FEASIBILTY STUDY OF
CHANDGANA POWER PLANT

ULAANBAATAR

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UNOFFICIAL TRANSLATION

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1. PROJECT INTRODUCTION

1.1. Project Objectives

The objective of this Project is to develop the feasibility study of the power plant to be constructed based on the Chandgana Tal coal mine located in the territory of Murun Soum, Khentii Province.

The “Chandgana Coal” LLC, which is a subsidiary company of the “Prophecy Resource Corp.” company, owns the special license for conducting exploration operation in 300 hector areas and exploitation operation in 32 hector areas of the Chandgana Tal coal deposit located in Tsaidam Nuur valley, Murun Soum, Khentii Province. The coal of the Chandgana Tal coal deposit belongs to brown coal category and is very suitable for the purpose of energy generation. Therefore, the issue of establishing a power plant based on the operations of the Chandgana Tal coal mine has been studied accordingly. The power plant to be constructed based on the coal mine is planned to have sufficient installed capacity to meet the new additional energy demand of the Central Energy System (CES) and the Eastern Regional Energy System (ERES) of Mongolia.

While developing the feasibility study of the power plant to be constructed based on the Chandgana Tal coal mine, many factors such as the present status and perspective of electric power demand and supply of the CES and ERES of Mongolia, the reserve, capacity and operational plan of the Chandgana Tal coal mine, unit capacity of the power plant equipment, standards, norms and normative to be imposed on the power plant and its equipment and technology, and environmental requirements have been taken into consideration duly.

1.2. Project legality

The Chandgana Tal coal deposit is located in the Tsaidam Nuur valley, Murun Soum, Khentii Province and situated 25 km to the west the Murun Soum center, 50 km to the east of the Jargaltkhaan Soum center, 55 km to the west of the Undurkhaan city, the Province Center, and 300 km to the east of Ulaanbaatar city respectively. The location of the deposit is shown in the Figure 1-1.

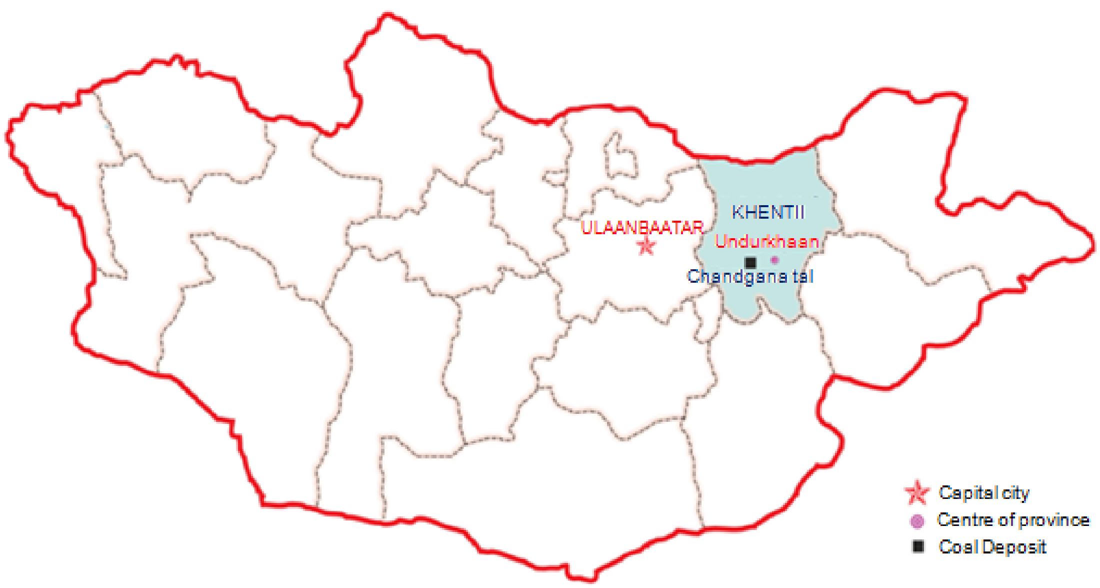


Figure 1-1. Location of Chandgana Tal coal deposit

There are four companies such as “Chandgana Coal” LLC, “Geo Erel” LLC, “Tefis Mining” LLC and “Berkh Uul” LLC, which own totally 6 exploration special licenses and 2 exploitation special licenses at this deposit area. The areas owned by these companies are shown in the Figure 1-2.

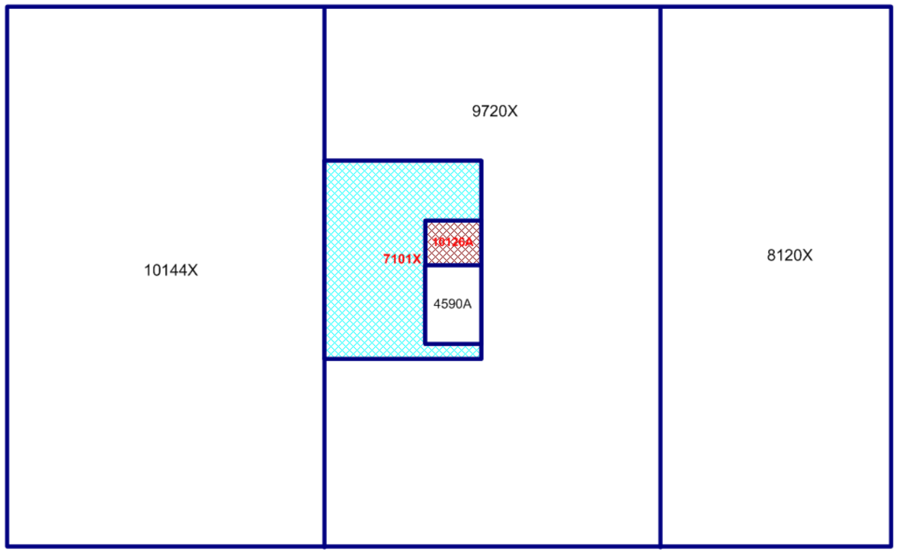


Figure 1-2. Licensed areas at the coal deposit

Out of these special licenses the "Chandgana Coal" LLC owns one exploration special license and one exploitation special license. The name, number and area size of its special licenses are shown in the Table 1-1.

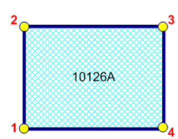
Table 1-1. Chandgana Coal LLC's licensed areas

	Name	Number	Area
1	Tsaidam Nuur	10126A	32 hectors
2	Chandgana tal	7101X	300 hectors

The geographical coordinates of the corner points of the area granted by the special licenses of the "Chandgana Coal" LLC" are shown bellow.

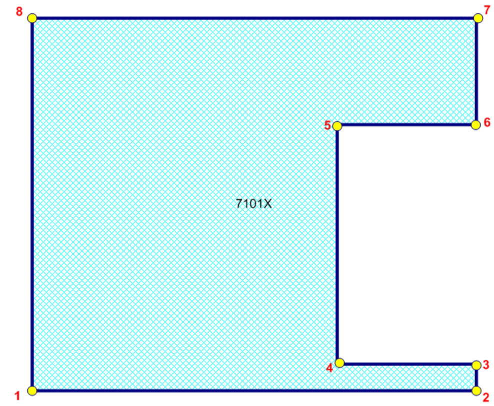
<u>Exploration license - 10126A</u>

1. 110^0 00' 57" 47^0 23' 21"
2. 110^0 00' 57" 47^0 23' 40"
3. 110^0 01' 23" 47^0 23' 40"
4. 110^0 01' 23" 47^0 23' 21"



<u>Area 32 hectors</u>

<u>Mining license - 7101X</u>



1.	110^0 00’ 00"	47^0 22’ 50"
2.	110^0 01’ 23"	47^0 22’ 50"
3.	110^0 01’ 23"	47^0 22’ 55"
4.	110^0 00’ 57"	47^0 22’ 55"
5.	110^0 00’ 57"	47^0 23’ 40"
6.	110^0 01’ 23"	47^0 23’ 40"
7.	110^0 01’ 23"	47^0 24’ 00"
8.	110^0 00’ 00"	47^0 24’ 00"

<u>Area 300 hectors</u>

1.3. Project Scope

The power plant to be constructed based on the Chandgana Tal coal deposit will have an installed capacity of 600 MW consisting of 4 blocks with 150 MW capacity each.

Within the scope of the feasibility study of this power plant the matters such as selection of basic equipment of the power plant, selection of its technique, technology and subsystems, their operational principles, the 220 kV electricity transmission line connecting the power plant to the CES and ERES, the investment required for construction of the plant and its transmission line, time required for full recovery of investment made, project’s economic profitability estimate etc. have been taken into consideration.

1.4. Study Methodology

The following study methodologies have been used for conducting the feasibility study of the Chandgana power plant:

1. The basic data required for the feasibility study of the Chandgana power plant have been developed by studying and making comparison analysis of the study works and reports such as the results of the previous geological survey works within the Chandgana coal deposit, the technical report of Chandgana Tal deposit, “Feasibility Study of the Tsaidam Nuur coal deposit” developed by “Bal Chuluu” LLC, the “Chandgana Tal coal mine. Report of detailed assessment of environmental impact” developed by “Gazar Eco” LLC.
2. The coal body model has been developed by using the SURPAC software and the data of the survey wells drilled at the Chandgana Tal coal deposit, and the scope of exploitation of the open pit mine was estimated accordingly.
3. In order to confirm the quality parameters of the coal samples were taken from 5 points and analyzed at the lab of the “Coal Test and Research Center”.
4. The preliminary survey work for determining the water resources to be used for the power plant and its potential reserve was conducted by “ECOS” LLC.
5. The general and detailed assessment of environmental impact of the power plant were done by the “ECOS” LLC and approved by the Ministry of Environment and Tourism.
6. The location of the power plant was selected. The plan and engineering and geological work of the selected site were conducted by “Barnab” LLC. Within this survey work a 1:500 scale plan map was made in totally 20 hectors land and engineering and geological conclusion was made by drilling 7 wells at the site

7. Since the Project investment and the amount of operational cost mainly depend on the scope of the Project, the technique and technology to be used, the capacity and world market prices of the related equipments, status of infrastructure development of the region, changes of world market price of fuel, raw materials, commodities and spare parts and level of manpower cost etc. the trends of the changes of the above mentioned factors have been estimated and assessed realistically.
8. For the purpose of making well grounded estimate of the economic efficiency of the Project investment, a diagram of impact of the factors has been prepared and economic and financial models have been developed further.
9. For the purpose of confirming the results of estimated final economic benefits of the Project, the Project results and the level of risks associated with the Project implementation have been estimated and the final conclusion has been made by way of determining impact of the probability of occurrence of the variable parameters of the financial model to the Project results and benefits for every 10,000 cases by Monte Carlo simulation method and by using Crystal Ball software.

2. CHANDGANA TAL COAL DEPOSIT

2.1. Location and Roads

The Chandgana Tal coal deposit is located in the eastern part of Mongolia or the Tsaidam Nuur valley, Murun Soum, Khentii Province and situated 25 km to the west the Murun Soum center, 50 km to the east of the Jargaltkhaan Soum center, 55 km to the west of the Undurkhaan city, the Province Center, and 300 km to the east of Ulaanbaatar city respectively. The Chandgana Coal LLC owns two special licenses for mineral resources exploration and exploitation covering a total area of 332 heactors of land. The location of the deposit and the location of the special license sites are shown in the Figure 2-1 and Figure 2-2 respectively.

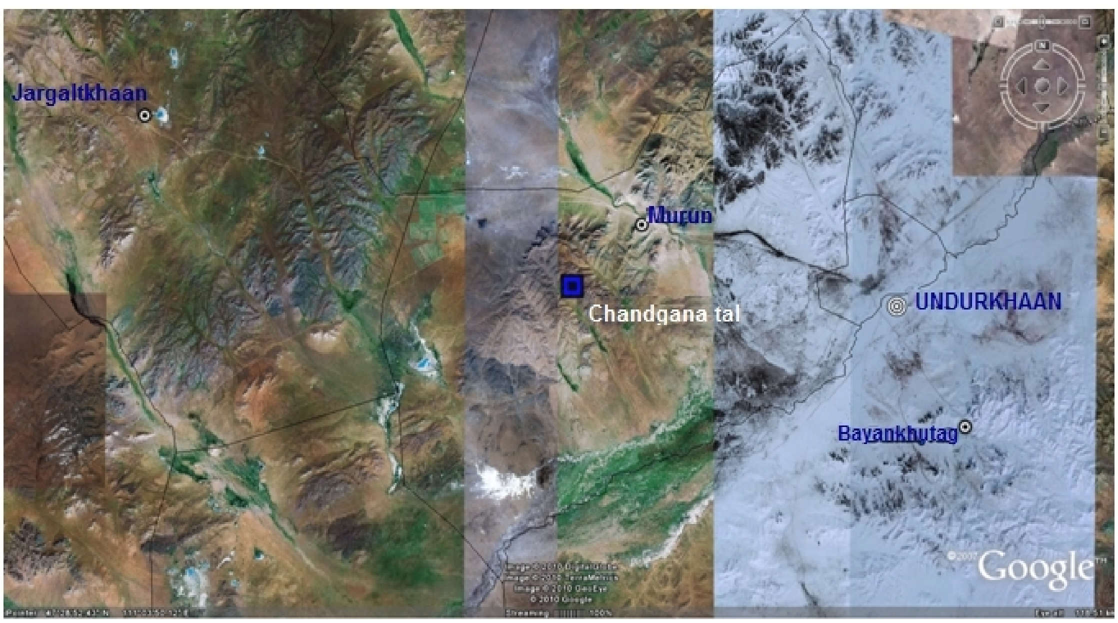


Figure 2-1. Location of deposit (by Google Earth software)

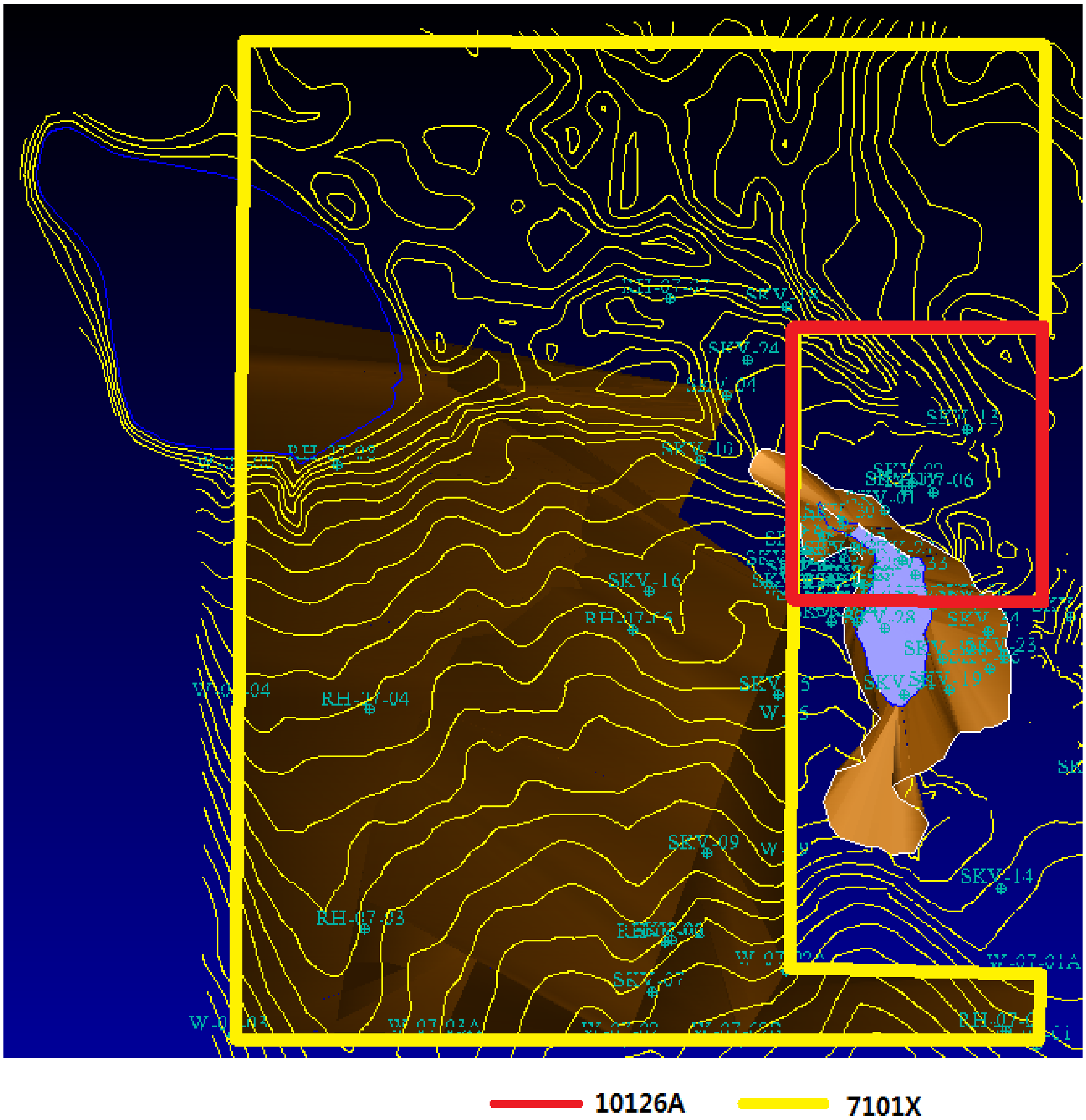


Figure 2-2. Location of licensed areas at the deposit

As far as roads are concerned the Ulaanbaatar – Undurkhaan paved road (AO501) runs at a distance of 7 km to the north of the Chandgana Tal coal mine. Therefore, it is required to use a dirt road to reach the paved road. The nearest railway station is the Baganuur station located at a distance of 180 km to the west of the deposit. The general scheme of roads is shown in the Figure 2-3.

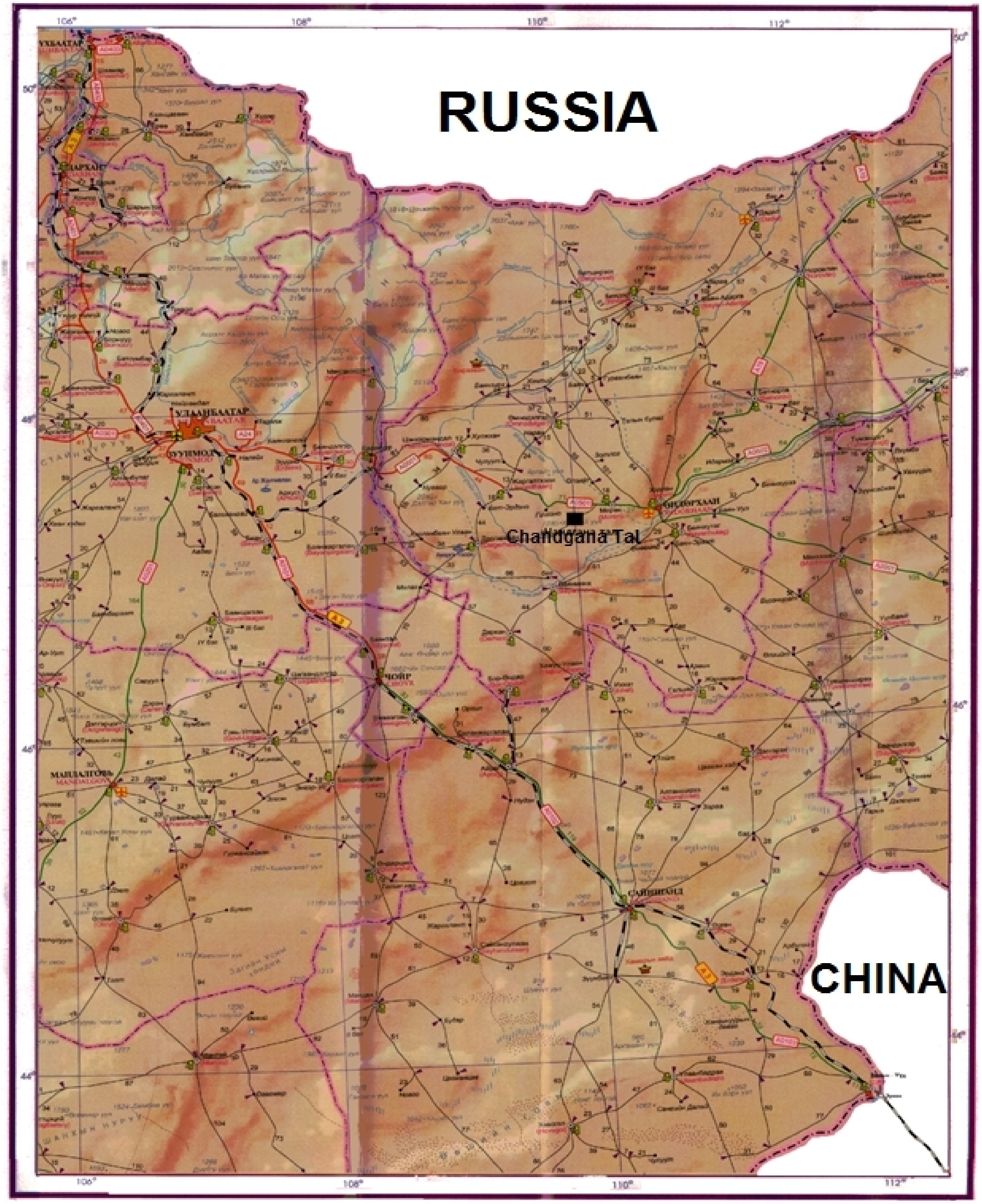


Figure 2-3. Scheme of access road and railways nearest to the deposit

2.2. Landscape

The territory of Murun Soum, Khentii Province belongs to Ulz Kherlen sub-region of Mongolian Eastern region, Asian district in terms of geomorphologic division. It is a plateau of a predominantly plain surface with small and medium mountains and with an average elevation of 1250 m above sea level.

In terms of seismic division it belongs to potential 6 -7 point earthquake zone.

In terms of natural environment division it belongs to the Khangai-Khentii mountainous region, Khunbun Tsuldan hills, lowlands, plain, dry plain of, lowland and steppe of Onon-Ulz river basin, northern dry plain sub-region, less than 10% of which is plain and less than 10% is salt marsh.

In terms of geographical formation it has planation surface and valley between mountains, elevated eroded surface in the lowland between mountains, puy, residual hills, light brown hills, fold hills and flat steppe with extremely dried planation surface. The predominant angle of steep slope of the surface is 1-6° and the distance between densely divided surface and lowland is about 1000 – 2000 m and the depth of surface division is 200-600 m.

The Chandgana Tal deposit is located in the eastern side of the Nilgiin lowland. The Nilgiin lowland has irregular profile. This lowland is divided into 3 lowlands called Undurkhan, Eastern Nilgiin and Western Nilgiin lowlands. This Nilgiin lowland joins with Bayanmunkh folds. The western mountain ridge continues for about 130 km. Its highest point is Dashbalbar mountain, which has an absolute height of 1579 km. The relative height of these mountain ridges measured from the level of the lowlands does not exceed 200-300 m. The northeastern slope is more declivous than the northwestern slope. Dashbalbar mountain has many sharp rock cliffs and many cuts. The eastern or the Khangar ridge continues for about 90-100 km and its width ranges from 7-10 km up to 15-30 km. Its highest points are Undurkhaan Ovoo and Ulaan Ovoo located near the Murun Soum area. The absolute hight is 1664 m.

2.3. Geological formation of the deposit

The systematic geological survey works of the coal deposit located in the territory of Murun Soum, Khentii Province have commebced since 1940 in a staged manner and as a result of these geological survey works the geological formation and stratigraphy of this area have been identified.

The geological formation of the region and the Chandgana Tal coal deposit identified as a result of the survey works is shown in the Figures 2-4 and 2-5 respectively.

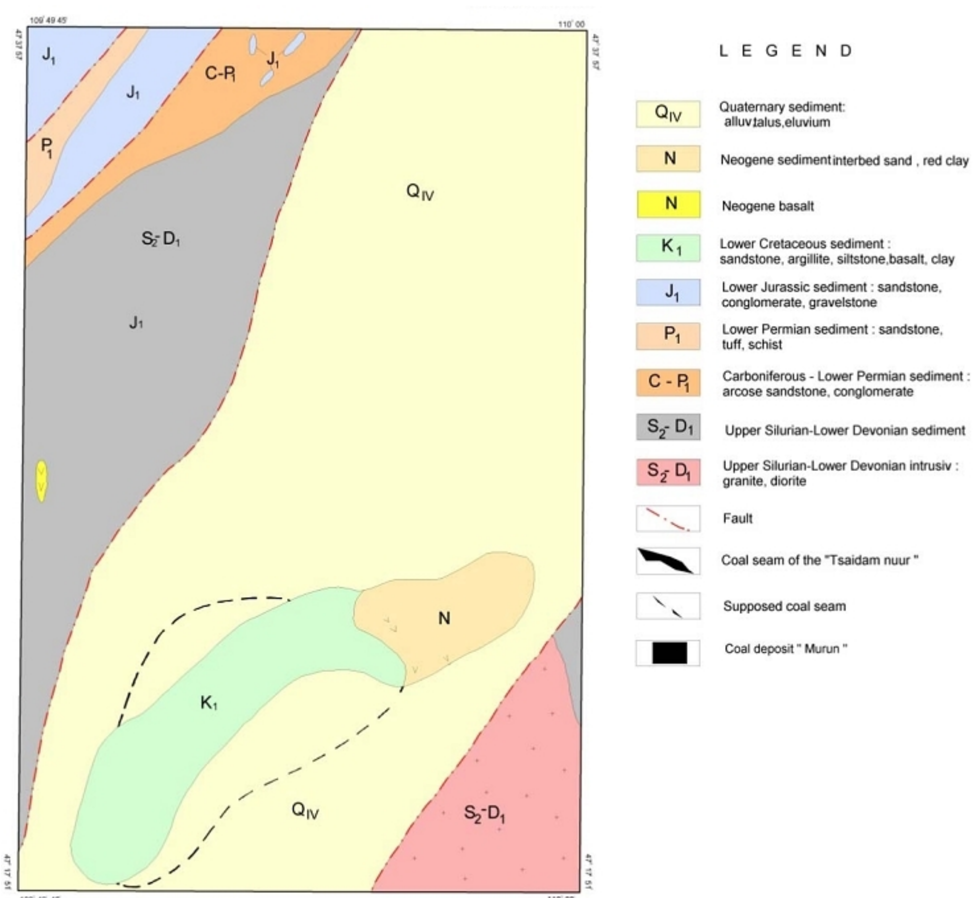


Figure 2-4 Regional geological map

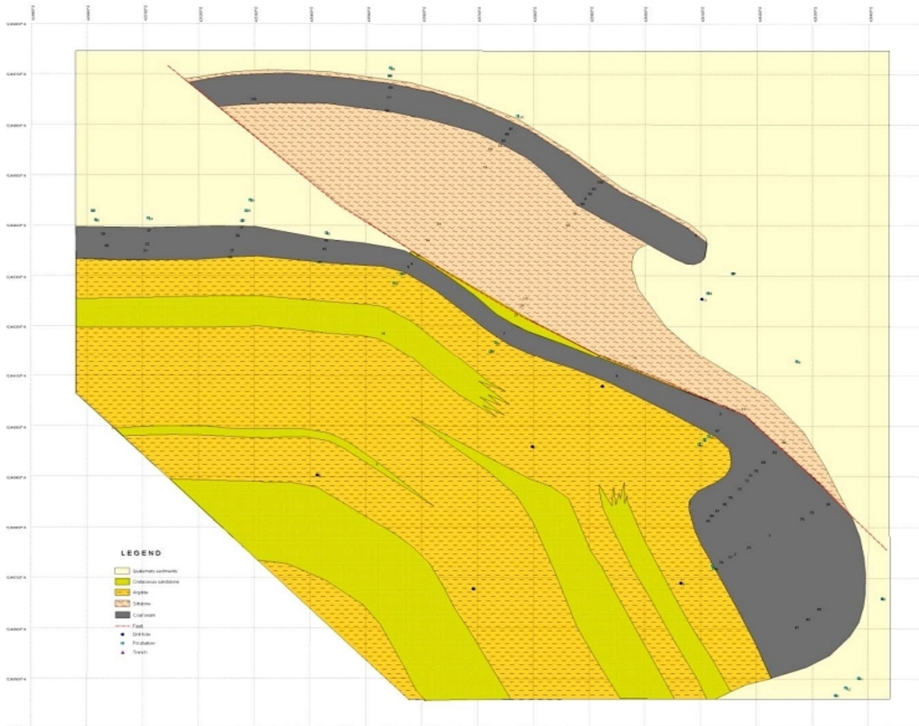


Figure 2-5. Geological map of the Chandgana Tal coal deposit

These figures show that the following sedimentary rocks and rocks of volcanic origin are wide sread in this region:

1. The rocks of phyllite type slate suite (S_2 –D) are the oldest in terms of aging and located in the western side of the Project area in a form of wide strip stretching from northwest to southeast direction. It has a form of thin sheet with yellowish grey, dark grey and greenish color. In terms of composition these rocks are quartz-feldspar-chlorite type quartz-sericite-chlorite slate.

   There is a small layer of yellowish grey and greenish gray sandstone in the upper level of the suite and also there are conglomerate layer adjoining it there. The conglomerate has greenish gray color. The gravel stones comprise of granite and quartz, jasper type rock and sandstone. The size of gravel stone ranges from 0.5-5.00 cm. This suite also has slated crystal volcanic tuff rock and dark and greenish gray porphyrite. Granite contact zone rocks are heavily metamorphosed, quartzified and has an intrusive trace. The thickness of this suite in this area is 900 m in average.

2. Arkose and silty micaceous sandstone suite ($C\text{-}P_1$) is located in the western side of the Project area in a form of wide strip stretching from northeast to north direction. In terms of composition it is composed of grauwacke consisting of quartz-feldspar dominated arkose sandstone, small grain black color sandstone and small grain conglomerate dominated silty micaceous sandstone. There is a calcified sandstone layer in the lower level of this suite and the age of this suite is determined based on it.

3. Permian sediment (P_1) is located in a small area of the northwestern side of the Project area adjoining to the Murun coal deposit directly. The Permiian sediment comprised of arkose sandstone layer and sandy-clayey slate layer alternating each other regularly. The sandstone has quartz-feldspar composition and varies grains of light gray color. The sandy-clayey slate has light and dark gray color. Among them black clayey slate can be found abundantly.

   There are 3 small layers of coal with compound texture in the middle of this suite:

   - The upper layer has 0.3-0.85 m thickness and it has two branches separated by 0.5.2.0 m thick clayey slate layer.
   - The middle layer is comprised of two packages with 0.5-1.4 m thickness. The separating rocks are 0.3-1m thick clay, sandy-clayey slate and sandstone.

- The lower layer has 0.43-0.7 m thickness and also comprised of 2 packages. The coal of this layer is metamorphosed to black clayey slate.

Ash of the upper and lower layers is high (40% -60%). Therefore they do not have any industrial importance. In case of the middle layer its thickness is relatively stable but its quality is poor and ash is 30% -50%. The total thickness of the Permian sediment of this area is 400 m in average.

4. Sandstone-conglomerate suite (J_1) is comprised of conglomerate and sandstone layers alternating each other. Some sections of the sandstone layer contains dark gray silicified slate. Conglomerate is comprised of black and light yellow color very smooth gravel stones with size of up to 10 cm. The gravel stones are composed of Paleozoic intrusive, metamorphosed sedimentary rocks, including granite, quartz porphyry, felsites porphyry, porphyrite, clayey and silicified slate, Permian sandstone, hornblende-phyllite type slate, jasper and quartz. The age of this suite is determined to be Lower Jurassic age.

5. Lower Cretaceous sediment is widely spread in this area and classified into the following three basic suites from bottom to the top:
    - Shariliin suite (C^{sh});
    - Tsagaantsav suite (C^{cc});
    - Zuunbayan suite (C^{dz}).

The rocks of these suites fill wide lowland and occupy most section of the region.

The lower layer of the Shariliin suite conglomerate has up to 300 m thickness and its upper sandy-clayey sub-suite has several tens of meters. The conglomerate body is comprised of bright red, red, orange and yellowish clay saturated with small gravels.

The upper sub-suite is comprised of brownish red color, up to 1 m thick clay with bright purple conglomerate layer.

The Tsagaantsav suite is comprised of effusive rocks such as volcanic rock, andesite volcanic rock, quartz porphyry and tuff. There is small amount of gray color dense argillite, black clayey slate and gray color small grain sandstone among these effusive rocks. The total thickness of this suite is 500 m.

The Zuunbayan suite is divided into two sub-suites. The lower dark gray sub-suite is not discovered in this area, but it is comprised of the following rocks:

- 45-62 m thick grayish blue and greenish gray color limestone-argillite containing limestone, sandstone and small amount of conglomerate;
- clayey slate body containing limestone layer;
- Clayey package with gray color clay.

The thickness of this lower dark gray sub-suite is 170-250 m. The upper greenish gray sub-suite (C^{dz2}) is divided into a 60-80m thick lower body and a 120-150 m thick upper body in terms of lithological composition.The lower body consists of gray color large grain sandstone and the upper body consists of dark gray argillite and alevrolite respectively. Totally 5 coal seam I, II, II, IV and V have been discovered in this suite. Thickness:

- I seam - 1-0.35 m thickness;
- II seam - 30.45-49.95 m;
- III seam - 0.2-2 m;
- IV seam - 0.1-0.7m;

- V seam – 0.15 m.

The thickness of the upper greenish gray sub suite is 200-220 m.

6. Tertiary sediment (T_1) is widely spread in central and northwestern section of the Project area. It is comprised of red color clay containing clay, loamy sand and low density large grain sand layer of the same color. The clay contains significant amount of sand and it can be very good construction raw material. The thickness of the clay in the central section reaches up to 30m but it increases towards the northeastern direction reaching 37.5 m. Also the average sand content increases to the same direction reaching 18.25 m. Besides sedimentary rocks the Tertiary sediment has effusive rocks as well.

7. Quaternary sediment (Q) in this area consists of alluvial, lake, proluvial-deluvial and eluvial sediments.

   The alluvial sediment is divided into 2 sections. The inner valley alluvial consists of slightly smoothed large grain gravel and large grain sandstone.

   The alluvial of the Murun river valley consists of small grain sand with gray clay lens in its upper section and large grain sand in its lower section. The sediment of lake origin consists of gray color clayey material with up to 10 m thickness.

   The clay and loamy sand of the lake sediment has single type regular composition but it is not spread widely. It is located mostly in the central section of the lowland in a form of narrow strip around small lake.

   The proluvial deluvial sediment is spread the most widely in this area and has various thicknesses. The large grain material cemented by loamy sand is polluted by small grain sharp edge fragments of various rocks.

Eluvial sediment has limited spread and it located in the water basin and some elevated places. Its total thickness is up to 3 m.

Intrusive and bedded rock is spread in the southeastern section of this area and consists of large grain granite massif.

The granite massif called Murun massif consists of two intrusive rocks such as gray and reddish brown color biotite cataclasised granite with smooth crystals and granite-diorite. Their boundary is clear and neither of them has been affected by contact change.

Paleozoic complex bedded rocks such as spessarite, diorite-porphyry, kersantite, felsites, malachite aplite are spread widely here. These rocks cross Paleozoic rocks as well besides the Permian suite, which contains granite and coal. These rocks are related to the post-Permian younger granite, which is spread widely in the area next neighboring with the region.

2.4. Deposit Tectonic

The stretch of the coal and coal containg rocks changes by 95-100˚ azimuth from east to southeastern direction and its decline changes by 5-8˚ from south to southwestern direction. A large cleavage with up to 10 m displacement can be observed.

The main element determining the structure of this area is the large graben, which is the northeastern end of the Bayanmunkh fold of the Nilgiin lowland. Its descended central section comprised of quite declivous brahisinclinal folded Cretaceous sediment, which is stretched along the northeastern direction and which's rock decline angle reaches 4-6˚ in the wing of the fold. The Cretaceous sediment in the brahisinclinal fold wing is fluctuation the major tectonic cleavages surrounding this graben has not been defined in detail, the thickness of the Cretaceous sediment shows that the scope of the fluctuation of the above tectonic cleavage is not less than 1000 m.

The Paleozoic rocks forming the wing of the graben have 40-60˚ decline. The location condition of the Paleozoic rock has a complex form depending on the two tectonic damages of cast type in northwestern section of the area. The Tertiary age red color sandy-clayey sediment is located on top of Paleozoic and Mesozoic rock in a horizontal position as a spot. The low density Quaternary sediment located in a horizontal position is spread widely covering over almost all the areas of Paleozoic, Mesozoic and Tertiary sediments.

2.5. Coal Reserve

There are 5 coal layers with 30-50 m thickness have been identified in this deposit and they are numbered from I down to V. Out of these five seam the number II seam has the highest thickness and can be considered as commercial discovery. The specifics and description of each coal seam have been given briefly as follows:

- <u>I seam.</u> This seam is located in the uppermost section and its average thickness is 0.35 m. This seam is not stable and occurred just in several sections of the deposit. Generally this seam is located on top of the layer II at an elevation of 45 m higher than the II seam.
- <u>II seam</u>. This seam has mixed composition consisting of many packages separated by 0.1-2.0 m distance between each other (the thicker sections are located in the eastern side and thinner sections are located in the western side). The overall thickness of this seam ranges from 30.45 up to 49.95 m.

- III seam. This seam is located 1.2-6.0 m lower than the seam II. The thickness of this seam ranges between 0.2 to 2.0 m. The results of the previous drilling works showed that this seam is wide spread in the western side of this deposit but there is no information that this seam exists in the eastern section.
- IV seam. This seam is located 20-23 m above the seam III. The thickness of this seam is relatively thin and mostly less than 1 m. Its thickness belongs to unstable category.
- V seam. This seam is located 5 m lower than the seam IV. This seam has not occurred in most of the drilling wells. In those wells where it has been discovered its thickness was less than 1 m.

The cross sections of the coal seam have been shown in the Figure 2-6 and the thicknesses of the coal seam have been shown in the Figure 2-7 respectively.

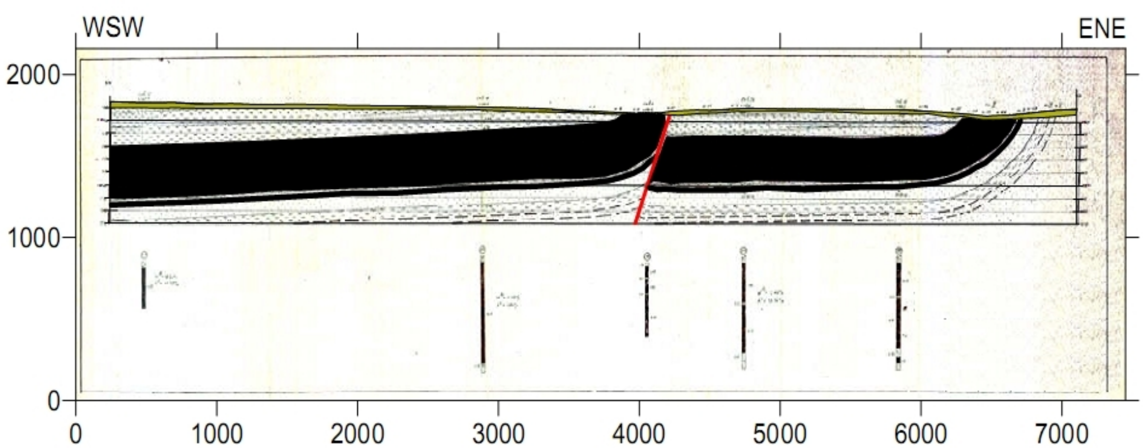


Figure 2-6. Cross section of coal seam

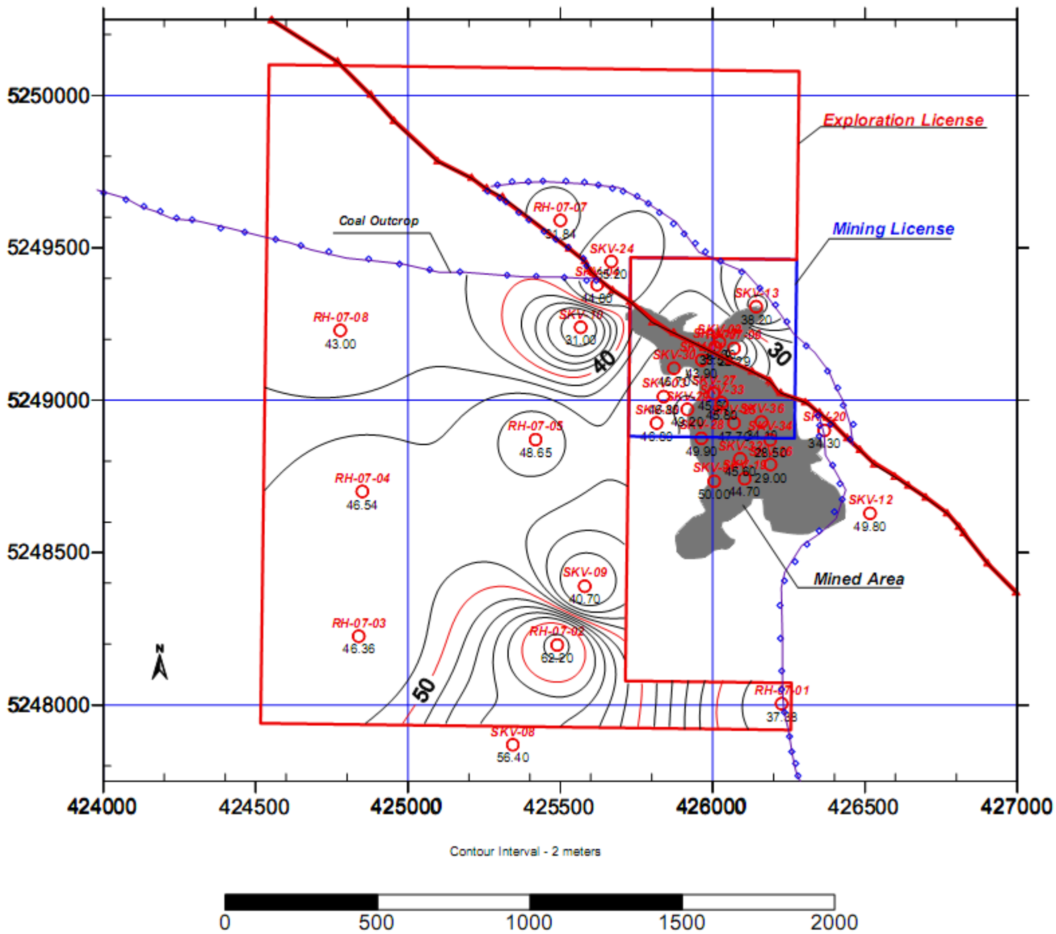


Figure 2-7. Coal seam thicknesses

The coal reserve of the Chandgana Tal deposit identified based on the results of the drilling works conducted there is shown in the Table 2-1 below.

Table 2-1. Coal reserve of the Chandgana Tal deposit

Unit: million tons

Area	Measured and identified reserve	Estimated	Total
Mining licensed area	9.3	-	9.3
Exploration licensed area	132.0	-	132.0
Total	**141.3**	**-**	**141.3**

Source: Technical Report on the Coal Resources of the Chandgana Tal Coal Project Khentii Aimag (Province) Mongolia, Behre Dolbear & Company (USA), Inc., page 49

3. ENERGY DEMAND AND SUPPLY

3.1. Brief Introduction of the Energy System

The energy sector of Mongolia consists of the Central Energy System (CES), Eastern Regional Energy System (ERES), Western Regional Energy System (WRES) and the Altai-Uliastai Energy System. The energy demand of those provinces, soums and urban areas which have not been connected to the centralized energy system is met by independent thermal and diesel power plants. The general scheme of the energy sector is shown in the Figure 3.1.

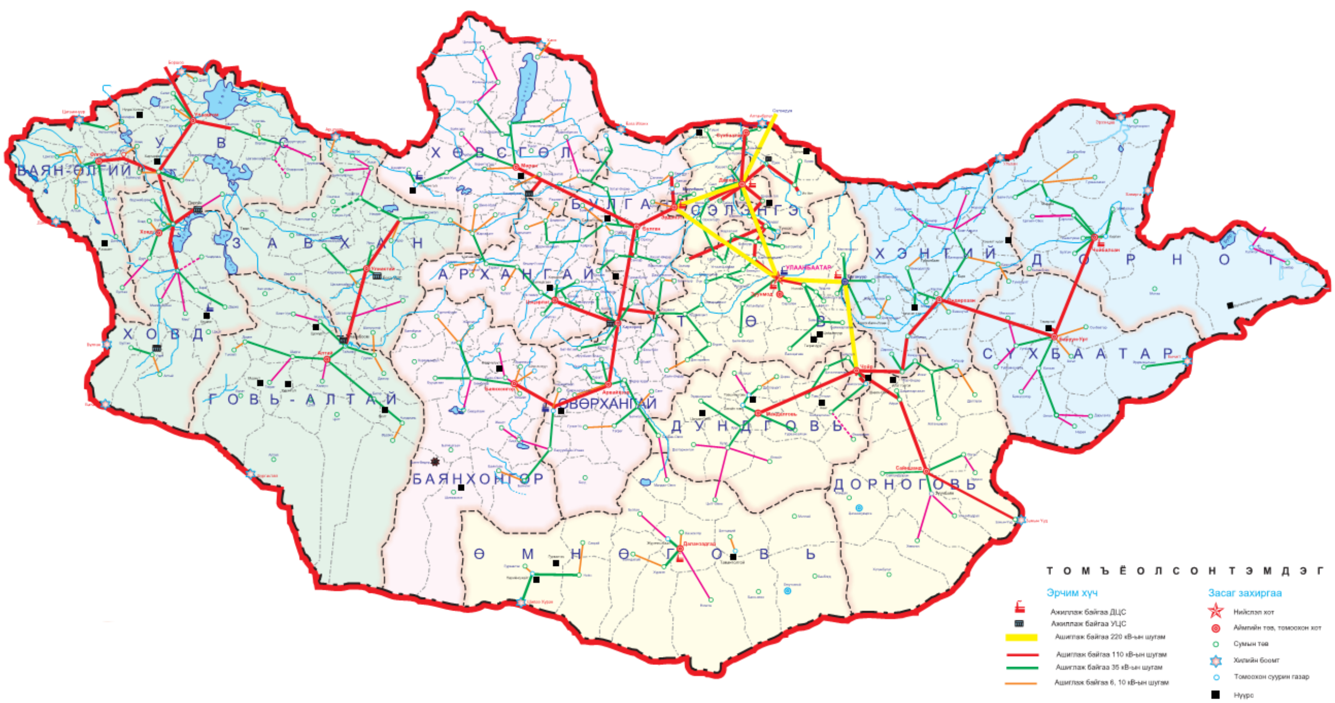


Figure 3-1. Mongolian Energy System

The WRES provides the province centers and soums of Uvs, Khovd, Bayan-Ulgii aomags with imported electricity from Krasnoyarsk, Russia and the the electricity produced by the Durgun hydro-power plant. The average annual consumption of this region is about 60.0 million kWh. The peak load in winter season is about 14.0 MW and the lowest load in summer season is about 900 kW respectively.

The ERES is based on Choibalsan thermal power plant and provides the province centers and 12 soums of Dornod and Sukhbaatar provinces with electricity. The Choibalsan power plant was put into operation in 1970 and has an installed capacity of 36 MW. The peak load of the ERES is 21 MW. It produced 97.0 million kWh electric energy and distributed 77.0 million kWh electricity to the customers in 2009.

The CES consists of 5 power plants, one transmission network and 4 distribution networks and it provides Ulaanbaatar, Darkhan and Erdenet cities, 13 province centers and over 270 soums with electricity. The total production capacity of this system is 974.3 MW.

The Chandgana power plant will be connected to the CES and ERES systems and cooperates with them. Therefore, the demand and supply of these two systems have been studied accordingly.

3.2. CES Power demand and supply

3.2.1. General

Totally 91% of the electricity production is produced by the CES and 96% of the electricity demand of the country is met by the CES. This system consists of five power plants such as the Ulaanbaatar power plants No. 2, No.3 and No.4, Darkhan city power plant and Erdenet city power plant, the central region power transmission network as well as power distribution networks of Ulaanbaatar, Darkhan, Erdenet and Baganuur. This system provides over Ulaanbaatar, Darkhan, Erdenet, Baganuur cities and over 270 soums of Tuv, Dundgobi, Dornogobi, Arkhangai, Khentii, Selenge, Bulgan, Uvurkhangai, Khuvsgul, Bayankhongor and Gobi-Sumber provinceas.

The power plants of the CES used to have a centralized control and management until 2001 and reorganized into 18 companies with different operations such as production, transmission, distribution and supply.

The holders of special licenses for production, transmission, distribution and supply operate within the framework of “single customer model” approved by the Energy Regulatory Authority (ERA). In other words, a single customer called Central Regional Electricity Transmission Grid (CRETG), a state owned shareholding company has been purchasing electricity from 5 power plants and the electricity imported from Russia and reselling to 9 electricity distribution companies since September 2002.

The revenue collected from the customers of the central region has been allocated by the bank automatically everyday to the “zero balance” revenue accounts and to the accounts of the producers, transmission companies and distributors according to the preestablished percentage through a consolidated account. This percentage is preestablished by the “meeting of the holders of special licenses”, which has representations of all the 10 special license holders involved in the regulation of the electricity payment cash flow. The single buyer model is shown in the Figure 3-2.

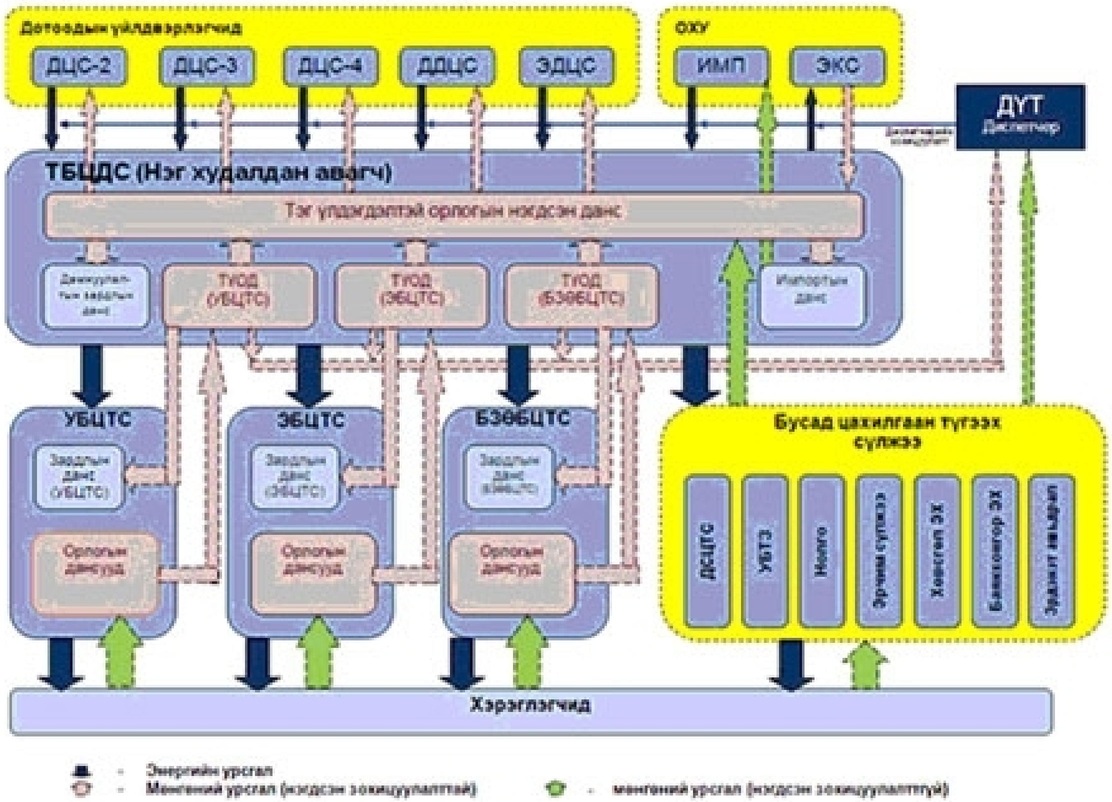


Figure 3-2. Single buyer model

3.2.2. CES's power plants and electricity generation

The present total installed capacity of the CES is 794.3 MW. The basic technical parameters of the power plants are shown in the Table 3-1.

Table 3-1. Power plants of CES

Power plants	Year of establishment	Installed capacity, MW	Potential capacity, MW	Internal demand, %	Thermal capacity, GCal/h
TPP – 2	1961 – 1969	21.5	18.0	16.4 %	31.0
TPP – 3	1968 – 1982	136.0	107.4	21.0 %	518.0
TPP – 4	1983 – 1991	560.0	460.1	14.8 %	1045.0
Darkhan PTT	1966, 1986	48.0	39.1	18.5 %	181.0
Erdenet TPP	1987 – 1989	28.8	22.2	22.8 %	120.0
Total		794.3	646.8		1895.0

Since all the existing thermal power plants of the CES are coal fed, designed to operate at basic load mode or regime and have less capability to regulate load and frequency at peak loa, electricity is imported from Russian Federation in order to meet and regulate the electricity demand of the system.

The total capacity of the two lines to import electricity from Russia is 300 MW. They are connected to Darkhan sub-station of the 220/110/35 kW CES. According to the agreement between the CES and the Russian Federation it is possible to import 120-160 MW electricy at any time.

The electricity production and distribution of CES is shown in the figure 3-3. This Figure shows that the average annual growth of CES electricity production between 1996 and 2009 is about 3.7%.

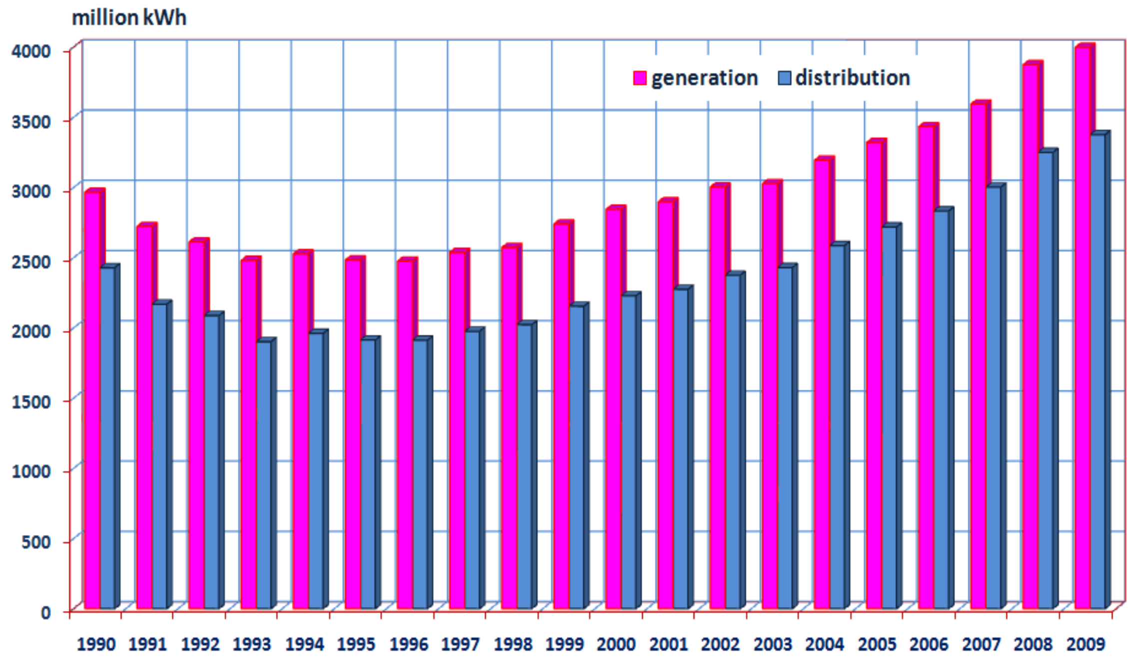


Figure 3-3. Electricity generation and distribution of CES

The peak load of the CES has been increasing year by year due to electricity demand reaching 673 MW in 2008 and 693 MW in 2009 respectively. The peak load of 2009 increased by 3% compared with 2008. The peak load survey of CES is shown in the Figure 3-4.

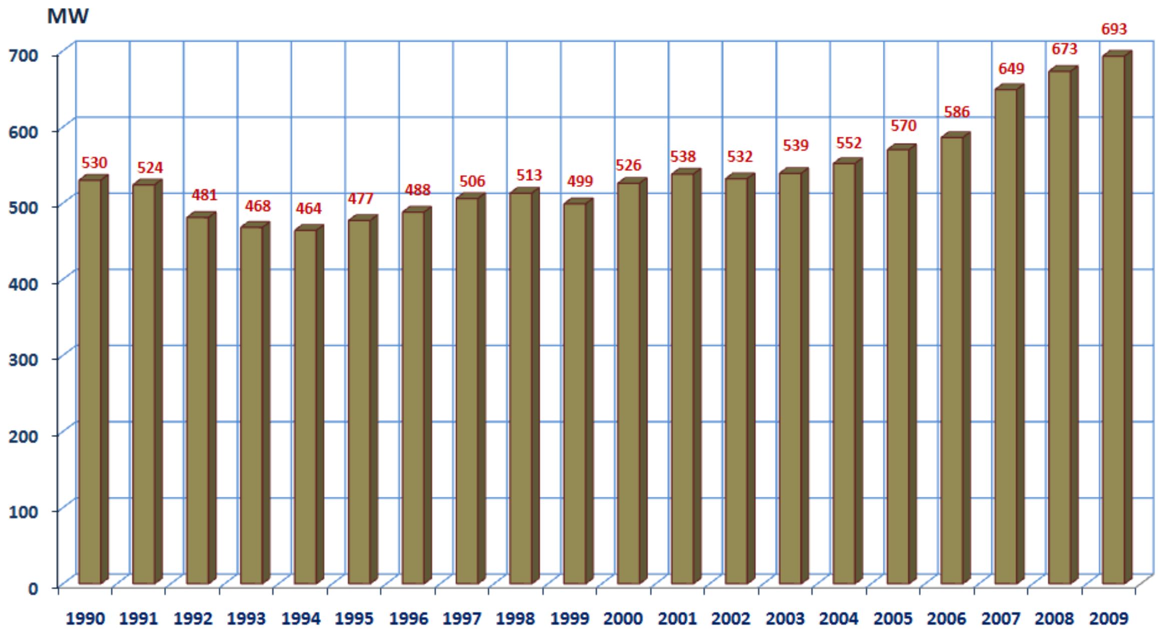


Figure 3-4. Peak Load of CES

In order to cover the peak load and regulate its frequency electricity is imported from Russia. As a result of the technical modernization of the power plants the volume of electricity imported from Russia has been reduced since 1999, however, due to the increase of the electricity demand the import volume tends to increase since 2006. The changes of import and export of CES are shown in the Figure 3-5.

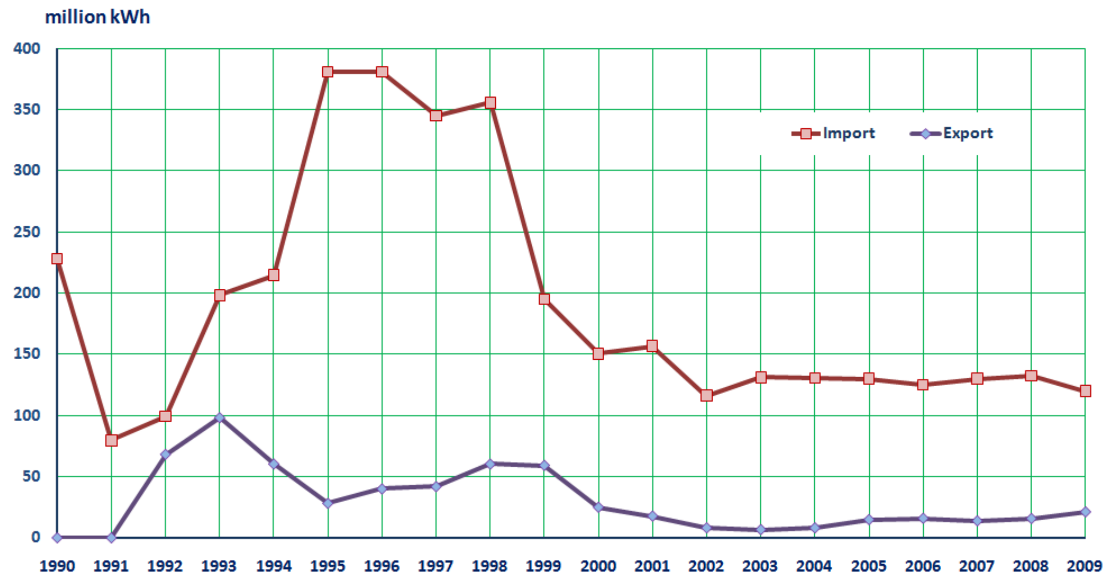


Figure 3-5. Import and Export of CES

3.2.3. CES Transmission Grid

The CES basic transmission grid consists of the 220 kV and 110 kV overhead transmission lines (OHTL) and substations constructed mostly by the design of Russian Federation. As of today the CES uses 1044 km long 220 kV and 38196 km long 110 kV OHTL as well as six 220 kW and fifty four 110 kV substations respectively. The basic 220 kV and 110 kV electricity transmission grid of the CES is shown in the Figure 3-6.

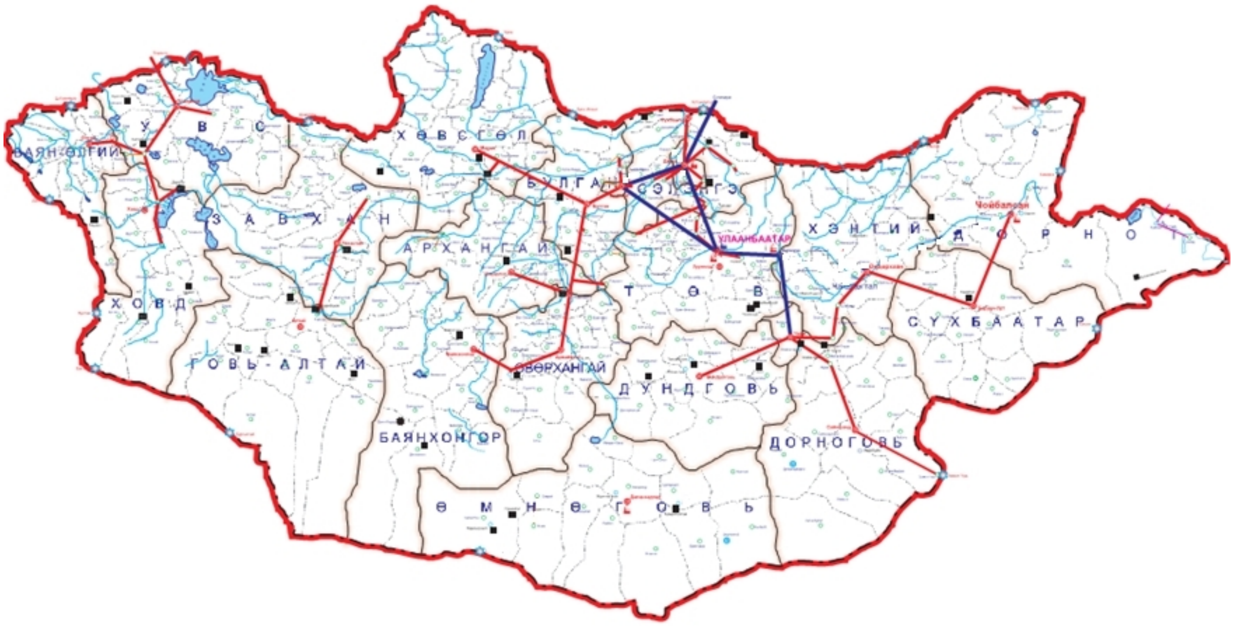


Figure 3- 6. The 220 kV and 110 KV OHTL

The 220 kV OHTLs were constructed during the period between 1976 and 1996. They have one AC type aluminum wire for each phase and 15 pieces of isolators per each wire according to the requirements of Russian design. The aluminum wires with 240 mm^2, 300 mm^2 and 400 mm^2 cross sections are used as transmission wire. All the 220 kV OHTLs were built with iron supports.

But the Darkhan – Ulaanbaatar, Baganuur-Choir and Choir-Mandalgobi OTLs have combined reinforced concrete and iron supports. Reinforced concrete supports have been used since 1983 and they are constructed according to the Russian design. This reinforced concrete structure is desined to have a possibility of hanging only one circuit line for each support and each phase has one wire.

3.2.4. Electricity Tariff

According to the 2001 Mongolian Law on Energy the tariffs of the electric energy are reviewd and adopted by the Energy Regulatory Authority (ERA). The Article 26 of the Mongolian Law on Energy states that the ERA shall adhere to the following principles while determining the tariffs of the special license holders:

1. To be based on the real cost and expenses of operations;
2. To allocate costs and expenses for each category of customer in consistency with the requirements of the customers on electricity and heating supply;
3. To be able to regulate energy consumption
4. To emsure stability of prices;
5. The revenue of a special license holder shall be sufficient to keep its financial capability at normal level;
6. The structure of tariffs of electricity and heat shall be clear and simple for the customers;
7. Energy production, transmission, distribution, supply and dispatcher regulation operations shall adhere to the principle of having the least expensive cost in consistency with the requirements of technological reliability;
8. The cost shall be based on the performance of the expenses incurred in recent years and the structure of the cost shall not include future investment to be made and depreciation to be calculated for modernization cost.

The existing electricity tariff for business entities and organizations is 79.80 MNT per kW/h, 77.00 MNT per kW/h for residential ger area households and 79.80 MNT per kW/h for residential apartment building households respectively.

The breakdown of tariff structure of the electricity sold to the customers shows that 59.85% of the retail price of electricity covers production cost, 2.14% covers transmission loss, 3.95% covers transmission cost, 11.11% covers distribution loss, 18.68% covers distribution cost and 4.26% covers supply cost respectively (See Table 3-2 and Figure 3-7).

Table 3-2. Structure of retail prices of CES electricity

Unit: MNT/kWh

Production cost	Transmission		Distribution		Supply cost	Customer price Loss
	Loss	Cost	Loss	Cost		
47.77	1.71	3.15	8.87	14.91	47.77	1.71
59.85%	2.14%	3.95%	11.11%	18.68%	59.85%	2.14%

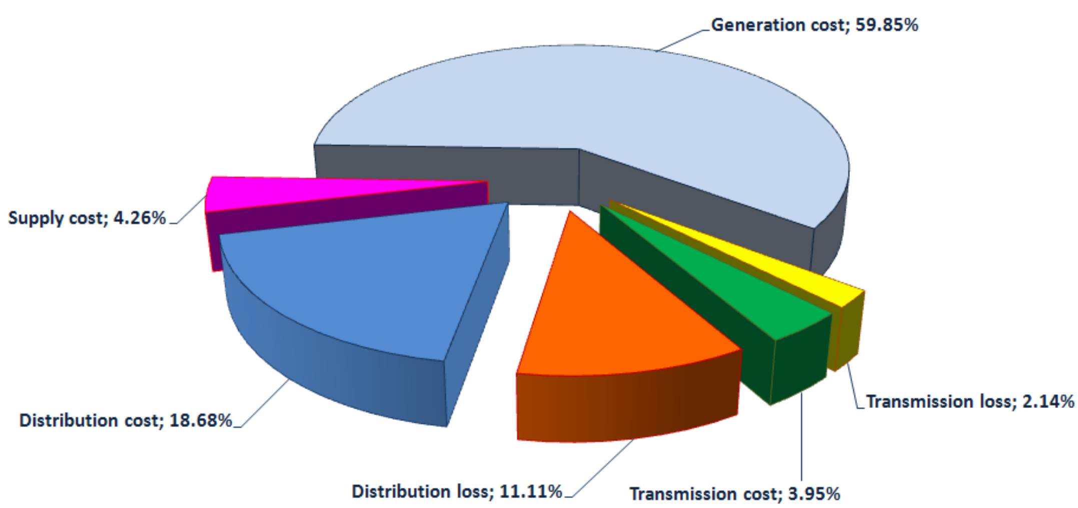
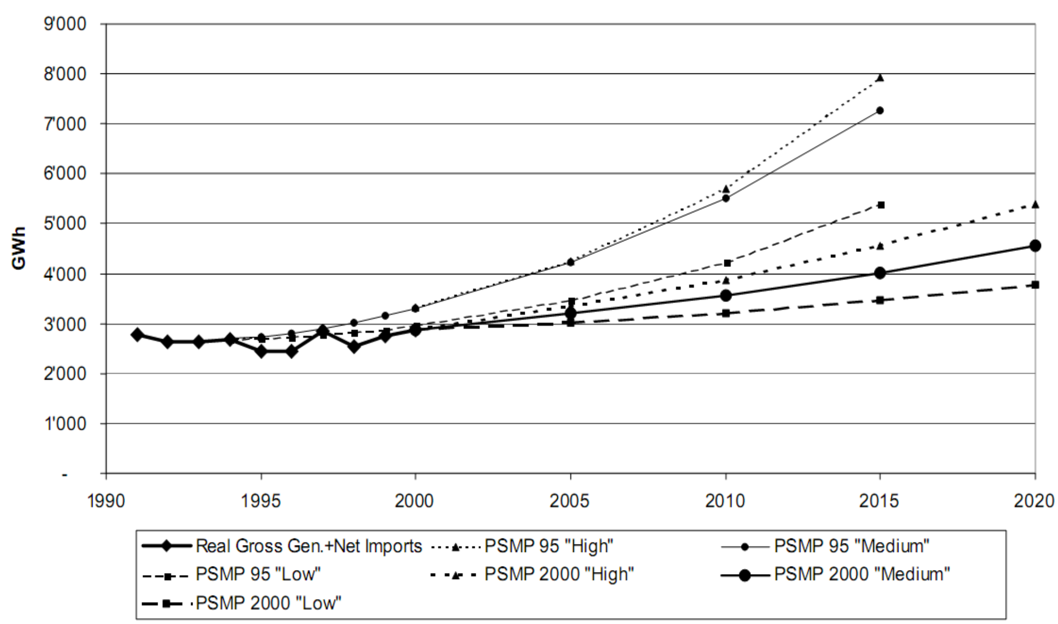


Figure 3-7. Structure of electricity retail price of CES

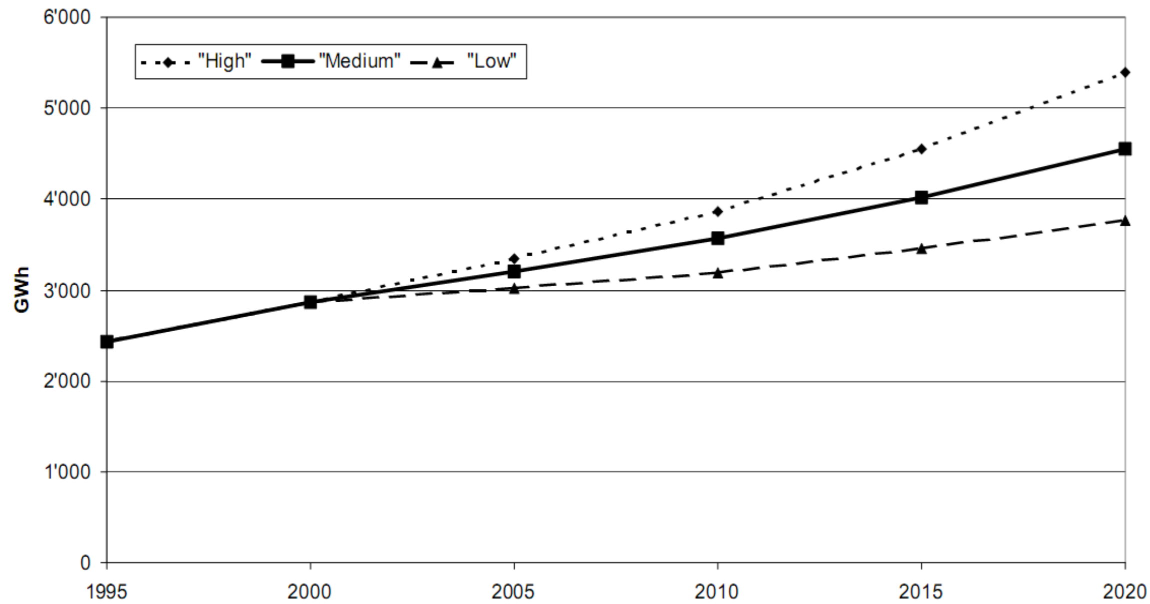
3.2.5. Future perspective

Numerous study works have been conducted and the Master plan has been developed concerning the future perspective of the demand and supply of CES electricity. The reports of 1995 “Energy Sector Master Plan” and 2002 “Report on Improvement of Energy Sector Potential” reflected the electricity consumption, production and volume of peak load of the CES in three different growth rates such as high, medium and low growth rate as shown in the Figure 3-8 through Figure 3-10.

These estimates were made based on 2000 CES indicators. The average annual electricity production growth is estimated to be 3.2% in case of high growth rate, 2.3% in case of medium grouth rate and 1.4% in case of low grouth rate respectively. The grouth rates were estimated based on the assumption that the electricity and heating system operations would be profitable and the energy saving would improve profitability in the energy demand and consumption side.

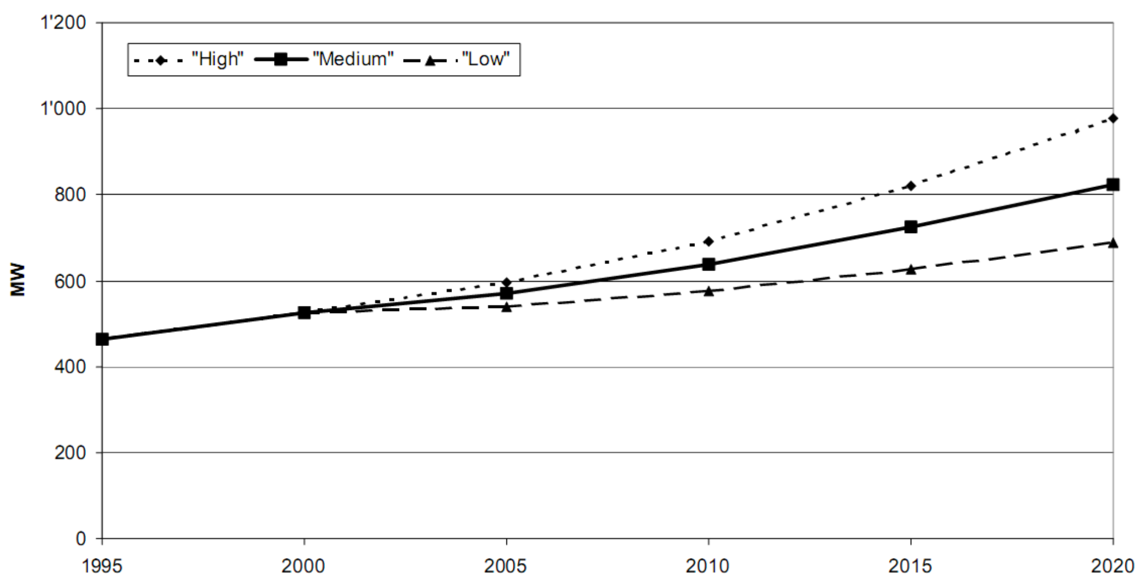


Source: Capacity Building for Energy Planning, ADB research report



Source: Capacity Building for Energy Planning, ADB research report

Figure 3-9. Forecast of Gross Generation for CES, GWh



Source: Capacity Building for Energy Planning, ADB research report

Figure 3-10. Forecast of Gross Peak Load for CES, MW

Actually, the CES electricity production reached 3,998 million kWh and the peak load reached 693 MW in 2009, which was similar to the estimate with “high” growth rate.

The estimate of CES electricity demand and supply perspective was made based on the existing production capacity, electricity peak load of CES as well as the perspective of new demand of CES electricity. The result of the estimate is shown in the Table 3-3.

Table 3-3. Perspective of CES electricity demand and supply

		2010	2011	2012	2013	2014	2015
1	Generation capacity	656	656	656	656	638	638
1.1	Power Plant #2, MW	18	18	18	18	18	18
1.2	Power Plant #3, MW	110	110	110	110	80	80
1.3	Power Plant #4, MW	460	460	460	460	460	460
1.4	Darkhan Power Plant, MW	42	42	42	42	54	54
1.5	Erdenet Power Plant, MW	26	26	26	26	26	26
2	Demand	711	768	964	1166	1297	1375
2.1	Existing peak load, MW	711	768	829	896	967	1045
2.2	New Potential Customer						
	Ulaanbaatar area, MW			60	120	150	150
	Darkhan-Selenge area, MW			25	50	80	80
	Erdenet-Bulgan area, MW			50	100	100	100
3	Deficit of capacity, MW	-55	-112	-308	-510	-659	-737
4	Required capacity						
4.1	Import, MW	120	120	120	120	120	120
4.2	Required capacity of new power plant, MW	0	0	-188	-390	-539	-617

This Table shows that 188 MW electricity deficit will occur by 2012 and 617 MW shortage will occur by 2015 in case if a new source of electricity production will not be put into operation.

3.3. Electricity demand and supply of Eastern Regional Energy System

3.3.1. General

The ERES includes Dornod province central power plant, 185 km long high voltage electricity transmission line connecting Dornod and Sukhbaatar provinces as well as two 110/35/6 kV substations. As of 2009 ERES produced 97.0 million kWh electricity and distributed 77.0 million kWh electricity annually. The installed capacity of the power plant is 36 MW and the peak load in winter season reaches 21 MW.

In 1929 the Russian workers' cultural center installed the first time small capacity diesel station, which lighted the first electric lamp in Choibalsan city and placed the beginning of use of electric energy.

The joint decision of the governments of the People's Republic of Mongolia and the USSR to establish the first 12 MW capacity power plant in Choibalsan city with the technical and economic assistance of the USSR was made on 19th April 1965 and the foundation of the power plant was established on 17th June 1967. Three furnaces of TP-35Y type 2 turbines of AP-6-35-5 type were installed as a first line of the power plant during the period 1967- 1970. Further expansion of power plant was done during the period 1979-1982 by installing three new BKZ-75-39/fb type furnaces and two PT12-35/10 model turbogenerators and the installed capacity of the power plant was increased to 36MW electricity and 173.5 Gcal/h heat capacity. This power plant was modernized by using German loan fund during the period 1998-2002.

The "Eastern Region Energy System", a state owned shareholding company (ERES SC) was established on 9th July 2001 by the Mongolian Government Resolution No.164.

3.3.2. Present status of ERES

As of today the ERES SC provides totally 11,221 households of 22 soums, organizations and mining and concentration factories of 4 mining companies (“Emeelt Mines” LLC, Shin Shin LLC, Shanlun LLC and Tsairt Mineral LLC”) of Dornod and Sukhbaatar provinces with electricity. 3 soums are supplied with imported electricity from Russia and China and one soum uses wind energy. The electricity scheme of ERES is shown in the figure 3-11.

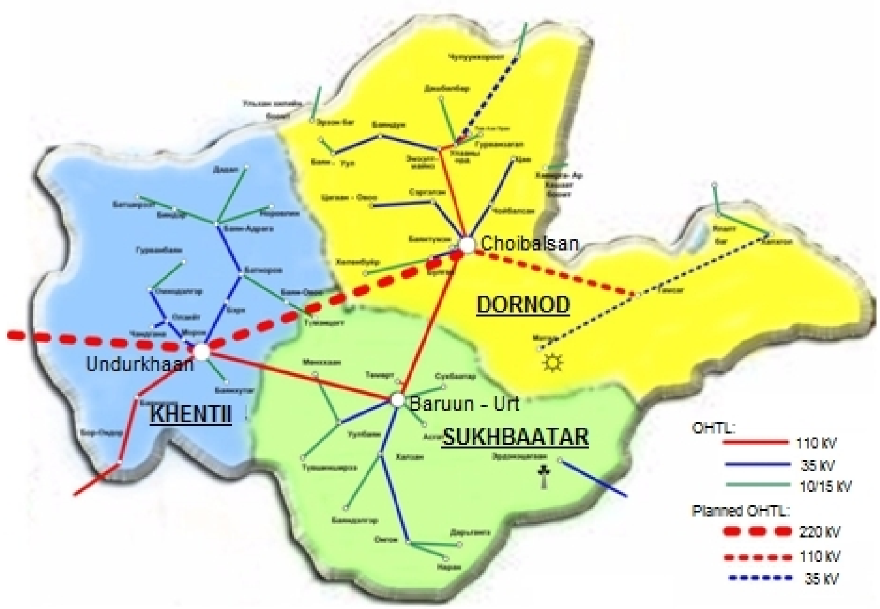
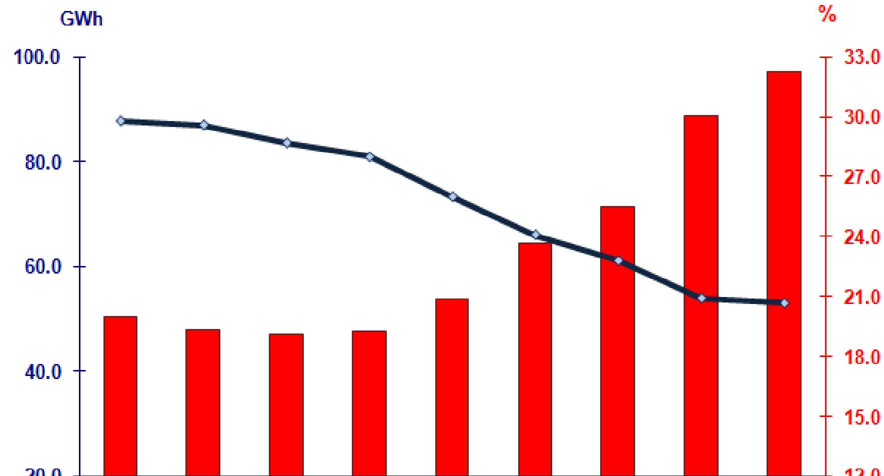


Figure 3-11. ERES Transmission line scheme

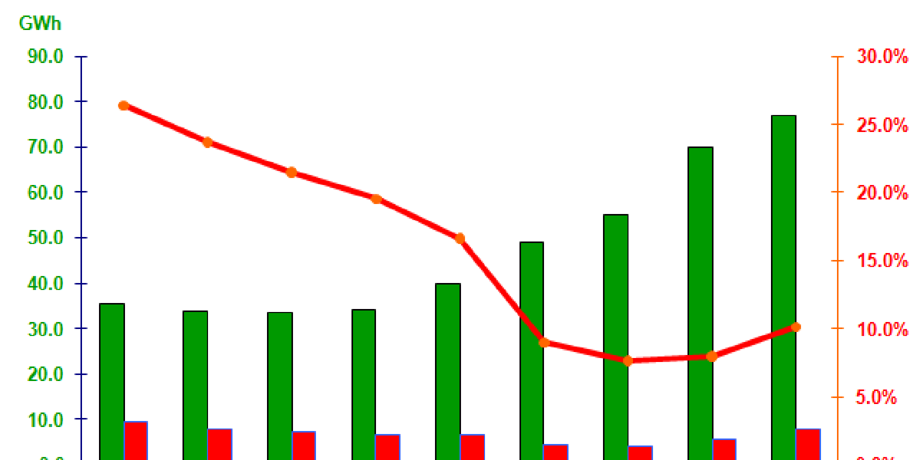
As a result of the modernization of the power plant by using German government loan fund during the period between 1998 – 2002 not only the reliability of and volume of electricity produced by the power plant was improved but also the power plant’s internal consumption of electric energy has been reduced significantly year by year. The production and internal consumption of electricity are shown in the Figure 3-12.



	2001	2002	2003	2004	2005	2006	2007	2008	2009
Generation	50.5	48.0	47.0	47.6	53.8	64.5	71.3	88.6	97.0
In house use	29.80	29.60	28.70	28.00	26.00	24.10	22.80	20.92	20.67

Figure 3-12. Electricity Generation and inhouse use of ERES power plant

About 8 % of the electricity produced by this power plant is lost during distribution process. (See the Figure 3-13).



	2001	2002	2003	2004	2005	2006	2007	2008	2009
Distribution	35.4	33.8	33.5	34.3	39.8	49.0	55.1	70.1	77.0
Distribution loss	9.3	8.0	7.2	6.7	6.6	4.4	4.2	5.6	7.8
Distribution loss	26.4%	23.7%	21.5%	19.5%	16.6%	9.0%	7.6%	8.0%	10.1%

Figure 3-13. Electricity distribution and distribution losses of the ERES

About 44.5% of the electricity produced by the ERES SC is consumed by Dornod province, 20.9% by Sukhbaatar province, 26.6% by the Tumurt Zinc Mine and 8.0% by the other mining companies such as the Tsav, Emeelt Mines LLC, Xin Xin LLC respectively.

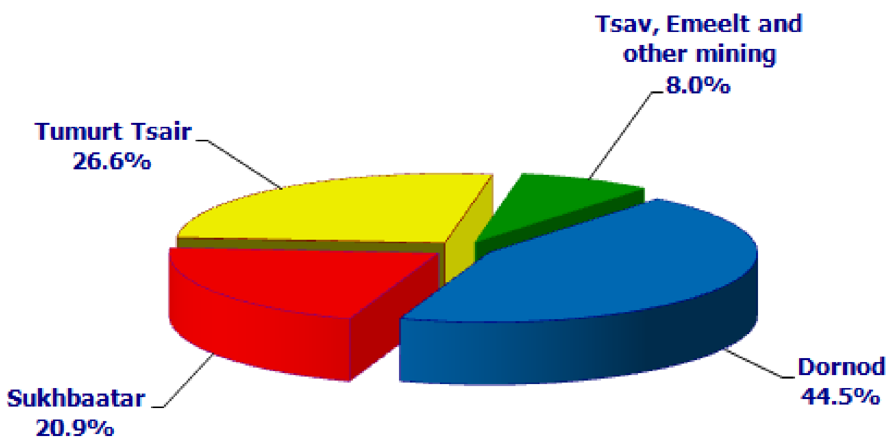


Figure 3-14. Allocation of electricity distribution

3.3.3. Electricity price and tariff

The tariff of the ERES SC is controlled and approved by the ERA according to the Mongolian Law on Energy. The ERES SC holds 6 types of special licenses such as electricity production, heat production, electricity distribution, heat distribution, regulated supply of electricy and regulated supply of heat etc. and it adheres to the tariff approved by the ERA when providing the customers with electricity and heat. The tariffs of ERES SC electricity sold to the customers are shown in the Table 3-4 through Table 3-5 below.

Table 3-4. Electricity tariff measured by ordinary meters

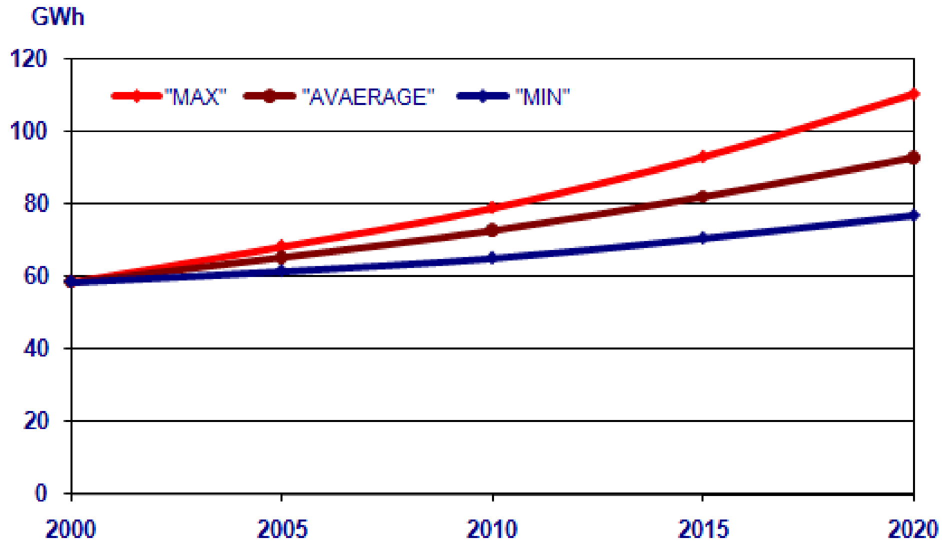
No	Customer classification	Measuring unit	Price (Exclusing VAT)
1.1	Factories, business entities and organizations	MNT/kWh	79.80
1.2	Households	MNT/kWh	79.80

Table 3-5. Electricity tariff of by time differential tariff

No	Customer classification	Measuring unit	Price (Excluding VAT)
Factories, business entities and organizations			
1.1	Day time consumption /06:00 – 17:00/	MNT/kWh	79.80
1.2	Evening consumption /17:00 – 22:00/	MNT/kWh	133.00
1.3	Night time consumption /22:00 – 06:00/	MNT/kWh	46.00
Households			
2.1	Day time consumption /06:00 – 21:00/	MNT/kWh	79.80
2.2	Evening and night time consumption /21:00 – 06:00/	MNT/kWh	40.00

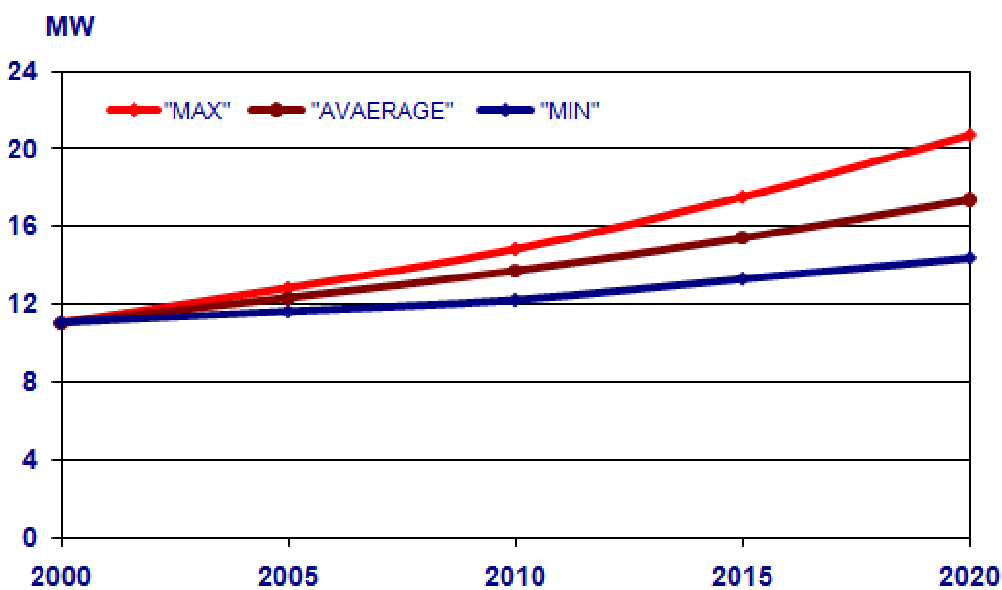
3.3.4. Future Perspective

There are not many documents that have determined the future perspective of eastern region energy system. The 2002 “Report on Improvement of Energy Sector Potential” reflected the electricity production and volume of peak load of the CES in three different growth rates such as high, medium and low growth rate based on the 2000 indicators (electricity production was 58.7 mln kWh, distribution was 42.0 million kWh and peak load was 11 MW respectively) of ERES and these estimates are shown in the Figure 3-15 and Figure 3-16 below:



Source: Capacity Building for Energy Planning, ADB research report

Figure 3-15. Forecast of gross generation of the ERES, 2000



Source: Capacity Building for Energy Planning, ADB research report

Figure 3-16. Forecast of gross peak load of the ERES, 2000

According to these forecasts the average annual electricity production growth is estimated to be 3.2% in case of high growth rate, 2.3% in case of medium grouth rate and 1.4% in case of low grouth rate respectively. As a result of these estimates the “higher” option of the production of the

ERES will reach 110.5 miln kWh and the peak load will reach 20.7 MW by 2020, 93.1 million kWh and 17.4 MW according to the "medium" option and 77.61 mln kWh and 14.4 MW according to the "lower" option respectively. Actually, the 2009 ERES electricity production reached 97.0 million kWh and peal load reahed 21 MW, which were completely different from those estimates.

The energy demand of the existing and the new major mining companies in the Dornod and Sukhbaatar aiamgs such as the the petroleum exploitation factory of the "Petro China Dachin Tamsag" LLC, the mining factory of the "Central Asia Uranium" LLC, uranium mining of the "Emeelt Mines" LLC, the lead mining of the "Xin Xin" LLC and the zinc and lead mining of Tumurtei Ovoo deposit will likely to increase significantly in the near future.

The demand and supply of the ERES have been estimated based on the capacity of the ERES power plant, 2009 peak load and the energy demand of the new mining projects under implementation and planned to be implemented in the Dornod and Sukhbaatar provinces. The results of these estimates are shown in the Table 3-6.

Table 3-6. Perspective of ERES electricity demand and supply

	2010	2011	2012	2013	2014	2015
1 Generation capacity	24	24	24	24	24	24
1.1 Choibalsan Power Plant, MW	24	24	24	24	24	24
2 Demand	21	23	79	126	149	151
2.1 Existing peak load, MW	21	23	24	26	29	31
2.2 New potential demand						
Mining projects in Dornod, MW			35	65	70	70
Mining projects in Sukhbaatar, MW			20	35	50	50
3 Capacity deficit, MW	0	0	-55	-102	-125	-127

This Table shows that the ERES will face capacity shortage of 55 MW by 2012 and 127 MW by 2015 in case if no new energy production source is added into the ERES.

4. DESCRIPTION OF THE PROJECT IMPLEMENTATION SITE

4.1. Project Implementation Site

There are no area without containing coal and available for construction of a power plant at the site of the special license areas No.10126A and 7101X owned by the “Chandgana Coal” LLC. Therefore, the site of the planned power plant is selected to be at the “Chandgana Khavtgai” located in the 11654 special exploration license site 9 km away to the east of the above site. The location of the Chandgana Khavtgai special license area is shown in the Figure 4-1.

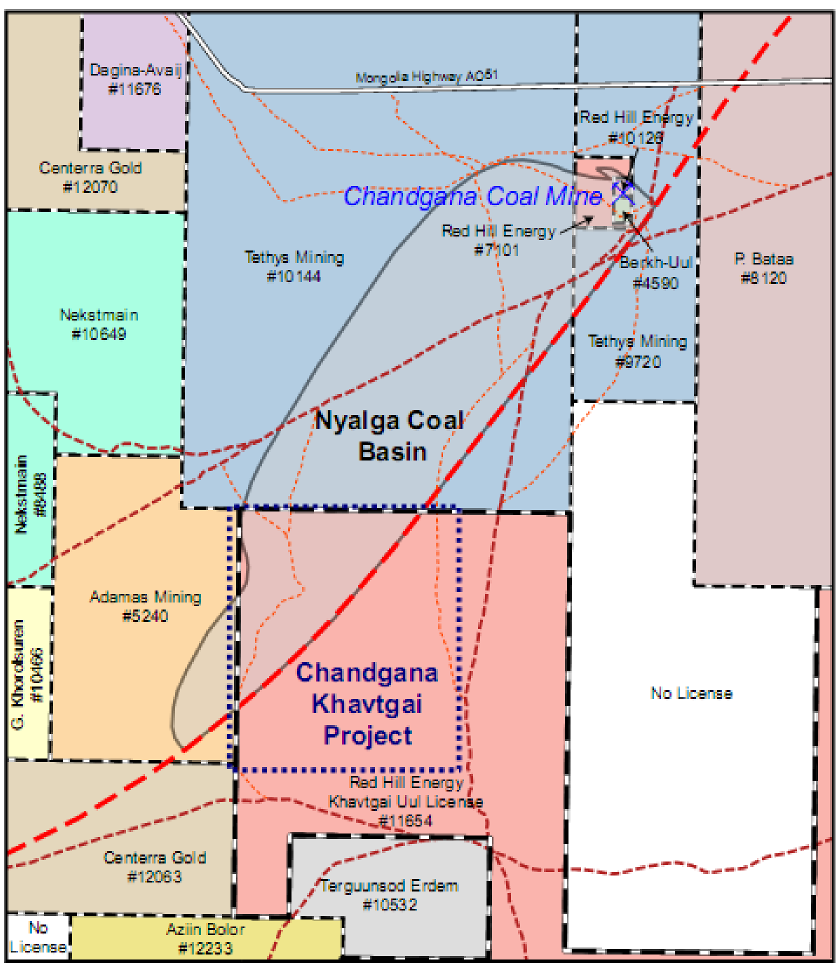
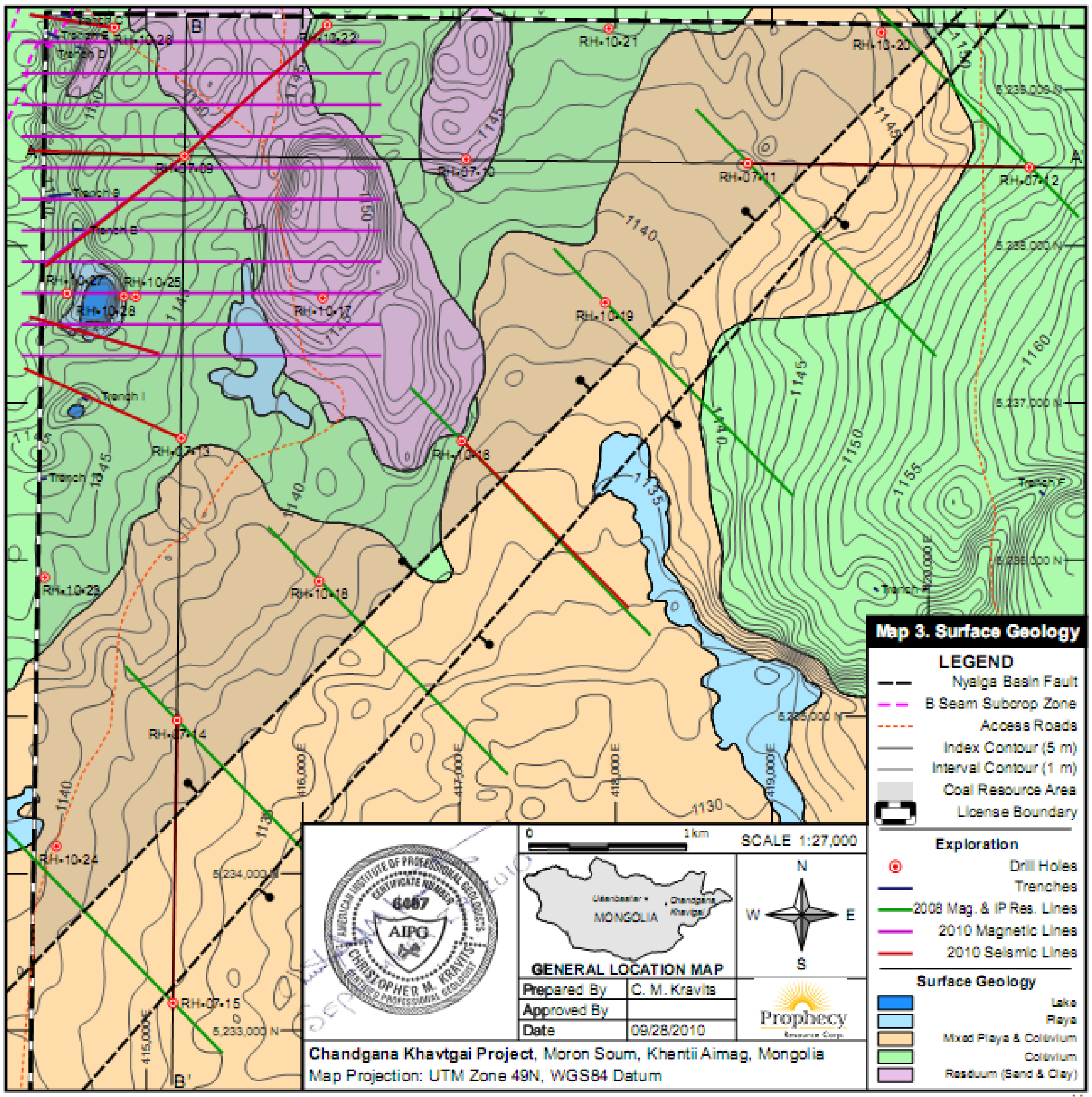


Figure 4-1. Chandgana Khavtgai exploration licensed area, 11654X

The Chandgana Khavtgai coal deposit belongs to the Khangai Khentii elevation in terms of geological structure zoning. The 1:200,000 and 1:50,000 scale geological mapping works have been done in this area. The general overview of the special license 11654 X site owned by the "Chandgana Coal" LLC is shown in the Figure 4-2 and its topographical map is shown in Figure 4-3 respectively.



Source: Updated Technical Report on the Coal Resources of the Chandgana Khavtgai coal resource area, Khentii aimag, Mongolia, 2010

Figure 4-2. Geological overview

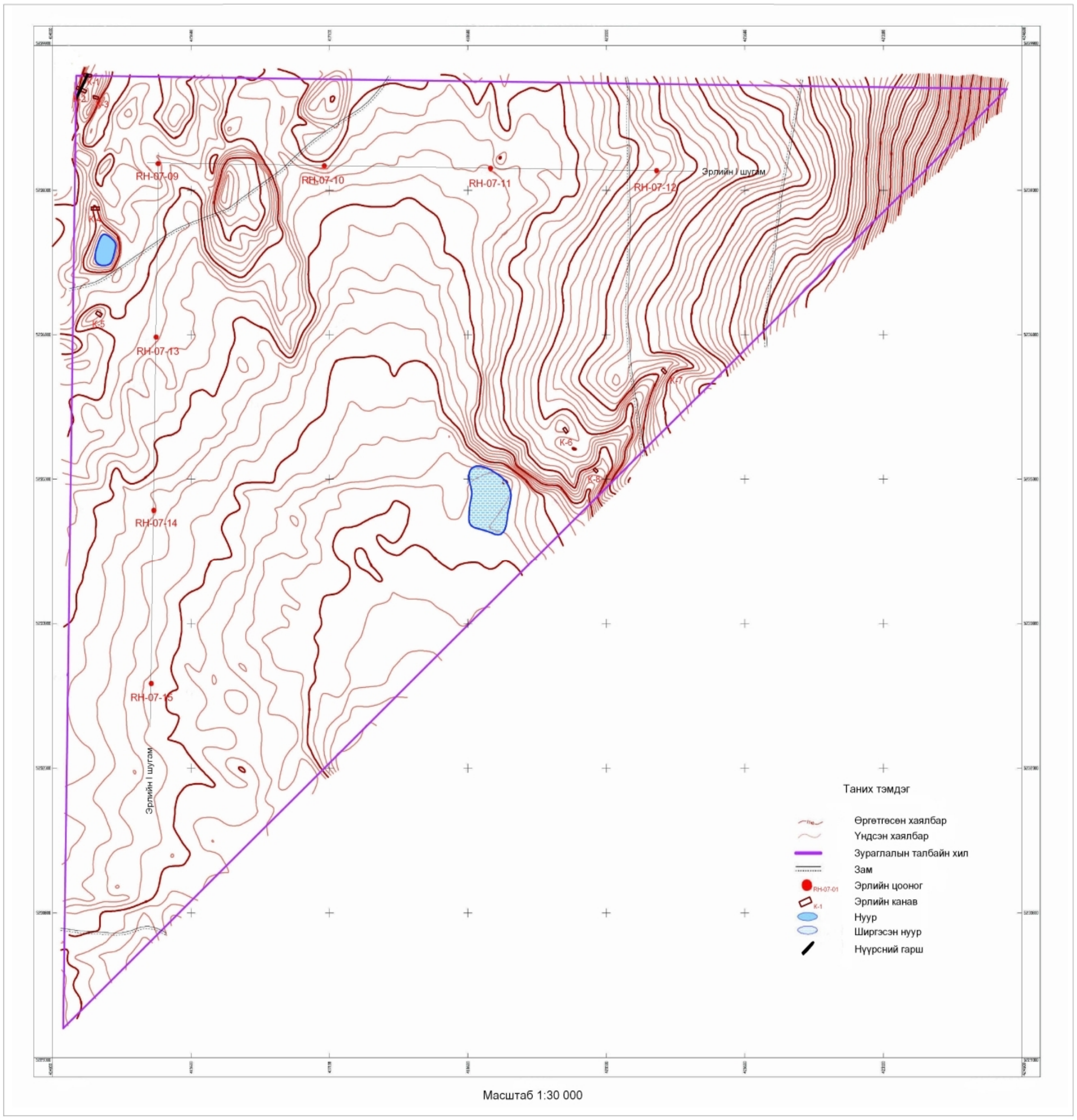


Figure 4-3. Topographical map

4.2. Environment and Climate Conditions

4.2.1. Environmental and Climatic General Parameters

The Murun Soum, Khentii province belongs to the tough continental climatic region in terms of Mongolian climatic zoning and is located in the third zone in terms of climatic classification used for building facility planning. This zone is very cold and has a lot of snow in winter. In summer season it is considered a hot and dry zone.

The climatic parameters used for building facility planning and determined by the meteorological station of the Murun Soum, Khentii Province are shown in the Table 4-1.

Table 4-1. General climatic parameters of the Project implementation site

No	Parameters	Unit	Degrees / rates
1	Maximum air temperature	^oC	38.9
2	Minimum air temperature	^oC	-46.3
3	Average annual air temperature	^oC	0.2
4	Average annual precipitation	mm	205.35
5	Maximum daily precipitation	mm	80.1
6	Relative humidity:		
	In winter season at 1PM	%	67%
	In summer season at 1 PM	%	43%
7	Average wind speed:		
	Average annual wind speed	m/sec	3.7
	In April	m/sec	4.9
	In May	m/sec	4.7
8	Duration of heating period	days	228
9	Average temperature of soil surface:		
	In January	^oC	-23.3
	In February	^oC	-18.9
	In July	^oC	23.6
	Average annual temperature	^oC	1.9
10	Predominant wind direction	Western and northwestern directions	
11	Snow load on horizontal surface	kg/m^2	50.0

4.2.2. Air temperature

The basic indicators of climatic and weather conditions have been determined based on the multiple year reports of the Undurkhaan Meteorological Station.

Spring continues for relatively short period of time and spring weather is unstable: warm days and cold nights. The weather severeness is higher than winter. Wind increases drastically toward the end of spring and weather gets warmer day by day as heat of the sun increases. The driest and the most powerful wind, dust and snow storms occur 2 or 3 times a year.

The average annual air temperature is -2.12˚C. The warmest period is July when the height of the sun is the highest. The Project implementation area average temperature in July is 21.06˚C and the absolute maximum temperature reaches 34.9˚C.

The average temperature of the coldest month of January is -23.64 ˚C and the absolute minimum temperature is -46.3˚C.

The highest daily air temperature is reached by around 2 PM and the lowest temperature is reached by 5-6 AM before sunrise.

According to the Underkhaan city Meteorological Station the average temperature in winter months of December, January and February ranges between -21.17˚C and -23.64˚C and that of the summer months of June, July and August ranges between 17.56˚C and 21.06˚C respectively. The absolute maximum air temperature of more than 30˚C may be observed in May, June, July, August and September and the absolute maximum cold temperature of a little less than -40˚C may be observed in December, January and February.

The multiple year average indicator of air temperature in this region is shown in Figure 4-4.

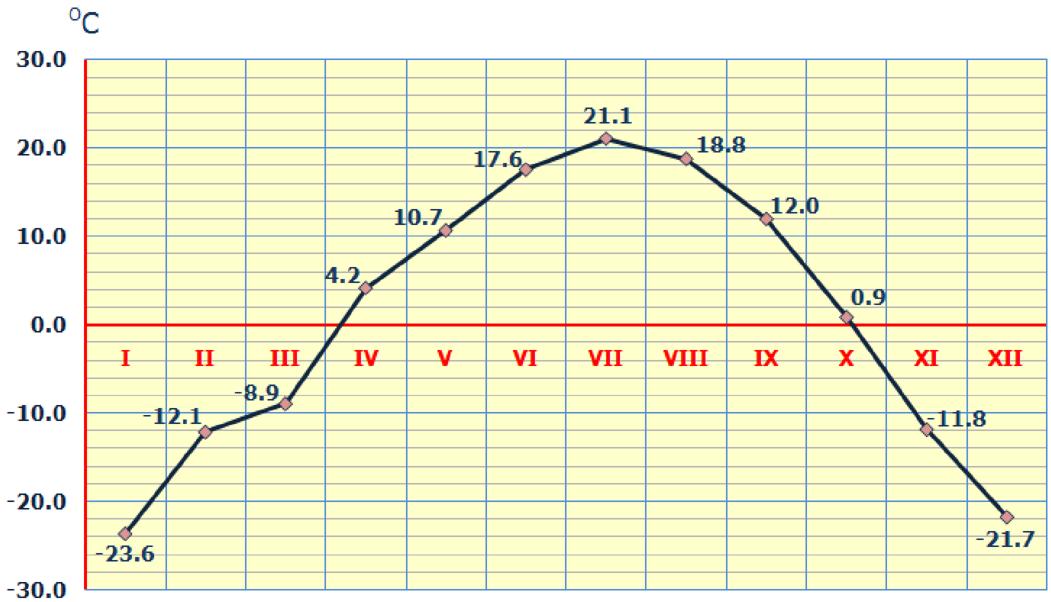


Figure 4-4. Air temperature /average/

4.2.3. Air pressure and Wind

The multiple year records of the Underkhaan city Meteorological Station show that the average air pressure in this region is 892.6 hPa. The high value of air pressure is 900.8-902.3 hPa in December and January winter months and the low value is 889.2-890.5 hPa in May, June and July summer months respectively.

The multiple year average indicator of air pressure of the Project area is shown in the Figure 4-5.

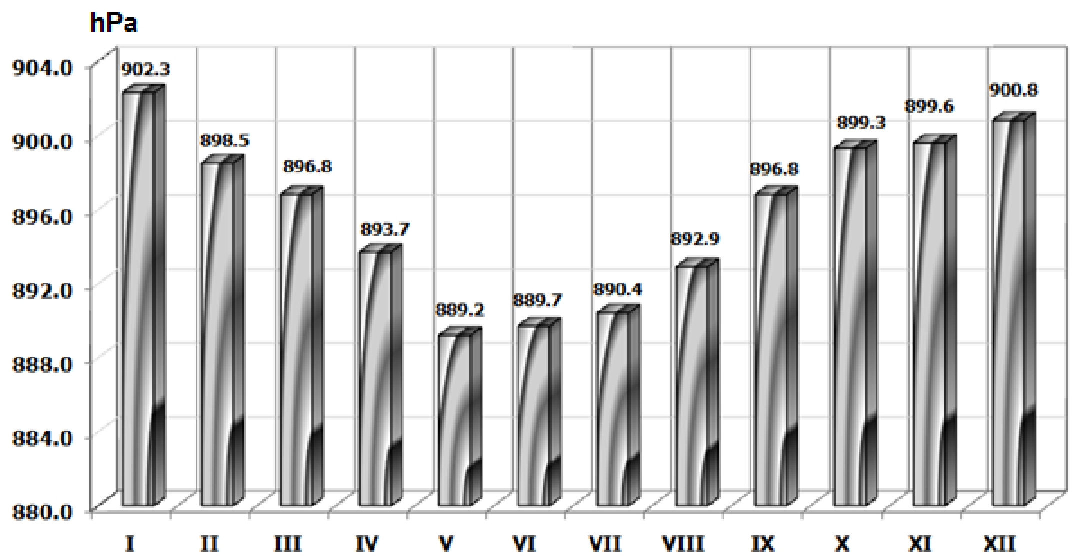


Figure 4-5. Air pressure

Since this region has counter cyclonic winter weather, it is situated under high pressure environment and windy or windless days repeat frequently. Therefore, in warmer season the cyclonic atmospheric front impact is activated and the weather becomes unstable and cloudiness increases to drop most of the precipitation. Also due to this atmospheric impact local winds and storms are created. As it is a plain region wind speed is relatively high throughout the whole year. The average wind speed is 3.9 m/sec. (See the Figure 4-6)

The average wind speed in spring months is 5-5.6 m/sec and in winter and summer months 3.2-3.7 m/sec. There is a case that the maximum wind speed exceeds 20 m/sec higher. The number of windless days in a year is about 20 days.

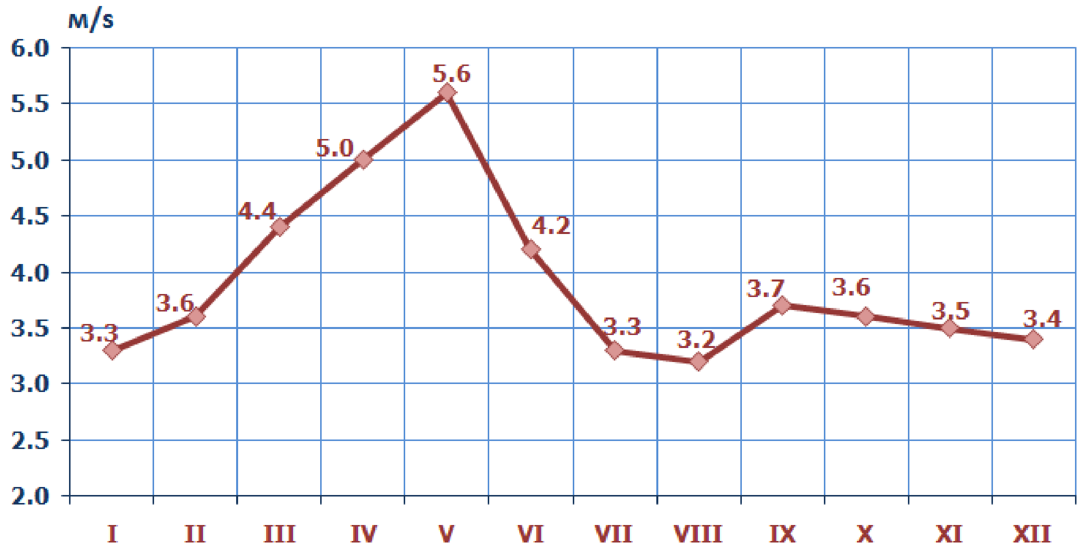


Figure 4-6. Wind speed

Eastern, northeastern and northwestern direction winds are predominant in the Project implementation region and the wind directions and frequency are shown in the Table 4-2 and in the Figure 4-7 respectively.

Table 4- 2. Predominant wind directions and frequency

Unit: %

Time	DIRECTION							
	N	NE	E	SE	S	SW	W	NW
January	15.1	26.7	9.3	0	12.9	9.4	13.8	12.8
June	20.7	18.6	6.5	2.7	7.7	12.2	14.3	17.3
Annual average	20.6	14.9	5.2	2.6	12.9	13.9	12.8	17.0

Notes: N –north, NE - northeast, E – east, SE- southeast, S – south, SW- south west, W- west, NW- northwest

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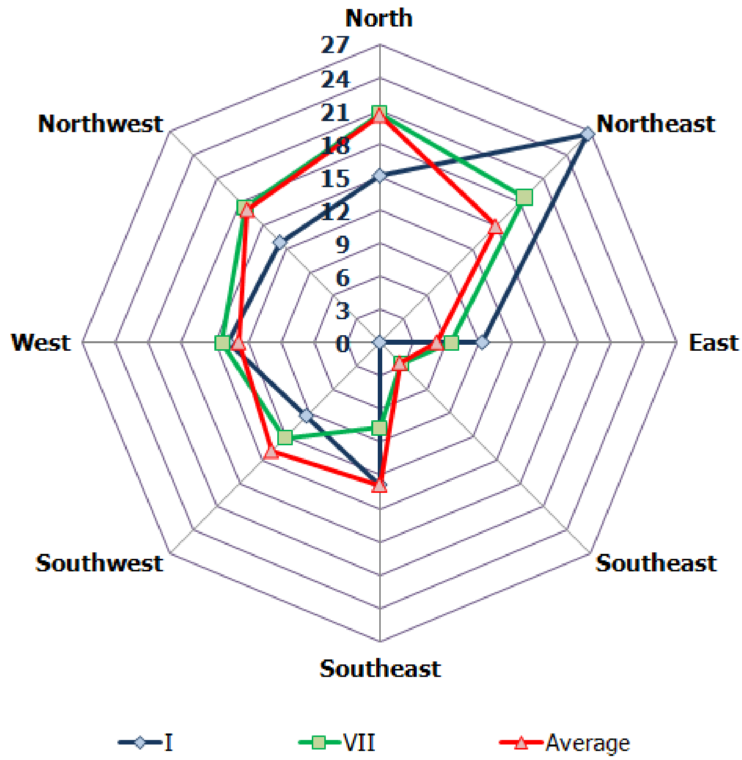

Figure 4-7. Wind direction frequency

4.2.4. Precipitation and Relative Humidity of Air

Since our country is isolated from ocean and sea, elevated high above sea level and surrounded by high mountains, it has a continental climate with low precipitation. The annual average precipitation in the territory of Murun Soum, Khentii Province is about 205.35 mm. Most of the precipitation or 78-85% falls during warm seasons (June-October), but 25-15% during cold seasons.

The annual average relative air humidity of this region is 60%. It reaches its high value of 74% in winter and it is relatively lower in spring and autumn about 57% in average. But summer season has more rainfall and quick evaporation, therefore, the relative air humidity is lower about 46-

4.2.5. Lightening

The Project implementation region belongs to a medium level lightening impact zone where the annual lightening impact duration is 20-40 hours. (See the Figure 4-8).

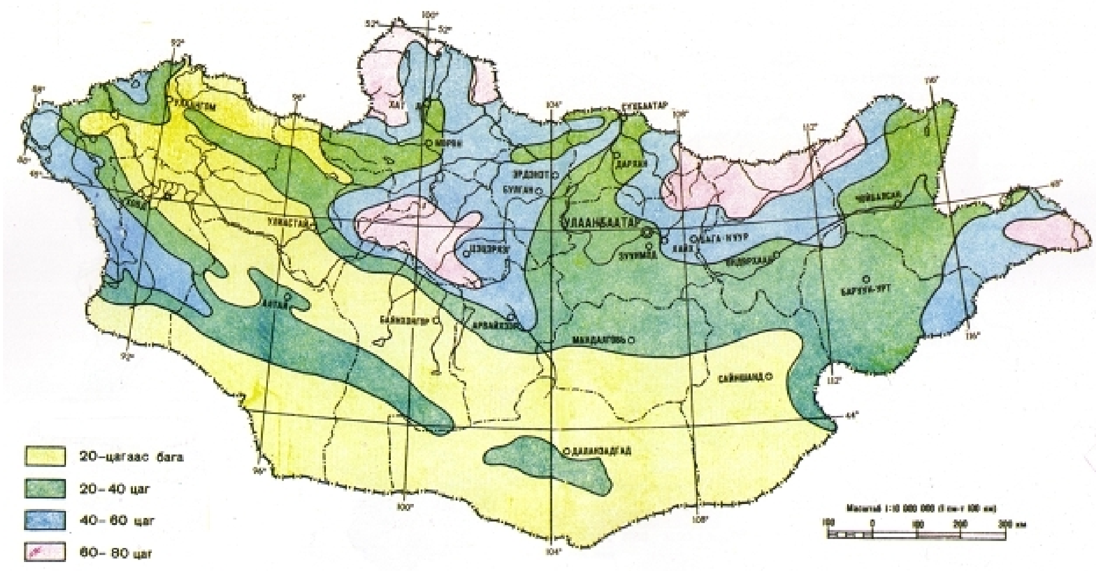

Figure 4-8. Lightening impact duration

As a dangerous climatic phenomenon lightening generates several km long electrical field and atmospheric electrical discharge between land surface and clouds, which strikes various electrical equipment, electrical and telecommunication lines and provides electrostatic, electromagnetic and thermodynamic impacts. Therefore, it is required to consider the electromagnetic and dymanic impacts of lightening on the power plant equipments and to take measures to reduce such impacts while developing the detailed design of the power plant.

4.3. Geotechnical study of the site

The power plant is planned to be constructed near the “Chandgana Khavtgai” coal deposit located at the special license area 11654 X Owned by the Chandgana Coal” LLC. The location of the power plant site is shown in the Figure 4-9.

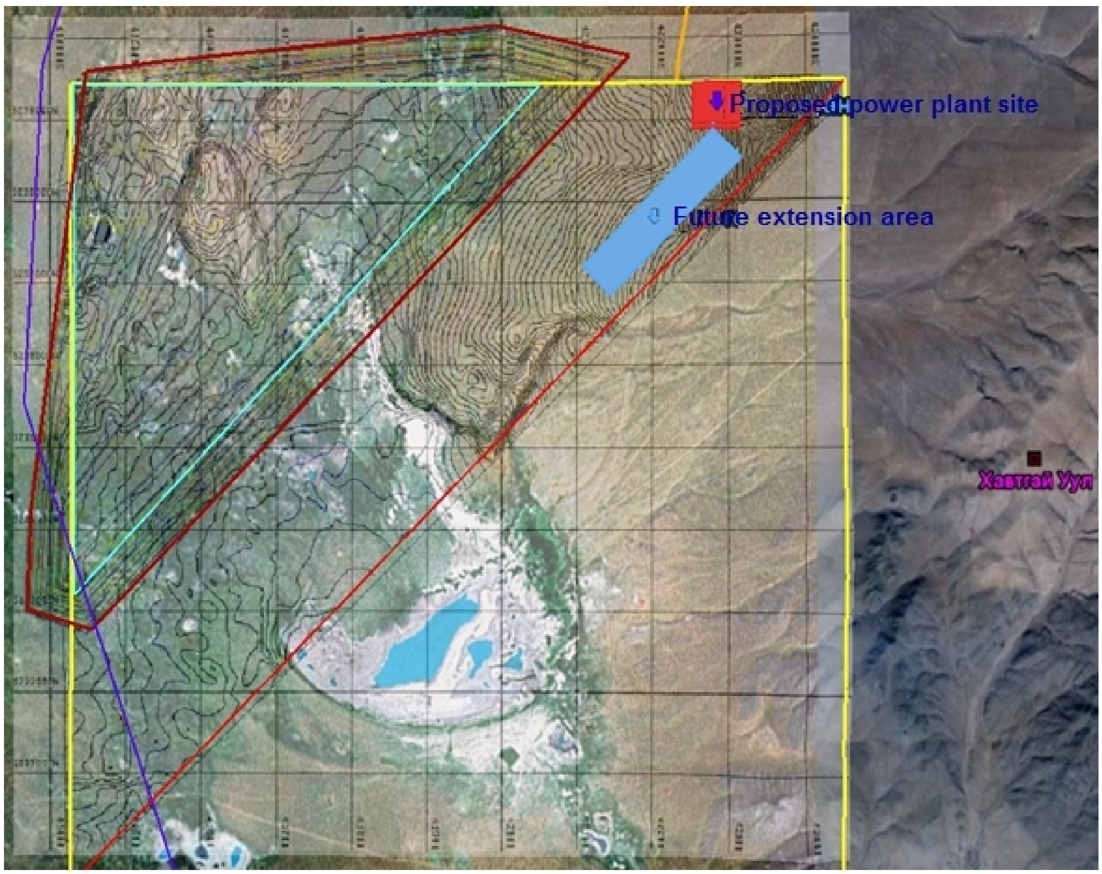

Figure 4-9. Proposed power plant site

The map of the power plant site and the engineering and geological survey work were done by the “Barnab” LLC. Within the framework of this survey work the 1:500 scale topograpgical maps of totally 20 areas were developed and 7 drilling wells with 5.0-6.0 m depth were drilled at the site where the basic equipments of the power plant will be installed. During the process of drilling certain number of samples with damaged and undamaged structures were taken from the soil layer and delivered to the soil analysis bab for the purpose of making analysis of the soil physical and mechanical features. The general map of the surveyed area is shown in the Figure 4-10 and the locations of the wells are shown in the Figure 4-11 respectively.

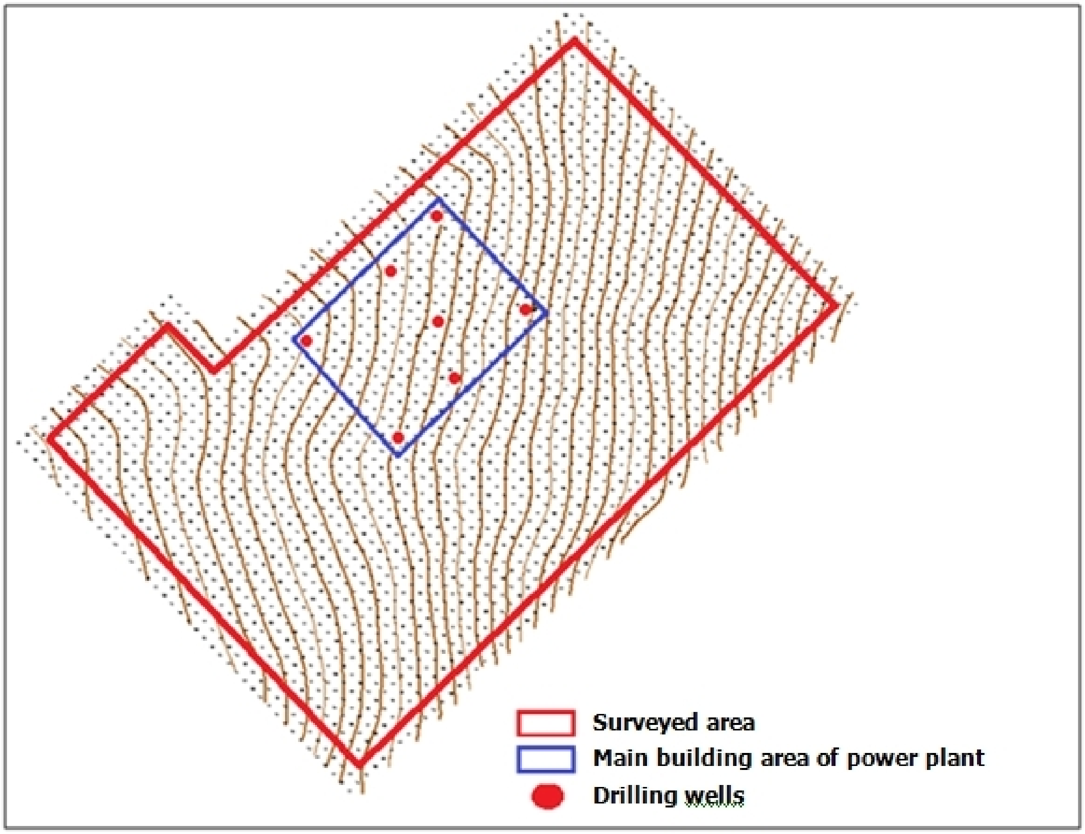

Figure 4-10. The area covered by the topographical mapping

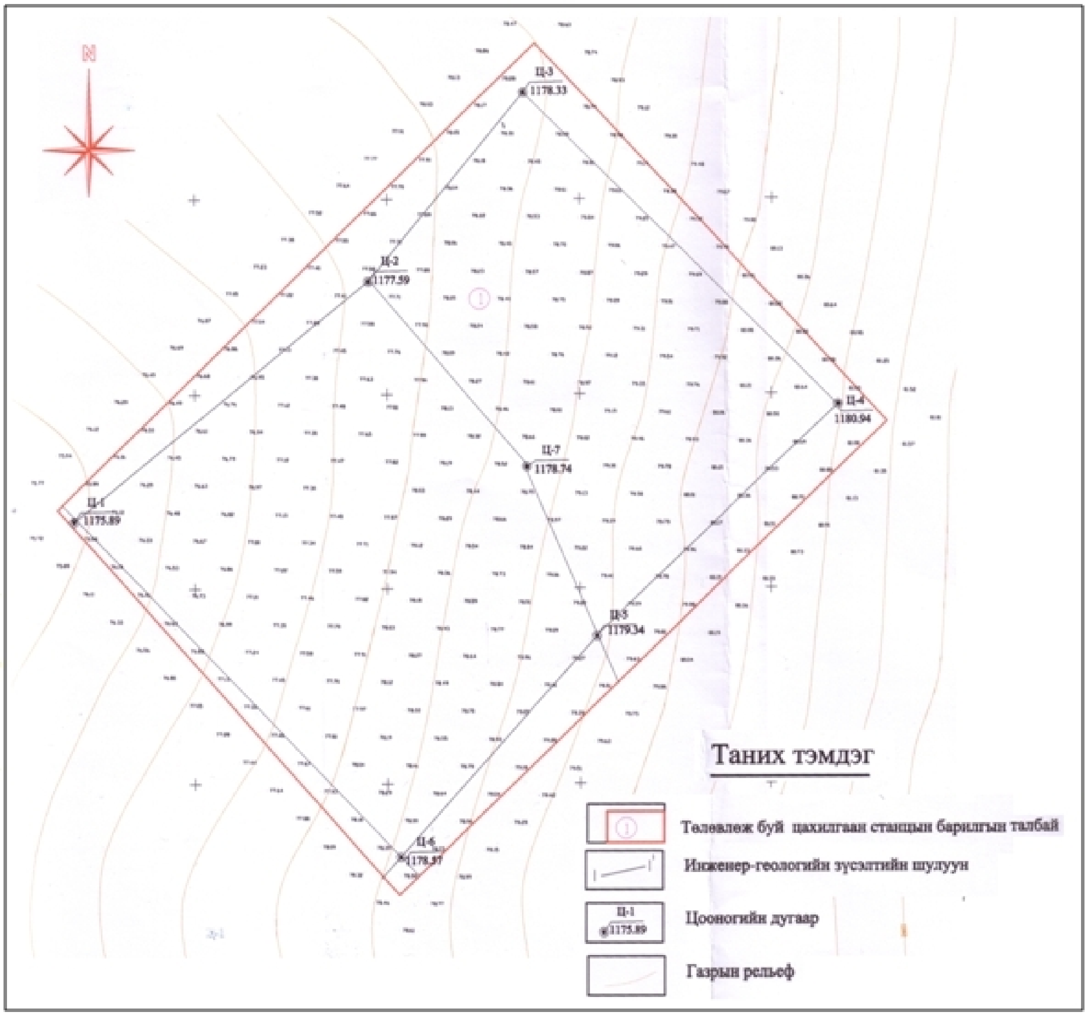

Figure 4-11. Location of driliing wells

It was determined by the survey work that mostly sandy and gravel-sandy soil with various colors (brownish yellow, bright yeallow and grayish white) of Modern and Upper & Middle Quaternary age deluvial origin are spread predominantly in this area.

In terms of geomorphology the site of the planned power plant buildings will be located at the foot of the “Khavtgai Mountain” situated in the territory of Murun Soum, Khentii Province. This site surface is a surface formation sloping from the east down to southwest. The elevation of the surface is 1176.10-1180.90 m above the sea level. No underground water has been discovered in the drilled wells.

The engineering & geological sections of the wells are shown in the Figures 4-12 through Figures 4-16, and the explanation of the symbols used in these figures is given in Figure 4-17 respectively.

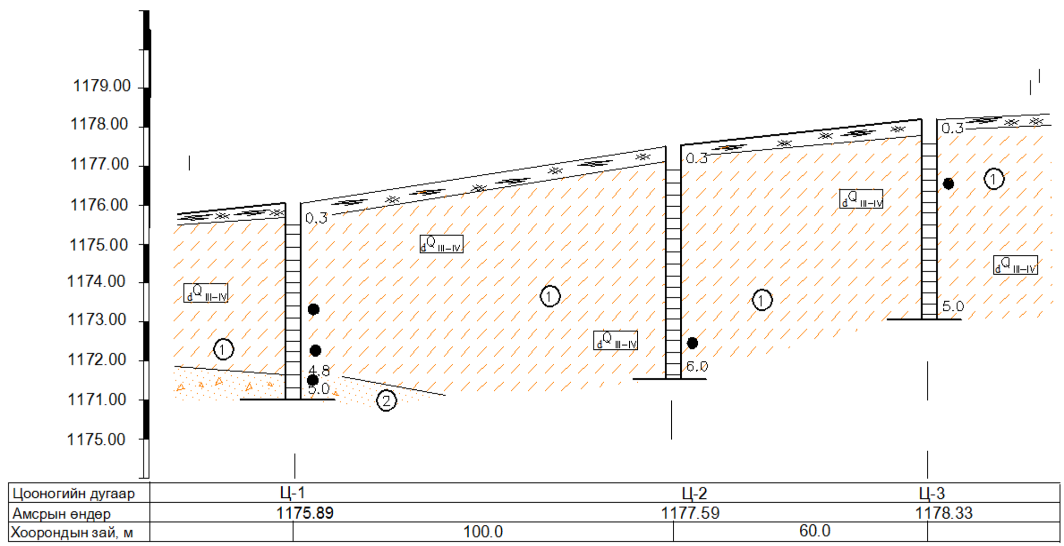

Figure 4-12. Engineering & Geological cross section of DH1-DH2-DH3

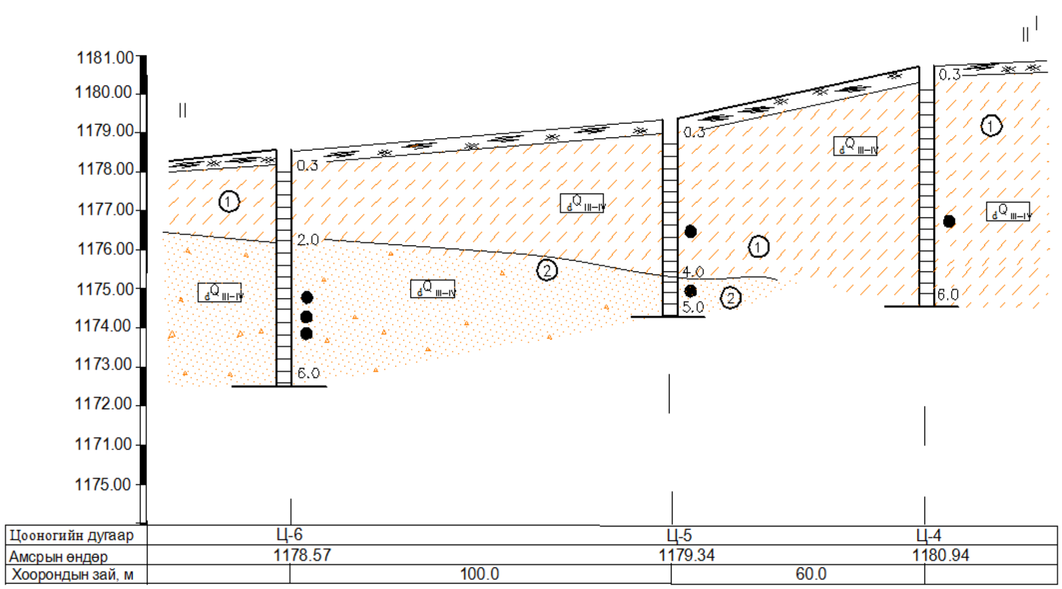

Figure 4-13. Engineering & Geological cross section of DH6-DH5-DH4

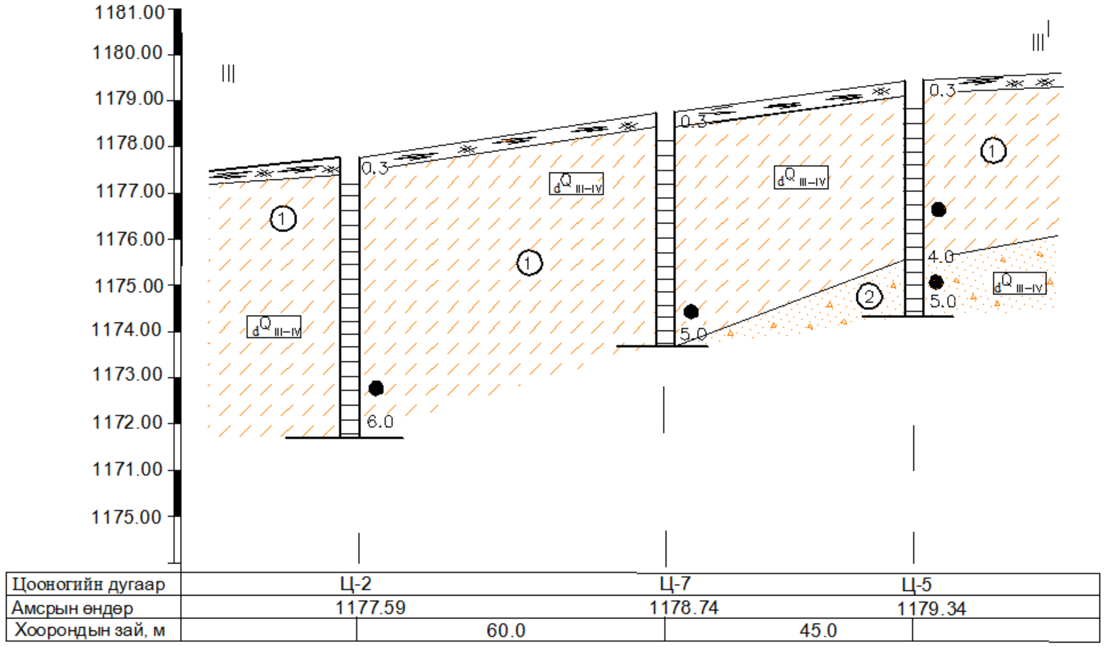

Figure 4-14. Engineering & Geological cross section of DH2-DH7-DH5

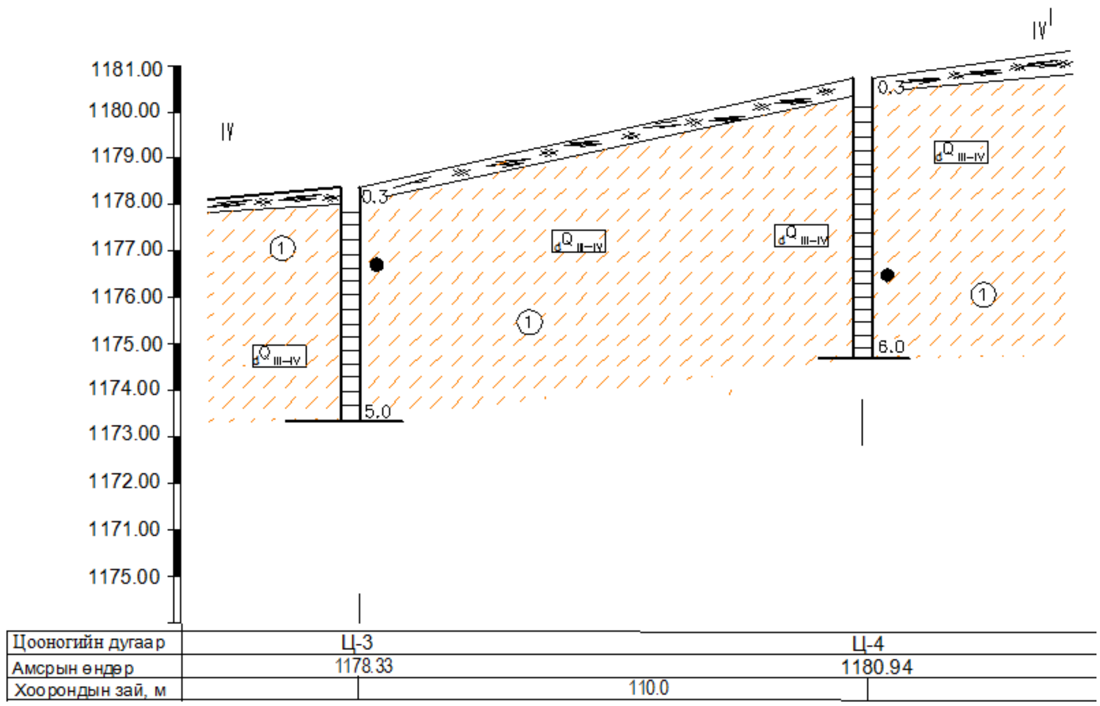

Figure 4-15. Engineering & Geological cross section of DH3-DH4

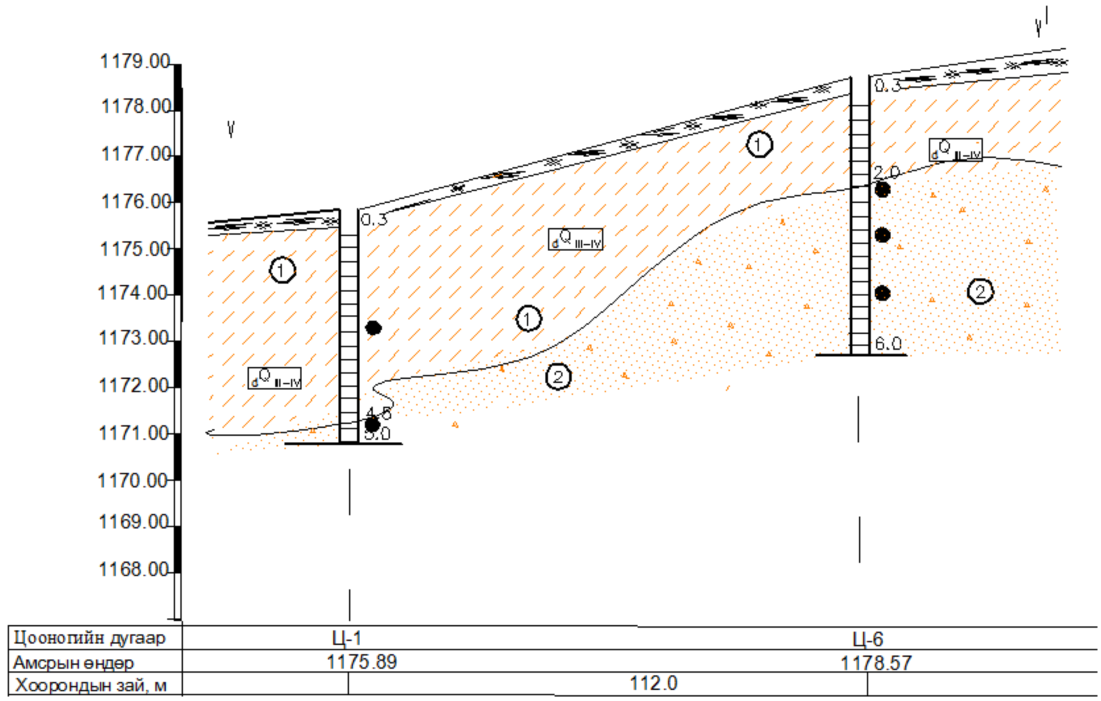

Figure 4-16. Engineering & Geological cross section of DH1-DH6

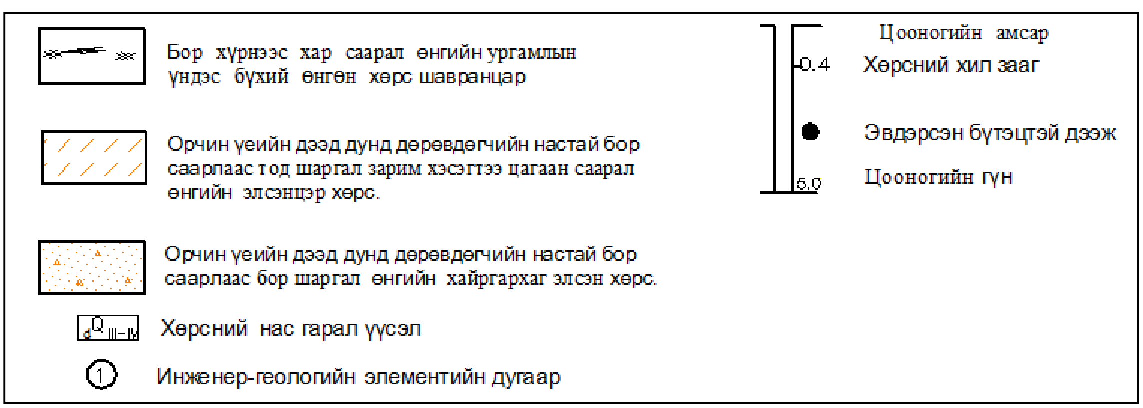

Figure 4-17. Legends for Figure 4-12 – Figure 4-16

The engineering & geological sections shown in the Figure 4-12 – Figure 4-16 as well as the results of the soil physical and mechanical analysis show that the following 3 types of soil layers are spread in the survey site:

1. Upper surface soil. Dark brown to brown color upper surface soil and clay with plant roots spread in the upper section of the surface.
2. From brownish gray to bright yellow, sometimes white gray color, firm sandy soil of Modern and Quatenary age deluvial origin ($_dQ_{III-IV}$) About 71.1% of composition of this soil consists of various grain sand, 19.7% of pulverescent section, 8.1% of clayey section and 1.1% of gravel respectively. The physical properties of the soil are shown in the Table 4-3 and the mechanical properties of the soil are shown in the Table 4-4 respectively.

Table 4-3. Physical properties of the soil (sandy soil)

No	Physical features	Symbols	Measuring unit	Value
1	Natural moisture	W	%	0.112
2	Flow limit	W_L		0.216
3	Weathering limit	W_P		0.158
4	Elasticity number	I_P		0.058
5	Mineral density	P_S	gr/cm^3	2.70
6	Natural density	P	gr/cm^3	1.97
7	Density of solid particles	P_d	gr/cm^3	1.78
8	Porosity	n	%	34.18
9	Porosity index	e		0.520
10	Moisture level	S_r		0.58
11	Consistency			0

Source: Conclusion on engineering and geological survey at the site allocated for developing construction design of the power plant to be constructed near the Chandgana coal mine in the territory of Murun Soum , Khentii Province" Barnab LLC, UB, 2010, Page 8

Table 4-4. Indicators of mechanical properties of soil layer (sandy soil)

No	Properties	Symbols	Measuring unit	Value
1	Friction force	$C^{H}=C^{I}$	kPa	18/0.18/
		C^{II}	kPa	12
2	Internal friction angle	$\varphi^{H}=\varphi^{I}$	degree	29
		φ^{II}	degree	25
3	Deformation module	E	MPa/kg cm^2	25 /250/
4	Calculation resistance		kPa	300

Source: Conclusion on engineering and geological survey at the site allocated for developing construction design of the power plant to be constructed near the Chandgana coal mine in the territory of Murun Soum , Khentii Province" Barnab LLC, UB, 2010, Page 9

3. Brownish yellow color low moisture gravel-sandy soil of Modern and Upper & Middle Quaternary age deluvial origin ($_{d}Q_{III-IV}$) Its fragmented materials consist of sedimentary and metamorphosed rocks and its granular composition includes quartz, mica and feldspar. About 53.7 % of composition of this soil consists of various grain sand, 31.0 % of gravel, 12.5% of pulverescent section and 2.8.1% of clayey section respectively. The physical properties of the soil are shown in the Table 4-5 and the mechanical properties of the soil are shown in the Table 4-6 respectively.

Table 4-5. Soil physical properties (gravel-sandy soil)

No	Physical properties	Symbols	Measuring unit	Value
1	Natural moisture	W		0.076
2	Mineral density	P_S	gr/cm^3	2.69
3	Natural density	P	gr/cm^3	2.01
4	Density of solid particles	P_d	gr/cm^3	1.87
5	Porosity	n	%	30.51
6	Porosity index	e		0.439
7	Moisture degree	S_r		0.46

Table 4-6. Mechanical properties of soil layer (gravel-sandy soil)

No	Properties	Symbol	Measuring unit	Value
1	Friction force	C_I	kPa/kgcm^2	2 /0.02/
		C_{II}	kPa/kgcm^2	1.3
2	Internal friction angle	φ^0	degree	40
		φ^{II}	Degree	34
3	Deformation module	E	MPa/kgcm^2	45 /450/
4	Calculation resistance		kPa/kgcm^2	400 /4/

Source: Conclusion on engineering and geological survey at the site allocated for developing construction design of the power plant to be constructed near the Chandgana coal mine in the territory of Murun Soum , Khentii Province" Barnab LLC, UB, 2010, Page 9

Based on the above mentioned physical and mechanical properties of the soil, the site of power plant is concluded to have normal engineering and geological conditions. Therefore, when developing the detailed design of the power plant it is required to consider the fact that the engineering and geological conditions of the power plant site are normal and to reflect them in the design accordingly.

According to Research Center for Astranomy and Geophysics at Mongolian Academy of Science, the site where power plant being planned is located in the 7th grade zone of seismology. Therefore, it is advised to have detailed seismic study for the site conducted by the Center during next stage of the project study.

5. COAL AND WATER SUPPLY

5.1. Coal Supply

5.1.1. Coal reserve and characteristics

The coal of the Chandgana Tal coal deposit belongs to a brown coal category and is a low calorie coal. Certain study works have been conducted for the purpose of determining the possibility of using the Chandgana Tal deposit coal for local energy consumption only. Therefore, no detailed petrographical analysis has been made on the Chandgana Tal deposit coal so far. During 2007 drilling an analysis of the properties of coal located in 30 m depth was performed. The results of this analysis are shown in the Table 5-1 through Table 5-3.

Table 5-1. Results of coal analysis

Well No.	Thickness, m	Density	Moisture, %		Ash	Non-volatile gas	Hydrogen	Total sulfur
			Working	Air Dried				
RH-07-01	30.44	1.48	40.38	29.52	15.58	28.02	26.88	0.54
RH-07-02	47.95	1.49	38.86	25.36	15.12	28.35	31.17	0.76
RH-07-03	39.51	1.43	38.42	25.24	12.62	29.00	33.14	0.71
RH-07-04	41.20	1.39	40.63	27.07	9.63	30.09	33.21	0.68
RH-07-05	41.92	1.41	40.66	27.21	12.02	29.44	31.33	0.71
RH-07-06	18.00	1.40	40.83	27.06	12.55	28.29	32.10	0.75
RH-07-07	28.05	1.39	43.85	28.66	10.35	28.21	32.78	0.72
RH-07-08	37.85	1.39	43.54	27.45	11.28	28.61	32.66	0.58
Weighted average	27.85	1.45	40.68	27.01	12.49	28.82	31.68	0.68
Note: Ash, non-volatile gas, hydrogen, sulfur and heating calories are calculated on air dried basis								

Well No.	MJ /kg	Kcal /kg	Btu/F	Mineral substance	Kcal/kg (MAF)	Btu/F (MAF)
RH-07-01	16.14	3855	6940	17.12	4652	8374
RH-07-02	17.29	4129	7433	16.75	4960	8928
RH-07-03	18.24	4355	7840	14.02	5066	9119
RH-07-04	18.70	4467	8041	10.77	5007	9013
RH-07-05	17.66	4218	7593	13.37	4869	8764
RH-07-06	17.62	4208	7574	13.97	4891	8804
RH-07-07	17.94	4286	7714	11.57	4847	8725
RH-07-08	18.17	4340	7812	12.50	4960	8928
Weighted average	17.74	4238	7628	13.86	4919	8854

Table 5-1 continued

Well No	Kcal/kg (DA)	Total sulfur, % (DA)	SO_2 f/mln Btu (DA)
RH-07-01	4567	0.64	1.56
RH-07-02	4865	0.90	2.06
RH-07-03	4984	0.81	1.81
RH-07-04	4943	0.75	1.69
RH-07-05	4795	0.81	1.88
RH-07-06	4811	0.86	1.99
RH-07-07	4780	0.80	1.86
RH-07-08	4892	0.65	1.48
Weighted average	4841	0.78	1.79

Well No	HGI	Carbon	Hydrogen	Nitrigen	Oxigen	Chlorine
RH-07-01	51.0	40.19	2.33	0.49	11.35	0.004
RH-07-02	42.0	43.34	2.86	0.48	12.08	0.005
RH-07-03	38.0	46.37	2.73	0.35	11.98	0.004
RH-07-04	39.0	48.30	2.82	0.50	11.00	0.004
RH-07-05	48.5	44.54	3.08	0.46	12.95	0.005
RH-07-06	50.0	44.72	2.88	0.31	11.73	0.005
RH-07-07	57.0	44.17	2.80	0.35	12.95	0.004
RH-07-08	65.0	44.37	2.54	0.49	13.29	0.007
Weighted average	47.9	44.58	2.76	0.44	12.04	0.005

Table 5-2. Ash analysis result

Well No	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2
RH-07-01	39.85	16.68	17.84	7.92	5.03	1.67	0.64	0.76
RH-07-02	42.37	18.91	12.55	8.43	4.38	0.64	0.70	0.78
RH-07-03	40.09	17.61	12.80	10.13	4.37	0.64	0.62	0.81
RH-07-04	35.97	14.90	11.58	14.28	5.05	0.58	0.85	0.69
RH-07-05	32.73	14.60	21.65	10.90	4.74	0.46	0.74	0.64
RH-07-06	39.27	17.75	12.57	10.23	5.31	0.62	0.67	0.73
RH-07-07	38.01	15.36	10.65	12.15	5.19	0.64	0.82	0.67
RH-07-08	41.41	14.41	12.42	12.28	3.78	0.85	0.69	0.66
Weighted average	38.73	16.29	14.16	10.76	4.65	0.75	0.72	0.72

Table 5-2 continued

Well No	Mn_3O_4	SO_3	P_2O_5	SrO	BaO	ZnO
RH-07-01	0.44	8.64	0.22	0.073	0.059	0.014
RH-07-02	0.22	9.56	0.13	0.087	0.065	0.018
RH-07-03	0.24	11.11	0.18	0.120	0.085	0.017
RH-07-04	0.24	13.56	0.40	0.200	0.110	0.018
RH-07-05	0.43	11.61	0.39	0.130	0.093	0.020
RH-07-06	0.20	11.51	0.11	0.088	0.060	0.016
RH-07-07	0.25	14.11	0.33	0.140	0.093	0.016
RH-07-08	0.47	11.28	0.18	0.140	0.097	0.015
Weighted average	0.31	11.31	0.25	0.124	0.084	0.017

Table 5-3. Ash melting temperature, ^{O}C

Well No	Commencement of deformation during oxidization process	H=-W	H=W	Melting	Commencement of deformation during reduction of oxidization	H=-W	H=W	Melting
RH-07-01	1225	1231	1246	1263	1156	1162	1166	1186
RH-07-02	1238	1242	1248	1265	1165	1173	1179	1201
RH-07-03	1233	1238	1242	1259	1167	1173	1177	1197
RH-07-04	1208	1212	1216	1232	1153	1157	1163	1187
RH-07-05	1230	1241	1247	1267	1141	1147	1157	1181
RH-07-06	1232	1238	1247	1263	1179	1183	1187	1202
RH-07-07	1200	1208	1218	1236	1162	1167	1173	1194
RH-07-08	1191	1195	1201	1217	1142	1150	1156	1183
Weighted average	1220	1226	1233	1250	1157	1163	1169	1191

The results of the above mentioned analysis show that the Chandgana Tal deposit coal belongs to brown coal category. During the development of technical and economic feasibility study some samples from 5 locations were taken and analysised at the “Coal Test and Analysis Central Lab” of the Mineral Resources Authority for the purpose of confirming the coal properties. The results of the analysis is shown in the Figure 5.1

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АШИГТ МАЛТМАЛЫН ГАЗАР
НҮҮРСНИЙ ТУРШИЛТ, СУДАЛГААНЫ
ТӨВ ЛАБОРАТОРИ

СОРИЛТЫН ДҮНГИЙН ХУУДАС

Хаяг:Улаанбаатар хот
Хан -Уул дүүрэг 4-р хороо
Утас:341371-236

Бүртгэлийн дугаар **№ 90** **2010.11.09.** **огноо**

Дугаар 2010он/№82

Дээжийг ирүүлсэн ААНБ,иргэн "Инержи интернэшнл" ХХК

Дээж авсан, хүлээлгэн өгсөн албан тушаалтан Г. Чулуунбор, Дэд Захирал

Дээж авсан цэг	**Дээжийн тодорхойлолт**	**Лабораторийн дугаар**
Чандганы уурхай	Дээд үе №1	388
	Ачилт хийж байгаа давхарга №4	389
	Доод үе № 3	390
	Дунд үе /прослойк/ №2	391
	Нээсэн давхарга /баруун / №5	392

Ирүүлсэн дээжийн тоо хэмжээ	**Шинжилгээнд хүлээн авсан**	**Шинжилгээ хийсэн**
5ш	2010.11.03	2010.11.05

Шинжилгээний аргын стандарт	Шинжилсэн үзүүлэлтийн нэр хэмжих нэгж	Чанарын үзүүлэлтүүд					
		Лабораторийн дугаар					
		388	389	390	391	392	
MNS 0655-79	Чийглэг % W^p	41.5	40.5	40.9	35.7	42.0	
MNS 0652 -79	Үнслэг % A^p	9.0	6.1	7.7	18.3	9.9	
MNS 0654-79	Дэгдэмхий % V^r	45.3	37.3	43.5	54.2	48.3	
MNS 3903-86	Хүхэр % $S^c_{общ}$	1.94	1.03	0.83	1.63	1.73	
MNS 0669-87	Илчлэг ккал/кг $Q^a_б$	5231	6034	5598	4480	5007	
	Илчлэг ккал/кг $Q^н_б$	2848	3394	3130	2705	2678	
MNS ISO 501:2003	Хөөлтийн зэрэг S						
ISO 335: 1974	Барьцалдах чанар RI						
MNS 3217- 1982	Нягт ρ г/см3						

Сорилтын үр дүн нь тухайн ирүүлсэн дээжинд хүчинтэй.

Тамгаар Баталгаажуулсан

Лабораторийн эрхлэгч Д.Отгонбаяр

Шинжилсэн

Мэргэжилтэн Б.Эрдэнэцэцэг
Д.Ууганчимэг
Д.Жавзансүрэн

Хуулбарлан хэрэглэхийг хориглоно

Figure 5-1. Chandgana tal's coal analysis result

Translation of Figure 5-1

"Coal Test and Analysis Central Lab" of the Mineral Resources Authority
Address: 4th Khoroo, Khan-Uul Distrcit, Ulaanbaatar city Tel: 341371-236

TEST RESULT SHEET

Register No. 90 Date: 09.11.2010
Ref.No: 2010/82

The samples delivered by: Energy International LLC
The samples received and returned by: G.Chuluunbor, Deputy Director

The samples are taken from: Chandgana Coal Mine

The sample description:		Lab. Registration No.
	The upper layer No. 1.	388
	The loading stratum No.4.	389
	The lower layer No.3	390
	Middle stratum No. 2	391
	Newly discovered stratum (western) No.5	392

Number of samples delivered: 5 pieces
Date of delivery for analysis: 03.11.2010
Date of analysis: 05.11.2010

Standard of analysis method	Parameters analyzed	Quality indicators				
		Lab registration number				
	Measuring unit	388	389	390	391	392
MNS 0655-76	Moisture % W	41.5	40.5	40.9	35.7	42.0
MNS 0652-79	Ash % A	9.0	6.1	7.7	18.3	9.9
MNS 0654-79	Non-volatile gas % V	45.3	37.3	43.5	54.2	48.3
MNS 3903-86	Sulfur % S	1.94	1.03	0.83	1.63	1.73
MNS 0669-87	Calorie Q Kcal/kg	5231	6034	5598	4480	5007
	Calorie Q Kcal/kg					
MNS-ISO 501-2003	Fermentation degree S					
ISO 355 1974	Friction quality R_1					
MNS 3287 1982	Density gr/cm^2					

The test results are valid for only the samples tested.
Approved by: D.Otgonbayar, Lab. Manager
Analyzed by: B.Erdenetsetseg, D.Uuganchimeg
D.Javzansuren

The results of the coal analysis show that the working moisture of the Chandgana Tal coal is 35.7-42.0%, ash 6.1-18.3%, non-volatile gas 37.3-48.3% and the minimum heat generating capacity 2678-3394 Kcal/ kg respectively.

Since the Chandgana Tal deposit coal belongs to brown coal category, which has low calorie, it can be used for production of electric energy.

5.1.2. Potential of coal supply to the Power Plant

The Chandgana Tal deposit coal was mined for the purpose of meeting the coal consumption demand of Khentii province. According to the “Technical Report on the Coal Resources of the Chandgana Tal Coal Project, Khentii Province (Province) Mongolia, Behre Dolbear & Company (USA), Inc., the 10126A and 7101X special license areas owned by the Chandgana Coal LLC company have total coal reserve of 141.3 million tons of coal, out of which 64.6 mln tons of coal reserve is a measured A category reserve and 76.7 mln tons of coal reserve is an indicated B category reserve.

Since this deposit has sufficient coal reserve there would be no shortage of coal supply for the new power plant to be established there.

The planned power plant will be located 9 km south ro the Chandgana Tal coal mine. Therefore, it is possible to transport coal to the power plant by using trucks or a conveyer system.

However, the operating capacity of the mine, the capacity of the equipments and machinery to be used for the mine and its operational plan have not been made clear so far. Therefore, while developing the detailed design of the power plant, it is necessarily required to consider the capacity of the Chandgana Tal coal mine and its operational plan in consistency with the capacity of power plant equipment and its

5.2. Water supply

5.2.1. The hydrogeological condition of the region

The valley between hills, where the Chandgana Tal coal deposit is located, belongs to steppe zone. The hydrogeological condition of the region under this study is characterized by its mixed geological formation, relatively high division of the relief and continental dry climate. The conditions such as a shortage of precipitation, evaporation volume exceeds precipitation and the difficulty of underground water exchange etc. form unfavorable condition for creation of underground water in this region. These conditions serve as the factors that create fresh, salty or saline underground water in its hydrogeological structure, which consists of numerous small underground water lenses, aquifers and basins.

In terms of hydrogeology the hydrogeological structures such as artesian basins in the lowlands between hills, hydrogeological massifs within the elevated hill system as well as open tectonic cleavages and water cleavages can be classified in this region.

Pore aquifer type underground water exists in the hydrogeological basins with water containing collector located in the sedimentary- volcanic sediments filling the valleys and lowlands between hills, crevice-ground water exists in the elevated hydrogeological massifs surrounding the lowlands and valleys and crevice-vein type underground water is spread in the water tectonic cleavages and transfer zones respectively.

The fact that the wide valley containing the Chandgana Tal coal deposit not only has some traces of underground water natural occurrences such as springs and wells but also there is the Murun river running 15 km away from the deposit serves as a natural sign or a physical and geographical factor for assessment of the hydrogeological condition and the nature of formation of underground water of this region. Also the mountainous parts of the region have more precipitation compared with the lowlands or valleys between hills. The fact that the lowlands or valleys between hills have relatively less precipitation and some years volume of evaporation exceeds the volume of precipitation can be an important factor for determining the hydrogeological condition of the region.

In terms of tectonic structure, this region forms structures consisting of sedimentary and metamorphosed rocks. These are divided by hypogenous bodies of various ages and composition. The major cleavages stretching basically from northwest to southeastern direction have specifics of being divided by horizontal cleavages and having modular structure in some places. The zones of this hydro geological frowning massif are separated by tectonic cleave between each other and the major cleavage zones serve as blocking zone of underground water flow. But small cleavage zones branching off these major cleavages have water in them as determined by previous surveys.

The underground water of the hydrogeological frowning massif of the mountainous zone basic rocks of the region has a peculiarity of being formed in the erosion crevices upper zone by being fed by air precipitation and condensation of water vapors in the air. The underground water in the hydrogeological basin of lowlands and valleys between hills is fed not only by the precipitation secretion but also by the temporary water flow from external region.

There are Quaternary and lower Cretaceous sedimentary deposits of various origin, terrigenous-calcareous rocks, hypogenous rocks of various age and composition spread in this survey area and above mentioned all units of lithology-stratigraphy contain underground water in them. Underground water has hydraulic feature with free or pressure water forms.

Underground water with free form is created in hydrogeological massif's erosion upper crevice and reaches to the valleys between hills through erosion channel. The composition and structure of the rocks of this region show that the basins, lowlands or valleys between hills have mostly free water. But in the central sections of lowlands and valleys have pressure water unevenly.

Based on the specifics of geology and tectonics, historical long term geological development and physical-geographical conditions of the above mentioned region's underground water formation, the aquifers, complexes and water zones may be classified in the following manner by considering the collector type environment, which is used for determining the hydrodynamic conditions of creating underground water wealth of the rocks and sediments of various composition:

- Pores, pore-water layer aquifers
- Crevice and crevice-vein water zones.

The above mentioned classification by using water secretion environment is in its turn divided into water containing aquifers, complexes and water zones according to the age of water containing aquifer, composition and structure of rock and sediment, and their water level.

5.2.2. Quaternary sediment aquifer

Pores, pore-water layer aquifers spread widely in this region and underground water is contained in Quaternary sediments of river and movement origin. The water aquifers of Quaternary sediments of river and movement origin spread widely in the southern, central, northwestern and northeastern sections or lowlands and valleys between hills of the region. These aquifers consist of medium rounded gravels, bed rocks, pebbles and sands of various grains. Clayey materials are included in the composition of sediment of lake origin in the central section of the lowlands.

The composition, thickness, water transmission ability, permeability and water level of the sediments of these aquifers vary depending on accumulation condition and type of origin of the sediments in the region. The water aquifer at the Chandgana valley consists of sand filled gravel, pebbles and bed rocks.

The data of some wells registered within the area show that underground water in that area has free surface form, occurrence depth of 0.8-1.4 m and yield of 0.1-0.5 L/sec. Pore-water layer aquifer spread widely in the Murun river valley and plain. In order to solve the water supply of the power plant, it is important to have a hydrogeological detailed survey done by a professional organization in this Murun river valley.

The water level of the Quaternary sediment aquifer is relatively high and it is advantageous in terms of drinking water volume and quality compared with other aquifers.

The porous Quaternary sediment of river origin consists of sand with well grounded gravel along the river bank and pebbles. But the porous sediment of mountain foot origin consists of clay and sand containing mountain rock fragments.

The water containing rocks of the Quaternary sediment aquifer are pebbles, gravel, gravel containing sand and sand. This water aquifer contains pore-water layer underground water. The sediment of alluvial-proluvial origin located along temporary stream river and dry pebbles contain more water compared with other Quaternary sediments. In most cases its upper layer is well saturated with water but sometimes water can be found in the depth of 5-15 m. The pores of aquifer not only has hydraulic connection with pore-water layer underground water but also has connection with rock crevice water located underneath or in parallel.

The ground water of Quaternary porous sediment occurs in a depth of 0.8-25 m depending on land surface relief. The chemical composition of ground water varies and its hydrocarbonate-sulphate mixed mineralization is about 0.2-1.6 g/l

The water flow regime of the Quaternary sediment aquifer is unstable and changes on seasonal basis. In other words, in spring and summer seasons the water level is increased and the water level decreases by 1.5-3.0 m during winter or low precipitation dry season.

The Quaternary sediment within the Chandgana deposit does not contain underground water and it plays a role to transfer ground water or to handle secretion of precipitation water down to the lower water layer.

5.2.3. Water complex of Lower Cretaceous Zuunbayan suite

This water complex of Lower Cretaceous Zuunbayan suite has been studied well in connection with the use of the Chandgana Tal coal deposit. The water containing rocks of this aquifer are sandstone with crevices and coal layers. Argillite and alevrolite alternating layer with relatively low water permeability is located in between the sandstone and coal layers. The rocks of the Lower Cretaceous Zuunbayan suite are relatively good water containing aquifers and create a single water complex with hydraulic connection with each other. Most of these aquifers accumulate free surface water except certain sections where low pressure water is accumulated. The coal layer and the sandstone crevices underneath contain crevice-water layer type ground water.

The Chandgana Tal coal deposit is located at the elevation of 1150-1160 m above sea level. But the elevation of the Murun river valley is 1110 m. Therefore, the general direction of underground water flow is directed to the northeast or to the direction of the Murun river.

Hydrogeological survey work has been conducted at the Chandgana Tal coal deposit area since 1962. This survey has determined that the crevice-water layer type ground water level is situated at the elevation of 1145 m and the thickness of water complex is 60.8 m in average. The coefficient of secretion of the water containing rocks is 5.88 m / day.

A survey was conducted in 2002 by the order of the “Berkh Uul” LLC, which used that deposit at that time, to determine the volume of ground water to be leaked into the mine pit. The materials of this survey show that 12,990.1 m^3 / day or 541 m^3/h water is estimated to leak into the 90,000 m^2 mine pit at the initial stage.

5.2.4. Power plant water supply possibility

Generally, the reserve of water to be leaked into the mine pit is divided into two groups:

1. Static reserve
2. Dynamic reserve

The static reserve is the volume of the water contained in the rock collector or crevices of the aquifer. But dynamic reserve means the volume of water coming from outside sources (precipitation, flood, river, lake, outside region feeding) into the aquifer rocks. In other words, the dynamic reserve can be understood as a potential water reserve to be used long term.

The dynamic reserve of an open pit mine occupying large area is calculated as follows:

Where:

H – aquifer thickness, in m;

h – Dynamic level of water, in m;

K – Coefficient of secretion of water containing rocks, m /day;

L – Length of open pit mine;

R – Impact radius;

The dynamic reserve identified by using the above mentioned formula is 7400.4 m^3/day or 308.3 m^3/h. This shows that only within the coal deposit the dynamic ground water reserve is 7400.4 m^3/day. However, this dynamic reserve is not sufficient for the 4x150 MW power plant water supply.

The results of hydrogeological survey work conducted in this region show that the Chandgana coal deposit area underground water flow direction is headed to the northeastern direction or Murun River. In other words, it is proved that underground water accumulation region is Murun river area. Therefore, the water demand of the new power plant can be met by the underground water accumulation region located near the Murun River. However, no hydrogeological survey has been conducted to determine the water reserve of the Murun River and its basin. Therefore, it is impossible to make a conclusion that the power plant water demand can be met fully by using the underground water reserve of the Murun river basin.

Since water supply issue plays an important role in power plant operation, the uncertainty of water reserve to be used for this power plant can have not only significant impact on the Project implementation but also may cause significant risk. Therefore, it is required to conduct a detailed hydrogeological survey in order to determine sufficient water reserve to be used for the power plant and to reduce the potential risks.

Therefore, it is considered appropriate to conduct detailed hydrogeological survey at the Murin river basin and to determine the water reserve in detail during the detailed design stage of the power plant.

6. PROJECT REQUIREMENT

The requirements to be imposed on the power plant to be constructed on the basis of the Chandgana Tal coal deposit can be divided into the following three sections:

- Location requirements
- Technical requirements
- Environmental requirements

6.1. Location Requirements

The location of the power plant should be selected in a distance so that it could cause no harm to the coal mine to be exploited in the future, any other factories and facilities to be constructed near the coal mine and their respective operations.

The existing dirt road is required to be improved or changed in order to construct the power plant and to transport coal to be used for the operation of the power plant.

The area of the power plant should be selected so that the buildings and facilities to be located inside its fence could have the most optimized location and conditions of any further expansion could have been met realistically.

6.2. Technical Requirements

The technical specifications of the power plant to be constructed based on the Chandgana Tal coal deposit and all the equipments, machinery related to it should be consistent with environmental and climatic conditions of the region. The environmental and climatic parameters of the Project implementation site are given in the Table 6.1.

Table 6-1. The environmental and climatic parameters of the project site

No	Parameters	Unit	Volume
1	Maximum air temperature	^{o}C	38.9
2	Minimum air temperature	^{o}C	-46.3
3	Annual average air temperature	^{o}C	0.2
4	Calculated outside air temperature		
	one coldest day	^{o}C	-39.1
	three coldest days	^{o}C	-38.0
	5 coldest days	^{o}C	-36.9
	ventilation	^{o}C	-31.3
	per day of warmer season	^{o}C	26.6
5	Annual average precipitation	mm	205.35
6	Maximum precipitation per day	mm	80.1
7	Relative humidity:		
	At 01:00 PM winter months	%	67%
	At 01:00 PM summer months	%	43%
8	Average wind speed:		
	Annual average	m/sec	3.7
	Average of April	m/sec	4.9
	Average of May	m/sec	4.7
9	Duration of heating	days	228
10	Average temperature of soil surface		
	January	^{o}C	-23.3
	February	^{o}C	-18.9
	July	^{o}C	23.6
	Annual average	^{o}C	1.9
11	Predominant wind direction	West, northwest	
12	Snow load on horizontal surface	kg/m^2	50.0

The power plant consists of the following complete set of basic and auxiliary equipment, technological lines and independent systems:

- Power plant site or engineering and other building facilities located at that site;
- Furnace and auxiliary equipment;
- Turbine, generator and auxiliary equipment;

- Feed water pipeline, feed water reheating equipment, deaerator
- Fuel receiving, storage and transmission systems;
- Oil slurry lubrication material storage container plant;
- Feed water and chemical water treatment system;
- Drinking and fire protection water system;
- Waste water treatment system;
- Administration office, repair shop, warehouse;
- Furnace and workshop building;
- Electricity distribution open facilities, electrical equipment;
- Basic transformers, batteries
- Power plant equipment control, safety and protection system, telecommunication equipment;
- All equipment lightening protection, ground connection and other safety equipment;
- Ash removal system;
- Cooling water system;
- All equipment installation and connection works;
- Power plant site preparation earth work, construction of foundation, drainage and flood protection systems;
- Building facilities, roads and parking area construction inside the power plant fence;
- Power plant fence and security;
- Connection of the power plant with substation;
- Electric power transmission lines;
- Power plant water supply pipeline;
- All the spare parts and auxiliary materials required for power plant construction, test and commissioning;

The design of the power plant should consider the operational lifetime of the basic equipment and the engineering facilities at least 25-30 years.

The standards widely used in Mongolian and international engineering building facilities. All the equipments, machinery and appliances to be supplied and the works to be performed within the Project must meet the respective requirements of national and international legislation, standards and norms.

The equipments to be supplied and installed at the power plant must be brand new and meet commonly accepted international standard requirements.

The construction materials and construction and installation works must meet the requirements of not only Mongolian national legislation, rules and standards but also the international standards.

6.3. Environmental Requirements

The environmental requirements to be imposed on the power plant construction and operation consist of the Mongolian Law on Environment Protection, the Law on Air, toxic waste standards as well as all other relevant rules.

As of today Mongolia uses over 3500 national standards as well as over 10 international standards, out of which over 140 standards are environment related standards and totally 8 environmental embargo standards. The environmental standards include standards such as air, drinking water, surface water, soil standard etc. Embargo standards include standards such as air pollution standard, standard of waste water to be supplied to water treatment facility etc.

The power plant is required to implement environmental quality control system ISO 14000 international standard in its operation.

The following environmental legislation and standards must be adhered to during construction and operation processes of the power plant:

- Law on environmental protection, 1995
- Law on EIA, 1998
- Water law, 2004
- Land law, 2002
- Law on payment of use of water and mineral water reserve, 1995
- Drinking water, hygiene requirement and its control MNS 900:2005
- Improved toilet and refuse pit
- Damaged land rehabilitation, definition of terms MNS 5915:2008
- Removal and storage of fertile soil during earth work MNS 5916:2008
- Planting vegetation on damaged land, technical requirement MNS 5918:2008
- Environment. Removal of fertile soil during earth work, technical requirement MNS 4917:2000.
- Environment. Planting vegetation on damaged land, technical requirement MNS 4918:2000
- Environment. Soil used for covering damaged land. Technical requirement MNS 4919:2000.
- Environment. Side gradient of damaged land. Technical requirement MNS 4920:2000.
- Байгаль орчны хамгаалалын стандартын систем. Үндсэн дүрэм MNS 0017-0-0-06:1979.
- Environmental protection standard system. Mongolian climate. Basic indicators. MNS 4191:1993.
- Environmental protection standard system. Business entity ecological certificate. Basic rules. MNS 4219:1994.
- Air quality. General concept. Measuring unit MNS 4226:2000.
- Atmospheric air quality indicator, general requirement. MNS 4585:1998.

- Environmental protection. Atmosphere. Urban area air quality control rules. MNS 0017-2-3-16:1988.
- Environmental protection. Hydrosphere. Protection of underground water from pollution. General requirement. MNS 3342:1982.
- Water quality. Sampling. Ground water sampling recommendations. MNS ISO 5667-11:2000.

Besides adhering to the above mentioned standards, the impact of power plant on environment must be subject to the limits determined by the 1998 World Bank instruction manual “Prevention from and reduction of pollution” and the existing effective rules, standards and norms of Mongolia.

The power plant must meet fully the requirements of the “Permissible amount of air pollutants produced by a power plant according to the World Bank” given in the Table 6-2 and “Mongolian air quality standard 4598-2007”, which determines the maximum permissible amount of air pollutants of chemical origin in the air of external and internal environment of urban areas.

Table 6-2. Maximum permissible amount of air pollutants

No	Indicators	World Bank rules
1	SO_2	< 0.2 t/day/MW or 2000 mg /Nm^3
2	NO_X	< 750 mg/m^3 , Dry or 6% CO_2
3	CO	No limit
4	Particles (of all sizes)	< 50 mg/Nm^3

Table 6-3. Maximum permissible amount of air pollutants of chemical origin in the air of external and internal environment of urban areas

/MNS 4585/2007 standard/

Indicators	Average measuring duration	Measuring unit	Tolerable content, permissible level
Sulfuric gas (SO_2)	10 min average 20min average 24 h average Annual average	mkg/m^3	500 450 20 10
Carbon protoxide (CO)	30 min average 1 h average 8 h average	mkg/m^3	60000 30000 10000
Nitrogen dioxide (NO_2)	20 min average 24 h average Annual average	mkg/m^3	85 40 30
Kzone (O_3)	8 h average	mkg/m^3	100
Particle (Total weighted substance)	30 min average 24 h average Annual average	mkg/m^3	500 150 100
Less than 10 micron size particle (PM10)	24h average Annual average	mkg/m^3	100 50
Less than 2.5 micron size particle (PM2.5)	24 h average Annual average	мкг/$м^3$	50 25

The basic equipments of the power plant must meet the requirements specified in the Table 6-2 and the Table 6-3 in any case of normal load fluctuation of 50% -100%.

The quality of waste water to be discharged by the power plant must meet the environmental standard as well. The requirements of power plant waste water quality are shown in the Table 6-4.

Table 6-4. Waste water quality requirements

Indicators	MNS 4943:2000 standard	World Bank rules
pH	6 – 9	6 – 9
Substance to be weighted	< 35 mg/L	< 50 mg/L
Oxygen required for chemical purpose	< 50 mg/L	Not specified
Oxygen required for biochemical purpose	< 20 mg/L	Not specified
Mineral, oil and fat	< 6 mg/L	< 10 mg/L
Chromium (total)	< 0.3 mg/L	< 0.5 mg/L
Copper	< 0.3 mg/L	< 0.5 mg/L
Iron	< 1.0 mg/L	< 1.0 mg/L
Zinc	< 1.0 mg/L	< 1.0 mg/L
Remaining chlorine	1.5 mg/L	< 0.2 mg/L
Temperature increase	Not specified	< 3°C

Power plant produces not only air pollutants but also produces significant amount of noise. Therefore, according to health requirement the power plant must be subject to the noise limit specified in the Table 6-5.

Table 6-5. Noise limits

Environment	Maximum noise limit (within time interval) db	
	Daytime (07:00–22:00)	Nighttime (22:00–07:00)
Residential district	55	45
Industrial district	70	70

7. PROJECT DESCRIPTION

Scope of works for a power plant erection project relaying on the Chandgana Tal coal deposit has been determined as the following on the basis of electricity demands of the Central Energy System and Eastern Regional Energy System, coal and water reserves to be exploited in the power plant and quality indicators.

7.1. Power plant location

The power plant is planned to be located in the northeast of the Chandgana khavtgai site with an exploration license No 11654X which is under the ownership of the Chandgana Coal LLC and is in the south and nine kilometers far from the deposit. This location will not interfere into the development of the Chandgana Tal and Chandgana Khavtgai mines and dominant wind direction of the region meets the requirements not to impact negatively on the mine and other constructions. Locations of the Chandgana Tal and Chandgana Khavtgai specially licensed sites and the power plant are shown in the Figure 7-1.

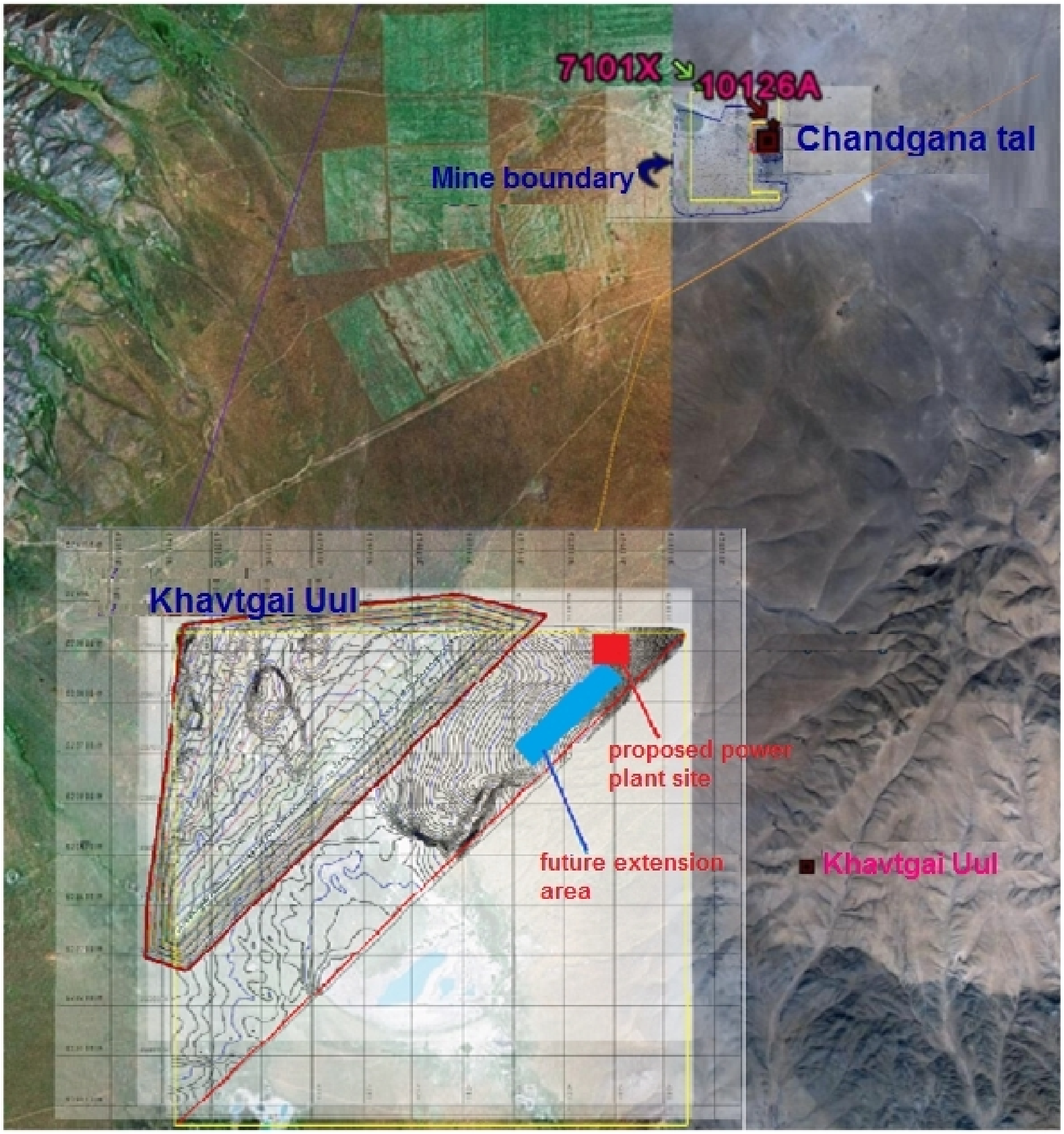

Figure 7-1. Location of power plant

7.2. Coal and water supply

Ignite coal of the Chandgana Tal mine will be exploited by the power plant. The coal heat contents are varing 2678 – 3394 kcal/kg and we are estimating the average coal heat content is 3144 kcal/kg.

Technology water consumption of the power plant is planned to be provided with artesian water of the Murun River basin which is located in the north of the coal deposit.

7.3. Selection of the power plant capacity

Results of a research work conducted on 2010-2015 perspectives of the energy system of the Central and Eastern regions of Mongolia are shown in the table 7-1.

Table 7-1. Electricity demand and supply perspective of the CES and ERES

	2010	2011	2012	2013	2014	2015
CENTRAL ENERGY SYSTEM						
1 Generation capacity	656	656	656	656	638	638
1.1 Power plant #2, MW	18	18	18	18	18	18
1.2 Power Plant #3, MW	110	110	110	110	80	80
1.3 Power Plant #4, MW	460	460	460	460	460	460
1.4 Darkhan Power Plant, MW	42	42	42	42	54	54
1.5 Erdenet Power Plant, MW	26	26	26	26	26	26
2 Demand	711	768	964	1166	1297	1375
2.1 Existing peak load, MW	711	768	829	896	967	1045
2.2 New potential demand						
Ulaanbaatar area, MW			60	120	150	150
Darkhan-selenge area, MW			25	50	80	80
Erdenet-Bulgan area, MW			50	100	100	100
3 Capacity deficit, MW	-55	-112	-308	-510	-659	-737
4 Required capacity						
4.1 Import from Russia, MW	120	120	120	120	120	120
4.2 Required Capacity of new power plant, MW	0	0	-188	-390	-539	-617
EASTERN REGIONAL ENERGY SYSTEM						
1 Generation capacity	24	24	24	24	24	24
1.1 Choibalsan Power Plant, MW	24	24	24	24	24	24
2 Demand	21	23	79	126	149	151
2.1 Existing peak load	21	23	24	26	29	31
2.2 New potential demand						
Mining projects in Dornod, MW			35	65	70	70
Mining projects in Sukhbaatar, MW			20	35	50	50
3 Capacity deficit	0	0	-55	-102	-125	-127
REQUIRED CAPACITY OF NEW POWER PLANT, MW	0	0	244	492	644	744

Judging from the table 7-1, a deficiency of 390 MW-capacity may cause in CES and 102 MW -capacity may cause in ERES or a total of 492 MW-capacity deficiencies may cause in 2013.

If the loss of electricity transmission line was calculated at 3% and internal consumption of the power station was calculated at 10%, a new source of minimum 563.3 MW capacity will be required to provide 492 MW electricity demand. Therefore, a capacity of the power plant to be erected relaying on the Chandgana Tal coal deposit is planned to be at 600 MW.

Four blocks with 150 MW-capacity have been planned in order to assure reliable operations of the power plant and to maintain reasonable level of investment.

7.4. Power transmission line and substation

The nearest sub-station that could be connected with CES from the Chandgana power plant is the 220 kV Baganuur substation. For ERES, the nearest point that may be connected with ERES is Undurkhaan. Therefore, 150 kilometer-long 220 kV two circuit power transmission line and 60 kilometer long 220 kV one circuit electricity transmission line have respectively been planned to be connected from the Chandgana power plant up to the 220 kV Baganuur substation and Undurkhaan substation on the basis of demand, supply and electricity transmission capacity.

Schemes of the planned power transmission air route are shown in the Figures 7-2 and 7-3.

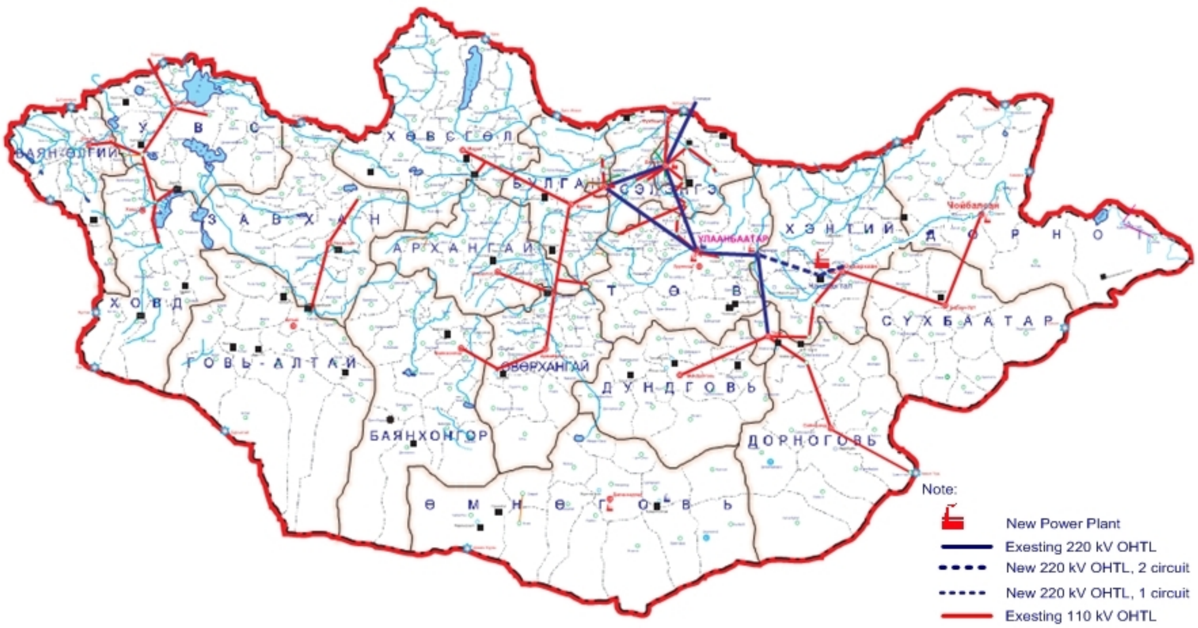

Figure 7-2. Transmission line scheme

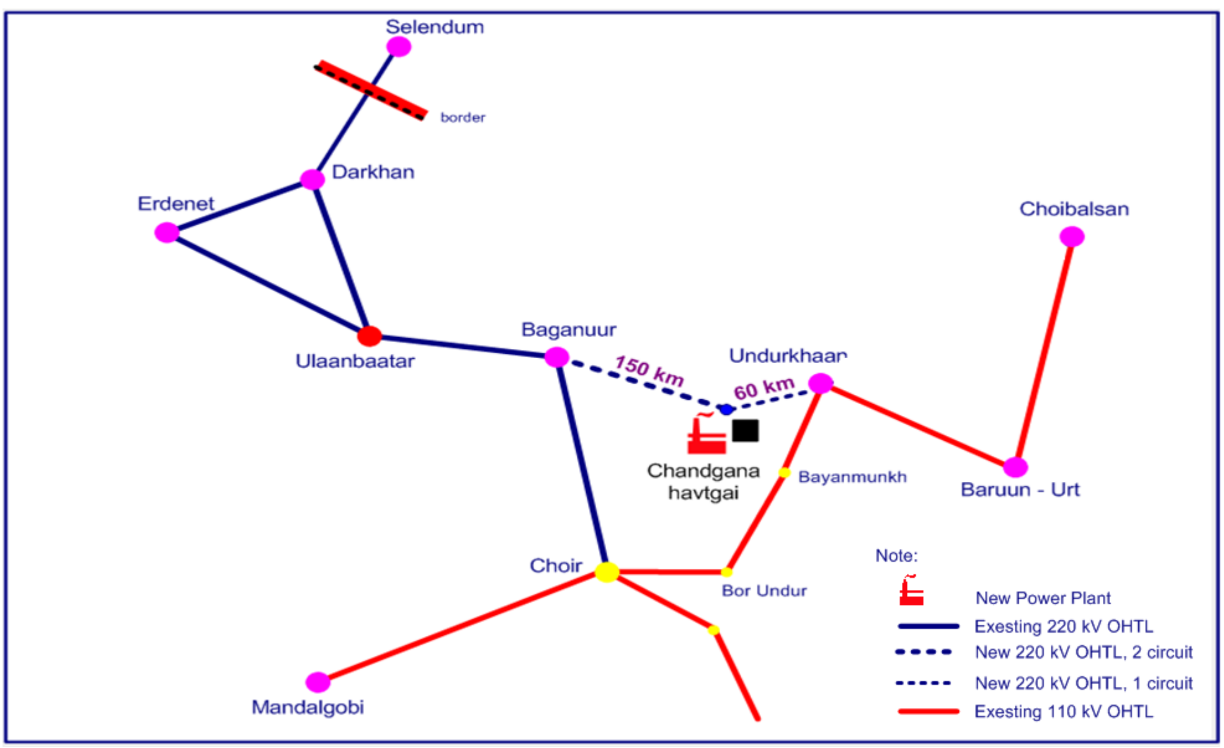

Figure 7-3. Scheme of transmission lines connecting the power plant to CES and ERES

7.5. System stability calculations

The static and dynamic stability calculations have been done for the parallel operation of Power Plant and CES, and EES. Is has been assumed that this power plant will be interconnected to the CES via 220 kV double circuit transmission line, and 220 kV transmission line will connect it to the EES through 220 kV Undurkhaan substation.

The detailed calculations and conclusions for each case regime have been made for the following options such as stand alone operation of Chandgana tal power plant, parallel operation of power plant with one certain power grid, and parallel operation with both CES and EES systems. All calculations were performed based on DAKAR and PROJECT softwares developed by Russian developer particularly for Mongolian power grid and extensively used as well as in Russia. As the result, the main electrical diagram for interconnection to grids was developed based on these studies, and equivalent circuit, main line parameters, transmission capability were determined as well. In addition, an evaluation of power plant's operational regime was done too. The most important is that power plant's optimal capacity limit of main equipment has been determined which suits positive stability of the system.

The following conclusions are made based on results of system dynamic stability calculations:

1. In case of failure of one unit of power plant the CES will face power shortage and system stability will be jeopardize. Selection of 150-200 MW capacity unit will eliminate such problem and system stability will be maintained.
2. In case of existence of 220 kV "Ulaanbaatar – Baganuur - Chandgana" transmission line and failure of one section of this line the remaining line is not capable to transmit 450 MW power, and system's dynamic stability will fail. Therefore, it's necessary to

have 3 parallel lines, and emergency regime conditions will be fulfilled.

3. The option of connecting Chandgana power plant to CES and EES has been calculated based on assumption of winter regime when peak load is 730 MW, EES load is 19 MW, 20 generators in operation at 5 power plants of CES, 2 generator operating at Chandgana Power Plant, and 3 generators working at Dornod power plant. The regime calculation was positive assuming that Chandgana power plant is connected to CES via 220 kV double circuit line and single 220 kV transmission line connects to EES. It means that there will not be any problem to connect CES and EES through Chandgana power plant. System operation will be normal.
4. The reactive power of Chandgana power plant in normal operation is to be between 120 to 240 MVar.
5. Calculations shows that during aggravated and limited circumstances Chandgana power plant is able to supply 450 MW of power to the Central Power grid, and voltage level is in normal level.
6. Based on calculations Chandgana power plant could be a reliable and stable operating source which could operate in parallel not only with the CES but also with the EES.

According to system's dynamic stability calculations, selection of 4x150MW capacity for Chandgana power plant will not have problem operating in parallel with power grid. In order to maintain stable and planned power supply to the CES the number of circuits and design structure of transmission line is of crucial importance. This study need to be done within the next feasibility study on power transmission line and substations to meet all necessary detailed requirements for system stability.

The detailed report on “Calculation of operational regime of Chandgana power plant to operate in parallel with CES and EES” is attached to the feasibility study.

8. TECHNICAL AND TECHNOLOGICAL SPECIFICATION

8.1. General

It has been determined that installed capacity of proposed Chandgana tal Power Plant is to be 600 MW or 4 x 150 MW for the initial stage based on demand and supply forecasts of Central Energy System and East Energy System, environmental and infrastructure factors discussed in previous chapters, and with possibility for further extension.

The power station shall have a design life of 30 years and shall be capable to operate in a range of 40 – 100% boiler load without supplemental fuel. Net capacity will be in the range of approximate 54 – 135 MW (40-100% MCR) for each boiler unit.

The proposed power plant configuration will fully meet general, technical and environmental requirements listed in chapter 6 of this study, and suitably operate in particular region's climate conditions.

The diesel engine-generator-units will generate electrical power in case of emergency. These engine-generator-units can also be used to feed the power station with electricity in case of boiler shut down of all four units (black case scenario). Diesel fuel tanks are located next to the diesel-generator-unit. Those tanks will feed the diesel-generator-unit as well as the boiler ignition systems during start-up operation or in cases where backup firing might be required.

The conceptual design of the power station will consider the rural conditions as well as extreme ambient conditions and the plant will have sufficient facilities for equipment repair works and maintenance services.

8.2. Equipment Arrangement

Unit dedicated air cooled condensers are located south of the boiler houses considering the predominant wind direction from west/northwest in this region. Main equipment arrangement is shown in Figure 8-1.

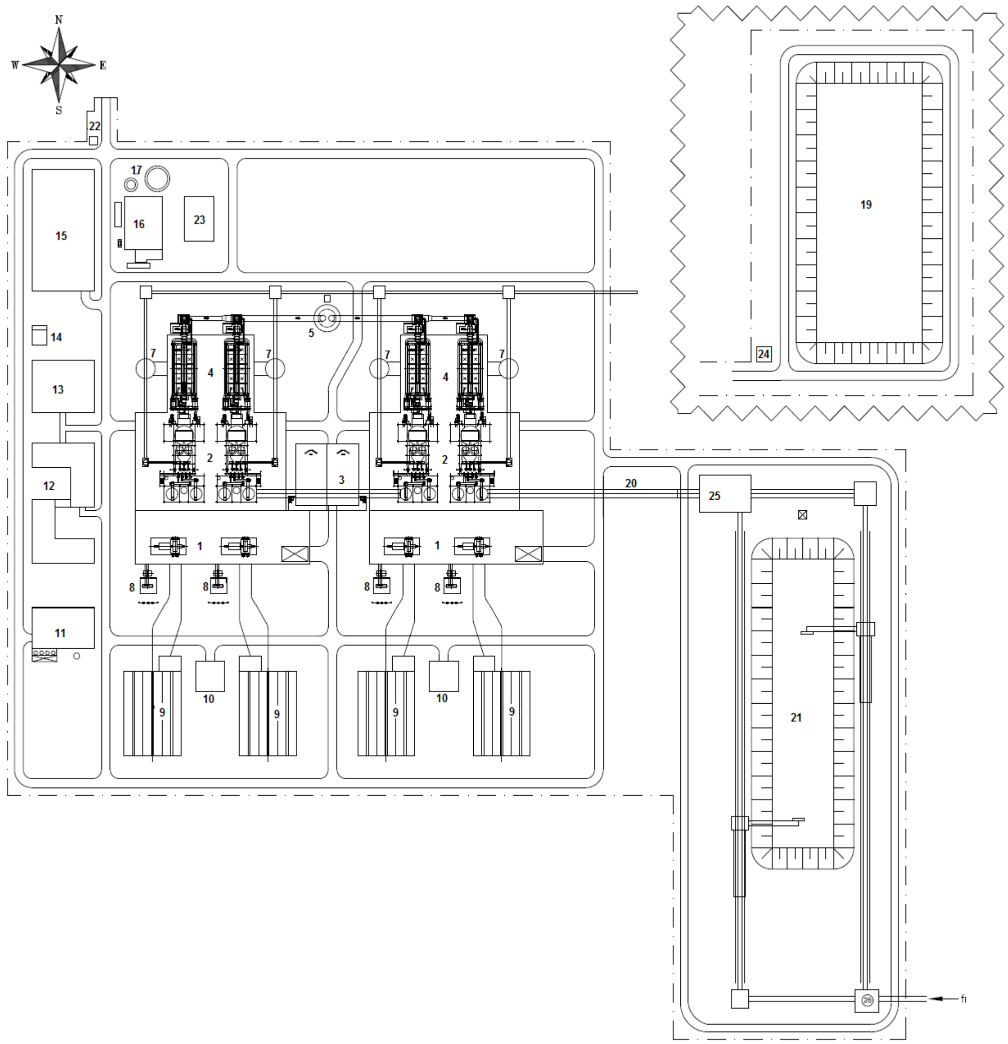

Figure 8-1. Main equipment arrangement

Legend:

1. Turbine house, 2. Steam generator, 3. Central Control Room, 4. Flue gas filter, 5. Stack, 6. Bottom ash silo, 7. Fly ash silo, 8. Transformer, 9. Air cooled condenser (ACC), 10. ACC secondary system, 11. Water treatment plant, 12. Administration building, 13. Social building, 14. Sewage plant, 15. Workshop and storage building, 16. Diesel generator, 17. Light fuel tanks (LFO), 18. Ash pipelines, 19. Ash pond, 20. Coal belt conveyer, 21. Coal stock yard, 22. Gate house, 23. Auxiliary steam boiler, 24. Pump station, 25. Coal yard central control room, 26. Travel tower 1 (including crusher)

The general layout drawings are shown in Figures 8-2 and 8-3. The zoomed in drawings are attached in Appendix.

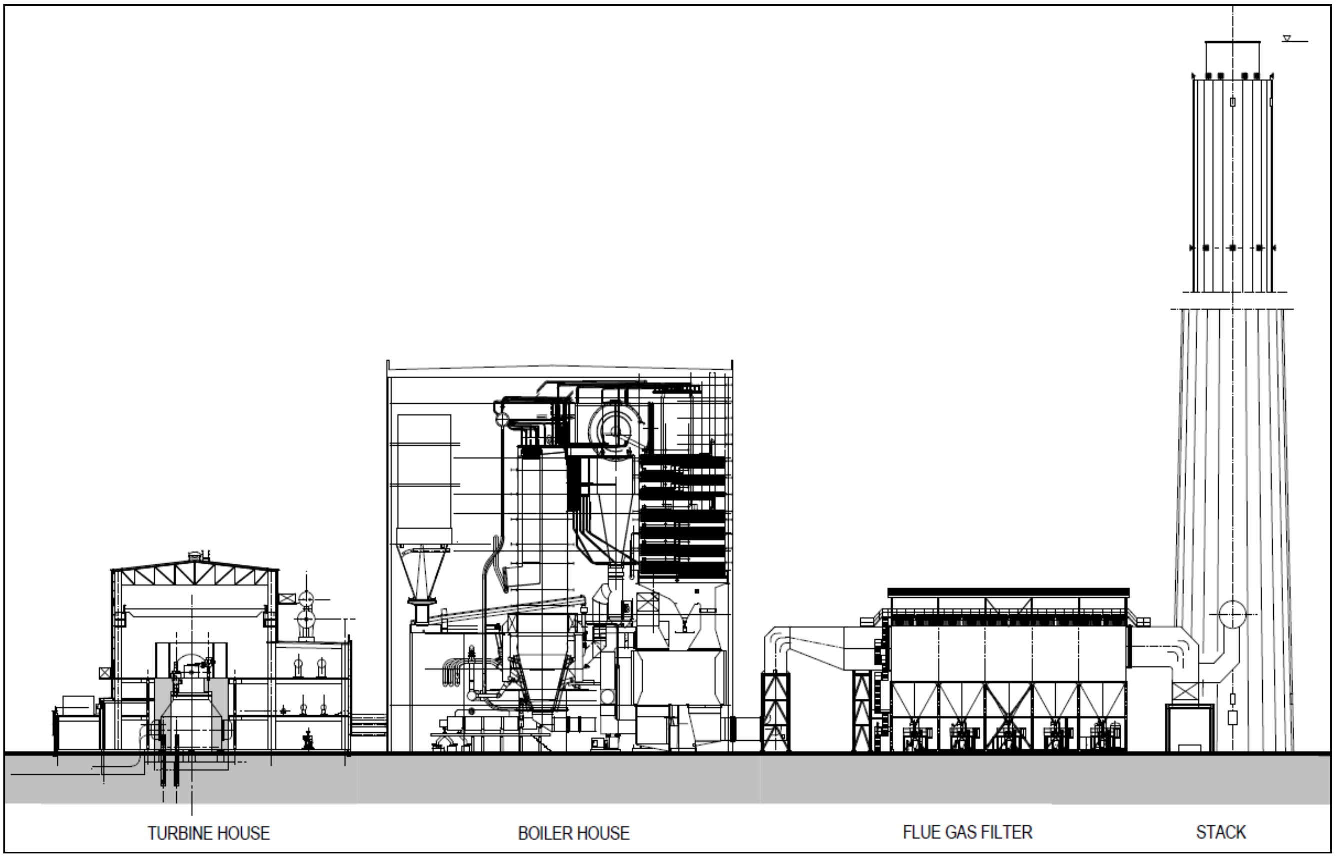

Figure 8-2. Equipment arrangement – Section view

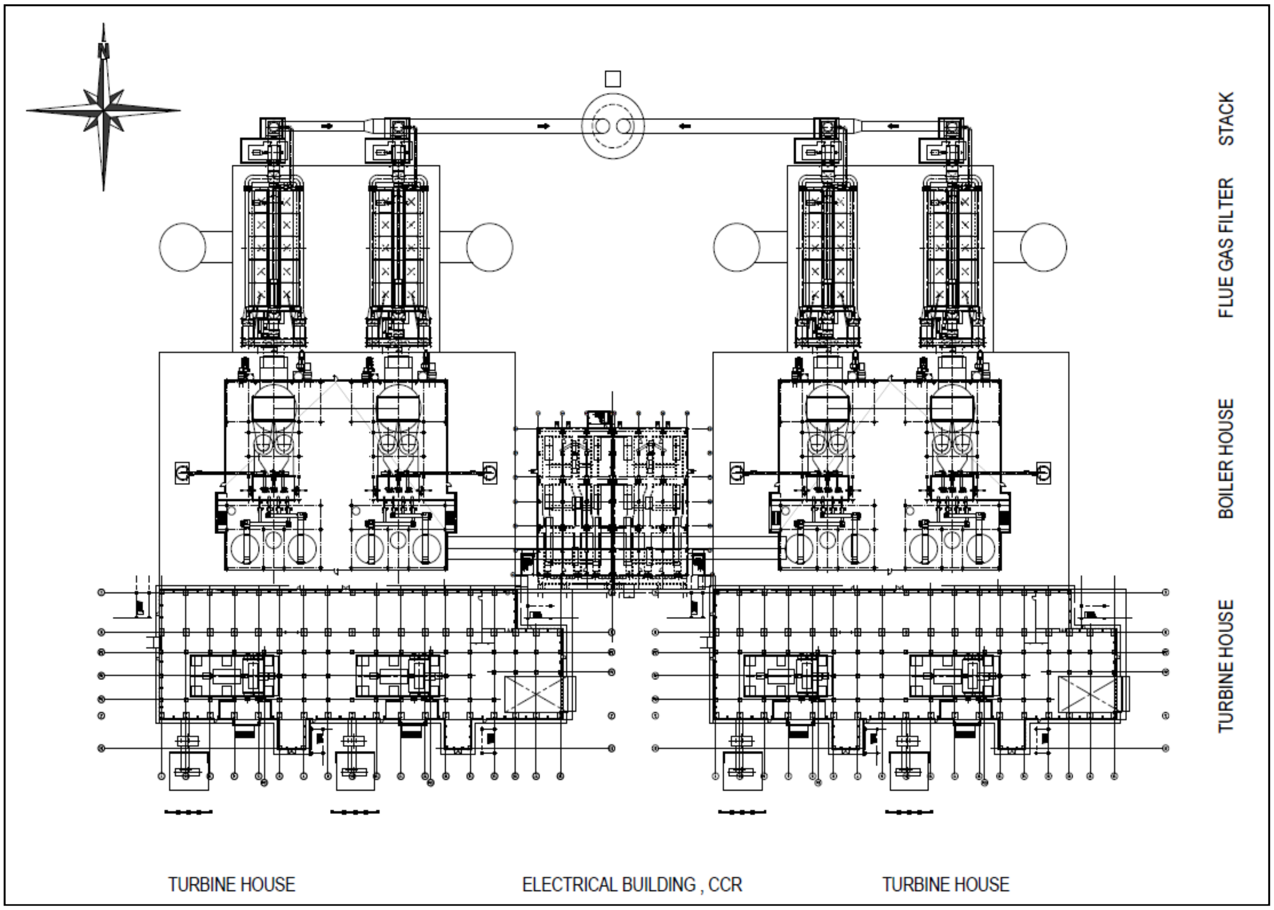

Figure 8-3. Equipment arrangement – Layout

The power station layout has a mirror design, each with 2 x 150MW units. The lowest wind probability is in southeast direction and common plants and social building are therefore located in northwest direction.

The coal yard is located east of the boiler houses to minimise corresponding coal drifts into the plant area.

To ensure high reliability the majority of the equipment is located in house. The housings shall protect the equipment from environmental conditions such as extreme temperatures, strong wind, sand drifts, etc.

Each two boilers are located in a common boiler house with a central designated to supervise the power plant operation. Also the electrical control room is integrated in this building.

Two turbine halls are located south of the boiler houses. The four turbine/generator units and the associated equipments are located inside the turbine halls.

Each unit has a dedicated generator connected with a step-up transformer and a self supply transformer.

Unit dedicated air cooled condensers are located south of the boiler houses. The cooling system is designed for an annual average ambient temperature, i.e. generating capacity may have to be slightly reduced at peak temperatures in summer but can reliably operate with full load in winter times.

Flue gas handling equipment consists of ID-fans, fabric bag filters and one common chimney. They are located north of the boiler houses. The entire power station is equipped with one chimney. The chimney is constructed as a common wind shell with two flues inside, each flue for two boiler units.

Administrative buildings, workshops, storage building, and social buildings are forming a parallel line to the main power plant. Common plants are also located within this line. Major common plants are water treatment, waste water treatment together with storage facilities for dedicated chemicals.

An underground emergency pond for fire fighting water together with associated pump station is located southwest of the main power plant systems. This pond can also be used to collect rain water in limited quantities.

Fly ash from fabric bag houses, air pre-heaters, etc. and bottom ash from disposal. Only minor intermediated storage facilities are required as the ash will be immediately transported to the deposit. The ash deposit shall be located in the vicinity the power plant.

Coal will be delivered direct from the coal mine. The coal will be transported with belt conveyor from the mine to the coal yard. The coal yard is equipped with an intake crusher and with two stacker / re-claimer.

Coal might be transported direct from the coal mine to the boiler house or can be stored in the coal yard. The system is able to store coal coming from the mine and to reclaim coal to the boiler house at the same time. The system is also able to blend different coal qualities if required. The entire coal handling equipment is designed to operate 24 hours per day, i.e. continues multi-shift operation is required.

The entire power station including coal yard will be fenced. Access roads will be constructed to provide access to all major maintenance and storage areas. Gate house(s) will be available for workers and employees as well as for heavy truck traffic whereas truck traffic will be safely guided in order to avoid dangerous situation with workers and employees.

8.3. Main Equipment

The installed capacity of power plant is planned to be 4 x 150 MW for the initial stage. All main equipment such as steam generator units, turbines and generators will be of modern technology and meeting international standards.

1. <u>Steam Generator Unit</u>

The Circulating Fluidized Bed (CFB) type boiler has been selected based on chemical characteristics of Chandgana Tal coal.

This description of a Circulating Fluidized Bed steam generator has to be understood as a typical one. Depending on the finally selected supplier, the CFB technology could verify within its design features. The following description is based on the technology of a well known and proven supplier. Furthermore the type of steam generator could be natural or forced circulation design. The steam generator unit will be a drum boiler equipped with all necessary heating surfaces and connecting lines, single reheating, Circulating Fluidized Bed (CFB) combustion, as well as a light oil firing system for start-up and backup.

Each steam generator unit will be constructed in a steel supporting structure. The steam generating supporting structures are integrated part of a common boiler house, each boiler house for two steam generator units, i.e. two boiler houses in total. Common platforms, stairs and walkways for operation and maintenance are integrated.

The air ducts with primary fans, secondary air fans and fluidizing air blowers as well as the steam coil and the regenerative air heaters are located inside the boiler houses. The flue gas ducts, the fabric bag filter and the induced-draft (ID) fans are located outside the boiler house in separate housings.

The steam generator equipment permits fully automatic operation, including start-up and shutdown, remote controlled from the Central Control Room (CCR).

The steam generator will be designed as a fully welded version suspended in a steel sup-porting structure. Due to the extreme weather conditions, the steam generating units including coal bunkers will be arranged inside the steam generator houses. The coal handling plant service platforms above the coal bunkers will also be enclosed and equipped with a dust extraction and filter system.

Design and equipment of the steam generator will enable quick, simple, safe and reliable daily start-up and shutdown while ruling out damage, excessive strain and increased wear. It also will enable block shutdown in a safe manner. Daily start-ups and shutdown will be possible in order to be able to operate upon demand.

Start-up of the steam generator unit from cold will require auxiliary steam for pre-heat purposes and to heat-up the boiler feed water system.

The steam generator units together with the turbine units are operating in sliding or fixed pressure mode depending on the steam generator concept. The final super-heaters will be configured for parallel flow to the flue gas flow, however in case of non-permissible heat loadings only. Draining and venting of heating surfaces will be possible. Each steam generator unit will be equipped with a single train design for combustion air and flue gas.

Steam-heated air heaters will be provided downstream of FD fans to avoid operation conditions below acid dew point at start-up and turndown operations.

The entire systems will be designed for high reliability and availability. At the end of an operation period between maintenance shut-downs, the steam generator and all other plant parts will be able to operate at MCR and will still have adequate reserves to permit plant operation without difficulty and to counteract the usual disturbances and fluctuations.

Those load changes are possible without excessive strains to any of the parts of the steam generating units beyond the permissible limits.

If required for plant blackout and to protect steam generator heating surfaces, an emergency feed pump sized for 5-10% MCR capacity which has a power source separate from the main feed water pump.

2. Turbine Unit

Besides start-up, no-load and shut-down operations, steam turbines generally will be designed to meet mean and peak-load conditions. The following operating requirements will be met:

- Normal and idle operations of the plant will be possible under prevailing ambient conditions without any damage.
- The turbine will be capable of continuous operation in an island operation for internal consumption.
- The turbine will be capable of 100 % base load operation as well as cycling operation with daily start-up and shut-down.
- It will be possible to control load drop to idling or island operation for internal consumption from full load without turbine trip.
- The steam turbine will be capable of being operated in modified sliding pressure mode.
- 100 % normal load continuously or with different duration of operation with daily start-up and shut-down.
- Short-term peak load will be possible.
- The turbine will be capable of operating over the entire load range without restrictions between 100 % load and minimum load. Minimum load will be specified.
- Idling for an unlimited time at nominal speed will be possible.
- Transient thermal gradients occurring during an interruption of start-up or full-load drop shall cause no damage. Immediate re-start will be possible. Three repeated starts will be possible within an hour without impermissible warming-up.
- Load drop at 100 % normal-load and at peak-load will be considered.

3. Generator

The generator including its auxiliary and ancillary systems will be designed for the same or a higher MTBF as the steam turbine. The generator will have the same life expectancy as the steam turbine, taking into account the operating cycles expected for the entire turbine-generator set.

- Cooling method — Air-cooled
- Rated active power — 150 MW_e
- Rated Frequency — 50 Hz
- Speed — 3000 min^{-1}

For further details refer to Electrical Section.

4. Air cooled condenser

The Air Cooled Condenser (ACC) uses the direct dry cooling mechanism. The condenser will be charged with ambient air, which takes up the condensation heat. The air flow will be forced by fans.

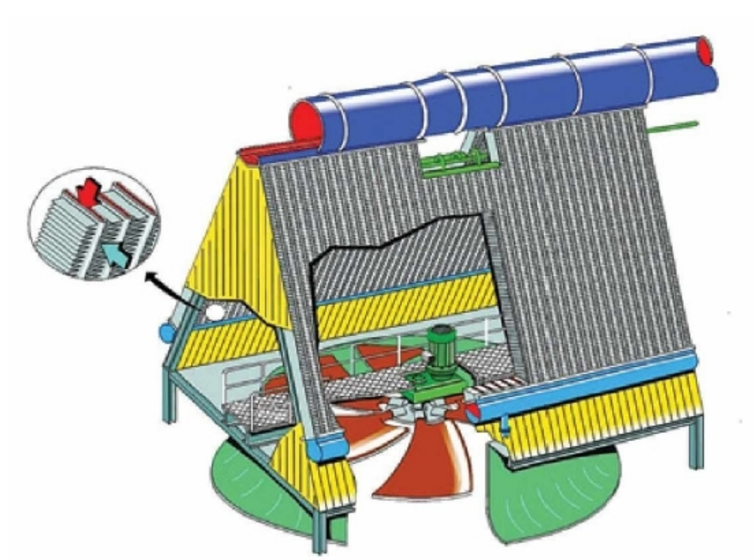

Figure 8-4. Air cooled condenser

The steam will be led through a steam distribution line to 3 ACC fields in A-Frame design which is the most popular ACC style used in power plants of all sizes. In the respective fields a steam duct will feed the condenser bundles in which the steam will be condensed in co-current flow with the condensate. Some bundles of each field will be dephlegmator bundles. The depfhlegmator bundles will be operated in counter flow to reduce the subcooling of the condensate, to evacuate the condenser as well as to extract gases from the condenser.

The condensate will be collected in a piping system and by slope fed to the condensate tank. The condensate will be pumped out the tank back to the water – steam process.

The design point for the ACC will be about 3°C ambient temperature to assure a reliable and efficient operation with all expected ambient conditions. In cases of low ambient temperatures the fan speed can be reduced so that there won't be any freezing problems.

In cases of part load and minimum ambient temperatures one or two ACC fields will be shut off in combination with fan speed controlling.

The design pressure for 100% load and 3°C ambient temperature will be approximately 55mbar. In cases of higher temperatures the power output at 100% load will be reduced by higher condenser pressure

8.4. Combustion system

The fuel of the power plant will be the Chandgana Tal deposit coal and this coal is included in the sub- bituminous/lignite coal classification. Minimum average heat generation capacity will be 3,144 kcal/kg.

The combustion of fuel in a Circulating Fluid Bed (CFB) Boiler takes place in the furnace, in which the process of evaporation the boiling water will occur. The boiling water will flow from the steam drum via a down comer

The furnace walls are designed as a vertical chamber composed of fin welded water-wall tubes in which the CFB process occurs. This includes the fluidization of the furnace bed material which is composed of the following material: ash, fuel, sorbent. Properly sized fuel is fed via gravimetric feeders into the furnace and burned at a relatively low combustion temperature. If required, fine grain sorbent might be introduced into the furnace which will be calcinated and oxidized enabling it to react with the sulphur dioxide formed during the combustion of sulphur containing fuels. The product of this reaction is calcium sulphate (gypsum), a solid, which adds to the bed inventory and is easily removed with the ash that is formed during the combustion process.

The bed material is fluidised with a combination of primary air, secondary air, and combustion gases. The primary air is introduced to the furnace through fluidising air nozzles which are located at the grate of the furnace. The introduction of this primary air initiates fluidisation of the bed material. The subsequent formation of combustion gases along with the introduction of secondary air in the furnace produces sufficient upward velocity of gas to cause the bed material to form a gradient of suspended solids throughout the height of the furnace. This column of suspended solids is in constant motion in which particles either exit the furnace with the combustion gases or reflux back down the column towards the furnace grate.

The solids that are conveyed out of the furnace are separated from the combustion gas in a particle separator and are continuously returned to the lower portion of the furnace by a recycle loop. The very high internal and external circulating rates of the solids, characteristic of the circulating fluid bed results in consistently uniform combustion temperatures throughout the furnace.

Solids residence time in the furnace can be on the order of minutes for each cycle of the solids circulation. This is due to the high slip velocity between the combustion gases and solids, which causes the solids to proceed through the furnace at a much lower velocity than the combustion gases. The long residence time of the solids and the constant solids circulation produces high combustion efficiencies and high heat transfer rates to the furnace water-wall tubes.

The combustion of the fuel occurs in two zones: a primary reducing zone in the lower section of the furnace and the final combustion zone located above the upper level of secondary air inlets to the furnace.

The primary combustion zone is located between the primary fluidizing air nozzles and the upper secondary air inlets. One level of secondary air inlets is located between the primary air nozzles and the upper secondary air inlets where the combustion process is staged at sub-stoichiometric air requirements. Final combustion using excess air takes place in the upper region of the furnace, above the upper secondary air inlets. This staged combustion process effectively suppresses NO_x formation.

The height of the furnace is designed to assure adequate particle residence time. Residence time in the CFB improves carbon burnout and sulphur capture while maintaining low NO_x levels.

The combustion of the fuel produces two material streams: combustion gases and ash. All of the combustion gases exits the furnace via outlets located in the upper region of the furnace. Carried along with this gas are any solids that may have been entrained in the gas stream. This stream of material enters the particle separator that removes a majority of the solids from the combustion gases.

Light Fuel Oil (LFO) fired start-up oil burners perform the preheating of the CFB furnace up to the furnace temperature required for solid fuel firing which is depending on the volatility of the solid fuel. Combustion air for the start-up burners is supplied from the secondary air fan.

When the CFB furnace temperature reaches the temperature required for solid fuel firing, solid fuel firing can be initiated. At this time the start-up burner fuel flow can be reduced and solid fuel flow increased until the allowable furnace temperature for unsupported solid fuel is achieved. At that point the start-up burners may be shut off.

Start-up burner combustion air will be introduced through a control damper supplied by an automatic modulating actuator. The ignitor and main burner gun are automatically retractable, and manually removable for maintenance purposes. Blast gates are furnished to allow for removal of the ignitor and main burner gun while the CFB is in operation.

Particle separator and convective heat transfer section

The gases exit the top of the cyclone particle separator and are then ducted to the convective section of the boiler. In a typical CFB arrangement, the gas travels the following path after exiting the particle separator:

- First, the combustion gas enters a steam cooled backpass enclosure that contains super-heater, re-heater, and economizer surface
- Second, the gas is cooled by the air-heater
- Third, the remaining particulate matter entrained in the combustion gas is removed in the Fabric Bag Filter
- Fourth, the cleaned combustion gas is exhausted to the atmosphere via the induced draft fan to a stack

After flowing through the furnace and the particle separator, combustion gas enters the convective backpass. In the backpass, super-heater, re-heater, and economizer surfaces absorb the sensible heat from the combustion gas and use it to superheat steam and to preheat the feed water flowing to the drum.

High pressure feed water flows through the horizontal economiser, which is arranged in the convective backpass, to the steam drum in sub cooled conditions.

Saturated steam from the steam drum first enters steam-cooled cyclones. Steam from the outlet of the steam-cooled cyclones enters the sidewalls and flows to the convection super-heaters.

Once entering the first horizontal super-heater, steam is flowing counter to the combustion gas flow direction. Cold reheat steam flows into the horizontal and is flowing upward in, counter flow to the combustion gas flow direction.

Air and flue gas system

The combustion air is supplied to the CFB furnace in three main streams:

- Primary air, supplied by a primary air fan (approximate 70% air flow to furnace)
- Secondary air, supplied by a secondary air fan (approximate 30% air flow to furnace)
- Fluidizing air, supplied by a fluidizing air blower.

Primary air is introduced through a plenum/grate assembly located at the bottom of the refractory covered furnace section. Secondary air is introduced into the furnace section by means of multiple ports located in the furnace walls. Fluidizing air is introduced into the seal pots through fluidizing air nozzles.

The flow of air into the furnace is integrated and recorded and is automatically proportioned to the fuel feed rate to maintain the required excess air ratio for combustion.

Steam-heated air heaters will be provided downstream of the primary and secondary air fan to avoid operation conditions below acid dew point at start-up and turndown operations.

A Ljungstrom regenerative air pre-heater is provided to realize a highly efficient heat transfer surface, compact for a large amount of heat duty.

Fule gas path

Flue gas from the steam generator systems will be treated in order to fulfil national standards as well as limits set by the World Bank (IFC Standard according to "Pollution Prevention and Abatement Handbook 1998").

The flue gas from the regenerative air pre-heater will be guided to a fabric bag filter and further downstream to an ID fan and to the stack.

The flue gas will be discharged through a common stack for all four units. The stack consists of a common wind shell with two flues inside. Each flue is connected with two steam generator units.

Auxiliary steam generator

One auxiliary steam generating unit will be provided for securing the auxiliary steam supply for periods with none of the four boiler units in service. The auxiliary steam generator consisting of:

- Number of auxiliary steam generator 1
- Size of auxiliary steam generator 30 t/h
- Fuel Light fuel oil (LPO)

The conceptual design of the fire-tube / smoke-tube boilers will include a dry-back reversal chamber in a well-tried design. This includes also all equipment and systems required for safe and reliable operation of the complete plant and the electrical and I&C equipment.

The auxiliary steam generators will allow simple and reliable load control, start-up and shut-down operation. The system will rule out damages, overstressing and increased wear during all operation modes.

The respective forced-draft fans will overcome the entire air and flue gas resistance (with furnace pressure control) up to the connection to the stack.

Auxiliary steam will be needed during still stand of main steam generators for heating and during start up process of main steam generators for steam air heater, feed water heating, oil atomizers of fuel oil igniters etc.

8.5. Thermo-Dynamic System

The 150MW reheat condensing turbo set will consist either of one single flow high-pressure (HP) turbine and one single flow intermediate-pressure (IP) turbine or of an single flow HP and a single flow IP in an combined casing, depending on the turbine manufacturer. In both cases the turbine train will be completed by one double flow low-pressure (LP) turbine and one generator.

The live steam will leave the boiler with a pressure of about 130bar and a temperature of about 535°C and will be fed through the HP piping to the HP turbine. After leaving the HP turbine with a pressure of about 22bar and a temperature of about 300°C the steam will be reheated in the boiler to a temperature of about 535°C and will fed the IP turbine. After expanding in the IP turbine to a pressure of about 2bar, the steam will be fed through an overflow pipe to the LP turbine.

The LP turbine will expand the steam to a vacuum pressure of approximate 60mbar and moisture content of about 10%.

After leaving the LP turbine the steam will be totally condensed in the air cooled condenser.

Table 8-1 shows key thermodynamic data

Table 8-1. Thermodynamic key data

Item	Unit	Value
Live steam pressure	bar	132
Live steam temperature	°C	535
Live steam mass flow	kg/s	125
Cold reheat pressure	bar	25
Cold reheat temperature	°C	320
Hot reheat pressure	bar	20
Hot reheat temperature	°C	535
Hot reheat mass flow	kg/s	105
Exhaust steam mass flow	kg/s	86

The thermal system of steam generator unit consists of common steam header which connects main and auxiliary equipments and other relevant systems. The principal thermodynamic system's diagram is shown in Figure 8-5.

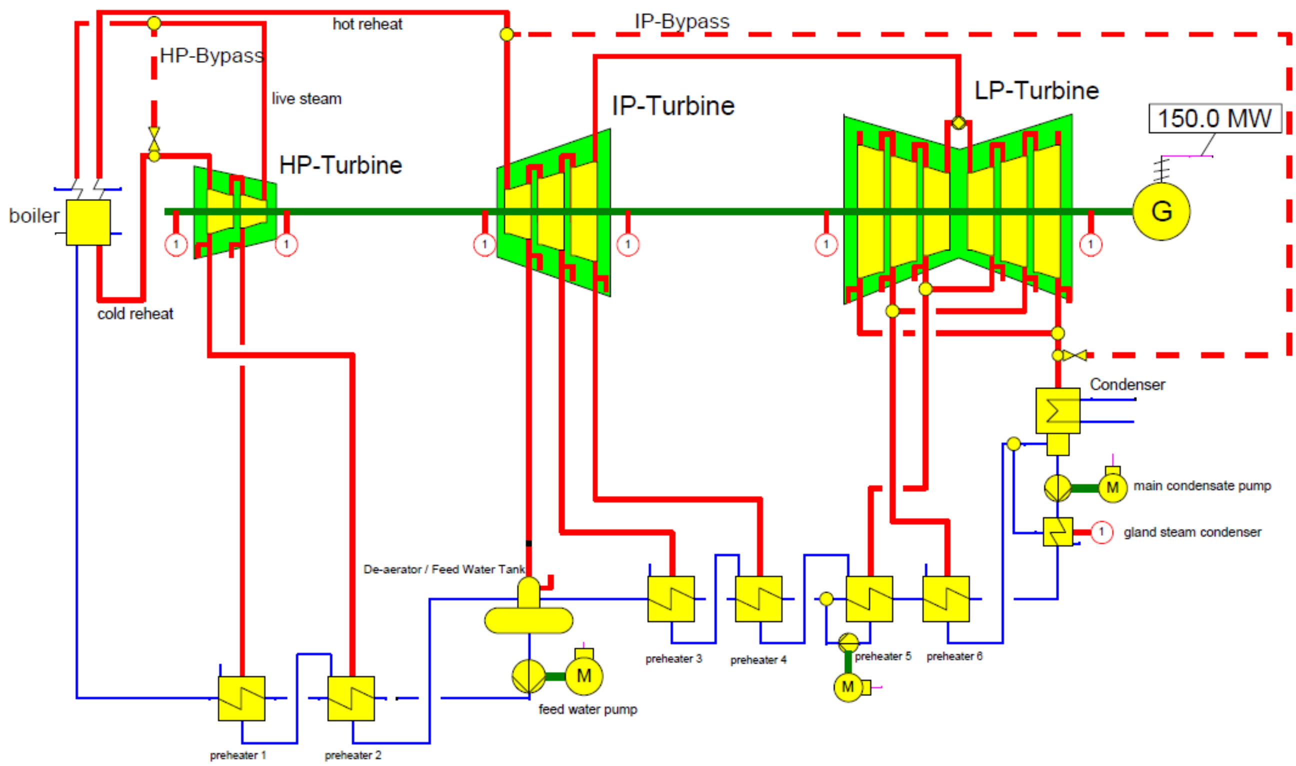

Figure 8-5. Thermodynamic schema

The turbines will be arranged on one shaft with the generator. The turbine will dissipate thermal energy into mechanical energy. The generator will dissipate this mechanical energy into electrical energy which will be discharged into the electrical grid, after branch the needed auxiliary power.

The ACC will dissipate the condensation heat to the ambient air. The cooling system will be designed for an ambient air temperature of +3°C to allow sufficient operation conditions all over the year. This design will ensure the full design capacity in winter times but will consequently lead to a reduction of power generation capacity in summer. At peak temperatures of +40°C the reduction will be approximate 10-13% of the design gross capacity.

A complete HP and IP steam turbine by-pass system will be installed. The purpose of this system is to facilitate the start-up of the plant and to improve the operational flexibility during rapid load changes.

In case of by-pass operation the HP steam will be expanded and sprayed down to the cold reheat steam condition and be discharged in the cold reheat system without passing the HP turbine. This is necessary to ensure that the re-heater in the boiler will be cooled. After reheating the IP steam will also be expanded and sprayed down and will be fed directly into the condenser.

The condensate will be pumped by condensate pumps through the multistage HP and LP preheating train. The regenerative feed water pre-heating is an important factor for increasing the efficiency of the water steam cycle by increasing the feed water temperature before entering the boiler and lowering the amount of steam which has to be condensed.

The preheating train will consist of a gland steam condenser 4 LP pre-heaters, one feed water tank and two HP pre-heaters. The first two pre-heaters (no 5 and 6) will be fed by extractions of the LP turbine. Pre-heater no 3 and 4 will be fed by extractions from the IP turbine. In case of any event of fault of the pre-heaters there will be a bypass system to ensure a high availability of the plant.

The condensate of the first pre-heater downstream the condenser and the condensate of the gland steam condenser will be led back into the condenser tank. The condensate of pre-heater no 3 and 4 will be cascaded down to the pressure level of pre-heater 5 and be pumped into the main condensate flow downstream pre-heater 5.

After passing the LP pre-heaters the condensate will have a temperature of approximately 130-140°C and will enter the spray type de-aerator which is located in the feed water tank. The de-aerator removes the gases from the condensate. From this point on the condensate is going to be called feed water. The feed water will be stored in the feed water tank, which is necessary for transient operation modes.

The feed water will be sucked out of the feed water tank through the feed water suction line by the feed water pumps. All feed water pumps will be provided with minimum flow recirculation lines at the outlet to protect against low load operation. These recirculation lines will be routed to the de-aerator/feed water storage tank. The feed water pump sets will be fully adequate to supply not only boiler feed water requirements, but all necessary supplies of spray water to the boiler super heaters and re-heaters, as well as to the HP by-pass.

Downstream the feed water pumps the above mentioned HP pre-heaters are located. HP pre-heater no 2 will be fed by the cold reheat. HP pre-heater no 1 will be fed by an extraction of the HP turbine. The condensate of both HP pre-heaters will be cascaded down and be led into the feed water storage tank. After leaving the second feed water pre-heater the feed water will have a temperature of approx. 230–240°C. In case of any event of fault of the economizer there will be a bypass system to ensure a high availability of the plant.

8.6. Coal handling system

The coal handling system is planned to match 4 x 150 MW capacity and be located in area which will not affect future place for plant extension.

The Power Plant will be located in 9 km distance from the coal mine. The coal will be transported by a belt conveyor system from the mine to the coal handling plant of the power station.

The main technical data for the design of the coal handling system are shown Table 8-2.

Table 8-2. The main technical data of the coal handling system

Item	Unit	Size
Capacity	MW	4 x 150
Coal consumption	t/h	360
	t/d	8640
Coal storage capacity	t	60480
	days	7
Coal pile		
Type	-	longitudinal
Shape	-	trapezoidal
Number	-	1
Length	m	225
Base width	m	70
Height	m	14
Capacity	t	120000
	days	14

The entire coal handling plant will be operated in a three-shift system.

Coal handling system is shown in Figure 8-6.

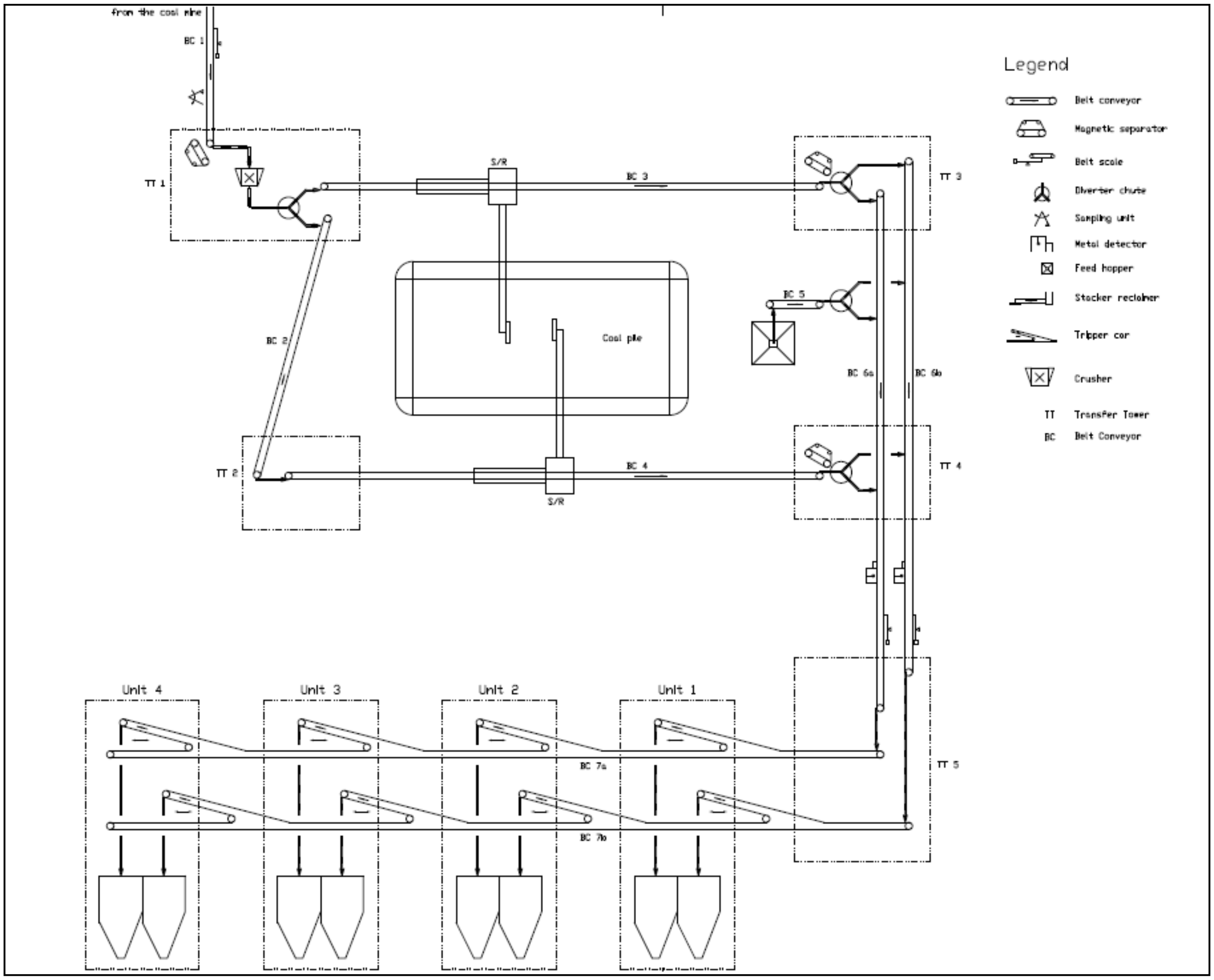

Figure 8-6. Coal handling system

In regular operation the coal coming out of the mine will be directly conveyed to the coal bunkers inside the boiler buildings. The present design is based on two bunkers per unit. The useful capacity of the bunker will be equal to the amount of coal needed for the operation of three hours full load operation with worst coal.

The main equipment of the coal handling plant includes the following:

- Two (2) rail-mounted stacker/reclaimer machines for piling the coal in the stock yard or reclaiming the coal from the pile
- Belt conveying system from the battery limit between power plant

- Belt conveyors from the stockyard to the boiler house bunkers; that conveying line consists of two redundant belt conveyor systems, two times 100 percent
- Towers for the transfer points of each conveyor; complete including roof and cladding
- Crushers for a particle size of ≤30mm, installed in transport tower 1 (TT1)
- Galleries for all elevated conveyors, fully enclosed, including flooring, cladding, roofing
- One (1) sampling plant installed on belt conveyor BC 1 in front of the transfer tower TT 1; taking samples from a moving stream of coal, designed as a hammer type sampler
- One (1) magnetic separator installed at the discharge pulley of the belt conveyor BC 1 in transfer tower TT 1. (This one is only necessary in the case there is no separator at the beginning of the belt conveyor line out of the mine.)
- Two (2) magnetic separators installed in the conveyor lines from the stockyard to the boiler bunkers, installed at the discharge pulleys of the belt conveyors BC 4 and 5 in transfer tower TT 3 and TT 4.
- Several belt scales, installed in the conveyor lines as indicated in the coal handling flow sheet in order to measure the flow rate as well as the coal quantities conveyed on all relevant conveying lines
- Electrical equipment;
- Instrumentation and control
- All necessary steel structure, including necessary platforms for control and maintenance
- Hoisting facilities, special tools for maintenance and spare parts; each tower will be equipped with a mobile crane underneath the roof equipped with a mobile hoist, designed for the heaviest part

monorails complete with lifting block trolleys and hoists have to be provided.

- Water/snow scrapers for the stockyard conveyors and all other conveyors which are not enclosed for special reason
- Metal detectors, installed at the conveyor lines to the boiler house coal bunkers
- Dust suppression system by spraying water for the entire storage yard: operated from the control room, in total or partly
- Mobile (automotive) vacuum cleaning system for all the towers and galleries; within each tower and each gallery itself a fixed pipe system will be installed.
- One (1) feeding hopper installed on the storage yard close to the towers BC 3 and BC 4 fed by mobile equipment for emergency coal supply of the bunkers in the hazard of a breakdown of the reclaimer
- Each of the coal bunkers will be equipped with an ultrasonic, continuously operating level measuring system indicating the bunker level to the main control room and the coal handling control room; in addition a separate max. level indicator is foreseen for each bunker

Coal Stock Yard

The capacity of coal stock yard will be able to feed 4 x 150 MW plant and to have a reserve for 14 day uninterruptable coal supply. Coal delivered by conveyer belt system will be either supplied to stock yard or to coal bunkers which are interconnected to each other.

The size of coal yard will be of 70 m in width and 225 m long. The coal yard is equipped with two stacker/reclaimer machines. As the coal consumption of all four units running under full load is about 8640 tonnes per day. In case of a break down or a malfunction of one machine, the units could run with the second machine.

The stacker/reclaimer will be able either to stack the coal or to reclaim the coal from the pile. Each reclaimer will take out the coal from the pile and feed the respective longitudinal stockyard belt conveyor. Both longitudinal belt conveyors will be equipped with a system to drain the belt from rain water before transporting coal. This device shall also allow for taking off the snow in winter.

Further on one end of the stockyard a reclaim hopper will be arranged. This is for contingency. In case there is a malfunction of the reclaimer this hopper shall ensure the coal supply to the boiler bunkers. It shall be possible to feed the coal to this hopper by mobile equipment (front-end loaders).

In case of normal operation the coal coming from the mine will be conveyed directly to the boiler bunkers with adapted capacity, if the capacity of the mine belt conveyors is higher than of the conveyors of the coal handling plant. The final capacity of conveyer belt system will be determined during design stage.

The stacker/reclaimers can be operated manually or in semi-automatic mode. The machines are designed to operate on all motions and maintain full stability at wind speed as per respective standard. The maximum allowed operating wind velocity shall be in accordance with FEM standards; above which the machine will be rail clamped.

The operation of the stacker/reclaimers will be controlled from a very well positioned operator’s cabin which allows an excellent view over the working range as well as over the travelling area.

Crusher

Large sized coal will be crushed by crusher. The size of crushed coal will be 30 mm or less. Two crushers will be installed for reliability purpose from which one shall be in operation and the second one as stand-by.

The by-pass line will be placed on crusher's screen with purpose of sending fine coal to the conveyer belt located after crusher and further to coal silo of boiler.

Belt Comveyors

All the belt conveyors will be designed, supplied and erected according to ISO, DIN or equivalent standards.

All the belt conveyors will be of the 45° troughed carrying idler type. A general policy of standardization of plant items, such as pulleys, idlers, shaft sizes, bearings, gear boxes, motors throughout the system will be applied to achieve maximum interchangeability and keep stockholding requirements to a minimum.

The driving unit of each conveyor will include an electric motor and gearbox of approved design and manufacture. All gears will be totally enclosed and oil immersed and equipped with visible oil level indicator.

Flexible couplings of approved type will be provided between the motor and the gearbox. At conveyors requiring 30 kW or more a fluid coupling will be included between motor and gearbox.

All main conveyors of the single belt conveyor line will be equipped with a standby drive unit, i. e. each of these belt conveyors must be supplied with 2 x 100% drive units. A manual operated clutch of approved design will be provided between the gearbox and the drive pulley of the conveyor.

Each conveyor will be provided with a suitable tension unit to cater for belt stretch and to maintain an adequate slack side tension in the belt. Conveyors having short distances between head and tail pulleys may be fitted with screw type take-ups. The screw take-ups are fitted with a tension monitor to give indication of tension in the conveyor belts for the acceptable tension range required for operation of the conveyor. All other conveyors shall be provided with a gravity counterweight take-up type, or power driven, load cell controlled type.

Conveyor belting will conform to relevant ISO, DIN-standards or equivalent codes. The belt speeds shall not exceed 3.5 m/s. All belts will be of the flame resistant construction type, including the covers. Wherever recommendable from the technical and/or economical point of view textile construction belts will be preferred.

8.7. Water treatment system

Water needed for make-up and cooling systems will be supplied from underground wells located at Murun river basin.

The water treatment facilities consisting mainly of (refer to drawing no. 6269-8_1009 Water Balance ACC):

- Water treatment plant
- Potable water system
- Biological sewage plants
- Chemical dosing for the water-steam-cycle
- Condensate polishing plant (option)
- Storage concept of storm water
- Water- and coal-laboratory
- Measurements und sampling units for the water-steam-cycle

Water treatment plant

The following treatment stages will be understood as plant concept to meet requirements of boiler feed water and environmental concerns:

- Ultrafiltration plant
- Reverse osmosis plant
- Demineralisation plant

The water treatment plant will be monitored from a control room, arranged at the second floor of the water treatment building.

Due to the salt concentration in the raw water a demineralisation plant for production of demineralised water will be used as make-up water for the water-steam-cycle. To minimize the demand of chemicals for the regeneration of the ion-exchanger a reverse osmosis plant upstream of the demineralization plant will be foreseen. Furthermore the content of sediments and suspended organics in the raw water may cause problems due to incrustations on the surface of the membranes in the reverse osmosis plant, therefore an additional ultra filtration plant will be integrated upstream of the reverse osmosis plant, by use of hollow fibre module. The modules of the ultra filtration plant and the reverse osmosis plant will be mounted on common racks.

To remove the solid particulate matter on the hollow fibre module of the ultra filtration plant during the filtration phase, the hollow fibre module shall be backwashed opposed to the filtration direction in regular time intervals.

In course of time the required feed pressure in the modules of the reverse osmosis plant will increase slowly when the membrane elements have reversible deposits. If the maximum allowable pressure in the feed pipe is reached, the cleaning of membranes in the reverse osmosis plant will become necessary.

The backwash equipment for the ultra filtration plant and the chemical cleaning system for the reverse osmosis plant will be foreseen.

After the ultra filtration and reverse osmosis plant the treated raw water will be stored in temporary storage basins.

The demineralisation plant will consist of cation-, anion-, and mixed-bed ion exchanger, to reach the quality requirements for demineralised water. After exhaustion of the ion-exchanger the regeneration shall be started.

During the cleaning process of one line in the reverse osmosis plant, only the second line is in operation. In this case the increased ionic loading freight will be regarded in view of the capacity of the ion exchanger.

The regeneration of the exchangers will be provided as internal regeneration. Regeneration waste water from the ion exchanger has to be collected and neutralised in a separate neutralisation basin.

To eliminate the free carbon dioxide downstream of the cation exchanger a degasifier will be foreseen. The CO2 loaded air will be discharged through a roof top vent with a mist eliminator.

In normal case one line of the demineralisation plant is in operation, the second line is in standby position. In case of increased demand on demineralised water both lines shall be operated temporary.

Water treatment technical specifications are shown in Table 8-3.

Table 8-3. Characteristics of demineralisation plant

Item	Unit	Data
Configuration of each stage		2 x 50%
Flow rate for demineralised water	m^3/h	70
Quality of demineralised water		
Conductivity	µS/cm	0.080
Silica	mg/l	0.010
Sodium	mg/l	0.005
DOC	mg/l	0.200

To reach the aforementioned quality parameters in the demineralised water sufficient number of suitable measurements will be foreseen.

Demineralised water has be stored temporary in a demineralised water tank equipped with a carbon dioxide trap to protect the demineralised water against air and CO2 contamination in order to limit the conductivity in the tank.

Storage and handling of various chemicals and regenerates for the water treatment plant will be designed in such a way, that handling of chemicals during unloading and transfer to storage shall be kept to a minimum. Liquid chemicals will be stored in tanks lined and constructed from durable corrosion resistant material.

Tanks will be equipped with electric trace heating and insulation with metal covering if necessary to keep the chemicals in proper conditions for use at any time. Each bunded basin or tank shall separate retain the whole tank volume in the event of spillage or leakage.

Potable water system.

The raw water for the production of potable water is extracted from the well water basin and shall be filtered and sterilised by dosing of sodium hypochlorite. The network pressure downstream of the potable water conditioning plant fed the potable water into the network and then to the consumer for using as drinking water, for canteen, laboratory, toilets and showers. Backwash-water arising in the filtration stage shall be delivered to the sedimentation stage of the ultrafiltration waste water.

For dosing of sodium hypochlorite a dosing-station with lattice box for storage of the chemical agent and dosing system shall be foreseen.

Biological sewage plants.

To reach the requirements of the authority in case of the waste water quality the sanitary sewage of the power plant facilities shall be fed via a separate drainage system into a biological sewage treatment as hereinafter described.

Population equivalence: In order to determine the population equivalence and thus the excremental sewage, the operational status with 500 people has to be regarded during regular plant operation.

The arising waste water from the aforementioned consumer can be divided in (see also water balance diagram)

- Waste water with low content of organic impurities can be used after separate treatment as reuse water for the water treatment plant
- Waste water with high content of organic impurities included coliforme bacterias (shall not be used for reuse to avoid negative influence in the pre-demineralization units)

For that reason independent treatment of both waste water types are necessary. This plant concept is necessary in order to minimize the discharge waste water amount. Both biological sewage plants shall to be operated on basis of activated sludge process with common sludge stabilization (aeration process). Excess sludge arises from both biological

Chemical dosing for the water-steam-cycle.

To reduce the corrosion in the water/steam cycle an alkalisation of the water and steam is required. For the steam cycle a fully volatile alkalisation agent will be dosed.

For alkalinisation of the water-steam and condensate cycle to a pH value between 9.1 and 9.3, dosing of ammonia with a corresponding dilution station, a storage tank and an extraction device will be provided.

For additional conditioning of the drum boiler non-volatile trisodium phosphate is used for alkalinisation. The utilization of trisodium phosphate demand dosing may become necessary in order to lift the pH-value of the boiler water.

Condensate polishing plant

A condensate polishing plant shall be erected to retain the specified steam quality for the process. The need for a condensate polishing plant is envisaged to take care of minor leakages in condenser etc. resulting in ingress of solid and liquid impurities into the condensate system which may be harmful if allowed to continue.

The condensate polishing system shall maintain the feed water and boiler water chemistry within targets at those times when the condensate gets contaminated. The need for this system arises from the availability demanded from the power plant, the frequency of load changes etc. which may introduce particulate impurities or result in minor leaks in condenser adversely affecting condensate quality.

After the formation of the condensate in the condenser and the additional feeding of the make-up water (demineralised water), followed by degasification in the condenser, the condensate polishing plant will basically remove the ionic impurities.

The whole quantity of condensate will be treated in a 2 x 50 % condensate polishing plant. The plant will be installed inside the machinery house.

The condensate polishing plant will consist of cation- and mixed bed ion-exchanger. After exhaustion of the ion-exchanger the regeneration shall be started.

The regeneration of the exchangers will be provided as internal regeneration. Regeneration waste water from the ion-exchanger will be collected and neutralised in a separate neutralisation basin.

Measurements and sampling units for the water-steam-cycles

The water quality of the water-steam-cycle has to meet the requirements of the boiler and steam turbine manufacturers. Number and type of the online measurements as well as the number of sampling points will meet the international standards. The measurements and sampling units for the water-steam-cycle shall be arranged on central sampling racks located in the turbine building.

Cooling water purification system

Water reinforcing agent and sulphuric acid will be used with the purpose of keeping the water feature as it is and removing the sediments in the cooling water.

Biocide will be used for the cooling water in order to protecting the internal surface of the cooling water transmission pipe and equipment from corrosion.

Water and coal laboratory

The analytical laboratory, divided in coal and water laboratory, will be fully equipped and furnished with apparatus, accessories, reagents etc. to carry out all necessary tests and analysis required to control, operate and maintain the power plant and auxiliaries in an appropriate manner.

All chemicals, reagents etc. required for pre-commissioning, commissioning and normal operation of the plant will be provided.

8.8. Electrical System

Electrical Concept

The electrical system at site will consist of electrical components necessary for the generation, transformation, switching, control and protection of electrical power.

The electrical system consists of generator transformer, a generator circuit breaker and a unit auxiliary transformer, one medium voltage (MV) switchgear per unit for the auxiliary supply, redundant uninterrupted power supply inside each sub-system, among others for the I&C system, emergency oil pumps and protection devices.

Electrical single line diagram

The general electrical single line diagram has been developed for the Power Plant.

The electrical system at site will consist of electrical components necessary for the generation, transformation, switching, control and protection of electrical power for the following purposes:

- Generation of power for export to the external grid and for the power plant auxiliaries
- Distribution at site to auxiliary loads and services of internal plant facilities.
- To provide and supply electrical energy during abnormal plant systems situations requiring safe and at least uninterruptible.

Design, manufacturing, installation and operation will be in accordance with the applicable EN/IEC codes and standards or standards of equivalent accepted status. In addition the Mongolian grid code and other relavant technical rules have to be taken into account.

Electrical part

The electrical concept described hereafter will meet a power plant size of 4 x 150 MW. It is proposed to combine two units to one electrical sub-system, so that the whole power plant will consist of two identical electrical sub-systems.

- Electrical System: system of the four units, consisting of 2 identical sub-systems
- Electrical Sub-System: system of two units

The power plant will be connected grid via 220/110/35 kV outdoor switchyard. It is supposed that the following grid connections will be available for the new power plant:

- One 220 kV main grid connection for each unit, for energy export, start up and shut down of the unit
- One independent grid connection for standstill supply. Its necessity depends on the characteristic of the 220 kV grid

Electrical single line diagram has been planned as follows:

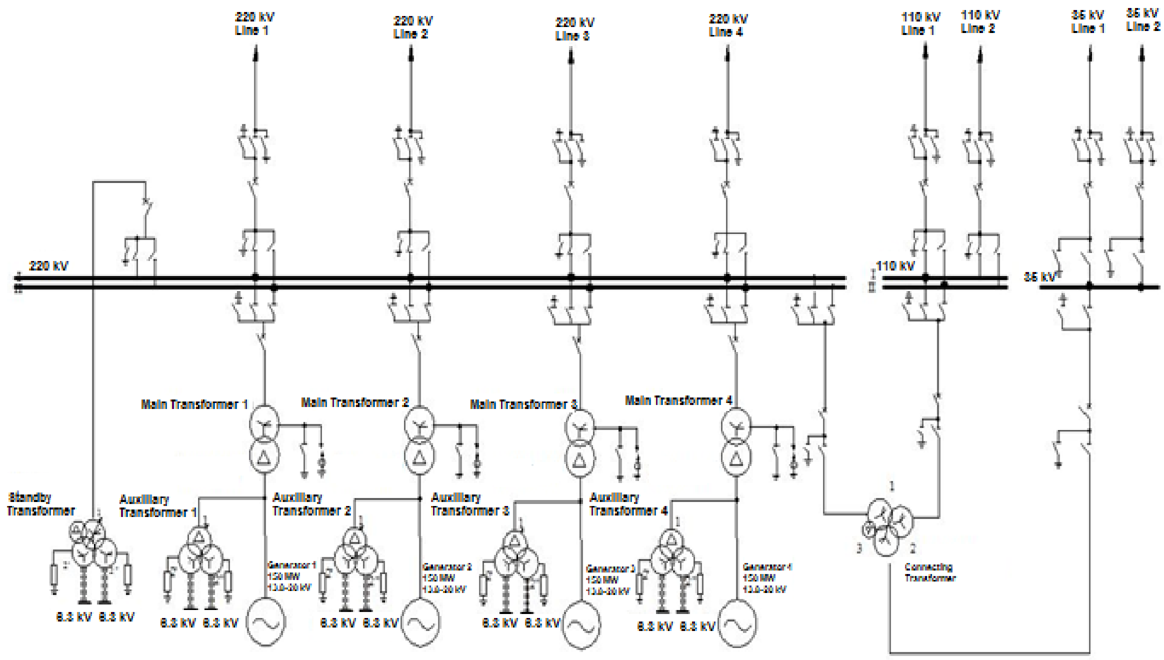

Figure 8-7. Electrical single line diagram

The Power Plant will be connected to the Baganuur - Choir branch of CES via 150 km long 220 kV double circuit transmission line as well as to the Eastern Energy System through 60 km long 220 kV overhead transmission line.

Four generators of 150 MW capacity each and 220/110/35 kV outdoor switchyard will be the part of power plant. 220 and 110 kV double busbars each for each voltage will be located outside of plant while 35 kV single busbar is in indoor. Four outgoing lines will go to outdoor switchyard. Four generators will be connected through their corresponding transformers to 220kV outdoor switchyard. Three winding coupling transformer will connect 220, 110 and 35 kV voltages. In addition, one reserve transformer will be interconnected to 220 kV busbar.

Auxiliary power system

Each unit has own auxiliary transformer and auxiliary power supply subsystem. Each subsystem is divided into medium (MV) and low voltage (LV) parts.

In regards of MV, in case when main auxiliary power is failed 6.3 kV consumers will be fed by switch at 6.3 kV bus. Low voltage transformer will feed 380 voltage system and 6.3 kV system will be connected to 200 kW and more capacity electric equipment for internal needs.

Electric board of low voltage will be compounded of two parts and will be fed by the low voltage transformer to be provided from 6.3 kV.

Each unit will have generator transformer for full load, generator breaker and auxiliary transformer. Each auxiliary transformer will supply power to main units as well as loads of second unit within the syb-system. One MV circuit breaker will be installed for auxiliaries.

General electrical diagram for auxiliary power is shown in Figure 8-8.

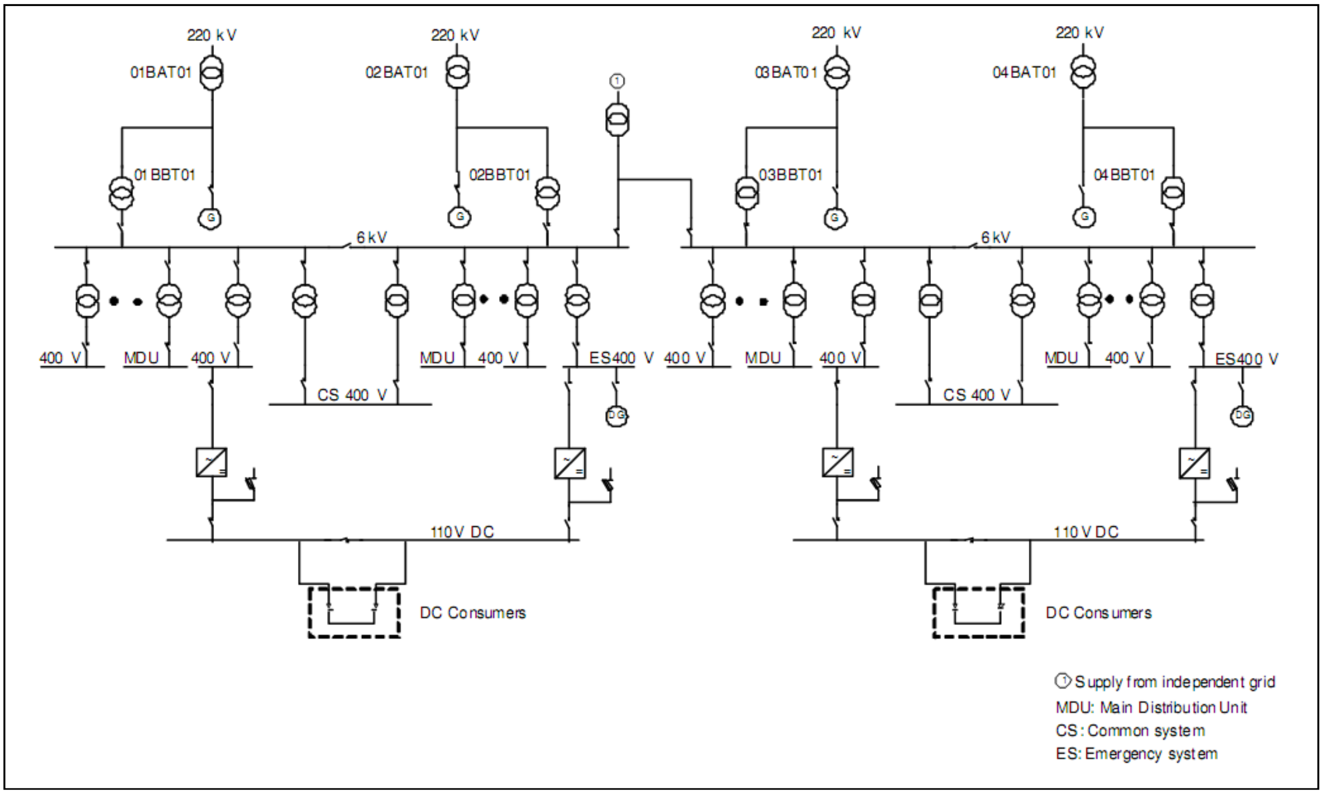

Figure 8-8. General electrical diagram for auxiliary power

Auxiliary transformer

One auxiliary transformer for each unit or totally 4 transformers will be installed. The generator output voltage between 13.8 and 20 kV will be stepped down to 6.3 kV. Output voltage will depend on supplier of equilpment. Transformers will be connected to generator buses.

Auxiliary transformers should have capacity to cover loads of all plant's equipment. The MV system will be 6.3 kV systems.

Medium voltage allocation equipment

The allocation facility of 6.3 kV will be located in a building and the transformer for internal needs and basic allocation equipment of 6.3 kV will be linked with the feed pipe in two sides through power cable.

The steam turbine generator 1, 2, 3 and 4 will be fed from 6.3 kV allocation equipment.

The 6.3 kV allocation facility entrance will have automatic and manual bus transmitters and it has a duty to switch off the transmission system when a defect has caused to any transformer for internal needs and 6.3 kV bus.

A vacuum type quick-break switch will be installed in the 6.3 kV-allocation facility. 1000 kW and less capacity engines and 1250 kVA and less capacity transformers will have a vacuum type contactor and a fusion fire defender. The transformer having more 1250 kVA capacity and engines having 1000 kW capacity will be equipped with vacuum quick-break switch.

Low voltage switchgear

The 400 V low voltage load center is provided with power by the low voltage preparatory transformer and central load transformer which will be fed by 6.3 kV allocation facilities.

Industrial equipment will be connected to have two-side feed and some common equipment of the power plant will be connected to have one side feed.

The central allocation facility of 400 V loads will be linked with the central load transformer and low voltage preparatory transformer through power cable or a new cable.

Emergency diesel generating set

For the power supply in case of an emergency shut down one diesel generating set will be installed. The diesel engine, generator, fuel tanks, pipes and pumps, starter battery, exhaust system and cooling equipment.

The diesel generator will supply consumers necessary to bring and to hold the unit under safe conditions until the failure is repaired. These consumers are mainly the fire fighting pumps, lubricating oil pumps, turbine turning gear, sump pumps, rectifier, and uninterruptible power supply, emergency-lighting.

Lighting system

Lighting systems have been planned to provide lighting level of their own zone and covering scope. All outside lightings will be regulated by photo electric elements and will be installed in the locations where natural light could be used on the best level.

The units designated for 400 V, three-phase and 60A welding works will be located in and out of the turbine workshop, furnace workshop and other industrial parts.

A phase switches of 220 V designated to connect some mobile equipment and lightings will be placed in and out of the power plant.

The 220 V standard switches will be installed in the control rooms, office rooms and other necessary units of the power plant.

Ground connection and lightning conductor system

The plant's ground connection system will cover all the areas where the industrial equipment have been placed. The ground connection system will be a copper network which connects underground all electric equipment, generators and facilities. This network has been planned to have less resistance and a possibility to operate safely in any defect and accident condition. The ground connection system will be connected to the lightning protection system.

An ground connection network will be installed in order to erect facilities of electric equipment and to install electric equipment which is out of the plant zone and this ground connection system will be done under the same procedures of non-industrial zone. The network located out of this plant will be connected with the power plant's ground connection system through the measurement and communication cable protector in order to reduce potential energy which will be originated in a large quantity during an accident and defect.

Lightning protection system will be installed in the control facility and other structures.

Uninterruptable DC power supply

The uninterruptible power supply can be divided into the DC and AC part. The AC part is fed by DC/AC inverters from the DC grid. Each sub-system (electrical system of two units) will be equipped with a redundant 110V DC and 24V DC supply mainly consisting of 110 V batteries - 2 x 100 %, rectifiers - 2 x 100%, switchgears - 2 x 100 %, decoupling diodes inside the consumers, 24V DC/DC converters fed by the 110 V DC grid, 24V switchgears - 2 x 100 % and decoupling diodes inside the consumers.

The batteries will be of the GroE type, i.e. lead-acid type with a lifetime up to 15 years. Batteries and rectifiers operate in stand-by parallel mode, i.e. during normal operation the consumers are fed by the rectifiers. In case of failure at one rectifier or of the infeed voltage the supply of the connected consumers will be taken over without interruption by the battery or the second rectifier. As soon as the voltage returns, the battery will be recharged and the consumers supplied again by the rectifiers in parallel. The discharge time for each battery will be about one hour.

Uninterruptible AC power supply

Each sub-system (electrical system of two units) will be equipped with a 400V/230V AC supply for safety relevant small sized AC consumers, mainly consisting of 2 DC/AC inverters, quick change over device for each converter and 2 switchgears.

The inverters will use the 110V DC grid as the standard source, and the normal AC system as the alternate source in the event of an inverter failure. Inverter and quick changeover equipment operate in parallel permanently. A fault at the inverter is being secured by the automatic changeover device to the parallel operating 400V grid.

For repair and maintenance works one inverter can be switched off. In this case the safe bar is supplied by a manually switched repair infeeder.

Electricity control- management system

Basic equipment control. Electric equipment system control operations will be conducted through the distance control system (DCS) in the central control room.

DCS system has a duty to automatically run and stop the generators with the help of CRT screen, keyboard and mouse or control normal operation of the generator. Some manually controllable keys like operation termination key during an accident, FCB accident key and key to switch on the diesel generator during an accident will separately be installed in order to provide equipment safety operations.

The control – management system will administer the following systems and equipment:

- Generator – transformer equipment
- High voltage system for internal needs
- Low voltage system for internal needs
- Direct current system
- Uninterruptable feed

Sub-station control. The network control system will completely be provided with equipment which will manage, control and inspect the sub-station equipment. Structure of the network control system will be in the staged form. Control of high voltage allocation facility will comprise of the following three independent levels:

- Level 1. Sub-station control (Control will be placed on LCD screen in the centralized control room of the power plant)
- Level 2. Intermediate control (Control board in the high voltage allocation facility)
- Level 3. Manual control near equipment. (It is designated only for repair works)

Electrical protection

Generator, basic transformer and stimulation transformer (if required), transformer for internal needs and 6 kW and 400-W feeder will have a protection system.

The generator and transformer equipment defender will comprise of the equipment based on digital and microprocessor and two groups named A and B. Each defender group will be differentiated as connected to the current transformer and voltage transformer.

Medium voltage quick-break switch of 6.3 kW and its feeder will have an integral microprocessor defender which will be placed in the cabin of the quick-break switch.

Low voltage system of 400 W will have dry-type circuit breaker which will be operated automatically and it will protect its circuit..

Automatic equipment

ABT equipment will be installed in each 6.3 kV bus.

Equipment relied on a microprocessor will be provided to each equipment to make records during accidents.

Each of the equipment will have ASS system.

Automatic voltage regulator system (AVR) will be installed in each equipment.

A screen and ground connection detector relied on microprocessor will be installed in the direct current section bus and sub-allocation panel.

Control system of coal handling system

A control system with programmable logic controller (PLC) will be installed in the coal transmission system control. This control system will comprise of the worksite of machinists of the relevant equipment, programmable logic controllers, input/output models and cables.

Control system of fabric bag ash filter

A system with a programmable logic controller (PLC) will be installed in the fabric bag ash filter system.

PLC and the plant computer system will include the worksite of machinists of the relevant equipment, programmable logic controllers, cables and other equipment. This system will be operated in mutual relationship with DCS system.

Fire alarm and smoke detector system

Fire alarm and smoke detector system will be installed in all parts of the power plant in order to ensure security of people and equipment. The fire protection panel will be placed in the central control room. Heat and smoke sensors will be placed in important places such as the control room, power distribution room, special platform for cable canal, and air cooling and exit. The plant will also be provided with a speaker, communication system and telephones with the purpose of announcing the emergency condition and instructions to people. The fire alarm system to be provided under the project will be a centrally controlled two –bus system and alarm system. Sensors of the systems will be reliable and spot type sensors are considered as the best.

8.9. Ash removal system

The solids separated from the gas stream in the cyclone particle separator are returned to the furnace via the seal pot located at the end of each standpipe of each particle separator.

The inventory of solids in the CFB is controlled by the discharge of ash from the circulating loop (Primary Loop) of solids. Ash leaves this loop through two streams: solids entrained in the combustion gas at the particle separator outlet and solids discharged from the furnace through the bed drains. Ash which passes over to the convective pass with the gas stream is collected and removed from system at two locations:

- From the convective pass and/or air heater ash hoppers
- From the Fabric Filter ash hoppers

The ash discharged from the furnace is cooled in ash coolers that also control the rate of discharge of the ash from the system. A low pressure and temperature water source is required for proper operation.

The fly ash collected in the different accumulation sections in the steam generator will be pneumatic conveyed to the respective ash silo. To avoid operational problems, all ash silos are located inside the boiler house. Each unit is equipped with an independent ash silo and a dedicated conveying system. Each two units are equipped with a common pressurised air compressor for the ash transport.

Ash hopper and pneumatic conveying systems are located inside weather protection housing underneath the fabric bag filter.

8.10. I&C System

General

The general management room provided with a distance control system (DCS) for furnaces, turbines and generators will be installed in the main building of the power plant. This distance learning system includes the measurers, control equipment, management and adjustment equipment, communication equipment, defenders and alarms designated for the internal parts of furnaces, turbines, generators and transformers, power system for internal needs, steam and water sampling and proportioner system, and circulation water pump.

Sub-systems of the power plant such as chemical water treatment, industrial waste water system, fuel and oil system, hydrogen farm system, ash and slug removal system, water system for domestic needs and desulphurization system will be included in the automation system.

The measurement and management systems will be reliable, regularly operated and appropriate to use as well as will provide conditions to be easy to repair. A machinist to operate this system must have two and more years of working experience in a similar power plant.

Well equipped measurement and management systems will well provide exploitation operations of the power plant.

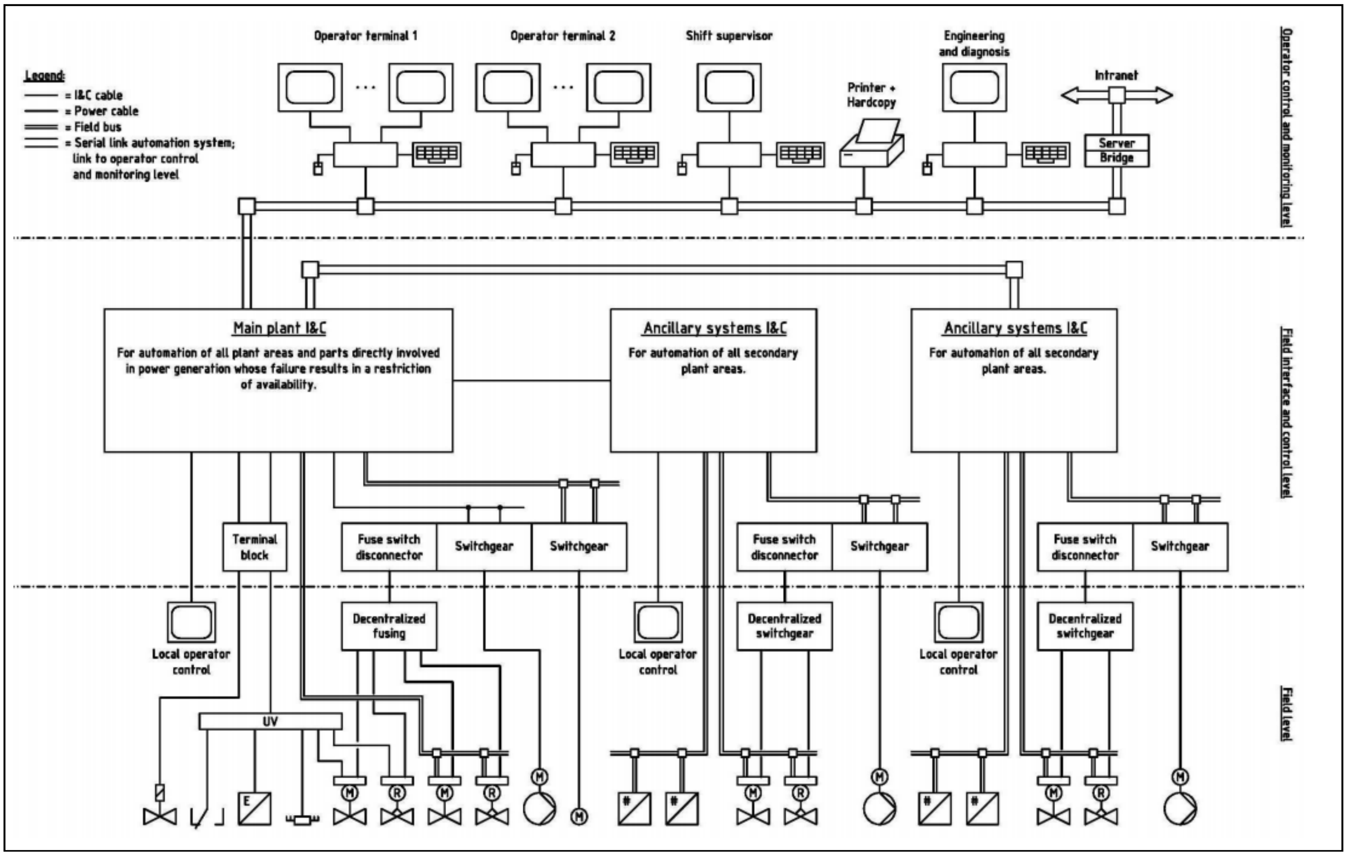

Figure 8-9. Control system diagram

Control methodology

For this project, furnace, turbine and generators of the power plant will have a centralized control. The sub-system and all internal needs' systems of the power plant will be equipped in the central control system. The sub-system will run directly without any human attendance and the control system on the ground will be operated according to a fixed procedure.

Arrangement of control room

The central control room will be placed in the power control facility which is located between two boiler houses. There is a full possibility to lead the level with the turbine exploitation floor. Rooms for engineers, electronic equipment rooms and meeting rooms will be located in a parallel line next to the control room.

Control boards of a duty engineer and machinist, control panel, printing equipment board and fire detector and alarm system will be installed in the control room. DCS will be connected with the system control, all internal needs‘ system of the power plant and alarm buttons will be linked with the control board of machinists. A big screen, alarm givers and some sensors will be installed in the control board.

Control level

A distance control system has been chosen for the control system. The DCS has a possibility to complexly control and operate the furnace, turbines, generators, generator – transformer parts, and power and general systems for internal needs.

As a result of the equipment measurement and control systems, a few engineers, technicians and workers will have an opportunity to handle the power plant operations. Activities to run the equipment and to handle, adjust and terminate the equipment operations and to remove abnormal operation conditions will be conducted from the equipment control room.

A programmable logic control designated to administer the sub-system of the power plant will be placed in the control room. Normal operation of the sub-system will be run by a machinist with the help of the programmable logic control from the control room of the relevant equipment.

Besides, a machinist of the central control room has a possibility to control and handle the sub-system operations through all the internal needs‘ management and control network. Machinists can run and stop normal equipment of the sub-system and handle schemes and exploitation conditions during the operation period from the production board in the central control room.

Control system duties

The basic equipment to place control over the equipment is the distance control system (DSC). This DCS, instrument standard mechanisms and measurers (such as buttons to be used during an accident and production equipment), mechanisms on the relevant equipment and measurers (measurers on the relevant equipment and independent control system installed in the basic equipment) will create the equipment control system.

The software of DCS system will have the following levels:

1. Monitoring level
   - Signaling, operating, monitoring
   - Archiving, logging, provision data (data export)
2. Plant control level
   - process model
   - Setpoint control
3. Group control level
   - Functional group control
   - Group controller
   - Higher-level plant protection

4. Interface and component control level
   - Automatic transfer gear, computingfunction
   - Fail-safe control and locking
   - Individual closed-loop control and interlocking
   - Actuator control and interlocking
   - Alarm processing, forming of limiting values
   - Signal processing and distribution (analog and binary)
   - Actuator control and interlocking

- Alarm processing, forming of limiting values
- Signal processing and distribution (analog and binary)

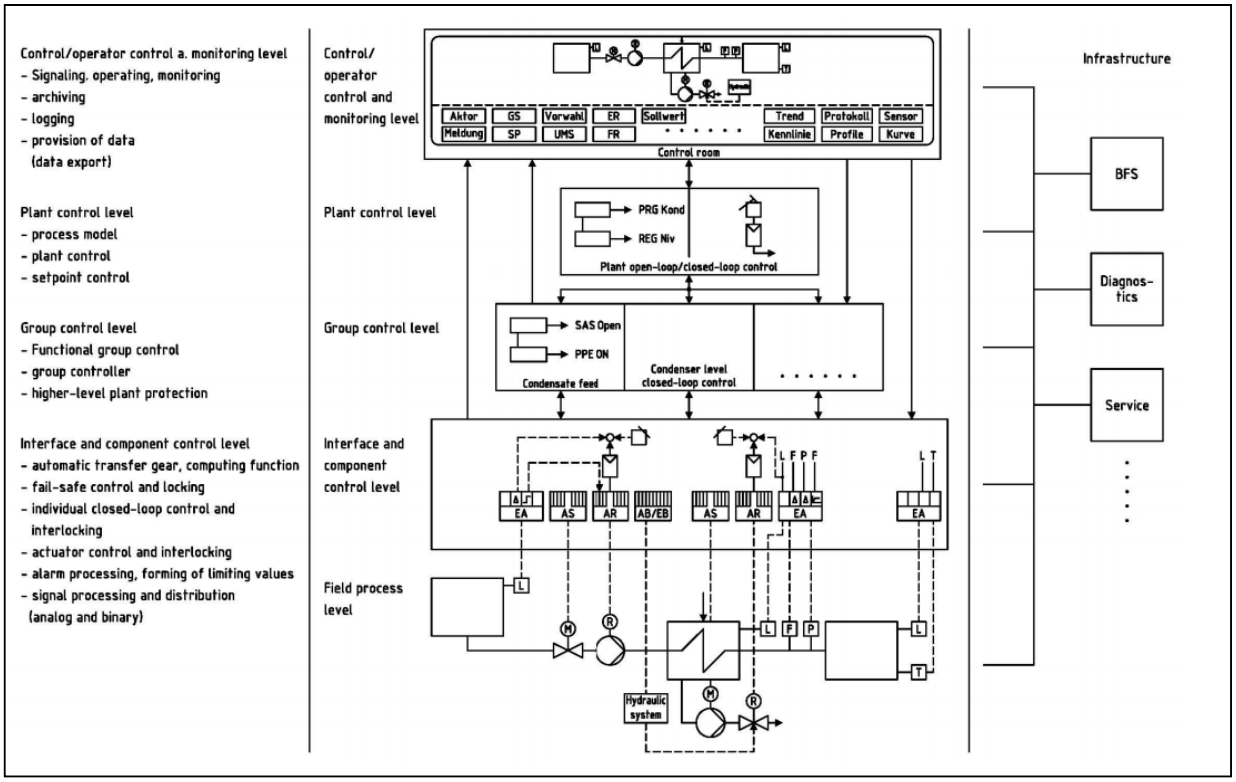

Figure 8-10. Software scheme

DCS will entirely be provided with equipment to collect data through multi-channels and high speed with the purpose of being reliable and ready. The equipment interlock, protection controllers and important analogical controllers must have multi-channels.

The sequence control system will be done in a three-level control management namely control functional group level, sub-group management and machinist control.

Direct Electric Heating (DEH), Management Electric Heating (MEH) and Basic Point System are the management system of the given equipment. Normal operation of the equipment control system will be guaranteed by a way of connecting the above systems with DCS.

Televisions for flame control in the furnace fire chamber and cauldron level control will be produced with their furnace.

I&C automation laboratory

The I&C automation laboratory shall be fully equipped.

8.11. Heating, Ventilation and Air Conditioning System

Overview

Internal environment of the power plant was divided into heating, ventilation and air conditioning conditions.

a. Indicators in the building used for the calculation of heating and air conditioning systems

The heating and air conditioning systems must be meeting the conditions of air temperature and relative humidity inside building facilities, which is shown in the Table 8-4.

Table 8-4. Air temperature and relative humidity inside building facilities

Facilities	SUMMER		WINTER	
	Temperature, ^{O}C	Relative humidity, %	Temperature, ^{O}C	Relative humidity, %
Computer room	26 ±1.0	60 ±10	20±1.0	60 ±10
Electric equipment room and control room	26 ± 1.0	60 ±10	20±1.0	60 ±10
Administration building	26 ~ 1.0	60 ±10	20±1.0	60 ±10

The CCR, local control rooms and main office rooms, where employees are working permanently, will be designed for a maximum temperature of

+26°C in summer seasons and a minimum temperature of +20°C in winter seasons.

Electronic rooms will be designed for a maximum average daily temperature of +26°C, electrical rooms will be designed for a maximum average daily temperature of +35°C.

The technical areas of the plant will be designed in such a way that the temperature in all working and maintenance areas will not exceed +45°C and the daily average temperature will not exceed +40°C. The temperatures under the boiler- roof and the turbine house-roof will not exceed +50°C.

All areas inside buildings, where water or other fluid pipes are installed, electrical rooms and electronic rooms will be designed for a minimum temperature of +5°C during winter periods.

During shut-down of the power-plant all areas where equipment could be damaged due to temperatures below zero will be heated in winter to ensure a minimum temperature of +5°C.

For dust reduction all air intakes to buildings will be provided with dust filters. Very effective dust filters will be provided for all electrical and electronic rooms including CCR-room.

b. Ventilation system

The ventilation system bears a duty not to exceed the air temperature inside the building facilities from the fixed limit. The fixed limit volume is shown in the Table 8-5.

Table 8-5. Air temperature during the period of ventilation

Building facilities	Maximum temperature in summer
Furnace workshop (in worksite)	32 ^{O}C
Turbine workshop (in worksite)	32 ^{O}C
Coal cleaning unit, facility of coal crusher, gallery of trestle and belt conveyer	40 ^{O}C
Chemical substance warehouse and hydrogen farm	40 ^{O}C
Battery room	40 ^{O}C
Ash and slug pump room	40 ^{O}C
Circulation water pump room	40 ^{O}C
Air compressor room	40 ^{O}C
Electricity allocation facility room, electric equipment room , cable channel room	40 ^{O}C
Transformer room	40 ^{O}C
Diesel engine room	40 ^{O}C
Management control equipment room	26 ^{O}C
Sanitary room	26 ^{O}C

c. System to ease dust in the air

A system to ease dust will be used in order to let the volume of dust in air inside the building facilities be less than 10 mg/m^3.

Heating system

The project will be carried out in the area which has extreme continental weather. Therefore, heating equipment will be installed in all building facilities which require a heating system. The heating system will be heated by steam and hot water taken from the power plant.

Ventilation system

The turbine workshop has been equipped with natural (ordinary) ventilation system in order to eliminate humidity and heat increase depending on technical equipment and pipeline heat. Pure air outside the building facilities will come in through the gate of turbine workshop building and windows of the first and second floors and other floors where operations will be run and will reduce heat and humidity volume inside building facilities by a way of thrown out to the atmosphere through the ventilator placed on the workshop building roof. In case of loss of hydrogen in the hydrogen gas system of generator, this natural ventilation system will prevent from explosion by getting accumulated in the hydrogen turbine hall.

Ventilation lattices are needed to be placed in addition in the medium and exploitation floors in order to increase the air flow volume in the natural ventilation system. Location and quantity of the ventilation lattices will depend on locations, repairs and exploitation requirements of equipment and pipes.

The furnace workshop has been equipped with the natural ventilation system in order to eliminating the humidity and heat increase depending on the technical equipment and pipeline heat. Pure air outside the building will come through the door of furnace workshop building and windows of the first floor and operation floors and will reduce heat and humidity increase in the building facilities by a way of thrown out to the atmosphere through the ventilator placed on the roof of furnace workshop.

A ventilation system for fire protection will be installed in the computer room and equipment control room. The ventilation system will be connected with the fire protection system by блокировк.

The allocation facility room will have an emergency ventilation system compounded of natural and coercive ventilations. The emergency ventilation system will be used to decline the allocation facility heat in summer time.

If the natural ventilation was insufficient in other ventilation needed places, a coercive ventilation system will be provided.

Air conditioning system

Each equipment control room (including the electric equipment room and engineer room) will have air – air type conditioning system and the cooled air will enter the control room through ventilation channel and pipes. Air cooling water will be provided from the central cooling station.

The air conditioning system will be operated through the year.

Volume of pure air in the air conditioning system has been calculated to be 10% out of the total air expenditure in order to provide a positive pressure for the building facilities and in accordance with hygienic requirements.

The air conditioning pipeline will have walls to prevent from fire transmission and its floor will have a cock to prevent from fire penetration. The cock will be closed automatically and the air conditioning system will stop when air temperature in the air conditioning pipe increased up to $70^{O}C$.

Control system in the air conditioning room will be provided with equipment to control fittings to be used, to automatically control the air conditioning system, to control indicators on the screen, and to give sonorous and light alarms if abnormal impacts increased more.

The air conditioning system will be connected with the fire alarm system through an interlock. In case the fire has gained ground, the air conditioning system will be stopped automatically in the relevant time and the system will manually be connected with the operation after completely extinguishing the fire.

Dust ease system for coal transmission

Mechanic dust collection equipment will be installed in every coal transmission junction. Mixed dust and air concentration in the dust accumulator will be not less than 120 $mg/m^{3.}$

The coal transmission station, crusher workshop and coal hoppers will have wet type dust easers and the facility for raw coal storage will have dry type dust easers. The dust ease system operation will be connected with the coal transmission system by a блокировк.

The dust ease equipment in the raw coal hopper facility could be used to give off methane.

The facilities such as coal transmission junctions, crusher‘s building, trestle and belt conveyer gallery will have equipment to conduct wet cleaning.

8.12. Fire Fighting Systems

The fire protection system will be designed mainly in accordance with the NFPA-codes (U.S. National Fire Prevention Association codes). Especially NFPA 850 will be used as a guideline for the plant fire protection design.

The fire protection system consists of 2 parts:

- Preventive Fire Protection by a separation of special hazardous areas of the power plant from the surroundings by special fire protection civil design.
- Fire Fighting Equipment which shall ensure an effective fire fighting.

Preventive Fire Protection

All load-bearing structures will be executed with non-combustible materials.

A separation of all electrical rooms, I&C-rooms and oil storage rooms (e.g. main oil room) from the surroundings by fire-resistant enclosures or a separate location will be foreseen. Additionally the main oil transformers and the oil storage tanks will be located with a sufficient distance from the other buildings and structures, so that the risk of fire flash over is minimized. Smoke and heat extraction systems shall be foreseen in special areas like fire-resistant staircases, electrical and I&C-rooms. Where explosive equipment or material are installed or stored explosion proofed materials and equipment will be designed (e.g. in battery rooms).

Fire Fighting Equipment

The fire protection system will be divided into five basic parts namely; hydrant system of water to extinguish fire, fire extinguishing system with automatic water sprayer, system to extinguish fire by using pure gas, system to extinguish fire with foam and fire extinguisher.

Hydrant fire extinguishing system

The hydrant fire extinguishing system will comprise of fire water pump and water pipes and hydrants located in and out of the building facilities. The pipes of water transmission system for fire protection will be made in the annular and grid shapes in the main building facilities of the power plant, combustion and lubricant material reservoirs and coal sites. The hydrants located outside the buildings will be placed along the water transmission pipes and the hydrants inside the buildings will be erected in the main buildings of the power plant, coal transmission facilities and administration building.

Automatic water sprayer fire extinguishing system

Equipment including fire water pump and a network of pipelines placed inside the buildings to automatically spray water to extinguish fire will be included in the automatic water sprayer fire extinguishing system. Various sensors and automatic alarms will be installed in this fire extinguishing system. Fire extinguishing control's main panel will be located in the basic control room.

System to extinguish fire by pure gas

The system to extinguish fire by pure gas will be installed in the basic control room, electric equipment room, engineers' room, relay protection room and other related places. Equipment designated to put off fire by such gas will be installed in the criss-cross of cables and in the horizontal crossing of basic steam and oil lines.

Pure gas agent of the fire protection system is designated to remove air by fully covering the part which is being combusted. In modern time, CO_2 and FM – 200 gases and inert gas have been used as the protection system agent. The inert gas has been selected as the agent of system to extinguish fire by pure gas.

System to extinguish fire with foam

This system will include concentration reservoir, foam and liquid mixer, foam mixer, foam nozzle and pipes and it will mostly be used for combustive oil reservoir and pumps and their building facilities. We will protect fire transmission from one oil reservoir to other one with less expansion foam by installing the fire extinguishing and cooling water systems.

The foam concentration reservoir and liquid mixers will be located in the foam pump which is next to the reservoirs of combustion and lubricant materials and will have a capacity to provide 6 liter/min.m^2 of mixed foam.

Fire extinguisher

Fire extinguishers will be placed in the zone where the power plant‘s building facilities and important equipment are located. The fire extinguishers will be two basic types namely; transportation and mobile. Three types of fire extinguishers with powder, CO_2 and foam agents will be used depending on the relevant regional peculiarities and ground fire threats.

8.13. Construction works

Architecture and design

Turbine building, deaerator system, coal hopper and furnace facilities will be included in the main buildings of the power plant. The basic component of these building facilities is reinforced concrete.

1. Main buildings of the power plant

   The main buildings of the power plant will comprise of turbine halls, deaerator platforms, coal hoppers and furnace workshops which will have reinforced concrete components.

Exterior coating will be painted metal fashion plate. Interior surface will be made of tapestry bricks.

The turbine hall, deaerator platform and coal hopper roof will be made of water resistant reinforced concrete plates.

Number, lanes and organization of stairs and platforms will be planned in accordance with the fire protection rules, regulations and standards. Each one lift has been calculated to be provided to each furnace.

Fore resistant gate must be placed in necessary places.

2. Central control building

The central control building will be made of reinforced concrete components. Accumulator rooms, communication room, cable canals, electricity bus, alternating current engines and other facilities will be included in the building.

Interior surface of the building will be made of tapestry bricks and its roof will be made by water resistant reinforced concrete plates.

3. Other main production buildings

These buildings will be made of metal or reinforced concrete components.

Their coating will be done with tapestry bricks and roofs will be made of water resistant reinforced concrete plates..

4. Subsidiary and related facilities

Subsidiary and related facilities will comprise of the administration building, repair workshop, warehouse, fire point building, vehicle garages and entrance gates

These facilities will be made of metal or reinforced concrete components and coating will be done with tapestry bricks as well as roofs will be made of water resistant reinforced concrete plates.

5. Main construction architecture of the power plant

External appearance and enhancement of the power plant buildings will be done to create good impression in the surrounding environment and its color and shape will be recognizable as a power plant from the external appearance.

Reinforcement structure of the main building

The main building structure will be reinforced concrete frame.

The main building columns will be installed in a hard foundation casted underground as mass solid structure.

The turbine building roof will be made of metal steel and will be cased in heat separating and water proof folded steel leaf. Roof and floor plate coating of the deaerator and coal hopper platforms will be made of reinforced concrete component installed in metal beam.

The turbine – generator foundation will be made of reinforced concrete components. This foundation's components must be separated from the foundations of other equipment and not to exert deformational impact to nearby components.

A reinforced concrete smoke chimney will be installed in the power plant. The chimney height will be 210 meters.

8.14. Ash pond

For the power plant operated with 4 x 150 MW coal will annually produce 50.0 x 10^4 m^3 ash and slug. An ash pond will be built near the power plant

Ash will be kept in the ash reservoir in dry type. Total size of the ash reservoir will be sufficient to contain 1500.0 x 10^4 m^3 ash by calculating to operate this power plant for 30 years.

If the ash discharged from the power plant was calculated to be 100% used for other purposes, there would be no requirement to build the ash reservoir.

9. ENVIRONMENTAL IMPACT

9.1. General

Impacts to be exerted on the surrounding environment by the Chandgana power plant, Chamdgana-Baganuur route 220 kV two-circuit power transmission line and Chandgana- Undurkhaan route 220 kV one-circuit power transmission line and ways to reduce the impacts have provisionally been defined within the scope of this research work.

The Chandgana power plant is located in the northeast part of the Chandgana Khavtgai coal deposit, which was specially licensed for exploration under No 11654 and its installed capacity will be 600 MW. The power plant will comprise of 150 MW capacity four turbo-generators, four CFB steam generator other auxiliary and ancillary equipment. Basic fuel of the power plant will be the ignite coal of the Chandgana Tal deposit. Liquid fuel or fuel oil will be used with the purpose of running the furnace and supporting the combustion in the furnace. Water for the power plant consumption has been calculated to be provided from the artesian water in the Murun River basin located in the north of the deposit.

Scope of the power plant project will include works to erect around 150 kilometer-long and 220 kV two-circuit power transmission line between the power plant and Baganuur district of Ulaanbaatar and about 60 kilometer-long and 220 kV one- circuit power transmission line in the route of Undurkhaan, Khentii province.

The impacts to be exerted by the power plant on the surrounding environment could be divided into the impacts which will cause during the construction fitting works and exploitation period.

The power plant will cause temporary negative impacts on the surrounding environment during the construction fitting works of power

Approximately 15 meter-wide 315 hectares of area will be impacted negatively for a temporary period during the construction and fitting works of a total of 40 hectares and 210 kilometer (150+60) long power transmission line.

In case, levels of exhaust gas, wastewater and sound to be given off during the power plant operation were not held by standard amount, negative impacts may cause to the surrounding environment and human health.

9.2. Environmental impact

The following negative impacts may cause during the power plant operation:

- On the air quality if the substances in exhaust gas exceeded the permissible standard amount,
- On the regional water quality if the wastewater quality exceeded the permissible standard amount,
- On the surrounding environment and human health if the sound from the power plant exceeded the permissible standard amount.

For the power transmission line, dust to be originated during the construction works and equipment transportation will cause temporary negative impacts on air and earth qualities.

Air quality

Permissible amount of air pollutant substances to be discharged with exhaust gas from the power plant will be limited under articles of the World Bank's Pollution Prevention and Abatement Handbook 1998 and rules, regulations and standards which are currently in force in Mongolia.

The World Bank permissible amount of air pollution limit to be caused by power plants to the surrounding environment is shown in the Table 9-1 and 4598-2007 Air Quality Standard which is on force in Mongolia to define permissible amount of chemical origin pollutant substances in the air of settlement areas and internal environment is also shown in the Table 9-2.

Table 9-1. Permissible amount of air pollutant substances

№	Properties	World Bank rules and regulations
1	SO_2	< 0.2 ton/day/MB or 2000 mg/Hm^3
2	NO_X	< 750 mg/m^3 , Dry type and 6% CO_2
3	CO	Limit was not fixed
4	Dust (amount of all types)	< 50 mg/Hm^3

Table 9-2. Maximum permissible amount of air pollutants of chemical origin in the air of external and internal environment of urban areas

/Air quality standard. MNS 4585/2007/

Name of indicators	Average measurement amount	Measurement unit	Permissible content
Sulphuric gas (SO_2)	10 minute- average 20 minute- average 24 hour average Annual average	mkg/m^3	500 450 20 10
Carbon monoxide (CO)	30 minute- average 1 hour average 8 hour average	mkg/m^3	60000 30000 10000
Nitrogen dioxide (NO_2)	20 minute- average 24 hour average Annual average	mkg/m^3	85 40 30
Ozone (O_3)	8 hour average	mkg/m^3	100
Dust (Total weighed substances)	30 minute- average 24 hour average Annual average	mkg/m^3	500 150 100
Dust less than 10 microns (PM10)	24 hour average Annual average	mkg/m^3	100 50
Dust less than 2.5 microns (PM2.5)	24 hour average Annual average	mkg/m^3	50 25

Exhaust gas to be discharged from the power plant furnace will be thrown to air after cleaned through the electric ash holder. A system to continuously control amounts of these substances in the exhaust gas thrown to the air will be installed in the chimney with the purpose of controlling whether the contents of substances in the exhaust gas have been in the permissible amounts.

The ash holding equipment to clean ash and dust in the exhaust gas will completely meet the standard requirements stated in the above table.

The ash holding equipment's capacity will be able to completely clear off the exhaust gas to be discharged during the full capacity operation of the power plant and will have a reserved capacity to completely clean the ash to be produced during the suck of extra air to be given off during the furnace operation and combustion of high-ash coal.

The system for continuous control of contents of the substances in the exhaust gas will place control over sulphuric oxide (SO_2), nitrogen oxide (NO_x) and hydrogen and dust contents in each furnace. The system will be able to tame a sample from the exhaust gas for inspection, analyze the inspection results and make a report on the results.

The dust to be given off during the operations of coal transmission and ash removal systems will cause negative impacts on the surrounding environment.

Dust abatement equipment will be installed in the coal transmission system. A dust accumulation system will be installed in order to coal crushers and coal hoppers.

A system for removal of ash and slug to be discharged from furnaces in dry type will be exploited and the ash will be delivered to the ash reservoir by a lorry.

Measures to be taken to abate with water the dust to be originated due to the construction works and equipment transportation during the fitting works, to hold negative impacts to be caused to the earth and plants at minimum level and to restore the earth if circumstances required.

Water

Waste water to be discharged from the power plant will cause definite impacts on the nearby rivers, earth and artesian water. Especially the waste water is directly related to the activities of coal transmission and unloading units, repair workshop, warehouses of carbon and other dangerous materials and their transportation units, ash removal unit, waste water system, coal blowing system, waste water discharged from furnaces and cleaning works, laboratories, waster water accumulation and cleaning systems and rain water collection system.

The waste water removal system will purify waste water of the coal site and the power plant and will re-use the purified water. The waste water will be given to the affinager or reservoir and will be accumulated there until there will be a possibility to remove solid waste and clean its oil contents by manual work.

The maximum permissible amount to be contained in industrial and domestic waste water , which could be given to the water source, and limits of other indicators are shown in the Table 9-3.

Table 9-3. Waste water quality requirements

Indicators	MNS 4943:2000 standard	Rules and regulations of the World Bank
Hydrogen exponent, pH	6 – 9	6 – 9
Weighting substance	< 35 mg/lit	< 50 mg/lit
Necessary chemical hydrogen	< 50 mg/lit	Not defined
Necessary biochemical hydrogen	< 20 mg/lit	Not defined
Minerals and fat	< 6 mg/lit	< 10 mg/lit
Chrome (total)	< 0.3 mg/lit	< 0.5 mg/lit
Copper	< 0.3 mg/lit	< 0.5 mg/lit
Metal	< 1.0 mg/lit	< 1.0 mg/lit
Zinc	< 1.0 mg/lit	< 1.0 mg/lit
Remaining chlorine	1.5 mg/lit	< 0.2 mg/lit
Temperature increase	Not defined	< 3°C

The waste water system for domestic needs will accumulate waste water from the power plant facilities and will transmit to the waste water purification system. The waste water purification system could purify the waste water in accordance with the related standards and regulations.

Solid waste substances

In case, if the system for removal of fine grain ash and slug to be discharged from the power plant did not meet the standard requirements, it may cause negative impacts on air quality of the surrounding environment, land surface, earth and artesian water.

The ash removal system has a duty to accumulate and keep the ash to be produced as a result of coal combustion in the furnaces. The system will comprise of two sub-systems namely slug removal and fine grain ash. The fine grain ash to be discharged from the furnaces will be differentiated by the ash holding equipment and will be transported by the pneumatic by water in order to prevent from dust and will be transported to the ash reservoir on sealed trucks.

The slug to be given off from the furnaces will be cooled down with the help of cooling water in the below part of furnaces and air. The slug will be transported by a scooped excavator from the furnace's below part and will be kept in the ash hoppers. The ash will be delivered to the ash reservoir by transporting heavy trucks.

Sound.

Sound to be caused by the power plant will be meeting the criteria stated in the World Bank rules and regulations. The limit of noise level is shown in the Table 9-4.

Table 9-4. Limit of noise level

Receiver	Maximum permissible amount, dB(A)	
	Day time (07:00-22:00)	Night (22:00-07:00)
Near residents, organizations and schools	55	45
In industrial districts	70	70

9.3. Environmental management

An environmental preservation plan will be drawn up on the basis of research works on impacts to be caused on the surrounding environment by the Chandgana power plant and basic environmental indicators of the relevant region and more attention will be paid to the following issues during the project implementation period:

- Impacts by the power plant on air quality,
- Impacts to be caused on living standards of nearby herding families in connection with the project realization,

- Sound impacts to be exerted on houses of the project employees and nearby herding families,
- Impacts of dust to be discharged during the construction works of the power plant and exploitation operations,
- Impacts to be caused to earth and plants during the construction fitting period,
- Operations and control of ash and waste water removal systems,
- Impacts which may cause to the surface and artesian water during the operations of coal storage and transportation and due to explosive and fire threatening materials and waste.

9.4. Environmental legislation and standards

The following laws, rules and regulations and standards, which are in force in Mongolia and in international practices, will be followed during the construction fitting and exploitation periods of the Chandgana power plant and 220 kW power transmission line:

- The Constitution of Mongolia
- The Law of Assessment of Environmental Impacts of Mongolia
- The Law of Environmental Protection of Mongolia
- The World Bank's Pollution Prevention and Abatement Handbook 1998
- The Environmental Assessment of International Financing Corporation
- The Law on Land of Mongolia
- The Law on Land Payment of Mongolia
- The Law on Air of Mongolia
- The Air Quality Guidelines of World Health Organization
- Air quality standards, MNS 4598/2007
- The Law on Water of Mongolia

- Water pollution compensation rules and Environmental Protection Council of Mongolia
- Water source protection rules and the joint order 143/A/352 by the Ministries of Environment and Health
- Regulations on hygienic and protection zone establishment of water sources and the joint order 165/335/A/171 by the Ministries of Infrastructure, Environment and Health
- Other related laws and standards

9.5. Ways of reducing environmental impacts

General.

The following measures will be carried out for the basic equipment selection with the intention of reducing the impacts to be caused to the surrounding environment by the exhaust gas to be discharged by the power plant

- Electric ash holding equipment with 99.7% efficiency coefficient will be used with the purpose of declining the amount of ash and dust to be given off by the power plant.
- A desulphurization system will be installed with the intention of cleaning the sulphuric oxide.
- A control system will be installed to continuously control secretion amount of the pollutant substances in the exhaust gas. This system has a possibility to be handled by the central control system of the power plant.

Waste water

Waste water will not be thrown outside without any control during the normal operation of the power plant. Waste water to be secreted during the power plant operation will be accumulated and will be cleaned through re-used for the power plant operation. The waste water which is not possible to be re-used will be removed in accordance with the related standards and regulations.

All types of waste water to be discharged from the power plant will be purified by the purification equipment which is operated in stages for removing oil from the waste water, cleaning minerals and solid waste in water and conducting neutralization. The waste water quality will completely meet the requirements of Water Quality and Waste Water-MNS 4943:2000 standard. Indicators of the quality of waste water to be secreted from the power plant's waste water system is shown in the Table 9-5.

Table 9-5. Waste water quality indicators

Indicators	Waste water quality indicators
Hydrogen exponent , pH	6.5 – 8.5
Weighting solid substance	< 10 mg/lit
Necessary chemical hydrogen	< 40 mg/lit
Necessary biochemical hydrogen	< 20 mg/lit
Minerals and fat	< 10 mg/lit
Metal	< 4.0 mg/lit

Noise.

Sound coming from the power plant will not impact on the surrounding environment and will meet the requirements for the limit of noise level in the surrounding environment shown in the Table 9-4 and for the workplace noise level standard shown in the Table 9-6.

Table 9-6. Workplace noise level standard

№	Indicators	Unit	Value
1	Inside building: Noise level in buildings and its rooms and when doors and windows of buildings are closed		
1.1	Control room and administration building	dB(A)	60
1.2	Outside workshops, warehouse and buildings where exploitation and repair works	dB(A)	85
1.3	Inside all the building facilities and closed buildings which do not have any sound resistant bulkhead	dB(A)	70
1.4	Noise level in the stairs and platforms of the power plant and exploitation and repair operation sites according to the measurement conducted in 3 kilometers distant from the equipment surface	dB(A)	<85
2	Noise level outside building facilities in the power plant site	dB(A)	70-85
3.1	Noise level measured 1 kilometer distant from the power plant's independent equipment and systems	dB(A)	<85

The following measures will be taken in order to reduce noise level:

- Noise diffusive equipment will be installed in the line and cocks where steam will be blown out from the furnaces and the equipment will decline the noise more than 5 – 30 dB.
- Noise diffusive equipment will be installed at the primary ventilator of the furnaces and the equipment capacity will be more than 20 dB.
- Some equipment will be covered by noise resistant bulkheads in order to protect health of workers and employees and the equipment will decline the noise by 20 dB and more.
- Noise resistant bulkheads will also be installed in the building facilities and equipment such as air compressor room and pump stations which make more noises. The equipment capacity will be 5 – 30 dB and the relevant room's noise will be less than 85 dB.

9.6. Environmental rehabilitation

Safety operations will be conducted during the power plant operation in order to prevent from environmental pollution. Measures such as introduction of environmental management being used on a wide range on the international level, environmental protection and restoration, and provision of trees and greeneries in the power plant's site will be taken to improve the plant's ecological condition.

10. PRELIMINARY PLAN OF PROJECT IMPLEMENTATION

The following issues have been required to be conducted before erection of the Chandgana power plant.

1. To conduct a detailed hydro-geological in the Murun River basin to determine water sources that could be used by the power plant
2. To confirm the water resource approval and exploitation right
3. To take special permissions related to the power plant erection (erection of energy facilities, land and technical design etc)
4. To conduct a geotechnical survey by selecting 220 kW power transmission line to be built for FES and ERES
5. To draw up a detailed design and feasibility study of the power plant and power transmission line
6. To conduct environmental assessment of the power transmission line and to get it approved
7. To establish engineering, provision and conduct (EPC) for the power plant and power transmission line erection
8. To make exploitation and maintenance agreements
9. To establish coal supply agreements
10. To solve investment and financing issues of the power plant
11. To take a permission to start construction fitting works of the power plant

According to the provisional plan, construction works of the 4 x 150 MW Chandgana power plant will be done within 24 months since award of all related permissions.

The construction fitting works of the power plant will be performed in the following stages:

1. To get the basic design done and approved
2. To provide preparation works for the construction fitting

3. To do detailed selection of design and equipment
4. Production of equipment
5. Construction fitting works of the power plant
6. Equipment transportation and installation works
7. Training courses for workers and employees
8. To partially hand over and receive equipment
9. To conduct an experiment for the power plant operation
10. To put the power station into permanent operation

The preliminary plan of power plant construction and installation works is shown in the Figure 10-1.

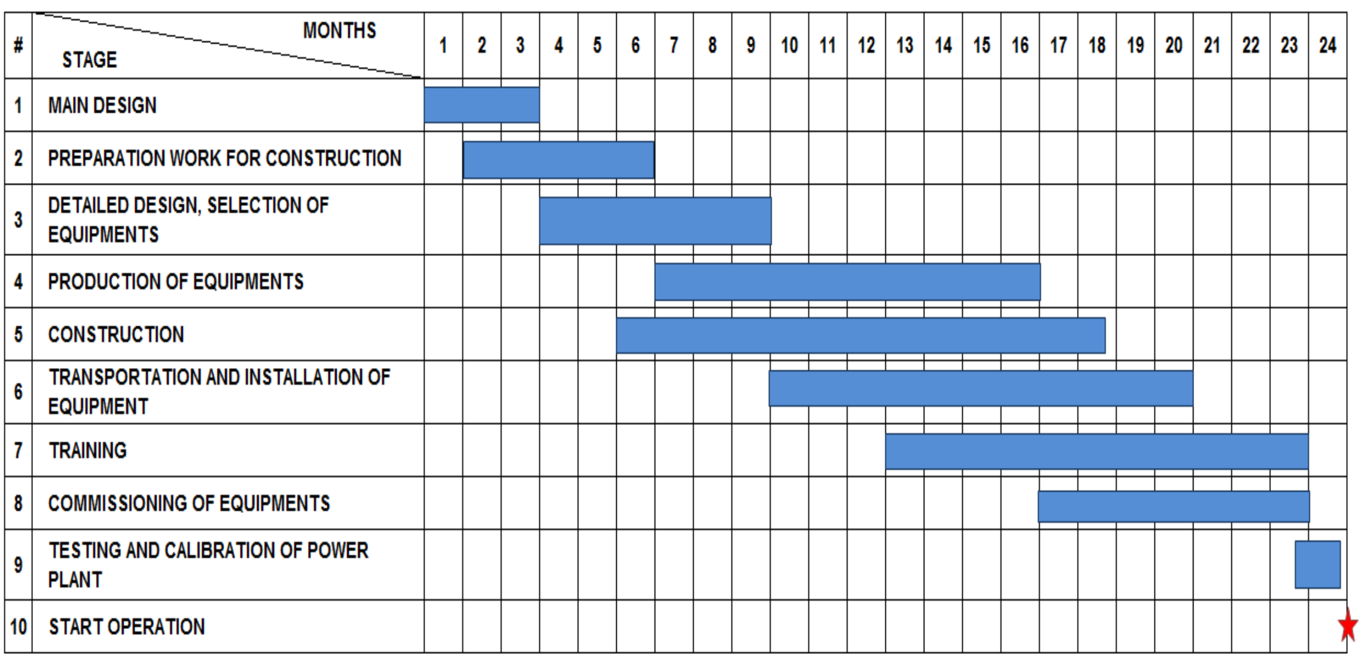

Figure 10-1. Preliminary plan of the power plant construction and installation works

11. INVESTMENT AND ECONOMIC ASSESSMENT

11.1. Influence diagram

An influence diagram which may impact on the project results has been done with the intention of factually calculating the economic assessment of 4x150 MW Chandgana power plant.

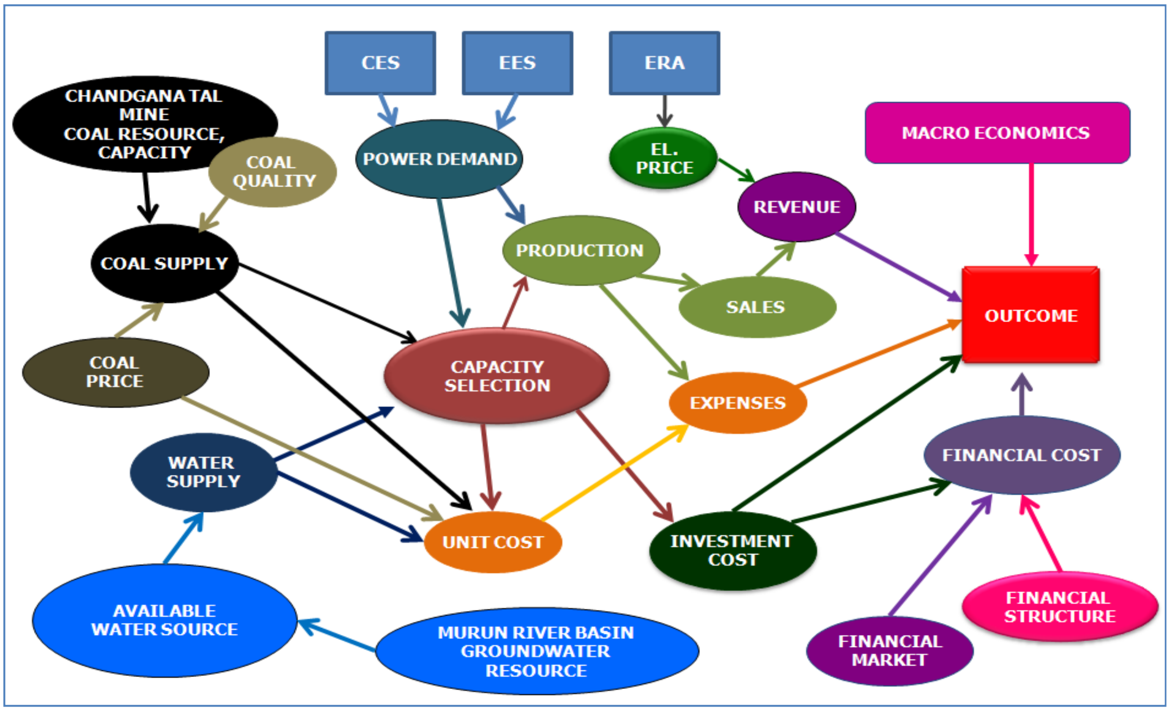

Figure 11-1. Influence diagram

Judging from the diagram, indictors such as the electricity price to be sold to the CES and ERES, investment, coal price and quality and exploitation expenditure level may mostly impact on the project results. Other indicators like power demand of CES and ERES, project coal supply, coal quality and exploitable water resource will mainly impact on the selection of power plant capacity and technique-technologies.

11.2. Financial model and its structure

A financial model for estimation of the project investment and economic results has been worked out on the basis of the diagram of factors which may impact on the project results.

The financial model will comprise of the following sub-sections:

1. Basic estimation data
2. Estimation of installed capacity exploitation
3. Estimation of production, distribution and exploitation expenses of the power plant
4. The project's financing estimation
5. Electricity price estimation
6. The project's cash flow enumeration

These sub-sections are mutually related to each other and there will be a possibility to factually analyze the project's economic assessment by including the basic estimation data.

Structure and estimation indicators of each financial model sub-part have been introduced below in brief.

Basic data:

All kinds of alternating indicators exploited in the financial model or the power plant's investment, capacity, internally needed power amount, price level of electricity to be sold, its change situation, financing structure, loan, loan interest and data for time have been integrated in the data. Basic estimation data of this section is shown in the Figure 11-2.

MAIN ASSUMPTION FOR THE ESTIMATION

Project general data:

Preparation or Lead time	1	year
Duration of construction	3	year
Estimation period	30	year
Power Plant capacity		
Unit capacity	150	MW
Number of units	4	
Total installed capacity	**600**	MW

Date of operation time:	Years after construction started	Months
Unit 1	1	6
Unit 2	2	
Unit 3	2	6
Unit 4	3	

Discount rate	10.00	%

Project CAPEX:

Unit capital cost for power plant	1,100	$/kW
Total CAPEX	**721000**	thousand USD
Power Plant	660000	thousand USD
Transmission lines:		
Chandgana-Baganuur, two circuit 220 kV OHTL	40000	thousand USD
Chandgana-Undurkhaan, single circuit 220 kV OHTL	16000	thousand USD
Other	5000	thousand USD

Other assumptions:

VAT	10	%
Custom tax rate	5	%
Income tax rate		
Up to 3 billion MNT of income	10	%
Above 3 billion MNT of income	25	%
tax discount	0	%/ of investment
Working capital	5000	thousand USD
Closure	15000	thousand USD
Exchange rate	1250	MNT/USD
Escalation of exchange rate	1	%

Coal assumptions;

Heat content, as received	3144	kcal/kg
Coal price		
Price	12	$/ton
Transportation cost	0.7	$/ton
Coal price escalation	1	%
Heat content of ignition fuel	9500	kcal/kg

Power plant assumptions:

In-house use	8	%
Electricity heat rate	2383	kcal/kW
Transmission line loss	3	%
Costs;		
O&M Costs:		
Fixed portion of O&M costs	1.00	%/of investment
O&M Cost escalation	1.00	%
Variable portion of O&M costs	0.15	cents/kWh
Salary cost:		
Cost escalation	1	%
Insurance	0.1	%
contingency	10	%

Sale:

Base Electricity price	0.055	$/kWh
Expectation of electricity price	a	

a - BASE (price escalation is constant)
b - Variable

Assumptions for estimation options;

I. "BASE" scenario

Annual price escalation	1	%
Top boundary of price	0.08	$/kWh

II. "VARIABLE" scenario

Price change rate	year	$/kWh
first years of operation	5	0.055
next	10	0.065
rest of operating years		0.080

Variables:

Debt financing	yes	***Yes or No***
Debt financing structure:		
Equity	30	%
Debt	70	%
Debt service		
Term	15	year
Interest rate	6	%
Grace period	3	year

Figure 11- 2. Overview of the sub-section ''Basic estimation data''

Estimation of the installed capacity exploitation

This sub-section has calculated operation hours of the basic equipment for the given year, electricity amount to be produced by the power plant and installed capacity utilization estimate on the basis of a frequency of running repairs and overhauls to be conducted for the basic equipment, their duration, preparation and idle standing after an accident.

Overview of the sub-section of installed capacity utilization estimate of the basic equipment is shown in the Figure 11-3.

UNIT UTILIZATION

General parameters:

Installed capacity		600		MW
Number of units,	150 MV	4		
Number of planned outages		2		times a year
		min	max	
Duration of planned outages		10	20	days per year
Number of overhauls	ones eve	4		year
Duration of overhaul		90		days
Duration of "0" stoppage		3		days per year
Number of emergency shutdown		2		times a month
Duration of emergency shutdown		24		hours
Contingency of duration unit outages				
for overhaul		0		%
for planned outages		3		%
for emergency shutdown		3		%
Duration of standing reserve		10		%
Utilization rate of units, hours		**7384**		
Available electricity generation, GWh		**4431**		

ESTIMATION:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Utilization rate of units, hours	0	0	3470	5737	7059	6608	6591	6567	6964	6523	6097	6477	6857	6429
Total duration of normal operation	0	0	3856	6374	7844	7342	7323	7296	7738	7248	6775	7197	7618	7143
Total standing reserve hours	0	0	386	637	784	734	732	730	774	725	677	720	762	714
Available electricity generation, GWh	0.0	0.0	578.3	2868.4	4706.2	4405.2	4394.0	4377.9	4642.6	4349.0	4065.0	4318.3	4571.0	4285.7
Installed capacity, MW	0	0	150	450	600	600	600	600	600	600	600	600	600	600
Unit No. 1														
Unit capacity	0	0	150	150	150	150	150	150	150	150	150	150	150	150
Duration for overhaul	0	0	0	0	0	90	0	0	0	90	0	0	0	90
Duration for planned outages	0	0	19	19	20	10	21	22	23	10	24	25	25	10
Duration of "0" stoppage	0	0	3	3	3	3	3	3	3	3	3	3	3	3
Emergency shutdown duration	0	0	0	23	24	25	25	26	27	28	29	30	30	31
Duration of total stoppage	0.0	0.0	21.9	45.7	47.0	127.7	49.7	51.1	52.5	130.8	55.5	57.1	58.7	134.3
Duration of normal operation, days	0	0	161	319	318	237	315	314	312	234	309	308	306	231
hours	0	0	3856	7663	7632	5695	7568	7534	7499	5620	7427	7389	7350	5536
Available electricity generation, GWh	0.0	0.0	578.3	1149.4	1144.8	854.2	1135.2	1130.1	1124.9	843.0	1114.1	1108.4	1102.5	830.5
Unit No. 2														
Unit capacity	0	0	0	150	150	150	150	150	150	150	150	150	150	150
Duration for overhaul	0	0	0	0	0	0	0	0	0	0	90	0	0	0
Duration for planned outages	0	0	0	20	21	21	22	23	23	24	10	25	26	27
Duration of "0" stoppage	0	0	0	3	3	3	3	3	3	3	3	3	3	3
Emergency shutdown duration	0	0	0	24	25	25	26	27	28	29	30	30	31	32
Duration of total stoppage	0.0	0.0	0.0	47.0	48.3	49.7	51.1	52.5	54.0	55.5	132.5	58.7	60.4	62.1
Duration of normal operation, days	0	0	0	318	317	315	314	312	311	309	232	306	305	303
hours	0	0	0	7632	7600	7568	7534	7499	7464	7427	5580	7350	7310	7269
Available electricity generation, GWh	0.0	0.0	0.0	1144.8	1140.0	1135.2	1130.1	1124.9	1119.6	1114.1	836.9	1102.5	1096.5	1090.3
Unit No. 3														
Unit capacity	0	0	0	150	150	150	150	150	150	150	150	150	150	150
Duration for overhaul	0	0	0	0	0	0	90	0	0	0	90	0	0	0
Duration for planned outages	0	0	0	20	21	21	10	23	23	24	10	25	26	27
Duration of "0" stoppage	0	0	0	3	3	3	3	3	3	3	3	3	3	3
Emergency shutdown duration	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duration of total stoppage	0.0	0.0	0.0	23.0	23.6	24.2	103.0	25.5	26.2	26.9	103.0	28.3	29.1	29.9
Duration of normal operation, days	0	0	0	160	341	341	262	339	339	338	262	337	336	335
hours	0	0	0	3828	8194	8179	6288	8148	8132	8115	6288	8080	8062	8043
Available electricity generation, GWh	0.0	0.0	0.0	574.2	1229.0	1226.8	943.2	1222.2	1219.7	1217.2	943.2	1212.0	1209.3	1206.4
Unit No. 4														
Unit capacity	0	0	0	0	150	150	150	150	150	150	150	150	150	150
Duration for overhaul	0	0	0	0	0	0	0	90	0	0	0	90	0	0
Duration for planned outages	0	0	0	0	20	21	21	10	23	23	24	10	25	26
Duration of "0" stoppage	0	0	0	0	3	3	3	3	3	3	3	3	3	3
Emergency shutdown duration	0	0	0	0	11	11	11	12	12	13	13	13	14	14
Duration of total stoppage	0.0	0.0	0.0	0.0	33.8	34.7	35.7	114.8	37.7	38.7	39.8	116.3	42.0	43.2
Duration of normal operation, days	0	0	0	0	331	330	329	250	327	326	325	249	323	322
hours	0	0	0	0	7949	7927	7904	6005	7856	7831	7805	5969	7751	7723
Available electricity generation, GWh	0.0	0.0	0.0	0.0	1192.3	1189.0	1185.6	900.7	1178.4	1174.6	1170.8	895.4	1162.7	1158.5

Figure 11-3. Overview of the sub-section "Installed capacity utilization

Expenses estimate of the power plant production, distribution and utilization:

Expenses for coal expenditure, coal price, power plant utilization, fixed and variable costs of repairs and depreciation cost have been estimated in this sub-section except power production and distribution of the power plant and power consumption for internal needs. Overview of the sub-section of the electricity production, distribution and operational cost estimate is shown in the Figure 11-4.

ESTIMATION OF GENERATION AND PRODUCTION COSTS

Assumptions:

Installed Capacity	600	MW	Unit investment cost	1100	$/kW
Plant utilization		hours	Total investment with custom tax	**757050**	thousand USD
In-house use	8	%	Coal price		
			Price	12	$/ton
			Transportation cost	0.7	$/ton
Electricity heat rate	2383	kcal/kWh	Coal price escalation	1	%
Heat content, as received	3144	kcal/kg	Fixed portion of O&M costs	1	% of total investment
Heat content of ignition fuel	9500	kcal/kg			
Ignition fuel cost	5	%/coal costs	O&M Cost escalation	1	%
			Variable portion of O&M costs	0.15	cents/kWh
Investment schedule			Employees	250	
First year	50%		Monthly average salary	800	USD
Second year	40%		Salary escalation	1	%
Third year	10%		Insurance	0.1	%
			Contingency	10	%

Depreciation cost estimation assumptions::

	Percentage	Depreciation period
Building	20%	30
Main equipments	70%	30
Other	10%	10

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
UTILIZATION OF INSTALLED CAPACITY														
Utilization of installed capacity,%	0.0%	0.0%	25.0%	75.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
PRODUCTION														
Generation, GWh	-	-	578.3	2,868.4	4,706.2	4,405.2	4,394.0	4,377.9	4,642.6	4,349.0	4,065.0	4,318.3	4,571.0	4,285.7
In-house use, GWH	-	-	46.3	229.5	376.5	352.4	351.5	350.2	371.4	347.9	325.2	345.5	365.7	342.9
Electricity distribution, GWh	-	-	532.1	2,638.9	4,329.7	4,052.7	4,042.5	4,027.7	4,271.2	4,001.1	3,739.8	3,972.8	4,205.4	3,942.9
COAL CONSUMPTION														
Coal, thousand ton	-	-	438.3	2,174.1	3,567.1	3,338.9	3,330.5	3,318.2	3,518.9	3,296.3	3,081.1	3,273.1	3,464.6	3,248.4
COAL PRICE														
Coal price, $/ton	-	-	12.96	13.08	13.22	13.35	13.48	13.62	13.75	13.89	14.03	14.17	14.31	14.45
O&M EXPENSES														
O&M fixed costs, thousand USD	-	-	7,276.5	7,422.1	7,570.5	7,721.9	7,876.3	8,033.9	8,194.6	8,358.4	8,525.6	8,696.1	8,870.0	9,047.4
Salary cost component, thousand USD	-	-	2,306.8	2,352.9	2,400.0	2,448.0	2,497.0	2,546.9	2,597.8	2,649.8	2,702.8	2,756.8	2,812.0	2,868.2
O&M variable costs, thousand USD	-	-	798.1	3,958.4	6,494.5	6,079.1	6,063.7	6,041.5	6,406.8	6,001.6	5,609.7	5,959.2	6,308.0	5,914.3
Coal costs, thousand USD	-	-	5,678.9	28,448.0	47,141.2	44,567.0	44,898.8	45,181.4	48,392.5	45,785.1	43,223.3	46,375.8	49,581.2	46,951.4
Ignition fuel costs, thousand USD	-	-	283.9	1,422.4	2,357.1	2,228.3	2,244.9	2,259.1	2,419.6	2,289.3	2,161.2	2,318.8	2,479.1	2,347.6
Insurance, , thousand USD	-	-	757.1	757.1	757.1	757.1	757.1	757.1	757.1	757.1	757.1	757.1	757.1	757.1
Contingency, thousand USD	-	-	1,710.1	4,436.1	6,672.0	6,380.1	6,433.8	6,482.0	6,876.8	6,584.1	6,298.0	6,686.4	7,080.7	6,788.6
TOTAL	-	-	18,811.5	48,796.9	73,392.4	70,181.5	70,771.7	71,301.8	75,645.2	72,425.3	69,277.6	73,550.3	77,888.1	74,674.6
CALCULATED DEPRECIATION														
Building	-	-	5,047.0	5,047.0	5,047.0	5,047.0	5,047.0	5,047.0	5,047.0	5,047.0	5,047.0	5,047.0	5,047.0	5,047.0
Major equipments	-	-	17,664.5	17,664.5	17,664.5	17,664.5	17,664.5	17,664.5	17,664.5	17,664.5	17,664.5	17,664.5	17,664.5	17,664.5
Others	-	-	7,570.5	7,570.5	7,570.5	7,570.5	7,570.5	7,570.5	7,570.5	7,570.5	7,570.5	7,570.5	7,570.5	7,570.5
Total, thousand USD	-	-	30,282.0	30,282.0	30,282.0	30,282.0	30,282.0	30,282.0	30,282.0	30,282.0	30,282.0	30,282.0	30,282.0	30,282.0

Figure 11-4. Overview of the sub-section “Electricity production, distribution and operational cost estimate”

Project financing estimate:

The financing estimate has been performed with possibilities for 100% financing the project its own investment and for calculating the loan interest and its repayment on the basis of the loan amount, duration and interest in the condition to finance an amount of the project investment with a loan. The project financing estimate is shown in the Figure 11-5.

PROJECT FINANCING ESTIMATION

General assumptions:

Capital cost structure		
Equity	30	%
Debt	70	%
Loan term and conditions:		
Interest rate	6	%
Term	15	year
Grace period	3	year

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
FINANCING REQUIRED	-	378,525	302,820	75,705	-	-	-	-	-	-	-	-	-	-
In which: Equity financing	-	227,115	-	-	-	-	-	-	-	-	-	-	-	-
Debt financing	-	151,410	302,820	75,705	-	-	-	-	-	-	-	-	-	-
LOAN INTEREST AND PRINCIPAL PAYMENT														
Accumulated loan	-	151,410	454,230	529,935	529,935	485,774	441,613	397,451	353,290	309,129	264,968	220,806	176,645	132,484
Principal repayment	-	-	-	-	44,161	44,161	44,161	44,161	44,161	44,161	44,161	44,161	44,161	44,161
Interest repayment	-	9,085	27,254	31,796	31,796	29,146	26,497	23,847	21,197	18,548	15,898	13,248	10,599	7,949

Figure 11-5. Overview of the sub-section ''Project financing estimate"

Electricity price estimate:

The electricity price estimate has been conducted in two variants namely basic and variable.

For the basic price variant, annual electricity price of the project utilization will be estimated on the basis of the basic electricity price of the year in which the power plant will launch its operation and average electricity price growth. For the variable price variant, electricity price has been planned to be stable during definite years of the power plant operation like the first five years, first ten years etc.

Overview of the sub-section of the electricity price estimate is shown in the Figure 11-6.

ESTIMATION OF ELECTRICITY PRICE

Assumptions:

Base Electricity price		0.0550	$/kWh
Top boundary of price		0.080	$/kWh
Expectation of electricity price		a	
I. "BASE" scenario			
Annual price escalation		1.0	%
II. "VARIABLE" scenario			
Price change rate			
	Operation first	5	*years*
Electricity price		0.055	$/kWh
	next	10	*years*
Electricity price		0.065	$/kWh
	past years		
Electricity price		0.08	$/kWh

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Electricity price (with VAT)	0.0000	0.0000	0.0550	0.0556	0.0561	0.0567	0.0572	0.0578	0.0584	0.0590	0.0596	0.0602	0.0608	0.0614

Figure 11-6. Overview of the sub-section of the electricity price estimate

Project cash flow estimate:

The sub-section of the project cash flow will estimate electricity sales income, value added tax, production expenses, loan interest repayment, net income, income before tax, income tax, entity income tax, net income after tax, working capital, investment, loan financing, loan repayment, net money flow, accumulated net money flow, discounted net money flow, accumulated discounted net money flow, current project value and internal earning level. Overview of this sub-section is shown in the Figure 11-7.

PROJECT CASH FLOW ESTIMATION

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
GENERATION, GWh	-	-	578.3	2,868.4	4,706.2	4,405.2	4,394.0	4,377.9	4,642.6	4,349.0	4,065.0	4,318.3	4,571.0	4,285.7
SALE, GWh	-	-	532.1	2,638.9	4,329.7	4,052.7	4,042.5	4,027.7	4,271.2	4,001.1	3,739.8	3,972.8	4,205.4	3,942.9
ELECTRICITY PRICE, $/kWh	-	-	0.055	0.056	0.056	0.057	0.057	0.058	0.058	0.059	0.060	0.060	0.061	0.061
REVENUE, thousand USD	-	-	29,263.7	146,593.1	242,919.8	229,654.9	231,365.0	232,821.1	249,368.0	235,931.8	222,730.9	238,976.0	255,493.4	241,941.8
VAT, thousand USD	-	-	2,660.3	13,326.6	22,083.6	20,877.7	21,033.2	21,165.6	22,669.8	21,448.3	20,248.3	21,725.1	23,226.7	21,994.7
PRODUCTION COSTS, thousand USD	-	-	18,811	48,797	73,392	70,182	70,772	71,302	75,645	72,425	69,278	73,550	77,888	74,675
INTEREST EXPENSES, thousand USD	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLOSURE, thousand USD	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INCOME, thousand USD	-	-	7,792	84,470	147,444	138,596	139,560	140,354	151,053	142,058	133,205	143,701	154,379	145,273
DEPRECIATION, thousand USD	-	-	7,571	22,712	30,282	30,282	30,282	30,282	30,282	30,282	30,282	30,282	30,282	30,282
INCOME BEFORE TAX, thousand USD	-	-	221	61,758	117,162	108,314	109,278	110,072	120,771	111,776	102,923	113,419	124,097	114,991
INCOME TAX, thousand USD	-	-	22	15,080	28,930	26,718	26,960	27,158	29,833	27,584	25,371	27,995	30,664	28,388
TAX DISCOUNT	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INCOME AFTER TAX, thousand USD	-	-	199	46,679	88,231	81,595	82,319	82,914	90,938	84,192	77,552	85,424	93,432	86,603
WORKING CAPITAL, thousand USD	-	-	(5,000)	-	-	-	-	-	-	-	-	-	-	-
INVESTMENT, thousand USD	-	(378,525)	(302,820)	(75,705)	-	-	-	-	-	-	-	-	-	-
DEPRECIATION, thousand USD	-	-	7,571	22,712	30,282	30,282	30,282	30,282	30,282	30,282	30,282	30,282	30,282	30,282
LOAN FINANCING, thousand USD	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LOAN REPAYMENT, thousand USD	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CASH FLOW	-	(378,525)	(300,050)	(6,315)	118,513	111,877	112,601	113,196	121,220	114,474	107,834	115,706	123,714	116,885
ACCUMULATED CASH FLOW	-	(378,525)	(678,575)	(684,890)	(566,377)	(454,500)	(341,899)	(228,703)	(107,483)	6,991	114,825	230,531	354,246	471,131
DISCOUNTED CASH FLOW	-	(344,114)	(247,975)	(4,744)	80,946	69,467	63,560	58,087	56,550	48,548	41,575	40,554	39,419	33,857
ACUMULATED DISCOUNTED CASH FLOW	-	(344,114)	(592,089)	(596,834)	(515,887)	(446,420)	(382,860)	(324,773)	(268,223)	(219,675)	(178,100)	(137,546)	(98,126)	(64,269)
NET PRESENT VALUE/ NPV	228,272													
INTERNAL RATE OF RETURN/ IRR	13.58%													

Figure 11-7. Overview of the sub-section of the “Project Cash Flow Estimate

11.3. Basic estimation data

The financial model‘s basic estimation data will include indicators like unit investment, power amount for internal needs, price level of the electricity to be sold and its change trends, exploitation expenses, heat production capacity of coal, the power plant‘s heat consumption, financing structure, loan and loan interest and duration.

Investment

Unit investment of the power plant has been estimated to be 1100 $/kW. Investment for erection of a 150 kilometer-long and 220 kV two circuit power transmission line between the power plant and CES will be 40.0 million USD. Besides, 16.0 million USD has been planned to be invested to build a 60 kilometers long and 220 kV one circuit power transmission line between the power plant and ERES. Other infrastructure and additional investment amount has been estimated to be 5.0 million USD. According to this estimate, total investment amount for the power plant will be 721.0 million USD and if 5% customs duty was included the investment will amount in total 757.05 million USD.

Utilization and repair expenses

Coal and fuel oil expenses and fixed and variable costs of utilization and repair works, and labor and depreciation costs have been estimated for the power plant utilization expenses.

The power plant will exploit coal of the Chandgana deposit. Reasonable coal sale price of the coal mine has been calculated on the basis of its coal's heat production capacity and heat production quality and prices of coals from other mines. Coal price of the Chandgana tal coal mine has been enumerated to be 12 $/tons, annual average coal price growth – to be 1% and coal transportation expenses – to be 0.7 $/tons.

The power plant's coal consumption has been estimated by considering its heat consumption as 2383 кcal/kg and minimum heat production of the coal as 3144 kcal/kg.

Liquid fuel or fuel oil expense has been estimated to be 5% of the coal expenses.

A total of 250 people have been planned to be employed by the power plant and average monthly pay of per person has been planned to be paid at 800 USD as well as average annual wage has been expected to be 1%.

The utilization and repair expenses have been estimated as the following:

- Fixed cost amount of the power plant's utilization and repairs is to be 1.0% out of the total investment,
- Average annual growth of the fixed cost for utilization and repair works is to be 1.0%,
- Variable cost of the utilization and repair works is to be 0.15 cent/kWh.

For the depreciation cost, 20% of the total investment of the power plant will be spent on building facilities, 70% - machineries and miscellaneous cost - 10%. The depreciation cost has been computed under the straight line method.

Electricity price:

The electricity price to be sold by the power plant has been enumerated to be 0.055 $/kWh (including VAT), average annual electricity price growth - 1% and maximum limit of electricity price 0.08 cent/kWh.

11.4. Economic Analysis and Results

The Crystal Ball program was used in order to confirm the project's final economic and financial results estimated in accordance with the financial model. Impacts of distribution probability of variable indicators of the financial model on the project results and profitability were estimated under the Monte-Carlo simulation method. The project results and risk level related to the project implementation were calculated by a way of defining for 10000 occasions.

As a result of calculation of the basic price level discount at 10%, the project net present value 228.3 million USD, internal rate of return 13.58% and investment repayment duration 7 years.

Results of the estimation of a probability of the project net present value to be above zero is shown in the Table 11-1 and Figure 13-8, respectively.

Table 11- 1. Probability of the net present value to be above zero

Probability	Net Present Value /in thousand USD/
0%	819,038
10%	515,906
20%	435,965
30%	372,310
40%	317,898
50%	268,322
60%	217,749
70%	167,130
80%	115,368
90%	46,388
100%	(260,834)

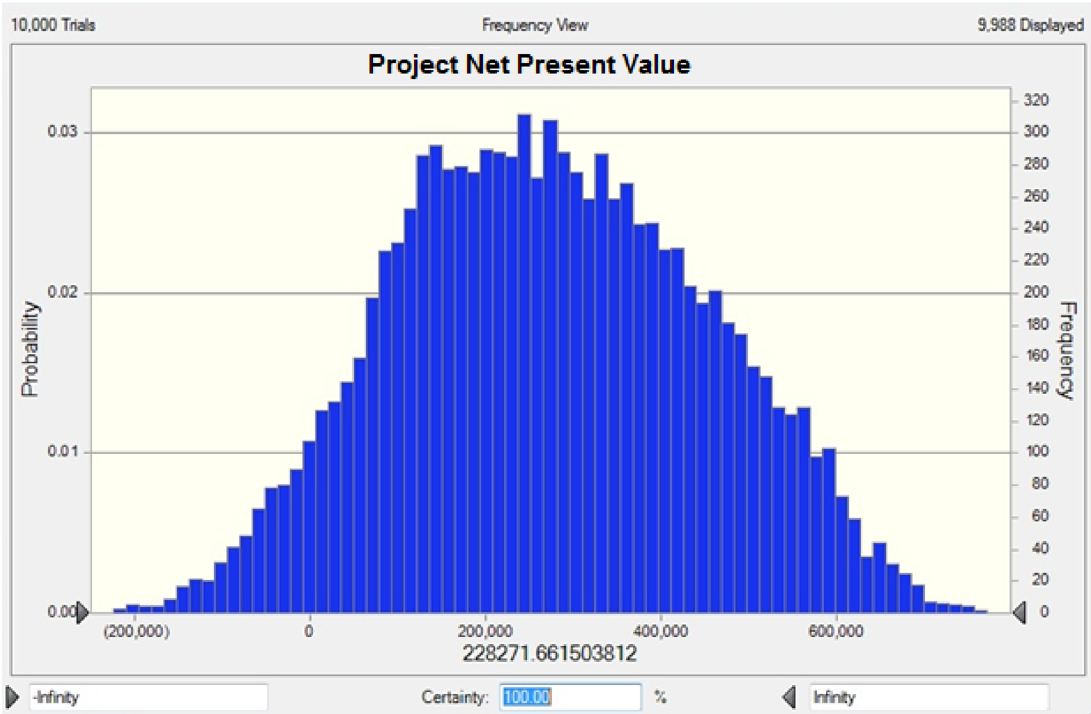

Figure 11-8. Project net present value

Judging from the above Table 11-1 and Figure 11-8, a probability of the project successful implementation or current net value to be above zero has been 91.5%. This is a higher indicator for the power plant project.

A sensitivity study has been conducted by using the Crystal Ball program with the purpose or defining the indicators which mainly impact on the project's economic profits and their impact levels. The study results are shown in the Figure 11-9.

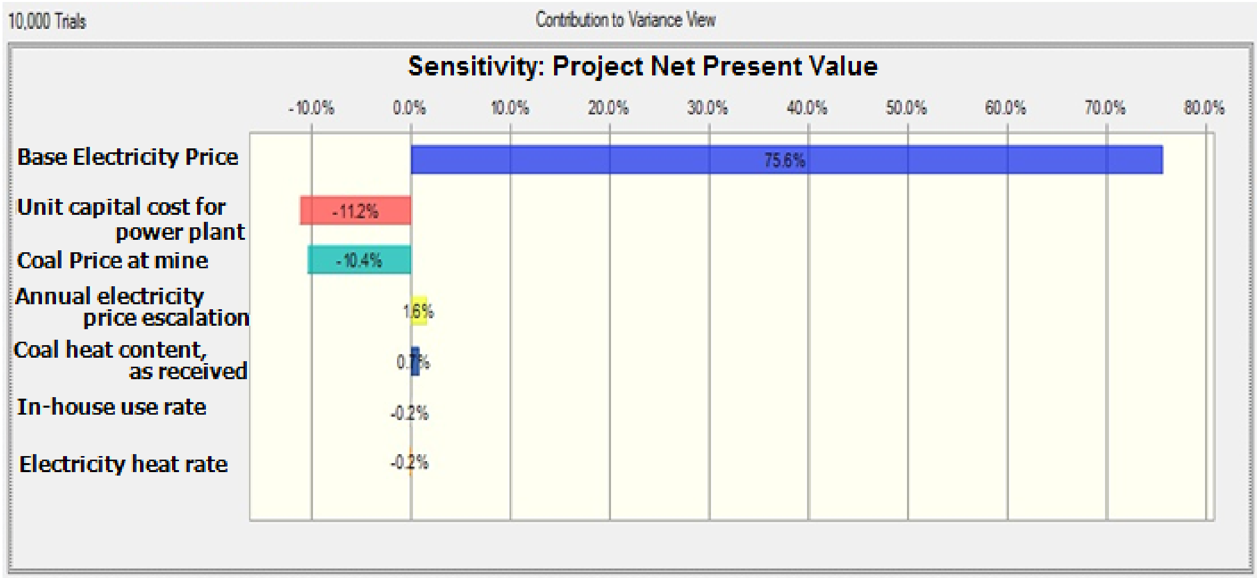

Figure 11-9. Sensitivity study

Judging from the sensitivity study, the project's cash flow and net present value do mainly depend on the price of electricity to be sold by the Chandgana power plant, unit capital cost, coal price at mine, coal heat content, electricity heat rate, electricity in-house use rate and annual escalation rate of the electricity price.

The Figures 11-10 and 11-12 present how the project net present value and internal rate of return depend on the power plant's unit investment, electricity price, and coal price change in the mine.

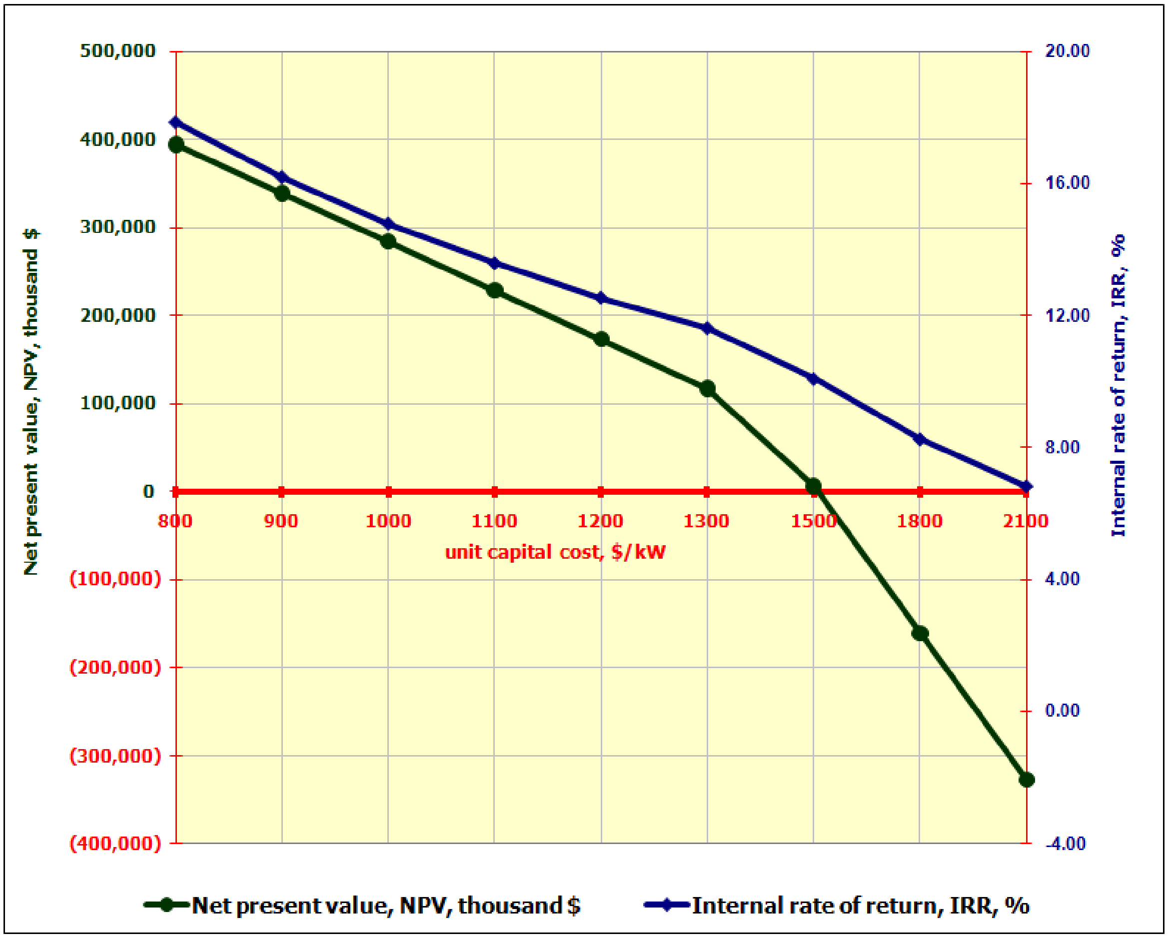

Figure 11-10. Correlation between unit investment and net present value (NPV) and internal rate of return (IRR)

Judging from the Figure 11-10, the project current value and internal rate of rate will be raised when the unit capital cost was less. For example: when the unit capital cost was 1100 $/kW, NPV will be 228.3 million USD. When IRR was 13.58% and the unit capital cost reduced until 900 $/Kw, NPV will be to 339.1 million USD and IRR will be 16.18%.

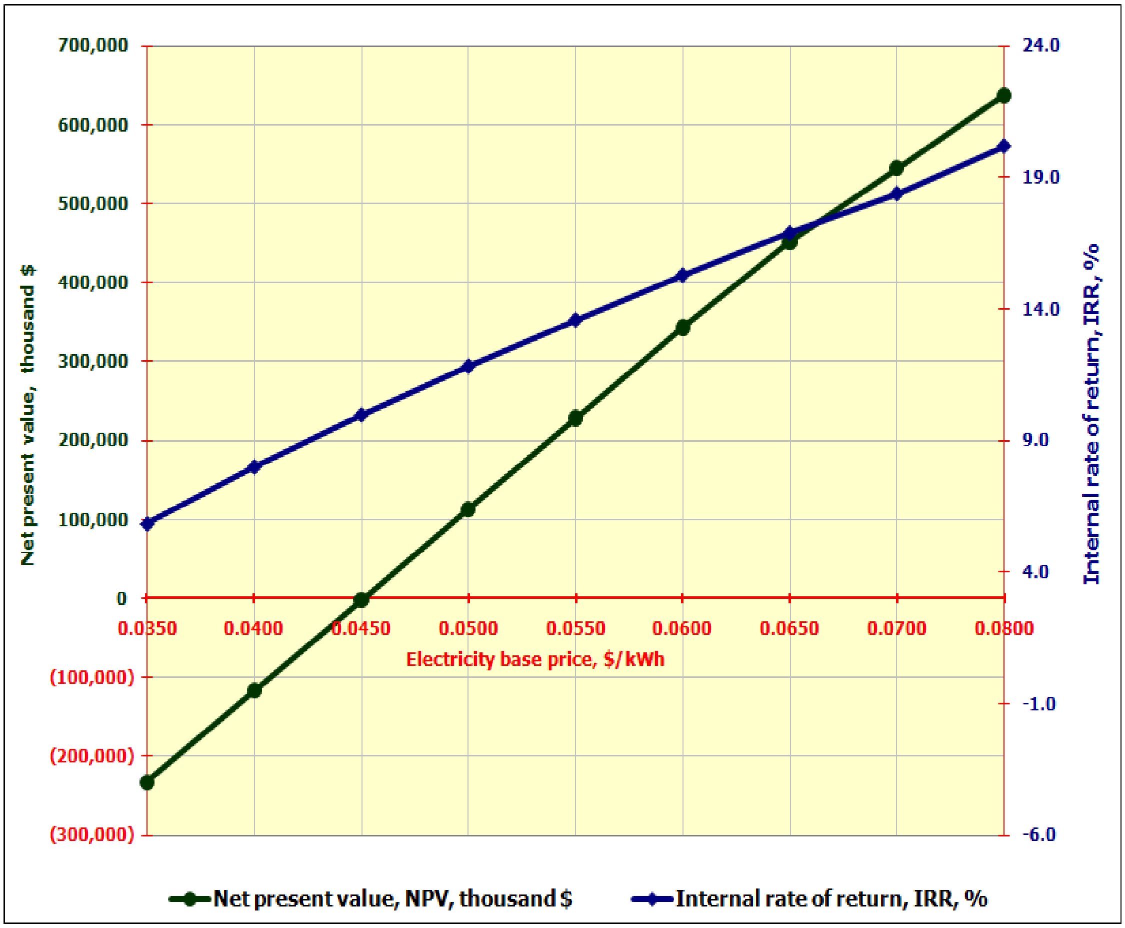

Figure 11-11. Correlation between the basic price of electricity and NPV and IRR

Judging from the Figure 11-11, the increase of basic price of electricity impacts positively on the current project value and internal rate of return. For example: if the basic price of electricity was 0.055 $/kWh, NPV would be 238.3 million USD. If IRR was 13.58% and the basic price of electricity increased up to 0.060 $/kWh, there would be a possibility to increase NPV up to 342.9 million USD and IRR up to 15.28%. If the basic price of electricity became 0.045 $/kWh, NPV would reduce up to – 2.1 million USD and IRR would decline up to 9.97%.

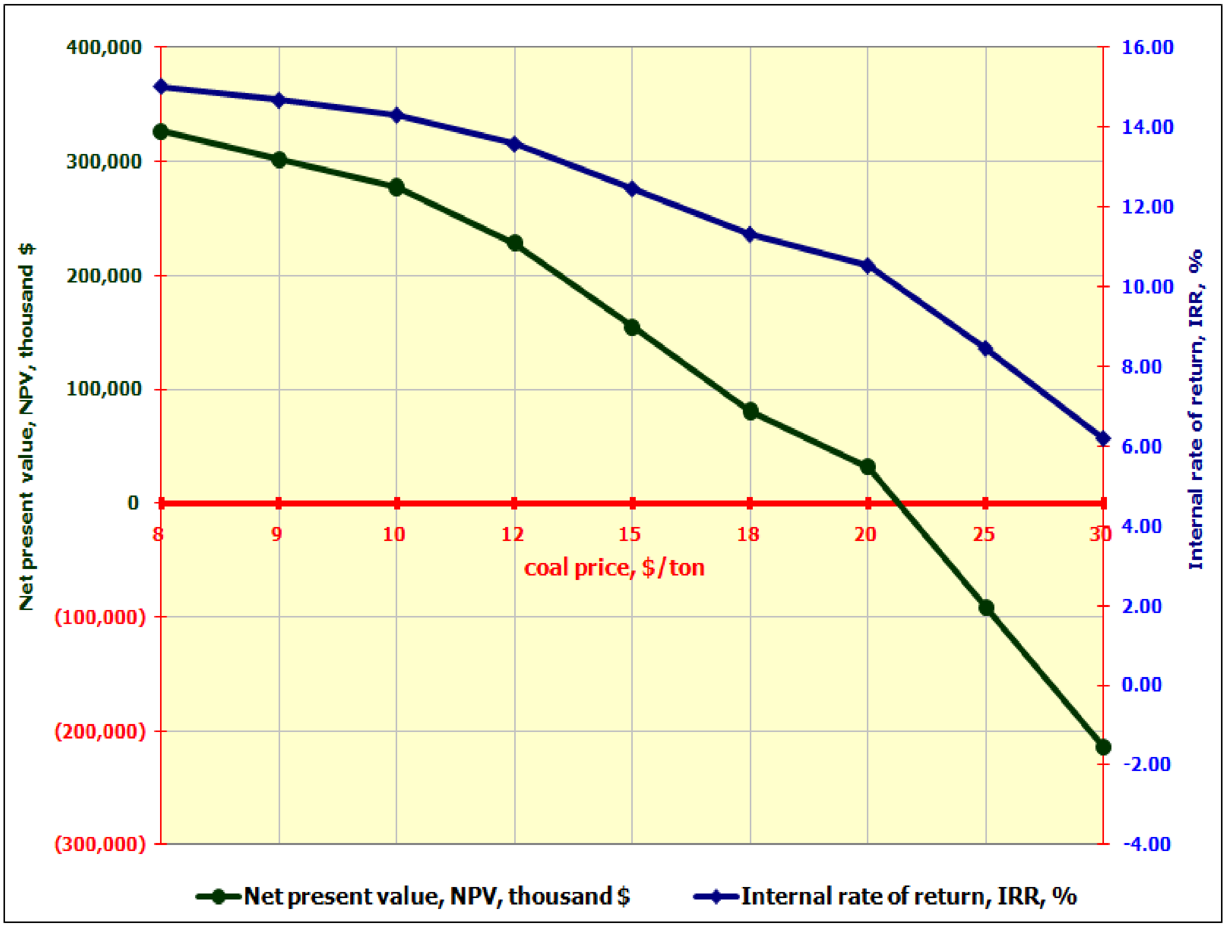

Figure 11-12. Correlation between coal price at the mine and NPV and IRR

Judging from the Figure 11-12, if the coal price at the mine held as less as possible, it would positively impact on the current project value and internal rate of return. For example: when the price at the coal mine was 12 USD/tons, NPV will be equal to 238.3 million USD. If IRR was 13.58% and the coal price reduced up to 10 USD/tons, NPV would be equal to 277.4 million USD and IRR will increase up to14.31%.

Judging from the above correlation graphs, there is a requirement to study in detail the indicators such as the electricity price to be supplied by the power plant, the power plant's investment level and unit capital cost, and coal price at the coal mine at the detailed design of the power plant and the next stage of feasibility study. Detailed study of above mentioned risk factors during the next stage of research and taking measures for risk mitigation would have significant importance to raising the project profitability.

CONCLUSION

The following conclusions have been done on the basis of the feasibility study and results of estimates of the power plant to be erected relaying on the Chandgana tal coal mine in Murun soum of Khentii Province:

1. There are technical and economic possibilities to erect and utilize 4x150 MW Chandgana power plant.
2. Judging from the future trends of electricity demand and supply of the Central and Eastern regional energy system, the 4x150 MW Chandgana power plant erection project is more significant to provide power consumption growth in the current condition where the energy demand has increased and power production source has become insufficient.
3. When the discount rate was 10%, the project net present value would be 228.3 million USD, the internal rate of return would be 13.58%, and a probability of project success or having positive net present value for the project would be 91.5%. This confirms the project is feasible for successful implementation. Although the project economic indicators are more attractive it is recommended that to have detailed study for risk mitigation during the next stage of project implementation.
4. A detailed hydro-geological prospecting has been required to be conducted to determine artesian water resource in the Murun River basin in Khentii Province with the intention of defining the water source to exploit for the power plant needs.
5. In case, if the mine and power plant investor was the same legal party, the project financing possibilities would increase. Therefore, in case the mine was operated as a center of expenses, there would be a possibility to increase the power plant's profitability level.
6. The main requirement to carry out the project will depend on power demand and electricity price rate to be sold by the power plant.

energy purchase and sales and it is significant to launch the project implementation.

APPENDIX