INTERNATIONAL CONSORTIUM

PROJECT FOR CONSTRUCTION OF LARGE POWER PLANT AND EXPORTING ELECTRICITY PRODUCED IN MONGOLIA

Brief Presentation

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Ulaanbaatar city, Mongolia
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PRESENTATION OF STUDY ON CONSTRUCTION OF BOOROLJUUT /TSAIDAMNUUR/ 6,600 MW POWER PLANT IN MONGOLIA AND POWER EXPORTING PROJECT

Project general information

The Government of Mongolia under the "Government Policy on Energy" approved by Resolution No. 63 of the Mongolian Parliament (the Great Khural) dated 19th June 2015, has formulated the strategic objectives to develop the regional cooperation on energy, to introduce the advanced and energy efficient technologies, to attract the foreign investment, and to increase the private participation in the energy sector, and "to construct the large power plants and the ultrahigh voltage direct current (UHVDC) power transmission lines to export the electricity" in 2015 – 2023 in the first stage under this strategic objectives.

Within the framework of this strategic objective, the feasibility study was conducted to prepare the study report for the power exporting project and the construction of the large power plant based in Booroljuut coal deposit located in Tsaidamnuur coal basin in the northern side of Choir Nyalga basin area in Mongolia.

Booroljuut coal deposit is located in Booroljuut steppe in Tsaidamnuur coal basin in Bayan and Bayanjargalan Soums of Tuv Aimag (province) in Mongolia, and has the approved resources of 3.6 billion tons of coal.

This coal deposit has a geographic advantage of located not so far from Ulaanbaatar city, in the northern region of Mongolia, close to Chines border and near to the railway.

The "BKB" led Consortium formed by Korean, Chinese and Mongolian companies is preparing to implement the project and made the feasibility studies on construction of 6,600 MW power plant based in Booroljuut coal deposit in Tsaidamnuur basin and the UHVDC power transmission overhead lines (OHL) connecting to China to export the electricity.

Consortium members: Busan Korea Biotechnology Co., Ltd (BKB, Korea), COGAS (Korea), KEPCO (Korea), Steelflower Co., Ltd (Korea), BHI Co., Ltd (Korea, USA Foster Wheeler CFB manufacturer), GE International Inc. (USA General Electric), HEXA International Co., Ltd (Myanmar), Chinese Power Company (TBEA), Mongolian Power Company.

The Consortium concluded the agreement and the Memorandum of Understanding (MoU) on cooperation with "Tsetsens Mining & Energy" LLC, who owns the deposit, on the use of coals and bringing the deposit to economic turn, and the contract to purchase the coal mine.

The feasibility study report was prepared for the Consortium to implement the power exporting project and to construct the Booroljuut coal based 6,600 MW power plant and to export the electricity to China connecting by UHV (±800kV) DC transmission line

<u>The current conditions of the power sector in Mongolia and the power sector in China, development trends and demand forecasts</u> are studied. The electricity demand in China is increasing immensely due to the increase of population and economic growth. 74% of the coal resources is located in the northern part of China. However, there is a lack of water resources in the northern and central parts of China, and the new power plant was not possible to construct in these regions. Recent years, the air pollution has increased by 37%. So, there is a trend of increasing the Chinese emissions to 30% of world emissions by 2025. Therefore, the power import is forecasted to reach 23% of the total demand in China. While demand growth will be 60%, the power generation growth is to be 47%. The installed capacity of power generation plants reached 1,385.26 GW as of September 2015. There is a forecast of power shortage of 9720 MW in Beijing-Tianjin-Tangshan power system, and power shortage of 4260 MW in Hebei province by 2020.

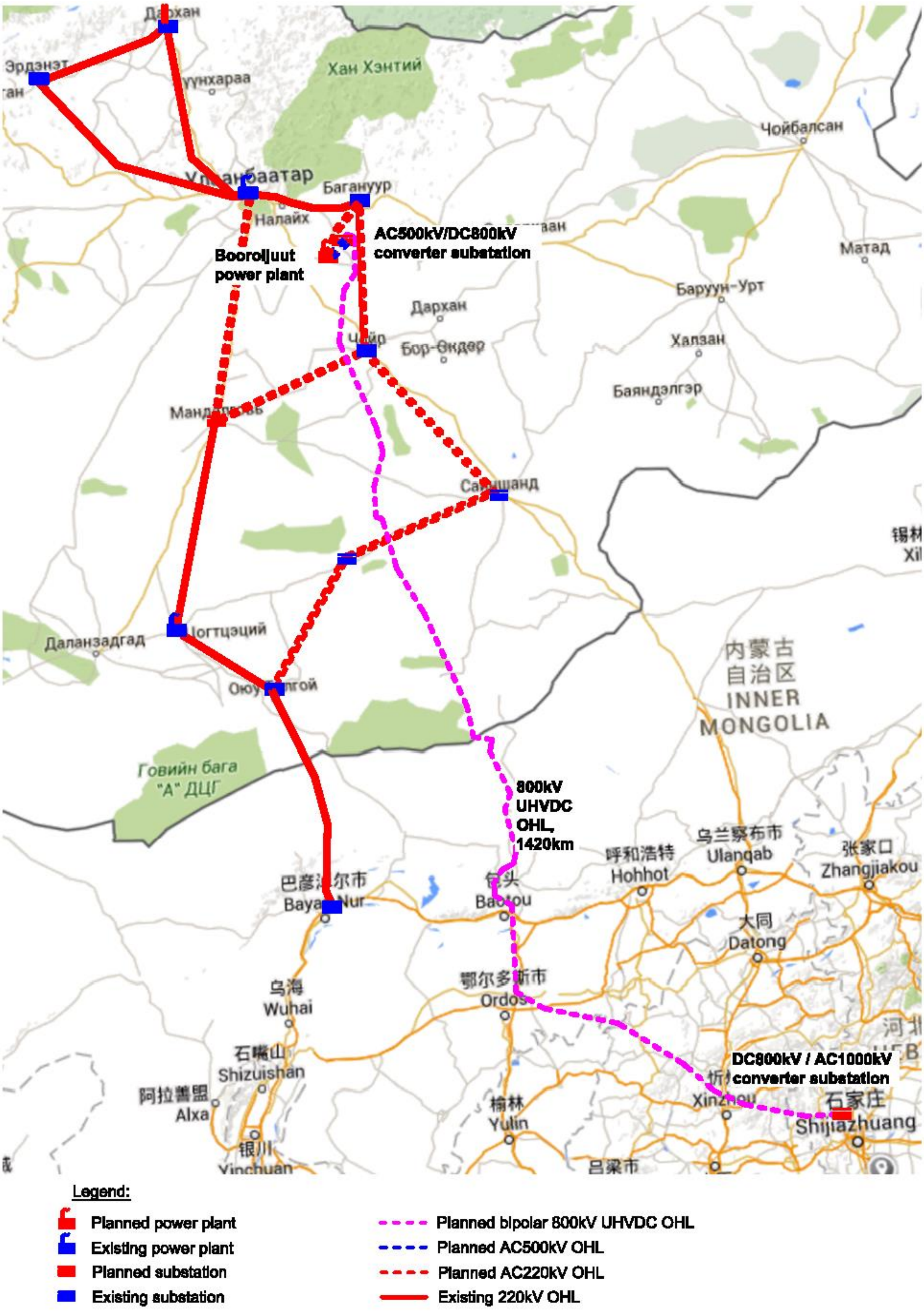


Figure 1. Project Conceptual Plan

Location of Power Plant

It is planned to place the Booroljuut power plant in the north-eastern part outside the licensed area of Booroljuut coal deposit. 400 hectare of land is needed for constructing the power plant. The construction material factory is planned to be developed using the ash wasted from the power plant and 100 hectare of land is needed for this purpose. The preliminary site location of the new power plant and the site conceptual plan are shown in the figure below:

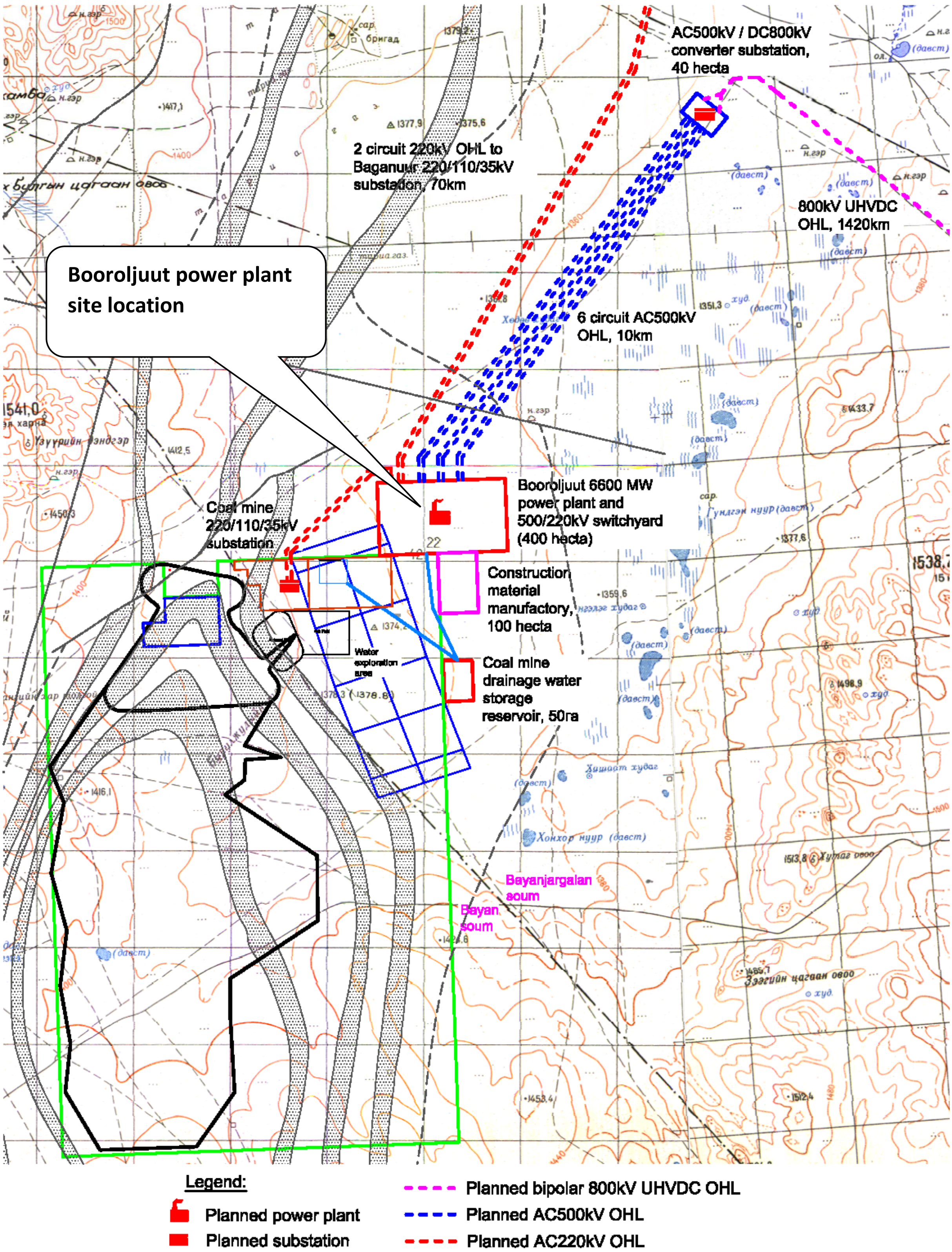


Figure 2. Site Location of Booroljuut Power Plant in Tsaidamnuur Coal Basin

Geology, Hydrogeology and Engineering Geology Conditions of Power Plant Site

The consultant team has conducted surveys and studies on geographic location, geological condition, hydrogeological condition, engineering geological condition, soil condition /geotechnical study/, water resources, infrastructure development and construction materials resources at the power plant planned site in the Booroljuut coal deposit of Tsaidamnuur coal basin located in Bayan and Bayanjargalan Soums of Tuv Aimag (province) in Mongolia.

Environment Baseline Condition Assessment of Power Plant Site

The environment studies and baseline assessment of the power plant site have been performed and the complete report is provided in the appendix of the FS report.

Installed Capacity of the Power Plant

The main objective of this project is to construct the power plant using the low ranked lignite coal and to export the electricity. It is planned to construct Booroljuut 6,600 MW Power Plant in the Tsaidanuur coal basin based on the Client's request.

Based on studies and considering the maximum and suitable size of the main equipment, availability of the unit, technological achievements, reliability of the equipment, the unit capacity 600 MW is selected. Therefore, Booroljuut power plant has the total installed capacity of 6,600 MW (600 MW x 11 units = 6600 MW). The power plant is arranged in the unit scheme (one boiler connects to one turbine-generator).

Design Coal Property

The coal properties have been evaluated and studied. The design coal characteristics is shown in the table below:

Table 1. Design Coal Property

Name		**Booroljuut**
Volatile matter	%	46,7
Ash	%	11,2
Inherited humidity	%	10,7
Carbon	%	42,06
Sulphur	%	0,67
Hydrogen	%	3,76
Oxygen	%	14,21
Nitrogen	%	0,91
Heating value /calorific value/	ккал/кг	3440

CONCEPTUAL DESIGN OF THE POWER PLANT

Selection of Main Equipment

The main equipment of the power plant is the boiler and turbine-generator. The conceptual designs are prepared and (i) type of turbine and the number; (ii) live steam parameters; (iii) technological schematics; and (iv) type of steam boiler and its number are selected for the main equipment.

Technological Arrangement. The power plant is arranged in an unit type, and has the supercritical pressure, and steam reheat.

Boiler Selection. Types of available boiler designs and combustion technologies have been studied and evaluated. Based on the assessments and comparison of the boiler designs and technologies, the circulating fluidized bed (CFB) boiler with supercritical parameters and once-through water circulation is selected.

CFB boiler parameter for 600 MW unit:

- Boiler live steam flow : 1900 t/h
- Boiler live steam pressure : 25.4 MPa
- Live steam temperature : 571 ˚C
- Boiler feed water temperature : 284 ˚C
- Type of coal : Booroljuut Lignite
- Auxiliary fuel : No.2 fuel oil (AST D975) (diesel fuel)

Turbine Selection. The condensing turbine is selected due to no process steam use and heating. The supercritical 600 MW turbine with air-cooled condensers are suitable.

The parameters for 600 MW supercritical turbine-generator is shown below:

Turbine, generator parameters:

- Generator rated capacity : 600 MW
- Turbine steam pressure : 24.2MPa
- Live steam temperature : 560 °C
- Turbine steam flow : 1808 t/h
- Vacuum pressure in turbine outlet : 11 kPa
- Boiler feed water temperature : 284 °C
- Number of feed water heaters : 8 stages of heaters
- Generator rotation/ frequency : 3000 rpm / 50Hz
- Generator rated power factor (cosφ) : 0.95
- Generator rated voltage : 20 kV
- Generator cooling : hydrogen
- Generator efficiency at full load : 98.95

The in-plant (internal use) use of electricity of the power plant is about 8.6% of the installed capacity due to the application of the air cooled condensers and CFB boiler auxiliary. The power plant efficiency is about 40.1 %.

Boiler Auxiliary. The boiler auxiliary equipment is selected and the conceptual designs are summarized below.

Combustion system. Boiler furnace has the fluidizing bed consisted of finned water wall tubes, fuel, limestone, ash and sand. The crushed coal with certain sizes is supplied to the boiler furnace, and the complete combustion is taken place in the low temperature and NOx emission is reduced. The pulverized limestones are fed to the furnace, burnt with coals, the limestone absorbs the Sulphur oxides and forms the gypsum which is easily removed together with the ash. The coal is crushed to size of smaller than 5 cm before delivery to the coal bunkers

Coal feeding system. The coal is fed to the boiler with gravimetric coal feeders from the coal bunker and coal feeding auxiliary.

Limestone handling system. The limestone is transported from limestone storage house to boiler limestone bunkers with pneumatic system. The limestone conveyor system is used for unloading from the bunker and supplying the boiler.

Combustion air system supplies the required air for coal combustion, starting the CFB boiler, sealing air in a normal operation, cooling, fluidizing bed, and transporting. The air consisted of the primary air and secondary air given to the furnace of CFB boiler, air for transporting the limestone, and fluidizing bed air. The FD fan is drafted the ambient air and supplied the pressurized air. The air from FD fan is divided into the secondary air and sealing air. The primary air fan is used for fluidizing the bed.

Flue gas system. The flue gas system is used to heat the water and steam by the boiler back pass heating surfaces and to transfer the heat to the primary and secondary air with air heaters. The flue gas temperature drops from 895°C to 135°C at the boiler design load and the design coal. The particulate matter (ash) is removed and reduced to the permissible value by the electrostatic precipitator. The gas system consists of the boiler backpass heating surfaces, electrostatic precipitators, air heaters, and induced draft fans (ID fan).

The combustion air and flue gas system is used to deliver the primary and secondary air heated at the certain temperature through the burners to the boiler furnace, and the flue gases as a result of combustion from the furnace are sucked by ID fan and removed through the chimney to the atmosphere.

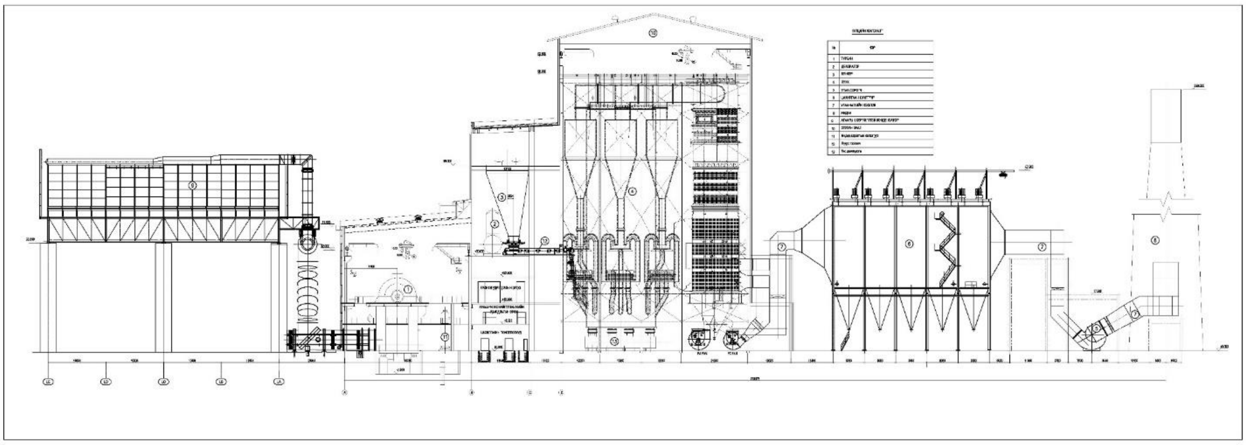
Electrostatic precipitator. There are various methods used for removing the fly ashes from the flue gases to reduce the particulate matter (PM) to the permissible value of the MP and ash emissions emitted from the power plants to the atmosphere. The bag filter and the electrostatic precipitator are the most efficient methods to remove the ashes. The bag filter has higher operation cost although the installation is lower. The electrostatic precipitator is selected for this project.

Fly ash and bottom ash handling system. It is recommended for the project power plant that the dry vacuum conveying system is utilized to transport and remove the fly ash and bottom ash. This vacuum system is suitable for this power plant because it has lower investment cost, low emissions, lower operation & maintenance (O&M) cost, and lower water consumption.

It is recommended that the ash & bottom ash handling system is designed to remove and transport the ashes sufficiently at the plant full operation load, the capacity of the dry ash storage silos must be designed to fully utilize for the construction material production and other purposes.

The Chimney must be selected based on the standards and norms for the emissions permissible values emitted to the atmosphere and the preliminary calculations are shown below.

Үзүүлэлт	unit	Number of units connected to one chimney	
		Two units connected	Three units connected
Number of boilers connected to one chimney	pcs	2	3
Preliminary height of a chimney	m	250	250
Diameter of chimney outlet	m	18	20
Flue gas speed at outlet	m/s	25	25



Turbine Auxiliary. The selection and conceptual designs of the turbine auxiliary equipment is prepared.

Low and high pressure heaters. The boiler feed water is heated in the three high pressure heaters, a deaerator, four low pressure heaters for each unit.

Feed water pumps. Each unit has the feed water pumps with electric drive or turbo drive. The capacity of the feed water pump is designed for the maximum boiler feed water flow with 5% reserve margin.

Condensate system. The condensate system is designed for the turbine outgoing steam is cooled down to the condensate and collected in the hot chamber and delivered through the sealing steam condenser and low pressure heaters to the deaerator.

Turbine condenser cooling system. To select the suitable condenser cooling system, the air cooled condensers are compared with the water cooled condensers. For this project, it is needed to reduce water consumption in the power plant, and to minimize the use of the water. The air cooled condensers are selected for the project power plant. In this regard, the water consumption in the power plant will be greatly reduced due to the air cooled condenser.

Water cooling system. The closed loop water cooling system is utilized for equipment cooling in the power plant to minimize the water consumption. The circulating water cooling system is designed for cooling auxiliary equipment. The cooling tower with fin fans is used for cooling the circulating water.

Water Supply.

The consultant team has conducted the studies for the water resources at the Booroljuut power plant construction site during site surveys and visits.

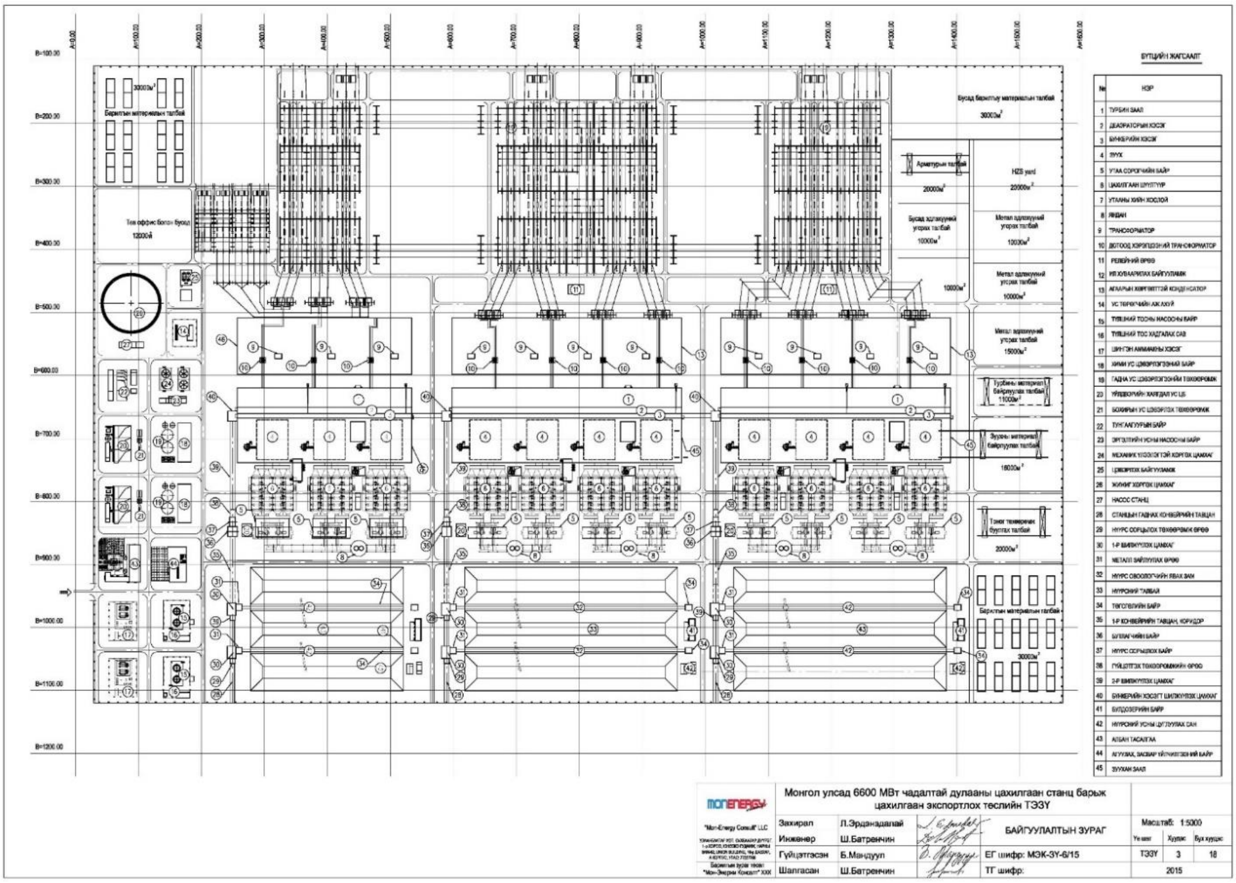
<u>Water consumption.</u> The water is usually used for restoring water losses of circulating water, the demineralized water to restore the plant internal water loss, and tap water in the typical power plants. The water amount to be consumed in the plant is calculated for Booroljuut power plant and shown below.

Hourly raw water consumption in Booroljuut power plant is 5633 t/h, and the annual raw water consumption is approximately 24.4 million tons/year at full load operation of the plant.

The water treatment plant must be designed to treat the plant technological and boiler water needs and to restore the losses.

<u>Water supply plan.</u> The section 5 of this FS report addresses the study on the water resources in the Tsaidamnuur /Booroljuut/ basin and prepared the water supply plan for the Booroljuut power plant

Based on the water resource study, Booroljuut power plant has planned to be supplied by the underground water at the coal deposit site, mining drainage water, accumulated rain water in the closed reservoir. To secure the water supply to the plant, the construction of the water reservoir in the valley of Kherlen river located 50 -70 km from the power plant and the water supply pipelines to the plant is also studied and it was considered one of the possible solutions to secure the reliable and full water supply.



Coal supply.

The coal consumption in the power plant is calculated. Coal consumption in Booroljuut 6600 MW Power Plant: Hourly consumption is 3447 t/h, daily consumption - 57,910 t/day, and annual consumption - 21,137,004. Total coal consumption at full load operating for 40 years is 845,480,160 tons.

Coal supply plan:

The approved coal resource is 3.6 billion tons and it is sufficient for whole life of the newly constructed power plant. The power plant is the mine mouth located and the coal could be supplied to the power plant using the coal conveyor system, and considering the reserve and emergency operation the coal transportation system with trucks could be added.

Coal storage yard:

However, the power plant is located at the mine mouth, the coal storage yard in the power plant must be designed for the safety and reliability reason. The coal could be accumulated in the coal storage yard, be transported directly from the mine or the coal yard by the conveyor and delivered through the coal crushers to the boiler coal bunkers, and fed to the boilers. The coal yard is open type, and has tall fences and walls to prevent flying due to the wind and storm. The water is sprayed frequently to keep the coal moisture and prevent flying the coal dust. The capacity of the coal yard shall be designed for coal storage sufficient for 10 days operation of the power plant.

Coal conveyor system:

The coal conveyor system is designed to transport and unload the raw coal from the mine or coal yard by using coal conveyors or trucks to the coal yard, to weigh, to take coal samples and analyze, to transport the coal to the bunker, to crush the coal to the required sizes and to deliver coal to the boiler bunker. The coal handling system shall be equipped with open yard for coal unloading, storage and piling up, coal crushers, coal conveyors, the equipment for fly dust capture/removal and water spraying, firefighting and extinguisher. The coal conveyors sloping shall be not higher than 18°. The coal conveyor system shall be equipped with coal sieve, crushers, metal detectors, electromagnetic metal captures.

Integrated Control & Instrumentation System.

The power plant has fully automated, computerized, Distributed Control System (DCS), and integrated control & instrumentation system.

Other facilities.

The diesel fuel system, air compressor station, and firefighting systems shall be designed in the power plant.

Buildings and Construction Arrangement. The arrangements, plans, designs, construction arrangements, structural engineering, and requirements for the main power buildings, facilities, auxiliary equipment buildings, and other facilities are defined and conceptually designed.

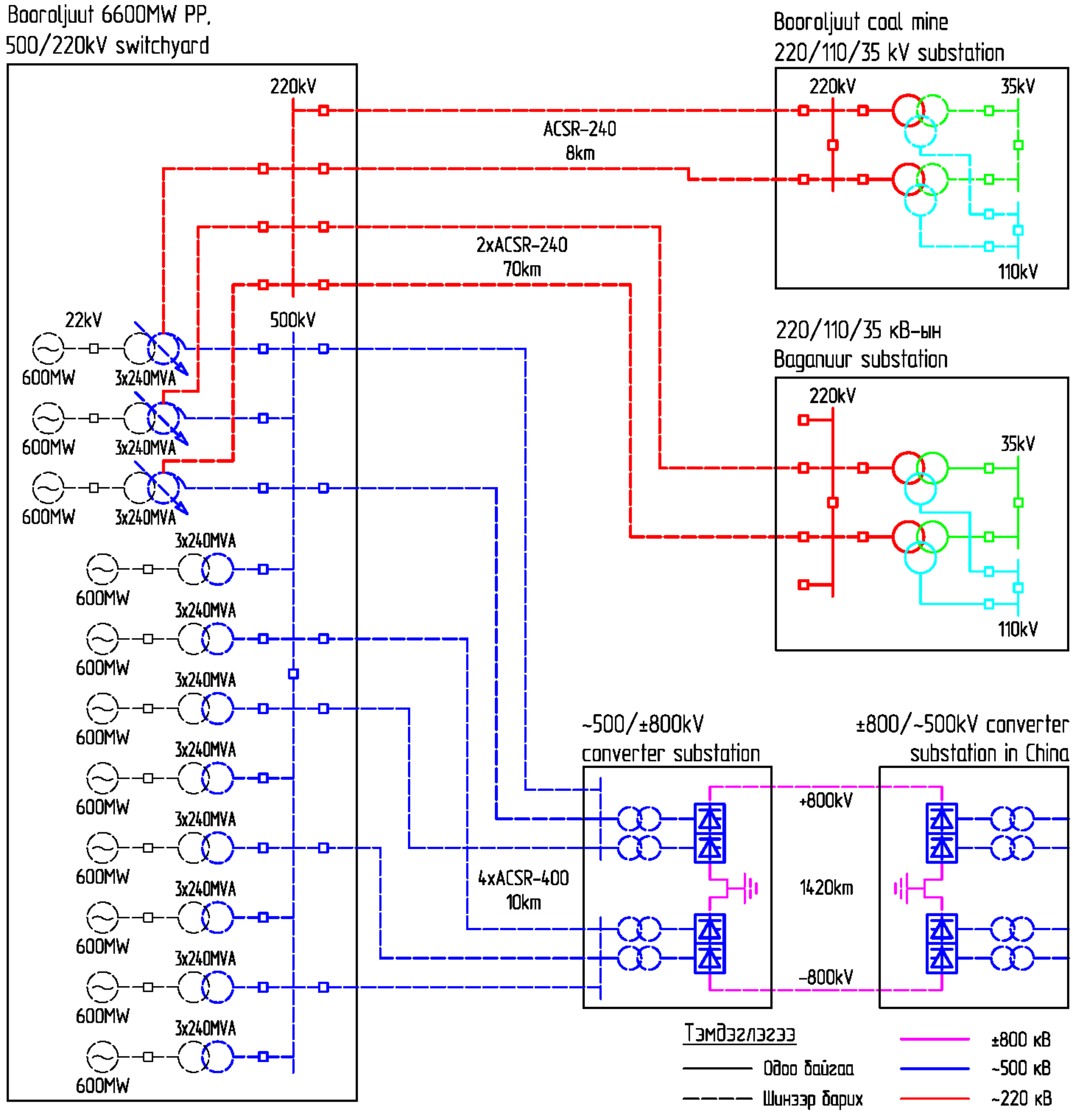
The number of workers and human resource requirement is preliminarily defined.

Environment protection measures. The environment protection measures technological decisions and solutions, applicable standards during the construction period, designing, construction and commissioning, and generation technologies are addressed and provided in the report.

Electric Equipment and Electric System.

The most optimal option to connect the Booroljuut coal mine mouth power plant to the Chinese grid is to convert the alternate current (AC) to direct current (DC) and transmit the electricity using the ultrahigh voltage (UHV) DC overhead lines (OHL). The electric system is designed to supply the certain electricity to the Central Energy System (CES) and the electric connection plan (scheme) is as below:

- 10 km long 500kV AC-400 six-circuit lines (with 4 conductors each) from 500/220 kV substation at Booroljuut power plant to the convertor station (to convert 500kV alternate current to 800kV direct current)
- 8 km long 220kV double-circuit line to 220/110/35kV substation at the Mine site
- 70 km long 220 kV double circuit lines to the 220/110/35kV Baganuur substation
- 1420 km long 800kV DC lines with AC-720 (six conductors for each line) from ~500kV/±800kV convertor station to the AC substation near to Shijizhuan city in Hebei province of China



Зураг 4. Экспортын цахилгаан станцыг хэрэглэгчтэй холбох схем

The open 500/220kV switchyard outside the power plant, in-plant electric equipment and system, power supply to the buildings, 500 kV AC lines, 800 kV AC lines, and the convertor station are conceptually designed.

Regime Calculation and Grid Connection Study for Power Plant.

11 units, 600 MW each unit, and total installed capacity 6,600 MW are planned in Booroljuut power plant. 6000 MW shall be supplied to the Chinese grid if approximately 10% of installed capacity is in-plant use.

Transmission capacity of the DC transmission line is 2 to 5 times higher than the transmission capacity of the AC line of the same voltage.

If we consider that the AC line transmitted at least two times bigger capacity than the AC line, 6,000 MW capacity could be transmitted by the 700 – 850 kV DC line.

The regime calculations are performed for options such as the power plant operated separately, in parallel operation with CES, and transmitted electricity to the Chinese grid and CES.

Two options for determining transmissions capacities of the DC and AC transmission lines are evaluated.

Based on the grid connection analysis, it was concluded that 6,000 MW could be transmitted to the Chinese grid by using 800 kV UHV DC two lines, and in parallel operation with CES in delivery of 200MW.

Technical & Economic data. The technical and economic data is prepared based on 6200 hours installed capacity utilization factor for 6,600 MW power plant and shown in the table below.

Turbine specific heat consumption, $q_э=Q_э/N_э$	kJ/kWh	7555
Efficiency for electricity generation, 3600/qэ*100	%	47.7
Installed capacity utilization hour	hour	6200
Reference fuel specific consumption for electricity generation	g/kWh	277
Annual electricity generation, n*Nэ*5700	GWh	37620
In-plant use of electricity (percentage of installed capacity)	%	8.63
Annual electricity distributed	GWh	37394.6
Reference fuel heating value	kJ/kg	29300
Coal heating value	kJ/kg	14402
Hourly coal consumption	t/h	3447

OTHER CONSTRUCTION AND DEVELOPMENT PROJECTS

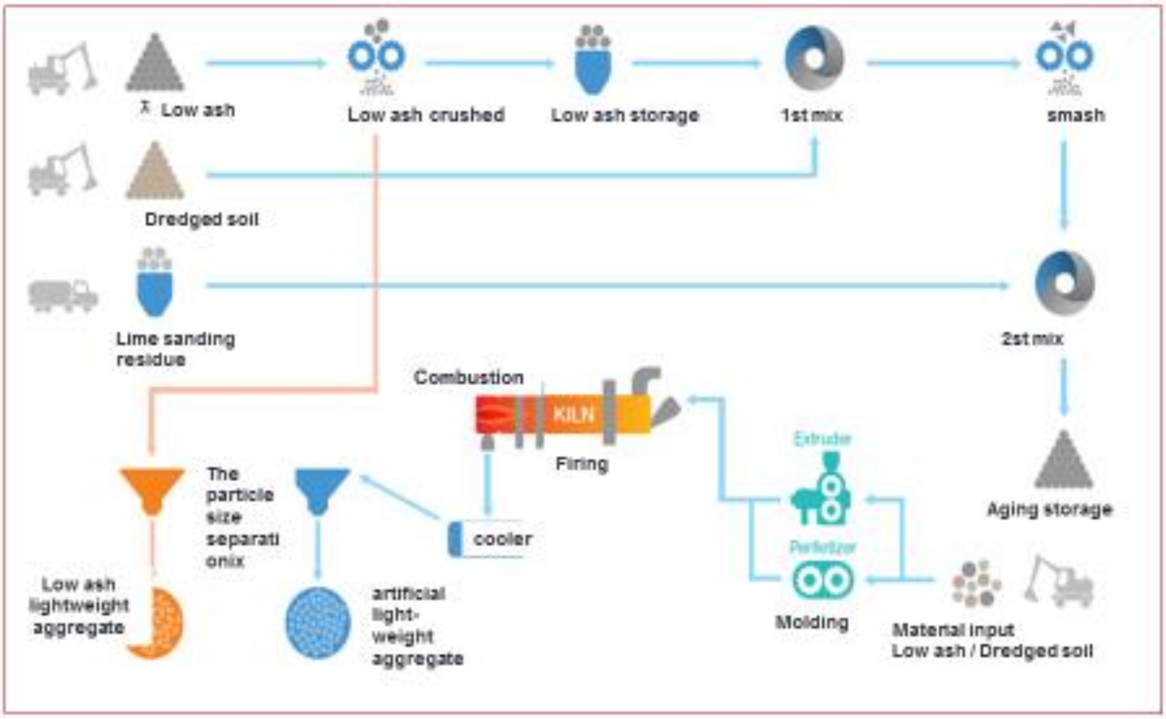
In order to maximize the effectiveness of the project the Consortium performed several studies planned to implement the following construction projects to:

- Produce construction materials by using ash
- Produce synthetic fuel from coal /Clean Coal Technology/
- Development and construction of new town

Production of Building and Construction Materials Using Ash:

Studying to reprocess the coal ash from power plant to produce lightweight aggregate mixing with dredged soil and lime sanding residue. These lightweight aggregates used for concrete structure, thermal insulation, sound absorption, building fire protection properties etc.

Plan of the production facilities of lightweight aggregate in collaboration with power plant equipment



DME Gas Production Project /Clean Coal Technology Project/:

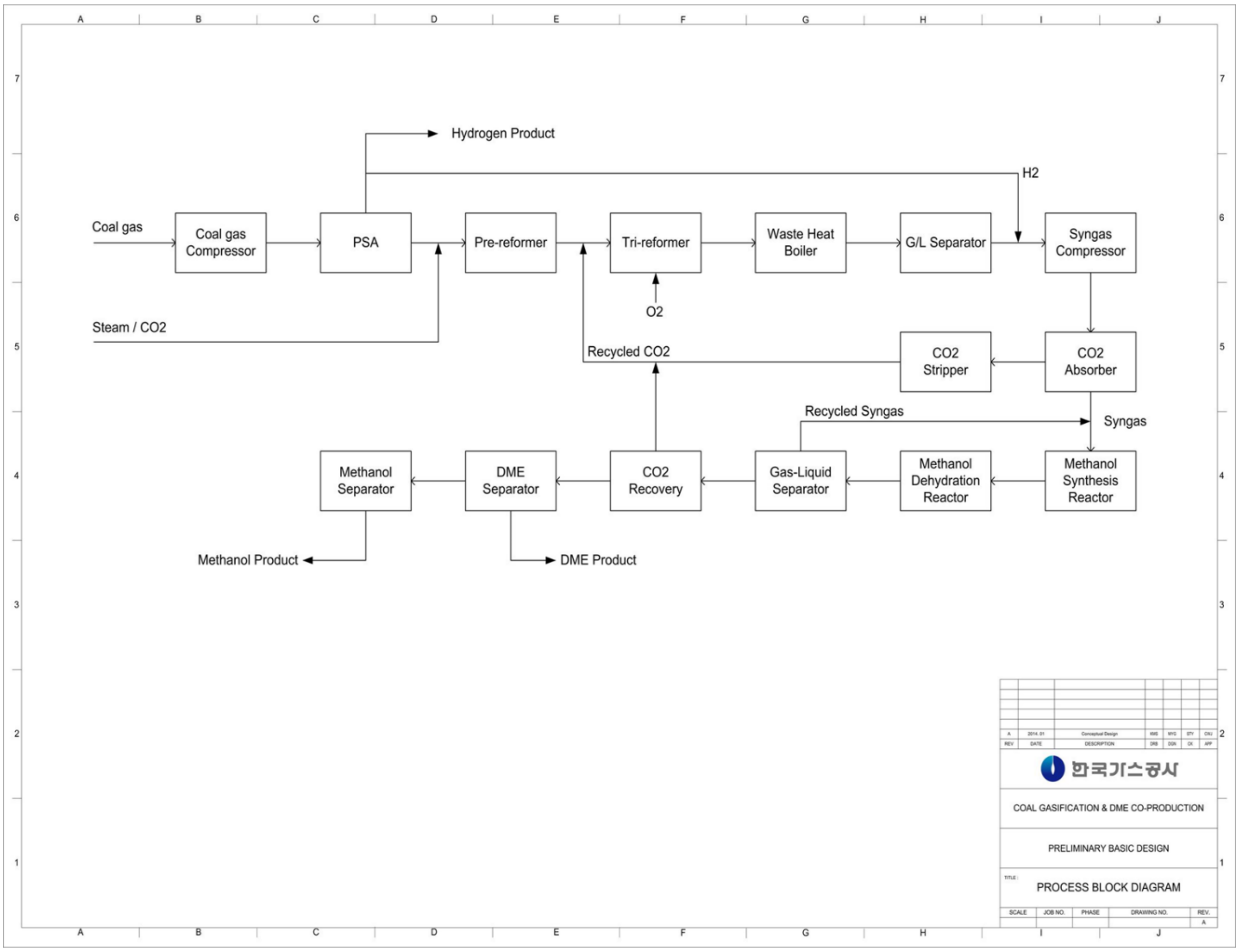
DME is synthetic gas produced from various raw materials such as natural gas, coal, CBM (Coal Bed Methane), biomass etc. in Europe, US and Asian countries. From these raw materials, synthetic gas composed of hydrogen, carbon monoxides produced and through synthetic reaction, DME is processed. DME (Di-Methyl Ether) is new synthetic fuel that eco-friendly energy and not harmful to human body The DME fuel demand is increased in China, Japan and ROK every year.

DME (Di-Methyl Ether) is new synthetic fuel supplied to residential and commercial buildings. As a part of the global environment protection and eco-friendly energy development, the technology has been developed mainly in the East Asia, such as China, Japan and other countries, from the year of 1990.

Especially, it receives great attention because it has many advantages of energy diversification, prevention of global warming, cleaning CO_2 or other emitted gases etc. by replacing oil, actively counteracting climate change.

DME market is expanding its utilization area in diverse aspects. In the earlier stages, only aerosols were used but through the technology development, and as DME was available as LPG or diesel alternative fuel, it became available for residential and industrial combustors, heater and other different areas. Past few years, as eco-friendly fuel, DME's international acknowledged increased and mainly centering on the regions of Asia, the DME market expanded. Especially, China holds 90% of World DME market and maintains the largest scale DME market. For South Korea and India, DME market is being pioneered in order to reduce the import dependency of LPG, but Japan or Sweden are centered as the diesel alternative fuel.

BKB, KOGAS, BH, GE, SDE (Sendo electric) are jointly conducted a study to construct DME fuel factory at Buuruljuut coal deposit in Mongolia and developed basic report.



Coal has abundant deposits but as non-renewable resource, China, U.S., Russia, Japan, and India use the most and hold about 76% of world usage. DME is manufactured with direct synthesis or Indirect Synthesis from coal as raw material. Coal has two processes in which one manufactures DME with synthetic gas (H_2+CO) through methanol synthesis process or by directly producing synthetic gas with DME reactor.

After 1997 when Kyoto Protocol adopted to prevent Global Warming, worldwide CO_2 quantity control makes enlargement of coal-powered installation almost impossible, and the reality is that each government is giving effort to adopt the policy of reduction of power output that use fossil fuel. Therefore, coal use as fuel is expected to be reduced or converted with clean fuel. Therefore, DME has high possibility of being used as the alternative fuel to take place as the new power demand fuel or as the alternative fuel that replace coal power.

Therefore, the DME project will be most important construction within the framework of the power plant project.

Construction of New Town:

Within the framework of the project, the new town with population of 20000 for appox.3000 families in 1500000 square meter territory with all infrastructures planned to be constructed. The town is planned to be constructed in two stages

- First stage 2017-2020: apartments and school
- Second stage 2021-2025: apartments, houses, office and park

This will provide for employees, their families and children to live in comfortable living conditions.

Investment expenditures of above projects are not included in the Investment and financial analysis of the Power plant project.

Investment and Financial Analysis for the Power Plant & Power Exporting Project.

The investment and financial analysis, tariff, and financial sources required for power plant construction, power generation, exporting, and transmission of 6,600 MW power plant and power exporting project are executed and prepared using the current method and guidelines.

Based on the analysis and calculations, the project total investment is 12,882 million US dollars, or 25.7 trillion MNT at exchange rate of 2000 MNT = 1$, and the unit investment cost of the power plant is 1440 US$/kW and 1952 US$/kW if included transmission lines and convertor station costs.

70 % of the total investment cost (9017.4 million US dollar) is financed from the loan sources, and remaining 30% (3864.6 million US dollar) – own capital investment. It is considered that the bank loan has 15-year payment period with annual interest rate of 6 %, and the loan would be paid back within 15 years with the interest rates in accordance with the loan condition.

It is calculated that the electricity generated in Booroljuut power plant and supplied to the Chinese grid is at an amount of 35.5 billion kWh, and tariff is 135 MNT/kWh or 0.068 $/kWh (0.44 RMB/kWh).

Based on the investment and financial analysis, the weighted average cost of capital is 9.6%, project net present value – 7422.7 million UD$ and the internal rate of return (IRR) of this project – 12.9%, and the main conditions for successful implementation of NPV>0 and IRR>WACC are fulfilled.

The payback period of the investment is 6.9 years, and the discounted payback period is 12.6 years.

The sensibility analysis is made in conditions for the investment cost, operation cost, increase and decrease of the power sales income up to 10-20 %. Based on the sensibility analysis, this project could bear the project external negative impacts, and be sustainable project, and it was concluded that the great importance is taken not reduce the planned amount of exporting electricity.

This project has a great impact on Mongolian social and economic development. The foreign investment is increased by 12.9 billion US dollar, and 400 million tons of coal is entered annually to economic turns, and value-added product at an amount of 2 billion US$ of electricity is exported to China.

The 500 million US dollars consumed as local purchasing the limestones, water, diesel fuel, other materials and services needed for generation operation of the power plant, and wages of workers, and social costs.

More than 1340 workers would be employed during the construction and operation of the power plant.

The profit taxes, and social charges given to the state, water fees and land use fees are given to the local government and approximately 9 billion US dollars to be paid to the state budget as an income taxes during 30 years of the project operation.

It is concluded that this project is highly profitable and fully implementable project financially and economically.