CHAPTER 4
POWER GENERATION

Chapter 4 Power Generation

4.1 Feasibility of Generation by Utilizing Thar Coal

4.1.1 Development Plan for the Power Plants

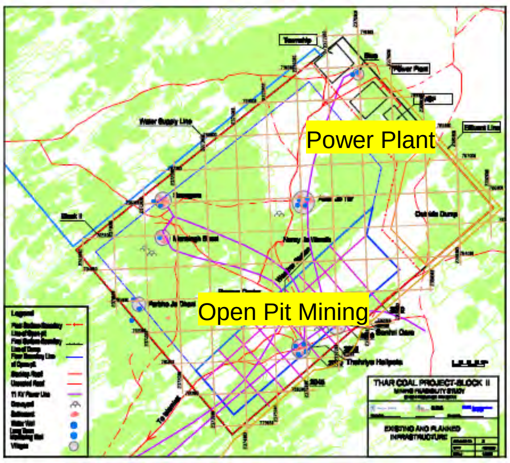
According to the National Power System Expansion Plan 2011-2030, there are many power plants of up to 37,000 MW capacity, which are planned to be constructed in the Thar coalfield. At present, the developer for three blocks, namely Block I, Block II, and Block VI, has initialized development of power generation plants, as listed in Table 4.1-1. Candidate sites of power plant are also shown Figure 4.1-1.

Table 4.1-1 Development Plan of Power Plants

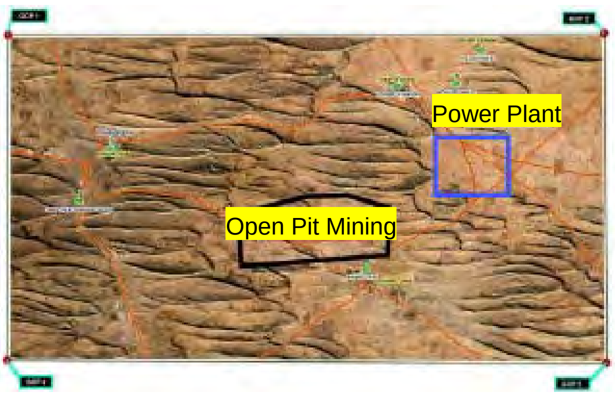
	Block I	Block II	Block VI
Developer	Global Mining Company of China	Engro Powergen	Oracle
Capacity	900 MW	Initially 600 MW Increased to1200 MW	Initially 300 MW finally 1100 MW
Type	CFBC Boiler (assumed)	Conventional PC Boiler +FGD*6 (assumed)	CFBC Boiler (assumed)
Submission *1	Not yet	Yes	Not yet
Evaluation *2	No	Under process	No
Issuance *3	No	Under process	No
Tariff *4	No	Not yet	No
Security Doc. *5	No	Not yet	No
Water Source	Not described	From LBOD ($1.0 m^3/s$, 35 cusec)	Ground water

Source : TCEB

Note: *1 : Submission of proposal and registration to PPIB, *2 : Evaluation approved by PPIB Board
*3 : Issuance of LOI, *4 : Tariff determination and issuance of generation license by NEPRA
*5 : Security document/financial close (FC), *6 : FGD (Flue Gas Desulfurization)



Block II of Engro (600 MW)



Block VI of KESC (300 MW)

Source : JICA Survey Team

Figure 4.1-1 Candidate Sites of the Power Plant

4.1.2 Constrained Condition in the Thar Coalfield

There are two major constrained conditions for installing coal thermal plants in the Thar coalfield, as follows:

(1) Combustion of Lignite Coal

The coal reserves in the Thar coalfield are estimated at 175 billion tons. However, the coal is classified as lignite coal, which contains high moisture and has low heating value. The component analysis of the Thar coal is shown in Table 4.1-2.

Table 4.1-2 Component Analysis of the Thar Coal

As Received Values (%) *Average of Block I~VI					Heating Values (kcal/kg)	
Moisture	Ash	Volatile Matter	Fixed Carbon	Sulphur	As received	Dry
46.77	6.24	23.42	16.66	1.16	3,208	6,030

Source: Coal Resources of Sindh Province December 2003 Sindh Coal Authority

Almost all of the coal thermal plants of subcritical and supercritical type are adopted to pulverized coal (PC) combustion, of which efficiency reaches more than 40%. However, the efficiency of the plants utilizing lignite coal is generally still less than 40%, because lignite has high moisture content and low heating value.

Therefore, it is necessary to upgrade the boiler for lignite coal such as adopting coal drying equipment and widening the heat-absorbing area in the furnace.

(2) Water Supply

Since it is necessary to supply sufficient volume of water for operating thermal power plants, water source is one of the major issues for a plant which is located far from a coast or river. In Japan, most of the thermal power plants are located at coasts in order to use huge amount of cooling water.

Since the Thar coalfield has no water source nearby, Engro Powergen plans to take water from LBOD for the development of Block II, after being treated by R.O[1].. The intake volume of water is planned to be 1.0 m^3/s (35 cusec) at the initial stage and 2.8 m^3/s (99 cusec) at the final stage.

4.1.3 Applicable Power Generation Plant in the Thar Coalfield

There are two types of boilers for utilizing lignite coal. One is the Pulverized Coal (PC) Boiler

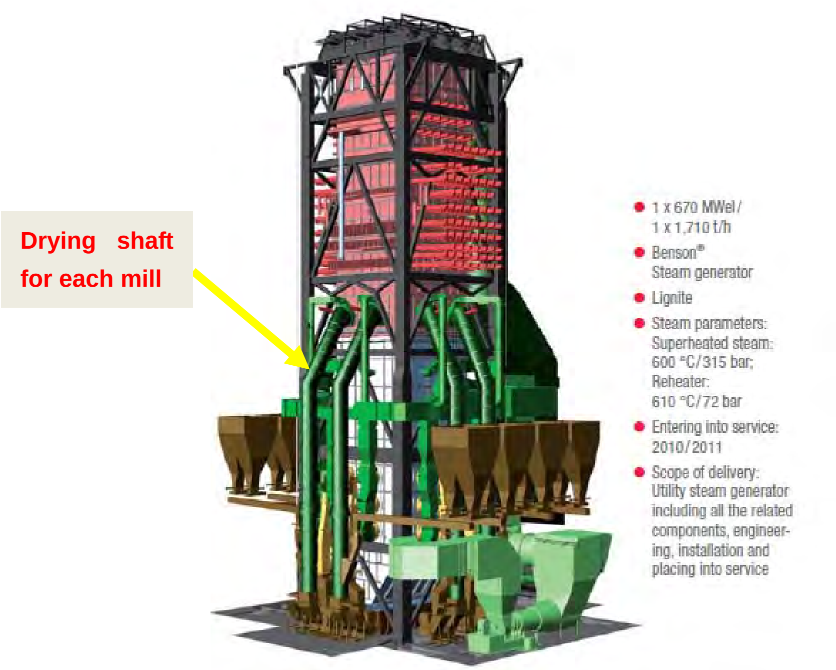
[1] Reverse Osmosis water purification system

and the other is Circulating Fluidized-Bed Combustion (CFBC) Boiler.

(1) Pulverized Coal Boiler

A typical design of lignite coal fired boiler is shown in Figure 4.1-2. Recently, a boiler, which is already in operation, has been installed based on this CAD model. The combustion gas is used directly for drying coal in this type boiler. The part of off-take gas, of which temperature at the furnace outlet is around 1,000°C, is led to the pulverizing mill through a drying shaft, controlled and applicably mixed with cold air flowed from FDF[2]. This type of boiler is reliable and most popular, and used for medium and large scale operations.

In Japan, all electric utility companies are mainly used the sub-bituminous coal which is imported from many countries. Almost of the generation unit are adopted PC Boiler. Since the properties of import coal, such as heating value, contained moisture, volatile matter rate and fixed carbon rate are varied widely, it is required to adopt the optimum design for equipment and control system. Japanese manufacturers have high level skills and knowhow for these designs. Of course it is applicable for lignite combustion boiler. They have the many experiences in overseas, e.g. the Boxberg R Power Station in Germany, the Elbistan B Power Station in Turkey, and the rehabilitation of the Thermal Power Station No.4 in Mongolia.



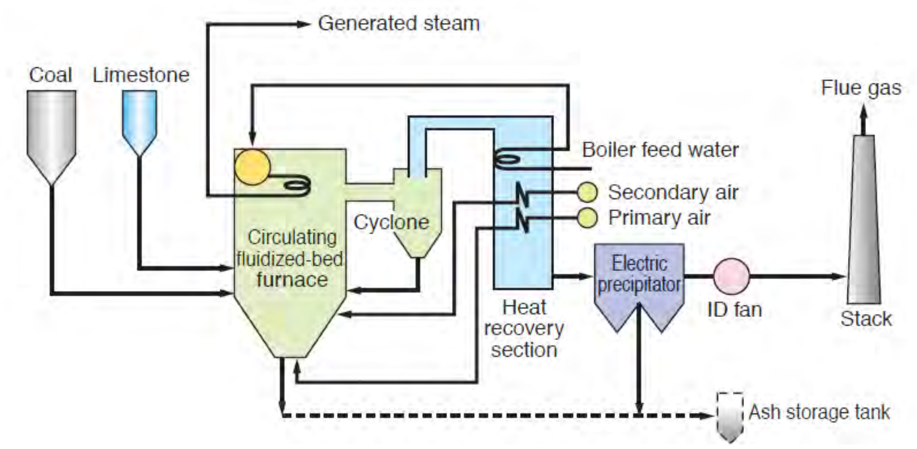
Source :Coal Firing Systems and Component by Hitachi Power Europe DmbH

Figure 4.1-2 CAD Model of Lignite Coal Combustion Boiler (Boxberg R Power Station)

2 Forced Draft Fan

(2) Circulating Fluidized-Bed Combustion (CFBC) Boiler

The circulating fluidized-bed combustion (CFBC) boiler installed gradually is considered a middle class boiler. The advantages of such boiler are that it is low polluting and accepting various kinds of coal. The typical combustion process of CFBC is shown in Figure 4.1-3.



Source : Clean Coal Technologies in Japan (NEDO)

Figure 4.1-3 Process Flow of Circulating Fluidized-Bed Combustion Boiler

Particularly, NOx and SOx emissions can significantly be decreased without additional environmental abatement facilities. CFBC boilers can be de-sulphurized in the furnace using limestone, which reacts with SOx. For de-nitration, the PC boiler operates at combustion temperatures of around 1,400°C to 1,500°C, whereas CFBC boiler operates at lower temperatures, ranging from 850°C to 900°C. Consequently, thermal NOx tends to be generated for a combustion temperature exceeding 1,100°C. In such case, emissions can be suppressed by CFBC.

However, since maximum capacity of CFBC boiler in practical use is currently around 400 MW, it is necessary to deliberate consideration for its scale-up to 600 MW.

(3) Steam Condition

Plant efficiency goes up with the corresponding rise in maximum steam pressure and temperature. The relation of the maximum steam pressure, maximum steam temperature, and plant efficiency for each steam condition is shown in Table 4.1-3.

Table 4.1-3 Comparison of Steam Condition and Plant Efficiency

Steam Condition	Steam Pressure	Steam Temperature	Boiler Type (Steam Cycle)	Plant Efficiency (LHV net)*1
Subcritical Pressure	16.6 (MPa)	538 (°C)	Drum	36%
Supercritical (SC) Pressure	24.1 (MPa)	566 (°C)	One-through	38%
Ultra Supercritical (USC) Pressure	31.0 (MPa)	596 (°C)	One-through	41%

Source: JICA Survey Team (Based on METI JAPAN (2012))
Note: The case of sea water cooling system is installed; in the case of wet cooling system, it is assumed to decrease efficiency by several percent.

Two types of combustion process (PC, CFBC), as explained in the previous section, are available for the three steam conditions in Table 4.1-3. However, a 300 MW class boiler generally adopts a drum type boiler (Subcritical), while a 600 MW class boiler adopts a one-through type boiler (SC or USC). Because it becomes too much big sizes of boiler drum, and it is not able to adopt the SC or USC steam condition.

As both steam pressure and steam temperature become higher, the plant efficiency is increased. Meanwhile for a one-through type boiler, more stringent quality control of boiler water and more stable super-heater steam temperature control is required to prevent it from deterioration or damage for the boiler tube.

The USC steam condition is latest technology and the plant efficiency is estimated to improve around 3%. It is said that contribute of reduction for carbon dioxide. Some of more than 600MW class units are adopted USC steam condition in the developed countries.

It is necessary to use the materials which are very different composition compared SC, withstanding more high temperatures for USC. Compared with increasing material cost and the effect of improving efficiency, it is estimated only a few at 600MW. Detailed feasibility study to select the steam condition of USC or SC is recommended.

It is supposed that there is a lot of merit at more large capacity unit e.g. in case of 1000MW class.

(4) Provision for Water Supply

It is difficult to compare the quantity of water in these different conditions, e.g., the difference of the cooling type and ambient temperature. However, most quantity of the supplied water is spent as cooling water. The water supply cost is estimated by the JICA Survey Team at around 80 ¢ / ton. Typical usage of water for coal thermal reference plants is shown in Table 4.1-4.

Table 4.1-4 Water Usage for Coal Thermal Power Plants

	Plant Capacity	Water usage for cooling per 100 MW	Total water usage for cooling	Calculation base	Cooling type
Engro-Powergen (Plan)	1,200 MW	0.083 m^3/sec (2.92 cusec)	1 m^3/sec (35 cusec)		
China (model)	1,000 MW	**0.063 m^3/sec** (2.24 cusec)	0.634 m^3/sec (22.4 cusec)	20 Mt/year*1	Wet cooling
USA (average in US)	-	0.075 m^3/sec (2.65 cusec)	-	2,700 l/MWh*2	Wet cooling
India (simulation)	1,000 MW	**0.083 m^3/sec** (2.94 cusec)	0.833 m^3/sec (29.4 cusec)	3,000 t/h*3	Wet cooling
India (simulation)	1,000 MW	**0.0153 m^3/sec** (0.54 cusec)	0.153 m^3/sec (5.4 cusec)	550 t/h*3	Dry air cooling
Japan (existing)	440 MW	5 m^3/sec (177 cusec)	22 m^3/sec (777 cusec)	22 m^3/sec*4	Sea water cooling

Source :Prepared by the JICA Survey Team

Note:

*1 : Coal Initiative Reports White Paper Series“ Coal in China Resources, Uses, and Advanced Coal Technologies “ Mar. 2010
*2 : Water Conservation Options for Power Generation Facilities (Power website in September 1 2012)
*3 :“Report on Minimisation of Water Requirement in Coal Based Thermal Power Stations” issued by the Central Electricity Authority India in January 2012
*4 : Not include water for boiler use

According to a simulation in India at ambient temperature of 38°C, adoption of the dry condenser type cooling system instead of the wet type cooling system raised the internal auxiliary power consumption twice, i.e., by more than 7%. Therefore, cautious comparison should be made between the lowered efficiency for dry cooling system especially during summer season and increasing cost for the needed additional water supply. The difficulty of adopting dry type cooling for the Thar coalfield is explained in the next section.

As shown in table 4.1-4, the quantity of cooling water is less than 0.1 m^3/sec (3.5cusec) per 100MW in the reference plants adopted a wet cooling type. Therefore, the quantity of the water supply plan of 1.0 m^3/sec (35cusec) for 1,200MW generation is appropriate. In addition, it is estimate that 20 to 25 million tons per year, which is equivalent to 0.63 m^3/sec (22.2 cusec) to 0.79 m^3/sec (27.7 cusec) groundwater shall be pumped up for mining according to the simulation of dewatering discussed in clause 3.4-2. The water also can be used for wet cooling supplementary after purification.

It is mentioned in ESIA Thar Coal Project Block I , Chapter 2 (08 of 21) that “Synergies in terms of water salinity may also be found in terms of having the coal slurry produced saline water that would assist with slag formation in the gas fires. If the lignite is to be used in FBC or PC units, excessive salinity would lead to bed fusion and fouling, which may damage the combustion unit. The RWE[3] study proposes pre-drying of high moisture lignite, which will

[3] RWE Corporate, utility company in Germany

provide adequate quantities of desalinated (pure) water at the rate of 285 tons per hour, could be utilized in the power plant, residences and agriculture, after due chemical treatment. Accordingly, the project is required to have the lignite drying plant recover the said quantities of water at the site.**"**

However, the desalination and pre-drying of high moisture lignite have different technical problem. Due to lack of technical data, it is assumed that even if it is possible to reuse the moisture from coal, the water cost will be high and the quantity will be less than that required.

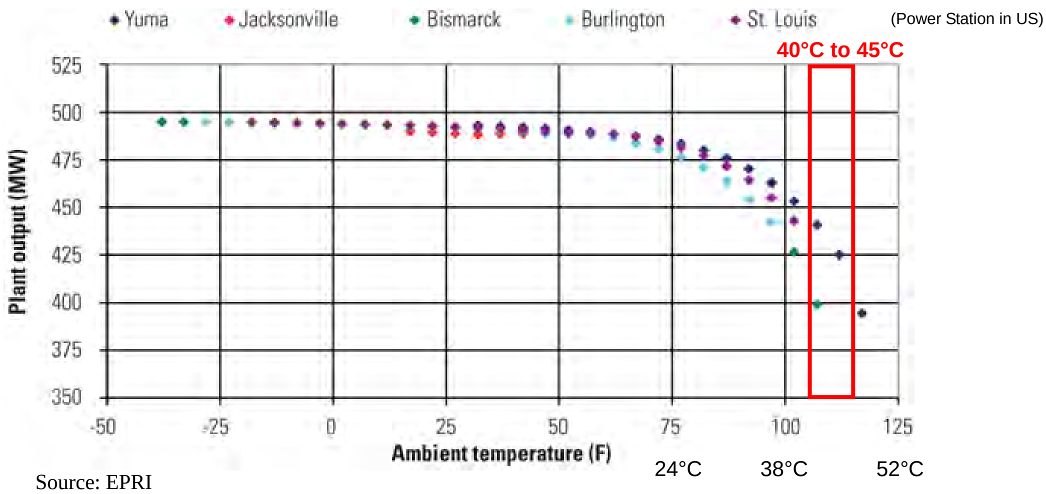
(5) Difficulty of Adopting Dry Cooling System in the Thar Coalfield[4]

The heat exchange efficiency of the dry cooling system is lower compared to the wet cooling system. Therefore, it is estimated that the total capital cost for power plants with dry cooling is typically more than 10% higher than power plants equipped with wet cooling system, due to requirements for large finned-tube heat exchangers, fans and drive motors, and steel structures to provide ground clearance for proper air circulation. The capital cost of the dry cooling system itself is three to five times higher than for a wet cooling tower. The performance of typical 500 MW coal-fired plants using dry cooling system related with atmosphere temperature and plant output is shown in Figure 4.1-4. The water temperature in the hot well increases with increasing atmosphere temperature, and the turbine back pressure also increases.

Therefore the turbine efficiency decreases due to reduce the heat drop of the turbine. As shown in Figure 4.1-4, the power output down rate is estimated 10 to 15%, down at 40°C and 15 to 20% at 45°C.

[4]http://www.powermag.com/water/Water-Conservation-Options-for-Power-Generation-Facilities_4906_p2.html

Water Conservation Options for Power Generation Facilities (September 1, 2012)

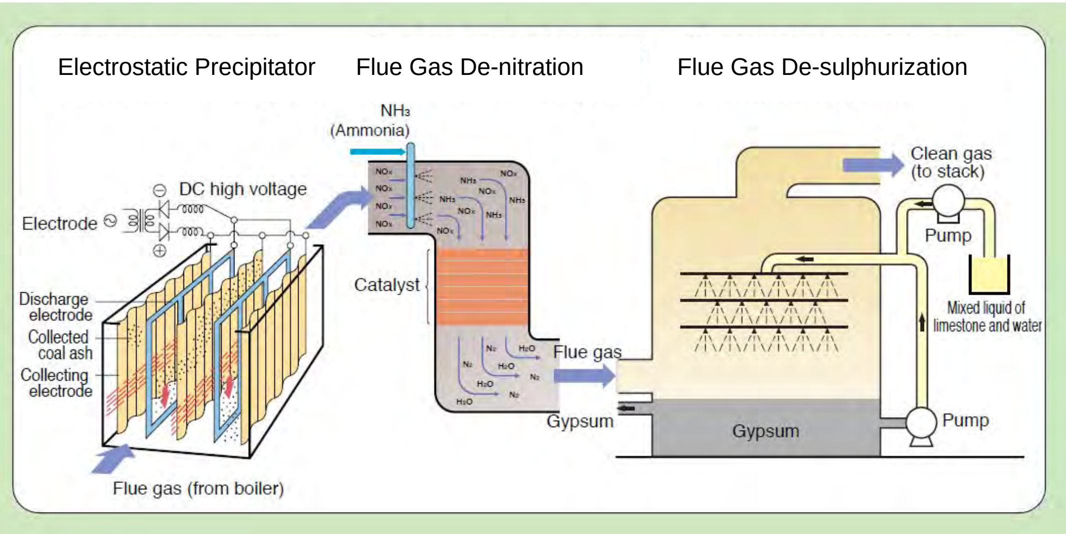


Source: EPRI

Figure 4.1-4 Hot Day Power Loss

(6) Provision for Environmental Pollution

For the coal-fired boiler, installations of the de-nitration and de-sulphurization (FGD[5]) facilities after electro-static precipitator are necessary in general, in order to comply with the World Bank Guideline (IFC[6] Guideline) for environmental standards. A typical environmental pollution control facility is shown in Figure 4.1-5.

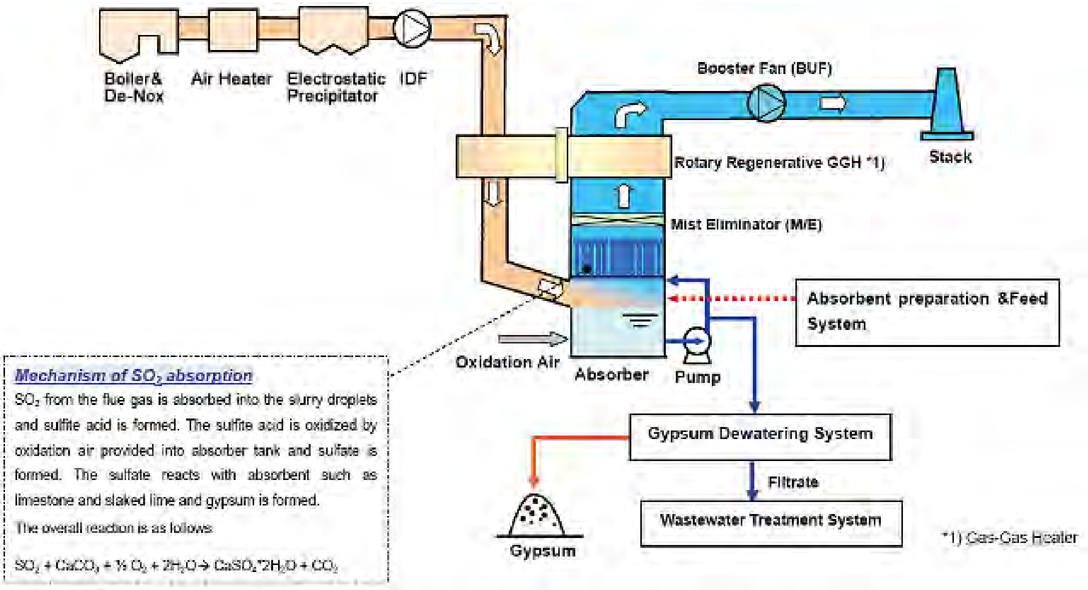


Source : Clean Coal Technologies in Japan (NEDO)

Figure 4.1-5 Typical Environmental Pollution abatement Facility

5 Flue Gas De-sulphurization
6 International Finance Corporation

For applying PC boiler, it is necessary to install FGD system to meet the environmental standard as the content of sulphur is more than 1% for the coal in Thar coalfield. The typical de-sulphurization process is shown in Figure 4.1-6. Slurrified limestone is splayed in the exhaust gas which includes SOx gas. Then, SOx gas and limestone ($CaCO_3$) react and change to gypsum ($CaSO_4$). Therefore, sulphur in coal is removed as gypsum ($CaSO_4$). This is the most common de-sulphurization system. The installation cost is estimated to increase the 10 to 15 percent the cost of the main facilities. However it has some potential to reduce less than 10 percent by introducing a simplified suitable system for Thar coal. Japanese manufacturers have the highest level technology for the environment pollution abatement in the world due to the strict environmental regulation in Japan.



Courtesy: MHI Web Site

Figure 4.1-6 Typical De-sulphurization Process

For de-nitration, Low NOx Burner can be applied instead of flue gas de-nitration shown in the figure 4.1-5.

(7) Recommendation for Combustion of Lignite Coal Boiler

The composition of Thar coal shows it has low heating value (3,200 kcal/kg), and contains high moisture, thus it is possible to adopt the existing generation technology in the Thar coalfield. As indicated in Figure 4.1-2, the direct drying type PC boiler use lignite coal, which was recently constructed by a Japanese manufacturer, is recommended. Its plant capacity is almost the same as the planned plant in the Thar coalfield, and its construction cost is estimated to be US$1,700/kW to US$1,800/kW. The environmental pollution control facility is recommended to be installed as shown in Figure 4.1-6. For the de-sulphrization system by

Japanese manufacturer, it is possible to save water due to the lower temperature in the reacting vessel and to reduce the vaporized water. Therefore, Japanese technology has enough superiority.

The CFBC and PC boilers are recommended to be applied for generating 300 MW (Subcritical) class and 600 MW (Supercritical) class of power generation, respectively, at present. The drum-type boiler is the only adopted subcritical boiler due to limitations in drum capacity.

The recommendation for the relation between generation capacity and boiler type for is shown Figure 4.1-7.

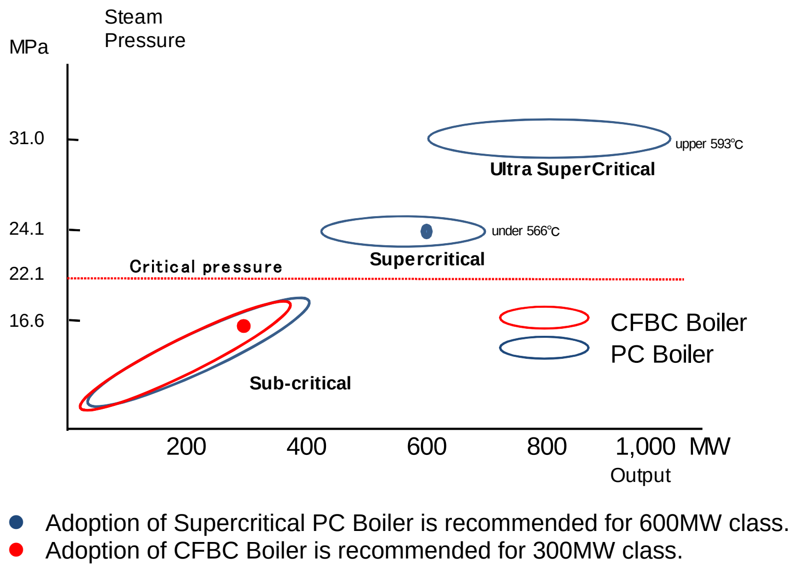


Figure 4.1-7 Recommendation of Boiler Type for Thar Coal

It is recommended to install de-sulphrization system for PC boiler for complying the environmental regulation.

The JICA Survey Team assumed that adoption of dry cooling type condenser system in the Thar coalfield is not feasible, as the day time temperature rise to more than 40°C lasting for eight months a year. The decrease in capacity will reach 10%~15% at 40°C and 15%~20% at 45°C.

Therefore detailed feasibility study to utilizing the air cooling type is recommended.

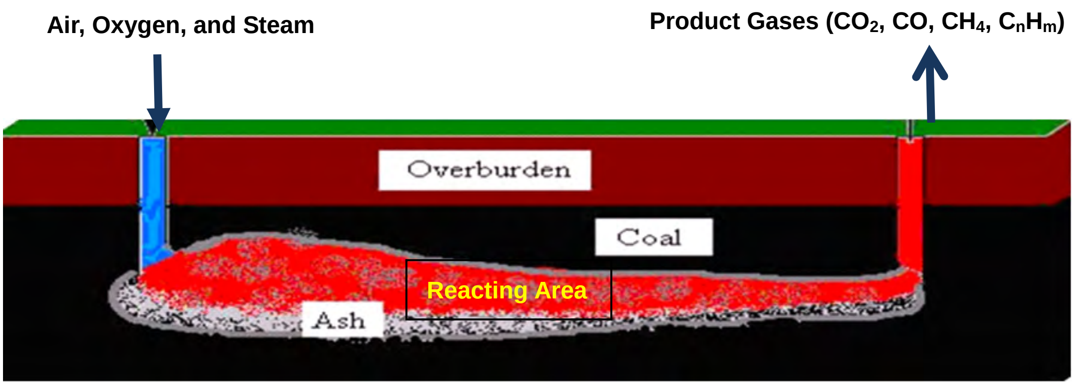
4.2 Feasibility of Generation by Utilizing Gas Produced from Underground Gasification

4.2.1 General Information

Commercial Underground Coal Gasification (UCG) has been successfully operated for more than 50 years in Angeren, Uzbekistan, supplying UCG synthesis gas for a 100 MW power station. UCG is an in-situ gasification process carried out in non-mined coal seams using injection of oxidants such as compressed air, steam or oxygen, and bringing the product gas to surface through production wells drilled from the surface. The process of coal gasification is burning through incomplete combustion in underground coal seams. Consequently, the mass of coal is decomposed into carbon dioxide (CO_2), hydrogen (H_2), carbon monoxide (CO), methane (CH_4), and some other gases.

4.2.2 UCG in the Thar Coalfield

Schematic model system and summary of UCG in the Thar coalfield is shown in Figure 4.2.1, and Table 4.2-1, respectively.



Source: Underground Gasification Project Thar

Figure 4.2-1 Schematic Model System of UCG in the Thar Coalfield

Table 4.2-1 Summary of UCG in the Thar Coalfield

Description	Specifications
Land acquisition	27 acres (11 ha)
Pilot burn was ignited	11 Nov, 2011
Length of gasification reactor (cavity)	Estimated 25m, diameter 2.8 m
Demonstrated success	2 wells out of 43 wells
Heating value of produced syngas	945 kcal/Nm^3 8 times less than natural gas (10,000 kcal/Nm^3).

Source: Underground Gasification Project Thar

Photo 4.3-1 Overall View of the Project

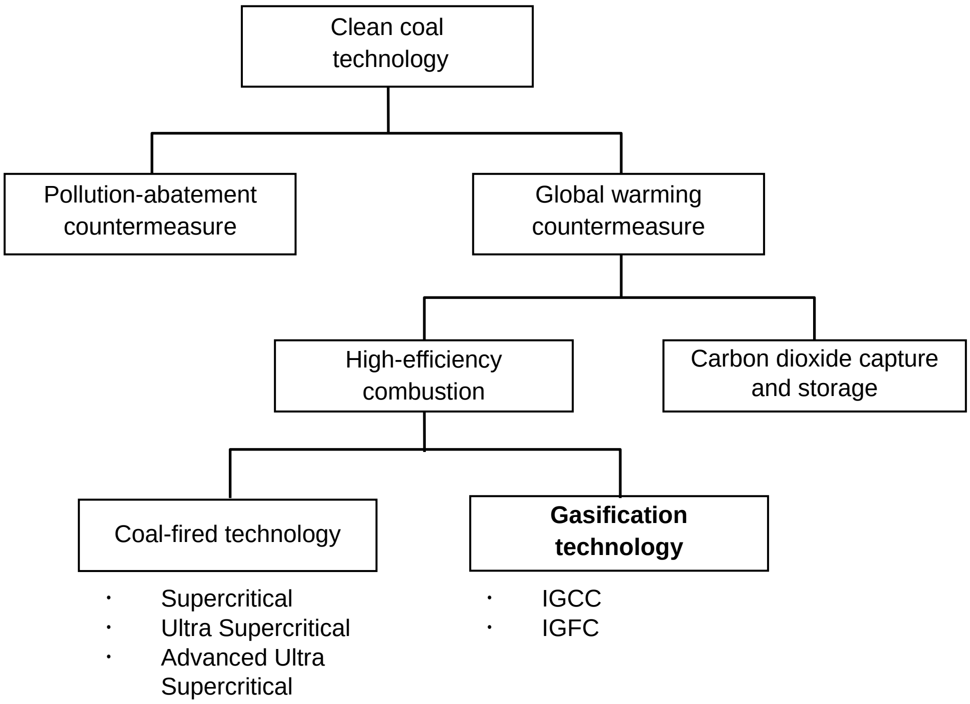
Photo 4.3-2 Air and Gas Pipelines

It is mentioned that the next stages of development include the establishment of the gas purification plant and installation of 8 MW to 10 MW power plant, by utilizing syngas for supplying power to the project's internal use and for residences., Furthermore, it leads to production of chemical by-products such as diesel oil and fertilizer.

Since the pilot plant is only for research and development purpose, the generating capacity is less, such that it cannot contribute enough to compensate for the shortage due to the power demand in Pakistan at present.

4.3 Coal Thermal Generation Technology in Japan Utilizing Lignite Coal

Thermal power generation utilizing coal has much increased recently. Coal is abundant and widely available at a stable price compared with natural gas and oil. However, from the viewpoint of environmental impact and global warming, it is necessary to consider environmental mitigation and the reduction of carbon dioxide exhaust. The clean coal technology (CCT) in Japan has reached the top level in the world for coal utilization as an energy source. Some on-going new technologies such as coal gasification and the reforming of low rank coal are explained hereinafter.



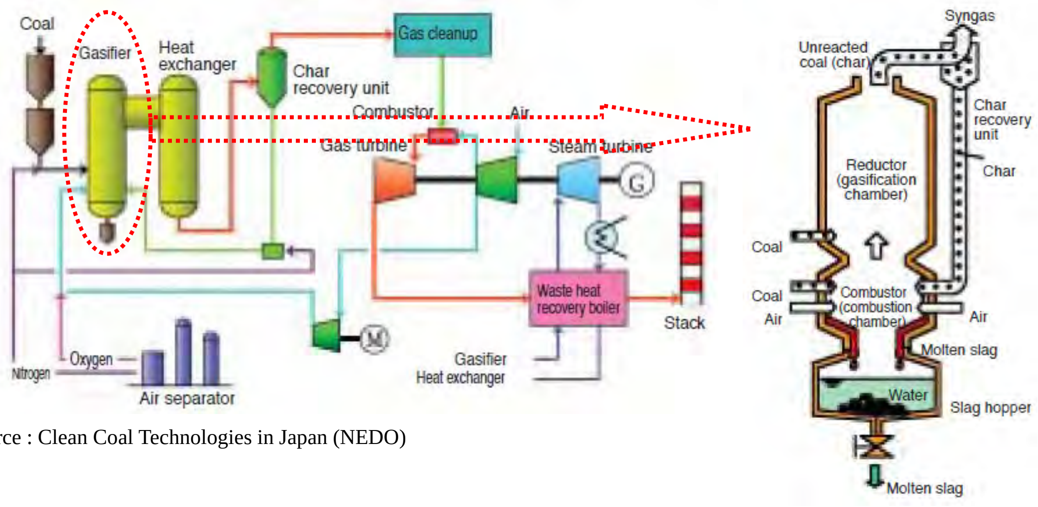
Source : Prepared by the JICA Survey Team

Figure 4.3-1 Configuration of CCT for Power Generation in Japan

4.3.1 Gasification Technology

(1) Integrated Coal Gasification Combined Cycle (IGCC)

The preparatory verification study of IGCC project in Japan started in 1999 with the 250 MW demonstration plant having been operated stably with low pollutant emission. In the 1990s, although some other IGCC plant projects have started operation, less updated information are disclosed. The schematic diagram of the demonstration plant is shown in Figure 4.3-2.



Source : Clean Coal Technologies in Japan (NEDO)

Figure 4.3-2 Schematic Diagram of Demonstration Plant (left) and the Structure of Gasifier (right)

The structure of a gasifier is shown at the right side of Figure 4.3-2. The fuel coal is supplied from the lower part of the combustion chamber, and the gasification coal is supplied the lower part of the gasification chamber. The produced gas in the gasification chamber, after dust is removed in the gas cleanup, is sent to the gas turbine (1,200°C -class). The thermal energy of the combustion gas is utilized as heat source by the steam in the heat recovery steam generator (HRSG). The gasifier is applied with air-blown type IGCC system and expected to realize high thermal efficiency compared with oxygen-blown IGCC.

Although the IGCC is under validation phase at present, its commercial operation will start soon. The list of advantages of the IGCC is given in Table 4.3-1.

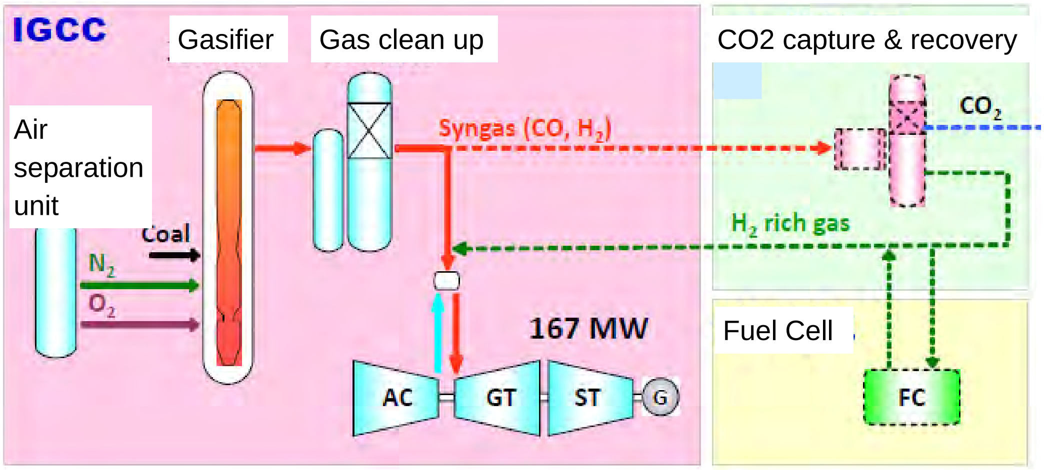
Table 4.3-1 Advantages of IGCC

No.	Advantage	Description
1	High efficiency	The efficiency of IGCC is 42% due to boiler is 1,200°C class for the validation phase at present. However, in case of 1,700°C is adopted, efficiency will be more than 50%.
2	Utilization of lignite coal	It is possible to use lignite coal for the gasification
3	Reduction for the usage of water	Since IGCC is combined cycle used by gas turbine, it is possible to reduce water by around 30% compared with existing coal thermal plants.

Source :Prepared by the JICA Survey Team

(2) Integrated Coal Gasification Fuel Cell Combined-Cycle System (IGFC)

The new clean coal technology- integrated coal gasification fuel cell combined-cycle system (IGFC) - has just started in Japan. Figure 4.3-3 shows the system outline for the future zero-emission technology. For IGFC, fuel cell is added to its technology; consequently, a triple combined generation system will be achieved and aimed for more high-efficiency.



Source : CCT Workshop 2012 (J-POWER)

Figure 4.3-3 System Outlook for the Future of Zero-emission Technology

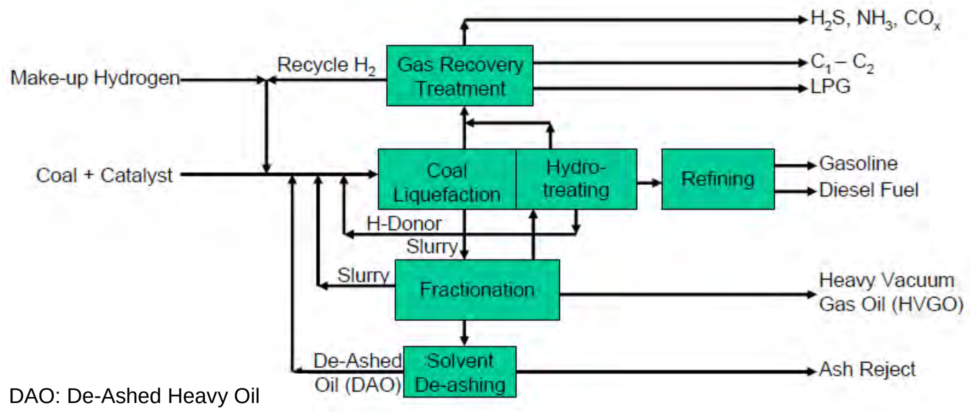
Based on the pilot plant test of the Coal Energy Application for Gas, Liquid & Electricity (EAGLE), the new 170MW class oxygen-blown demonstration plant IGCC named Osaki CoolGen project, is planned to be constructed to verify the reliability, operational characteristics and cost, and other aspects of oxygen-blown IGCC systems. The demonstration test is going to start in 2017, including trials utilizing the latest CO_2 separation and capture technology.

As the efficiency of IGFC is assumed at 55%, it has more advantages compared with IGCC.[7]

4.3.2 Coal Liquefaction Technology

Coal liquefaction is a process of converting coal from a solid state to liquid fuels, which usually serve as substitutes for petroleum products. Coal liquefaction processes were first developed in the early part of the 20th century but later their application gradually declined due to the relatively low price and wide availability of crude oil and natural gas. Large-scale applications have existed only in a few countries, e.g., South Africa since the 1960s and recently, in China. The oil crises in the 1970s and the threat of depletion of conventional oil supplies highlighted a renewed interest in the production of oil substitutes from coal during the 1980s. However, the wide availability of inexpensive oil and natural gas supplies in the 1990s in effect ended the near-term commercial prospects of these technologies. Coal liquefaction technology can be classified as either direct or indirect process. The typical process of direct liquefaction technology is shown in Figure4.3-4.

[7] Chugoku Electric Power Co., Inc., Electric Power Development Co., News Release

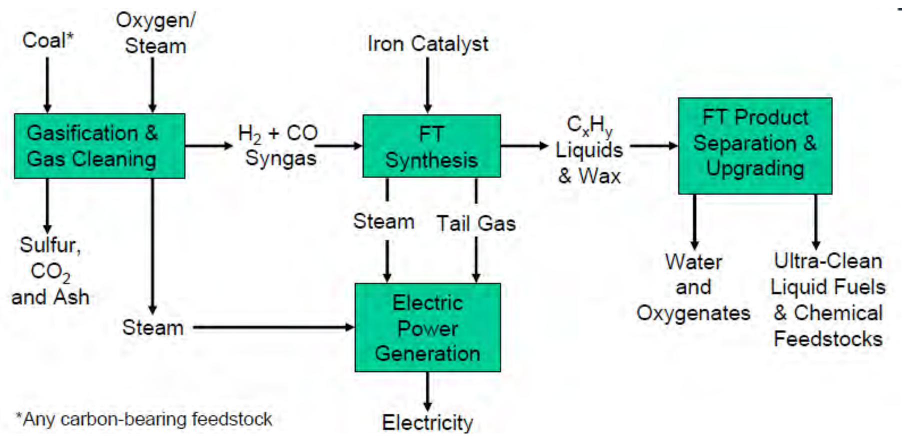


Source: Overview of Coal Liquefaction (US-India Coal Working Group Meeting 2005)

Figure 4.3-4 Typical Flow of Direct Liquefaction Process

The Direct Coal Liquefaction (DCL) process shows that the slurry of pulverized coal, additive hydrogen and recycled catalytic substance liquid are thermally decomposed and changed into low-molecular structure such as synthetic fuel liquid or crude oil under high temperature and high pressure. One of these processes named Blown Coal Liquefaction (BCL) by KOBELCO in Japan was completed technically but did not progress to commercial stage. The commercial plant (3,000 t/day) was recently constructed by Shenhua in Inner Mongolia and in China in 2008.

The typical process of indirect liquefaction technology is shown in Figure4.3-5.



Source: Overview of Coal Liquefaction (US-India Coal Working Group Meeting 2005)

Figure 4.3-5 Typical Flow of Indirect Liquefaction Process

Indirect liquefaction process has two steps. The first step is gasification of coal to syngas ($CO+H_2$), then from gas-to-liquid (GTL). During coal gasification, air and steam are added to raw coal, which is heated to several hundred degrees. The carbon in the coal reacts with the oxygen and water, producing other gases such as carbon dioxide, carbon monoxide, hydrogen, and methane. Carbon dioxide is waste and can be vented to the atmosphere; the other combustible gases are sent for GTL processes such as the Fischer-Tropsch synthesis, methanol synthesis and dimethyl ether synthesis. Fischer-Tropsch synthesis is a common GTL process that has been used by Sasol in South Africa. The indirect process yields a large number of by-products. However the efficiency of the overall liquefaction process is low.

It is not straightforward to compare and evaluate each technology because the construction cost, plant efficiency and the produced gas composition change depending on the coal component and site condition.

However, it must be qualitatively mentioned that the Sasol-Lurgi gasification process is the most common process for low rank coal.

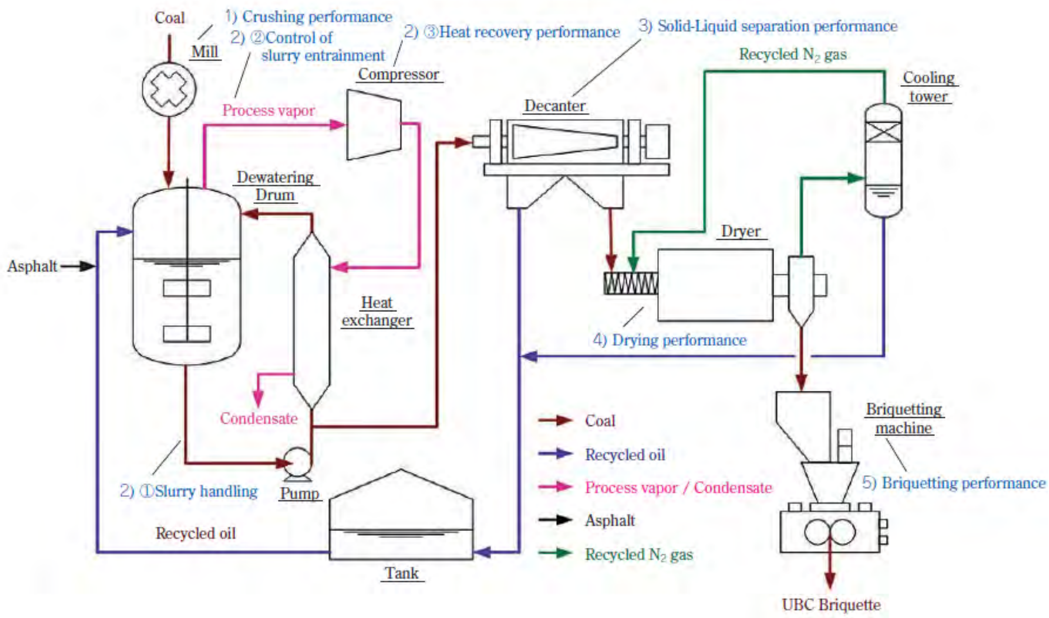
The direct process is necessary with some challenges for hydrogen supply. Indirect liquefaction is one of the options for a difficult case of getting oil or gas.

4.3.3 Other New Technologies

Besides the technology of gasification, there are so many trials and upgrading technologies for utilizing abundant lignite coal or low rank coal at the global level. The major point is the deformation or dewatering of high moisture content. The technical approach of Japanese manufacturers involves utilizing low rank coal produced in Indonesia.

(1) Upgraded Blown Coal (UBC) Process by KOBELCO

Kobe Steel (KOBELCO) has been working on the technological development of upgrading low ranked coal since the early 1990s. The process, called Upgraded Blown Coal (UBC) process, is based on the principle of “Tempura”, meaning Japanese battered deep-fried food, which efficiently removes the water contained in low rank coal in heated light oil. The UBC process is shown in Figure 4.3-4.



Source : Kobelco Technology Review No.29 Dec. 2010

Figure 4.3-6 UBC Process Diagram

The UBC process includes crushing low rank coal, dispersing the crushed coal in light oil containing heavy oil such as asphalt, and dewatering the dispersion at the temperature of 130°C to 160°C under a pressure of 400 kPa to 450 kPa. This process, whose conditions are rather mild, is expected to resolve the issues associated with the conventional processes for dewatering low rank coal. The major improvements are to minimize the heat loss of the product and to decrease the burden of wastewater treatment.

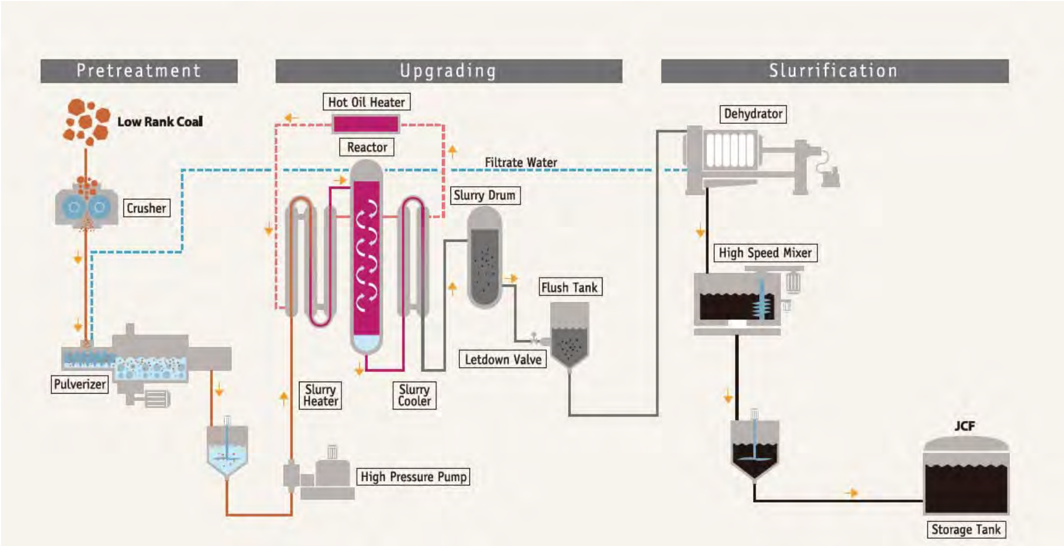
Kobelco is going to start the construction of a briquette-making plant (600 t/day) in Indonesia in 2012 for commercialized study. The estimated production cost of the briquette made from the coal containing 60% moisture, would be competitive to the cost of thermal coal at US$90/ton[8].

(2) Commercialization of New Liquid Fuel Produced from Low Rank Coal

A new coal slurry fuel produced from low rank coal named JCF, has been developed by JGC Co., Ltd. The demonstration plant, with production capacity being approximately 10,000 tons per year, has been completed in Indonesia in May 2012. Its test operation will be done until March 2014. The objectives of the demonstration are to ease the transport and storage, as well as the same combustibility as heavy oil. The estimated price of the coal slurry fuel is said to be 30%-50% lower than the market price of heavy oil.

The slurrification process for low rank coal is shown in Figure 4.3-5.

[8] Reference: Kobelco Technology Review No.29 Dec. 2010, Development Trend of Reforming Technologies of Low Rank Coal in Japan and Overseas M11021 (CRIEPI May 2012)

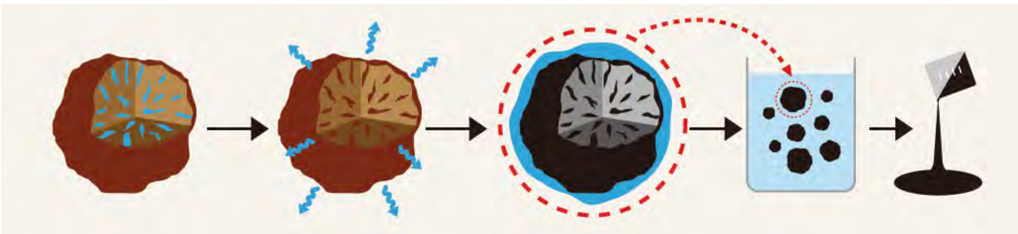


Courtesy: JCF Brochure by JGC Co.Ltd.

Figure 4.3-7 New Slurrification Process for Low Rank Coal

When crushed low rank coal (LRC) is immersed in high-pressure, high-temperature water (15 MPa at 330°C), their properties are changed from hydrophilic to hydrophobic, and water in numerous pockets in the LRC is expelled. By adding special additives, the water expelled from LRC can be used for converting the newly upgraded LRC into slurry, which is composed of small solid particles suspended in a liquid, and which has fluid-like properties[9].

The property change of low rank coal is shown in Figure 4.3-8.



Raw coal ⇒ De-watering (15 MPa, 330°C) ⇒ from hydrophilic to hydrophobic ⇒ Slurry

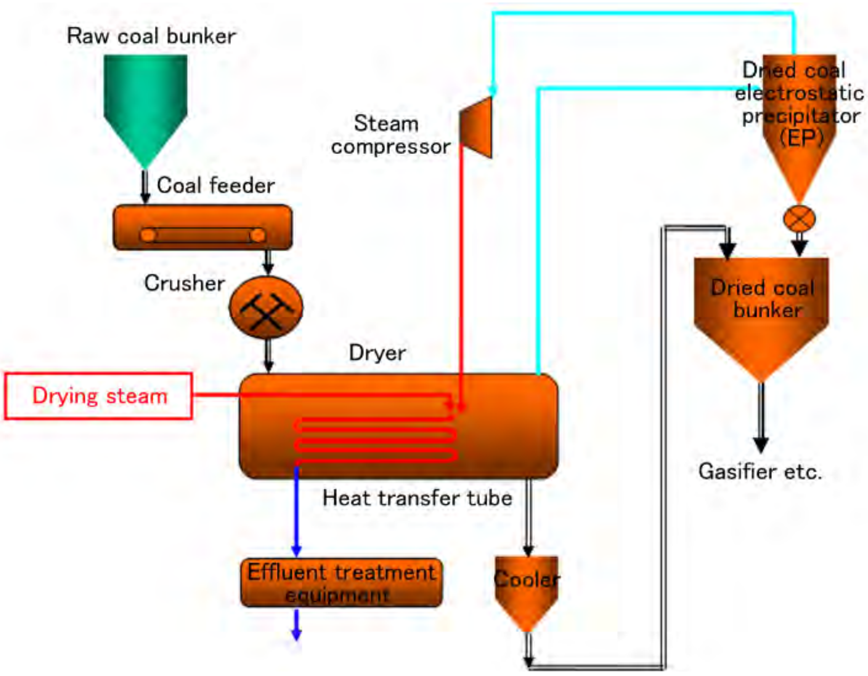
Courtesy: JCF Brochure by JGC Co., Ltd.

Figure 4.3-8 Property Change of Low Rank Coal

(3) The Highly Efficient Blown Coal Drying Technology

In this system, LRC is pre-dried with steam in the drying equipment initially. The system flow diagram of the system proposed by MHI is shown in Figure 4.3-9.

9 JCF (JGC Coal Fuel) Brochure



Courtesy :MHI Technical Review Vol.48 No.3 (September 2011)

Figure 4.3-9 Schematic Diagram of Brown Coal Drying System

LRC is fed from a raw coal bunker, pounded to an appropriate size by a crusher, then transferred to a dryer. The produced steam-dried coal is cooled and fed to a boiler. Dust is removed from the steam generated from the coal. Some of this steam is recompressed by a compressor using the heating steam in the dryer. This approach permits recovery of the latent heat of evaporation.

4.3.4 Superiority of Japanese Technology

Table 4.3-2 Development Status of Clean Coal Technology

	Facility Size	Development Cost*1 (compared existing level)	Development Stage	Estimation of Applicability for Thar
1)Lignite Coal Boiler	Small to Large	Small	Commercializing	◎
2)CFBC Boiler	Middle (~400 MW)	Small	Commercializing	◎
3)IGCC	Middle (~300 MW)	Large	Demonstration	△*2
4)IGFC	Middle (~150 MW)	Large	Demonstration	△*3
5) Coal Liquefaction, Gasification	Middle	Large	Commercializing (Low Efficiency)	△*2
6) UBC	Small (~15 MW)	Large	Demonstration	△*2
7)Coal Slurrification	Small (~10 MW)	Middle	Demonstration	△*2
8) Drying Technology	Middle (~250 MW)	Middle	Demonstration	△*2

Source : JICA Survey Team

Note *1 : Small ; as same as existing technical level, Middle; less than 1.5 times , Large; more than 1.5 times,
2 : within after five or ten years, *3 : within after 10 or 20 years

The other technologies such as IGCC, gasification and liquefaction are just at demonstration stage at present. IGCC is recognized as having technically high level efficiency but need some more cost reduction, and gasification and liquefaction shall be subjected to more technical challenge such as reliability for large scale production. However, if the demonstration operation will be successfully finished, their technologies will have the superiority over those of other countries. Among these technologies, the most promising to have the next applicability is likely the IGCC. The UBC, liquefaction and slurrification technologies are expected to have the potential for the upgrade of the transportation process.

CHAPTER 5
INFRASTRUCTURES

Chapter 5 Infrastructures

5.1 Transmission Line

5.1.1 Present Situation

(1) Power Plant

There are no coal thermal power plants in the Thar coalfield area at present. However, many power plants are planned to be constructed in the future. The concrete development plan for power generation in the Thar coalfield at the moment is shown in Table 5.1-1. Although the completion year of the power plants is not clear, at least 3200 MW in total is planned to be erected by the private sector in the near future. To convey the generated power to Karachi or other areas, erection of another 500 kV transmission line between Thar and the existing major 500 kV transmission line is necessary.

Table 5.1-1 Development Plan of Power Plants in the Thar Coalfield

Name of Block	Name of Developer	Capacity	Remarks
Block I	Global Mining Company	900 MW	
Block II	Engro Powergen	1,200 MW (Final)	
Block V	Government of Pakistan	-	UCG Pilot Project
Block VI	Oracle & KESC	1,100 MW (Final)	

Source: TCEB

(2) Transmission Network System

In Thar, 132 kV and 66 kV transmission lines come from the power grid in the west for supplying power to the area and eastern border to India. The nearest 500 kV substation is located in JAMSHORO, which is around 250 km away from Thar. Consequently, in order to supply generated power from the Thar coalfield to power consumption areas, it is necessary to install the 500 kV transmission line before the commissioning test for the power plant.

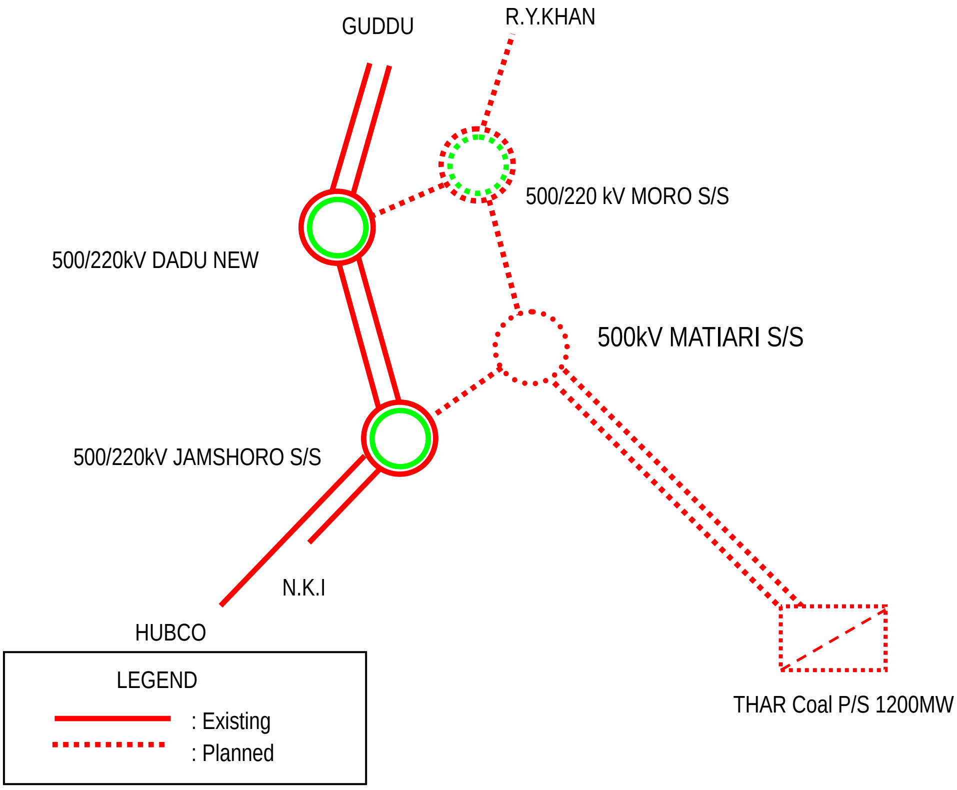
Photo 5.1-1 66 kV Islamkot Substation

Photo 5.1-2 66 kV Transmission Line

5.1.2 Expansion Plan of 500 kV Transmission Line

(1) Expansion Plan for the 500 kV Network System to Thar Coalfield

Under the above situation, NTDC has planned an extension of the 500 kV network system to Thar. The 500 kV and 220 kV grid map surrounding the Thar coalfield from 2016 to 2017 is shown in Figure 5.1-1.

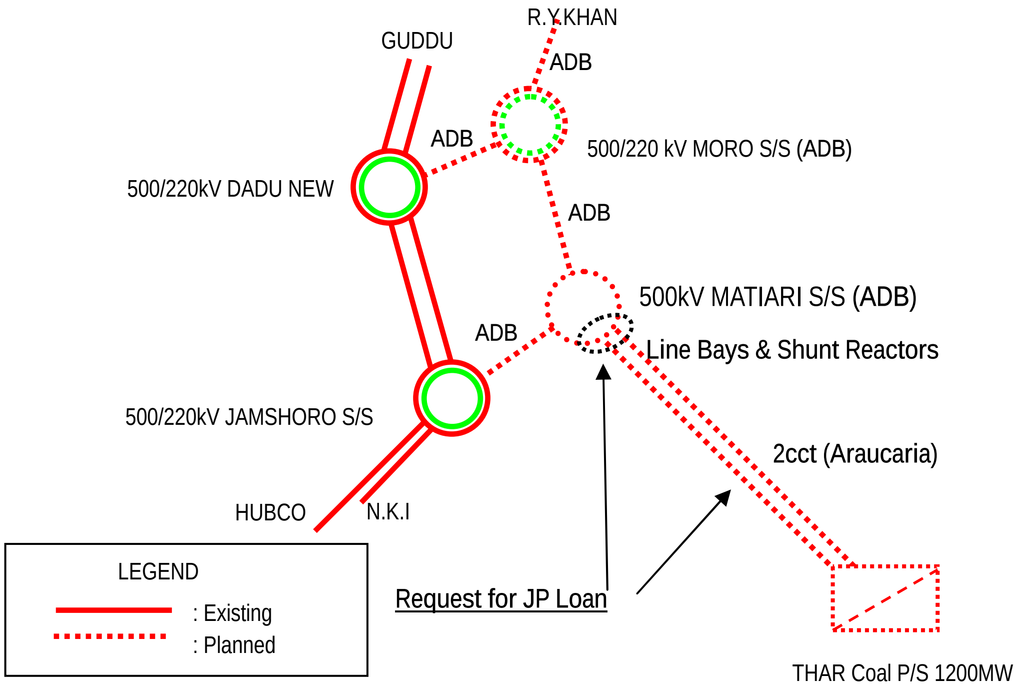


Source: NTDC

Figure 5.1-1 500/220 kV Grid Map Surrounding Sindh from 2016 up to 2017

(2) Plan of Fund Source for Expansion of 500 kV Network

NTDC divides the scope of works for the expansion of the 500 kV network system by fund source as shown in Figure 5.1-2 and Table 5.1-2. As for the expansion of the 500 kV transmission line between Thar and Matiari, and expansion of the 500 kV Matiari S/S, NTDC strongly requests to use Japanese ODA loan. The remaining expansions of the 500 kV network system will be carried out utilizing the fund financed by ADB. According to the tentative schedule in PC-1, their network will be completed in June 2016.



Source: NTDC

Figure 5.1-2 Scope of Works for the Expansion of 500 kV Network System by Fund Source

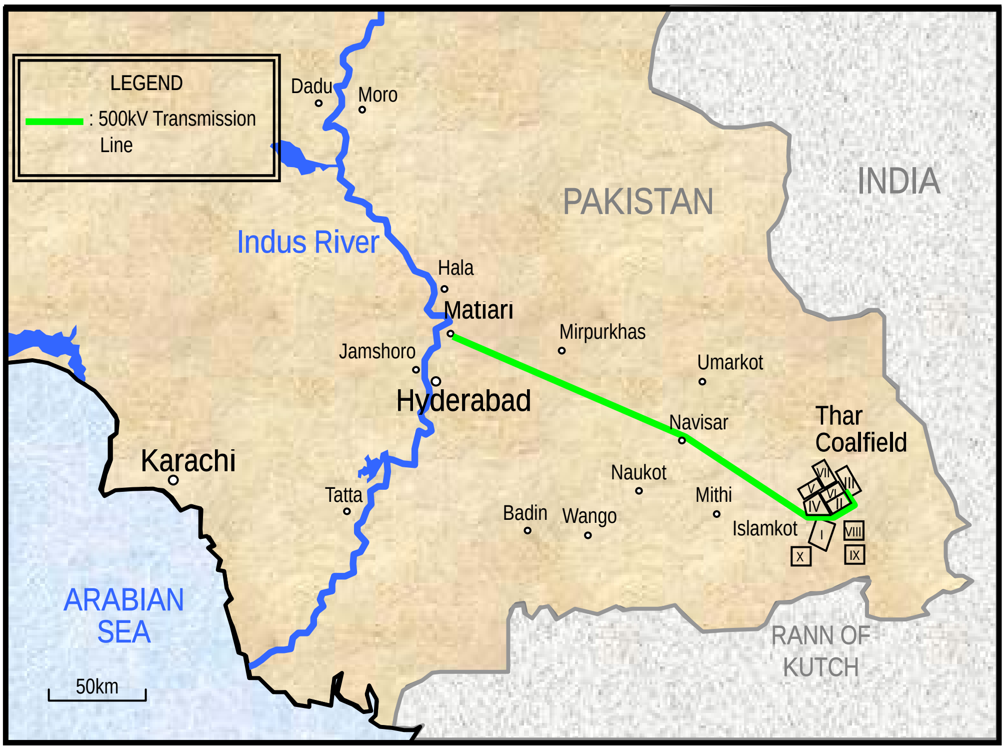
Table 5.1.2 Scope of Works for the 500 kV Network Surrounding Matiari S/S

No.	Description	Financed by ADB	Request for JP Loan	Owner of P/S
1.	Between Thar S/S and Matiari S/S			
1)	Construction of 500 kV Transmission Line		○	
2)	Construction of 500 kV Thar S/S (ENGRO P/S)			○
3)	Construction of 500 kV Matiari S/S	○		
4)	Extension of 2 x 500 kV Line Bays with 3 x 37 MVA Shunt Reactors at 500 kV Matiari S/S		○	
2.	Between 500 kV Matiari S/S and 500/220 kV Jamshoro S/S			
1)	Construction of 500 kV Transmission Line	○		
2)	Expansion of 500 kV Line Bay at 500/220 kV Jamshoro S/S	○		
3.	Between 500 kV Matiari S/S and 500/220 kV MORO S/S			
1)	Construction of 500 kV Transmission Line	○		
2)	Construction of 500/220 kV MORO S/S	○		

Source: NTDC

(3) Connection to the Thar Coalfield

Feasibility study of 500 kV transmission line between the Thar coalfield and Matiari had already been carried out by Canadian firm, SNC-LAVALIN International Inc., in association with National Engineering Services Pakistan (Pvt.), limited under a contract with NTDC. The PC-1 for the 500 kV transmission line has already been approved on August 28, 2012. Cost of the project is estimated at around Rs.22 billion. A route map of the 500 kV transmission line between Thar and Matiari, and the list of major items for the above project is shown below:



Source: Prepared by the JICA Survey Team

Figure 5.1-3 Route Map of the 500 kV Transmission Line between Thar and Matiari

Table 5.1-3 List of Major Equipment for the 500 kV Transmission Line between Thar and Matiari

No.	Description	Unit	Qty.
1	Tower	Nos.	694
2	Conductor (Arucaria)	km	6,300
3	Shield Wire	km	263
4	OPGW	km	263
5	Insulator 82 kN	Nos.	20,056
6	Insulator 160 kN	Nos.	290,996
7	Conductor accessories, hardware and grounding sets, etc.	Lot	1

Source: PC-1 for Interconnection of Thar Coal-based 1200 MW Power Plant with NTDC

Table 5.1-4 List of Major Equipment for the Extension of 500 kV Matiari Switching Station

No.	Description	Unit	Qty.
1	Circuit Breaker	Sets.	5
2	Bus Isolator	Sets	8
3	Line Isolator	Sets	2
4	CT	Nos.	15
5	PT	Nos.	6
1)	Lightning Arrestor	Nos.	13
2)	Shunt Reactor (3 x 37 MVAR)	Nos.	2
6	Spare Shunt Reactor (1 x 37 MVAR)	Nos.	1

Source: PC-1 for Interconnection of Thar Coal-based 1200 MW Power Plant with NTDC

Table 5.1-5 Summary of Project Cost

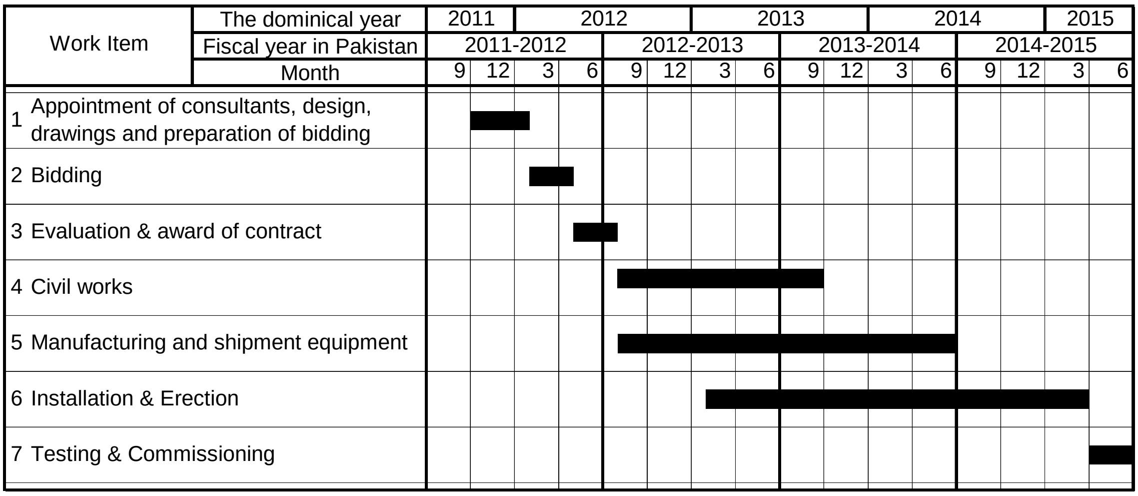
Unit: Rs. in million

No.	Description	Total
1	Construction of 500 kV Transmission Line (250 km)	15,945.36
2	Extension of 500 kV Matiari Switching Station	1,418.34
3	General (Transportation and Vehicle)	30.25
4	Engineering and Consultancy	347.91
5	Others (interest and others)	4,563.87
	Total	**22,305.73**

Source: PC-1 for Interconnection of Thar Coal-based 1200 MW Power Plant with NTDC

(4) Construction Schedule for 500 kV Transmission Line

The tentative construction schedule for the interconnection of Thar coal-based 1200 MW power plant with NTDC system is shown in Figure 5.1-4



Source: PC-1 for Interconnection of Thar Coal-based 1200 MW Power Plant with NTDC

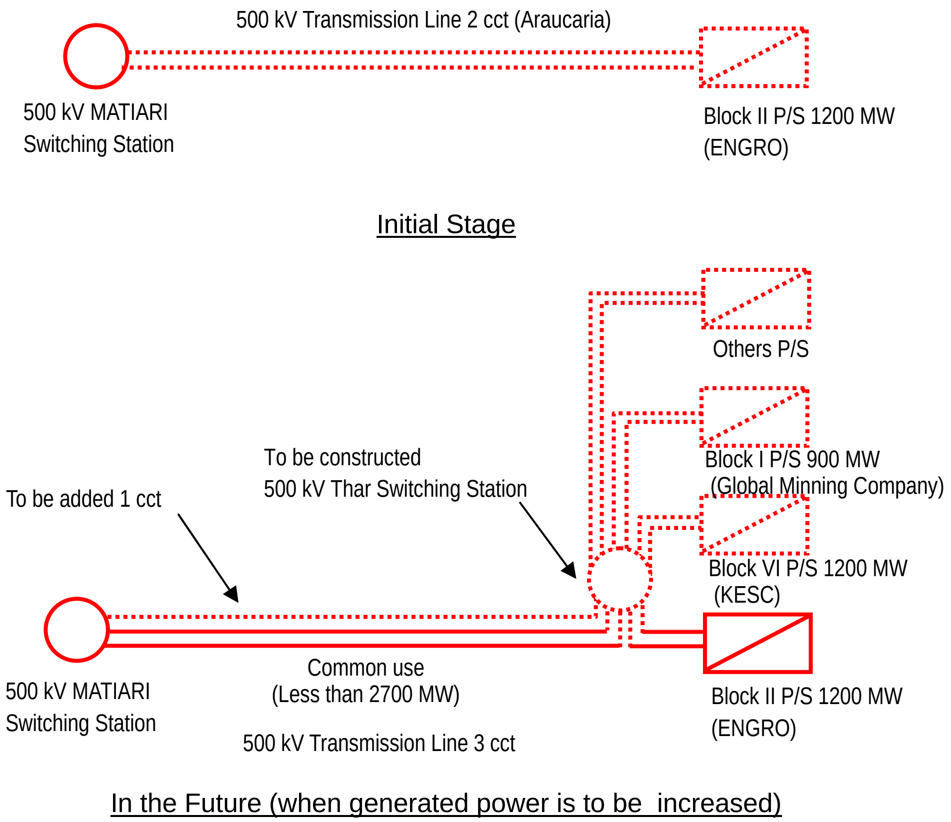
Figure 5.1-4 Tentative Construction Schedule

According to the tentative construction schedule, completion of connection to the Thar coalfield is in June 2015. However, since even design works have not been started at present, it seems impossible to complete the project as per the schedule. In addition, the schedule does not consider the period of loan agreement, and the pre-construction period, namely, bidding and evaluation, and award of contract, is too short. Therefore, it is necessary to revise the schedule drastically to make it realistic.

(5) Operation Method of 500 kV Transmission Line

The 500 kV transmission line between Thar and Matiari being designed as double circuit line will be constructed for connecting to power plants of Block II by Engro Powergen at the initial stage. Conductor for the 500 kV transmission line is designed utilizing Araucaria of All Aluminum Alloy Conductor (AAAC) in the FS, which has approximately 2700 MW allowable maximum transmission capacity at 75℃ of conductor temperature, where N-1 redundancy system is applied.

Generation capacity under the concrete development plan is at least 3200 MW as stated above, which exceeds the allowable capacity of 2700 MW. It is therefore necessary to construct a new transmission line after the generation capacity is realized.



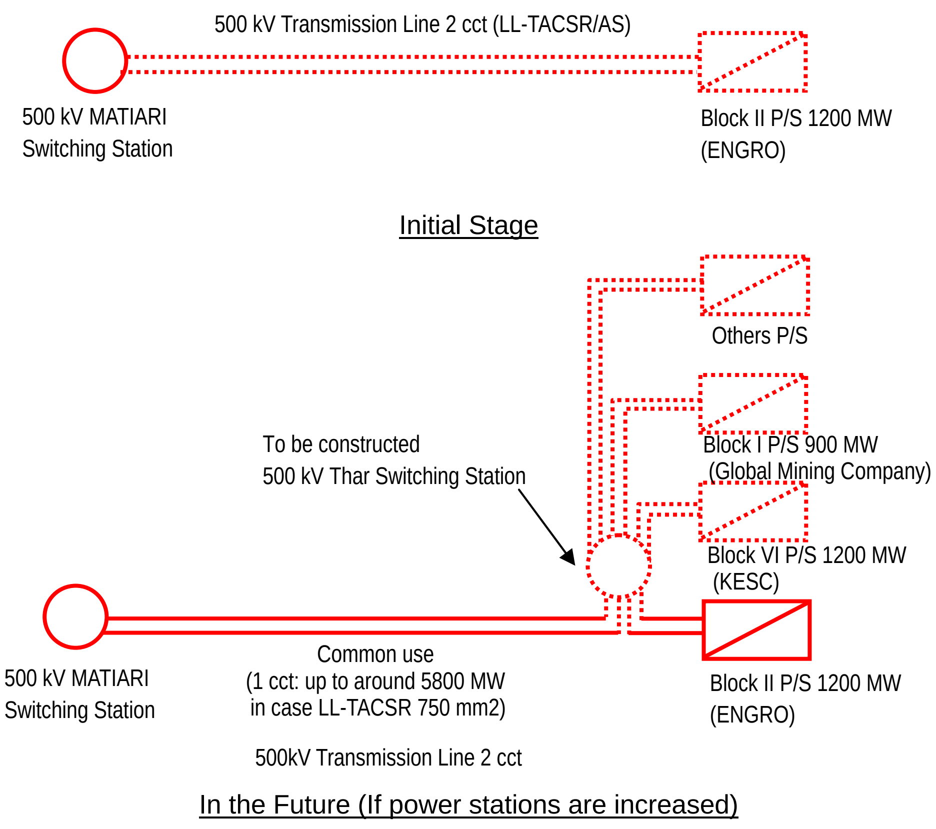
Source: JICA Survey Team

Figure 5.1-5 Operation Method of 500 kV Transmission Line (Original Plan)

5.1.3 Proposed Plan of 500 kV Transmission Line

1) Conductor for the LL-TACSR/AS

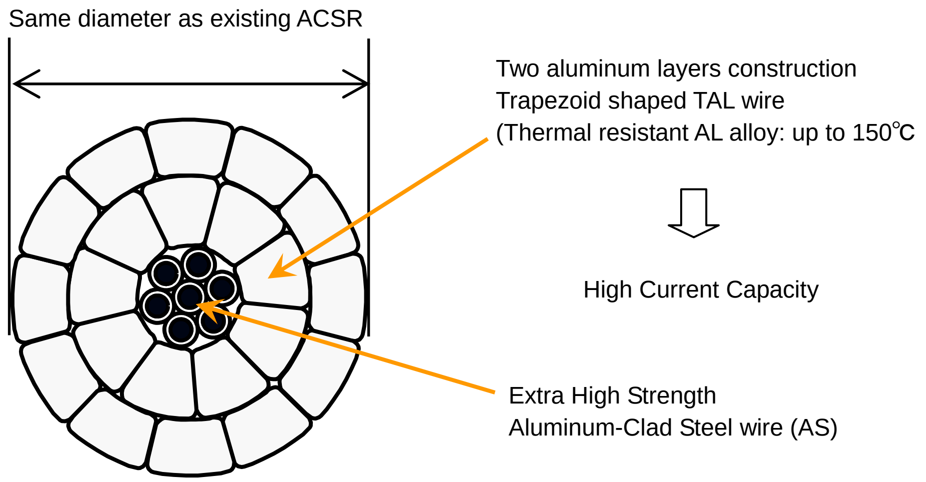
As 3200 MW of power stations are concretely planned, and as chunks of power plants are scheduled to be constructed in the future, utilizing normal conductor such as AAAC or ACSR for the 500 kV transmission line is considered to be not economical and suitable. At least, it is preferable to adopt a conductor that can transmit more than 3200 MW of generated power at present. Consequently, in order to reduce total cost, utilizing the **L**ow Electrical Power **L**oss **T**hermal Resistant **A**luminum Alloy **C**onductor **S**teel **R**einforced/**A**luminum-clad **S**teel Reinforced (LL-TACSR/AS) is recommended to increase the transmission capacity. The proposed operation method is shown in Figure 5.1-6.



Source: JICA Survey Team

Figure 5.1-6 Operation Method of 500 kV Transmission Line (Proposed Plan)

For reducing transmission loss and increasing transmission capacity, LL-TACSR has much advantage. Where the transmission line loss reduces, large size or number of conductors per phase must be selected normally. However, LL-TACSR achieves low loss by increasing aluminum area with the same diameter as existing ACSR. Detailed section of LL-TACSR/AC and its characteristics in comparison to AAAC are shown in Figure 5.1-7 and Table 5.1-6, respectively.



Source: JICA Survey Team

Figure 5.1-7 Section of LL-TACSR/AS

Table 5.1-6 Comparison between AAAC and LL-TACSR/AS

Description		AAAC "Araucaria" 820 mm^2	LL-TACSR/AS 430 mm^2	LL-TACSR/AS 550 mm^2	LL-TACSR/AS 750 mm^2
Overall Diameter (mm)		37.3	25.2	28.62	32.9
Sectional Area AL / Core(mm^2)		821.1	429.1 / 29.09	550.4 / 40.08	751.2/33.00
Nominal Weight (kg/km)		2269.5	1,399	1,814	2,310
Min. breaking load (kN)		242.24	106.9	140.5	159.9
D.C. resistance at 20 degrees (ohm/km)		0.0406	0.0677	0.0526	0.0387
Allowable continuous operation Temp.		75	150	150	150
Applicable N-1 System (Transmission Capacity)	Ambient Temp. at 40 degrees	Up to 2700 MW	Up to 4100 MW	Up to 4900 MW	Up to 5800 MW
	Ambient Temp. at 52.5 degrees	-	Up to 2300 MW	Up to 2700 MW	Up to 3200 MW
Transmission loss per year (kWh/year)	750 MW	14,323,432	23,541,254	18,409,241	13,828,383
	1500 MW	56,930,632	93,963,695	73,376,237	55,204,620
	3000 MW	230,485,146	375,858,082	299,491,746	225,884,486
Conductor Price (US$/m)		6.2	8.3	10.1	13.1

Source: JICA Survey Team

Particularly, LL-TASCR/AS is beneficial from the viewpoint of increasing the transmission capacity for the project. Although the initial cost will be higher than Araucaria, it has economical advantage considering the future expansion plan.

In addition, in case Araucaria is adopted, it cannot be operated with N-1 system for the expected capacity of 3200 MW even if ambient temperature is 40 degrees. The comparison of the estimated project cost for the 500 kV transmission line between Thar and Matiari S/S is shown in Table 5.1-8.

Construction cost of LL-TACSR 750 mm^2 will be higher by around 1.3 times compared with Araucaria. However, where power transmission capacity is increased to double, it can be operated with N-1 system even when the maximum ambient temperature is at 52.5 ^{O}C. Therefore, the LL-TACSR 750 mm2 is recommended for this transmission line.

Table 5.1-7 Comparison of Project Cost for 500 kV Transmission Line between Thar and Matiari S/S

Unit: Rs. million

Description	AAAC "Araucaria"	LL-TACSR/AS 430 mm^2	LL-TACSR/AS 550 mm^2	LL-TACSR/AS 750 mm^2
1. Construction Cost				
- Crop Compensation and Clearing	12.50	12.50	12.50	12.50
- Steel Towers	4,261.00	4,261.00 *1	4,474.05 *2	4,900.15 *3
- Conductor	4,415.13	5,510.65	6,553.79	8,284.58
- Insulator Strings	2,328.49	2,328.49	2,328.49	2,328.49
- Shield Wire and OPGW	676.73	676.73	676.73	676.73
- Hardware and Accessories	68.74	68.74	68.74	68.74
- Dampers	242.75	242.75	242.75	242.75
- Grounding Material	26.20	26.20	26.20	26.20
- Civil Works and Installation Cost	3,913.82	3,913.82 *1	4,109.51 *2	4,500.89 *3
2. Consulting Services (2%)	318.91	340.82	369.86	420.82
3. Others (Administration:2%,	797.27	852.04	924.64	1,052.05
Contingency:3%)				
Total	**17,061.54**	**18,233.74**	**19,787.26**	**22,513.90**

Source: Prepared by the JICA Survey Team

Note: Above project cost is based on PC-1 for Interconnection of Thar Coal-based 1200 MW Power Plant with NTDC System.

*1: Although sag will increase by around 2 m because the allowable continuous operation temperature is up to 150 ^{O}C, since LL-TACSR430 mm^2 is lightweight and has light tension compared with Araucaria, it is assumed that steel tower of total weight and civil works will be at the same level as Araucaria.

*2: Although sag will increase by around 2 m because the allowable continuous operation temperature is up to 150 ^{O}C, since LL-TACSR550 mm^2 is a little lightweight and tension is a bit lighter compared with Araucaria, it is assumed that steel tower of total weight and civil works will increase 1.05 times compared with Araucaria.

*3: Since sag will increase by around 5 m because the allowable current is high, it is assumed that steel tower of total weight and civil works will increase 1.15 times compared with Araucaria.

5.2 Water Supply

5.2.1 Present Status

In the Thar region, surface water is scarce and supply from other sources is expensive and not continued on regular basis due to consumption of high electrical cost incurred for pumping water from canal sources to the scattered villages[1].

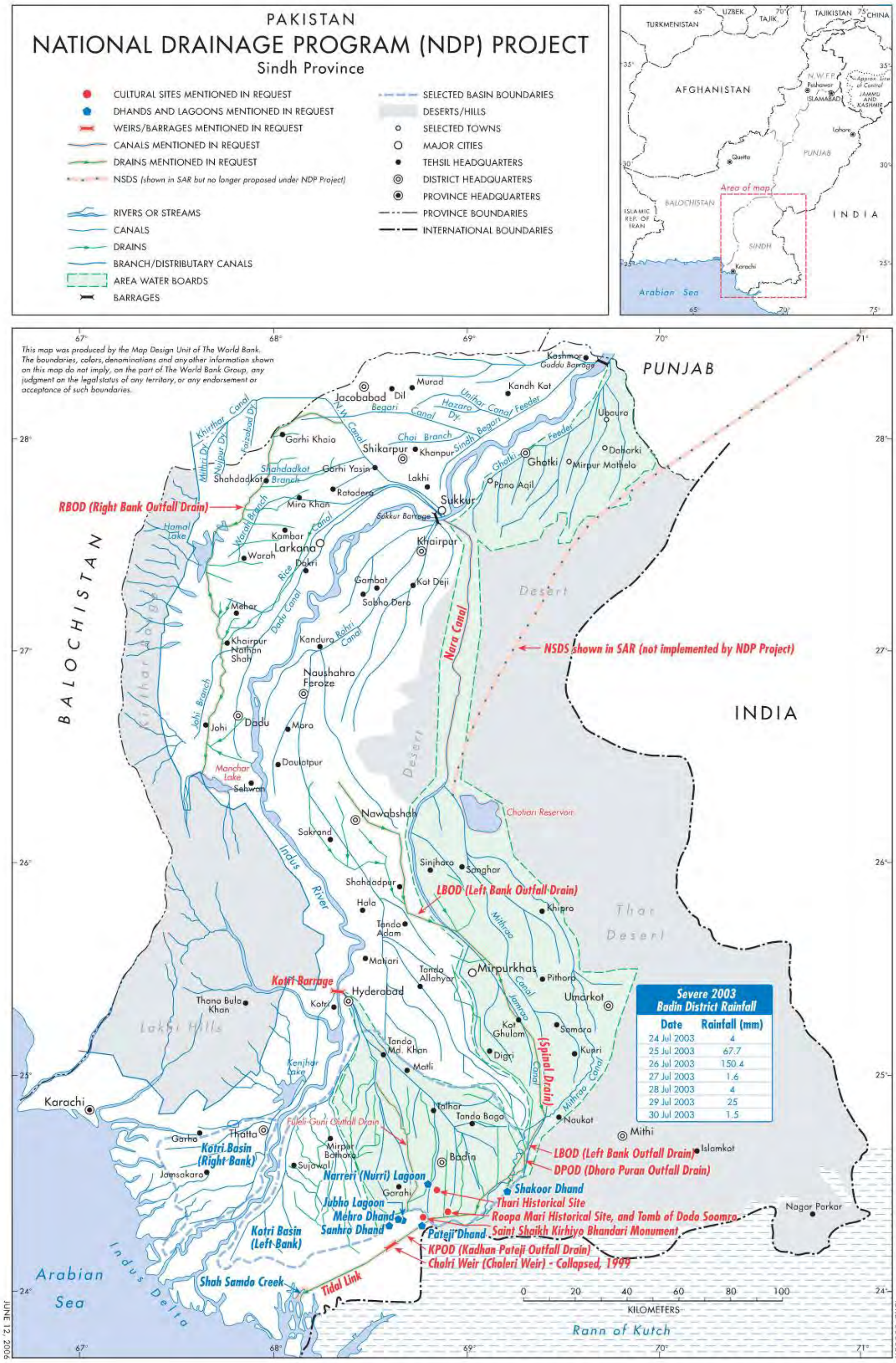
The map of the Pakistan National Drainage Program (NDP) Project in Sindh Province is shown in Figure 5.2-1. The Nara main canal branches out into distributaries. The nearest branch canal to the Tharparkar District is Mithrao Branch canal. A water pipeline for the domestic water supply to existing towns and villages has been constructed from one of the Naukot distributaries of Mithrao Branch. This pipeline is used to supply water to the population of Mithi area which is the headquarter of Tharparkar District, including a few other villages and towns of the district. Being at the tail-end of the system, water is in short supply and is available only on weekly basis through a 300 mm pipeline using multiple booster pumps.

Groundwater availability is at depth exceeding 60 m to 70 m, reaching up to 100 m in most places. All villages have dug wells containing water that is constantly brackish. Rainwater is stored in small earthen pot with narrow holes for drinking purposes but it hardly lasts for three to four months.

Mithi and Islamkot are the only places where piped water supply is available indoors, although limited to its central area. Almost all the cities and towns of Sindh are faced with a deficient supply of freshwater including the cities and towns located near the river Indus. The current pipeline has the capacity of meeting the present water requirements but is not likely to cater to the needs of coal-mining projects and operation phases.

Safe drinking water is a precious commodity and sanitation facility is a luxury that is hard to find in the rural towns and villages, more particularly in the underdeveloped or yet to be developed, Tharparkar District[2].

1 Government of Sindh, 2009
2 Environmental Management Consultants, 2012



Source: POE Drainage Master Plan

Figure 5.2-1 NDP Project Map

5.2.2 Outline of the Plan

There are two schemes for water supply: 1st, the wastewater supply scheme from LBOD up to Navisar, including installation of treatment plant, and 2nd is the treated water supply scheme from Navisar Reservoir to the Thar coalfield[3].

(1) Water Supply Scheme from LBOD

Water supply scheme from LBOD is in progress. Details of the scheme are as follows:

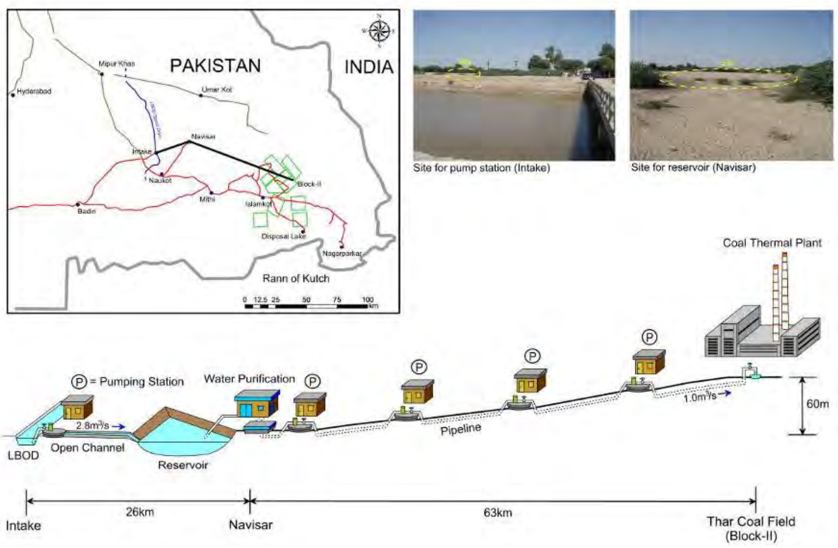
1) Component-I: LBOD Waste Water Scheme from LBOD at RD-362, its treatment and conveyance up to Navisar Reservoir.

- Sindh Irrigation and Drainage Authority is in charge in executing this scheme.
- LBOD water (2.8 m^3/s) will be extracted with elevated pumping station to Navisar Reservoir through a 26-km open channel.
- The water in the reservoir will be purified at 1.0 m^3/s with reverse osmosis (RO). Plant designed water up to 10,000 TDS in the vicinity of the reservoir in Navisar.

2) Component-II: LBOD Waste Water Supply Scheme from Navisar Reservoir to Thar coalfield.

- Navisar to Vajihar (Thar coalfield) uses about 63 km pipelines.
- Elevation of Vajihar is about 60 m higher than that of Navisar.
- Some booster pumping stations are planned to be constructed for water supply to the Thar coalfield.

Water supply scheme from LBOD is shown in Figure 5.2-2.



Source: JICA Survey Team

Figure 5.2-2 Water Supply Scheme from LBOD

3 Thar Coal and Energy Board, 2012

(2) Installation of Reverse Osmosis Plants

Sindh Coal Authority undertook the task for providing long-term and economical solution of potable water to the inhabitants living in the vicinity of coal mine areas of Thar Desert. Brackish/saline groundwater is converted into potable water through the sophisticated reverse osmosis (water desalination) technology.

A pilot project for this scheme was initiated and four RO plants were installed at Sabharo Shah Village, Islamkot town, Khetle and Mithi towns in Tharparkar District. These plants are successfully operating and potable water is being supplied through existing water supply schemes as well as through tankers, free of charge. As such, the Authority has succeeded in its objective to provide potable water for industrial uses and human consumption by installing RO plants in Tharparkar District. From these plants, pure and safe drinking water is being provided to 30 villages covering a population of about 40,000 people through pipeline and tankers. The main pipeline was installed from the Nara Canal to Nagarparkar via Mithi and Islamkot (GoS, 2009). RO#4 in Sohharoshah and RO#2 were visited during the 1st field survey on 30 September to 3 October. The operating and maintenance firm initially charged Rs.0.12 per gallon, but now at Rs.0.16 per gallon, including diesel power generation if there is no electricity on site.

Photo 5.2-1 Existing RO Plant (#4)

Photo 5.2-2 Method of Water Supply from RO

Raw water at RO#4 is supplied from a 200 m deep submersible pump in the coal seam floor aquifer, TDS is 5,000 ppm – 6,000 ppm. while RO#2 is supplied from 150m in depth, TDS 10,000 ppm. After pre-treatment by chemicals, raw water flows into the RO membrane column. The pH is controlled by caustic soda as post-treatment. Product TDS is controlled not to exceed 250 ppm. Membrane life is 3 to 5 years.

About 50% of the rejected raw water were running at 30 GPM Product/40 GPM Reject. The rejected water is drained to an open pit and seeps back into the sand dune aquifer.

5.2.3 Construction Schedule

The construction schedule for water supply is as follows[4]:

(1) Water Supply Scheme from LBOD

1) Component-I:

- The contract has already been awarded.
- The scheme will be completed by June 2014

2) Component-II:

- Consultants for the scheme have been selected.
- Preliminary survey is in progress.
- The scheme will be completed by October 2014.

(2) Installation of Reverse Osmosis Plants

The plan is to install 110 RO plants in the Thar coalfield and its adjoining area. Work is in progress. Currently, 45 are operating and 41 are under construction/pre-commissioning, 81 are already installed supplying 6.14 MGD capacity, and 29 are being installed with 2.2 MGD capacity.

5.2.4 Cost

Regarding water supply to the Thar coalfield, the cost of Component-I is Rs.5.0 billion, Component-II is Rs.4.078 billion and total is about Rs.9.1 billion. Government of Sindh (GoS) has allocated Rs. 2.0 billion for Component-I, Rs.1.0 billion for Component-II and total Rs. 3.0 billion in the year 2012 – 2013 (Thar Coal and Energy Board, 2012).

Size and quantity of the new pipeline and pump are calculated as shown in Table 5.2-1 on the basis of the Japan Design Guide of Water Utility 2012[5] (hereinafter called Guide of Water).

The typical type of pumping equipment used for water supply systems in Japan is vortex pump. Therefore, the type of pumping equipment used for the water supply system of the Thar coalfield will be the double suction vortex pump, which is adapted into the Japanese Industrial Standard (JIS). Moreover, in order to reduce costs, the pumping equipment is to be a general product of manufacturers and not as a special order product.

From the above condition, prior conditions of the number of pumps, specifications of pump, and diameter of the conveyance pipe are configured such that 1) Diameter of unit pump is not more than 0.5 m, and 2) Total head per unit pump is not more than 100 m.

[4] Thar Coal and Energy Board, 2012
[5] Issued by Japan Water Works Association

The cases of calculations are as follows:

1) Case 1: Number of pump unit per one pumping station =3, Diameter of water conveyance pipe =0.7 m, Number of steps of pumps =5
2) Case 2: Number of pump unit per one pumping station =4, Diameter of water conveyance pipe =0.7 m, Number of steps of pumps =6
3) Case 3: Number of pump unit per one pumping station =4, Diameter of water conveyance pipe =0.8 m, Number of steps of pumps =6

Table 5.2-1 Calculation of Pipeline and Pump

No.	Code	Item	Calculation Value			Unit	Formula	Remarks
			Case-1	Case-2	Case-3			
1	Q_1	Total Volume of Water Conveyance	60	60	60	m^3/min	$1m^3$/sec * 60sec	Current Plan
2	N_1	Number of Pump Unit per One Pumping Station	3	4	4			
3	Q_2	Discharging Volume of Unit Pump	20	15	15	m^3/min	Q_1/N_1	
4	v	Discharging Flow Velocity of Unit Pump	1.5	1.5	1.5	m/sec		Standard Value
5	D_1	Diameter of Unit Pump	0.6	0.5	0.5	m	146*(Q_2/v)^0.5	Not more than 0.5m (JIS Standard)
6	D_2	Diameter of Water Conveyance Pipe	0.7	0.7	0.8	m		
7	C	Coefficient of Flow Rate	110	110	110			New Ductile Cast-Iron Pipe (DCIP)
8	L_1	Total Length of Pipeline	63,000	63,000	63,000	m		Current Plan
9	N_2	Number of Steps of Pumps	5	6	6			
10	L_2	Water Conveyance Length per Unit Pump	12,600	10,500	10,500	m	L_1/N_2	
11	H_1	Total Actual Head	60.0	60.0	60.0	m		Current Plan
12	ha	Actual Head per Unit Pump	12.0	10.0	10.0	m	H_1/N_2	
13	hl	Loss of Water Head in Pipeline	127.69	106.41	55.53	m	(10.666*Q_1^1.85)/(C^1.85*D^4.87)*L_2	Formula of Hazen-Williams
14	hv	Velocity Head	0.11	0.11	0.11	m	v^2/2g	
15	H	Total Head per Unit Pump	139.81	116.53	65.65	m	ha+hl+hv	Not more than 100m (General Product of mfr)
17	Np	Rotary Speed of Pump	1000	1000	1000	min^{-1}		Standard Value (Guide of Water)
18	Ns	Specific Speed of Pump	109.99	109.20	167.93		Np*Q^0.5 / H^(3/4)	
19	Ha	Atmospheric Pressure	10.33	10.33	10.33	m		Standard Value (Guide of Water)
20	Hp	Satured Steam Pressure	0.43	0.43	0.43	m		30℃
21	Hs	Suction Actual Head	0	0	0	m		
22	Hl	Loss of Head in Suction Pipe	0	0	0	m		
23	hsv	Available Suction Head	9.90	9.90	9.90	m	Ha-Hp+Hs-Hl	
24	S	Suction Specific Speed	1200	1200	1200			Standard Value (Guide of Water)
25	Hsv	Required Available Suction Head	5.78	4.77	4.77		(Np*Q^0.5 / S)^(4/3)	
26	hsv-Hsv	Judgment of Cavitation	4.12	5.13	5.13	m		>1: OK

Source: Prepared by the JICA Survey Team

From the above prior conditions, the calculation results are presented below.

1) Case 1: Diameter of unit pump >0.5 m, Total head per unit pump >100m ･･･NG
2) Case 2: Diameter of unit pump =0.5 m, Total head per unit pump >100m ･･･NG
3) Case 3: Diameter of unit pump =0.5 m, Total head per unit pump <100m ･･･OK

Case 3 will be available. Therefore, the sizes and quantities of the equipment of water supply system are as follows:

Number of pump unit per one pumping station =4, Number of steps of pumps =6, Total number of pumps =24, Discharging volume of unit pump =15 m^3/min, Diameter of unit pump =0.5 m, Diameter of water conveyance pipe =0.8 m

Initial cost and operation and maintenance cost of the pipelines, the pumping stations and the water treatment plant are estimated as shown in Table 5.2-2 on the basis of case examples of nearby countries. Also, it is assumed that the period of operation and maintenance is 30 years from 2017, and mechanical and electrical equipments will be replaced after 15 years from the beginning of operation. From results of calculation, ground total cost is Rs 73,499 million, which is equivalent to Rs.77.7 per $1m^3$.

Table 5.2-2 Cost Estimation for Water Supply System

Item	Spec	Quantity	Unit Price (Rs)	Total (mil. Rs)
1. Initial Cost				
(1) Pipeline	Pipe works DCIP D800	63,000m	78,650	4,955
(2) Pumping Stations				
1）M&E	Pump ($15m^3$/min)	24 nos.	121,000,000	2,904
2）Civil		6 stations	121,000,000	726
(3) Water Treatment Plant	RO Plant $60m^3$/min	$86,400m^3$/day (treatment volume)	169,400	14,636
			Sub-total of Initial Cost	**23,221**
2. Maintenance Cost (Period = 30 years)				
(1) Pumping Stations		30yr. x 24nos.	6,050,000	4,356
(2) Water Treatment Plant		30yr. x 365days x $86,400m^3$/day	30	28,382
			Sub-total of Maintenance Cost	**32,738**
3. Replacement Cost (In the 15th year)				
(1) Pumping Stations	Pump ($20m^3$/min)	24 nos.	121,000,000	2,904
(2) Water Treatment Plant	RO Plant $60m^3$/min	$86,400m^3$/day (treatment volume)	169,400	14,636
			Sub-total of Replacement Cost	**17,540**
			Ground Total of 30years Cost	**73,499**

Source: Prepared by JICA Survey Team

5.3 Mine Water Disposal

5.3.1 Present Status

There are no open channels like river or canal in the Thar coalfield. Therefore, it is not easy to dispose the dewatered brackish/saline water.

5.3.2 Outline of the Plan

The 1.2 m diameter pipe will be used for dewatering. RWE estimated the amount of water for disposal at 1.5 m^3/s under the condition of 30 m water pressure head, and 1.2 m/s velocity. The elevation at the start point is 78 m and that of end point is 9 m, resulting in a difference of about 69 m

Scheme for disposal of 1.4 m^3/sec effluent from the Thar coalfield to depression has been approved. The depression is located near village Dakkar Shah, 7 km away from Ramsar Site.

5.3.3 Cost

Total cost for construction is estimated at Rs. 3.6 billion.

GoS has allocated Rs. 2.0 billion for this scheme in the year 2012 – 2013.

Photo 5.3-1 Candidate site for disposal water

5.3.4 Construction Schedule

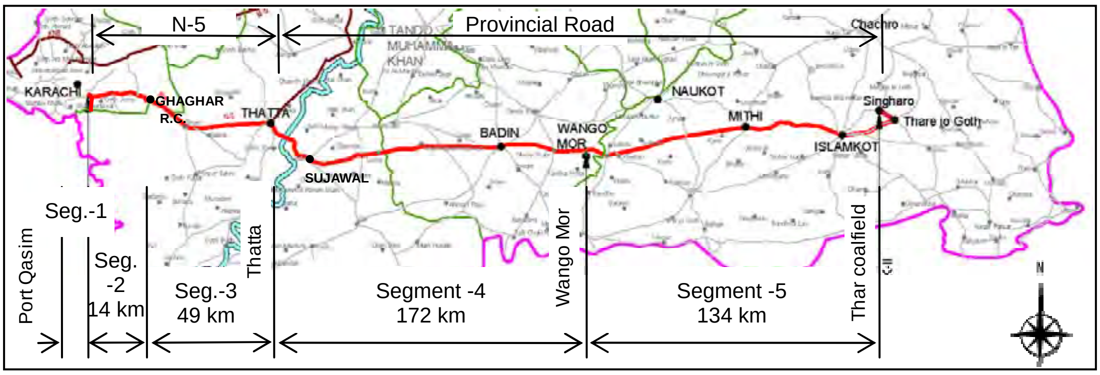
Consultant for the scheme has already been selected. However, topographic survey and detailed design is still in progress, as well as the evaluation of bids from contractors/firms. The scheme will be completed by December 2013.

5.4 Road

The planned access route to the Thar coalfield from the Karachi Seaport (Port Qasim) is the existing public road subject to upgrading. The route passes through major towns including Thatta, Badin, Wango Mor, Mithi, and Islamkot. The route map of the access road and the schematic diagram are shown in figures 5.4-1 and 5.4-2, respectively. The photos along the exiting route are attached in Appendix 5-3.

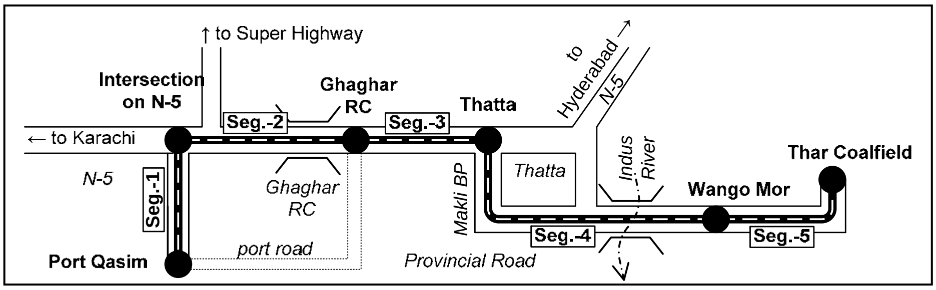
The route is divided into five segments in consideration of the study in this report as follows":

- Segment-1: Port Qasim to Intersection on N-5 (11 km)[6]
- Segment-2: Intersection on N-5 to Ghaghar Railway Crossing (RC)[7] (14 km)[6]
- Segment-3: Ghaghar RC to Thatta[8] (49 km)[9]
- Segment-4: Thatta to Wango Mor (172 km)[10]
- Segment-5: Wango Mor to Thar coalfield (134 km)[10]



Source: JICA Survey Team using data from SCA

Figure 5.4-1 Route Map of the Access Road to the Thar Coalfield



Source: JICA Survey Team

Figure 5.4-2 Schematic Route Map

The administrative organization of each Segment is; 1) The Port Qasim Authority for the

[6] A length measured using Google Earth
[7] At the intersection on the east side of the Ghaghar RC
[8] At the beginning point of the Makli Bypass
[9] The length provided by PPP Unit, Finance Department, GoS
[10] The improvement length provided by Sindh Coal Authority

Segments-1, and 2) The Works and Services Department (W&S) of GoS for Segments-2 to 5.

The administration for Segments-2 and 3 were transferred to GoS from National Highway Authority (NHA) in June 2012.

5.4.1 Present Situation

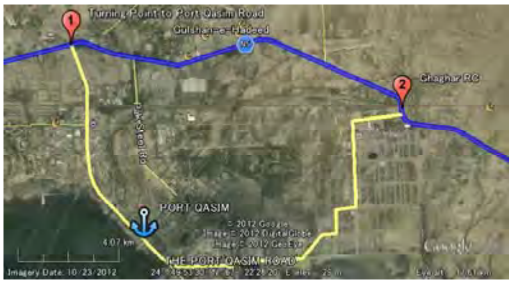
(1) Existing road condition

The JICA Survey Team carried out a visual road condition survey along the existing road between the Karachi City and the Thar coalfield on November 29 to 30, 2012 and on December 11, 2012. A mounted type driving video recorder and a handy GPS were used. The result of the survey is summarized as follows;

1) The Port Qasim – Intersection on N-5 (Segment-1)

This segment is part of the port road connecting Port Qasim and the intersection on the National Highway No.5 (N-5) at the point "1" in Figure 5.4-3. The intersection is approximately 30 km east from the center of Karachi. The segment is under the management of Port Qasim Authority who is the port management body.

Photo 5.4-1 Port Qasim Road



Source: SCA

Figure 5.4-3 Route of Port Qasim Road

The 2-lane road is asphalt paved having a total width of 12 m including shoulders. There are many ruts and cracks found on the surface.

This port road also connects N-5 at the point "2" in Figure 5.4-3, which is the Ghaghar railway crossing (RC), the beginning of Segment-3. However, trailers and heavy vehicles use the point "1" instead of "2" due to the road alignment. Moreover, pavement thickness along the route is insufficient to reach point "2". Thus, the intersection of point "1" is the sole access for heavy vehicles from the port to N-5.

2) Intersection on N-5 – Ghaghar RC (Segment-2)

This segment is part of N-5 in Karachi District. Thatta District starts from the end of the Ghaghar RC to the east. On this segment, there is a branch to a bypass road leading to the superhighway, located in the northern part of N-5.

The 2-lane road is asphalt-paved with each direction separated by a median. The road was rehabilitated recently so its condition is relatively good. There are overhead traffic sign boards, advertisement boards, pedestrian bridges, and low voltage electric cables crossing the road.

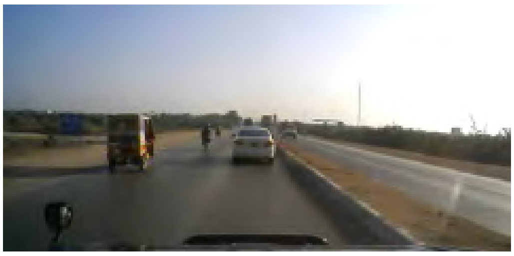


Photo 5.4-2 Road in Karachi District

A toll gate is installed at 2.5 km west of the Ghaghar RC where vehicles such as Toyota Prado is charged at a toll fee of Rs.25. Based on the collected information, toll fees are being collected by National Logistics Cell (NLC) who is under contract with NHA, and is responsible for the road maintenance of the segment.

3) Ghaghar RC - Thatta (Segment-3)

This segment is part of N-5 running through Thatta District. There are some towns along the segment including Dhabeji, Gharo, and Guijo.

The road has two lanes without median. There are many traces of patching works on the surface. Humps are installed on the roads with in the towns in order to reduce vehicle speed.


Photo 5.4-3 Beginning Point of the Segment

4) Thatta – Wango Mor (Segment-4)

This segment is part of the provincial road (S-85, S-72) under the management of GoS, having a road length of 172 km[11] with an asphalt-paved 1-lane and partially paved 2-lane without median. It passes through administrative boundaries of Thatta District and Badin District. The road between Thatta and Sujawal, including a large bridge crossing over the Indus River at 8 km east of Thatta, is in good condition due to funded improvement from ADB in 2006. The topography of this segment is flat and the road alignment has neither steep slopes nor small curves. The entire segment is constructed by filling without cutting.

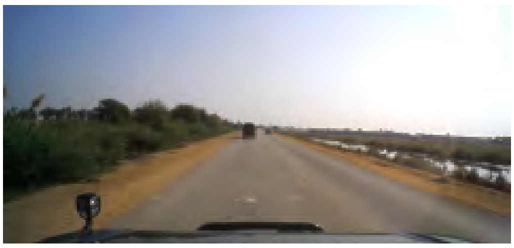


Photo 5.4-4 Road near Thatta

There are several towns along the road, which include, Sujawal, Golarchi, Badin, Nindo, Khoski, Shadi Large, and Wango Mor. There is an existing bypass road to avoid congested area in Badin. Humps are installed at a congestion area in these towns.

[11] Length provided by SCA including new bypass roads

The damaged road between Sujawal and Badin was restored from the devastation caused by the flooding of the Indus River in 2010. The carriageway is 7.3 m in width and earthen shoulders are 2.0 m to 3.0 m on either side between Thatta and Badin.

5) Wango Mor – Thar Coalfield (Segment-5)

Photo 5.4-5 Typical View in Segment-5

This segment is the part of the provincial road (S72-151, 154, 100, S71-004). It is 134 km long from Wango Mor in Badin District to the Thar coalfield in Tharparkar District via Mithi, the headquarters of the district, and Islamkot. The topography of this segment differs from each other, because most of the area is within the Thar Desert. There are relatively steep slopes where the road passes over sand dunes. The road width is from 3.0 m to 5.5 m, which is narrower than other two segments.

At many locations along the road, embankments and pavements are damaged by erosion due to rainwater, particularly at sag points. At some locations, road surfaces are covered by brown sand, which impedes safe vehicular traffic.

Herd often crosses along the road on the segment.

(2) Road improvement plan

The road improvement including road widening, reconstruction, and rehabilitation of structures and pavement are planned for the following three segments in order to secure transportation of heavy vehicles related to the Thar coalfield development:

- Segment-3: Ghaghar RC to Thatta : Improvement by PPP[12]
- Segment-4: Thatta to Wango Mor : Improvement by SCA using budget of GoS
- Segment-5: Wango Mor to Thar coalfield : Improvement by SCA using budget of GoS

Both Segments –1 and 2, which are not shown in the list, have no improvement plan since the heavy vehicle traffic along said segments is currently the same as that considered for the Thar coalfield developments.

The present situation of the road improvement plan is as follows:

1) Road Improvement by PPP scheme

The Financial Department of GoS aims to develop Segment-3 by PPP scheme. They are preparing related documents and taking necessary action for a procurement of private sector companies. The procurement is expected to start early next year. This PPP scheme will be the

[12] Public-Private-Partnership

third PPP project in the Sindh Province.

2) Road improvement by SCA

PC-1 Form[13]

The PC-1 Forms of the study road were approved for Part-1: from Ghaghar RC to Wango Mor, and for Part-2: from Wango Mor to the Thar coalfield area.

Subsequently, it was decided that the section between Ghaghar RC and Thatta, which is the Segment-3 in this report, will be omitted from the scope since it would be developed by a PPP scheme under the management of the Financial Department of GoS. In addition, construction cost will be increased based on the cost estimates. Therefore, SCA has been applied for approval of the revised PC-1 to GoS, and the process is ongoing.

EIA

According to interview with SCA, an EIA application for improvement of the study road is not required as the planned work is just partial and the right-of-way will not be changed for the improvement except for some small parts.

Design works

For the road improvement design works, SCA appointed two engineering consultant firms namely; 1) EA Consulting (Pvt.) Limited for Thatta to Wango Mor (Segment-4) and 2) AA Associates in association with Engineering Consultant Intl. (Pvt.) Ltd. for Wango Mor to the Thar coalfield (Segment-5). All design works were already completed.

The main design components of both Segment-4 and Segment-5 include widening of the road and upgrading of the road structures, in order to secure transportation of heavy vehicles during both construction stage and mining stage at the Thar coalfield. The detailed scope of the road improvement plan is described in subsequent Section 5.4.2.

5.4.2 Outline of the Road Improvement Plan

(1) General

The improvement plan for Segments -3 to 5 are as follows:

The Finance Department of GoS is planning the procurement of private sector and completion of the design works in 2013.

On the contrary, according to a presentation by SCA on November 28, 2012 and several interviews with SCA during the study period, road design works for Segment-4 and Segment-5,

[13] In accordance with the administrative process of development projects in Pakistan, PC-1 Form should be approved by the Planning Department of the Government of Pakistan prior to the bidding.

from Thatta to the Thar coalfield area were already completed, and the procurement process is ongoing. An outline of the road design works carried out by SCA is shown in Table 5.4-1.

Table 5.4-1 Road Design Works for Segment-4 and Segment-5

Segment-4: Thatta – Wango Mor (172 km)	
a. Consultant	EA Consulting (Pvt.) Limited
b. Route	Thatta (B.P.) - Sujawal - Diwan - Golarchi - Badin - Nindo - Khoski – Shadi Large - Wango Mor (E.P)
c. Design Components	- New bypasses; a) Sujawal Bypass, b) Badin Bypass, c) Nindo Bypass, d) Khoski Bypass, and e) Shadi Large Bypass - Rehabilitation/reconstruction of all structures for transmission of heavy vehicle from Sujawal to Wango Mor - Rehabilitation of flood damaged section of 25 km length between Sujawal and Badin. <u>Note: The improvements (widening) of some parts of the road are to be omitted due to the limited budget; however, basic road function for the mine development is supposed not affected. In addition, the segment between Thatta and Sujawal, which was improved through ADB funding, omitted from the scope due to good and technically satisfying conditions found after the review.</u>
d. Contract Packaging	Five packages
Segment-5: Wango Mor – Thar Coalfield Area (134 km)	
a. Consultant	AA Associates in association with Engineering Consultant Intl. (Pvt.) Ltd.
b. Route	Wango Mor (B.P.) - Mithi - Islamkot - Thar Coalfield Area (E.P.)
c. Design Components	- Widening to all section. - Additional widening at curve and intersection at 10 locations for long trailer. - Improvement of existing road including horizontal and vertical alignment. - Improvement of existing structures (e.g., bridges and culvers)
d. Contract Packaging	Seven packages

Source: JICA Survey Team using material from SCA

(2) Class of the road

The class and management of the road after improvement are considered as follows:

- Segment-3, Ghaghar RC to Thatta : Provincial Road, Private Sector, 27-year concession period after two-year construction.
- Segment-4, Thatta to Wango Mor : Provincial Road, W&S of GoS
- Segment-5, Wango Mor to Thar coalfield : Provincial Road, W&S of GoS

(3) Design vehicle

Design vehicle for the road improvement is focused on two types: one is a mining truck for earthwork and mining, and the other is a trailer for transporting mechanical equipment of electric power plant. A list of design vehicles is shown in Table 5.4-2. The same design vehicles are also to be considered in the design of Segment-3.

Table 5.4-2 Design Vehicles for the Road Improvement

Type	Mining Truck	Multi-axle Trailer
Image		
Maximum Dimension / Weight	31.0 m (L) x 5.5 m (H) x 5.5 m (W) 350 ton	

Source: JICA Survey Team with use of material from SCA

(4) Design speed

The design speeds considered for the roads are 100 km/h for Segment-3, and 80 km/h for Segments-4 and 5.

(5) Applied Design Standard

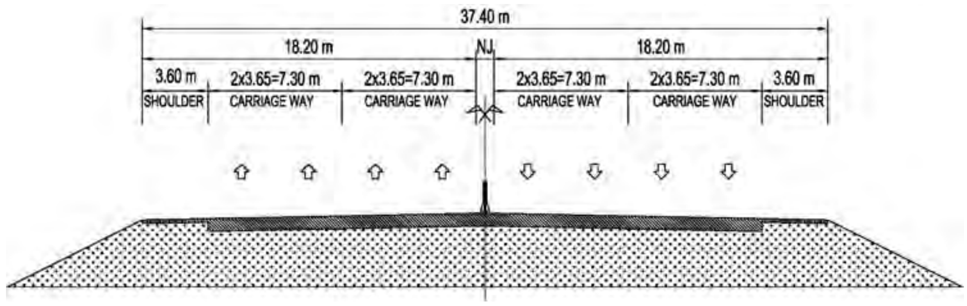
In Pakistan, AASHTO (American Association of State Highway and Transportation Officials) design code is widely applied for design of roads classified as national highways. In addition, for some major highways, the “Code of Practice for Highway Bridges issued by the Highway Department of Government of West Pakistan in 1967” is applied for designing bridges with due consideration to military loading consisting of 70 tons tracked vehicle.

On the contrary, for the provincial roads, the design practice of the W&S of GoS is applied. However, this is not suitable for heavy trucks along the road, which should be constructed with appropriate pavement structure.

For all the segments of the study road, AASHTO design code was applied.

(6) Cross section of the road

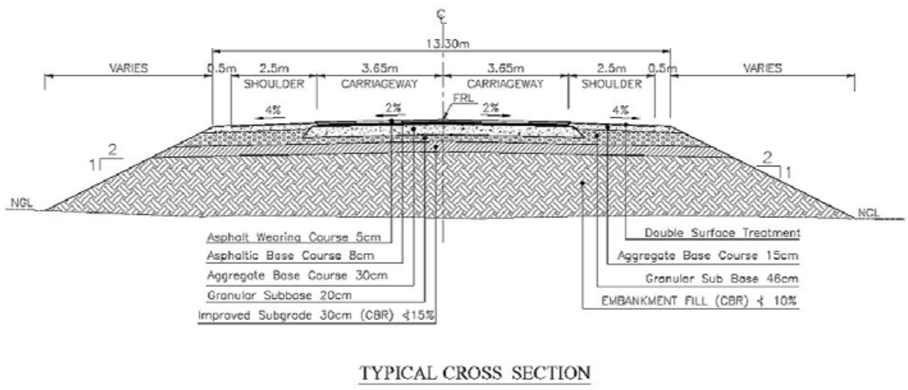
According to the interview with the PPP Unit of Finance Department of GoS, typical cross section of Segment-3 was considered as shown in Figure 5.4-4.



Source: interview from Finance Department, GoS

Figure 5.4-4 Typical Cross Section of Segment-3

The typical road cross section of Segment-4: Thatta to Wango Mor, was designed as shown in Figure 5.4-5. The width of its carriageway is 7.3 m (3.65 m x 2 lanes), with 2.5 m paved shoulders and 0.5 m earth shoulders at either side. Sidewalks were not considered in the section.



Source: SCA

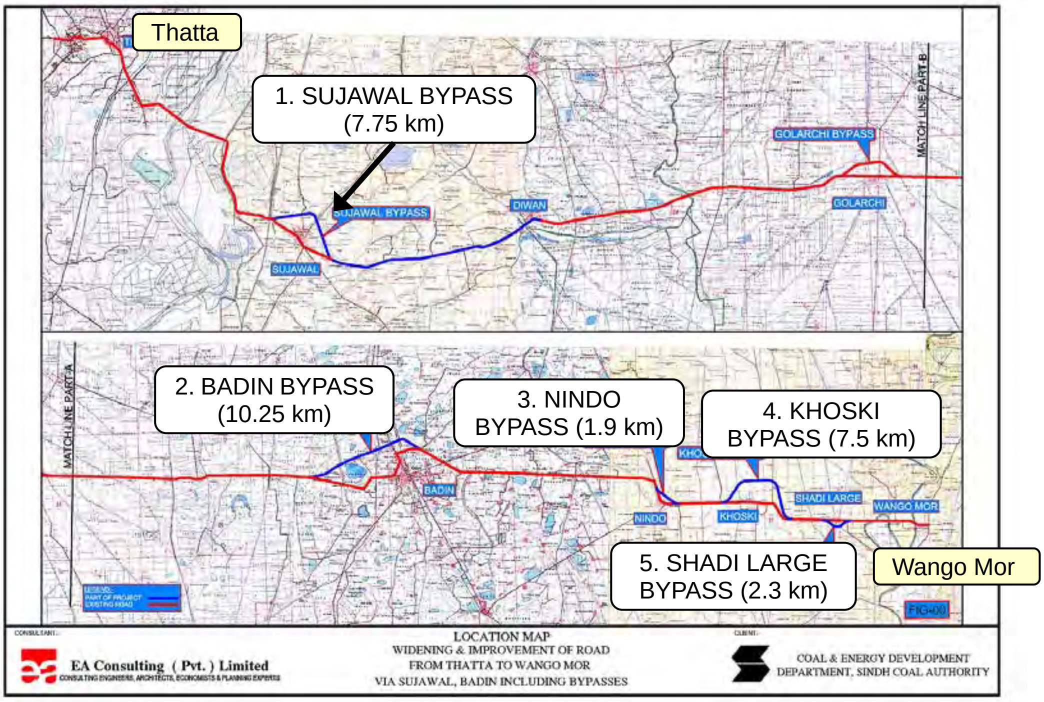
Figure 5.4-5 Typical Cross Section of Segment-4

The typical road cross section of Segment-5: Wango Mor to the Thar coalfield is slightly different from Segment-4. Its carriageway width is 7.3 m and has paved shoulders and earth shoulders of 2.0 m and 1.0 m at either sides, respectively.

According to SCA, the pavement of both Segment-4 and Segment-5 were designed considering future traffic volumes of heavy vehicles, under the situation that all mine blocks are operating. The pavement structure is the same for both segments.

(7) Road Alignment

On the study road, basically, road improvement involves widening of the existing road. Therefore, the alignment will be kept as it is except on new five bypasses serving as detour to congested towns. The location map of the new five bypasses designed in Segment-4 is shown in Figure 5.4-6.



Source: JICA Survey Team with using location map obtained from SCA

Figure 5.4-6 Location of New Bypasses

In Segment-5, slopes on the existing road laid on sand dunes are too steep for heavy vehicles; therefore, the vertical alignment will be improved. In addition, small radius of curves and intersections will be widened towards inward curve at 10 locations.

According to the information from SCA, the road alignment will be improved to secure the stopping and passing sight distances.

(8) Road structures

The major road structures on the study road are bridges and culverts. According to SCA, in order to secure transport of heavy vehicles, all existing structures are to be reconstructed and rehabilitated except for structures, which are confirmed to have enough strength.

5.4.3 Cost of the Improvement Plan

The cost of improvement of Segment-3 is not applicable since the section is planned to be developed by PPP.

The allocation of budget for the improvement of Segment-4 and Segment-5 is already approved by GoS in March 2012, as shown in Table 5.4-3.

Table 5.4-3 Construction Cost of the Road Improvement

Segment	Section	FY2011 (Rs. millions)	FY2012 (Rs. millions)	FY2013 (Rs. millions)	Total (Rs. millions)
Segment-3	Ghaghar RC - Thatta	N/A	N/A	N/A	N/A
Segment-4	Thatta to Wango Mor	10	1,668	1,356[*1]	3,034
Segment-5	Wango Mor to Thar Coalfield	10	1,840	1,551[*1]	3,401

Note: Fiscal Year of Pakistan start on 1st July
[*1]: expected to be increased after approval of revised PC-1 Form.

Source: JICA Survey Team

5.4.4 Schedule of the Improvement Plan

For Segment-3, it is planned to procure private sector. Design of the road improvement is also planned to be completed in 2013. Then, the commencement of construction work is expected to be in 2014, which will be completed by the end of 2015.

There are 12 contract packages for the road improvement of Segment-4 and Segment-5; between Thatta and the Thar coalfield area. Table 5.4-4 shows contents, status, and schedules of each package. All packages are expected to be completed by the end of 2014.

Table 5.4-4 Contents, Status and Schedule of Segments (as of 10 December 2012)

<table>
<tr><th>Package</th><th>Route / Major Item</th><th>Current Status</th><th>Commence -ment</th><th>Expected Completion</th></tr>
<tr><td colspan="5">Segment-3: Ghaghar RC – Thatta</td></tr>
<tr><td>-</td><td>Ghaghar RC – Thatta</td><td>Preparing of Procurement</td><td>Expected in January 2014</td><td>December 2015</td></tr>
<tr><td colspan="5">Segment-4: Thatta to Wango Mor</td></tr>
<tr><td>Pkg-1</td><td>Wango Mor to Khoski</td><td>Construction</td><td>November 2012</td><td rowspan="5">December 2014</td></tr>
<tr><td>Pkg-2</td><td>Noori village (Adjacent to Khoski) to Hassan Mangrio (near Badin)</td><td>Construction</td><td>December 2012</td></tr>
<tr><td>Pkg-3</td><td>Bhaneri (near Badin) to Goth Haji Allu (near Diwan sugar mill)</td><td rowspan="2">Bidding in Process</td><td rowspan="3">Expected in January 2013</td></tr>
<tr><td>Pkg-4</td><td>Diwan sugar mill to Pinu Baran (near Sujawal)</td></tr>
<tr><td>Pkg-5</td><td>Sujawal Bypass</td><td>Pre-Bidding</td></tr>
<tr><td colspan="5">Segment-5: Wango Mor to Thar Coalfield</td></tr>
<tr><td>Pkg-1</td><td>Wango Mor to near village Modar</td><td>Bidding in Process</td><td rowspan="6">Expected in January 2013</td><td rowspan="6">December 2014</td></tr>
<tr><td>Pkg-2</td><td>Village Dadwari Thakar to village Pasarko</td><td>Pre-Bidding</td></tr>
<tr><td>Pkg-3</td><td>Village Rohiro to Marvi petroleum Mithi</td><td rowspan="2">Bidding in Process</td></tr>
<tr><td>Pkg-4</td><td>Mithi to village Landhar</td></tr>
<tr><td>Pkg-5</td><td>Under preparation</td><td rowspan="2">Pre-Bidding</td></tr>
<tr><td>Pkg-6</td><td>Under preparation</td></tr>
</table>

Package	Route / Major Item	Current Status	Commence -ment	Expected Completion
Pkg-7	Under preparation			

Source: JICA Survey Team

5.4.5 Consideration

Upon completion of improvement of all segments, transporting very large or heavy equipment such a unit of the power plant will be possible after 2016.

5.5 Other Relevant Infrastructure

5.5.1 Thar Airport

The GoS has approved a scheme costing of Rs.972.070 million for construction of Thar Airport as shown in Photo 5.5-1. GoS has already released Rs.317.94 million to Civil Aviation Authority (CAA) and allocated Rs.654.12 million for this scheme for year 2012–2013. CAA has awarded the contract to the contractor and work for the project is in progress. About 25% progress has already been achieved. The airport would be completed by June 2013.

Photo 5.5-1 Thar Airport

5.5.2 Thar Lodge

The scheme for the construction of 20-bedroom accommodation for foreign and local investors at Islamkot has been approved with an estimated cost of Rs.40,987 million. The construction work is nearly completed (Photo 5.5-2).

Photo 5.5-2 Thar Lodge

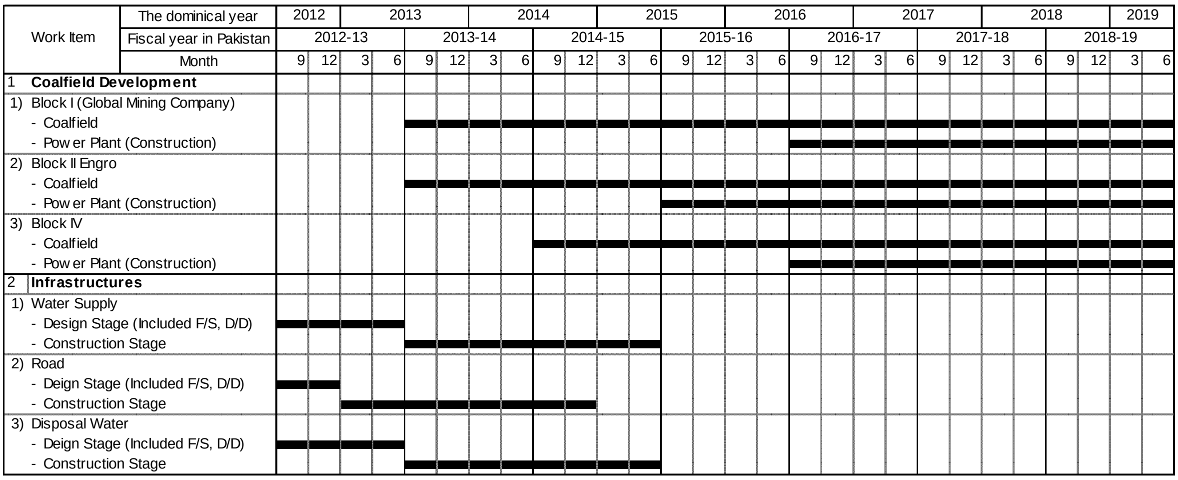
CHAPTER 6
CANDIDATE PROJECT FOR THE JAPANESE YEN LOAN

Chapter 6 Candidate Project for Japanese Yen Loan

6.1 Candidate Project for the Japanese Yen Loan

The overall development plan for the Thar coalfield by the private sector and the Government of Sindh is shown Figure 6.1-1. As noted above, development for the three blocks are carried out concretely; coal mining is scheduled to be started in the near future. Furthermore, construction of the power plant is scheduled to be started after the coal mining has commenced.

On the other hand, as there is a necessity to maintain infrastructures for water supply, effluent water disposal, and road in order to develop the coalfield and power plant, the project will be carried out steadily through the funding by the Government of Sindh. Consequently, support by the Government of Japan is not necessary at the moment.



Source: Prepared by the JICA Survey Team

Figure 6.1-1 Overall Development Plan for the Thar Coalfield

However, as for transmission line assuming a key role in Thar coalfield development, the Government of Sindh has not allocated any budget for the transmission line. NTDC is therefore strongly requesting to use Japanese yen loan.

Consequently, the candidate project for the Japanese yen loan will be the 500 kV transmission line between Thar and Matiari since support is necessary at present. In early case, it is necessary to complete the connection to the Thar coal transmission line until end of fiscal year 2018, which is the beginning time for the commissioning of the power plant

6.2 Thar - Matiari 500 kV Transmission Line Project

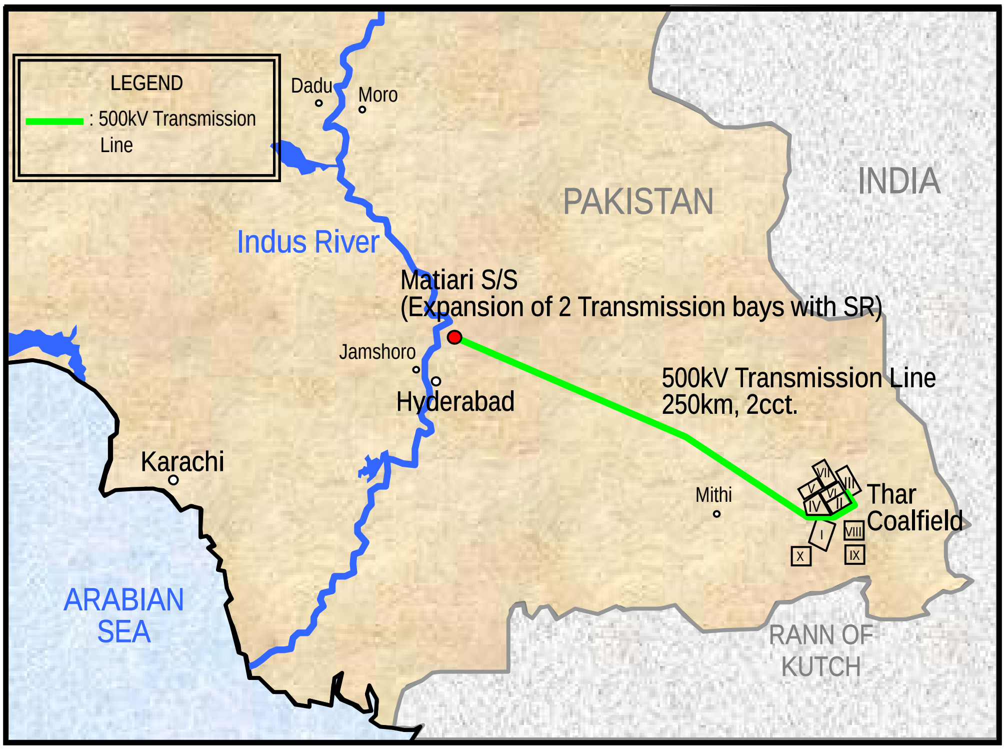
6.2.1 Summary of the Project

The 500 kV Matiari switching station for the interconnection of the 500 kV transmission line from the Thar coalfield will be completed by June 2015, as funded by ADB. Therefore, the candidate project supported by Japanese yen loan to be 500 kV transmission line between Thar and Matiari, including the expansion of Matiari switching station necessary for the incoming line from Thar. In addition, there are two alternatives for the applicable conductor of transmission line that is Araucaria of the existing plan by NTDC and low loss conductor. Summary of the project is as presented below;

Table 6.2-1 Summary of Candidate Project for Japanese Yen Loan

Description	Alternative 1	Alternative 2
1. Construction of Thar - Matiari 500 kV Transmission Line		
1) Distance, Number of Circuit	250 km, 2 cct	
2) Conductor	Araucaria(AAAC)	LL-TACSR/AS 750 mm2
2. Expansion of 500 kV Matiari Switching Station		
1) Equipment configuration	2 x 500 kV line bays along with 3 x 37 MVA shunt reactors	

Source: prepared by the JICA Survey Team



Source: Prepared by the JICA Survey Team

Figure 6.2-1 Summary of Candidate Project for Japanese Yen Loan

Photo 6.2-1 Candidate Site for Matiari S/S

Photo 6.2-2 Candidate Site for Power Plant in Block II

6.2.2 Applicability of Japan's Technique

As noted in Section 5.1.3, the initial cost will be high in case the LL conductor is adopted. However, at least 3200 MW in total will be planned to be erected by some private sector developers in the near future. As far as applicable for the Araucaria of the existing plan, it is necessary to newly construct transmission lines in order for the transmission to be stable for the above generation power.

Comparison of the construction cost in consideration of the integral plan is shown in Table 6.2-2. In consideration of the total cost, application of the LL conductor will be more economical. Consequently, utilization of the LL TASCR/AS 750 mm2 is recommended for this Japanese yen loan project.

Table 6.2-2 Comparison of Construction Cost in Consideration of Integral Plan

Unit: Rs. million

Description		Alternative1		Alternative2	
		AAAC "Araucaria"		LL-TACSR/AS 750 mm2	
1. Initial Stage (Japanese Yen Loan)					
1) Construction of 500 kV Transmission Line (D/C)		15,945.36	*3	21,041.03	*3
2) Expansion of Matiari S/S (2 line bays with SR)		1,418.34	*3	1,418.34	*3
Subtotal		17,363.70		22,459.37	
2.In the Future (For completion of the concrete development plan)					
1) Construction of 500 kV Transmission Line(S/C)		11,402.62	*4	0	
2) Expansion of Matiari S/S (1 line bay with SR)		709.17	*5	0	
3) Construction of Thar S/S (5 line bays)	*1	0		791.30	*6
4) Construction of Thar S/S (6 line bays)	*2	909.56	*6	0	
Subtotal		13,021.35		791.30	
Grand Total		**30,385.05**		**23,250.67**	

Source: Prepared by the JICA Survey Team

Note: Above project cost is based on PC-1 for interconnection of Thar coal-based 1200 MW power plant with NTDC system.
*1: Incoming line from power plants: 3 bays, To Matiari lines :2 bays
*2: Incoming line from power plants: 3 bays, To Matiari lines:3 bays
*3: These costs are referred to in Table 5.1-7.
*4: This cost is calculated based on PC-1 (S/C and tower is 70% of D/C)
*5: This cost is calculated based on PC-1 (50% of expansion of Matiari S/S)
*6: This cost is calculated based on PC-1 for Matiari S/S (Funded by ADB)

In addition, comparison of transmission line losses is shown in Table 6.2-3. The loss due to Araucaria AAAC and resistance is low, thus resistance of the conductor is not much different compared with LL-TACSR. Although it is possible to realize loss reduction, the advantage for reduction of transmission line loss is not a large value.

Table 6.2-3 Comparison of Transmission Line Loss

Transmission Capacity	Transmission Line Loss			
	AAAC “Araucaria”		LL-TACSR/AS 750mm2	
	(kWh/year)	%	(kWh/year)	%
1200 MW	40,427,891	0.64	38,989,849	0.62
2400 MW	161,885,641	1.28	157,510,967	1.26

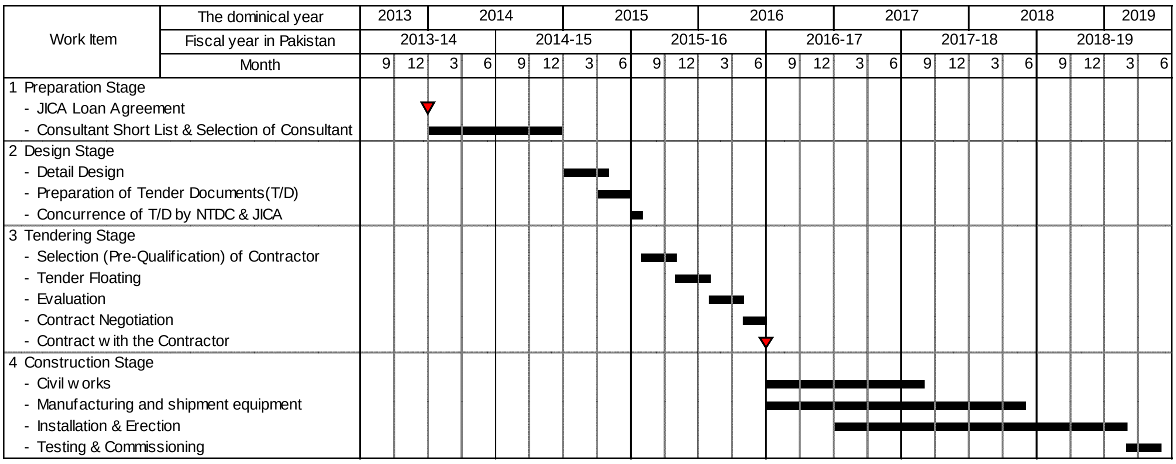
Source: Prepared by the JICA Survey Team

Note: Calculation basis is as below conditions.
Number of Circuit: 2, Power Factor:0.9, Load Factor:0.6

6.2.3 Implementation Schedule

The tentative implementation schedule of construction of the 500 kV transmission line is shown in Figure 6.2-2. The schedule was prepared assuming that the total duration of the project was estimated at 65 months from the preparation stage of the JICA loan agreement to the completion of the commissioning tests on-site.

In addition, completion of the transmission line was forecasted in November 2018. There is no obstacle in the overall plan of the coalfield development because completion can be expected before the commissioning test period of the power plant.



Source: Prepared by the JICA Survey Team

Figure 6.2-2 Implementation Schedule

6.2.4 Project Cost

The project cost for the application for Araucaria in the existing plan and LL-TACSR is shown in Table 6.2-3. Project implementation cost is revised based on PC-1, on the assumption for application of Japanese Yen loan. In addition, the eligible costs in Table 6.2-4 only correspond to the JICA-financed portion.

Table 6.2-4 Project Implementation Cost

Unit: Rs. Million

Component		Alternative 1 AAAC "Araucaria"			Alternative 2 LL-TACSR/AS 750 mm2		
		FC	LC	Total	FC	LC	Total
A. Eligible Cost:							
I) Procurement /Construction							
a.500kV Transmission Line	*1	13,399.44	1,956.91	15,356.35	17,963.68	2,250.45	20,214.13
b. 500kV Matiari S/S	*1	1,220.41	128.94	1,349.35	1,220.41	128.94	1,349.35
c. Price escalation	*2	1,253.02	513.18	1,766.20	1,644.20	585.40	2,229.60
d. Physical contingency (3%)		476.19	77.97	554.16	624.85	88.94	713.79
II) Consulting Services (2%)							
a. Base cost		286.77	61.10	347.87	376.49	73.30	449.79
c. Price escalation	*2	18.58	11.28	29.86	24.39	13.53	37.92
d. Physical contingency (3%)		9.16	2.17	11.33	12.03	2.60	14.63
B. Non-Eligible Cost:							
I) Land Acquisition							
a. Base cost		0.00	12.50	12.50	0.00	12.50	12.50
b. Price escalation	*2	0.00	1.47	1.47	0.00	1.47	1.47
c. Physical contingency (3%)		0.00	0.42	0.42	0.00	0.42	0.42
II) Administration Cost (2%)		0.00	388.59	388.59	0.00	500.47	500.47
III) VAT (16%)		0.00	440.25	440.25	0.00	502.91	502.91
IV) Import Tax (7.5%)		926.64	0.00	926.64	1,243.05	0.00	1,243.05
C. Interest during Construction							
a. Interest for Construction	*3	546.76	0.00	546.76	704.40	0.00	704.40
b. Interest for Consultant	*3	0.11	0.00	0.11	0.15	0.00	0.15
D. Commitment Charge (0.1%)		99.81	0.00	99.81	128.57	0.00	128.57
GRAND TOTAL (A + B+C+D)		**18,236.89**	**3,594.78**	**21,831.67**	**23,942.22**	**4,160.93**	**28,103.15**

Source: Prepared by the JICA Survey Team

Note: Above implementation cost is based on PC-1 for interconnection of Thar coal-based 1200-MW power plant with NTDC system.
*1: Construction cost includes cost items for the transportation and vehicles and others in the PC-1.
*2: Price escalation (FC: 2.1%, LC: 5.7%)
*3: Interests is applied for Japanese Yen loan (Construction:1.4%, Consultant:0.01%)

6.2.5 Support to Construction of Power Plants

At the present, it is assumed that construction of power plants are not necessary supported by Japan loan. However, in case it will need in the future, it is possible for support used by Japanese technology as mentioned chapter 4.

Probably, adoption of Japanese technology such as IGCC will be high cost as for initial cost, however, it is can be realized that high reliability, high efficiency and long life time of operation. Accordingly, since Japanese technology has advantage consideration of total cost, adoption of Japanese technology is recommended strongly for power plants in Thar coalfield.

In addition, environmental burden can be reduced by adoption for IGCC of high efficiency, in case of IGCC, carbon dioxide of 24% or less can be reduced compared with existing coal thermal plant.

CHAPTER 7
ENVIRONMENT AND SOCIAL CONSIDERATION

Chapter 7 Environmental and Social Consideration

7.1 Introduction

The main objectives of the survey discussed in this chapter are the environmental and social considerations for the transmission line construction project. According to the JICA Guidelines, in addition to the direct and immediate impacts of projects, the derivative, secondary and cumulative impacts as well as those associated with indivisible projects with regards to environmental and social considerations will be assessed. Therefore, the evaluation for power generation and other infrastructures (securing water for generation, sufficient water disposal, and development of roads for the transport of coal) are studied thoroughly in this Chapter.

7.2 Current Natural and Social Situation

7.2.1 General

The current situation of the natural and social environment around the Thar coalfield is confirmed by referring to the JICA Guidelines for Environmental and Social Considerations proclaimed in April 2010. Confirmation is conducted through site reconnaissance, interview with relevant authorities, and by interpreting the existing data. The major findings on the current environmental and social status are compiled hereinafter.

The Thar coalfield vicinity is covered by dune sand that extends to an average depth of over 80m. The climate in Thar Desert is semi-arid with a short monsoon period. Rainfall is often concentrated in a period of two to three days. Drought year recurs every three years. In general, annual rainfall is from 100 mm to 200 mm. The minimum annual rainfall is 24.6 mm and the maximum is 1500 mm as recorded in 1991 and 2011, respectively. Summer (mid-March to mid-June) is characterized by very hot temperatures, dry conditions, moderate wind from the southwest and low humidity. Monsoon (mid-June to mid-September) is characterized by high rainfall, high temperatures, high humidity, and high winds from the southwest. Post-monsoon summer (mid-September to mid-November) is characterized by cessation of rains and reduction in wind speed. Winter (mid-November to mid-March) is characterized by moderate temperature. The graph of average monthly rainfall and temperature is shown in Figure 2.2-7.

7.2.2 Current Status of Environmental Pollution

The environmental and social impact assessment (ESIA) report of Thar Coal Block II Mining Project by the Sindh Engro Coal Mining Company (SECMC) in September 2012 (hereinafter referred to as Thar Block II ESIA) provides the groundwater level and quality analysis data in the survey area. The communities residing in the Thar coalfield vicinity rely on rainfall and groundwater aquifers to meet their water needs. As the evaporation rate is high, very little moisture is retained in the soil. There are no perennial surface flows, hence, no systems of natural drainage lines and streams are found in the Thar Region. Water for domestic use is acquired from wells tapping the rain-fed top or quaternary aquifer. The thickness of the top aquifer varies between 4 m to 18 m and the aquifers are 30 m to 80 m below ground level.

A groundwater baseline survey, looking at the groundwater table and water quality, was conducted in the survey area. The groundwater resource survey covered 13 villages in the survey area. There are about 150 wells in these 13 villages. Of these 150 wells, 40 wells were selected for monitoring.

The analytical results of the major parameters are shown in Table 7.2-1, together with the National Environmental Quality Standards (NEQS) for drinking water. Water quality samples were obtained from the 40 wells and were analyzed for common chemical parameters and heavy metals. The results indicated that, in general, the water is unfit for human consumption. Sodium, sulfate, chlorides, and the total dissolved solids exceeded the target drinking water standards (the more stringent of the NEQS for drinking water and the World Health Organization drinking water guidelines) for almost all the wells. The total hardness in 16 of the 40 wells is above the target limits. Similarly, iron, aluminum, lead, and nickel also exceeded the target limits in several wells.

Table 7.2-1 Groundwater Quality in Thar Coalfield

Parameters	*Unit*	*NEQS* [a]	*WHO* [b]	*Target* [c]	*Min* [d]	*Max* [e]	*% Over* [f]
pH	-	6.5–8.5	6.5–8.5		7.48	8.42	
EC	µS/cm	– [g]	–		3,280	14,500	
Sodium	mg/l	–	200	200	500	2,460	100%
Magnesium	mg/l	–	–		10	240	
Calcium	mg/l	–	–		11	320	
Potassium	mg/l	–	–		9	58	
Sulfate	mg/l	–	250	250	150	712	90%
Chloride	mg/l	250	250	250	975	5,599	100%
Bicarbonate	mg/l	–	–		185	729	
Silica Dioxide	mg/l	–	–		11.2	15.4	
Hardness [h]	mg/l	500	–	500	68	1,705	40%
Sulfide	mg/l	–	–		<1.00		
Fluoride	mg/l	1.5	1.5	1.5	0.495	1.14	0%
TDS [i]	mg/l	1,000	1,000	1,000	1,996	9,584	100%
Iron	mg/l	–	0.3	0.3	0.05	0.675	15%
Aluminum	mg/l	0.2	0.2	0.2	0.075	0.28	39%
Manganese	mg/l	0.5	0.1–0.5	0.1	0.025	0.08	0%
Arsenic	mg/l	0.05	0.01	0.01	0.005	0.01	0%
Copper	mg/l	2	1 – 2	1	0	0	0%
Lead	mg/l	0.05	1	0.05	0.02	0.1	20%
Zinc	mg/l	5	3	3	0.025	0.05	0%
Cadmium	mg/l	0.01	0.003	0.003	0	0	0%
Nickel	mg/l	0.02	0.02	0.02	0.025	0.25	60%
Chromium	mg/l	0.05	0.02	0.02	0	0	0%
Cobalt	mg/l	–	–		0		
Selenium	mg/l	0.01	0.01	0.01	0	0	0%
Mercury	mg/l	0.001	0.001	0.001	0	0	0%

a National Environmental Quality Standards for Drinking Water
b World Health Organization Drinking Water Quality Guidelines
c More stringent of NEQS and WHO guidelines
d Minimum value among the 40 wells
e Maximum value among the 40 wells
f Percent of wells among the 40 wells that exceed the target limit
g Indicates that no limit has been prescribed
h Total hardness as Calcium Carbonate
i TDS is total dissolved solid

Source: Thar Block II ESIA

The Thar Block II ESIA also depicts the measurement data of air quality. Air quality sampling was carried out at five locations within the survey area. The following pollutants were selected for the monitoring program based on the expected emissions from the planned operations and the level of risk to human health posed by these pollutants: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), respirable particulate matter (PM_{10} and $PM_{2.5}$), dust deposition, and dust flux. A comparison of the results with the NEQS for the ambient air quality indicated that the nitrogen dioxide and sulfur dioxide concentrations met both IFC and NEQS limits. However, the level of PM_{10} and $PM_{2.5}$ were higher in the air due to the desert environment. The ambient air quality in Thar coalfield is shown in Table 7.2-2 below.

Table 7.2-2 Ambient Air Quality in Thar Coalfield

All values in microgram per normal cubic meter (μg/Nm^3)

Month	*Location*	*Sulfur Dioxide (SO_2)*	*Nitrogen Dioxide (NO_2)*	*Particulate Matter*	
				Less than 10 Microns (PM10)	*Less than 2.5 Microns (PM2.5)*
May	Mehari Bajeer	12.40	6.98		
	Saleh Jhanji	9.14	4.65		
	Pakistan Camp	4.49	2.39		
	Thario Halepota	a	3.23		
	Average	8.68	4.31		
June	Mehari Bajeer	5.83	2.95	138.89	13.89
	Saleh Jhanji	5.39	3.36	180.55	27.78
	Pakistan Camp	2.18	2.81	166.67	27.78
	Thario Halepota	3.37	2.22	222.22	55.55
	Average	4.19	2.84	177.08	31.25
July	Mehari Bajeer	2.99	3.31	83.33	13.89
	Saleh Jhanji	6.77	4.56	97.22	13.89
	Pakistan Camp	8.12	2.66	97.22	13.89
	Thario Halepota	1.6	2.88	111.11	27.78
	Average	4.87	3.35	97.22	17.36
Average	Mehari Bajeer	7.07	4.41	111.11	13.89
	Saleh Jhanji	7.10	4.19	138.89	20.84
	Pakistan Camp	4.93	2.62	131.95	20.84
	Thario Halepota	2.49	2.78	166.67	41.67
Overall Average		5.40	3.50	137.15	24.31
NEQS[b]		80	40	120	15

a Result discarded due to contamination
b. Maximum allowable annual concentration

Source: Thar Block II ESIA

No data on noise levels is available in the Thar Block II ESIA. However, given that the project area and its surroundings do not have any industrial base, the population density is low, and the number of vehicles is very small compared to other parts of the country, it is expected that ambient noise levels are likely to be low.

7.2.3 Current Status of Natural Environment

According to the Thar Block II ESIA, the relief in the Thar Desert varies between near sea level to more than 150 m. The sand dunes defining the topography are mostly longitudinal forming a northeast-southwest trend and are stabilized by shrubs and grass. In the inter-dunal valleys, the alluvial soil brought by rainwater is deposited in the depressions. The Thar Desert has diversified desert and semi-desert vegetation.

(1) Habitat Classification and Distribution

Habitats within the survey area were classified based primarily on geomorphology and soil texture, with considerations of variations within habitat types. The survey area is classified by geomorphological characteristics into agricultural fields, sand dunes, and plains. Agriculture fields are the dominant habitat, constituting 56% of habitats of the survey area. There is only one cropping season in the summer in which a variety of summer crops are grown. Sand dunes are the second dominant habitat, constituting 35% of the total habitat. They vary in height, ranging from a few meters to over a hundred meters. Plains constitute 9% (including 2% of the area covered by settlements) of the total habitat of the survey area. An established tradition of preservation of trees contributes to maintaining the vegetation cover in the Thar Desert. Grazing pressure, however, is significant and the ground vegetation in terms of grasses, scrubs, and bushes can be considered as uniformly degraded.

Source: JICA Survey Team

Photo 7.2-1 Typical Landscape in the Survey Area

(2) Vegetation

The flora and fauna reported in Thar Block II ESIA are based on literature research and field survey. A total of 137 plant species have been reported to be found in the Tharparkar area. None of the plant species found during the survey are neither listed under the International Union for Conservation of Nature (IUCN) Red List 2010 nor under the Pakistan legislation.

(3) Fauna

It is reported in the literature that twenty-seven species of mammals are reported to exist in the survey area. Striped hyaena (*Hyaena hyaena)* is one, which is listed in the IUCN Red List 2010 as Near Threatened. During the survey, a total of 88 bird species were observed in the area. A total of seven nests of Egyptian vulture (*Neophron percnopterus)* were identified in the survey area, five of which were empty and two were occupied. Furthermore, three empty nests were found on *Prosopis cineraria* trees, which are thought to be nests of either the white-backed vulture (*Gyps bengalensis)* or Egyptian vulture (*Neophron percnopterus).* Please refer to Photo 7.2-2. In addition, one active nest of a tawny eagle (*Aquila rapax)*, one active nest of a spotted owlet, and ten nests of an unknown bird species were also documented in the survey area.

Source: JICA Survey Team

Photo 7.2-2 Threatened Vultures in the Survey Area

Out of the 32 species of reptiles reported in the literature and likely to be found in the area, 17 were observed during the surveys conducted in the survey area. None of the species observed or reported in the area are listed in the IUCN Red List 2010.

The flora and fauna and threatened species in the survey area are shown in Table 7.2-3.

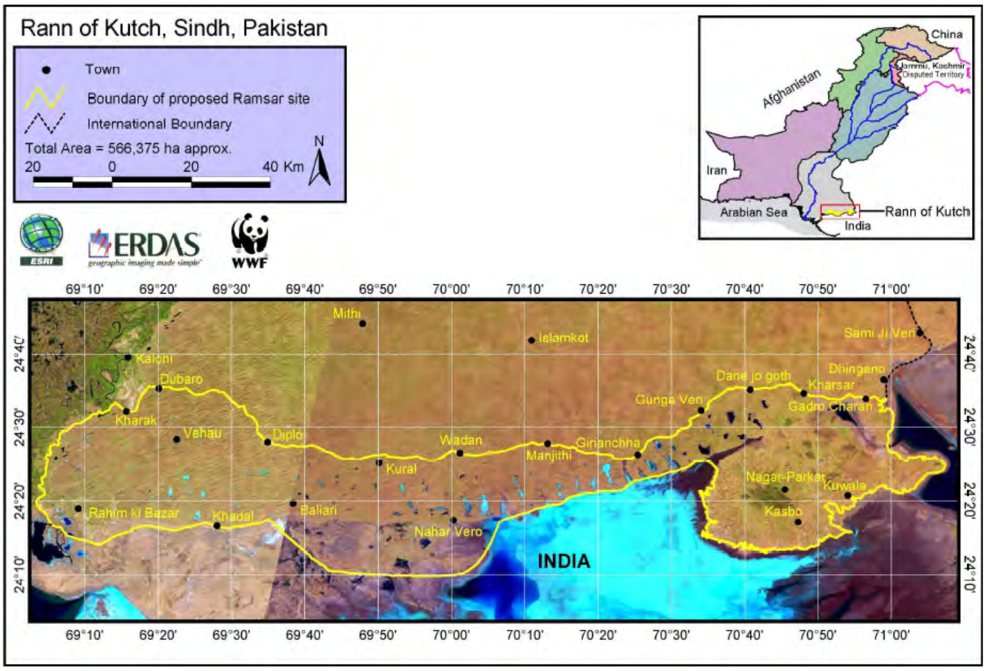
Table 7.2-3 Flora and Fauna and Threatened Species in the Survey Area

Classification		Total Number of Species	Threatened Species on Red List in the Survey Area
Flora		137	-
Fauna	Mammals	27	Striped Hyaena (*Hyaena hyaena): **NT(i) CR(p)** Asiatic Jackal (*Canis aureus*): **NT(p)** Indian Grey Wolf (*Canis lupus*): **EN(p)** Bengal Fox (*Vulpus bengalensis*): **NT(p)** Common Red Fox (*Vulpus vulpus*): **NT(p)** Indian Crested Porcupine (*Hystrix indica): **NT(p)** Balochistan Gerbil *(Gerbillus nanus):* **NT(p)** Indian Hairy-footed Gerbil (*Gerbillus gleadowi*): **NT(p)** Small Indian Civet *(Viverricula indica):* **NT(p)**
	Birds	88	Cinereous Vulture (*Aegypius monachus*): **NT(i)** Greater Spotted Eagle (*Aquila clanga*): **VU(i)** White-rumped Vulture (*Gyps bengalensis*): **CR(i)** Indian Vulture (*Gyps indicus*): **CR(i)** Slender-billed Vulture (*Gyps tenuirostris*): **CR(i)** Egyptian Vulture (*Neophron percnopterus*): **EN(i)** Laggar Falcon (*Falco jugger*): **NT(i)**
	Reptiles and Amphibians	31	-

CR: Critically Endangered, **EN**: Endangered **VU**: Vulnerable **NT**: Near Threatened
(i): IUCN 2010. IUCN Red List of Threatened Species, Version 2010.1.
(p): Pakistan's Mammals National Red List, 2006. Biodiversity Programme IUCN Pakistan
Source: JICA Survey Team based on Thar Block II ESIA

(4) Protected Area

The Rann of Kutch is the widest Ramsar site located at the south of the Thar coalfield. The Rann of Kutch and its adjoining tidal mudflats area is part of the Thar Desert. It is spread over an area of 566,375 ha and is an ideal habitat for a number of wild animals and birds of global significance. Moreover, it was declared as a wildlife sanctuary in 1980. The location map of Rann of Kutch is shown in Figure 7.2-1.



Source: Website of Ramsar Convention, http://www.wetlands.org/reports/ris/2PK019_MAP.pdf

Figure 7.2-1 Location Map of Rann of Kutch, Ramsar Site

7.2.4 Current Status of Social Environment

There are 61 villages and settlements in the survey area with a total estimated population of 55,150. Approximately 7570 live in nine villages inside Block II. The largest settlement in Block II has a population of 2000. Seasonal migration is seen in almost all of the villages.

(1) Ethno-Religious Composition

The villages in Tharparkar District have Muslim and Hindu neighbourhoods and communities of different castes. In the survey area, the population of Hindus and Muslims is 56% and 44%, respectively. Despite these socio-cultural and economic differences, social interrelationships between the Hindus and Muslims, as well as among the various caste subgroups of both religious groups, are reported to be harmonious.

(2) Infrastructure and Services

In Tharparkar District, high quality (blacktop) roads form only about 28% of the total road length. Most parts of the district are covered by telephone and mobile phone services. The towns of Mithi and Islamkot have provision shops, medical stores, internet facilities, and hotels. A weekly livestock market locally called “Mall Piri” is also held at Mithi. However, the access to postal, police, and local markets are relatively limited.

(3) Housing

The majority of the housing units in rural Tharparkar District are huts with pointed thatched roofs called *chaunras* and these are particular to the area. Over 50% of the structures in the surveyed villages were *chaunras*, while only 12% were made of pakka or masonry construction.

(4) Water Supply and Sanitation

Water supply is one of the major problems faced by villages in rural Tharparkar District. There are no rivers, and perennial springs are rare (none in the survey area). In addition, the underground water is brackish and saline and does not meet the World Health Organization (WHO) standards for drinking water. The main source of drinking water is rainwater, which is collected in traditional channels called *tarais*, underground and overhead tanks, and earthen jars. A large number of underground and overhead tanks are used in the surveyed villages to catch and store rainwater for drinking purposes.

(5) Health

The lack of adequate health facilities and low awareness on health issues in Tharparkar District is demonstrated by a high maternal mortality rate of 800 deaths per 100,000 live births in 1992. Moreover, it is shown by the high infant mortality rate (IMR) of the district in 1992 at 150 deaths per 1000 live births as compared with the national IMR rate of 100 and that for Sindh at 98. Health services are mainly provided through basic health units (BHUs), rural health centers (RHCs), and district head quarter hospitals that are equipped for primary health care services and to some extent comprehensive emergency obstetric care services. On average, villagers have to travel 24 km to access the nearest rural health center at Islamkot and 8 km to get to the nearest basic health unit.

The most common ailments reported were cholera and diarrhea in children and tuberculosis in adults, followed by influenza and malaria. It was also reported that almost all villages have been using local herbal medicines.

(6) Education

Although literacy rates in Tharparkar District are still way below those of Sindh and Pakistan, female literacy has doubled since 1998, and male literacy has also been increasing significantly. Tharparkar District fares better, nationally and provincially, in terms of net primary enrollment rate, ranking 51st out of 98 national districts and 7th out of 16 provincial districts.

(7) Livelihood

The average reported annual income per surveyed household was about Rs.150,000. Proceed from agriculture (crop farming) is the primary source of income which aggregately accounts for about half of the total household income. Overall household income from livestock sales and from out-migrant agricultural labor comes in second, jointly accounting for a quarter of the total household income. Tharparkar District has been consistently ranked as one of the most deprived districts provincially and nationally. In 2005, the provincial ranking of Tharparkar District was 15th out of the 16 districts of Sindh. In the surveyed villages, 19% of the 48 surveyed households fall below the poverty line (monthly per capita income of up to Rs. 1375). About 40% have per capita income between Rs. 1375 and Rs. 2750, while the remaining 31% of the households are economically stable.

7.3 Environmental and Social Regulatory Framework of Pakistan

7.3.1 Legal Framework for EIA

The laws, regulations, and guidelines related to the environmental and social considerations in Pakistan are reviewed. Major laws, regulations, and guidelines directly governing the EIA study for the project are listed as follows:

- Pakistan Environmental Protection Ordinance (PEPO), 1983;
- Pakistan Environmental Protection Act (PEPA), 1997;
- National Environmental Policy, 2005;
- Guidelines for the Preparation and Review of Environmental Reports, 1997;
- Guidelines for Public Consultation, 1997;
- Sector Guidelines for the Preparation of Environmental Reports;
- Pak-EPA (Review of IEE and EIA) Regulations, 2000;
- National Resettlement Policy, 2002;
- Project Implementation and Resettlement of Affected Persons Ordinance, 2001;
- The Sindh Katchi Abadis Act, 1987; and
- Sindh Public Procurement Rules, 2010.

In 1983, the Pakistan Environment Protection Ordinance (PEPO) was passed as the first substantive policy on the environment in Pakistan. This highlighted the need to have a framework of environmental laws in Pakistan in order to address emerging national issues. PEPO set three goals for the country’s environmental protection efforts, which are conservation of natural resources, promotion of sustainable development, and improvement of efficiency in the use and management of resources. Fourteen program areas were targeted for priority implementation, including energy efficiency improvements, renewable resource development/deployment, pollution prevention/reduction, waste management, institutional support of common resources, and integration of population and environmental programs. However, it is unfortunate that PEPO has remained largely unimplemented.

The Pakistan Environmental Protection Act (PEPA) was enacted on December 6, 1997, repealing the PEPO of 1983. The PEPA of 1997 provides the framework for the implementation of the National Conservation Strategy (NCS), establishment of Provincial Sustainable Development Funds, protection and conservation of species, conservation of renewable resources, establishment of environmental tribunals as well as the appointment of environmental magistrates, and framework for initial environmental examination (IEE) and environmental impact assessment (EIA).

The National Environmental Policy of 2005 provides an overarching framework for addressing the environmental issues facing Pakistan. This provides broad guidelines to the federal government, provincial government, federally administrated territories and local government for addressing environmental concerns and ensuring effective management of their environmental resources.

7.3.2 National Environmental Quality Standards

The NEQS were first promulgated in 1993 and were amended in 1995 and 2000. The following standards are specified:

- Ambient air;
- Allowable concentration of pollutions in gaseous emissions from industrial sources;
- Ambient noise; and
- Allowable concentration of pollutions in municipal and liquid industrial effluents and industrial gaseous emissions.

(1) Air Quality

Table 7.3-1 below shows the NEQS for ambient air.

Table 7.3-1 National Environmental Quality Standards for Ambient Air

Pollutant	Time-weighted Average	Concentration in Ambient Air		Method of Measurement
		Effective from July 1, 2010	Effective from January 1, 2013	
Sulfur Dioxide (SO_2)	Annual Average*	80 μg/m^3	80 μg/m^3	Ultraviolet Fluorescence Method
	24 hours**	120 μg/m^3	120 μg/m^3	
Oxides of Nitrogen (NOx)	Annual Average*	40 μg/m^3	40 μg/m^3	Gas phase chemiluminescence
	24 hours**	40 μg/m^3	40 μg/m^3	

Pollutant	Time-weighted Average	Concentration in Ambient Air		Method of Measurement
		Effective from July 1, 2010	Effective from January 1, 2013	
Nitrogen Dioxide (NO_2)	Annual Average*	40 μg/m^3	40 μg/m^3	Gas phase chemiluminescence
	24 hours**	80 μg/m^3	80 μg/m^3	
O_3	1 hour	180 μg/m^3	130 μg/m^3	Nondispersive UV absorption méthod
Suspended Particulate Matter (SPM)	Annual Average*	400 μg/m^3	360 μg/m^3	High volume sampling, (average flow rate not less than 1.1 m^3/minute)
	24 hours**	550 μg/m^3	500 μg/m^3	
Respirable Particulate Matter (PM_{10})	Annual Average*	200 μg/m^3	120 μg/m^3	B Ray absorption method
	24 hours**	250 μg/m^3	150 μg/m^3	
Respirable Particulate Matter ($PM_{2.5}$)	Annual Average*	25 μg/m^3	15 μg/m^3	B Ray absorption method
	24 hours**	40 μg/m^3	35 μg/m^3	
	1 hour	25 μg/m^3	15 μg/m^3	
Lead (Pb)	Annual Average*	1.5 μg/m^3	1 μg/m^3	ASS method after sampling using EPM 2000 or equivalent filter paper
	24 hours**	2 μg/m^3	1.5 μg/m^3	
Carbon Monoxide (CO)	8 hours**	5 mg/m^3	5 mg/m^3	Nondispersive infrared (NDIR) method
	1hour	10 mg/m^3	10 mg/m^3	
*Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24-hour at uniform interval. **24-hour/8-hourl values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.				

Source: Statutory Notification, SRO-1062(I)/2010, dated Oct 18, 2010, Ministry of Environment, Government of Pakistan.

(2) Noise

Table 7.3-2 below shows the proposed NEQS for noise.

Table 7.3-2 National Environmental Quality Standards for Ambient Noise

S. No.	Category of Area / Zone	Effective from July 1, 2010		Effective from July 1, 2012	
		Limit it in dB(A) Leq*			
		Day Time	Night Time	Day Time	Night Time
1	Residential Area (A)	65	50	55	45
2	Commercial Area (B)	70	60	65	55
3	Industrial Area (C)	80	75	75	65
4	Silence Zone (D)	55	45	50	45

Note: 1 Day time hours: 6:00 am to 10:00 p m
2 Night time hours: 10:00 p m to 6:00 p m
3 Silence zone: Zone which are declared as such by competent authority. An area comprising not less than 100 m around hospitals, educational institutions, and courts.
4 Mixed categories of areas may be declared as one of the four abovementioned categories by competent authority.

Source: Statutory Notification, SRO-1062(I)/2010, dated October 18, 2010, Ministry of Environment, Government of Pakistan.

(3) Water Quality

The NEQS for municipal and liquid industrial effluents has been established for the control of the pollution and have gone through modifications since 1993 as statutory notification by the Ministry of Environment, Local Government and Rural Development, Government of Pakistan. The standards limit the concentration of a number of quality parameters for discharge into the national waters as shown in Table 7.3-3.

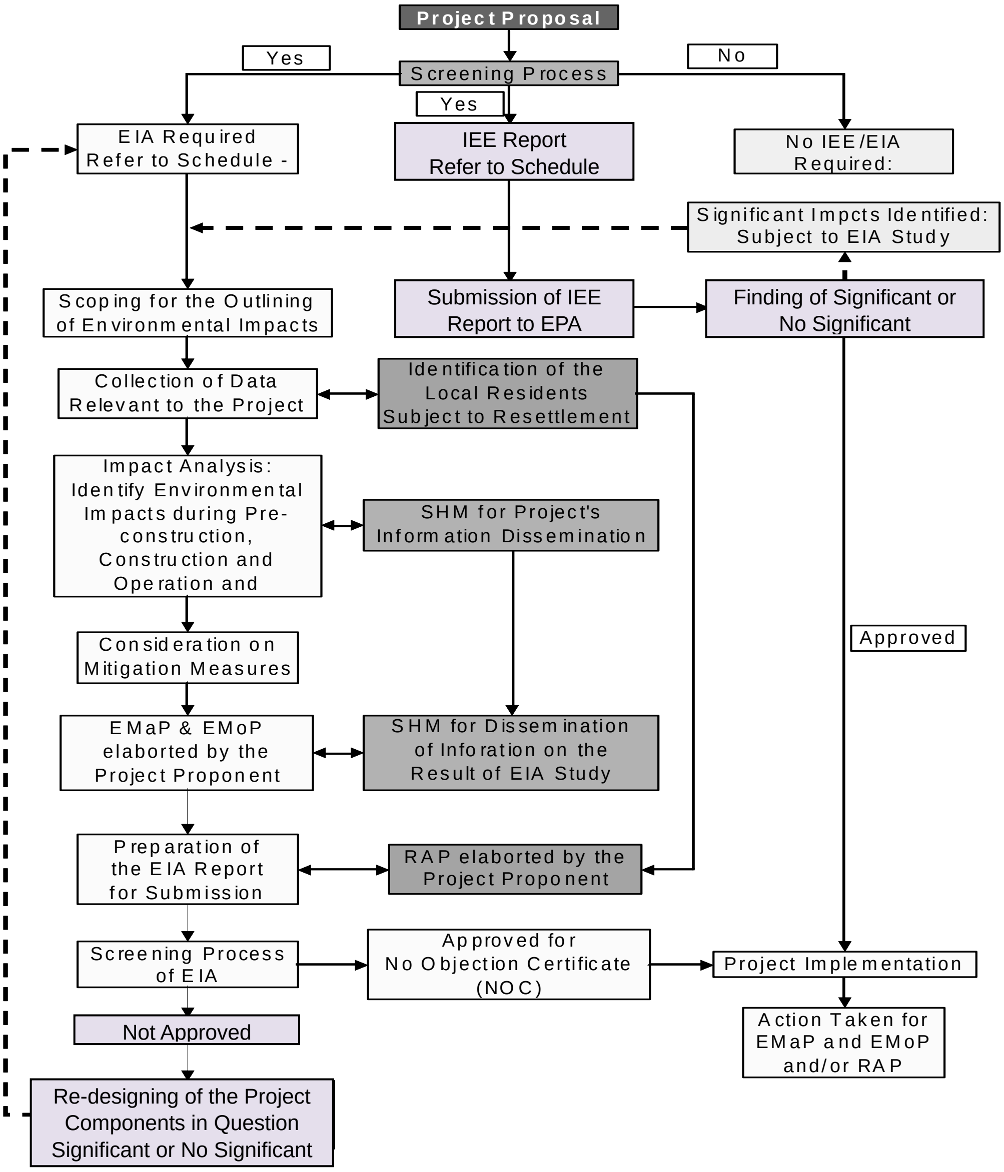
Table 7.3-3 National Environmental Quality Standards for Municipal and Liquid Industrial Effluents

S. No.	Parameter	Inland Waters	Sewage Treatment	Sea Waters	Unit
1	Temperature or Temperature Increase	<3	<3	<3	^oC
2	pH value (H^+)	6-9	6-9	6-9	
3	Biological Oxygen Demand $(BOD)_5$ at 20 ^oC	80	250	80	mg/l
4	Chemical Oxygen Demand $(COD)_{Cr}$	150	400	400	mg/l
5	Total Suspended Solids (TSS)	200	400	200	mg/l
6	Total Dissolved Solids (TDS)	3500	3500	3500	mg/l
7	Oil and Grease	10	10	10	mg/l
8	Phenolic Compounds (as Phenol)	0.1	0.3	0.3	mg/l
9	Chloride (as Cl^-)	1000	1000	SC	mg/l
10	Fluoride (as F^-)	10	10	10	mg/l
11	Cyanide (as CN^-) total	1.0	1.0	1.0	mg/l
12	An-ionic detergents (as MBAS)	20	20	20	mg/l
13	Sulphate (SO_4^{2-})	600	1000	SC	mg/l
14	Sulphide (S^{2-})	1.0	1.0	1.0	mg/l
15	Ammonia (NH_3)	40	40	40	mg/l
16	Pesticides	0.15	0.15	0.15	mg/l
17	Cadmium	0.1	0.1	0.1	mg/l
18	Chromium (trivalent and hexavalent)	1.0	1.0	1.0	mg/l
19	Copper	1.0	1.0	1.0	mg/l
20	Lead	0.5	0.5	0.5	mg/l
21	Mercury	0.01	0.01	0.01	mg/l
22	Selenium	0.5	0.5	0.5	mg/l
23	Nickel	1.0	1.0	1.0	mg/l
24	Silver	1.0	1.0	1.0	mg/l
25	Total Toxic Metals	2.0	2.0	2.0	mg/l
26	Zinc	5.0	5.0	5.0	mg/l
27	Arsenic	1.0	1.0	1.0	mg/l
28	Barium	1.5	1.5	1.5	mg/l
29	Iron	8.0	8.0	8.0	mg/l
30	Manganese	1.5	1.5	1.5	mg/l
31	Boron	6.0	6.0	6.0	mg/l
32	Chlorine	1.0	1.0	1.0	mg/l

Source: Statutory Notification, SRO-549(1)/2000, dated August 10, 2000, Ministry of Environment, Local Government and Rural Development, Government of Pakistan.

7.3.3 Environmental Impact Assessment (EIA) System

The environmental issues and their control in Pakistan are in general, governed by PEPA. The act defines the terms of environmental issues including the process on how the EIA study should be conducted. The act makes it mandatory for the project proponents to carry out IEE or EIA of development projects and incorporate environmental impact mitigation measures as part of the project planning. Figure 7.3-1 shows the EIA process in Pakistan.



Source: Modified by the JICA Survey Team based on Faisal Aslam: Environmental Impact Assessment in Pakistan – Overview, Implementation and Effectiveness, 2006

Figure 7.3-1 Environmental Impact Assessment Process in Pakistan

Pakistan EPA Review of IEE and EIA Regulations, 2000 defines and regulates the procedure of IEE and EIA for projects implemented within the borders of Pakistan. Especially, Schedule II in this regulation defines projects requiring EIA study as follows:

The projects in Schedule II are generally major projects that have the potential to affect a large number of people. They also include projects in environmentally sensitive areas. The impact of such projects may be irreversible and could lead to significant changes in land use and in the social, physical, and biological environment.

Illustrative list of sensitive sectors, characteristics, and areas in JICA Guidelines and Pakistani Guidelines is shown in Table 7.3-4.

Table 7.3-4 Illustrative List of Sensitive Sectors, Characteristics, and Areas in JICA Guidelines and Pakistani Guidelines

JICA Guidelines, 2010		**Guideline for the Preparation and Review of Environmental Reports**
1. Sensitive Sectors		
(1)	Mining, including oil and natural gas development	EIA
(2)	Oil and gas pipelines	IEE
(3)	Industrial development	IEE
(4)	Thermal power and	EIA (over 200 MW), IEE (less than 200 MW)
	Geothermal power	Not mentioned
(5)	Hydropower, dams, and reservoirs	EIA/Hydropower plant (over 50 MW) IEE/Hydropower plant (less than 50 MW)
	Dams and reservoirs	EIA/Dams and reservoirs (with a maximum storage volume greater than 50 million m^3 or surface area greater than 8 sq km); IEE/Dams and reservoirs (with a storage volume less than 50 million m^3 or surface area less than 8 sq km)
(6)	Power transmission and distribution lines involving large-scale involuntary resettlement, large-scale logging, or submarine electrical cables	EIA/Major power transmission lines (above 66 kV) including grid stations; IEE/Electrical transmission lines (11 kV or smaller) and large distribution projects
(7)	River/erosion control	Not mentioned
(8)	Roads	EIA/ Federal or provincial highways or major roads greater than Rs.50 million in value. Maintenance (rebuilding or reconstruction of existing roads is exempted from the requirement of an EIA). IEE/Federal or provincial highways (except maintenance, rebuilding or reconstruction of existing metalled roads) less than Rs.50 million in value.
	Railways	EIA/Major railway works
	Bridges	Not mentioned
(9)	Airports	EIA/ Major airport
(10)	Ports and harbors	EIA /Major ports and harbors development IEE/Ports and harbors development for ships less than 500 gross tons
(11)	Water supply that have sensitive characteristics or that are located in sensitive areas or in their vicinity	EIA/Major urban water supply infrastructure, including major head works and treatment

JICA Guidelines, 2010		Guideline for the Preparation and Review of Environmental Reports
		plants. IEE/ Minor head works and small systems
	Sewage and wastewater treatment that have sensitive characteristics or that are located in sensitive areas or in their vicinity	Not mentioned
(12)	Waste management and disposal	EIA/Waste disposal and/or storage of hazardous or toxic wastes (including landfill sites, incineration of hospital toxic waste) or waste disposal facilities for domestic or industrial wastes, where more than 10,000 m^3 of waste will be handled annually; IEE/ Waste disposal facility for domestic or industrial wastes, where less than 10,000 m^3 of waste will be handled annually.
(13)	Agriculture involving large-scale land clearing or irrigation	EIA/Irrigation and drainage serving more than 15,000 ha; IEE/Irrigation and drainage serving less than 15,000 ha or small-scale irrigation systems.
2. Sensitive Characteristics		-
(1)	Large-scale involuntary resettlement	Not mentioned
(2)	Large-scale groundwater pumping	Not mentioned
(3)	Large-scale land reclamation, land development, and land clearing	Not mentioned
(4)	Large-scale logging	Not mentioned
3. Sensitive Areas		
(1)	National parks, nationally-designated protected areas (coastal areas, wetlands, areas for ethnic minorities or indigenous peoples and cultural heritage, etc. designated by national governments)	EIA
(2)	Areas that are thought to require careful consideration by the country or locality	EIA

Source: Modified by the JICA Survey Team based on the JICA Guidelines and PEPA Regulations

7.3.4 Social Environment

(1) Resettlement Policy

The laws and regulations regarding the Resettlement Action Plan (RAP) in Pakistan are provided in the National Resettlement Policy, 2002. It does not only cover the affected persons (APs) subject to resettlement but also ensures an equitable and uniform treatment of resettlement issues. This policy defines the objectives as follows:

- Avoid or minimize adverse social impacts of a project wherever possible and where adverse impacts cannot be avoided, the mitigation measures and resettlement activities should be conceived and executed as development programs and the affected persons be provided opportunity to share the project benefits;
- APs should be provided with sufficient compensation and assistance for lost assets, that will assist them to improve or at least restore their living standards, income earning or production capacity to the pre-project level;
- Provide a development opportunity to all vulnerable groups. The vulnerable population should receive special assistance to bring them at least to a minimum living standard at par

with the pre-project level; and

- All population adversely affected by the project, should be eligible for sharing the social and economic benefits, anticipated after completion of the project.

The National Resettlement Policy, 2002 is further supplemented by the Project Implementation and Resettlement of the Affected Persons Ordinance, 2002 that has to be adopted by the state and local governments. This ordinance provides comprehensive and detailed procedures and definitions for land acquisition and resettlement of the APs.

(2) Policy on the Public Consultation

Pakistan Environmental Protection Agency has set out the Guidelines for Public Consultation in October 1997 and it defines the objectives of consultation as follows:

Public involvement is a feature of environmental assessment and can lead to better and more acceptable decision making. It can be time consuming and demanding, yet without it, proposals are seldom soundly based, and there is likely to be resentment from affected people. Public involvement, undertaken in a positive manner and supported by a real desire to use the information gained to improve the proposal, will lead to better outcomes and will lay the basis for ongoing positive relationships between the participants. The objectives of public involvement include:

a) Informing the stakeholders about what is proposed;
b) Providing an opportunity to those unrepresented to present their views and values, therefore, allowing mere sensitive consideration of mitigation measures and trade-offs;
c) Providing those involved in planning the proposal with an opportunity to ensure that the benefits of the proposal are maximized and that no major impacts have been overlooked;
d) Providing an opportunity for the public to influence project design in a positive manner;
e) Obtaining local and traditional knowledge (corrective and creative), before decision making;
f) Increasing public confidence in the proponent, reviewers, and decision makers;
g) Providing better transparency and accountability in decision making;
h) Reducing conflict through the early identification of contentious

issues, and working through these to find acceptable solutions;

i) *Increasing a sense of ownership of the proposal in the minds of the stakeholders; and*

j) *Developing proposals which are truly sustainable.*

As mentioned above, the guidelines for public consultation introduce effective ways to inform the general public of the contents of the project during the planning stage and that eventually consensus building is reached toward the implementation of the project.

Incorporating public involvement into the stages of environmental assessment is explained in the guidelines and that public consultation meetings have to be carried out after the works on developing options and assessing and mitigating impacts to obtain public comments and assessment.

7.4 Screening and Categorization of the Project

7.4.1 Transmission Line Project

According to the JICA Guidelines for Environmental and Social Considerations (JICA Guidelines), projects are classified into categories relating to the extent of environmental and social impacts, taking into account outline of the project, scale, site condition, etc. Category A, in principle, includes projects in sensitive sectors, projects that have the potential to have significant adverse environmental impacts, and projects located within or near sensitive areas. Moreover, a project causing large-scale involuntary resettlement is classified under Category A project. Proposed projects are classified as Category B if their potential adverse impacts on the environment and society are less adverse than that of Category A projects. Generally, they are site-specific; few, if any, are irreversible; and in most cases, normal mitigation measures can be designed more readily. The project is considered a major project if it has a length of 250 km and it needs the compensation for agricultural land even though it is expected to be without destruction of a natural protected area and deforestation. Therefore, according to the JICA Guidelines, the project could be classified as a Category A project.

According to the Pakistan Environmental Protection Agency Regulation, 2000, a proponent of a project falling in any category listed in Schedule A shall file an EIA with the Federal Agency. Since the listed projects are generally major national projects and that they will cause potential effect on a large number of people, the transmission line project is expected to be classified in the “transmission lines (11 kV and above) and grid station” in Schedule II. The Project needs to comply with the official procedure for EIA approval prescribed in the Pakistan legislation. Therefore, it is suggested that the transmission line project, as the project proponent, must follow the necessary steps on the EIA before the implementation of the project.

It is expected presently that the project needs compensation for agricultural land and doesn’t need resettlements. However it has a length of 250 km and there are many villages around the project area. It might have possibilities of in-migrants to the project are in future. Therefore it is necessary to check the status of villages as the project progresses.

7.4.2 Other Indivisible Projects

According to the JICA Guidelines and PEPA Regulations, results of the screening and categorization of indivisible projects are shown in Table 7.4-1. These projects are not supported directly by JICA. However JICA defines the follow projects as the indivisible projects. Other projects must not be conducted if without the project supported by JICA: and the project supported by JICA does not have feasibility if without other projects. The transmission line project doesn't have feasibility if without coal mining projects, the thermal power generation projects, and the other infrastructure projects. Hence these projects should be considered as indivisible projects.

Table7.4-1 Screening and Categorization of Indivisible Projects

Projects	Categories by JICA Guideline, 2010 Appendix3		PEPA (Review of IEE and EIA) Regulations, 2000	
Coal Mining Projects	A	Sensitive Sector	EIA	
Thermal Power Generation	A	Sensitive Sector	EIA	1,200MW (over 200MW)
Road Project	A	Sensitive Sector	EIA	Federal or provincial highways or major roads greater than Rs. **50 million** in value.
Water supply	A	Sensitive Sector	EIA	Major urban water supply infrastructure, including major head works and treatment plants.
Sufficient Water Disposal	A	Sensitive Sector (as a reservoir)	IEE	Dams and reservoirs with a storage volume less than 50 million m^3 or surface area less than **8 sq km**)

Source: JICA Survey Team based on JICA Guidelines and PEPA Regulations

7.5 Scoping of the Environmental Impacts

7.5.1 Transmission Line Project

Preliminary scoping of environmental and social impacts of the transmission line project are shown in Table 7.5-1 below.

Table 7.5-1 Preliminary Scoping of Environmental and Social Impacts of the Transmission Line Project

Item	Pre-Construction / Construction Stage	Operation Stage	Description
Pollution control			
1. Air Pollution	B-	D	Some negative impacts on air quality are expected due to the operation of heavy equipment/vehicles as well as traffic incidental to construction works, although the expected impacts will be temporary during the construction stage.
2. Water Pollution	C	D	Some impacts on groundwater quality would be caused by the turbid water generated from construction yards of drilling works during construction stage. However, the expected impacts would be insignificant since groundwater level is deeper than the depth of excavation.
3. Soil Contamination	C	D	There are no project components or activities which could cause soil pollution. However, in case the soil at the construction sites is already contaminated due to other reasons, the construction activities of the project may cause negative impacts.
4. Solid Waste and/or Industrial Discharge	C-	D	It is expected that the project will generate construction waste during the construction stage. The solid waste from the construction works will be managed according to the concerned Pakistani regulations and guidelines, therefore, it is not expected to cause serious impacts.
5. Noise and Vibration	B-	D	Various impacts of noise and vibration are expected due to the operation of heavy equipment/vehicles, although the expected impacts will be temporary during the construction stage.
6. Ground Subsidence	D	D	There are no project components or activities that may cause negative impacts on ground subsidence since groundwater level is deeper than the depth of excavation.
7. Odor	D	D	There are no project components or activities that may generate foul or offensive odor.
8. Bottom Sediment	D	D	There are no project components or activities that may cause negative impacts on bottom water sediments to which aquatic life depends.
Natural Environment			
9. Geographical Conditions and Geological Conditions	D	D	There are no project components or activities that may cause negative impacts on the geographical and geological conditions, since earthwork volume is small.
10. Soil Erosion	D	D	There are no project components or activities that may cause negative impacts on soil erosion, since earthwork

Item	Pre-Construction / Construction Stage	Operation Stage	Description
			volume is small.
11. Flora	C	D	Some negative impacts on flora might be expected due to cutting of threatened vegetation during the construction stage.
12. Fauna	C	C	Some negative impacts on fauna might be expected due to cutting of trees which have nests of threatened vultures in breeding season during the construction stage. Bird strikes of vultures on electric transmission lines might be expected during the operational stage.
13. Ground Water	D	D	There are no project components or activities that may cause negative impacts on the ground subsidence since groundwater level is deeper than the depth of excavation.
14. Water Body (River, Lakes, etc.)	D	D	There is no project component or activity, which would cause significant change or impacts on hydrological conditions within and around the project area.
15. Natural/Ecological Reserves and Sanctuaries	D	D	There are no natural/ecological reserves and sanctuaries within and around the project area.
Social Environment			
16.Involuntary Resettlement	B-	D	The project is proposed to be far from residential areas. However, land acquisition is needed since there are agricultural land in the project area
17 Local Economies (employment, livelihood, etc.)	B+	D	Some positive effects on the local economy is expected because of possible increment on business/employment opportunities generated by the project implementation.
18. Water Rights	D	D	No impact on water use or water rights is expected due to the project implementation.
21. Land Use and Utilization of Local Resources	B-	B-	Some negative impacts on land use and utilization of local resources are expected due to construction works during the construction stage and the existence of facilities during operational stage.
22. Social Institutions and Community	D	D	No impact on social institutions and the community is expected since there is no significant part of the local community would be affected by the project.
23. Existing Social Infrastructures and Services	B-	D	Some negative impacts on the existing traffic conditions are expected due to traffic congestions that will be caused by the construction activities, although the expected impacts will be temporary during the construction stage.
24. Poor, Indigenous, or Ethnic People	D	D	No impact on poor indigenous or ethnic people is expected because of the characteristics of the transmission line project.
25.Misdistribution of Benefits and Damages	D	D	No impact on misdistribution of benefits and damages is expected because of the characteristics of the transmission line project.
26. Local conflicts of Interest	D	D	No impact on local conflicts of interest is expected because of the characteristics of the transmission line project.
27. Gender and Children's Rights	D	D	No impact on gender and children's rights is expected because of the characteristics of the transmission line

Item	Pre-Construction / Construction Stage	Operation Stage	Description
			project.
28. Cultural Heritage	D	D	There are no project components or activities that may cause negative impacts on cultural heritage.
29.Landscape	B-	B-	As a result of the construction and existence of the transmission line, the semi-desert and agricultural landscape would be changed.
30. Infectious Diseases such as HIV/AIDS	B-	D	During construction, increments of risks on infectious diseases among the construction workforce are probably expected.
31. Working Conditions (including occupational safety)	B-	B-	Increment of risks on traffic safety is expected due to the operation of heavy equipment and heavy vehicles during the construction stage. Increment of risks on electric safety is expected due to the electrical works during the operational stage.
Others			
32. Accident and Hazards	B-	D	There are possible accidents and hazards due to the operation of heavy equipment and vehicles during construction, although the project does not require special methods of construction.
33. Global Warming	B-	B+	The possibility of increased greenhouse gas (GHG) emissions is expected due to the operation of heavy equipment and vehicles as well as traffic congestion incidental to the construction works, although the expected probability will be temporary during the construction stage. It is expected that the GHG emissions would be reduced due to the low electrical power loss system.

Rating

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progress)

D: No impact is expected

Reference: Appendix 5 of JICA Guidelines for Environmental and Social Considerations (April 2010)

Source: JICA Survey Team

7.5.2 Other Indivisible Projects

Preliminary scoping of environmental and social impacts of other indivisible projects is shown in Appendix 7-1. The scoping done is very rough and preliminary since the detailed plans and mitigation measures of each project are still unknown. Therefore, the rating was conducted based on the general characteristics of each project.

The Sino-Sindoh Resources has completed the ESIA of the Thar Coal Block I Mining Project while the ESIA of Thar Coal Block II Mining Project by the SECMC based on Pakistani laws is in progress. According to these reports, the environmental and social impact assessments, mitigation measures for each impact, stakeholders' consultation, and environmental management plan including monitoring plan were examined appropriately.

In addition, the Strategic Environmental and Social Assessment (SESA) by GoS is also underway. The SESA study entitled "Environmental and Social Studies including Resettlement Frameworks, Land Use Plan for Thar Coal Fields" comprised two components namely; i) Environmental and Social studies and ii) Land Use Plan.

The objective of component I, "Environment and Social Studies" that will be carried out over 22,000 sq km in Tharparkar District and adjacent areas of the coalfield which could be affected, is to ensure that there is a basis for measuring and determining the positive and negative impacts of mining, power generation, transmission, and associated activities on the environment, people and their livelihoods, and cultural heritage of the Thar coalfield vicinity.

The objective of component II is to develop appropriate mitigation mechanisms for the environment as well as the social aspects of mining, power generation, and associated activities, and integrates them into the planning and development phase of the future mining and power projects. The implementation of these provisions will (i) minimize the adverse effects of the development on the environment and people, and to make this development sustainable, and (ii) comply with internationally applicable good practices (e.g. Equator Principles) for environmental and social sustainability to attract international investors for the future development projects in Thar coalfield.

CHAPTER 8
FINANCIAL AND ECONOMIC ANALYSES

CHAPTER 8 FINANCIAL AND ECONOMIC ANALYSES

8.1 Objectives and Methodology of the Financial and Economic Analyses

The financial and economic analyses aim to examine the viability of the projects (both 1,200MW coal fired thermal power plant and construction of 500 kV, 250km transmission line) by calculating the internal rate of return (IRR) and the net present value (NPV).

8.1.1 Financial Analysis

Financial analysis is conducted to evaluate the profitability of the respective projects from the viewpoint of the implementing organization (Engro Powergen for the generation project and NTDC for the transmission project). To obtain the financial internal rate of return (FIRR) and the financial net present value (FNPV), net benefit of the project is derived considering 1) the benefits i.e., incremental revenue of tariff from the generation project and use of system charge (UoSC) of transmission line and 2) the cost based on the market price.

As there are two alternatives for the transmission projects, financial analysis is conducted for each.

Table 8.1-1 Financial Analysis for the Generation and Transmission Projects

Project	Financial Analysis
Generation	Generation
Transmission	Alternative 1
	Alternative 2

Source: JICA Survey Team

Financial cost excludes price contingencies, interest during construction (IDC), and other financial charges against the project cost. FIRR and FNPV are calculated based on the cash flow before tax and interest payments.

8.1.2 Economic Analysis

Economic analysis is conducted to evaluate the viability of the project from the viewpoint of the national economy. To obtain the economic internal rate of return (EIRR) and the economic net present value (ENPV), the benefit of the project is derived considering 1) the increased benefit based on the saved cost by replacing alternative energy sources (e.g., diesel generators) and 2) the economic costs.

The transmission project alone cannot bring about the expected economic benefit as the transmission line cannot transmit electricity without electricity generated by a power plant. Therefore, economic analysis is conducted by comparing 1) the combined economic cost of both generation and transmission projects and 2) the economic benefit calculated based on the saved cost from alternative energy sources.

Table 8.1-2 Economic Analysis for the Generation and Transmission Projects

Item	Remark
Economic Cost	1. Economic cost of the generation project 2. Economic cost of the transmission project
Economic Benefit	1. Economic benefit by saving the alternative energy sources due to the incremental net generation
Net Economic Benefit	Net economic benefit is calculated by subtracting the economic cost from the economic benefit.

Source: JICA Survey Team

Note: Consumption of 1) auxiliary consumption and 2) transmission and distribution loss is deducted from the gross amount of generation, as the saving is calculated based on the electricity received by the consumers.

In the EIRR and ENPV calculation, the cost of the project is converted to economic cost in order to evaluate the actual cost for the national economy. In this regard, transfer payment within the national economy (e.g., tax) is excluded from the calculation as it is neither a benefit nor a cost for the country.

8.1.3 Methodology

The cash flow of the project is prepared to calculate the IRR and NPV. These figures are calculated based on the following formula. The IRR is equal to the discount rate that results in zero NPV. For the calculation of the NPV, a predetermined discount rate is used.

$$\sum_{t=1}^{n}\left\{(B-C)_t \div (1+r)^t\right\}=0$$

Where, C=cost, B=Benefit, t=*t*th year (1,2,3…n), n=project life, r=internal rate of return

For the calculation of both the IRR and NPV, two cases namely, “with project” and “without project”, are normally considered to determine the net incremental benefit and cost. However, the incremental benefit of “without project” is not taken into account in this analysis as there is no assumed significant foregone benefit due to the project (e.g., revenue from agricultural products coming from the project site).

8.2 Assumptions used in the Financial and Economic Analysis

This section lists and describes the assumptions that are used for calculating IRR and NPV.

8.2.1 Project Life, Salvage Value, and Price Base

Both generation and transmission projects are assumed to have a useful economic life of 40 years after the completion of construction.[1] At the end of the economic life, the projects are assumed to have no salvage value. Benefits and costs are expressed in terms of 2012

[1] The assumption of project life is same as that used in NTDC, “Proforma PC-1: Interconnection of Thar Coal Based 1200 MW Engro Power Plant with NTDC System”, February 2012.

constant prices.

8.2.2 Physical Contingency and Price Escalation

Physical contingency is defined as the monetary value of additional resources that may be needed beyond the base cost to complete the projects. It is estimated as a percentage of the base cost. Physical contingency generally varies, depending on the source of the base cost. In the analysis, the base costs are assumed to be 5% and 3% for the generation and transmission projects, respectively.

Price escalation allows for any fluctuation in the foreign exchange and commodity price, between the time of the cost estimate and loan approval. Price escalations are assumed at 2.1% and 5.7% for foreign cost and local cost, respectively.

Price escalation is excluded from the financial and economic analysis due to the uncertainty of price fluctuations in the future and the assumption on the application of the 2012 constant price.

8.2.3 Tariff

The tariff of Thar coal thermal power plant is assumed to be based on 1) the capacity charge (fixed charge) and 2) the energy charge (variable charge), which is calculated based on the formula of calculating the tariff of thermal power plants, as shown in Table 8.2-1. The NTDC's report[2] states that the variation in power/energy cost imposed by the government is treated as "pass-through" item and is transferred to the electricity consumers.[3] Therefore, it is assumed in the financial analysis that the revenue from the energy charge offsets the cost of coal and water used for the generation.[4]

Table 8.2-1 Assumptions on Tariff of Coal Thermal Power Plant (Unit: Rs./kWh)

	Capacity Charge	Energy Charge
1st-10th year	4.262	5.349
From 11th year	2.173	5.349

Source: JICA Survey Team

The use of system charge (UoSC) of transmission line is assumed to be Rs.100.15/kW/month based on the current tariff.

[2] NTDC, "Proforma PC-1: Interconnection of Thar Coal Based 1200 MW Engro Power Plant with NTDC System", February 2012.

[3] According to NEPRA's notice of hearing advertised in the newspaper, the energy charge consists of 1) fuel cost and 2) variable operation and maintenance cost, and fuel is a pass-through item.

[4] Water is treated as part of fuel and not included in the cost of financial and economic analyses. This treatment is same as that in the study of other similar projects. Economic analysis treats the tariff differently from the financial analysis. See "8.5.2 Economic Benefit" for more details.

8.2.4 Operation and Maintenance (O&M) Cost

The O&M cost for the generation project is not included in the cost in the analysis, as it is regarded as "pass through" item, which is automatically reflected in the energy charge. However, overhaul cost (fixed O&M cost) of approximately Rs.16 million is added every five years after the completion of construction.

The O&M cost for the transmission line is assumed to be 2% of the capital cost.

8.2.5 Conversion Factor

The standard conversion factor (SCF) is an indicator to estimate the level of distortion in the market due to policies, duties, or subsidies of the government. The SCF is applied in the economic analysis when the local cost, which is assumed to be distorted, is to be converted into the economic cost in order to eliminate distortion.

The SCF is calculated as 0.97 based on the following formula, and figures from the recent terms of trade and duties.[5] As shown in Table 8.2-2, this figure is nearly equal to one. It can be concluded that there is not much distortion in the prices of commodities.

SCF= [Import (CIF) + Export (FOB)] / [(Import + Import Duty) + (Export + Export Tax - Export Subsidy)]

Table 8.2-2 Terms of Trade (Unit: Rs. million)

Import	Export	Import Duty	Export Tax	Export Subsidy
2,910,990	1,640,928	164,900	0	0

Source: Pakistan Statistical Year Book 2011, 9.1 Foreign Trade, 18.1 Revenue Receipts of the Federal Government

Regarding labor cost, it is assumed that there are no significant distortions in the wage of skilled labor. However, in the case of unskilled labor, underemployment exists in Pakistan.

Monthly minimum wages in Pakistan are recommended by the federal government under the labour policies and set by the provincial minimum wages boards under the Minimum Wages Ordinance, 1961. Pakistan's first minimum wage was introduced in 1992 when it was set at Rs.1500 per month. Then, it was set at Rs.4000 in 2006 and Rs.7000 in 2010.

Table 8.2-3 below shows that a significant number of workers are working below the 2001 minimum wage.

Table 8.2-3 Percentage of Wage Earners Earning below the Minimum Wage of 2001 (Rs.2,500 per month)

Year	Regular Worker	Non-regular Worker	All Workers
1997/98	11.6	32.7	18.0
2001/02	14.7	43.0	29.4
2003/04	14.1	39.2	25.8

Source: Dr. Mohammad Irfa, "Pakistan's Wage Structure during 1990/01-2006/07", December 2008, p.29

[5] The standard conversion factor of 0.91 was applied in ADB's "Report and Recommendation of the President to the Board of Directors: Proposed Loan Patrind Hydropower Project (Pakistan)" September 2011. SCF of 0.97 in this report can be regarded as reasonable figure, considering the figure of the ADB's recent report.

The figures in the above table implied that the opportunity cost of unskilled labor is likely to be less than the minimum wage rate.

Table 8.2-4 Monthly Wages of Regular and All Workers by Type of Enterprise 2003-04 (Unit: Rs./month)

	All Workers	Regular Workers
Government	6,585	6,656
Formal	4,501	5,596
Informal	2,875	3,027

Source: Dr. Mohammad Irfa, "Pakistan's Wage Structure during 1990/01-2006/07", December 2008, p.9

The average wage of workers in the informal sector is nearly half of that of the formal sector as shown in Table 8.2-4 above. Therefore, a conversion factor of 0.5 is applied to the cost of unskilled labor when it is converted to economic cost.

Cost of unskilled labor is assumed to share 30% of the local cost portion of procurement and construction. As a result of the calculation, the conversion factor of the local cost of procurement and construction is 0.829 as shown in Table 8.2-5.

Table 8.2-5 Calculation of Conversion Factor on Local Cost of Procurement and Construction

Item	% of Local Cost	Conversion Factor	Weighted Average
Unskilled labor	30%	0.5	0.15
Other items	70%	0.97	0.679
		Total	**0.829**

Source: JICA Survey Team

8.2.6 Cut-off Rate

The cut-off rate is used as a deciding factor whether the project is viable from the viewpoint of the implementing organization and the national economy, by comparing it with FIRR and EIRR, respectively.

In principle, the cut-off rate adopted in the financial analysis is calculated based on the concept of opportunity cost of capital. However, the interest rate of the loan to the implementing organizations is not equal to the opportunity cost of capital. The recent interest rate of the treasury bill of Pakistan, which is regarded as the opportunity cost of capital, is approximately 10% at present as shown in Table 8.2-6. In this report, the cut-off rate of 12%, not 10% is used to determine the viability of the project in terms of the FIRR. It is also used as the discount rate for calculating the FNPV in order to make the calculation of IRR and NPV conservative and to comply with other studies of similar projects, which used 12% as a discount rate.

Table 8.2-6 Cut-off Yield of the Treasury Bills

Treasury Bill	Weighted Average Rate
3 months	9.2754%
6 months	9.2962%
12 months	9.3631%

Source: State Bank of Pakistan, auction as of December 12, 2012, http://www.sbp.org.pk/departments/stats/NDSP.htm#b

The Asian Development Bank (ADB) used 10%-12% as the social discount rate for the economic analysis, and such rate is regarded as the social opportunity cost of capital in Pakistan.[6]

Although it is difficult to find a theoretical justification for the social discount rate used by development partners, a rate of 12% is applied for the calculation of EIRR as this is being adopted by major international financial institutions.

8.2.7 Auxiliary Consumption and Transmission and Distribution Loss

The percentage of auxiliary consumption of a coal fired thermal power plant is assumed to be 5% of the total amount of generation.

Transmission losses of 0.64% and 0.62% are applied to Alternative 1(AAAC “Araucaria”) and Alternative 2 (LL-TACSR), respectively.

From the recent figure of Electricity Marketing Data, 18.5% of distribution loss is applied to calculate the net incremental generation and benefit in the economic analysis.[7]

8.2.8 Use of Water and Coal for Generation

Thar coal fired thermal power plant uses water and coal for generation. As the energy charge (variable charge) is assumed to be decided on cost-plus basis, the costs of water and coal are regarded as “pass-through” items in the financial analysis. Based on this assumption, both the costs of water and coal, and the revenue of energy charge are assumed to be balanced and are not excluded from the calculation for financial analysis.

On the other hand, in the economic analysis, water is assumed to have no opportunity cost and is zero cost. Economic cost of Thar coal is assumed to be US$25 per ton, which is much lower than the expected domestic sales price, since the value of the coal produced in Indonesia with the similar quality is priced at this level.

The economic cost of coal per kWh is calculated by using the same formula used in Table 2.5-4.

[6] ADB, Report and Recommendation of the President to the Board of Directors: Proposed Loan Patrind Hydropower Project (Pakistan), September 2011

[7] Electricity Marketing Data 36th Issue, “Statistics at Glance: PEPCO (Public and Private)”, June 2011

Table 8.2-7 Calculation of Economic Price of Coal

	Item	Formula		Unit
a	Caloric value (Block II)		3,212	kcal/kg
b			0.252	kcal/Btu
c		a/b	12,746	Btu/kg
d			3,412	Btu/kWh
e	Net thermal efficiency		37.0%	
f	Heat rate	d/e	9,222	Btu/kW
g	Coal cost per ton (US$)		25	US$/ton
h	Coal cost per kWh (US¢)	g/1000*f/c*100	1.809	US¢/kWh
i	Coal cost per kWh (Rs.)	h/j	2.057	Rs./kWh
j	Exchange rate		88	Rs./US$

Source: JICA Survey Team

Note: Coal cost per ton is free-on-board (FOB) price and does not include the cost such as insurance and freight as coal is valued at the border price as the tradable goods.

8.3 Identification and Quantification of Financial and Economic Costs

Financial and economic costs are identified and quantified based on the estimation of project costs. Financial costs and economic costs are used for calculating FIRR/FNPV and EIRR/ENPV, respectively.

8.3.1 Financial Cost

The financial cost is derived from the project cost, which is indicated in the estimation of project costs. Financial cost consists of 1) initial investment cost and 2) O&M cost.

Project cost includes procurement and construction cost, inland transportation, consulting services, and physical and price contingencies. On the other hand, financial cost is used to estimate the performance of the project from the viewpoint of the implementing organization, and excludes price escalation and interest during construction (IDC).

Table 8.3-1 Financial Cost of the Generation Project upon Completion of Construction (Unit: Rs. million)

Items	**Financial Cost**		
	F/C	L/C	Total
Construction & procurement	125,434	45,470	170,904
Price escalation	0	0	0
Physical contingency	6,963	2,961	9,923
IDC/commitment charge	0	0	0
Consulting services	1,251	506	1,757
Total: Eligible Portion	133,647	48,937	182,584
Total: Non-eligible Portion	0	42,665	42,665
Grand Total	133,647	91,603	225,249

Note: The total cost may not match due to rounding. This principle on rounding is applicable to all the tables on costs and benefits.
Source: JICA Survey Team

Table 8.3-2 Financial Cost of the Transmission Project upon Completion of Construction (Unit: Rs. million)

Items	Alternative1			Alternative 2		
	F/C	L/C	Total	F/C	L/C	Total
Construction & procurement	14,620	2,086	16,706	19,446	2,407	21,853
Price escalation	0	0	0	0	0	0
Physical contingency	479	78	557	638	90	728
IDC/commitment charge	0	0	0	0	0	0
Consulting services	287	61	348	382	74	456
Total: Eligible Portion	15,386	2,225	17,611	20,465	2,571	23,036
Total: Non-eligible Portion	927	821	1,748	1,262	1,005	2,267
Grand Total	16,313	3,046	19,359	21,727	3,576	25,304

Source: JICA Survey Team

Table 8.3-3 Annual Allocation of Financial Cost (Generation) (Unit: Rs. million)

Year	Financial Cost		
	F/C	L/C	Total
Year 1	198	70	268
Year 2	171	91	263
Year 3	20,034	13,751	33,785
Year 4	39,923	27,411	67,334
Year 5	53,228	36,523	89,751
Year 6	20,093	13,757	33,850
Total	**133,647**	**91,603**	**225,249**

Source: JICA Survey Team

Table 8.3-4 Annual Allocation of Financial Cost (Transmission) (Unit: Rs. million)

Year	Alternative 1			Alternative 2		
	F/C	F/C	L/C	Total	L/C	Total
Year 1	89	18	107	118	22	140
Year 2	4,017	759	4,776	5,349	890	6,239
Year 3	5,050	908	5,957	6,731	1,065	7,797
Year 4	4,864	908	5,772	6,479	1,065	7,544
Year 5	2,293	454	2,747	3,050	533	3,583
Total	**16,313**	**3,046**	**19,359**	**21,727**	**3,576**	**25,304**

Source: JICA Survey Team

8.3.2 Economic Cost

Economic cost is derived from the project cost, which is indicated in the estimation of project cost. Costs of project items in local currency are converted to economic costs by applying the corresponding conversion factors. Costs of items that are already at border price need not be adjusted.

Economic cost is used to estimate the performance of the project from the viewpoint of national economy, and excludes price escalation, duty and taxes, and IDC. Duty and taxes are excluded from the economic cost as they are transfer payments within the economy of a country and are not real cost to the national economy.

As mentioned earlier, economic analysis is conducted by combining the cost of generation and transmission projects and comparing it with the economic benefit from the saved cost of alternative energy source.

Table 8.3-5 Economic Cost of the Project upon Completion of Construction (Generation and Transmission Alternative 1)

(Unit: Rs. million)

Items	**Generation**			**Transmission Alternative 1**		
	F/C	L/C	Total	F/C	L/C	Total
Construction & procurement	125,434	37,695	163,128	14,620	1,729	16,349
Price escalation	0	0	0	0	0	0
Physical contingency	6,963	2,872	9,834	479	76	555
IDC/commitment charge	0	0	0	0	0	0
Consulting services	1,251	491	1,742	287	59	346
Total: Eligible Portion	133,647	41,058	174,705	15,386	1,864	17,250
Total: Non-eligible Portion	0	2,021	2,021	0	383	383
Grand Total	133,647	43,079	176,726	15,386	2,248	17,634

Source: JICA Survey Team

Table 8.3-6 Economic Cost of the Project upon Completion of Construction (Generation and Transmission Alternative 2)

(Unit: Rs. million)

Items	**Generation**			**Transmission Alternative 2**		
	F/C	L/C	Total	F/C	L/C	Total
Construction & procurement	125,434	37,695	163,128	19,446	1,995	21,441
Price escalation	0	0	0	0	0	0
Physical contingency	6,963	2,872	9,834	638	87	725
IDC/commitment charge	0	0	0	0	59	59
Consulting services	1,251	491	1,742	382	72	454
Total: Eligible Portion	133,647	41,058	174,705	20,465	2,155	22,620
Total: Non-eligible Portion	0	2,021	2,021	0	497	497
Grand Total	133,647	43,079	176,726	20,465	2,652	23,117

Source: JICA Survey Team

Table 8.3-7 Annual Allocation of Economic Cost (Generation and Transmission Alternative 1) (Unit: Rs. million)

Year	**Generation**	**Transmission Alternative 1**	**Total**
Year 1	266	107	372
Year 2	260	4,391	4,651
Year 3	26,506	5,255	31,761
Year 4	52,779	5,255	58,033
Year 5	70,345	2,627	72,972
Year 6	26,571	0	26,571
Total	**176,726**	**17,634**	**194,360**

Source: JICA Survey Team

Table 8.3-8 Annual Allocation of Economic Cost (Generation and Transmission Alternative 2) (Unit: Rs. million)

Year	**Generation**	**Transmission Alternative 2**	**Total**
Year 1	266	140	405
Year 2	260	5,756	6,016
Year 3	26,506	6,888	33,395
Year 4	52,779	6,888	59,667
Year 5	70,345	3,444	73,789
Year 6	26,571	0	26,571
Total	**176,726**	**23,117**	**199,843**

Source: JICA Survey Team

8.4 Identification and Quantification of Financial and Economic Benefits

Financial and economic benefits are identified and quantified in this section. These benefits are derived from the 1) incremental generation from a coal thermal power plant and 2) transmission of electricity, which will be achieved through the implementation of the project.

Firstly, the calculation methodology of incremental generation and transmission will be explained.

Secondly, the financial benefits are quantified based on 1) incremental power generation and incremental revenue by selling electricity to NTDC for the generation project and 2) incremental transmission and incremental revenue by transmitting electricity to distribution companies for the transmission project.

Thirdly, the economic benefits are calculated based on the saved cost by replacing the alternative energy sources (e.g., uninterrupted power supply (UPS) equipment and diesel generators).

8.4.1 Financial Benefits

The financial performances of the projects are evaluated from the viewpoint of the direct beneficiary (i.e.,Sindh Engro Coal Mining Company for generation and NTDC for transmission).

(1) Financial benefits of the generation project

Financial benefit of the generation project is identified as the increased revenues from electricity sales to NTDC. If the generation project is implemented, more electricity will be sold and revenues will be obtained by the company. Project outputs are valued by the tariff.

Generation (GWh) = Capacity (MW) x 24 hours x 365 days x Plant factor (%) /1000

The benefit is calculated until the end of the project life (40 years). For financial analysis, the benefit of incremental revenue can be calculated in a particular year, by multiplying the incremental electricity generated with the tariff of generation. The tariff consists of 1) energy charge (variable charge) and 2) capacity charge (fixed charge), as explained in Section 8.3.3.

Revenue = Capacity (MW) x Fixed charge + Generation (GWh) x Variable charge (Rs./kWh)

As no opportunity cost (e.g., the forgone benefit of agricultural products that used to be produced by the land where the coal thermal power plant will be located) is assumed, the gross revenue is equal to what is calculated based on the above formula.

(2) Financial benefits of the transmission project

Financial benefit of the transmission project is identified as the increased revenues from transmission of electricity to distribution companies. If the transmission project is implemented, more electricity will be transmitted and revenues will be obtained by the NTDC.

The benefit is calculated until the end of the project life (40 years). For financial analysis, the benefit of incremental revenue can be calculated in a particular year, by multiplying the monthly average peak demand (MW) with the UoSC (Rs./kW/Month).

Revenue = Monthly maximum demand (MW) x UoSC (Rs./kW/Month) x 12 months

As no opportunity cost is assumed such as forgone benefit of agricultural products that used to be produced along the land of the transmission line, the gross revenue is equal to what is calculated based on the above formula.

8.4.2 Economic Benefits

In determining the economic benefit of the project, two types of benefits are normally identified. The value of economic benefit from electricity consumption is based on the 1) induced market, which is brought about by the increased electricity consumption (i.e., incremental benefits) and 2) diverted market, which is the current energy consumption where the electricity replaces alternative energy sources such as kerosene lamps, uninterruptible power supply (UPS), and/or diesel generators (i.e., non-incremental benefits).

With a huge deficit in electricity supply and prolonged load shedding in Pakistan, the electricity produced by the projects will not increase the electricity consumption or replace the existing generation capacity, but simply act as substitute to the alternative energy source. Thus, the entire output of the projects is considered as non-incremental.

In identifying the economic benefit level, the saved cost is calculated from the viewpoint of consumers, by using the economic cost of alternative energy sources as the upper limit and the economic price of the tariff as the lower limit.

(1) Economic Price of Tariff

Electricity is the only product that will be generated from the projects. Electricity is assumed to be a non-tradable output since it is produced only for domestic economy and not exported to neighboring countries. The economic price of the tariff resulting to Rs.6.0625/kWh is calculated using the SCF of 0.97 as shown in Table 8.4-1.

Table 8.4-1 Economic Price of Tariff

Average Tariff	Calculation	Economic Price
Rs.6.25/kWh	Rs.6.25/kWh x 0.97	Rs.6.0625/kWh

Source: Electricity Marketing Data, “Statistics at a glance: PEPCO (Public and Private)”, 36th Issue, 2011

(2) Avoided Cost of Alternative Energy

There are two major sources of energy that can be saved by the incremental supply of electricity, which is made possible by the project. Table 8.4-2 below shows that the diesel generators are mainly used by industrial and agricultural users while the UPS is used by commercial and domestic (residential) users as alternative source of lighting and for the use of electric appliances such as television, radio and computers.

Table 8.4-2 Assumption on the Alternative Energy Sources Based on the Types of Consumers

Alternative Source	Type of Consumers
UPS	Domestic, commercial users
Diesel generator	Industrial, agricultural, others

Table 8.4-3 shows the current average consumption of the users in each category.

Table 8.4-3 Average Electricity Consumption per Consumer (Unit: kWh)

	Domestic	Commercial	Industrial	Agricultural	Others
Annual	1,778	1,934	64,819	31,529	760,440
Monthly	148	161	5,402	2,627	63,370

Source: Electricity Marketing Data, "Table D-5: Electricity Consumption per Consumer", 36th Issue, 2011

Note: "Others" include public lighting (374 GWh/year), bulk supply (3,544 GWh/year), traction (2 GWh/year), and supply to KESC (5,499 GWh/year).

The UPS is selected as an alternative energy source instead of kerosene lamp, which is often used for calculating the saved cost, since the latter is not widely used in Pakistan. Table 8.4-4 shows that nearly half of the expenditure on energy is spent on the electricity bill. On the other hand, less than 3% is spent on kerosene. Furthermore, load shedding is widespread in Pakistan, leading electricity consumers to prepare for load shedding by using the UPS.

Table 8.4-4 Household Expenditure on Energy (Unit: Rs., %)

	Pakistan	Urban	Rural
Average monthly expenditure	**713**	**904**	**622**
Firewood	22.1%	7.5%	32.1%
Kerosene	**2.8%**	**0.8%**	**4.2%**
Charcoal	0.1%	0.0%	0.1%
Coal	0.1%	0.0%	0.2%
Dung cakes	3.6%	0.8%	5.5%
Natural gas	9.1%	20.3%	1.4%
LPG	3.8%	3.6%	3.9%
Electricity	**50.4%**	**63.1%**	**41.7%**
Candles	2.0%	1.7%	2.3%
Agricultural residues	4.5%	0.7%	7.1%
Accessories (bulbs, etc.)	1.5%	1.5%	1.6%

Source: USAID Pakistan, "Energy Sector Assessment for USAID/Pakistan", Table 9: Average Monthly Expenditure in Rupees on Energy in Pakistan Households (Winrock 2007), June 2007

Electricity users tend to utilize the alternative energy sources due to load shedding and unstable power supply. These are replaced as soon as uninterrupted stable power is supplied. The cost of alternative energy source, which is normally higher than the retail tariff, is regarded as the upper limit to calculate the saved cost, which is explained in the following section.

Diesel generators

Diesel generators, one of the major alternative sources of power supply, can be replaced using incremental power supply from the increased capacity of generation. The saved cost on diesel generators can be regarded as economic benefit.

More than 80% of crude oil is imported from overseas.[8] As the Government of Pakistan regulates the price of petroleum products and imposes tax and market margin, such transfer payment within a country is deducted from the prescribed price in order to calculate the true cost to the country.

Table 8.4-5 Economic Cost of Hi-Speed Diesel Oil (H.S.D) (Unit: Rs./litter)

Prescribed Price	98.82
- Petroleum Levy	(5.18)
Net Price of H.S.D. (excluding transfer payment)	**93.64**

Source: Oil & Gas Regulatory Authority, Press Release, December 31, 2011

The cost of generation by a diesel generator consists of fixed and variable costs. Fixed cost (i.e., purchase cost of equipment) is excluded in the calculation as it is regarded as a sunk cost at the time of calculation.

Table 8.4-6 Variable Cost of Diesel Generation

Item		Figure	Unit
Installed capacity	A=kVA*Power Factor	9.2	kW
Power factor	Power factor = 0.8	0.8	
Load factor	Load factor = 0.4	0.4	
Net generation	B=kW*8760*Load factor	32,237	kWh/year
Economic cost of diesel oil	C=Market price-tax and margin	93.64	Rs./L
Fuel consumption	D=Web site info	2.40	L/hour
Fuel cost	E=Fuel consumption (liter per hour)*8760*Load factor*Fuel price per liter	787,475	Rs./year
Variable O&M cost	F=Fuel cost*1%	7,875	Rs./year
Total cost	**G=E+F**	**795,350**	**Rs./year**
Variable cost per kWh	**H=G/B**	**24.67**	**Rs./kWh**

As a result of the calculation, Rs.24.67/kWh is decided as the upper limit of the economic cost of diesel generators.

UPS

The domestic and commercial customers tend to use the UPS as a back-up in case of load shedding. Since the economic life of UPS is relatively short, both fixed and variable costs per kWh are calculated as shown in Table 8.4-7.

[8] Adeel Ahmad, Mithilesh Kumar Jha, "Status of Petroleum Sector in Pakistan - A Review", Oil and Gas Business, 2007

Table 8.4-7 Fixed and Variable Costs of UPS

Items		Figure	Unit	Remark
Price of UPS	A=survey	23,500	Rs.	Quotation from UPS dealer
Capacity of UPS	B=survey	1,400	VA	Quotation from UPS dealer
Economic life	C=assumption	5	year	
Annualized cost	D=A/C	4,700	Rs./year	
Equivalent wattage	E=B*power factor	1,120	watt	Capacity (VA)xpower factor (0.8)
Hours of use per day	F=assumption	10	hours	
Equivalent kWh per year	G=E*F*365/1000	4,088	kWh/year	
Fixed cost per unit (kWh-Value)	**H=D/G**	**1.1**	**Rs./kWh**	
Unit price of battery	I=survey	7,500	Rs./unit	Quotation from UPS dealer
Necessary no. of battery	J=survey	3	unit/year	Quotation from UPS dealer
Cost of battery per year	K=I*J	22,500	Rs./year	
Tariff	L=assumption	6.06	Rs./kWh	Economic cost of tariff
Efficiency	M=assumption	0.5		
Recharging cost	N=G*L/M	49,567	Rs./year	
Variable cost per unit (kWh-Value)	**O=(K+N)/G**	**17.6**	**Rs./kWh**	
Total cost of UPS	**P=H+O**	**18.8**	**Rs./kWh**	

As a result of the calculation above, Rs.18.8/kWh is the upper limit of the economic cost of the UPS.

(3) Saved Cost

The saved cost represents the economic value of electricity consumption of the consumers. This is not equal to the retail tariff of electricity. Often, the retail tariff rate tends to be subsidized and does not adequately reflect economic benefit. In the economic analysis, economic benefits are equated with savings from using electricity for lighting, irrigation, industrial, and other works, by utilizing UPS and diesel generators as major sources of alternative energy.

It is assumed in the analysis that the difference between 1) the weighted average retail tariff and 2) what consumers are actually paying for the alternative source of energy is the saved cost as illustrated in Figure 8.4-1.

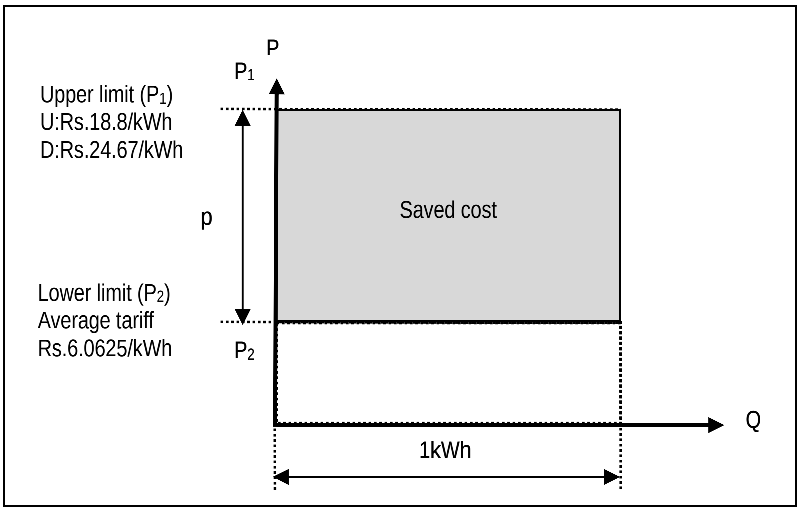


Figure 8.4-1 Saved Cost

Note: "U" represents "UPS", while "D" represents diesel generation.

Domestic consumers are assumed to be using UPS. While irrigation users are assumed to be using diesel-powered irrigation pumps as backup for their electric-powered pumps, commercial users, on the other hand, are assumed to be using mainly UPS as backup for electric lighting while very few utilize diesel generators. Moreover, industrial users are assumed to be using diesel generators, although there are some who do not own such equipment.

Table 8.4-8 Calculation of Saved Cost of Alternative Energy Sources

Tariff Category	**Alternative Source**	**Consumption (GWh)**		**Economic Price (Rs./kWh)**		**Difference (Saved Cost)**	**Weighted Saved Cost**
				Upper Limit	**Lower Limit**		
			(a)	(b)	(c)	(d)=(b)-(c)	(e)=(a)*(d)
Domestic	UPS	29,507	43%	18.78	6.0625	12.72	5.45
Commercial	UPS	4,466	6%	18.78	6.0625	12.72	0.82
Industrial	Diesel generator	16,371	24%	24.67	6.0625	18.61	4.42
Agricultural	Diesel generator	9,585	14%	24.67	6.0625	18.61	2.59
Public lighting	UPS	372	1%	18.78	6.0625	12.72	0.07
Others	Diesel generator	8,577	12%	24.67	6.0625	18.61	2.32
		68,878	100%			**Total**	**15.67**

Source: JICA Survey Team

Based on the consumption share of each tariff category, the weighted saved cost is calculated at Rs.15.67/kWh as shown in the above Table 8.4-8.

8.5 Conclusion of Financial and Economic Analyses

Based on the assumptions, costs and benefits are calculated and described so far. The financial and economic IRR and NPV are calculated and presented in this section.

8.5.1 FIRR and FNPV

(1) Base Case

Benefit and cost are compiled and calculated considering the 2012 prices in order to obtain the FIRR. Moreover, the opportunity cost of capital (12%) is used as a discount rate for calculating the FNPV.

The generation project showed a positive NPV and slightly higher return than the cut-off rate for FIRR. However, it should be noted that this return can only be achieved if the cost of the generation is immediately translated into tariff. If the approval on the tariff by the NEPRA and the notice of the government's gazette are delayed and/or the petition on tariff increase is partially approved or disapproved, the rate of return of the generation project will reduce accordingly.

Both alternatives for the transmission project showed negative NPVs and below the cut-off rate for FIRR (12%). The FIRRs of the transmission projects are significantly lower than the cut-off rate. This is because the same fixed tariff is applied regardless of the length of the transmission line. The longer the transmission line, the lower the IRR due to the higher capital cost. However, as the peak demand increases after the completion of other Thar generation projects, the FIRRs of the transmission project alternatives are expected to increase.

Table 8.5-1 FIRRs and FNPVs of the Projects

Case	FIRR	FNPV (Rs. million)	FNPV (US$ million)
Generation	14.1%	22,765	239
Transmission (Alternative 1)	4.0%	(8,479)	(89)
Transmission (Alternative 2)	1.8%	(13,140)	(138)

Source: JICA Survey Team

The FIRR of Transmission (Alternative 2) is lower than Transmission (Alternative 1). Table 8.4-5 shows that the capital cost of the former is more expensive than the latter at the initial stage, while the expected transmission loss is almost the same between the two alternatives. However, if the cost for accommodating the future expansion of generation is taken into consideration, the additional cost of Alternative 2 (Rs.0.8. billion) will be significantly smaller compared to Alternative 1 (Rs.13 billion).[9] As a result, the total cost of Alternative 2 (Rs.22.9 billion) becomes smaller than Alternative 1 (Rs.30.4 billion) and the FIRR of the former is expected to become higher than that of the latter.

2) Sensitivity Analysis

Sensitivity analysis is conducted for the financial analysis as the actual condition may be different from those assumed for the base case. In the sensitivity analysis, the following factors are assumed; 1) tariff increase (10%), 2) cost increase (10%), and 3) delay in construction (one year).

Table 8.5-2 Sensitivity Analysis for the Generation Project (FIRR & FNPV)

Case	Benefit	Cost	FIRR (%)	FNPV (Mil Rs.)	FNPV (Mil US$)
Base case	No change	No change	14.1%	22,765	239
Tariff increase (+10%)	+10%	No change	15.5%	38,579	404
Cost increase (+10%)	No change	+10%	12.8%	9,229	97
Delay in construction (1 year)	No change	No change	13.8%	17,003	178

Source: JICA Survey Team

[9] See Table 6.2-2 for more detail of the cost.

Table 8.5-3 Sensitivity Analysis for Transmission Alternative 1 (FIRR & FNPV)

Case	Benefit	Cost	FIRR (%)	FNPV (Mil Rs.)	FNPV (Mil US$)
Base case	No change	No change	4.0%	(8,479)	(89)
Tariff increase (+10%)	+10%	No change	4.8%	(7,809)	(82)
Cost increase (+10%)	No change	+10%	3.2%	(9,997)	(105)
Delay in construction (1 year)	No change	No change	3.8%	(7,922)	(83)

Source: JICA Survey Team

Table 8.5-4 Sensitivity Analysis for Transmission Alternative 2 (FIRR & FNPV)

Case	Benefit	Cost	FIRR (%)	FNPV (Mil Rs.)	FNPV (Mil US$)
Base case	No change	No change	1.8%	(13,140)	(138)
Tariff increase (+10%)	+10%	No change	2.6%	(12,470)	(131)
Cost increase (+10%)	No change	+10%	1.1%	(15,124)	(159)
Delay in construction (1 year)	No change	No change	1.6%	(12,189)	(128)

Source: JICA Survey Team

As indicated in the above Tables 8.5-2 to 8.5-4, the tariff increase (10%) caused a slight increase in the FIRR and FNPV, while the cost increase (10%) and delay in construction (one year) slightly decreased the figures. In conclusion, changes in the assumptions do not significantly affect the results of the financial analysis.

8.5.2 EIRR and ENPV

(1) Base Case

The benefit and cost are compiled and calculated using the economic cost, in order to obtain the EIRR. Moreover, a social discount rate of 12% is used to calculate the ENPV.

Table 8.5-5 EIRR and ENPV

Case	EIRR	ENPV (Rs. million)	ENPV (US$ million)
Generation + Transmission (Alternative 1)	28.9%	242,181	2,539
Generation + Transmission (Alternative 2)	28.9%	237,995	2,495

Source: JICA Survey Team

In both cases, economic benefit is ensured as the EIRRs are significantly higher than the cut-off rate (12%), and the ENPVs are positive. Thus, the projects can be justified for implementation as it contributes to the national economy’s enormous savings from the alternative energy sources.

(2) Sensitivity Analysis

A sensitivity analysis is conducted for economic analysis. Similar to the financial analysis, the increase in economic benefit, cost overrun of construction, and delay in construction are analyzed.

Table 8.5-6 Sensitivity Analysis for Transmission Alternative 1 (EIRR & ENPV)

Case	Benefit	Cost	EIRR (%)	ENPV (Rs. million)	ENPV (US$ million)
Base case	No change	No change	28.9%	242,181	2,539
Benefit increase (+10%)	+10%	No change	31.2%	283,879	2,976
Cost increase (+10%)	No change	+10%	27.0%	230,177	2,413
Delay in construction (1 year)	No change	No change	28.8%	215,447	2,258

Source: JICA Survey Team

Table 8.5-7 Sensitivity Analysis for Scenario Transmission Alternative 2 (EIRR & ENPV)

Case	Benefit	Cost	EIRR (%)	ENPV (Rs. million)	ENPV (US$ million)
Base case	No change	No change	28.9%	237,995	2,495
Benefit increase (+10%)	+10%	No change	31.2%	279,704	2,932
Cost increase (+10%)	No change	+10%	27.0%	225,561	2,364
Delay in construction (1 year)	No change	No change	28.8%	211,612	2,218

Source: JICA Survey Team

The impact of the changes in condition on the results of EIRR and ENPV is insignificant. Even if the cost increase and delay in construction are treated separately, the EIRR and ENPV will decrease slightly.

CHAPTER 9
CONCLUSIONS AND RECOMMENDATIONS

Chapter 9 Conclusions and Recommendations

9.1 Conclusions

9.1.1 Thar Coalfield Development

(1) Coalfield Development

Utilization of the abundant domestic resources is very good for the country. The quality of Thar coal is not suitable to be sold in the international market. On the other hand, lignite, with similar qualities, is widely utilized in many countries. Thar coalfield has been developing steadily, and a boost in its development is expected.

In order to further develop the Thar coalfield, infrastructure development should be carried out at the same time. Road, power plant, transmission lines, water supply/wastewater disposal, township development, etc., are included in the plan, in which smooth execution is necessary.

Project owners have to manage the environmental protection measures, while the government has to monitor and address the environmental issues. Also, accident or disaster caused by the mining activities should be minimized. Human resources development for the government staff is also important for the integrated coalfield development.

(2) Construction of Power Generation Plant

Mine-mouth power plants are planned in Thar coalfield. Since extracted coal at the coalfield is classified lignite, which is unsuitable for long transportation. Same as the development for the coalfield, the contraction plan of concrete mine-mouth power plants of 900 MW at Block I, 1200 MW at Block II, and 1100 MW at Block IV is ongoing. Hence, it is progressed staidly for upgrading rerated infrastructures of power plants.

Since the construction of the power plants will be carried out after the start of coal mining, and due to the confidentiality of information from the private sectors, detailed information for the construction of the power plants were not obtained in this Survey. However, after the coal mines of each block have started their operation, the construction of the mine-mouth power plants using the extracted coal in the Thar coalfield will be estimate definitely.

(3) Infrastructures

In order to propel the development of the Thar coalfield, water supply system, wastewater disposal system, and road for transporting construction and mining equipment, which are funded by the Government of Sindh, shall be carried out. Therefore, it is unnecessary to seek support for the above infrastructures from the Japanese government at present. In addition, it is noted that the abovementioned construction of infrastructures is not affected by the overall plan for the Thar coalfield development.

For the transmission line, although NTDC has a plan to extend the 500 kV transmission line to the Thar Desert, the budget is not allocated. Therefore, in order to promote the Thar coalfield development, it is necessary to fund the construction of the 500 kV transmission line.

9.1.2 Candidate Project for Transmission Line

(1) Summary of Candidate Project

The 500 kV transmission line will be constructed in the Thar coalfield for transmission of power to the consumption area, in order to generate power in the Thar Desert. At present, no power plants are in the Thar Desert; hence, the construction plan for the power plant will be expedited by installing the 500 kV transmission line. Summary of the candidate projects for the Japanese Yen loan is shown below:

a. Construction of Thar - Matiari 500 kV Transmission Line
   1) Distance, number of circuits : 250 km, 2 cct
   2) Conductor : Araucaria (AAAC) or LL-TACSR/AS 750 mm^2

b. Expansion of 500 kV Matiari Switching Station
   1) Equipment configuration : 2 x 500 kV line bays along with 3 x 37 MVA shunt reactors

(2) Environmental and Social Considerations

The candidate 250 km transmission project needs to provide compensation for the agricultural land, although it is expected that destruction of natural protection area and deforestation are avoided. Therefore, according to the JICA guidelines, the candidate project could be classified as a Category A project. It is expected presently that the project needs compensation for agricultural land and doesn’t need resettlements. However it has a length of 250 km and there are many villages around the project area. It might have possibilities of in-migrants to the project are in future. Therefore it is necessary to check the status of villages as the project progresses.In addition, according to Pakistan Environmental Protection Agency Regulation (PEPA), the candidate project needs to comply with the EIA procedure.

Subsequently, the EIA process for the project should commence. Moreover, it is necessary to determine environmental measures such as mitigation of noise pollution during construction stage, and social considerations such as appropriate compensation for local people.

Regarding the indivisible projects such as thermal power projects, and infrastructure projects, TCEB and the developers have started the EIA process based on PEPA regulation, and the Strategic Environmental and Social Assessment. However, it should be confirmed whether the progress of the environmental and social considerations are appropriate in the future.

(3) Applicability of Japanese Technology

As for the candidate project for the Japanese Yen loan, there are two alternatives which utilize different kinds of conductors. In these alternatives, the adoption of LL conductor from Japanese technology, due to its advantage on total cost, is recommended for this project. It is realized that available transmission capacity by applying LL conductor will be increased compared to that of Araucaria of AAAC, leading to reduction of total cost to around Rs.6,580 million.

9.2 Recommendations

9.2.1 Recommendation for Coalfield Development

(1) Mining system and equipment

The selected mining system for Block II is the use of middle-sized fleet of truck and shovel (T&S). At the initial stage of the development, the mining contractor will carry out the pre-stripping works of overburden materials. As the road improvement will take a couple of years, utilization of small-sized fleet of D&T is a more realistic method. The production level using the T&S method is easy to control, and this advantage will be continued in the future. When the first mining equipment needs to be replaced, introduction of the bucket wheel excavator (BWE) may be an option. However, its flexibility of production is lower than that of the T&S method, and its investment cost is very high. From the viewpoint of operating cost, BWE has the advantage on energy source, because it can be operated using the electricity generated at mine-mouth power plants. In case the utilization of the BWE will prevail in the future, it will become more preferable because of the following two reasons: 1) long equipment life, and 2) limited mine life. However, since multiple benches will be needed at the Thar coalfield, huge-sized BWE is not recommended.

The T&S mining method will promote big working opportunities. Labor cost will increase in the future depending on the economic growth. In effect, the production cost of lignite may increase. Moreover, although utilization of bigger equipment can reduce the required amount of manpower, reasonable production cost is maintained. In this case, further improvement of the road from the port is essential.

(2) Necessity of stable production

Lignite is not suitable for long storage time because of its spontaneous combustion characteristics. In other words, in the event of scheduled maintenance or breakdown of the power plant, demand for lignite will be reduced and the mine production will greatly influence the production level. Considering the fixed cost portion of the production cost, achieving the budgeted production level is very important. In the Lakhra coalfield, the mines control the production level in order to meet with the demand of the power plant.

(3) Quality control of lignite

For a stable combustion at the power plant, it is necessary to supply lignite with the designed quality. Based on the obtained quality data, heat value and sulfur contents may be stable on a year by year basis, although some fluctuation may be predicted. Contamination when extracting lignite using heavy equipment cannot be avoided, but it is recommended to remove the impurities as much as possible. Periodic analysis of quality is useful in estimating the delivered quality. As a result, the required quantity of lignite and volume of desulfurizing agents for the power plant will be estimated.

(4) Lignite transportation

In Block II, it expected that transportation of lignite will become worse and may need to be improved in the future.

For the development of the whole coalfield which includes many power plant constructions, the comparison between supplying cool water to Thar coalfield and lignite transportation to the river/sea side might be significant (this matter is beyond the scope of the Study). If 6.5 million ton of lignite for 1200 MW will be transported by 20 t dump trucks, the daily delivery will be around 900 units, which means that a delivery of every 2 minutes is required. When another 10 or 20 units of power plant needs lignite, a road with bigger transportation capacity or a special road exclusive for lignite transportation maybe needed. Railroad transportation is also suitable for large transportation capacity, but such capacity is dependent on the number of rail tracks, number of wagons, and speed of the fleet.

9.2.2 Recommendations for Power Generation Development

(1) Existing coal thermal technologies of CFBC or PC are recommended in the Thar coalfield. As the capacities of boilers being planned are 300 MW to 600 MW, which have enough heat capacity, and are able to provide stable combustion under high moisture condition, installation of coal pre-dry system is not recommended. Otherwise, increased plant heat loss will occur due to the added heat source for drying. Moreover, it may limit the output, or in worst case, generation may stop when plugged to the fuel supply system, due to the adherence of wet coal in the piping.

One of the options, which is the installation of 400 MW X 3 unit capacity, is considered instead of the 600 MW X 2 unit, due to the following reasons:

(2) CFBC boiler could reduce the construction cost, because the installation of FGD is no longer necessary. Moreover, it could reduce the influence of power system stability during a unit trip or a periodic maintenance.

(3) Water cooling system which can prevent the lowering of plant efficiency in hot ambient atmosphere is recommended. Ground water can be used as an alternative cooling water and may result to a savings in the supply of water from Navisar in the Thar Desert.

(4) Coal reformation technologies, such as upgraded or liquidation are advantageous in terms of transportation and handling, and few merits for mine-mouth generation as these need additional energy for its operating process. When stable coal supply for generating enough power to meet the power demand can be achieved in the future, adoption of these new technologies is recommended to be considered.

(5) Coal gasification for generation (IGCC and IGFC) is still just at the demonstration stage, and is difficult to apply for large-scale generation at present. The most common process of coal liquefaction is the combined Sasol-Lingi Gasification and FT synthesis process.

(6) However, the first stage of this project should concentrate on power generation, because there are further issues on technologies such as gasification, liquefaction, and pre-drying system in the Thar Desert.

APPENDICES

Functions of Thar Coal Energy Board, Sindh Coal Authority and Coal & Energy Departments

Coal & Energy Development Department

1. Development of Coal Resources.
2. Grant of Licenses, Permits, Leases for Coal mining.
3. Inspection of Coal Mines.
4. Regulating & Monitoring of Coal Mining Operations, Coal Gasification, Coal Gas extraction, Coal to Liquids & other auxiliary activities and collection of royalties thereof.
5. Negotiation of Agreements and consultations with the Federal Government if and when considered necessary.
6. Negotiations/Consultations with Private Investors.
7. Maintenance of up to date Master Plans of Exploration Licenses, Permits and leases granted renewed, assignment and surrenders including their publication in the official gazette.
8. Serves as Secretariat of Mineral Investment Facilitation Authority (MIFA), Thar Coal & Energy Board.
9. Geological Surveys.
10. Notifying rules and regulations.
11. Import, purchase, distribution and price fixation of coal & coke.
12. Coal based Energy Development-Coal based power generation.
13. Public Private Partnership and Joint Ventures in Coal & Coal based power generation.
14. Services Matters, except those entrusted to the Services & General Administration Department.

Thar Coal Energy Board

1. To act as one-stop organization on behalf of all the ministries, departments and agencies of the Government of Pakistan and the Government of Sindh in the matters relating to formulation of policies;
2. To accord approval of projects for coal mining in Thar and for coal fired power generation plants or for other uses of Thar coal;
3. To appraise, evaluate and approve all investment proposals and projects received from the investors;
4. To assist investors in obtaining necessary consents, licenses, permits, and other legal documents required to operate, explore and develop the Thar Coal resources;
5. To monitor the progress of investment programmes and projects at all stages and ensure through inter-agency and inter-provincial coordination, prompt implementation and operation;
6. To encourage and promote international and national investment for the development of Thar Coal;

Functions of Thar Coal Energy Board, Sindh Coal Authority and Coal & Energy Departments

7. To coordinate and facilitate the domestic, foreign and international institutions for financing of the proposed projects;
8. To coordinate and facilitate the activities of Federal, Provincial and District Governments and their respective agencies related to Thar Coal including infrastructure development;
9. To correspond with concerned local and international agencies except in matters involving commitment of the Government of Pakistan;
10. To develop and approve, fiscal incentives for investors for development of Thar Coal deposits;
11. To call special meetings of relevant government agencies to discuss, review, resolve issues related to the development of the Thar Coal;
12. To approve any affiliation necessary with international organizations related to the development of the Thar Coal;
13. To determine and control the price of coal;
14. To open and operate bank accounts in local and foreign currencies;
15. To charge or levy fees for any services rendered to the investors;
16. To develop a marketing, image building and public relations strategy to generate interest in the potential and opportunities of Thar Coal and publicize its activities; and
17. Any other function related to development of the Thar Coal deposits.

Sindh Coal Authority

1. To accelerate the pace of activities relating to coal development and shall be specifically for responsible for planning, promoting, organizing, undertaking appropriate projects in this behalf and implementing programmes for exploration, development, exploitation, mining, processing and utilization of coal;
2. Prepare and execute schemes and take such steps as may be necessary in connection with the execution of such schemes;
3. Advise Government in all matters connected with conservation, development working and utilization of geology to evaluate coal deposits;
4. Publish results of research and development activities of coal resources of the Province, from time to time, for general information;
5. Promote joint ventures specially with foreign investors for development of coal resources of the Province;
6. Take such steps as may be necessary or conductive to the attainment of its object.

PPIB (Private Power and Infrastructure Board) and
NEPRA (National Electric Power Generation Authority)

Function of PPIB [1]

The Private Power and Infrastructure Board (PPIB) was created in 1994 as "One Window Facilitator" to promote private sector participation in the power sector of Pakistan. PPIB facilitates investors in establishing private power projects and related infrastructure, executes Implementation Agreement (IA) with Project Sponsors and issues sovereign guarantees on behalf of Government of Pakistan.

The functions of PPIB are:

a. to implement the power policies, award projects to sponsors or private power companies, prepare all necessary or appropriate documentation, execute any of such documentation with private power companies, their sponsors, lenders and, whenever necessary or appropriate, other interested parties;
b. to recommend and facilitate development of power policies;
c. to take decisions on matters pertaining to power and related infrastructure projects set up by private sector or through public-private partnership, and other issues pertaining thereto;
d. to coordinate with the Provincial Governments, local governments, Azad Jammu and Kashmir (AJ and K) and regulatory bodies in implementation of the power policies, if so required;
e. to coordinate and facilitate the sponsors in obtaining consents and licences from various agencies of the Federal Government, provincial governments, local governments and AJ and K;
f. to work in close coordination with power sector entities and play its due role in implementing power projects in private sector or through public-private partnership as per power system requirements;
g. to function as a one-stop organization on behalf of the Federal Government and its Ministries, Departments and agencies in relation to private power companies, their sponsors, lenders and whenever necessary or appropriate, other interested parties;
h. to draft, negotiate and enter into security package documents or agreements and guarantee the contractual obligations of entities under the power policies;
i. to execute, administer and monitor contracts;
j. to prescribe and receive fees and charges for processing applications, and deposit and disburse or utilize the same, if required;
k. to obtain from sponsors or private power companies, as the case may be, security

[1] NEPRA home page http://www.ppib.gov.pk/N_ppib2.htm

instruments and encash or return them, as deemed appropriate;

l. to coordinate with the provincial governments and regulatory bodies in implementation of the power policies, if so required;

m. to act as agent for development, facilitation and implementation of power policies and related infrastructure in the Gilgit Baltistan areas and AJ and K;

n. to open and operate bank accounts in local and foreign currencies as permissible under the laws of Pakistan;

o. to commence, conduct, continue and terminate litigation, arbitration or alternate dispute resolution mechanisms at whatever levels may be necessary or appropriate, and hire and pay for the services of lawyers and other experts therefore; and

p. to perform any other function or exercise any other power as may be incidental or consequential for the performance of any of its functions or the exercise of any of its powers, or as may be entrusted by the Federal Government.

Function of NEPRA[2]

(1) Genesis

In 1992, the Government approved WAPDAs Strategic Plan for the Privatization of the Pakistan Power Sector. This Plan sought to meet three critical goals:

a. Enhance capital formation,
b. Improve efficiency and rationalize prices, and
c. Move over time towards full competition by providing the greatest possible role for the private sector through privatization.

This major decision was taken to improve the viability of Pakistan's electric power sector which was characterized by extensive government involvement in management, political interference, and a tariff plagued by cross-subsidies. A critical element of the Strategic Plan was the creation and establishment of a Regulatory Authority to oversee the restructuring process and to regulate monopolistic services.

The existence of an independent and objective regulatory entity reduces the perception of risk to investors in a market. Accordingly, an autonomous regulatory agency is essential for the immediate need and long-term stability of the sector.

Pakistan has been successful in attracting substantial foreign investment in the power sector, but the absence of a transparent regulatory regime led investors to secure their investment

[2] NEPRA home page, http://www.nepra.org.pk/nepra.htm

through long-term contracts. Consequently, a substantial part of the sector has been carved out for “long term contract regulation” and the rest of the sector has to carry whatever risk arises from changing circumstances and realities. Pakistan has had to pay dearly for the absence of an acceptable and established regulatory environment for the commercial operation of the sector.

The December 16, 1997, issue of the Gazette of Pakistan proclaimed the enactment of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997, which had become effective on 13 December 1997.

NEPRA has been created to introduce transparent and judicious economic regulation, based on sound commercial principals, to the electric power sector of Pakistan. NEPRA reflects the country's resolve to enter the new era as a nation committed to free enterprise and to meet its social objectives with the aim of improving the quality of life for its people and to offer them opportunities for growth and development.

(2) Preparing for the Future

Pakistan is attempting to restructure the electric power sector to catch up and keep pace with the gigantic strides the power utility business has made during the 20th century. The World is moving towards an integrated electric power system. Electricity is produced, traded and sold across international boundaries in many parts of the World. Pakistan has to immediately start working towards creating an environment that will not only enable but also attract international trading in electricity. If we do not keep pace with the changing global environment, we will be isolated and left even further behind than where we found ourselves at the end of the previous century.

A first step to creating a climate conducive to investment and economic development is the need to enunciate a new regime to regulate the utility business of the future. NEPRA is one such name and it proposes to establish a new form of governance in Pakistan through its regulatory regime.

The NEPRA statute reflects the desire of the Government to establish an autonomous regulator body to improve the efficiency and availability of electric power services by protecting the interest of the investor, the operator and the consumers and to do so with a view to promoting competition and to deregulate power sector activities where there is competition.

PPIB (Private Power and Infrastructure Board) and
NEPRA (National Electric Power Generation Authority)

(3) NEPRA's Role

NEPRA's main responsibilities are to:

a. Issue Licences for generation, transmission and distribution of electric power;
b. Establish and enforce standards to ensure quality and safety of operation and supply of electric power to consumers;
c. Approve investment and power acquisition programs of the utility companies; and
d. Determine Tariffs for generation, transmission and distribution of electric power.

NEPRA will regulate the electric power sector to promote a competitive structure for the industry and to ensure the co-ordinated, reliable and adequate supply of electric power in the future. By law, NEPRA is mandated to ensure that the interests of the investor and the customer are protected through judicious decisions based on transparent commercial principals and that the sector moves towards a competitive environment.

A primary challenge is to quickly create a track record of NEPRA's working such that it demonstrates its objectivity and impartiality. NEPRA has to demonstrate that its decisions are neither arbitrary nor influenced by individual and personal discretion. It is accordingly proposed that to introduce transparency and accountability in NEPRA, all regulatory decisions regarding licensees will be published and made public property.

(4) Support for NEPRA

The Government is committed to and wishes to establish an independent, strong and judicious regulatory regime by virtue of the new enactment. The enactment of NEPRA clearly signifies the Government's desire and effort to change from public to private ownership; from political to commercial priority in economic decision making; and from subjective to objective decision making in utility operations.

The people of Pakistan are, individually, the guardians of the future of their children and they, collectively, are responsible for the future well being and prosperity of Pakistan. NEPRA will need their support in creating an appropriate regime to regulate the electric power sector and to set a new trend for governance in Pakistan for the new millennium.

a. Regulations for better facilitation of the project sponsors at the provincial level.

b. NEPRA has promulgated the NEPRA Upfront Tariff (Approval & Procedure) Regulations,

PPIB (Private Power and Infrastructure Board) and
NEPRA (National Electric Power Generation Authority)

c. 2011 wherein solar, biogas, hydel, wind and coal technologies have been qualified for grant of upfront tariff by NEPRA.

d. NEPRA has announced up font tariff for wind power technology during 2011 to facilitate the investors while at present the proposal of the Punjab Power Development Board for approval of upfront tariff for hydel power project in Punjab is under process at NEPRA.

NEPRA Notice of Hearing for Development of Determination of Upfront Tariff for Coal Power Projects (Date: May 08, 2012)

All the stakeholders, interested/affected persons and the general public are hereby notified that NEPRA keeping in view the current power crisis in the country, high cost of generating electricity from the oil and decreasing gas availability to the power sector has decided to play a pro active role in the development of Coal power projects, Which are likely to have comparatively lower tariffs because coal is abundantly available both locally as well as internationally. Accordingly on the basis of proposal for Upfront Tariff submitted by the Private Power & Infrastructure Board and the information otherwise available, NEPRA in exercise of its powers under rule 3 (1) of the NEPRA (Tariff Standards and Procedure) Rules, 1998 read with regulation 3 of the NEPRA Upfront Tariff (Approval & Procedure) Regulations, 2011, has decided to develop determine and approve the upfront tariff for generation of electricity from Coal.

THE SALIENT FEATURES OF THE UPFRONT TARIFFS PROPOSED BY PPIB ARE AS UNDER:

1. The proposed levelized upfront tariff for the different capacities is given hereunder;

Capacity	Origin of Coal	Form of Financing	Fuel cost	Val. O & M	Energy Charge	Capacity Charge		Levelised Tariff at 60% Plant Factor	
						1st 10Yrs.	11-30 Yrs.		
			(Rs./kWh)			(Rs./kWh/Hour)		(Rs./kWh)	
200 MW	Local	Local	4.5679	0.1842	4.7521	5.0753	1.9613	11.4038	12.9589
		Foreign	4.5679	0.1842	4.7521	3.4947	1.7656	9.5732	10.8786
200 MW	Imported	Local	3.7397	0.1563	3.8941	4.6483	1.7086	9.9353	11.2901
		Foreign	3.7397	0.1563	3.8941	3.1884	1.5561	8.2609	9.3874
600 MW	Local	Local	4.4693	0.1767	4.6460	5.0966	2.0134	11.3512	12.8991
		Foreign	4.4693	0.1767	4.6460	3.4489	1.7779	9.4245	10.7096
600 MW	Imported	Local	3.6340	0.1552	3.7892	4.5926	1.7144	9.7732	11.1060
		Foreign	3.6340	0.1552	3.7892	3.0933	1.5337	8.0397	9.1360
1,000 MW	Local	Local	4.1975	0.1708	4.3683	5.2675	2.0557	11.2836	12.8223
		Foreign	4.1975	0.1708	4.3683	3.5515	1.8109	9.2773	10.5424
1,000 MW	Imported	Local	3.398	0.1542	3.5522	4.7022	1.7211	9.6592	10.9763
		Foreign	3.398	0.1542	3.5522	3.1493	1.5340	7.8636	8.9359

2. The tariff models for local coal excludes Thar Coal for which a separate tariff mechanism is required owing to certain costs particular to Thar coal Projects including development surcharge, etc and a separate mechanism shall be devised m due course.
3. The Key Assumptions used to arrive at the above tariff requiring input /comments from stakeholders are as below:
   a. Projects to be set up shall install new plant machinery and equipment
   b. Plant Factor= 60%
   c. Net Thermal Efficiency and Annual Generation;

Capacity	Thermal Efficiency		Annual Net Generation GWh
	Local Coal	Imported Coal	
200MW	34%	35%	1,576.80
600MW	34.75%	36%	4730.40
1,000MW	37%	38.50%	7884.00

NEPRA Notice of Hearing for Development of Determination of Upfront Tariff for Coal Power Projects (Date: May 08, 2012)

d. Proposed Construction Period is 40 months for 200 MW plant and 48 months each for 600 MW and 1000 MW

e. Fuel will be a pass through Item and reference fuel cost component of tariff will be adjusted as per actual delivered coal price. Assumed coal price is US$ 100.35/ton for imported coal and US$ 57/ton for local

f. The LHV calorific value of 23,038.07Btu/Kg for imported coal and 11,023 Btu/Kg. for local coal have been assumed.

g. IRR on Equity is 20% for local coal projects and 17% for imported coal projects.

h. Working capital requirement is worked out on the basis of Coal Inventory (15 days for local coal and 60 days for imported coal); and Receivables (30 days)

i. These tariff models have been worked out on 30 years Project Life and finance is based on 100% local loan and 100% foreign loan respectively. In case the project is financed through a combination of Local and Foreign Debt Financing, the debt repayment and interest charges component of upfront tariff for each year will be adjusted as per actual percentage of local and foreign debt financing.

j. The reference exchange rate is US$ 1 = PKR 88

k. The Debt servicing component on Local financing is Kibor (11.91%) + 3.5%; whereas, the debt servicing component on Foregn9n financing is Libor (0.45%) + 4 .5%.

l. The EPC cost and O & M Costs are under;

Capacity	EPC Cost (US $ in million)		Variable O & M Cost (US $ in million)		Fixed O & M Cost (US $ in million)	
	Local Coal	Imported Coal	Local Coal	Imported Coal	Local Coal	Imported Coal
200MW	250	236	3.3	2.8	5.734	5.645
600MW	720	672	9.5	8.34	16.663	16.124
1,000MW	1,250	1,160	15.3	13.81	25.98	24.19

4. Following indexations and escalations will be available on quarterly basis for the upfront tariff for coal based projects:

Tariff Component	Indexation/Escalation	Tariff Component	Indexation/Escalation
O & M (Local)	WPI	Interest (Local Loans)	KIBOR
O & M (Foreign)	US$ to Pak Rupees & US CPI	Interest (Foreign Loans)	LIBOR (or other applicable benchmark) & Exchange Rate as applicable
Return on equity	US$ to Pak Rupees	Principal Repayment (Foreign)	Exchange Rate as applicable
Insurance	US$ to Pak Rupees in case of foreign currency insurance cost	Cost of Working Capital	KIBOR

The tariff once approved will be applicable after achieving Commercial Operation along with allowed indexations and escalations. The upfront tariff will be reviewed and revised quarterly on the basis of indexations I escalations. The eligible companies will also be given coverage against the indexations and escalations during the construction period of the project.

NEPRA Notice of Hearing for Development of Determination of Upfront Tariff for Coal Power Projects (Date: May 08, 2012)

5. The following issues and costs associated with coal based power projects have not been covered in the tariff and also require input /comments from stakeholders:
   a. Quality of Coal/ Design coal;
   b. Locations/ sites of Plant;
   c. The technologies to be used in coal plants, (e.g., Pulverized coal (PC) combustion or Fluidized beds combustion (FBC) technology) and the type of boilers to be used (sub-critical, super critical or ultra super critical);
   d. Mechanism for Transportation of local coal (railway etc) and the cost associated with it;
   e. Cost of hedging as opposed to quarterly indexations of Interest;
   f. Cost of Coal indexation adjustment mechanism;
   g. Loss during transportation_ of coal; and
   h. Cost of opening Letter of credit in respect of first import of coal;
6. This upfront tariff shall be applicable for projects achieving financial closing before 31st December 2014.
7. Any interested person who desires to participate in the proceedings may file an intervention request from the date of publication of this notice. Such intervention request shall state the name and address of the person filing the same, objections and the manner in which such person is or is likely to be substantially and specifically affected by any determination in the proceedings. The intervention request may also contain the contentions of the person, the relief sought and the evidence, if any, in support of the case. The intervention request shall be signed, verified and supported by means of an affidavit in the same manner as in the case of the petition.
8. Any person may also file the comments in the matter and the Authority, if deemed fit, may permit participation of such person into the proceedings and also may consider those comments in the final determination.
9. All stakeholders and interested I affected persons are also informed that in order to arrive at a just and informed decision, the Authority has decided to hold a hearing in the subject matter according to the schedule mentioned below:

Date : May 08, 2012

10. Time and Venue hall be informed later on.

All communication should be address to: communications should be addressed to:

Registrar NEPRA
2nd Floor, OPF Building, Shahrah-e-Jamhuriat, G-5/2, Islamabad.
Phone: 051-920 7200 Fax: 051-921 0215, Email: office@nepra.org.pk

For further information please visit our website: www.nepra.org.pk.

Assumption of Tariff for 600MW & 300MW Class Coal Thermal Generation

Assumption of Tariff of Generation (**600** MW Class)

	Fuel (Coal) a	Water b	Val. O & M c	EPP d = a+b+c	CPP e	Tariff f = d+e/0.6
1st to 10th years	*5.250*	*0.212*	*0.236*	5.698	4.599	**13.361**
11th to 30th years	*5.250*	*0.212*	*0.236*	5.698	2.371	**9.650**

Fuel (Coal)

1. Heating Value (Block II): 3,211 kcal/kg, 12,742 Btu/kg (0.252 kcal/Btu)
2. Price of coal: US$60/ton
3. EPC cost: US$960 mil. for 600 MW (US$1,600/kW)
4. Net thermal efficiency: 34.75%
5. Heat rate: 9.819 Btu/kW (3,412 Btu/kWh divided by34.75%)
6. Coal cost per kW
   - US$60/1,000 x (9,819/12,724)= US¢4.62/kWh (Rs.5.250/kWh)

Valuable O & M

Rs.0.1767 x US$960mil./US$720 mil. = 0.1767 x 1.333 = Rs.0.236

CPP

1. 1st to 10th years: Rs.3.4489 x US$960mil./US$720 mil. = Rs.3.4489 x 1.333 = Rs.4.599
2. 11th to 30th years: Rs.1.7779 x US$960mil./US$720 mil. = Rs.1.7779 x 1.333 = Rs.2.371

Assumption of Tariff of Generation (**300 MW** Class)

	Fuel (Coal) a	Water b	Val. O & M c	EPP d = a+b+c	CPP e	Tariff f = d+e/0.6
1st to 10th years	*5.375*	*0.212*	*0.251*	5838	4.753	**13.760**
11th to 30th years	*5.375*	*0.212*	*0.251*	5.838	2.401	**9.840**

Fuel (Coal)

1. Heating Value (Block II): 3,211 kcal/kg, 12,742 Btu/kg (0.252 kcal/Btu)
2. Price of coal: US$60/ton
3. EPC cost: US$510 mil. for 300 MW (US$1,700/kW)
4. Net thermal efficiency: 34%
5. Heat rate: 10,035 Btu/kW (3,412 Btu/kWh divided by34%)
6. Coal cost per kW

- US$60/1,000 x (10,035/12,724)= US¢4.73/kWh (Rs.5.375/kWh)

Valuable O & M

Rs.0.1842 x US$510mil./US$375 mil. = 0.1842 x 1.36 = Rs.0.251

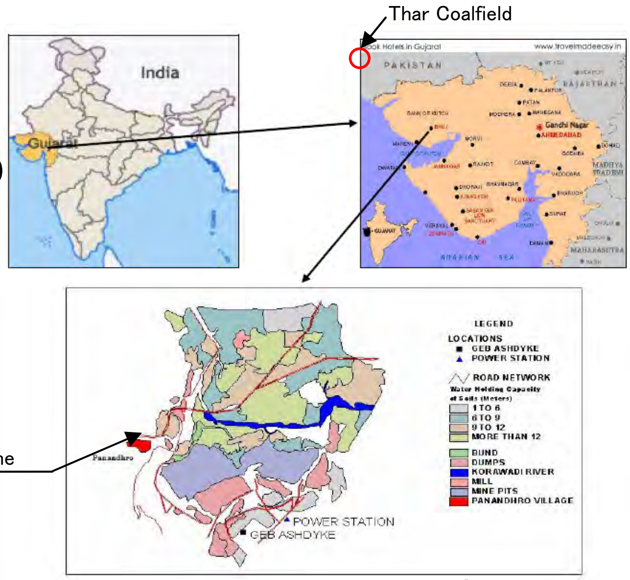
CPP

1. 1st to 10th years: Rs.3.4947 x US$510mil./US$360 mil. = Rs.3.4947 x 1.36 = Rs.4.753
2. 11th to 30th years: Rs.1.7656 x US$510mil./US$360mil. = Rs.1.7656 x 1.36 = Rs.2.401

Valuable O & M and CPP are calculated in proportion of EPC costs assumed by JST and assumed by PPIB.

Information of Panandhro Lignite Mine

- Owner: GUJARAT MINERAL DEVELOPMENT CORPORATION LTD.
- Location: Panandhro, Fulra & Khanot, Lakhpat, Kutch, Gujarat in India
- Nearest Railway station: Bhuj (130 km)
- Commencement Period: 1973-74
- Lease Area: 1151 ha
- Mineral Mined: Lignite and Limestone
- Mineable Reserves: 109 million tons (Lignite)
- Overall Ratio: 1: 3.64
- Production: 55,000t (1^{st} – 15^{th} Jan. 2013) (approximately 3 to 5million tons/y)
- Quality
  - Total Moisture: 37.85%
  - Ash: 10.92%
  - Volatile Matter: 29.43%
  - Fixed Carbon: 21.8%
  - Calorific Value: 3018.96 Kcal/kg



Source: Prasoon,Dipanwita,Gurdeep,

- Mining: Opencast Mining, Using hydraulic excavators and dumper combination, Dozer, Water sprinkler, Graders
- Geological Formation

Period	Series	Formation
Recent		Top Soil
Lower Origocene	Lower Nari	Hard and Compact Siliceous Limestone
Upper Eocene	Kirthar	Nummulitic Limestone
MiddleEocene	Laki	Shales, Clays, Lignite
Lower Eocene		
Unconformity		
Paleocene	Supratrappeans	Clays, Sands Altanated Formations
Unconformity		
Upper Cretaceous		Basic Volcanic Rocks / Traps

- Usage: This lignite is being supplied not only GEB's Power Station at Panandhro but also to industrial units (textiles, chemicals, ceramics, bricks, captive power etc.) all over the Gujarat State.

Information of Panandhro Lignite Mine

Panandhro Lignite Mine Working

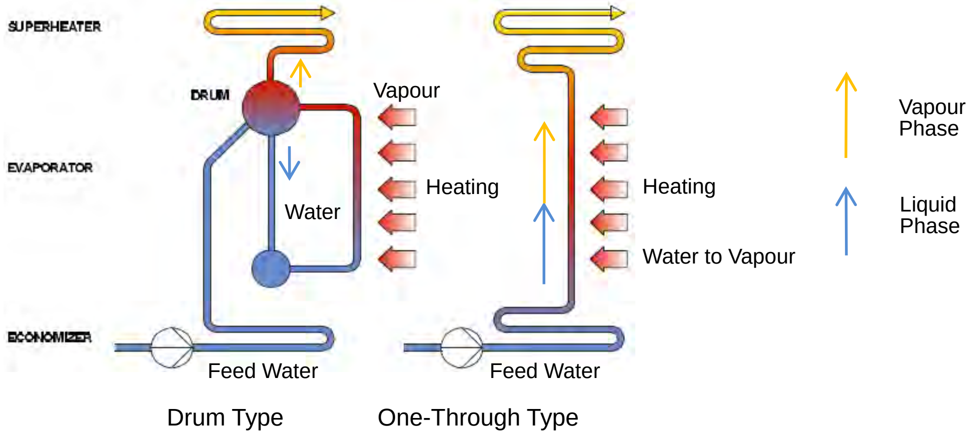
Source: GMDC Web-site http://www.gmdcltd.com

In Panandhro, lignite deposit occurs at shallow depths without hard strata as roof and interburden it is being extracted by opencast methods from 1974. Based on lignite field characteristics the entire field is divided into four mineable blocks. Overburden, interburden and lignite are being removed by different mining methods like manual mining, mechanized mining and mining by bucket wheel excavators. The lignite bearing area of Panandhro lignite field has an extent of 8.3 sq km. The formations belonging to upper cretaceous period to lower Oligocene period are exposed in an around the field. Lignite in this field appears to be made of several seams separated by bands or intercalations. As many as ten seams have been reported in several bore holes drilled at Panandhro lignite field. The thicknesses of these individual seams vary from a minimum of 0.10 m. to 10.50 m.[1].

[1] Source: Assessment of Groundwater Resources of Panandhro Lignite Mining Region, Gujarat State, India 2011

Basic Information for Thermal Power Generation

1. The difference of Drum Type Boiler and One-through Boiler



Souse: Foster Wheeler Boiler Technology

Figure 4.1 The difference of Boiler Type

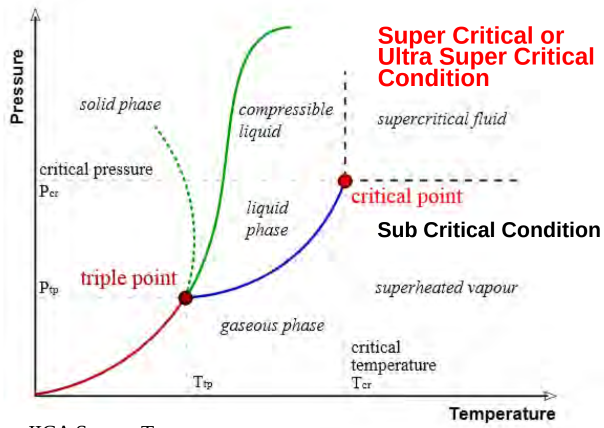
Drum Type Boiler

Feed water is heated in furnace and separated water and steam. Steam is more heated to superheated vapour.

One-through Boiler

Feed water is heated and it is directly changed the phase from liquid to vapour called super critical fluid when it excesses critical point of water in furnace.

2. The fluid of exceeding critical point of water

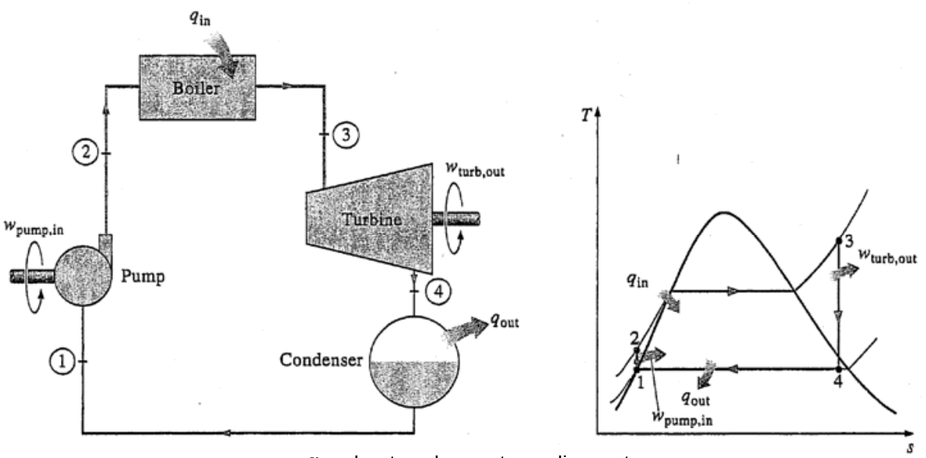


Source: JICA Survey Team

Figure 4.2 Typical phase diagram of water and the steam condition

Generally material has three phases depend on temperature. Typical example is water has solid phase (Ice) liquid phase and vapour phase (Steam) in normal pressure. When it is transcended the critical point (22.1MPa, 374^{0}C), which condition is not separated the three phase. This condition is called super critical fluid. Super Critical and Ultra Super Critical Boiler is used this steam condition of the Supercritical fluid.

3. Rankine Cycle



q_{out}: heat exchange to cooling water
q_{in} : heating in furnace
$w_{turb,out}$: for generation

Source: Figures from Cengel and Boles, Thermodynamics, An Engineering Approach, 6th ed., McGraw Hill, 2008

Figure 4.3 The explanation of Rankine Cycle

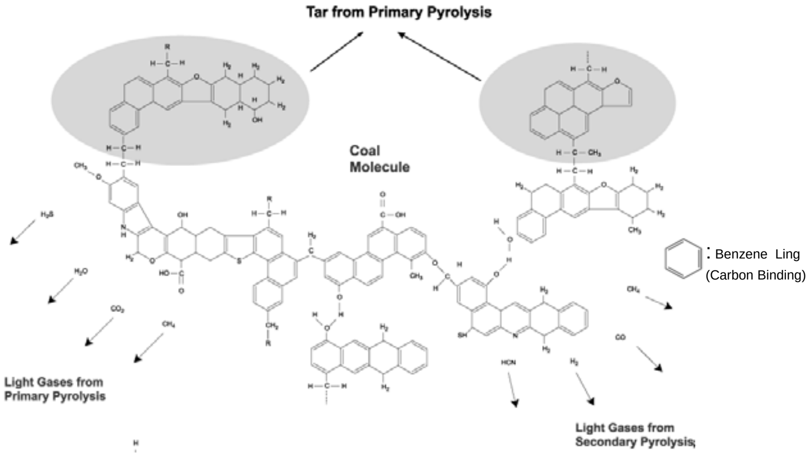
Figure 4.3 is typical model of steam cycle generation (left), and the relation between steam energy and steam temperature (right). Thermodynamics technology is very difficult to understanding, however explained simply, main points are mark 3 and 4, the mark 3 has maximum energy (max. steam pressure and temperature), and the mark 4 has minimum energy (exhausted steam pressure and temperature from turbine). Therefore the difference of this gap is larger, the efficiency rate of turbine work is better.

The consequently it is necessary that the condition of generation is the point 3 is higher and the point 4 is lower, it as much as possible.

4. Coal Molecule Structure Rerated Liquefaction and Gasification

Coal is a compound comprised of carbon, hydrogen, oxygen and some mineral. Crude oil and natural gas is also same compound comprised. The difference of them is molecule size. The volume of molecular of coal is huge. Crude oil and gas are in the order corresponding to decrease. Typical structure and decomposition of coal are shown Figure 4.4.

Therefore Gasification means that large molecular binding of coal separate off small molecular of liquid or gas by adding hydrogen or steam in high temperature and pressurised circumstance.



Source : Energy and Fuels1988, 2, 405

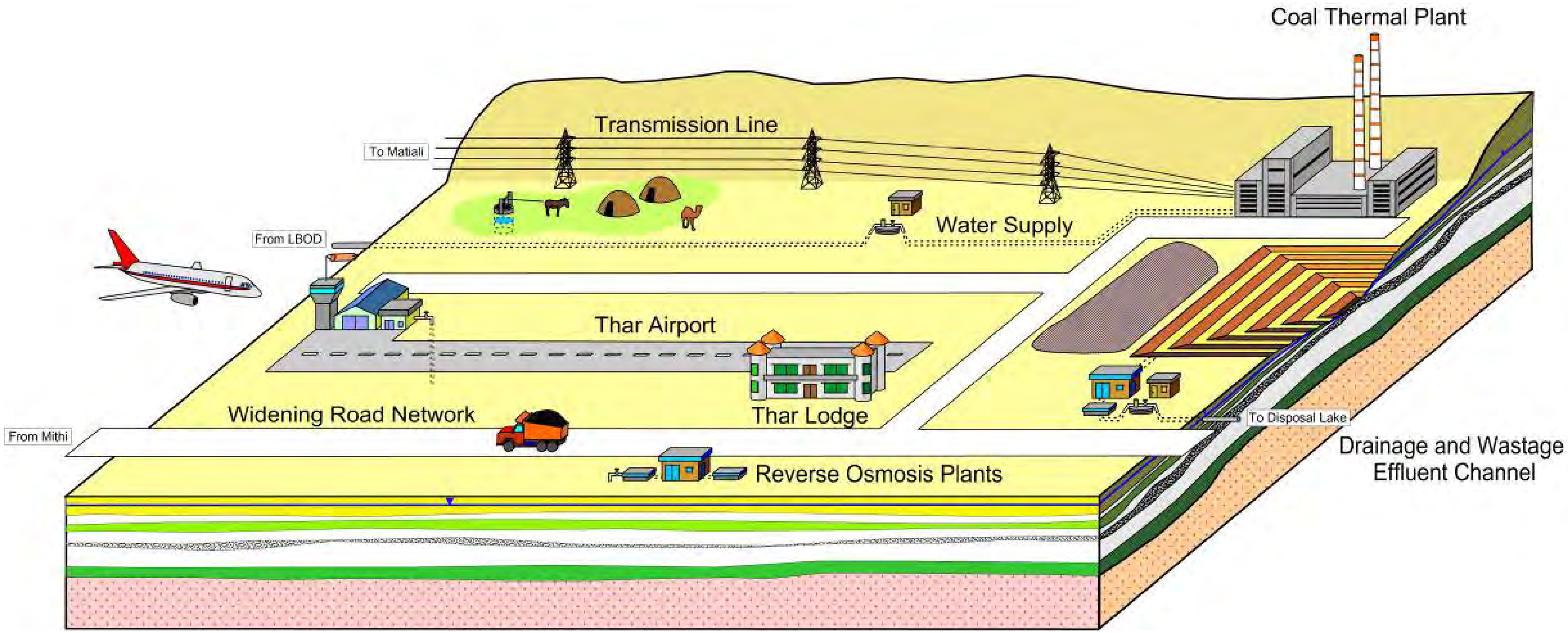
Figure 4.4 : Molecular Structure and Decompositions of Coal

5. Usage of latent heat in coal moisture

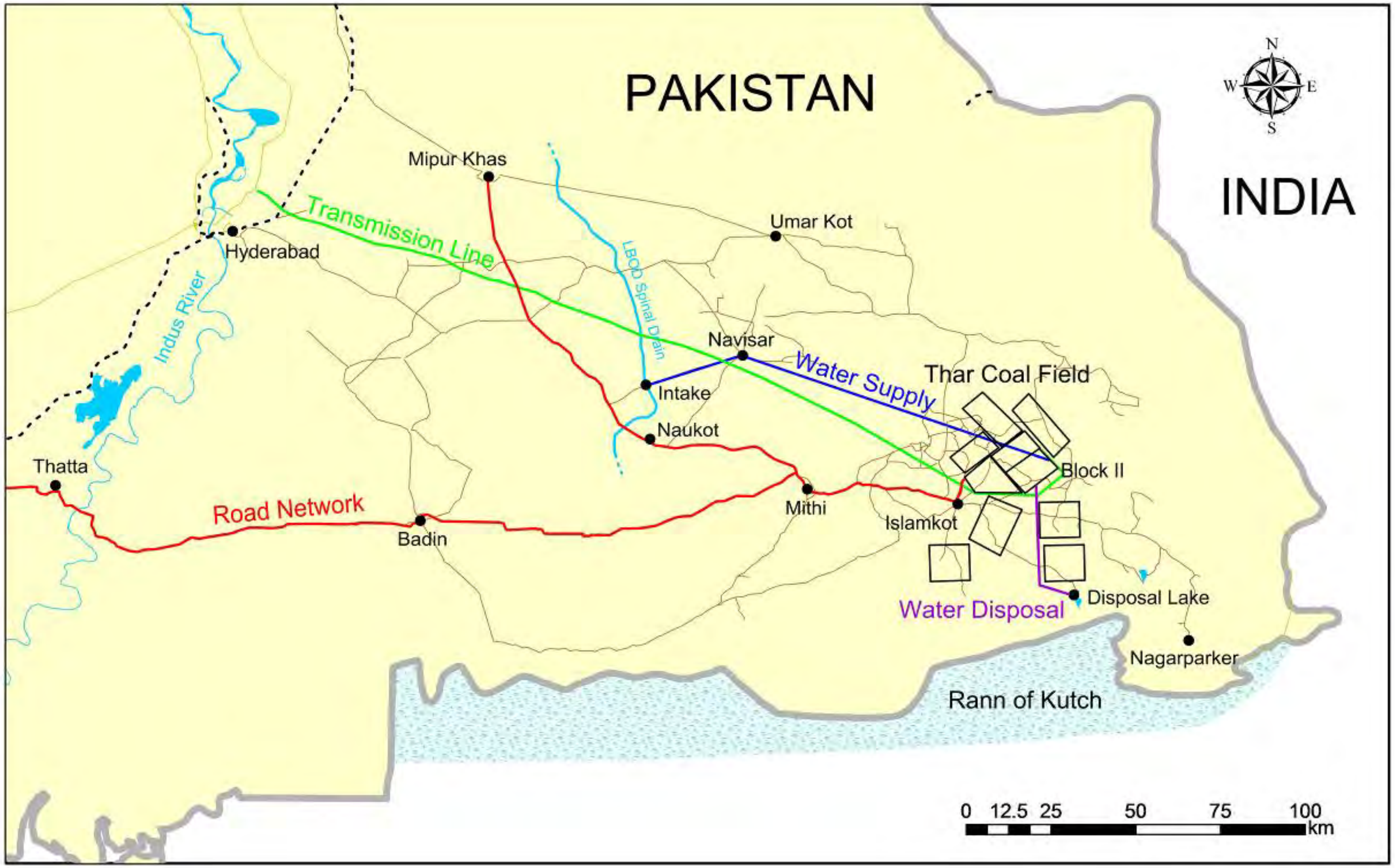
In the case of direct combustion, the temperature of coal moisture is heated around 1300^{0}C as same as the exhaust gas in furnace. Its heat energy is able to recover at such as super heater, economizer and air heater. Finally the exhaust gas temperature from a stack is necessary to be held more than150^{0}C due to keep up to the dew point of sulphic acid.

However pre-drying system for coal is necessary the other heat source for drying of latent heat to change the phases, which is liquid to vapour. In addition the energy of vapourizesd moisture is difficult to recover because of low temperature (It is estimated hundred-something degree). Therefore total efficiency of plant added pre-drying system is lower than direct combustion boiler.

Appendix 5-1 Summary of Infrastructures in Thar Coalfield



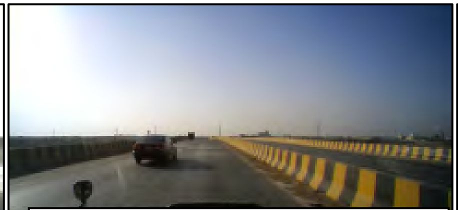
Appendix 5-2 Route Map of Infrastructures in Thar Coalfield



Appendix 5-3 Route Map of Access Road to Thar Coalfield (Segment-1)

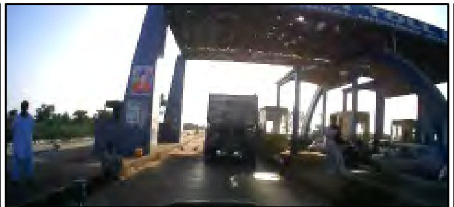

①Port Qasim Road

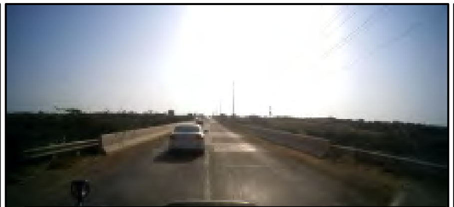

③ Typical View


⑤ Ghaghar Railway Crossing (B.P.)


⑦ Near Gharo Town


② Long Row of Trucks


④ Toll Gate (not in use)


⑥ Bridge on the Road


⑧ Thatta Bypass

Appendix 5-3 Route Map of Access Road to Thar Coalfield (Segment-2)

①Thatta Bypass (B.P. of the Route)

③Sujawal Town

⑤BadinTown (having median)

⑦Khoski Town

②Bridge over the Indus River (no shoulder)

④Typical View (2-lane)

⑥Nindo Town

⑧Wango Mor (E.P. of the Route)

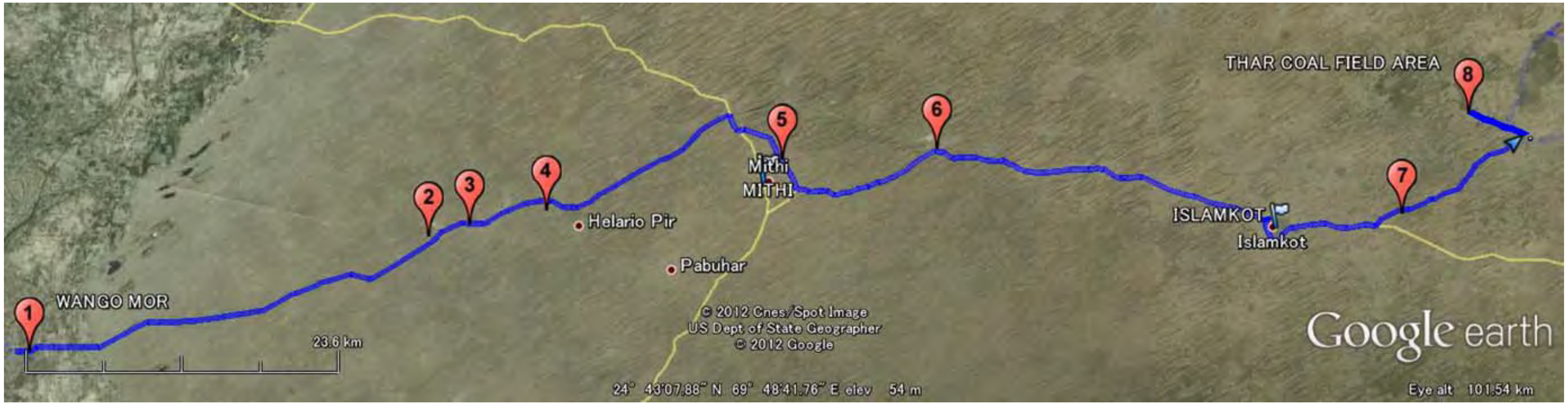
Appendix 5-3 Route Map of Access Road to Thar Coalfield (Segment-3)


①Typical View (1-lane)


③Erosion of the Embankment


⑤Sand (Dune) on the Road


⑦ Access to Block II Area




②Passing each other on the 1-lane road


④Damage of the Pavement


⑥Repair Works


⑧ Block II Area

Appendix 7-1 Preliminary Scoping of Environmental and Social Impacts of the Indivisible Projects

Item	Thermal Power	Mining	Secure Water	Sufficient Water Disposal	Road Development	Description
Pollution control						
1. Air pollution	A-	B-	B-	B-	B-	-Negative impacts on air quality are expected due to operation of the thermal power projects if without enough mitigation measures. -Some negative impacts on air quality are expected due to operation of heavy equipment/ vehicles as well as traffic jam incidental to construction and operation works of each project.
2. Water pollution	C	A-	C	A-	B-	-Negative impacts on surface water and ground water quality as acid rock drainage and metal leaching are expected due to the mining projects and the sufficient water disposal project if without enough mitigation measures. -Some negative impacts on river water quality would be caused by the turbid water generated from bridge works on the development of road. -Some potential negative impacts on groundwater quality would be caused by the turbid water generated from construction yards of digging works during construction stage. However the expected impacts would be small since groundwater level is deeper than the depth of excavation.
3. Soil Contamination	C	A-	C	C	C	-Negative impacts on soil are expected due to the mining projects if without enough mitigation measures. -In case that the soil at the construction sites is already contaminated by other reasons, the construction activity of the each project may cause the negative impacts.
4. Solid Waste and/or Industrial Discharge	B-	B-	B-	B-	B-	-It is expected that the each projects will generate the construction waste in the construction stage. The solid waste from the construction works will be managed according to the Pakistan regulations and guidelines concerned, then it is not expected to cause the serious impacts.
5. Noise and vibration	B-	B-	B-	B-	B-	-Some negative impacts of noise and vibration are expected due to the operation of the heavy equipment/vehicles of the each project.
6. Ground subsidence	D	B-	D	D	D	-Some impacts of ground subsidence are expected due to drawdown of groundwater in the mining projects. -Some negative impacts of ground subsidence are expected due to rehabilitated land after the mining. -There are no project components or activities except the mining projects

Item	Thermal Power	Mining	Secure Water	Sufficient Water Disposal	Road Development	Description
						that may cause the negative impacts on the ground subsidence since groundwater level is deeper than the depth of excavation.
7. Odor	C	C	C	C	C	- Some negative potential impacts on odor are expected due to noxious or offensive odor emissions in each project.
8. Bottom sediment	D	D	D	B-	D	- Some negative impacts on sediment are expected due to sufficient water disposal project.
Natural Environment						
9. Geographical Conditions and Geological Conditions	D	B-	B-	D	D	-Some negative impact on geographical conditions and geological conditions are expected due to the digging.
10. Soil Erosion	D	B-	D	B-	D	-Some negative impacts on soil erosion are expected due to changes to hydrological flow regimes.
11. Flora	C	C	C	C	C	Some negative potential impacts on flora might be expected due to cutting threatened plants during the construction stage on each projects.
12. Fauna	C	A-	C	C	C	-Some negative impacts on fauna are expected due to cutting trees which have nests of threatened vultures in breeding season in the mining project. Same negative potential impact for vultures might be expected in the other projects. - Some negative potential impacts on fauna in the wetland are expected due to sufficient water disposal to the salt lake.
13. Ground Water	D	A-	D	D	D	-Negative impacts on ground water level are expected due to the drawdown of groundwater in the mining projects.
14. Water Body (River, Lakes, etc.)	D	D	D	D	A-	-Negative impacts on water bodies are expected due to sufficient water disposal to salt lakes.
15. Natural/Ecological Reserves and Sanctuaries	D	D	D	D	A-	-Negative impacts on natural/ecological reserves and sanctuaries are expected due to sufficient water disposal to the Run of Kutch, Ramsar site.
Social Environment						
16.Involuntary Resettlement	D	A-	B-	B-	B-	-Negative impacts on involuntary resettlement are expected due to the mining project if without enough mitigation measures. -Some negative potential impacts might be expected due to the other projects.

Item	Thermal Power	Mining	Secure Water	Sufficient Water Disposal	Road Development	Description
17 Local economies (employment, livelihood, etc.)	B+	A+	B+	B+	B+	Positive effect on the local economy is expected because of possible increment of business/ employment opportunity generated by the each project implementation.
18. Water right	D	C	C	D	D	-Some positive potential impacts are expected due to the secure water project. -No impact on water use or water right is expected due to the projects implementation.
21. Land use and utilization of local resources	D	A-	B-	B-	B-	-Negative impacts are expected due to the major change of land use and utilization of local resources by the mining projects if without mitigation measures. -Some negative impacts on land use and utilization of local resources are expected due to construction works during the construction stage and existence of facilities during operation stage.
22. Social institutions and community	D	A-	D	D	D	-Negative impacts are expected on social institutions and community due to the mining projects if without mitigation measures. -No impact on social institutions and community is expected since no significant part of the local community would be divided by the other projects.
23. Existing social infrastructures and services	D	A-	D	D	D	-Negative impacts are expected on social institutions and community due to the mining projects if without enough mitigation measures. -No impact on social institutions and community is expected since no significant part of the local community would be divided by the other projects.
24. Poor, indigenous, or ethnic people	D	C	D	D	D	-Negative potential impacts might be expected on poor, indigenous, or ethnic people due to the mining projects. -No impact on poor indigenous or ethnic people is expected because of characteristics of the other projects.
25.Misdistribution of benefits and damages	D	C	D	D	D	-Negative potential impacts might be expected on misdistribution of benefits and damages due to the mining projects. -No impact on poor indigenous or ethnic people is expected because of characteristics of the other projects.
26. Local conflicts of interest	D	C	D	D	D	-Negative potential impacts might be expected on local conflicts of interest due to the mining projects. -No impact on poor indigenous or ethnic people is expected because of

Item	Thermal Power	Mining	Secure Water	Sufficient Water Disposal	Road Development	Description
						characteristics of the other projects.
27. Gender and Children's rights	D	C	D	D	D	-Negative potential impacts might be expected on gender and children's right due to the mining projects. -No impact on poor indigenous or ethnic people is expected because of characteristics of the other projects.
28. Cultural heritage	D	D	D	D	D	-There are no project components or activities that may cause the negative impacts on effect on cultural heritage.
29.Landscape	B-	B-	B-	B-	D	-As a result of the construction and existence of the facilities, the semi-desert and agricultural landscape would be changed.
30. Infectious diseases such as HIV/AIDS	B-	B-	B-	B-	B-	-During construction stage, increments of risks are probably expected on infectious diseases among the construction workforce.
31. Working conditions (including occupational safety)	B-	B-	B-	B-	B-	-Increment of the risks on traffic safety is expected due to the operation of heavy equipment and heavy vehicles during the construction stage. -Increment of the risks on safety is expected due to the operation of each equipment in the operation stage.
Others						
32. Accident and Hazard	C	C	C	C	C	There is a possibility of accident hazard due to operation of the construction heavy vehicles, though the project is not special method of construction.
33. Global warming	A-	B-	B-	B-	B-	-Negative impacts are expected on global warming due to the Greenhouse Gas (GHG) emission in the operation of the thermal power projects. -Some negative impacts is expected due to the operation of heavy vehicles as well as traffic jam incidental to the construction works, although the expected probability will be temporary during the construction stage.

Rating

A+/-: Significant positive / negative impact is expected.

B+/-: Positive / negative impact is expected to some extent.

C+/-: Extent of positive / negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progress)

D: No impact is expected

Reference: Appendix 5 of JICA Guidelines for Environmental and Social considerations (April 2010)

Source: JST

Financial and Economic Analyses (300MW & 600MW)

1. Assumptions

Table Assumptions

	Unit	300MW	600MW
Capacity Charge (1st -10th year)	Rs./kWh	4.753	4.599
Capacity Charge (11th year-)	Rs./kWh	2.401	2.371
Energy Charge	Rs./kWh	5.838	5.698
Coal cost	Rs./kWh	2.239	2.193

Note: Assumptions that are not described here are same as those used for the case of 1200 MW.

2. Financial Cost

Table Financial Cost of the Generation Project upon Completion of Construction (Unit: Rs. million)

Items	300MW			600MW		
	F/C	L/C	Total	F/C	L/C	Total
Construction & procurement	35,542	12,900	48,442	66,867	24,300	91,167
Price escalation	0	0	0	0	0	0
Physical contingency	2,005	851	2,856	3,743	1,597	5,340
IDC/commitment charge	0	0	0	0	0	0
Consulting services	1,075	438	1,513	1,251	506	1,757
Total: Eligible Portion	38,623	14,188	52,811	71,861	26,403	98,265
Total: Non-eligible Portion	0	12,240	12,240	0	22,923	22,923
Grand Total	**38,623**	**26,429**	**65,051**	**71,861**	**49,326**	**121,187**

Note: The total cost may not match due to rounding. This principle on rounding is applicable to all the tables on costs and benefits.
Source: JICA Survey Team

Table Annual Allocation of Financial Cost (Generation) (Unit: Rs. million)

Year	300MW			600MW		
	F/C	**L/C**	**Total**	**F/C**	**L/C**	**Total**
Year 1	204	70	274	198	70	268
Year 2	181	88	269	171	91	263
Year 3	5,816	3,983	9,799	10,766	7,410	18,176
Year 4	15,206	10,479	25,684	21,390	14,728	36,118
Year 5	13,376	9,180	22,557	28,513	19,612	48,125
Year 6	3,840	2,629	6,469	10,824	7,415	18,239
Total	**38,623**	**26,429**	**65,051**	**71,861**	**49,326**	**121,187**

Source: JICA Survey Team

3. Economic Cost

Table Economic Cost of the Project upon Completion of Construction (Generation) (Unit: Rs. million)

Items	300MW			600MW		
	F/C	F/C	L/C	Total	L/C	Total
Construction & procurement	35,542	10,694	46,236	66,867	20,145	87,012
Price escalation	0	0	0	0	0	0
Physical contingency	2,005	825	2,830	3,743	1,549	5,292
IDC/commitment charge	0	0	0	0	0	0
Consulting services	1,075	425	1,500	1,251	491	1,742
Total: Eligible Portion	38,623	11,944	50,567	71,861	22,185	94,046
Total: Non-eligible Portion	0	582	582	0	1,088	1,088
Grand Total	**38,623**	**12,526**	**51,148**	**71,861**	**23,272**	**95,134**

Source: JICA Survey Team

Financial and Economic Analyses (300MW & 600MW)

Table Annual Allocation of Economic Cost (Generation) (Unit: Rs. million)

Year	300MW	600MW
Year 1	272	266
Year 2	267	260
Year 3	7,713	14,267
Year 4	20,126	28,304
Year 5	17,693	37,707
Year 6	5,079	14,331
Total	**51,148**	**95,134**

Source: JICA Survey Team

4. FIRR and FNPV

(1) Base Case

Table 8.5-1 FIRRs and FNPVs of the Generation Projects

Case	FIRR	FNPV (Rs. million)	FNPV (US$ million)
300MW	13.3%	4,169	44
600MW	14.2%	12,605	132

Source: JICA Survey Team

2) Sensitivity Analysis

Table Sensitivity Analysis for the 300MW Generation Project (FIRR & FNPV)

Case	Benefit	Cost	FIRR (%)	FNPV (Mil Rs.)	FNPV (Mil US$)
Base case	No change	No change	13.3%	4,169	44
Tariff increase (+10%)	+10%	No change	14.6%	8,570	90
Cost increase (+10%)	No change	+10%	12.1%	186	2
Delay in construction (1 year)	No change	No change	13.0%	2,788	29

Source: JICA Survey Team

Table Sensitivity Analysis for the 600MW Generation Project (FIRR & FNPV)

Case	Benefit	Cost	FIRR (%)	FNPV (Mil Rs.)	FNPV (Mil US$)
Base case	No change	No change	14.2%	12,605	132
Tariff increase (+10%)	+10%	No change	15.6%	21,155	222
Cost increase (+10%)	No change	+10%	12.8%	5,316	56
Delay in construction (1 year)	No change	No change	13.8%	9,481	99

Source: JICA Survey Team

Financial and Economic Analyses (300MW & 600MW)

5. EIRR and ENPV

(1) Base Case

Table EIRRs and ENPVs of the Generation Projects

Case	EIRR	ENPV (Rs. million)	ENPV (US$ million)
300MW	27.5%	57,990	608
600MW	29.9%	122,055	1,279

Source: JICA Survey Team

Note: EIRR and NPV are calculated without including the economic cost of the transmission project based on the assumption that the transmission line is already connected with the coal thermal power plant.

(2) Sensitivity Analysis

Table Sensitivity Analysis for 300MW Generation Project (EIRR & ENPV)

Case	Benefit	Cost	EIRR (%)	ENPV (Rs. million)	ENPV (US$ million)
Base case	No change	No change	27.5%	57,990	608
Benefit increase (+10%)	+10%	No change	29.7%	68,415	717
Cost increase (+10%)	No change	+10%	25.7%	54,856	575
Delay in construction (1 year)	No change	No change	27.5%	51,660	542

Source: JICA Survey Team

Table Sensitivity Analysis for 600MW Generation Project (EIRR & ENPV)

Case	Benefit	Cost	EIRR (%)	ENPV (Rs. million)	ENPV (US$ million)
Base case	No change	No change	29.9%	122,055	1,279
Benefit increase (+10%)	+10%	No change	32.3%	142,904	1,498
Cost increase (+10%)	No change	+10%	27.9%	116,331	1,219
Delay in construction (1 year)	No change	No change	29.9%	108,744	1,140

Source: JICA Survey Team