

SJVN THERMAL (P) LIMITED

(A wholly owned subsidiary of SJVN Limited - A Mini Ratna & Schedule 'A' Central Public Sector Utility, under the Ministry of Power, Govt. of India).

PRE FEASIBILITY REPORT (UPDATED)

1320 MW (2x660) Buxar
Thermal Power Project,
near Chausa, District
Buxar, Bihar

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1. INTRODUCTION

The Electricity Act 2003 has opened up significant investment opportunities in the generation sector by de-licensing electricity generation. The power generation market is entering a competitive mode and cost of generation has become a critical parameter in determining the long-term viability of projects. Coal based stations located at pithead offer most economical power.

The generation capacity of India as on 31st March 2016 is 2,98,000 MW, out of this the power generation capacity in Bihar is 2,985 MW including the allocated shares from central generating stations. The estimated peak load demand in Bihar at the end of 12th 5-year plan (2016-17) is 5,018 MW and at the end of 13th 5-year plan (FY 2021-22) is 9,306 MW (as per 18th EPS published by CEA). And all this in a scenario when the per capita power consumption in Bihar is lowest at 265 units per annum, against the national average of 1,060 units per annum. Thus requiring the state to add power generation capacities of 1,000 MW each year.

To meet up with this overall national objective and to enable Bihar access to additional power required to sustain the high growth rate being witnessed, Govt. of Bihar and the erstwhile Bihar State Electricity Board formed a Joint Venture with IL&FS Group, namely, Bihar Power Infrastructure Company Pvt. Ltd. (BPIC) for development of power project in record time.

With exorbitant Gas & LNG prices, compounded by un-certainties of crude pricing does not offer a viable option. Hydro & Nuclear power have also not lived up to the expectation and the only viable long-term option, which is widely accepted today, is coal. And keeping in view the advantages linked to coal mines in Jharkhand / West Bengal, BPIC developed a power project in Bihar.

BPIC has taken an initiative to visit various sites in Bihar for locating the project and has identified Chausa as one of the potential site. The configuration proposed for the Project is two Units of 660 MW each, gross installed capacity of 1320 MW. BPIC incorporated a Special Purpose Vehicle (SPV) namely Buxar Bijlee Company Private Limited, as its wholly owned subsidiary for developing the said project. BPIC carried out EIA studies in terms of the TOR issued by MOEF and also the public hearing. However, the project could not be placed for final environment clearance because of unavailability of coal linkage. Recently, the project have been awarded a coal block namely Deocha Pachmi coal block in West Bengal and also the project company has executed an MOU for procuring the imported coal. The project has since then been acquired by SJVN Ltd and the project company has been renamed as SJVN Thermal Pvt Ltd – and is presently its wholly owned subsidiary company.

In terms of the PPA executed between the Project Company and erstwhile Bihar State Electricity Board, 85% of power generated by the Project shall be supplied to discoms in Bihar and the balance power would be available for supply elsewhere. Due to the locational advantage of the Project in terms of availability of coal, water and evacuation facilities the power is expected to be highly competitive.

The total cost of the project would be around 9,591 Crores (at April, 2014 price levels). The Project would be financed at a debt equity ratio of 70:30 and First unit will be commissioned within a time span of 38 months from the date of issue of Notice to Proceed (NTP) to EPC contractor. Subsequently, Second unit would be commissioned in 42 months from notice to proceed (NTP) to EPC contractor. The promoter, viz. SJVN Ltd shall finance the project through a mix of Debt and Equity.

The proposed power project is envisaged to be operated through imported coal (though the project has also been awarded the Deocha Pachami coal block in West Bengal, the coal block is likely to be commissioned at a later time after COD of the project) and the water required would be drawn from Ganges River (about 3 kms from the proposed site).

The objective of this Pre Feasibility Report is to assess the feasibility of the project such as site features, basic plant configuration, salient technical features, project execution plan, etc. for the proposed Power Plant.



2. NEED FOR THE PROJECT

After creation of the state of Jharkhand, the State of Bihar was left with an installed capacity of approximately 584 MW only. Further, the generation from its installed capacity has been quite low (due to very old units, shut-down, obsolescence and other reasons) and Bihar has to depend entirely upon Central allocations for meeting its power requirement.

Bihar region has a widespread deposit of low-grade coal, which is predominantly used in thermal power plants across the country. In terms of connectivity between states Bihar has good connectivity and is in vicinity of the Northern and Western Grid.

2.1 Need for the Project

The Central Electricity Authority (CEA) has estimated the peak load shortfall in 2015-16 at around 7%. The shortages have been in the range of 7 to 12% during the past few years and the trend is likely to continue in the immediate future as the load growth is likely to surpasses the capacity augmentation in the pipeline.

The estimated peak load demand in Bihar at the end of 12th 5-year plan (2016-17) is 5,018 MW, against a present installed capacity of 2,983 MW, which includes the central allocations as when. Further, at the end of 13th 5-year plan (FY 2021-22) is 9,306 MW (as per 18th EPS published by CEA).

The following is the data provided by CEA:

Region	2015-16				2014-15				2013-14			
	MUs				MUs				MUs			
	Req	Avail	Diff	%	Req	Avail	Diff	%	Req	Avail	Diff	%
NR	340,488	324,021	-16,467	-4.8%	328,944	318,837	-10,107	-3.1%	309,463	290,880	-18,583	-6%
WR	346,650	345,848	-802	-0.2%	288,062	289,029	967	0.3%	294,659	291,856	-2,803	-1%
SR	288,004	283,473	-4,531	-1.6%	298,180	260,366	-37,814	-12.7%	277,245	258,444	-18,801	-6.8%
ER	124,608	123,635	-973	-0.8%	118,663	114,677	-3,986	-3.4%	108,203	106,783	-1,420	-1.3%
N.E.R.	14,487	13,636	-751	-5.2%	14,823	12,248	-2,575	-17.4%	12,687	11,866	-821	-6.5%
All India	1,114,235	1,090,713	-23,522	-2.1%	1,048,672	995,157	-53,515	-5.1%	1,002,257	959,829	-42,428	-4.2%

Source: CEA, LGBR, Monthly and annual power generation reports till 31st March.,
 ,MU-Million Units. Req-Requirement, Avail-Availability, Diff-Difference.

This shows a shortfall of 23,522 MU in 2015-16 ie about 2.1 % shortage and the same is expected to increase in exponential rate.

The expected demand in 12th and 13th five year plan is indicated below. The expected future scenario does not show a matching of demand and supply.

Region	Energy Requirement (MUs)		Peak Load (MW)	
	2016-17	2021-22	2016-17	2021-22
Northern Region	337,461	498,246	60,934	86,461
Western Region	318,806	489,033	62,015	86,054
Southern Region	297,816	432,014	57,221	82,199
Eastern Region	132,088	203,256	24,303	35,928
North-Eastern Region	12,486	18,908	2,966	4056
All India	1,098,995	1,611,809	199,540	283,470

Source: Eighteenth EPS of CEA.

2.2 Power Scenario of Potential Consumers

Even though bulk of the power generated from the power projects setup by the SPV would be consumed by Bihar, it is proposed that some fraction of it would be sold to other nearby states, in terms of the policy of the Ministry of Power to keep certain capacity under unallocated category.

Bihar is facing an acute shortage in power supply. While the demand for power in Bihar has been growing at a rapid rate, its supply has not kept pace. Hence, Bihar would have to rely increasingly on power generated from outside the state.

Bihar demand and supply status over past few years has been as follows:

Actual Power Supply Position	2015-16	2014-15	2013-14
Energy Requirement (MUs)	24,050	15,917	15,391
Availability (MUs)	23,748	13,477	14,759
Shortages (MUs)	(-) 4,531	-2,440	-632
Shortages (%)	- 1.6%	-15.3%	-4.1%
Peak Demand (MW)	3,735	2,750	2,465
Peak Demand Met (MW)	3,484	2,038	2,312
Shortages (MW)	-251	-712	-153
Shortages (%)	-6.7%	-25.9%	-6.2

Source: CEA, LGBR, Monthly and annual power generation reports till 31st March.

CEA has made projections for the future demand of power in the state as follows:

Expected Power Supply Position	2016-17	2021-22
Energy Requirement (MU)	29,447	52,975
Peak Load (MW)	5,018	9,306

Source: Report on Eighteenth Electric Power Survey of India.

2.3 Cost of Power Purchase

The Project is expected to generate power at around Rs. 3.50 per kWh. Bihar is buying significant amount of power at a rates much higher than Rs. 3.50 per kWh. The average power purchase cost of Bihar is Rs 4.01 per unit (as per BERC Tariff order for FY 2015-16). Moreover, the projection of Rs. 3.50 per kWh from the project is in 2019-20. De-escalating for inflation, the tariff from the proposed project is expected to be cheaper than many other sources.

Besides, as observed in the past, there has been great volatility in the pricing of power from petroleum & gas fuels.

2.4 Conclusion

Keeping in view of the projected power demand and the need to have lower power tariff, the proposal to put up power plant closer to coal source is justifiable.



3. PROJECT OVERVIEW

BPIC has been looking at sites in and around Chausa village, District Buxar for locating the Project. The important criterion for site selection being adopted by BPIC is as follows:

- i) Total land required for setting up the project facility shall be around 1,000 to 1,500 acres at a stretch including the green belt and water bodies.
- ii) The project site shall be close to the water source and near the source of fuel i.e. coal.
- iii) The project site requires minimum displacement of habitation and away from the habitation area.
- iv) The project site is closer to highway with hindrance free approach for transportation of heavy equipment. **Project site is well connected by roads.**
- iv) The project site is close to railway lines to enable efficient transportation of coal. Coal will be sourced from abroad as imported coal for 4 years and subsequently from the coal block allocated to the project in West Bengal and the transportation for the proposed site will be by Railway wagons.
- v) The plateau of the project site shall be as flat as possible. **The terrain is flat.**
- vi) The project site shall be free from forest growth.

The site comprising 1,064.69 acres of land area is located approximately 10 kms from Buxar city on Ghazipur road. The site offers mostly barren

land owned by the local villagers. Hindrance free approach for the transportation of heavy equipment & coal is provided through the main road which is 1 km from site and Eastern railway main line, 3 km from site. The site is approximately 3 kms from River Ganga, which is the source of water for the Power project. The water requirement for the project is estimated at 55 cusecs on continuous basis. The terrain is flat and above the high flood level. Nearest airfield at Patna is more than 135 km from site and hence the chimney would not fall within the approach funnel of the airport runway. The project site is free from reserve forestlands, sanctuaries and monuments and meets the environment requirements and guidelines.

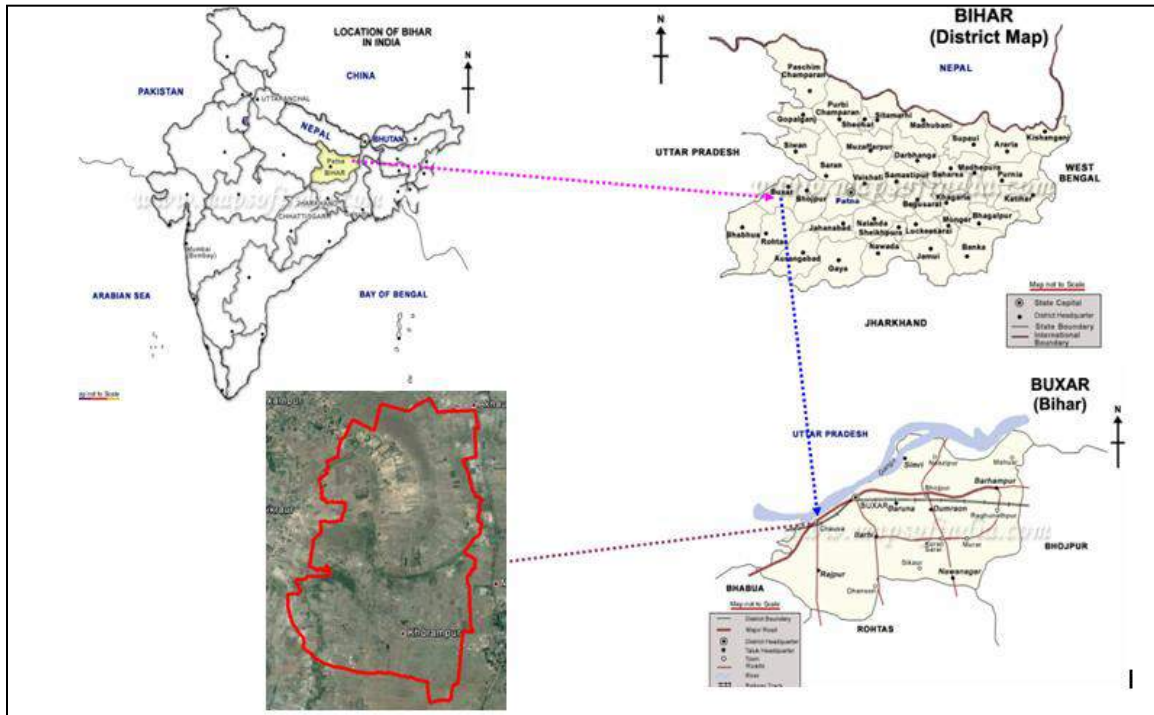
The detailed breakup of the land is being worked out and will be provided in the Detailed Project Report.

3.1 Plant Location Data

1. Location
Village / City : Chausa (10 km from Buxar city)
District : Buxar
State : Bihar, India.
2. Nearest Railway Station : Chausa
3. Nearest Airport : Patna
4. Nearest Harbour : Haldia, WB
5. Access Road : On the Road from Buxar to Sasaram
6. Possibility of Transportation of fuels : Railways

7. Availability of water : Ganges River Water

Project location map is presented below.



3.2 FUEL

Coal will be the primary fuel for the power plant. The coal required for the 2x660 MW Thermal Power Project will be 3.9 MTPA (imported coal) or 6.25 MTPA (Domestic coal) at 85% PLF. The project is envisaged to be operated on imported coal through MMTC for 4 years and domestic coal, when the Deocha Pachami coal block allocated to the project is likely to start the coal production.

Further, secondary fuel would be required for the initial start up. Light Diesel Oil (LDO) and Heavy Fuel Oil (HFO) will be used as Secondary fuel. The annual requirements of LDO and HFO are 500 m³ and 2000 m³ respectively.

3.3 Construction Power and Water

The aggregate power requirement for the power plant has been estimated at 5 MVA. The project will draw construction power from the nearest 33 KV line or higher that may be available near the site.

Water required for construction purposes would be drawn from Ganges River or sourced from local water authority.



4. PROJECT DETAILS – TECHNICAL

4.1 Technology & Layout

The project proposes to use conventional coal fired boilers, which is a proven technology for power generation.

Around 447 acres of land would suffice to accommodate the main Power plant, which would include besides the main power block, the Electrostatic Precipitator, the chimney, coal handling plant, space for FGD (if required in future), transmission switchyard, Water systems (including cooling towers), etc.

The layout shall include railway tracks proposed to be used for transporting fuel – either by Indian Railways using the main line or a merry-go-round system, depending on where the site is located with reference to the coalmines.

The coal storage of 30 days requirement of crushed coal is proposed to be provided at the power plant.

A common multi-flue concrete chimney for the two units has been proposed for this project. A chimney height of about 275 mtrs has been considered in accordance with the guidelines given by the Central Pollution Control Board.

The plant is proposed to have a 50-meter wide green belt around perimeter as well as plantation in the other dust prone areas like coal and ash areas.



While finalizing the plant layout the general principles under consideration are as under:

- All facilities of the 2 x 660 MW units are in close proximity to each other to the extent practicable so as to accommodate all facilities efficiently within the plant boundary and space provision for one more unit of 660MW capacity.
- One(1) no. of multiflue chimney
- Sufficient area in the turbine hall allowing the laydown of all turbine components during overhauls.
- Location of Water source and method of drawl.
- Space for coal storage for thirty (30) days.
- Space for ash disposal.
- Facility for dry ash disposal road tankers/ trucks starting with 25% utilization in the first year and 100 % utilization during the 4th year
- Space for fuel oil receiving, storage and handling etc.,
- To facilitate movement of men and materials between the various facilities both during initial construction and also during subsequent operation and maintenance.
- Major external functional system are so oriented that any maintenance work as well as subsequent construction work can be

carried out without any interference and/or hindrance to the operational units.

- Steel storage yard and pre-assembly yard required for storing and assembling of plant equipments during construction phase and later this space will be converted into green belt during the operational phase.
- Power evacuation corridor for connection to grid.
- Approach road to power plant from the National Highways.
- Unit system concept will be adopted for following systems with no interconnection with other units of the plant:
 - a) Steam water cycle except with the interconnection on the Auxiliary steam system.
 - b) Circulating water system.
 - c) Auxiliary cooling water system.
 - d) Closed circuit cooling water system.
- Coal Handling system, Ash disposal, Fuel oil receiving & storage, River water intake, DM plant, Waste water treatment plant, Fire protection, Labs, Workshop, Hydrogen Generation plant etc. will be common for all the units. However the phasing of equipment, supply & erection will be detailed under project implementation.

4.2 Plant Configuration

Unit size trend in India for large supercritical plants are 660MW and 800 MW. The cycle efficiency for similar steam and feed water parameters are more or less the same.

Although 800 MW units have an advantage over 660 MW units on technical aspects, a 660 MW unit is expected to have a faster delivery period of 32 to 37 months as compared to 38 to 43 months of 800 MW units. Further, 660 MW units can be sourced from China which would be cheaper than other makes. This is evident from the trends seen in various supercritical technology based mega and ultra mega power projects which are on-stream. Some of the current projects and their unit sizes are listed below for comparison:

Project	Unit Size	Fuel
Sipat – I, NTPC	3x660 MW	Indian Coal
Barh – I, Bihar, NTPC	3x660 MW	Indian Coal
Sasan UMPP, M.P.	6x660 MW	Indian Coal
Krishnapatnam UMPP, AP	6x660 MW	Imported Coal
Adani, Mundra, Gujarat	2x660 MW	Imported Coal

Therefore, for the purpose of establishing the design basis for the Main Plant and Plant Auxiliaries system a unit size of 660 MW is being considered.

4.3 Design Parameters

The coal based Thermal Power Station is designed as a Two-unit station of 660 MW (at Maximum Continuous Rating) capacity each.

To achieve efficiency without sacrificing availability, it has been decided to operate the steam parameters in the super-critical range.

6.25 MMTPA of coal is required for the 1320 MW Power Plant. Coal for the proposed thermal power station is expected to be made available from Deocha Pachmi coal block in West Bengal. The coal with average gross

calorific value of about 3300 Kcal/Kg is considered for design and estimation purposes.

The steam parameters have been fixed at approximately about 250 kg/cm² and 565° C/595° C in line with the established practice of most of the international manufacturers of 660 MW capacity machines. Single reheat is envisaged in the turbine cycle in conformity with prevailing practice. The condenser vacuum i.e. heat sink level is considered to be 76 mm Hg absolute on consideration of circulating water inlet temperature of 33 Degree Celsius (max).

The design of the system and system components for the proposed station would consider the following basic design parameters:

Maximum ambient temperature	50 Degree Celsius
Seismic Zone	Zone IV as per IS:1893 (Part-I) 2002
Maximum wind velocity	39 m/sec
Power supply to drives (3-Ph, 50 Hz, DOL-start)	Up to 160 KW rating at 415 V Between 160 KW to 2000 KW rating at 6.6kV Above 2000 KW rating at 11 KV
Control voltage for electrical equipment	At 220 V DC (unearthed)
Power supply for instrumentation and control	At 240 V AC (UPS)

Adequate provisions have been made for spare capacities in various systems and system components both in size and number in accordance with good engineering practice for high availability of the plant.

The plant will be designed to operate as a base load station. However, continuous operation under two shift and cyclic modes during certain periods will also be envisaged:

Examples of Possible operation modes:

- Base load operation
- Peak load operation
- Island operation
- Frequency support

4.4 Thermodynamic Cycle

A super-critical pressure reheat steam cycle with regenerative feed heating arrangement is proposed.

The main steam from the boiler, after expansion through the HP turbine, would be sent back to the boiler for reheating. The reheated steam, after expansion through double flow IP and LP turbines respectively would be exhausted into the main condenser, where the exhaust steam from the LP turbine would be cooled and condensed by circulation of cooling water and its vacuum would be maintained by two (2) (1 working + 1 standby) 100% capacity vacuum pumps. The feed heating system would consist of four (4) stages of low pressure heaters, one (1) gland steam condenser, one (1) de-aerator and three (3) stages of high pressure heaters. The condensate from the hot well would be extracted by 3 x 50% capacity condensate extraction pumps (2 working + 1 standby) and pumped to the de-aerator through condensate polishing unit (when in use), gland steam condenser and the LP heaters. The feed water after being de-aerated in the de-aerator would be drawn by the boiler feed pumps and pumped to the respective boiler through the high-pressure heaters. Three (3) 50% capacity boiler feed pumps have been envisaged for each unit. Out of the

three pumps Two will be Turbine driven and One will be Motor driven. The boiler feed pumps will be provided with variable speed hydraulic coupling, lube oil system, automatic leak off and minimum flow bypass valves. Feed water would be heated up in the feed water heaters progressively by bled steam drawn from cold reheat line and extraction points of the IP Turbine and Condensate water would be heated in the LP Heaters by steam extracted from the extractions from LP Turbine

Condensate drain from the HP heaters would be cascaded to the de-aerator feed storage tank and drain from the LP heaters would be cascaded to the condenser through the drain cooler.

Auxiliary steam for the station will be drawn from a suitable point in the boiler and after pressure reduction and de-superheating would be used for various services. Auxiliary steam system shall supply steam to the de-aerator, turbine gland sealing system (during light load and start-up conditions), fuel oil heating and atomization system etc. Provision for steam supply to auxiliary steam system from cold reheat piping through adequately sized pressure reducing and de-superheating station will be made. The 660 MW units would also be provided with adequately sized HP and LP turbine bypass stations for quick hot start and boiler stability with large load rejections.

4.5 Power-House & Ancillary Building

The superstructure of the powerhouse building is expected to be enclosed type in fabricated structural steel work. The roof and floors will be RCC slab on steel truss/beam. Side cladding may be of plastered brickwork supported on steel wall beams, double skin insulated metal sheeting or PC panel.

The superstructure of the CW pump house, DM plant etc. will be of steel and enclosed with brick walls, un-insulated metal or aluminum cladding.

All other building, viz., the workshop, store, control room buildings, pump houses, administrative building etc. will have RCC frames with cast-in-situ roof and masonry cladding. In case of long span roof, however, steel truss with AC/metal sheeting would be adopted. Foundations in all cases will be of RCC spread or raft Type.

4.6 Steam Generating Unit

The Steam Generator shall be of Single pass (Tower type) or two pass type using either spiral wall (inclined) or vertical plain / rifled type water wall tubing. The steam generator shall be direct Pulverized coal fired, top supported, single reheat, radiant, dry bottom with balanced draft and suitable for outdoor installations. The water wall of Steam Generator shall be suitable for variable pressure operation from Sub critical to Super critical pressure range. The SG shall be of once through type with supercritical steam parameters.

The capacity of Steam Generating units would ensure 4 to 5% margin over the steam requirement of the Turbine at Valve Wide Open condition (VWO is 5% above TMCR) to cater to the auxiliary steam requirement for soot blowing operation, fuel oil heating system and normal derating of the Steam Generating unit after prolonged use.

The Steam Generators would be capable of maintaining main steam and hot reheat steam temperatures of designed value between 60-100% MCR load or better. The Steam Generator would be capable of operation with “the HP heaters out of service” condition and deliver steam to meet Turbo-generator requirement at 100% MCR.

The steam generator would also be suitable for operation with HP-LP turbine bypass system. Economizer section of the boiler would be non-steaming type with provision for re-circulation during start-up, chemical cleaning etc. Super-heater and re-heater would be provided with de-superheating stations with provision for spraying water for temperature control. Spray water will be feed water.

Each unit comprises of Two (2) nos of regenerative air pre heaters each with electric motor drive and manual cranking facility for emergency. Each Air pre-heater will be designed for 60% of BMCR load. Steam coil air pre-heaters (SCAPH) will be provided in each FD fan discharge duct to maintain cold temperature above acid dew point during boiler start-up and low load operating conditions.

The boiler would be provided with a set of soot blowers, automatic sequential electrically operated type, arranged for on-load cleaning of the heat transfer surfaces e.g. water walls, super heaters, re-heaters, economizers and air heaters.

The boiler furnace and flue gas passage would be designed for appropriate low velocities in order to minimize erosion and slagging effect.

Suitable balanced draft system would be provided for the steam generator with two (2) forced draft and two (2) induced draft fans. Each of these fans would be capable of meeting the air requirement at 60% boiler MCR load. The forced draft fans would be axial impulse type with inlet vane control arrangement or axial reaction type with hydraulic blade pitch control for regulation of airflow. The 60% capacity induced draft fans would be double suction radial type with speed control arrangement through variable speed hydraulic coupling or inlet vane control arrangement for regulation.

Each steam generator unit would be equipped with suitable pulverized coal firing arrangement comprising crushed coal silos, raw coal feeders, pulverizing mills, primary air fans, seal air fans, fuel and air pipes, burners etc. as necessary.

Vertical type bowl mills are considered. Number of pulverizers would be so selected as to have one pulverizer available as standby for maintenance when the boiler is operated with worst coal at 100% boiler MCR. With design coal, one pulverizer would remain standby and another would be available for maintenance at 100% Boiler MCR.

The steam generating units will be provided with Heavy Fuel Oil (HFO)/LSHS pressuring and heating units for supplying HFO/LSHS to the oil burners for hot start up and for stabilization of combustion of pulverized coal. The HFO/LSHS system would be capacity sufficient to meet minimum 30% of boiler MCR load. Light oil system (capacity 10%) would also be provided for cold start up and warming up purposes.

Boiler Feed Pumps and Drives

Three (3) 50% capacity horizontal multistage, barrel casing centrifugal feed pumps, would be provided for each unit. Out of which two no.s of feed pumps will be turbine driven and One no. will be electric motor driven. Normally two no. of Turbo driven pumps will be in operation while the third feed pump will act as standby. The head, capacity, net positive suction head (NPSH) etc. would be selected to be compatible with the heat cycle considered to meet the boiler MCR without encroaching on normal margins.

Each boiler feed pump would have one (1) matching capacity single stage booster pump. The booster pump would take suction from de-aerator and

discharge into the suction of corresponding boiler feed pump, which in turn, would supply feed water to boiler through high-pressure heaters.

Each feed pump would be provided with an automatic minimum recirculation flow control arrangement to protect the pump under low load operation.

De-aerating Heater and Closed Heaters

Each unit would be provided with a variable pressure type de-aerating heater with a feed water storage tank of about 6 minutes storage capacity. The de-aerator would be of the spray-cum-tray type and would be designed to de-aerate all the incoming condensate and drain flow to keep the dissolved oxygen content of the feed water below the permissible limit. Vent condenser would be provided integral with de-aerator to minimize wastage of steam.

The de-aerator would normally operate with extraction steam from the turbine. However, during low load operation and start-up, the de-aerator pegging will be done with steam drawn from the auxiliary steam header. The de-aerator would be placed at a suitable elevation to provide sufficient NPSH for the boiler feed pumps without restricting the drain flow from the next HP heater.

All the heaters shall be Horizontal type. The recommendations of ASME standard TDP-1 (part-I) for preventing water damage to turbine would be followed.

4.7 Turbine Generator Unit

The steam turbine will be standard multi-stage, three cylinders, tandem compound, single reheat, condensing type operating at 3000 RPM with about eight (8) uncontrolled extractions of regenerative feed heating. The

turbine is designed for main steam inlet parameters of about 250 kg/cm² (a) at 565°C/595 °C before emergency stop valves of HP turbine and reheat steam temperature shall be 565/ 595° C at inlet to IP turbine and exhausting against condenser pressure of 76 mm Hg abs, at design condenser cooling water temperature.

A steam turbine for 660 MW unit size normally has a barrel type HP cylinder, horizontally split double flow IP and LP cylinders with the LPT exhausting directly into spring mounted surface type, two-pass condenser having divided water box. There are about eight stages of uncontrolled steam extractions, for various HP and LP feed water/condensate heaters downstream of the HP turbine exhausts. The turbo-generator set would be designed for a maximum continuous rating (MCR) at 660 MW.

A quick acting 60% HP and LP turbine bypass station would be provided to act not only to stabilize boiler condition with sudden load dump/turbine trip out but also serve as a protection to the turbine during pressure rise resulting from sudden load throw off. In addition, it will enable quick start-up of the unit following a hot trip out by proper matching of boiler steam and turbine metal temperatures. This would reduce thermal shock and help repeated hot start of the unit.

A fully automatic gland sealing system would be provided for the turbine, which will have provision for receiving steam from auxiliary steam header or cold reheat steam header during start-up and low load operation. At higher loads steam leakage from HP glands is fed to the LP glands so that requirement of external supply is minimum. The turbo-generator would be equipped with the highly sensitive electro-hydraulic governing stable operation under any grid fluctuation and load throw off condition,

The turbo-generator would be equipped with an electric motor driven or oil turbine driven rotor turning gear for uniform heating/cooling of the machine at starting/after shut down. The turbo-generator unit would be provided with self-contained lubricating oil system for supplying oil to the turbine and generator bearings and also to the generator seal oil system. The lubricating oil would be cooled by cooling water system utilizing cooling tower water as the cooling medium. The TG set will be provided with independent non-inflammable control fluid system for hydraulic/electro-hydraulic governing of the TG set through separate fluid tank, 2 x 100% duty motor driven pumps and separate piping system.

The generator will be directly coupled to the steam turbine and will have a nominal rating of 660 MW at 0.85 power factor. The generator would deliver power at 21000 volts (+/-) 5%, the commonly used voltage for such capacity, 3 phase, 50 Hz.

The generator stator winding would be directly cooled by circulation of DM water through hollow conductors and stator core and rotor by circulation of hydrogen gas filling the air space. The DM water, hydrogen gas and also sealing oil, supplied to generator shaft seals to prevent hydrogen gas leakage, would in turn be cooled by closed cooling water system utilizing DM water as cooling medium. The generator excitation system would be static or brush-less type and capable of maintaining steady generator terminal voltage under variable under variable load conditions and also ensure generator stability under transient conditions. The excitation system would be complete with automatic voltage and all necessary metering and supervision equipment.

Necessary protective and supervisory system to ensure trouble-free, safe and efficient operation of the turbo-generator will be provided.

4.8 Condensing Equipment

The double-pass surface condenser capable of maintaining the required vacuum while condensing steam at the maximum rating of the turbine would be provided. The condensers would be water cooled in a closed circuit cooling system using Natural draft cooling towers with clarified water. The condenser arrangement would be such that on-load maintenance of half of the condenser at a time is possible by isolating the same from cooling water inlet and outlet sides. The condenser would be of divided water box design with rolled steel construction of body and water chamber. Shot chlorination or application of biocides would be adopted to restrict biological growth and consequent fouling of heat exchange surfaces. It is proposed to install in the future, if needed, automatic tube cleaning arrangement to maintain desired level of cleanliness of the tubes. The condensers would be designed to accept the full quantity of steam during turbine HP and LP bypass operation without any undue vibration, thermal stress etc. Condenser axis would be at right angle to turbo-generator axis.

Three (3) vertical condensate pumps of 50% capacity would be provided to pump condensate from condenser hot well to de-aerator through drain coolers, condensate polishing unit (when in use), gland steam cooler and various low-pressure heaters. Two (2) 100% capacity vacuum pumps will be provided to maintain the vacuum in the condenser by expelling the non-condensable gases. One vacuum pump would operate during normal plant operation. During start-up both the pumps may be operated so that the desired vacuum can be pulled within a short time.

4.9 Coal Handling Works

Conveyor galleries, trestles, superstructure of crusher house and transfer houses will be made of fabricated steel. Intermediate floors and roof will be of RCC slab except Conveyor galleries where AC roof and side sheeting's will be provided. The track hopper and conveyor tunnels will be of concrete box section with appropriate water proofing arrangement. The coal stockpile area is proposed to be provided with concrete paving with slab on grade. The coalbunkers in the mill building will be of structural steel frame with mild steel skin plate having stainless steel lining at the bottom one third of the hoppers.

4.10 Switchyard

Switchyard structures including equipment supports will be of galvanized steel. The foundations will be of RCC spread footing. Cable trench, pits etc. will be of RCC with pre-cast RCC covers. Peripheral and internal roads will be provided for access during equipment maintenance. The entire area will be enclosed with suitable safety fencing and control gate.

4.11 Chimney

A common multi-flue concrete chimney for the three units has been proposed for this project. The total height of the chimneys will be 275 meters above grade level as per existing norm of the country for the station size. External cage elevator (electric driven) will be provided for construction and maintenance. The chimney shaft will be of RCC with slip form construction on a RCC raft foundation. As per statutory requirements, aircraft warning light and lightning electrodes etc. on the top of the chimney would be provided.

4.12 Electrostatic Precipitators

The dust at the inlet of the Chimney shall be reduced to 100mg/Nm³ as prescribed by the Government of India, for this purpose adequately sized electrostatic precipitators shall be envisaged.

The steam generating units will be provided with three sets of electrostatic precipitators. Each precipitator would have two parallel gas paths, any of which can be isolated for maintenance when required keeping the other paths on operation. Each path will comprise seven fields in series for collection of fly ash, of which, six fields would be in service and the other one would remain as standby. The ESP would have an efficiency of around 99.9% and will comply with the particulate emission restrictions of 100 mg/Nm³ imposed by the Pollution Control Board. Each ESP would be provided with adequate number of ash hoppers having capacity suitable for storing ash collected in at least one (1) shift operation of the boiler at 100% MCR.

4.13 Flue Gas De-Sulphurization (FGD)

From the available data on sulphur content in coal, no desulphurization plant is considered necessary. With the available details of sulphur content in coal about 2905 Kg/hr of SO₂ would be let off from each unit. The ground level concentration, as computed, would be within the limiting values set by MOEF, Govt. of India. In the present study, however, space provision has been kept for installing FGD (in future) as per the latest guideline of MOEF.

The supercritical technology using supercritical steam parameters (i.e. steam pressure of about 250 kg/sq. cm with temperatures ranging between 565 °C/595° C) efficiency of the cycle increases leading to lower

coal consumption per MW and hence lower ash generation and lower CO₂ and SO_x and NO_x emissions per MW. Irrespective of the above latest technologies will be used for controlling these pollutants.

4.13 Control and Relaying

The power-house control room will have a number of control and relay panels for the generators, its auxiliaries, 11 kV/6.6 kV switchgear and 415 V switchgear. All required control, protective relays and metering for generator including excitation system, unit and station transformers to safeguard against abnormal system conditions will be provided in this control room. Control elements for main plant drives will be located in plant DCS.

Synchronization of the generator will be done from the power house control room which will be provided with measuring instruments like Volt, MW, MVAR meter, frequency meter, synchro-scope etc. pad mimic with switch position indication. Audio-Visual annunciation will be provided in the control room to draw the operator's attention for abnormal operating condition and tripped condition in DCS. All important points will be monitored in DCS and important events will be connected to the sequence of the events recorders.

In view of the magnitude of the dimension of the switchyard, a switchyard control room will also be constructed therein. The EHV switchyard control room will be provided with necessary relays, control and metering panels to enable control and supervision of the 400 kV substation equipment, it will also be provided with duplicate status and indications for generators, generator transformer and station transformers.

4.14 Protective System

For protection of equipment against abnormal systems conditions, adequate protective devices will be installed in the respective switchgears and/or control and relay panels. A group of such protective devices may be necessary to protect the equipment under different abnormal conditions arising in the system.

For equipment exposed to atmosphere, protection against lightning surges and switching surges will be provided with lightning arrestors at suitable locations, over and above the shielding wires and lightning masts to safeguard the equipment.

In all cases, proper discrimination would be achieved so as to isolate the faulty elements only, keeping the healthy part of the system in service.

4.15 Intercommunication System

An intercommunication system will be provided to facilitate plant operation by establishing quick communication among the operating personnel at various locations of the plant.

Two-channel voice communication system with Paging mode as well as Private mode is envisaged. Speech in 'paging' mode will be heard all over the plant on selective basis while the 'private' mode will facilitate conversation between two or more stations through closed talk channel with discrimination against background noise.

Handsets for transmitting or acknowledging messages would be installed at all important locations. The sound level thorough the area covered by a TG unit varies from place to place. Each unit will be divided on the basis

of sound level and adequate power amplifiers will be used to cover these zones. Each handset/loudspeaker station will have its own pre-amplifier, line amplifier suitable for long line signal transmission and power amplifier to suit loudspeaker capacity. Provision for spare power amplifiers to suit loudspeaker capacity. Provision for spare power amplifier will be made to serve as standby.

4.16 Illumination System

For outdoor yard illumination, floodlights will be installed at suitable locations to provide the requisite level of illumination. Pole mounted high-pressure sodium vapor lamp fixtures will be used for approach and work roads. Generally fluorescent fixtures will be used for indoor illumination. A combination of sodium vapor, fluorescent, compact fluorescent and incandescent fixtures will be used for turbine hall and boiler platforms/galleries.

The illumination levels at all places within the plant will be maintained in accordance with internationally accepted codes. The lighting system design will ensure uniform illumination at working levels.

Power illumination system will be supplied from 415 V bus through lighting distribution boards. Power for the lighting distribution boards, will be obtained from 415 V bus through 415V/415V lighting transformer to lower fault level in the lighting system. Lighting transformers will be located in main lighting Distribution boards.

A suitable number of lighting panels will be located in each area, supplied with power from the main lighting distribution boards. Lighting Panels will be installed at convenient locations for ease of operation. In addition to normal illumination, emergency AC and DC lighting will be provided in the

power station complex. The emergency AC lighting will be supplied from AC emergency lighting boards, which are connected to the AC emergency MCC. During emergencies, diesel generator will energize the AC emergency MCC. The station emergency DC lighting will be fed from the station 220volt DC distribution system during extreme emergencies. On failure of AC supply, the station emergency DC supply will receive power from the DC system. For isolated buildings in remote areas where station 220 V DC is not available, DC lighting will be derived from a self contained battery with charger unit with lamp, energized upon loss of normal AC supply to such isolated areas.

4.17 Power Evacuation System

To evacuate the generated power, it is proposed to set up a 400 kV switchyard. The cost of transmission lines, towers and all works beyond the interconnection point are not included in the project cost.

The generator will be directly coupled to the steam turbine and will have a nominal rating of 660 MW at 0.85 power factor (lag). Generation voltage will be about 21 kV with variation of $\pm 5\%$ (or as per manufacturer's standard), 3 ph, 50Hz and will be connected directly to the 400 kV switchyard bus through generator transformer consisting of three single phase units each rated for 260MVA, 420/21kV.

Three voltage levels viz. 11000 volts 6600 volts and 415 volts have been selected to supply power to unit and station auxiliaries.

Unit auxiliaries like ID fan, FD fan, PA fan, coal mills etc. will be fed from unit transformers. Two (2) Unit transformers will be provided to feed the unit auxiliaries of each 660 MW generator. Three (3) station transformers will be provided to feed the station auxiliaries and station start up facilities.

For each 660 MW set, 3 boiler feed pumps (of which 2 will be turbine driven and third will be electrical driven), each of 50% full load capacity will be provided. ID Fans, FD fans, CEP pumps, PA fans and coal mill motors for each unit will be supplied from two nos. 35 MVA(approx.) 21/11.5 kV unit transformers; Three (3) station transformer each rated about 100/50/50 MVA., 400/11.5/11.5 kV will feed station auxiliary loads, viz coal handling plant, ash handling plant, water system etc.

The station auxiliary systems will be fed from the station transformers through a number of 11 kV breakers. Necessary 11 kV/6.6 kV, 11kV/433 V transformers and 415 V switchgear/MCCs will be provided. In addition to the above, each of the systems above will have its own requirement of electrical equipment/devices e.g. motors, power control centre's and/or MCC for further distribution of power wherever necessary, control panels, limit switches, power and control cables for distribution within the system itself as well as local control station etc.

4.18 Plant DC System

A reliable DC power source will be provided to supply those loads required to function in the event of loss of AC power, to enable safe shutdown of the plant. The DC power supply system comprises:

- 220 volt DC battery
- Battery charger (float and boost charged)
- DC distribution and sub-distribution boards.
- Battery

Normal requirement of the battery is to supply power for the following: -

- Control and monitoring of the entire plant.

- Alarm and annunciation of plant condition under emergency, during the first one minute after occurrence of emergency the battery will be called on to supply the following loads:
- Tripping power for all major circuit breakers simultaneously
- Starting of emergency drives to protect the machines from damage.
- Plant emergency DC illumination system
- Indication alarm and annunciation
- Other miscellaneous loads

Storage battery sets of ten hours, discharge rate, having 110 cells for 220 volts would be selected for a duty cycle of 3 hours for DC lighting and 1 hour for other consumers.

220 V battery sets of adequate capacity will cater to the need of the power plant complex. Since the proposed 400 kV sub-station will be of considerable magnitude, a separate 220 V battery set of adequate capacity is proposed to be used for control and supervision of 400 kV switchyard equipment/system.

4.19 Grounding & Lightning Protection

The 11kV/6.6 kV system for the proposed 660 MW units will have low resistance grounding with fault current limited to 300 Amps. 415 V power supply system will be solidly grounded. DC system will be ungrounded. The equipment body grounding is adopted to provide protection to personnel from potential hazards caused by ground faults and lightning discharges through low resistance-conducting path of the ground. A stable ground grid will be provided for grounding equipment and structures maintaining the step and touch potentials within safe limits. An earth mat will be laid in and around the power station and also in other hazardous areas as necessary. This mat will be buried at a suitable depth below the

ground and provided with ground electrodes at suitable intervals. All metallic parts of equipment supposed to be at earth potential will be connected to the ground mat, including structures, buildings, transmission towers, plant rail road tracks, the perimeter fencing etc. Lightning protection system will be installed for protecting the building/structures against lightning discharge, through lightning masts on stacks, power house building, towers in switchyard, floodlight towers etc. and connecting then with the ground grid.

4.20 Emergency Power Supply system

In order to meet the emergency requirements, two diesel generators will be installed. One no. , 415 V, 3 phase, 3 wire, 50 Hz DG set for each unit is contemplated, (though the exact rating of DG sets may have to await the detailed design of the power station). One no. common standby DG set of identical set shall be provided.

4.21 Employee Facilities

Apart from the main power house building, there will be building structures to accommodate the under-mentioned activities and facilities required to be provided for the operation, maintenance and administration personnel:

- Administrative
- Technical activities (Drawing and Engineering Office)
- Canteen
- First-aid centre, fire control & gate office
- Private Transport Parking
- Training Facility

- Toilets, washrooms, change-rooms, drinking water etc. provided in main buildings and yard to meet requirements of the Factories Act.

4.22 Residential Colony and Community Facilities

The current estimate of the permanent workforce stipulates a total of about 600 employees working for operation, maintenance and administration of the proposed plant of 1320 MW installed capacity. At this stage, it is proposed to build residential quarters for an approximately 600 employees. These will include all levels of employees working in the Plant. In addition, barracks for the security staff, a Project hostel and a guesthouse are also contemplated.

Certain community facilities would require to be created, to meet the diverse needs of its employees. The surrounding township may not have enough facilities to accommodate the large work force of this Plant. These facilities include play areas, health centre and a small hospital, bank, post office, an appropriately sized school, etc. These will be planned and constructed according to needs.

5. ENVIRONMENT ASPECTS

Environment Management Plan plays a vital role in safeguarding the environment largely through reducing the negative impacts of the project. The proposed project has positive and negative impacts during operation phase for which mitigation measures are suggested. Environmental monitoring program and implementation arrangements are also being planned for the proposed project.

5.1 Ash

Pollution Control Authorities has stipulated that E.S.P and suitable air pollution control equipment should be installed for the control of fugitive emission and for the control of pollution during the transportation of raw material and fly ash. The concentration limit for pollutants is as follows:

Suspended Particulate Matter	50 mg / Nm ³
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Electrostatic Precipitators installed will ensure that State Pollution Board requirement will be maintained throughout the life of the power plant.

Bottom Ash disposal shall be by a slurry conveying system. The fly ash will be collected in dry form. Adequate measures will be taken for sprinkling of water at strategic locations to ensure that fly ash don't get air borne. The ash pond area will be provided with impervious lining.

Fly ash has high pozzolonic properties and form cementaceous material when mixed with lime and water and it is suitable for commercial uses like Cement Industry, Brick Industry etc.

The supercritical technology using supercritical steam parameters (i.e. steam pressure of about 250 kg/sq. cm with temperatures ranging between 565° C/595° C) efficiency of the cycle increases leading to lower coal consumption per MW and hence lower ash generation.

A green belt of 50 meters width will be created along the plant boundary and the ash disposal area. Adequate plantation shall be done around the ash disposal area to check dispersion of ash in the surrounding air.

5.2 Air Pollution

The Air pollutants from the proposed units are:

- Sulphur dioxide in flue gas
- Nitrogen oxides in flue gas
- Suspended Particulate Matter (SPM) in flue gas
- Carbon monoxide in flue gas.
- Coal dust particles during storage/handling

Currently sulphur dioxide levels are controlled by dispersing the pollutant to atmosphere through a tall stack. As prescribed by the Central Pollution Control Board, Govt. of India, the prescribed minimum stack height for Generation Capacity of 500MW or more is 275M. For the proposed plant, a common multi-flue concrete chimney for the three units with height of about 275 mtrs has been proposed with continuous monitoring system. ID fans will be used to maintain an exit velocity of 25 m/s for adequate disposal of gaseous pollutants and a continuous record of exit velocity will be maintained. Continuous monitoring analyzers like opacity meter NO_x, SO_x, CO analyzers shall be included.

The power plant will use coal burners of proven, advanced design to reduce NO_x production, and the boiler furnace will be provided with over-fire air ports to further reduce NO_x production.

The ESP having efficiency not less than 99.9% is envisaged. The particulate emission would not exceed the prescribed limit of 100 mg/Nm³.

Carbon monoxide (CO) another kind of pollutant hardly exists in the modern power stations as design of combustion control equipment and the furnace eliminates, almost completely the possibility of incomplete combustion.

Railway transportation is proposed for transportation of coal from mines to power plant. Dust generated in the coal handling area will be minimized by providing suitable dust suppression/extraction systems.

The ambient air quality shall not exceed the following standards prescribed by the Central Pollution Control Board/ MoEF&CC:

The supercritical technology using supercritical steam parameters (i.e. steam pressure of about 250 kg/sq. cm with temperatures ranging between 565 °C/595° C) efficiency of the cycle increases leading to lower coal consumption per MW and hence lower ash generation and lower CO₂ and SO_x and NO_x emissions per MW. Irrespective of the above latest technologies will be used for controlling these pollutants.

5.3 Water Pollution

Closed Circuit Cooling Device is proposed to be used in the Power Plant to ensure minimum requirement for makeup water. The ground water

quality will be continuously monitored in the project impact area in consultation with central Ground Water Board. The Effluent Handling System Package will ensure that treated effluent will not be discharged into the river and will be completely reused in the plant process. The water required for the power plant will be taken from River Ganges.

5.4 Noise Pollution

Several noise suppression and attenuation features shall be designed into the plant for the protection of personnel at all normally accessible locations within the plant boundary, both inside and outside the different buildings, and for the protection of the inhabitants living in the vicinity of the power plant.

The steam generator and auxiliaries will perform continuously within noise limits as per relevant standard specifications but not more than 85 dBA at 1 meter from any equipment. Personal protective equipments (PPE's) shall be provided to the persons working in high noise area.

5.5 Green Belt

The landscaping and ground cover system meant to enhance the appearance of selected areas, enhance soil and slope stabilization of the land of the power plant, and assist in reducing the noise level and fugitive dust generated by the plant.

As per the stipulations of MoEF, green belt will be provided all around the power plant boundary by planting trees and the total green area including landscaping area will be 1/3rd of the plant area.

5.6 Forest Clearance

The project site does not fall under any forest region.

5.7 Clearance for Stack Height

The adequate clearances from Airport Authority of India (AAI) for construction of chimney of would be obtained.

5.8 Monitoring Plan

A monitoring plan would be worked out during DPR/EIA preparation that would be adhered to during the operational phase of the Project.

5.9 Clearances required for the project

The table below indicates the list of clearances that are required to be obtained for thermal power projects:

Sl. No.	Particulars	Concerned Authority
1.	Fuel Linkage	Ministry of Coal
2.	Water Availability	Deptt. of Water Resources, Govt. of Bihar
3.	Land Availability	Deptt. of Land Reforms/Govt. of Bihar
4.	Pollution Clearance for Water and Air	State Pollution Control Board
5.	Environment & Forest Clearance	Ministry of Environment & Forests
6.	Chimney height clearance	Airports Authority of India
7.	Registration of Company	Registrar of Companies, Bihar/Jharkhand
8.	Fuel Transportation	Ministry of Coal / Ministry of Railways
9.	Mega Power Status	Ministry of Power
10.	Open Access	PGCIL and BSEB

6. PROJECT IMPLEMENTATION SCHEDULE

The project is scheduled to be implemented and commissioned in a period of 48 months from the financial closure date.

The detailed implementation schedule is being worked out and will be provided in Detailed Engineering Report.

7. PROJECT COST ESTIMATES

The estimated cost of the power project is around 9,591 Crores as per the revised estimates at April 2014 price level.

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