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Study for Recovery and Utilization of Coal Mine Gas in Russia(Kuznetsk Coal Basin)

March, 2000

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"Basic Study for Promoting Joint Implementation and Others" -Study for Recovery and Utilization of Coal Mine Gas in Russia (Kuznetsk Coal Basin) Consignee: Japan Coal Energy Center Completion Date of Survey Report: March, 2000 (303 Pages)
The purpose of this Survey is to link the energy substitutes and the reduction of global warming gases in Russian coal mines, with the promotion of joint implementation projects of the Kyoto-mechanism, recovering gas which is released in developing coal mines efficiently and emitting into the air as less as possible, utilizing these recovered gas positively for power generation and others, and ensuring mine safety of coal mines, by introducing to the coal mines in Russia Japanese technologies and facilities connected with coal mine methane recovery/control and utilization of gas.

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Introduction

This paper summarizes the outcome of the "Study on the Recovery and Utilization of the Coal Mine Methane Gas in the Kuznetsk Basin, Russia," a basic study for the promotion of joint implementation, conducted in the fiscal year 1999 by the Japan Coal Energy Center (JCOAL), commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

In December 1997, the Third Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3) was held, and the Kyoto Protocol was adopted, aiming at a reduction of the average emission by 5% below 1990 levels in the commitment period 2008 to 2012, to prevent the global warming caused by greenhouse gases such as carbon dioxide gas. Japan was allocated to reduce such gases by 6% as the aim value. The Kyoto Protocol also defines Kyoto Mechanisms, such as, "joint implementation" by developed countries, "clean development mechanism for developing countries" and "emissions credit trading" and other flexible measures to facilitate achievement of the goal, and these measures should be utilized in achieving the goal.

Russia, which we investigated, maintains the world largest resources of fossil fuel. Among all, the production of coal reached up to 400 million tons a year at one stage, third largest in the world after China and the U.S.A. After the collapse of Russian economy, however, the coal production dropped together with the other energy resources, and it went down to the 230-million-ton level in 1998. Under such circumstances, coal still plays an important role, sharing 60% of all the energy for the base industries including the electric power and the iron and steel making industries in Russia.

On the other hand, equipment used for the coal mining activity has become exhausted and obsolete, frequently causing gas explosions and other serious accidents in the mines. For example, in the period from 1990 to 1994 compared with the previous five years, the number of explosions and outbursts doubled, and the fatalities increased by 3.5 times. In the Kuznetsk Basin, where the investigation was conducted, the rate of gas recovery from the coal mine is much lower (17%) than developed countries after the Russian economy collapsed, and in reality, gas is not recovered sufficiently also from the mine safety point of view.

Thus, several programs have been devised and conducted to ensure the mine safety and to improve the working environment, including options to close the obsolete mines and to carry out structural reforms in developing potential mines. These efforts have resulted in some achievements, for example, increasing the coal production in the Kuznetsk Basin for the year 1999 compared with the previous year.

Substantial improvements, however, cannot be expected, when the efforts are made only internally. For example, almost all the recovered gas is discharged into the atmosphere in the Kuznetsk Basin, due to the lack of effective gas utilization facilities.

Introduction and propagation of facilities and technologies to recover and utilize the coal mine methane gas is highly needed in Russia, also from the view point of ensuring the mine safety and establishing the business management, as well as preventing the global warming.

As a part of the investigation, the feasibility study was carried out for the project of the recovery and utilization of the coal mine methane gas in Russia, with a view to link it to the joint implementation project between developed countries, facilitated by the Kyoto mechanisms.

We would like to thank the Ministry of Fuel and Energy of Russia, NEDO, Russian Science Academy Siberia Coal Institute, and many other institutions for their information and cooperation provided to the investigation.

March, 2000

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Summary

This paper relates to Chertinskaya mine, a Belovougol branch of Kuzbassugol Coal Production Association (CPA), selected and investigated as a model mine, in cooperation with the Ministry of Fuel and Energy of Russian Federation as the counterpart.

Kuzbassugol CPA, formed after merging three coal production associations in 1999, is the largest coal production group in the Kuznetsk coal basin, operating over 17 underground mines, and accounting over one third of the annual production in the region. As far as the utilization of the mine gas is concerned, an attempt was made in Chertinskaya mine for generation of power, but it abandoned the idea after the gas utilization plant introduced for the purpose failed to meet the local conditions, such as the large variation in the volume and concentration of gas and low gas concentration, which are typical characteristics of the mine gas. The instability of both volume and concentration of gas is caused by the factors such as the low coal production due to the stagnating Russian economy, obsolete machinery, and insufficient gas drainage due to lack of gas drainage equipment. These same factors are also causing frequent mine-gas-related accidents in the Kuznetsk coal basin. In addition, the administration has been put in difficulty, due to the deterioration of working environment caused by the lack of machinery and obsolescence of the mine, coupled with the low efficiency in production.

This site study encompassed the issues on the gas recovery from underground and surface of the mine, the gas utilization facilities and the present status of these issues at the mine of Chertinskaya. As the current gas drainage system is not effective enough at the moment, the mine gas is diluted by increasing the airflow in the mine, besides draining the gas through bleeder wells and vertical gob wells and discharging it into the atmosphere on the ground. The main factor which makes the gas drainage ineffective is the lack of machinery to bore the holes with the length over 100 meters and with the appropriate diameter required for the long wall mining. On the other hand, in view of the gas utilization, it is necessary to keep the gas in an appropriate volume in an appropriate concentration, and the gas leakage to the air must be prevented for the control of ventilation. In relation to this, the sealing method and the caulking method in boring holes were observed to be further improved.

It is indispensable to recover and control the gas for the mine safety, and the gas drainage must be given the first priority for the purpose of mine safety. At the same

time, stabilization of gas supply to the gas utilization plant would mitigate generation of greenhouse gas, and would facilitate effective use of clean energy, as well as contributing to the mine safety. This study, therefore, examines the gas utilization plant on the assumption that reliable mid-range (300 meters) boring machines and gas control technology will be introduced and propagated to meet the above purpose.

Taking into account of the establishment of the gas recovery and control technology, and based on the current mining conditions and the past performance in Chertinskaya, a study has been made to forecast the volume of recovery and concentration of the gas. Based on the production plan amounting to 700,000 tons in 2000 and up to 1 million tons in 2004, the study estimates that the mine will release a total of 26 to 36 million cubic meters of gas every year, and it will be possible to recover its 40% at the gas concentration between 30% and 35%. The monthly gas recovery, however, is expected to fluctuate largely, therefore, assuming the above conditions as the bases of the design for the gas utilization plan, the study was made to examine the possibility of the plant that would stably utilize the gas without discharging it into the atmosphere.

The business plan prepared by the Belovougol branch was referred to in examining the gas utilization plant. According to the review that was made to examine alternatives of the gas utilization, various problems have been found for the utilization of gas. For example, automotive fuel needs high concentration of methane, and the demand for the boiler fuel drops during summer. After identifying these problems, power generation has been selected as the target user of the gas utilization as it offers a large demand. A study is currently under way from various aspects to determine whether the methane gas from Chertinskaya, which is low in the concentration, should be used for either gas turbine or gas engine. In terms of the operability, appropriate methane concentration, net generation capacity, and maintainability, the power generation by gas engine seems more practicable and more efficient with the ignition using pilot oil. Installing three 1,710-kW units (including in-house use of 170 kW) for the annual coal production of one million tons would produce the total power of 4,620 kW at the sending end. Also, waste heat recovery would recover 1.3 tons/hour-unit of steam. The fluctuation of gas supply from the mine may be adjusted by increasing and decreasing the number of units to operate, and the fluctuation of gas concentration may be dealt with the ignition of pilot oil. The site is located in the cold region, and temperature in winter is assumed for the study to drop to 50 degrees centigrade below zero.

Extensive benefits are expected to be achieved under the current condition of Russian coal mines after establishing the gas recovery and control technology as proposed in this study, and developing the mine gas utilization project utilizing such technology. The Chertinskaya mine alone would substitute energy, generating 34,721 MWh of power a year at the sending end. According to the statistics from the Institute of Coal and Coalchemistry Siberia Branch RAS, the number of gas hazard emerging issues in the underground mines amounted to 368 in the Kuznetsk coal basin in 1998. For mine safety reasons, these mines need to remove around 200 million cubic meters of gas in addition to the 1998 level. Establishing an effective gas recovery and control technology in addition to the utilization of the recovered gas would bring about the energy substitution amounted in approximately 128,000 toe a year, and this also will reduce the greenhouse gas by estimated 2,800,000 tons of CO_2 a year.

The volume of the coalbed methane resources in the basin is estimated at 13,085 billion cubic meters, and the potential of the recovery and utilization of mine gas would further increase with developing new mines and deepening existing mines.

Utilizing the technology from Japan actively with the cooperation between Japan and Russia, the joint implementation would contribute to the mitigation of global warming, and to the structural reform, which is under way by the Ministry of Fuel and Energy of Russian Federation.

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I PROJECT BASICISSUES

The essentials:

The political, economical and social circumstances

The days of Yeltsin who had influenced on political, economical and social aspects in Russia as the mightiest man of power finally ended after the election of the Lower House in December, 1999, followed by resignation of the President Yeltsin and inauguration of the Acting President Putin. The reins of government was ideally transferred to a good successor for the existing power. Russia is now rushing headlong into a political season toward the presidential election to be held in March, 2000. The key to the future of Russian Federation would be whether Putin who is the likeliest to be elected President for the next term could bring domestic political, economical and social stability into Russia and win people's trust in him.

The situation of energy in Russian Federation

Though the recovery from economic crisis has made very slow progress, the fact is that the estimated amount of underground resources such as oil, natural gas, coal, etc. and their productions in Russian Federation are prominent in the world. Moreover in Russian economy, the energy-related industries occupy a very high place. The revenue of foreign currencies resulted from the export of oil and natural gas is especially the most important source of funds for the national treasury. The coal industry adopted the main policy of the closure of unprofitable coal mines, development of new ones and countermeasure against unemployment, while the development has showed little progress due to the fund shortage and the production has dropped considerably to a level of partial dependence of domestic demand on imports. In the field of power industry, the percentage of thermal power station, utilizing natural gas for fuel among others is large. From the environmental standpoint of view, it is desirable, but they are mostly superannuated and are required to modernize.

Joint implementation project

Russian Federation already ratified the United Nations Framework Convention on Climate Change and its policy to tackle the reduction of greenhouse effect gases has been confirmed. Nevertheless, while Russia is the third country in the world of greenhouse effect gases emission, its targeted reduction percentage is just zero due to the vast land and the economic sluggishness. Necessity for joint implementation project

watching the emission right trade in future is therefore quite high because of possibility of becoming a measure for earning foreign currencies.

This Project to carry out the recovery and utilization of methane has merits of its effective utilization as substitute for coal/oil as well as reduction in emission of methane into the air, which has 21 times of greenhouse effect by carbon dioxide, and contributes to securing safety for prevention of gas explosion inside coal mine. It would be right to say that the Project will meet a keen interest for the partner Messrs. Kuzbassugol.

1.The situation of Russia

Russian Federation with the capital of Moscow has the population of 150 million in the largest size of land in the world. More than 80% of the people is Russian, but it has a large number of minority races speaking more than 100 languages. In religion the Russian Orthodox Church prevails. The origin of the nation goes back to the ninth century. After the Mongolian rule, having gone through imperial regime and socialism revolution it got to the formation of Russian Federation by dissolution of the former Soviet Union in the end of 1991. Under the President having mighty power, the two-chamber system is framed. The foreign policy holds a structure to keep independent Russian course at the same time when it employs the basic policy in cooperative alignment with the West including the U.S.A. In the economy the major industries are mining, steel, machine, etc. backed with world-biggest underground resources. The export consists mainly of primary products, and import of manufactured goods. It fell into an economic crisis in August of 1998 taking the opportunities of moratorium declaration of foreign debts and devaluation of the ruble. But the export increased remarkably afterwards owing to the steep rise in oil price and the ruble depreciation having brought the increase in revenue of foreign currencies as the result, and the economy is now recovering but slowly.

The President Yeltsin whose strength undeniably declined resigned his post all of a sudden at the end of 1999, and Prime Minister Putin who brought the strife of Chechen started in last August to a close with big military strength was appointed to the Acting President of Russia. The possibility of Putin's taking office as the President of Russia at the presidential election to be held in March of 2000 is considered to be quite high.

1. 1 The political , economic and / social circumstances

1.1.1 The political situation

President Yeltsin's resignation

On December 31, 1999 (18:00 Japan Standard Time on the same date), Russian President Boris Yeltsin announced his resignation through TV broadcasting. The points are described as below:

"The reason of my resignation is not my health. It is because I would like to leave the next millennium of Russia to persons who is younger and more energetic. In order to accomplish this, I appoint Prime Minister Vladimir Putin the Acting President from 12:00 (18:00 JST) today on. The presidential election shall be held by March 26, and not in June next year".

There seem to have been the following factors behind the announcement.

①On December 30, the final confirmation of the number of votes in the State Duma (the Lower House) election was officially released. The major parties such as the Edinstvo (Unity) and the Union of Right Forces unexpectedly won a large number of votes enough to clear the way for Mr. Yeltsin to transfer his post to Mr. Putin.

②Mr. Yeltsin needed to advance the schedule for the next presidential election as much as possible, so that he could take advantage of the "Putin boom" which had continued temporarily since last summer thanks to the accomplishment in the Chechenia conflict and that no sufficient time be given to other candidates for the presidential campaign.

③Mr. Yeltsin could not maintain his physical strength enough to stay in his post.

④Mr. Yeltsin's safety after his retirement would be secured by Mr. Putin, ex-KGB security agent, and this was in harmony with his own interests. He got a promise from Mr. Putin in advance for his safety which would be guaranteed by an (acting) presidential order, although its legal effect is doubtful.

The prospects for the post-Yeltsin Russia:

①The policy line of the new administration; It seems that the basic economic line in the post-Yeltsin era will not change from the continuity of capitalism. After the collapse of the Soviet Union, the newborn Russia suddenly turned to the right through "radical economic reform". Later, Russia experienced a reversal turn due to the Communist Party that regained high popularity and Russian nationalism that was raised, but we believe that no further turning to the left beyond the moderate course will happen (or no return to communism is possible). At the same time, radical economic reform is inconceivable even if Union of Right Forces members such as Anatoly Chubais recover their strength in the administration. In other words, it is estimated that economic reform and democratization will proceed at a slow Russian pace. No matter how the new administration will be, it has no choice but to expect the continued support from the West even if Russian nationalism is further raised and a "strong Russia" is advocated. With regard to the Western countries, they cannot just look on it because they need to prevent its nuclear weapons and refugees from draining out. Therefore, diplomatic relations between Russia and the West may temporarily be worsened, but it is expected that basically they will not change.

②Circumstances for investments; As Mr. Yeltsin left Russia's economy to Prime Minister Viktor Chernomyrdin during his administration, "President Putin" is also expected not to intervene in the economic affairs directly but to have the prime minister or his brains implement economic policies. The most possible is that Mr. Putin appoints repeatedly those in the Union of Right Forces who experienced policy-making in the economic field. Taking it into consideration that the power of conservatives and communists was weakened in the parliament, once Putin is elected for the next President, we can expect Russia's political situation to be more or less stable, legislation to move ahead thanks to the improved relations between the Office of the President, the federal government and the parliament, and the overall circumstances for investments to be better. However, power struggle inside the administration and the business world which affects the government is still likely to begin again. Particularly, it is anticipated that the energy issue can be used for political struggle as usual and that the enactment of laws concerning energy can be delayed, because it is seen to be a "money-making machine." It is expected that the increase in oil prices encourages more investments by Russian oil companies.

(1) The national structure

1) The following items characterize the 1993 Russian Constitution that went in force after the collapse of the Soviet Union.

(a) The 1993 Constitution is a new constitution in Russia that was adopted in a referendum after the change in the political system. It places Russia as a democratic and republican constitutional state based on the sovereignty of the people. It excludes one-party rule and guarantees the diversity of ideologies and a multiparty system. Also, it specifies the president as the head of state and national power as being used based on the separation of the legislative, administrative and judicial branches.

(b) The term of the president is 4 years. The president is elected directly by the people. Persons eligible for the presidency shall be Russian citizens aged 35 years or older who have lived in Russia for at least 10 years. The maximum period of the post shall be two terms.

(c) The president possesses the enormous authority as follows;

①To appoint the prime minister by taking an agreement from the State Duma, and to decide the resignation of the entire cabinet.

②To dissolve the State Duma (The president issues an official notice of a referendum.).

③To impose the state of emergency.

(d) Chapter 1 (the Fundamentals of the Constitutional System), Chapter 2 (the Rights and Liberties of Man and Citizen), and Chapter 9 (Constitutional Amendments and Revisions) are so important that it is not allowed to revise them in an ordinary procedure and that a Constitutional Assembly must be called. As for the other chapters, they can be revised if 3/4 or more of the total number of the Federation Council (the Upper House) members, 2/3 or more of the total number of the State Duma members, and legislative authority of 2/3 or more of all the subjects of the Russian Federation (89 states and republics) agreed.

2) The Federal Assembly

The Federal Assembly consists of representatives of the people and is a legislative organization. It is a bicameral system - the State Duma (the Lower House) and the Federation Council (the Upper House). The former is constituted by 450 members of 4-year term (225 are elected by proportional representation and the rest are from small constituencies), and the latter is composed by 178 members - 2 persons (representatives of legislative and administrative bodies) from each of 89 subjects of the Russian

Federation. The State Duma has the right to agree with regard to an appointment of the prime minister which is proposed by the president.

3) The Government of the Russian Federation

The Government of the Russian Federation exercises executive power in the Russian Federation and consists of federal ministers, the Chairman of the Government of the Russian Federation, and Deputy Chairmen of the Government. The president appoints the prime minister by taking an agreement from the State Duma and cabinet ministers by accepting a proposal from the prime minister.

The resignation of the entire cabinet may be done at the initiative of the president or upon his or her decision that the cabinet resign en mass after the State Duma's passing a vote of nonconfidence in it. The State Duma is dissolved by the president when he or she chooses the dissolution instead of the resignation of the entire cabinet as a countermeasure against the no-confidence resolution, or when candidates for prime minister proposed by the president are refused three times consecutively in the State Duma.

4) The Presidential Decree

This is placed under the Constitution and the laws of Russia. Although it is supposed to be enforced by delegation of or in order to execute the laws, as much of the laws are missing presently, it has virtually replaced the laws. (the legislative function)

(2) Political parties

1) Political parties

The 1993 Constitution enabled various parties to emerge because it approved a multiparty system. They are classified roughly into four groups - communists, moderates, nationalists, and democrats. On December 19, 1999, there was an election for the State Duma (the Lower House: 450 members). The KPRF, Communist Party of the Russian Federation, polled 24.29 % of the votes, gaining 111 seats. The percentages of the votes and the numbers of seats gained by each party are as follows.

①At first, this election was regarded as a preliminary stage to the presidential election that would be carried out in June. The camp (consisting of the Edinstvo and others) close to the Administration, the KPRF, and the "Otechestvo (Fatherland) - All Russia" (leaders: Yevgeny Primakov, Ex-Prime Minister, and Yuri Luzhkov, Mayor of Moscow) - these three camps were leading the election campaign.

②In the early stage of the campaign, the strong forces were the Communist Party that maintained a solid base of supporters and the Otechestvo - All Russia, a centre-left coalition between Mr. Primakov and Mr. Luzhkov. Then, the Edinstvo (centre) supported by the Administration drew more attention due to the large popular support to prime minister Putin for his hard-line stance in the Chechenia conflict. The focal point was how much more support they could gain.

③The Edinstvo won supports from a wide variety of voters. At the same time, the Union of Right Forces, formed mainly by young reformists, secured a certain number of seats. The "Zhirinovsky Alliance," that was seen to be close to the present administration, was sure to maintain seats in the parliament. Under the circumstances, it was generally viewed that the result of the election was the "victory of the camps close to the present administration."

The numbers of seats gained by each party:

Name of party	Number of seats based on proportional representation	Number of seats for small constituencies	Total number of seats
1. KPRF (left)	67	46	113
2. Edinstvo (centre)	64	8	72
3. Otechestvo - All Russia (centre left)	37	31	68
4. Union of Right Forces (reformist)	24	5	29
5. Yabloko (moderate reformist)	16	4	20
6. NDR (Our Home is Russia, centre)	0	20	20
7. Others		102	102

(Footnote 1: Russia's election system - The State Duma)

The Lower House consists of 450 members of 4-year term. 225 are elected by proportional representation and the rest are from small constituencies (Note: There is no small constituency in Chechenia, so the actual number from the latter is 224). In

order for the candidates to be elected by proportional representation, at least 5% of the votes (the cutoff point) will be required. Seats are allotted according to the percentages of the votes obtained.

(Footnote 2: The percentage of the votes obtained by proportional representation and the number of seats (the total number of seats: by proportional representation, and in small constituencies) in the previous election)

KPRF	157 seats	22.3%	(99 seats, 58 seats)
LDPR (Liberal Democratic Party of Russia)	51 seats	11.18%	(50 seats, 1 seat)
NDR	55 seats	10.13%	(45 seats, 10 seats)
Yabloko	45 seats	6.89%	(31 seats, 14 seats)

2) Outlines of main political parties

Outlines and characteristics of major political parties are as follows. (Members of parties and caucuses are frequently changing in the State Duma, so the distribution of the seats often varies depending on the period of a research)

(a) The KPRF (Communist Party of the Russian Federation, communist)

The leader is Gennady Zhuganov. Mr. Zhuganov graduated from the Orel Teachers College. Member of the State Duma. He ran for the presidential election in 1996 but finished just behind Mr. Yeltsin, the successful candidate. The party was formed in June, 1990. It was obliged to suspend its activities due to the Russian Republic Executive Order in August, 1991, but later, the party was reorganized again. Now it is the biggest political party in the State Duma.

Mr. Zhuganov has been active for the alliance between nationalists and communists who protest the Yeltsin administration that has been obviously Western-oriented since 1991. He has come out with Russian nationalism and Russia's right of the state, rather than the stand of Marxism-Leninism as a political party.

The KPRF has made clear its anti-Yeltsin position. Its activities as a thorough protester led to the positive result in the State Duma election in 1995 and the large support to Mr. Zhuganov in the presidential election in 1996. However, it is ironic that such successes have made the party lose its protesting stand against the Yeltsin administration and invited criticism to the leadership as a result.

(b) The Edinstvo (Unity, centre)

The leader is Sergey Shoigu, Civil Defense, Emergencies and Natural Disasters minister. The party was established to prepare for the State Duma election, which the former president Yeltsin held last December. The Edinstvo is considered as one of the ruling parties.

(c) The Otechestvo (Fatherland) - All Russia (centre left)

The leader is Yevgeny Primakov, ex-prime minister. One of the principal members is Yuri Luzhkov, Mayor of Moscow.

(d) The Union of Right Forces (reformist)

The leader is Sergey Kiriyenko, ex-Prime Minister. Main members include Mr. Kiriyenko, Boris Nemtsov, ex-The First Vise-Premier, and Irina Khakamada. The party is trying to be close to the Edinstvo.

(e) The NDR (Our Home is Russia, centre)

The leader is Mr. Chernomyrdin, former Prime Minister. He graduated from the Kuibyshev Institute of Technology in 1966. The party was formed in May, 1995 as one of the ruling parties at the initiative of Mr. Yeltsin, who desperately felt the necessity to establish his own strong power base.

The specific policies of the party are to strengthen the roles of national management in economic and social fields and not to accept groundless inequalities in the market growth, such as mass unemployment and an extreme gap in the living standard. The NDR supports the present administration from the stand that a powerful and wise government promises a future that is free from danger or upheaval.

(f) The LDPR (Liberal Democratic Party of Russia, nationalist)

The leader is Mr. Zhirinovsky. He graduated from Moscow University. He has run for the presidency twice. The party was established in March, 1990. As he seems unprincipled and immoral in his behavior, many nationalists tend to refuse the LDPR members to be included in the same category as them.

Mr. Zhirinovsky gained the third largest number of votes in the first presidential election. But, he could only be in fifth place in the second election in 1996, obtaining merely 5.7% of the votes and he has been losing his old vigor.

(g) The Yabloko (democrat)

The leader is Grigory Yavlinski. He graduated from the master course of the Moscow National Economic Institute. Member of the State Duma. He was involved in economic reforms in the State of Nizhniy Novgorod. He ran for presidency in 1996. The party was established in January, 1995, and it gained 6.89% of the votes in the State Duma election in December, 1995.

Mr. Yavlinski is an uncompromising opponent not only of the communists but also of the Yeltsin administration. The party goal is the creation of a socially directed market economy and a country under the rule of law which is equipped with strong military forces. The party appeals the necessity of creating the middle class and implementing efficient privatization and anti-monopolization measures. It advocates to defeat the present administration as a "criminal and monopolistic oligarchy".

(h) The DVR (Russia's Democratic Choice, democrat)

The leader is Yegor Gaydar. He graduated from the Department of Economy, Moscow University in 1956. Ex-The First Vice-Premier of the Russian Republic. The DVR was organized in June, 1994. The forerunner of this party was the "Russia's Choice" that was formed in 1993. In the foundation meeting, they raised goals to fully accomplish the protection of human rights, nonviolence, the denial of totalitarianism, and the establishment of individual rights in the economic field. The principle of free economic system was reaffiremed at the occasion.

The DVR could not gain an opportunity to practice its political influence. Mr. Gaydar strongly criticized Russia's policy towards Chechenia. Because of these, the party was far from coming into political power. In the 1995 State Duma election, it was unable to gain the minimum percentage of the votes (5%) required to get a seat by proportional representation. One of the principal members of the party is Anatoly Chubais, President of the Russian Unified Energy System.

1.1.2 The economic situation

(1) The present economic situation in Russia

In Russia the real GDP in the term of January to March decreased by 2.8% and in the term of April to June increased by 1.4%, respectively, compared to the corresponding period of the previous year, and it is supposed the Russian economy was bottomed out. The industrial production increased by 5.2% in the term of April to June, thereafter by 12.8% in July and by 16.0% in August, respectively, compared to the corresponding

period and month of the previous year because of improved production of substitutes for imported goods, etc. owing to the Ruble depreciation. The consumer expenditures decreased remarkably by 20.2% in the term of April to June and by 23.6% in July, respectively, compared to the corresponding period and month of the previous year. The fixed investment decreased by 1.0% in the term of April to June and by 1.0% in June, respectively, compared to the corresponding period and month of the previous year as for the real gross fixed investment (by the government and private sectors).

The unemployment rate (of ILO standard) has been shifting at a high level increasing by 12.6% in the term of April to June and 12.4% in July, respectively. The prices of commodities increased by 126.5% in July (by 2.8%) and by 120.9% in August (by 1.2%) compared to the previous year (the previous month), respectively, but thereafter the increasing rate decreased greatly down to 62.0% (1.5%) in September all as for the consumer price index.

The trade surplus (including "shuttle trade" by private traders) has had a tendency of increase by $6.47 billion in the term of January to March and $7.21 billion in the term of April to June. The export has been decreasing less by 9.2% in the term of April to June compared to the same term of the previous year after the 15.9% decrease in the term of January to March. In the meantime, the import has continued decreasing largely by 48.3% in January to March and 42.7% in April to June for decreases, respectively.

When looking at the monetary conditions, the money supply (M2) increased by 46.6% in May and by 54.0% in June compared to the same month last year. Ruble has taken some stable movement of depreciation by 3.4% against the U.S. dollar as of 30th of September compared to June this year. (The source: "Overseas Economic Report (The third quarter, 1999)", The Economic Planning Agency)

(2) The negotiations with IMF

At the Köln Summit the early reopening of loan by IMF to Russia was declared. The several IMF-related bills were passed in the Duma. Then followed the visit of the IMF's mission to Russia this time. It seems that an agreement was concluded concerning the economic policy of the fiscal year 1999 by and between the government and the central bank of Russia. Based on the said circumstances, the present economic situations in Russia are summarized as below:

(3) The performance of Russian economy

1) The performance of Russian economy has comparatively been developing favorably in 1999. Especially, compared to the time when the international oil price began to rise in March to April this year, the industrial production mainly led by export goods has recovered, the exchange of ruble and the inflation have been held down, the tax revenue has increased, the surplus of current account has been enlarged, and the reserves of foreign currency and gold have steadily been increasing (by $12.2 billion as of 25th of June).

2) To the contrary, negative sides are seen in reduction of real income and fall of home consumption since the devaluation of ruble in last August. In addition, the production of grain in Russian agriculture dropped and a bad harvest is forecasted this year following the last year's one. (70 to 80 million tons in the ordinary year, 47.8 million tons in1998 and 51 to 55 million tons forecasted in 1999)

3) The prices of petroleum products such as gasoline, etc. were boosted considerably heightening national uneasiness of life. On 16th of June, the government of Russia organized a headquarter for countermeasures of stabilizing petroleum/petroleum products market and controlling their price advances, (headed by The First Deputy Premier Akshonenko), and at the same time signed the agreement with the heads of monopolistic huge enterprises in Russia got together at Moscow in order to freeze the prices of products and the charges. (The stage to prepare signing of the agreement was directed by the First Deputy Premier. The enterprises which signed the agreement were: 'Gazprom', the Ministry of Railways of Russia, Russia United Energy System, Transneft, Lukoil, Yukos, Surgutneftegaz, Sidanko, Sibneft, Rosneft, Slavneft and others. This agreement was effective till December 31, 1999.)

4) To the contrary of the said comparatively favorable performance in the economy, the problem of accumulated foreign debts are very serious for Russia: The additional loan of $45 billion (during the period of 18 months from the start of finance; please refer to the 'Note' below.), which is said to have basically been agreed between the former Primakov Cabinet and IMF in April this year is definitely important to avoid default for the Russian government. Furthermore, the approval about the additional loan by the IMF Executive Board is also extremely important to make rescheduling of accumulated foreign debts progress in Paris Club, etc.

   In order for the IMF Executive Board to approve the above loan and materialize the finance concerned, the Russian government must execute "the Prior Action" agreed with IMF along with the additional loan of $45 billion in April this year.

(Note) As the understanding from the side of IMF, just the "Economic Program" was agreed. The loan was promised to consult with the IMF Executive Board for a requisite to support the implementation of the "Economic Program".

(5) In the Prior Action there are two categories: Accomplishment by a measure of new legislation and by that of non-legislation.

1) The measure of new legislation

The Prior Action implemented by new legislation is generally called the "IMF loan-related bills" consisting of four block bills (33 bills in total including modifications/additions of the existed, etc.). This bill was, since its submission to the Duma (the Lower House) by the former Primakov Cabinet on May, 11, deliberated in concentration till June, 25 (though some bills were added later). As the result, the "bill for levying new tax on gasoline station" was not legislated by the Duma because of fear for price soaring of gasoline, but the three block bills, the "bill for restructuring financial institutions", the "bill for levying new tax on large size motorcar and on large size motor bicycle" and the "bill for issuing bond of the central bank of Russia" were passed. The three block bills are to be deliberated in the assembly of the Russian Federation (the Upper House) held on July, 2 to 3. The passed bills will be transferred to the office of the President and come into force after signature and promulgation by the President. In the meantime, the office of the President has declared against the "bill for issuing bond of the central bank of Russia" from the first. The attention must be paid to a possibility of no signature by the President (no effectuation).

The details of deliberation on each of the bills in the Duma are as follows:

・ The bill for levying new tax (uniform tax) on gasoline station:

In the Prior Action which was agreed in the economic program with IMF at the end of April last year, the raise of commodity taxes on gasoline and alcohol was prescribed originally, and was restrained afterwards as the result of investigation within the department of the government of Russia because of the supposed tax increase that might directly hit the national consuming life. Instead, the alternative bill which introduces new tax for levying uniformly on gasoline stations based on their location conditions was brought in. The increase in the revenue by this is anticipated to amount to 40 billion rubles for half a year accounting for about a half of the increased revenue due to the bill package.

On the other hand, many oppositions against the bill appeared ; At the deliberation in the budget committee of the Duma on May, 20 it was voted down, and at the deliberation in the first reading of the plenary session of the Duma on June, 9 its adoption was postponed (while the bills rejected by each committee were transferred to the plenary session). The adjustment committee was then organized and the modified bill was brought in. But this modified bill was again rejected at the first reading of the plenary session of the Duma on June, 17 (with 219 noes, 101 ayes and 6 absentees). In the department of the government of Russia further investigation on revised bills was provably made thereafter. The government did not submit again the bill to the Duma supposing no chance of its legislation in the near future after too many oppositions in the first reading. The final day of the spring session of the Duma of the 25th came eventually. The First Deputy Premier Khristenko told that he will submit again the bill to the autumn session of the Duma.

Concerning this bill, meanwhile, Premier Stepashin thought at one time to try to ask the confidence in the present government to the Duma in case the bill will be rejected. On the occasion of the international economic forum at Sankt Peterburg on the 16th of June, he had talks with Managing Director Camdessus who expressed his satisfactions about good performance in Russian economy and concentrated deliberations of the IMF finance-related bills at the Duma and his support to Premier Stepashin. It is supposed that he may then have had his judgement like 'it's of no use to try to overreach ourselves at this moment'.

In this connection, The First Deputy Premier Akshonenko gave his strongly-worded statements on the process of deadlocked deliberations at the Duma such as 'there are still more possibilities of taxes on other commodities in case of fail in gasoline station' or 'Russia is possible to solve its economic problems by itself if financial support from IMF is not available in the end after the rejection of the IMF loan-related bill by the Duma'.

・ The bill for restructuring financial institutions;

The purpose of this bill is to restructure the depressed financial institutions with "Financial Institutions Restructuring Organization (ARKO)". As the requisites for becoming the object of financial institutions to be restructured, it was stipulated that it is necessary to possess its private deposit in the amount of more than 1% of the total private deposit amount held by all the financial institutions in Russia or to possess its fund in the amount of more than 1% of the total asset amount held by all the financial institutions in Russia.

After the deliberation at the budget committee of the Duma on the 20th of May, the first reading at the plenary session of the Duma on the 2nd of June and the second reading on the 23rd it was finally approved at the third reading on the 25th of June.
Concerning the legal status of the Financial Institutions Restructuring Organization (ARKO) to implement restructuring financial organizations (whether to be state organ or state operation) there were some disputes, but this was in the end settled by the conclusion of the state operated enterprise at the deliberation on the 23rd of June.

・ The bill for levying new taxes on large size motor car on large size motor bicycle;
The purpose is to levy new taxes on motor car having capacity of more than 2,500 cc and on motor bicycle of more than 500 cc.
After the deliberation at the budget committee of the Duma on the 20th of May, the first reading at the plenary session of the Duma on the 4th of June and the second reading on the 23rd, it was approved at the third reading on the 25th of June.
On the way of deliberation some modifications such as increase in basic tax amount, introduction of reduced tax rate proportionate to utilization year of motor car and others, etc. were made. At the same time it seems that additional modification was also made to the effect of tax exemption on four-wheel driven motor car manufactured domestically. There might be some disputes from various fields in the future from the standpoint of preferential treatment for domestic industries.

・ The bill for issuing bonds of the central bank of Russia;
This issue is purposed to provide with measure for absorbing surplus ruble money kept by commercial banks.
The bill was passed at the second and third readings of the plenary session of the Duma on the 23rd of June after the deliberation and the adoption of the revised bill at the budget committee of the Duma on the 7th .
The office of the President was told to be against the bill in question at first. Opposition from the side of the Office will become weaker supposedly since the term of the law was determined to be in force only for a limited period of time. It would be necessary to watch for a while how the situation will change in the future.

2) The measure of non-legislation

Among the prior actions of non-legislation major issues are described below:

- The restriction of access of petroleum companies being in arrears of tax to petroleum pipeline;

The measure was taken by decision of the government on the 8th of June.

- The abolition of two parts' trade in the foreign exchange market (MICEX);

MICEX was so far divided into two parts, A.M. part (where the exporters sold 75% of their acquired foreign currencies by compulsion and the buyers were the importers and/or the central bank only) and P.M. part (on free trade), and there were two foreign exchange rates. IMF was against this system because it is considered to be a restriction on current transaction of foreign currencies and insisted on its unification. The market was eventually unified into one on the 29th of June, in which the U.S. dollar money sold by the exporters compulsorily became possible to be purchased by all the attendants to the market.

- To remove the restriction by the central bank banning foreign bank's purchase of foreign currencies in the foreign exchange market by using its ruble money kept in the commercial bank in Russia;

Because of a possibility of irregularity towards the IMF Article 8, IMF strongly maintained its demand for the abolition. Nevertheless, the central bank of Russia has requested IMF to continue the system for the time being in order to keep the stability of ruble rate. The abolition would possibly be put off.

- To raise the rates of commodity tax on alcohol and gasoline;

In the agreement between IMF and Russia at the end of April, raising of the commodity tax rates on alcohol and gasoline was specified but as mentioned above it was abandoned in the end. (This is just for reference.)

- To clear the suspicion of unlawful spending by FIMACO of IMF loan financed to the central bank of Russia;

Its goal is to make clear a suspicion that the central bank of Russia transferred secretly the foreign currency reserves and IMF loan to FIMACO in Jersey Island of British territory from 1992 to 1998 and applied the same.

The company, Pricewater House entrusted for the investigation by the government of Russia submitted its report with the conclusion of no illegality about the central bank. The Supreme Public Prosecutors Office of Russia also concluded that there was no facts constituting a crime on the 30th of June. Nevertheless, it is considered necessary to keep watching the situation of whether this case finished completely or not.

- Restructuring of banks;

The central bank of Russia revoked on the 17th of May the banking license on 12 banks of Menatep, Unicombank, Univest, Derzhavny, Interbusinessbank, Kontakt, MV, Slavija, Erkombank, Krasnodarbank, Kurgaansovbank and Nizhnevartovsk Commercial Inovation Bank. And this was immediately followed by its decision of revoking on the 29th of June the banking license on 4 banks, Oneximbank, Mosbusinessbank, Promstrolbank, and Mezhkombank.

- To enforce a reduction of the value added tax starting not sooner than January 1, 2000;

Russia is at present compiling its budget of the year 2000 within the government. On this budgeting process it is informed that there is no government's intention of reducing value added tax till the end of 2000.

1.1.3 The social circumstances

The social circumstances for the recent one year (in 1999) are outlined as below:
The anxious physical conditions of the President Yeltsin continued these several years. While his entering and leaving hospital was repeated, the corruption and bribery cases surrounding the President's family came up to the surface. The government and the Duma were opposed to each other backed by the movement of releasing the Public Prosecutor General who tried to pursue the case from his office. A political instability by displacement and nomination of the prime ministers in succession (Primakov, Stepashin and Putin) was created, and Russia thus rushes headlong into a political season of the election of the Lower House in December, 1999 and toward the presidential election in March of 2000.
In the meantime, while the second Chechen strife that broke out in March, 2000 became intensified, social insecurity was increased by active terrorist outrages aiming at residential districts in Moscow and local cities. The government of Russia concluded these as the acts by the Chechen people and it encountered severe criticism by the Western countries. Russia any way reached to a settlement for the strife taking its resolute military step. Backed by the national popularity of Prime Minister Putin who eventually brought the strife to the settlement, at the election of the Lower House in December, the party in power 'Unity' put down the Primakov-Lebed alliance ('Our Fatherland-All Russia') and won.
In addition to the above political insecurity and racial strife, there are many more problems to be solved such as crime of violence, gulf between rich and poor, educational devastation, insufficient social security and others.

1.2. Situation of energy

1.2.1 General outline of energy

Russia has continuously been the biggest country in the world possessing fossil fuel resources since the era of former Soviet Union, and is one of the strongest countries in the world producing oil/gas.

The energy industry of Russia is the biggest industrial sector in Russia, to such extent that it has produced in recent years 25~27% of total production of the steel industry, accounting for about 50% of total exports of Russia, and contributing to nearly 40% of the total state fiscal revenue. It is not too much to say that movement of the energy industry decides life and death of the Russian economy.

However, the strong energy industry faces numerous problems amid general slump and continuing sharp decrease in production in Russian economy. First of all, working volume of the mining decreases because of large reduction of investment, the confirmed deposit is slow to increase, and exploited well keep decreasing, whereas suspended wells increase.

While outdated and obsolete situation of development and refining facilities become obvious, directly causing reduction of production, large-scale mine and pipeline accidents occur frequently. Compared to high development technology of the West, also backwardness of Russian technology is prominent.

Overcoming of the above problems needs a lot of machinery and materials for development, as well as much fund, but it is absolutely impossible for the sole domestic power to deal with it under the distress of Russian economy. Foreign support and cooperation are inevitably necessary.

Table1.1-1 Production of fuel/energy resources in Russia

	1991	1992	1993	1994	1995	1996	1997	1998
Oil (million tons)	461	401	354	318	307	301	306	303
Natural gas (billion cub. m)	642	640	617	607	595	575	544	564
Coal (million tons)	354	337	305	271	262	255	244	232
Electricity (billion kW/h)	1,068	1,009	957	876	862	847	834	826
Nuclear power generation (billion kW/h)			119	98	99	109	108	

1.2.2 System for production management of energy

The energy industry in the era of Soviet Union was naturally state-owned, and strictly managed by ministry in charge of it. First there were Ministry of Oil Industry, Ministry of Gas Industry, Ministry of Coal Industry, Ministry of Electricity Industry, Ministry of Atomic Power, and others in the conference of Cabinet ministers (government), which were taking direct charge of production. Above them there was the state planning committee (Gosplan), which drew up overall production plan of the whole Soviet Union, and set up the quota (objective figure of production) of each Ministry. Based on this plan such system as an organ named the state allocation committee (Gossnab) distributing goods, then consumer goods being allocated to Ministry of Commerce, and producer goods being distributed to each Ministry had been established.

However, after the Soviet Union collapsed, and the principle of market economy was introduced, the energy producing system first changed, Ministry of Fuel and Energy was established in the Russian Republic, and all the energy covering oil, gas, coal, and electricity (nuclear power generation is under the control of Ministry of Nuclear Power) came to be controlled in an united form.

List of vice-ministers of Ministry of Fuel and Energy of Russia (field under their control)

①Mr. Kalyuzhny, Minister

②Mr. Kochnev, The First Deputy Minister (balance, oil and refined products supply, ecology)

③Mr. Avalishvile, The first Deputy Minister (budget, finance, PSA, foreign economic activity)

④Mr. Garipov, Deputy Minister (feed-stock, geology, oil & gas field licensing, ecology)→ Deputy Minister in charge of Kyoto protocol and supporting system of Ministry of International Trade and Industry for F/S

⑤Mr. Korsun, Deputy Minister (energy saving, emergency situations, labor management)

⑥Mr. Nidzeljsky, Deputy Minister (cooperation with CIS, Baltic and other foreign countries)

⑦Mr. Morozov, Deputy Minister (balance, energy supply, taxes)

⑧Mr. Kudryavy, Deputy Minister (all matters related to electric power supply)

⑨Mr. Novikov, Deputy Minister (budget, finance, credits)

⑩Mr. Stanev, Deputy Minister (oil & gas transportation, pipelines)

⑪Mr. Ustyuzhanin, Deputy Minister (natural gas, LPG, LNG)

⑫Mr. Yanovsky, Deputy Minister (energy related policy and legislation, strategy, prospect development)

1.2.3 Oil

The crude oil production markedly decreased from 462 million tons in 1991 to 370 million tons in 1995. Russia boasts the biggest production per one country, but the above figure shows considerable decline of production for the past several years, because the production had kept the level of about 600 million tons from 1980 to 1990. In the oil industry, much different from the gas industry, more than 15 oil companies such as LUKOIL Company, YUKOS Company and Rosneft Company stand side by side, and each of them is engaged in management of [from well to gasoline stand].

The export quantity of crude oil of Russia (not including the export to CIS countries) increased from 57 million tons in 1991 to 96.84 million tons in 1995, and it brought about foreign currency of 10.4 billion dollars in 1995. During this period the export quantity of oil product had shifted in level off, with the export quantity of 42.10 million tons and revenue of foreign currency of 3.9 billion dollars in 1995.

The oil production in 1997 was about 360 million tons, recording 1.4% increase on a year-to-year basis. Above all joint venture companies (companies in which foreign capital participates) as a whole increased production by nearly 20%. Moreover, strenuous efforts of domestic large oil companies were prominent. For instance, besides 5% growth of production on a year-to-year basis by the biggest LUKOIL Company which accounts for nearly 20% of the oil production in Russia, the production of other large oil companies such as YUKOS Company and Company slightly increased all together. However, the fund obtained by sale of oil has not been invested for reproduction depending on company (particularly this tendency is remarkable in companies governed by finance capital), it is very possible that the tendency of production toward stabilization will terminate in a short period. By the state statistical committee of Russian Federation, the export quantity of oil in 1997 was 127 million tons, an increase of 0.7 % over the year before.

On the whole every oil company has difficulty in management owing to such disease as heavy tax, decline of export efficiency (particularly the decline of the international price of crude oil which had been lasting since around autumn in 1997 damaged each company), decline of domestic effective demand, and cash shortage spreading at production sites, and every company other than quite partial exceptions (Surgutneftegaz Company, and others) has enormous amount of debt (non-payments of tax, etc.) to the government of Russian Federation.

Table1.1-2 Oil production (including gas condensate) by company in Russian Federation in 1998

Name of company	1998		1999	
	Crude oil production (10 million tons)	Year-to-year rate (%)	Crude oil production (10 million tons)	Year-to-year rate (%)
LUKOIL	53,667.1	100.46	53,354.0	99.42
YUKOS	34,111.3	95.82	34,187.5	100.22
Surgutneftegaz	35,171.4	103.73	37,573.2	106.83
Tatneft	24,439.6	99.60	24,064.5	98.47
Tyumen Oil Company	19,651.5	94.09	20,060.1	102.08
SIDANKO	19,902.9	98.26	19,555.4	98.25
Sibneft	17,313.8	95.31	16,322.7	94.28
Sibneft	12,891.4	83.49	12,261.2	95.11
Rosneft	12,626.1	96.81	12,554.0	99.43
Slavneft	11,783.8	95.80	11,929.7	101.24
Eastern Oil Company	10,735.9	95.99	10,532.1	98.10
ONACO	7,888.0	99.42	7,952.6	100.82
KomiTEK	3,511.6	97.82	3,628.8	103.34
YUNCO	—	—	—	—
Grozneft	845.7	136.08	118.4	14.00
Ingushneftegazkhimprom	123.3	111.57	137.1	111.19
Arcticmorneftegazrazvedka	22.2	98.03	20.2	90.99
East Siberian Oil Company	10.0	65.58	12.6	126.00
Gazprom	9,452.6	104.42	9,915.1	104.89
Other Russian companies	8,912.1	134.74	9,229.2	103.56
Foreign capital-participating companies	19,608.6	108.42	20,968.9	106.94
Total of Russian Federation	303,370.5	99.32	304,377.3	100.33

1.2.4 Natural gas

The natural gas industry was the only industry of which the level of production did not decline in Russia where production of each industry declined. The production had maintained the order of roughly 600 billion cubic meters from 1990 to 1998, and total quantity of export to foreign countries stayed at an extent of slight decline.

There are some reasons why it could maintain the production in the difficulties. One of them is relatively recent establishment of natural gas industry, and moreover a potential for maintaining production had still remained, because of its start by introducing American developed equipment.

Another reason is political. Ex-prime minister Chernomyrdin was at the post of Minister of Gas Industry in the former Soviet Union. It can be said that smooth maintenance of the production was the reason for drawing him up to the post of prime minister, as well as raising his authority, and there is a background that he had to maintain the production in order to keep his position as prime minister.

As mentioned before, the production of natural gas in Russia had stabilized at a level of annual production of roughly 600 billion cubic meters without experiencing large decrease in production. However, the break-even line of natural gas production decreased as much as about 5%, partly because Gazprom Company, the biggest gas company in Russia, took drastic measures such as temporary closing of unprofitable production sites from economic point of view.

Table1.1-3 Natural gas productions by companies in Russian Federation in 1998

Name of company	Natural Gas production (billion cubic meters)
Gazprom	553.1
(Breakdown)	
Urengoigazprom	223.1
Nadym gazprom	65.1
Jamburggazdobycha	179.6
Surgut gazprom	46.7
Tyumen Trans Gas	0
Orenburggazprom	25.5
Astrakhangazprom	7.6
Severgazprom	3.3
Kubangazprom	2.0
Kavkaz Trans Gas	0.2
Total of Russian Federation	591.0

Table1.1-4 Countries to which Natural gas of Russian Federation was exported in 1998

	Volume (million cubic meters)	Amount (1,000 dollars)
Ukraine	53,409	3,156,283
Germany	32,315	2,195,592
Italy	17,289	1,295,349
France	10,865	727,471
Czech	8,788	682,696
Hungary	7,294	561,917
Slovakia	7,099	543,872
Poland	6,900	492,277
Turkey	6,663	496,461
Austria	5,689	428,742

What is important is that natural gas is relatively clean energy sources suitable for environmental conservation. The entire world seeks this clean energy, and the following projects are under implementation and planning by gasprom.

- Yamal gas pipeline project (to Europe)

  This is a grand project to connect the gas fields in Yamal peninsula with European markets via Belarus and Poland. Ultimately two lines of the pipe with diameter of 1,420mm are scheduled to be laid from Yamal peninsula to Europe, and the construction is well under way, the completion being roughly seen. The distance of laying from Yamal peninsula to the border between Poland and Germany is expected to be about 4,500km. Although the total cost of the project is various by information source, but there are some views that it will amount to more than 40 billion dollars.

- Black Sea submarine gas pipeline (Blue Stream) project (to Turkey)

  The export of natural gas to Turkey is now implemented by using the pipeline passing through Ukraine, Moldova, Romania, and Bulgaria, but necessity to lay a new pipeline is arising to cope with increase in demand in future in Turkey. As the routes for the new pipeline, classifying roughly, three routes of 1) the same route as the existing pipeline (that is, a route leading to Turkey via Ukraine, Moldova, Romania, and Bulgaria) , 2) a route leading to Turkey via Georgia and Armenia, and 3) a route entering directly the territory of Turkey from the territory of Russia via Black Sea have been cited as candidates, but Gazprom considers from geopolitical point of view the third route (commonly called as [Blue Stream]) as the most important, and started to move for the realization.

- Gas pipeline project to China (conception of East Asian Energy Community)

  The markets Gazprom considers as more potential than Europe are China, Japan, and further other Asian countries, and at the present when the prospect for advancing to the south looks bright, the construction of pipeline toward the east is becoming a big subject of Gazprom. The conception of Gazprom is not solely to lay one pipeline to China, but to construct a pipeline network targeting Asian market, and supply gas to this market. It is conceivable that this is a strategy to make also local pipelines of various places in Asia a part of this pipeline network, and the advance to Vietnam is considered as its start. Such strategy of Gazprom is clear, and it is the most important subject following the realization of the above-mentioned Yamal and southern (Turkey) projects.

1.2.5 Coal

For the 15 years from 1975 through 1990 the coal production of Russia had kept a level of roughly 400 million tons, which was the production of the third in the world after China and USA. Although the coal production has declined recently due to various difficulties, it was 240 million tons in 1997, and coal has remained unchanged in fulfilling an important role in the energy of Russia. As to the demand for coal in Russia, the electric and steel industries consumes about 60 % of coal, and such big coal mines as Donbass, Pechora, Kuzbass, South Yakut, and Kansk-Achinsk are connected by railway network with steelworks and power stations.

The crisis into which the coal industry in Russia falls is that it is deepened by a big change in the traditional production and economic system. Speaking concretely, most of the coalfields of Russia lies in rather remote areas from consuming places. While coal was transported to those areas with railway fares which had been fixed very low till then, the fares much increased as a result of introduction of market principle into them, too, as Russia shifted toward market economy, and the traditional distribution system collapsed.

Furthermore, the price of coal itself is changing. Till then the energy in Russia including oil and gas had been supplied inside the country at the price of one fifth of international price, but the price of energy inside Russia came to be raised largely along with introduction of market economy. It influences much electricity and steel industries which consume coal.

That is, the coal industry which was subsidized by the government and was selling at especially low policy price suddenly fell into deficit industry by introduction of market economy. The side using coal also fell into management crisis. Industry unable to pay even this low price of coal appeared one after another, which resulted in delaying modernization of equipment, and even delayed payment of wage has happened. Against it the Russian coal labor union staged large-scale protest activities by rushing into strikes in 1990, 1991, 1995, and 1998 in whole Russia including the state of Kemerovo, Republic of Komi, north Kavkaz, and the state of Rostov, but at the moment there is no effective solution. For instance wage payment by currency reprinting is against the guide of IMF, because it is connected directly with inflation.

In the end of 1997, 100% state-owned company [Rosugul] was broken up by request of the World Bank, and each of the affiliated coal mining companies became independent. [Rosugol] had taken charge of the management of the stocks possessed by the federal government, and had put under its control more than 90% of coal production in Russia. The state-owned stocks of more than 10 coal mining companies was scheduled to be sold within 1998, but it was not implemented as schedule owing to such reasons as failure of auctions and resistance of local autonomous bodies.

The federal government centers on coal policy closing of unprofitable coal mines and development of new ones, the accompanying measures against unemployment and absorption of laborers into new coalfields. The number of coal mines had been reduced to 112 as of December 1, 1998, reduction by half compared to 1993 (232). However, construction in development of new coalfields has been suspended one after another because of shortage of investment fund, and it became difficult to absorb laborers of the closed coafields. Moreover, measures against unemployment, revival of towns, and improvement of infrastructure following close of coal mines have not been implemented sufficiently due to shortage of the budget. [Independent Newspaper] dated December 10, 1998 reported that only 3.5% of contributed budget was invested in renewal of equipment and modernization of companies, and the 34.6% was used for support to deficit companies.

Uncollected cost of coal mining companies amounted to 8.7 billion rubles as of the beginning of December 1998. Cash accounts for only 20% of the total payment of the cost, and the rest is settled either by barter or offset. Above all the cost unpaid by electric power companies to which the biggest quantity of coal is supplied is serious. A part of coal mining companies concluded agreement with electric power companies, and have tried to collect the cost.

As mentioned before the coal production of Russia in 1997 was 240 million tons, and recorded reduction of 4.8% on a year-to-year basis. Coal production by company and the trend of coal export/import of Russian Federation is as follows.

Table1.1-5 Coal production by companies in Russian Federation in 1998(the term from January to November)

Name of company	Production (1,000 tons)	the year before = 100
Krasnoyarskugol	28,872.1	96
Kuzbassrazresugol	28,457.0	110
Ease Siberiya Ugol	13,582.7	111
South Kuzbass	8,243.1	100.2
Kuznetskugol	8,205.0	96
Yakutugol	7,919.1	88
Vorktaugol	7,979.7	91
Leninskugol	7,649.0	104
Prokovievskugol	5,938.0	93
Rostovugol	4,941.0	69
Intaugol	4,545.0	80.5
Raspatskaya Coalfield	4,856.0	116
Cheryabinskugol	4,447.0	82
Gukovugol	4,135.9	92
Daljvostugol	3,853.0	80
Chernikovetsugol	3,088.3	129
Promorugol	2,722.0	63
Belovougol	2,675.7	89
Vakhrushevugol	2,377.0	90
Vogosherskaya Coalfield	2,305.0	89
Nothern Kuzbassugol	2,218.1	98
Turaugol	1,236.0	62
Kiseryovskugol	1,878.0	84
Severovostokugol	602.0	80
Bashikirugol	373.3	39
Arkutskugol	304.1	79
Kizelugol	182.0	37
Sakhalinugol	130.0	29
Total	199,561.0	94

Table1.1-6 Trend of coal export/import of Russian Federation

	1997		1998	
	Quantity (1,000 tons)	Amount (million dollars)	Quantity (1,000 tons)	Amount (million dollars)
Export	23,092.9	829.6	23,477.7	626.4
Among export; Export to countries except CIS	19,703.3	702.4	18,224.2	491.2
Import	15,098.0	250.3	14,945.4	184.8
Among import; Import from countries except CIS	421.0	18.1	333.6	14.6

1.2.6 Electricity

The biggest electric power company in Russia is a holding company named Russian United Electricity System (hereinafter called UES) which was established in 1992 by Ministry of Electricity of the former Soviet Union and Ministry of Fuel and Energy of Russia as the parent, which possesses 72 local electric power companies, 34 (someone says 35) large-scale power stations, and others under the control. Besides, UES owns all the transmission lines between areas.
In addition to them, in Russia there are electric power companies which have not direct capital relationship with UES (hereinafter called independent electric power company). Irkutsk Energo, Tatenergo (These two companies are local electric power company, but they are not under the control of UES), Rosenergoatom (A concern which controls 8 nuclear power stations), and others are in the category of independent electric power company.

Local electric power company existing in each constituent member of the Federation (There are 74 companies in the whole country) owns all the transmission lines in the area in its charge, as well as most of the main cables, and conducts sale (retail) of electricity in the area.
It seems that in principle each local electric power company sells electricity to end consumers, but it seems not rare that separate company (intermediary traders) sells electricity to end consumers. Electricity rate in each constituent member of the Federation is decided by [local electricity committee] of the area.

As the following table also shows the transition in recent years of quantity of power generation and consumption of electricity in Russia, the power generation quantity of Russia had decreased only about 20% during the period between 1990 and 1996. Since the industrial production of Russia had decreased by about 53% during this period, it can be said that the drop of the electricity consumption amount was not so extreme as that of the industrial production. It seems that such factor as below lurks in the background of the phenomenon like this.

① Increase of electricity consumption in the service sector and at home
② Speaking technologically, there is a considerable number of production equipment to which it is necessary to keep turning on electricity, though the production is stopped.
③ Production sector consuming big quantity of electricity such as production sectors of new ground metal of aluminum and steel production goes relatively well.

Table1.1-7 Quantity of power generation and consumption in Russia between 1990 and 1998

(unit: billion kW/h)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Quantity of power generation	1,082.2	1,068.2	1,008.5	956.6	875.9	860.0	847.2	834.0	826.0
Import of electricity	35.5	35.1	27.7	24.7	22.2	18.4	12.3		
Export of electricity	43.4	47.2	44.0	43.4	41.7	38.0	31.8		
Quantity of electricity consumption	1,073.8	1,056.1	992.2	937.9	856.4	840.4	827.7		
Among the consumption:									
Industrial sector	625.9	605.2	554.6	512.8	447.0	440.2	424.9		
Agricultural sector	96.4	103.4	102.9	103.8	97.7	88.6	85.9		
Transportation sector	103.8	96.7	86.7	76.7	68.4	65.2	64.9		
Other sectors	247.7	250.8	247.9	244.6	243.3	246.4	252.0		

The electricity balance in Russia is as shown in the following table, but it is to the last the average figure of the whole country, and the power generation balance much differs by area in Russia which possesses a large territory. For instance, in the central black earth area the share of nuclear power generation amounts to as much as 78.3% (the figure in 1996). Besides, it is as high as 52.4% also in the north-western area. Conversely in the areas such as Volga-Vyatk, North Kavkaz, West Siberia, and East Siberia, the share of nuclear power generation is zero. Furthermore, the share of hydroelectric power generation is as low as 0-1.6 % in the central area, the area of West Siberian, and the central black earth area, but it shows the figure of as high as 65.8% in the area of East Siberia where water power resources are rich.

Table1.1-8 Electricity balance in Russia (unit: %)

	1992	1993	1994	1995	1996	1997	1998
Thermal power station	71	69.2	68.6	69.4	68.8	68.1	68.2
Hydroelectric power station	17.1	18.3	20.2	18.2	18.3	18.9	19.2
Nuclear power station	11.9	12.5	11.2	12.0	12.9	13.0	12.6

The transition of the ratio of fuel source at thermal power station is as per the following table, and in Russia conversion to gas as fuel at thermal power stations is rather advanced.

Table1.1-9 Ratio of fuel source at thermal power station (unit: %)

	1992	1993	1994	1995	1996
Natural gas	61.4	62.1	61.9	61.7	62.3
Solid fuel	13.6	12.0	11.7	11.6	10.1
Oil	25.0	25.9	26.4	26.5	27.6

Many of the power stations in Russia are generally rather old, but renewal of the facility makes very slow progress due to shortage of fund. From ideal point of view, it is necessary to close annually the facilities of nine million kW, and put into operation new capacity of the same kW, but the facilities newly put into operation between 1992 and 1996 was only 150kw per year on average.

Concerning nuclear power station, there are nine in operation in Russia , which are located in Balakovo, Kalinin, Kol'skii, Kursk, Leningrad, Novovoronezhskii, Smolensk, Bilibino, and Beloyarskii (Total number of power generation unit is 29) with total normal output of 21,300mw. Among 29 power generation units, 13 units are VVER type (pressurized water reactor of ex. Soviet Union type), 15 units are RBMK type (reactor of graphite moderator light water cooling channel type), and one unit is BN type (fast breeder reactor).

In terms of the system, eight nuclear power stations except that in Leningrad are under the control of a concern [Rosenergoatom]. The nuclear power station in Leningrad is the only independent operation organ which is not under the control of Rosenergoatom, and it is under the direct control of Ministry of Nuclear Power of Russia.
For the past several years, the sector of nuclear power generation of Russia has annually produced nearly 100 billion kWh of electricity. In industrial areas of Russia remote from producing districts of organic fuel, the ratio of nuclear power generation in consumed electricity is quite big. For instance, in the central area of Russia (including the city of Moscow) the ratio of nuclear power generation is more than 15%, in the north-western area (including the city of Sankt-Peterburg) it reaches about 50%. Others: the central black earth area (80%), Kol'skii peninsula (70%), Chukot self-governing district (60%: Bilibino nuclear power station)

1.2.7. Present status of gas recovery and use in Russia

Many coalmines in Russia have been recovering gas for the purpose of the mine safety. However, using the recovered gas has only been done in Pechora basins in small scale, and tried in some mines in Kuznetsk.

(1) Kuznetsk basin

They started to drain gas to reduce gas content in mine in Kuzbass in 1951. Then, more mines started gas drainage, and in 1990, 48 coalmines in the basin employed it with 216 million cubic meters of recovered methane. Initial gas drainage method was to drill in-seam or cross-measure wells from main entries of the active mine. However, it was difficult to get enough gas drainage efficiency because of insufficient number of wells in operation, short life of the wells, and low coal seam permeability.

Later, they introduced new gas drainage technology to take out gas from adjacent strata via surface well, and improved the gas drainage efficiency.

Table1.1-10 Indices of degasification application at Kuzbass mines

Indices	Indices fluctuation per years						
	1951	1960	1970	1980	1985	1990	1995
Number of mines employing degasification	2	4	24	34	43	48	26
Degasification technique:	1	2	3	3	3	3	3
Working seam (%)	100	50	33	43	26	22	18
Associated seams and gob areas (%)	-	-	54	43	48	50	52
Combined (%)	-	50	13	14	26	28	30
Amount of captured methane (mln.m^3)	0.68	2.40	32.21	89.91	127.51	216.00	163.86

In Kuznetsk basin, Chertinskaya mine of Belovougol Co. is now try running 1 MW gas power generating engine made by Caterpillar Corp., in USA. We will mention the detail in coming chapter.

(2) Pechora basin

In Pechora coal basin, they started commercial base gas drainage in 1956. In 1988, they achieved the maximum recovery of 290 mln.m^3. They are recovering about 200 mln.m^3 in recent years. Vorkutaugol mine in the basin started draining gas in 1975. Currently they have 4 boiler houses (14 steam boilers) and generating 150 tons of steam per hour. In 1994 these boiler houses consumed 31.8 mln.m^3 of methane. The annual average methane concentration in methane-air mixture was 35%.

In the meantime, in Severnaya mine refinery plant, they are using coal dryers of 16 tons per hour steam capacity using CBM as the fuel. They are also using a gas air heater fueled by methane, and the thermal output is 18 Gcal per hour at 15,000m^3/min airflow rate. It can heat the air by +2 °C. They are using yearly total methane of 30-35 mln.m^3 in boiler houses, coal dryer and gas air heater

The tables below show recent performance and plan in Pechora basin. Even though the figures show a small difference from those we mentioned in this chapter, we think they are valuable information to know the status of gas recovery volume and kind of usage in the basin. (Both tables are from Science Academy of Russia Siberia Institute/Russia CBM Center.)

Table1.1-11 Coal production and CMM emission on Pechora coal basin mines in 1998

Underground Mines	Coal Output (10^6 ton)	Captured Methane (10^6 m^3)	Vented Methane (10^6 m^3)	Utilized Methane (10^6 m^3)
JSC Vorkutaugol	8.8	181.7	289.8	
Vorgashorskaya Mine	2.6	7.6	33.7	
Intinskaya Coal Company	6.2	0	18.7	
Zapadnaya Mine	2.2	0	7.4	
Total:				36

Table1.1-12 Coalbed Methane actual and scheduled amount for utilization in Pechora coal basin

Mine	Captured methane in 1995 (mln. m^3)	Methane utilization, actual/planned (mln. m^3/year)					Excess+, Deficiency−, of methane mln.m^3/year
		Boiler Stations	Coal Drying Units at Preparation Plant	Independent Gas Air Heater	Generated Electric Power	Motor Fuel	
Vorkutinskaya	28.6	9.0/2.0	-/10.0	-/4.0	-/3.8	-	-0.2
Zapolyarnaya	20.2	6/6	-	/4.0	/3.8	-	+0.4
Êîmsomolskaya	22.7	18.0/-	-	/4.0	-	-	+0.7
Severnaya	55.2	VRSU-1.2/-	10.0/-	4.3/-	-/38.0	-/1.7	-
Yuznaya	15.8	-	-	-	-	/15.8	-
Central'naya	13.5	-	-	-/4.0	-/7.6	-/1.9	
Àyach-Yaga	16.8	-	-	- -	-	/16.8	
Vorgashorskaya	9.8	-	-	-	-	/9.8	
Total	182.6	34.2/8	10/10	4.3/16	53.2	46.0	+0.9

1.3 Needs for project by joint implementation.

The government of Russia ratified on December 28, 1994 United Nations Framework Convention on Climate Change (UN FCCC), and announced at the third conference of the convention-conclusion countries (COP3) held in Kyoto in December 1997 a commitment which obligated legally to reduce from the level in 1990 the average emission for the period from 2008 to 2012, in order to prevent the global warming caused by greenhouse effect gas. Though Russia is the third biggest country in the world next to USA and China in emission of greenhouse effect gas, its targeted reduction value is as relatively moderate as 0 % due to the influence of the economic stagnation since 1999, and others. In fact the government of Russia is to have rich credit for reduction of emission of greenhouse effect gas.

As everybody knows, the economy of Russia is in stagnation. The biggest reason is the succession of the whole debt of the former Soviet era, but the financial resources are solely the revenue of foreign currency by exporting rich natural resources (gas, oil, etc.) for the government of Russia which has no way to check capital flight abroad, and cannot find effective measures against infestation of black market economy, whereas the whole people focuses on tax evasion. This tendency seems to continue for the moment, but emission allowance trading of greenhouse effect gas can be another means for obtaining foreign currency for the government of Russia.

Summary of the above is as follows, and it is judged that joint implementation, and others are highly needed by the government of Russia.

- The government of Russia has ratified UN FCCC, and corresponds to reduction of greenhouse effect gas with legal binding power.
- Emission allowance trading of greenhouse effect gas will be a means for obtaining foreign currency.
- A group centering around Ministry of Fuel and Energy to correspond to candidate projects for joint implementation has been composed.

Hereafter concrete description will be provided as to matters of collection and utilization of methane at coal mines.

2. Necessity of Introducing Technology of Alternative Energy by Object Business Category

Methane generated in the course of coal mining has global warming effect of 21 times that of carbon dioxide (CO_2), if left as it is, but if it is collected, it is possible to utilize as alternative energy of coal/gas for such purposes as electricity supply for coal mine, regional heat supply, and city gas. Since mismanagement of coal mine gas will also lead to accident of gas explosion, and hinder coal production, collection of the methane gas can contribute to safe operation of coal mine.

As to utilization of methane, collection and utilization of methane at coal mines have been implemented also in Japan since before the World War II in the areas of Sorachi, Yubari, and Kusiro, respectively. Its utilization for power generation started in 1935, and besides Sorachi area there have been actual results at such coal mines as Sunagawa, Akahira, Ashibetsu and Shimizusawa. As a matter of course, a long history to tackle collection and utilization of methane at coal mines exists also in such representative coal producing countries as USA, the former Soviet Union, China, Poland and South Africa.

However, the coal industry of the former Soviet Union which had received thick protection of planned economy received destructive blow by the collapse of socialistic system, and unemployment caused by closing of unprofitable coal mines has turned to social problem. Originally collection of methane at coal mines must be implemented simultaneously in parallel with coal mining by positive investment/renewal in materials and equipment, but efficient collection and utilization of methane at coal mines have not been enabled, because coal mining companies have lost fund to spare due to reduction of subsidy.

3. Significance /Needs /Effect of the Project Concerned, as Well as Diffusion of the Fruits to Similar Kinds of Industries, etc.

The project concerned aims to collect the methane which releases from the Kuznetsk coalfield which is the biggest in Russia and stays unused, and make use of it for utilities in pit by utilizing it for fuel of power generation. At Belovougol Company it is a subject to raise the rate of collection of coal mine gas which is emitted into air without utilization, and to execute its effective utilization, based on the programs of the government of Russian Federation and the state government of Kemerovo.

Furthermore, while coal mine gas contributes to reduction of greenhouse effect gas as alternative energy to coal, it has the following effects in terms of improvement of productivity at coal mine, and improvement of income and expense.

- It can reduce production cost by utilization of coal mine gas for power generation at mine site
- Stable production and safety at coal mine can be secured by stable supply of electricity. (Suspension of operation by power failure, and disaster by stop of safety device can be eliminated.)
- It is possible to reduce heating cost for pit entrance and pit in winter time by utilization of exhaust gas of power generation by gas.

Three coal producing companies of Belovougol, Severkuzbassugol, and Leninskugol were integrated into Kuzbassugol Company by the reorganization in autumn of last year. That is, the present position of Belovougol Company is "Belovo branch of Kuzbassugol Company". In Kuzbassugol Company there are powerful coal mines such as Komsomolets and Pervomaiskaya coal mines as representatives which face the problem of methane at coal mines. If this project is implemented at Cherstinskaya coal mine in Belovougol Company, it is expected to be spread to these gassy coal mines, in the same Kuzbassugol Company. Moreover, it is expected to be also implemented at Abashevsk coal mine, and other mines owned by Kuznetskugol Company which lies in the southern part of Kuznetsk coalfield.

Speaking further, the spread to coal companies in the zone of the former Soviet Union and Eastern Europe will be possible.

II MATERIALIZATION OF PROJECT PLAN

The essentials:

The Kuznetsk coalfield is known all over the world as the big coalfield and its CBM resource amount is estimated to amount to more than 13 trillions cubic meter. This abundant gas resource constitutes on the other hand a big hindrance to safety of operation in underground coal mine, and in addition, when emitted in the air affects as a global warming gas at twenty-one times intensity compared with carbon dioxide. Materialization of a project plan is herein proposed to contribute to securing safety of coal mine, reducing global warming gas and improving profitability of coal mine by effective recovery and utilization of this coal mine gas.

The survey was carried out concerning conditions of gas emission, technologies of gas recovery and its utilization circumstances at the site of project implementation, and the present situation was clearly described. Based on the result of the said survey, effective gas recovery and control methods are proposed, and especially regarding boring equipment technological switchover from the current short distance boring to the middle distance boring is recommended.

The recovered gas for securing safety in coal mine is in general is in low concentration and shows high fluctuations in both concentration and amount. But by estimating and utilizing such recovered gas most efficiently as much as possible, the introduction of facilities for utilizing gas, which are highly applicable to coal mine gas to be helpful to betterment of enterprise's profitability and contribute to the reduction of global warming gases is herein proposed.

Because this project is a case implemented jointly by and between Japan and Russia, not only technological matters to be born between these two parties but also other collaborations to be adjusted from this time on are mentioned.

1. Plan of project

1.1 Outline of the area as the object of projects

1.1.1 The state of Kemerovo, social/economic situation, energy circumstances and others of Kuznetsk coal basin

(1) The state of Kemerovo

The state of Kemerovo is an area belonging to West Siberia with a large-scale region of coal and other industries, and is adjacent to the state of Altai, the Republic of Khakas, and the state of Krasnoyarsk.

Population	3,063,000 (the 12th in Russia)
Area	95,500 square km (the 31st in Russia)
Capital	Kemerovo City (population 513,000, 1925～)
Other main cities	Novokuznetsk (population 593,000), Leninsk-Kuznetskiy (population 131,000), Kiselevsk (population 125,000)
Ethnic makeup	Russian 90%
Distance from Moscow	3,160 km

1) Politics

The state of Kemerovo is a conservative area with a history of political struggle and labor dispute. The people of state have traditionally voted communists, and the former President Yeltsin was defeated by the Chairman of the Party Zhuggrobin in the presidential election of 1996.

In the summer of 1997 social tension mounted, which led to dismissal of the Governor Kislynk by the President, and change to the former party leader Tuleev of the Kemerovo Party

Tuleev is quite popular in the state of Kemerovo, and he won nearly 95% of the votes in the reelection in October1997. The new governor is a famous communist and Russian nationalist, and is also known for his radical political opinion and anti-market principle. Nevertheless, because he seems to be of surprisingly intimate relationship with the central government, there are also some people who are distrustful of him among orthodox communists.

2) Economy

The natural resources of the state of Kemerovo rank high compared to the national average. The per capita GDP of 12.4 million rubles is better than the average figure of the whole Russia (9.64 million rubles), similar to the per capita exports.

The state of Kemerovo lies in Kuzbass coalfield which is the biggest in Russia with the confirmed deposits of 94 billion tons, and its coal mining industry is the central existence in the economy of the state. The industrial stagnation arose with arrival of the era of post communism, and a serious problem related to payment of coal cost and transportation caused large decrease in the coal production and unpaid wages as well as social tension.

The state of Kemerovo is rich in iron ore, manganese and oil shale. In Novokuznetsk there is a quite developed steel manufacturing complex as well as aluminum and zinc processing industries though their scale are smaller than it. The chemical sector produces bituminous coal for coke, fertilizer and others, while the machine manufacturing sector produces mining equipment. The industries of the state of Kemerovo are supported by three thermal power stations and one hydroelectric power station.

3) Policy for business climate by finance

The finance of the state of Kemerovo is the 14th among 80 areas, and is in better position than other two rankings. Either the per capita income or the federal tax (2.20 million rubles and 1.16 million rubles, respectively) is better than the average, though the differences are not big. The per capita deficit is 88,200 rubles, lower than the average, and the dependence on subsidy is also lower than the average. 78.3% of the expenditure of the state is covered by its own revenue.

The state of Kemerovo: Fiscal figures (1995 and 1996)

	1995	1996
Annual revenue	6,375,690	8,484,184
Annual expenditure	6,455,347	8,735,386
Surplus/deficit	(91,474)	(271,607)

Unit: million rubles ($US 1=4,640rubles, 1995ave.)

The state of Kemerovo appropriated a deficit of 91 billion rubles in 1995, and covered it by borrowing from commercial banks and reduction of budgetary surplus. Annual expenditure increased by 35% in 1996, and the deficit also increased slightly, amounting to about 3.2 % of the annual revenue.
However, this fiscal condition is better than many other local governments. She came to rely on loan from the central government to fill the deficit in 1996.

(2) Social/economic situation, energy circumstances and others of Kuznetsk coal basin

Kuznetsk coalfield is a huge coal producing center next to Donbass coalfield of Ukraine among the countries of the former Soviet Union, and lies in the state of Kemerovo of West Siberia. Because the trans-Siberian railway had been developed, coal mining started approximately in the middle of the 19th century. Kemerovo City lying at the north end of the coalfield, and Novokuznetsk City in the south are important industrial centers.

Kuznetsk coalfield has had the following problems in the course of transition of planned economy to market economy caused by the collapse of the former Soviet Union.

- Reduction of coal market
- Decline of coal price
- Price competition among coal-producing companies
- Shortage of parts necessary for coal mine equipment
- Difficult fund raising
- Labor saving which does not progress
- Unstable quality of coal
- Environmental problem

However, under the present situation that the government of Russia itself faces serious fiscal crisis, rehabilitation of the coal industry does not proceed according to plan, but it rather keeps on deteriorating. Delayed payment of wages of coal mine laborers and unemployment following closing unprofitable coal mines have already been social problem. Coal-producing companies have been wholly responsible for welfare such as school and hospital in the regions in the "system under the umbrella of the big local company", one of the negative legacy of socialistic planned economy. However, present quite weak coal-producing companies can never afford to do so financially as before.

In such hard realities Ministry of Fuel and Energy and the state government of Kemerovo are promoting the following countermeasures.

- Privatization of coal-producing companies
- Improving efficiency of coal production
- Closing unprofitable coal mines
- Correspondence to environmental problem
- Investment of development fund in new hopeful coal mines

Concretely it is planned to produce coal of 400 million tons per annum, and improve production efficiency to 5-10 times by such means as putting coal production on break-even line, and shifting it from focus on raw material coal to that on general coal through implementation of closing unprofitable coal mines and investment in hopeful coal mines by the year 2000, as well as intensifying support to opencast coal mines by the year 2010.

1.1.2 Coal and CBM resources in Kuznetsk Coal Basin

Kuznetsk basin is an extensive intermontane trough in western Siberia, about 2,200km north of Moscow. Siberian continental plate and Tarim micro plate collided during early Carboniferous and early Permian period and formed this Siberian Platform. Coal deposits in Kuznetsk coal basin developed along the trough end running through the south end of Siberian Platform.

The basin has an area of 26,700km^2. The coal seams are contained in the continental layer of Carboniferous, Permian, Triassic and Jurassic period, but we find the majority of the coal seams in the Koltchuginskaya and the Balakhonskaya series, Permian period. We can find plenty of coal seams - there are more than 100 minable seams. (See Table of 2.1-1) The strata consist of clay, sandstone, shale, agglomerate and mudstone, etc.

(1) Coal Reserves

In this region, the main strata we can see are from Paleozoic and Mesozoic (secondary) era, containing rich coal. In the marine sedimentary rock stratum that crops out around the basin, we can see various lower Paleozoid systems from Cambrian to Carbon. In the basin, we can see four series that contain coal: Balakhonskaya and Koltchuginskaya (Paleozoic), Maltsevskaya and Tarbaganskaya (Mesozoic). Especially, Koltchuginskaya and Balakhonskaya series contain rich coal, and are mined commercially.

In Kuznetsk basin, they are dividing the above two coal containing series into 25 coal areas. The areas from 1 to 13 belong to Koltchunginskaya series and they are mining the coal in areas of Anzhersky, Kemerovsky, Bachatsky, Prokop'evsk-Kiselevsky, Aralichevsky, Bunguro-Tchumyshsky, Kondomsky and Tom-Usinsky.

They are mining coal from Balakhonskaya series by open cast and underground method in Leninsky, Belovsky, Uskatsky, Erunakovsky, Tersinsky, Baidaevsky, Osinovsky and Tom-Usinsky areas. (See Fig.2.1-1 General Geologic Map of Kuznetsk Coal Basin)

Generally, the coal from Balakhonskaya series ranges from coking /fat to lean ranks, and the one from Koltchuginskaya series ranges from long flame to coking fat. (See Fig.2.1-2 Distribution of Coal Ranks in Kuznetsk Coal Basin)

Now, among the above 25 areas, we would like to introduce 3 areas that are involved with our main topic this time, the recovery and utilization of CMG. All these 3 coal mining areas are active mining site where they have branches of coal mining companies in Kuzbassugol CPA that we will mention in the coming chapters.

1) Kemerovsky Area

Kemerovsky area is located in the northern part of the basin. The major geological structure of the area is formed by Kemerovskaya syncline. With a complex fold, widened from north to south. The fold is complicated by additional minor folds - Kedrovsko-Krokhalevskaya, Glushinskaya brachysynclines and more intensed Promyshlenovskaya fold, Butovskaya, Rovnenskaya brachysynclines and Biryulinskaya syncline etc.

The eastern wing of Kemerovskaya syncline consists of monoclinal bedding at 15°-20° to 35°-40° sediments dip. Alykaevsky formation is remarkable in its commercial coal bearing capacity, and it contains more than 8 operational coal seams of 0.8-3 m thickness.

The western wing of Kemerovskaya syncline with 35°-50° sediments' dip has complicated structure with additional folds of mainly steep and sometimes vertical wings. The syncline's wing has the biggest displacement of 400-meter amplitude. Commercial coal seams are-contained in the Ishanovsky and in the Kemerovsky formations. The Kemerovsky formation bears 6 to 10 operational thickness coal seams, and Volkovsky seam is the greatest in thickness.

The level of coalification goes up within a stratigraphic cut from upper layers to lower ones, and traversely from east to west. Pervomaiskaya, Biryulinskaya and Berezovskaya mines are developing seams in the eastern wing of Kemerovskaya syncline.

2) Leninsky Area

Leninsky area is located in the western outskirts of central Kuzbass. The area's main structure is wide, flat synclines of Nikitinskaya, Leninskaya and Egozovo-Krasnoyarskaya. In Leninskaya syncline, they are mining the coal in Kirova, The 7th of November, Zarechnaya, Komsomolets, Polysaevskaya, Oktaybrskaya and Kuznetaksaya mines. In Egozovo-Krasnoyarskay syncline, they are mining coal in Kolmogorovskay and Inskaya mines.

Area's coal deposits belong to Erunakovskaya and Ilyinskaya subseries of Kolchuginskaya series. Erunakovskaya subseries consists of three formations and the thickness is less than 1,610 m. Ilyinskaya subseries has the thickness of about 1,540m.

(3) Belovsky Area

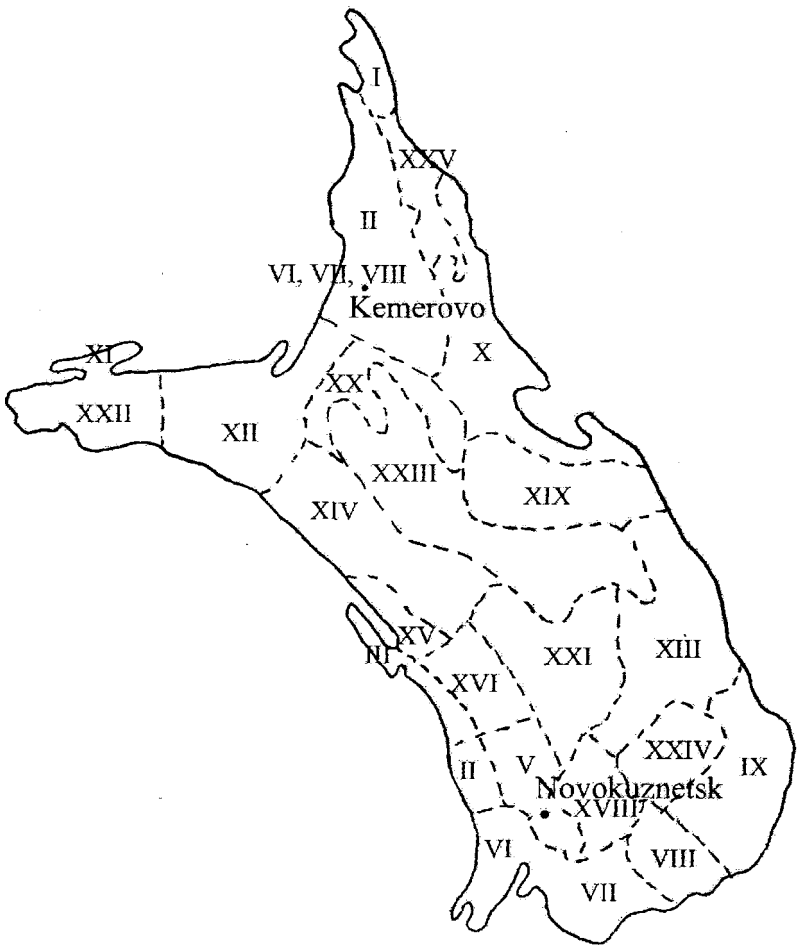
Belovsky area is located in Prisalaeer zone of linear folding. The area has three tectonic blocks divided along strike by Afonino-Kiselevsky and Kutonovsky ramps at 750-3,500m amplitude. The best developed areas in the above blocks are Belovskaya, Chertiskaya and Ubinskaya synclines that are separated by Babanovskaya, Novorossiyskaya and Kalinovskaya anticlines. They have working underground mines of Novaya and Chertinskaya mines in Chertinskaya brachysyncline.

The coal deposits are containd in Kolchginskaya series. There are commercial coal mining seams in Gramoteinsky (8 minable coal seams), Leninsky (3-7 minable coal seams), Uskatsky (8 minable coal seams) and Kazankovo-Markinsky (18 minabele coal seams) formations, and coal seam thickness varies between 0.7-3.8 m.

Table2.1-1 GENERAL STRATIGRAPHY OF COAL BEARING SEQUENCE OF KUZNETSK BASIN

Geological age	Series	Thickness of formation	Development of caol seam		
			No. of oprational coal seam	Total thickness of coal seams	Coal content in formations
Jurassic	Tarbaganskaya Series	800 − 1,800m	3 − 14	3−27m	2.0 − 3.5%
Triassic	Maltsevskaya Series	350 − 1,540m	−	−	−
Permian	Koltchuginskaya Series				
	1. Erunakovsk (sub-series)				
	1-1 Taylugansk Formation	580 − 900m	14 – 29	19 – 129 m	2.7 – 16%
	1-2 Gramoteinsk Formation	320 − 530m	8 – 14	8 – 53 m	1.5 − 10.0%
	1-3 Leninsk Formation	390 − 720m	1 – 15	5 – 31 m	0.7 – 5.3%
	2. Ilinsk (sub-series)				
	2-1 Uskatsk Formation	200 − 540m	1 – 14	1 – 26 m	0.3 – 7.8%
	2-2 Kazankovo-Markinsk Formation	240 −1,400m	0 – 13	0 – 19 m	0 – 1.5%
	3. Kuznetsk Formation	500 − 1,700m	−	−	−
	Balakhonskaya Series				
	1. Upper Balakhonsk (sub-series)				
	1-1 Usyatsk Formation	65 − 290m	5 – 10	2 – 20m	6.0 − 15.0%
	1-2 Kemerovsk Formation	100 − 270m	6 – 9	15 – 51 m	6.0 – 40.0%
	1-3 Ishanovsk Formation	90 − 420m	3 –11	8 – 35 m	7.0 – 8.0%
	1-4 Promezhutochny Formation	90 − 700m	1 – 9	2 – 23 m	1.3 – 5.6%
Carboniferous	2. Lower Balakhonsk (sub-series)				
	2-1 Alykaevsk Formation	85 – 550m	1 – 11	1 – 21 m	0.3 – 5.1%
	2-2 Mazurovsk Formation	70 – 490m	0 – 5	0 – 7 m	0 – 2.8%
	3. Ostrogsk Formation	150 – 1,000m	−	−	−

(Source : Modified from Bikadorov , et al 1980)



Area in Barakhonskays series that have operational coal seam:
I-Anzhersky; II-Kemerovsky; III-Bachatsky; IV- Prokopievsko-Kiselevsky; V-Aralichevsky; VI -Bunguro-Chumyshsky; VII -Kondomsky; VIII-Mrassky; IX- Tom-Usinsky;X- Krapivinsky;XI Zavjalovsky; XII- Titovsky; XIII-Tersinsky

Area in Kolchunginskaya series that have operational coal seam:
XIV-Leninsky; XV-Belovsky; XVI-Uskatsky; XVII-Osinnikovsky; XVIII-Baidaevsky; XIX-Saltymakovsky; XX-Plotnikovsky; XXI-Erunakovsky; XXII-Doroninsky; XXIII-Tsentral'nyj; XXIV-Tutujassky; XXV -Barzasky

Fig 2.1-1 General Geologic Map of Kuznetsk Coal Basin
(Source: Russian Academy of Science Siberian Coal Institute)

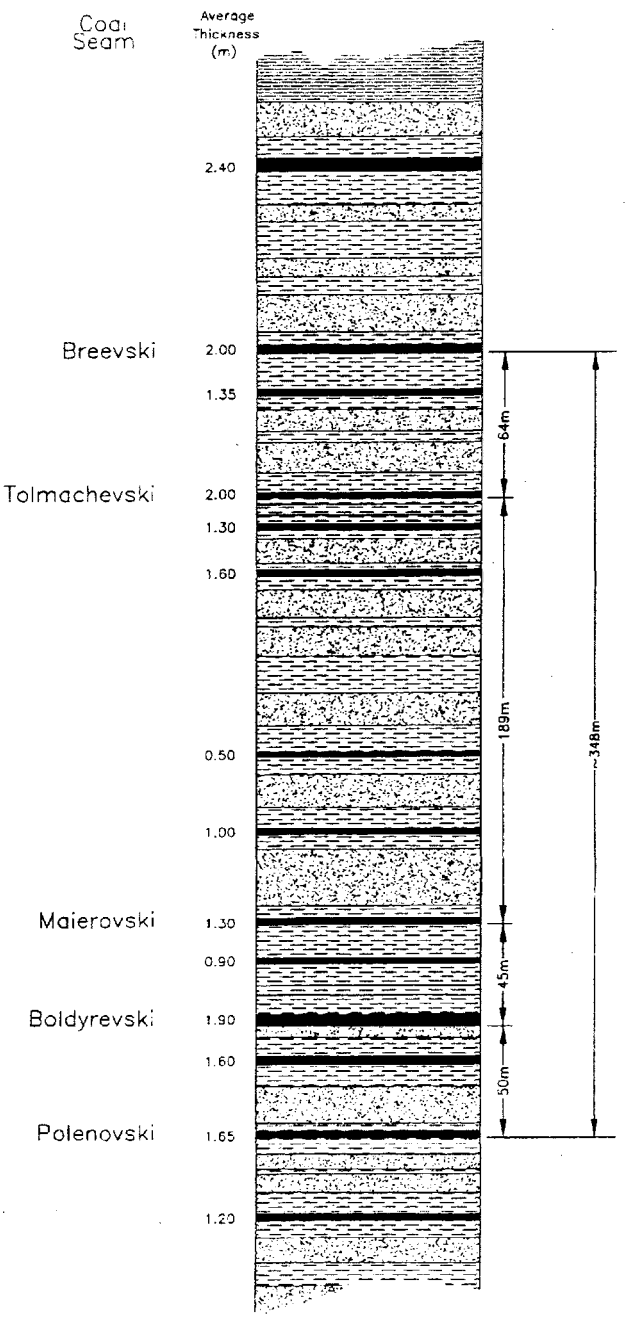
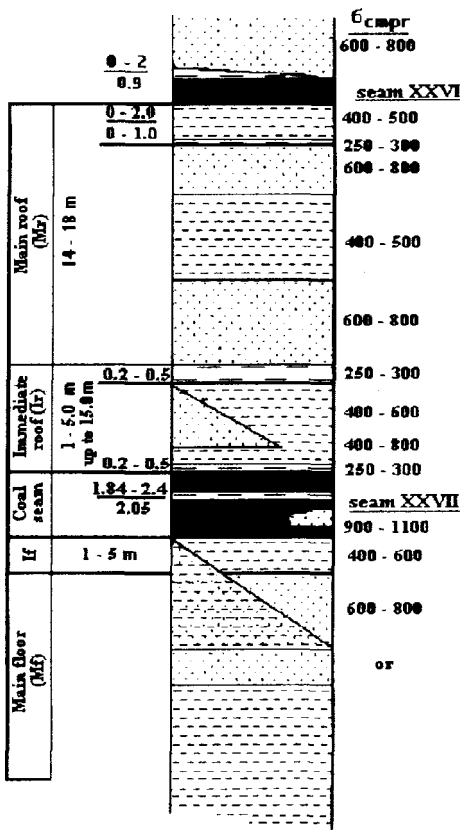


Fig 2.1-3 Stratigraphic Section Lininskaya Formation (Kirov Mine)
(Source:Russian Academy of Science Siberian Coal Institute)



Uniform, gray sand with dissemination of vegetation residue, fissured

Carbon-like clay stone, semi dull coal, durable
Large-grained silt stone

Fine-grained sand stone, light gray, laminated due to detritus or occasionally due to silt stone, or
uniform, cracks free

Large -grain silt stone, dark gray, laminated due to sand, soft fractured

Sand stone dark gray, monolithic with scarce residue of vegetation, soft fractured

Carbon like clay stone interlayered with coal in a roof
Sand stone, gray, dark gray, fine grained due to silt stone and detritus, fractured along stratification

Medium rain silt stone, slim laminated due to sand stone, fissured
Semi-bright coal, laminated with a deformed layer 0.40-0.8 m thick and thin lens, medium rigid

Fine grained, gray silt stone, deformed

Gray sand stone, fine grained, laminated due to detritus, fissured

Silt stone , dark gray, large-grained, laminated due to sand stone, fissured

Fig 2.1-4 Stratigrapic Section Berezovo-Berulinsky Formation (Pervomayskaya Mine)
(Source:Russian Academy of Science Siberian Coal Institute)

(2) CBM Resources

Inferred recoverable coalbed methane resources in Kuznetsk basin's coal seams are estimated 13,085 bn m^3 to an absolute depth of 1,500 m. The average CBM resources density in the estimated area is 716.5mil. m^3/km^2. The volume of potential methane resources in the coal seams of minable thickness is 12,211 bn m^3 (93.3% of coalbed methane in the basin), and those in thin, unworkable ones and interlayers sums up to 875 bn m^3 (6.7% of coalbed methane in the basin).

Table2.1-2 CBM resources in Kuzbass Basin

Volume of CBM resources in Kuzbass Basin (Down to absolute depth of 1,500m)		
In coal deposits with minable seams	12,211 bn m^3	93.3%
In unworkable thin seams and interlayers	875 bn m^3	6.7%
Total	13,085 bn m^3	100.0%

1) CBM Resources in each depth level

Kuzbass's potential methane resources in upper layers (down to 900 m depth) is 7,448 bn m^3 (56.9% of basin's coalbed methane). The volume of the gas possible to recover down to 300m depth is 2,488 bn m^3 (19.0% of coalbed methane of the basin). In deeper layer of the basin (900-1,500 m), estimated methane resource is 5,637 bn m^3. (41.3% of coalbed methane of the basin).

Table2.1-3 CBM resources by depth

Depth	CBM resources	Ratio
~ 300m	2,488 bn m^3	19.0%
300m ~ 900m	4,960 bn m^3	37.9%
900m ~ 1,500m	5,637 bn m^3	43.1%
Total	13,085 bn m^3	100.0%

2) CBM resources per possibility of recovery

* We estimate Kuzbass's CBM volume in P1 category (possible to recover at present time) to 374 bn m^3 (2.8% of coalbed CBM of the basin). This includes CBM resources in balance coal reserves of 166.3 bn m^3 (44.4% of CBM assessed as category P1).
* We estimate CBM volume in P2 category (possible to recover in near future) to 1,572.3 bn m^3 (12% of coalbed CBM of the basin).
* We estimate CBM volume in P3 category (possible to recover in long future) to as much as 11,137.6 bn m^3, which is the majority of total CBM in Kuzbass. (85.2% of total coalbed CBM of the basin).

Table2.1-4 CBM resources by possibility of recorvery

Category	CBM resources	Ratio
P1: Possible to recover now	366.4 bn m^3	2.8%
P2: Possible to recover in near future	1,570.2 bn m^3	12.0%
P3: Possible to recover in long future	11,148.4 bn m^3	85.2%
Total	13,085 bn m^3	100.0%

3) CBM resourses per stratum

Potential CBM resources in Balakhonskaya (6,631 bn m^3) and Kolchuginskaya (6,454 bn m^3) series are almost equally distributed.

But if we see CBM resource in the cut of Balakhonskaya series, it differs greatly across the subseries. For example, methane resource in Upper Balakhoskaya subseries is more than four times greater than in the Lower Balakhonskaya subseries.

Recoverable CBM resource in Lower Balakhonskaya subseries is 1,179 bn m^3 (9% of estimated CBM resource of the entire Kuzbass coal strata down to 1,500 m depth). Among that, the methane resource in workable coal seams is 1,089 bn m^3 (92.4% of methane resource in Lower Balakhonskaya subseries). The methane volume in unworkable coal seams (due to insufficient thickness) and interlayers is 89.6 bn m^3 (7.6%).

Table2.1-5 CBM resources by stratum

Name of stratum	CBM resources 13,085 bn m^3	
Kolchuginskaya series	6,454 bn m^3 (49.3%)	
Operational seams	(6,009 bn m^3)	
Unworkable seams and interlayers	(445 bn m^3)	
Balakhonskaya series	6,631 bn m^3 (50.7%)	
	All Kuzbass zone except Prokopjevsk-Kiselevsk area	Prokopjevsk Kiselevsk area
Upper Balakhonskaya subseries	4,851 bn m^3	Operational seam 567 bn m^3 Unworkable & interlayers 34 bn m^3 Subtotal 601 bn m^3
Operational seams	(4,453 bn m^3)	
Unworkable semas and interlayers	(398 bn m^3)	
Lower Balakhonskaya subseries	1,179 bn m^3	
Operational seams	(1,089 bn m^3)	
Unworkable seams and interlayers	(89.6 bn m^3)	

In all the area except Prokopjevsk-Kiselevsk area, the estimated volume of CBM in the upper Balakhonskaya subseries is 4,851 bn m^3 (37.1% of potential methane in the whole Kuzbass). Among this, the volume in workable seams is 4,453 bn m^3 (91.8 % of CBM methane resource of the subseries), and the volume in unworkable seams and interlayers is 398 bn m^3 (8.2%). In Prokopjevsk-Kiselevsk area, they only estimate the total CBM volume in Balakhonskaya series, not breaking it down to volume in each subseries, and it amounts to 601 bn m^3 (4.6% of estimated CBM resource down to 1,500 m depth in Kuzbass). Among them 567 bn m^3 are in minable coal seams and 34 bn m^3 are in unworkable ones and interlayers .

CBM resource in workable seams in Koltchuginskaya series is 6,009 bn m^3 and the volume in unworkable ones and interlayers is 445 bn m^3 (93.1% and 6.9% accordingly of CBM volume in this series in the whole Kuzbass zone).

Meanwhile, please refer the composition of the recovered coalmine gas to Table 8.1-2a～2d of coal seam condition and gas composition, 3-4 to 3-7 at the end of this report (Appendix).

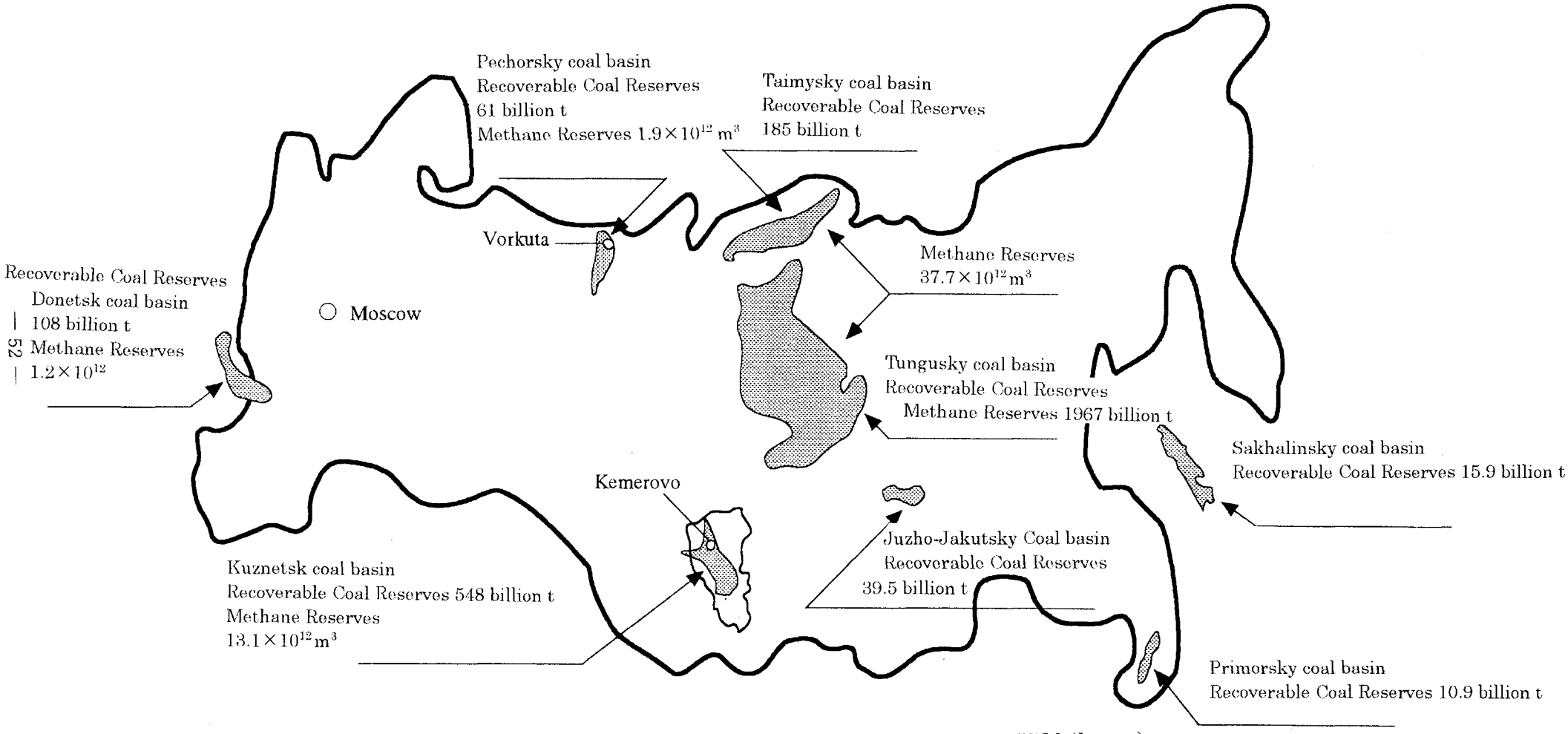


Fig 2.1-5 Hard Coal and methane Deposits of Russia(Source: Russian CBM Center)

(3) Introduction of underground mines in Kuznetsk basin

In 1998, they actually mined coal in 50 underground mines. (Appendix Table8.1-1a~1d: Kuznetsk basin, underground mine statistical data). From the table, you can see the coal output, number of employees, kind of coal and number of gas outburst incidence (368 incidence in 1998). They didn't have any serious gas accident, but it is true that the gas is highly dangerous.

In Fig.2.1-6, we show mines having high specific gas emission. Through this, we can see the necessity of gas recovery and potential benefit of gas resources. In the following table, we show the change of gas emission in each coal production association. The gas emission has gone down rapidly in recent years, but it is because of the decrease of total output of the mine.

Table2.1-6 Change of gas emission in coal production association

Year	Output (1,000t)	Emission from ventilation		Gas drainage from the seam		Total methane generated	
		Gas concentration (%)	Gas content (%)	Gas content (%)	Pure methane (1,000m^3)	(m^3/min.)	(1,000m^3)
1	2	3	4	5	6	7	8
Severokuzbassugol							
1994	5,020	<0.75	67,171.68	3.5 – 90.0	2,733.12	133	69,904.80
1996	4,251	<0.75	41,259.60	3.5 – 90.0	0.00	78.5	41,259.60
1998	2,445	<0.75	24,282.72	3.5 – 90.0	0.00	46.2	24,282.72
Leninskugol							
1994	11,359	<0.75	12,677.72	3.5 – 90.0	83,780.64	400.6	210,555.36
1996	9,965	<0.75	158,557.00	3.5 – 90.0	2,592.00	306.6	161,148.96
1998	8,390	<0.75	165,211.00	3.5 – 90.0	7,869.00	329.3	173,080.08
Belovougol							
1994	4,538	<0.75	61,621.34	3.5 – 90.0	52,223.62	216.6	113,844.96
1996	3,315	<0.75	50,393.10	3.5 – 90.0	4,900.00	105.2	55,293.12
1998	2,900	<0.75	28,009.30	3.5 – 90.0	5,524.00	63.8	22,522.28
Kisekevskugol							
1994	3,874	<0.75	49,369.61	3.5 – 90.0	1,455.91	96.7	50,825.52
1996	3,929	<0.75	22,443.12	3.5 – 90.0	0.00	42.7	22,443.12
1998	2,571	<0.75	21,076.56	3.5 – 90.0	0.00	40.1	21,076.56
Prokop'evskugol							
1994	6,976	<0.75	10,322.84	3.5 – 90,0	9,723.60	214.9	112,951.44
1996	5,261	<0.75	95,974.56	3.5 – 90.0	0.00	182.6	95,974.56
1998	4,700	<0.75	70,167.60	3.5 – 90.0	0.00	133.5	70,167.60
Kuznetskugol							
1994	20,846	<0.75	415,486.80	3.5 – 90.0	44,991.36	876.1	460,478.16
1996	20,035	<0.75	442,856.00	3.5 – 90.0	11,000.00	863.5	453,855.60
1998	19,739	<0.75	359,409.00	3.5 – 90.0	10,088.00	703	369,496.80

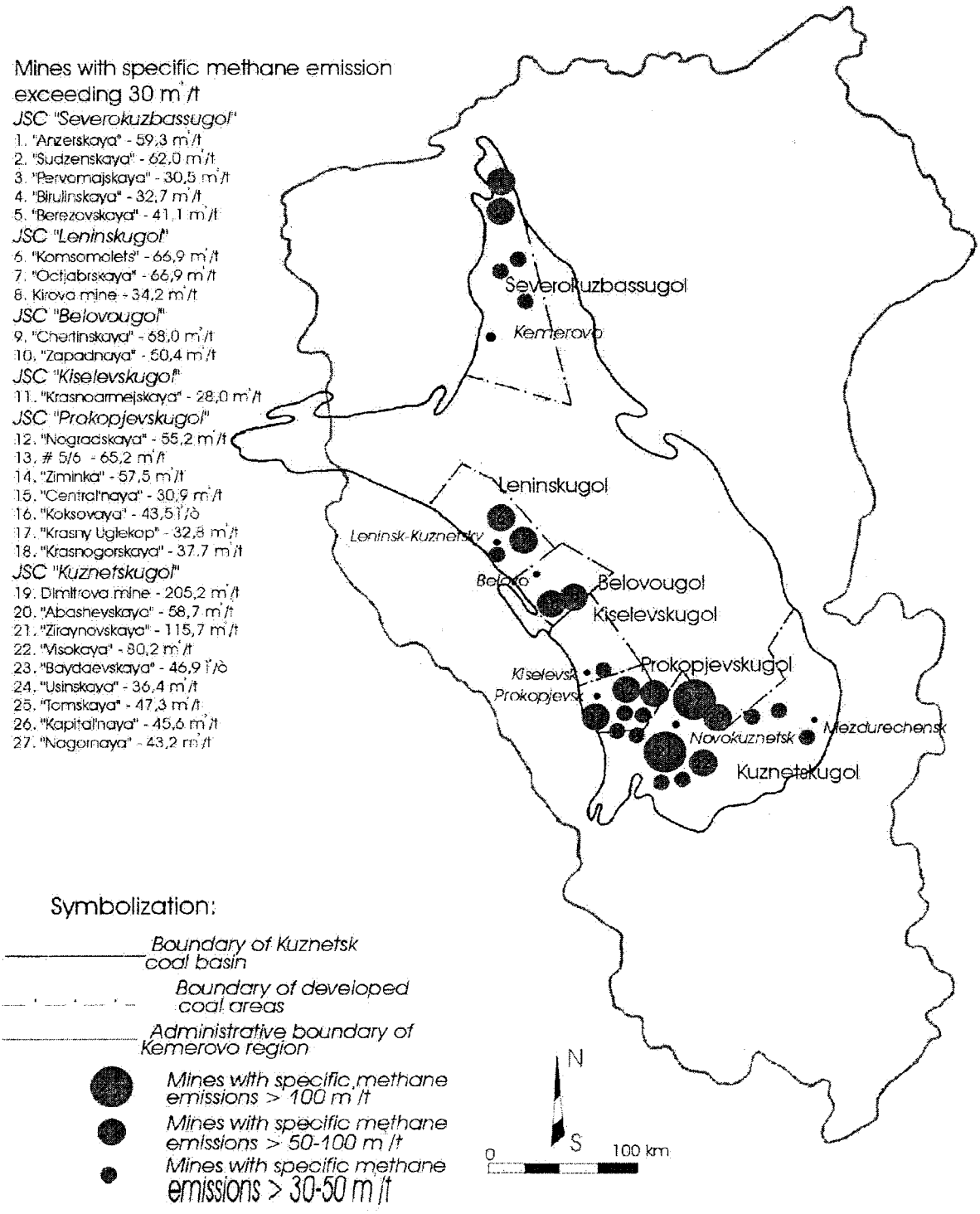


Fig 2.1-6 Mines of Kuznetsk Coal Basin

Viewing the location of production associations and the list of mines and their associations.

(Source: Russian Academy of Science Siberian Coal Institute)

(4) Gas Recovery and Utilization Plan at Kuznetsk coal basin

At Kuzbass, utilization of coal mine methane has been focussed from the viewpoint of solution against an environmental pollution caused by coal combustion and effective energy utilization. To use at the coal mine factory and to use as a fuel for local area heating are planned as its utilization subject. For example, 144 coal burning boilers at Belovo city, 99 at Kemerovo city, 67 at Kiselevsk city, 64 Mezdurechensk city accumulating about 2,000 coal burning boilers are operated in Kuzubass which cause considerably an environmental pollution. About 300 steam boilers at coal mines are able to burn a mixture of coal and methane. Thereby, the air pollution can be reduced annually by the amount described below.

Methane	675,000 ton
Carbon dioxide	3,780,000 ton
SO_2	28,800 ton
NOx	1,400 ton
Dust	123,000 ton

Coal production as major industry at Kuzubass requires a big electric consumption. The electric consumption for the coal production on each coal mines in 1995 is as follows:

Belovougol	284.78MkWh
Severokuzbassugol	637.84MkWh
Prokopjevskugol	864.15MkWh
Kuznetskugol	987.73MkWh
Leninskugol	596.57MkWh
Kiselevskugol	342.24MkWh

Therefore, an electrical power generation by gas engine or gas turbine power generator using coal mine methane is a right substitutable method with low energy consumption and highly efficient electric power generation.

According to a feasibility study, made by the Methane Center of the Institute of Russian Scientific Academy at Kemerovo city, on selected 10 methods to utilize of coal mine methane such as sale of the gas as it is, sale of the concentrated gas, supply to boilers, use for drying coal, heating use and power generation or the like, the most economically efficient process among these utilization methods was a self-use electrical

power co-generation to generate electricity and steam.

The combustion of the mixture with coal in a boiler or utilization in self-use electric power generation of coal mine methane are actually very difficult from the viewpoint of Russian economic status. The reason is that there is no economic structure to gain profit balancing with facility investment and to compensate production costs of electricity and steam with each rate of them.

At Kemerovo state, there is a methane utilization plan classified into three: short-term plan (1-2 years), middle term plan (2-5years) and long term plan (5-10years).
At the short-term plan, methane with concentration as is recovered is combusted with coal in a coal combustion boiler.
At the middle term plan, methane is concentrated, the gas production rate is increased, gas distribution facilities are built and methane is utilized in various industries such as those of power generating facilities by gas or the like.
At the long-term plan, further high quality methane is produced in a great amount and is used as an independent energy source for one more industries.
Therefore, legislation and financial support and others by the central government, research institutes, finance institutions, etc., are required.
A general views on the status of utilizing coal mine methane shows that the use is just on a start line.

Plan for gas recovery and use in Kuznetsk basin

1) Kemerovo state had set up a program for developing and using coal mine gas - "Program to recover commercial methane from mining area and high gas emission coal seams in operating and closing coal mining companies" under Kemerovo state Resolution No. 14, March 30, 1998. The purpose of this program was to cope with the change in coalmine capital caused by structural reformation of coal industry, and to meet the necessity to use coal and gas resources in comprehensive manner.
   It is obvious that Chertinskaya coal mine of Belovougol branch, is most advanced in preparing the implementation of the plan. They are planning the following technological development based on their coal mining experience and high-level expert training.

* Provide methane recovery wells in mined out areas finished mining
* Pre-mining gas drainage technology for the virgin field
* 3,200m-long gas pipeline from methane recovery well to methane using facility
* Stationary vacuum pump station (BBH-150 type pump)
* Methane using facilities: Gas - Diesel Power Generator (Caterpillar - 1,000kW, EP - 200kW)
* Gas - Stand for automobile type SHG-3
* Boiler facilities for coal mine

They evaluated other coalmines and public corporations in terms of actual gas quality and danger of gas outburst, or technical application to achieve coal output and gas recovery volume, and selected Pervomaiskaya coal mine. Presently, they are investigating how to apply technology for using the gas.

2) Russia CBM Center and ICF Kaiser Corp. (USA) have jointly proposed "Coal mine methane emission volume reduction project in Russian Federation - Kuzbass" for United Nations Development Plan (UNDP). In this project, they will select Russian Federation Fuel - Energy Agency for Government Implementing Agency, and Russian Academy of Science - Siberian Branch Coal - Coal Chemical Institute for Executing Agency.

The project has passed stage "A" examination, and now in United Nations Russian Branch (Moscow), they are examining capital financing issues to move forward to stage "B" examination

3) Russia CBM Center and United States Environment Protection Agency (US EPA) are jointly setting up a project of "Financing project for coal mine methane utilization in boiler facilities in Pervomaiskaya coal mine (Severokuzbassugol CPA)".

4) In relation to 1) above, Belovougol branch is setting up "Business Plan" for industrial use of methane gas from their coal mines. Relevant regulations for this are Resolution of the Ministry of Fuel and Energy of Russia Extensive Conference on March 20, 1998, and the Ministry of Fuel and Energy of Russia Ordinance on April 19, 1999.

1.2 The contents of the project

1.2.1 Gas recovery and control project

The current countermeasures for gas at Chertinskaya coal mine rely solely on gas drainage by gob wells from the surface of the earth and on gas dilution by increasing in the quantity of underground ventilation airflow. In order to step up the gas drainage for securing safety and to utilize such recovered gas positively, fortification of gas drainage technologies and introduction of gas control technologies for utilizing recovered gas are required. As for the underground gas drainage technologies, while aiming at the long distance boring technology which is able to deal with high productivity working face that appeared along with the structural reform in Russia now under promotion, at first the introduction of middle-distance technology having proven track record in Japan to make the gas drainage of the whole area in working face length possible and to perform the efficient gas drainage is herein planned. Establishments of the technology of sealing for goaf to supply gas in a stable manner to the gas utilization facilities, while preventing gas leakage into the ventilation air, of gas monitoring system for continuous watch of gas conditions including safety standpoint, and of integrated gas control system which is useful for gas utilization were also planned.

1.2.2 Gas utilization project

At Chertinskaya coal mine of Kuzbassugol, 15 years ago, piping of 3.2 km and vacuum pump station were to be installed in order to recover methane from gob wells at the coal mine and to utilize for mixed firing in steam boiler. When the construction reached approximately to 95% completion, this project came across Perestroika and failed in the end. Later the economic grant of 1,000 kW gas engine from EPA of the U.S.A. was provided and they started power generation for their private use overcoming a variety of difficulties. But little operation was attained due to a very low concentration of methane. At Cheritinskaya coal mine, they are positive about utilization of methane, worked up their own business plan for utilization of coal mine methane and studied about gas turbine power generation, gas engine power generation, mixed firing power generation and supply to steam boiler. They have a plan of capital investment making approaches to the state government yet no materialization has been seen.
Furthermore, the coal production has decreased owing to the economic depression.

Because of the slow-down of gas recovery and lowered methane concentration, it is considered difficult to utilize economically by themselves. Kuzbassugol, the government of Kemerovo State, Methane Center of Science Academy and Department of Fuel Energy of the Russian Federation, all of them expressed their cooperation and expectation for this feasibility study.

1.3 Green house effect gases and others as the subjects

At Cheritinskaya coal mine, a huge amount of methane is emitted along with coal drilling. Methane is one of the major gases of global warming, and therefore recovering coal mine methane and utilizing it for fuel mean the reduction of greenhouse effect gases.

That is, as the result of utilization, methane which gives much effect on warming is annihilated through combustion. In addition, the combustion of methane generates carbon dioxide eventually. The greenhouse effect gases for the subject of the project are confined to methane and carbon dioxide.

1) Greenhouse effect of methane

It is generally known that the figure for assessing how much a certain gas affects global greenhouse effect is indicated as GWP (Global Warming Potential) of that gas. The GWP is a coefficient, which assesses how much the greenhouse effect is per the same weight as carbon dioxide. The GWP, as shown by the following formula, differs in its figure according to the assessing time (time after emission of warming gas).

In general, the global warming exponent of a subject gas is indicated as below;

$$GWP(j) = \frac{\int_0^n a_j c_j dt}{\int_0^n a_{CO_2} c_{CO_2} dt}$$

In the above formula, 'aj' stands for the heat radiation ability of compared gas j per concentration unit, and 'cj' for the concentration of compared gas. 'dt' stands for the time after emission of the gas 'j', and 'n' for the year after emission. The denominator indicates the figure in question of carbon dioxide as the subject.

When GWP is calculated regarding methane, the result becomes as below;

GWP	20 years	63
GWP	100 years	21
GWP	500 years	9

These figures include yet some uncertainty of ±35%.
In the IPCC manual the GWP figure of 100 years is adopted.
And in this Report also, the GWP figure of 100 years about methane, i.e. 21 is adopted.

2) Carbon dioxide

By combustion of coal mine methane, carbon dioxide at equal mole with methane is generated as shown in the following formula:

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

The carbon dioxide generated as above is assessed for the global warming gas that generates from the concerned utilization facility of coal mine methane.

2. Outline of Implementing Site (Companies)

(1) The outline of Kuzbassugol

1) Kuzbassugol was established in July of 1999 amalgamating its 3 branches, Belovougol, Leninskugol and Severkuzbassugol. Because of short time from the inaugulation, its substance of finance has not yet been published.

Mr. Mazikin:	The First Vice-Governor of Kemerovo state government
Mr. Bereznev:	ditto
Mr. Zaidenvarg:	Director of reorganization and elimination of non-profitable mines and open-pits (Coal committee, Ministry of Fuel and Energy)
Mr. Lukjyanov:	Head of Division (ditto)
Mr. Voziyanov:	Deputy Head of Division (ditto)
Mr. Burakov:	ditto
Mr. Denisenco:	President of Kuzbassugol
Mr. Zolotykh:	Technical Director (Kuzbassugol)
Mr. Loukart:	Deputy Head of Division (ditto)
Mr. Dobrov:	President of Belon
Mr. Zubritsky:	President of Koks

2) Production of coal

(Actual production)	14,973,000 tons/year	1999
(Estimation)	15,210,000 tons/year	2000
	17,128,000 tons/year	2001
	18,823,000 tons/year	2002
	21,618,000 tons/year	2003
	24,234,000 tons/year	2004
	24,380,000 tons/year	2005

(2) Outline of Belovougol

Belovougol is based on Belovo (population approximately 200,000) in the Kemerovo Region in the central west of the Kuzbass Basin, operating coal mines. This organization was formed in 1990 as a coal production association (CPA), after reorganizing the coal mines that belonged to one of the coal production associations in the Kuznetsk Basin. Belovougol CPA had six working coal mines until recently (all are underground mines), and two of them were closed one after another in the recent years.

This year (July 1999), Belovougol merged with Leninskugol CPA, located in the neighboring mine area, and Severouzbassugol CPA, located in the north of Kuzbass, and a new company called Kuzbassugol* was established (see Fig 2.2-1: Location of Coal Production Associations). The new company has been financed by the following organizations.

Russian Federation Property Administration Committee:	77.9%
Kemerovo Region Property Administration Committee:	16.2%
Private individuals:	5.9%

The official role of Belovougol, therefore, is the Belovougol branch function of Kuzbassugol. Coal produced by Belovougol in the Belovo area is used for coke, iron making, thermal plants, power plants, and municipal service facilities.

*See Table 2.2-2 Coal Mines under Kuzbassugol.

2.1 Extent of concern of implementing site (companies)

Belovougol Company has expressed in writing strong interest concerning [Promotion of Project for Recovery and Utilization of Methane at Coal Mines], which is due to the following background.

- Introduction by Belovougol of power generating facility manufactured by Caterpillar. Positive stance for recovery/utilization of methane at coal mines
- The support as the state government to Belovougol by the Department of Energy of

the state government of Kemerovo. Designation of Chertinskaya coal mine as "Coal mine in need of measures for methane at coal mines"

- Joint establishment of "Russian CBM Center" by US Environmental Protection Agency with Russian Science Academy. The concern of the USA about this subject can be guessed.
- Russian CBM Center recommended Chertinskaya coal mine of Belovougol to be objected, and disclosed various data supporting the F/S this time.
- The state government of Kemerovo expects the ripple effect of this matter. In Kuzbass coalfield, Pervomaiskaya coal mine of Kuzbassugol and Abashevsk coal mine of Kuznetskugol were similarly designated as "Coal Mines in need of measures for methane at coal mines".
- Governor Taleev of the state government of Kemerovo has already addressed a letter to Ministry of Fuel and Energy requesting early realization of this subject.
- Support to this subject by Ministry of Fuel and Energy. Concretely "Comprehensive Solution of the Extraction and Utilization of Methane at Coal Mines of Russia" was drawn up by the Ministry. A promise of "Ministry of Fuel and Energy will in any case support the coal industry" has been obtained from the former Vice-Minister Telegina of Ministry of Fuel and Energy.
- Kuzbassugol is the state enterprise of coal production under the control of the Ministry of Fuel and Energy, which has also its deep interest in the progress of this project.
- The concern of Gazprom which will study CBM development at Kuznetsk coalfield
- Expectation of coal producing companies to "Kyoto Protocol". Expectation to a possibility that recovry of methane at coal mines will create the value of money by emission right trading of greenhouse effect gas
- Creation of new employment. While the unemployment of coal mine laborers following close of unprofitable coal mines becomes a social problem, the labor force to be engaged in management and operation of the newest facility scheduled to be introduced will be necessary.
- Correspondence to environmental problem. Electricity so far purchased from coal-fired thermal power stations will be unnecessary by obtaining electricity necessary in pit from power generating facility utilizing methane. Accordingly, air pollution problem caused by exhaust gas such as SO_X, NO_X and CO_2 will be alleviated.

2.2 Status of related facilities at the implememting site

2.2.1 Coal and mine gas from Belovougol

The company currently operates four coal mines. The main coal seams are found between the measures of Balakhonskaya series and Kolchuginskaya series of the Permian period to Carboniferous period. Coal deposits are folded, and coal seams are enclosed in a closed synclinal structure. Coal mines of Chertinskaya and Novaya are located in the Chertinsk coal field, producing coking coal (the recently closed Zapadnaya coal mine is located in this field). On the other hand, coal mines of Inskaya and Kolmogorovskaya are located in the Egozovo Krasnoyarsk coal filed, producing general coal.

(1) Chertinsk Coal Field

This coal field has its axis running from northwest to southeast, having an extended wing into northeast and a short wing into southwest, forming the asymmetric synclinal folds on a short axis in the area of 8 km by 3 km. The inclination of folded legs varies in the range between 25 and 50 degrees in the angle, making slow inclination at the end of the fold between 5 and 10 degrees. No major rifts are found in the area of the short axis syncline.

The coal measures contain alternated seams of sand stones and silt stones. Other parts consist of layers of mud stones, coal seams, and thinner layers of these within them. The main coal measures consist of 13 coal seams of 0.5 meters or more in thickness. The main working coal seams are enclosed in the upper horizon of the measures, consisting of five coal seams (#2, 3, 4, 5, and 6) of 1 to 3 meters in thickness. The coal seams are located at the depth between 100 and 600 meters.

The Chertinsk coal field produces coking coal (with the brand name of Ж). The coal properties are as follows: ash (32.3-32.5%), moisture (6.5-7.0%), sulfur (0.5%), volatile matter (38%), calorific value (8,300 kcal/kg, daf-base), plastic layer thickness (30 mm for the Y index indicating the maximum thickness of plastic layer).

As of January 1, 1999, the coking coal deposits amount to 63,015,000 tons for the balance reserves, and 39,041,000 tons for the industrial reserves. Belovougol claims

that the deposit lasts for the next 15 years in this field, with the methane resources of 4 billion cubic meters. The coal production plan for the year 2005 and after is not known, but it is believed that the amount of the remaining coal deposits is rather small.

(2) Egozovo Krasnoyarsk Coal Fields

The Egozovo Krasnoyarsk coal field operates two coal mines. Kolmogorovskaya is located on the northeast wing of the Mokhovo Pesterevsk anticline in the field, and Inskaya is located on the southwest wing of the Egozovo Krasnoyarsk syncline. The working coal seams run at the dip from 5 to 10 degrees at Kolmogorovskaya, and from 10 to 20 degrees at Inskaya.

The coal measures contain layers of sand stones, silt stones and mud stones. The main coal measures contain 26 coal seams of 1.2 to 7.0 meters in thickness. The coal seams are located at the depth between 180 and 300 meters. This field produces general coal (with the brand name of Д , Г and ДГ). The coal properties are as follows: ash (15.6-18.3%), moisture (10.2-11.6%), sulfur (0.2-0.7%), volatile matter (43-45%), calorific value (7,600-7,700 kcal/kg, daf-base).

As of January 1, 1999, the general coal deposits amount to 475,121,000 tons for the balance deposit, and 397,952,000 tons for the industrial deposit. Belovougol claims that the deposits last for the next 180 years in this field, with the methane resources of 8.5 billion cubic meters. The coal production plan is not known, but it has a large coal deposits. On the other hand, the gas output is not large enough to raise potential for the recovery and use of the gas from the two mines (Table2.2-1 Summary of Belovougol Mines).

Table2.2-1 Summary of Belovougol Mines (1994)

Mines	Coal production (10^3 t)	Gas emission (10^6 m^3)			Specific gas emission (m^3/t)
		Discharged	Extracted	Total	
Chertinskaya	880	27.6	34.1	61.7	70.1
Inskaya	1,720	3.0	0.0	3.0	1.7
Kolmogorovskaya	255	3.4	0.0	3.4	13.3
Novaya	789	11.7	3.3	15.0	19.0
Source: PIER, 1995, EPA Report 1996					

Note: In addition to four mines listed in the table, Pionerka (specific gas emission of 9.9 m^3/t) and Zapadnaya (specific gas emission of 60.0 m^3/t) were in operation in 1994, but they were closed later.

Table2.2-2 Coal Mines under Kuzbassugol (based in Kemerovo city) (1998 data)

Mines	Coal production (1,000 tons)	Gas emission (m^3/min)	Mining depth (max. meters)	Gas content (m^3/t)*
Severokuzbassugol				
Fizkulturnic	380	0.86	550	13 ~ 15
Sibirskoye	550	1.94	395	12.5 ~ 14
Pervomainskaya	750	15.85	580	18 ~ 25
Berezovskaya	495	18.41	410	20 ~ 23
Volkova	270	7.03	290	11 ~ 14
Lenninskugol				
Kirova	2,119	60.4	500	18 ~ 23
Koltchuginskoye	815	6.5	480	16 ~ 18.5
7th November	1,948	32.6	305	13 ~ 16.5
Jaroslavskogo	480	17.1	570	19.8 ~ 21
Komsomolets	830	85.8	450	16.5 ~ 19
Zaretchnaya	520	9.7	260	12 ~ 15
Polysaevskaya	1,448	48.5	405	15 ~ 18
Oktyabrskaya	1,130	68.7	360	13 ~ 16.5
Belyougol				
Chertinskaya	550	44.04	630	21 ~ 27
Novaya	580	21.9	400	18 ~ 24
Kolmogoroskaya	540	5.24	300	14 ~ 16.5
Inskaya	1,230	4.48	330	13 ~ 15.5

* Gas content at the maximum depth (dry ash free m^3/t)

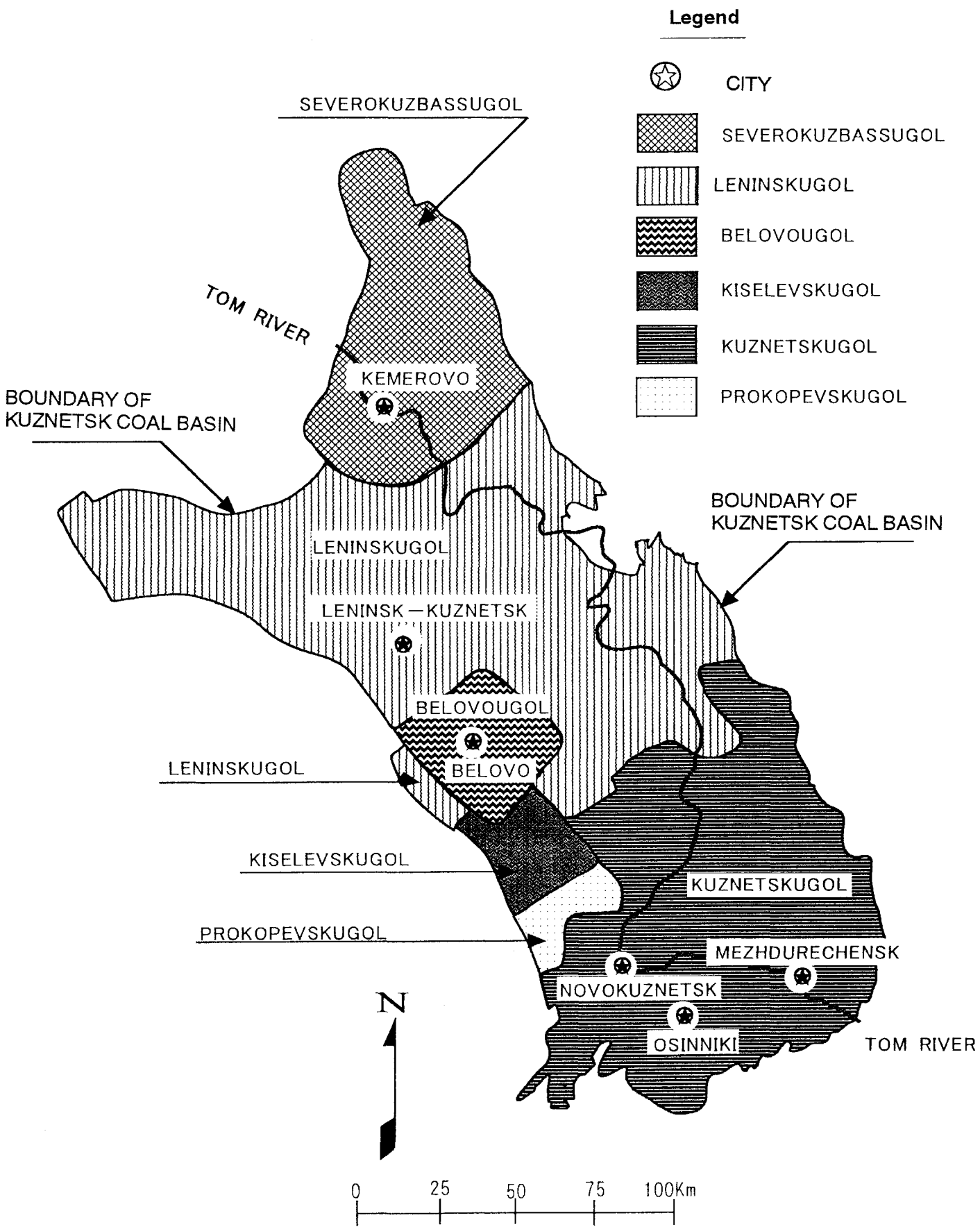


Fig 2.2-1 Location of Coal Production Associations in the Kuznetsk Coal Basin in Russia
(Source:Skochinsky Mining Institute)

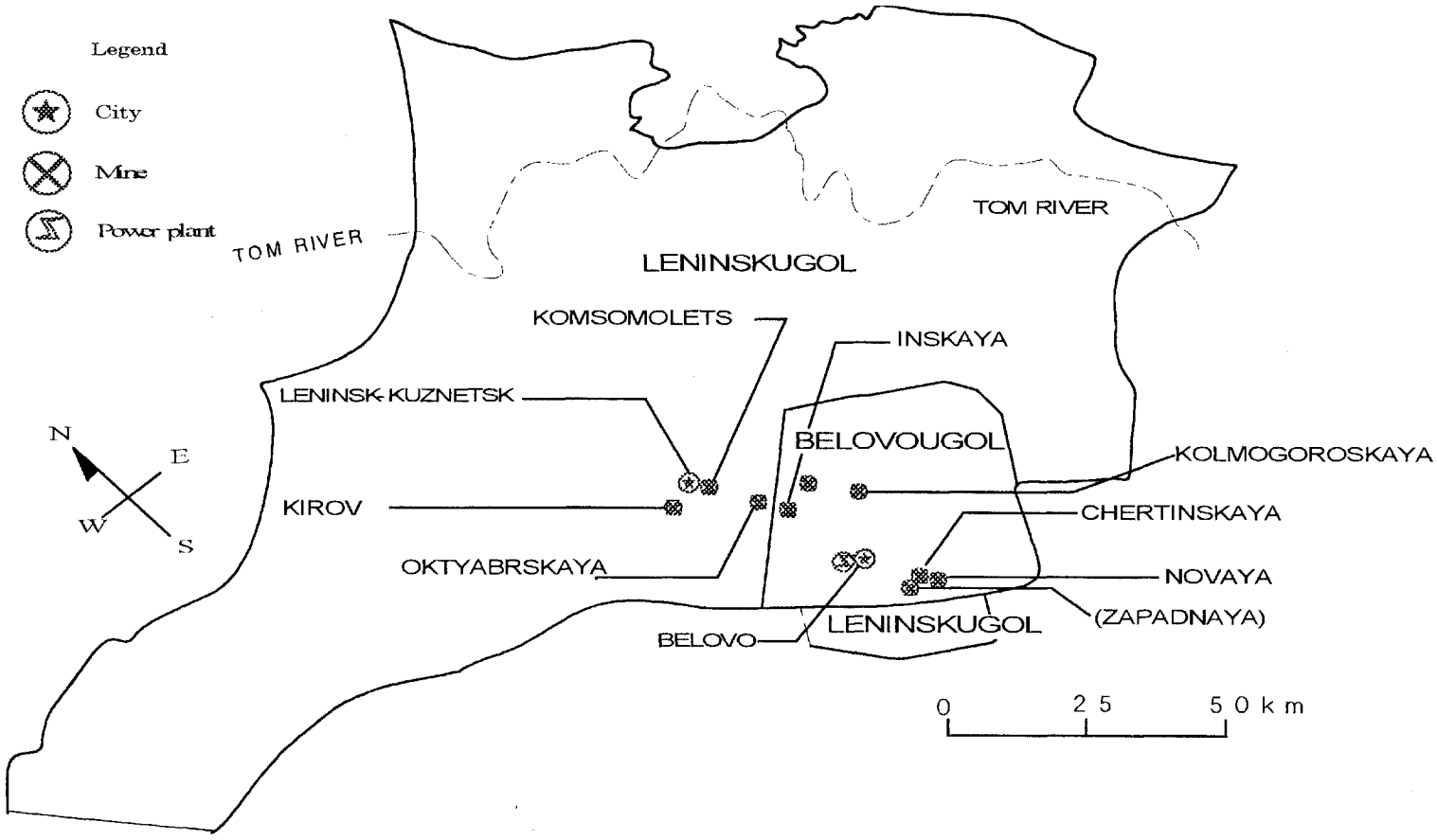


Fig 2.2-2 Velovougol and Leninskugol Coal Production Associations

Source: Skochinsky Mining Indstitute

: EPA Report 1996

2.2.2 Outline of Belovougol coal mines

(1) Chertinskaya

Chertinskaya began to produce coal in 1952. The mine was expected to produce 1.1 million tons a year, but it stagnated down to 0.5 to 0.7 million tons in the recent years due to economic and other circumstances around the mine. Mining has been completed in the area close to the surface, and currently the coal seams #2, 3, 4 and 5 are reached, which are the deepest seams in the central area of the field. As of January 1, 1999, Belovougol estimates the balance reserves at 36,422,000 tons with the methane resources of 2.5 billion cubic meters.

(2) Novaya

Novaya began to produce coal in 1956. It plans to produce 750,000 tons a year. Currently, mining activities are undertaken in the southeast wing of the Cherchinsk field. Belovougol plans to add the coal seams #4 and 5, containing the balance reserves of 2,380,000 tons. For the future, the company plans to develop the balance reserves of 48,250,000 tons, consisting of thin seams of 0.8 to 1.0 meters in thickness. The company estimates the methane resources at 500 million cubic meters.

(3) Kolmogorovskaya

Mining activities are undertaken in the northeast wing on the Mokhovo Pesterevsk anticline in the Egozovo Krasnoyarsk field. As of January 1, 1999, it has the balance reserves of 365,275,000 tons in eight seams that are to be mined. Currently, mining activities are undertaken with two seams. The demand for coal is strong. It estimates the methane resources at one billion cubic meters.

(4) Inskaya

Inskaya is located in the middle of the Egozovo Krasnoyarsk field. It went into operation in 1956, planning to produce 1.5 million tons a year. As of January 1, 1999, it has the balance reserves of 409,849,000 tons of steam coal. Eight coal seams are available, and four of them are to be completed in the near future. Belovougol assumes that it could produce 2.5 million tons a year with the introduction of new technologies. It estimates the methane resources at 7.5 billion cubic meters.

Table 2.2-3 Coal Production (Actual and Plan)

(Unit: 1,000 tons)

Mines	1994	1995	1996	1997	1998	1999	2000
1) Chertinskaya							
Raw coal	880.3	700	445	547	550	678	700
Clean coal	530	398	262	318	302	358	421
2) Inskaya							
Raw coal	1,719.7	1,392.7	1,424	1,338.2	1,231.8	1,500	1,800
Clean coal	374.9	213.7	89.4	66.8	108.3	90	140
3) Kolmogorovskaya							
Raw coal	254.6	515.6	632	677.1	583.3	550	500
Clean coal	-	-	-	-		-	-
4) Novaya							
Raw coal	786.8	842.7	639.4	607.6	546.5	608	630
Clean coal	387	464	359	330	275	401	392
5) Pionerka							
Raw coal	464.9	138.9	-	-	-	-	-
Clean coal	305	89	-	-	-	-	-
6) Zapadnaya							
Raw coal	433.3	518.1	300	159.8	59.8	-	-
Clean coal	248	328	179	98	37	-	-
Total							
Raw coal	4,539.6	4,108	3,440.4	3,329.7	2,971.4	3,336	3,630
Clean coal	1,844.9	1,492.7	889.4	812.8	722.3	849	953

2.2.3 Gas recovery technology and equipments of Chertinskaya mine

(1) Outline of the coal mine

As it is mentioned before, there are five coal mines in the Chertinskaya coal field, including Zapadnaya that has been closed. Chertinskaya, which is the subject of this investigation, has a large amount of gas, and operates mining in the northeastern part of the field where coal seams are well developed on a rather gentle inclination.

1) Spudding method

The working area is reached through shafts and then through either level or inclined drift. In addition to five shafts for the main ventilation system equipped with fans, several shafts are available for the intake and discharge of air. Main exhaust fans are provided to three of the five shafts with fans, and pressure fans are available for the remaining two shafts (used for transport of workers and equipment and for coal unloading skips). During the winter, warm air is supplied into the mine through these two shafts, after air is passed through steam fins. The main inclined gallery consists of three drifts: an air way, a transportation way, and a coal conveyor belt way. Mining depth is between 400 and 650 meters.

2) Mining method

Coal is mined with retreating longwall caving method, in the direction of the strike. The panel length is generally between 500 and 1,200 meters, and the length of working face is between 120 and 150 meters. The mine is promoting modernization of the face operation, introducing a fully mechanized system, using a double ranging drum shearer, called the combine, and a self-advancing support, called the complex. The following table shows the specifications of the #563 longwall face that was witnessed during the visit to the mine.

Table2.2-4 Specifications of #563 Longwall Face

Face parameter:		Face Equipment:
Working height:	2 meters	Self-advanced support:
Working coal seam:	#5 seam	Polish made shield support
Coal seam dip:	0-8 degrees	(Glinik frame width: 1.5 meters)
(currently 6 degrees toward one end of the pan)		Two-legged telescopic type.
Face length:	150 meters	Model: OKP-70 (?)
Panel length:	900 meters	Coal getting machine:
Productivity:	1,000 t/day	Russian made double ranging shearer
	(2,000 t/day planned)	Cutting motor: 105 kW x 2
	40 workers/day	Rack pinion driven,
Face ventilation volume: 660-2,016 m^3/min		Model: 2GSH-68

A heading machine called GPKS is used for driving, which is cutting coal and soft rocks, also loading them.

Specifications of GPKS:

Power 660V

Cutting motor 45 kW or 55 kW (selected depending on the cutting hardness)

Drive motor

Loading motor

Hydraulic motor

3) Production in the recent years

Coal is currently produced from two longwall faces and three drilling sites. Although a fully mechanized system is applied as it is mentioned above, the cutting capacity of the coal getting and heading machines is much lower than those employed in the U.S.A., Australia, or Japan, due to the size of the motor used. In addition, the productivity is extremely poor due to the stagnating coal market, insufficient availability of the gas drainage equipment, and high volume of gas content. The production cost will be further increased to restrain the management, if the current conditions remain unchanged. The working face advances 60 to 65 meters every month for the #563 longwall where a visit was made (producing 1,700 tons a day with two longwall faces in 1998). Regular advancement of the working face is needed for effective and stable gas recovery/utilization.

* The mine has danger of sudden outburst of coal and gas, associated with the danger of coal dust explosion. Introduction of an effective gas drainage equipment and technology is indispensable to maintain the operation of the mine.

Chertinskaya produced the maximum of 1.9 million tons in 1988, and maintained this level for a while (1.82 million tons in 1989). As the Soviet Union collapsed, the coal production dropped in 1991. In the past, the mine probably ensured the production volume by increasing the number of working faces, but for the future the productivity should be taken into account, aiming at the maximum production with the minimum working faces and improving the overall control and other systems.

Table2.2-5 Recent Production of Chertinskaya (Planned figure for 1999)

	1990	1991	1992	1993	1994
Coal production (1,000 t/year)	1,755	926	1,096	1,135	880
	1995	1996	1997	1998	1999
Coal production (1,000 t/year)	700	450	700	550	678

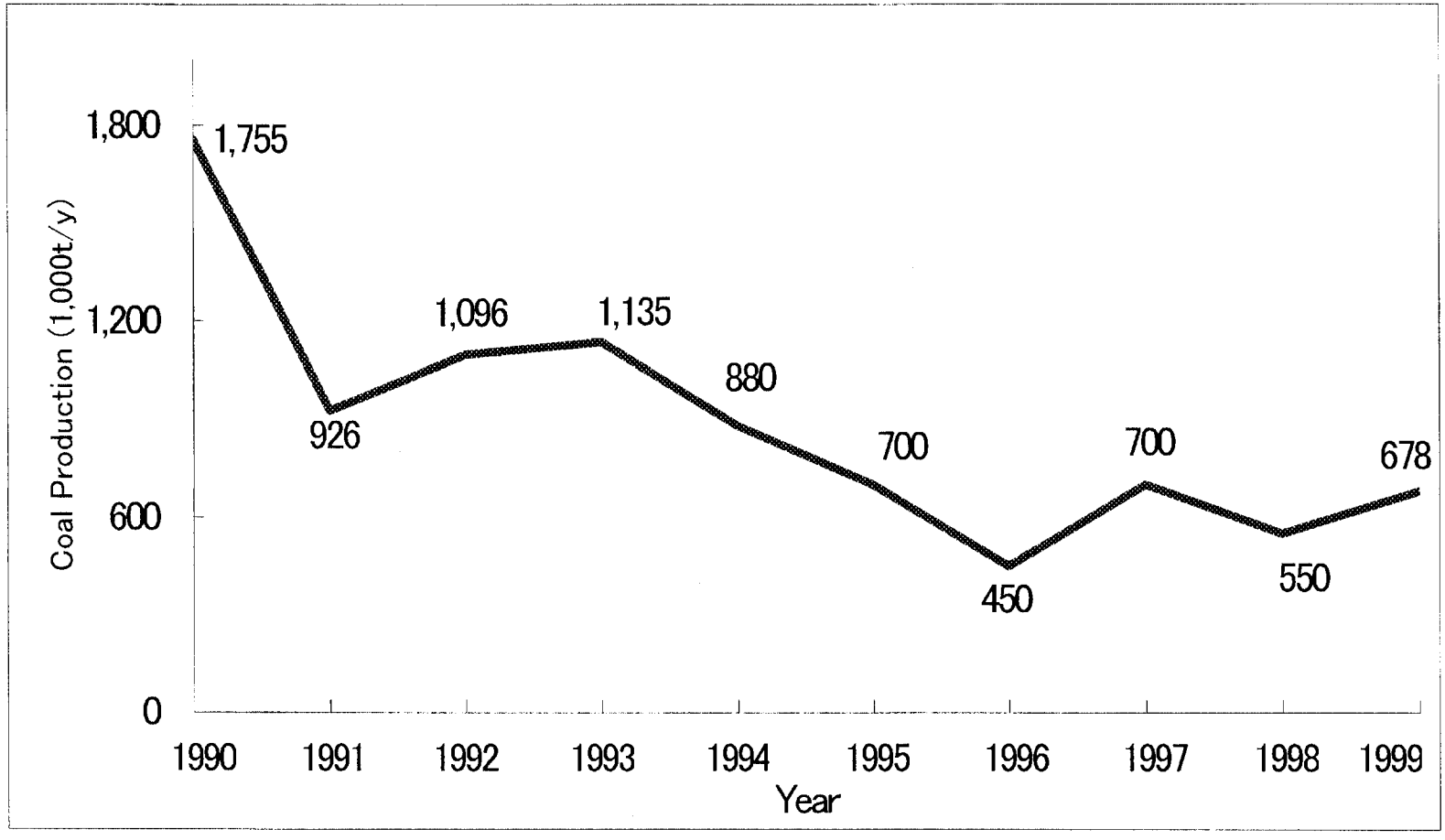


Fig2.2-3 Recent Production of Chertinskaya (Planned figure for 1999)

(2) Geology and CMG Resources

The main working seams for Chertinskaya are the seams #2, 3, 4, and 5. Also, the seams #1, 3a, and 6 are available as the main seams. These coal deposits belong to the Kolchuginskaya layer group, with the coal seams in the range of 0.7 to 3.01 meters in thickness. The rock layer, found in the top and bottom pans in the coal layer, consists of alternated layers of sand stones and silt stones. The interlayer distance between coal seams is narrow for the coal seams #4 and 5, and it is approximately 35 meters. This is one of the reasons for the large emmision of gas during mining, especially for these two seams.

The gas content is greater with these two coal seams, and they are the major sources of CMG. No measurement data is available for the coal seam permeability, but it is expected to be relatively high, since gas can be removed from the unworked area.

The mine is drawing attention, as one of the most suitable sites for the recovery and utilization of gas in the Kuznetsk Basin, because it is relatively easy to recover gas as mentioned above, and also it offers a high density of CMG resources per unit area (0.8 to 1.2 billion m^3/km^2 in Chertinskaya). For the total CMG resources, the gas reserves amount to 2.5 billion cubic meters as described above for the development of coal mine, but the quantity of the available CMG resources including 1,800 meters underground is the largest in the central Kuznetsk Basin, see Table2.2-6.

Table2.2-6 Total CMG Resources for Coal Mines in the Central Kuznetsk Basin

	CMG Resources (billion m^3)	
	Forecast (app. 1,800m)	Industrial
Belovougol	380.0	8.26
Chertinskaya	280.0	5.355
Kolmogorovskaya	92.0	0.51
Zapadnaya*	89.2	1.3
Novaya	71.0	1.1
Leninskugol	640.0	29.3
Kirova	132.0	6.9
Komsomolets	96.0	8.7
Oktyabrskaya	111.0	5.4
Polysaevskaya	79.0	2.3
7-go Noyabrya	32.0	2.7
Kolchuginskoe	112.0	1.9
Yaroslavskogo	78.0	1.4

* Closed in 1998.

Source: Mines of Coal Mining Stock Companies "Belovougol" and "Leninskugol," N.N.Krasyuk, S.S.Zolotykh, A.I.Zharov, D.I.Zhmurovsky (1999)

Table 2.2-7 Chertinskaya Colliery Parameters of coal seams and recovered gas

Main working coal seams	Name of Coal seams	Thickness (m) Max.	Ave.	Min.	Seam dip (°- °)	Working depth (m)	Gas content (m^3/t)	Coal quality	Recovered gas composition
	2	1.44	1.33	1.13	0 - 18	350	15 - 21	Typical quality	Analysis data (%)
	3	3.01	2.74	2.13		505	18 - 24	Coal rank Rich coal	CH_4
	4	1.95	1.5	1.26		537	19 - 29	Moisture: 6.5 %	C_2H_6
	5	2.36	2.0	1.62		626	22 - 32	Ash: 32.3%	C_3H_8,
								Volatile matter 38%	C_4H_{10im}
Other main coal seams	1	1.23	0.96	0.70			3.3 - 16.2	Fixed carbon	CO_2
	3a	1.16	0.88	0.70			0 - 20	Total sulfer 0.5%	CO
	6	1.13	0.85	0.70			6 - 25	Heating Value 8,300 kca/kg	N_2
									O_2
									H_2S
									Note: Sampling place

Table 2.2-8 Chertinskaya Colliery Parameters of coal seams and recovered gas

	Coal seams	Seam thickness (m) Max.	Ave.	Min.	Inclination (°- °)	Mining depth (m)	Gas deposit (m^3/t)	Coal quality	Recovered gas chemistry
Main working coal seams	3	3	2.7	2.3	0 - 13 Ave. 8	480	20	Typical quality	Analysis (%)
	4	1.6	1.5	1.4	12 - 13 Ave. 12	380 - 520	18 – 20	Coal rank Rich coal	CH_4 - 80
	5	2.4	1.8	1.6	28 - 13 Ave. 5	490 - 610	20 – 22	Moisture: 1.9-3.5%	C_2H_6 - NA
								Ash: 18-28.5%	C_3H_8 - NA
								Volatile matter 36.3-38.7%	C_4H_{10im} – NA
Other major coal seams	1		1.5		Ave. 9			Fixed carbon 85.4-86.9%	CO_2 - 2.5
	2	1.5	1.3	1.2	Ave. 19			Total sulfer 0.4-0.5%	CO - 0
	3a		0.6		Ave. 22			Heating Value 8,500 kca/kg	N_2 - 12.2
	6	1.1		0.7	Ave. 22				O_2 - 5.3
									H_2S - NA
									H_2 - 0
									Sampling location: Vacuum pump Station No.14, #318 L/W face *

* Sampling #3 coal seam, 1992.

Scale: 1/2000

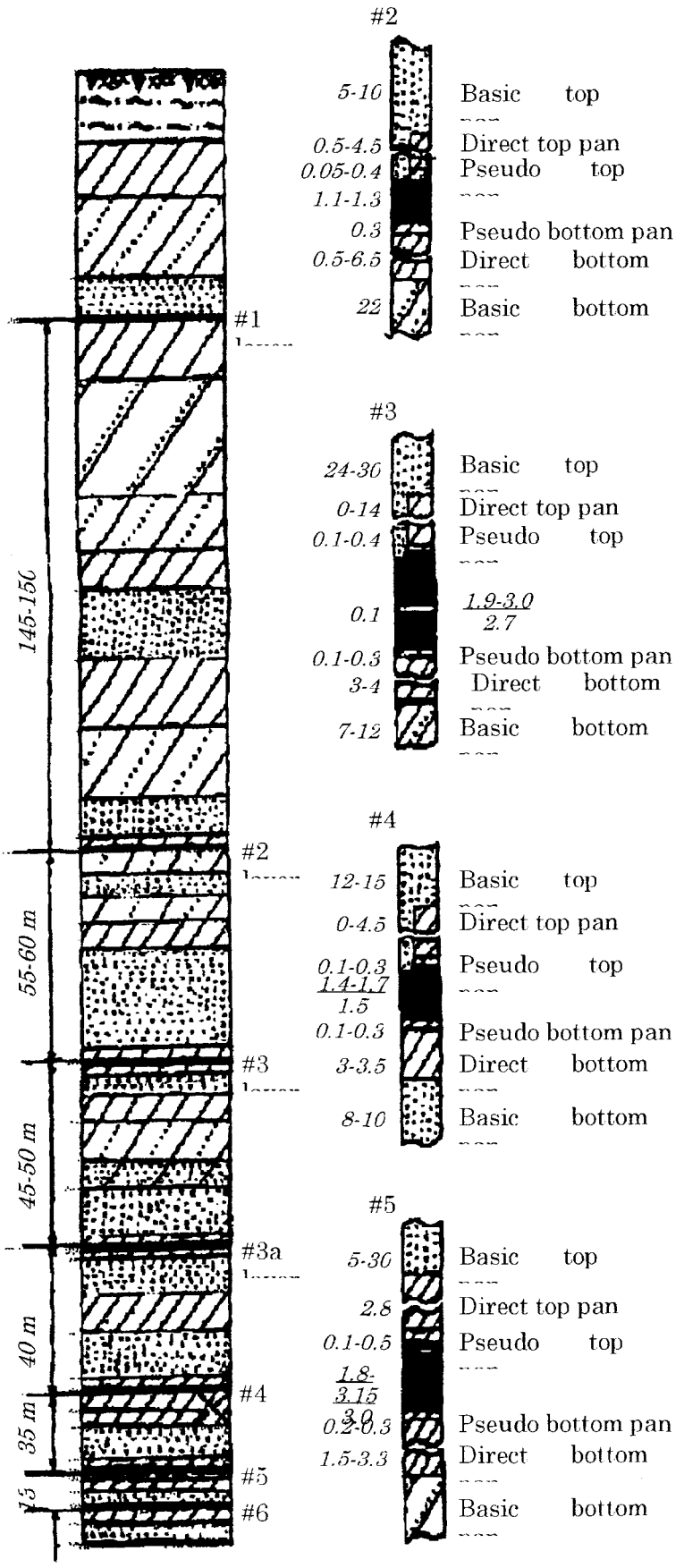


Fig 2.2-4 Stratigraphic Cross Section of #1 to #6 Layers in Chertinskaya
(Source: Chertinskaya Mine)

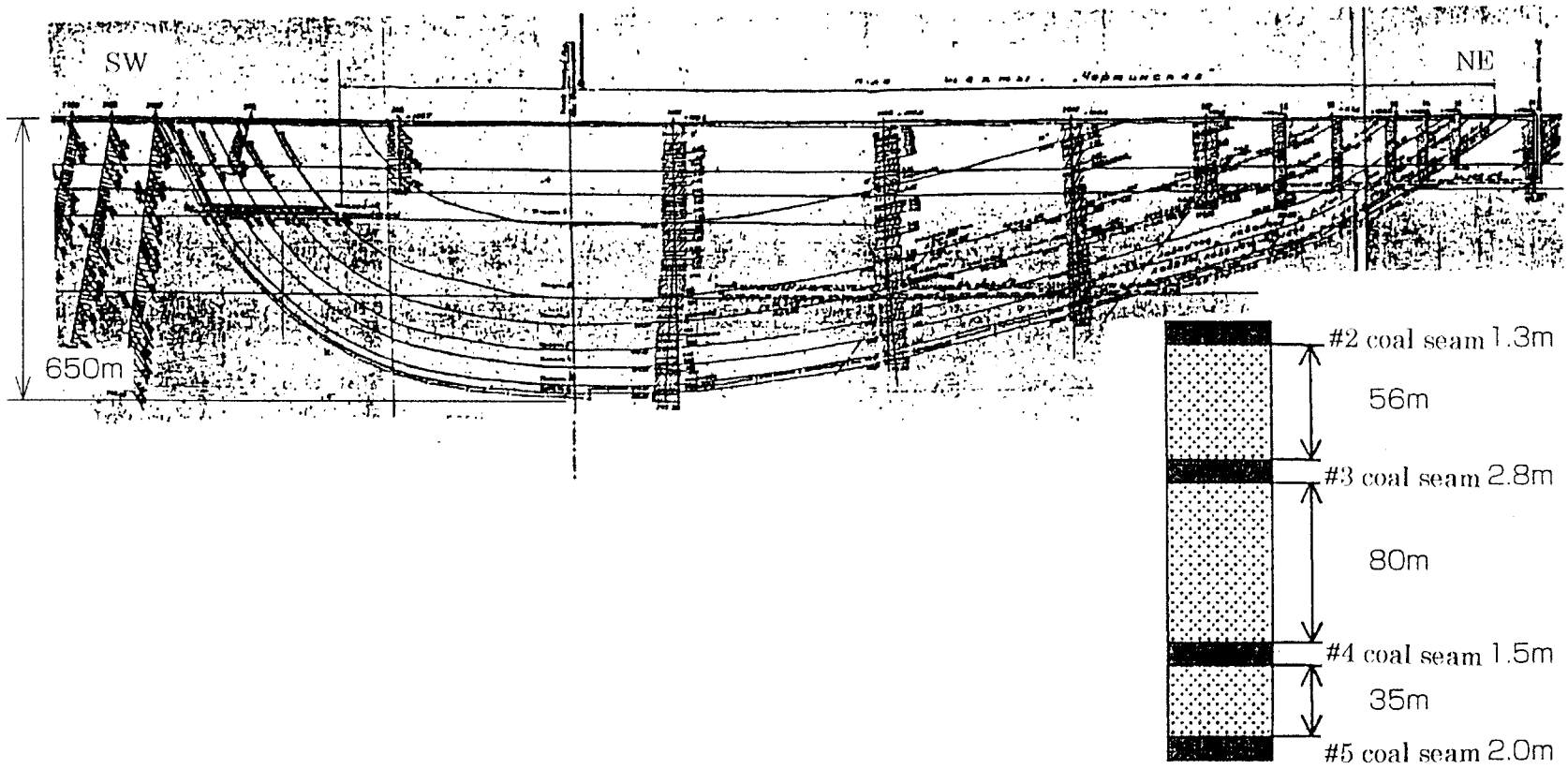


Fig2.2-6 Profile of Chertinsk coalfield

(3) Coal Mine Gas Emission and Gas Recovery

The mine is one of the top gassy mines in the central Kuznetsk Basin, and efforts have already been made for the removal of gas in the past. More recently, however, gas is removed mainly through ventilation, due to the obsolescent equipment and the insufficient capacity of the boring machines.

For information on the mine gas, two sources are available; raw data collected by the mine itself and statistic information organized by the Russian CBM Center. The Chertinskaya mine is equipped with a few vertical shafts: the shafts ventilated with the main fan and the exhaust shafts without fans, as well as the fixed ventilation system for simple exhaustion bleeder shafts (VMSG). This may cause some variations of data while organizing it, but the available information is good enough to see the trend, and both sources will be used based on the nature of study.

1) Emission of mine gas

Although the production dropped in Chertinskaya after achieving the maximum production of 1.9 million tons in 1988, the specific gas emission went beyond 70 m^3/t in 1994. The specific gas emission varies according to the mining method, mining conditions, mine age, length of working roadways, and process of old working faces. Also, the sequential order of mining different seams (when having multiple working seams) and the ratio between the longwall coal versus heading coal may influence the specific gas emission output. The gas emission varies year to year, as shown in Table2.2-9, but it is a useful indicator in estimating a range of emission based on the coal production of the mine.

Table2.2-9 Specific Gas Emission

	1990	1991	1992	1993	1994
Coal production (1,000 t)	1,755	926	1,096	1,135	880
Total gas emission (m^3/t) (1,000m^3/t)	127.4 66,961	93.1 48,933	94.9 49,879	106.4 55,924	117.5 61,758
Specific gas emission (m^3/t)	38.2	52.8	45.5	49.3	70.2
	1995	1996	1997	1998	1999*
Coal production (1,000t)	700	445	547	550	281.9*
Total gas emission (m^3/t) (1,000m^3/t)	66.2 34,794	31.6 16,609	52.3 27,489	44.0 23,126	48.0 15,206
Specific gas emission (m^3/t)	49.7	37.3	50.3	42.0	53.9

* The 1999 production is for the period from January to July (220 days) only.

The planned coal production for 1999 is 678,000 tons.

2) Gas Recovery

The gas drainage rate was around 50%* with stable coal production before the Soviet economy collapsed. The rate went up to 55% in 1992 and 1994 also after the collapse, but it has reduced to a quite low level since then (it dropped to 2.8% in 1996, and there may have been a particular reason for this drop). (* see the section 2.4.6(3)).

In the recent years, the gas recovery is unstable due to the sharp reduction in the coal production and because of the lack of underground gas drainage equipment. Furthermore, some working faces were left untouched for a few years after the panel was prepared, because of the reduction in the coal production. It is possible with this practice that gas was already released from coal seams before the mining started. For example, the preparation of entries for the face #563 started in 1991 and completed in March 1993, but it only began to produce coal in April 1999 (as a general rule for the gassy mine like this, however, the gas should be removed from the panel preparation entries six months before starting to produce coal).

Table2.2-10 Recovered Gas and Recovery Rate (pure methane)

Fiscal Year	Coal Production (1,000t)	Methane from main fan (1,000m^3)	Drained methane (1,000m^3)	Total methane emission (1,000m^3)	Specific gas emission (m^3/t)	Gas recovery rate (%)
1992	1,096	22,075	27,804	49,879	45.5	55.7
1993	1,135	NA	NA	55,924	49.3	NA
1994	880	27,673	34,059	61,732	70.1	55.2
1995	700	24,546	10,270	34,816	49.7	29.5
1996	445	12,031	4,573	16,604	37.3	2.8
1997	547	21,944	5,519	27,463	50.2	20.1
1998	550	16,924	6,223	23,147	42.1	26.9
1999*	282	13,299	1,901	15,200	53.9	12.5

* The 1999 production is for the period from January to July (220 days) only.

This mine had six to eight working faces to ensure the production volume, but currently two or three faces are available for production. Instead of maintaining a number of faces of reduced productivity, it is desirable to reduce the number of faces and to improve the productivity, to ensure the planned production for the management, as well as to improve the recovery and control of gas. Without improving the productivity of the working faces, a satisfactory gas recovery rate may not be expected.

The mine will achieve the gas recovery rate similar to the level achieved during the stable period in the past, if it produces coal in a stable way based on the future mining plan (described later)

Table 2.2-11 Concentration of the Recovered Gas

Fiscal year	Total drained gas (m^3/year) (m^3/min)	Pure methane (m^3/year) (m^3/min)	Methane concentration range (%)	Average concentration of recovered gas (%)
1992	NA	27,804,240 52.9	NA	NA
1993	NA	NA	NA	NA
1994	85,380,480 162.4	34,058,880 64.8	20～60	40.0
1995	41,101,920 78.2	10,270,224 19.54	10～40	25.0
1996	7,621,200 14.5	457,272 0.87	2～10	6.0
1997	14,927,040 28.4	5,518,800 10.5	15～60	37.0
1998	17,292,240 32.9	6,223,104 11.84	15～60	36.0
1999*	6,105,600 6.0	1,900,800	10～50	31.1

(4) Gas Recovery Today

The Cheritnskaya mine had a plan to use the coal mine gas and implemented a 1-MW gas engine from Caterpillar, but gas has not been utilized since the engine failed November 1998. The mine is the only mine that recovers gas with the established gas utilization plan in Kuzbass coal basin.

The gas drainage boring equipment placed in the mine at the mine is not capable of recovering the gas efficiently as described later, and the vertical gob wells are relied upon to drain gas from the goaf to the ground. In addition, the bleeder vertical wells are used to exhaust gas directly from the face to the ground.

For the heading face, pilot boring machines are used, capable of drilling dozens of meters.

1)Load on ventilation

The mine ventilation is provided, using two shafts with pressure fans and three shafts with exhaust fans. The total exhaustion for the main fans for the three shafts is described as 18,200 m^3/min for 1994, but it is 20,990 m^3/min in 1999. Meanwhile, the coal production was 880,000 tons in 1994, and the planned production for 1999 is 678,000 tons. The increasing depth of mining faces and the change of working coal seams may be the reason for the change in the ventilation volume. In any case, as shown in Table2.2-12, the total annual ventilation over the coal production, or the ventilation required for a ton of coal produced, is on the increase.

The gas recovery rate sharply dropped after reaching the peak in 1994. The ventilation should be reduced and the gas drainage should be intensified to improve the working environment in the mine, to provide safety measures against the gas, and to utilize the gas.

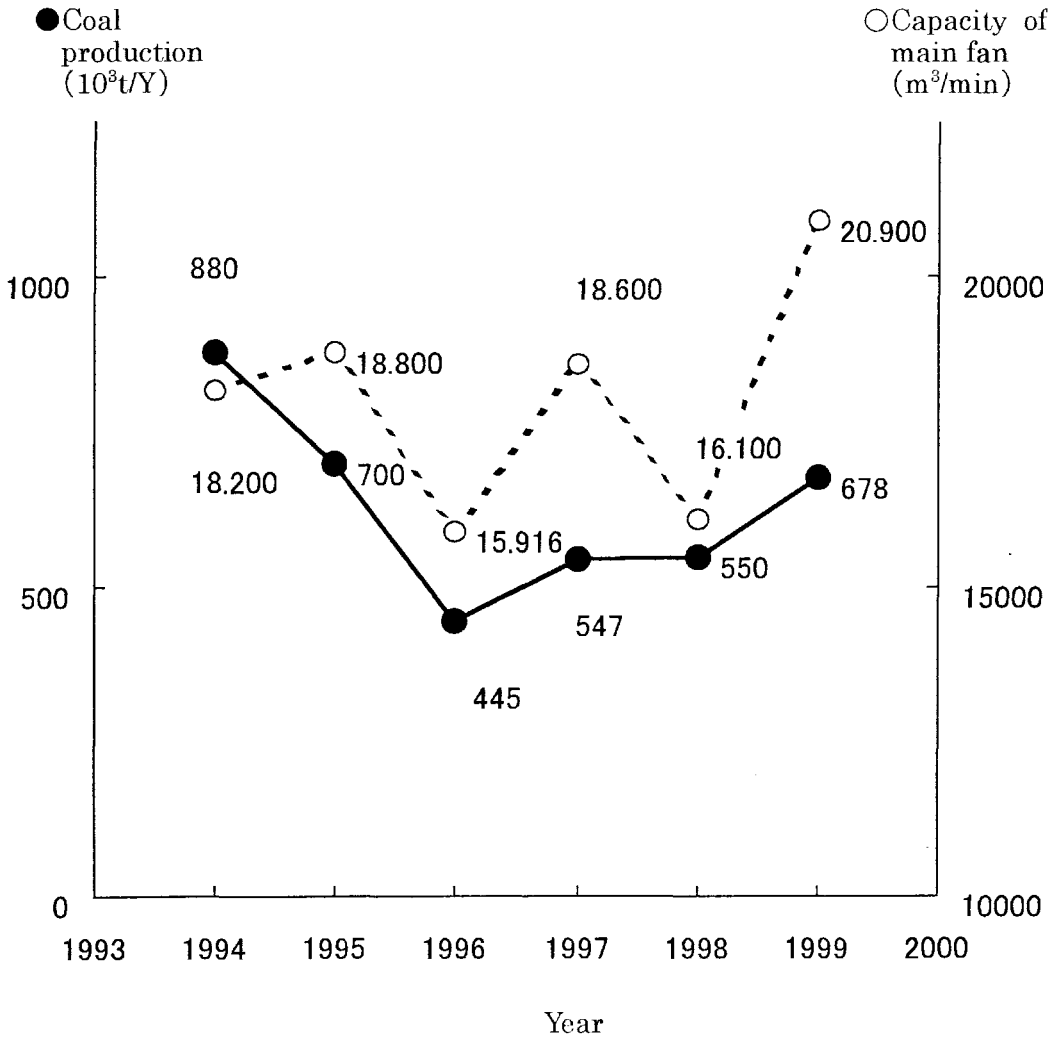


Fig2.2-7 Capacity of the main fan and ventilation volume required per ton of Coal Production (m^3/t)

Table2.2-12 Ventilation by Main Fan and Vented Methane

Year	Coal production (1,000t)	Methane in Main Ventilation			Ventilation air per ton of coal production (m^3/t)
		Total Vented air (m^3/min)	Gas concentration (%)	Total methane (m^3/min)	
1994	880.3	5,800 4,300 8,100 18,200	0.3 0.35 0.25	17.4 15.0 20.25 52.65	10,867
1995	700.0	5,600 3,500 9,700 18,800	0.3 0.3 0.2	16.8 10.5 19.4 46.7	14,116
1996	445.0	5,200 3,200 7,546 15,916	0.25 0.2 0.15	13.0 6.4 11.32 30.72	18,834
1997	547.0	5,500 3,600 9,500 18,600	0.25 0.25 0.2	13.75 9.0 19.0 41.75	17,872
1998	550.0	4,600 3,400 8,100 16,100	0.2 0.2 0.2	9.2 6.8 16.2 32.2	15,386
July 1999	(678.0) 281.9	6,300 4,200 10,490 20,990	0.2 0.2 0.2	12.6 8.4 20.98 41.98	16,272

2)Gas drainage and effects

Gas is drained combining different methods, as described below (see Fig2.2-17: Gas Drainage from Longwall Face), but gas is totally discharged into the atmosphere due to the fact that the gas utilization plant (Caterpillar-1,000 kW, EP-200 kW) is not available.
Also, a vertical well has been built from the ground to recover gas from old mined area for the source of the gas utilization.

a. Bleeder well
b. Vertical gas drainage well for goaf (Gob well)
c. Pilot boring
d. Horizontal in-seam boring
e. Cross measure gas drainage boring
f. Sealing
g. Gas drainage system

(a) Bleeder well

The bleeder ventilation system is applied to the face #563, to which a visit was made. After going through the working face, 70% of the airflow goes through the tailgate, and finishes into the mine ventilation system. The remaining 30% of the air, the bleeder air, goes through the ventilation way built in the goaf side, and passes through the bleeder ventilation well, which is directly connected to the ground, and it is sucked by the fixed ventilation system (VMSG) on the ground, then discharged into the atmosphere. The bleeder well is 600 mm in diameter at the top and 390 mm at the bottom of the well, exhausting 240 to 250 m^3/min of gas (concentration of 1.8%) through this system. The ventilation volume was 284 m^3/min (concentration of 1.6%) with the suction of 95 mmHg during the visit on the ground while the mining activity was suspended. Therefore, the volume of pure methane is approximately 4.5 m^3/min (Photo: Fixed Installation of Ventilation system VMSG).

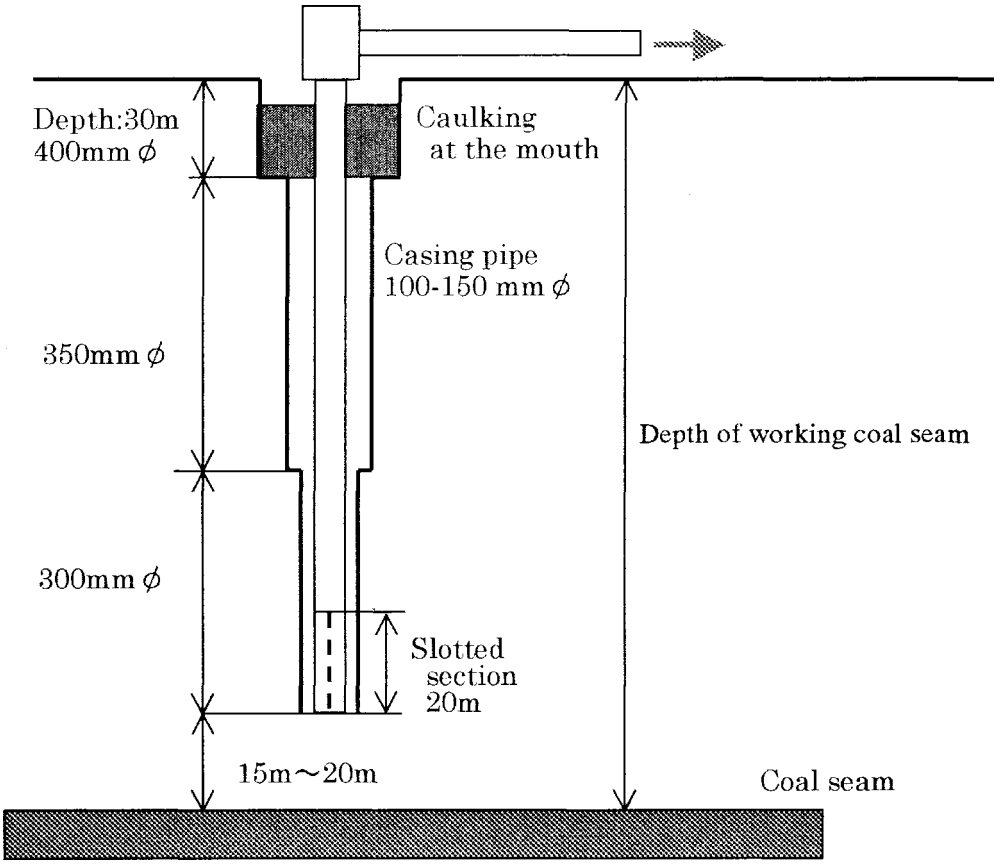


Fig2.2-9 Vertical Gob well

(c) Pilot boring

This mine has the danger of gas outburst, and sufficient care must be taken against the gas behavior while advancing the in-seam driving. The advancing rate is 12 meters a day on average in general, trying to maintain 6 meters of remaining boring length for the advancing face. The pilot boring hole length is 18 meters. Gas is drained out when it emits more than $3m^3$/min from the boring hole in the mine, otherwise it is diluted and removed with ventilation. The ventilation volume for heading is approximately $180m^3$/min for the cross sectional area of $12m^2$ (entry width: 4 meters for bottom width, 3.2 meters for top width, and 2.5 meters in height).

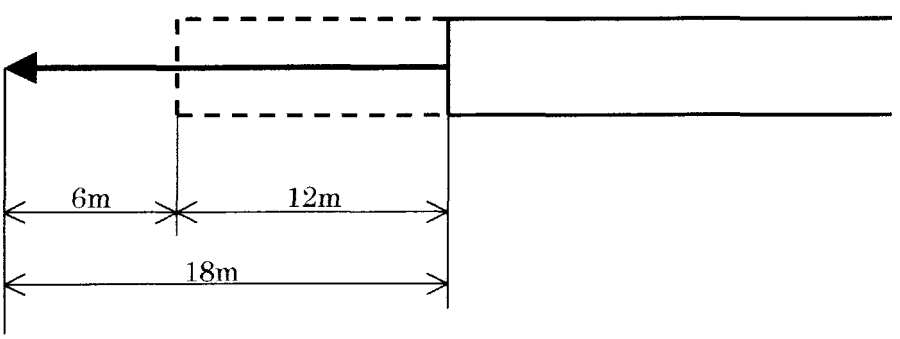


Fig2.2-10 Pilot boring (1)

The pilot boring, called the barrier method described below, is applied for boring in the entry with a large output of gas. A boring seat is placed every 30 meters in the entry, and boring is carried out for approximately 40 meters for from one to three holes (water may come out). The drill hole diameter is 65mm with the hole bottom diameter of 42mm. The boring mouth diameter is 180mm, with a stand pipe of 100mm in diameter inserted, and connected to the gas pipe with concrete caulking. Gas may be extracted in order of 3 to 5m^3/min for pure methane during the pilot drilling, lasting for approximately six months, and it is blinded with a flange afterward. The suction pressure is between 50 and 60mmWG.

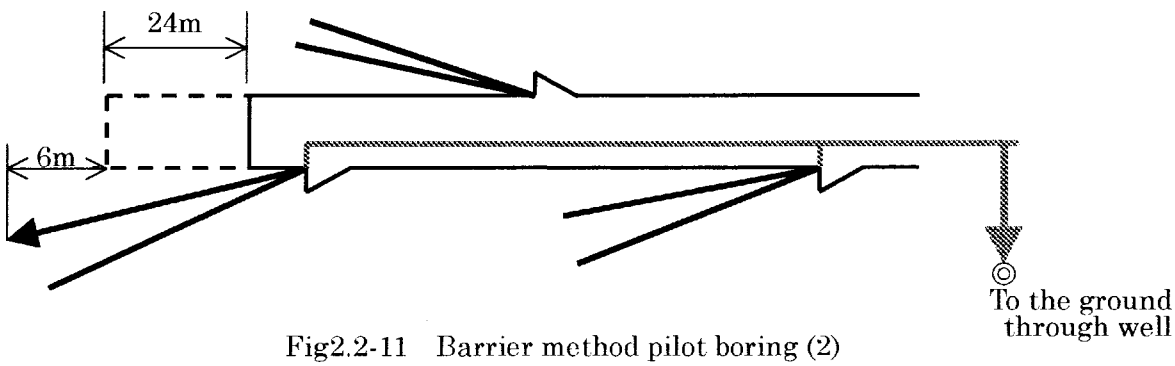


Fig2.2-11 Barrier method pilot boring (2)

(d) In -seam horizontal boring

In addition to the barrier gas drainage, an in-seam horizontal boring is carried out every 15 to 20meters into the panel at the right angle from the entry for the longwall panel. The figure shows only one side to make the drawing simple, but in practice, a number of boring holes are made on both sides. These holes serve two purposes. The first purpose is to remove of gas in unworked panel for six months before starting the operation of the longwall face. Gas is drained from the area (affected area) within 10meters of radius through the boring hole. Therefore, the boring hole length is approximately 65meters for a working face length of 150meters. The gas drainage amounts to 10 to 15m^3/min, converted to pure methane, during the gas drainage period. The second purpose is to control coal dusts of the face. After gas is drained and the preparation is made for mining operation at the face, water is supplied to the coal wall using these holes. Water is supplied at the pressure between 150 and 200kg/cm^2, but it could be reduced to between 6 and 15kg/cm^2, depending on the condition of the coal seam. Water volume is between 30 to 35litters/min for 24hours.

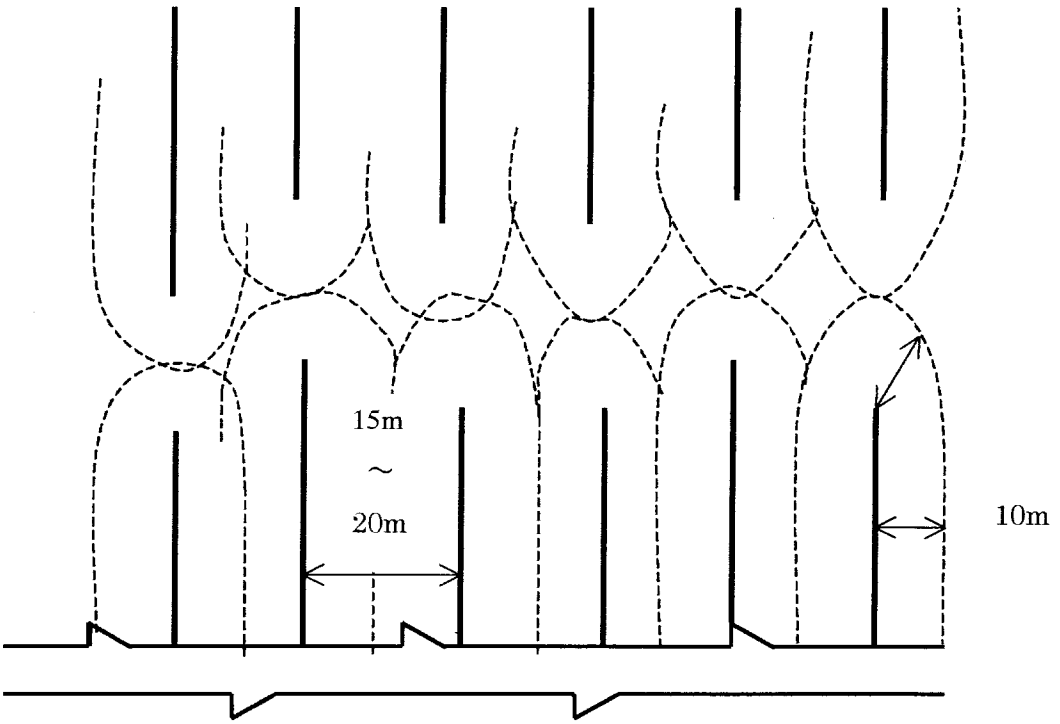


Fig2.2-12 In-seam horizontal boring

(e) Cross measure gas drainage boring

To recover gas that emits from the disturbed zone in the roof during the mining activity on the coal panel, boring work is carried out to create two holes for the length between 52 and 60 meters (at the angle of 25 to 30 degrees) into the side wall of the tailgate entry toward the roof strata of the goaf, at the interval of approximately 35 meters, as shown in the Fig.2.2-13. Of these cross measure boring holes, any three stations located at the closest to the working face are used, moving one to another. Each hole may be used for seven day for the drainage of gas. The suction pressure is between 50 and 60 mmHG. The drainage must be prepared in case water comes out. The gas drained is a mixture of gas and air, and it amounts to 24 m^3/min with six boring holes for three stations (methane concentration of 5% to 40%). Gas recovery is approximately 7 m^3/min, converted to pure methane.

The recovered gas is transported through the mine gas pipeline* of 150 mm in diameter, connected to the bottom of the well drilled from the ground (* see the gas section system).

The boring hole is of 65 mm in diameter. A 5-meter-long casing of 100 mm in diameter is inserted to the mouth for expansion with cement caulking, but the entire length is open hole except the bore mouth.

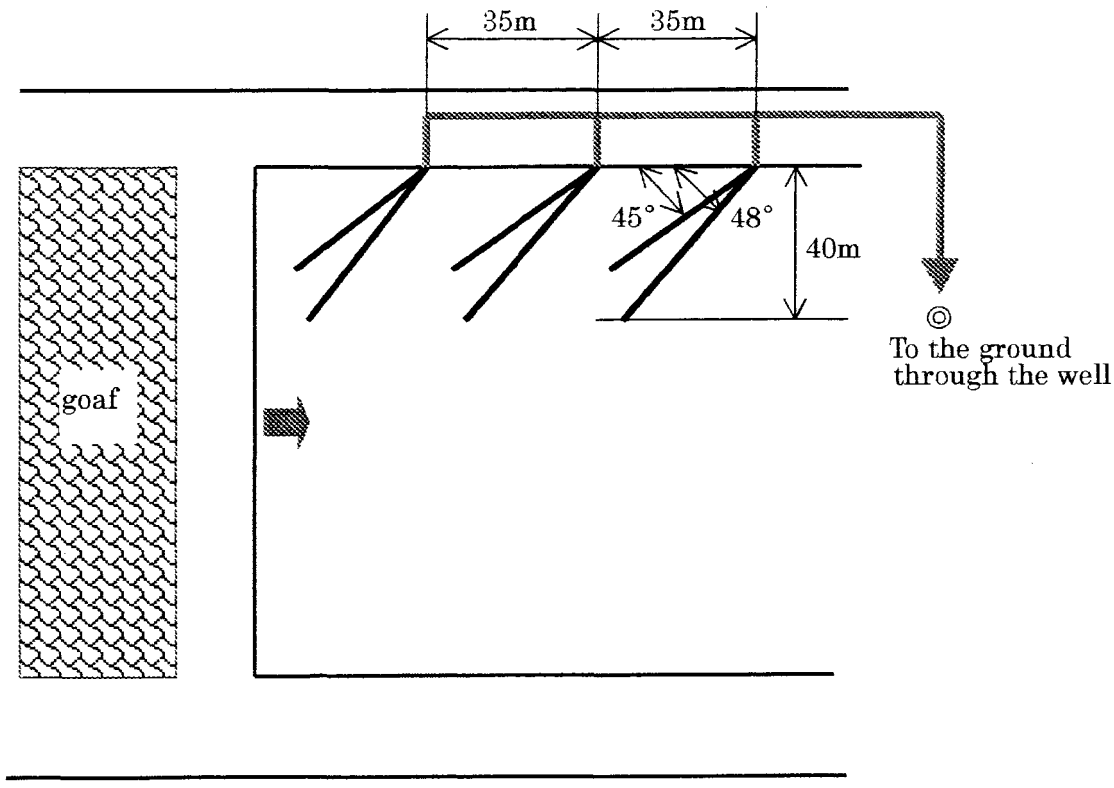


Fig2.2-13 Cross-measure gas drainage boring (plane view)

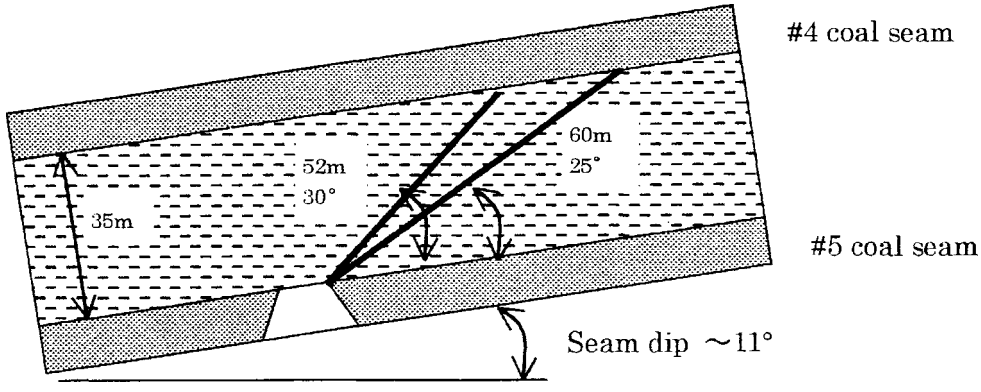


Fig2.2-14 Cross measure gas drainage boring (cross section)

(f) Sealing

The sealing practice of the old face is a simple one. It is built at 3.5 meters from the entrance of the entry on one panel of the finished face. In general, two concrete walls of 0.6 meter in thickness are built at a distance of 3 meters between the two. The wall is built, stacking concrete blocks, and it is finished with concrete on the wall. Before building these walls, the side wall is dug for 30 to 40 cm in the entry. According to our observation of cracks on the coal wall, it should be dug till the more solid coal face appears.

When the spontaneous combustion is assumed possible, a mixture of clay and water in the ratio of 1 to 3 is filled between the two concrete walls, using a pump. To observe the condition of gas and water in the sealed area, two observation pipes are put into the wall.

Gas drainage from sealing is not practiced in this mine.

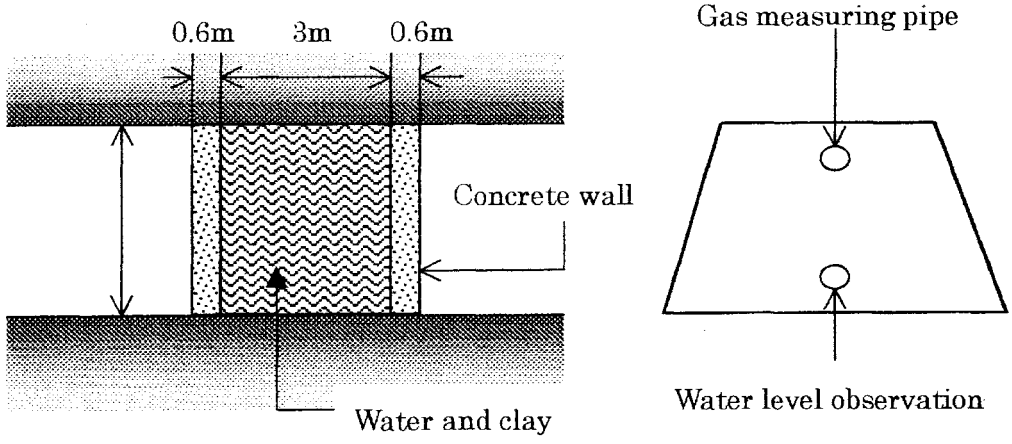


Fig2.2-15 Illustration of Sealing

(g) Gas suction system

The gas is collected from the barrier boring, in-seam horizontal boring, and cross measure boring, built on the tailgate and maingate of the longwall face, and it is sent into the main collection steel pipe of 150 mm in diameter (connected with flange) built in each entry. The gas passes through the vertical boring hole built from the ground near the working face, and sucked by the mobile vacuum pump (BBH-50 or BBH-150) located on the ground.

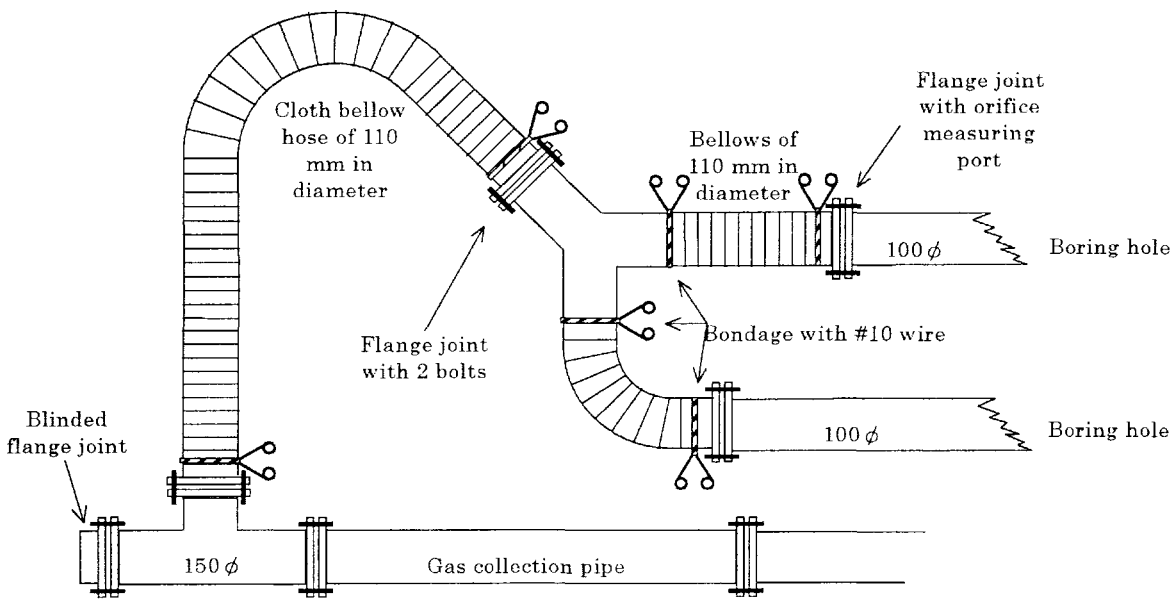


Fig2.2-16 Connection of Gas Pipe

Also, a cloth bellow hose of 110 mm in diameter is used for the bend to the main collection pipe and between the well port and the mobile vacuum pump on the ground. The length of the pipe line from the working face to the bottom of the vertical boring hole is approximately 950 meters for #563, and 1,300 meters for #544.

In Chertinskya, the gas collection pipes are installed for the shortest distance to send gas outside, instead of building a pipeline network in the mine. When operation starts at the face, the main pipe of air way is converted to supply water to the coal face. During the mining work on the face, the gas is drained, using the bleeder well, vertical gob wells, and cross measure boring holes.

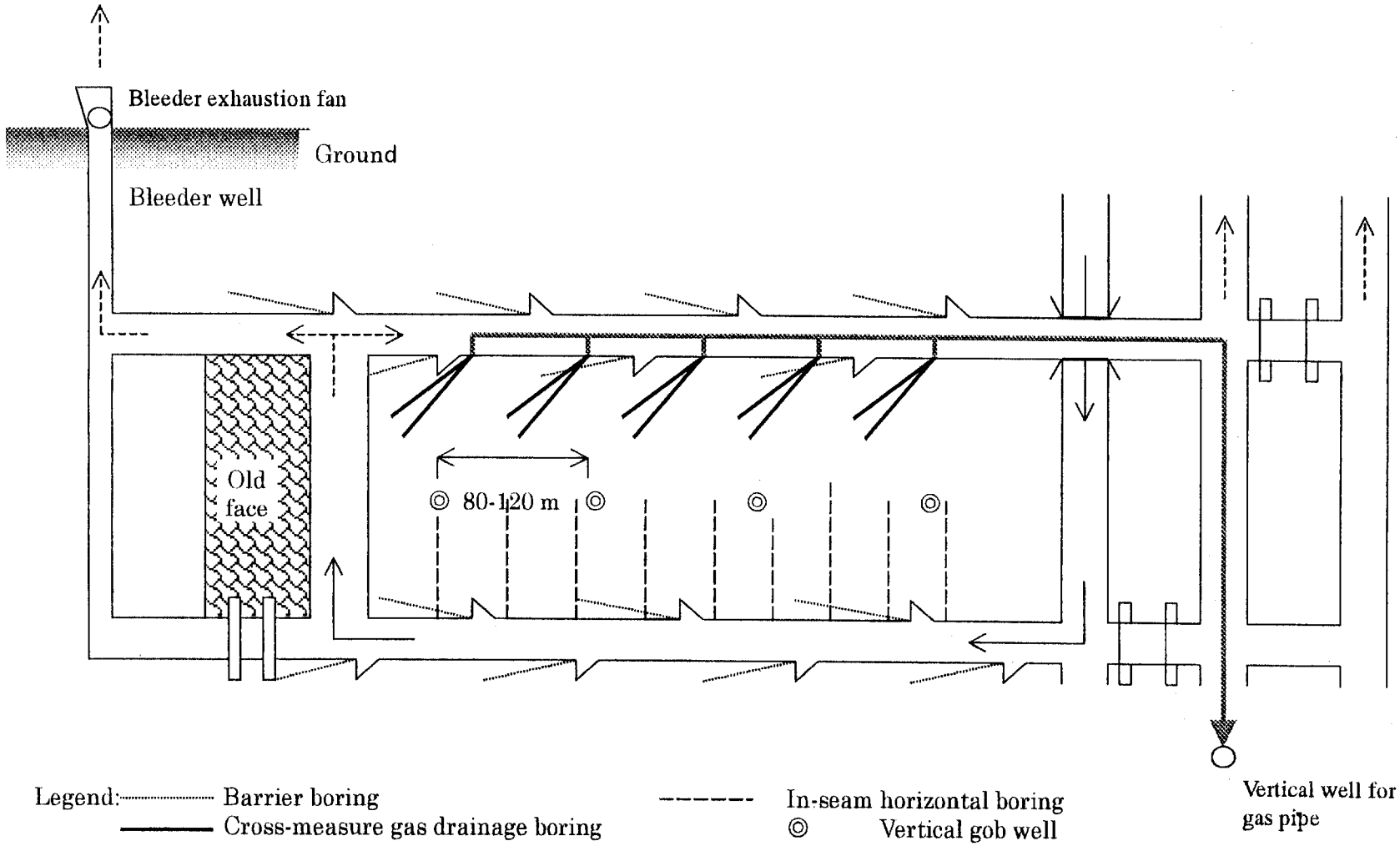


Fig.2.2-17 Gas Drainage for Longwall Face in Chertinskaya
(#563L/W: #5 Coal Seam, September 1999)

3) Gas emission from the coal seam #5 (#563L/W)

The longwall face #563 is located approximately at 600 meters, in the deepest point, in the mine. The face length was 150 meters initially, but it was changed to 140 meters. Table 2.2-4 below shows the face parameters.

The combine was being replaced for the face during our visit, suspending the mining practice, and the face ventilation volume was 810 m^3/min that time. The ventilation volume required is between 660 and 2,016 m^3/min, depending on the number of face workers and the production volume.

According cheir explanation, the gas emission should be between 20 and 25 m^3/min during the face mining practice, combining the recovery and ventilation. Table 2.2-13 shows the volume and concentration of gas for the ventilation and various gas drainage methods at the working face and around the working face (including the bleeder).

Table2.2-13 Gas emission from #563 Face*

	Gas and Air (m^3/min)	Gas concentration (%)	Pure methane (m^3/min)
Ventilation			
Return air side	526(Current)	0.22	1.2
Bleeder side	284(Current)	1.6	4.5
Intake-air side	810(Current)	0.02	(0.2~0.3)
Gas in airflow			5.7
Gas drainage			
Cross-measure boring	24	5~40	1.2~9.6
Gobwells	33.5	30(~90)	10.1
Drained gas	57.5		11.3~19.7
Total gas emission			17.0~25.4

* Figures in the table are collected during the visit and from the mine personnel. The ventilation and total gas emission should increase while producing coal from the face. As of September 1999, the working faces are #563, #562 and #544. Some example operating data of the mobile vacuum pump for gas drainage are listed at the appendix.

4) Gas recovery from old mine

After introducing the gas engine from Caterpillar (currently broken down), gas is extracted from the old mines to stabilize the gas supply. Currently, two holes are used for gas recovery, but a set of two holes lasts only eight days (35 m^3/min, 60% concentration), therefore, they are examining the possibility of adding two more holes to move a set of two holes every eight days. The existing gas source comes from the old face of #381 longwall, using the wells drilled 4 to 6 years ago.

To improve the gas utilization positively for the future, gas must be extracted from these old mines and sealed areas. Extracting gas from the sealed area also reduces the volume of gas emission to the working face.

2.2.4 Gas utiligatian technology and facilities of Chertinskaya mine

As stated before, at Chertinskaya there was a plan to utilize coal mine methane gas as a part of internal utility. The Union of Russian Energy Department Coal Industry Committee proposed to accept gratuitously a 1MW power generator manufactured by the USA Caterpillar from the Environmental Ministry of the USA and they agreed about it. In 1997 the power generator was supplied and connected with a gas supply line and with an internal power distribution facility, and thereafter the operation started in October 1997.

It is out of operation at present because of various troubles after the start of operation. The power plant facility, the operation experiences and problems are summarized below. In case of utilizing the coal mine methane gas for an internal utility, it is useful to understand the present status such as the internal power supply and steam supply for project planning.

(1) Status and experience of gas power plant utilization

1) Existing gas engine power generator

(a) Gas engine power generator

① Gas engine power generator manufactured by the USA Caterpillar

As described before, the 1 MW gas engine power plant of the USA Caterpillar has been existing, and its specification is as follows:

Items	The numerical value	Items	The numerical value
Capacity of power generation	965kW	Serial number	FL 068-08
Voltage of power generation	400V	Production number	30-150324
Frequency	50 Hz	Production country	United Kingdom
Gas consumption	$6m^3$/minute as equivalent to pure methane	Production year	1995/03
Number of cylinder	6	Weight	30.5ton

This is located inside an area of the main office building and is also adjacent to a former gas station and is outdoors in a package type.

② Gas engine power generator made in Russia

One Russian-made 200kW gas engine power generator has been located neighboring to a gas well. This engine has been reconstructed into a gas engine from a diesel engine with 12 cylinders for a war tank. An electricity generated by this transferable power generator is transferred by a 60 mm^2 cable (the cable is placed on the ground) to a transformer about 50 meters away and, thereby increased in the voltage to 6kV, supplied to the coal mine through an overhead cable. However this generator has been made as a trial one and actually is not operated continuously.

(b) Gas supply to the Caterpillar generator

The supply the power generator with gas is carried out through a gas pipeline constructed about 5 years ago from an about 3.2km away from gob well with a depth of 250 meters. A fluctuation ratio of its gas concentration is as big as 70% to 30% in a day.

(c) Electricity from the Caterpillar generator

The electricity generated by the power generator has 400V and the voltage is elevated to 6,000V by adjacent to dry transformer for exclusive use (with a capacity of 1,500kVA). And the electricity is then transferred to No.29 circuit of No.21 transformer substation therein owned by Chertinskaya, which is 300 meters away and is consumed as its internal electricity.

2) Operation experience and problems

(a) Operation experience

The power generator started its operation in July 1998 and accumulated power generation till September 17, 1999 was 424,514kWh. In this connection, the actual results in smooth operation on September 6, 1999 was 16,300kWh and its capacity factor was 70%. When the capacity factor is 70%, the accumulated operating hour is 628 hours, which converted to about 26 days and during about 14 months from its start operation of the power generator till its stop because of its hindrance, a total operating period was less than one month. The capacity factor from the operation start till the stop because of its hindrance was about less than 5%.

(b) Problems

① Circuit protection

Chertinskaya asked permission to Kuzbass Eenergo of an electric company for connection with self-use power generation to the internal electric supply distribution system. Kuzbass Energo hesitated to give the permission because of apprehensions that fluctuation or the like of the voltage from the Caterpillar generator might cause some effects on electric distribution system. Under a condition that Chertinskaya constructed a protection system against the system connection, the permission was obtained. They spent 18months to obtain the permission. The Caterpillar did not join to this permission obtainment.

② Protection against opposite current

A power generator has a protection circuit to prevent a reverse electric current from an electricity-sending end during its operation stop. However, when Chertinskaya constructed the protection system against the system connection, it was not complete, as they did not fix up their opinion with the Caterpillar. During its adjustment after the operation stop of the power generation, an electricity flew backward from upstream (transformer substation) to the power generator because the protection circuit did not work well so that the generator was broken.

③ Freezing of gas pipeline

As pump for gas recovery is a water-sealed one at gas well, tremendous amount of steam enters into a pipe together with methane. In winter of 1998, water froze to cause clogging of pipe so that methane transportation was stopped to make the operation of the power generator halt. The countermeasure has not yet been accomplished this year.

④ Control system

When computer controlling the power generator was broken, it takes a very long time to purchase repair parts. When it is operated under low concentration of methane and when electric power generation exceeds 500 kW, the voltage and frequency become unstable. When methane concentration becomes less than 40%, operators at the coal mine can not control the operation and then the engine stops.

⑤ Education and maintenance

The Caterpillar hardly educated its operators, and only delivered them a part of drawings when it handed over them the power generator facility. And the operation and maintenance manuals are quite simple ones written in English. As the operators at Chertinskaya can not understand English, they can not operate it completely. At hindrance they can not do anything about it. And as the power generator is built-in within a big container and installed outside door, it is imagined to be very difficult to maintain it under –40°C in winter season.

⑥ Lack of study on coal mine methane recovery feature

Recovery features of coal mine methane gas of Chertinskaya differs largely from the ones in the USA in low gas concentration and in big fluctuation of gas concentration and amount. In general, when the gas concentration become low, it is in principle unavoidable that an output of the engine becomes unstable. Although the Caterpillar power generator has a lot of experience in a high concentration methane gas (50~60%) of such as USA or Australia, it was not suitable for a power generation facility utilizing gas of Chertinskaya with big fluctuation of its concentration (30%~40%).

(2) Status of electric power facility and internal power demand

In this research, as utilization of coal mine methane to supply with a power generation facility is planed, a detail study relating to electricity used in the coal mine on facility, demand and supply and internal distribution system was made. Documents from Chertinskaya were their answer to our questionnaire and a piece of single line connection diagram, and in order to complement these we made a hearing and a field survey.

1) Internal electric power facility

In this chapter, a status of main facilities, installed on the ground at Chertinskaya coal mine and caught in the extent of this field survey is outlined here. The voltages used in the coal mine are 6,000V, as well following 400, 220, 127. 36V etc., and a direct current 24V and 12V are used for control purpose. As an electric current source for control, alternative current with 36V is used in an independent circuit system, while it is as low voltage as possible from the viewpoint of preventing a spark at switching. A main power facility is described below.

① Shaft winder

There are two kind of winders: one is for man and article and the other is coal, but bearing load appears temporary as their operation is carried out only in and out. Winding speed is 5.7m/sec for man and article; 7m/sec for coal, and in general two winders are placed per one shaft.

② Conveyer

It is operated during a coal production as the coal produced is transferred from coal mining area to coal preparation plant so that the operation rate is about 35~40%.

③ Coal getting machine

As it is used only during coal production at the coal mining area, its operating hourly rate is also about 35~40% as well the conveyer.

④ Pump

As it is fluctuated with pumped-up water amount, an operation mode and time are various.

⑤ Ventilation fan (blower)

A blower is an important facility and so two blowers of normal one and spare ones are arranged. Electricity is supplied to these two blowers through different two 6kV-distribution cables. As the driving voltage for the blowers is 600V, it is decreased by transformer with 6kV/0.6kV placed on an electric pole to supply with it through 60 mm^2 cable about 50meter distance. The cable was laid down on the ground, in addition.

⑥ Methane gas drainage facility

A methane gas recovery facility to recover methane gas released from the coal mine and to discharge it in the air is also installed at nearby place of the blowers. As driving voltage of the methane gas recovery facility is 600V as same as the blowers, the supply of electricity to the recovery facility is carried out by dividing 600V low voltage distribution cable supplying with the electricity to the blowers. In the area where the methane gas recovery facility is located, there is a lodge in which a guard stays for 24 hours and relating facilities are arranged. The low voltage electricity (220V or 400V) is used for lighting, etc. in the lodge.

⑦ Lightening load

The total lightening load in the coal mine is not clear while the voltage for lightening is 220V on the ground and 127V in the coal mine.

Table 2.2-14 List of main electric facilities

Equipment	Electric capacity (kW)	Number	Total electric capacity
Elevator(winch)	500 500 1,300	1 1 1	500 500 2,300kW 1,300
Conveyer	140 220 90	6 3 4	840 660 1,860 kW 360
Ventilation fan	400 600	2 3	800 2,600 kW 1,800
Pumps	400 160	8 8	3,200 4,480 kW 1,280
Steam boiler	140 140	4 2	560 840 kW 280
Drum cutter	280 110	3 5	840 1,390 kW 550
			Total 13,470 kW

2) Internal electric power demand

Relating to electric power demand at Chertinskaya coal mine, daily electric power demand with hours (daily load), monthly demand and prediction in future will be stated.

(a) Daily load

The contracted electricity of Chertinskaya is 8,200kW, which is the regulated number for 2hours from 7.5o'clock to 9.5o'clock in the morning when load of total electricity demand is the highest and during other times in which they can use electricity in spite of the contracted electricity. The highest electric power demand at Chertinskaya is 11,000kW and therefore the difference from the contracted electricity is 2,800kW. Management of Chertinskaya mentioned that if they can use electricity more during regulated hours from 7.5o'clock, they can improve their operation efficiency. Therefore, if more than 2,800kW of private power generation become possible, their operation

efficiency is improved in spite of the electricity regulation. A daily load is shown in Figure 4-4**.

(b) Monthly electricity demand

A monthly demand does not show big fluctuation, demand in winter season is bigger than in summer by about 500kW. This is supposed to be an increase in electricity demand by operating steam boilers or the like for heating.

Monthly internal electricity demand is shown in Fig.2.2-18 and Table 2.2-15.

(c) Demand prediction in future

Relating to the prediction on electricity demand, it is not carried out because of unnecessary as the demand has increased little recently.

In experience, in the past the consumption increased sometimes 10% in a year, but it is now about 5~7% per year. According to the expansion of the demand, there was a plan to build a new transformer substation, but it has not completed because of the recent demand stagnation.

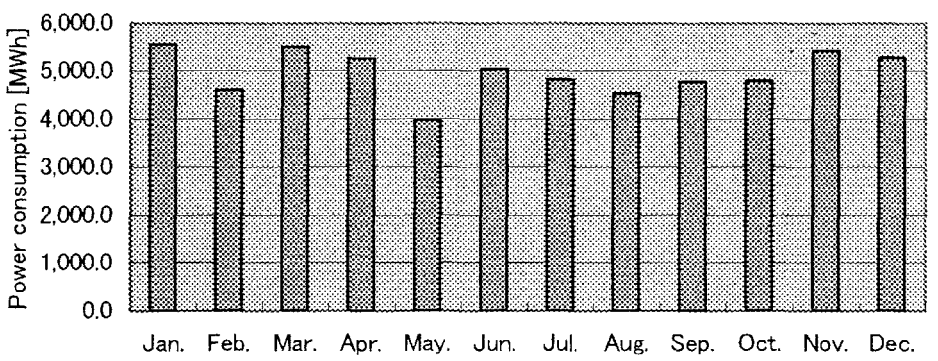


Fig. 2.2-18
Annual power consumption of Chertinskaya
(1998)

Table 2.2-15 Annual power consumption of Chertinskaya

Month	Power consumption [MWh]
Jan.	5,562.0
Feb.	4,605.0
Mar.	5,512.9
Apr.	5,261.3
May.	3,990.3
Jun.	5,038.0
Jul.	4,830.0
Aug.	4,531.8
Sep.	4,776.0
Oct.	4,804.6
Nov.	5,428.7
Dec.	5,277.7
Total	59,618.3
Monthly ave.	4,968.2

(3) Purchased electric power and its supply method

1) Electric power supply method

The electric power is supplied from a local electric power supply company of Kuzbass Energo to Chertinskaya coal mine, and the supply method is as follows;

(a) No.22 transformer substation (owned by Kuzbass Energo)

As shown in Fig 2.2-19, at No.22 transformer substation of Kuzbass Energo (hereinafter called No.22 transformer substation.) electric power is received by two circuits of 110kV power transmission line from Belovo power plant and supplied these after decreasing the voltage to 35kV and 6kV, and each voltage rank is divided into two sections. A main transformer has two units with input voltage of 110kV and output voltage of 35kV and 6kV, and the capacity of each unit is 40,000kVA (No.1) and 31,500kVA(No.2). The operating ratio of each unit is about 50% for No.1 and about 67% for No.2.

110kV and 35kV switches are all oil-sealed type and installed outside, and 6kV switch of a cubicle type (air insulation) is installed inside. Each mother cables are all overhead cables. In connection with 6kV mother cable it is overhead cable arranged in the internal area of the transformer substation and the electricity is transmitted to the cubicle (switch) chamber from a wall face of the transformer substation.

The electric power supplied from No.22 transformer substation to No.21 owned by Belovougol (hereinafter called No.21 Transformer Substation) is accomplished by 6kV two circuits. Furthermore, other than No.21 Transformer Substation, 4 feeders composing of No.30 and No.32 of section 1, No.27 and No.31 of section 2 of No.22 Transformer Substation are directly connected with Chertinskaya coal mine. These 4 circuits supply directly with the electricity to a near place of load facilities from No.22 Transformer Substation and the electricity is transformed in that place to an appropriate voltage for application.

At No.22 Transformer Substation, operators work in two shifts per day (change on every 12 hours) to watch the operation status of the transformer substation and watch alarms at accident and operate equipment, too.
An authority of the operating equipment of the transformer substation is separated into three stages, which are an oblast level (Kemerovo state), a city level (Belovo city) and the transformer substation level in Kuzbass Energo. For example, 110kV equipment are operated according to the instruction of superior control but equipment with less than 35kV may be operated by the authority of No.22 Transformer Substation's own free will.
A control room of No.22 Transformer Substation is very orderly comparing with one of No.21 Transformer Substation and equipment also works well. And in the control room, electrodynamometers for 6kV consumers are arranged, amount electricity used by each consumer is calculated by Kuzbass Energo here, and power rate is charged in accordance with the amount used. In case of Japan the meter is placed at each consumer side, an electricity reader visits each consumer to read the meter so that each consumer may control its own amount used because the meter is placed inside of the consumers' compound. In Chritinskaya, the electricity amount used is only known at the meter of Kuzbass Energo.

(b) No.21 Transformer Substation (owned by Chertinkaya)

The electricity is fed from No.22 Transformer Substation to No.21 Transformer Substation by two 6kV circuits. In No.21 Transformer Substation, the electricity is received through No. 3 feeder of the section 1(the electricity source being No12. feeder of the section 1 of No.22 Transformer Substation) and through No.11 feeder of the section 2 (the electricity source being No11. feeder of the section 2 of No.22 Transformer Substation). The 6Kv mother cables of No.21 transformer substation is connected by a connection switch which is kept open at all times, but if the electricity to one mother cable is stopped, it is possible to continue supply with electricity through other mother cable by connecting the connection switch.

In general, in case of an accident of one mother cable, the operation load of 6kV receiving cable should be 50%, but actual operation load is about 60~70%. Under this condition, when the one cable is out of order, other mother cable is overloaded, so that supply with the electricity is continued by judgment of a chief engineer of Chertinskaya by restricting the load.

A capacity of the power transmission line between No.22 Transformer Substation and No.21 Transformer Substation is 1,200A and three cables (each cross section area is 240mm^2) are arranged in a row. Namely the capacity of each cable is 400A. By the way, while a linear distance between No.22 Transformer Substation and No.21 Transformer Substation is about 250 meters, the length of cable is recorded about 540 meters. Probably the cable root is presumed to be winding.

At No.21 Transformer Substation, the electricity distribution is rendered not only by 6kV cable but also by lower voltage cable after decrease of the voltage by 6kV/0.4kV transformer to internal area of the coal mine. Two cables of normal and spare cable supply with the electricity to an important load, but an exchange from the normal cable to the spare one is carried out manually (by hand) and its operation requires 1~5 minutes.

At No.21 Transformer Substation, operators work in four shifts per day (change on every 6 hours) to watch the operation status of the transformer substation and watch alarms at accident and operate equipment. too. As mentioned before, the meters are placed at side of Kuzbass Energo (No.22 transformer substation) and as Kuzbass Energo measures the consumption, the side of Chertinskaya does not record the operation status such as loading electricity or the like on the 6kV power transmission

redistributed from No.21 Transformer Substation. Even if they try to record, it is difficult because of many out-of-order equipment at No.21 Transformer Substation.

2) Voltage and frequency

The receiving voltage at Chertinskaya coal mine is 6,000V as rated voltage in general and the first tap at the transformer substation is usually set up at 6,300V for the voltage to become 6,000V at a heavy load. However, at even 6,300V in case of the heavy load, the voltage is actually decreased.

- The fluctuation rate of voltage is about 10%~15% and the voltage is about 5,900V at the maximum load in the morning (7o'clock ~ 10o'clock) and at the maximum load at night (18o'clock ~ 22.5o'clock). To the contrary, the voltage increases to 6,600V at the minimum load.
- The reason why the heavy load appears in both the morning and night is that cocking devices are used as heaters at home to cause the heavy load. At Belovo city, in general, cooking devices are electric heaters and gas is hardly used. (The use of gas is restricted in general at home and is prohibited at an apartment.)
- In accordance with a contract with Kuzbass Energo if the electricity used during heavy load exceeds the contracted amount, high penalty is charged and for that reason, restriction on load has to be carried out during the heavy load. Therefore, repairing construction or the like is accomplished during daytime of light load (10o'clock ~ 14o'clock).

Regarding the frequency, as the side of Chertinskaya coals mine, namely the side of No.21 Transformer Substation does not measure it, the frequency at the side of Kuzbass Energo becomes the frequency of the electricity received. The frequency controller which is installed at No.22 Transformer Substation keeps 50Hz, but the fluctuation of frequency is not recorded.

As meters to measure receiving voltage and its frequency, and meters to measure generating voltage and its frequency, are equipped on a controller board of the Caterpillar power generator, it is possible to measure the frequency, but Chertinskaya has not recorded it.

3) Rate for purchased electricity

At present, Chertinskaya coal mine is supplied with the electricity from Belovo coal-fired power plant of Kuzbass Energo.

- The output of Belovo coal-fired power plant is totally 1,200,000kW (200,000kW x 6) and its operation rate in summer is about 50% and it is operated at the output of about 600,000kW.
- The full output (1,200,000kW) requires to consume about 13,000tons of coal per day and 1/6 part of the coal is Belovo coal.

Regarding the power rate of Kuzbass Energo, in addition to that a consumer with contract more than 750kW pays according with the amount used (pay on amount), the consumer has to contract on the power rate during heavy load (contract on the maximum consumption).

- The power consumption during the heavy load (7.5o'clock ~ 10o'clock in the morning) does not exceed the contracted amount (8,000kW at Chertinskaya).
- In case the power consumption exceeds the contracted amount, they has to pay the penalty which is ten times of the standard rate, and for that reason they has to carefully operate not to exceed the contracted amount.
- A contract power consumption of Chertinskaya coal mine is 11,000kW at present during light load, but it is restricted in less than 8,200kW during heavy load.
- If the contract amount exceeds 11,000kW, they may consume 11,000kW during heavy load, but considering the present status being unable to pay the power rate to Kuzbass Energo without delay, it is very difficult.
- Regarding the two stage power rate, as the standard rate for heavy load is 62.17rubles per 1kW for a consumer with contract exceeding 750kW, they pay Kuzbass Energo 8,200kW x 62.17=509,794 rubles and further relating to the power rate for the amount they pay 0.12 rubles per 1kWh. The actual result of annual power consumption (1998) is shown in the former Chapter.
- A consumer with the contract less than 750kW does not contract on heavy load but the power rate on the amount is 0.22 rubles per kWh.
- Chertinskaya pays at present for a half of the power rate with cash and for remaining half with coal, but is in Kuzbass Energo's big debt. Kuzbass Energo asks them to pay by cash but not to supply them with electricity. However, even if

the electricity is restricted, they can not stop ventilation fans and pumps. Therefore, they plan to supply with electricity equivalent to load for ventilation fans and pumps by self- power plant.

If it is possible to use the recovered methane gas for self-power plant, Chertinskaya coal mine plans at first for its internal use. Under circumstance of the amount of output power, selling its surplus amount to Kuzbass Energo will be considerable in future.

However, for example, considering that Belovo thermal power plant is operated with about 50% output, it is difficult at present that Kuzbass Energo buys the surplus electric power from self-power plant of Chertinskaya coal mine. And as the law relating to selling electric power not only at Belovo city but also in the whole Russia has not been consolidated, it is one of the important subject in Russia to consolidate law relating to the sale of electric power from self-power plant.

4) Internal power distribution facility

In former Chapter, the outline about No.22 Transformer Substation owned by Kuzbass Energo (hereinafter called No.22 Transformer Substation) and No.21 Transformer Substation owned by Chertinskaya coal mine (hereinafter called No.21 Transformer Substation) are stated. In this Chapter, the internal power distribution facility at No.21 Transformer Substation is described below.

A single line diagram (outline drawing) of the power distribution facility including No.22 Transformer Substation is shown in Fig.2.2-19 and connection relation of CB (circuit breaker) and LS (line switch) at each facility are summarized in Table 2.2-16.

a) No.21 Transformer Substation (6kV unit)

Repeating the former Chapter, electric power is supplied by two 6kV circuits from No.22 Transformer Substation to No.21 Transformer Substation. As shown in Fig.2.2-19 the 6kV mother cable is divided into two sections, the 6kV unit of No.21 Transformer Substation, receives electric power by No.3 feeder of the section 1 (the power source being No.12 feeder of section 1 of No.22 Transformer Substation) and No.11 feeder of the section 2 (the power source being No.11 feeder of section 2 of No.22 Transformer Substation), and both sections are connected with No.8 feeder.

The total number of CB is 33, and its items are allocated to 2 for receiving electric power (No.3 and No.11), 1 for connection (No.8), 30 for power distribution (17 for the

section 1 and 13 for the section 13, respectively), respectively. Equipment, which power to be supplied from CB, is summarized in the Table 2.2-16.

No.21 Transformer Substation not only redistributes 6kV cable received electricity to Chertinskaya coal mine compound by 6kV cable but also steps the voltage down by 6kV/0.4kV transformer to distribute with low voltage circuit (400V).
Main power distribution facilities are composed of 0.4kV unit of No.21 Transformer Substation, pit transformer substation (ΓOP+50m), pit transformer substation (ΓOP-150m), and No.1, No.3, No.4, No.6 and No.18 of 6kV distribution towers or the like. Here, (ΓOP+50m) and (ΓOP-150m) of the transformer substation in the pits shows height above the sea level as standard of the Baltic Sea, and both facilities exist in the coal mine pit (under ground).
And the distribution towers redistribute the electric power supplied by 6kV after transferring the voltage to voltages to be used by load facility located nearby the distribution tower. By distributing with voltage as high as possible till near to load facilities, voltage decrease effect or the like is decreased as small as possible.

In a coal mine, as there are, a lot of important equipment from the viewpoint of preservation and for that reason, main distribution facilities are composed, in general, of two sections to supply electric power to the equipment by the normal line and the spare line.(refer to Table 2.2-16)

b) No.21 Transformer Substation (0.4kV unit)
At No.21 transformer substation, 6kV/0.4kV transformer for internal power distribution of lower voltage other than 6kV unit is installed. As shown in Fig 2.2-19, the 0.4kV unit receives electric power through No.4 feeder of the section 1(the power source being No.2 feeder of the section 1 of No.21 Transformer Substation) and through No.19 feeder of the section 2 (the power source being No.15 feeder of the section 2 of No.21 Transformer Substation) and both sections are connected with No.16 feeder.
As described before, 0.4kV unit is also divided into two sections, and the capacity of transformer (6kV/0.4kV) of each section is 1,000kVA. They say that operation ratio for each transformer is not known, however, from the viewpoint of working and spare equipment, the transformer should be operated at less than 50%.
However, operators at No.21 Transformer Substation stay there for 24 hours per day, and as in the case of accident they restrict load, the usual operation ratio seems to exceed 50%.

Total number of LS at No.21 Transformer Substation (0.4kv unit) is 33, its items are allocated to 2 for receiving (No.4 and No.19), 1 for connection (No.16) and 30 for power distribution (17 for the section 1and 13 for the section 2), respectively. The electric power from this unit is supplied to various low load equipment in the coal mine compound.

c) Pit transformer substation (Γ OP+50m)

As shown in Fig 2.2-19, the pit transformer substation receives the electric power through No.10 feeder of the section1 (the source being No.40 feeder of the section1 of No.21 Transformer Substation) and through No.1 feeder of the section 2 (the source being No.21 feeder of the section2 of No.21 Transformer Substation) and both sections are connected with No.5 feeder.

Total number of LS at the pit transformer substation (Γ OP+150m) is 10, and its items are allocated to 2 for receiving electric power, (No.1 and No.19), 1 for connection (No.5), 7 for distribution electric power(4 is for the section1 and 3 for the section 2, respectively),respectively. The electric power is redistributed from the pit transformer substation (Γ OP+50m) to the pit transformer substation (Γ OP-150m).

d) Pit transformer substation (Γ OP-150m)

The pit transformer substation (Γ OP-150m) which differs from other facilities, is divided into four sections. The pit transformer substation (Γ OP-150m), as shown in Fig 2.2-19, receives the electric power through No.26 feeder of the section 1, No.1 feeder of the section 2, No.18 feeder of the section 3 and No.10 of the section 4; and the section 1 and the section 3 are connected by No.13 feeder, and the section 2 and the section 4 are connected by No.7 feeder, respectively.

Total number of LS at the pit transformer substation (Γ OP-150m) is 26, and its items are allocated to 4 for receiving electric power (No.1,No.10, No.18 and No.26), 3 for connection (No.7, No.13 and No.19) and 19 for the distribution power (6 for the section 1, 5 for the section 2, 4 for the section 3 and 4 for the section 4, respectively), respectively.

Further, the electric power is redistributed from the pit transformer substation (Γ OP-150m) to 6kV pit power distribution tower.

e) Distribution tower

The power distribution tower, which is installed at the nearest loading facilities, distributes them the electrical power after transferring the voltage to suitable voltage for each facility. The single line diagram of Chertinskaya coal mine shows that there are five power distribution towers of No.1, No.3, No.4, No.6 and No.18. The distribution towers are also divided into two sections as well as other facilities.

No.1 power distribution tower receives the electric power from No.17 feeder of the section 1 (the power source is No.25 feeder of the section 1 of the pit transformer substation (Γ OP-150m)) and No.1 feeder of the section 2 (the power source being No.2 feeder of the section 2 of the pit transformer substation (Γ OP-150m)), and redistributes it to loading facilities. Both sections are connected with No.9 feeder.

No.3 power distribution tower receives the electric power from No.16 feeder of the section 1 (the power source is No.21 feeder of the section 1 of the pit transformer substation (Γ OP-150m)) and No.2 feeder of the section 2 (the power source being No.8 feeder of the section 2 of the pit transformer substation (Γ OP-150m)), and redistributes it to loading facilities. Both sections are connected with No.8 feeder.

No.4 power distribution tower receives the electric power from No.1 feeder of the section 1 (the power source is No.14 feeder of the section 1of the pit transformer substation (Γ OP-150m)) and No.16 feeder of the section 2 (the power source is No.6 feeder of the section 2 of the pit transformer substation (Γ OP-150m)), and redistributes to loading facilities. Both sections are connected with No.8 feeder.

No.6 power distribution tower and No.18 power distribution tower which differ from other distribution towers in supply root, are supplied directly by 6kV feeder from No.22 Transformer Substation owned by Kuzbass Energo.

No.6 power distribution tower receives the electric power through No.11 feeder of the section 1 (the power source being No.32 feeder of the section 1 of No.22 Transformer Substation) and through No.1 feeder of the section 2 (the power source being No.30 feeder of the section 2 of No.22 Transformer Substation), and redistributes it to loading facility. Both sections are connected with No.6 feeder.

No.18 power distribution tower receives the electric power through No.6 feeder of the section 1 (the power source being No.30 feeder of the section 1 of No.22 Transformer Substation.) and through No.1 feeder of the section 2 (the power source being No.27 feeder of the section 2 of No.22 Transformer Substation), and redistributes it to loading facility. Both sections are connected with No.4 feeder.

The above is the outline of the internal power distribution facilities of Chertinskaya coal mine. As mentioned first on the loading facilities, the coal mine does not manage strictly data relating to the electrical demand on each facility, and so the data are omitted because it is impossible to collect them. In the actual execution of the project, it is required to search on loading facilities and securely to manage data.

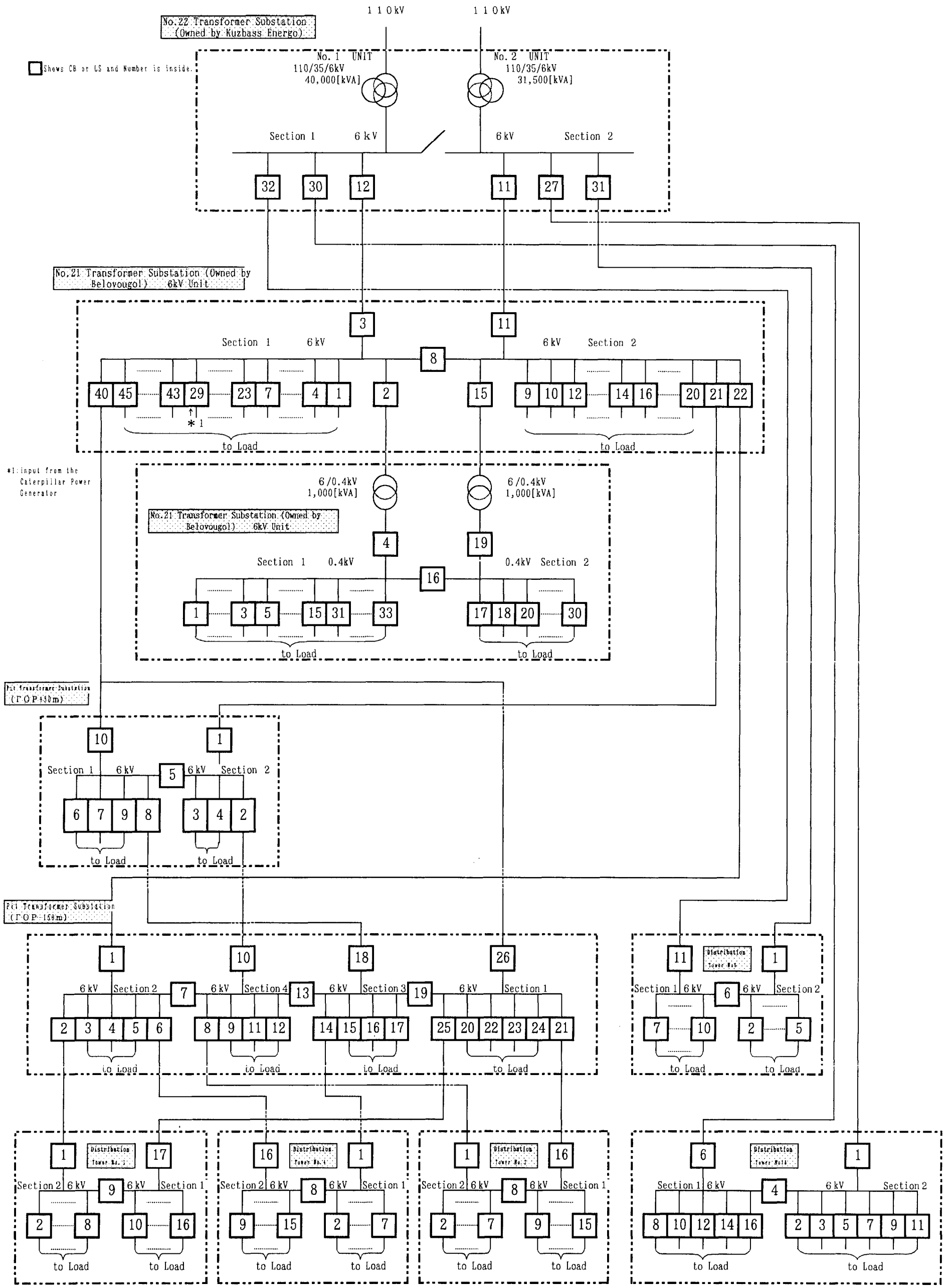


Fig.2.2-19 Single Line Diagram of Distribution Facility of Chertinskaya Coal Mine

Table 2.2-16 Circuit Outline List of Distribution Facility at Chertinskaya (CB,LS Connection Relationship)

	No.22 Transformer Substation	No.21Transformer Substation (6kV Unit)			No.21Transformer Substation (0.4kV Unit)			Pit 21Transformer Substation (ΓOP+50m)			Pit 21Transformer Substation (ΓOP-150m)			No.1 Distribution Tower			No.3 Distribution Tower			No.4 Distribution Tower			No.13 Distribution Tower			No.6 Distribution Tower		
	Distribution	Receiving	Distribution	Connection Relationship	Receiving	Distribution	Connection Relationship	Receiving	Distribution	Connection Relationship	Receiving	Distribution	Connection Relationship	Receiving	Distribution	Connection Relationship	Receiving	Distribution	Connection Relationship	Receiving	Distribution	Connection Relationship	Receiving	Distribution	Connection Relationship	Receiving	Distribution	Connection Relationship
Section 1	12	3	1	→	To Load																							
			2	→	4	1~3	→	To Load																				
						5~15	→	To Load																				
							16																					
						31~33	→	To Load																				
			4~7	→	To Load																							
				8																								
			23~28	→	To Load																							
			29	←	From Caterpillar Generator																							
			40	→	→	→	→	10		5																		
			↓						6.7	→	To Load																	
			↓						8	→	18		13															
												14	→	→	→	→	→	→	→	→	2~7	→	To Load					
			↓									15~17	→	To Load								8						
			↓										19															
			↓						9	→	To Load																	
			(40)	→	→	→	→	→	→	→	26	20	→	To Load														
												21	→	→	→	→	16	9~15	→	To Load								
												22~24	→	To Load					8									
												25	→	17	10~16	→	To Load											
													19															
			43~45	→	To Load																							
	30	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	6	8,10,12,14,16	→	To Load		
																									4			
	32	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	11	7~10	To Load
Section 2	11	11		8																								
			9,10	→	To Load																							
			12~14	→	To Load																							
			15	→	19		16																					
						17,18	→	To Load																				
						20~30	→	To Load																				
			16~20	→	To Load																							
			21	→	→	→	→	1	2	→	10		7															
												8	→	→	→	→	1	2~7	→	To Load								
												9,11,12	→	To Load					8									
													13															
									3,4	→	To Load																	
										5																		
			22	→	→	→	→	→	→	→	1	2	→	1	2~8	→	To Load											
												3~5	→	To Load		9												
												6	→	→	→	→	→	→	→	16	9~15	→	To Load					
													7									8						
	27	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	1	2,3,5,7,9,11	→			
																									4			To Load
	31	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	1	2~5	
																												6

(4) Present status on internal steam supply

There are 6 boilers for an internal utility, and their total capacity is 80tons(10tons × 4 and 20tons × 2). However, at present the utility of about 40% of the maximum capacity is available. There are many reasons such as low quality of coal and water, superannuation of a steam drum, piping and insulation material or the like.
As only 40% of the maximum capacity are available, heating is insufficient in winter. Both steam pressure and steam amount are insufficient and for that reason efficiency of the boilers becomes low because of heat loss caused by a steam leak caused by superannuation of the steam drum and piping and caused by superannuation of insulation materials.
Water for boiler is water dew up from the coal mine (water for industry), contains a lot of salts and its quality does not satisfy the specification of water for boiler. There exists an old water treatment facility but it hardly functions because of it ages, and there is danger of clogging pipes.
However, as they can not stop boilers in winter, present status is that they continue operating as it is even though quality of water is poor.
A control room is also superannuated and at present it is not known how to be operated. On a control panel and an instrument panel there are equipment with which wire does not connected, and omission of instrument, which might be used for another purpose, is found, and recording paper is missing. At present, the control using control device is hardly carried out.
On the point of this research, one 10 tons boiler and one 20 tons boiler are under repair where they exchange a steam pipe. A cross section of a discarded pipe are clogged by rust and scale till its half.

(5) Present status of internal pipeline

Most of methane gas is discharged in the air as it is and only a part of methane gas is recovered. This is the gas pipeline constructed 15 years ago according to a plan to utilize it for boiler fuel, which is 200A pipe and has been constructed about in a length of about 3,200 meters. The utilization plan for boiler has come to a deadlock because of Perestroika. At present it is used for supply with gas to the Caterpillar gas power generator. It is completely rusted and is placed on wooden pillows at the field and is placed on a lack in the internal area.

(6) Maintenance shop

There is no machining factory nearby and for that reason, they have a repair shop in the internal area. The shop is one-storied house with area of about 500m^2, and under its ceiling hoist rails are arranged and about ten machines such as a lathe, a miller, a drilling machine or the like are arranged and in addition two small air hammers and two small furnaces for quenching are arranged. In another room there is a repair shop for instrument with space of 20m^2. There no instruments containing computer were found. Moreover, lightening in the repair shop is dark, repair machine and facility for repair are 30 years to 40 years old. About 30 repairmen are working there.

2.3 Project implementing capability of Belovougol

(1) Technological capability

Their gas recovery and control technologies are on a considerably high level. In the stable production time of coal before the collapse of Russian economy, the recovery percentage of gas was high and it is supposed that the utmost technological efforts were made using boring equipment with limited capacity. Therefore, regarding the most effective method of venting under the geological conditions of the Chertinskaya coal mine, having thorough knowledge about the relation between gas behavior and mining conditions, it is expected that high technologies are possessed from the standpoints of not only active business but theory. The stipulated underground gas level has even now been observed combing a variety of venting methods while related facilities have become obsolete. At the same time for the control of gas a monitoring system which is yet simple was introduced a few years ago to operate. Therefore, in order to implement this project planning of the technological transfer on the operation of new facilities to be introduced are applicable for the engineers of the coal mine bringing sufficient technological results.

For the utilization technologies of methane those of mixed combustion into coal-fired steam boiler, gas engine and power generation facility of gas turbine are considered. As for the utilization into steam boiler two 20 t/h boilers and four 10 t/h boilers in total of 80 t/h capacity were already been possessed and operated to controlled in the Cheritinskaya coal mine. Based on this situation abilities of design, construction and control on the mixed combustion facility for steam boiler would be sufficient.

In addition they also possess and operate various kinds of driving facilities by diesel engine, and so their technological abilities are considered high.

(2) Management system

The top responsible person in charge of project management is the First Vice-President Zolotykh of Kuzbassugol. At the project site, the President Larin and the Chief Engineer Zharov of the subsidiary Belovougol are to be in charge of the system management as shown in Paragraph (6). The detailed management system would be determined when the contents of project execution will be concluded.

(3) Management basis and principles

In July of 1999, Kuzbassugol was established amalgamating three branch companies that include Belovougol. The management basis of each branch company is placed under Kuzbassugol. Among eleven executives of the company, two are the Vice-Governors of Kemerovo State and this means that the intention of the state government may reflect on the management of Belovougol. Their management principles are when enumerated: improvement of the existing coal mine, setting up of new coal mine and planning partition of the existing coal mine while maintaining present coal production.

(4) Capability of financial load

The coal industry in Russia is generally speaking in financial difficulties, and International Bank for Reconstruction and Development and Japan Bank for International Cooperation are furnishing accommodation for restructuring funds of coal industry on the obligatory condition of closure of ineffective coal mine. The industry is now driven into a hard situation. Belovougol is the deficit company as described below and therefore seems to be difficult to raise necessary funds even in part by itself. This group (JCOAL, Tokyo Electric Power company, Marubeni, Toyo Engineering, and other participants) would accordingly arrange required funds through financing, etc.

Approximate sales:	360 million rubles
Expenditure:	470 million rubles
Capital:	390 thousand rubles
Coal production(1998):	About 3 million tons

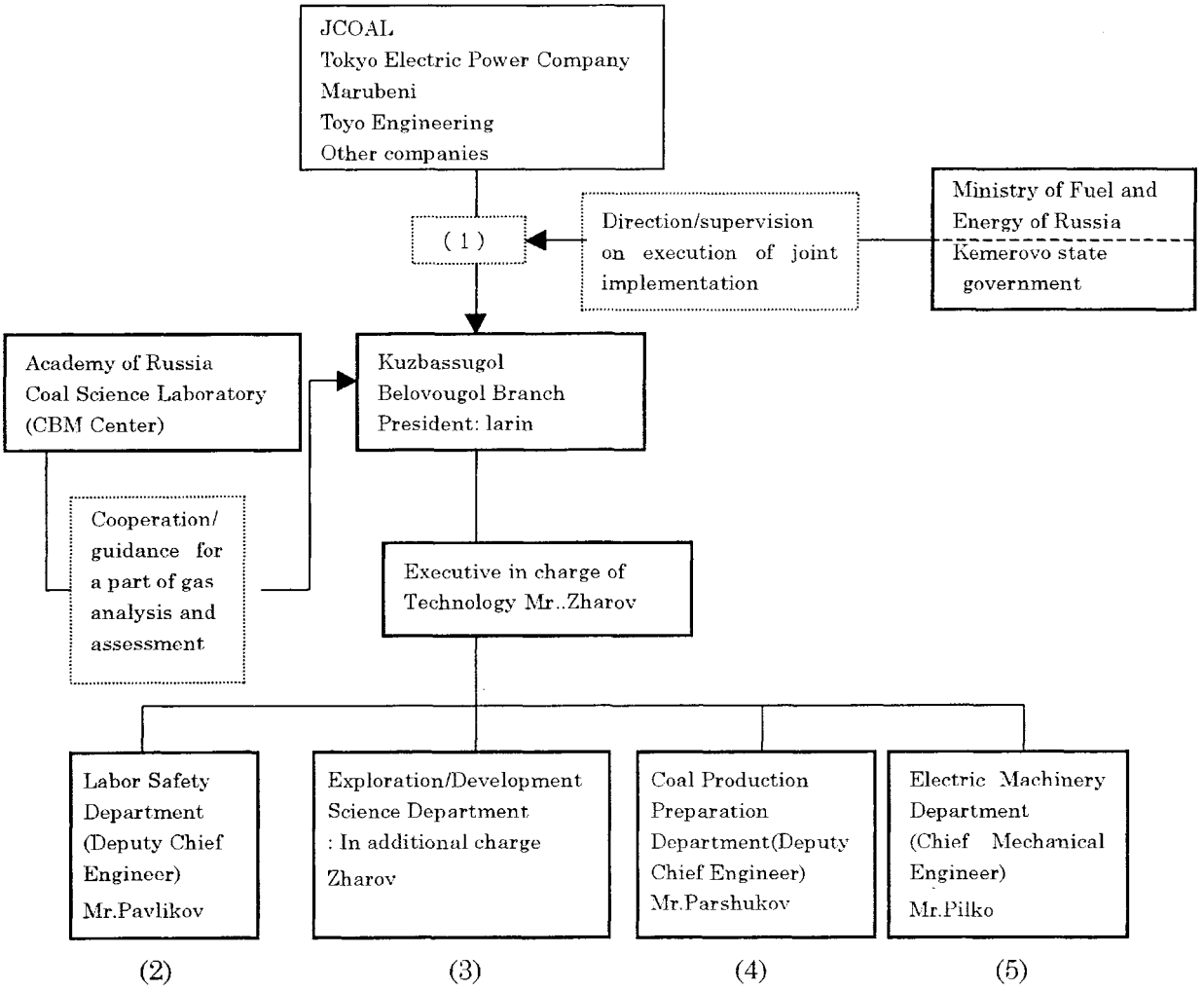
(5) Capability of personnel load

As mentioned above Belovougol introduced power generation facility utilizing methane from Caterpillar and Gazprom and has acquired knowledge relating to recovery and utilization of coal mine methane. In order to execute the project the following departments as well as engineers of the Chertinskaya coal mine are to be in charge:

- Technology Development Department headed by Mr. Zharov, Chief Engineer (6 staffs in total), who holds the additional post of Professor of Kuzbass National Institute of Technology
- Labor Safety Department (7 staffs in total) headed by Mr. Pavlikov, Deputy Chief Engineer
- Coal Production Preparation Department (3 staffs in total) headed by Mr. Parshukov, Deputy Chief Engineer who has the degree of Master of Science Technology
- Power and Machinery Department (5 staffs in total) headed by Mr. Pilko, Chief Mechanical Engineer

All of the enumerated above are on a high level of technology and are considered to have no difficulties for performing the project.

(6) Implementation system



(1) To procure/provide technology, equipment and finance based on bilateral agreement

(2) To control matters related to underground and surface labor safety (security) of coal mine

(3) To control mainly matters related to the recovery/control of gas in mine

(4) Ditto

(5) To control mainly matters related to the gas utilization facility

2.4 Specification of related facilities at implementing site after remodelling

A. Gas Recovery and Control Project

Even though Chertinskaya coalmine have methane gas recovery technology and own gas utilization facilities (gas power generating system, etc.), they still haven't established an efficient system that controls gas from recovery to utilization in an integrated way. As the coal from this coalmine has high content of methane gas, they have some intentions to modernize the methane gas recovery system and to improve safety and productivity in the coalmine and make a good use of methane gas, but in fact, they are not taking any actions yet. Here, based on the result of the study this time, we would like to propose gas recovery ratio improvement action plan, for the purpose of modernizing Chertinskaya colamine, by referring to gas recovery and control systems in Japanese coalmines, where we have the similar geologic conditions and are supplying the recovered gas to City Gas in regular basis.

2.4.1 Concept of gas recovery plan

Here, we will set up a plan by putting the gas drainage method and theory adopted in Chertinskaya coalmine as the base, then applying new drilling technology and effective gas drainage technique and equipments used in Japanese coalmine (Taiheiyo Coal Mine).

(1) As the main system, we adopt underground measure gas drainage boring.
The present main gas recovering method in Chertinskaya coalmine is vertical gob well. Chertinskaya coalmine has 3 working coalseams (# 3, # 4 and # 5 coalseam), and drilling from the surface is only effective in the first coalseam they drill. If they try to drill the other coalseam from the surface too, they need to use highly technical drilling method and will require much time and cost because they will have to drill through the goaf of the previous mining or areas disturbed by the previous mining. Furthermore, the surface drilling has negative factors like high cost, difficulty in the work during winter and need of installing pipelines, etc.

From the above reasons, we can think of gas draining occasions where it is effective to combine gob well surface boring and under ground boring, or where underground boring only is sufficient. Here, we would like to propose the latter one - a system that adopts underground cross measure gas drainage boring method.

(2) Selection of boring machine

Cross measure boring they do presently has the hole of 50 ~ 60m long. We think it necessary to aim mid- to long-hole boring in order to extend the effective period, to reduce the number of holes and to simplify the control in this gas drainage boring. However, it is not advisable to aim the long-hole boring from the beginning. We think it effective to extend the hole length step by step so that they have time to set up standards for gas drainage boring and time to build up technical skill. Therefore, in this plan, we set the aim of drilling hole length to app. 300m.

(3) Improvement of gas drainage technology at site

For efficient gas drainage and obtaining proper quality for gas utilization, improvement of caulking method and valve control at bore hole mouth and installing auto-water drain equipment, etc. are carried out.

(4) Sealing method and utilization of gas from sealed area

Complete sealing method must be applied to goaf in coal mine to prevent from spontaneous combustion. Furthermore, the goaf is utilized as gas reservoir for stable gas use.

(5) Gas drainage monitoring system

They are already using simple monitoring system from Britain, but we take #544 face as the model, and propose continuous measuring・monitoring system that is capable of proving the effect of the gas recovering system.

2.4.2 Gas drainage plan taking #544 $^{L}/_{W}$ face as the model

Judging from the performance of the present gas draining boring of Chertinskaya coalmine, we think the gas emission from the coalseam and stratum must be fairly good. Therefore, we set up the plan based on the following drilling conditions. (Fig.2.2-21,2.2-22)

(1) Boring hole arrangement (Position and number of drilling hole)

Drilled hole length: 300m (upward), 200m (downward)
Average holes: 3 holes (upward), 1 hole (downward)

1) Upward holes

- Drill one hole toward app. 20m above the working coalseam. It is an in-mine boring hole that works as the vertical gob well.
- Drill 2 mid-long boring holes toward around the neighborhood of the upper coalseam. They are the holes that works like the set of conventional cross measure gas drainage holes.

2) Downward holes

- Drill one hole toward the lower coal seam to collect gas coming from the lower coalseam.

We must design the drilling direction and angle so that the system can drain enough volume of gas as compared with their present drainage volume in Chertinskaya coalmine, through their surface well for the bleeder, vertical gob well and cross measure gas drainage boring.
However, the position and number of these drilling holes can differ according to the geological condition of the mining area and to the conditions accompanied with mining, such as cracking or natural fracture. Therefore, we have to pursue the appropriate hole arrangement by monitoring the result of gas recovery and emission performance during the course of this project.

(2) Boring space and installation of the boring station

In the case of sudden gas emission from gas drainage hole or gas suction pipe, and for better gas drainage efficiency, we will set up the drilling station in the return air way (tailgate) of the face. The hole length is 300m, but we make the space between the station 200m, considering recoverable zone of gas drainage hole and boring angle, etc.*

However, because they use the return air way to transport lumbers and materials used in the face, we have to install the station by digging into the face side of coalbed. We make the station to be 5m long, 4m wide and 2.5m high (Fig.2.2-20), so that using 1.5m long rod will not be a problem. And we install stagnant gas removing facilities inside the station.

* : Based on the experience of mid-hole (hole length app. 300m) gas drainage boring in Taiheiyo coalmine, the effective length while the gas drainage is possible is about 200m.

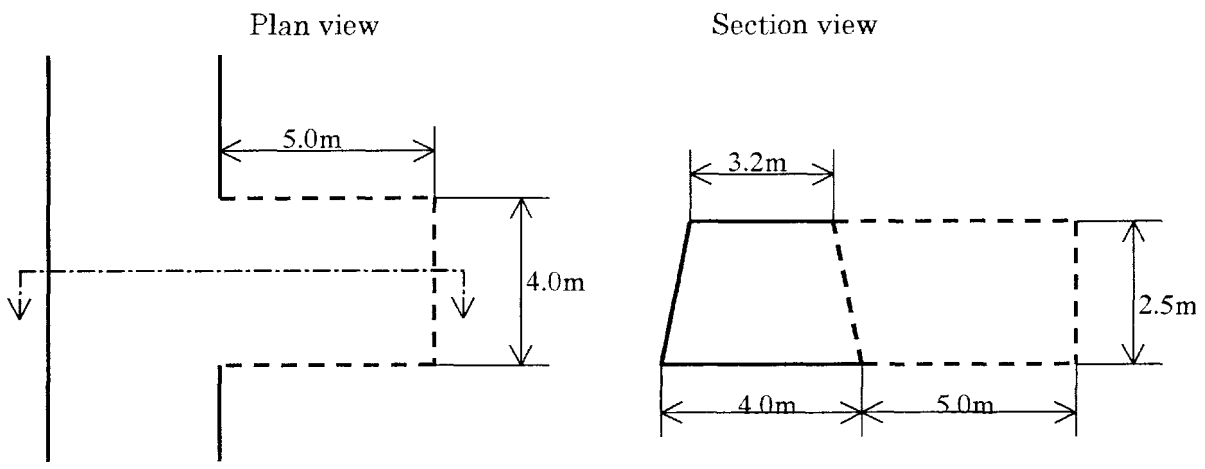


Fig.2.2-20 Gas drainage boring station

(3) Bore mouth diameter and maintaining method of the hole

Gas volume drained through one hole is fairly large in Chertinskaya coalmine, but the gas concentration is low. In methane gas recovery this time, it is better to supply higher concentration gas to gas utilization facilities. Therefore, we start with calculated drilling diameter for this project and maintaining method adopted in Taiheiyo coalmine, but as we go along with the actual gas drainage, we will seek the optimum diameter and maintaining method.

As the geological characteristics (especially the kind of rock) in Chertinskaya coalmine is similar with the one in Taiheiyo coalmine, and as the drained gas concentration varies, we will use the drilling hole with the following diameter and maintaining method.

- We make the final diameter of each hole 120mm dia. (bore 77mm dia, reamed 120mm dia)
- Total casing with 3-inch steel pipe (with strainer) for all the holes
- Do caulking on bore mouth (about 6m)
- Suction: 50 ~ 60mmWG + α

(4) Days necessary for boring

Before starting mining of the face, we need to make at least one station to be ready for draining the gas. In estimating the days necessary for completing one station, we take the mid-hole gas draining boring work data in Taiheiyo coalmine having similar kind of rock composition, and calculate as follows.

Installation・fixing bore mouth		6 days
Bore drilling	{(300m x 3 holes) + (200m x 1 hole)} ÷ 70m/day	16 days
Reaming	{(300m x 3 holes) + (200m x 1 hole)} ÷ 120m/day	10 days
Casing insert	{(300m x 3 holes) + (200m x 1 hole)} ÷ 200m/day	6 days
Position change, removal	change 3 times *	3 days
Total		41 days

* : Change of drilling direction within the station

(5) Number of boring machine needed

From the explanation by Chertinskaya coalmine, the advancing speed in their typical face (about 150m long, seam dip about 10 degree) is 60 ~ 65m/month. And the distance between each station in this project is 200m. Therefore, we have 3 months of interval from starting gas suction in one station till starting suction in another station.
At the same time, we need to add a few days to the days calculated in above (4), which is the time needed to remove the boring machine from the finished station and set it up at the next station, and we think total of app. 2 month period is sufficient to complete drilling of one station. Based on this, one set of boring machine per face is enough for gas drainage boring.
Therefore, for the boring plan of #544 face, we suggest to use 1 unit of mid-distance boring machine RK (explained in the latter section), but since Chertinskaya coalmine have total 3 active faces, they may need 2 units of RK and one unit of TOP-TM*.

* : Mid-distance boring machine for drilling softer stratum and for practicing long-distance directional boring technique.

(6) Total drilling length in present and in plan

When we compare the present status of #544 face in Chertinskaya coalmine with the amount of boring work suggested for this project, which we listed in the table below, we can expect a big reduction of gas drainage drilling length. Besides, we do not do any boring from the surface, there will also be a big reduction of total work load.

Table2.2-17 Comparison of boring work load

	Present		Plan	
	Cross measure boring	Surface boring	Cross measure boring (Upward)	Cross measure boring (Downward)
No. of station	25	9	5	5
No. of hole	50	9	15	5
Hole length (m)	2,800	4,500	4,500	1,000
Total hole length(m)	7,300		5,500	

(7) Control of boring hole

We are sure in the long history of coal mining, Chertinskaya coalmine has already established control standard for boring holes. But especially from the point of recovered gas utilization , we would like to recommend the following control items for the safety of boring work, for securing higher concentration of drained gas and for preventing accident from used holes.

1) Gas drainage method while drilling (action to prevent gas outburst • immediate suction system)

While drilling, we install a stand pipe at the steel guide flange, and connect it to the main drainage pipe through the gas suction hose. With this system, we can immediately drain the gas in case of gas blowing. And if necessary, we install preventer at the boring machine side to prevent the gas to run off.

2) Stopping of draining suction and standard for redraining the stopped hole

We must stop gas drainage through low-concentration gas drain hole when the gas concentration in the main drainage pipe becomes less than 30%, and must redrain when it becomes more than 30%. We do this by opening and closing the sluice valve at the flange of each drainage hole.

3) Timing of drainage start and finish

Cross measure drainage boring is a kind of gob well boring. In Taiheiyo coalmine, it is when the hole bottom gets closer to about 20m behind the face when disturbance of stratum begins and gas starts to emit. Therefore, we make sure to complete gas drainage facilities before this disturbance timing, so that we can start drainage immediately when the gas starts to emit. Finishing of suction is basically when the hole mouth reaches 5 ~ 10m to the face.

As we expect the gas emission is better in Chertinskaya coalmine than Taiheiyo coalmine, we think they can drain the gas in earlier stage than the above. They must make sure to complete the gas drainage facilities before the gas starts to emit.

4) How to seal the hole after finishing gas drainage

We seal the hole by filing mortar cement up to 50cm from the mouth of stand pipe, or use steel plate to close it blindly.

2.4.3 Outline of boring machine to be introduced

(1) General purpose boring machine for mid-distance (RK type)

Mid-distance boring machine called RK type is an electro-hydraulic machine. We fix the machine with 4 pcs. of screw type expansion poles. It consists of 3 major portions - the pusher/puller, the transmission and the base. It is easy to carry, and we can put it up at the boring site. We use electrical water supply pump of WLMG-15 type to use with the boring machine.

In Japan, for drilling, we use BW rod of 1.5m long and 53.9mm dia. with wrench flat cut at rod coupling, with a bit of 3-impeller 77mm dia cross bit with sintered artificial diamond tip mounted on it. First we drill the bore of 6 ~ 10m, then expand it with reaming. Then we insert the steel stand pipe of 5.5m long. After that, we further drill the bore to the aim of around 300m, and ream the whole length to 120mm dia. From the bottom of the drilled hole to about 50m in front of the bore mouth, we insert 3-inch steel pipe with 0.5m strainer pipe at every 10m, and complete the hole in whole casing. Lastly, we finish it by pouring cement at bore mouth to prevent leakage.

RK type boring machine specification

Motor Electric motor		11 kW
Maximum torque		210 kg-m
Maximum thrust force		3.0 t
Spindle rotation		50~500 rpm
Dimension	Width	1,050 mm
	Height	1,560 mm
	Length	2,260 mm
Weight		1,300kg(excluding motor)

WLMG-15H type pump specification

Motor Electric motor	11 kW
discharge pressure	22 ~ 70 kg/cm^2
Discharge volume	67 ~ 210 l/min
Weight	500 kg

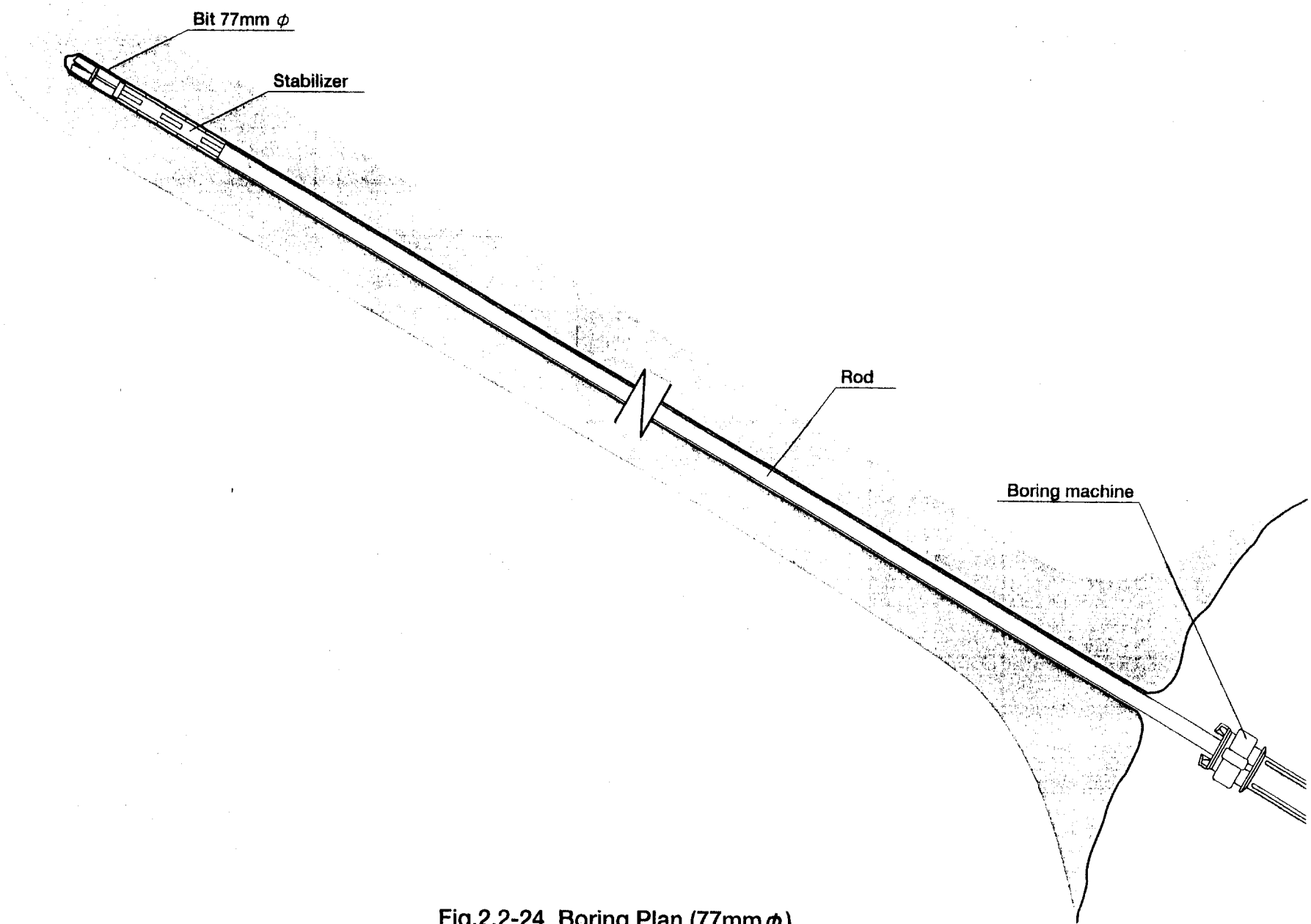


Fig.2.2-24 Boring Plan (77mm φ)

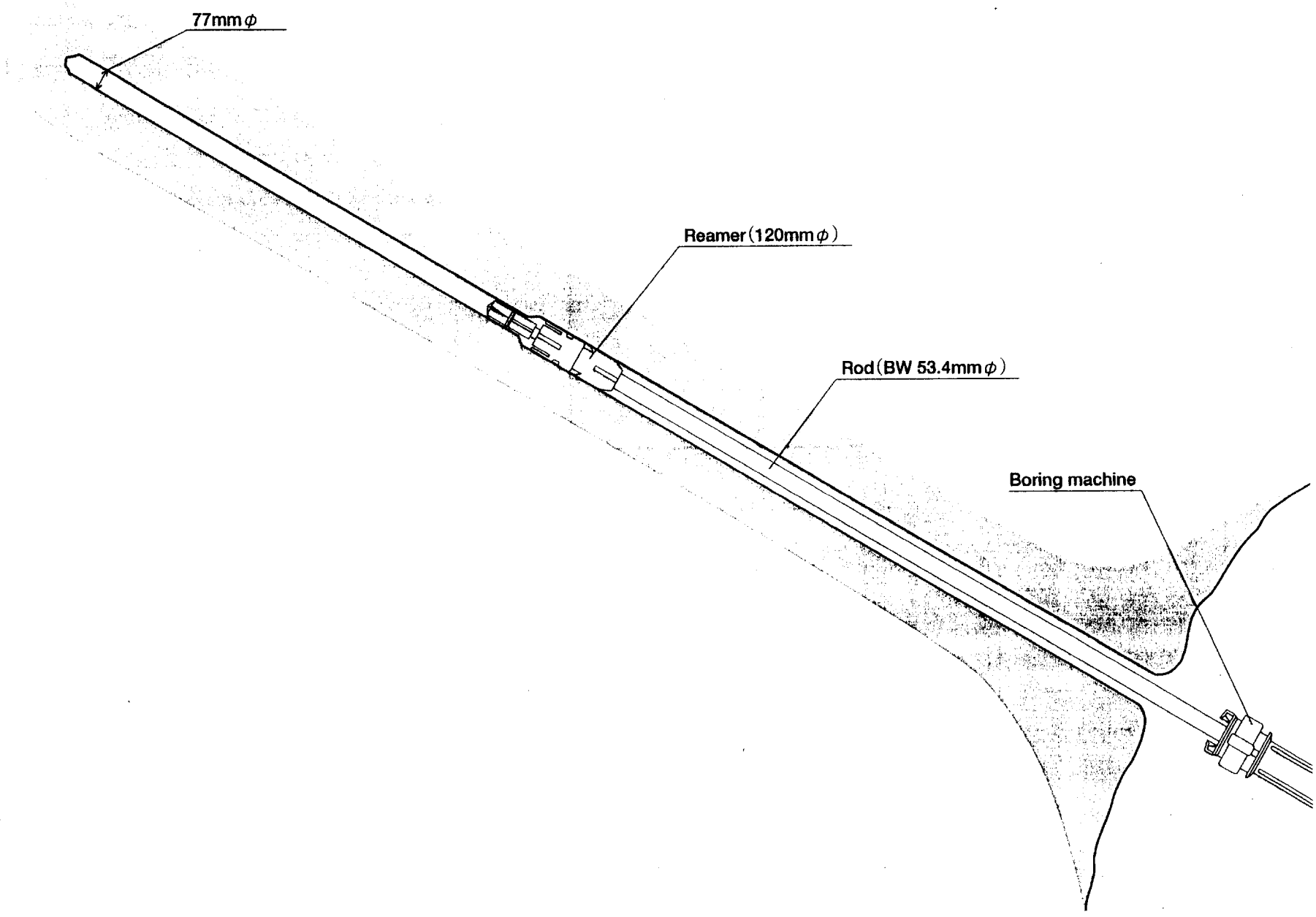


Fig.2.2-25 Boring Plan (Reaming 120mmφ)

(2) Double pipe shield method, directional boring method of mid- to long-distance boring machine

1) Mid- to long-distance boring machine (TOP-TM, TOP-L)

In Japan (Taiheiyo coalmine), we have already established technology of long-hole boring of about 550m using horizontal long-distance boring machine (TOP-L type), and have a lot of experience in drilling gas drainage hole in L/W face. We can drain the gas for a long time according to the drilled hole length, but because it is a large equipment including the attachments, it requires the drilling station with large space. Another difficulty is it requires skilled technique in controlling the drilling work, etc.

Therefore, we have developed TOP-TM type - easier-to-handle mid-distance boring machine, still having the capability of double pipe shield method and directional boring. The drilling method is same with TOP-L type, but the equipment itself is smaller in size, and is easy to transport, install and operate. Now the machine is capable of drilling about 300m hole, but we are aiming at about 500m of drilling. It doesn't need large size boring station like TOP-L - the station of 5 ~ 6m is enough, and unlike RK type, it can drill through soft strata or fractured-in portion.

Both boring machines are electro-hydraulic driven. We use 4-point wire binding to fix the main machine. We can take it apart to 3 major portions - the pusher/puller, the swivel head and the slide base, and we can put it up at the drilling site. We use electrical water supply pump of WLMG-15H, but when we do directional boring, we have to use triplex pump as we need 400 liter/min of supply volume and water pressure of 80kg/cm^2.

We use double-threaded round screw type casing rod with the length of 3.0m for TOP-L, 1.5m for TOP-TM, having diameter of 130mm (sometimes we use 165mm for TOP-L), 105mm and 80mm. We use crown or cross type bit mounted with sintered artificial diamond tip matching with each rod diameter.

Specification	TOP-L Boring Machine	TOP-TM Boring Machine
Motor (Electric motor)	55 kW	22 kW
Maximum torque	1,400 kg-m	1,110 kg-m
Maximum thrust	12 t	6 t
Spindle rotation	0~199 rpm	0~91 rpm
Dimension Width	1,290 mm	800 mm
Hight	1,130 mm	1,008 mm
Length	8,670 mm	3,870 mm
Body weight without motor	3,500 kg	2,400 kg

In drilling towards the aiming hole length, sometimes we have to drill through unexpected fratured-in area or soft strata. In order to cope with it, we have to make 4 kinds of drilling method available to select anytime, which are single (normal, reverse) method and double pipe (normal, reverse) method. For this, after installing the boring machine, we drill a hole to fix the bore mouth, insert the stand pipe (130mm dia or 160mm dia) about 8m, and caulk with cement. We install devices (like preventor, etc.) on the flange of the mouth before starting the main drilling.

2) Double pipe shield method

Double pipe shield method is effective when we drill through soft strata or caved-in area. It drills with the outer pipe by protecting the fracture zone etc., and drill with the inner pipe at the same time (See Fig.2.2-31). At the start of drilling, we use outer pipe of 130mm dia and inner pipe of 105mm dia, and when we reach to the fractured-in area, we use the outer pipe of 130mm dia as the shielding pipe and use the combination of outer pipe of 105mm dia and inner pipe of 80mm dia, and keep reducing the pipe diameter in telescopic manner. In conventional boring machine, we have to stop drilling and apply casing when we reach to the fractured-in area, but with double pipe shield method, we can continue drilling.

Meanwhile, there are two methods in supplying the water while drilling; normal method and reverse method. In general purpose drilling, we use single · normal method of supplying water through the rod of single pipe to cool the bit, and circulate the water and the cuttings backward to the open end of the hole through the gap between the rod and hole wall. In reverse method, we circulate the water in completely opposite way. Fig.2.2-26 shows the reverse system in double pipe shield and single rod methods. In double pipe shield method, we circulate water using outer and inner pipes. Because it generates almost no water flow between the outer pipe and the hole wall, it doesn't damage the hole wall.

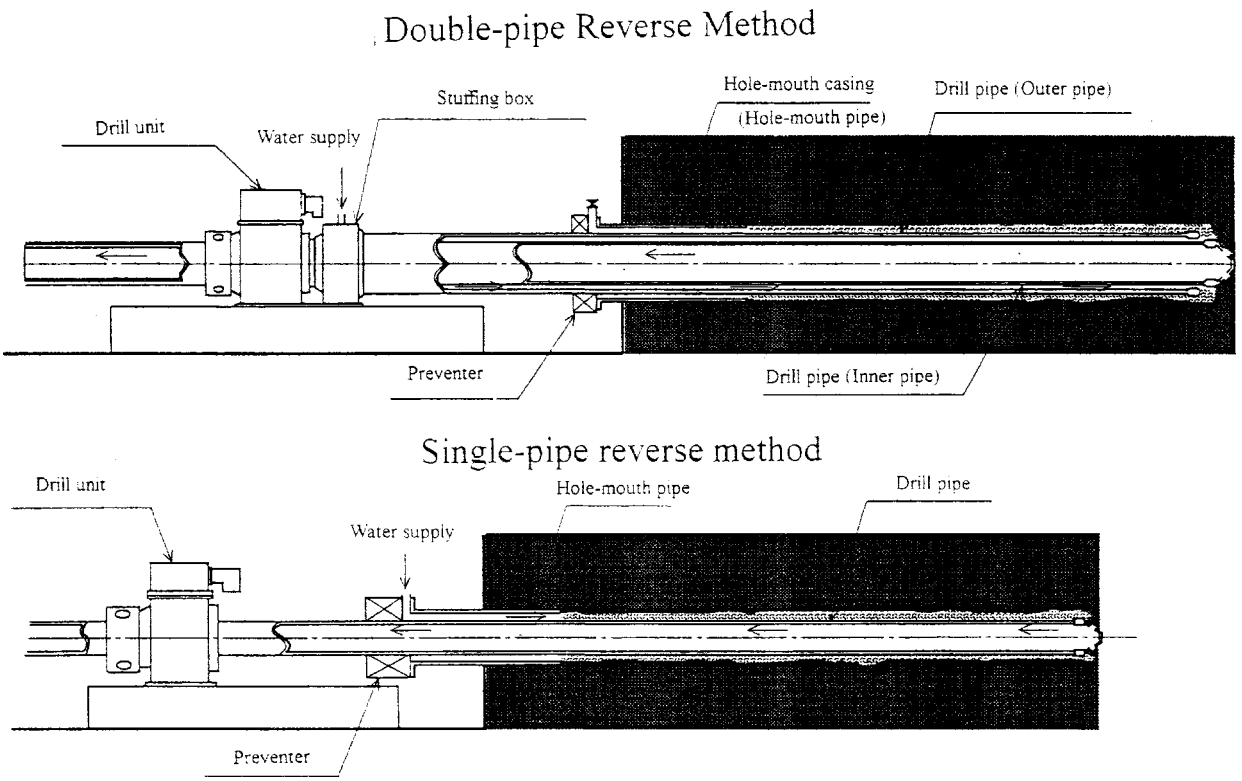
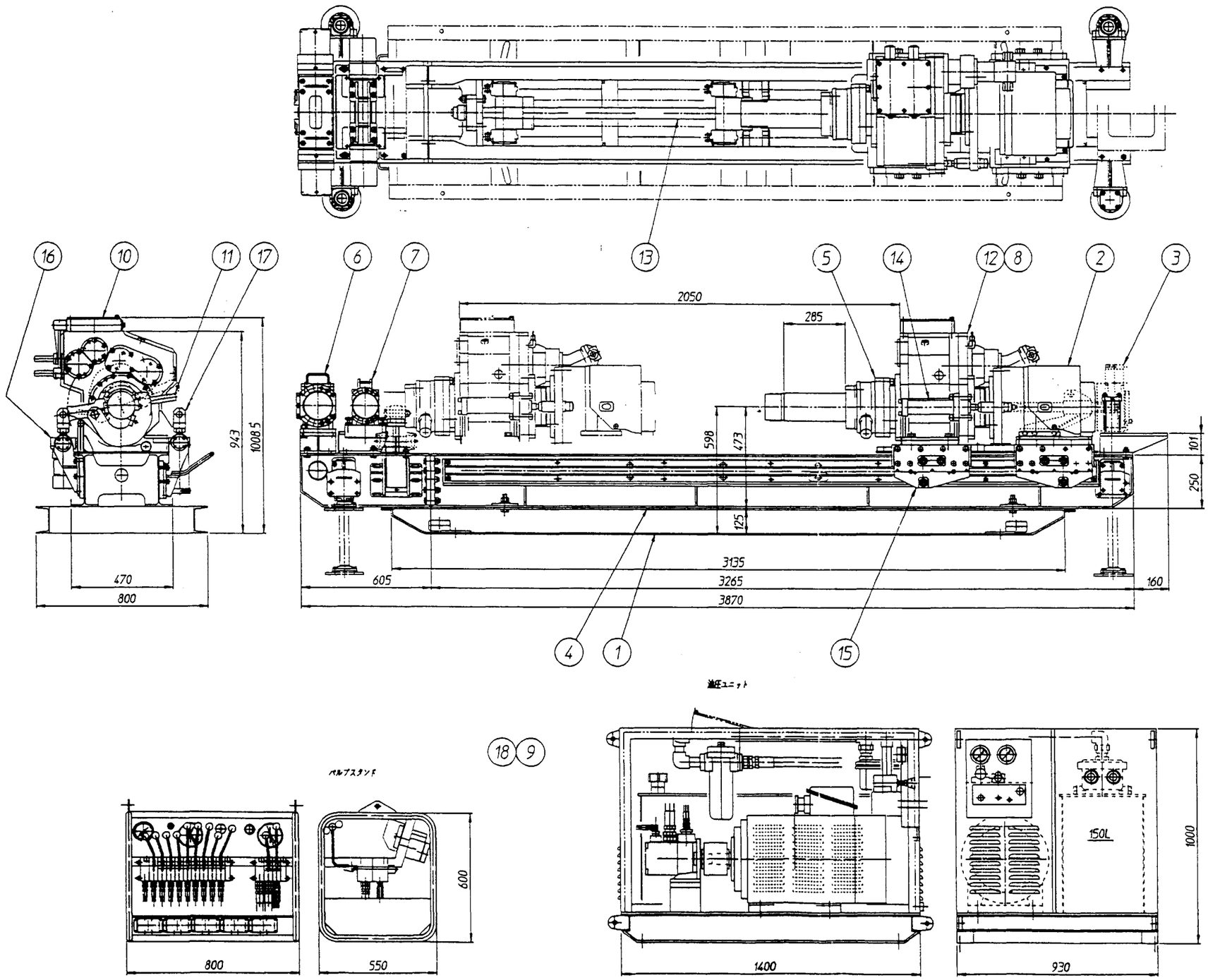


Fig 2.2-26 Reverse methods

仕様

1) スイベルヘッド
1-1) 型式・・・・・・・・・・・・・・ 油圧モータトップドライブ方式
1-2) スピンドル内径(mm)・・・・・ Ø110
1-3) スピンドル回転数(rpm)・・・ (0~15),0~26,0~53,0~91
1-4) スピンドルトルク(kN-m)・・ (10.9), 6.4, 3.1, 1.8
1-5) 使用ロッド・・・・・・・・・・・ 外管 TR105, 内管 TR80
TR130 TR105
1-6) チャック・・・・・・・・・・・・ 外管フランジ,内管油圧式
内管チャックストローク 150mm
1-7) 指向性ボーリング用非回転チャック 油圧クランプ型,Ø80
2) プルダウン
2-1) フィード方式・・・・・・・・・・ 油圧シリンダ倍速方式
2-2) フィード力(kN)・・・・・・・ MAX. 59
2-3) フィード速度(m/min)・・・ 掘削時 2.1 急速時 17.4
2-4) フィードストローク(mm)・・・ 2050
3) 掘削方向・・・・・・・・・・・・・・ 水平, (傾斜時:別置架台使用)
4) 掘削水平揺動角 ・・・・・・・・・・ ±5°
5) 電動機・・・・・・・・・・・・・・・ 坑気防爆 400V,22kw-4P
6) ロッドホルダ・・・・・・・・・・・・ 外管内管油圧式
7) ブレークアウトトング・・・・・・・ 油圧式 (左右選択型)
8) 先端駆動型ドリル用非回転チャック装備
9) 重量(kg)・・・・・・・・・・・・ 本体 2400Kg
油圧ユニット 950Kg(ドライ)
バルブスタンド 130Kg

※ Low回転はレバーロック方式とし、通常掘削は2nd基準とする.



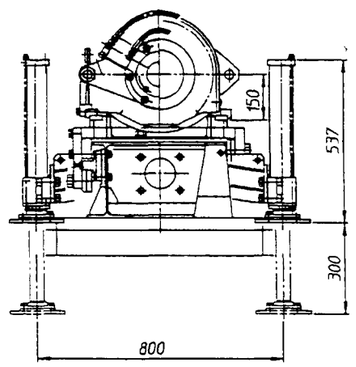


Fig 2.2-28 TOP-TM Assembly draning

TOP-TM2 総組立図
M.Hirohata
B6102-636
99-7-27

Illustration of long-hole Boring (TOP-L)

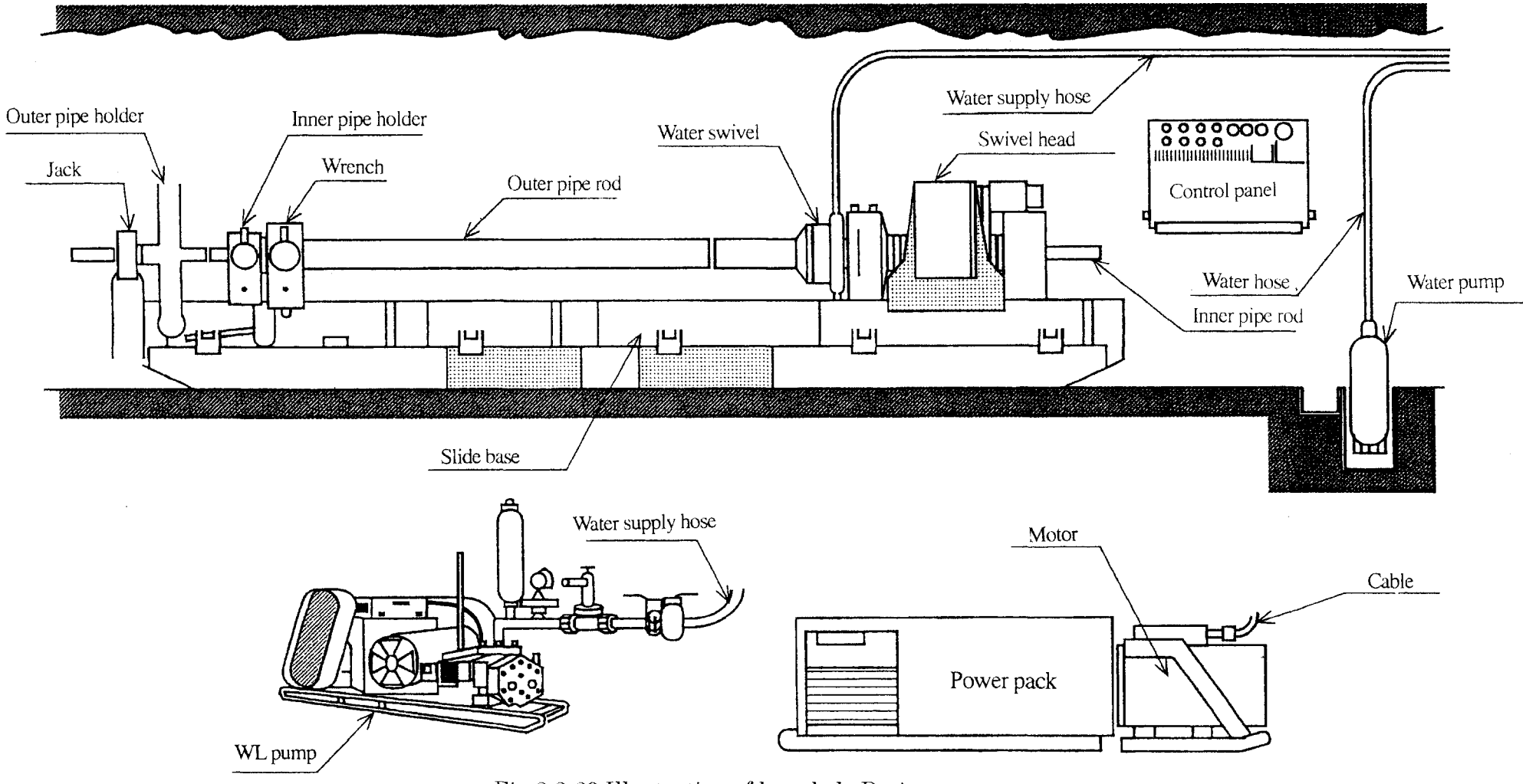


Fig 2.2-29 Illustration of long-hole Boring

(3) Directional boring method

Taiheiyo coalmine succeeded in establishing in-mine long-distance directional boring technology through many times of improvement based on the combination of direction measuring technology provided by an Australian boring company, and Japanese made boring machinery. It is a boring technique to enable aimed (planned) drilling by freely controlling the drilling direction with the combination of tip driving (hydraulic downhole moter) bit, bent sub (bent pipe), position monitoring device and the boring machine.

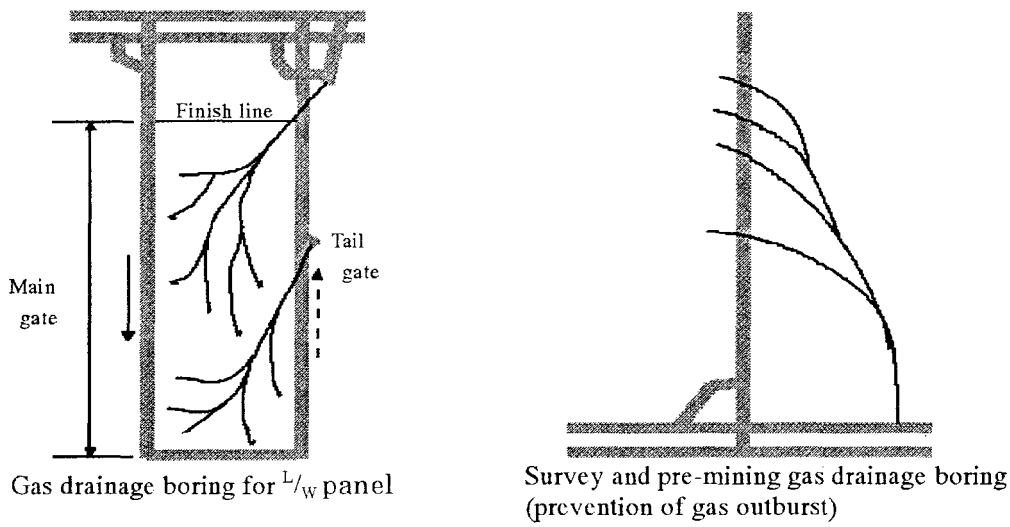


Fig.2.2-30 Conceptual drawing of gas drainage directional boring

The bit rotates with the water pressure and volume (water volume 400 l/min, pressure 80 kg/cm^2) from the triplex pump, but the rod does not turn. We can monitor the bit position in real time in the monitor box, and can freely control tiltangle and direction of the hole.

By using this machine, we can increase gas drainage efficiency because we can drill exactly to the best gas draining position, and can have branch holes from the single hole, etc. Besides, we can utilize this technology in fault search boring, pilot boring and water drainage boring, etc.

With directional boring in the present stage, we can have precise directional control in the stable strata, but it is difficult to drill through the softer strata or fractured-in area, because we haven't established its application to double pipe shield method. At present in Taiheiyo coalmine, we are developing directional boring method in TOP-TM double pipe shield method, and enjoying good results.

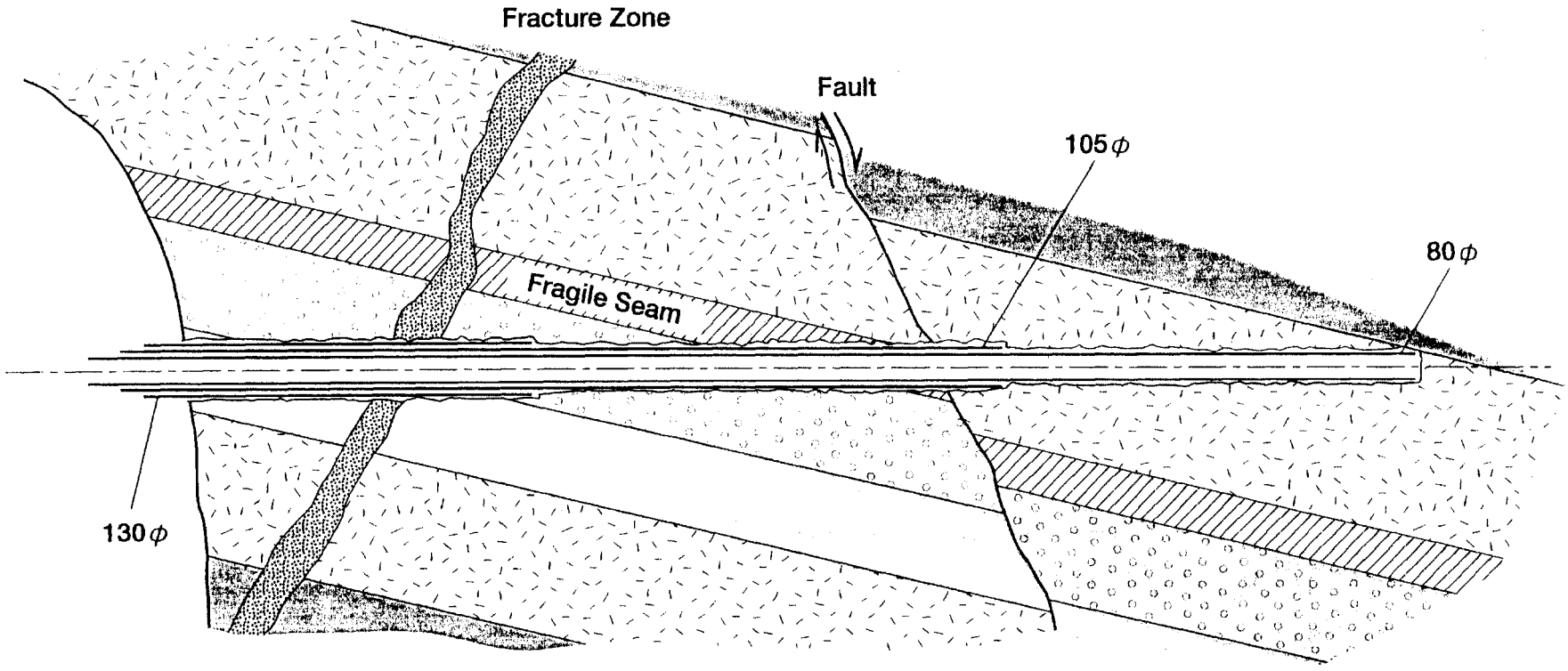


Fig.2.2-31 Illustration of Shield System by Double-pipe Method

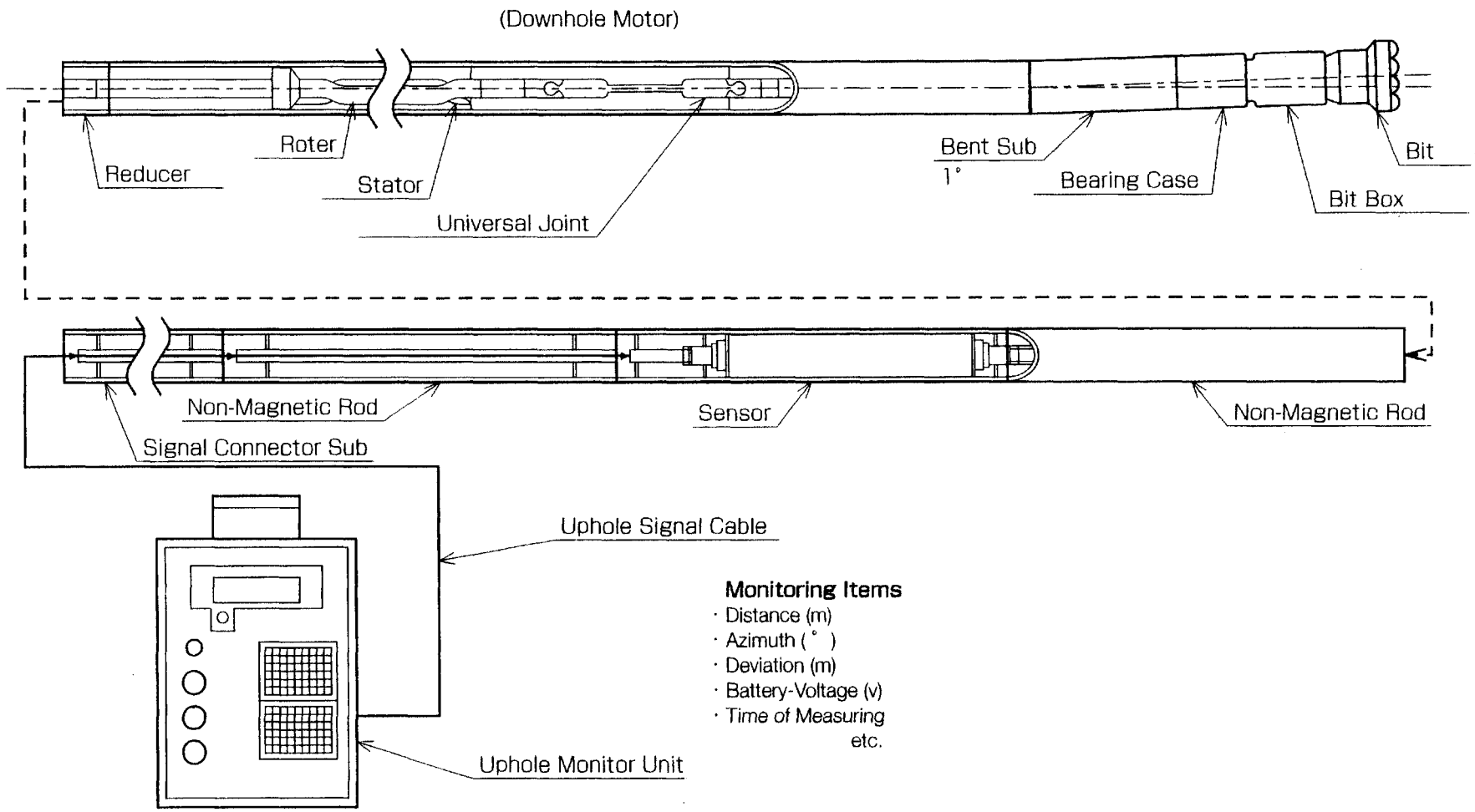


Fig.2.2-32 Schematic View of the Directional Drilling System

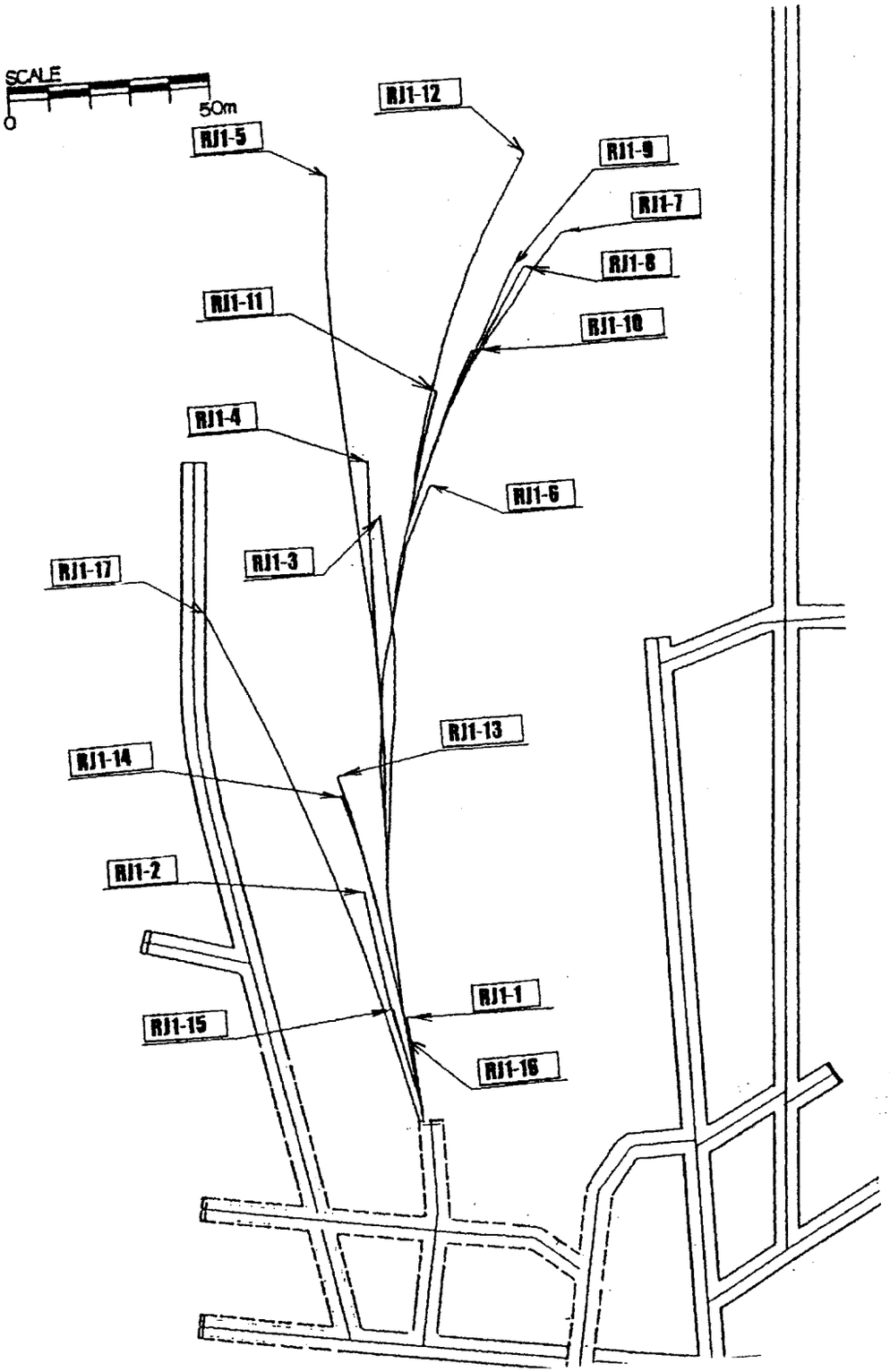


Fig 2.2-33 Plane View of Directional Boring at Trial Site

2.4.4 Sealing method water, drain installation and completion of drilled hole

(1) Sealing method

After we seal goaf area or used entry completely, methane gas emitted from strata and coalseam accumulates in the sealed chamber. We can use this gas like the methane gas collected from the working face, and the chamber works like a reservois. Therefore, we can use the sealed gas as a stable gas resource when drained gas volume from the working face is insufficient or its concentration gets lower.
In Japan (Taiheiyo coalmine), we install automatic gas draining device at the sealed area, which can automatically respond to the pressure differential and concentration change in the chamber, and drain the gas with automatic negative pressure control.

In Chertinskaya coalmine, they seal the finished faces, too. But they are not collecting gas except some of the sealed area, and its air tightness may not be enough mainly because there is less danger of spontaneous combustion. In this project, we want to prevent gas leak from the goaf to the entry, and at the same time from gas utilization point of view, we want to use the sealed goaf as a gas holder when the gas collection from the working face decreases. Especially, we need to seal finished L/W face with enough strength and air tightness because it tends to collapse or get cracks by the rock pressure caused by mining.

For this project, we would like to introduce wet type filling seal method using fly-ash cement, which we have been using in Taiheiyo coalmine for many years, because we think this is a method easy to do and suitable for the above sealing purpose. However, presently in Taiheiyo coalmine, we supply the fly-ash from the base on the ground, but this time, we suggest the easiest way to fill and seal with fly-ash at the sealing site. We are planning to set up the model sealing at 4 places; each 2 places in maingate and tailgate side entries at the beginning and end of #544 face.

Main equipment we introduce

Agitating mixer	1 unit
Supply pump	1 unit
Supply piping	100m
Sealing material	4 sets

(2) Water drain installation

Generally, we have inflow water in the drilled gas drainage hole, and in order to prevent water ingress to the main gas pipe, we need to install simple water draining device *1 on the drilling station at the bore mouth. In this project, we are planning to set up water drainage device enough for 2 stations, judging from drilling work schedule and gas drainage period.

Main equipment we introduce

Air drive type auto water draining equipment	2 unit
Suction hose	12 pcs.
Valve	14 pcs.
8-inch gas drainage pipe and accessory	2 units
Water draining hose and accessory	2 units

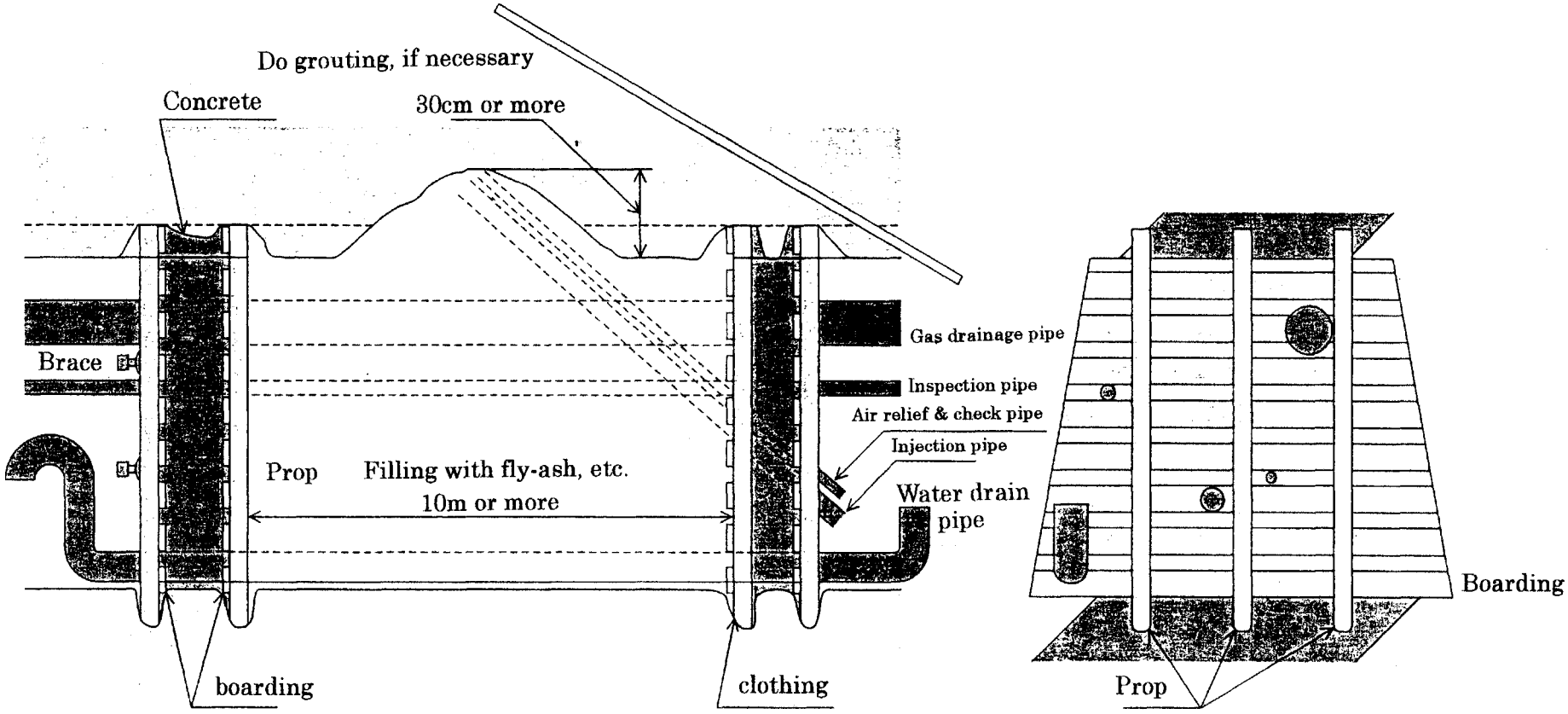
Besides, we suggest to install manual water drain *2 at places like temperature changing position in the main gas pipe line, changing point of horizontal and slanted road way, upward turning point of the line and around the blower. For daily maintenance of water drain equipment, it is absolutely necessary to set up inspection routine to be done by expert once per shift, to check gas drainage station, water draining places and removal of drain from gas pipe line, operating condition of equipment and gas drainage condition, etc.

*1 : Auto water draining device developed by Taiheiyo coalmine, consists of tank, float and valve, etc. It has drain discharge capacity of 15 ~ 20 l/min.

*2 : Simple house-made device in Taiheiyo coalmine. With a pipe, it creates a differential elevation greater than the suction, and prevents water sucked into gas drainage pipe (Fig.2.2-35).

(3) Completion of drilled hole

After drilling to the aimed length, we alternately join 3-inch steel pipe (5m/pc.) and 3-inch strainer steel pipe (0.5m/pc.) with socket in 10m interval, and insert it into the hole to make whole casing with steel pipe. Then, caulk about 6m from the bore mouth with cement and use it as gas drainage hole (Fig.2.2-36).



Notes in sealing construction

① Select the place where the surrounding rocks are not loose.
(If you cannot find the suitable place, do grouting in surrounding rocks to increase the air tightness.)

② Do propping and bracing deep enough.

③ Dig in and extend the injection pipe and check pipe 30cm or more higher than the edge so that the filling material reaches the roof rock.

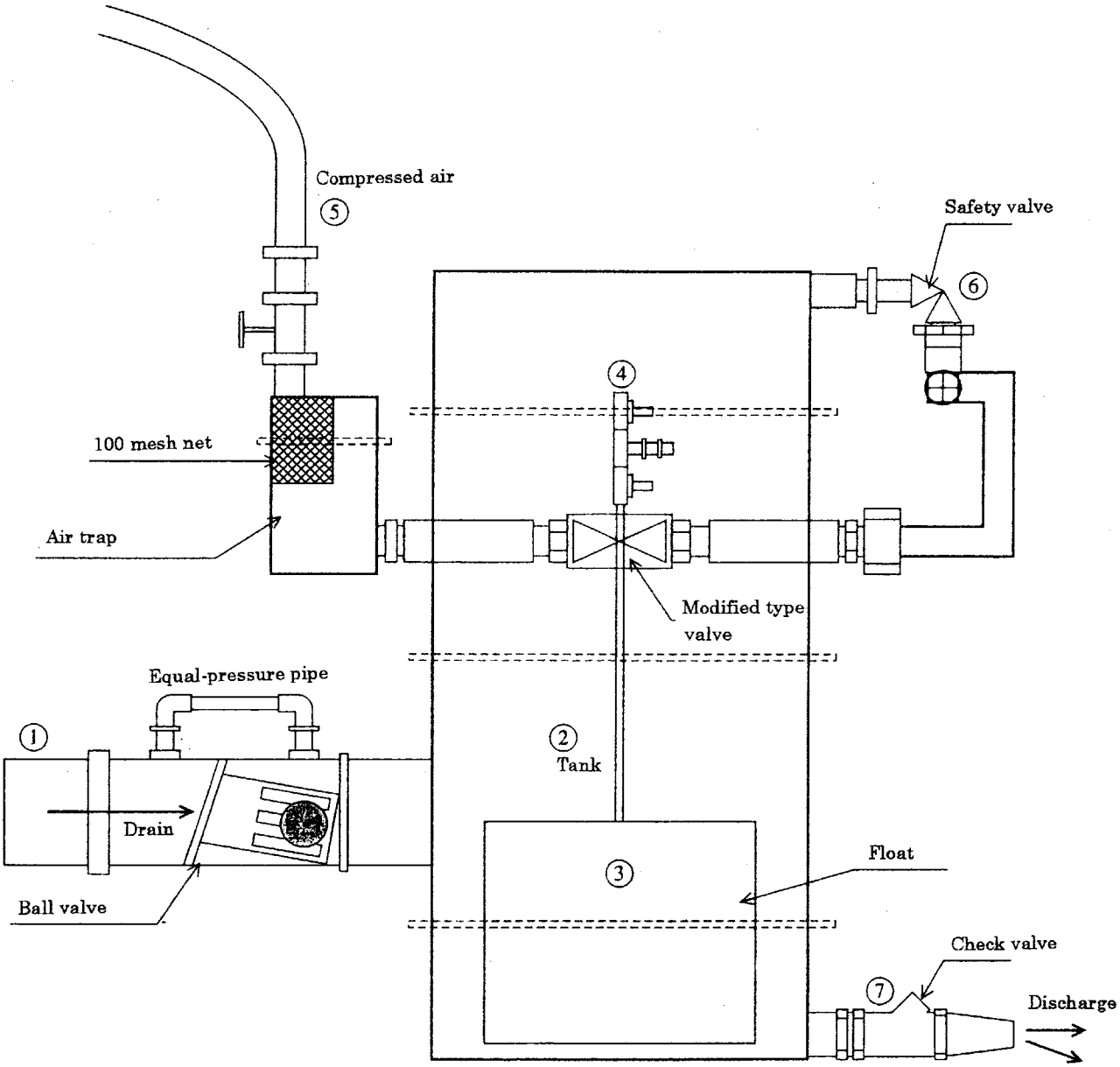
④ Be sure to do refilling so that the filling material adheres to the roof rock.

⑤ Install gas drainage pipe and inspection pipe at higher place some distance away.

⑥ Bend the end of water draining pipe to downward U-shape to prevent plugging by caving-in, etc.

⑦ Always fill water inside the water draining pipe to prevent air coming out through the pipe.

Fig2.2-34 Sealing work diagram



<Principles of Operation >

(1) Drain enters through (1), and builds up in the Tank. As the water level goes up, the Float (3) ascends and thereby opens the valve (4). As the valve (4) opens, air enters through (5) and closes the ball valve (1) and simultaneously pushes the check valve (7) open, causing the drains to burst out of the tank. (Approx. 3 liter each time)

Fig.2.2-35 Air-drive Automatic Water Drain Installation

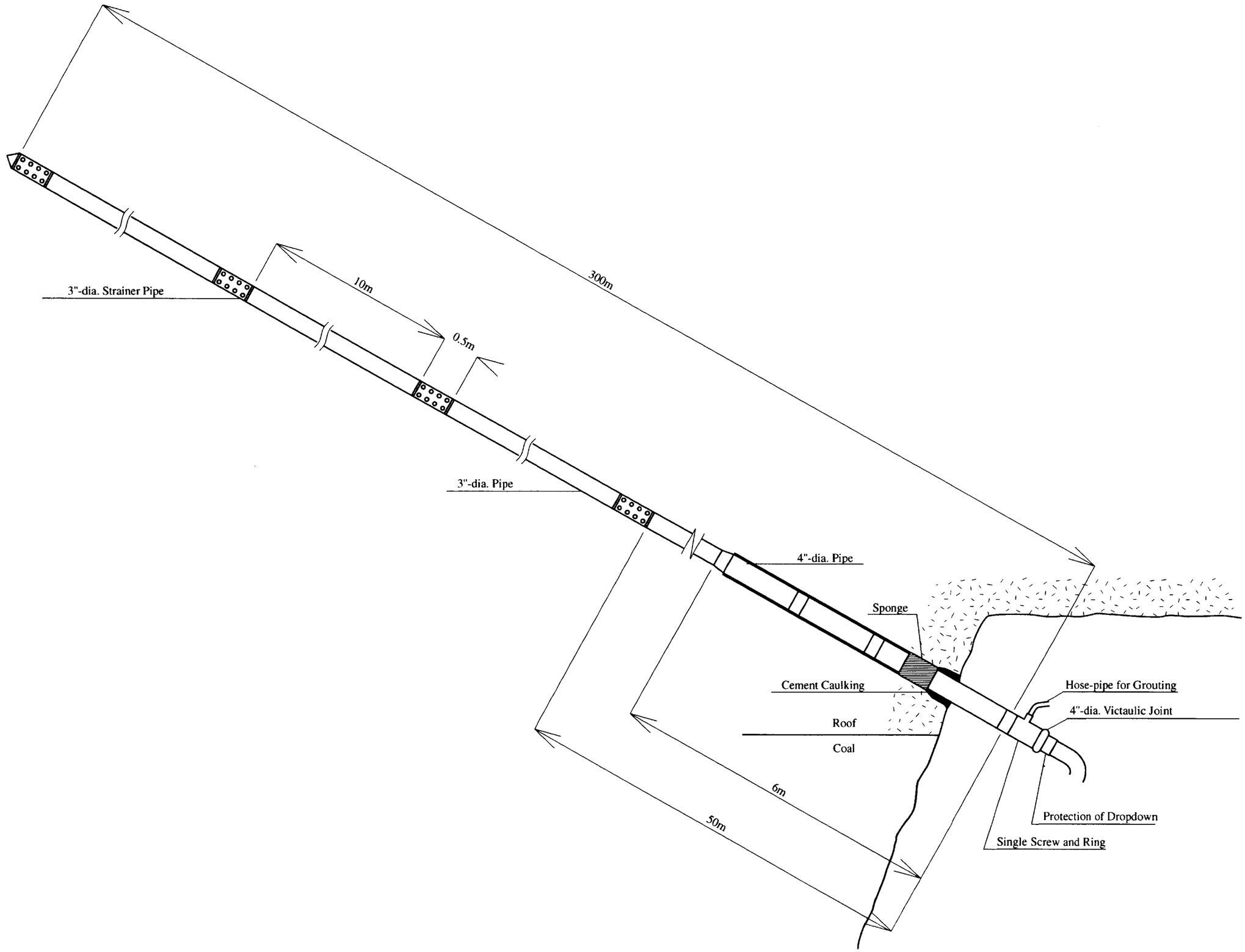
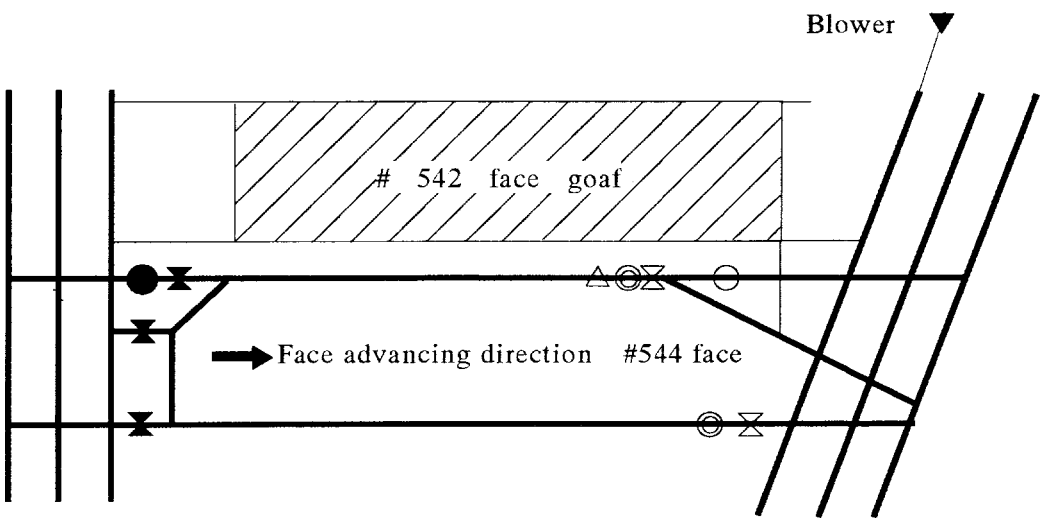


Fig.2.2-36 Casing and Caulking Method

2.4.5 Gas drainage monitoring system

We need to establish a monitoring system to assess the effect of overall gas recovery technology and control system regarding the gas drainage of working face and sealing goaf to be introduced to #544 face as the model face. Besides that, we can use this monitoring system for data collection to make gas recovery and control more effective in future, for gas utilization and for securing safety mine. Here, in order to quantify the effect of gas recovery, we propose a system in which a continuous measurement is available in the monitoring room on the ground, by installing various sensors in the gas pipe line system.



◎Measuring point of in-take, exhaust air while the face is in operation

△Measuring point inside of #544 face gas drainage pipe

▼Measuring point inside of gas drainage pipe at the entrance of gas suction blower on the ground

⧗Sealing in the beginning

●Measuring point inside of start sealing

⧖Sealing in the end

○Measuring point inside of finish sealing

Fig.2.2-37 Sketch of measuring points in #544 face

(1) Monitoring of gas emission and recovery condition of #544 face during active mining and after mining finish

We install measuring device and do 24-hour continuous measuring in order to monitor gas emission volume from the mining start of #544 face.

1) Measurement of in-take, exhaust air

The purpose is to measure methane gas volume exhausted through ventilation.

Place to install (◎ in the Diagram)

- At the in-take air way of #544 face
- At the return air way of #544 face

Item to monitor: Methane concentration, air velocity

2) Measurement inside gas drainage pipe from #544 face

The purpose is to measure methane gas volume drained from the working face.

Place to install (△ in the Diagram)

- Inside the gas drainage pipe at the entrance of tailgate of #544 face

Item to monitor: Methane concentration, flow volume, CO concentration, negative pressure and temperature

3) Measurement at the inlet of gas suction blower on the ground

The purpose is to monitor drainage condition in the section between #544 face and the surface blower inlet

Place to install (▼ in the Diagram)

- Inside the gas drainage pipe at the inlet of gas drainage blower on the ground

Item to monitor: Methane concentration, flow volume, CO concentration, negative pressure and temperature

4) Measurement inside sealed entry

The purpose is to monitor drainage condition of emitted gas collected in the goaf well

Place to install (● and ○ in the Diagram)

- Sealed area in the beginning of tailgate of #544 face
- Sealed area in the end of tailgate of #544 face

Item to monitor: Methane concentration, flow volume, CO concentration, negative pressure and temperature

* However, when we measure sealed area in the end of tailgate in #544 face, we use the measuring device taken from inside the gas drainage pipe of #544 face.

(2) Measurement · control · equipment

For various methane gas measuring devices installed in the gas drainage system, we can get the readings at site. But we are going to do continuous and centralized monitoring in the monitoring room on the ground by introducing · installing the following devices.

1) Sensors

This is a device to convert the gas volume value etc. to electrical signal (current) and output and transmit to the control unit. We install it around #544 face.

Quantity to introduce: 3 sets of sensors (methane concentration, CO concentration, negative pressure, flow volume, temperature and air velocity)

Specification	CH_4 gauge	CO gauge
Principle	Optical interferometer	Constant potential electrolytic
Detection range	0~100%	0~100ppm
Display method	Concentration indicator	Concentration indicator
Output signal	DC0.2~1.0mA	DC0.2~1.0mA
Explosion proof structure	Intrinsical safety explosion proof structure	Intrinsical safety explosion proof structure

Specification	Negative pressure gauge	Flow volume gauge
Principle	Piezo effect	Thermistor type
Measurement rage	0~500mmH_2O	0~15m/s
Response time	90% response within 5 seconds	90% response within 5 seconds
Display method	LED method	With indicator
Output signal	DC0.2~1.0mA	DC0.2~1.0mA
Explosion proof structure	Intrinsical safety explosion proof structure	Intrinsical safety Explosion proof structure

Specification	Thermometer	Anemometer
Detecting principle	Thermistor type	With temperature transducer & heater
Detecting range	0~50°C	0~10m/s
Display method	With LED digital method	With indicator
Output signal	DC0.2~1.0mA	DC0.2~1.0mA linear output
Explosion proof Structure	Intrinsical safety explosion proof structure	Intrinsical safety explosion proof structure
Linearize		Compute with built-in CPU

2) Transmitter

This is a device to gather and transmit signals from multiple sensors through one line. We install at 3 underground places , and 1 place on the ground.

Quantity to introduce:	8 sets of transmitter	
Specification:	Input power	AC100V
	Transfer method	MODEM method
	Transmit impedance	600Ω±20%
	Transmit points	3 points in analog,
		8 point in digital
	Transmit distance	10km maximum

3) Receiver

This is a device to convert the signal sent from multiple transmitters to RS-232C and transfer it to personal computer. We install 1 unit on the ground.

Quantity to introduce:	1 set of receiver	
Specification:	Input power	AC100V
	Transfer method	MODEM method
	Data output	11Bit straight binary
	Transfer impedance	600Ω±20%
	Interface	RS 232 C
		(Transfer speed 1,200bps)

4) Transmitting cable

A cable to effectively transmit analog or digital signal. We use twisted pair cable same with telephone line.

Quantity to introduce:	1 set of receiver
Specification:	Polyethylene insulation with copper tape shield for in-mine telephone. Non-halogen sheath cable Size COEE-FR0.9sq x 10p

5) Display recorder device

This is a device to sort out RS-232C signal sent from the receiver for each sensor, and process and display it. We install it in the monitoring room on the ground.

Quantity to introduce: 1 set of receiver

6) Automatic control of sealed gas

After finishing mining, we seal and isolate the goaf. As time passes, emitted methane gas fills the goaf. Sometimes, this gas causes us a trouble by leaking through the sealed portion out to the active entry due to the change of air pressure. In order to prevent this gas leak due to air pressure change, we control the gas in goaf by setting up sealed gas auto control device developed in Taiheiyo coalmine. We install 2 sets of this device at the beginning and end of sealed tailgate of #544 face.

Quantity to introduce: 2 sets of Sealed gas auto control device

7) Others

	Power cable 1 set	Sensor cable 1 set
Type	In-mine explosion proven product EP rubber insulated chloroprene dabtire cable	In-mine explosion proven product EP rubber insulated chloroprene dabtire cable
Size	600V, 3PNCT 5.5sq×3c+5.5sq×1c	600V, 3PNCT 3.5sq×4

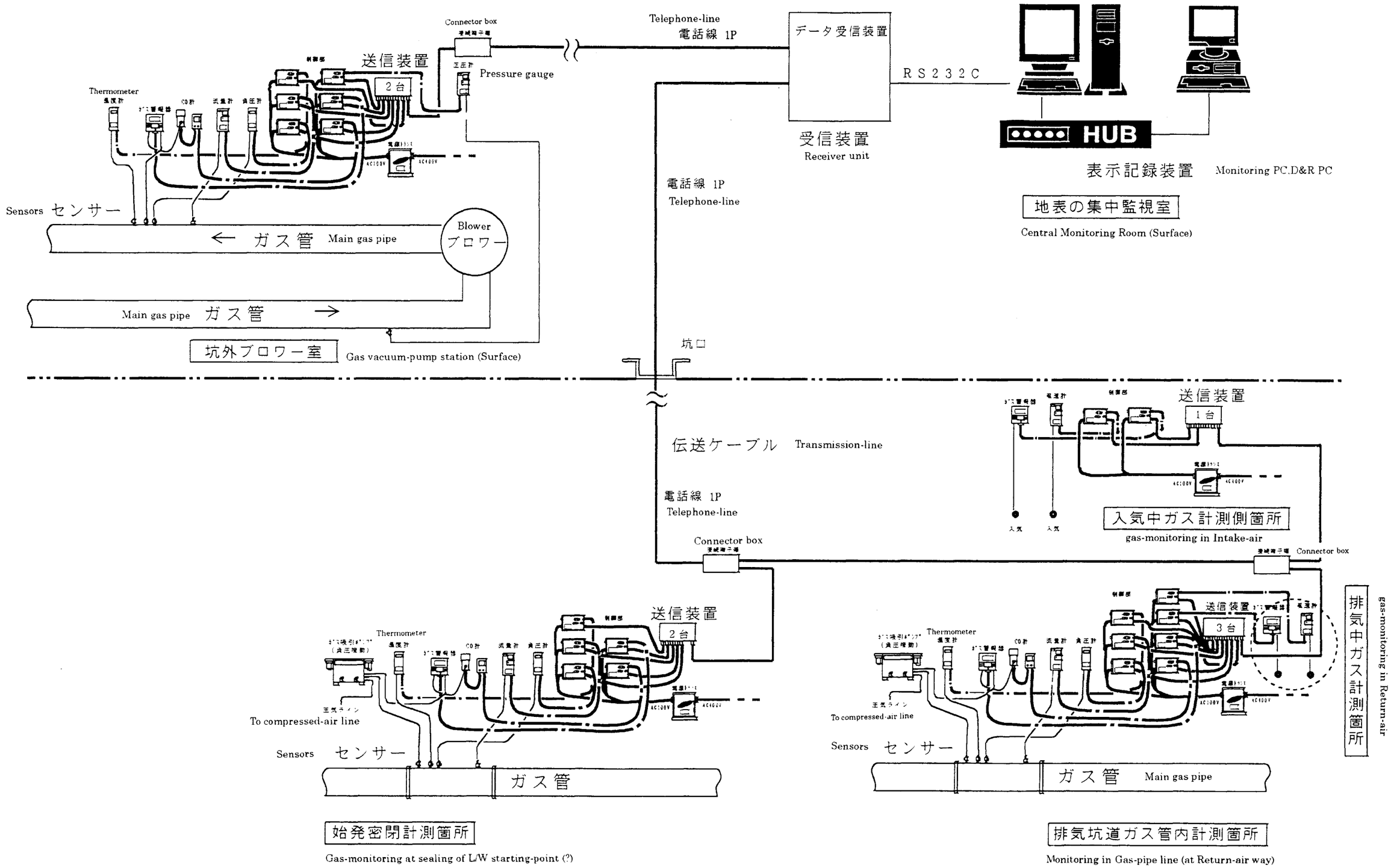


Fig 2.2-38 Gas Monitoring System

2.4.6 Estimate of volume and grade of recovered gas in future

We have already presented the current status of gas draining technology and actual gas recovery performance in Chertinskaya coalmine. Now based on the current status, we estimate the future gas emission volume, recovery volume and concentration, etc.

(1) Relationship of working coal seam and gas emission

1) Relationship of gas emission in # 5 coal seam # 4 coal seam and # 3 coal seam

(a) If we mine # 4 coal seam first, because the distance to the lower # 5 coal seam is small (35m), gas in # 5 coal seam comes out. But the gas content in # 4 coal seam is a little smaller than # 5 coal seam. (Gas content: #4 coal seam = 24m^3/t, #5 coal seam = 27m^3/t).

(b) Meanwhile, if we mine # 5 coal seam first, the effect from the upper # 4 coal seam will not be as great as in the case of (For your reference, coal seam thickness is: # 4 = 1.5m, # 5 = 2.0m)

Because of the above reason; <u>we can define that the gas emission (m^3/min.) from # 4 coal seam face is equal with the one from # 5 coal seam</u>.

* : People in Chertinskaya coal mine have explained that if they mine # 4 coal seam face first, the gas emission from # 4 coal seam is rather greater than from #5 coal seam face. Here, we regard them equal for calculation convenience, as well.

(c) However, # 3 coal seam is rather far away from # 4 coal seam (app. 80m), influence from the lower coal seam is negligible, therefore gas emission will be smaller in proportion of gas content.
The gas emission of # 3 coal seam face is 0.78 times of the one from # 5 coal seam face.
(Mean value of # 3 coal seam gas content = 21.0, mean value of # 5 coal seam gas content = 27.0)

Table2.2-18: Gas content in each coal seam in Chertinskaya coalmine

Coal seam	Seam thickness (m)	Ave. coal seam thickness (m)	Gas content (m^3/t)	Gas content mean value (m^3/t)
1	0.7～1.23	0.96	3.3～16.2	9.75
2	1.13～1.44	1.33	15～21	18.0
3	2.13～3.01	2.74	18～24	21.0
3a	0.70～1.16	0.88	0～20	10.0
4	1.26～1.95	1.50	19～29	24.0
5	1.62～2.36	2.00	22～32	27.0
6	0.70～1.13	0.85	6～25	15.5

2) Relationship of coal production and gas emission

Even the coal production and gas emission are small in recent years, gas emission increases/decreases in proportion of increase/decrease of coal production, as you can see in Fig.2.2-39 graph based on Table 2.2-19.

We can get the gas emission volume as follows based on premises 1) and 2).

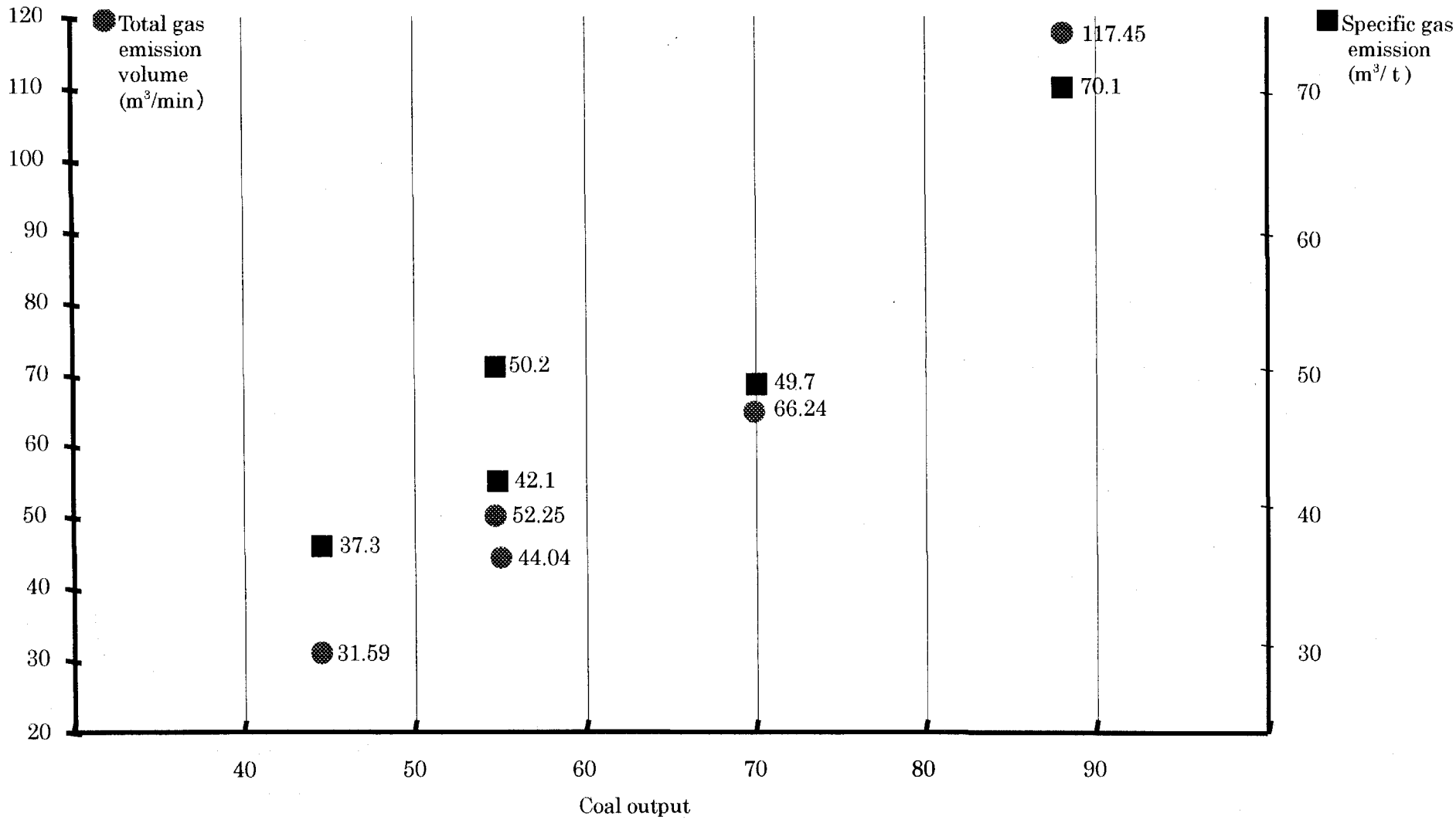


Fig.2.2-39 Relationship of yearly coal output and gas emission volume

Table2.2-19 Summary table of gas condition in Chertinskaya coalmine

Year	Coal production (1,000t)	Vented methane in main exhaust fan			Drained methane			Total emission	Specific gas emission (m^3/t)	Gas recovery ratio (%)	Air flow per production coal (m^3/t)
		Total exhaust (m^3/min)	Gas concentration (%)	Pure methane (m^3/min)	Drained volume (m^3/min)	Gas concent-ration (%)	Pure methane (m^3/year)	Total methane volume (m^3/year)			
1994	880.3	5,800 4,300 8,100	0.3 0.35 0.25	17.4 15.0 20.25 52.65	162	40	(64.8 m^3/min) 34,058,880	(117.45 m^3/min) 61,731,720	70.1	55.2	10,867
1995	700.0	5,600 3,500 9,700	0.3 0.3 0.2	16.8 10.5 19.4 46.7	78.2	25	(19.54) 10,270,224	(66.24) 34,815,744	49.7	29.5	14,116
1996	445.0	5,200 3,200 7,546	0.25 0.2 0.15	13.0 6.4 11.32 30.72	14.5	6	(0.87) 457,272	(31.59) 16,603,704	37.3	2.8	18,834
1997	547.0	5,500 3,600 9,500	0.25 0.25 0.2	13.75 9.0 19.0 41.75	28.4	37	(10.5) 5,518,800	(52.25) 27,462,600	50.2	20.1	17,872
1998	550.0	4,600 3,400 8,100	0.2 0.2 0.2	9.2 6.8 16.2 32.2	32.9	36	(11.84) 6,223,104	(44.04) 23,147,424	42.1	26.9	15,386
July 1999	281.9	6,300 4,200 10,490	0.2 0.2 0.2	12.6 8.4 20.98 41.98	20.0	30	(6.0) 1,900,800	(47.98) 15,200,064	53.9	12.5	16,272
Ave-rage								(59.9)	50.6		

(2) Forecast of gas emission volume

1) Forecast of total gas emission

The followings are the main resources of gas in coalmine.

a) Gas emission from longwall mining face
b) Gas emission from heading
c) Gas emission from goaf area
d) Gas emission from roadway side

Therefore, the total gas emission volume is the total of the above. In order to estimate the total, we forecast the total gas emission from Chertinskaya coalmine by extrapolation, using actual gas emission from mining face and other submitted data.

- At the time of study, 3 faces were working - 2 faces (#563 and #542) in # 5 coal seam, and 1 face (#414) in # 4 coal seam.
- We use actual result of #563 face in section 2.2.3 (Table 2.2-13) for the gas emission from # 5 coal seam.
- If we suppose gas emission volume in 2 faces (#563 and #542) in # 5 coal seam and a face (#414) in # 4 coal seam is equal, as we agreed in previous (1)-(f), the total gas emission volume of Chertinskaya coalmine in 1999 is as follows:

Gas emission volume from #563 face 17.0~25.4 m^3/mim
Total gas emission = 17.0~25.4 m^3/mim x 3 = 51.0~76.2 m^3/mim ·····(1)

Then, to calculate emission volume of # 4 coal seam, we obtain the ratio of gas content mean values of # 4 and #5 coal seams in Table 2.2-18 :

$$\frac{24m^3/t}{27m^3/t} = 0.89$$

and we take the emission of #563 face and multiply the ratio. Thus, the gas emission values will be as follows.

Gas emission from #563 face	17.0~25.4 m^3/mim
Gas emission from #542 face	17.0~25.4 m^3/mim
Gas emission from #414 face	15.1~22.6 m^3/mim
Total	49.1~73.4 m^3/min ·····(2)

From the results (1) and (2), we can calculate the total gas emission from Chertinskaya coalmine expressed in pure methane volume with the following equation:

$$49.1 \sim 73.4\ m^3/mim + \alpha\ m^3 / min$$

Meanwhile, planned coal production for this year is 678,000t/year. When we compare the calculated gas volume and coal production with the actual coal output and total methane emission in recent years* (See Table 2.2-19, Fig.2.2-39), they conform with each other fairly well. *: Coal output from 1994~1998; 445,000~880,000t/year, gas emission volume; 31.59~117.45 m^3/min.

As we can see, if they maintain the mining condition at the time of this study, we think the total gas volume in terms of pure methane will be at least 50~70 m^3/min.

Therefore, <u>we can forecast the total gas emission for 1999 to be 26.28 million m^3.</u>

$$50\ m^3/min \times 60 \times 24 \times 365 = 26{,}280{,}000\ m^3/year$$

2) Forecast of specific gas emission

As planned coal production for 1999 is 678,000t, the specific gas emission becomes 38.7 m^3/t.

$$26{,}280{,}000\ m^3/year \div 678{,}000t/year = 38.7\ m^3/t$$

The above 38.7 m^3/t is close enough to 37.3 m^3/t (in 1996) of minimum specific gas emission in Table 2.2-19.

Specific gas emission in each working coal seam is as follows.

5 coal seam = 38.7 m^3/t
4 coal seam = 38.7 m^3/t
3 coal seam = 29.3 m^3/t (0.78times of #5 coal seam)

(3) Forecast of gas recovery ratio

When we look at the past gas recovery ratio in Chertinskaya coalmine, the ratio has come down to 3~29.5% in recent years which used to be more than 50% before. For the reason, we can think of the following.

- Decrease of coal output
- Increase of ventilated gas (less effort to drain out the gas)
- Insufficient capacity of boring machine
- Deterioration of gas recovery facilities
- Change of mining order
- Decrease of gas emission volume
- Transition to difficult geologic condition for gas recovery

However, if we assume that Chertinskaya coalmine will continue to use the present gas recovery system, we can get the forecast of the gas recovery ratio from the gas recovery ratio in #563 face where we have studied.
Since the gas we can recover and use comes only through gas drainage, we can obtain the recovery ratio using the Table 2.2-13 in section 2.2.3.

11.3 m^3/min / 17.0 m^3/min x 100% ≒ 66%
19.7 m^3/min / 25.4 m^3/min x 100% ≒ 77%

11.3 m^3/min / 25.4 m^3/min x 100% ≒ 44%
(The case of minimum recovery ratio in the Table)

From the above results, the best gas recovery ratio in the whole Chertinskaya coalmine is 66~77%. From the actual gas recovery ratio during stable production period in the past (Fig.2.2-40), and from the Table2.2-10*, it is around 40~60% range (excluding recent 5 years). *: 55.7% in 1992, 55.2% in 1994

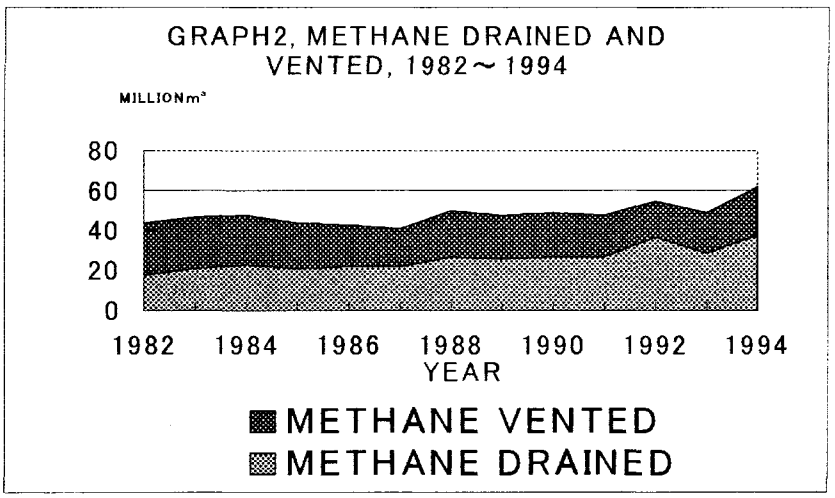


Fig.2.2-40 (Source: EPA report, Sept., 1996)

For your reference, in the example (Fig.2.2-41) of gas recovery ratio in Japanese coalmine, it is 30~60% in 1981, and it is around 30% in Taiheiyo coalmine working with coal seam having low permeability.

With the overall judgement from the above, we estimate in Chertinskaya coalmine, it is possible to recover at least 30~50% of gas.

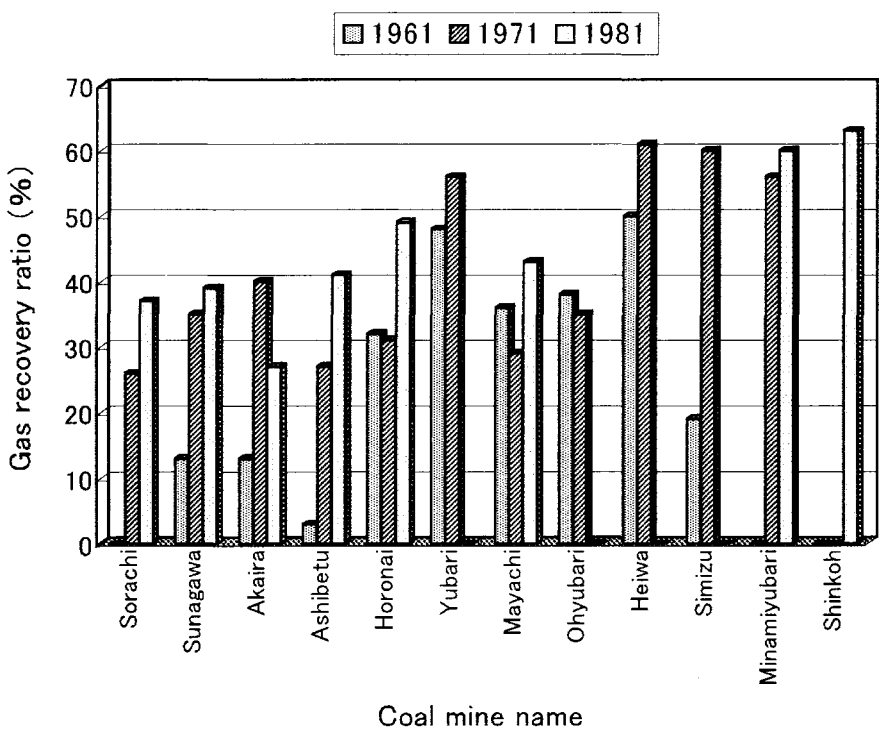


Fig.2.2-41 Gas recovery ratio in Japanese coalmine

(4) Forecast of the concentration of the recovered gas

We can collect gas through cross measure boring and gob well of L/W face, or through pilot boring during roadway driving, etc. In general, we can collect higher concentration gas from pilot boring, but the volume is small. On the other hand, we can collect larger volume of gas through L/W face. Here, we take the data of #563 face that we studied, to represent the drained gas concentration for the whole Chertinskaya coalmine.
We can express the drained gas concentration as follows.

$$\frac{\text{Drained pure methane volume}}{\text{Drained volume}} \times 100$$

We obtain concentration range using values in the Table 2.2-13.

$$\frac{11.3CH_4m^3/\min}{57.5m^3/\min} \times 100\% = 19.6\%$$

$$\frac{19.7CH_4m^3/\min}{57.5m^3/\min} \times 100\% = 34.3\%$$

From the above calculation, the drained gas concentration of Chertinskaya coalmine becomes 20%~34%. Because generally, drained gas concentration in cross measure boring fluctuates much, it is difficult to obtain precise gas concentration, but when we see the actual result of the coalmine in the past (Table2.2-11), it is 25%~40%. And even in Taiheiyo coalmine (in Japan) where the coal seam is difficult in draining gas, they keep the average drained gas concentration around 40%.

With the overall judgement from the above, <u>we estimate it is possible to secure at least 30~40% of concentration by improving the drainage method</u>.

(5) Gas recovery volume and concentration based on coal production plan

Here, we use the previously forecased gas emission volume and recovery ratio, and recovered gas concentration to estimate future gas recovery volume and concentration based on 2000~2004 coal production plan presented by Chertinskaya coalmine.

1) Coal production plan and total gas emission volume

From the point of gas user's view, it is better to estimate the gas volume in minimum, in order to secure effective operation of gas utilization facilities. Therefore, to calculate the specific gas emission, we have based on the minimum possible volume (See clause (2) of 2.4.6). We show the result of calculation applying the specific gas emission in each working coal seam to 2000~2004 coal production plan presented by Chertinskaya coalmine in Table2.2-21 (Coal production plan and total gas emission volume).

- For heading coal, we obtained coal output in each coal seam, and divided it by the proportion of L/W coal output in each coal seam.
- With this Table 2.2-21, we can estimate the total gas emission volume for year 2000 to be app. 26.77 million m^3 of pure methane with the output of 678,000tons. And we can estimate the total gas emission volume in years 2001~2004 to be 24.76~35.67 million m^3.
- As you can see in monthly total gas emission volume in year 2000, total gas emission per minute varies much in each month. For example, the total emission becomes maximum volume of 3.05 million m^3 in April, and becomes minimum volume of 1.74 million m^3 during June to October. The yearly average of total gas emission per minute is 50.8 m^3/min, but it becomes 40 m^3/min during June to October. In designing the capacity of gas usage facilities, we have to take this variation of volume into account.
- Therefore, for years after 2001, we have to pay good attention not only to yearly average of gas emission, but also to the monthly fluctuation of coal output in the production plan.

2) Recovered gas volume and gas concentration

- We calculate the recovered gas volume using future total gas emission based on the coal production plan of Chertinskaya coalmine, and forecast of gas recovery ratio of 30~50% that we obtained in clause (3).
- For gas concentration, we use the gas concentration forecast of 30~40% that we obtained in clause (4).

Then, we calculate the possible combination of these conditions as follows, and show the results in Table2.2-22～24.

Drained gas concentration at 30%, 35%, 40%, with gas recovery ratio of 30%

Drained gas concentration at 30%, 35%, 40%, with gas recovery ratio of 40%

Drained gas concentration at 30%, 35%, 40%, with gas recovery ratio of 50%

3) Summary

* When we design the gas utilization facilities, considering the present gas drainage system and method, we think it appropriate to use the gas recovery ratio of 30%, and the drained gas concentration of 30% to enable the stable and effective operation of the facilities. In this case, during the lowest period of July, August and October 2000, we can induce app. 39.0 m^3/min of pure methane gas. However, for the period of 2001 to 2004, we have to be careful about the monthly drained gas volume because the monthly coal output information is not available in the coal production plan.

* When they introduce gas recovery and control method suggested in gas recovery improvement plan described in the next chapter, we think it appropriate to design the gas utilization facilities using the gas recovery ratio of 40%, and the drained gas concentration of 30~35% for the stable operation.

Table2.2-20 Summary table of recovered gas volume and concentration

Gas recovery system	2000	2001	2002	2003	2004
Forecast of gas emission volume:					
①Gas emission volume (10,000 m^3/year)	2,677.6	2,476.2	2,810.5	3,535.7	3,567.1
②Gas emission volume (m^3/min)	50.8	47.1	53.5	67.3	67.7
Present system:					
③Recovered pure methane gas volume (① x 30%) (10,000 m^3/year)	803.3	742.9	843.2	1,060.7	1,070.1
④Recovered volume of 30% concentration gas	2,677.6	2,476.2	2,810.5	3,535.7	3,567.1
Improvement plan:					
③Recovered pure methane gas volume (① x 40%) (10,000 m^3/year)	1,071.0	990.5	1,124.2	1,414.3	1,426.8
③Recovered volume of 35% concentration gas	3,060.1	2,829.9	3,212.0	4,040.8	4,076.7

Table 2.2-21 Coal production plan and forecast of gas emission volume

Panel No.	Coal seam	2000													2001	2002	2003	2004
		1	2	3	4	5	6	7	8	9	10	11	12	Total				
429	#4	20	15	15	20	20	20	20	20	20	20	20	20	230	30			
416	#4														150	130		
431	#4															80	300	80
418	#4																	220
563	#5	30	33	34	34	8								189				
359	#3											6	25	31	230	169		
357	#3															121	320	59
351	#3																	231
544	#5	20	20	20	20	20	20	20	20	20	20	20	20	240	240	30		
546	#5															210	280	
555	#5																	310
Volume of L/W coal (1,000 t)		70	68	69	74	48	40	40	40	40	40	46	65	640	650	740	900	900
Volume of Heading coal (1,000 t)		5	5	5	5	5	5	5	5	5	5	5	5	60	50	60	100	100
Total production (1,000 t)		75	73	74	79	53	45	45	45	45	45	51	70	700	700	800	1,000	1,000
Total gas emission (10,000 m^3)		290.0	282.5	286.4	305.7	205.1	174.2	174.2	174.2	174.2	174.2	191.0	245.6	2,677.6	2,476.2	2,810.5	3,535.7	3,567.1
Total gas emission per minute (m^3/min)		65.0	67.6	64.2	70.8	45.9	40.3	39.0	39.0	40.3	39.0	44.2	55.0	50.8	47.1	53.5	67.3	67.7

Table 2.2-22 Forecast of drained gas at 30% of recovery ratio

Year Month	2000												2000 Total	2001	2002	2003	2004
	1	2	3	4	5	6	7	8	9	10	11	12					
Total coal production [1,000 t]	75	73	74	79	53	45	45	45	45	45	51	70	700	700	800	1,000	1,000
Total gas emission (pure methane) [m^3/min]	290.3	282.5	286.4	305.7	205.1	174.2	174.2	174.2	174.2	174.2	191.0	245.6	2,677.6	2,476.2	2,810.5	3,535.7	3,567.1
Total gas emission per minute (pure methane) [m^3/min]	65.0	67.6	64.2	70.8	45.9	40.3	39.0	39.0	40.3	39.0	44.2	55.0	50.8	47.1	53.5	67.3	67.7
Recovered gas volume per minute at 30% of recovery (pure methane) [m^3/min]	19.5	20.3	19.3	21.2	13.8	12.1	11.7	11.7	12.1	11.7	13.3	16.5	15.2	14.1	16.1	20.2	20.3
Recovered volume per minute of 30% concentration gas [m^3/min]	65.0	67.6	64.2	70.8	45.9	40.3	39.0	39.0	40.3	39.0	44.2	55.0	50.8	47.1	53.5	67.3	67.7
Recovered volume per minute of 35% concentration gas [m^3/min]	55.7	58.0	55.1	60.6	39.4	34.6	33.4	33.4	34.6	33.4	38.0	47.1	43..4	40.3	46.0	57.7	58.0
Recovered volume per minute of 40% concentration gas [m^3/min]	48.8	50.8	48.3	53.0	34.5	30.3	29.3	29.3	30.3	29.3	33.3	41.3	38.0	35.3	40.3	50.5	50.8

Table 2.2-23 Forecast of drained gas at 40% of recovery ratio

Year Month	2000												2000 Total	2001	2002	2003	2004
	1	2	3	4	5	6	7	8	9	10	11	12					
Total coal production [1,000 t]	75	73	74	79	53	45	45	45	45	45	51	70	700	700	800	1,000	1,000
Total gas emission (pure methane) [m^3/min]	290.3	282.5	286.4	305.7	205.1	174.2	174.2	174.2	174.2	174.2	191.0	245.6	2,677.6	2,476.2	2,810.5	3,535.7	3,567.1
Total gas emission per minute (pure methane) [m^3/min]	65.0	67.6	64.2	70.8	45.9	40.3	39.0	39.0	40.3	39.0	44.2	55.0	50.8	47.1	53.5	67.3	67.7
Recovered gas volume per minute at 40% of recovery (pure methane) [m^3/min]	26.0	27.0	25.7	28.3	18.4	16.1	15.6	15.6	16.1	15.6	17.7	22.0	20.3	18.8	21.4	26.9	27.1
Recovered volume per minute of 30% concentration gas [m^3/min]	86.7	90.0	85.7	94.3	61.3	53.7	52.0	52.0	53.7	52.0	59.0	73.3	67.7	62.7	71.3	89.7	90.3
Recovered volume per minute of 35% concentration gas [m^3/min]	74.3	77.1	73.4	80.9	52.6	46.0	44.6	44.6	46.0	44.6	50.6	62.9	58.0	53.7	61.1	76.9	77.4
Recovered volume per minute of 40% concentration gas [m^3/min]	65.0	67.6	64.2	70.8	45.9	40.3	39.0	39.0	40.3	39.0	44.2	55.0	50.8	47.1	53.5	67.3	67.7

Table 2.2-24 Forecast of drained gas at 50% of recovery ratio

Year Month	2000												2000 Total	2001	2002	2003	2004
	1	2	3	4	5	6	7	8	9	10	11	12					
Total coal production [1,000 t]	75	73	74	79	53	45	45	45	45	45	51	70	700	700	800	1,000	1,000
Total gas emission (pure methane) [m^3/min]	290.3	282.5	286.4	305.7	205.1	174.2	174.2	174.2	174.2	174.2	191.0	245.6	2,677.6	2,476.2	2,810.5	3,535.7	3,567.1
Total gas emission per minute (pure methane) [m^3/min]	65.0	67.6	64.2	70.8	45.9	40.3	39.0	39.0	40.3	39.0	44.2	55.0	50.8	47.1	53.5	67.3	67.7
Recovered gas volume per minute at 50% of recovery (pure methane) [m^3/min]	32.5	33.8	32.1	35.4	23.0	20.2	19.5	19.5	20.2	19.5	22.1	27.5	25.4	23.6	26.8	33.7	33.9
Recovered volume per minute of 30% concentration gas [m^3/min]	108.3	112.7	107.0	118.0	76.7	67.3	65.0	65.0	67.3	65.0	73.7	91.7	84.7	78.7	89.3	112.3	113.0
Recovered volume per minute of 35% concentration gas [m^3/min]	92.9	96.6	91.7	101.1	65.7	57.7	55.7	55.7	57.7	55.7	63.1	78.6	72.6	67.4	76.6	96.3	96.9
Recovered volume per minute of 40% concentration gas [m^3/min]	81.3	84.5	80.3	88.5	57.5	50.5	48.8	48.8	50.5	48.8	55.3	68.8	63.5	59.0	67.0	84.3	84.8

B. Gas Utilization Project

As stated in the former Chapter, both amount emitted and concentration of the coal mine methane gas of Chertinskaya are decreased because of decrease of coal production reflected difficult situation of Russian economy. However, in accordance with the production plan of Chertinskaya coal mine, coal production increases in future as stated in the former Chapter. This gas utilization project is based on this plan. As transportation of coal mine methane gas and its use are closely related, the plan is fully considered the mutual relationship of the parties concerned. In this Chapter, the conceptional study on gas recovery facility at gas well is carried out, and a power plant as a method on gas utilization is selected. A process for power generation is studied primarily on a gas engine process and a gas turbine process, and the outline of a facility on gas engine process selected is studied.

2.4.7 Gas collecting facility

Study assumption

The recovery gas amount is determined based on the future prediction mentioned in the section2.4.6 and this study is carried out based on a gas amount recovered in the year 2003 when the project will be executed. The recovery amount planned in the year 2003 is in average about 27m^3/minute as pure methane and considering reliability it will be about 90m^3 as air mixed gas with 30% concentration. At present, fluctuation of the recovery amount caused by proceeding coal production is big at Chertinskaya, and the recovery amount is about 126m^3/minute as gas with 30% concentration in the most biggest month and about 70m^3 in the smallest. While arrangement and location of the gas discharging well depend on their coal production plan, in this study movable three pump stations are planed to recover gas.

(1) Vacuum pump and transfer pump

1) Assumption of pump selection

As mentioned before, three pump stations are planned. A gas amount transferred per one station is determined as 30Nm^3 considering margin. As the location of the pump station moves according to the proceeding coal production, the pump station is determined to be movable by placing compactly on a vehicle. Therefore, a study on what a vacuum pump to recover gas and a pressure pump to transfer gas are together installed on the same vehicle is carried out. And as mentioned in the section2.2.4 of 「Present Status」, gas must be dehumidified by a dehumidifier to prevent from clogging the pipeline by freezing caused by a low temperature in winter on the way of transportation (Dehumidifying will be stated in this Chapter.). Vacuum pressure necessary to absorb gas from a boring pit of a coal mine is – 45kPa, and an outlet pressure is required about 600kPa considering pressure drop caused by the dehumidifier and the pipeline.

2) Pump selection(vacuum pump and transfer pump)

The vacuum pump and the transfer pump are connected together for use, and for that reason, types of pumps without fluctuation and with easy regulation of pressure balance are selected.

Vacuum Pumps and transfer pumps which have their capacity of 30Nm^3 and work at pressure between – 45kPa and 600kPa are available among wet type pumps (thickener type), root pumps and screw pumps.

The wet type pump is quite possible because it can be used as a vacuum pump and a transfer pump too and it has been also used in Chertinskaya coal mine. However, a big pump with about a capacity of 600kPa is expensive; and in a principle, the gas transferred contains a lot of water, so it is not practical because clogging of pipe is induced by freezing water in the gas during severe winter.

The root pump is suitable for middle size on pressure and capacity, but it is not practical because its efficiency becomes low to obtain vacuum degree of about –45kPa.

The screw pump is suitable for a vacuum degree and outlet pressure required by this project, so the screw pump is adopted.

3) Outline of pump specification

· Process gas	methane 30%～40% (remaining is air)
· Inlet pressure	- 45kPa
· Outlet pressure	600kPa
· Type	screw (one/one unit) (skid type)
· Motor	500kW
· Electricity consumption	less than 500kW
· Rough size (meter)	3.5 x 8 x 3.5 (height)
· Rough weight (ton)	20

(2) Dehumidifier

1) Assumption of study

A water content in the coal mine methane gas is 8g/m^3 in winter, and at present, the water content increases as much as twice to 14g/m^3 because of transportation by a water sealed pump, so the pipeline was clogged by freezing water during winter. In this project plan, the screw type pump which does not increase in the water content of the gas, is adopted, but when a gas amount transferred is 30m^3/minute, ice about 10 tons clogs the pipeline during severe winter (−30℃). This is equivalent to 200meters of 250A pipe. Therefore, the water content in the gas is decreased to 0.2g/m^3 by dehumidifier before transportation of the gas to the pipeline during the anticipated period of clogging caused by freezing.

2) Process selection

The dehumidifying process is classified to a wet type process, which uses liquid (ethylene glycol, etc.) and dry type process, which uses molecular sieve or silica gel or the like. A feasibility turning point between the wet type process and the dry type process exists in gas flow rate of about 400m^3/minute, and in this research the dry type process is studied.

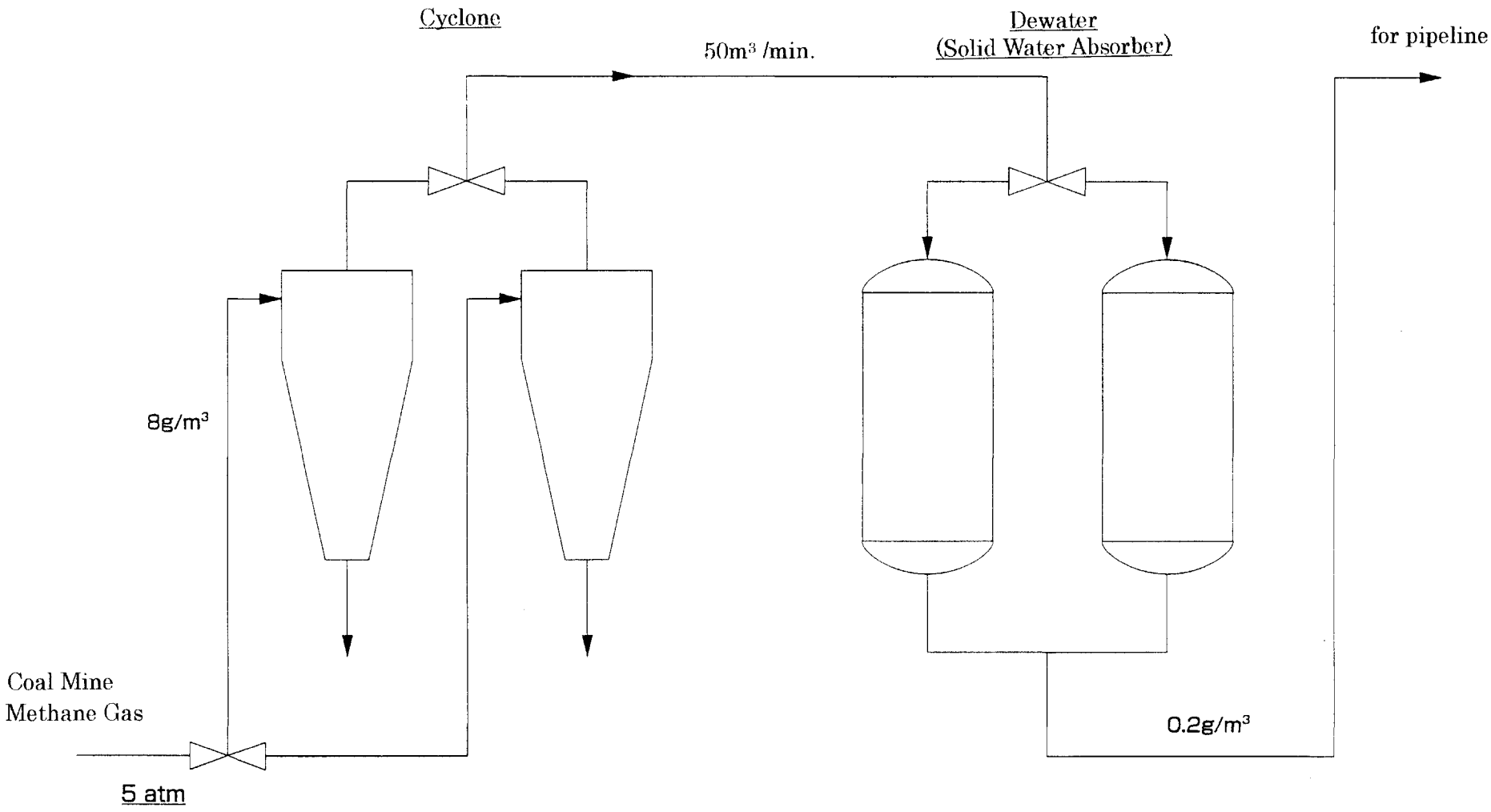


Fig.2.2-42 Dehumidifier for Coal Mine Methane Gas

3) Study on facility

The dehumidifier separates particulate water by cyclone separator using centrifugal force beforehand and thereafter adsorbs water content by a dewater charged solid water adsorber. Fig 2.2-42 shows its outline of flow.

(3) Pipeline

1) Assumption of study

The wells which transfers the methane gas recovered by boring from coal seams to the surface of the earth is changeable according to movement of a coal production area. In this connection, in this study a permanent pipeline is constructed near to the main coal mining area and against the movement of coal mining area a temporary pipeline is constructed to expand thereto and to connect with the permanent pipeline. Temporary gas storage of methane gas for the power plant is accomplished by placing a gas tank, but the water sealed gas tank does not work during severe winter season at Chertinskaya, also a big spherical tank is not suitable from its construction cost. In this research, taking cost-down into consideration, the pipeline is planned to have a function to hold the gas.

2) Piping plan

The methane gas is collected from three main mining areas, and for that reason, the pipeline composes of three branch lines, as shown in Fig 2.2-43 of the outline of piping plan. The longest pipeline is about 3km. The pipeline is mainly constructed on a field being surface of the coal mining, and the surface shows inequable sinking during a long time caused by collapse of the coal seam after coal mining. Therefore, a usual method to construct pipeline underground is not practical because there might be a gas explosion caused by the gas leak drained by pipeline inequable sinking and of economical loss caused by gas leakage. Taking the above into consideration, the pipeline is constructed on the ground in this study. It is important to make the right of land clear at the actual detail piping plan of the pipeline to proceed with the construction without delay, and so even though length of the pipeline gets longer, the pipeline should be constructed on the land owned by Chertinskaya or on an official land. Furthermore, though the dehumidifying is planed, a discharge valve is arranged to discharge dew effectively from a bottom of bending part on its way.

3) Specification of facility

a) Piping

A gas amount transferred from a well is predicted to be 50Nm^3 at the maximum. A construction cost for the pipeline depends on a diameter of the pipe under condition that a distance is constant. The smaller the diameter of pipe is, the less the cost of the pipe is, but pressure drop is increased and capacity of compressor for gas transportation gets big too, and this increases in its cost and its operation cost. Taking above into consideration, the piping system has to be determined. In this research, transportation distance is about 3km, so the necessary pressure at the power plant is about 0.2MPa. Taking the above into consideration, 250A pipe is selected because of that while 200A diameter of pipe makes the pressure drop of 0.3MPa during severe winter season too big and this makes the compressor cost for transportation be too big, 300A diameter pipe makes the construction of pipeline too big.

b) Foundation (Support structure)

Support for a pipeline composes of pillows made by concrete placed about every ten meters depending on situation of the field, when the pipeline passes through on the field, and a lack on which pipeline passes through when traffic condition is heavy. Temperature difference at Chertinskaya between summer and winter seasons is nearly 90℃, and therefore, the pipeline shows expansion and contraction about 1 meter per 1km. For a countermeasure for this, the pipeline is fixed to anchors made by concrete at about every 1km to make crooked portion there horizontally to compensate the expansion or contraction.

c) Material

The piping material is STPL material, because the usual carbon steel is anticipated to low temperature brittleness break caused by – 50℃ during severe winter season.

4) Gas storage amount

The total length of the pipeline is about 6km. In this study, the gas is stored till the pressure of 0.5MPa at the maximum when the gas generation is big, and the pressure in the pipeline keeps at 0.2MPa when the gas generation is small. In this case, the gas amount stored in the pipeline is about 900m^3.

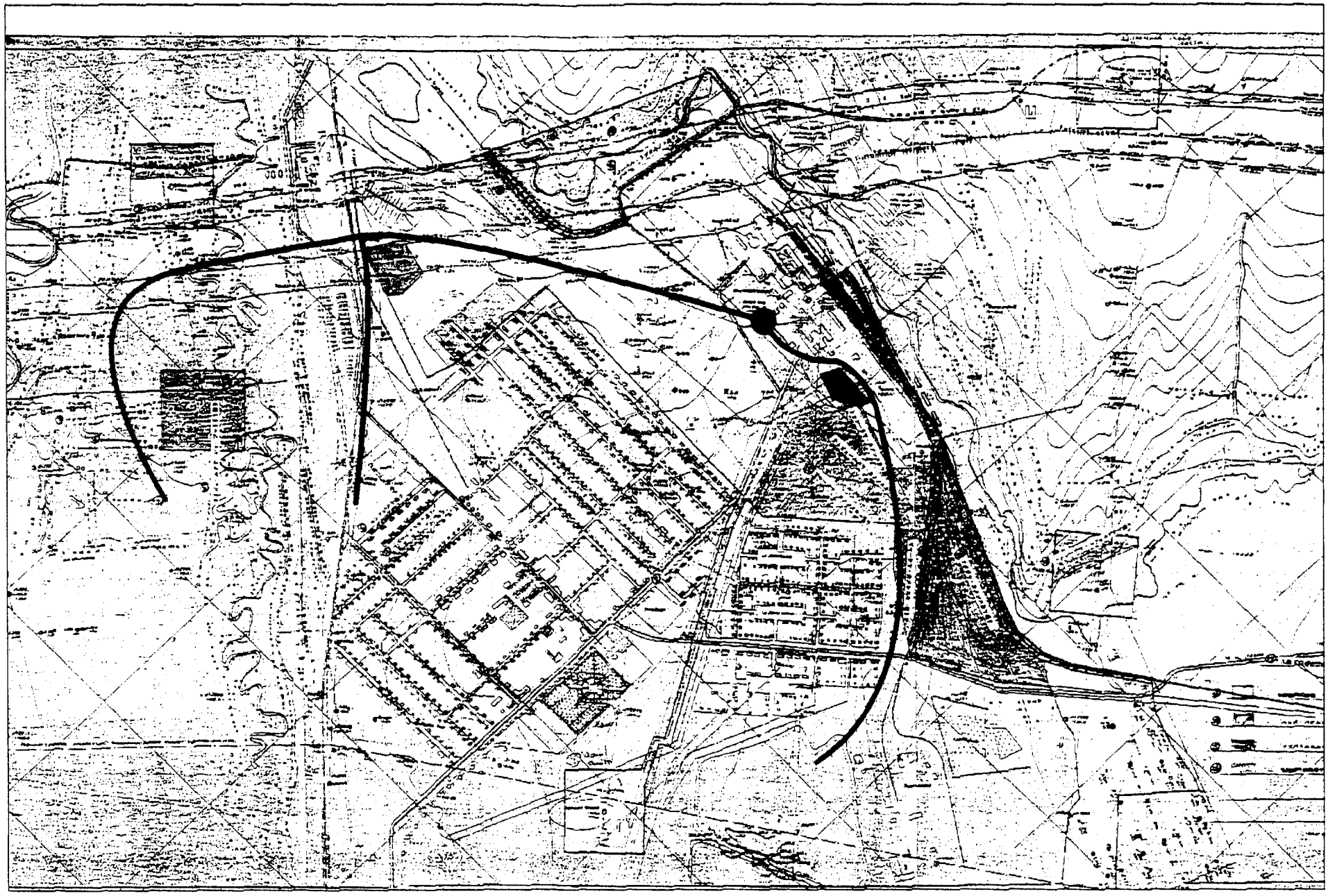


Fig 2.2-43 Chertinskaya Coal Mine Methane Pipeline Conceptual Plan

2.4.8 Process selection of power plant

(1) Assumption

1) Amount of gas recovered

As mentioned in section 2.4.6, the coal mine methane gas changes its amount released with the amount of coal production. The amount of gas for the power plant is planned based on the amount of gas recovered in the year 2003 when the project is realized. The amount of gas recovered with 14,150,000m^3/year (26.9m^3/min as pure methane) is planned in the year 2003 in accordance with the plan. However, the amount of gas released which is affected by the coal production amount, is fluctuated with seasons. As mentioned before the gas amount recovered changes with seasons, the facilities is planned to cope with the fluctuation between 38m^3/min and 18m^3/min (as pure methane) taking this into consideration.

2) Recovered gas concentration

The higher the recovered gas concentration is, the higher the economical effect for its use is, but as mentioned before it seems difficult to obtain methane gas with high concentration. In this study, assuming that methane concentration is 30%, the facility which is able to cope with concentration change between 30% and 35% and generates the power continuously, is planned.

3) Technical level

Chertinskaya's engineers operate and maintain the power plant when the plant is constructed. The technical level is compensated by education in certain limit, however, various factories to support it are required there for the maintenance. In Chertinskaya and in the neighborhood there are scarcely factories for support, so it is difficult to maintain a high level facilities. Especially, there is no factory capable of an overhaul of the turbine in the neighborhood.

4) Power plant capacity

As mentioned in the section2.2.4, Chertinskaya coal mine is restricted its power consumption with the contract with the electric power company. As modernization of their facility is promoted with the self-power generation and their productivity is improved, the power plant with power generation capacity as much as possible is desirable. On the above assumptions, a suitable power generation

process is selected based on a study on gas turbine power generation and gas engine power generation in the following Chapter.

(2) General feature of gas turbine power generation facility

Since the gas turbine gets in practical use in the year 1936, it showed a remarkable improvement that proceeded with developments for airplane and for power generator, and at present big capacity engine with more than 20MW has been developed. Here, feature outlines of the gas turbine engine are stated.

1) Light weight and small size
A lot of working gas flows with high speed through internal structure of the body, so size of the facility per outlet power is small.

2) Suitable big outlet power
Inlet temperature of the turbine is heated to high temperature and thereby it is possible to obtain outlet power with 300MW per one.

3) Less maintenance frequency
It is rotational equipment with little number of sliding parts except bearing, so maintenance frequency is little. However, it requires accuracy because of high speed rotating equipment.

4) Less consumption of cooling water and lubricant oil
Consumption of a lubricant oil is little because of small number of sliding parts.

5) Easy transportation and installation
Transportation and installation is easy because its weight is light and it is packaged.

6) High utility value of waste heat
Temperature of waste gas from turbine is 500℃, so recovery of the waste heat is big.

7) Low heat efficiency

It is less than 30%, in case of an electric power generation with small sized plant and with a single cycle.

8) Expensiveness

The cost of a mass-produced gas turbine engine is becoming less, but gas turbine engine for special fuel such as coal mine methane gas is expensive.

9) Big input power at start-up

Input power requires from 2% to 3% of usual output power.

10) The output power becomes low about 0.8% per 1℃ up of atmospheric temperature.

(3) Study on gas turbine using coal mine methane gas

The conceptional study on the gas turbine utilizing the coal mine methane gas with 30% concentration for fuel is carried out. The low fuel concentration of 30% causes many problems in consideration of the gas turbine efficiency.

1) Volume of fuel

Usual gas turbine works with gas at about 11,000-8,000kcal/Nm^3. However, 30% methane gas is about 2,500kcal/Nm^3, which is about 1/4. Therefore, four times fuel gas has to be supplied, so it requires a correspondent capacity with economic demerit

2) Start-up feature

At the start-up of gas turbine it requires suitable combustion feature for the start-up, and for that reason, liquid fuels such as kerosene or the like are required at the start-up. Therefore, it must be a dual fuel type gas turbine.

3) Gas fuel supply device

The fuel is fed to combustion chamber after compression with 1.2~1.4MPa, and as it must compress 70% extra air in case of 30% methane fuel, big compression facility and compression energy is necessary.

4) Amount of electric power generation

Taking the above into consideration, a rough calculation on the amount of electric power generation is carried out; and considering about maintenance, 3 gas turbines having a rated output capacity with 1,400kW/one corresponding with about 1,000 kW/one at a generating end of power generator and also corresponding with about 700kW/one at a sending end, as an internal consumption is about 300kW, are to be installed. Therefore, the total output at sending end of the power generation plant becomes about 21,000kW.

(4) General features of gas engine electric power generation

Gas engine has been developed since 19th century, and many types of gas engine are now in practical use or under development. These outlines are as stated below;

1) Direct ignition method

The direct igniting method ignites gas mixture in a main combustion chamber composing of cylinder head, piston and liner. As this type of engine has a basic problem which the ignition and spreading are unstable in case of a fuel with low heat energy such as methane with 30% concentration, it is hardly adopted.

The solution is that a liquid fuel (heavy oil or diesel oil) having about 10% heat calorie against the total heat calorie to be supplied is injected by fuel injection pump into the chamber and the gas is ignited. In this case, a lot of liquid fuel is required, so it is not applicable to Chertinskaya. The gas ignition engine ignites, with grove plug, a gas mixture with liquid fuel of about 5%, which is compressed up to 250 atom and is injected into the cylinder. This method saves liquid fuel, but result in high driving power drop of high-pressure compressor etc., and costs for high-pressure facilities are high, so it is not suitable for Chertinskaya either.

2) Additional combustion chamber method

The additional combustion method has been developed at high speed as a lean-burn engine for NOx reduction. The engine composes of a main combustion chamber and two additional combustion chambers placed on an upper side of cylinder. The ignition plug is placed in the additional chambers. It is a new type engine to realize both an efficient combustion of a lean fuel gas by injecting a highly concentrated fuel gas into the additional chambers and by igniting by a

plug to give a big ignition energy to lean fuel gas in the main combustion chamber (thin gas mixture) when usual city gas is used as fuel, and NOx regulation recently getting severe. The additional combustion chamber method has a spark ignition method and a pilot oil ignition method.

When usual city gas is used as the fuel at the spark ignition method, highly concentrated fuel gas with about 3% heat calories against the total heat calories is injected into the additional combustion chambers, and the concentrated fuel is mixed together with the lean fuel gas in the cylinder to get a theoretical gas mixture during process of compression, and the gas mixture is then ignited by the ignition plug. A fire jet from the additional combustion chamber spreads to the main combustion chamber to combust the lean fuel gas in the main combustion chamber, and its expansion energy pushes down the cylinder. Closely theoretical methane gas mixture with air needs a big energy for its ignition, so it requires the ignition plug to be ignited because it is not ignited by itself. The reason is that its temperature is kept low, even though the cylinder is compressed and the combustion spreading speed of methane is not so fast and the energy of the fire jet is not so big either. However, comparing with the type without additional combustion chambers, it is possible to combust lean fuel gas and for that reason, discharging amount of NOx is little. The spark ignition method has a feature to combust such lean fuel gas, but it requires a high concentrated methane gas to be injected into the additional combustion chambers. But there is not the pipeline for transportation of a small amount of high concentrated methane in Chertinskaya (constructed 40km away), so this method is not applicable. However, in stead of highly concentrated fuel gas, a pilot oil ignition method to use a little liquid fuel (diesel oil) has been developed. Furthermore, this method is highly stable and it is the most suitable for a gas engine to use coal mine methane gas, so an explanation on it is made below.

(5) Study of gas engine for using coal mine methane gas

As mentioned before, the pilot oil ignition method injects a small amount of fuel oil (about 1% heat calories against the total heat calories generated) in stead of highly concentrated fuel gas into the additional combustion chambers compressed by the cylinder. This misty fuel oil ignites at the moment of the injection. The ignition gives the lean fuel gas in the main combustion chamber an energy from 5,000 to 10,000 times of usual ignition plug method as high speed fire jet.

Thereby the lean fuel gas is combusted in a quite short time. While in the spark ignition method, the highly concentrated fuel gas mixes unequally with the lean fuel gas in the main combustion chamber, fuel concentration does not stabilize. After ignition, it is spread combustion of the lean fuel gas, so it takes a certain time to combust. At this point, the pilot oil ignition is high fire jet energy, so the lean fuel gas combusts in a moment and the efficiency becomes high. The operation is stable without knocking, and in addition to increasing efficiency, a load on the plug (use only at start-up) is also decreased, so lifetime of the plug is lengthened. This engine is suitable for gas with low combustion energy (low concentrated methane) or for gas with unstable concentration.

The coal mine methane of Chertinskaya has low methane concentration, and its concentration is also unstable, so the pilot ignition method is practical.

(6) Comparison and selection of gas turbine and gas engine

Table 2.2-25 shows comparison between a gas turbine and a pilot ignition gas engine. A gas turbine generates a small amount of electric power, and requires a lot of electricity for a high-pressure compressor for a fuel gas. Its combustion of fuel gas is unstable with fluctuation of methane gas concentration. Technical solution for this adopts a duel fuel type engine, and it is not practical from the viewpoint of cost. Thereby, the pilot ignition gas engine is adopted in Chertinskaya electric power generation project.

Table2.2-25 Comparison between Gas Turbine and Gas Engine with Pilot Oil Igniter

(In case of 30% methane concentration of Chertinskaya coal mine)

Items	Gas Engine	Gas Turbine	Remarks
System Feature	Waste heat recovery as steam and hot water	Large waste heat recovery as steam	Efficiency becomes low when use of fuel gas with low heat calories. (As power generation efficiency of gas engine is much higher than turbine, it has an advantage on a plant mainly generating power.)
Heat efficiency	Electricity 30% Hot water 10% Steam 15% Total 55%	Electricity 15% Steam 45% Total 60%	
Net power generation	4,620kW	1,750kW	Operability at 30% methane concentration. Auxiliary driving power of gas turbine is mainly for a fuel gas compressor, because big power is required to compress low concentrated fuel gas to highly pressurized gas.
Auxiliary driving power	A little less than 10% amount of generated power	30% amount of generated power	
Operability	Stable	unstable	
Pilot fuel	1% of total heat calories generated	Not necessary	
Influence of atmospheric temperature	none	Yes(output decrease in hot summer)	Rated output power of a gas turbine is stated in general at 15°C. Correction when high atmospheric temperature in summer is necessary.
Maintenance	Possible at the spot	Transfer specified maintenance shop when overhaul	
Fuel gas feature (methane concentration)	More than 30%	More than about 70% for mass-produced article	For 30% methane, a gas turbine becomes special duel fuel type.
Influence on start-up and shut-down frequency Maintenance interval	No influence	To be influenced	For a gas turbine at start-up about 100 liters kerosene is necessary, one start-up and shutdown corresponds to about 10-30 hours operation, so in case of many start-up and shut-down, a gas engine has an advantage.

2.4.9 Facility capacity (Gas engine generator)

Selection of the facility capacity is calculated based on heat calories of usable fuel and a suitable type is selected.

(1) Outline of fuel

1) Supply gas condition

- Average gas amount supplied annually : 14,150,000 Nm^3 (as pure methane)
  Gas amount supplied per hour : 1,615 Nm^3/hour
- Heat calories of fuel in low level : about 10,800 kJ/Nm^3 (2,580kcal/Nm^3)
  (CH_4 30% concentration)
- Fuel gas supply pressure : 0.196 MPa (2.0kgf/cm^2)

(2) Adopted gas engine and output selection

- Gas engine is a pilot oil igniter gas engine with high ignition energy. Also, for start-up of the engine, an ignition plug is used together.
- Output selection
  - Pilot oil ignition gas engine :L (V) 22AG Type
  - Output of 6L, 8L, 12V, 16V,18V using coal mine methane gas is shown in Table 2.2-26.
  - Assuming that the efficiency at an end of engine crank axis is 30% (2,108.5kcal/ps・h) and the average efficiency of power generator is 95.5%;
    FQ of gas amount (as pure methane) necessary to generate an electric power with one hour・1kW is:

$$FQ = \frac{2,108.5 \times 1.05}{8,600 \times 0.7355 \times 0.955} \fallingdotseq 0.367 Nm^3/kWh$$

  - There is the following relation between number of engine and output.

$$\text{Engine output (kW)} = \frac{\text{Gas amount supplied } (1,598 m^3/\text{hour})}{0.367 \times \text{Number of engine}}$$
$$= 4,407 \text{ (kW)}$$

Result when the above is applied to the main specification of 22AG type engine in Table2.2-27, is shown in the next Table2.2-26.

Table2.2-26 Required number of each type and methane gas consumption rate

Type	6L22AG	8L22AG	12V22AG	16V22AG	18V22AG
Number	7	6	4	3	3
Output(kW/one)	625	840	1,275	1,710	1,920
Average gas consumption(%)	100	87.4	86.4	85.9	76.5
Non-consumption rate(%) of gas in maximum gas generation month	40	22	20	20	6

(3) Selection result

12V and 16V show similar gas consumption rate, but 16V is less by one in number. Facility cost is advantageous at the cost when number is small if the output does not change widely. Also 18V seems to be the excessive facility because of the low gas consumption rate in average. According to this study, the following power generating process was selected.

1) Type : 16V22AG
2) Output(kW), Frequency(Hz) :1,710kW/50Hz
3) Number : 3

Table 2.2-27 Main Specification of 22AG Type Engine

	Type		Unit	6L22AG	8L22AG	12V22AG	16V22AG	18V22AG
Power generator	Rated Output		kW	625	840	1,275	1,710	1,920
	Frequency		Hz	50				
	Voltage		V	6,000				
	Fuel consumption	Gas	Nm^3/h	742.8	993.0	1,491.3	1,989.5	2,234.0
		Pilot oil	L/h	2.7	3.6	5.4	7.2	8.1
Gas engine	Type			Pilot ignition/turbo charger/air cooler/4 cycle gas engine				
	Cylinder number			6	8	12	16	18
	Cylinder diameter		mm	220				
	Piston distance		mm	300				
	Rotation number		min^{-1}	1,000				
	Rated output		kW	668.5	893.6	1,342.0	1,790.5	201.5
	Fuel consumption	Gas		Coal mine gas				
		Pilot oil		Diesel oil				
	Rough weight		kg					
	Ignition method			Pilot oil ignition gas engine				
	Start-up method			Compressed air start-up (air motor)				
	Cooling method			Second cooling water by radiator (first and second cooling water system)				
	Lubrication method			Forced lubrication(by engine driven by gear pump)				
Power generator	Type			Release protection/Salient pole/Revolving-field type/ self-ventilation				
	Kind			Three phase current synchronous power generator(JP20)				
	Capacity		kVA	781.2	1,050.0	1,593.7	2,137.5	2,400.0
	Pole number			6P (50Hz)				
	Voltage		kV	6.0				
	Power factor		%	0.8(delay)				
	Exiting method			Brushless.				
	Efficiency		%	93.5	94.0	95.0	95.5	95.5
	Rough weight		kg					
Waste heat boiler	Steam amount		kg/h				1,340	1,505.0
	Steam pressure		MPa	0.392 (4.0kgf/cm^2G)				
	Inlet water temperature		℃	15 (the normal temperature・soft water)				
	Exhaust gas outlet temperature		℃	185				
Warm water recovery	Warm water recovery amount		m^3/h				61.0	69.0
	Warm water temperature		℃	Inlet temperature /outlet temperature 40 ℃ /45 ℃ Temperature difference Δt = 5℃				

(4) System and description of main equipment specification

1) System description

As mentioned in former Chapter, the engine feature of the pilot ignition gas engine compresses the fuel gas by a compressor up to about 0.4MPa, and feed the fuel gas with closely theoretically mixed gas to the engine. The gas fed is compressed by the cylinder, and diesel oil in correspondence with 1% heat calories against the total calories is injected into the additional combustion chambers to be ignited by itself, and thereafter the combustion fire is fed to the main combustion chamber to ignite the lean fuel gas in a moment. The cylinder receives this expansion energy to convert rotational energy. This pilot oil ignition energy is more than the plug ignition energy by from 5,000 times to 10,000 times, so the lean fuel gas combusts stably.

The energy obtained by the engine is fed to the electric power generator to generate electricity. A waste heat boiler to obtain steam and hot water recovers the heat of exhaust gas.

Figure 2.2-44 shows the outline of the system flow, and Figure 2.2-45 shows the detailed flow sheet.

2) Main equipment

Equipment outline

This facility is a co-generation system composing of the gas engine electric power generation plant to use the coal mine methane gas and steam recovery from the exhaust gas as heat source and hot water recovery from the first cooling water.

The main equipment is installed indoors. This investigation is carried out based on Japanese standard, and it is necessary to execute based on Russian equipment production standard and equipment installation standard at the stage of detail study.

As shown in the Figure 2.2-44 「System Outline Flow」, the electric power generation plant composes of following equipment:

- Gas engine
- Electric power generator
- Fuel gas system
- Pilot oil system
- First cooling water system
- Second cooling water system
- Start-up air system
- Instrument air system
- Exhaust gas system
- Power generation equipment and electric article

3) Main equipment specification description

a) Gas engine

Type	: 16V22AG
Number	: 3
Main Specification	: Refer to Table 2.2-26 Main Equipment List

b) Electric power generator

Number	: 3
Main Specification	: Refer to Table 2.2-27 Main Equipment List

*The gas engine and the electric power generator are directly connected and installed on a mutual stand floor.

c) Electric distribution board

Constitution and number of board

- Electric power generation board :3
- Gas engine control board :3
- Direct current board :1 (Attachment of a lead storage battery)
- Internal transforme :1

  Inlet voltage : 6,000V, Outlet voltage : 400V

  Dry mold (F type)
- Sending circuit braker board :1

Figure 2.2-46 shows the engine external form.

(3) System outline description

1) Fuel gas system

The fuel gas system composes of equipment and piping or the like to compress the coal mine methane gas collected from each coal mine and to transfer it to the gas engine for its fuel.

The coal mine methane gas is fed to engine fuel gas main pipe through separator valve, strainer, gas pressurizer, safety interception valve and flow meter. The gas fed to the engine is supplied to combustion chamber composing of cylinder head, piston, cylinder liner and is ignited by spark of ignition plug placed in the combustion chamber or by energy obtained from the pilot oil and is combusted.

No.	Equipment	Action and Remarks
1	Fuel Gas Pressurizer	To pressurize fuel gas necessary for the gas engine operated by instruction from the electric power generation board. (Pressurerizes from 0.196MPa to 0.392MPa) Stop by instruction to stop the gas engine.
2	Safety Interception Valve	To arrange starting condition of engine, open the starting electromagnetic valve in electromagnetic valve container by instruction to start, feed fuel gas to the gas engine. Pneumatically operated ball valve to be closed by instruction to close, to intercept fuel gas, and to stop the engine.
3	Emergency Close Valve and Open Valve	To prevent from spread of fire or gas leak at an occasion of fire or gas leak at power plant by releasing gas in pipe and receiver tank in the air. Namely, at an occasion of fire or gas leak, to close the emergency close valve and to open the emergency open valve and to release the gas from releasing pipe in the air.
4	Fuel Gas	Description : Coal mine gas CH_4 content : CH_4 concentration 30~36% Heat calories at the minimum : 10,800kL/Nm^3(2,580kcal/Nm^3) Consumption : 1,989.5Nm^3/h/one

2) Pilot oil system

This line works to stabilize the combustion condition by obtaining big ignition energy by injecting a small amount of liquid fuel (pilot oil: diesel oil) by using piston into the combustion chamber being high temperature by compressing.

The pilot oil is fed to the engine through storage tanks (5,500 L x 2) and pilot oil supply pump.

No.	Equipment	Action and remarks
1	Pilot oil tank	Welded steel tank to store the pilot oil or diesel oil. Volume (5,500 L x 2) corresponds to about 21day's based on operation of three pumps at the same time. (Pilot oil: 7.2 little/hour/one)
2	Pilot oil supply pump	Engine-driven gear pump

3) Lubricant oil system

The lubricant oil is charged in the lubricant oil pan located at the bottom of a mutual stand floor and made in a body by welding. The system is a circulating circuit in which the lubricant oil passes through cooler and lubricant oil filter and returns to the lubricant oil pan by engine-driven lubricant oil pump. Lubricant priming pump is installed to lubricate sliding parts before the engine start-up,

warming up operation for improving start-up operation by cooperating with electrical heater to start and to stop according to oil temperature during the engine stop. The Lubricant oil for the gas engine has to be exclusive oil for the gas engine.

No.	Equipment	Specification and remarks
1	Lubricant oil	Description : Lubricant oil plate designated by manufactures Viscosity : SAE30 or 40 First charge : 2,500 l Consumption : About 36.5 L/day/one
2	Lubricant oil pump	Composing of filter, cooler and regulator valve.

4) First cooling water system

The first cooling water system is a circulation circuit to cool cylinder head forming a combustion chamber of a body of the gas engine and highly heated part of an outer circumference at cylinder liner by combustion.

It is a closed circuit in which the cooling water from the first cooling pump of which pump is placed separately, cools the engine body, exchanges heat by warm water heat exchanger, passes through heat exchanger for discharging heat and returns to the first cooling pump. If there is not warm water recovery (no use for warm water), it exchanges heat with the second cooling water by the heat exchanger for heat discharge to control its temperature at the designated temperature by temperature control valve.

Expansion tank is able to absorb a volume expansion by temperature change.

No.	Items	Specification and remarks
1	First cooling water	Quality of cooling water : Soft water or city water Additive :Essential in spite of water quality to prevent from scaling and rusting. Antifreezer : To prevent from freezing, if necessary Consumption : About 25~50 L/per day /one
2	Warm water circulation pump, electric heater	As similar to lubricant oil, device heats up for improving start-up operation.

5) Second cooling water system

The second cooling water system is a closed circuit composing of the second cooling water pump, air cooler to cool the combusted air, which is compressed and becomes high temperature by turbo charger, lubricant oil cooler, heat exchanger for discharge heat and radiator installed outdoor; and the cooling water exchanges heat with each heat exchangers in the circuit.

As similar to the first cooling water, 200 litters expansion tank is installed.

No.	Items	
1	Second cooling water	Quality of cooling water : City water or industrial water Additive :Essential in spite of water quality to prevent from scaling and rusting. Antifreezer : To prevent from freezing, if necessary When stopped in a long time, it is necessary to drain out water. Equipment :Including radiator, cooling water pump and expansion pump

6) Start-up air system and instrument air system

Start-up air system:

The gas engine rotates its engine by being toothed pinion gear placed on an extreme point of the air turbine with engine flywheel each other, and continues its work by transferring air run to self-ignition.

The start-up air system and the instrument air system supply with air for pneumatically driven equipment such as the air turbine.

No.	Items	Action and remarks
1	Start-up air compressor	Compressor keeps always air pressure in air tank to secure pressure to start the engine by automatically operating according to on/off of pressure switch attached to the air tank.
2	Instrument air compressor	Likewise the start-up air compressor, operates automatically to start and to stop.

7) Exhaust gas system

The exhaust gas combusted in the engine is discharged in the air through silencer and exhaust gas boiler.

No	Items	Action and remarks
1	Damper unit Purge fan Electric driven valve	Soon after the stop of gas engine, purge fan starts up, damper close, electric driven valve opens, and pressurized air from the purge fan purges remaining gas from the damper till the end of discharge in the air.
2	Exhaust gas	When boiler works : Outlet temperature of chimney 185℃ (planned) NOx≦600ppm(O2=0 equivalent value) Exhaust gas amount about 221.0Nm^3/min./one When boiler stops : Outlet temperature of the chimney 400℃ (planned)
3	Boiler feed water	Water quality : Softened water Without dissolved O_2 Blow water : Discharge temp. about 100℃ Ph about 11.5

(4) Gas engine room ventilation capacity

Temperature of the engine room where the gas engine is installed is raised by generated heat from the engine or the like, and particularly in summer, the temperature of the engine room is kept constant by enough ventilation. Necessary ventilation amount based on the ventilation plan of the engine room is calculated hereunder.

The ventilation amount of the engine room is calculated as follows;

(Per one engine)

1) Engine combustion air (V_{au})

Engine type	: 16V22AG
Engine output	: 1,790.kW (2,435PS)
Excess air rate	: 2.3 (Oxygen concentration in the exhaust gas =12.0)
Theoretical air amount	: 2.6 ~ 3.2
Fuel consumption rate	:2,108.5kcal/ps·h

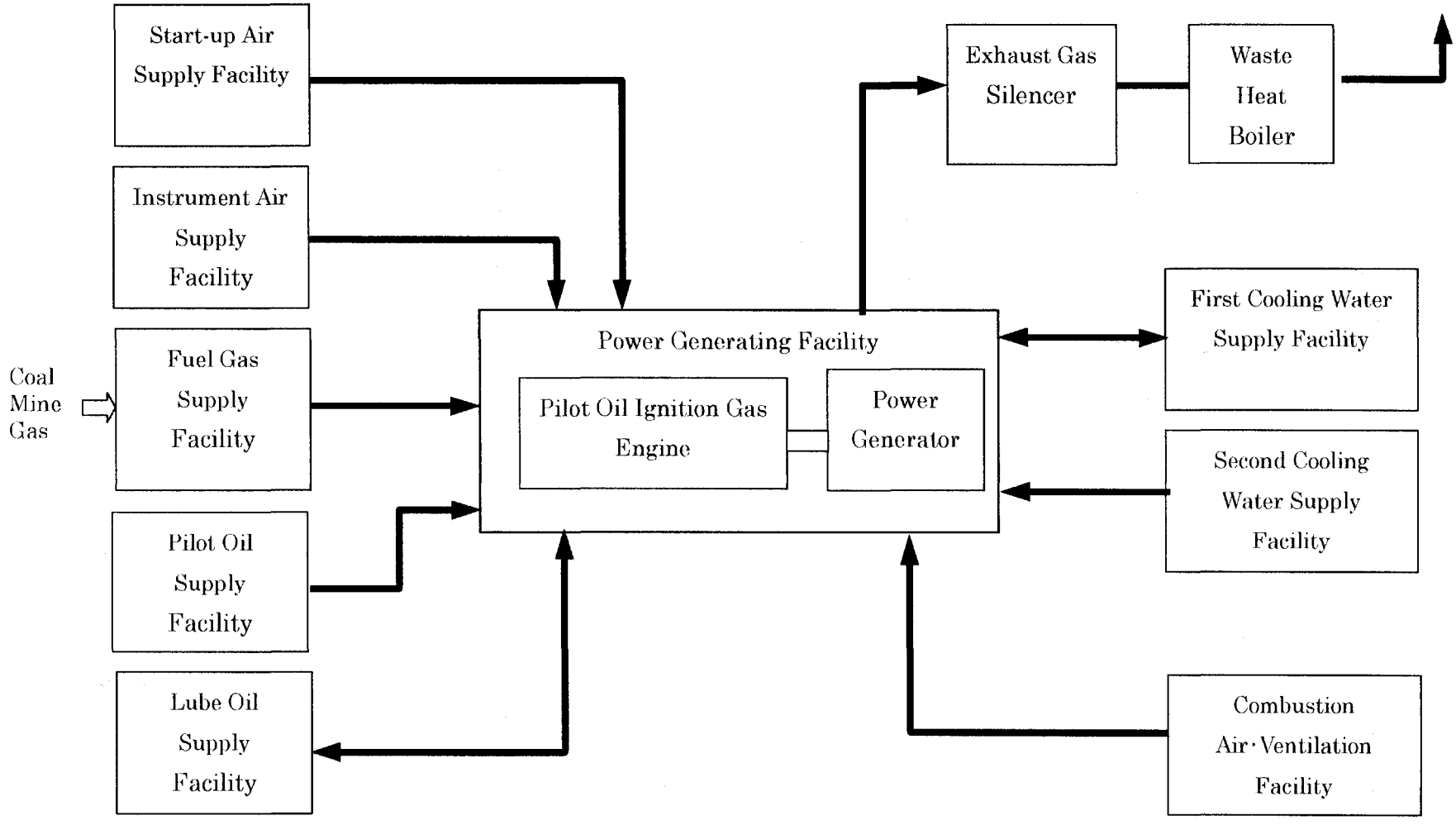


Fig2.2-44 Power Generation Facility Block Flow

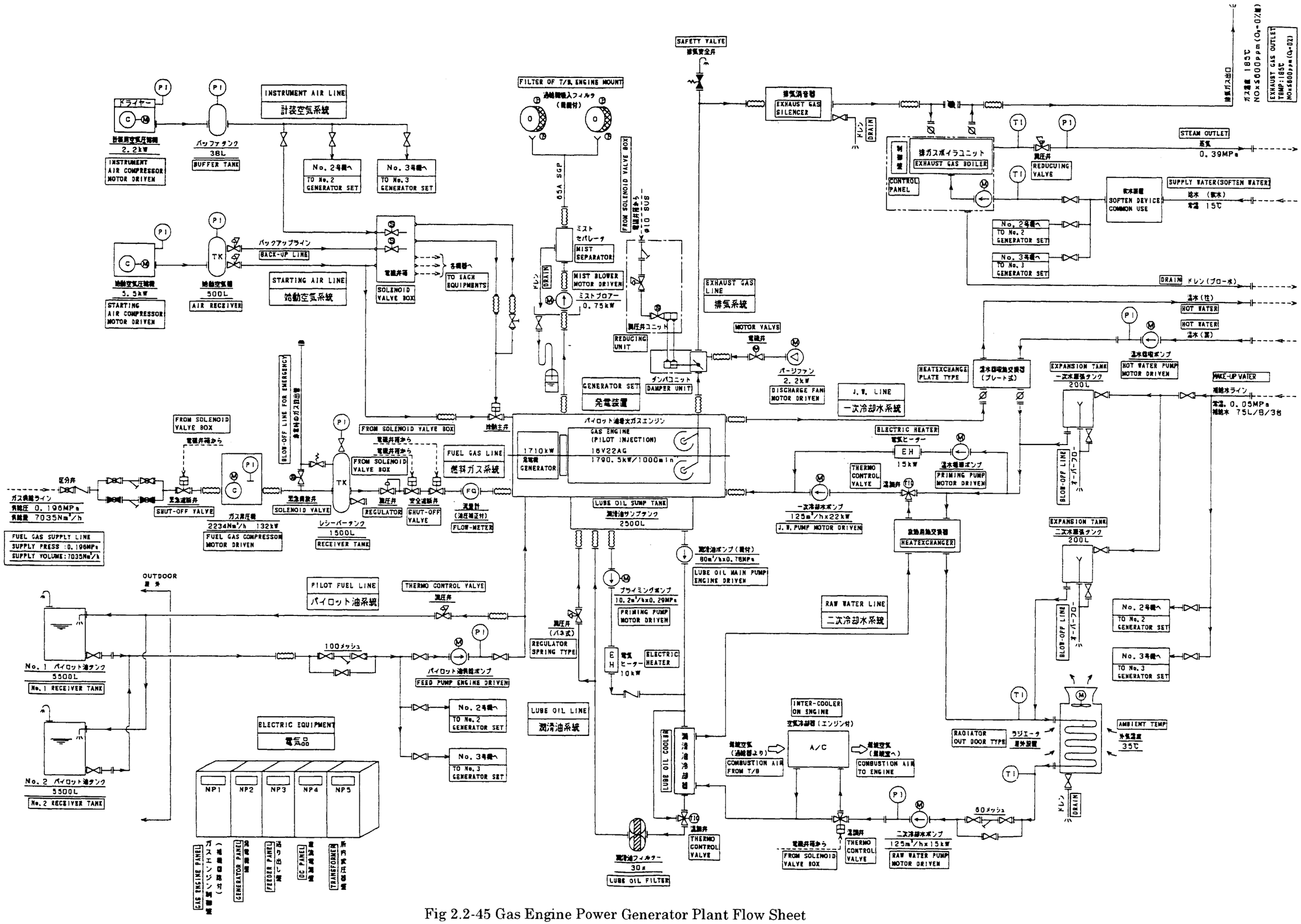


Fig 2.2-45 Gas Engine Power Generator Plant Flow Sheet

PARTICULARS			
GAS ENGINE		A. C. GENERATOR	
MODEL	16V22AG	TYPE	TSL-AJF
RATED OUTPUT	1790. 5 kW	CAPACITY	1710 kW
CYL. BORE	220mm	POWER FACTER	0. 8
PISTON STROKE	300mm	VOLTAGE	6000 V
NO. OF CYLS	16	AMPERAGE	205. 7 A
RATED SPEED	1000min^{-1}	FREQUENCY	50 Hz
TURBOCHARGER	NR /R	NO. OF POLES	6
ENG. WEIGHT	27000 kg	GEN. WEIGHT	9750 kg
TOTAL WEIGHT(DRY)	APPROX. 44750 kg (INCLUDING COMMON BASE PLATE, FLYWHEEL AND TURBOCHARGER)		

主 要 目			
火花点火ガス機関		三相交流発電機	
型 式	16V22AG	型 式	TSL-AJF
出 力	1790. 5kW	容 量	1710kW
シリンダー径	220 mm	力 率	0. 8
行 程	300 mm	電 圧	6000 V
回 転 数	1000 r/s^{-1}	電 流	205. 7A
シリンダー数	16	周 波 数	50 Hz
過給機型式	NR /R	極 数	6 P
質 量	27. 0 t	質 量	9. 75t
全 質 量	約 44. 75t (台座その他含む)		

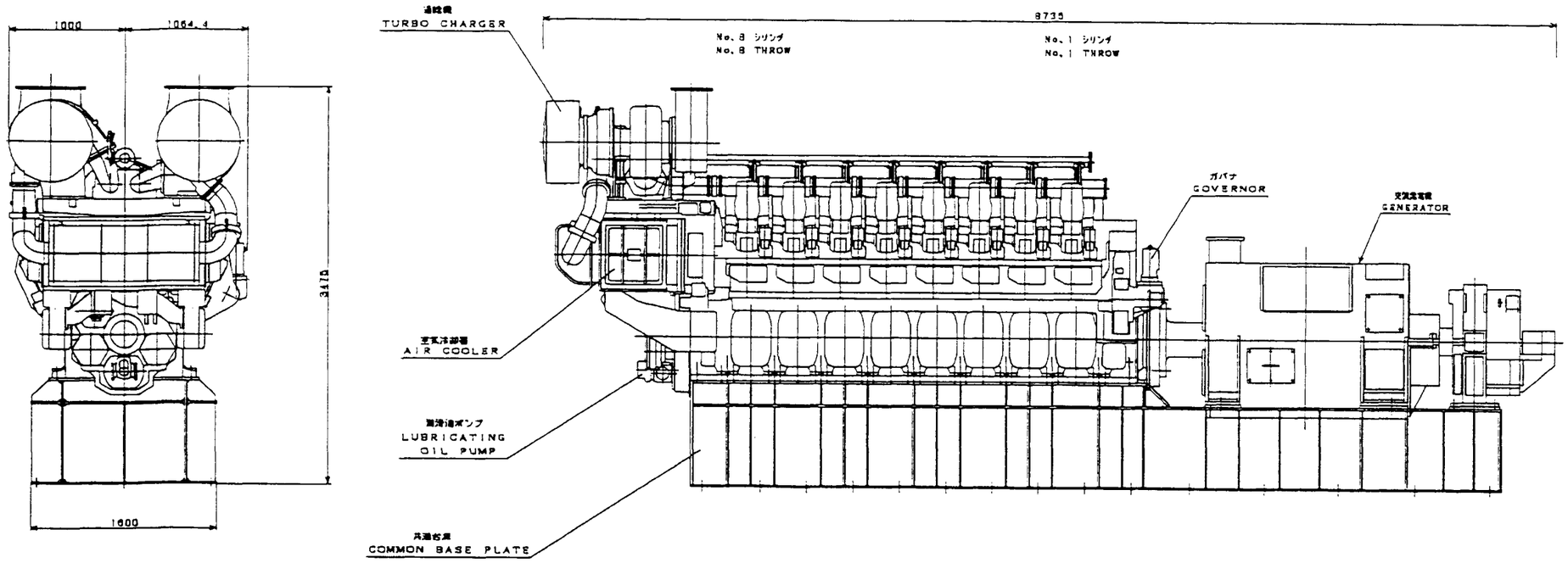


Fig 2.2-46 Gas Engine Power Generator Outer Shape

Combustion air amount (V_{au})

$$V_{au} = \frac{2{,}435 \times 2{,}108.5 \times (2.6\sim3.2) \times (2.3-2.3 \times 0.7) \times 1.05 \times 1.11}{2{,}580 \times 60}$$

$$= 69.3 \sim 83.4 \ m^3/min.$$

2) Discharging heat from power generator (Q_{gen})

Power plant output : 1,710kW

Power plant efficiency : 95.5%

I kW·h generated heat : 2.6~3.2

$$Q_{gen} = \frac{1{,}710 \times 860 \times (\frac{1}{0.955} - 1)}{60}$$

$$= 1{,}154.9 \ kcal/min.$$

3) Discharged heat from the engine body (Q_E)

Engine output : 1,710kW (2,435PS)

Fuel consumption rate : 2,108.5kcal/ps·h

Discharging heat rate : 3.5%

$$Q_E = \frac{2{,}435 \times 2{,}108.5 \times 0.035}{60}$$

$$= 2{,}994.9 \ kcal/min.$$

4) Ventilation amount to discharging heat (V_u)

Specific heat of air : 0.241 kcal/kg · ℃

Specific gravity of air : 1.185kg/m^3 (Atmospheric temp. 25 ℃)

Temperature difference between room and atmospheric temperature Δt : 20℃

$$Vu = \frac{(1{,}154.9 + 2{,}994.9)}{0.241 \times 20 \times 1.185}$$

$$= 726.6 \ m^3/min.$$

5)Total ventilation amount (V)

$V = V_{au} + V_u$

$= (69.3 \sim 83.4) + 726.6$

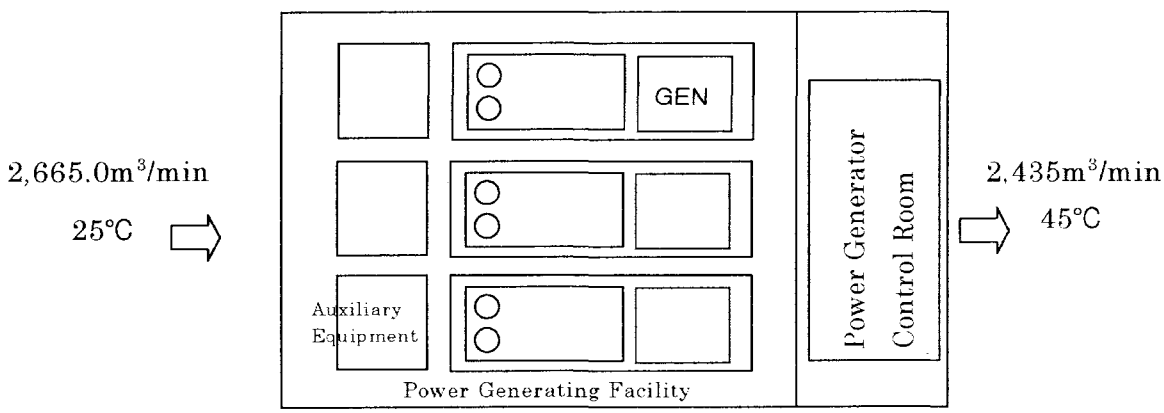
$= 795.9 \sim 810\ m^3/min./one$

The minimum necessary ventilation amount considering discharged heat from auxiliary equipment of the engine is determined as follows;

$V = 875 \sim 900\ m^3/min./one$

Note : Supply coal mine fuel gas is calculated as $CH_4 \fallingdotseq 30 \sim 36\%$ and the balance is air.

6) Calculation result is shown in Figure. (3 engines operate at the same time.)



(5) Plot plan

As mentioned before, the power plant composes of the following facilities except the body of power generation plant.

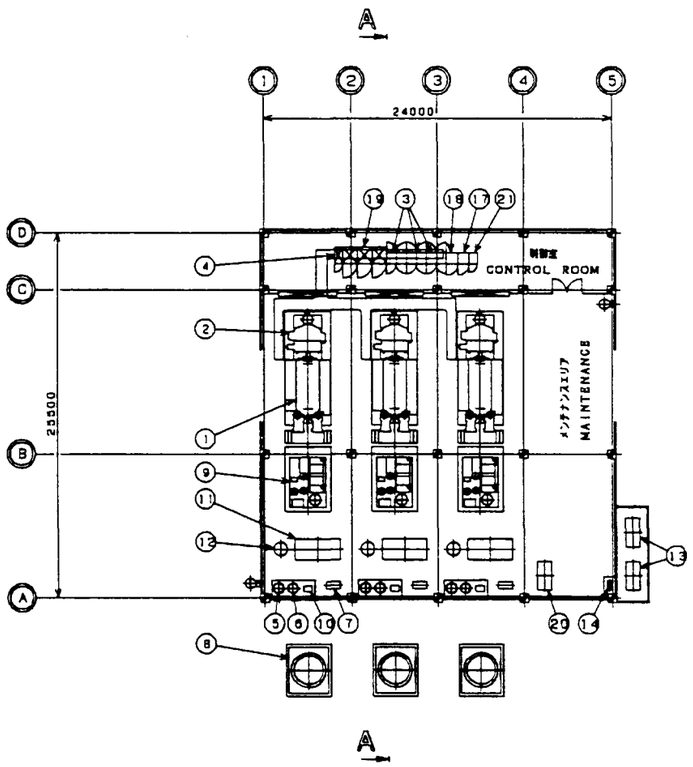
- Fuel gas supply facility
- Pilot oil supply facility
- First cooling water facility
- Second cooling water facility
- Start-up air facility
- Instrument air facility
- Exhaust gas facility
- Power generation facility and electric article

In general, these facilities are installed outdoors or in a simplified building in Japan, but in a circumstance of Belovougol the temperature in the winter has the most effluence on these facilities. To design equipment with the lowest planning temperature of –50°C, results in big cost increase, and makes its maintenance difficult. In this study, some of the facilities to stand for this temperature condition are installed outdoors, the most of them is installed indoors, and temperature in the building is controlled at the normal temperature by air conditioning. The power generators are arranged in three rows and each power generator have independently 2 meters in-depth concrete-made basement to support the weight and to prevent the other equipment from vibration. The building has a maintenance room inside of it, and has a ten-ton crane at the ceiling part to transfer main equipment to hang up at the overhaul. Electric instrument facilities are arranged in the control room and are isolated from the power generation room by a sound proof wall.

Size of the building has 24m x 25.5m x 11m of height and about 600m^2 of area. The pilot oil tanks and the radiator are installed outdoors, so necessary area is about 40m x 40m, namely 1,600m^2. The plot plan is shown in Fig.2.2-47.

番号	名　称	数量	備　要
1	ガスエンジン発電装置	3	16V22AG
2	交流発電機	3	1710kW
3	ガスエンジン制御盤	3	
4	同期盤	1	
5	一次冷却水膨張タンク	3	
6	二次冷却水膨張タンク	3	
7	二次冷却水ポンプ	3	
8	二次冷却水冷却塔	3	
9	補機ユニット	3	
10	ミストブロワ	3	
11	ガス昇圧機	3	
12	ガスレシーバータンク	3	
13	パイロット用燃料タンク	2	5500L
14	パイロット用燃料移送ポンプ	1	
15	排気消音器	3	
16	排ガスボイラ	3	
17	直流盤	1	
18	所内変圧器盤	1	
19	発電機制御盤	3	
20	排ガスボイラ用軟水装置	1式	
21	フィーダ盤	1	

No.	DESCRIPTION	Q'TY	REMARKS
1	GAS ENGINE	3	16V22AG
2	A. C. GENERATOR	3	1710kW
3	GAS ENGINE CONTROL PANEL	3	
4	SYNCHRO-PANEL	1	COMMON USE
5	JACKET WATER EXPANSION TANK	3	
6	RAW WATER EXPANSION TANK	3	
7	RAW WATER PUMP	3	
8	RADIATOR	3	
9	AUXILIARIES UNIT	3	
10	MIST BLOWER	3	
11	FUEL GAS COMPRESSOR	3	
12	RECEIVER TANK(FOR FUEL GAS)	3	
13	PILOT FUEL TANK	2	5500L
14	FEED PUMP	1	COMMON USE
15	EXHAUST GAS SILENCER	3	
16	EXHAUST GAS BOILER	3	
17	D. C. PANEL	1	
18	TRANSFORMER	1	COMMON USE
19	GENERATOR CONTROL PANEL	3	
20	SOFTEN DEVICE FOR EXHAUST BOILER	1SET	COMMON USE
21	FEEDER PANEL	1	COMMON USE



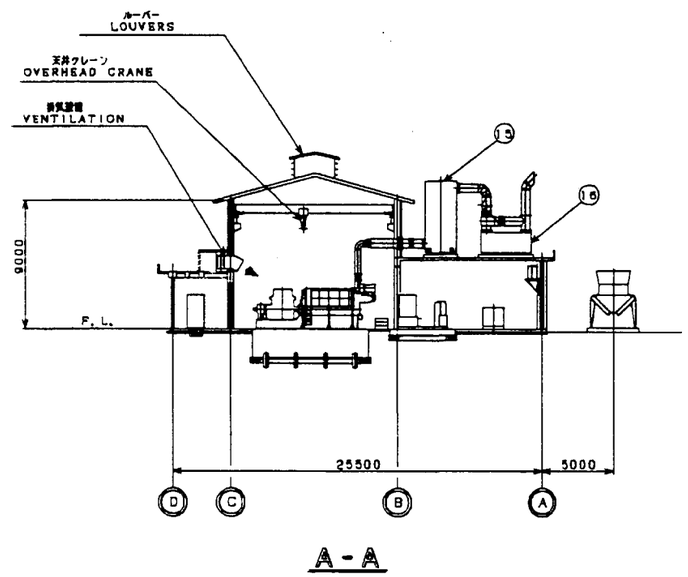


Fig 2.2-47 Gas Engine Generator Facilities Layont

2.5 Scopes to be provided by both parties such as finance, facilities and equipment, services, etc. in executing the project.

2.5.1 Finance

As described in Paragraph 2.3 (4) concerning the capability of finance load, it is considered difficult to provide funds for project implementation by Kuzbassugol itself. Further discussions with the company in future would be necessary for the project, but in any way to plan to extend required funds in definite measures of financing, etc. from the candidates for fund source as listed in the section 3.2.

2.5.2 Facility equipment and services, etc.

(1) Project of gas recovery and control

1) Basic notion

The engineers of the coal mine in question know best about the behavior of gas releasing along with mining at coal mine in Russia. On the other hand, Japanese engineers are thoroughly acquainted with effective operating method of the introduced facilities and with practicing behavior at site, which was cultivated at coal mine in Japan. On this account, at the stage of project implementation Japanese side will propose the basic design and operational contents, but technological studies concerning practical operation at execution site and detailed design have to be gone through by both parties. Manufacturing design of the supplied facilities and technological guidance will be performed by Japanese side, but the equipment and materials, which are in general easily procured by Russian side and a part of electrical equipment which are placed under restriction by the underground safety regulations will have to be procured in Russia. All facilities to be introduced will have to be operated by Russian engineers on their own responsibilities.

2) Equipment and services, etc. procured in Russia

- Electric motor equipment (for boring machine and pumps, etc.) used in underground
- A part of electrical equipment cables and of electrical machinery and equipment, etc. used in underground site
- Casing pipes and gas pipeline, etc. in boring
- Local transportation and installation works of facility equipment
- Any and all management, operation and maintenance of equipment after the acceptance of their deliveries

3) Equipment and services, etc. procured by the Japanese side

- The design and manufacture of other main facility and procurement of parts than equipment and materials and apparatus as listed in (2) above are to be carried out in Japan.
- The installation and commissioning of the facility at site are to be carried out by Russian side. But the technical supervisory services (which include providing related manuals) related to the above are to be provided for by the Japanese side, along with the services of operation, maintenance and practical training for coal mine.

(2) Gas utilization project

1) Basic idea

For the gas utilization project, the actual facility construction is planned with these objects in view: to utilize Russian technologies and personnel capabilities as much as possible.

The most practically usable resources are the Russian manpower. The work allotment of construction at site, etc. by the Russian side is planned. And the heavy machinery for construction, etc. is provided for with Russian equipment. Among the construction works at site the followings are planned to procure in Russia, provided that the design, technical supervisory service and construction management are carried out by the Japanese side.

2) Scope of works by the Russian side

- Full construction work of pipeline (including piping materials and coating)
- Full construction work of buildings of engine and power generation facility (except the procurement of materials which are difficult to procure from Japan)
- Foundation work
- Erection and installation works

3) Scope of works by the Japanese side

The other major facilities (such as mainly gas engine/power generation facility, vacuum pump/compressor, etc.) are procured by the Japanese side and the installation work at site is carried out by the Russian manpower, provided that technical supervision and management are by the Japanese side. Furthermore, the technical direction is given for the operation and maintenance of coal mine.

2.6 Prior conditions, points at issue, etc. in executing the project

Under the current social and economic conditions of Russia, there are many points at issue in order to materialize the project on a commercial base.

- Whether the Project is included in the frame of the future plan of joint implementation between Japan and Russia: Concerning this point, Fuel Energy Department, State Government of and Belovougol are all supporting.
- Tax exemption: 'Japan Center' was, for example, set up at Moscow, Vladivostok, etc. with gratuitous fund of Ministry of Foreign Affairs of Japan. But the authorities concerned have demanded tax collections against the invoiced amount in spite of the gratuitous aid. The subject of taxes is therefore anticipated to encounter even if the Project is included in the Joint Implementation Projects.

2.7 Technical implementation program

A. Gas Recovery and Control Project

2.7.1 gas recovery and control system introducing program

Here, we make up technical implementation program on the assumption of introducing the gas recovery and control system we are proposing this time to #544 face. Therefore, we calculated boring length or cable length for central monitoring etc. based on #544 face. Moreover, we have made up the work schedule and monitoring schedule for preparing boring, gas draining and sealing work, based on the mining schedule of #544 face shown in overall mining schedule proposed by Chertinskaya coalmine.

1) Implementation program for the scale of #544 face (Fig.2.2-48)

a. Mining period is about 2 years (24 months).
b. We start to prepare boring machine (manufacturing, transporting) about 6 ~ 7 months prior to the start of drilling work.
c. We start drilling work 2 months prior to mining start. It takes 9 months.
d. Gas drainage period is from drilling finish till draining finish after mining finish.
e. We do sealing work for 1 month before working the face and for 1 month after finish mining and removal of equipment.
f. Drainage period of sealed gas is from the start of draining till the end of this project, according to the condition of the sealed gas.
g. We prepare monitoring equipment (manufacturing, transportation) 6 month prior to the start of gas drainage.
h. Monitoring work period is from the start of gas drainage till the end of this project.

2) Implementation step

a. Assistance to assemble the equipment, technical training and dispatch of expert

b. To decrease number of boring stations, and change the boring hole length from present 50 ~ 60m to the mid-distance of 300m.

c. To establish caulking method for boring mouth (Air inflow prevention = to maintain gas concentration)

d. Install auto drain device at the boring station (Keep the water drain away from gas drainage pipe)

e. To establish monitoring system like auto concentration gauge, etc.

f. To establish wet type filling sealing technique, and to install auto differential pressure gauge

g. To introduce mid-distance boring machine to other faces, and to introduce directional boring technology

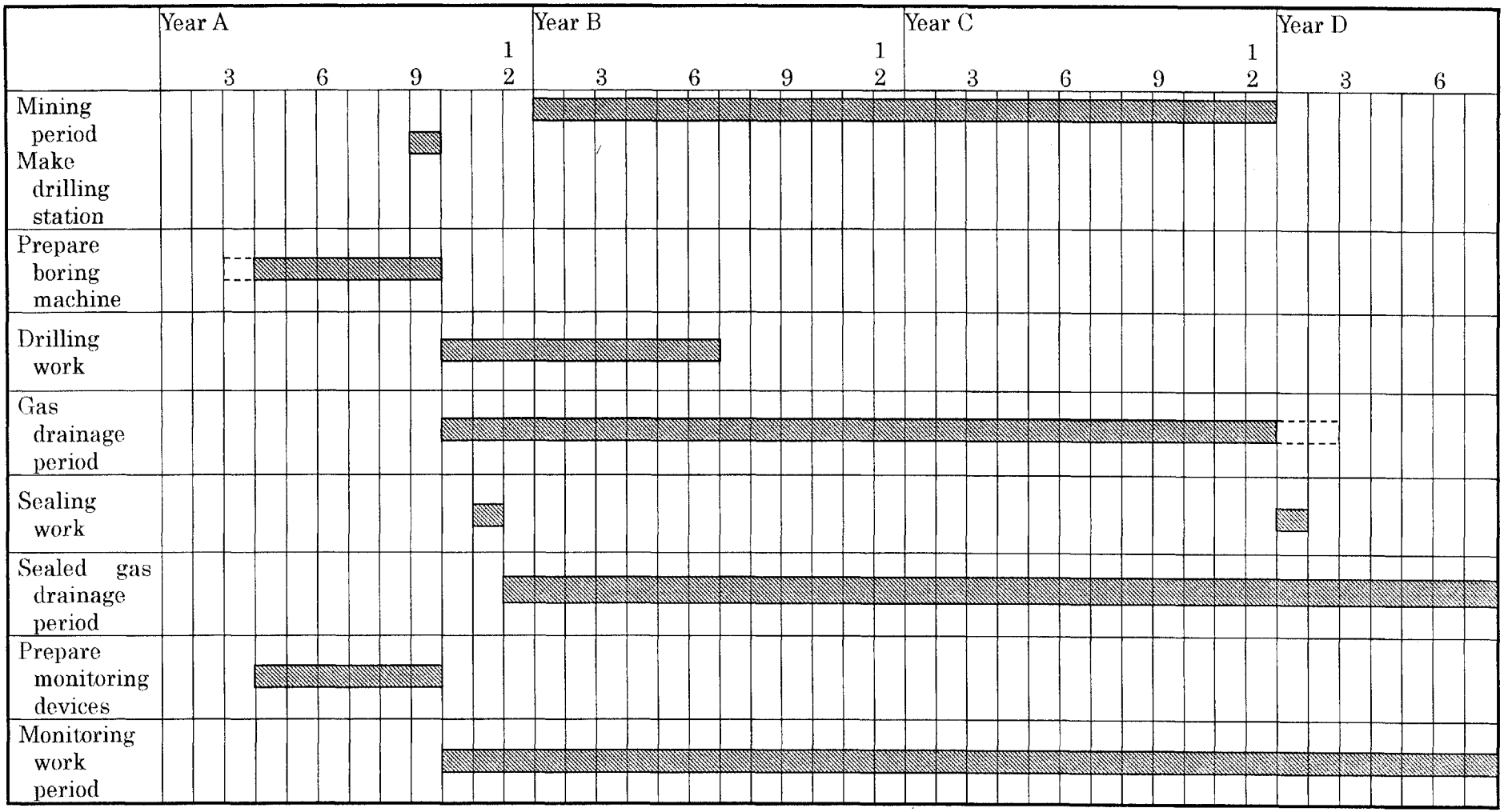


Fig.2.2-48 Process of technical implementation

2.7.2 Technical transfer plan

We need to provide special training and dispatch technical adviser, etc. for them to practically understand and familiarize themselves with the introduced system, and to operate it under the most suitable condition. In paragraph 1-6-1, we have presented a program based on #544 face as the model. But in order to improve gas recovery ratio in the whole Chertinskaya coalmine, they need to gradually introduce the boring machine in other faces, and in future, they need to learn and introduce directional boring technology.

Expert dispatch plan

Item	Technology transferred	1st year	2nd year	3rd year	4th year	5th year
Detailed study, Design		- - - - - -				
Introduce system for #544 face	Mid-distance boring technology		.....	———		
	Sealing equipment technology		.....	———		
	Suction equipment technology		.....	———		
	Monitoring equipment technology		.....	———		
Introduce to other faces	Mid-distance boring			.....	———	
	Directional boring			.....	———	
Equipment optimization Evaluation Modification					- - - - - -	
Gas recovery Evaluation Modification		- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -

Assembly assistance .....

Technical advisor ———

B. Gas Utilization Project

(1) Introduction and construction program of gas utilization equipment

By giving considerations to the following four points, the schedule of facility construction was examined.

a. The temperature in winter season goes approximately down to –50°C.

b. It is 6,000km far from Japan in straight line.

c. A detailed estimation of methane generation is necessary using the most recent data.

d. A detailed adjustment which includes protection coordination related to in-house electricity is necessary.

In order to execute the said points detailed prior study is to be implemented to set the preconditions for design and thereafter the design and manufacturing works are to be progressed. The equipment procured in Japan is transported via the Siberian Railway from Nakhodka spending about one month. In addition, the field construction during the season from the middle of October to March is impossible considering the temperature in winter season.

Taking the above conditions into consideration, the time schedule of work was made as shown in the following table.

Construction Time Schedule of Coal Mine Gas Utilization Facility at Chertinskaya Coal Mine:

Split of Works;	1st year	2nd year	3rd year	4th year
Detailed survey				
Design				
Arrangement/ Manufacture of materials				
Building/ Foundation work				
Pipeline construction				
Transportation/ Installation at site				
Commissioning				
Commercial operation				

3. Materialization of Finance Plan

3.1 Fund plan in executing the project

In Russian economy, emergency measures such as ruble devaluation on August 17th three years ago, freeze of private debt repayment for 90 days, conversion of short term national bonds to be redeemed by 1999 to 3, 4 and 5 years' ones, etc. were taken. This on the contrary increased a gloom on the market and caused continued fall of rouble, pullout of foreign currencies, suspension of settlement of accounts among companies due to a bank crisis, uneasiness at repayment of deposits, etc. The future of Russian economy looked gloomy.

More than one year later, Russia showed a remarkable recovery in its economy. In last June, Gross Domestic Production (GDP) increased by 3.2% compared with that of the same month of the previous year and 9.0% increase as for the production of the mining and manufacturing industries. The increasing rate of inflation remains 1.9% as compared with last year.

Then why was Russian economy recovered? It is basically by correction of overestimation of ruble. Russia maintained the rate of foreign exchange as 4.5 to 6 rubles per 1 USD from July of 1995 to the beginning of 1998 under the guidance of International Monetary Fund (IMF). But it failed in 1998 because the rate was supported by unreasonable policy to make up for the deficit national finance. The exchange rate of ruble has recently fallen down to some 27 rubles which are less than one fourth compared with that in the first half of 1997. As the result the rate has become rather stable.

Ruble went down first and because the consumer commodity price went up, the real wages then fell and that led to the decline of consumer's purchasing power. In January to June of 1999 the real disposable income decreased by 26% and the import decreased heavily. The amount of import in the first quarter of 1999 dropped to one half in US dollar. Though the export went up due to the increase in oil price, the decrease in import contributed much to the improvement in Russia's balance of payment.

But the decline of ruble had much more effect on the increase in production of import substitutes because the price of domestic product became economical comparatively to that of import. In January to June of 1999 food production increased by 7% compared with the same term of the last year. Plastics 32%

increase, tractor 29% and chemical fertilizer 22%. This tells that in Russia also there exists an economic principle where production will increase if the price competitiveness goes up.

The reorganization of banks has progressed and uncertainty of money market has been brought to a settlement. Nonpayment of wages has been decreasing.

The prospect of 'no more growing crisis' is based on the outlook that sooner or later a financial assistance by the Western countries and the international financial institutions will be reopened. There might be some anticipation by Russian side practicing upon the West's weakness that as far as nuclear disarmament of Russia is not carried into effect, and Russia is regarded as a major military power in the world, the West cannot assume a wait-and-see attitude toward intensified worsening of Russian economy. Until the assistance by the West will be reopened, both public and private foreign liabilities are actually in a condition of default. But because the default announcement means a cessation of diplomatic relations with Russia, no country can step into such level. The present situation is therefore that the West dares to keep the current inescapable condition and IMF settles hard bargaining with Russia by coaxing her to reschedule intentionally their past credit for deferred repayment in case financing is reopened. Generally speaking, it is anticipated; "Reopening of finance by the West would have to be waited till the election of the President and the situation would anyhow be very severe because investment in industries is impossible within the current Russian economic mechanism even if financing is reopened."

The detailed track record of assistance toward Russia by each institution in the West before the currency crisis of Russia is described in Appendix hereof. In order to materialize this Project, utilization of funds to be raised from the following institutions with enough results is studied;

1) Japan Bank for International Cooperation
2) Export Import Insurance Department, Ministry of International Trade and Industry
3) International Monetary Fund
4) International Bank for Reconstruction and Development
5) European Bank for Reconstruction and Development

3.1.1 Total funds required

A Gas Recovery and Control Project

(1) Budget plan to implement gas recovery and control equipment

We plan the budget based on intention of purchasing local Russian made products, such as motors for in-mine use with explosion proof and special specification, steel pipes and some of the cables that we can buy locally, because it has technical and economical advantage.

Introducing equipment		Budget (Yen) *1		
Equipment specification	Q'ty	Japan made (+ Australia)	Russian made	Total
Mid-distance boring equipment RK-3A	2 set	122,070,000	48,218,000	170,288,000
Mid-distance directional boring equipment TOP-TM	1 set	142,610,000	24,732,000	167,342,000
Suction equipment	3 set	6,474,000	-	6,474,000
Sealing equipment	2 set	22,851,400	1,052,000	23,903,400
Central monitoring system	2 set	169,766,350	8,880,000	178,646,350
Expert dispatch (technical service) *2	1 set	51,014,890	-	51,014,890
Total		514,786,640	82,882,000	597,668,640

* 1 : Price of Japan made products includes domestic tax, transportation cost to the site and estimated insurance fee.

* 2: As rough estimate, we applied 11% of price of Japan made equipment.

(2) List of estimated price of introducing equipment

The price of Japan and Australia made products includes taxes, transportation cost to the site and estimated insurance fee.

Equipment name	Equipment specification	Price (yen)	Remark
Mid-distance boring machine 85,144,000	Mid-distance boring equipment RK-3A (Made in Japan) Boring machine (RK-3A), Pump & parts • Accessory 1 set Rod (300m + spare parts) strata bit, reaming bit, stabilizer, accident recovery tools, attachment tool, etc. (Made in Russia*) Motor & switch, etc. (For 11kW boring machine, 11kW pump) 660V Casing pipe (4,750m/min)	(61,035,000) (24,109,000)	* Includes cost of modification and installation
Mid-distance directional boring machine 167,342,000	Mid-distance directional boring equipment TOP-TM (Made in Japan)- Boring equipment Boring machine and pump (three-throw type) and parts • accessory Rod (TR105,130) Bit (TR80,105,130 for outer & inner) (Made in Australia) - Directional equipment AMT meter Downhole motor MECCA Rod (TR80) Bit Collector, stabilizer, etc. (Made in Russia *) Motor, switch, etc. (For 22kW boring machine, 55 kW pump Casing pipe (4,750m/min)	(75,140,000) (67,470,000) (24,732,000)	* Includes cost of modification and installation

Equipment name	Equipment specification	Price (yen)	Remark
Central monitoring equipment 89,323,175	(Made in Japan) Transmitter, receiver, data processor, CP peripherals (includes Bus system), Display • recording equipment, Measuring equipment, various sensors, etc. (Made in Russia *) Transformer (660V-220V) Power cable (2,000m) Communication cable (6,000m)	(84,883,175) (4,440,000)	1 set for 1 face in-mine, and blower room, monitoring room on the ground
Suction equipment 2,158,000	(Made in Japan) Water draining installation, suction hose, suction pipe in the boring station, valve, joint, measuring pipe, etc.	(2,158,000)	For 1 face
Sealing equipment 11,951,700	(Made in Japan) Pump & parts • accessory Mixer & parts • accessory Suction control - differential pressure gauge (Made in Russia *) Motor (for pump, mixer) Switch, etc. (for pump, mixer) Pipes, lumber, steel material valves, drying cloth, etc.	(11,425,700) (526,000)	

B. Gas Utilization Project

The gas utilization project consists of the following equipment:

1) Vacuum/gas compressor pump of $30m^3$/minute (–450kPa. 0.6MPa): 3 units (portable equipment)
2) Dehumidifier of $30m^3$/minute; 3 units (portable equipment)
3) Pipeline 200A; 6km of stretched extension
4) Gas engine power generator (pilot control) of 1,710kW/unit; 3 units (installed within building)

Out of the above, a part of the costs for local labor and pipeline and building facilities was calculated by the funds raised locally.
Further, the required capital includes allowance for construction at site, construction cost, interest during construction, expenses before commercial operation, commissioning, etc.

The total required capital cost is 1,800 million Japanese Yen of which breakdown is shown in the following table:

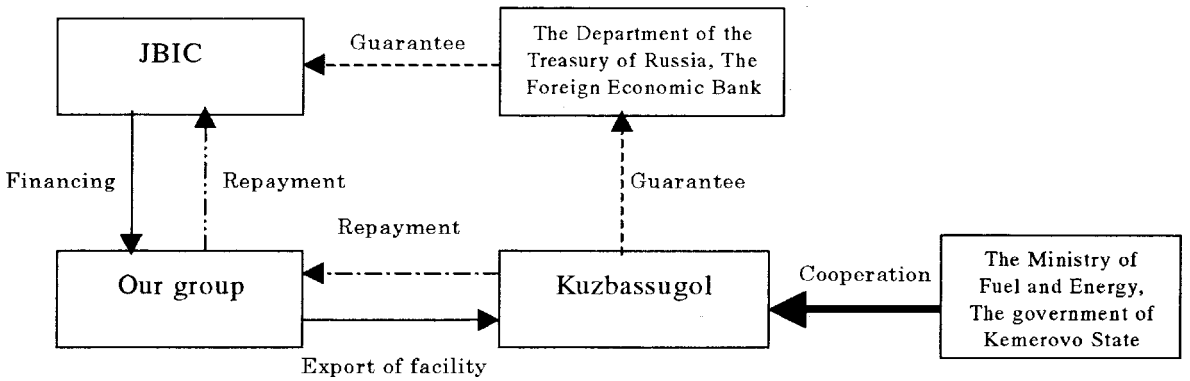
Equipment;	Budget of equipment (100 million Japanese Yen);	Notes;
Allowance for construction	0.9	5% of the total construction cost
Power generation equipment	12.5	Building included
Pipeline	1.1	
Vacuum/gas compressor pump	3.1	
Dehumidifier	0.4	
Total	18.0	

This figure is the amount which includes equipment design, procurement, transportation, installation at site and commissioning costs, provided that it does not include those for power transportation and distribution equipment outside of the building of power generation and steam supply equipment.

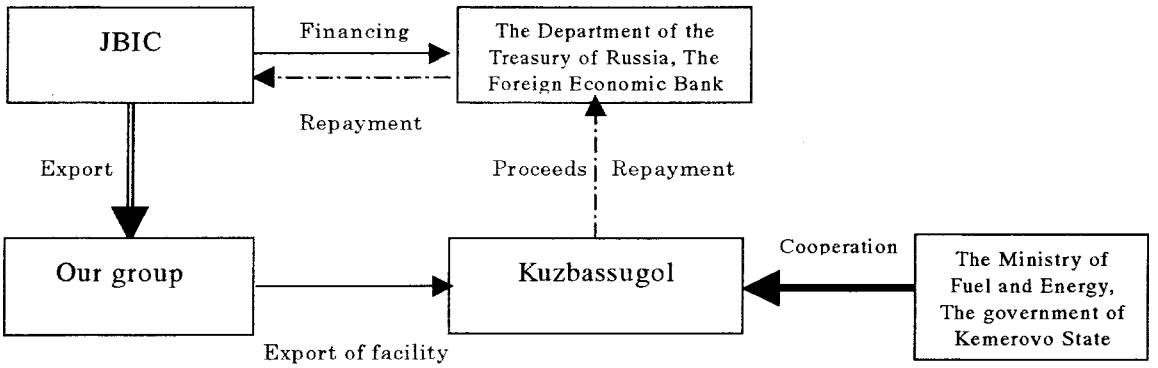
3.1.2 Fund raising, etc.

The following methods of raising funds are to be studied.

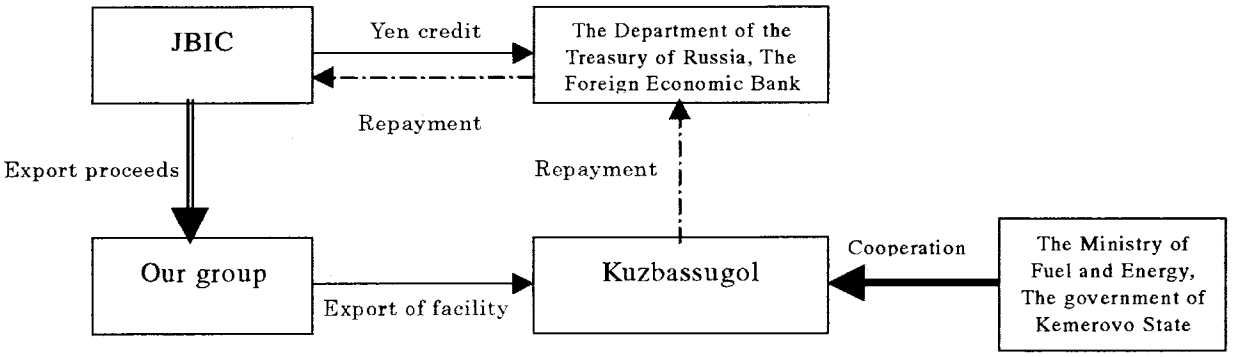
Utilization of trade insurance by The Ministry of International Trade and Industry (MITI):



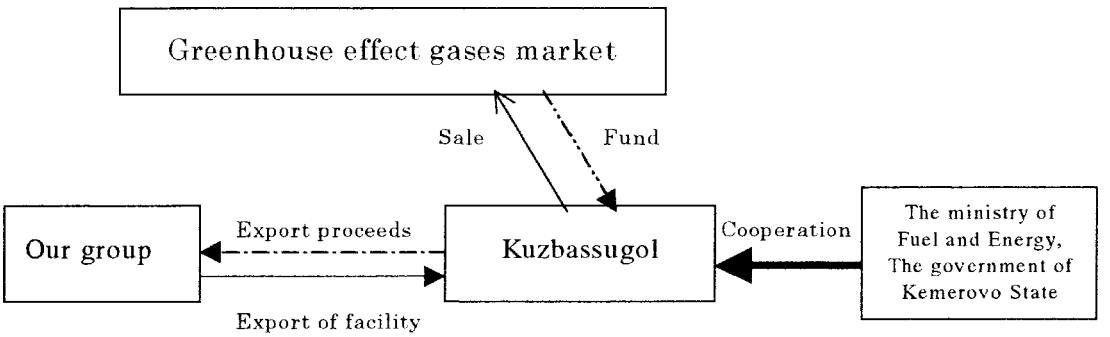
Utilization of trade insurance by Japan Bank for International Cooperation (JBIC):



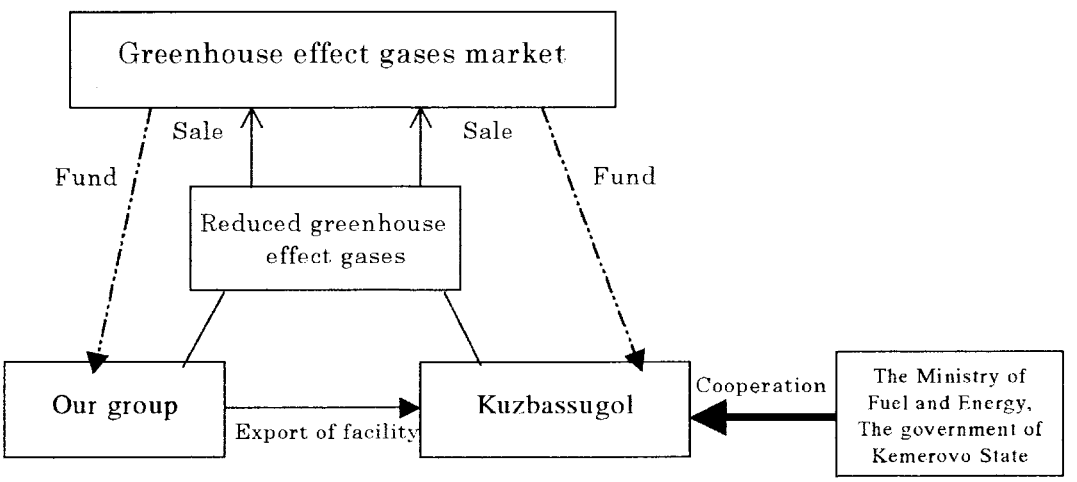
Expectation of yen credit by Japan Bank for International Cooperation:



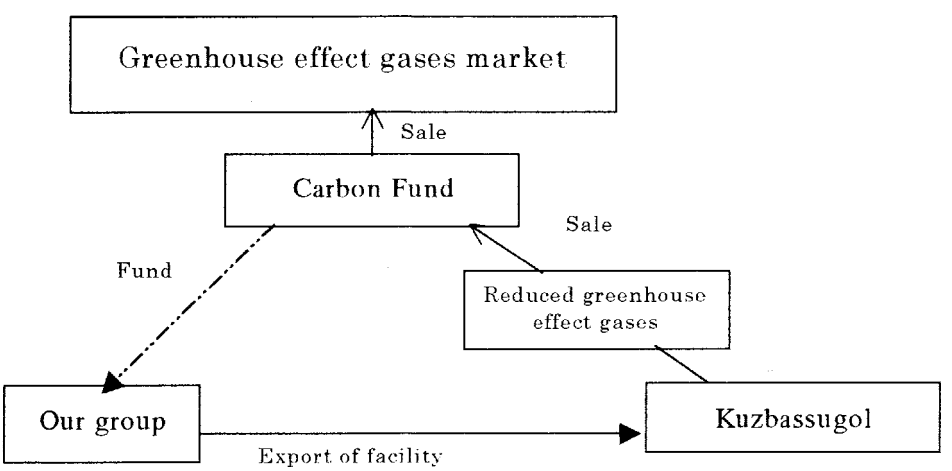
Application of the emission trade of greenhouse effect gases:



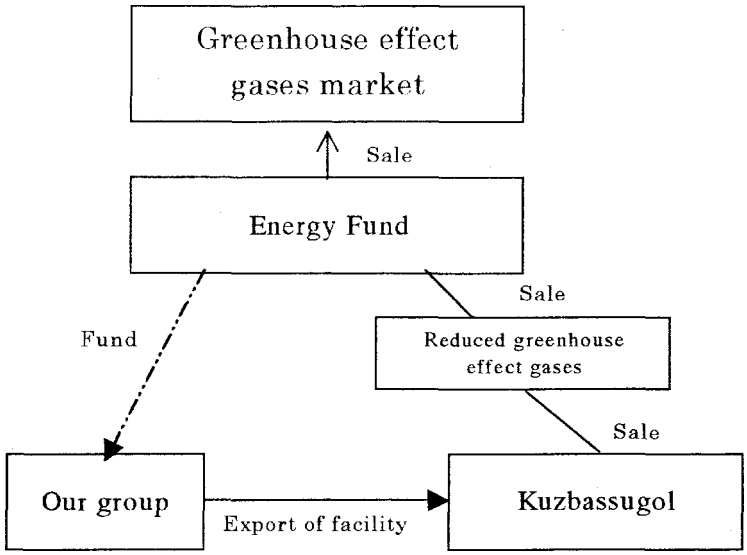
Sharing of the emission of greenhouse effect gases (The joint implementation):



Application of the Carbon Fund by International Bank for Reconstruction and Development (IBRD):



Application of the Energy Fund by European Bank for Reconstruction and Development (EBRD):



Kuzbassugol will take in cooperations by Kemerovo State and the Ministry of Fuel and Energy and have talks with the Department of the Treasury of Russia and Foreign Economic Bank about sublet financing conditions.

3.2. Prospects for fund raising

Owing to the result of the election of the Lower House in December, 1999, and unexpected resignation of President Yeltsin, nomination of the Acting President Putin and moved-up election of the President, Russia has come to be opaque in her future. But it is anticipated that possibility of large deviation from the existing economic policy aiming at free market economy and of outbreak of political disorder will be small.

The biggest urgent problem considered necessary to be improved is the external payment of foreign debts. The outstanding balance of external liabilities for Russia is about 160,000 million USD (out of which about 103,000 million USD is the debt of former USSR). 1,000 to 2,000 million USD is said to be a limit for disposition from 12,000 million USD of her official reserve. Though reopening of finance by IMF is therefore the key for debt repayment, they say that USA at the back of IMF expresses disapproval of reopening of finance by the reason of prolonged Chechen strife. In case the second finance (in the amount of 640 million

USD) out of 4,300 million USD by IMF is extended quietly, positive movement by Paris Club is expected and support by official fund money (international financing institutions, bilateral basis, etc.) is reopened, the present crisis would be overcome. International isolation of Russia would not be the best plan judging from the viewpoint of Iraqi issue and supervision over nuclear arms. Financing would therefore be executed expectedly by IMF with very rigid conditions. But if an announcement of default concerning Russia's foreign debts repayment is made from the side of creditors (governments, banks, etc. of the West), the result would be the worst one.

Even if IMF's fund is actually supplied, the current situation of Russia amidst her economic emergency will nevertheless be unchanged. It would be nothing but prolongation of problems of Russia, if negotiations with IMF will reach an agreement this time, without settling her such structural issues as a huge sum of unbalanced finance, domestic capital behind a black-market economy, capital flight, etc. Recurrence of crisis is inevitable in case of no change of her economic constitution depending on foreign capital.

Under these circumstances, the followings are kept in our view for raising funds to materialize the Project, and aiming at its attainment by combining these items a study is required.
(The study for a definite raising method will be made in the future based on the methods described in section 3.1.2.)

- Utilization of trade insurance by MITI
- Utilization of export finance by Japan Bank for International Cooperation
- Expectation of yen credit by Japan Bank for International Cooperation
- Application of trade for reduction volume of greenhouse effect gases
- Sharing of reduction volume of greenhouse effect gases (Joint Implementation)
- Utilization of carbon fund by IBRD
- Utilization of energy fund by EBRD

4. Items Related to Joint Implementation Conditions

4.1. Adjustment items with the coordinating country to materialize joint implementation such as setting execution conditions of project and split of works, etc. taking into account of actual situations of project implementation site.

4.1.1 Adjustment matters with the coordinating country

In order to secure an identification of the joint implementation project by the government of Russian Federation, the following adjustments and confirmations for this project must be made in due succession:

(1) Kuzbassugol

This company owns Pervomainskaya Coal Mine with abundant gas reserves as well as Chertinskaya. The countermeasure for gas is therefore the urgent issue. The company, based on these circumstances already stated that it will do its best, if the gas issue would be possible to solve by the joint implementation project.

(2) The government of Kemerovo State

It has tackled with its policy of thorough execution of countermeasures for gas at Abashevskaya Coal Mine owned by Kuznetskugol in addition to the Coal Mines of Chertinskaya and Pervomainskaya. At the same time and in the same way, it considers the joint implementation as a measure for executing the scrap-and-build projects of the coal industry and as one of measures for solving the gas issue. It will work positively upon the government of Russian Federation, the Ministry of Fuel and Energy, etc.

(3) The Ministry of Fuel and Energy of the government of Russian Federation

The Director of the Department of Environment has mentioned that the Ministry of Fuel and Energy should be in charge of the joint implementation for Russian Government, because 80% of the emission of all the greenhouse effect gases in Russia is derived from the companies controlled under the jurisdiction of the

Ministry of Fuel and Energy. The Coal Committee explained him that the coal industry will secure 10 to 17% framework and is interested in materialization of the joint execution through the Ecocoalfund(Please refer to section 4.2.4 hereof).

As described above, the Russian side is in general positive about positioning this project at the joint implementation projects. It is necessary for the future to conclude the scope of supply and the investment amount of this project through the basic design and to obtain the approval of the Ministry of Fuel and Energy.

4.1.2 Split of works

The split of works between the Japanese and Russian sides to implement this project is considered as follows:

(1) The Russian side

a. The decision on the coal mine as subject and the establishment of project organization at site
b. The conclusion about uncertain factors by study at site for the survey concerned (a coal production plan for the basis of gas emission estimation, etc.)
c. More detailed study concerning local situations for acquiring detailed design data
d. Adjustment with companies for local cooperation and conclusion of construction cost at site
e. Construction at site

(2) The Japanese side

a. Determination of project organization of the Japanese side

b. Determination of detailed design, project schedule and capital investment cost, etc. based on the data at site
c. Procurement of facilities and transportation to the site
d. Supervision of construction at site

4.1.3 Technical adjustments

Adjustments to be made with the Russian side

(1) Concerning gas recovery technology:

- Adjustments with the actual situations on coal mine, mining plan of the coal mine side and venting plan are necessary.
- Practically technical and detailed adjustments such as site selection, test method, implementation method, introduction time into mine, etc. are necessary.

(2) Concerning gas utilization facility:

The following adjustments in designing facilities are necessary;

- Adjustments on how to think the protective circuit system of power transmission and distribution from power generation facility
- Adjustments on piping tie-in and others of steam supply, etc.
- Adjustments on tie-on of methane recovery piping
- Adjustment on pipeline route

4.2 Possibility of agreement on project concerned for joint implementation.

As mentioned above, possibility of agreement on this case for joint implementation, etc. is very high by the following reasons because high effect of greenhouse effect gases reduction is possible with comparatively small investment cost as one of the reasons;

- The executing company Belovougol has to settle the issue of coal mine methane recovery in order to continue production of coal at Chertinskaya coal mine. In other words, this case has to be realized by all means sooner or later.
- Kuzbassugol, parent company of Belovougol owns other Pervomaiskaya coal mine having abundant eruption of methane than Chertinskaya. The company intends to bring results of joint implementation, etc. at first at Chertinskaya and then introduce the same concept at Pervomaiskaya.

- The government of Kemerovo plans to introduce the same concept at Abashevsk coal mine of Kuznetskugol also and to solve the issue of methane emission of Kuznetsk one by one. The Government has furthermore the intention to participate in transactions of greenhouse effect gases emission.
- The Department of Fuel Energy has its responsibility for realization of the case as the competent government section of Russia in charge of promotion of joint execution projects. Because promotion of restructuring in coal industry is one of finance conditions imposed to Russia by IMF, the Department of Fuel Energy cannot neglect coal-related cases (right or wrong).
- The financial conditions for Russia is now in a big difficulty. If under such conditions trade of right of greenhouse effect gases emission turns out a measure for the acquisition of foreign currency, it is expected quite naturally that she will make her best efforts to realize joint execution, etc.

4.2.1 Policy/principle for development of coal mine gas

Ministry of Fuel and Energy and the state of Kemerovo jointly made [Program for recovery and utilization of methane at coal mines]. At Ministry of Fuel and Energy the minister put signature on [Comprehensive Solution of the Extraction and Utilization of Methane at Coal Mines of Russia]. Both the central government of Russia and local governments commend recovery and positive utilization of coal mine gas, in such manner as the proclamation dated March 30, 1998 of the state of Kemerovo of [Industrial Extraction of Methane from High Gas Containing Coalbeds at Operating and Closing Coal Enterprises of Kemerovo Region]. Particularly the governments designates the coal mines of Chertinskaya, Pervomainskaya, and Abashevsk as "Coal Mines in need of measures for methane at coal mines", and promotes collection and utilization of methane at coal mines.

Kuznetsk coalfield is promoting a restructuring program of coal mine as collateral condition of the finance by IMF/World Bank to the coal industry of Russia. Improvement of safety and productivity is impossible without modernization of recovery system of coal mine gas as a part of the program, and powerful coal mines are studying modernization of recovery system of coal mine gas.

4.2.2 Actualities of development of coal mine gas

Following the above-mentioned program drawn up by Ministry of Fuel and Energy [Comprehensive Solution of the Extraction and Utilization of Methane at Coal Mines of Russia], Belovougol Company which is the object of the said project needs a budget of 112 million rubles including own fund of 23.8 million rubles. The program of the same company for utilization of coal mine gas stipulates as a subject such matter as collection of coal mine gas for securing safety at coal mine labor, and its industrial utilization.

Actualities of program implementation are as follows.

(The first stage)

October 1998 The power generating plant of Caterpillar Company (1,000 kW) was put into operation. To that end, the gas pipeline with a diameter of 420mm of 3,200m length was laid, and one unit of gas extraction equipment was installed.

October 1999 Generator of the power plant went wrong. Whether to finance for the repair, or install a new generator is under consultation with Caterpillar Company, Skochinsky Research Institute, and Ministry of Fuel and Energy.

Installation of computer for measuring deposit of methane gas at existing coal mines, and others.

(The second stage)

As the depth of mining at coal mine increases, gas extraction from coal seam becomes indispensable, which needs installation of boring machine of the West possible to drill coal seam with depth up to 1,500m, pipeline for transportation of methane, measuring device for gas component, and vacuum pump station. (It is implemented at a part of coalfields.)

(The third stage)

Research of method/technology for recovery of gas from coal seam with high pressure. Gas extraction for the purpose of securing safety at coal mine labor before start of full-scale coal production is to be implemented. Moreover, recovery of methane at undeveloped coalfields is under study.

The methane at these undeveloped coalfields are called Coalbed Methane (CBM), which means the gas which is mainly composed of methane generating as a result of coalification/maturity of coal. and is preserved inside coal in coal seam. For economical recovery of CBM, it is the point to raise the permeability of coal seam, as well as the rate of recovery from well. However, though geological survey on quantity of CBM resources is not much implemented except USA, and valuation data rather fluctuates, the quantity of the resources in coal resources possessing countries such as China, USA, the former Soviet Union, Canada, and Australia is estimated to be at least approximately 84 trillion cubic meters.

Since in Russia the heavy and chemical industries have developed in the Kuznetsk coalfield as the center, there is such merit as nearness of production sites to consuming places. Furthermore, CBM as clean resources is much expected also from the aspect of environmental conservation.
Gazprom Company, the biggest gas producing company in Europe, pays attention to CBM resources of Kuznetsk coalfield, and studies possibility of commercial production by introducing American technology.

4.2.3 Laws and regulations related to development/utilization of coal mine gas. stipulation of coal mine

In [Comprehensive Solution of the Extraction and Utilization of Methane at Coal Mines of Russia] of Ministry of Fuel and Energy, is described [Acquisition of technology and introduction of plant by Belovougol Company aiming at industrial utilization of coal mine gas], and introduction of the following equipment is stipulated.

- Fixed type vacuum pump station
- Trunk pipeline from fixed type vacuum pump station to mobile pump station
- Power generating equipment of 200- 1,000kWh
- Gas supply equipment for car
- Development of new and efficient technology for recovery/utilization of coal mine gas aiming at securing safety of labor, and utilization as fuel for cogeneration, as well as utilization as alternative for fuel gasoline for car

Moreover, Law of Russian Federation No.81-FZ (dated June 20,1996) established "Concerning state regulation in the field of production and utilization of coal, as well as specialty of social protection of laborers in the coal industry", and there are laws and regulations on the following contents.

- State regulation in the field of production and utilization of coal
- Specialty of social protection of those engaged in coal producing work
- Social protection of those engaged in heavy labor and dangerous work in coal producing work

4.2.4 Policy/principle for joint implementation

As mentioned above, interest of the government of Russia in joint implementation is quite high. The government of Russia has completed ratification of UN FCCC, and concrete work toward realization of candidate projects for the joint implementation has been started. For example, they are the Ecocoalfund, etc. as described below.

ECOCOALFUND

1) The government of Russian Federation acknowledged the Coal Committee as the qualifying agencies to qualify projects related to the coal industry. For an organization established to aim at the emission trade, the Ecocoalfund is applicable in the coal industry.

2) The Ecocoalfund is a system to promote the emission trade related to the coal industry now under study by the national projects. Its major activities are according to the program concerned;

① To plan and design a project as a fund including technological aspects.
② To raise the investors.
③ To execute the project with the fund modernizing Russian coal mines, etc.

3) The most important of the projects related to the reduction of greenhouse effect gases is the coal mine methane project. In the case of a project for recovering and utilizing coal mine methane, ① improvements of safety at coal mines and of production efficiency and ② development of new energy resources are planned using the fund to be obtained by the emission trade.

4) The mechanism of allotment and determination of the emission in the Russian coal industry is as follows;

① A bilateral government-to-government agreement is made.
② A council by representatives of each Ministry is held to determine allotment for each industry.

③ 10 to 17% of the total framework is anticipated for allotment to the coal industry.
④ After the determination of the emission framework, the Ecocoalfund applies the project to the Coal Committee complying a definite formality.

⑤ The Coal Committee approves to start the project. Each enterprise implements each specific project.
⑥ The Ecocoalfund raises funds using its credits for fund and makes allotment to each executing enterprise of projects.

⑦ The acknowledgements of monitoring and the reduction amount of the emission are made by the state institutions. The implementing institutions are now under discussion from the technological and legal points of view. Installation as a department within the Coal Committee has been studied for a concrete idea.
⑧ Concerning fines and penalties, taxes, etc., which institution to conduct is under discussion.

III PROJECT EFFECT

The essentials:

This project aims at generating power by using methane gas released from coal mine as fuel for gas engine and preparing a part of necessary internal power consumption and therefrom big energy substitution effect is expected.

As methane gas that is all discarded at present in the air and has greenhouse effect coefficient (GWP) of 21 is changed to equivalent mole of carbon dioxide by using fuel, reduction effect of greenhouse effect gas is big. As the calculation result, the substitution energy effect becomes annually about 9,000toe and reduction amount of the green house effect gas becomes annually about 200,000 ton (equivalent to carbon dioxide).

1. Energy Substitution Effect

1.1 Technical ground for energy substitution effect

At Cheritinskaya the methane gas from the coal mine is all discarded at present in the air.
Purpose of this project is to substitute electric power from the existing thermal power plant with power generated by using recovered methane gas that is discarded at present, as fuel.
As the result, oil or coal to be consumed at the existing thermal power plant is substituted and this is technical ground for energy substitution.

1.2 Base line for the calculation of energy substitution effect

To calculate energy substitution effect, at first, the amount of power generated by the gas engine using coal mine gas has been calculated and also the amount of the pilot oil consumed for the power generation has been calculated.

Necessary energy (converted to petroleum) to generate the same amount of energy by the gas engine has been calculated. The energy substitution effect is the amount that subtracted the amount of pilot oil from the energy consumed by the thermal power plant to generate energy corresponding to the total power generated from the coal mine methane. Namely;

Energy substitution effect	=	Energy consumption on the assumption that total power generated by using coal mine methane is generated by the existing thermal power plant	−	The pilot oil consumption by the gas engine power generator

1.3 Substitution energy effect, generation period and accumulated amount (Total power generation using coalmine methane gas)

(1) Total power generation at the power generating end of the gas engine

As the amount of methane recovery at Cheritinskaya coal mine is stated in Chapter II.2, the annual usable amount in the year 2003 is predicted to be 14.15Mm^3/year. This amount fluctuates in some extent with the seasons as mentioned in the Chapter. The gas engine power generating facility is designed to compensate this fluctuation with the seasons by having the excess capacity of about 15% on its average gas recovery amount. Therefore, in a month when the gas generation amount is small, one among three engines is able to stop for its maintenance. For that reason, discharge of coal mine methane gas caused by the maintenance is not considered in this study.

Total power generation by the gas engines is:
Total power generation = Total methane gas amount used (Pure methane equivalent Nm^3/year) ÷ 0.367Nm^3/h · kW*
*: Gas engine methane consumption as stated in section 2.4.9.(Chapter II)
Total power generation = 14,150,000 ÷0.367 = 38,555MWh

(2) Total power generation at the sending end of the gas engine

As mentioned in section 2.4.9, the gas engine power generator has various auxiliary facilities to generate electric power. The main facility among them is fuel gas compressor for pressurizing fuel gas, first/second cooling water pumps or the like, and the total necessary energy becomes 170kW/one.
The average capacity factor of the gas engine is 85.5% and so internal utility power for auxiliary facilities is as follows:

The total internal utility electricity =170(kW) x 3 x 24 (hours) x 365(days) x 0.858 (capacity factor)
=3,833MWh/year

Therefore, the total power at the sending end
= 38,555-3,833
= 34,721MWh/year

(3) Pilot oil consumption at gas engine power generation

Necessary amount of the pilot oil is 1% of the energy corresponding to the fuel gas. Total energy of the fuel is calculated from total fuel methane from coal mine.
Total energy of the fuel = 14,150,000(Pure methane equivalent m^3/year) x 8,500kcal/m^3
= 120,275 x 1,000Mcal
The amount of pilot oil
= 120,275 x 1,000Mcal ÷ 100 ÷ 10,000kcal/kg
= 120t/year

(4) Energy consumption at the existing thermal power plant

Necessary energy equivalent to petroleum for the existing thermal power plant to generate 34,721 MWh of power, as equivalent power of heat is 2,646kcal/kWh and equivalent heat of petroleum is 10,000kcal/kg:
34,721 x 1,000 (kWh) x 2,646 (kcal/kWh) ÷ 10,000kcal/kg
=9,194t/year

(5) Amount of substitution energy effect or the like

a. Amount of substitution energy effect
As mentioned at the first in this Chapter, the energy substitution effect is the amount that subtracted the amount of pilot oil from the energy (equivalent to petroleum) consumed by the thermal power plant to generate energy corresponding to the total power generated from the coal mine methane gas. Therefore;
The substitution energy effect = 9,187(t/year) – 120(t/year)
= 9,067 toe/year

(6) Gas generation period and accumulated amount

The lifetime of the facility related to this project is thought to be more than 20 years. But considering the coal mine situation, etc. it is estimated to be 15 years on the safety side. Accumulated substitution energy effect for 15 years becomes: 9,067 toe/y x 15 years = 136,000 toe.

1.4 Concrete confirmation of energy substitution effect

Concrete confirmation of energy substitution effect is to measure the total power generated from coal mine methane gas with watt-hour meter and to calculate its equivalent energy to petroleum.

While measuring the pilot oil consumption for power generation, the amount to be subtracted the pilot oil consumption from the above equivalent energy to petroleum becomes the energy substitution amount. Therefore, the equipment for the confirmation composes simply of a watt-hour meter installed at the gas engine power generator and an oil flow meter for supplying pilot oil to the gas engine.

2. Reduction Effect of Greenhouse Effect Gas

2.1 Base of the reduction amount

As the reduction effect of greenhouse effect gas, the coal mine methane which has been discharged in the air, has 24 times of greenhouse effect to carbon dioxide. While this methane is combusted in the engines to convert to carbon dioxide and then to discharge in the air, as appeared from the following equation, methane with 21 times of greenhouse effect is disappeared and carbon dioxide with one time of greenhouse effect is generated.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

2.2 Baseline of the reduction amount

In addition to this reduction of greenhouse effect gas, by generating electric power using methane gas, it is not necessary to generate equivalent power by the existing power plant and so reduction of carbon dioxide generated from the fuel used at the power plant is accomplished.
And this gas engine consumes liquid fuel (diesel oil) corresponding to 1% of total energy of methane fuel as pilot oil fuel, and so carbon dioxide generated from this pilot oil is added to generated greenhouse effect gas. This is shown as a diagram below;

Reduction amount of greenhouse effect gas 【T】	=	Decreased amount of greenhouse effect gas 【A】	−	Generation amount of greenhouse effect gas 【B】

2.3 Decreased amount of greenhouse effect gas generation period accunuleted amount

2.3.1 Greenhouse effect gas

(1) Decreased amount of greenhouse effect gas 【A】

Decreased amount of greenhouse effect gas is a sum of reduction amount of coal mine methane and generated amount of carbon dioxide by consuming fuel to generate equivalent power to substitute for electric power on the assumption that equivalent amount of generated power using coal mine methane gas is substituted for electric power generated by the existing thermal power plant. Namely;

Decreased amount of greenhouse effect gas 【A】	=	Reduction amount of coal mine methane gas (equivalent to carbon dioxide)	+	Decreased carbon dioxide at the existing power plant by substitution of the equivalent electric power

1) Decreased amount of coal mine methane gas

Decreased amount of methane gas (consumption) is as follows;

Weight of methane gas of $1Nm^3$ is 0.67kg and greenhouse effect (GWP) is 21.

Annual coal mine methane consumption is $14,150,000m^3$.

Reduction of greenhouse effect gas of coal mine methane gas is the amount equivalent to carbon dioxide as follows;

$= 14,150,000m^3 \times 0.67\ kg/m^3 \times 21$

$= 199,091\ t\text{-}CO_2/year$

2) Reduction of carbon dioxide by substitution of equivalent electric power

Substitution of electric power is annually 34,721MWh as stated in the former Chapter. The power equivalent to heat is 2,645kcal/kWh and the carbon emission coefficient of petroleum is 20.0 t-C/TJ. Therefore, reduction of carbon dioxide by substitution of equivalent electric power is calculated as follows;

Reduction of carbon dioxide by substitution of equivalent electric power

= 34,721MWh x 10^3 (kWh/mWh) x 2,646 (kcal/kWh) x 4,185.5 (J/kcal) x 20.0 x10^{-12}t-C/J

= 7,691 t-C/year

Equivalent carbon dioxide is carried out by multiplying ratio of molecular weight of CO_2 to C (44/12). Therefore;

=28,200t-CO_2/year

From the above calculation, decreased amount of greenhouse effect gas 【A】;

【A】 = 199,091 + 28,200

= 227,289 t-CO_2/year

(2) Generation amount of greenhouse effect gas 【B】

The generation amount of greenhouse effect gas is the amount of carbon dioxide generated by combusting coal mine methane gas recovered as fuel, and the amount is equal to mole of methane disappeared. And also when the gas engine use pilot oil, carbon dioxide generates by combustion of pilot oil. The generation amount of the greenhouse effect gas sums these amounts. Namely;

Generation amount of greenhouse effect gas 【B】	=	Carbon dioxide generated at methane combustion methane	+	Carbon dioxide generated at pilot oil combustion

1) Generation of carbon dioxide at methane combustion

By combustion of coal mine methane gas, its equivalent mole of carbon dioxide is generated and so it is calculated as follows:

Generation of carbon dioxide by methane combustion = methane volume x density x molecular weight of carbon dioxide÷molecular weight of methane

= 14,150,000m^3 x 0.67kg/m^3 x 44 x 16

= 26,071 t-CO_2/year

2) Generation of carbon dioxide at pilot oil combustion

Generation of carbon dioxide at pilot oil combustion is calculated by using its annual consumption of 120t, equivalent heat of 42.62TJ/kt, carbon emission coefficient of 20.0t-C/TJ, and molecular weight ratio of carbon to carbon dioxide as follows;

= 120 x 42.62 x 20 x 44 ÷12

= 375t/year

Therefore, the generation amount of the greenhouse effect gas 【B】:

【B】 = 26,071 + 375

= 26,446 t/year

3) Reduction amount of greenhouse effect gas 【T】

Reduction amount of the greenhouse effect gas 【T】:

【T】 = Decreased amount of greenhouse effect gas 【A】−Generation amount of greenhouse effect gas 【B】

= 227,289 – 26,446

= 200,843 t/year

2.3.2 Generation period and accumulated amount

The gas engine is operable for more than about 20 years with maintenance. In this study the operation period, namely reduction period of the greenhouse effect gas is determined to be 15 years. Accumulated amount becomes about 3,000,000 t-CO_2.

2.4 Concrete confirmation method of the greenhouse effect gas (Monitoring method)

2.4.1 Background

The contribution, which is above a certain limit (the baseline or regulation value), is quantitatively measured and may be traded off in the market.

Monitoring and evaluation, generally referred to as M&A, are indispensable features in quantifying such a contribution.
Monitoring is to collect and edit the information required for the evaluation, that is conducted throughout the lifetime of a global warming mitigation contribution project, starting from the planning stage and including the period after the completion.
It is not as easy as it is generally perceived to quantitatively evaluate the contribution to the mitigation of global warming. To establish this practice as an international standard, it requires extensive technical expertise with experience.

We have so called think tanks around us that will help form a new order in the global scale. In fact, it has been some time since these think tanks began to compete each other, each claiming themselves as the prominent group of expertise. And creation of a manual is the concretization of such efforts.
Among others, IPCC guidelines, and M&A issued by the U.S. Environment Protection Agency and the World Bank GEF are well recognized.
It will be ideal if the emission credits convince everyone like the currency does. To realize as closely as to this ideal status, it requires publication of precise monitoring and carry out a high level of transparent evaluation.
It is important, therefore, that this project should provide stakeholders with related information.

Instruments used for measurement needs to be accurate and highly reliable with transaction certificates, and such instruments must also be controlled in a reliable way as they are the source of information. In a general way, it is said that the investment above two percent of the emission credits is not economical.

2.4.2 Basic ideas about monitoring

This project relates to recovery and utilization of coal mine methane gas. The monitoring work shall be simple, as it only concentrates on measuring the total emission and recovery of methane gas at the mine site, and on measuring the methane gas at the inlet to the utilization plant. The measurement will eventually provide the leakage from the pipeline.

The monitoring items for the recovery are as follows:

Monitoring items	Method of data collection	Monitoring frequency
Gas flow (take note on the flow speed distribution Gas pressure Gas temperature Gas composition	Generating and summarizing the measurement and record provided by the central monitoring control equipment, and examining whether or not to provide such information to Internet/GII.	Basically, it is monthly. Instantaneous measurements shall be integrated for recording.

The monitoring items for the utilization are as follows:

Monitoring items		Method of data collection	Monitoring frequency
Volume and properties of CMG			
	Volume of intake CMG to the plant	Integrating flow meter (temperature and pressure compensated)	Hourly measurement, with daily, monthly and yearly records.
	Properties of intake CMG to the plant	On-line CH_4 analyzer and lab analysis	3 measurements a day.
	Volume of the intake CMG used for fuel	Integrating flow meter (temperature and pressure compensated)	Hourly measurement, with daily, monthly and yearly records.
Power generation		1) Operation daily report of the power plant	Hourly measurement, with daily, monthly and yearly records.

To take into account of the use of methane gas as an alternative energy to coal, the baseline for the conversion of methane gas should be provided in the beginning. Power generation should be set for the coal fired boiler generation, and the municipal gas should be set for either the coal oven or coal briquette stove. And a variety of data items are needed to be prepared for different cases.

For example, how the baseline emission gas changes when the power generation load changes must be examined sufficiently beforehand.

2.4.3 Monitoring the recovery

The measurement should put focus on the gas generation in the mine and the recovered volume. The following describes the method of monitoring.

(1) Monitoring the gas emission in the coal mines

In general, the greenhouse gas emitted from coal mines is methane gas, which is the main component of the coal seam gases.

The plan has been prepared based on the coal mine system used in Japan, where coal mine methane gas is monitored by outlet route.

(2) Outlet route of coal mine methane gas

Gas may be removed from underground mines using the following three different routes:

1) Through the ventilation system using the main ventilation fan, and discharged into atmosphere from the ventilation outlet together with the exhaust air,
2) Drained through the gas drainage boring holes and from enclosed sealing goaf area, and recovered by the blower station (gas may be discharged into atmosphere without being utilized)on the ground, and
3) Gas remained in mined coal, carried out of the mine.
   Of these three routes, the volume of gas remained in coal and carried out of the mine (item 3 above) is much less than other gases (items 1 and 2), since the majority of such remained gas is emitted within the mine underground before the coal is actually mined, and such gas is also emitted from coal during transportation to the ground. Therefore, monitoring should concentrate only on the gas for the items 1 and 2 above.

(3) Monitoring the ventilation shaft mouth (at the main ventilation fan station)

The following parameters should be collected at the main fan: 1) methane density, 2) air velocity, 3) negative pressure, 4) ventilation volume, 5) airflow temperature, 6) humidity, 7) temperature in the ventilation fan room, 8) main fan vane opening, and 9) main fan motor current.

The above information shall be collected in the central monitoring room through the cable for the purpose of processing, calculation and recording.

- The negative pressure at the main fan station to be transmitted to the central monitoring room as one of the main data items (continuous recording).
- An anemometer to be installed before the main fan, transmitting the measurement to the central monitoring room as one of the sub-data items (continuous recording).
- The methane gauge to be installed before the main fan, transmitting the measurement to the central monitoring room (continuous recording).

Temperature and humidity information shall be added for calculation of the theoretical compensation using computer to provide the emission volume on real-time. (In addition, the ventilation attendant shall measure the ventilation pressure and the cross section of the mine roadway with at a fixed frequency, and the ventilation shall be examined every month for the overall performance of the entire mine).

(4) Monitoring the gas drainage volume (recovered gas)

The total volume of gas drained (and recovered) through the gas drainage system in the mine may be monitored at the gas blower station on the ground. In order to make the plan of ventilation, gas drainage, and gas utilization according to the coal production plan, the volume of gas emission and recovery must be measured by face, mining block, and method of gas drainage, therefore, the following gas measurement shall be carried out at the fixed points on the underground gas drainage pipeline.

1) Setting the measuring points,

a) Ground gas blower station,

b) Before the gas pipe junction,

c) Division according to the gas drainage boring hole, main port for sealing area, and pipeline route,

d) Division according to the drainage pipeline (gas drainage boring, sealing area, etc.) to monitor each mining area, and

e) Division and recording according to the mining block, L/W face and heading.

2) Monitoring method

Most sensors used for measuring the gas in various points shall be explosion-proof, and operated and monitored through the central monitoring system. To visualize the monitoring, the monitoring computer screen shall show mimics of the gas pipeline system on the mine layout screen, providing the status (or change) of the gas condition at the key points on the gas pipeline.

Transmitting data:

The measurement data shall be sent and collected in the central monitoring room for the purpose of processing, calculation and recording, using the following transmission forms.

- Monitoring data measured at sensors shall be sent as analogue signal in the form of current to the underground substation in the mine.
- The analogue signal shall be converted into digital signal at the substation, and it is transmitted to the central monitoring room through fiber optic cable in the form of optic signal (multiple transmission of various data).

Measurement data:

Gas is measured at the end of the pipeline for methane density, CO density*, volume of drained gas, and pressure in the pipe (see Fig 2.2-38: Gas Monitoring System).

* CO is measured against spontaneous combustion.

(5) Monitoring agencies

1) Responsibilities

- The ventilation department shall conduct daily maintenance of instruments and sensors.
- The technology and mechanical/electrical departments shall take care of equipment after receiving the transmission.
- The planning department shall control the central monitoring room to give command.

2) Monitoring frequency

The monitoring shall be continuous, but sampling (data collection) shall take place every 30 seconds. A large computer shall be used to record the data, and the record shall be transferred on to the optic disk every week, to provide the past values, current values, and trend (change over time) of the gas condition at any time.

2.4.4 Concrete confirmation method of the greenhouse effect gas

Monitoring of the coal mine methane gas is facilitated comparing with other greenhouse effect gas. It is easy to confirm by monitoring the gas amount and concentration of the gas recovered from the coal mine and fed to the inlet of the gas engine and by monitoring methane gas concentration in the gas engine.

3.Influence to the Mine Productivity

The effect of gas recovery/control technologies to the improvement of productivity at coal mine is quite big. In Japan also, in case of insufficient gas elimination an action to stop mining work in the working face is taken. Therefore, the gas drainage of mining panel in the present working face operation is also quite significant, and contributes to the improvement of productivity providing the workers with the assured working place. If the gas draining amount is insufficient, the gas must be diluted with increase in quantity of ventilation air. This is one of the causes of deterioration of working environment, too.

In coal mines in Russia, the economical coal production for enterprise is required for the future. In order to sell coal for commercial article at a competitive price, more improved productivity is necessary. A plan to realize a limited number of large scaled working faces with high productivity rather than a several number of working faces with low productivity should be drawn for efficiency in the aspects of not only operation management but also intensification of facility and capital investment. For that purpose, the tendency is that the extension of length of the present working face as double as of advanced coal production countries and the speed-up of working face proceeding several times are required. The gas in the whole working face cannot be recovered sufficiently in the case of such working faces by short distance boring, and the preparation of boring for gas drainage which follows the advancing speed of working face becomes impossible.

Preparing for such a situation the establishment of technologies of middle/long distance boring is indispensable. In addition, because sudden increase in coal production per one working face causes shortening of time for gas release, insufficient gas drainage makes a large amount of gas flow into mining site.

From the point of gas processing, thus recovered gas is a useful energy resource. In spite of such benefit, a large scale working face with high productivity consumes a large amount of power and a limited number of working face affects much productivity and safety in case of stoppage of mining due to accidents. Therefore, though it may be power for safety supplied at mine-site, the self-supply of a part of power consumed in the large amount brings big merits for the management of coal mine.

As the conclusion, it is expected that this project would eventually contribute much to the improvement of productivity.

IV PROJECT FEASIBILITY

The essentials:

The calculation on the project profitability was made by obtaining the construction capital plan of the utilization project and the operational variable/fixed costs, etc. As the result of this, ROI became 3.3% before tax and 1.7% after tax. The reason why a certain degree of profit is expected is that methane from coal mine as fuel is acquired without cost.

Concerning the effect of the project against cost, the effect on reduction of greenhouse effect gases (conversion amount of carbon dioxide) amounts to 111.6t-CO_2-y/million Yen and that of alternative energy to 5.0toe/million Yen. In the meantime, The initial capital investment necessary for reduction of 1ton of greenhouse effect gases a year becomes 9,000Yen.

1. Economic Effect of Return on Investment

1.1 Feasibility calculation base

1.1.1 Project conditions

(1) Schedule

Starting after detail feasibility study, schedule for the project execution composes of design for 5 months, procurement of equipment and materials and manufacturing for 10 months, construction of building for 4 months, transportation and installation for 7 months and start-up operation for 1 month. It requires for 2 years (24 months) in total considering overlap of a part of them. Especially, from November to March, it is difficult to carry out outdoor work and indoor work without heating at the site. The construction schedule is longer than that in Japan.

(2) Capacity factor of the power plant or Others

Capacity factor of the power plant is determined to be 85.8%, while generation amount of the coal mine gas fluctuates depending upon the coal production, as stated in Chapter III-1. The total generated electric power at the sending end is 34,721/MWh except the internal use. This is consumed internally, and so an expense to purchase electricity is deducted. The cost by deducting purchase is determined to be 4 yen/kWh.

(3) Operator and staff for the plant

The plant composes of the gas transfer facility and the power generation facility. The gas transfer facility is installed at three points on the surface of the coal layer and feeds the gas through the gas pipeline to the power plant. Following operators and staffs are required for management and operation department and maintenance department.

	Manager	Engineer	Worker	Total
Operation, Management and Maintenance	1	4	20	25 (personnel)

1.1.2 Finance plan

(1) Facility construction fund

Necessary founds for the project composes of facility construction cost, initial working capital, interest during construction, cost during commissioning and contingency.
The total fund necessary for all facilities and equipment and construction relating to the project is estimated to be 1.80 billion-yen.

(2) Fund raising plan

The equity capital is 20% of the total capital cost for all the facilities and equipment and construction, and remaining funds are furnished by long term loan※. The term of repayment is 40 years (10 years of grace period and 30 years by installed equal repayment of principal and interest) and the interest rate is 2% applying CIRR one.

※ It has not yet been a stage where a certain specific loan is selected. Accordingly, the interest rate of Commerce Interest Reference Rate (CIRR) is used here.

(3) Repayment plan

Repayment on the cost of the plant construction is 50% in the first year of operation and 50% in the following year.

1.1.3 Operation cost

The operation cost composes of variable costs and fixed costs.

(1) Variable cost

While the variable costs compose of fuel cost, utility cost etc., in this Chapter pilot oil cost is accounted. The pilot oil is consumed 120 tons per year.
The price of the pilot oil was assumed to be 40,000 yen/ton.

(2) Fixed cost

The fixed cost composes of labor cost, maintenance cost and administration cost.

a. Labor cost

Average salary was assumed to be 20,000 yen/month, an indirect cost such as a welfare cost or the like is estimated 100% of the salary and therefore the labor cost becomes 40,000 yen per month/person.

b. Management and maintenance cost of facility

Management and maintenance cost of the facility is estimated 1.5% on 80% of the total construction cost.

c. Fire insurance and taxes on the fixed asset

The fire insurance and taxes on the fixed asset are estimated 0.5% on 80% of the total construction cost.

The fixed cost is the total of above labor cost, management and maintenance cost of the facility and the fire insurance and taxes on the fixed asset.

(3) Tax and project life, etc.

Tax levied on the income of a corporation is 46.7% in total and 19.4% out of the number is local tax. It is assumed that preferential treatment on tax for utilization of nonuse energy for 5 years in future from standpoint of environmental protection. It is also assumed that value-added tax is not imposed because they produce and consume the gas for their own use. The project life is 15 years, and depreciation is carried out by straight-line method and salvage value is 10 %.

1.2 Project feasibility

Based on the condition of steam calculation, the project feasibility was calculated, and ROI and ROE were also calculated.

The best reason why this project is profitable on a certain degree is that the cost of the coal mine gas is estimated to be free of charge. The calculation result is shown below.

1. Return on Investment before Tax	3.3%
2. Return on Investment after Tax	1.7%
3. Return on Equity after Tax	8.7%

2. Project Effect to Capital Cost

The project effect to the investment cost to show how much the greenhouse effect gas is decreased to the investment, or how much the energy is substituted was calculated.

2.1 Energy substitution effect

(1) Substitution energy effect per 1 million-yen of the project expense

As the substitution energy effect is 9,067 ton/year, the substitution energy effect is:
= 5.0toe-y/million-yen.

2.2 Greenhouse effect gas reduction effect

(1) Greenhouse effect gas reduction effect per 1,000,000 yen of the project expenses (CO_2 equivalent)

The reduced greenhouse effect gas (CO_2 equivalent) is 200,843 t-CO_2 per year, and the total expense is 1,800 million-yen and the greenhouse effect gas reduction effect per 1million-yen of the project expense is therefore:
=111.6 t-CO_2-y/million-yen

(2) Greenhouse effect gas reduction effect per 1million-yen of the project expense (Carbon equivalent)

Similarly, the carbon equivalent is:
= 30.4 t-C-y/million-yen

(3) Initial investment to reduce one ton of the greenhouse effect gas

The initial investment is 1.8 billion-yens, and the reduction amount of the greenhouse effect gas is 200,843 ton (carbon dioxide) and therefore the initial investment per 1ton of the reduction of the greenhouse effect gas is about 9,000 yen (81 USD).

It would therefore be proper to say that the effect of the reduction of greenhouse effect gases against the capital investment in this project is quite satisfactory.

V CONFIRMATION OF DIFFUSION EFFECT

Essentials:

In the subsidiary companies of Kuzbassugol Coal Production Association(CPA) to which the studied coal mine belongs, several mines for the candidates as the site to introduce technologies of this project have been found. In these mines potential gas resources in coal seam are abundant and considerable amount of gas emission is expected as mining shifts to further depth. At the whole coal mine of Kuznets the amount of drained gas is yet much more small from the standpoint of safety. For the purpose of securing safety only, an addition of more than 200 millions m^3 of gas recovery is expected. In spite of the gas utilization facility at the part of the said coal mine, recovered gas has yet utilized little due to such reasons as gas amount, unstable gas concentration, problems about applicability of facility, etc. Therefore, a possibility of diffusion of this project is quite high establishing gas recovery/control technologies and introducing gas utilization facilities with excellent applicability.

Because the introduced coal mine gas utilization system is applicable to the coal mines under any conditions, for the Kuzbassugol CPA group the effect of alternative energy is about 30,000 toe / year and the reduced amount of greenhouse effect gas is 650,000 t-CO_2/year, if this system is diffused. The effect of diffusion to the whole Russia is 320,000 toe/year and 7,100,000 t-CO_2/year, respectively.

1. Possibility of Diffusion of the Concerned Technology to be Introduced for Project in the Subject Country

As stated so far, gas drainage technology in Russia has a long history. In Kuznetsk basin, they started gas drainage in 1951. In 1990, the basin achieved the maximum yearly gas drainage volume of 216million m^3 from their 48 coalmines. Besides that, Pechora basin started commercial base gas usage from 1956, and they achieved the record of 290million m^3 gas drainage volume in 1988.

However, the economical recession started in 1990 in Russia have given a serious impact on every aspect of coalmine operation. It has brought decrease of production volume due to the drop of coal demand, decay of coalmine facilities and stagnancy in developing new technology; and these results have further influenced on poorer coalmine work environment and drop of coal productivity.

Therefore, their performance of coalmine gas recovery and usage in recent years is remarkably lower than their achievement in the past. Especially, the gas drainage technology is important to maintain safety in the coalmine, and if they can utilize the recovered gas in effective way, they can solve environmental pollution problem, and can expect great benefit in improving the economy of the coalmine.

If they can propagate the Project proposed in this report, they can enjoy the benefit both in reducing greenhouse gas of the Earth and better management of the coalmine.

1.1 Diffusion degree of gas drainage technology

1.1.1 Gas drainage volume from safety point of view

According to "Kuznetsk basin underground coalmine statistical data" provided by Science Academy of Russia Siberia Coal Institute, Kuznetsk basin underground coalmines suffered from as many as 368 incidences of dangerous situation of gas outburst. Dr. Prochikove of Russia CBM Center in the Institute has pointed out that the level of gas danger during mining is still high, even though the methane emission volume has decreased due to the remarkable decrease of production volume in Kuznetsk basin, caused by the economical recession in the whole Russia.

He has come up with his own gas drainage standard and index, and calculated necessary additional gas volume to be drained in order to prevent gas outburst accidents. (Table5.1-1) The calculated result says that in order to make the year of 1998 no accident performance, it is necessary to drain yearly extra gas of 198.5million m^3 in addition to the actual drainage of that year.

Therefore, from safety point of view, they need to drain yearly total gas volume of app. 230million m^3 including the actual drainage volume of 33 million m^3 in 1998. Moreover, aside from Chertinskaya coalmine, they have picked up Komsomolets coalmine in Leninskugol, Abashevskaya coalmine and Kapitalnaya coalmine in Prokp'evskugol to give priority in terms of gas usage. Aside from Chertinskaya coalmine, if we estimate gas drainage effect in other 3 coalmines, we can say that for safety, they need to drain and use 100 million m^3 of gas in the 3 coalmines.

Table5.1-1 Breakdown list of Kuzbass coalmines by gas emission standard

(Source : Dr Prochikove)

Class	Coalmine, Coal Company (Shaded row)	Index	Required value of gas drainage ratio	Required value of methane recovery (million m^3/year)
7	Berezovskaya	0.37	0.16	1.53
	Severokuzbassugol	-	-	1.53
4	Jaroslavskogo	0.43	0.12	1.09
5	Komsomolets	1.31	0.7	31.52
7	Polysaevskaya	1.35	0.07	1.67
8	Oktyabrskaya	1.72	0.49	17.56
	Leninskugol	-	-	51.84
1	Chertinskaya	1.29	0.47	7.89
2	Novaya	0.44	0.17	1.97
	Belovougol	-	-	9.86
2	No. 12 Coalmine	0.42	0.05	0.53
	Kiselevskugol	-	-	0.53
1	Koksovaya	1.29	0.38	5.15
6	No. 5-6 Coalmine	0.39	0.7	10.09
9	Zyminka	0.32	0.26	2.36
10	Krasnogorskaya	1.34	0.49	7.93
	Prokop'evskugol	-	-	25.53
2	Baudaevskaya	0.19	0.6	4.02
4	Abashevskaya	2.31	0.49	32.51
6	Yubileinaya	1.17	0.27	8.7
10	Kapitalnaya	1.91	0.62	30.68
11	Shushtalepskaya	0.15	0.5	2.36
12	Vysokaya	0.15	0.62	3.35
14	Lenina	1.22	0.28	8.25
15	Tomskaya	0.78	0.52	12.98
16	Usinskaya	0.64	0.44	6.42
	Kuzneskugol	-	-	109.27
	Kuzbass	-	-	198.56

1.1.2 Propagation of gas drainage equipment

If you see the present status of gas volume necessary to drain from safety point of view described in the previous paragraph, and number of coalmines that perform gas drainage as of 1998 and propagation of in-mine gas drainage method (Table 5.1-2), you can understand how much degree you are in shortage of gas drainage equipment at present.

Table 5.1-2 Number of coalmine performing gas drainage in Kuznetsk basin

	1951	1960	1970	1980	1985	1990	1995	1998
Coalmines performing gas drainage	2	4	24	34	43	48	26	13
Inducing methane (million m^3)	0.7	2.4	32.2	89.9	127.5	216.0	163.8	33.0

Table5.1-3 Condition of gas drainage in Kuznetsk basin

Coalmines using gas drainage	Number of mined faces in 1998		Gas drainage method	
	Total	Faces doing gas drainage	Surface well	In-mine boring
Kuznetsugol Co., Ltd.				
Abashevskaya	3	3	-	3(+gas ventilator)
Alarda	2	1	-	1
Tomskaya	2	1	-	1
Zyrayanovskaya	1	1	-	1(+gas ventilator)
Jubileynaya	3	2		1(+gas ventilator)
Sub-total	11	8	1	7
Mezduretchenskugol Co., Ltd.				
Lenina mine	4	1	-	1
Usinskaya	3	1	-	1
Sub-total	7	2	-	2
Belovougol Co., Ltd.				
Chertinskaya	3	1	-	1(+gas ventilator)
Leninskugol Co., Ltd.				
Kirova	4	2	2(+gas ventilator)	-
Koltchuginskaya	1	1	1	-
Polysaevskaya	3	1	1(+gas ventilator)	-
Yaroslavskogo	4	2	2	-
Total	11	6	6	-
Raspadskaya Co., Ltd.	8	2	-	2
Grand total 13	40	19	7	12

(Source: Russia CBM Center)

1.2 Increase of gas volume caused by improvement of L/W face productivity

Coal production in Russia has been low since the economical depression in 1990. But in the long-term perspective, the production volume must recover and increase. Presently, they are in a stage of closing coalmines with poor productivity and re-building the ones with good potential.

Present productivity per face in underground mines in Russia is, if we take Chertinskaya coalmine as an example, 1,000t/day to 2,000t/day per face. On the other hand, many productive faces in USA or Australia produce more than 20,000t/day. Even in Japan where the geologic condition and mining condition is poorer than USA or Australia, we normally produce 15,000t/day. In re-constructing coalmines in Russia, in order to achieve potential economical productivity, they have to change their system to large volume production with fewer, but larger-scale faces. When that happens, we can expect an increase of gas emission volume due to faster advance of the face and larger coal output. Besides, the existing mines will have to mine further down. Under that condition, it is impossible to rely only on the ventilation system to remove the gas, and they need to take active gas drainage effort.

Therefore in future, by the time they establish coalmines with higher productivity with the effort of re-construction, they at least have to regain the gas recovery ratio in eighties to the beginning of nineties. Kuznetsk basin has actually achieved 216million m^3/y of gas recovery, if they apply long-hole boring technique, and proceed to introduce and update various equipment, we think we can expect gas recovery of 200 to 300million m^3 that we examine and estimate in coming section 1-4-2.

1.3 Potentiality of gas resources

In estimating recoverable gas volume in near future, the gas emission in active coalmine becomes the important calculation factor. On the other hand, in estimating one for long future, potentiality of the gas resource becomes the important factor.

In terms of CBM resource described in the chapter II 1.1.2 of Kuznetsk basin, they estimate more than 7,000 billion m^3 of volume in mining coalbed within the depth of 900m (See Table2.1-3 CBM resource in each depth).

From the above condition, we can expect Kuznetsk basin to continue emitting good volume of gas in future, as long as they keep on mining. Moreover, in their past record, they have proved to recover more than 30% of gas emitted during mining with the conventional recovery method they are presently adopting. Therefore, we can forecast that the coalmine gas will increase in Kuznetsk basin as the Russian economy gets better in future, because

of the ample gas resource in the first place, even though the gas emission volume may fluctuate according to the change of coal production volume.

1.4 Range of propagation of the project

1.4.1 Kuzbassugol Coal Production Association (CPA)

Kuzbassugol CPA in which the subject coalmine of this project, Chertinskaya coalmine belongs, has many other high gassy coalmines as shown in the Table2.2-2 (See chapter II). In many of these coalmines, they don't have enough gas drainage facilities, and are not doing gas drainage (Table5.1-3).

Table5.1-4 Effective propagation range in Kuzbassugol CPA (Data of 1998)

	Severokuzubassugol	Lenninskugol		
	Berezovskaya	Komsomolets	Polysaevskaya	Oktyabrskaya
Coal output (t)	495,000	830,000	1,448,000	1,130,000
Maximum depth (m)	410	450	405	360
Gas emission (m^3/min) (m^3/year)	18.41 9,676,296	85.8 45,096,480	48.5 25,491,600	68.7 36,108,720
Specific gas emission (m^3/t)	19.55	54.33	17.60	31.95
Gas content * (m^3/t)	20～23	16.5～19	15～18	13～16.5

* : Gas content at the maximum depth (dry ash free m^3/t)

We have picked up and listed 4 coalmines in Table5.1-4, which we think have good unit gas emission, large absolute gas volume and possibility of economical gas usage. If they apply gas drainage technology on these mines and achieve the gas recovery ratio similar with Chertinskaya coalmine (40%), they can recover and use additional 46million m^3 of gas (gas emission in the 4 coalmines is 116,373,096 m^3/year in 1998) in coalmines other than Chertinskaya coalmine only in Kuzbassugol.

In the above calculation, we haven't included Pervomaiskaya coalmine of Severo-kuzubassugol as they do not emit much gas, but as they have the biggest potential volume in Kuzbassugol Co., Ltd., we can expect good volume of gas emission when they mine deeper than now.

1.4.2 In the whole Kuznetsk basin

The following table shows the present statistics of coal production volume and future plan values. As you can see from these figures, we can forecast that the total coal output volume from Kuznetsk will maintain the present level for the time being.

Table5.1-5 Change of coal production in future (1,000 t)

	Severokuzbassugol Leninskugol Belovougol Kiselevskugol Prokop'evskugol Kuzunetskugol	Oblkemerovougol	Total
1994	52,613 (Clean coal)	3,535 (Clean coal)	56,148 (Clean coal)
1995	51,748 (Clean coal)	4,067 (Clean coal)	55,815 (Clean coal)
1996	46,756 (Clean coal)	4,147 (Clean coal)	50,903 (Clean coal)
1997	46,767 (Clean coal)	4,018 (Clean coal)	50,785 (Clean coal)
1998	40,745 (Clean coal)	2,725 (Clean coal)	43,470 (Clean coal) 96,014 (Raw coal)
2000			89,350 ~101,550 (Raw coal)
2005			95,100 ~119,150 (Raw coal)
2010			100,050 ~127,800 (Raw coal)

(Source: Russia CBM Center)

However, when we look at each coalmine, general trend is to close coalmines with poor profitability, and re-build ones with good potential. Therefore, we need to develop more effective boring technology and introduce gas drainage technology that can cope with the increase of gas volume due to large coal output and faster advance of the face, as coalmines go through qualitative change and large scale coal faces emerge by gathering and rationalizing the faces.

The following Table shows the change of gas emission volume of Kuznetsk basin in recent years, except the data of Oblkemerovougol which is not available.

Change of gas emission volume (1,000m^3)

	1994	1995	1996	1997	1998
Severokuzbassugol	69,905	54,505	41,260	34,690	24,287
Leninskugol	210,555	205,352	161,149	164,513	173,080
Belovougol	113,845	87,302	55,293	56,712	33,533
Kiselevskugol	50,826	27,594	22,443	23,284	21,077
Prokop'evskugol	112,951	96,808	95,975	76,317	70,168
Kuzunetskugol	460,478	468,414	453,856	400,244	369,497
Total	1,018,560	939,975	829,976	755,760	691,638

Change of coal production volume (Clean coal: 1,000t)

	1994	1995	1996	1997	1998
Severokuzbassugol	5,020	5,290	4,251	2,340	2,445
Leninskugol	11,359	9,959	9,965	9,893	8,390
Belovougol	4,538	4,109	3,315	4,000	2,900
Kiselevskugol	3,874	3,550	3,929	4,000	2,571
Prokop'evskugol	6,976	5,984	5,261	5,482	4,700
Kuzunetskugol	20,846	22,856	20,035	21,052	19,739
Total	52,613	51,748	46,756	46,767	40,745

When we calculate specific gas emission from the gas emission and coal output as shown in Table5.1-6, we can say that there are 16 to 19m^3/t of gas emission in average. In Japan, even from the coalmine where the gas drainage is not easy, we have taken effort and achieved drainage ratio of 30%. In coalmine with plenty of gas emission, it is possible to achieve 40%, which is the gas drainage ratio discussed in Chertinskaya coalmine. Therefore, as we discussed in the previous chapter, even though the coal production volume in Kuznetsk basin stays the same, if they actively carry out gas drainage by drilling, and familiarize gas drainage technology, we think they can recover in the range of 200 to 300 million m^3/year for the production level of year 1998.

Table5.1-6 Recoverable gas volume

	1994	1995	1996	1997	1998
Coal production (1,000t)	52,613	51,748	46,756	46,767	40,745
Gas emission (1,000m^3)	1,018,560	939,975	829,976	755,760	691,638
Specific gas emission (m^3/t)	19.36	18.16	17.75	16.16	16.97
Based on recovery ratio of 30% :	305,568	281,993	248,993	226,728	207,491
Based on recovery ratio of 40% :	407,424	375,990	331,990	302,304	276,655

Possible gas drainage volume above matches with the suggested gas drainage volume from safety point of view of 200 million m^3/year. Therefore, in order to secure mine safety, too, they need to introduce ・ propagate gas drainage technology.

1.4.3 For the whole Russia

The total methane emission in the whole Russia in 1997 is 4,000m^3/min, and the gas drainage volume is 855 m^3/min. In 64 coalmines in Kuznetsk basin in the same year, the methane emission is 1,457 m^3/min, and the gas drainage volume is 240 m^3/min *.

4,000 m^3/min = 2,100 million m^3/year, 855 m^3/min = 450 million m^3/year

1,457 m^3/min = 760 million m^3/year, 240 m^3/min = 126 million m^3/year

* Methane recovery and utilization at the existing mines in the Russia Federation 1998, Anatoly D. Ryaban, Victor S. Zabourdyaev

In future, when they propagate the proposed gas recovery and utilization technology throughout Russia, we estimate the additional gas volume they can recover and use amounts to app. 500 million m^3/yearas shown in the following equation.

(4,000 m^3 - 855 m^3) X 30% X 60 X 24 X 365 = 496 million m^3

;while 855 m^3 is the actual performance of gas drainage.

1.5 Summary of possibility of diffusion

Table5.1-7 Possibility of propagation of gas drainage

	Coal production (clean coal)	Recovered gas volume	Recovered gas concentration
Kuzubassugol Co., Ltd.	13.7 mln. t (in level of 1998)	46 mln. m^3/year * (Pure methane volume)	30~35%
Kuznetsk basin	43.4 mln. t (in level of 1998)	200 to 300 mln. m^3/year (Pure methane volume)	30~35%
The whole Russia	Gas emission (in level of 1997) 4,000 m^3/min	500 mln. m^3/year (Pure methane volume)	30~35%

* : The grand total is 56.5 mln. m^3/year after adding the one from Chertinskaya coalmine of 10.5 mln. m^3/year.

2. Effect Considering Diffusion

The system to generate electric power by feeding coal mine methane gas to the gas engine has a big possibility to be diffused taking its safety and economy into consideration. This system generating power by the gas engine using recovered coal mine gas is applicable to any concentration of coal mine gas and so that reason, the diffusion effect is big. How much the substitution energy effect and the reduction of the greenhouse effect gas per coal mine methane gas of one million m^3 /year (equivalent to methane) to be possible by installing the gas engine to use gas recovered from the coal mine is calculated in order to facilitate estimation of the diffusion effect. The substitution energy amount will be 640toe//year, and the reduction of the greenhouse effect gas will be 14,200t-CO_2/year.

2.1 Substitution energy effect

(1) Diffusion effect to Kuzbassugol

At Kuzbassugol CPA where Chertinskaya coal mine for the object of this project belongs to, as mentioned before, there are many coal mines releasing high coal mine gas. By installing the same type of gas engine power plant at these coal mines, electricity and heat are supplied. Usable amount of the coal mine methane gas is estimated to be 46,000,000m^3/year. The diffusion effect of the project at Kuzbassugol is estimated to be about 30,000toe//year for the substitution energy.

(2) Diffusion effect to the whole Kuznetsk coal mine

As mentioned in the former section1.5, coal mine methane gas of about 200million m^3/year estimated at the minimum is usable in the whole Kuznetsk coal mine. Estimating these, the substitution energy effect is estimated to be about 128,000toe//year.

(3) Diffusion effect to the whole Russia

As mentioned in the former section, coal mine methane gas of about 500million m^3/year estimated at the minimum is usable in the whole Russian coal mine. Estimating these, the substitution energy effect is estimated to be about 320,000toe//year.

2.2 Reduction effect of greenhouse effect gas

(1) Diffusion effect to Kuzbassugol

As mentioned above, coal mine methane gas of 46 million m^3/year estimated is usable in Kuzbassugol. Therefore, the reduction amount of the greenhouse effect gas is estimated to be about 650,000 t-CO_2/year.

(2) Diffusion effect to the whole Kuznetsk coal mine

As mentioned above, coal mine methane gas of about 200 million m^3/year estimated is usable in whole Kuznetsk coal mine. Therefore, the reduction amount of the greenhouse effect gas is estimated to be about 128,000 toe//year.

(3) Diffusion effect to the whole Russia

As mentioned above, coal mine methane gas of about 500 million m^3/year estimated is usable in the whole Russia. Therefore, the reduction amount of the greenhouse effect gas is estimated to be 7,100,000 t-CO_2/year.

VI INFLUENCE TO THE OTHER PHASES

1. At Kuznetsk coal mine unemployment of coal mine laborers originated from close of mines which were not on a paying basis as restructuring of coal industry has been progressed, becomes a social problem. This project is to recover efficiently methane from coal mine installing most advanced facility and fill power requirements in the mine with methane power generation for supply to user surplus power. For management and operation of this link of system, opportunity of new employment is generated to be one of possible cures for unemployment.
   In addition, the existing transformer/distribution station of Chertinskaya coal mine is becoming obsolete considerably. For the Mine stable power supply is expected by installing methane power plant and improvement of power transmission / distribution network becomes possible.

2. Furthermore methane power plant of Chertinskaya will have no need of current purchase of power from coal-fired power station. Air pollution problems caused by SO_X , NO_X , exhausted dusts, etc. which coal-fired power plant has puzzled over will be solved by methane power plant.
   To generate the electric power by the gas engine power generation using the coal mine methane gas discarded in the air till now gives influences on environment in the following points:
   Assuming that average heat capacity of coal is 5,800kcal/kg, sulfur concentration is 0.45%, and the generated electric power in Chertinskaya is generated by the thermal power plant of Kuzbass Energo in Belovo city, amount of sulfur dioxide generation is reduced to about 170 tons/tear. In addition, by saving coal, generation of dust or the like is restrained.

VII CONCLUSION

Conclusion

The issue of securing the safety and that of improving the productivity are considered inseparable issues for the structural reform of Russian coal mines, and the technological development of coal mine gas recovery is rated critical for the restructuring of coal mines. Also, the maximization of recovered gas utilization is the most desirable for environment, and discharging it into atmosphere cannot be ignored as we have global commitment for the environment. While the emission credits for carbon dioxide are significant for Russia, and Japan has been given the obligation to reduce carbon dioxide by 6 percent, therefore, this project would give Japan a valuable opportunity to present its contributive technology to the world.

The investigation has been conducted in full support of and with the understanding of the purposed by the Russian Ministry of Fuel and Energy, Russian Academy of Sciences CBM Center, Kemerovo Government and Kuzubassugol. These institutions, deeply interested in the subject, have expressed their support for the future cooperation.

1. Summary of Survey

The Chertinskaya mine, the subject of this investigation, is highly motivated for both gas recovery and gas utilization. The mine has experience of removing a large amount of gas during the peak production period, and it introduced a gas utilization plant, using the gas to generate power though for a short period of time. The mine has the top-level technological base for both gas recovery and gas utilization in the Kuznetsk coal basin, and it is the most suitable site for implementing this project.

The development work for the related equipment, however, has been delayed due to exhausted Russian economy. It has become difficult for Russia to swiftly modernize the machinery and to develop related technologies on its own. Based on the technological capacity of Russia, it is necessary to introduce excellent equipment and technologies from Japan.

In the meantime, regarding the profitability of the project calculated in this study, a conclusion was obtained that the economic feasibility in terms of return on investment is expected at a comparatively marginal extent.

1.1 Project of gas recovery and control

The underground boring equipment used today in Russia is not capable of conducting effective gas drainage (drilling around 100 meters) for the long wall mining method. For an effective gas drainage in the underground mine, longer boring holes are needed, and a plan has been made to introduce mid-range boring equipment (app. 300 meters), and to add directional boring and horizontal long hole boring techniques after learning and establishing the initial techniques.

From point of view of the effective utilization of the recovered gas and safety, establishment of the total gas control technique has been suggested, including techniques to store gas in goaf (sealing technique and stable gas supply technology for the utilization), gas drainage and control, and others.

Table7.1-1: Main equipment required for gas recovery and control

Equipment to be introduced	Basic capacity and description	Units
Mid-range boring machine (RK-3A)	Drilling length: 300 meters	2
Mid-range directional boring machine (TOP-TM)	Direction drilling, double pipe drilling	1
Suction equipment	Automatic water drain, etc.	3
Sealing equipment	Pump, mixer, valve, differential pressure gauge, etc.	2
Central monitoring system	Sensors, transmission device, data processing unit, etc.	2

Table7.1-2:Coal production plan of Chertinskaya and estimated gas recovery assuming the introduction of the gas recovery control technology

Gas drainage	2000	2001	2002	2003	2004
Coal production (1,000 t/y)	700	700	800	1,000	1,000
Estimated gas emission 1) Gas emission (10,000 m^3/y) 2) Gas emission (m^3/min)	 2,677.6 50.8	 2,476.2 47.1	 2,810.5 53.5	 3,535,7 67.3	 3,567.1 67.7
Estimated gas recovery 3) Pure methane ((1) x 40%) (10,000 m^3/y) 4) 35% gas	 1,071.0 3,060.1	 990.5 2,829.9	 1,124.2 3,212.0	 1,414.3 4,040.8	 1,426.8 4,076.7

1.2 Gas utilization project

A selection has been made for effective equipment, based on the design elements, including the volume of gas recovery, estimated gas concentration, month to month fluctuation of the gas volume, ambient temperature during winter, etc. It is difficult to recover the mine gas of high concentration for the safety reason, and the operation efficiency has to be stable even when the gas concentration is low. Taking this into account, the following comparison has been made for gas-fired power generation.

Table7.1-3: Comparison between gas turbine and pilot oil ignition gas engine (assuming the minimum mine gas concentration to be 30%)

Main parameters	Evaluation
1. System characteristics and heat efficiency	The gas turbine produces more steam, but gas engine gives better generation efficiency.
2. Net generation and operability	At the 30% concentration, the engine generates power approximately 2.6 times as much as the turbine in terms of the net generation (the turbine requires a larger power for compressing the fuel gas).
3. Maintenance	The turbine needs to be sent to the specified maintenance shop when overhaul.
4. Fuel gas properties	At the 30% concentration, the turbine needs to be specially designed for the dual fuel system (mass-produced turbines are designed for the concentration of 70% and more).

In particular, the pilot oil ignition gas engine is suitable for the gas utilization of this project, as it may be used for the gas with a low combustion energy (low methane concentration) and unstable concentration.

Table7.1-4: Main equipment for the gas utilization project

Equipment	Basic capability	Units (remarks)
1. Gas engine power generator (pilot oil ignition)	1,710 kW/unit	3 (installed in building)
2. Pilot oil tank	5.5 m^3/unit	2 (for around 20 days)
3. Vacuum pressure pump	30 m^3/min (-450 Pa - 0.6 Mpa)	3 (portable)
4. Dehumidifier	30 m^3/min	3 (portable)
5. Pipeline on the ground		New installation of 6 km(for extension)

1.3 Project effect

Utilizing the gas of the Chertinskaya mine, which is currently discharging all the gas into the atmosphere, would generate electric power of 34 MkWh a year. The effect of methane gas is equivalent to 21 times as much as that of carbon dioxide gas, and by not discharging it to the atmosphere, the greenhouse gas will be reduced by approximately 200,000 tons, the amount of methane gas converted as carbon dioxide gas. The greenhouse gas will be reduced by approximately 110 t/y (converted to carbon dioxide gas) for each million yen of the project cost required for the gas utilization, with the effect of alternative energy amounting to 5 toe a year.

1.4 Diffusion effect

Kuzbassugol CPA, which owns the Chertinskaya mine, owns other mines with the potential of mine gas, and the mines that will give a large amount of gas emission when the development goes deeper in the future. Also, in the Kuznetsk coal basin as a whole, there are many other mines that need to increase the volume of gas drainage in terms of safety. Gas drainage needs to be increased at least for the safety purpose now. The following table shows effects that may be achieved by improving the gas recovery and control technique in the mine and effectively utilizing the recovered gas in the gas utilization plant.

Table7.1-5: Effects of gas recovery and control technique and introduction of gas utilization plant

Effects	Expected volume of gas recovery	Energy produced by gas utilization	Reduction in greenhouse gas
Chertinskaya mine	app. 14 million m^3/y	app. 9,000 toe/y	200,000 t-CO_2/y
Kuzbassugol CPA	app. 46 million m^3/y	app. 30,000 toe/y	650,000 t-CO_2/y
Kuznetsk coal basin	app. 200 million m^3/y	app. 128,000 toe/y	2,800,000 t-CO_2/y
Russia total	app. 500 million m^3/y	app. 320,000 toe/y	7,100,000 t-CO_2/y

2. Observation

With its brilliant history of coal mines and distinguished coal research institutions, Russia is capable of handling high level of technologies. Since old mines became obsolete, the restructuring program has been introduced also in the Kuznetsk coal basin, to replace old mine with new ones. The Chertinskaya mine, which was studied for this investigation, owns high level of technical expertise, but it has some problems about the coal reserves after many years of operation. The parent body, Kuzubassugol, owns other young mines that are promising for gas recovery and utilization for the future. Therefore, when the current project is put in practice, technical expertise will certainly be transferred to other mines. In this regard, both Kuzubassugol and the Kemerovo government have expressed their ideas about other candidate mines for the project. The national program, which The Ministry of Fuel and Energy of the Russian Federation is working on, urges the necessity of improving the environment in the coal industry, utilizing the emission credits of the coal industry, and implementing practical projects, and this project will be promoted with the support of the federal government. Therefore, a higher economic feasibility of return on investment in this project than that on the present level is expected according as the emission trade develops in the future. The time when the joint implementation is materialized will be determined in comparisons of political stability in Russia, risk management and extent of economic feasibility for the project.

3. Future Issues

3.1 Technical development

In addition to the safety, Russian mines also need to improve the productivity. They need to introduce mid-range and long-range boring technologies and to establish a total gas control system for the gas drainage that allows highly productive mining for large-scale working faces. In terms of the mining and geological conditions, mines are different between Russia and Japan, as well as among individual mines, a few years of experience will be necessary to develop and improve the optimum system based on the introduced equipment. The following issues should be examined before introducing the technologies.

1) Gas recovery and control technique

- Any electric equipment to be introduced to a Russian mine needs to be examined for the explosion proof law.
- Examination of suction power for the gas drainage blower (possibility of applying the high degree of negative suction practiced in Japan).
- Examining the gas pipeline routes (underground system or ground boring system).
- Trying and examining the best boring method, specifications, location, etc.
- Examining the position and method of the boring stations, its influence to the working face, and solutions.

2) Gas utilization plant

- The current ground system will be used for the gas pipeline, but if the underground system is applied it will reduce the load of dehumidifier (to be examined before implementation).
- More economical plan may be designed, if the concentration of gas recovered from the mine is higher than what has been expected. (needs the actual data after the gas recovery plant is put in operation).

3.2 Joint implementation scheme

Utilizing the three flexible measures of the Kyoto Mechanism, this project is likely to be implemented jointly between Japan and Russia with participation of industries under the organization shown below, after a progress is made for the joint implementation and emission credits schemes, to aim at the mitigation of global warming. The project will also be interpreted as a contribution of Japan to the mitigation of global warming.

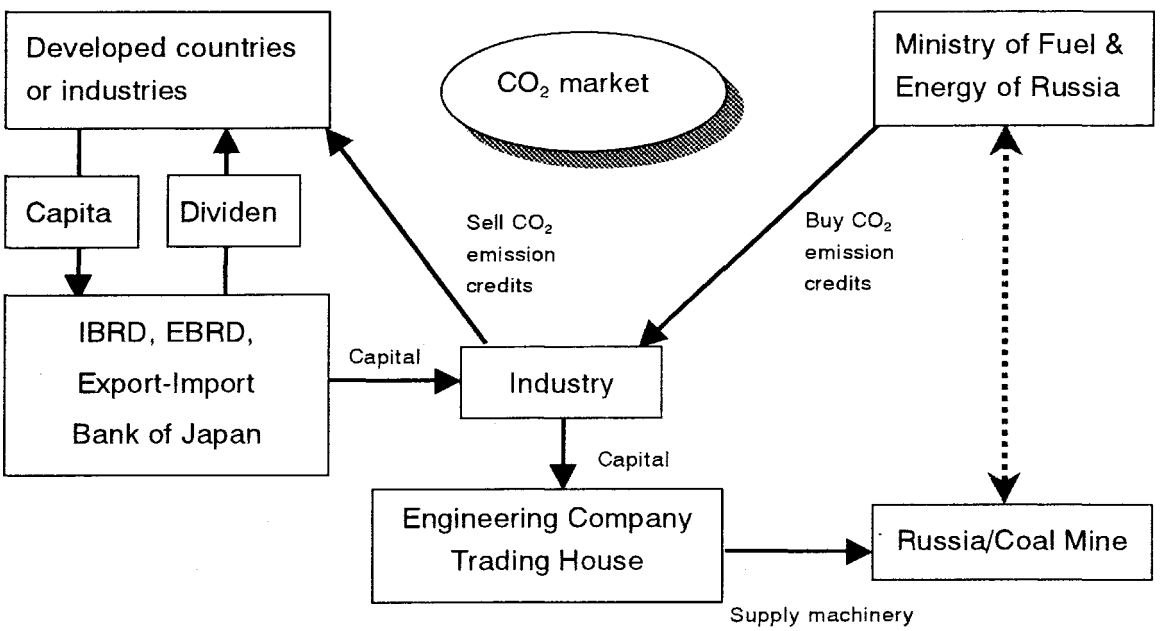


Fig7.3-1: Joint implementation with Russia (suggestion)

VIII APPENDIX

Materials

1. Kuznetsk Basin - Underground mine Statistical data

2. An Excerpt of Data of Mobile Gas Drainage Equipments

3. Production Program of Chertinskaya Coal mine(Year:2000～2004)

4. Cheritinskaya Gas Turbine Study Report

5. Main Institutions of Japan and Overseas for International Investment, Finance and Insurance

6. Performance Record of Aid to Russia by Institutions for International Investment, Finance and Insurance

References

Table 8.1-1-a Kuznetsk Basin - Underground mine statistical data

Coal mine name	Statistical data of Kuzbass in 1998										
	Present output (thou.t.)	Absolute methane generation CH_4 (m^3/min.)	Depth of mining face		Actual gas content in coal seam (dried, dust-free coal in m^3/t)				Kind of coal	Number of gas outburst incidence	Average number of workers (people)
			Maxi-mum	As of Jan. 1, 1999	Deepest point		Depth of mining point in 1999				
					Minimum	Maximum	Minimum	Maximum			
1	2	3	4	5	6	7	8	9	10	11	12
1. Sudzhenskaya			650	600	15	20	15	20	LB		149
2. Anzherskaya-Uzhnaya		0.57	250		16	18					
3. Fizkulturnic	380	0.86	550	500	13	15	12	14	LB	1	1,690
4. Sibirskoye	550	1.94	395	270	12.5	14	10	12	LB	6	1,957
5. Pervomaiskaya	750	15.85	580	320	18	25	12	15	C		1,314
6. Biryulinskaya			560	460	19	22	18	20	C		348
7. Berezovskaya	495	18.41	410	380	20	23	19	21	C		1,398
8. Uznaya			325	325	14.8	15	14.8	15.8			15
9. Volkova	270	7.03	290	235	11	14	9	12	G		552
10. Severnaya			380	310	15.5	19	11	13	CL		70
11. Butovskaya		1.52	250	250	11	13	11	13	KL		307
12. Yagunovskaya			310	310	13	16	13	16	Lw.B		33
13. Anzherskaya			830	830	12.5	14	10	12	LB		371
Severokuzbassugol	2,446	46.18								7	
1. Kirova	2,119	60.4	500	480	18	23	17.5	22	G	19	2,536
2. Koltchuginskoye	815	6.5	480	430	16	18.5	15	17.5	LFG	1	1,583
3. 7th November	1,048	32.6	305	305	13	16.5	13	16.5	G		2,078
4. Jaroslavskogo	480	17.1	570	470	19.8	21	17	19	LF	1	1,603
5. Komsomolets	830	85.8	450	430	16.5	19	16	18.5	G	12	2,115
6. Zaretchnaya	520	9.7	260	260	12	15	12	15	G	2	610
7. Polysaevskaya	1,448	48.5	405	405	15	18	15	18	G	5	1,775

TABLE 8.1-1-b (continuation)

1	2	3	4	5	6	7	8	9	10	11	12
8. Oktyabrskaya	1,130	68.7	360	360	13	16.5	13	16.5	LFG	8	1,611
9. Kuznetskaya			300	230	12.5	16	11	14.5			
Leninskugol	8,390	329.3								48	
1. Chertinskaya	550	32.2	630	610	21	27	21	26	F	21	1,612
2. Novaya	580	21.9	400	400	18	24	18	24	F	5	1,434
3. Zapadnaya			360	360	15	17	15	17	F		796
4. Kolmogoroskaya	540	5.24	300	290	14	16.5	14	16.5	LFG		804
5. Inskaya	1,230	4.48	330	330	13	15.5	13	15.5	LFG	1	2,037
6. Pionerka			360	280	11	15	11	14			
Belovougol	2,900	63.82								27	
1. Vakhrusheva	665	0	310	300	15.6	17.4	15.6	17.4			
2. Mine 12	600	19.8	340	240	16	22	12	16.5	CB,L	34	1,478
3. Kiselevskaya	373	4.3	180	180	11.5	12.5	11.5	12.5	G	2	1,794
4. Taibinskaya			330	300	12	15.5	11.5	14.5	LwB,CBUn		1,050
5. Karagailinskaya			235	170	9	12	8	10			
6. Dalnye Gory	483	4.5	240	145	11	13	10	11	G		1,419
7. Krasnokamenskaya	450	11.54	250	250	10	13	10	13	L	1	1,306
8. Cherkasovskaya			300	300	14.3	16.7	14.3	16.7			
9. Surtaikha			310	260	10.05	13.5	10.5	12.5			
Kiselevskugol	2,571	40.14								37	
1. Koksovaya	515	25.9	460	450	15.3	18.8	15.3	18.8	LwB, LB,C	23	2,567
2. Tsentral'naya			390	380	16	20	16	19			
3. Krasny uglekop			290	270	12.8	16.4	12.8	16.04			
4. Zenkovskaya	815	11.2	190	190	11	13.5	11	13.5	CB,L	1	2,293
5. Kyrgaiskaya	668	0.3	200	200	7	9	7	9	G		836
6. Mine 5-6	267	27.5	340	340	13.2	15.3	13.2	15.3	CL,CB,LwB	23	1,440
7. Dzerzhynskogo	671	17.3	280	280	12.4	16.4	12.4	16.4	CB,L	7	2,480

TABLE 8.1-1-c (continuation)

1	2	3	4	5	6	7	8	9	10	11	12
8. Kalinina			305	260	13	16	12	14	CB,LwB		1,169
9. Zyminka	403	17.1	350	260	15	18	11.5	13	CB,LwB	5	1,980
10. Krasnogorskaya	500	30.7	450	325	18.5	22.5	16.5	19.5	C,CL	20	1,029
11. Tyrganskaya	861	3.5	300	220	13	16	10	12.5	CB,LwB		1,914
12. Nogradskaya			400	400	13.7	17.6	13.7	17.6			
13. Severny Maganak			260	250	10	13	10	13			
14. Krasny Uglekop									C,CB,L		308
Prokop'evskugol	4,700	133.5								79	
1. Bungurskaya	42		220	220	10.5	13.5	10.5	13.5			
2. Baidaevskaya	159	12.6	600	570	17.5	22.5	17	22			
3. Zyr'anovskaya	745	49.2	600	600	17	22	17	22	F,GF	18	1,501
4. Abashevskaya	2,016	124.8	660	610	19	23	18	21	F	12	3,470
5. Novokuznetskaya	1,230	4.35	250	150	9	12	7	10	G		1,458
6. Yubileinaya	1,450	61.9	620	490	19	23	17.5	19	F	11	1,872
7. Polosykhinskaya	1,670	28.6	450	450	17.5	19.5	17.5	19.5	GF	9	
8. Nagornaya			450	380	15.5	19.5	14.5	17.5			
9. Esaylskaya	1,505	32.9	450	450	17	19	17	19	GF,G	3	1,362
10. Kapitalynaya	1,124	93.4	650	490	19	2	17	19	F	19	2,436
11. Shushtalepskaya	143	8.96	310	200	14	16	11	12.5	L		579
12. Vysokaya	123	10.2	540	450	18	20	16	18	F		296
13. SC Alarda	1,606	32.6	480	410	18	21	17	19	CB,L	17	2,613
14. Lenina	1,295	56.2	345	340	13	16	13	15	CL	19	2,392
15. Tomskaya	740	47.8	400	300	19	22	16	18	LB	11	1,194
16. Usinskaya	489	27.5	570	560	19	22	18	21	C	15	981
17. Raspadskaya	5,402	112.0	370	350	16	18.5	15	16.5	GF	32	4,982
18. Dimitrova			275	275	13.5	16.5	13.5	16.5			
19. Shevyakova			310	250	14	16	12.5	13.5			
20. Kazankovskaya			300	300	13.5	16	13.5	16			
21. Osinnikovskaya									F		324
22. Sokolovskaya											1,762

TABLE 8.1-1-d (continuation)

1	2	3	4	5	6	7	8	9	10	11	12
Kuznetskugol	19739	703.01								166	
1. Lapytchevskaya			290	280	11	12.5	11	12	Lw.B		411
2. Leninskoye	146	0.1	160	160	5	6	5	6	LF		486
3. Signal			280	250	8	11	7	10	LF		304
4. Gramoteenskoye	1,300	8.64	270	270	8.5	10.5	8.5	10.5	LF	4	2,309
5. Krasny Kuzbass		1.02	240	190	9	12	7	9	Lw.B		961
6. Bolshevik	1,165	1.48	260	260	10	13.5	10	13.5	G,GF		1,244
7. Severny Kandysh	114	0	130	130	4.5	5.5	4.5	5.5	L		721
8. Vol'naya			200	120	6	7.5	4	5			
9. Smytchka									L,LF		597
Oblkemerovougol	2,725	11.24								4	
Total on Kuzbass	43,470	1,327.19								368	

List of abbreviation for kind of coal:

LF – long flame	CL – coking leaned
LFG – long flame/gas	Cbun – coking/baking/undermetamorphosed
G – gas	CB – coking/baking
GFL – gas/fat/leaned	LB – leaned baking
GF - gas fat	L – lean
F – fat	A – anthracite
CF - coking fat	OC – oxidized coals
C - coking	Lw.B – low baking

TABLE 8.1-2-a PARAMETERS OF COAL SEAMS AND RECOVERED GAS ON USINSKAY MINE

	Names of coal seams	Thickness (m)			Seam dip (°~ °)			Working Depth (m)	Gas Content (m^3/t)	Perme-ability (md)	Gas Pressure (MPa)	Coal Quality		Recovered Gas Composition
		Ave.	Max.	Min.	Ave.	Max.	Min.							
Main Working Coal Seams	III	8.5	8.7	8.3	12	15	8	430-560	20-25			Typical Quality:		Analysis data (%)
	IV-V	9.5	10	8.5	12	15	8	320-450	15-20					
	VI	6.3			12							Coal rank	Coking	CH_4 – 20.0
	VIII-IX	6.4			7							Moisture (%)	1.6 – 1.9	C_2H_6 - n/a
	V	5.9	6.5	5.2	10	12	8					Ash (%)	20.7 – 23.4	C_3H_8 – n/a
Other Main Coal Seams	Via	1.3			9							Volatile matter (%)	22.4 – 23.5	C_4H_{10im} – n/a
	XI	1.9			13							Fixed carbon (%)	88.6 – 89.6	CO_2 – 0.4
	XII	2.3			14							Total sulfur (%)	0.35 – 0.45	CO – 0
												Heating value (kcal/kg)	8400	N_2 – 63.0
														O_2 – 16.6
														H_2S – n/a
														H_2 - 0
														Note: Sampling place Degasification pipeline

TABLE 8.1-2-b PARAMETERS OF COAL SEAMS AND RECOVERED GAS ON LENINA MINE

	Names of coal seams	Thickness (m)			Seam dip (° ~ °)			Working Depth (m)	Gas Content (m^3/t)	Perme-ability (md)	Gas Pressure (MPa)	Coal Quality	Recovered gas composition
		Ave.	Max.	Min.	Ave.	Max.	Min.						
Main Working Coal Seams	III	8,5	8,7	8,3	12	15	8	430-560	20-25			Typical Quality:	Analysis data (%)
	IV-V	9,5	10	8,5	12	15	8	320-450	15-20				
	VI	6,3			12							Coal rank Coking	CH_4 – 20.0
	VIII-IX	6,4			7							Moisture (%) 1.6 – 1.9	C_2H_6 - n/a
	V	5,9	6,5	5,2	10	12	8					Ash (%) 20.7 – 23.4	C_3H_8 – n/a
Other Main Coal Seams	Via	1,3			9							Volatile matter (%) 22.4 – 23.5	C_4H_{10im} – n/a
	XI	1,9			13							Fixed carbon (%) 88.6 – 89.6	CO_2 – 0.1
	XII	2,3			14							Total sulfur (%) 0.35 – 0.45	CO – 0
												Heating value 8400 (kcal/kg)	N_2 – 63.0
													O_2 – 16.8
													H_2S – n/a
													H_2 - 0
													Note: Sampling place Vacuum pump station

TABLE 8.1-2-c PARAMETERS OF COAL SEAMS AND RECOVERED GAS ON PERVOMAISKAYA MINE

	Names of coal seams	Thickness (m)			Seam dip (° ~ °)			Working depth (m)	Gas content (m^3/t)	Perme-ability (md)	Gas pressure (MPa)	Coal Quality		Recovered gas composition NOT APPLIED DEGASIFICATION
		Ave.	Max.	Min.	Ave.	Max.	Min.							
Main Working Coal Seams	XVI	2.6	3.2	1.6	16	30	7	320-400	15-18			Typical Quality:		Analysis data (%)
	XXIV	1	1.2	0.7	16	25	10	250	13					
	XXVI	1	1.2	0.7	20	25	16	250	13			Coal rank	Coking	CH_4
	XXVII	2.2	2.4	1.6	20	25	16	320-580	15-22			Moisture (%)	1.2 – 1.6	C_2H_6
												Ash (%)	8 – 12	C_3H_8
Other Main Coal Seams	Birulinsky	1.6			18							Volatile matter (%)	21.1 - 24.5	C_4H_{10im}
	XXVI	0.9	1		20							Fixed carbon (%)	88.7 - 90.3	CO_2
	XXXI	0.5			22							Total sulfer (%)	0.5 – 1.1	CO
	XXXII	1.1		1.1	22							Heating value (kcal/kg)	8500	N_2
	XXXIII	1		0.9	22									O_2
														H_2S
														Note: Sampling place

TABLE 8.1-2-d PARAMETERS OF COAL SEAMS AND RECOVERED GAS ON CHERTINSKAYA MINE

	Names of coal seams	Thickness (m)			Seam dip (°~ °)			Working Depth (m)	Gas content (m^3/t)	Perme-ability (md)	Gas pressure (MPa)	Coal Quality		Recovered gas composition
		Ave.	Max.	Min.	Ave.	Max.	Min.							
Main Working Coal Seams	3	2.7	3	2.3	8	13	0	480	20			Typical Quality:		Analysis data (%)
	4	1.5	1.6	1.4	12	13	12	380-520	18-20					
	5	1.8	2.4	1.6	13	28	5	490-610	20-22			Coal rank	Fat	CH_4 - 80
												Moisture (%)	1.9 - 3.5	C_2H_6 - n/a
												Ash (%)	18-28.5	C_3H_8 - n/a
Other Main Coal Seams	1	1.5			9							Volatile matter (%)	36.3-38.7	C_4H_{10im} - n/a
	2	1.3	1.5	1.2	19							Fixed carbon (%)	85.4-86.9	CO_2 – 2.5
	3a	0.6			22							Total sulfer (%)	0.4-0.5	CO – 0
	6	0.7		1.1	22							Heating value (kcal/kg)	8500	N_2 – 12.2.
														O_2 – 5.3
														H_2S – n/a
														H_2 – 0
														Note: Sampling place Longwall No318, coal seam 3, vacuum pump station No14 (1992)

2. An Excerpt of Data of Mobile Gas Drainage Equipments

Data of Mobile Gas Drainage equipments

Date	Equipment number	ガス抜き対象 Panel number	Differetial pressure (mmHg)	Suction pressure (mmHg)	Drained gas (m3/min)	Gas concentration (%)	Pure methan gas (m3/min)
1999/8/22	ЛЭУ−5	542	10	661	6.3	45.0	2.8
	ЛЭУ−1						
	ЛЭУ−11	544	140	289	42.0	1.0	0.4
	ЛЭУ−4	563	204	296	35.6	0.0	—
	В/У−13	563	952	—	245.0	2.1	5.1
1999/8/23	ЛЭУ−5	542	10	661	6.3	45.0	2.8
	ЛЭУ−1						
	ЛЭУ−11	544	—	289	42.0	1.0	0.4
	ЛЭУ−4	563	204	274	38.6	0.0	—
	В/У−13	563	952	—	250.0	2.0	5.0
1999/8/24	ЛЭУ−5	542	10	661	6.3	45.0	2.8
	ЛЭУ−1						
	ЛЭУ−11	544	—	319	48.0	1.0	0.5
	ЛЭУ−4	563	204	228	28.6	0.0	—
	ЛЭУ−6					80.0	
	В/У−13	563	952	—	250.0	1.6	4.0
1999/9/15	ЛЭУ−5	542	10	661	6.3	43.0	2.7
	ЛЭУ−11	544	—	319	48.0	1.0	0.5
	ЛЭУ−14	568					
	ЛЭУ−4	563	272	289	32.9	0.0	—
	ЛЭУ−6		440	152	42.0	43.0	18.1
	В/У−13	563	—	952	225.0	1.8	4.1
1999/9/16	ЛЭУ−5	542	10	661	6.3	43.0	2.7
	ЛЭУ−11	544	—	319	48.0	1.0	0.5
	ЛЭУ−14	568	Stoppage at 8 Sep 15				
	ЛЭУ−4	563	272	289	32.9	0.0	—
	ЛЭУ−6		400	182	40.0	40.0	16.0
	В/У−13	563	—	952	272.0	2.0	5.4
1999/9/17	ЛЭУ−5	542	10	661	6.3	43.0	2.7
	ЛЭУ−11	544	—	319	48.0	1.0	0.5
	ЛЭУ−14	568					
	ЛЭУ−4	563	272	289	32.9	0.0	—
	ЛЭУ−6		250	152	31.6	32.0	10.1
	В/У−13	563	—	952	250.0	1.8	4.5
1999/9/24	ЛЭУ−5	542	10	661	6.3	43.0	2.7
	ЛЭУ−11	544	—	288	40.0	5.0	2.0
	ЛЭУ−14	568					
	ЛЭУ−4	563	258	272	32.9	0.0	—
	ЛЭУ−6		300	167	34.6	35.0	12.1
	В/У−13	563	—	952	250.0	1.8	4.5
1999/9/25	ЛЭУ−5	542	10	661	6.3	43.0	2.7
	ЛЭУ−11	544	—	288	40.0	5.0	2.0
	ЛЭУ−14	568					
	ЛЭУ−4	563	258	272	31.9	0.0	—
	ЛЭУ−6		290	152	34.1	32.0	10.9
	В/У−13	563	—	952	260.0	1.8	4.7
1999/9/26	ЛЭУ−5	542	10	661	6.3	43.0	2.7
	ЛЭУ−11	544	—	288	40.0	6.0	2.4
	ЛЭУ−14	568					
	ЛЭУ−4	563	408	228	40.5	0.0	—
	ЛЭУ−6		260	152	30.0	32.2	9.7
	В/У−13	563	—	952	240.0	1.8	4.3

注）機械番号「ЛЭУ」シリーズは、移動式ガス誘導設備で使用しているポンプを示す。
機械番号「В/У」シリーズは、ブリーダー排気用ファンを示す。

3. Production Program of Chertinskaya Coal Mine (Year:2000～2004) (1,000t)

Panel number	Working coal seam	2000													2001	2002	2003	2004	Total
		Jan.	Feb.	Mar.	Apl.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	total					
429	4#	20	15	15	20	20	20	20	20	20	20	20	20	230	30				260
416	4#														150	130			280
431	4#															80	300	80	460
431	4#																	220	220
563	5#	30	33	34	34	8								139					139
359	3#											6	25	31	230	169			430
357	3#															121	320	59	500
351	3#																	231	231
544	5#	20	20	20	20	20	20	20	20	20	20	20	20	240	240	30			510
546	5#															210	280		490
546	5#																	310	310
Long wall mining		70	68	69	74	48	40	40	40	40	40	46	65	640	650	740	900	900	3,830
Heading		5	5	5	5	5	5	5	5	5	5	5	5	60	50	60	100	100	370
Total production		75	73	74	79	53	45	45	45	45	45	51	70	700	700	800	1,000	1,000	4,200

4. Cheritinskaya Gas Turbine Study Report

Study on supplying a gas turbine with coal mine methane gas recovered from Chertinskaya coal mine to generate power was carried out as follows;

Characteristic of Chertinskaya coal mine methane is that methane concentra-tion is 30~35% which is very low compared with usual gas turbine fuel, and its flow rate fluctuates. Installation of three gas turbines considering operability was studied.

(1) Outline of coal mine methane

<Gas supply condition>

1) Coal mine	: Cheritinskaya coal mine of the union of Russia
2) Annual gas supply amount	: 14,150,000Nm^3(equivalent to pure methane)
Hourly gas supply amount	: 1,600Nm^3
3) Net calorific value of fuel	: About 10,800kJ/Nm^3 (2,580kcal/Nm^3) (As 30% CH_4 concentration)
4) Fuel gas supply pressure	: 0.196Mpa (2.0kgf/cm^2)

(2) Coal mine methane gas applicable to gas turbine

Essential design point when to use the above coal mine methane as gas turbine fuel is as follows;

1) Component of fuel As methane is main component and its combustibility is suitable for gas turbine, it is no problem.
2) Calorific value of fue Regarding net calorific value of 2,580kcal/Nm^3, suitable range of net calorific value for usual gas turbine is about 11,000~8,000kcal/Nm^3 and calorific value per fuel volume is about 1/4 of usual fuel. Namely, fuel with 4 times of volume is required. On the other hand, fuel volume to be supplied to gas turbine fuel system is limited.
3) At start-up of gas turbine, fuel with proper combustibility for start-up is required. But as the gas mentioned above anticipates making start-up worse, liquid oil such as kerosene or diesel oil is used at start-up of gas turbine.
   Namely, duel fuel type gas turbine is adopted.

From the above, output and fuel consumption of gas turbine in this study are worse than those of usual gas turbine.

(3) Determinations of output and fuel consumption and of capacity(output) and performance of gas turbine

1) Determination of output and fuel consumption

Considering net calorific value of 2,580kcal/Nm^3 of the above fuel in this study, output and fuel consumption of the gas turbine in this study are determined as follows;

Output-lowering rate : 0.7

Fuel consumption : 4,300kcal/kWh (As efficiency at power generation end is assumed to be 20%, $\frac{860\text{kcal/kWh}}{0.2}$ =4,300kcal/kWh)

2) Gas turbine capacity (output)

Gas turbine output =

$$\frac{\text{hourly fuel supply amount (Nm}^3\text{/h) x net calorific value of fuel (kcal/Nm}^3\text{)}}{\text{gas turbine fuel consumption rate x fuel efficiency margine rate}}$$

$$= \frac{1{,}600\ (\text{Nm}^3\text{/h})/3 \times 8{,}500\ (\text{kcal/Nm}^3)}{4{,}300\text{kcal/Nm}^3 \times 1.05}$$

$$\fallingdotseq 1{,}000\text{kW}$$

Addition to the above gas turbine output, considering the output-lowering rate of 0.7,

Usual gas turbine output =1,000kW÷0.7≒1,430 kW

From the above, making usual 1,400kW (rating) class of gas turbine to be:

1,400kW x 0.7 =1,000kW

From this fuel specification in this study, as the turbine output becomes 1,000kW(rating).

3) Gas turbine type and performance specification

Gas turbine type :Simple open cycle one axis type

Gas turbine power generator output :1,000kW (at intake temperature of 15℃)

Gas fuel consumption rate :4,300kcal/kWh (at 1,000kW and 15℃・hour)

Gas fuel consumption :1,700Nm^3/h (Fuel gas net calorific value of 2,580kcal/Nm^3)

$$\frac{1{,}000\text{kW} \times 4{,}300\text{kcal/kWh}}{2{,}580\text{kcal/Nm}^3} = 1{,}700\text{Nm}^3$$

Fuel	At start-up	:Kerosene or diesel oil (from start-up till unloading rated rotation) Expected fuel consumption amount at start-upAbout 120L/each
	At unloading operation	:Coal gas : Net calorific value of 2,580 kcal/Nm^3 Component :CH_4(methane) more than 30% Balance is air.
	Air pollution gas such as NOx in exhaust gas	: NOx expected value 80ppm (O_2=17%) SOx none
	Start-up system	: Inverter control start-up by alternative currentmotor (about 30kW)
	Start-up time : About 10 minutes (including purge time of 5 minutes)	

(4) Specification of facility

1) Gas turbine power generator

- Gas turbine Type Dual fuel type

  Structure

Type Simple	Open cycle one axis type
Compressor Type	Axial-flow 8 stages
Burner Type	Annular type
Turbine Type	Axial-flow 3 stages
Bearing Type	Slide-bearing
Spindle revolution number	: 22,562 rpm
Reduction gear Type	Planet gear type
Output shaft revolution number	: 1,500rpm

- Axial joint Type Non-oil and bending type
- Power generator

  Rating

Using condition	: Continuous
Output	: 1,200kVA (1,000kW)
Power factor	: 0.8
Voltage	: 6,600V
Frequency	: 50Hz

Structure	Protection method	: Open protection type(JP20)
	Cooling method	:Self-ventilation type
Auxiliary facility	Space heater	: 1.0 kW

- Start-up facility

Start-up method	Electric start-up
Start-up motor	25kW alternating current inverter control

- Lubricant oil cooling facility — Air cooling radiator 1.5kW x 2 motor drive
- Fuel supply facility

Fuel oil high pressure pump	2.2kW	Number 1
Fuel oil low pressure pump	0.75kW	Number 1

- Enclosure

Applicable equipment ■Gas turbine ■Reducer ■Power generator

2) Combustion air facility

- In-take filter
- Type — Cartridge type ·3 stages

3) Exhaust gas facility

- Exhaust gas silencer :85 dB(A) (1 meter from out-let)

4) Ventilation facility

- Power generator ventilation fan — 2.0kW x 1
- Ventilation supply gas silencer — With enclosure

Ventilation exhaust gas silencer — With enclosure

5) Gas fuel supply facility

- Gas compression facility

Type		Oscillation type or screw type
Out-let flow rate		1,500Nm^3/h
Pressure	In-let pressure	2.0kgf/cm^{2}G
		(at 15 ℃ of in-let temperature)
	Out-let pressure	15.0kgf/cm^{2}G
Cooling method	Air cooling radiator	4.5kW x 1 motor drive
Motor capacity		300kW, AC 400V, 3ϕ 3W

Motor type	Flame-proof construction (d2G4),
	Full-voltage starting motor
Noise	8.8dB(A) at 1 meter from the facility

- Gas flow meter

Type	Mass flow meter (with temperature correction apparatus)

- Gas filter

Size	3 inch
Element	5 micron

6) Liquid fuel supply facility for start-up

- Fuel tank

Volume	200L (With stand) Square figure
Number	1

- Fuel flow meter

Type	Screw type flow meter

7) Instrument air supply facility

Type	Screw type /scroll type
Air out-let pressure	7.0~8.5 kgf/cm^{2}G
Power source	2.2 kW

8) Direct current source facility

Service	Breaker operation and control

9) Control panel and distribution panel

Gas turbine control panel (common drive with low pressure auxiliary equipment)

Power generator control panel

Power generator breaker panel (52G)

Type	Internal vertical self-standing board	1

Internal transformer panel

Type	Internal vertical self-standing board	1
Outer size	W1,000 x D2,000 x H2,350 (mm)	
Attachment	Load-break switch (LBS)	
	Transformer 6,600V/400V 100kVA	

10) Waste heat boiler

- Boiler body

Type	Indoor type tubular boiler
Maximum using pressure	10 kgf/cm^{2}G (at out-let of boiler)
Normal pressure	8 kgf/cm^{2}G (at out-let of boiler)
Steam temperature	Saturated steam temperature
Supply water temperature	30 °C (at in-let of economizer)
Designed evaporation amount	3,200 kg/h (at 0 % blowing)
Supply water quality	Soft water

- Attachment

Economizer	Made by fin steel tube
Water supply pump	Multi-stage turbine pump 2
	Capacity : 5.0m^3/h x 10 kgf/cm^{2}G
	Motor : 5.0kW x 2P (out-door type)
By-pass damper	3 way damper 1
Chemical feeding facility	Diaphragm type
Continuous blowing facility	Water supply heat exchanger type 1

(5) Regarding operation of facility

1) Start-up and stop

Start-up and stop operation of the gas turbine is carried out manually by [start-up and stop switch] on the gas turbine control panel.

At start-up of the gas turbine, it is started by kerosene or diesel oil. After completion of start-up, namely accomplishment of both rated rotation and rated voltage, it is exchanged to gas fuel.

2) Parallel closing and opening

After exchange of fuel following start-up of the gas turbine, generated power is automatically synchronized with commercial power source, and then the breaker of power generator is closed and output of power generator is increased until reaching at set value. When opening the breaker, stopping operation of gas turbine automatically decreases output of the power generator and then opening the breaker stops it.

3) Output control

That temperature of exhaust gas of the power generator or the gas turbine exceeds setup value during operation of the power generator in parallel with commercial power source decreases automatically output of the power generator, while load power which can not be prepared by the power generator is supplied by receiving side. However, when the load power to be supplied by receiving side is lowered to the minimum set value (the minimum receiving power), output of the power generator is lowered to keep the minimum receiving power.

4) Power factor control

When the power generator is operated parallel with commercial power source, the power factor of the power generator is controlled to be constant.

5) Operation of waste heat boiler

Waste heat boiler becomes under operation together with start-up of the gas turbine by setting boiler auxiliary such as water supply pump to be [automatic mode] on boiler control panel.

However, water level variation and others of dram at start-up is carried out manually.

6) When gas turbine, power generator and waste heat boiler are in the states as mentioned above, the gas turbine is tripped or the breaker is opened.

Figures of total flow sheet, outline of equipment and plot plan of equipment are shown.

5 . Main Institutions of Japan and Overseas for International Investment, Finance and Insurance

(1) Japan Bank for International Cooperation

Japan Bank for International Cooperation was established in October of 1999 by integrating each function of two former public institutions in Japan, the Export-Import Bank of Japan and the Overseas Economic Cooperation Fund. Its operation is mainly composed of two: Operations of international finance and others from a viewpoint of contribution to promotion of the export and import or overseas economic activities of Japan, or to stabilization of order in inter-national finance (operations of former EXIM Bank of Japan), and of overseas economic cooperation from a viewpoint of assistance to economic self-reliance of developing countries (operations of former OECF).

1) Operations of International Finance and Others

In order to promote economic relations mainly in trade of Japan with overseas countries by providing financial assistance, the Export Bank of Japan was set up in 1950 for the purpose of supporting or promoting finance for export and import and overseas investment executed by common financing institutions. In 1952 operations of import finance and guarantee were added to change its name to 'the Export-Import Bank of Japan'. It was integrated in October of 1999 into Japan Bank for International Cooperation.
The operations are classified broadly as follows:
Export finance (loan on company/personnel of Japan and direct loan on overseas ones), overseas investment finance (loan on company/personnel of Japan and direct loan on overseas ones), untied loan, refinance, bridge-loan, capital investment and guarantee of obligation.

2) Overseas Economic Cooperation

In order to contribute to industrial development or economic stabilization of Southeastern and other overseas developing regions (hereinafter referred to as 'Southeastern and other regions'), OECF was established in 1961 in accordance with the Law of Overseas Economic Cooperation Fund for the purpose of providing

operations required for smooth supply of necessary funds to implement their development or stabilization, of which loan or other credit are difficult to be furnished by former EXIM Bank of Japan or other general banks, and of facilitating overseas economic cooperation with such provision. In October, 1999, it was integrated into Japan Bank for International Cooperation.
The operations are classified as follows;

(a) To loan funds necessary for a project considered important to contribute to development of the industries in the Southeastern and other regions and to promote economic relations with Japan (hereinafter referred to as 'Development Project').

(b) In the case in which it is specifically necessary for execution of the Development Project, capital investment as a substitute for loaning funds as provided for in the preceding number.

(c) To loan funds necessary for a study to prepare for development of project or experimental execution of the Development Project.

(d) To loan funds (excepting funds required for the Development Project) to foreign governments (including foreign governmental institutions) in the Southeastern and other regions for import of goods considered important to contribute to stabilization of economy of the Southeastern and other regions.

(e) Study about overseas economic cooperation concerning each of the above operation.

(2) JICA-Japan International Cooperation Agency

JICA was established in 1974 for the purpose to contribute to development of economy and society of the regions referred below and to be instrumental in promotion of international cooperation through providing the following execution of operations;
Execution of technical cooperation with overseas developing regions (hereinafter referred to as 'Developing Regions'), and promotion of cooperation by the Japanese Government to the government of the Developing Regions with grant of funds and of

overseas cooperation activities by the youth, plan of smooth supply of funds, which are, from the viewpoint of cooperation, necessary for social development and developments of agricultural and forestry industries and the mining and manufacturing industries in the Developing Regions and difficult to be provided by the EXIM Bank of Japan or OECF together with providing related technologies, smooth execution of emigration to the Central and South American regions and others and emergency assistance for large-scale disaster in the Developing Regions. Through all of the above executions it aims at contributing to economic and social development of these regions and facilitating promotion of international cooperation.

The operations are broadly classified as follows:
Overseas technical cooperation, overseas cooperation crew of the youth, development cooperation, overseas migration, emergency assistance for disaster, training and security of specialist, incidental operations and operations to achieve goal.

(3) Export-Import Insurance Department, Ministry of International Trade and Industry

By establishing a system to insure risks such as restrictions of foreign exchange transaction brought about in foreign trade and other foreign transaction and others to which no relief can be provided by ordinary insurance, the Trade Insurance Law was enacted in 1950 for the purpose to plan a sound development of foreign trade and other foreign transaction.
The following trade insurance systems are available at present;

(a) Trade Blanket Insurance
To compensate for loss by inability to export goods, loss by increased cost of freight or marine insurance premium and loss by inability to collect charge, price or loan after shipment on export of plant and others from Japan or broker.

(b) Foreign Exchange Fluctuation Insurance
To compensate for exchange loss for an exporter by export of plant and others (Suspension of acceptance at present).

(c) Export Bill Insurance

To compensate for loss for bank and others by dishonor of documentary bill after shipment.

(d) Export Indemnity Insurance

To compensate for loss for bank and others by unfair confiscation of bond on export of plant and others.

(e) Advance Payment Import Insurance

To compensate for loss by inability to collect price of import goods paid in advance.

(f) Overseas Investment Insurance

To compensate for loss by expropriation, war, remittance risk or bankruptcy of overseas invested company.

(g) Overseas Business Funds Loan Insurance

To compensate for loss by inability to collect loan on overseas long-term business funds by bank and others.

(4) IMF: International Monetary Fund

IMF was established in 1945 for the purpose to shorten and reduce to a degree duration of imbalance in balance of payments of member nations.

It provides the following various kinds of finance operations as well as control functions such as removal of exchange control, exchange agreement, supervision of exchange policy of member nations, etc.;

- Credit tranche finance system: First credit tranche and upper credit tranche (Stan-by credit and enlarged credit extension)
- Special loan system: Buffer stock loan system and loan system for guarantee of export fluctuation accident (Export fluctuation compensation loan, grain import fluctuation compensation loan and exogenous accidental factor compensation loan)
- Transfer loan system: Enlarged structural adjustment facility
- Loan systems already terminated: Oil facility, trust fund, complementary loan system, enlarged limit loan system, structural adjustment facility and structural shift loan system

(5) IBRD: International Bank for reconstruction and Development

IBRD was established in 1945. Its original purpose was reconstruction of war-damaged member nations and assistance to development of developing countries. At present it intends solely to assist development of developing countries.
The operations are as follows:

1) Finance

(a) Finance object

a) Finance on investment project
- Specific project
- Investment project in specific economic section
- Finance brokerage institution sublease (Two-step loan)
- Emergency assistance
- Technology assistance

b) Adjustment finance
- Structural reform
- Section adjustment
- Rehabilitation of specific economic section
- Hybrid loan (Combination with finance on specific project)
- Reduction of debt

(b) Debtor

a) Government of member nation

b) Governmental institution of member nation, public body, private company, etc. (required guarantee by the government of member nation)

(c) Loaning, repayment and interest
A debtor has his option of loans of floating interest rate and single currency, of floating interest rate and currency pool and of fixed interest rate and single currency. (Combination of these in one loan is possible.)

2) Guarantee

(a) Form of guarantee

a) Partial risk guarantee

Guarantee of default caused by non-fulfillment of support agreement by the government concerned for a specific project (especially infrastructure project by activated private sector, etc.) on project finance.

b) Partial credit guarantee

Intention to lengthen loan term by giving IBRD's guarantee for later part within repayment term of a loan for a project for which long-term loan is difficult to be extended on the market conditions.

(b) Object of guarantee

- Commercial loan for a new investment project in finance qualified nation. (Capital investment and loan to public institution are not the object of guarantee.)
- For debtor, not only government but governmental institution and private company are possible. (Provided that counter-guarantee for the World Bank is necessary in giving the guarantee.)

(c) Rate of compensation

- 100% of principal and interest in partial risk guarantee.
- Only a part necessary at least for execution of project in partial credit guarantee.

(d) Rate of guarantee charge

- 0.25% per annum for non-executed portion of agreed guarantee.
- 0.25% per annum of basic charge + premium (0.15%~0.75% per annum) after request to perform guarantee

3) Other Operations

(a) Technology assistance

- Drawing up of development plan by dispatching mission of the World Bank.
- Advise and training of technical experts of developing countries by general training program.

(b) Holding of group meeting discussing assistance for developing countries.

(c) Research activities

- Research of economic development of developing countries, issue of foreign debts, etc.

(6) IFC: International Finance Corporation

FC was established at the 10th General Meeting of the World Bank in 1955 for the purpose of contributing to economic development of the country concerned (as a sister institution of the World Bank) providing investment and finance funds to private company in developing countries in cooperation with private overseas investors.

The operations are as follows;

1) Investment and Finance

(a) Financing (A loan)

- Loan with fixed or variable rate in key currency.
- Finance term is usually 8 to 12 years.
- Method of repayment and period of deferment are decided according to a cash-flow of project.

(b) Investment

- IFC remains as minor stockholder and does not take part in positive management.
- Its investment is maintained for whole 8 to 15 years and its goal is to sell in the market of the investment country.

(c) Loaning according to investment

- According to necessity of investment project, convertible debenture, deferred finance or finance cum subscription right are furnished.

(d) Risk management assistance

- Providing company in developing countries with measures for avoiding finance risks.
- Furnishing measures of derivatives such as currency swap, interest swap, forward interest, interest option, etc.

(e) Providing credit line investment fund, venture capital fund and lease transaction

a) Credit line investment fund

Setting a credit line as fund resource for banks in developing countries to provide their customer small companies with facility investment and working funds.

b) Venture capital fund

Setting fund to assist cash flow of unlisted companies. (Fund to promote especially privatization)

c) Lease transaction

To assist small companies in developing countries in which investment fund for capital goods is short by facilitating to set up lease industry.

2) Mobilization of Private Fund

(a) Loan participation program (B loan)

- Organization of joint financing with private bank.
- The private bank has obligation of finance and risk according to its share of participation, whereas obligation of the debtor on the loan agreement is born against the name of IFC (lender of record) lumping together with A loan.
- IFC collects principal and interest and controls its finance, and participation bank is dealt equally with IFC by the debtor and the country to which the debtor belongs on the loan agreement.

(b) Assistance of establishment of country fund, venture capital fund and dead fund, and indirect promotion of securities investment in developing countries through assistance to investment fund in securities in developing countries.

(c) Preparation of data base of capital market in developing countries

- Supply of information on stock market in developing countries (Emerging Market Data Base).
- Setting-up of Emerging Market Index Fund.
- Syndication of commercial paper.
- Assistance of converting into securities of bond

(d) Advisory Services

- Advice on PF organization.
- Project assistance, privatization and restructuring, development of capital market, overseas investment, advice on rearing small companies and technological assistance.

(7) EBRD-European Bank for Reconstruction and Development

For the purposes of assisting the Middle and Eastern European countries which are now driving forward their liberalization and democratization to shift to market economy and promoting voluntary activities of private sector and entrepreneur, EBRD was established in 1991.
The followings are its operations for beneficiary countries;

(a) Investment in and finance to private companies

- Stock subscription or guarantee of finance is possible, if necessary.

(b) Project finance for infrastructure project of public sector

- Provided that credit line for public sector is no more than 40%.

(c) Technological cooperation (Advise on policy, educational training, etc.)

(d) Employment of special fund deposited in EBRD

(8) EXIM: Export-Import Bank of the United States

EXIM was established in 1934 as Washington Export-Import Bank in order to create employment in the USA assisting export of US companies. (The original purpose at its establishment was promotion of export to create employment at the economic depression in 1930th and was to make the trade with former USSR smooth.)
Its operations are largely classified into medium- and long-term export credit guarantee, medium- and long-term export credit direct finance and short-term working fund guarantee.

(9) AID: Agency for International Development

AID was established in 1961 for the purpose of implementation and management of assistance program of the USA.
Main operation of bilateral assistance with donation.

(10) TDA: Trade and Development Agency

TDA was established in 1981 for the purpose of delivery of subsidies for execution of feasibility study, dispatch of study mission and training of specialists on projects of infrastructure and industry in developing and middle-income countries in order to support obtaining order of the project by the involved US companies.
Its operation is fund donation for feasibility study of development project in developing and middle-income countries. The cost on the feasibility study is usually shared between executing company and TDA (usually cutting into halves). In Reimbursement Program started in1995 in the case when the project is executed and the executing company of F/S has due economic profit, 2/3 of the donated amount is refunded to TDA as a success fee.

(11) OPIC: Overseas Private Investment Corporation

OPIC was established in 1971 for the purpose of promotion of direct investment by private company of the USA in developing countries. Its major operations are investment insurance, special investment insurance (of which object is the fields of finance and energy), direct investment, guarantee and investment fund.

(12) ECGD: Export Credits Guarantee Department

ECGD was established in 1919 in the Board of Trade for the purpose of promoting export of capital goods and the related services from the UK.
Its operations are various kinds of finance guarantees, insurance, overseas investment insurance and reinsurance.

(13) Hermes: Hermes Kreditversicherungsbank-AG

Hermes was established in 1917 as a private credit insurance bank and changed its name to the present one in 1937.
Its operations are short- and intermediate- term export insurance, foreign exchange fluctuation insurance and overseas investment insurance.

(14) COFACE:

COFACE was established in 1946 for the purpose of guarantee of risks on trade insurance to exporter and underwriting on overseas investment.
Its operations are market survey insurance, export credit insurance, foreign exchange fluctuation insurance, bond insurance and overseas investment insurance.

(15) SACE: La Sezione Speciale per l'Assicurazione del Credito all'Esportazione

SACE was established in 1912 as a corporation having special status, National Assurance Institution (Instituto Nazionale delle Assicurazioni, INA) for the purpose of execution of export credit insurance by the government, and in 1997 a special section SACE in INA in charge of export credit insurance became an independent corporation by the Law No. 227.
Its operations are export credit insurance/guarantee, foreign exchange fluctuation insurance, bond insurance and overseas investment insurance.

6 . Performance Record of Aid to Russia by Institutions

(1) Japan Bank for International Cooperation (Business for international finance, etc.)

Performance record:	1990	100 million USD (Humanitarian aid)
	1991	500 million USD (Humanitarian aid)
		200 million USD (Facilitation of trade and economic activity)
	1993	400 million USD (Facilitation of trade and economic activity)
	1998	1,500 million USD (Joint finance/structural adjustment facility loan with IBRD)

In addition, for extending two-step-loan to the Commercial Bank of Russia, now under study about formation of small and medium projects

(2) Japan Bank for International Cooperation (Business for international economic cooperation)

No record of yen credit financing because Russia is not at present a subject country for the yen credit

(3) JICA: Japan International Cooperation Agency

No record of various kinds of technical cooperation by JICA because Russia is not at present a subject country for the yen credit

(4) NEDO: New Energy and Industrial Technology Development Organization)

Entrusted by the Ministry of International Trade and Industry, now under execution of finance aid for the purpose of basic study on joint project promotion related to regulation of greenhouse effect gases and study and research concerning development trend, etc. on liquid fuel technology of natural gases

(5) Export Import Insurance Department of Ministry, International Trade and Industry

Performance Record: 1991 1,800 million USD
1993 1,100 million USD
1997 Insured mid-long term trade with the letter of guarantee issued by the Commercial Bank of Russia
1998 By increasing other commercial banks in Russia to be the object for trade insurance, studied about acceptance with credit by competent companies

(6) IMF: International Monetary Fund

March, 1996; Decided credit extension of 10,200 million USD with EFF (enlarged facility finance for 3 years) and 670 million USD out of the total amount to be extended at the end of July of 1998 July, 1998; Approved by the Council an additional support requested by the government of Russia. After the economic crisis started from August of 1998, credit was extended partly, but under pressure from the USA Government due to Chechen strife after that more extension has been suspended.

(Note) Details of the additional support (announced on July 13, 1998)
(100 million USD):

	1998	1999	Total
IMF	125*	26	151
World Bank	17	43**	60
Japan	6	9	15***
Total	148	78	226

* Out of 125, 13 committed already and 112 for additional support of this time. The loan of 48 was actually made in July of 1999 (Loan period; 5 years and loan rate; 4.6 to 4.8%. The loan of 56 was originally scheduled, but by the reason of rejection of a part of economic stabilization bill in the Lower House, reduction in the loan was partly made.)

** Out of 43, 11 committed already.

*** Out of 15, 8 contracted in July of 1998. The object is a rationalization project of coal division (by joint financing with the World Bank.) The loan of 4 was actually made in July of the same year.

(7) IBRD: International Bank for Reconstruction and Development

The aggregate financed amount at the end of June of 1997: 8,163 million USD for 36 cases and the balance of 3,675 million USD
The object: Social protection adjustment loan (800), structural adjustment loan (600), enterprise restructuring service project (85), educational reform project (71) and others

(8) IFC: International Finance Corporation

The aggregate invested and financed amount at the end of July of 1997: 235 million USD for 19 cases (280 million USD if syndicate loan included)
The object: Capital market rearing, privatization (Farmland), post-privatization (Seminar), infrastructure (Power), etc.

(9) EBRD: European Bank for Reconstruction and Development

The financed balance at the end of December of 1997: 1,128 million ECU (25% of the total amount) And the amount of loan not yet extended but approved already: 1,098 million ECU (25% of the total amount)
The object: Bank support by FIDP (Financial Institutions Development Project) and support by RSBF (Russia Small Business Fund)

(10) EXIM: Export-Import Bank of the United States

900 million USD was committed already (for oil-and-gas-related industries). Principle is to deal with private company's advance into Russian market positively. Out of the said commitment about 200 million USD finance committed to a big oil company has not yet actually made under the current confused situation of Chechen strife in 1999.Payment bonds are federal government guarantee, overseas escrow account and private bank guarantee.

(11) ECGD: Export Credits Guarantee Department

800 million USD was committed. Additional 250 million pounds was approved in December of 1997. Basic stance is to take notice of fulfillment of capital repayment

rescheduled by Paris Club and London Club.
For payment bond, risk-taking by private bank, private company and local self-governing body has become possible since October of 1997, (provided that there has been no record).

(12) Hermes: Hermes Kreditversicherungs-AG

Both in 1997 and 1998 1,500 million DM limit was set specially as mid-long term insurance, (provided that the limit per one case is 30 million DM and 100 million DM for East German products). There is no ceiling about those for short term and project finance.
Payment bonds are bank guarantee (in the total amount 300 million DM for 14 banks within a limit of 10 million DM per one case) as well as federal government guarantee, and state government guarantee is now under study. (Example: A scheme of 40% federal government guarantee and the remainder 60% coverage with local government guarantee or bank guarantee is now under study but has not yet reached to a conclusion.

(13) COFACE: Compagnie Francaise d'Assurance pour le Commerce Exterieur

The export credit of private bank by trade insurance coverage amounts to 4,000 million FF (settled in March of 1996), but due to problems on formalities by Russian side this has not yet been implemented (1,500 million FF for capital goods and 2,500 for petrochemical plant).
Payment bonds are federal government guarantee and overseas escrow account. Bank guarantee and local government guarantee are also now under study.

(14) SACE: La Sezione Speciale per l'Assicurazione del Credito all'Esportazione

420,000 million lira was concluded to extend for credit in April of 1996, but the whole credit amount has not been accommodated. The attitude toward Russia was decided to scale down credit limitations (in April, 1998) after the existing limits are absorbed judging from the past overexposure to Russia.
In principle, payment bond is limited to federal government guarantee.

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