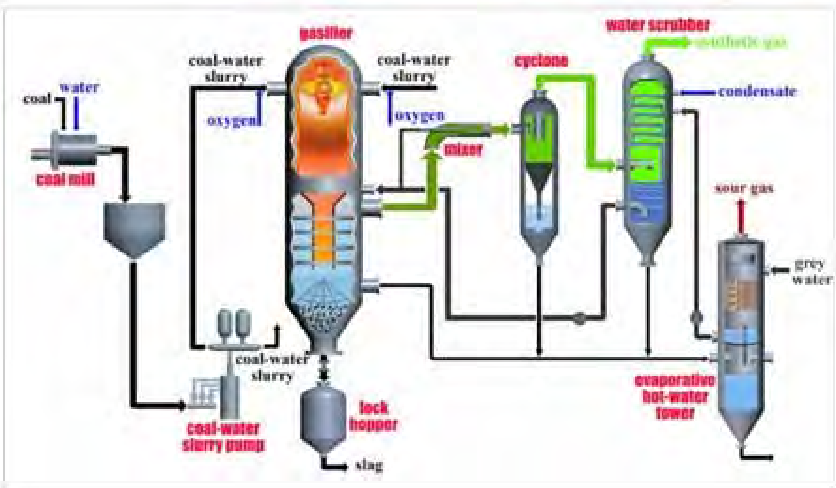
Supply of coal/water slurry (possible to use dry coal using a Stamet system)

- Continuous operation system
- Oxygen supply
- Gasifier made of refractory bricks
- Two types (radiant cooler and cooling)

· Suitable for bituminous coal, pet coke, or a blend of pet coke and low-rank coal

(e) East China University of Science and Technology -ECUST-

As shown in Fig. R-41 in this gasification method (OMB), a coal water slurry material is used. The slurry is supplied together with O_2 from the injection ports of four opposed burners at the top of the gasifier. Melted ash drops to the water tank at the bottom of the furnace, and is removed with the lock hopper as glass slag particles. Particles in the generated gases are also removed at the water tank.



Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

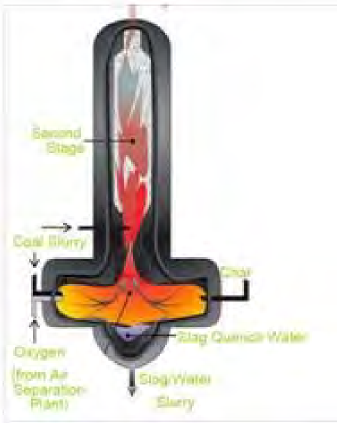
Fig. R-41 ECUST OMB Gasifier

The ECUST OMB gasifier is used in China for methanol and ammonia synthesis, and has the following characteristics:

· Coal/water slurry supply
· OMB design coal continuous supply system–Four burners
· Oxygen supply

(f) Conoco Phillips E-Gas

Conoco Phillips holds the E-Gas gasification technology originally developed by Dow Chemical. The E-Gas process is distinguished by a two-stage gasification method. The outline of this gasifier is shown in Fig. R-42.



Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

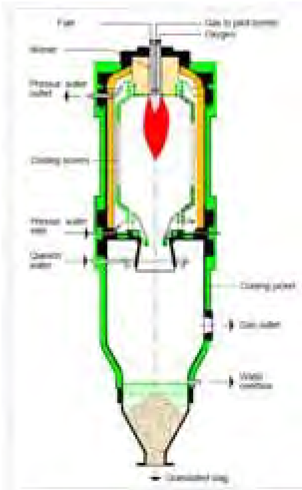
Fig. R-42 E-Gas Gasifier

This gasification system is made of refractory bricks, and uses a coal/water slurry supply. Synthesis gases generated in the first stage enter the second stage. Here a different coal/water slurry is injected, and thermal decomposition occurs. The generated gases pass through a cooler with a distinctive fire tube. The cooled synthesis gases then enter a filter, and dust is removed. The gasifier has the following characteristics:

- Coal/water slurry supply
- Two-stage gasifier
- Oxygen supply
- Gasifier made of refractory bricks
- Continuous slag removal system, dry particle removal
- Suitable for a wide range of coal from pet coke, Powder-River Basin sub-bituminous coal to bituminous coal and blends

(g) Siemens GSP/Noell

The Siemens gasifier is shown in Fig. R-43. The gasifier has dry supply, oxygen supply, top ignition of the reactor furnace, and the walls of the gasifier is made of water screen. The Shenhua DME project in China was given contracts for two 500 MW gasifiers. Currently, one plant is in operation producing 787 MWth of synthesis gas, and one plant is in design.



Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

Fig. R-43　Siemens Gasifier

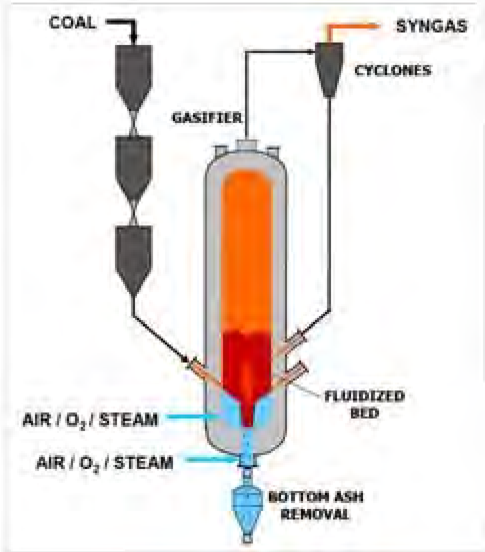
The gasifier has the following characteristics:

- Dry supply
- Oxygen supply
- Water screen on walls of the gasifier
- Suitable for a variety of fuels from bituminous coal to low-rank coal

(2) Fluidized Bed Gasification System

(a) U-Gas system

The U-Gas fluidized bed system is the process of Gas Technology Institute (GTI). The U-Gas process as shown in Fig. R-44, is a fluidized bed type gasifier with a dry supply system. From the lock hopper, granular coal, sand, coal, sulfur absorbent are supplied. Fluidization is performed from two places near the bottom of the gasifier, where air or oxygen and steam are introduced. Coal containing unburnt carbon is collected in the cyclone and returned to the bed. Plants in Shanghai, Finland, etc. have more than 20 years experience. Two plants are currently in operation manufacturing 520 MWth of syngas.



Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

Fig. R-44 U-Gas Gasifier

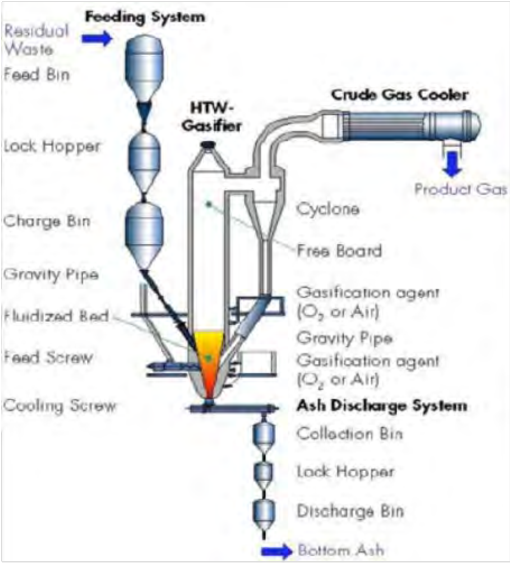
The U-Gas gasifier has the following characteristics:

- Fluidized bed gasifier
- Dry supply system
- Coal and coal/biomass blend
- Air or oxygen supply
- No slagging/ash does not accumulate in the bottom

(b) High-Temperature Winkler system

The High Temperature Winkler (HTW) gasifier is a circulating fluidized bed reactor furnace that operates in either air or oxygen supply mode. This is a dry supply, pressurized, dry ash gasifier. The main technical advantage is the capability to gasify a variety of fuel supplies in various states such as all grades of more reactive low-rank coal (sub-bituminous) with higher ash softening temperature, and biomass. Fig. R-45 shows a simplified scheme of the HTW gasifier system.

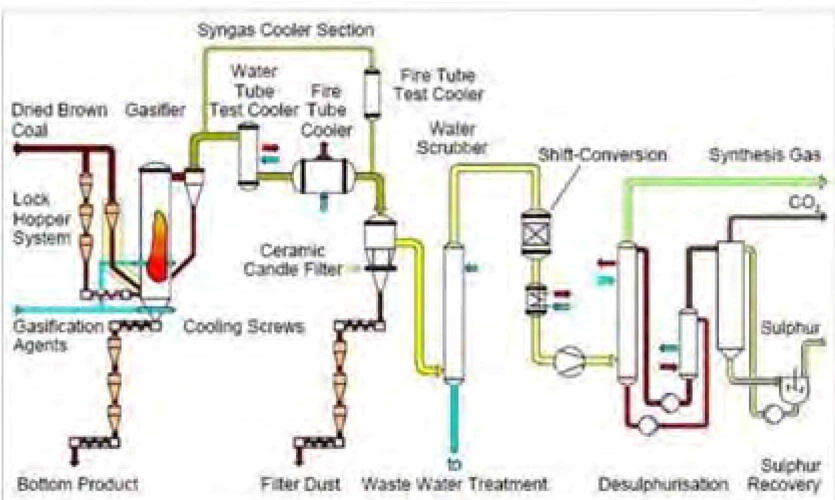
Pulverized coal is continuously supplied to the gasifier with a screw-type feeder. Air or oxygen and steam are supplied from the bottom of the gasifier. The fluidized bed is formed with ash or charcoal particles, and is maintained in the fluidized state by upward flow of the gasification agent (air, etc.). Fine particles in the generated gases and char are removed at the cyclone, and then the gas is cooled. Inside the filter, removed solids are returned to the gasifier for maximum carbon conversion. Ash is removed from the base of the gasifier with the ash release system consisting of the ash screw, lock hopper and discharge bin.



Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

Fig. R-45 Process of the HTW Gasifier

Fig. R-46 shows the simplified process flow for the HTW gasification process. There is a heat recovery system in the downstream of the gasifier, after which there is a ceramic candle filter system for removal of particles. In late 1996, a pilot plant was constructed in Berrenrath, Germany. It has been operating more than 10 years, and provides syngas for methanol manufacture.



Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

Fig. R-46 Typical Process Flow for HTW Gasification Process

The HTW gasifier has the following characteristics:

- Fluidized bed gasifier

- Dry supply
- Oxygen or air supply
- Dried bottom ash
- Utilization of lignite

(3) Fixed Bed Gasifier

(a) Lurgi gasifier

The Lurgi gasifier is the most practical gasifier used in the world. It is a fixed bed type system and operates on the heat below the melting point of ash. Its flaw is that it cannot process fine particles of coal. As shown in Fig. R-47, the coal is supplied from the lock hopper on top of the gasifier. Oxygen is injected from the bottom of the gasifier, and reacts with coal preheated by hot syngases rising from the coal bed. Ash falls from the bottom of the bed and is decompressed with the lock hopper.

The two most noteworthy uses of the Lurgi process are at the Sasol coal/gasoline refinery in the Republic of South Africa, and the Dakota Gasification Synthetic Natural Gas Plant in North Dakota. Both are characterized by continuous oxygen-feed gasifiers, and use low-rank coal supplied from nearby mines.

Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

Fig. R-47 Lurgi Gasifier

The Lurgi gasifier has the following characteristics:

- Dry supply system (with coal distributor)
- Fixed bed type
- Expandable with low-rank coal
- Waste liquid processing costs are high due to oil and tar generation

(b) British Gas/Lurgi Slagging Gasifier

The British Gas/Lurgi (BGL) coal gasifier is a dry supply, pressurized, fixed bed type slagging gasifier. The reactor furnace vessel is water cooled, and made of refractory brick. Fig. R-48 shows a system chart. Coal introduced from the lock hopper on top of the gasifier descends through the fixed bed. Drying and heat decomposition occur at the top of the furnace. Gasification reactions, reacting with oxygen, occur at the bottom. Oxidization occurs, ash dissolves at the very bottom, and slag is formed.

Source: Prepared by JICA Research Group based on Gasification Technology Council, Gasification technologies conference_2000-2011

Fig. R-48 BGL/Lurgi Slagging Gasifier

BGL technology was originally developed by British Gas, and two pilot gasifiers from 200 to 500 tpd were built in Westfield, Scotland.

The British Gas/Lurgi slagging gasifier has the following characteristics:

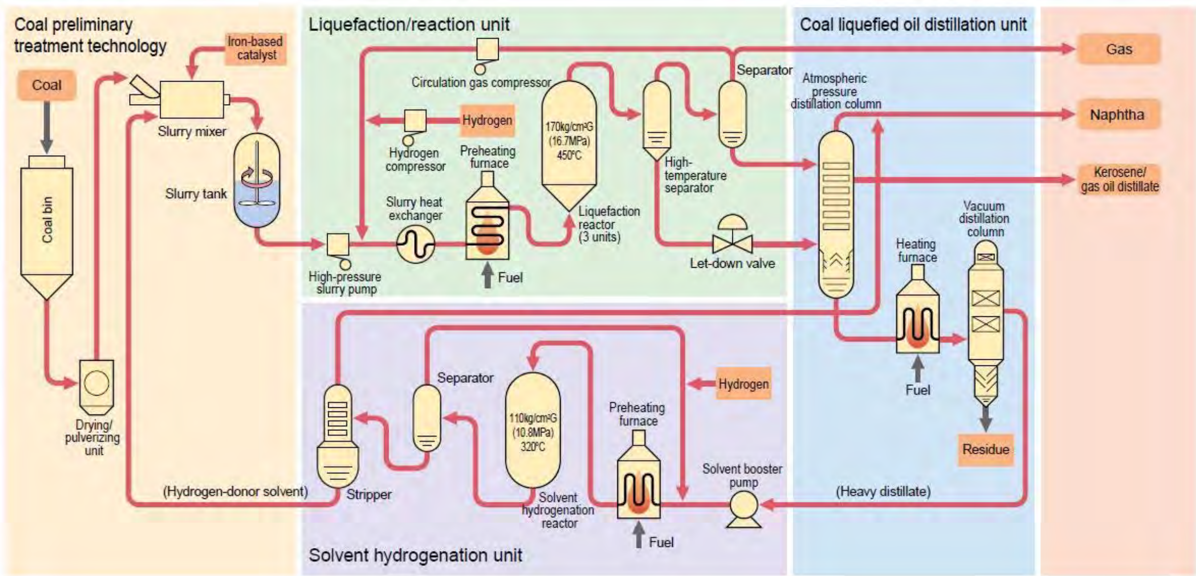
- The Lurgi furnace was modified to an ash dissolving type
- Dry supply
- Oxygen supply
- Gasifier made of refractory bricks
- Suitable for a variety of coal (waste utilization fuel, tires, lumber and blends of waste coal)
- Waste liquid processing costs are high due to oil and tar generation

1.3.5 Liquefaction Technologies

(1) NEDOL Process

The NEDOL (bituminous coal liquefaction technology) process is a technologically and economically superior process integrated the respective advantages of three bituminous coal liquefaction processes that are direct hydrogenation process, solvent extraction process and solvolysis process, and has the following characteristics. By using an iron based fine powder catalyst and a hydrogen donor solvent, high liquid yield is obtained under mild liquefaction reaction conditions. Coal liquids rich in light distillate are obtained. This process consists of reliable processes and is highly stable. Applicable to a variety of coal ranks from sub-bituminous coal to low coalification grade bituminous coal.

In 1988, a 1t/d process support unit (PSU) was set up at the Kimitsu Ironworks of Nippon Steel. Process flow of the PSU is shown in Fig. R-49. The PSU consists of four processes; coal storage/ preliminary processing, liquefaction reaction, and coal liquid distillation and solvent hydrogenation.

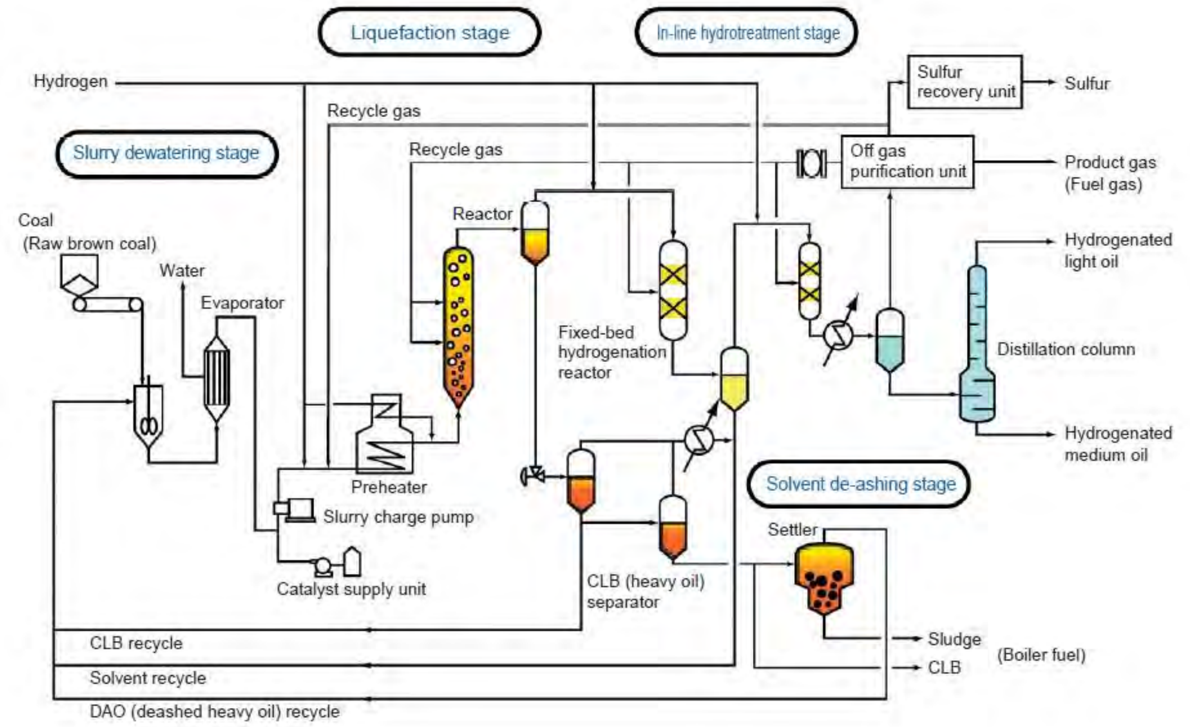


Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-49 Process Flow of NEDOL Method

(2) BCL

The BCL (brown coal liquefaction technology) process is shown in Fig. R-50. The process consists of four processes; the slurry dewatering process in order to efficiently remove the water content in low-rank coal, the liquefaction process to achieve a high coal liquid yield through use of a highly active limonite catalyst and bottom recycling technology, the in-system hydrogenation process to remove hetero-compounds in coal liquid (such as sulfur containing compounds and nitrogen containing compounds) and obtain high quality gasoline and light distillate, and the solvent deashing process to efficiently remove the ash content in coal and the added catalysts from the process system.



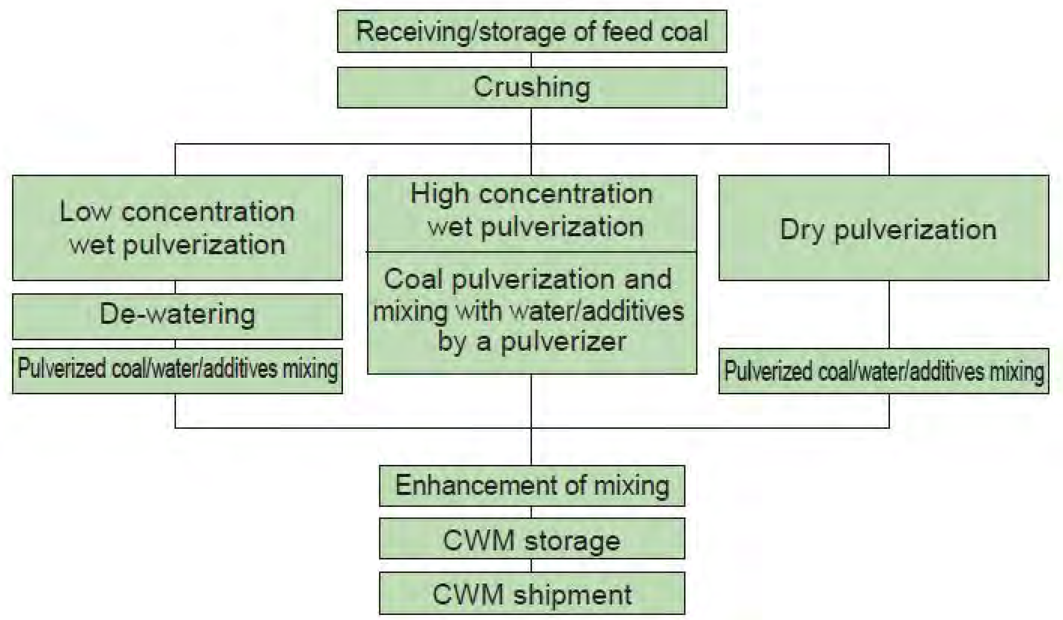
Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-50 Lignite Liquefaction Process Flow

(3) CWM

CWM (coal slurry manufacturing technology) is a mixture of water and coal, and is a liquid easy to handle without the drawbacks of spontaneous combustion and dust scattering. High concentration CWM can be burned directly without dewatering because it maintains fluidity and stability even if the amount of water added is reduced, due to research on size distribution of coal and development of additives such as dispersing agents. By adding very small amounts of additives, coal particles with certain specific size distribution evenly disperse about 70% of their weight concentration, enabling achievement of a stable coal and water slurry.

Regarding the manufacture of high concentration CWM, high concentration, low viscosity, high stability, good quality CWM can be manufactured by pulverizing coal to a size distribution appropriate for CWM, selecting proper additives (dispersing agent and stabilizer), and by properly mixing coal, water and additives. Block flow of the CWM manufacturing process is shown in Fig. R-51.

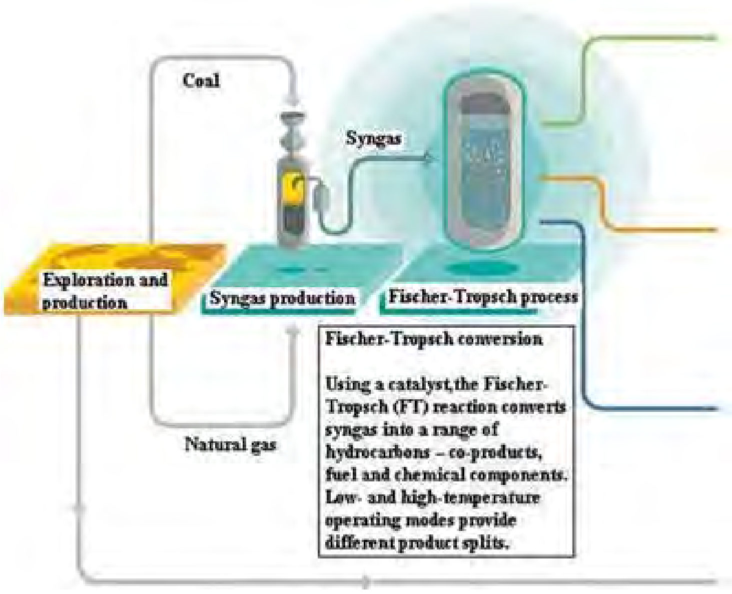


Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-51 Block Flow of CWM Manufacturing Process

(4) SASOL

The SASOL (indirect liquefaction) process is a type of indirect liquefaction process where coal is gasified (coal gasification) once, and the generated gases are separated and refined, then the gasses are used as raw materials and liquefied in a synthesis reaction. The cost of indirect liquefaction is regarded as higher in comparison to direct liquefaction, but currently several tens of thousands of barrels/day are commercially produced at the Sasol Plant in South Africa. The Sasol Co. plant model is shown in Fig. R-52.



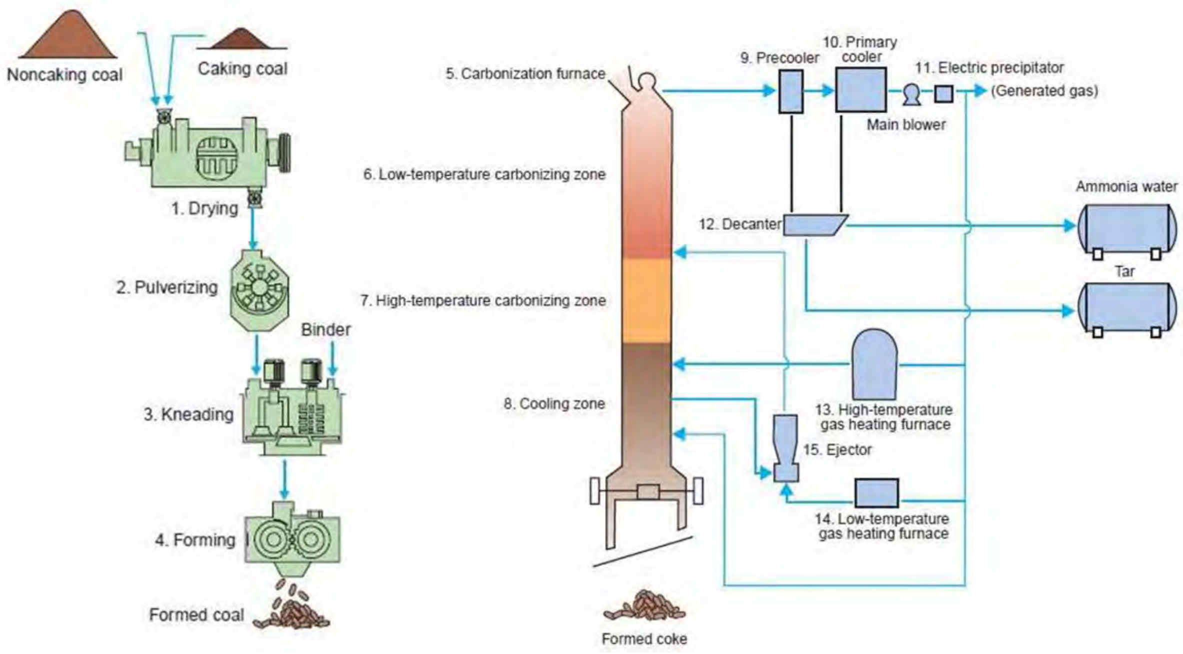
Source: Sasol Co., HP

Fig. R-52 Plant Model of Sasol Co.

1.3.6 Steel-making Technologies

(1) Formed Coke Process

The formed coke process is a procedure to obtain coke by first making formed coke from non-caking coal as the main raw material using a binder, and then carbonizing the formed coke in a vertical furnace. The process is shown in Fig. R-53. The formed coke process consists of a series of steps including raw material processing, shaping, carbonizing the formed coal, and cooling the carbonized coke, in particular, the carbonizing and cooling steps are conducted in a vertical furnace within an enclosed system, providing many superior features in terms of work environment, work productivity, ease of system starts and stops, required space and other conditions compared to conventional chamber ovens.

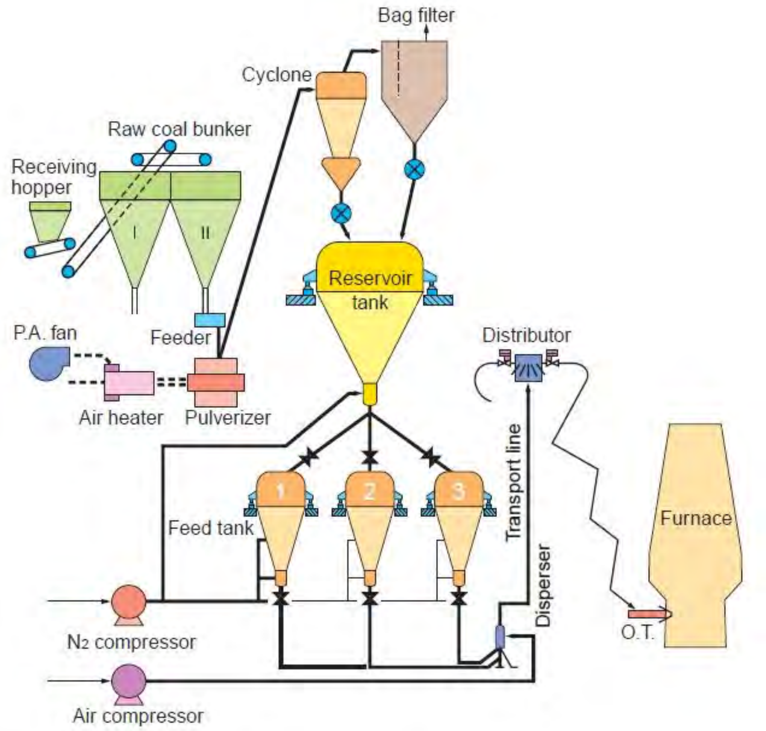


Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-53 Overview on the Formed Coke Production Technology Process

(2) PCI

The pulverized coal injection (PCI) operation is an operational technology exclusively based on coke that was considered as a development of inexpensive heavy-oil alternative fuel to reduce the blast furnace cost and ensure stable operation. This process has the following five characteristics: high-pressure transportation and injection lines with no mechanically rotating components, thereby avoiding trouble with wear and tear as well as breakdowns; no recycling of gas, assuring reliable operation; distribution of pulverized coal fed to individual tuyeres, ensuring uniform distribution utilizing the geometrically symmetrical flow characteristics of a fluid; drying, pulverizing, and collection of coal conducted in two parallel lines, assuring stable operation of blast furnace; and flow velocity of carrier air and pressure resistance of equipment set in consideration of prevention of fire and explosions. Fig. R-54 illustrates the operational process of pulverized coal injection (PCI).

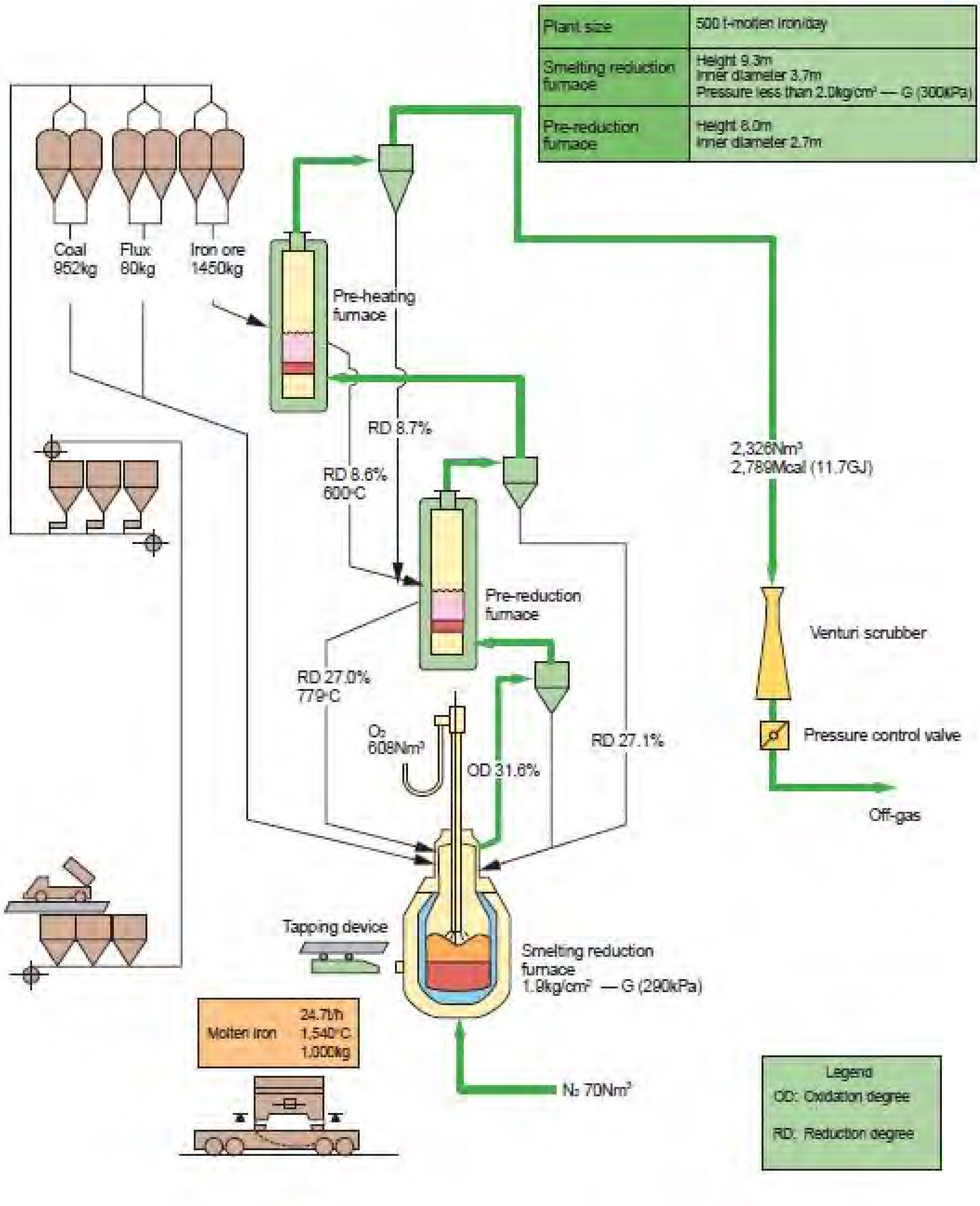


Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-54 Operational Process of Pulverized Coal Injection (PCI) (Japan: Oita No. 1 Blast Furnace)

(3) DIOS

The Direct Iron Ore Smelting Reduction Process (DIOS) is a technology to directly use non-caking coal in a powder or granular form, and iron ore without the use of coke or a sintering process, which are normally required in blast furnace processes, the non-caking coal is fed directly to a smelting reduction furnace, while the iron ore is preliminarily reduced before being fed to the furnace, thus producing molten iron. This process has the following eight characteristics: inexpensive raw materials and fuel (non-caking coal, in-house dust, etc.) can be used; low operating cost; responds flexibly to variations in production rate; compact facilities reduce facility investment; stable supply of high-quality iron source; effective use of coal energy; easy co-production of energy (co-generation); low environmental load (low SOx, NOx, CO_2, dust generation with no coke oven gas leaks). Fig. R-55 shows a flowchart of the DIOS plant.



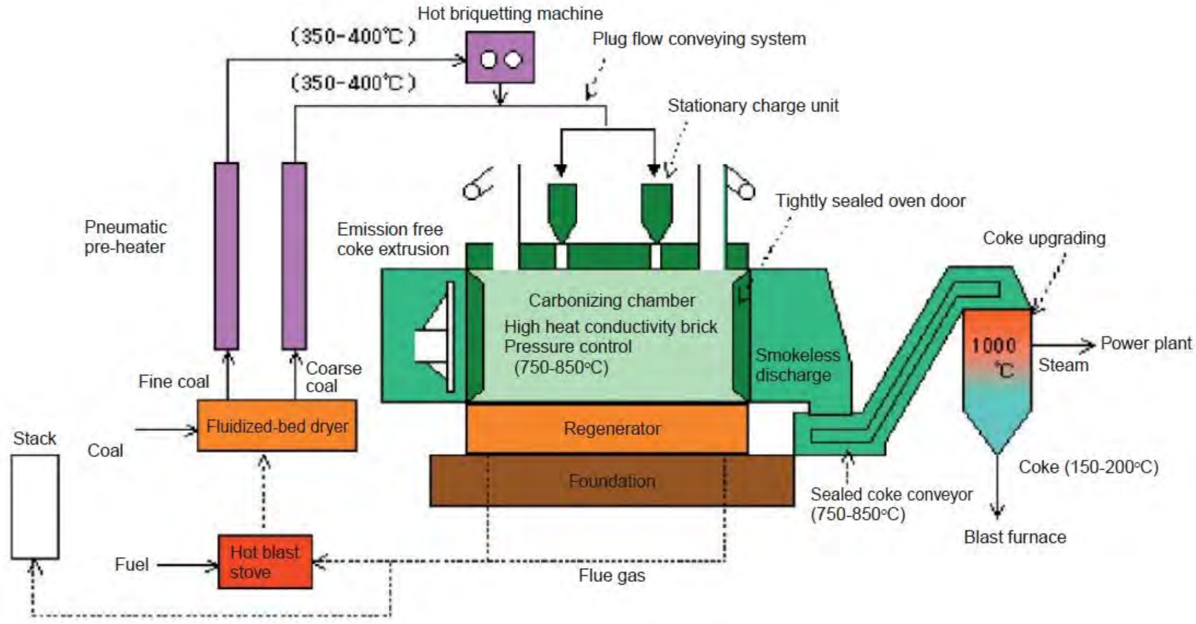
Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-55 DIOS Pilot Plant Flow

(4) SCOPE21

SCOPE21 is a process to achieve a 20% energy reduction compared to a 1200ºC coke furnace, by rapidly pre-heating the coal to 350ºC (low temperature carbonization) and then introduce it into a 850ºC coke furnace. SCOPE21, the Super Coke Oven for Productivity and Environment enhancement toward the 21st Century, was developed as an innovative, next-generation coke production technology with higher flexibility in applicable coal resources, superior in environmental protection and power saving as well as in productivity compared to the current coke production process. Fig. R-56 shows the process.

This process has the following four characteristics: the ratio of non-caking coal use can be increased to 50%; productivity is increased threefold; NOx generation is reduced by 30% with smokeless, odorless, and dustless operation; energy savings of 20%.
SCOPE21 is the only large development project for new coke process in the world with high hopes for commercialization.

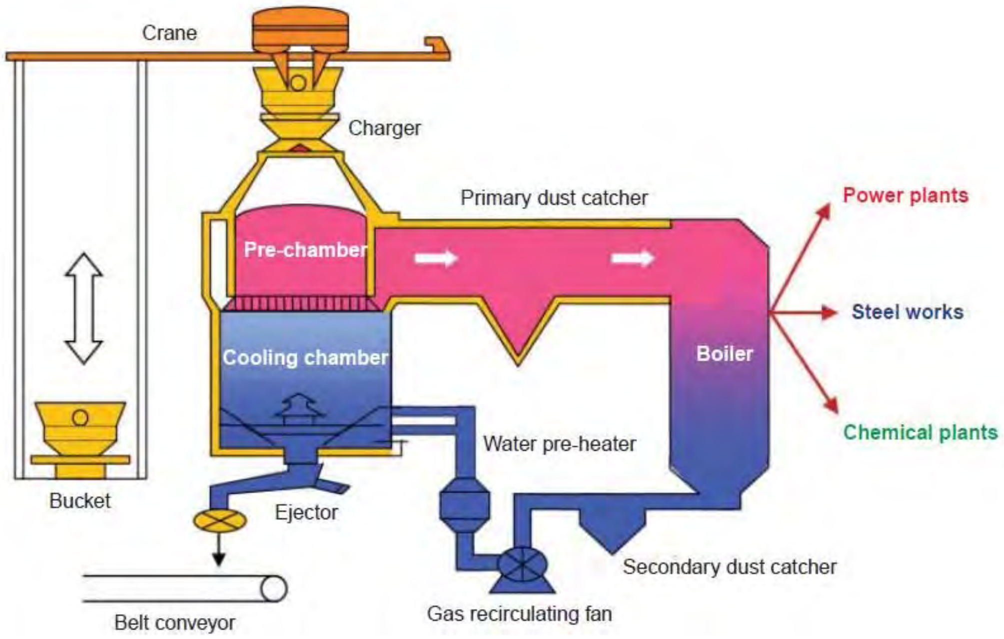


Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-56　SCOPE21 Process Flow

(5) CDQ

The CDQ coke furnace consists of plate-like carbonization chambers alternately arranged in a sandwich form to achieve higher thermal efficiency in carbonization. Raw material placed in the carbonization chambers is heated to a temperature between approximately 1,100-1,350ºC through the combustion of blast furnace gas in the combustion chambers, which are located on both sides of the carbonization chambers beyond the refractory bricks and is blocked from the air for 12-14 hours to allow carbonization. In this process, the fixed carbon contained in the raw material fuses and solidifies to become red-hot coke in the lower section of the carbonization chambers, and the volatile component vaporizes and decomposes, becoming gas to escape from the coke surface and be collected through a pipe located in the upper section of the carbonization chambers. When carbonization is complete, the red-hot coke (approximately 1,050ºC) is discharged from the coke oven, carried to the top of the chambers, fed into the chamber, cooled to approximately 200ºC through heat exchange with circulating gas blown from the bottom of the chamber while descending inside the chamber, and then ejected from the bottom of the chamber. The circulating gas that has been heated to 800ºC or higher on the other hand, generates high-temperature and high-pressure steam in the boiler and, after removing dust with a dust collector, sent back to the chambers for recycling. The generated steam is used as process steam or for power generation. Fig. R-57 shows the CDQ process flow.



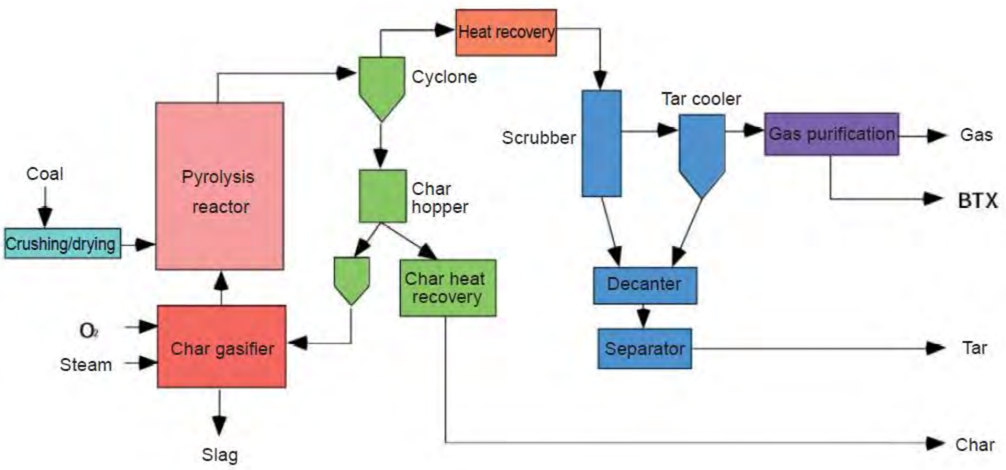
Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-57 CDQ Process Flow

1.3.7 Coal Pyrolysis Technologies

(1) CPX

CPX (multipurpose coal conversion technology) was developed mainly for the purpose of manufacturing medium-calorie gas as industrial fuel and liquid products as feedstocks for chemicals in order to expand the versatile use of coal. This process has the following characteristics: relaxed operational conditions; high overall thermal efficiency; multiple varieties of coal can be supported; efficient separation of coal ash; availability of diversified products; controllable yield of products. Fig. R-58 shows the process flow.



Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

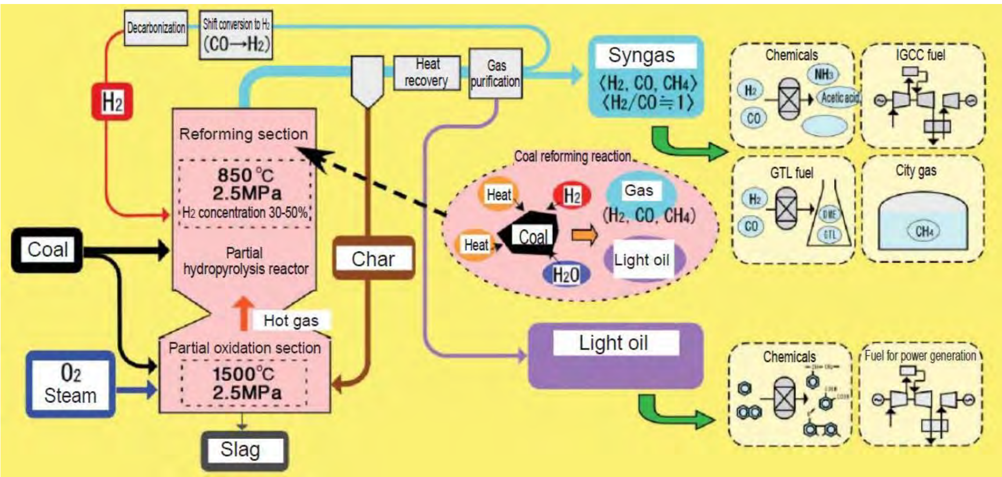
Fig. R-58 CPX Process Flow

(2) ECOPRO

The Coal Flash Partial Hydropyrolysis Technology is a technology that causes pulverized coal to react rapidly under high pressure (2-3MPa) and in a moderate hydrogen atmosphere to highly efficiently obtain, from one reactor, syngas that can easily be converted for use such as in integrated gasification combined cycle (IGCC) power generation, indirect liquefaction (GTL), and chemicals, while co-producing light oil for utilization as a feedstock for chemicals and fuel.

Fig. R-59 shows the entire process flow of this technology. At the partial oxidation section of a coal flash partial hydropyrolsyis reactor, pulverized coal and recycled char are gasified with oxygen and steam at a pressure of 2-3MPa and at a temperature of 1,500-1,600ºC to generate hot gas mainly composed of CO and H_2. At the reforming section directly connected through a throat to the partial oxidation section, pulverized coal is injected together with recycled H_2 into the hot gas stream from the partial oxidation section to complete the reforming reaction (partial hydropyrolysis) instantly under the condition of 2-3MPa in pressure, 700-900ºC in temperature, and approximately 30-50% in hydrogen concentration (H_2 in hot gas and recycle H_2 combined).

At that time, hot gas from the partial oxidation section also functions as a source of the reaction heat required at the reforming section. At the reforming section, a hydrogenation reaction adds H_2 to primary pyrolysis products, such as tar released from pulverized coal, changing heavy tar-like matter to light oil. The gas, light oil, and char produced at the partial hydropyrolysis reactor follow a process where, after char separation at the cyclone and subsequent sensible heat recovery, synthesis gas (syngas) should be formed by way of oil recovery, desulfurization, and other gas purification processes. A portion of the syngas is converted into H_2-rich gas in the course of a shift reaction and decarbonization (CO_2 recovery), and then after pre-heated via a heat exchange, it is recycled to the partial hydropyrolysis reactor's reforming section. The final syngas product is characterized by its main composition of H_2, CO, and CH_4 as well as hydrogen-rich contents of $H_2/CO \fallingdotseq 1$ and is used as a source gas for IGCC, GTL, and chemicals. Light oil is mainly composed of aromatic compounds with 1-2 rings such as benzene and naphthalene, which have applications for chemical manufacturing or fuel for power generation.



Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-59 Process Flow Sheet

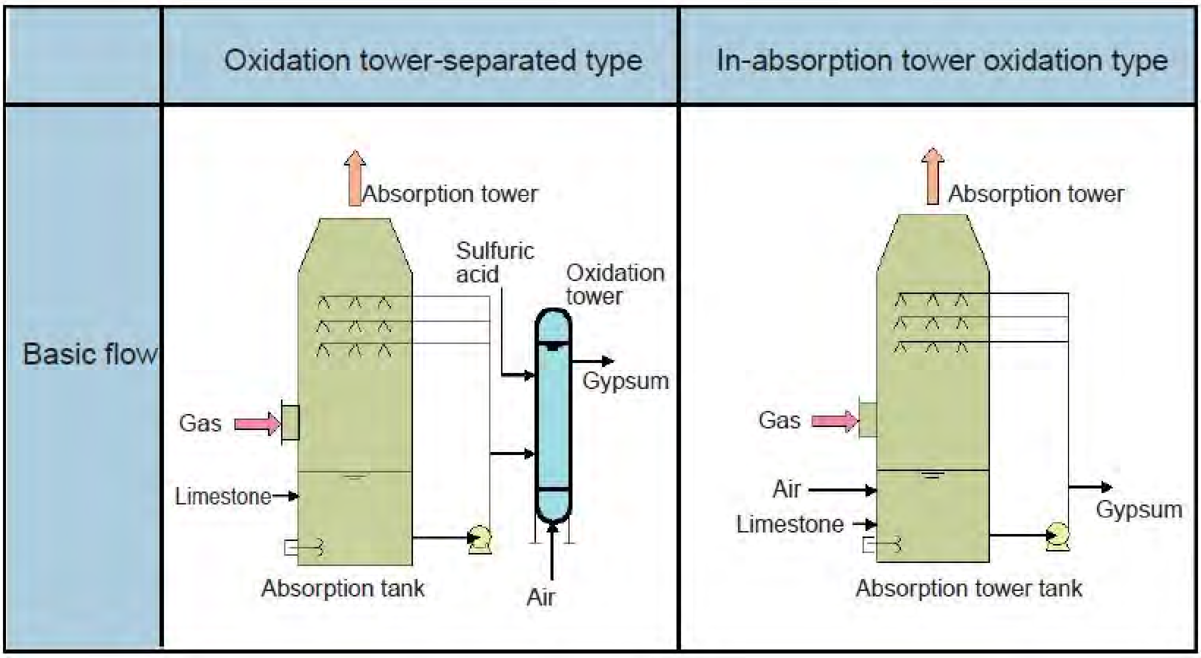
1.3.8 Flue Gas Treatment Technologies

(1) SOx Reduction Technology

(a) Wet limestone-gypsum process

There are two limestone-gypsum processes; a soot-separation process, in which a dust (cooling) tower is installed upstream for dust collection and HCl/HF removal and cooling, and a soot-mixed process without such a dust (cooling) tower. The soot- separation process is used when high-purity gypsum containing no soot or dust is desired. At present, however, more and more systems employing the soot-mixed process, which is less expensive to install, are being installed since high-performance dust collection devices, such as an advanced low-temperature electrostatic precipitator, which lowers soot/dust concentrations, have been developed. In the absorption tower, on the other hand, a water-mixed limestone slurry is reacted with SO_2 within the exhaust gas for the recovery of sulfur contents as gypsum ($CaSO_4$-2 H_2O).

There are two types of absorption towers, as shown in Fig. R-60: a $CaSO_3$-0.5H_2O separate tower oxidation system and a comprehensive single tower oxidation system. At present, single tower oxidation systems are less expensive to install and operate and their use is increasing annually. There are several methods to have recycled absorption liquid come into contact with SO_2 in the absorption tower section; the "spray method," which sprays the absorption liquid, the "grid method," which spreads absorption liquid on the surface of a grid-like pad, the "jet-bubbling method," which blows exhaust gas into the absorption liquid, and the "water-column method," in which absorption liquid flows in the absorption tower. For developing countries, a simple desulfurizer installable in the flue gas duct or at the lower part of a smoke stack has also been commercialized.



Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-60 Limestone-Gypsum Process-Based Desulfurizers

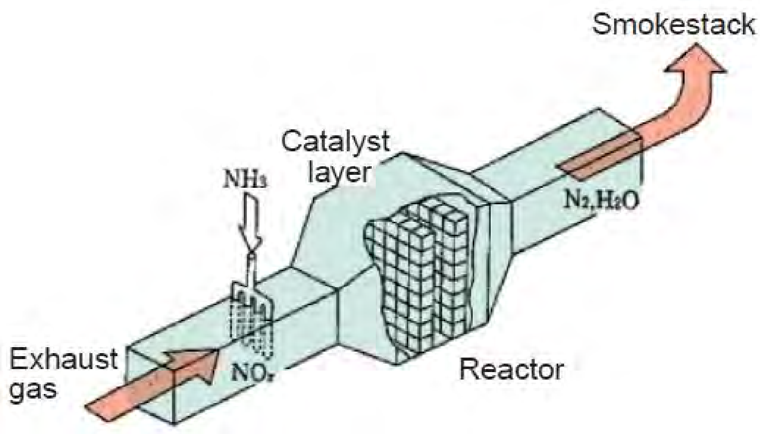
(b) Furnace desulfurization process

The furnace desulfurization process is used for fluidized-bed boilers. Limestone to be used for desulfurization is mixed and combusted with the coal, causing the following reaction to remove SO_2 at a furnace temperature of 760-860ºC. In pressurized fluidized-bed boilers, limestone does not break down into CaO due to the high partial pressure of CO_2, but SO_2 is removed in accordance with the following reaction.

(2) NOx Reduction Technology

(a) Selective catalytic reduction process

In this process, ammonia (NH_3) is blown into exhaust gas, allowing the ammonia (NH_3) to selectively react with nitrogen oxides NOx (NO, NO_2), and decompose them into water (H_2O) and Nitrogen (N_2). In the DeNOx reactor, since soot and dust are present in the exhaust gas, a grid- or plate-like catalyst is mainly used. The catalysts, as shown in Fig. R-61, are installed in the reactor to react with the NH_3 blown into the catalyst layer from its inlet, allowing NOx (NO, NO_2) to break down into water vapor (H_2O) and nitrogen (N_2). The catalyst is mainly composed of TiO_2, to which vanadium (V), tungsten (W), and the like are added as active ingredients.



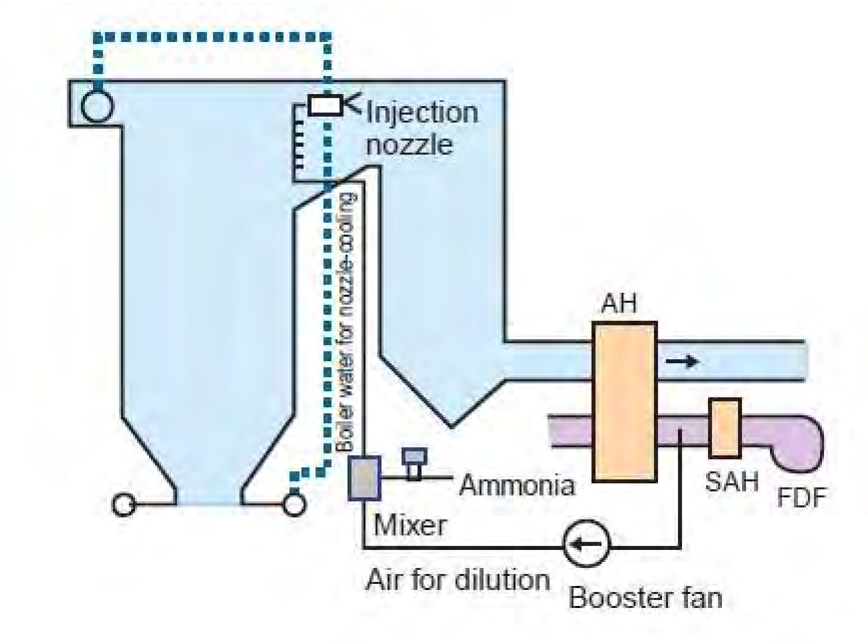
Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-61 Selective Contact Reduction Method Denitration Process

The temperature at which the catalyst attains optimal performance is 350ºC. At a temperature lower than this, SO_3 in the exhaust gas reacts with NH_3, producing ammonium hydrogen sulfate (NH_4HSO_4) that covers the surface of the catalyst, thereby reducing the ability to remove NOx. At a temperature higher than 350ºC, the NH_4HSO_4 decomposes, improving the removal of NOx regardless of the SO_3 concentration. At a temperature above 400ºC, NH_3 is oxidized and its volume decreases, thereby reducing its ability to remove NOx. The process is also designed to limit NH_3 leaks from the reactor to 5ppm or less. If a significant quantity should leak, it will react with the SO_3 in the exhaust gas, producing NH_4HSO_4, which clogs the piping when separated out by an air pre-heater. The NOx removal efficiency is around 80-90% for pulverized coal-fired thermal power plants. On the other hand, measures to equally disperse and mix the NH_3 with the exhaust gas as well as to create greater uniformity of the exhaust gas flows to cope with growing boiler sizes have been developed. These include placing a current plate, called a "guide vane" at the gas inlet, or dividing the gas inlet into grids, each to be equipped with an NH_3 injection nozzle.

(b) SNCR

SNCR is a process to, as shown in Fig. R-62, blow NH_3 into the boiler section where the exhaust gas temperature is 850-950ºC and to break NOx down into N_2 and H_2O without the use of a catalyst. Despite the advantages of not requiring a catalyst and its lower installation costs, the NOx removal efficiency is as low as 40% at an NH_3/NOx molar ratio of 1.5. Because of this, it is used in regions or equipment where there is no need for a high NOx removal efficiency. More NH_3 is also leaked than with the selective contact reduction method, requiring measures to cope with NH_4HSO_4 precipitation in the event of high SO_3 concentrations in the exhaust gas. This technology is mainly used at small commercial boilers and refuse incinerators.



Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-62 Selective Non-Catalytic Denitration NOx Removal Process

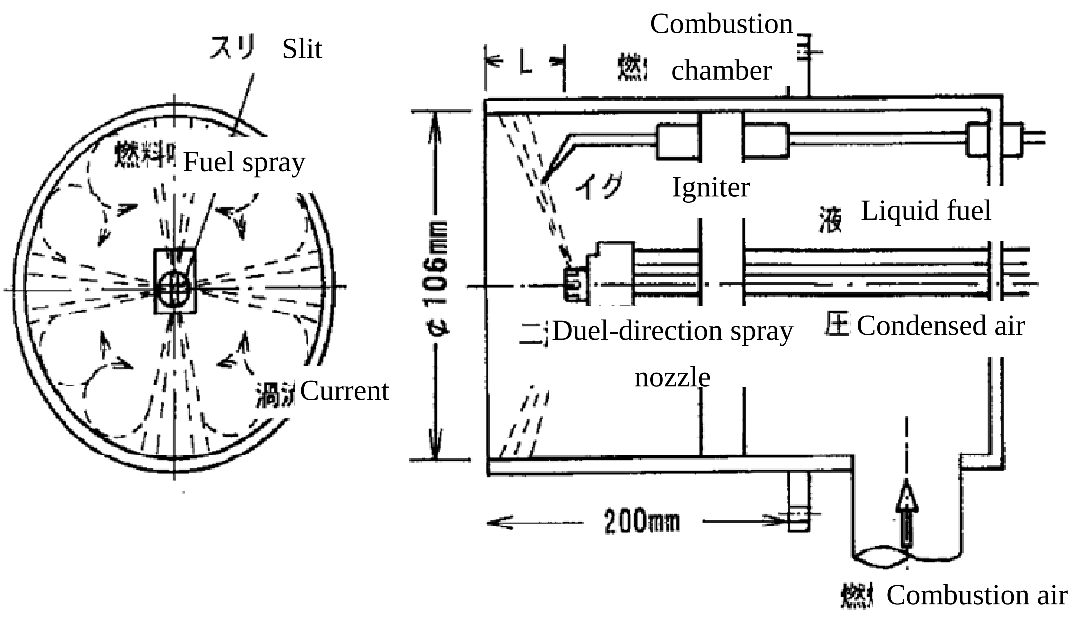
(c) Low-NOx burner technology

Low-NOx burner technology is a technology that limits the nitrogen oxide (NOx) produced during combustion. To limit the production of NOx, using fuel with a low percentage of organic nitrogen compounds, lowering oxygen concentration in the combustion area, shortening the retention time of combustion gases in high temperature areas, and eliminating localized high temperature zones to reduce combustion temperature are all effective and the application of these conditions result in limiting the amount of NOx produced. Specific methods include altering operational parameters and improving combustion equipment. Methods of changing operational parameters includes low air ratio combustion and lowering the air pre-heating temperature. Methods of improving combustion equipment includes employing two-stage combustion, recirculation of exhaust gas, and the use of low-NOx burners. Furthermore, types of low-NOx burners include mixing enhancement burners, divided ignition burners, and self-recirculating burners.

Two-phase burning is a complete combustion method where air for combustion is divided and supplied in two stages. During the first stage, the volume of supplied air is limited to 80 to 90% of the theoretical air volume and air lacking from the first stage is then supplied during the second stage. The formation of a reduced region in the first stage lowers the ignition temperature and oxygen concentration to limit the amount of NOx produced. Two-phase combustion is used in almost all large-scale boilers.

Exhaust recirculation is a technology where, in small-scale burners, part of the post-combustion exhaust gas is removed and feed back into the intake side. This results in a state of combustion with oxygen density that is lower than air, which reduces the peak combustion temperature and constrains the production of NOx.

The point of limited NOx combustion using a low-NOx burner is in the prevention of localized high temperature zones within the flame. One method of achieving this is the maximum atomization of liquid fuel in order to create an even air-fuel mixture. Furthermore, by causing the mixture of fuel spray particles and combustion air, the retention times of high temperatures within the combustion zone can be shortened, which achieves both low NOx production and high-load combustion. The result is a system that responds to demands for more compact combustion furnaces. One example of the structure for a mixing enhancement low-NOx burner is shown in Figure R-63.



Source: From "Mixing Enhancement-Type Low NOx Oil Burner" by the Technical Research Institute of Osaka Prefecture

Fig. R-63 Mixing enhancement-type low-NOx oil burner structure

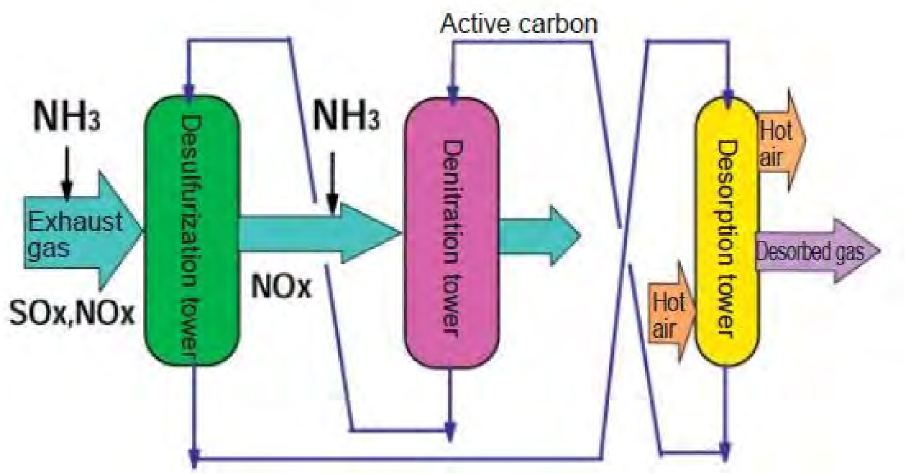
(3) Simultaneous De-SOx and De-NOx Technology

(a) Active carbon adsorption method

The active carbon adsorption method causes a reaction between SO_2 in exhaust gas and injected NH_3 on active carbon at 120-150ºC, thereby converting SO_2 into ammonium hydrogen sulfate (NH_4HSO_4) and ammonium sulfate ($(NH_4)2SO_4$) for adsorption/removal while decomposing NOx into nitrogen and water as does the SCR process. Fig. R-64 shows the process. The moving-bed adsorption tower (desulfurization tower) removes SO_2 in the first-stage and, in the second stage (denitration tower), NOx is decomposed. This method first removes SOx and then NOx since, as shown in the figure, the presence of high- concentration SO_2 tends to decrease the effectiveness of NOx removal.

Active carbon that has absorbed NH_4HSO_4 is heated to 350ºC or higher in the desorption tower to desorb NH_4HSO_4 after decomposing it into NH_3 and SO_2, while the active carbon is regenerated. SO_2 can be adsorbed and removed in the form of sulfuric acid (H_2SO_4) even if NH_3 is not injected in the desulfurization tower. However, since the following reaction with carbon occurs during desorption, consuming active carbon, NH_3 is added at the time of desulfurization to prevent such active carbon consumption.

Coal is used to reduce desorbed SO_2 into elemental sulfur at 900ºC for recovery. There is another method that oxidizes SO_2 into SO_3 to recover it as sulfuric acid. During the development of this technology, carried out at J-POWER's Matsushima thermal power plant, first, an active-carbon desulfurization method (with an adsorption tower) that can treat 300Km3N/h (90MW-equivalent) of gas was subjected to verification tests (1983-1986), obtaining removal efficiency of 98% for SOx and 30% for NOx. To improve the DeNOx removal efficiency, a combined desulfurization DeNOx pilot plant that can treat 3,000m3N/h of gas with two towers was tested (1984-1986). SOx was almost completely removed by the desulfurization tower in the first stage, while 80% of NOx was removed.



Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

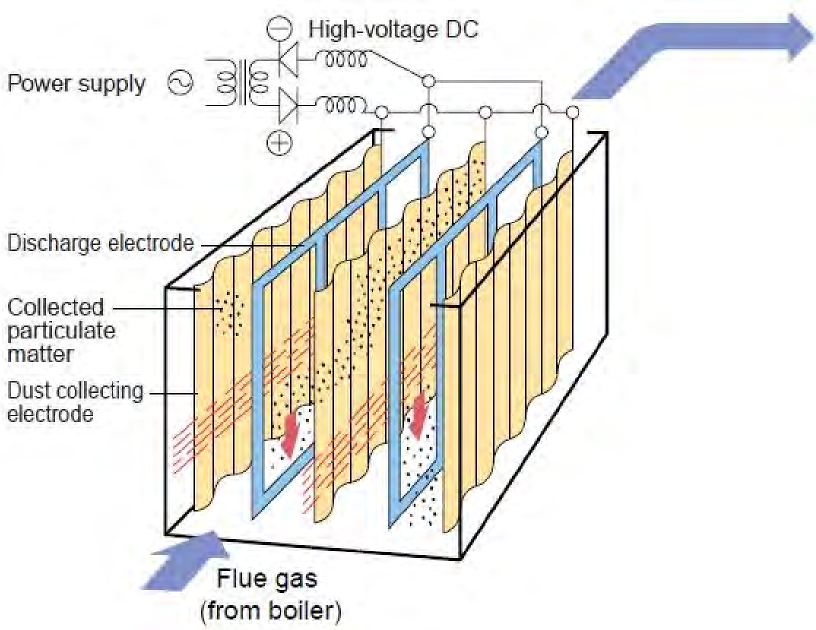
Fig. R-64 Active Carbon Method Desulfurization Process

(4) Particulate Treatment Technology and Trace Element Removal Technology

(a) Electrostatic precipitators

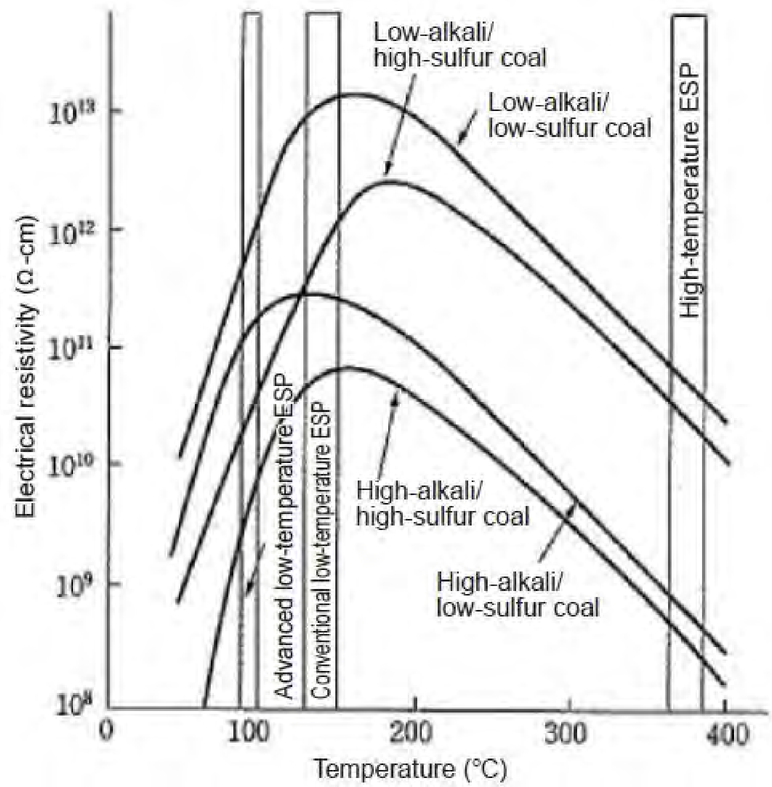
Electrostatic precipitators remove particulate matter in exhaust gas in accordance with the theory that dust charged by a negative corona at a discharge electrode adheres to a positive dust-collecting electrode. The particulate matter that adheres to the electrode is removed and falls when the cathode is tapped with a hammering device. The effectiveness of the dust removal depends upon the electrical resistance of the particulate matter, and is most effective in an electrical resistivity range of particles 10^4-$10^{11}\Omega\cdot$cm in size. Pulverized coal, where the thermal electrical resistance of many particles is high, requires various countermeasures be taken against such particles.

One such measure involves adjusting the temperature conditions for dust collection; electrical resistance changes are shown in Fig. R-66. Those successfully developed and commercialized based on such characteristics are a high-temperature electrostatic precipitator operated at 350ºC, a higher temperature than that of conventional low-temperature electrostatic precipitators (130-150ºC), in order to lower the electrical resistance, and an advanced low-temperature electrostatic precipitator, with its electrical resistance lowered by operating it at a dew point or lower temperature of 90-100ºC. Other than these, successful commercialized technology includes a moving electrode method, which brushes off particulate matter by moving the electrode to prevent back corona due to dust accumulation at the electrode, and a semi-wet electrostatic precipitator where a liquid membrane is applied to wash away dust. Other methods are commercialized electric discharge technologies, including an intermittent charge system to supply a pulsed voltage of several milliseconds, and a pulse charging system for several tens of microseconds.



Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

Fig. R-65 Active Carbon Method Desulfurization Process



Source: Prepared by JICA Research Group based on Clean Coal Technologies in Japan by JCOAL

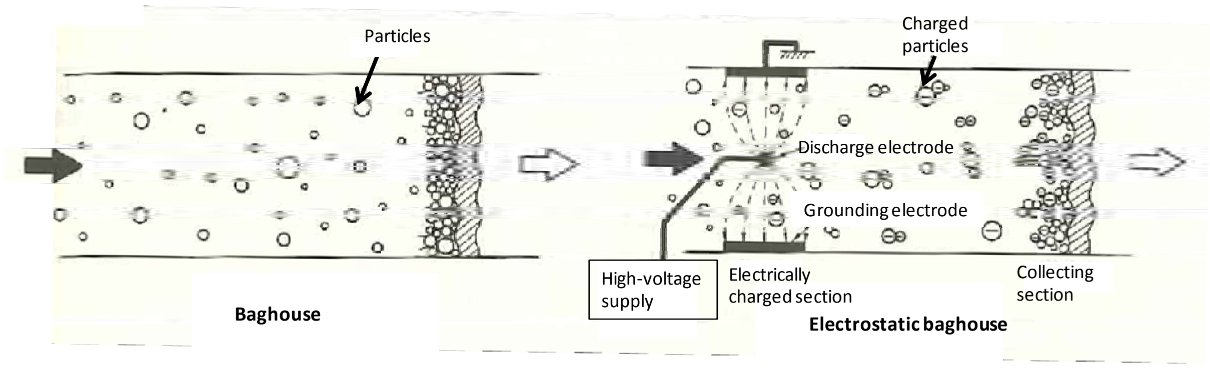
Fig. R-66 Relation between Dust Collection Temperature and Electrical Resistance

(b) Bughouses

A bughouse is a device that contains bags made of woven or nonwoven cloth or porous body, and widely used in pulverized coal thermal power and steel related industries, or particulate treatment in waste power generation because it is relatively immune to electrical resistivity of particles, which is the greatest challenge of electrostatic precipitators, highly effective for the collection of microparticles, and economical compared to the facility cost of electrostatic precipitator.

In a bughouse, since trapped dust will increase the pressure loss, cleaning of the dust is an important technological challenge and the cleaning method characterizes the bughouse. The types of bughouse include mechanical shaker, pulse jet, reverse air, reverse jet, and sonic jet.

When compared with the electrical precipitators, bughouses are inferior in trapping performance for particles around 0.1μm and have few times higher pressure loss, and to overcome these drawbacks, electrostatic bughouses have been developed. Fig. R-67 shows the structure of a conventional bughouse and an electrostatic bughouse.



Source: New Combustion Engineering in Global Environment (Fuji Technosystem Publishing)

Fig. R-67 Structures of Conventional Bughouse and Electrostatic Bughouse

1.3.9 Technologies to Effectively Use Coal Ash

(1) Effective Use of Ash in Cement/Concrete

Research has been conducted on utilizing fly ash in the cement sector as an alternative for pozzolana. Enhanced research on the use of fly ash as a good-quality alternative to pozzolana led to its first application as a concrete admixture in the late-1940’s, when it was used for structures like dams in the United States. This process was subsequently disseminated to other countries.

(a) Utilization as a clay-alternative raw material in cement

The raw materials for cement are limestone, clay, silica, and ferric oxide, with clay accounting for 15% of the total composition. Coal ash containing silica (SiO_2) and alumina (Al_2O_3) is also used as an alternative to clay. However, coal ash contains less SiO_2 and more Al_2O_3 than clay, which requires that more silica be used to offset the shortage of SiO_2. This deficiency limits the substitutability of coal ash for clay. At present, coal ash can constitute approximately 5% of the raw materials for cement but theoretically its use could be as high as around 10%. It can also be used as cement mixture, and Japan Industrial Standards (JIS) specify standards for fly ash cement, allowing the mixture to range from 5-30%. In general, fly ash can also be used as a Portland cement mixture, blended at 5% or less.

(b) Utilization as a concrete admixture

RCD is a concrete product finished by compacting concrete of ultra-thick consistency with a vibration roller. It has been developed as a rational construction technique for concrete dams, systematized as RCD construction method and commercialized for dam construction in Japan in 1978. In order to prevent cracks, dam concrete is generally not allowed to reach high temperatures. Due to this restriction for RCD, only a portion of the cement can be replaced by fly ash in order to limit temperature increases. (Generally, the replacement ratio is 20-30%.) As many as some 30 dams have thus far been built employing this construction method, making it a well-established engineering method, justifying the development efforts.

Pre-packed concrete is a concrete product fabricated by casting coarse aggregate of a designated grain size into a mold or place of application beforehand and injecting mortar into voids at an appropriate pressure. The mortar used must be one of high fluidity, with little material separation, and of moderate expansibility. For this purpose, fly ash is generally mixed at a rate of 25-50%. Applications include underwater concrete, mass concrete, and the repair/reinforcement of existing concrete work.

FEC is a two component-type, high- fluidity concrete product using cement and fly ash as powder materials. It can contain 40% or more fly ash, providing such characteristics as excellent self-filling capability requiring no compaction after casting, minimal cracking due to heat of hydration, which increases its long-term strength, as well as higher durability against alkali aggregate reactions and salt/acid damage.

FSC, using steel slag and coal ash as aggregates, is a plain concrete product developed for wave-breaker superstructure works and fixation blocks/tetrapods that do not require great strength.

(2) Effective Use of Ash in Civil Engineering/Construction and Agriculture, Forest and Fisheries

Outside of its application in concrete, coal ash is widely used in the civil engineering sector for road construction, foundation improvements, back-filling, or for use in other earthwork and in the construction sector as an artificial light-weight aggregate. On the other hand, in the agriculture/forestry/fisheries sector, it is used as a fertilizer or soil conditioner.

To cope with the anticipated large increase in the generation of coal ash in the future due to such factors as the construction of new coal-fired power plants, utilization technologies are now under active development out of the necessity to expand the utilization of coal ash.

(a) Road construction material

Fly ash can be used as an asphalt filler material, and clinker ash as a lower sub base material, frost heave depressant, and barrier material. Fly ash can be used for the upper/lower sub base and sub grade.

(b) Earthwork material

Fly ash can be effectively used for an embankment or reinforcement material since it is lighter than common earthwork materials. For this reason, a number of applications are available such as using fly ash in its original powder state with cement added as a solidifier to coal ash, utilizing it as a stabilizing material, using it in solidified state, or in granulated or processed state. Review is also underway for the intended commercialization of fly ash as a soil stabilizer or a construction sludge conditioner due to its high pozzolanic activation as well as its self-hardening property. Meanwhile, basic research of the elution of coal ash’s trace elements is continuing since fly ash’s use in earthwork must be in harmony with the environment.

(c) Artificial light-weight aggregate

Development efforts have successfully produced technology to pelletize/calcine coal ash and cement or the like into artificial light-weight aggregate. The resemblance of coal ash’s elements to the chemical composition of existing construction materials also allows it to be used as a clay-alternative raw material for ceramic products, such as clay roofing, bricks, and tiles, or as a cement mixture for boards (interior/exterior wall material for construction).

(d) Fertilizer

Fly ash, from pulverized coal-combustion ash, was designated as a special fertilizer in 1960, as was clinker ash in 1992. Several thousands of tons a year of potassium silicate fertilizer, containing hard-to-dissolve silicic acid contained in coal ash, is also produced.

(e) Soil conditioner

Clinker ash, whose chief components, SiO_2 and Al_2O_3, are almost the same as those of ordinary soil, is suitable for the growth of vegetables. Moreover, it is used to grow sod for golf courses or to improve the soil of poor-drainage areas or arable land since its countless spores retain water well, enabling fertilizers to be effective for a longer duration and, at the same time, its similarity in shape to sand provides comparable water permeability.

(f) Fisheries sector

There are long-established cases where coal ash has been used for fish breeding reefs and seaweed beds. A recent effort aims to use coal ash as a mounding material for a man-made undersea mountain range to cause artificial upwelling currents.

(3) Technology to Process Artificial Minerals (artificial zeolite) etc.

Coal ash contains valuable substances including cenosphere (hollow ash), magnetite, silica, alumina, iron oxide, and titanium oxide, as well as trace amounts of other valuable metals.

(a) Recovery of valuable resources through physical treatment

1)Magnetite recovery through magnetic separation

The recovery of magnetite (Fe_3O_4) from fly ash is performed prior to the chemical treatment process to recover valuable elements such as Si, Al, Ti, and Fe. Magnetite, recovered through a magnetic separation process, can be used, for example, as an alternative to a heavy separation medium.

(b) Recovery of valuable resources through chemical treatment

1) Direct hydrofluoric acid extraction method

An acid extraction method, which uses an acid mixture of hydrofluoric acid and hydrochloric acid, has been developed to recover valuable resources from fly ash. The SiO_2 recovered is characteristically of high purity (99.9% or higher) and fine particles (1μm or less).

2) Calcination method

In the calcination method, calcium is combusted with fly ash to convert the acid-stable mullite present in the fly ash into acid- soluble anorthite or gehlenite, resulting in a high recovery rate of Al.

(c) Zeolite production

1) Artificial zeolite

Zeolite is a generic term for hydrated crystalline alumina silicate that, as one of its characteristics, has a porous structure and therefore a large specific surface area. It also contains ion-exchangeable cations and crystallization water that can be adsorbed/desorbed. Because of such characteristics, zeolite can be used, for example, as an adsorbent, a catalyst, or a desiccant. Treating a coal ash-alkaline aqueous solution mixture hydrothermally produces various kinds of zeolite, depending upon the reaction conditions.

(d) Utilization in other sectors

1) Desulfurization agent

Dry desulfurization technology using coal ash has been commercialized, using a hardened mixture of coal ash, slack lime, and gypsum, which have excellent desulfurization capabilities.

2) Admixture/filler for polymeric materials (including rubber and plastic)

Fly ash, since it is a collection of small, round glass-bead-like fine particles, is being studied for possible use as a rubber filler or as an alternative to plastic admixtures including calcium carbonate, silica, alumina, wood flour, and pulp.

3) Other

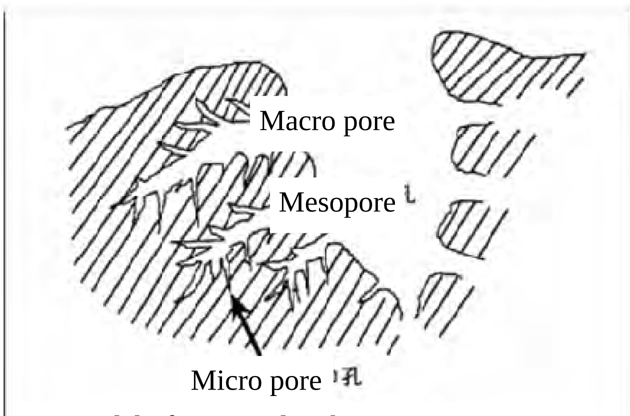
Other than the above, technology development is currently focused on coal ash characteristics-based applications, such as in an agent to prevent rust caused by oxidation in steel-making, as well as for use in water purification or for casting sand.

1.3.10 Activated carbon manufacturing technology

Activated carbon is typically an amorphous material composed of minute graphite crystallites and hydrocarbons that bind the crystallites, and is known for being a porous adsorbent. A major reason for the multi-functionality of activated carbon is thought to be its multiporous structure. Dispersed within the material are micro pores of varying diameter, and varying functions are achieved depending on this pore diameter. Micro pores (pore diameter: $<$2nm) provide a large surface area and display strong adsorption properties. Mesopores (2 - 50nm) can be used as a support for or to affix catalysts and deodorizing agents, with differing functionality achievable depending on the type of agent used.

Water processing utilizes adsorption ability that is based on this multiporous structure. The raw materials used for activated carbons are largely divided into coal-based materials (peat, lignite, charcoal, bituminous coal, etc.), woods materials (coconut, timber, sawdust), and other materials (petroleum pitch, compound resins (macromolecules), and various organic ash). The relationship between activated carbon raw materials and micro pore diameter distribution is such that compared to coal-based activated carbons, the dispersal of coconut-based activated carbons is concentrated where the pore diameter is smaller and thus there are few large-diameter micro pores. As such, coconut-based activated carbons are used in gas phase adsorption, where the target molecule size is smaller. Activated carbons using lignites or peat, which are also carbon materials but have a low degree of bituminization, have a larger proportion of mesopores. As such, this type of activated carbon is used for adsorption during the liquid phase of macromolecules (colored substances or humic acid), which have a larger molecule size.

In general, activated carbons are manufactured through a process of carbonization and activation of organic raw materials such as wood, coconut, or coal. Carbonization is a process during which the carbon, hydrogen, and oxygen within the raw material are heated to between 400 and 700°C in an inert gas atmosphere to partially remove volatile elements (normally, volatile elements are reduced to 20 to 35%), after which the raw materials are turned into a carbonized material appropriate for activation. Activation refers to a process by which carbonized material produced during the carbonization process are subject to high temperatures of 600 to 1,000°C in order to gasify the volatile elements and carbon molecules in the carbonized material by inducing a reaction using steam, carbon gas, and air. This gasification process results in the development of a micropore structure with pore diameters of 10 to 100Å and increase the interior surface area to 1,000m^2/g and higher. This process results in the production of activated carbons with superior adsorption performance. The internal surface area, micropore dispersal, and adsorption performance of the activated carbon not only varies significantly depending on the type of raw material, but will also vary widely depending on the so-called thermal history parameters (time of retention at the set carbonization temperature), temperature elevation speed, activation time at each activation temperature, activation gas density, and other factors. Figure R-68 shows a micropore structure model and properties of the micropore structure for activated carbons.



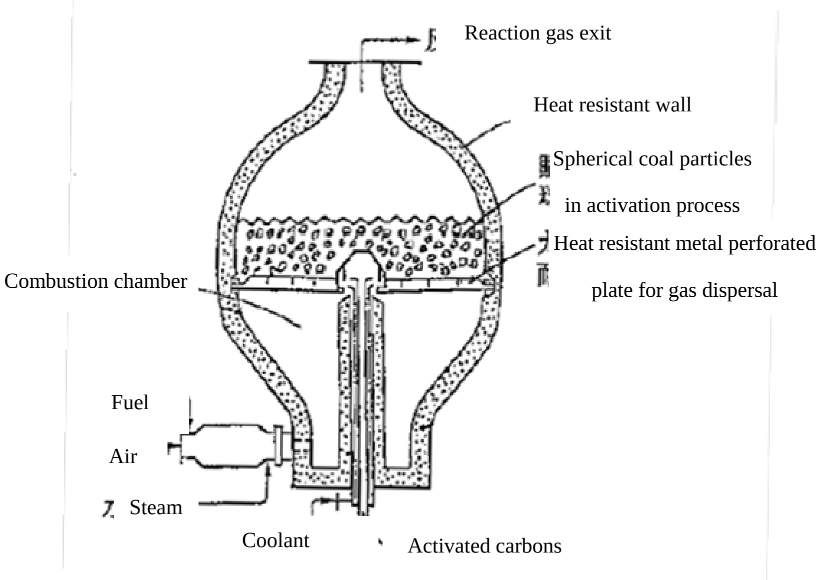
Common activated carbon micropore structure properties　　Activated carbon micropore structure model

Activated carbon raw material	State	Application	Relative surface area (m^2/g)	Average micropore diameter (nm)
Sawdust	Dust	Decolorization, distillation	1,321	3.54
Coal	Crushed	Waste water treatment	1,117	2.15
Coal	Crushed	Advance water purification	1,086	1.97
Coconut	Crushed	Water purification	1,038	1.77
Composite macromolecule	Fiber	Water purification	1,178	1.60

Source: from the JPO (JAPAN PATENT OFFICE) website

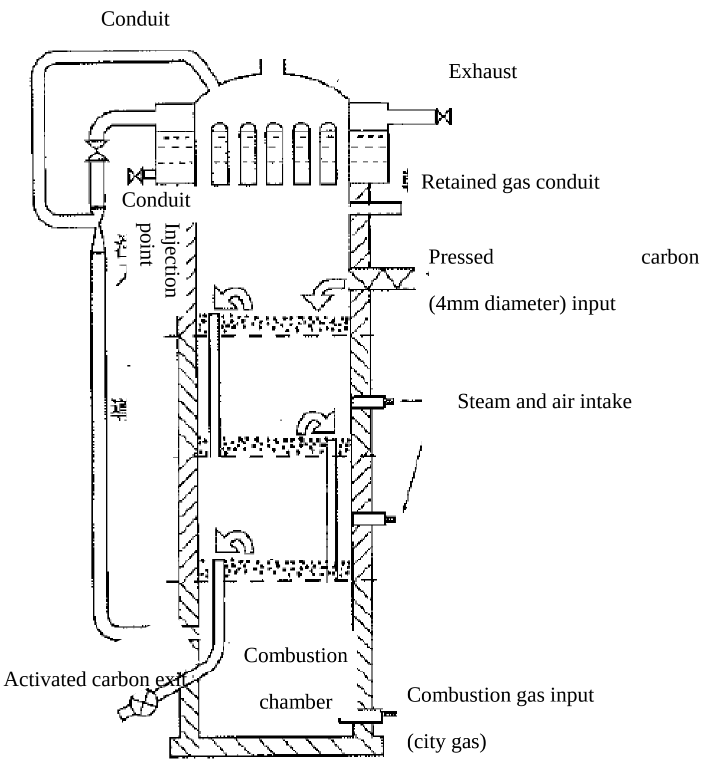
Fig. R-68 Micropore structure model and micropore structure properties of activated carbons

A moving bed reactor is optimal for activation of carbon particles capable of maintaining strength in fluidized state while at a diameter of around 1mm. These furnaces provide activated carbon with uniform strength characteristics that can often be difficult to achieve with other furnaces. Recently, these furnaces are also used as regenerators for spent activated coal. Figure R-69 shows a single-phase fluidized activation furnace and Figure R-70 shows a multi-phase fluidized bed activation furnace.



Source: From "Activated Carbon Application Technology" by Techno Systems Co.

Fig. R-69 Single-phase fluidized activation furnace overview



Source: From "Activated Carbon Application Technology" by Techno Systems Co.

Fig. R-70 Multi-phase fluidized activation furnace overview

1.4 Laws and regulations

1.4.1 "Regulations Concerning the Temporary and Permanent Closure of a Mine", The General Agency for Specialized Inspection Ordinance No. 309 dated August 21, 2003.

Ordinance No. 309, dated August 21, 2003, issued by the Director of the General Agency for Specialized Inspection

Regulations Concerning the Temporary and Permanent Closure of a Mine

1. General overview

1.1 The purpose of the regulations is to prevent health and safety risks to people and the environment within a mining area of a mining company to be temporarily or permanently closed and to confirm remaining mineral resources in the mine and register the said resources for the economical, effective, and safe development of those resources.

1.2 The regulations should be implemented by the appropriate government implementation agencies managing the mines under development and operations and managing geology and mines (hereinafter called as "Implementation Agencies") that are carrying out at surface or underground, at iron ore mines, on remaining materials and separation of mineral resources from water within the country, and local administrative office, contractors, and any other relevant parties.

1.3 The regulations outlines the measures and parameters that should be implemented by the mining license holders to mine mineral resources (hereinafter called as “mining license holders”), Implementation Agencies, local administrative offices, contractors, and other related agencies in response to the temporary and permanent closure of a mine.

1.4 Closure of a mine is referred to where the operations on mining mineral resources is to be closed temporarily when a mining license to mine mineral resources at the site in question remain valid.

1.4.1 When there is a major change in the geological conditions, hydrogeological conditions, or viability of a mine, the mine may be closed temporarily or permanently.

1.4.2 Closing a mine where the mining site and facilities including the mine water usage facilities for treatment of water produced during mining operations are left as they are for future re-use for commercial purposes is referred to as a "dry temporary closure".

1.4.3 Closing a mine where the water produced during mining operations is used for treatment with a water equipment to fill the mining site with such water is referred to as a "wet temporary closure".

1.5 The complete termination of the operations without any resumption of the operations on the mining of mineral resources is referred to as a "permanent closure".

1.5.1 When remaining mineral reserves in a mining area are confirmed and compared with the national mineral reserve registry, and if it is determined that there is no possibility to increase its reserves, then the mine will be subject to a permanent closure.

1.6 When there is a major change in the geological conditions, hydrogeological conditions, or viability of a mine, a reevaluation is made on the temporary or permanent closure of the mine.

2. Measures that should be implemented by a mining company in relation to an order of temporary closure and permanent closure

2.1 A mining license holder should make necessary preparation in accordance with the contents outlined in No. 4 of the regulations.

2.2 When a mine is to be temporarily closed or permanently closed, the mining license holder shall submit a written report to the General Agency of Specialized Inspection (hereinafter called as “Inspection Agency”), a supervising authority on geology and mines, one year before the planned closure of the mine.

2.3 If the Inspection Agency approves the temporary closure or permanent closure of a mine, the mining license holder should develop a plan outlining measures for preparatory works and submit it to the Inspection Agency for approval.

2.4 After full implementation of measures for preparatory works, the mining license holder should submit its official document of the temporary closure or permanent closure of the mine to the local administrative office, affiliated mines, contractors, Implementation Agencies, and the Inspection Agency at least two months prior to the planned closure date.

2.5 The agencies indicated in No. 2.4 of the regulations should make their own decisions and submit their reports to the Inspection Agency within one month of receipt of the mine closure document.

2.6 A committee (hereafter called as "Committee") of representatives from the Implementation Agencies, the local administrative office, the Inspection Agency, and the company owning a mining license should be established to address the temporary closure or permanent closure of the mine. The committee members to participate in the project on the temporary closure or permanent closure of the mine should be appointed via an order by the director of the Inspection Agency.

2.7 The committee should conduct an on-site inspection of progress for preparatory works for temporary closure or permanent closure and keep records. The committee members and inspectors should create meeting minutes that record their views on whether or not the mine should be closed. Said minutes should contain the following information:

A. Regarding the mine subject to temporary closure or permanent closure.

B. Regarding the measures taken for the health and safety of local residents in relation to the mine closure.

C. Regarding progress and performance of the measures in the plan developed for temporary closure or permanent closure of the mine.

2.8 Minutes created by the inspectors should be reviewed and determined by the Inspection Agency within 14 days.

2.9 The committee should determine the length of the temporary closure, taking account of the mining license holder. If the determined length is to be extended, the mining license holder should re-submit a report to the Inspection Agency to extend the closure period.

2.10 After the Inspection Agency has made a decision regarding permanent closure of a mine, the mining license holder should submit a report on mineral reserves, a geological report on mineral resources, and original maps on *Markscheider* to the National Geological Archives of Mongolia.

2.11 Prior to the decision regarding the temporary closure or permanent closure of a mine, the inquire should be made with the Implementation Agencies, the local administrative office, and any other relevant agencies for their opinions on any potential issues with regard to use of the mine, including issues on mining equipment, facilities, and exploitation.

2.12 A mine shall be temporarily closed or permanently closed based on the following conditions.

A. An official decision has been made by the mine management regarding the termination of exploitation and mining of mineral resources.

B. The mining license holder will fully implement required measures as shown in the plan developed for the temporary closure or permanent closure of the mine.

3. List of documents required for submission by a mine for temporary closure or permanent closure

3.1 The following documents are required for the temporary closure or permanent closure of a mine.

3.1.1 Basic mining operations plan

3.1.2 Integral map of a mine, geological cross-sections

3.1.3 Geological map

3.1.4 Report on the performance concerning the environmental protection plan and a document on the reclamation work plan.

3.1.5 Mineral resources application technology, maps on *Markscheider*, and maps on mineral resources.

3.1.6 Appraisal and estimation documents on remaining mineral reserves.

3.1.7 Volume of remaining mineral reserves left in each of the storages and the total remaining mineral reserves.

3.1.8 Regional maps showing volumes of ores and wastes, volume of valuable compounds. (Scale: 1:1,000, 1:5,000)

3.1.9 Maps showing surface facilities and establishment, and the conditions of water treatment facilities and the relevant areas. (Scale: 1:1,000, 1:5,000)

3.1.10 Maps showing the mining area, existence of underground workings and potential dangerous locations due to the mining operations for a mine subject to temporary closure . (Scale: 1:1,000, 1:5,000)

3.2 Basic explanatory materials on the following measures:

- Protection of machinery, equipment, facilities, and the mining site during the temporary closure or permanent closure of the mine.
- Records of materials for safety and for prevention of any potential danger to impact the relevant mines and other operators in closing a mine temporarily or permanently.
- Materials on the reclamation of the area surrounding the mine.
- Submit a copy of the report on the closure of the mine to the local administrative office, its relevant mines and other operators.

3.3 Chief engineer, chief mine surveyor and chief geologist for the mine shall sign each of the materials indicated as required in No. 3.2 of the regulations,.

4. Measures required as preparatory works for temporary closure or permanent closure of a mine

4.1 The following measures shall be implemented when closing an underground mine.

4.1.1 When closing a mine, surface holes produced as a result of mining operations for the mine closure should be filled with gravels. Fences and water dams shall be constructed for areas around valleys or depressions, or other areas with a potential risk of collapsing.

4.1.2 When completely sealing off an inclined slope with an angle of more than 45 degrees, a seal consisting of double lids made from steel and reinforced concrete. The lower lid should be laid 10m below the surface and the upper lid should be installed at a surface level. The space between the two lids should be filled completely with gravels.

4.1.3 For a inclined slope with an angle of less than 45 degrees, a reinforced concrete lid shall be installed 4 to 6m downward from the portal and fill the space completely with rocks from the outside. A water damn shall be constructed around the sealed location.

4.1.4 During the period of a dry temporary closure, cooperate with the mine preservation division (mine emergency response division) to conduct inspections should be conducted approximately once per year for preparatory works for the mining operations with cooperation of the Mine Safety Division (emergency response division of the mine). Replacement of support pillars and other repair works should be conducted as necessary.

4.1.5 For a wet temporary closure or a permanent closure of a mine, all machinery, equipment, facilities, water paths, rails, power transmission cables, etc., except those approved by the local administrative office and the Inspection Agency shall be removed and placed on the ground.

4.1.6 When a mining site under a wet temporary closure is to be utilized for other purposes or for reclamation for further exploitation of mineral resources, measures to prevent collapse or landslides of other mining sites by water leakage into holes or fractures of those sites.

4.2 The following measures shall be implemented when closing an opencut mine.

4.2.1 To prevent people or livestock from falling into temporarily closed or permanently closed mining sites, fences with the height of no higher than 2.5m shall be installed 5m from the edge of the top of the walls.

4.2.2 Warning marks shall be installed on the roads to be used by people, machinery and vehicles.

5. Miscellaneous

5.1 The local administrative office should conduct an inspection once closure preparations have been completed at a mine to be temporarily closed or permanently closed.

5.2 All costs in relation to a temporary closure or permanent closure of a mine shall be borne by a mining license holder of the mine.

5.3 When a mine is to be temporarily closed or permanently closed, if companies failing to implement the measures of the above regulations are not subjected to criminal prosecution, necessary measures shall be taken for penalization under the "Minerals Law", the "Underground Resources Law", the

"Natural Environmental Protection Law", and other relevant laws.

1.4.2 Environmental Standards of Mongolia

(1) Air Quality Standards of Mongolia

The environmental standards regarding general air pollutants of Mongolia are defined in MNS4585:2007 as follows:

Table. R-3 General Air Pollutants Allowable Contents and Allowable Levels

Guidelines	Measurement average duration / time	Unit	Allowable contents and allowable levels
Chemical impact			
Sulfur dioxide (SO_2)*	10 minutes 20 minutes 24 hours 1 year	µg/m^3	500 450 20 10
Carbon monoxide (CO) *	30 minutes	µg/m^3	60,000
	1 hour		30,000
	8 hours		10,000
Nitrogen dioxide(NO_2) *	20 minutes	µg/m^3	85
	24 hours		40
	1 year		30
Ozone (O_3) *	8 hours	µg/m^3	100
Soot and dust (total substance weight)*	30 minutes	µg/m^3	50
	24 hours		150
	1 year		100
PM_{10} *	24 hours	µg/m^3	100
	1 year		50
$PM_{2.5}$ *	24 hours	µg/m^3	50
	1 year		25
Lead (Pb)*	24 hours	µg/m^3	1
	1 year		0.5
Benzopyrene ($C_{20}H_{12}$)*	24 hours	µg/m^3	0.001

Source: MNS4585:2007

Allowable levels of PM_{10} and $PM_{2.5}$ in Mongolia are set at an approximately double the PM levels set in the WHO guidelines. Besides PM, the allowable levels of ozone (O_3), NO_2 and SO_2 are almost the same as those in the WHO guidelines.

(2) Environmental Standards for Power Plants / HOBs

1) Environmental standards at power plants

Allowable levels of air pollutants in flue-gas of power plants and steam/hot water boilers

Allowable levels in the flue-gas of power plants and steam/hot water boilers are defined in MNS5919:2008 as follows for four items, carbon monoxide (CO), nitrogen oxides (NOx), sulfur dioxide (SO_2), and fly ash:

Table. R-4 Maximum Allowable Levels of Nitrogen Oxides (NOx)

№	Capability D, Ton/Hour (Q,MBт)	Shape of combustion chamber	By combustion of 1kg standard fuel equivalent (g / kg.j.t)	Correlating with 1 MJ heat generated by combustion (g / MJ)	Content in fume (mg/m^3)	Per unit duration (g/Sec)
1. Boiler						
1	D=221...420	Coal dust volume	7.6	0.261	715.0	67.0
2	D=76...220	Coal dust volume	15.0	0.520	1,100.0	110.0
3	D=51...75	Coal dust volume	20.8	0.72	1,270	37.9
4	D=51...75	Simmering bed	4.75	0.2	320	9.8
5	D=26...35	Water cooling mount	14.1	0.482	900	16.03
6	D=26...35	Coal dust volume	14.7	0.500	710	13.1
7	D=11...25	Steel (iron alloy) bottom mount	15.6	0.54	950	18
8	D=11...25	Simmering bed	9.3	0.32	660	10.8
9	D≤10	Steel (iron alloy) bottom mount	21.0	0.8	1,150	14
10	D≤10	Simmering bed	13.0	0.48	680	8.4
2. Hot water boiler						
11	12<Q≤23.26	Water cooling mount	30.1	1.0	1,918.0	22
12	12<Q≤23.26	Steel (iron alloy) bottom mount	20.0	0.7	1,028,7	12.2
13	12<Q≤23.26	Simmering bed	15.5	0.5	1,044.3	7.9
14	4≤Q<12	Steel (iron alloy) bottom mount	25	0.85	1,500	18.0
15	4≤Q<12	Simmering bed	15	0.54	900	16.0

Source: MNS5919:2008

Table. R-5 Maximum Allowable Levels of Sulfur Dioxide (SO_2)

№	Capability D, Ton/Hour (Q,МВт)	Shape of combustion chamber	Sulfur content in coal equivalent	By combustion of 1kg standard fuel equivalent (g/kg.j.t)	Correlating with 1MJ heat generated by combustion (g / MJ)	Content in fume (mg/m^3)	Per unit duration (g/Sec)
1. Boiler							
1	D=221...420	Coal dust volume	Sш=0.02...0.077	13.2	0.45	1,200	112.5
2	D=76...220	Coal dust volume	Sш=0.02	20.75	0.70	1,485	164.8
3	D=51...75	Coal dust volume	Sш=0.02...0.083	33,1	1,18	1931,8	56,8
4	D=51...75	Simmering bed	Sш=0.02	9.13	0.31	615	18.8
5	D=26...35	Water cooling mount	Sш=0.02...0.035	27.3	0.93	1,740	30.6
6	D=26...35	Coal dust volume	Sш=0.083	36.6	1.25	1,770	60.8
7	D=11...25	Steel (iron alloy) bottom mount	Sш=0.077	35	1.2	1,690	29
8	D=11...25	Simmering bed	Sш=0.077	32	1,1	1560	26
9	D≤10	Steel (iron alloy) bottom mount	Sш=0.02...0.077	33	1.15	1,620	27
10	D≤10	Simmering bed	Sш=0.02...0.077	30	1.05	1,500	24
2. Hot water boiler							
11	12<Q≤23.26	Water cooling mount	Sш=0.02	42.5	1.45	2,710	29.7
12	12<Q≤23.26	Steel (iron alloy) bottom mount	Sш=0.024	32.6	1,11	1,670	19.8
13	12<Q≤23.26	Simmering bed	Sш=0.02	26,4	0,90	1720	13,4
14	4≤Q<12	Steel (iron alloy) bottom mount	Sш=0.02...0.077	31.0	1.1	1,630	18.5
15	4≤Q<12	Simmering bed	Sш=0.02...0.077	28	0.95	1,810	14.2

Source: MNS5919:2008

Table. R-6 Maximum Allowable Levels of Carbon Monoxide (CO)

№	Capability D, Ton/Hour (Q,MBт)	Shape of combustion chamber	By combustion of 1kg standard fuel equivalent (g/kg.j.t)	Correlating with 1MJ heat generated by combustion (g / MJ)	Content in fume (mg/m^3)	Per unit duration (g/Sec)
1. Boiler						
1	D=221...420	Coal dust volume	1.831	0.062	180	18.3
2	D=76...220	Coal dust volume	4.24	0.145	300	19.4
3	D=51...75	Coal dust volume	57.6	2.02	3,547.1	125.5
4	D=51...75	Simmering bed	93.0	3.17	6,245	191.2
5	D=26...35	Water cooling mount	97.25	13.9	3,320	111.45
6	D=26...35	Coal dust volume	1.812	0.06	87.65	1.49
7	D=11...25	Steel (iron alloy) bottom mount	13	0.45	960	58
8	D=11...25	Simmering bed	11	0.4	865	53
9	D≤10	Steel (iron alloy) bottom mount	14	0.485	1,030	62.4
10	D≤10	Simmering bed	12	0.44	940	75.5
2. Hot water boiler						
11	12<Q≤23.26	Water cooling mount	181.2	6.18	12121	92.2
12	12<Q≤23.26	Steel (iron alloy) bottom mount	78.6	2.7	4,050.0	36.2
13	12<Q≤23.26	Simmering bed	54.5	1.85	3,810	54
14	4≤Q<12	Steel (iron alloy) bottom mount	80	3.0	4,100	94
15	4≤Q<12	Simmering bed	75	2.8	3,850	88

Source: MNS5919:2008

Table. R-7 Maximum Allowable Levels of Fly Ash

№	Capability D, Ton/Hour (Q,MBт)	Shape of combustion chamber	Coal ash	By combustion of 1kg standard fuel equivalent g / kg.j.t	Correlating with 1MJ heat generated by combustion, g/MJ	Content in fume, mg/nм3	Per unit duration, g/Sec
1. Boiler							
1	D=221...420	Coal dust volume	Aш=0.84	2.35	0.08	200	50.8
2	D=76...220	Coal dust volume	Aш=0.84	151.1	5.15	10,800	420
3	D=51...75	Coal dust volume	Aш=0.84	304	10.5	21,000	650
4	D=51...75	Simmering bed	Aш=0.84	17.7	0.6	1,200	36.5
5	D=26...35	Water cooling mount	Aш=0.84 Aш=1.16	187.5	6.3922	11,900	225.00
6	D=26...35	Coal dust volume	Aш=0.84	218.5	7.45	10,600	194.97
7	D=11...25	Steel (iron alloy) bottom mount	Aш=0.73	225	7.8	10,900	200
8	D=11...25	Simmering bed	Aш=0.73	150	5.2	7,300	140
9	D≤10	Steel (iron alloy) bottom mount	Aш=0.73...1.63	250	8.7	12,000	220
10	D≤10	Simmering bed	Aш=0.73...1.63	170	5.8	8,000	150
2. Hot water boiler							
11	12<Q≤23.26	Water cooling mount	Aш=0.84	23.0	0.788	1,553.5	11.76
12	12<Q≤23.26	Steel (iron alloy) bottom mount	Aш=1.63	945.0	32.2	48,700	582.5
13	12<Q≤23.26	Simmering bed	Aш=0.84	9.6	0.326	670	9.49

14	4≤Q<12	Steel (iron alloy) bottom mount	Aш=0.73...1.63	230	9.5	13,000	240
15	4≤Q<12	Simmering bed	Aш=0.73...1.63	190	7.9	10,500	200

Source: MNS5919:2008

b) Allowable levels of air pollutants contained in flue-gas emitted from smoke stacks of new thermal power plants and heat power plants

Allowable levels on the flue-gas of thermal power plants and heat power plants to be constructed in the future are defined in MNS 6298:2011 as follows for the four items, CO, SO_2, NOx, and fly ash:

Table. R-8 Maximum Allowable Levels of CO, SO2 and Fly Ash

Province	CO (mg/m^3)	SO_2 (mg/m^3)	Fly ash PM, (mg/m^3)
Province I (area with a 1km^2 population density of 10/km^2 or higher and 1000/km^2 or lower)	180	400	50
Province II (remote area with a 1km^2 population density of 10/km^2 or lower)	300	600	200

Source: MNS6298:2011

Table. R-9 Maximum Allowable Levels of NOx

Volatile Matter	NOx (mg/m^3)
V_{daf}<10%	1,100
10%≤V_{daf}≤20%	650
V_{daf}>20%	450

Remark: V_{daf} - volatile matter in coal where its ash and moisture components are excluded

Source: MNS6298:2011

2) Environmental standards for HOBs and Ger

The allowable levels of flue-gas from low efficiency stoves[83] such as HOBs and Ger stoves are provided in MNS5457:2005.

The environmental standards apply to carbon monoxide (CO), nitrogen monoxide and nitrogen dioxide (NOx), sulfur dioxide (SO_2), and fly ash. The maximum allowable levels are specified as in Table R-10 and R-11.

[83] Water heating boiler with capability lower than 3.15MWt, boilers utilizing coal, liquid or gas fuel with a vapor generation capability of up to 2t/h

Table. R-10 Nitrogen Oxide and Sulfur Oxide

No	Stove capability (Q), MWt	Nitrogen monoxide and dioxide (NOx)				Sulfur dioxide (SO_2)			
		Emmission levels by combustion - of 1kg quality fuel g/kg,j,t	Equivalent g/Mj to 1MJ heat	Content in fume mg/m3	Volume emitted in unit duration g/sec	Emmission levels by combustion of 1kg quality fuel g/kg,j,t	Equivalent g/Mj to 1MJ heat	Content in fume mg/m3	Volume emitted in unit duration g/sec
1	Q≤0.8	6.75	0.23	450	0.3	12.0	0.4	800	0.4
2	0.8≤ Q ≤3.15	6.0	0.2	400	0.25	9.0	0.3	600	0.5

Source: MNS5457:2005

Table. R-11 Carbon Monoxide and Fly Ash

No	Stove capability (Q), MWt	Carbon monoxide (CO)				Coal ash (Dust)			
		Emmission levels by combustion of 1kg quality fuel g/kg,j,t	Equivalent g/Mj to 1MJ heat	Content in fume mg/m3	Volume emitted in unit duration g/sec	Emmission levels by combustione of 1kg quality fuel g/kg,j,t	Equivalent g/Mj to 1MJ heat	Content in fume mg/m3	Volume emitted in unit duration g/sec
1	Ger stove	-	-	4,000	-	-	-	2,500	
2	Q≤0.8	37.5	1.28	2,500	1.8	6.0	0.15	400	0.34
3	0.8≤ Q ≤3.15	30	1.02	2,000	1.5	4.5	0.2	300	0.23

Source: MNS5457:2005

1.4.3 Major Japanese safety regulations related to high pressure gas safety

The following is an excerpt from a collection of Japanese laws and ordinances

Table. R-12 Major Japanese regulations concerning high pressure gas safety

Law (enacted)	Relevant text
General high pressure gas safety regulations (May 25, 1966 Ministry of Commerce Order No. 53)	Chapter 1 General provisions (Article 1, Article 2) Chapter 2 Permits for to high pressure gas manufacturing and storage Section 1 Permits for to high pressure gas manufacturing (Article 3 to Article 17) Section 2 Permits for to high pressure gas storage (Article 18 to Article 30) Section 3 Completion inspections (Article 31 to Article 36) Chapter 3 Notifications concerning high pressure gas distributors (Article 37 to Article 41) Chapter 4 Notifications concerning the start of high pressure gas manufacturing (Article 42 to Article 44) Chapter 5 High pressure gas import inspections (Article 45 to Article 47)

	Chapter 6 Safety measures during transport of high pressure gas (Article 48 to Article 51) Chapter 7 Technical standards for residential equipment installation (Article 52) Chapter 8 Notifications concerning high pressure gas consumption (Article 53 to Article 60) Chapter 9 Technical standards concerning the disposal of high pressure gas (Article 61 to Article 62) Chapter 10 Voluntary safety measures (Article 63 to Article 78) Chapter 11 Safety inspections and voluntary regular inspections Section 1 Safety inspections (Article 79 to Article 82) Section 2 Voluntary regular inspections (Article 83 to Article 83-2) Chapter 12 Measures in times of danger (Article 84) Chapter 13 Certifications for completion inspections and safety inspections (Article 85 to Article 94) Chapter 13-2 Certifications for designated equipment (Article 94-2 to Article 94-9) Chapter 14 Miscellaneous provisions (Article 95 to Article 103) Supplementary regulations
Ordinance Concerning the Regulation of Dangerous Substances (September 26, 1959 Ordinance No. 306) Final revision: May 23, 2012, Ordinance No. 146	Chapter 1 General provisions (Article 1 to Article 5) Chapter 2 Permits for manufacturing sites, etc. (Article 6 to Article 8-5) Chapter 3 Manufacturing site location, structure, and facility standards Section 1 Manufacturing site location, structure, and facility standards (Article 9) Section 2 Storage site location, structure, and facility standards (Article 10 to Article 16) Section 3 Handling site location, structure, and facility standards (Article 17 to Article 19) Section 4 Fire extinguishing equipment, security system, and evacuation equipment standards (Article 20 to Article 22) Section 5 Miscellaneous regulations (Article 23) Chapter 4 Storage and handling standards (Article 24 to Article 27) Chapter 5 Transport and relocation standards (Article 28 to Article 30-2) Chapter 5-2 Hazardous material safety supervisor (Article 30-3) Chapter 6 Hazardous material safety director, handlers of hazardous materials, and certification for handlers of hazardous materials (Article 31 to Article 35-2) Chapter 7 Hazardous material facility safety workers (Article 36) Chapter 8 Preventative regulations (Article 37) Chapter 9 Fire prevention group (Article 38 to Article 38-2) Chapter 10 Projection room structure and equipment standards (Article 39) Chapter 11 Instructions during an emergency (Article 39-2 to 39-3) Chapter 12 Miscellaneous regulations (Article 40 to Article 42)
	[Hazardous substances] Class 1 (Oxidized solids): The substance itself is not flammable but possessing characteristics that result in the severe oxidation of other substance. When mixed with a flammable substance, can break down due to heat, shock, or wear and result in extremely violent combustion.

	Class 2 (Flammable substance: A substance that is easily ignited by flame or easily ignited at relatively low temperatures (less than 40°C), highly combustible with a high rate of combustion and cannot be put out easily. Class 3 (Spontaneously combustible substance and water reactive substance): Can combust simply due to exposure to air or will ignite or produce a flammable gas if mixed with water. Class 4 (Flammable liquid): A liquid that has combustion properties. Type 1 petroleum: Ignition point is below 21°C Type 2 petroleum: Ignition point is above 21°C and below 70°C Type 3 petroleum: Ignition point is above 70°C and below 200°C Type 4 petroleum: Ignition point is above 200°C Organic oils: Oils derived from animal fat or the seeds or fruit of plants Class 5 (Autoreactive substances): A solid or liquid that will produce significant volumes of heat at relatively low temperatures or advance to an explosive reaction as a result of heat-induced degradation. Class 6 (Oxidized liquid): The substance itself is not a flammable liquid but has properties that promote combustion when mixed with other flammables. Designated flammable substances: In addition to recognized semi-hazardous materials and special flammable materials, this includes substances found equivalent to hazardous materials or designated flammable substances via testing. Additionally, there are materials that interfere with fire prevention activities and the storage or handling of certain amounts shall require notification. Cottons, shavings, chippings, paper waste, string, straw, and other flammable solids.
Petrochemical Complex Disaster Prevention Law (December 17, 1975 Law No. 84) Final revision: June 27, 2012 Law No. 41.	Chapter 1 General provisions (Article 1 to Article 4) Chapter 2 Notifications and instructions for new facilities (Article 5 to Article 14) Chapter 3 Disaster prevention for designated operators (Article 15 to Article 22) Chapter 4 Emergency measures during disaster (Article 23 to Article 26) Chapter 5 Organization and planning for disaster prevention (Article 27 to Article 32) Chapter 6 Green facilities (Article 33 to Article 37) Chapter 7 Miscellaneous regulations (Article 38 to Article 48) Chapter 8 Penalties (Article 49 to Article 52) Supplement