Republic of India
Bihar State Power Generation Company Limited

Republic of India

Study on Barauni Thermal Power Station (660MW x 1) in Bihar

(Technical Assistance related to Japanese ODA Loan)

Final Report

January 2014

Japan International Cooperation Agency (JICA)

Kyushu Electric Power Co., Inc.

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Abbreviations

Abbreviation	Standard Nomenclatures	Remark
[A]		
ACSR	Aluminum Conductor Steel Reinforced	
ADB	Asian Development Bank	
AEC	Atomic Energy Commission	
AHP	Ash Handling Plant	
AIS	Air Insulated Switchgear	
AMF DG	Automatic Mains Failure Diesel Generator	
APH	Air PreHeater	
[B]		
BAL	M/s Bhagavathi Ana Labs, Hyderabad	Environmental Consultant appointed by BSEB
BBMB	Bhakra Beas Management Board	
BC	Bus Coupler	
BEE	Bureau of Energy Efficiency	
BERC	Bihar Electricity Regulatory Commission	Bihar State Regulatory Commission: Tariff, Regulation.
BHEL	Bharat Heavy Electricals Limited	
BMCR	Boiler Maximum Continuous Rating	
BRGF	Backward Region Grant Fund	
BSEB	Bihar State Electricity Board	
BSPHCL	Bihar State Power (Holding) Company Limited	Electricity company in Bihar State
BSPGCL	Bihar State Power Generation Company Limited	Bihar State Power Generation Company owned by BSPHCL
BSPTCL	Bihar State Power Transmission Company Limited	Bihar State Power Transmission Company owned by BSPHCL
BTPS	Barauni Thermal Power Station	
BTPS Stg II	Barauni Extension Project. Unit #8 & #9	
BWRD	Water Resource Department, Government of Bihar	Bihar State water Drawl approval Agency
[C]		
C&I	Controls & Instruments	
CB	Circuit Breaker	
CEA	Central Electricity Authority	

Abbreviation	Standard Nomenclatures	Remark
CEA TS	Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010	CEA Technical Standards
CEMS	Continuous Emission Monitoring System	
CERC	Central Electricity Regulatory Commission	
CHP	Coal Handling Plant	
CIL	Coal India Limited	
CMIMS	Computerized Maintenance & Inventory Management System	
COD	Commercial Operation Date	
CPCB	Central Pollution Control Board	
CPRI	Central Power Research Institute	
CPU	Central Processing Unit	
CWC	Central Water Commission	National water Drawl approval Agency
[D]		
D/C	Double Circuits	
DCS	Distributed Digital Control System	
DEA	Department of Economic Affairs, Ministry of Finance	
DM	Demineralized Water	
DPR	Detailed Project Report	
DVC	Damodar Valley Corporation	
[E]		
EAC	Expert Appraisal Committee	
EC	Environmental Clearance	
ECL	Eastern Coalfields Limited	Coal supplier of Barauni TPS
EDMS	Electrical Distribution Monitoring System	
EHS Guidelines	Environmental, Health, and Safety Guidelines	
EHV	Extra High Voltage	
EIA	Environmental Impact Assessment	
EMP	Environmental Management Program	
EMS	Energy Management System	
EPS	Electric Power Survey	CEA electric demand survey

Abbreviation	Standard Nomenclatures	Remark
ERLDC	Eastern Regional Load Dispatch Centre	Eastern Region including Bihar State Load Dispatch Center subsidiary of POSOCO
ERP	Enterprises Resource Planning System	
ERPC	Eastern Regional Power Committee	Eastern Region including Bihar State Power Committee
ESP	Electrostatic Precipitator	
[F]		
FF	Foundation Fieldbus	
FGD	Flue Gas De-sulfuring	
FS	Feasibility Study	
FY	Fiscal Year	
[G]		
GCB	Generator Circuit Breaker	
GGH	Gas-Gas Heater	
GHG	Greenhouse Gas	
GIS	Gas Insulated Switchgear	
GOI	Government of India	
GPS	Global Positioning System	
[H]		
HART	Highway Addressable Remote Transducer	
HPS	Hydroelectric Power Station	
[I]		
IDF	Induced Draft Fan	
IEEJ	Institute of Energy Economics of Japan	
IEGC	Indian Electricty Geid Code	CERC Grid Code
IFC	International Finance Corporation	
IGCAR	Indira Gandhi Center for Atomic Research	
IGCC	Integrated Gasification Combined Cycle	
IPP	Independent Power Producer	
[J]		
JCOAL	Japan Coal Energy Center	
JEPIC	Japan Electric Power Information Center	
JICA	Japan International Cooperation Agency	
JIS	Japanese Industrial Standards	

Abbreviation	Standard Nomenclatures	Remark
JSEB	Jharkhand State Electricity Board	
[L]		
LA	Loan Agreement	
LILO	Line In Line Out	
LS	Line Switch	
[M]		
MMI	Man Machine Interface	
MNRE	Ministry of New & Renewable Energy	
MoEF	Ministry of Environment & Forests	EIA approval Agency
MoF	Ministry of Finance	
MoP	Ministry of Power	
MoUD	Ministry of Urban Development	
MPU	Micro-Processing Unit	
MYT	Multi Year Tariff	
[N]		
NAAQS	National Ambient Air Quality Standards	
NBPDCL	North Bihar Power Distribution Company Limited	Bihar State Power Distribution Company owned by BSPHCL
NFPA	National Fire Protection Association	An authority in USA
NGT/NGR	Neutral Grounding Transformer/Resistor	
NH-31	National Highway Route 31	Adjacent to site
NLDC	National Load Dispatch Center	
NTPC	National Thermal Power Corporation Limited	DPR of 1 x 250MW #10 Extension prepared
[**O**]		
O&M	Operation and Maintenance	
[P]		
PADO	Performance Analysis Diagnosis and Optimization System	
PGCIL	Power Grid Corporation of India Limited	Transmission Company of India government Enterprise
PIMS	Plant Information and Management System	
PLF	Plant Load Factor	
POSOCO	Power System Operation Corporation Limited	Power Grid operation company owned by PGCIL subsidiary of

Abbreviation	Standard Nomenclatures	Remark
		five region LDC and NLDC
Pre-FS	Preliminary Feasibility Study	This report
PRM	Plant Resource Manager	
PTL	Power Links Transmission Limited	Joint venture Transmission Company of Tata Power and PGCIL
[R]		
R&M/LE	Renovation and Modernization / Life Extension	
RISC	Reduced Instruction Set Computer	
[S]		
SBPDCL	South Bihar Power Distribution Company Limited	Bihar State Power Distribution Company owned by BSPHCL
SC	Super Critical	
SCCL	The Singareni Collieries Company Limited	
SCR	Selective Catalytic Reduction	
SEAC	State Level Expert Appraisal Committee	
SEB	State Electircity Board	
SEIAA	State Environment Impact Assessment Authority	
SERC	State Electricity Regulatory Commission	
SIL	Safety Integrity Level	
SIS	Safety Instrument System	
SLD	Single Line Diagram	
SOE	Sequence of Event	
SPCB	State Pollution Control Board	
SS	Substation	
STEAG	STEAG Energy Services (India) Pvt. Limited	Owner’s Technical Engineer of Units No.8/9 Extension Project
SWAS	Steam and Water Analysis System	
[T]		
Tie-Tr	Tie Transformer (i.e. 440 kV/220 kV)	
TL	Transmission Line	
TMCR	Turbine Maximum Continuous Rating	
TOR	Terms of Reference	EIA procedure
Tr	Transformer	
Transf. Bus	Transfer Bus	

Abbreviation	Standard Nomenclatures	Remark
TPS/TPP	Thermal Power Station/Plant	
[U]		
UPS	Uninterruptable Power System	
USC	Ultra Super Critical	
UTPCC	Union Territory Pollution Control Committee	
[W]		
WS	Water Intake System	

Executive Summary

Abstract

The "Study on Barauni Thermal Power Station (660 MW x 1) in Bihar" concluded that the construction of a 660 MW Super Critical (SC) unit is possible instead of the original plan of a 250 MW subcritical coal-fired power plant. Three candidate sites have been selected in the Study, including Planned site of Unit No.10 (originally a 250 MW subcritical), Residential Area and Site in the South Adjacent to Units No.8/9.

1 Background

The State of Bihar is located in the eastern part of India. The State of Bihar has been one of the poorest states in India, but in recent years, it has attained a remarkable economic growth. The GDP growth rate in the whole country during 2011 and 2012 was recorded at 6.9 % while it reached 13.1 % in Bihar.

Although India is in the midst of such rapid economic growth, the establishment of power infrastructures is not catching up the increasing power demand. During the period from April 2010 to May 2011, the country's peak demand at peak was 122,287 MW, while peak met was 110,256 MW, resulting in a supply deficit of 9.8 %. Demand for electric energy was 861 billion kWh, while supply was 788 billion kWh, again leading to a supply deficit of 8.5%. In July 2012, a large-scale power blackout occurred in New Delhi. Because of this, the northern region of the country was left without electricity for almost 2 days, and affecting the daily lives of more than 600 million people, which is more than half of the whole population. A power shortage has become a serious public concern.

Under these circumstances, the Government of India (GOI) plans to ensure a power supply of 88,537 MW including additional capacity under the 12th National Power Plan. As a part of this plan, obsolete Units No.4/5 (50 MW x 2) in the Barauni TPS have been planned to replace with new development of Unit No.10 (250 MW x 1).

However, the GOI had examined the introduction of more efficient systems, leadings to its reassessment of the original project structure, construction of a 250 MW subcritical boiler as an alternative to Units No.4/5. After this reassessment, the GOI officially requested the Government of Japan to conduct the Preliminary Feasibility Study (Pre-FS) to examine a possibility of constructing a 660 MW-class SC unit instead of 250 MW x 1. The Study responds to this official request.

2 Contents of the Study

The contents of the Study are as follows:

(1) Examine planned area of Unit No.10 and assess of space available upon removing the obsolete plant and developing the site

(2) Examine existence of a power station's plan to reuse any part of obsolete plant and identify of reusable facilities

(3) Select candidate sites

(4) Estimate necessary amount of coal equivalent to 660 MW operation plan and collect procurement of coal

(5) Collect information of topography and geology around the Barauni TPS

(6) Examine water resource and intake point

(7) Examine ash disposal area and effective utilization plan

(8) Identify items for the environmental and social considerations

(9) Determine main plan configuration of a 660 MW SC unit based on references in Japan, etc.

(10) Present conditions to make construction possible in the case that is impossible

(11) Propose recommendations for the next Feasibility Study

3 Selection of Candidate Sites

As Candidate sites, (a) Planned area of Unit No.10, (b) Residential Area, (c) Existing Area and (d) Site in the South Adjacent to Units No.8/9 were carefully selected for examination under this Study.

4 Examination of Facility Configuration and Necessary Size

The configuration of power generation facility and its necessary size were examined. Regarding power generation facility, a standard configuration in India (no Selective Catalytic Reduction (SCR) and Flue Gas De-sulfuring (FGD) are often-adopted) and popular configuration in Japan (both SCR and FGD are installed) were examined in the layout. In addition, their necessary sizes (longitudinal and lateral) were confirmed.

5 Conclusion of Possibility of Setting up a 660 MW Super Critical Unit

By overlaying 2 facility configurations in above Section 4 on the candidate sites which were selected above Section 3, the reasonability of configuration as generating facility together with interference between location and facility was examined. As a result of the Study, it was concluded that 3 candidate sites of (a), (b) and (d) were possible for setting up a 660 MW SC unit.

Table Candidate Sites and Possibility for Construction

Candidate Site	Conclusion of Possibility
(a) Planned Area of Unit No.10	Possible (Figure 1 and 2)
(b) Residential Area	Possible (Figure 3 and 4)
(c) Existing Area	Not Possible (Figure 5)
(d) Site in the South Adjacent to Units No.8/9	Possible (Figure 6 and 7)

The Team recommends “Configuration Adopted in Japan” in “Planned Site of Unit No.10”.

[Reasons for Recommendation]

- Considering the current condition that the land acquisition for ash disposal area Units No.8/9 is going slower than initially expected, the Study Team evaluates that it would be difficult to acquire new land for additional plant area of a 660 MW SC unit.
- It seems that the planned site of Unit No.10 cannot be utilized for future extension of Barauni TPS considering expanding trend of single unit electrical output.
- In the future process for the GOI to officially request to JICA’s ODA loan, environmental and social consideration should be fully considered.

However, it assumed that the construction/maintenance of Unit No.10 is done in a narrow area like an urban side where coal-fired TPPs are operated in Japan. When constructing a 660 MW SC unit in such a narrow area, it is necessary to consider the facility design in a narrow area, the strict process control in construction, and the smooth accessibility of maintenance should be carefully considered.

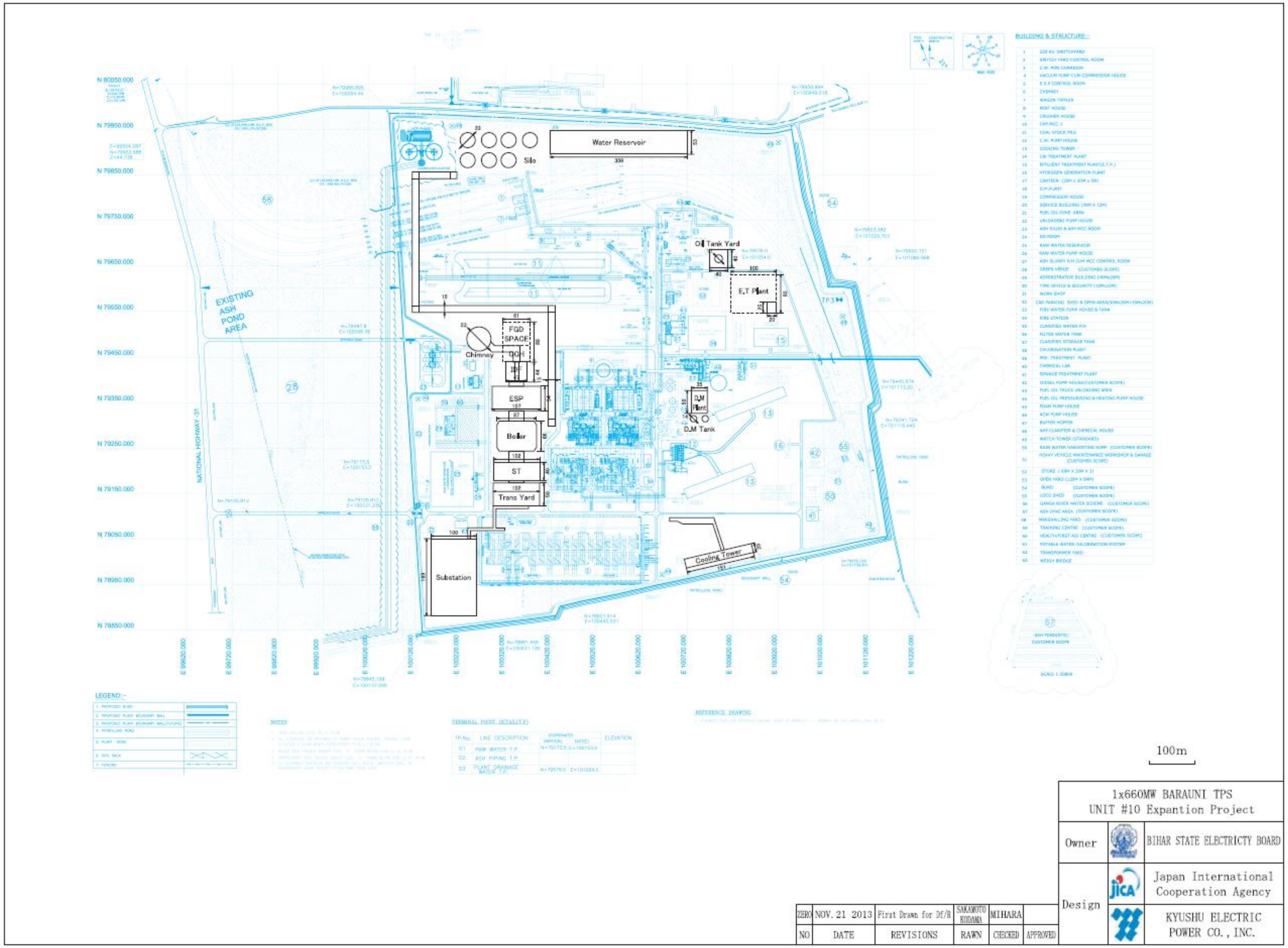

Figure 1 Configuration Adopted in India in Planned Site of Unit No.10 (CONSTRUCTION POSSIBLE)

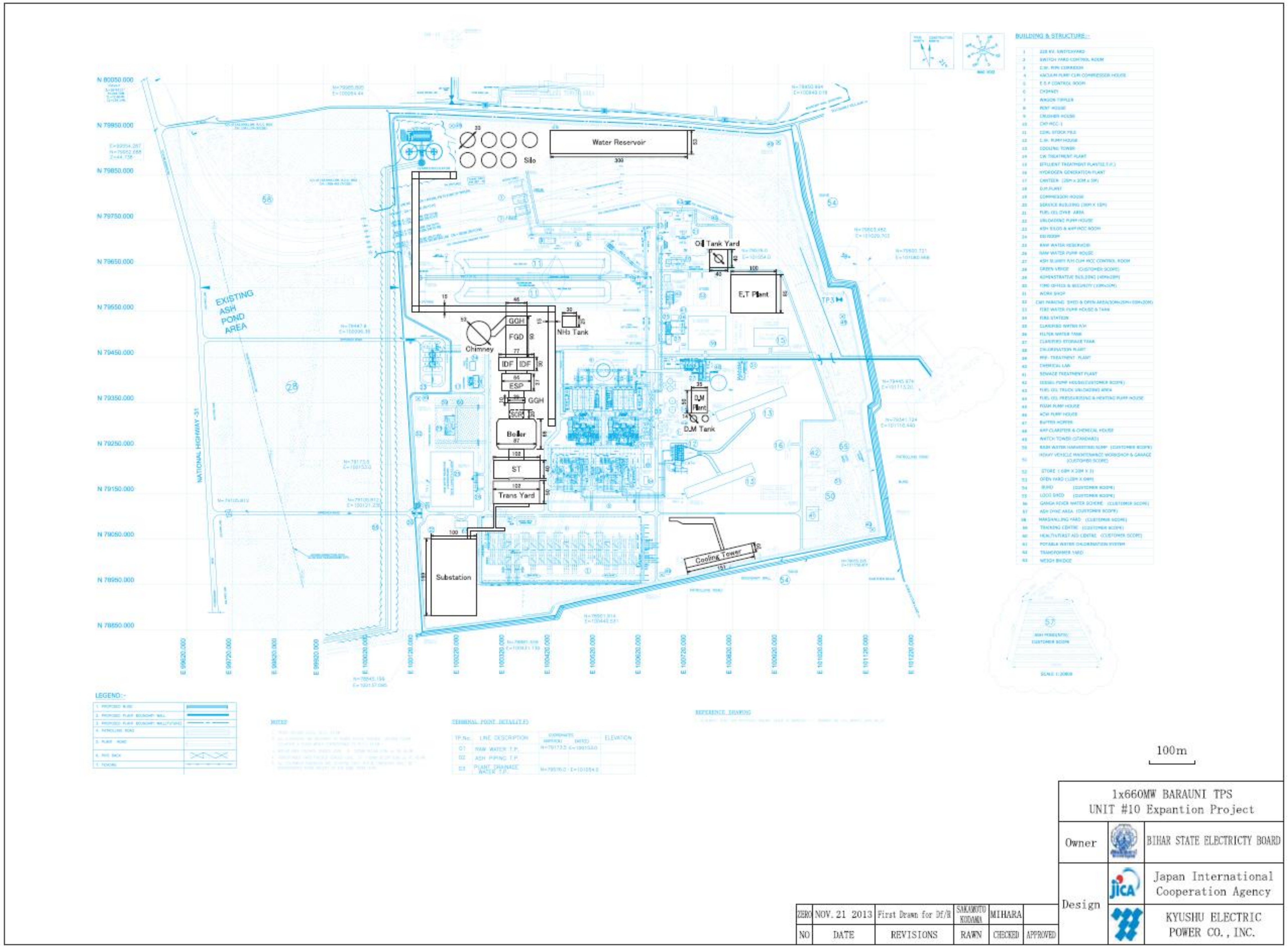

Figure 2 Configuration Adopted in Japan in Planned Site of Unit No.10 (CONSTRUCTION POSSIBLE)

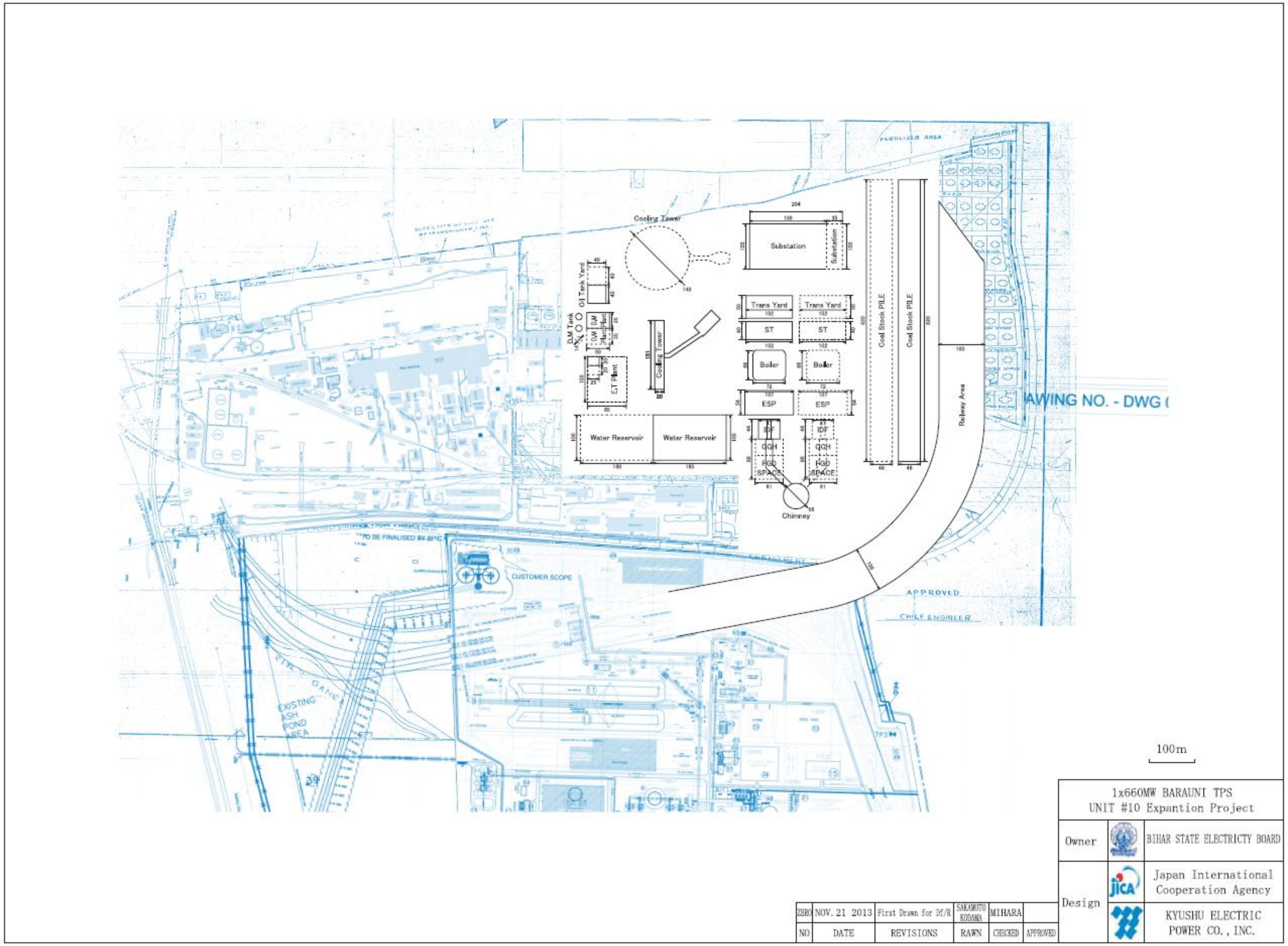

Figure 3 Configuration Adopted in India in Residential Area (CONSTRUCTION POSSIBLE)

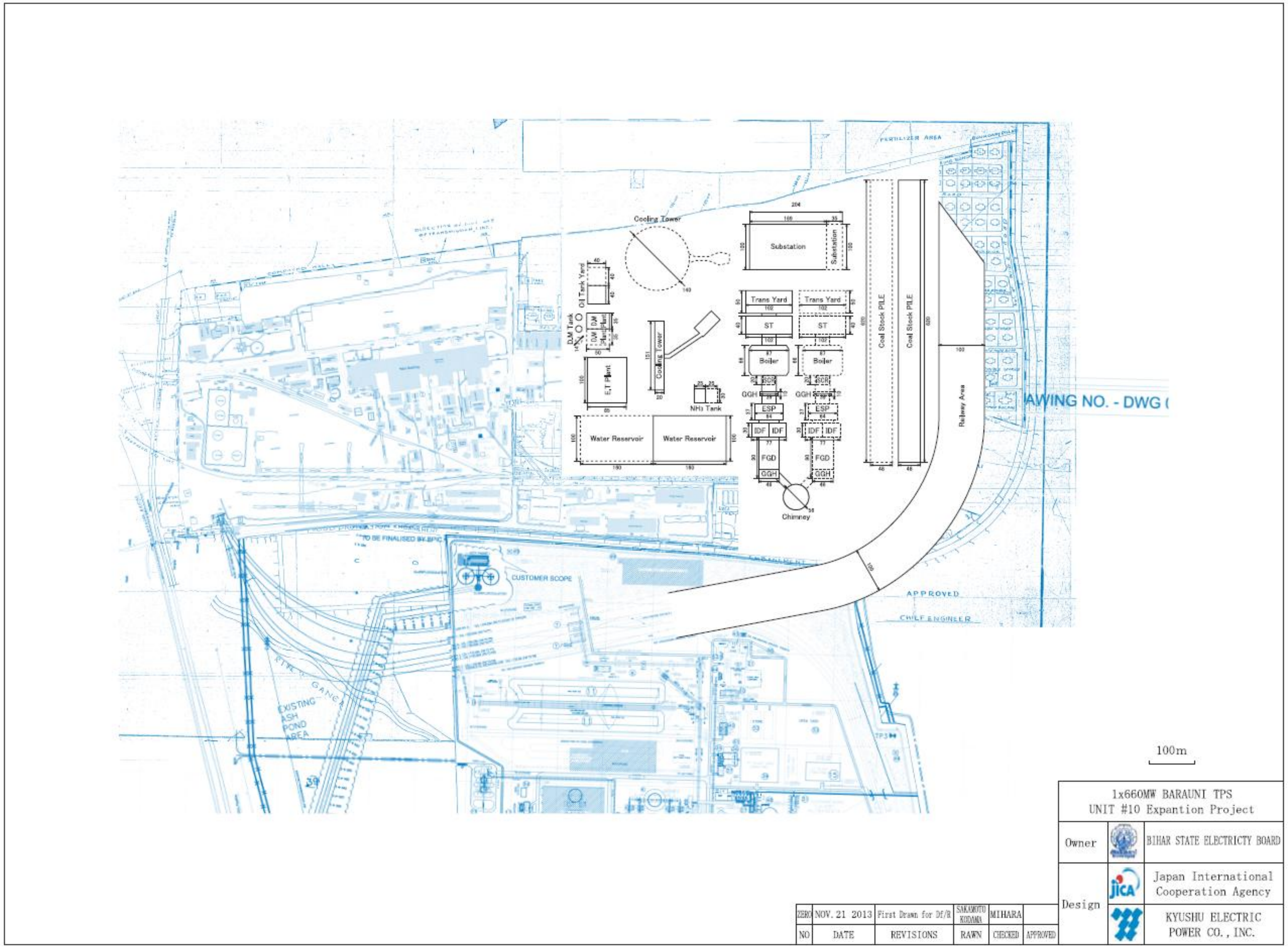

Figure 4 Configuration Adopted in Japan in Residential Area (CONSTRUCTION POSSIBLE)

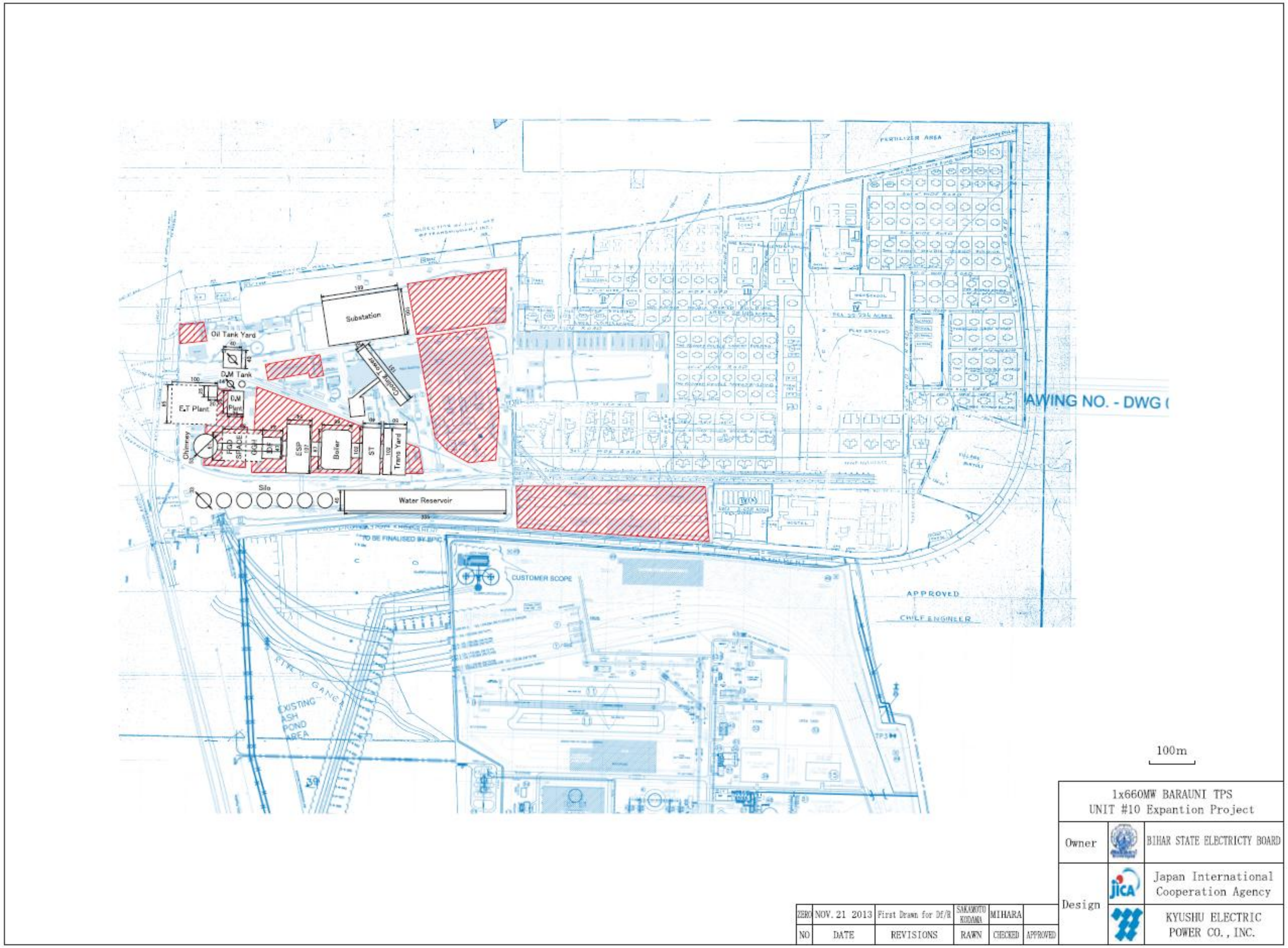

Figure 5 Configuration Adopted in India in Existing Plant Area (CONSTRUCTION NOT POSSIBLE)

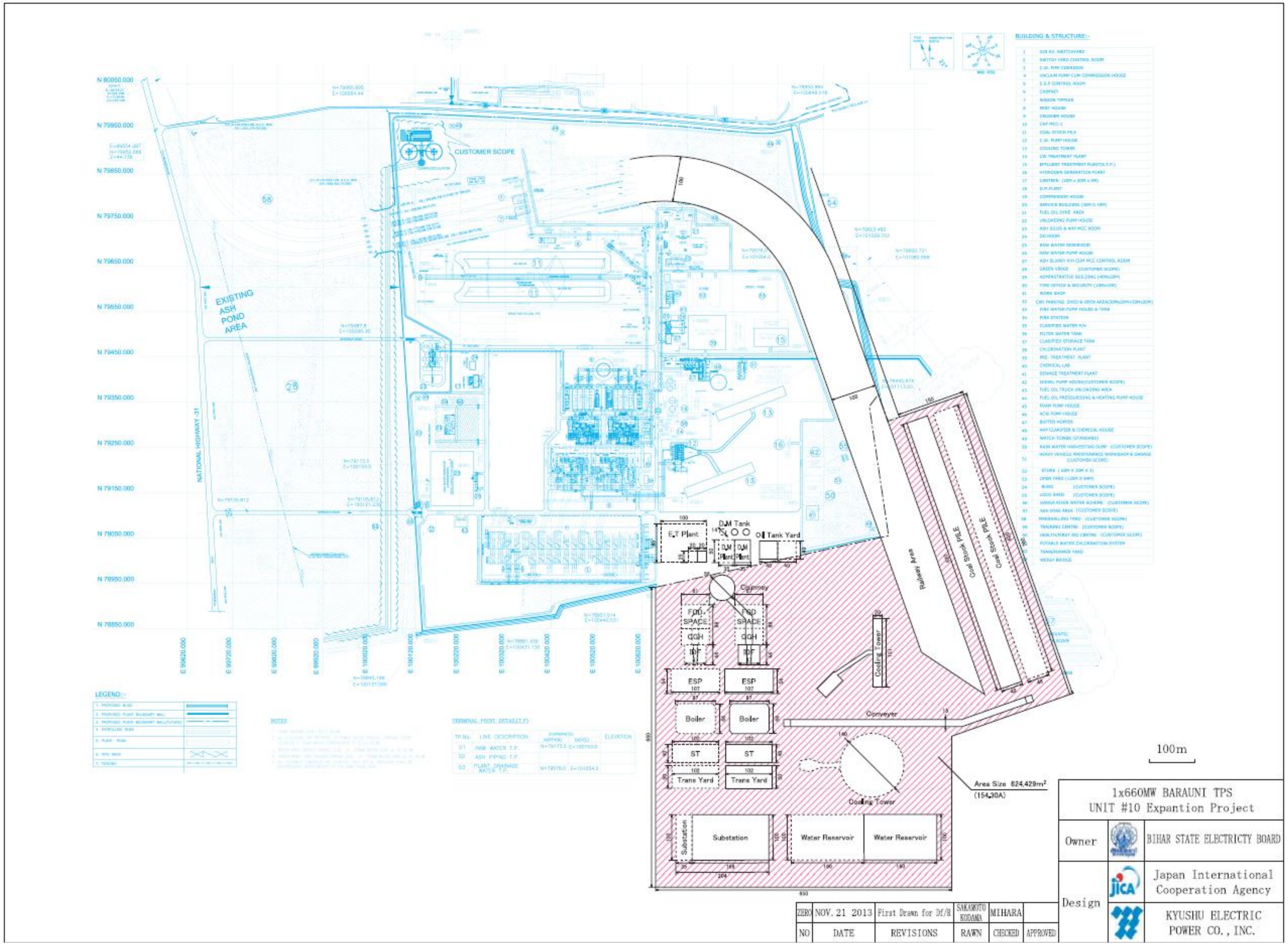

Figure 6 Configuration Adopted in India at Site in the South Adjacent to Units No.8/9 (CONSTRUCTION POSSIBLE)

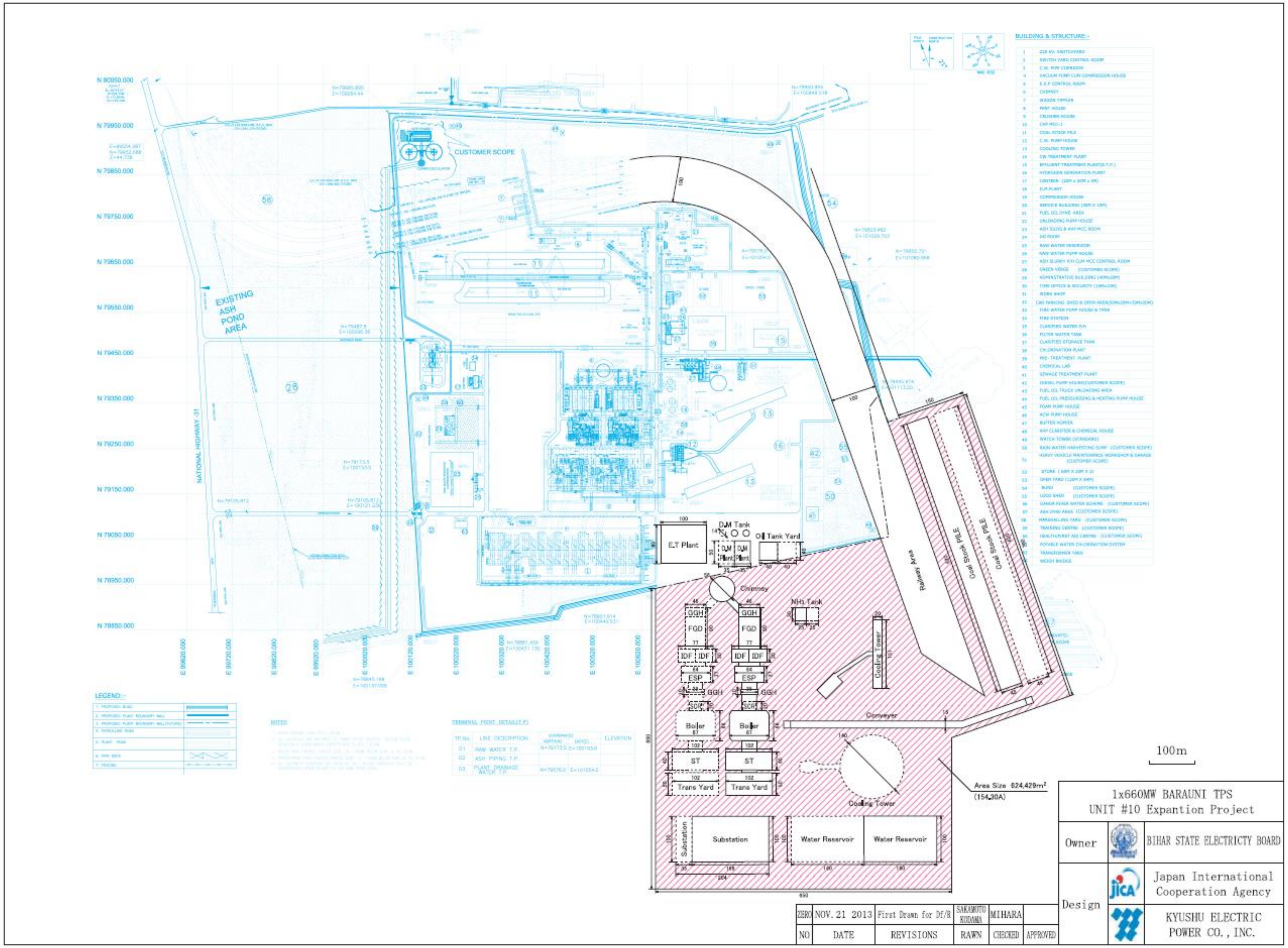

Figure 7 Configuration Adopted in Japan at Site in the South Adjacent to Units No.8/9 (CONSTRUCTION POSSIBLE)

Chapter 1 Summary of Study

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Chapter 1 Summary of Study

1.1 Background

The State of Bihar is located in the eastern part of India. Within the said state, there is Bodh Gaya, which is said to be a place where the Buddha attained enlightenment, and this Buddhist holy site is well-known for pilgrimages and tourists around the world. The State of Bihar has been one of the poorest states in India, but in recent years, it has attained a remarkable economic growth. The GDP growth rate in the whole country during 2011 and 2012 was recorded at 6.9 % while it reached 13.1% in Bihar.

Although India is in the midst of such rapid economic growth, the establishment of power infrastructures is not catching up the increasing power demand. During the period from April 2010 to May 2011, the country’s power demand at peak was 122,287 MW, while power supply at peak was 110,256 MW, leading to a supply deficit of 9.8 %. Demand for electric energy was 861 billion kWh, while supply was 788 billion kWh, again leading to a supply deficit of 8.5 %. In July 2012, a large-scale power blackout occurred in New Delhi. Because of this, the northern region of the country was left without electricity for almost two days, and affecting the daily lives of more than 600 million people, more than half of the whole population was affected. A power shortage has become a serious public concern.

Under these circumstances, the Government of India (GOI) is planning to ensure a power supply of 88,537 MW including newly developed under the 12th National Power Plan. As part of this plan, obsolete Units No.4/5 (50 MW x 2) in Barauni Thermal Power Station (TPS) have been planned to replace with new development of Unit No.10 (250 MW x 1).

An existing plan of a 250 MW subcritical boiler under this project is inferior to a Super Critical (SC) and/or Ultra Super Critical (USC) once-through boiler in thermal efficiency. SC and USC type boilers/technologies have advantages environmentally and economically as compared to the subcritical type, such as reduced exhaust emissions per unit power generation and improved fuel consumption rate.

Due to the above reasons, GOI had examined the introduction of more efficient systems, leadings to its reassessment of the original project structure, construction of a 250 MW subcritical boiler as an alternative to Units No.4/5. After this reassessment, GOI officially requested the Government of Japan to survey the preliminary feasibility to construct a 660 MW-class SC unit which already exists in India at the relevant plant site. The Study responds to this official request.

1.2 Purpose of Study

In order to consider the relevant site as a candidate for a future ODA loan project, the JICA Study Team (hereinafter referred to as " the Team") is to understand the background, the purpose and the content of the said project of construction of 660 MW x 1 SC coal-fired power plant and conduct an initial survey on the feasibility of the construction. Referring to the information of the current plan of construction of 250 MW x 1, the Team aims to establish a layout of a 660 MW SC unit with the extent of reuse of the existing equipment and/or facilities after the construction of the new unit. Based on the result of this Study, the Team will also make recommendations so as to what kind of studies need to be covered during the Feasibility Study (FS). If the Team concludes that it would not be possible to construct a new 660 MW SC unit under the current site conditions, then the Team will make suggestions as to what Bihar State Power Generation Company Limited (BSPGCL) can do to construct 660 MW x 1, referring to the information on the current plan of construction of 250 MW x 1.

1.3 Member List of the JICA Study Team

Table 1.3-1 shows the details of the Team members:

Table 1.3-1 Member List

	Name	Role	Designation
1	**Michio MIHARA**	**Team Leader** Planning of Overall Construction (Plant Design and Electrical)	Deputy General Manager & Group Manager Engineering Group International Business Division Kyushu Electric Power Co., Inc.
2	**Akihiro SHINYASHIKI**	**Sub-Team Leader** Planning of Coal-fired power plant (Layout Study)	Chief Engineering Group International Business Division Kyushu Electric Power Co., Inc.
3	**Yasunori SAKAMOTO**	Planning of Coal-fired power plant (Reuse Study)	Assistant Manager Engineering Group International Business Division Kyushu Electric Power Co., Inc.
4	**Yasuo YUTOKU**	Planning of Coal-fired power plant (Civil)	Assistant Manager Technical Strategy Group Engineering Division Kyushu Electric Power Co., Inc.
5	**Shigeru MAEDA**	Environmental and Social Consideration	Assistant Manager Business Development Group International Business Division Kyushu Electric Power Co., Inc.

1.4 Study Schedule

(1) Preparation

Period: October 11, 2013 (Friday) to October 16, 2013 (Wednesday)

The Team prepared an Inception Report describing an outline of the survey, prepared a presentation for it and arranged a trip.

(2) First Site Survey

During the first site survey, the Team visited BSPGCL and Barauni TPS to observe the situation at the site and to collect the information necessary for analysis work in Japan.

Table 1.4-1 Schedule of First Site Survey

Working day at site (Total days)	Date (Day)	Program	Stayed at
1	17 Oct. (Thu)	Travel from Fukuoka to Delhi via Narita	Delhi
2	18 Oct. (Fri)	Discussion at JICA New Delhi Office Visit STEAG Energy Services (India) Pvt. Limited (STEAG)	-do-
3	19 Oct. (Sat)	Preparation of Documents	-do-
4	20 Oct. (Sun)	Leave Delhi for Patna (by air)	Patna
5	21 Oct. (Mon)	Kick-off Meeting with Officials of BSPGCL Leave Patna for Barauni (by road)	Barauni
6	22 Oct. (Tue)	Meeting at Barauni TPS with Concerned Officials Followed by Site Survey, Collecting Information	-do-
7	23 Oct. (Wed)		-do-
8	24 Oct. (Thu)		-do-
9	25 Oct. (Fri)		-do-
10	26 Oct. (Sat)	Leave Barauni for Patna (by road)	Patna
11	27 Oct. (Sun)	Preparation of Documents	-do-
12	28 Oct. (Mon)	Visit BSPGCL Office & Collecting Information	-do-
13	29 Oct. (Tue)	Preparation of Documents	-do-

Working day at site (Total days)	Date (Day)	Program	Stayed at
14	30 Oct. (Wed)	Wrap-up Meeting with Managing Director and Concerned Officials of BSPGCL Leave Patna for Delhi (by air)	Delhi
15	31 Oct. (Thu)	Visit STEAG Travel from Delhi to Narita	In-Flight
16	1 Nov. (Fri)	Arrive Narita Leave Narita for Fukuoka (by air)	

(3) Analysis Work in Japan

Period: November 5, 2013 (Tuesday) to December 6, 2013 (Friday)

During analysis work in Japan, the Team drew up a schematic dimensional design, had an interview with main equipment manufacturers and surveyed references in Japan based on information collected in India and compiled the Draft Final Report.

(4) Second Site Survey

During the second site survey, the Team gave an explanation to BSPGCL based on the Draft Final Report compiled during analysis work in Japan and also exchanged opinions.

Table 1.4-2 Schedule of Second Site Survey

Working day at site (Total days)	Date (Day)	Program	Stayed at
17	15 Dec. (Sun)	Travel from Fukuoka to Delhi via Narita	Delhi
18	16 Dec. (Mon)	Leave Delhi for Patna (by air) Present outline of draft final report (BSPGCL) Exchange opinions	Patna
19	17 Dec. (Tue)	Visit Barauni TPS(BSPGCL) and Barh TPS (NTPC)	Patna
20	18 Dec. (Wed)	Wrap-Up Meeting with BSPGCL and JICA	Patna
21	19 Dec. (Thu)	Leave Patna for Varanasi	Varanasi
22	20 Dec. (Fri)	Travel from Varanasi to Narita via Delhi	In-Flight
23	21 Dec. (Sat)	Leave Narita for Fukuoka (by air)	

(5) Organization Work in Japan

Period: December 24, 2013 (Tuesday) to January 20, 2014 (Monday)

The Team examined several points of the contents of Draft Final Report for completion of Final Report based the additional information during the second site survey.

(6) Submission of Final Report

January 20, 2014 (Monday)

1.5 Contents of Survey

1.5.1 Specific Procedure of Survey

Currently in Baurani TPS, Units No.8/9 are under construction as an extension project. The planned site of Unit No.10 (250 MW x 1) is reserved in the western part of Units No.8/9. While this area is reserved for a substitute plant for the obsolete Units No.4/5 (50 MW x 2) located in the existing plant area, the Team surveyed the situation at such planned site, the existing plant area of Barauni TPS etc. and investigated the possibility of constructing a 660 MW SC unit, especially with respect to space. Specifically, the Team conducted a site survey on the contents described below and assessed whether or not the planned site could accommodate the configured plant.

[Contents of Site Survey]

(1) Examine planned site of Unit No.10 and assess space available upon removing the obsolete plant and developing the site
(2) Examine existence of a power station's plan to reuse any part of obsolete plant and identify of reusable facilities
(3) Select candidate sites
(4) Estimate necessary amount of coal equivalent to 660 MW operation plan and collect procurement of coal
(5) Collect information of topography and geology around the Barauni TPS
(6) Examine water resource and intake point
(7) Examine ash disposal area and effective utilization plan
(8) Identify items for the environmental and social considerations

[Contents of Analysis in Japan]

(1) Determinate main plan configuration of a 660 MW SC unit based on references in Japan, etc.
(2) Present conditions to make construction possible in the case that it is impossible
(3) Propose recommendations for the next FS

1.5.2 Organization of Results of Survey and Study

The Team identified the available area through the site survey and examined the possibility of obtaining a good location in such area based on the work flow shown in Figure 1.5-1.

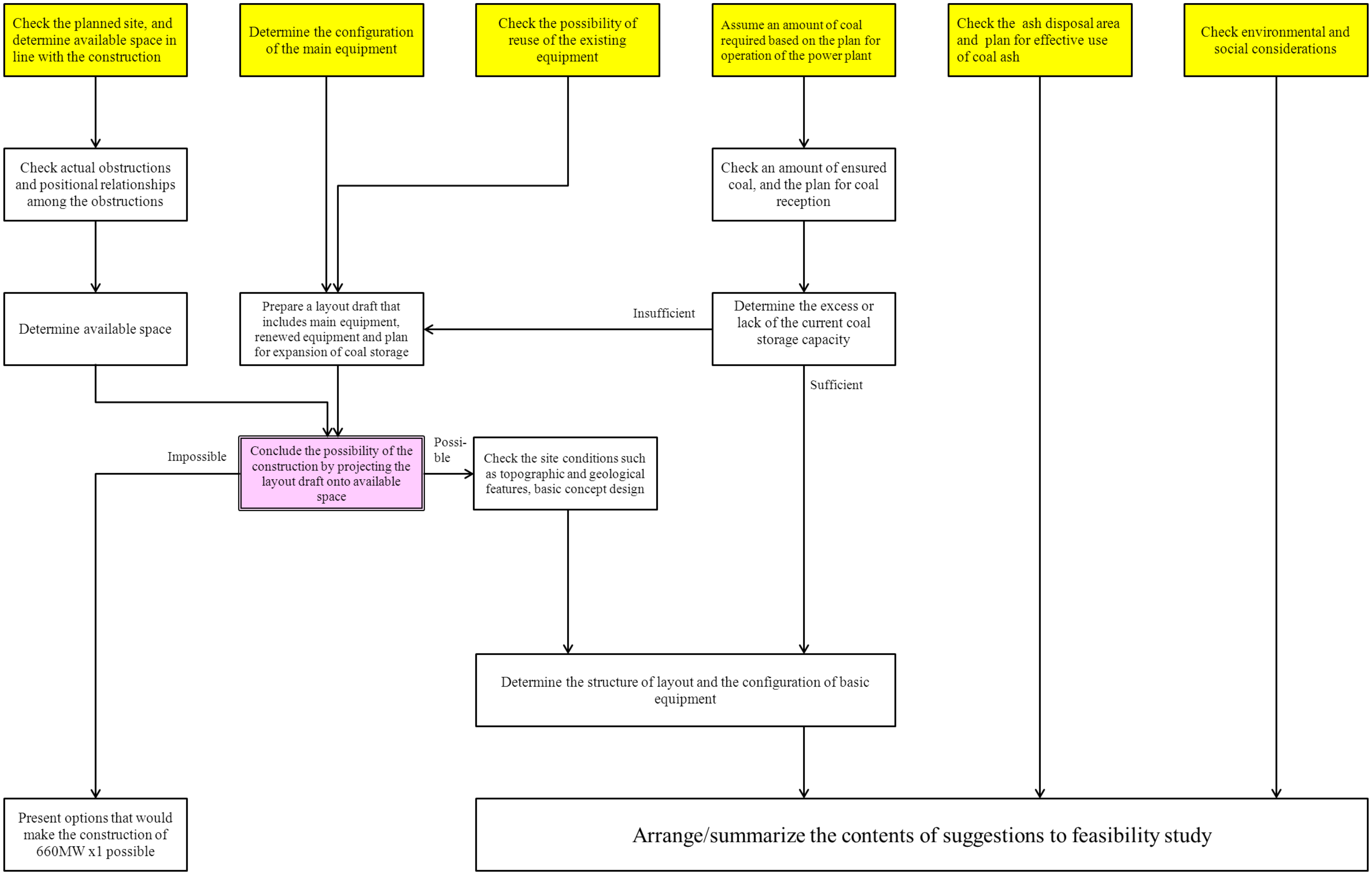

Figure1.5-1 Flow of Study/Investigation Results Arrangement

Chapter 2 Current Situation and Challenges Faced by Power Sector in India

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Chapter 2 Current Situation and Challenges Faced by Power Sector in India

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Chapter 2 Current Situation and Challenges Faced by Power Sector in India

2.1 Position of Electricity Development Plan in National Development Plan

(1) Electricity Development Plan in the 12th Five Year Plan

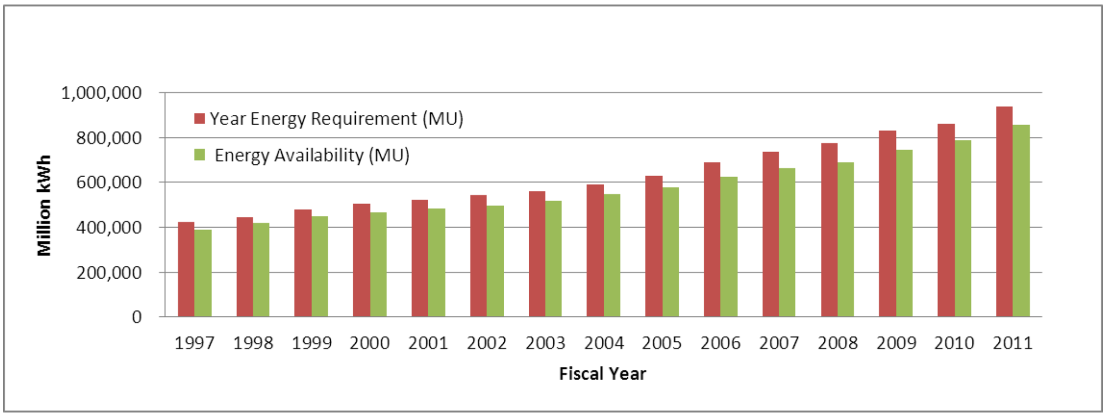
As a national-level plan stipulated in the constitution, India settles on its Five Year Plan, which presents its development goals and individual projects accordingly in such fields as economy, public finance, employment, education, social-welfare, environment, industry, agriculture, transportation, urban-development, energy, etc.

Currently the 12th Five Year Plan targeting from Fiscal Year (FY) 2012-13 through 2016-17 is under implementation, and the expected annual GDP growth rate during this period is approximately 8 % on average. Regarding the expected GDP growth sector by sector, it is approximately 4 % and 10 % in the agriculture sector and the industry sector respectively.

The plan assesses that the electricity drives all economic activities, and that reliable power supplies could enable the rapid and comprehensive growth. Therefore, the plan regards the electricity as the most important infrastructure.

However, the development of electricity infrastructure has not caught up with India's economic growth. The actual electricity generation during the period of the 11th Five Year Plan covering from 2007-08 through 2011-12, was 876,880 GWh against assumed electricity demand of 1,038,000 GWh in the plan, leading to a shortfall of 16 %, and continuous electricity deficit.

According to the Annual Report issued by the Ministry of Power (MoP), the average gap rate of electricity supply and demand during 10 years period up to 2011-12 was 8.9 % (Refer to Figure 2.1-1).



Source: MoP, Annual Report 2012 - 13

Figure 2.1-1 Electricity Demand and Supply

The 12th Five Year Plan estimates that 1,403,000 GWh should be supplied by 2016-17 and that the projected growth rate of the power generation will be 9.8 %. It estimates that the required capacity addition should be 75,785 MW, but a capacity of 88,537 MW in total is actually planned with considering the case where the demand-supply gap is at peak. Table 2.1-1 shows the planned power generation expansion by sector.

Table 2.1-1 Sector Wise and Mode Wise Capacity Addition by Sector during 12th Five Year Plan (Unit: MW)

Sector	Hydro	Thermal				Nuclear	Total
		Total	Coal	Lignite	Gas/LNG		
Central	6,004	14,878	13,800	250	827.6	5,300	26,181.6
State	1,608	13,922	12,210	0	1,712.0	0	15,530.0
Private Sector	3,285	43,540	43,270	270	0.0	0	46,825.0
Total *1	10,897	72,340	69,280	520	2,539.6	5,300	88,536.6
Renewable Energy	—	—	—	—	—	—	30,000
Total *2	10,897	72,340	69,280	520	2,539.6	5,300	118,536.6

*1: excluding renewable energy

*2: including renewable energy

Source: 12th Five Year Plan of India (2012-2017)

Since coal is the most abundant among the available primary energy sources in India, the main way to add power generation capacity is to have coal based thermal power generation. While it is assessed that India should have sufficient construction capacity for expanding its power generation facilities, it is recognized that the supply of coal and natural gas as fuel would be a big issue. Coal India Limited (CIL), a state-own company undertaking exploitation of coal mines and supply of coal in India, could not meet its coal production targets in the 11th Five Year Plan. It is inevitable in the 12th Five Year Plan that coal production should be increased from 540 million tons in 2011-12 to 795 million tons in 2016-17 and a failure to increase production of domestic coal would probably put a significant influence on the energy policy of India.

Aiming to sustainable economic growth and effective utilization of fuels, GOI intends to proactively promote the introduction of more efficient SC coal based TPSs and USC coal based TPSs instead of subcritical ones. It was announced that half of the 12th Five Year Plan target and the coal based addition in the 13th Five Year Plan would be through SC units.

According to the 12th Five Year Plan of India, the latest USC coal based TPS has an efficiency of 46 % against 34 % in the case of subcritical TPS, and 40 % in the case of SC TPS.

Accordingly, it is assessed that USC TPSs and SC TPSs could save on coal consumption and reduce carbon dioxide emissions. For example, while a conventional TPS with a capacity of 10,000 MW at around 70 % Plant Load Factor (PLF) generates 60,000 GWh, introducing an USC TPS would enable saving of 0.165 kg/kWh coal if coal of 4,000 kcal/kg were used and reduction of annual coal consumption by 9.9 million tons for 60,000 GWh.

As SC technology has been fully matured, though the cost is around 0.7 % higher than a subcritical one in kW,[1] it is specified that coal should be supplied preferentially to SC TPSs to encourage the adoption of SC technology.

USC technology requires the development of special materials with super-high-temperature resistant and high-pressure resistant characteristics. GOI intends to promote domestic production of USC TPS equipment through investing in R&D on USC TPSs. It is expected that USC TPSs will be adopted during the period of the 13th Five Year Plan and the initial USC TPSs jointly developed by Bharat Heavy Electricals Limited (BHEL), National Thermal Power Corporation Limited (NTPC) and Indira Gandhi Centre for Atomic Research (IGCAR) will commence operation in 2017. GOI intends to promote improvement of SC and USC technology as a medium-to-long-term goal.

(2) National Electricity Plan

In the National Electricity Plan formulated based on the 12th Five Year Plan by the Central Electricity Authority (CEA), an organization that provides advice and support Central Government on matters relating to electricity policy and formulation of plans, it is forecasted that energy requirement will be 1,354,874 GWh and peak demand will be 199.54 GWh in 2016-17, the last fiscal year of the 12th Five Year Plan. It is stated in the National Electricity Plan that a capacity addition of about 79,690 MW is required during the 12th Five Year Plan to meet the All-India demand projections and 66,600 MW, corresponding to 84 % of this capacity, should be fulfilled by coal based TPSs.

Table 2.1-2 Type Wise Capacity Additions during 12th Five Year Plan

Total Capacity		79,690 MW
Hydro		9,200 MW
Nuclear		2,800 MW
Thermal		67,690 MW
	Coal	66,600 MW
	Gas	1,090 MW

Source: CEA, National Electricity Plan (2012-2017)

[1] NEDO, Feasibility Studies with the Aim of Developing a Bilateral Offset Credit Mechanism FY2011 / Studies for Project Development and Organization / Program organization research of Ultra Super Critical (USC) coal-fired thermal power plant construction project in the Republic of India

Although this plan is formulated with the intention to utilize abundant domestic coal of which proven reserves are approximately 118,100 million tons,[2] it is estimated that forecasted coal supply to the Power Sector in 2016-17 will fulfill only 72 % of the demand, and this means a deficit of 238 million tons as shown in Table 2.1-3. It is expected that part of the deficiency corresponding to approximately 164 million tons will be fulfilled by import coal from CIL. Resolving the coal supply issue is considered to be an absolutely critical factor for stable electricity supply.

Table 2.1-3 Availability/Shortfall of Coal in 2016-17

<table>
<tr><th colspan="2">Requirement
(Million Tons)</th><th colspan="2">Availability
(Million Tons)</th><th>Supply Source</th></tr>
<tr><td colspan="2" rowspan="5">842</td><td colspan="2">604</td><td></td></tr>
<tr><td rowspan="4">Contents</td><td>415</td><td>CIL</td></tr>
<tr><td>35</td><td>Public Owned Coal Utility SCCL</td></tr>
<tr><td>100</td><td>Captive Blocks allocated to Power Utilities</td></tr>
<tr><td>54</td><td>Import by TPSs</td></tr>
<tr><td>Remarks</td><td colspan="4">SCCL: The Singareni Collieries Company Limited (Central Government 49 % + Andhra Pradesh State Government 51 %)
Captive Mines: Mines which supply coal to specific consumers and to which private investment is permitted.</td></tr>
</table>

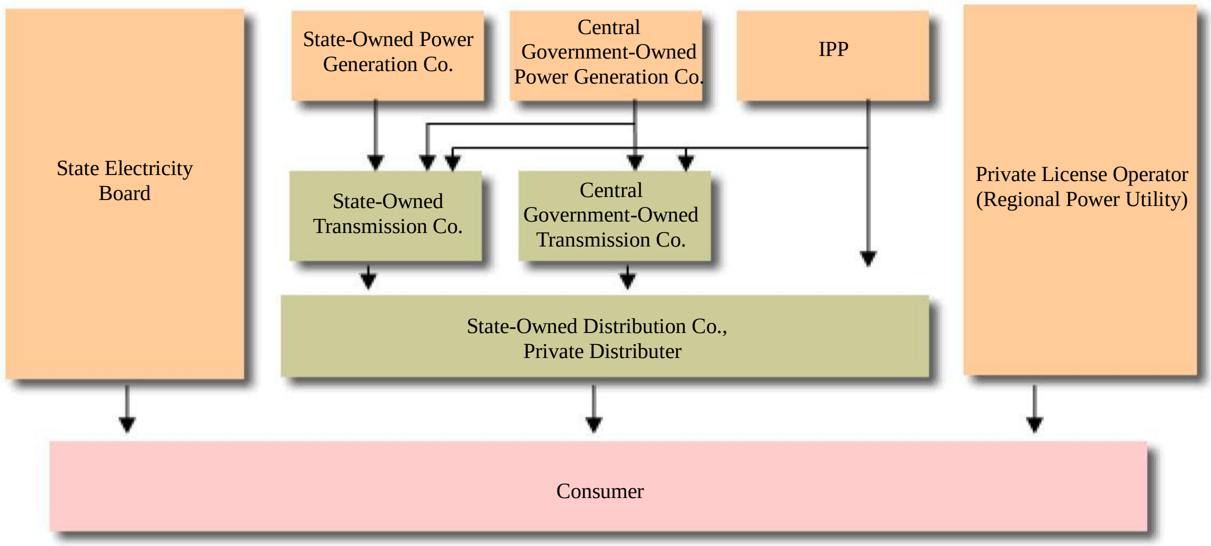
Source: Prepared by the Team based upon CEA, National Electricity Plan (2012–2017)

The same as the 12th Five Year Plan, adoption of clean coal technology is proactively encouraged for efficient utilization of coal and reduction of greenhouse gases (GHG) and adoption of SC technology is promoted also from the viewpoint of long-term energy security of India. It is also laid out that the number of plants with a higher steam condition should be increased and USC technology and Integrated Gasification Combined Cycle (IGCC) technology should be adopted as the strategy for reducing GHG.

[2] Energy Statistics of India 2013

2.2 Structure of Power Sector

In the power sector in India, agencies of Central Government and State Governments undertake formulation of policies and regulation of business, while public power generation and transmission utilities owned by Central or State Government as well as private utilities operate the respective electricity businesses.



Source: JEPIC, website (http://www.jepic.or.jp/data/ele/ele_08.html)

Figure 2.2-1 Electricity Supply Structure in India

In Central Government, MoP has the primary responsibility for developing electricity and undertakes formulation of plans, drafting of electricity policies, supervision of the progress of development projects, training, human resources development and legislation relating to thermal/hydro power generation and transmission/distribution.

Furthermore, the Central Electricity Regulatory Commission (CERC) is established as an organization that shall regulate the power tariffs of national government-owned power generation company and transmission tariffs between states and provide advice to Central Government on regulations of electricity tariffs.

The Atomic Energy Commission (AEC) has jurisdiction over nuclear power generation, while the Ministry of New and Renewable Energy (MNRE) has jurisdiction over power generation by renewable energy.

In every State Government, the State Electricity Board (SEB) that was established pursuant to the Electricity (Supply) Act (hereinafter referred to as “the Electricity Act”) enforced in 1948 had managed the electricity business in these states. Pursuant to the Electricity Act enforced in 2003, SEB was divided and privatized so as to be unbundled into state power generation companies, state transmission companies, state distribution companies and such like, though the progress of reorganization differs among states. The State Electricity Regulatory Commission

(SERC) which was established for regulation of electricity business in the state undertakes issuing of licenses to transmission and distribution operators in the state and makes decisions on tariffs of power generation, transmission, distribution, etc.

2.3 Electricity Policy

The Electricity Act 2003 presented a framework for reformation of the power sector in India. It specified division of SEB, abolition of licenses in the power generation sector except hydro power generation, implementation of free access to transmission/distribution systems (liberation of systems), reduction and abolition of internal mutual subsidies, permission for electricity trade, promotion of rural electrification, thoroughly implemented meter-reading, enhanced control against stealing electricity, etc.

Pursuant to this law, the National Electricity Policy was formulated in 2005 and a policy on electricity tariffs, policy on electrification of rural areas etc. was drafted in 2006.

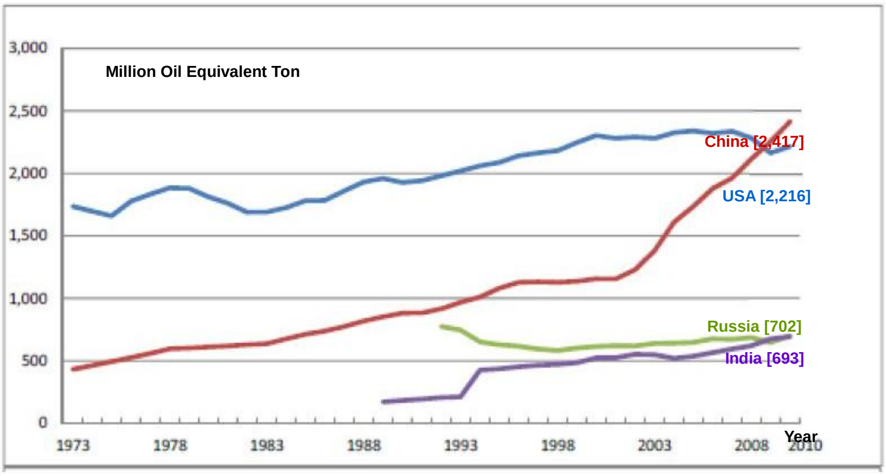
In the National Electricity Policy drafted in 2005, MoP listed the following seven objectives:

(1) Ensure an electricity supply to all families within 5 years
(2) Balance electricity supply and demand and secure appropriate operation reserve by 2012
(3) Supply electricity of high reliability and high quality with affordable electricity tariff
(4) Increase available electricity per person by 1,000 kWh/year by 2012
(5) Secure 1 kWh/day per family as the minimum consumption by 2012
(6) Have the power sector return to a financial profit and achieve commercial feasibility
(7) Protect consumers' interest

It is estimated that if the available electricity per person up to 2012 increases by 1,000 kWh/year, expansion of capacity of no less than 1 billion kW should be required. It is stated that supply of electricity by coal based TPSs should be essential in addition to expansion of hydro power generation capacity in order to meet such demand.

2.4 Current Situation, Future Plan and Challenge of Electricity Demand/Supply

Against the background of economic growth in recent years, energy consumption in India has remarkably increased, jumped 4 times during the past 20 years, and now ranked fourth in the world in terms of primary energy consumption, following China, USA and Russia and surpassing Japan.[3]



Source: JEPIC Website (http://www.jepic.or.jp/data/gl_date/gl_date02.html)

Figure 2.4-1 Trend of Major Countries' Primary Energy Consumption

India has seen annual GDP growth almost exceeding 4 % since the 1990s, which represents the highest growth among BRICs countries after China. It is forecasted in the study report "World in 2050" published by PricewaterhouseCoopers (PwC) that China, USA and India will become the three major economies of the world.

While the village electrification rate[4] has reached to approximately 94 %[5] under such rapid economic growth, however, the development of domestic infrastructure has not caught up with the demand. The situation regarding electricity in India is such that the supply capacity was 110,256 MW against peak demand of 122,287 MW during the year 2010-11, which represents a deficit of 9.8 %, and at the same time generated power was 861 billion kWh against demand of 788 billion kWh, which represents a deficit of 8.5 %.

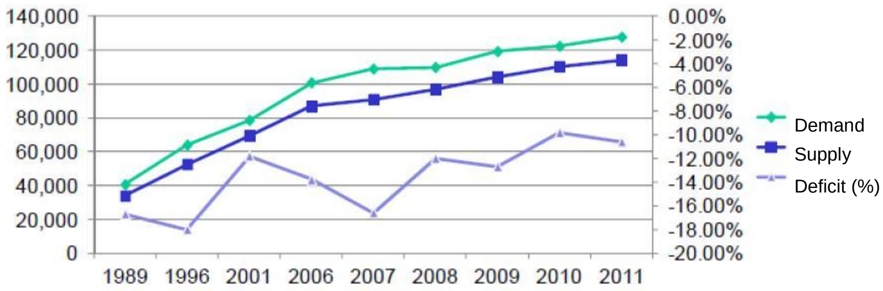
[3] IEE Japan, May 2011
[4] 1) Basic infrastructure such as Distribution Transformer and Distribution lines are provided in the inhabited locality as well as the Dalit Basti/hamlet where it exists.
2) Electricity is provided to public places like Schools, Panchayat Office, Health Centres, Dispensaries, Community centers etc.
3) The number of households electrified should be at least 10 % of the total number of households in the village.
[5] CEA (2013), "Monthly Review of power Sector Reports 2013 Jan."

Table 2.4-1 All-India Actual Power Supply Position (2010-11)

	Peak (MW)	Energy (Billion kWh)
Requirement	122,287	861
Availability	110,256	788
(-) Shortage / (+) Surplus	(-) 12,031	(-) 73
(%)	(-) 9.8 %	(-) 8.5 %

Source: CEA, National Electricity Plan (2012-2017)

As mentioned above, India faces continuous power shortages as supply capacity does not match demand.



Source: CEA, National Electricity Plan (2012-2017)

Figure 2.4-2 Trend of Growth of Electricity Demand and Deficit of Supply

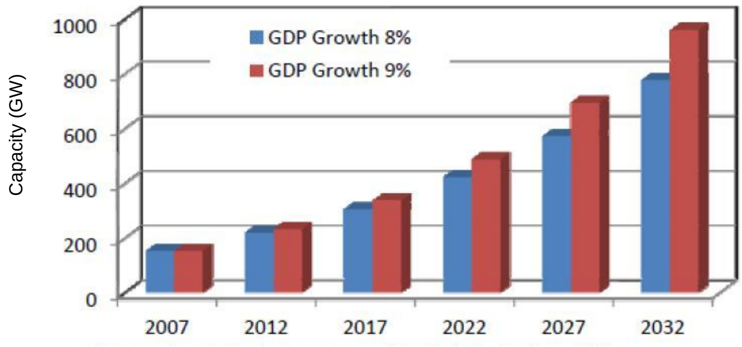
This is not only due to a shortage of power generation capacity but also due to a reduction in generation capacity because of insufficient supply or deteriorated quality of fuel to coal based power plants, which represent the main power plants among various existing plants, or improper maintenance of plants.

Accordingly, India is addressing the deficit of electricity by allocating electricity that can be supplied from the system to each state, and the states shall comply with such allotment of electricity. If demand in a state exceeds its allotted electricity, therefore, the state shall procure it from the outside or cut the demand.[6]

Nevertheless, under such circumstances, a large-scale blackout occurred for 2 days in New Delhi and the northern part of India in 2012, which resulted in a catastrophe affecting 600 million people, more than 50 % of the total population.

If the future annual GDP growth of India is 8-9 %, it will be required to increase its supply capacity by 6.5 %/year in order to meet domestic demand.

[6] IEE Japan, Materials for Study Report & Discussion Meeting No.51 (September 2012)



Source: JCOAL, World Coal Report Vol.5, P.38 (2012)

Figure 2.4-3 GDP Growth and Increase of Power Generation Capacity

In order to resolve such continuous electricity supply deficit, GOI formulated the National Electricity Plan, and intends to systematically enhance its electricity infrastructures.

2.5 Trend of Electricity Supply in Bihar State

Bihar State is located in the east of India. There is no coast in the state but it is close to the port of Kolkata. The Ganges River flows in the center of the state. It borders on Nepal in the north, on Jharkhand State in the south, on West Bengal State in the east and on Uttar Pradesh State in the west.

The state is the poorest in the nation as its net product per capita is approximately 1/3 of the national average and approximately 1/7 of Delhi metropolitan.[7]

During the period of the 11th Five Year Plan, however, the state achieved an annual growth rate of 12.8 % against the national average of India, 7.4 %. The growth rate of income per capital of the state during the 11th Five Year Plan reached 10.4 % which was 4 percentage points higher than the national average of India.

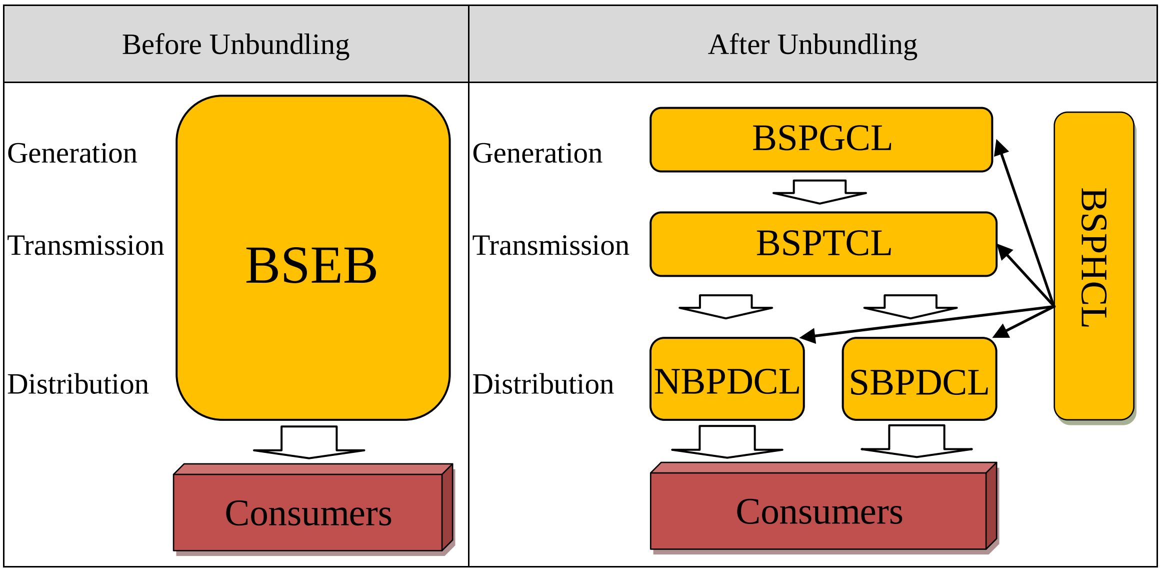
State Government sets the objective of annual growth rate as 12-13% during the period of the 12th Five Year Plan. In order to achieve such growth rate, the state sets the objective such as development of infrastructures on faster pace.[8]

Bihar State Electricity Board (BSEB), which had undertaken power supply to the state pursuant to the Electricity Act enforced in 2003, was divided into 5 public utilities and privatized. It was unbundled under Bihar State Power (Holding) Company Limited (BSPHCL) into BSPGCL, Bihar State Power Transmission Company Limited (BSPTCL), North Bihar Power Distribution Company Limited (NBPDCL) and South Bihar Power Distribution

7 Ministry of Statistics and Programme Implementation, State Domestic Product and other aggregates, 2004-05 series

8 BSPHCL, Business Plan for Bihar State Power Transmission Company for control period from FY2013–14 to FY2015–16 Business (November 2012)

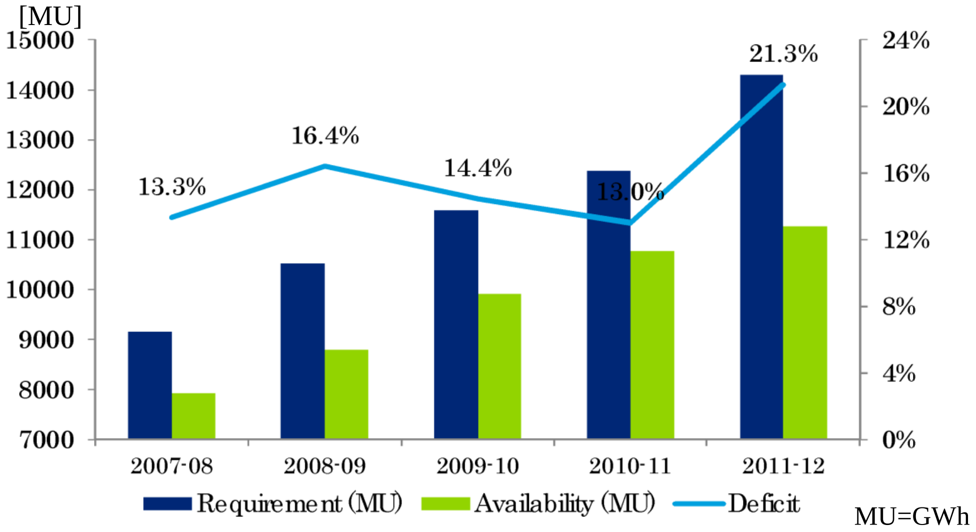
Company Limited (SBPDCL) (Refer to Figure 2.5-1). BSPHCL is responsible for formulating demand/supply forecasts based on the economic growth rate, etc.



Source: Prepared by the Team based on BSPHCL, Business Plan for BSPTCL for control period from FY2013-14 to FY2015-16 (November 2012)

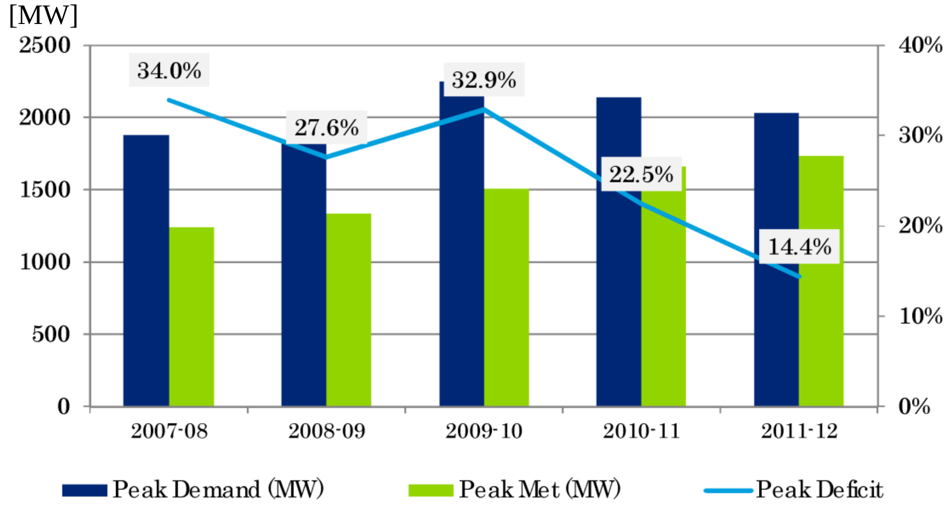
Figure 2.5-1 Structure of Bihar State Electricity Board before and after Unbundling

Figures 2.5-2 and 2.5-3 show the trend of electricity demand/supply and peak power during the period of the 11th Five Year Plan, 2007-08 through 2011-12. The electricity supply of the state in 2010-11 fell below demand by 13 % and there was a deficit of peak power of 22.5 %. The national deficit rates of India in 2010-11 were 8.5 % and 9.8 % respectively. It is indicated that there has been a continuous deficit in electricity supply and the electricity supply of the state is relatively vulnerable as compared with the national average electricity supply.



Source: BSPHCL, Business Plan for BSPTCL for control period from FY2013-14 to FY2015-16 (November 2012)

Figure 2.5-2 Electricity Demand/Supply in Bihar State

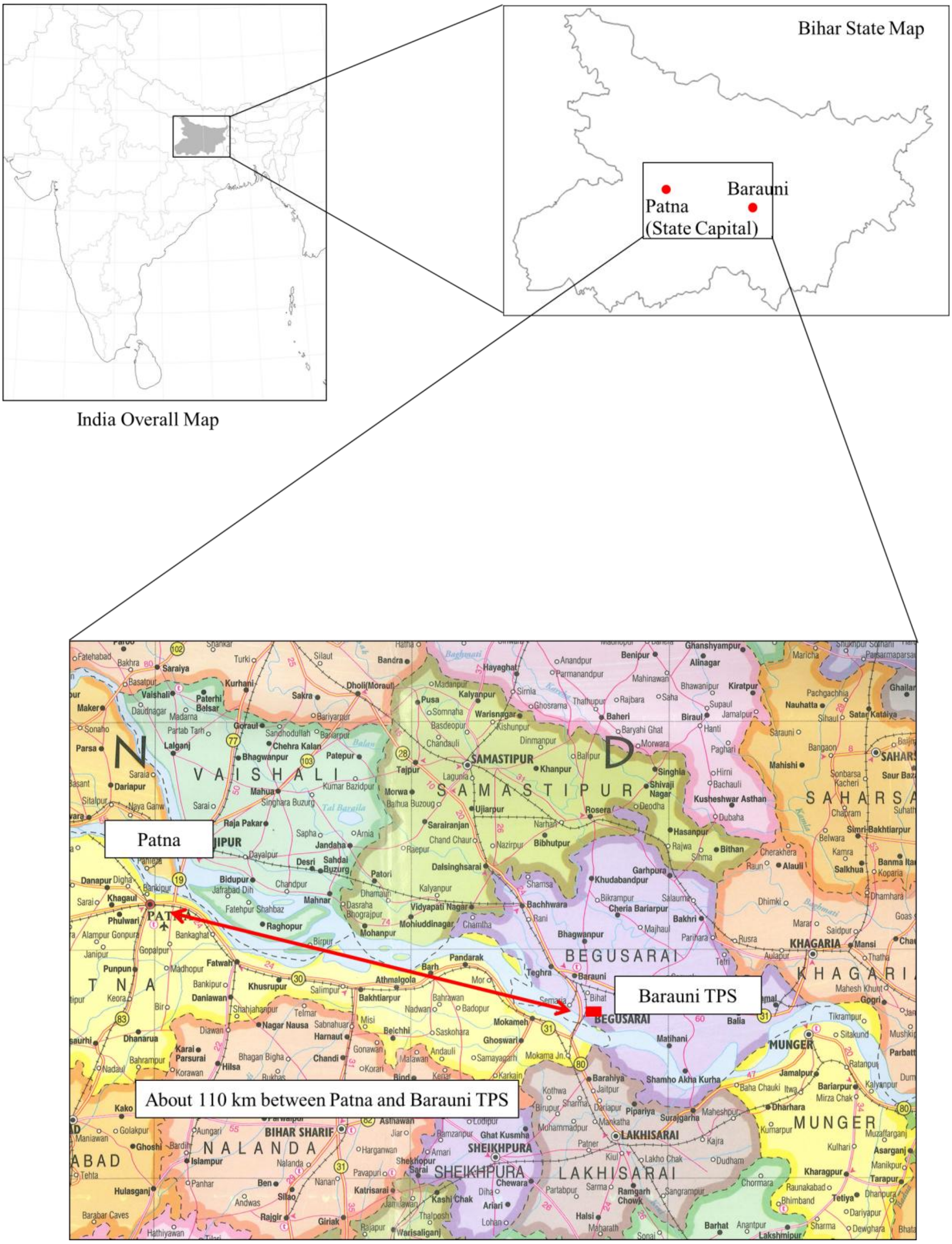


Source: BSPHCL, Business Plan for BSPTCL for control period from FY2013-14 to FY2015-16 (November 2012)

Figure 2.5-3 Demand/Supply of Peak Power in Bihar State

State Government forecasts that the peak power will drastically increase in the near future from the current 2,000 MW to 6,000 MW in association with future rapid growth. In order to promote growth and respond to increased electricity demand in the state, State Government formulates various programs to add power generation capacity and new allotment of electricity from Central Government and projects in the private sector. Specifically, it has a plan to resolve the deficit of peak power by 2015-16 by increasing the available capacity from 2,573 MW in 2012-13 to 5,243 MW in 2015-16, expanding the number of power generation plants in the state, increasing the allotment of electricity from NTPC, introducing the Independent Power Producer (IPP), etc. Barauni TPS, which is the target of this Study, is one of plants subject to capacity expansion.

Chapter 3 Outline of Barauni Thermal Power Station



Location of India/Bihar/Barauni Thermal Power Station

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Chapter 3 Outline of Barauni Thermal Power Station

3.1 Outline of Barauni Thermal Power Station

Barauni TPS is located in the District Begusarai on the north bank of the Ganges, about 110 km away from the east of Patna, the state capital of Bihar.

Though infrastructure such as oil refinery and fertilizer mills existed in the vicinity of Barauni TPS, Barauni TPS is deemed as a major work site for local residents. And the small town was formed by people who worked at the power plant in the vicinity of the entrance of the power plant, at the entrance from National Highway Route 31 (NH-31) which the Team had used as an investigating route during their stay in Barauni.

Figure 3.1-1 Distant View of Barauni TPS

Barauni TPS started commercial operation in the middle of the 1960s as a coal-fired thermal power plant owned by BSPGCL. Then, it began commercial operation of units up to No.7. Currently, Units No.8/9 are under construction. An outline is as follows.

Table 3.1-1 Outline of Barauni TPS

Unit	Equipment Specification	Rated Output (MW)	Commencement of Commercial Operation	Present Situation	Manufacturer
No.1	Coal-fired Subcritical type unit	15	Jan. 26, 1966	Abolished	Yugoslavian
No.2		15	Jan. 16, 1963		
No.3		15	Oct. 20, 1963		
No.4		50	Nov. 9, 1969	Shutdown due to an environmental pollution problem on Apr. 24, 1996	Polish
No.5		50	Dec. 1, 1971	Shutdown due to an environmental pollution problem on Mar. 15, 1995	
No.6		110	Dec. 1, 1984	R&M/LE[*1] ongoing	BHEL made
No.7		110	Mar. 31, 1985	R&M/LE[*1] ongoing	
No.8		250	-	Under construction	
No.9		250	-	Under construction	

*1: R&M/LE, Renovation & Modernization and Life Extension

(1) Situation of Units No.1-3 (15 MW x 3)

Abolished as a power plant, the cooling tower and the turbine building are left without being used, though parts of the power equipment such as the chimney, boilers and ElectroStatic Precipitator (ESP) have been already removed. Most of the site concerned can be reused, so remaining facilities will be removed in case of future implementation of new plan.

Figure 3.1-2 Current Units No.1-3

(2) Situation of Units No.4/5 (50 MW x 2)

Units No.4/5 have been stopped since the environmental pollution problems occurred from 1995 through 1996. A renovation plan has been submitted to CEA, but CEA did not approve this plan because there was no prospect of its realization. Then, it was decided to abolish these units and to construct new Units No.8/9 instead. However, the turbine buildings and the boilers are left unused. Like Units No.1-3, most of the site concerned can be used, so remaining facilities will be removed in case of future implementation of new plan.

Figure 3.1-3 Current Units No.4/5

(3) Situation of Units No.6/7 (110 MW x 2)

As of October 2013, Units No.6/7 were under renovation for re-operation (R&M/LE). This rehabilitation is specified in the 12th Five Year Plan. It was reported that the scheduled completion date of this rehabilitation has been delayed over 1 year.

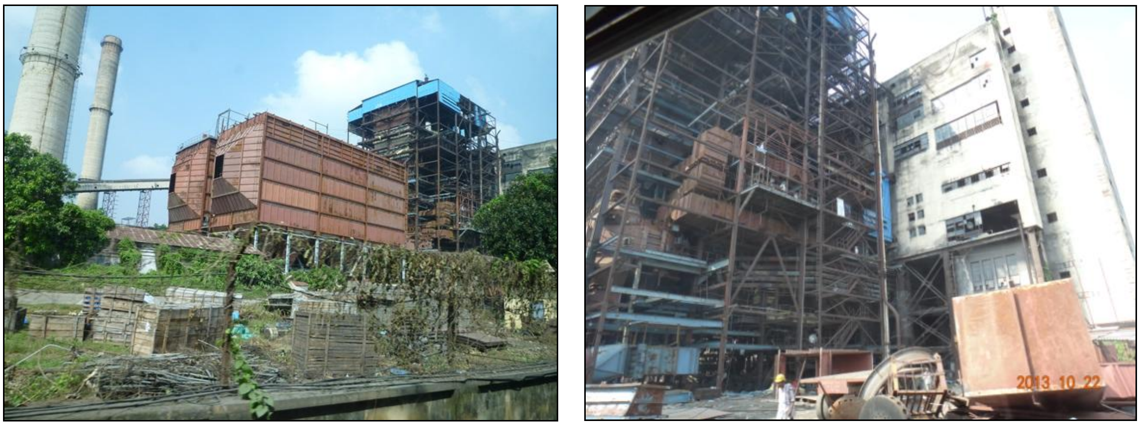

Figure 3.1-4 R&M/LE Situation of Units No.6/7

(4) Situation of Coal Storage Yard and Coal Handling Plant

In Barauni TPS, a railway carriage comes in and coal is transported by railway. However, it seemed not to be used for a long time and few coal was remaining in the coal storage yard. The coal storage capacity is secured in the coal storage yard by having digging type storage. Because the belt conveyors are becoming old, sufficient maintenance is required before Units No.6/7 can be reoperationalized.

Figure 3.1-5 Wagon Tippler (Coal Unloading Equipment)

Figure 3.1-6 Situation of Coal Storage Yard

(5) Situation of Units No.8/9 (250 MW x 2)

It was decided to construct Units No.8/9 as alternatives to the obsoleted Units No.4/5. As of October 2013, the turbine building, boiler, and ESP were being assembled. In addition, Unit No.8 will be commissioned in June 2014, and Unit No.9 is scheduled to be commissioned in October 2014. But it was confirmed that construction work had been delayed by more than 2 years compared with the original schedule.

Figure 3.1-7 Construction of Units No.8/9
(Turbine Building)

Figure 3.1-8 Construction of Units No.8/9
(Left: Unit No.8 Boiler, Right: Unit No.9 Boiler, and Center: Turbine Building)

3.2 Past Operation Results of Barauni Thermal Power Station

Table 3.2-1 shows the operation result of Barauni TPS which is open to the public. The operation results are currently available only for the 2005-2010 fiscal years because the R&M/LE construction of Units No.6/7 started in the second half of fiscal 2011. Unit No.7 and Unit No.6 are planned to be completed by March 2014 and June 2014 respectively.[3]

As shown in Table 3.2-2, the PLF which is less than 10 % for the period indicates that this power station had not been used as a base load unit, but as a peak load unit to be operated when the supply is tight. The reasons why the equipment utilization of Units No.6/7 which could operate during the period concerned was reduced can be operating problems caused by the aging progress since Units No.6/7 were built around the middle of the 1980s.

Additionally, the actual amount of procurement of coal during the 2005-2009 fiscal years was 50 % or less against the original plan in almost all fiscal years (Refer to Table 3.2-3). Data on power generation and allocation of the distribution of coal would indicate that the priority of operating Barauni TPS after 2005 fiscal year had considerably decreased.

Table 3.2-1 Operating Situation of Barauni TPS

Fiscal Year	Installed Capacity (MW)	Plan (GWh)	Results (GWh)	Achievement (%)	Year-on-year (%)	PLF (%)
2005	220	418	120.86	28.9	78.6	6.27
2006	220	300	37.25	12.4	30.8	1.93
2007	220	315	132.37	42.0	355.4	6.87
2008	210	578	102.94	17.8	77.7	5.34
2009	210	360	264.71	73.5	257.2	14.06
2010	210	310	217.79	70.3	82.27	6.27

Source: CEA, Monthly Generation Report, website (http://www.cea.nic.in/mon_gen_arch.html)

[3] CEA Thermal Renovation and Modernization Division Quarterly Review Report Renovation & Modernization of Thermal Power Stations {2nd Quarter of 2013-14}

Table 3.2-2 Coal Supply to Barauni TPS

Fiscal Year	Installed Capacity (MW)	Plan (x 1000 MTs)	Results (x 1000 MTs)	Achievement (%)
2005	220	330	162.00	49.1
2006	220	420	42.72	10.2
2007	220	345	99.60	28.9
2008	210	360	67.59	18.8
2009	210	340	314.61	92.5

Source: Eastern Coalfields Limited (ECL), Sales & Marketing Information Consumer Profile website (http://easterncoal.gov.in/salesmktg.html)

3.3 Assessment of the Policy of Barauni Thermal Power Station

With aim at securing a supply capacity of an additional 2,000-2,500 MW by 2011-2012, India and Bihar State advances the renewal of Units No.6/7 and newly establish Units No.8/9 of Barauni TPS.[4]

Moreover, aim to secure a supply capacity of 5,243 MW until 2015-2016, Bihar States advances new electric power development and construction of a subcritical coal-fired thermal power plant with a rating of 250 MW x 1 instead of Units No.4/5 (50 MW x 2) under the 12th Five Year Plan. However, as a result of the study on the environmental consideration and the introduction of a highly effective power generating machine, the construction of a 660 MW SC coal-fired unit has been examined instead of a subcritical plan.

[4] Government of India, ROAD MAP FOR DEVELOPMENT OF POWER SECTOR IN BIHAR, A REPORT OF THE SPECIAL TASK FORCE ON BIHAR (July 2007)

Chapter 4 Site Survey Results

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Chapter 4 Site Survey Results

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Chapter 4 Site Survey Results

4.1 Basic Information of Project

General information concerning the new increase project of a 660 MW SC coal-fired thermal power generation equipment that is the object of this survey is as follows.

Table 4.1-1 Essential Information of Project

	Item		Content
1	Project Name		Barauni Thermal Power Station 660 MW power plant extension project
2	Project Owner		Bihar State Power Generation Company Limited
3	Plant Basic Specification		Fuel: Coal Generator Output (Gross): 660 MW Boiler type: Super Critical Pressure
4	Location		Barauni, Begusarai District, Bihar State Lat. 25°23′36″N Long. 86°1′26 ″E
	Nearest City		Barauni, Patna, Bahadurpur
	Access	Road	There is the Barauni-Mokama line of NH-31 on the west of the power plant.
		Railway	There is Hathidah Station at a distance of 3.5 km from the site and Barauni Station at a distance of 15 km from the site.
		Ship	430 km from Kolkata Port
		Airport	110 km from Patna Airport
5	Altitude		41.76 m
6	Seismic Zone		Zone IV as per IS 1893
7	Acquisition of Weather Information		The nearest weather meteorological observatory exists in Bahadurpur.
8	Ambient Temperature	Average of the highest temperature	42.4 °C
		Average of the lowest temperature	8.4 °C

	Item		Content
9	Relative Humidity (average)		52 %
10	Precipitation		About 80 % of the annual rainfall is concentrated in the June-September period
		Annual average rainfall	1,119.1 mm
		The maximum precipitation for 24 hours	352.8 mm
11	Direction and Velocity of the Wind		No wind peculiar to this region
		Peculiar wind direction	To the west from the east
		Maximum wind speed	17 m/sec
		Wind pressure (Min./Max.)	990 hPa/1,011.5 hPa

Source: Prepared by the Team based upon Development Consultants, Detailed Project Report for 2 x 250 MW Coal Based Extension Thermal Power Station at Barauni, Dist. Begusarai in Bihar
http://www.imd.gov.in/section/hydro/distrainfall/bihar.html
http://www.imd.gov.in/section/nhac/mean/110_new.htm

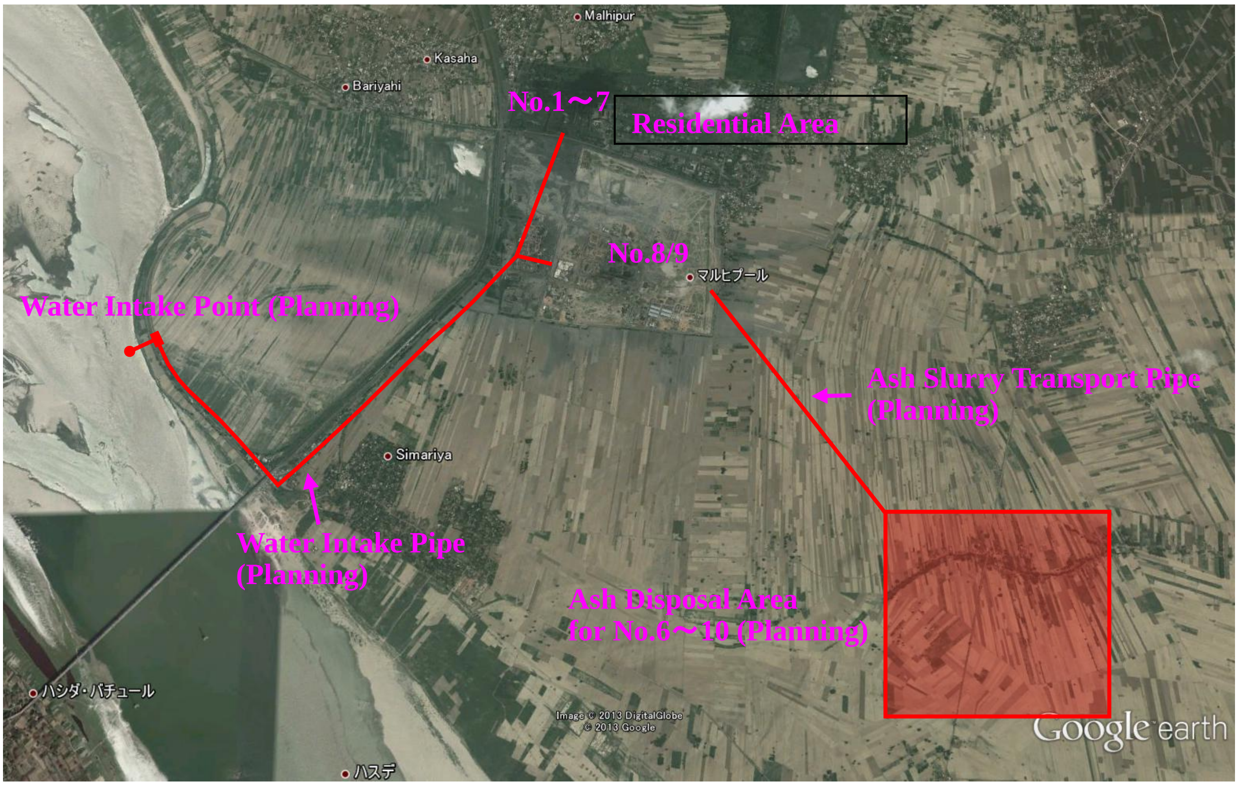


Figure 4.1-1 Image on Location of Barauni TPS and Related Facilities (Google Aerial Photo)

4.2 Specification of the Area which can be Built, and the Equipment which can be Diverted

4.2.1 Survey Target Area

Based on the collected information prior to the site survey, 4 target area as shown in Figure 4.2-1 (Existing Plant Area, Residential Area, Planned Area of Unit No.10 and Site in the South Adjacent to Units No.8/9) were selected for field survey.

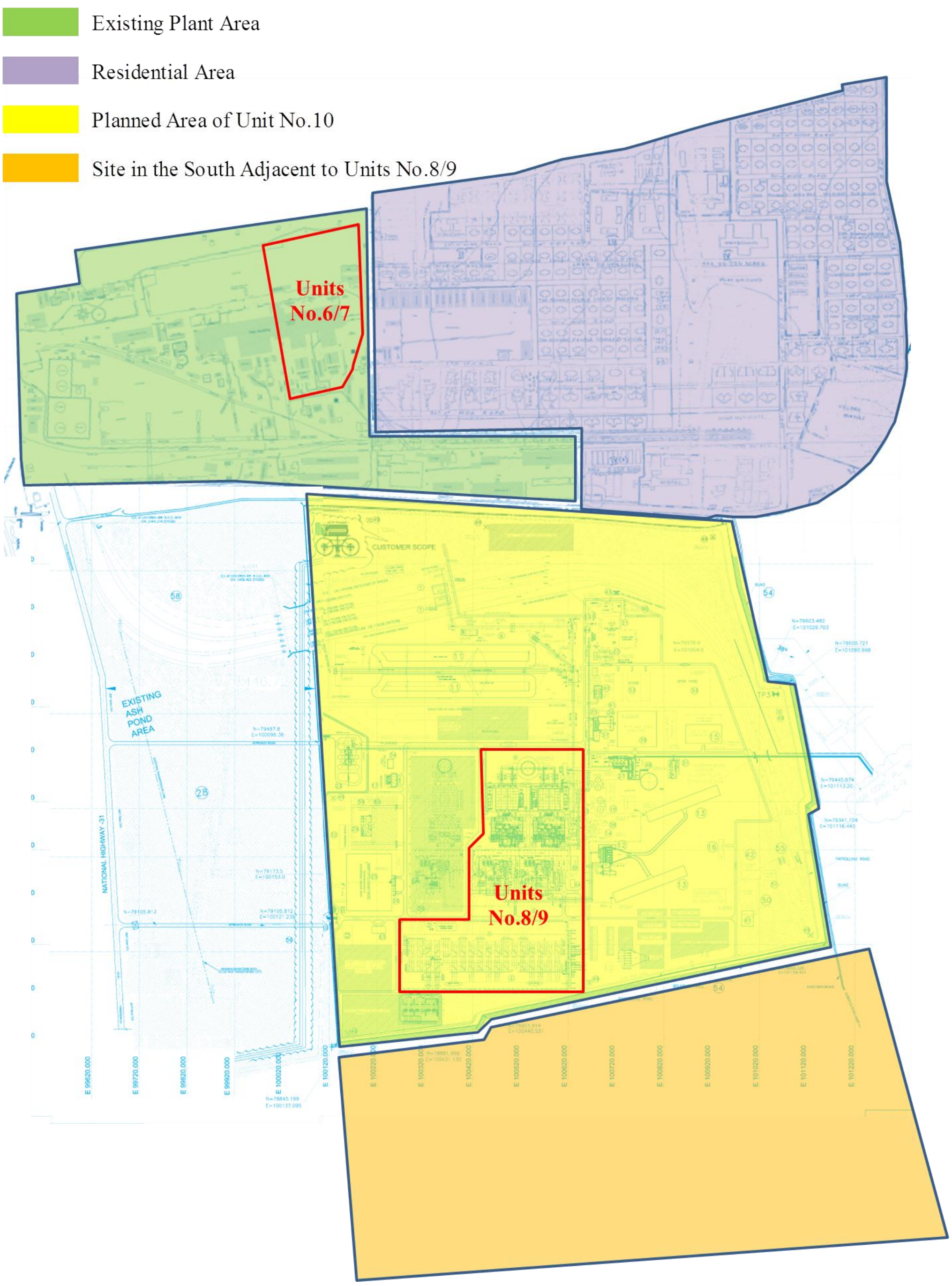


Figure 4.2-1 Target Area for Field Survey

4.2.2 Existing Plant Area

Confirmation has been made to specify the available range that can be used for the construction of 660 MW SC unit and some of the reuse plan of the equipment located in the existing area for Barauni TPS.

(1) Existing Facilities Reuse Plan

A lot of structures of Barauni TPS are left dilapidated without being removed. Therefore, it is necessary to undertake the removal of unnecessary equipment in order to reuse the area. As a result of interviews with the power plant side, the ones with the reuse plan of the premises equipment are shown in Table 4.2-1. Facilities excluding this can be removed and be leveled.

Table 4.2-1 Existing Facilities Reuse Plan of Barauni TPS

Equipment Name	Reuse Plan
Security Guard Station	There is need to provide a new location when removing it.
No.1-3 Cooling Tower	Reused as reservoir water for fire-fighting
Heavy Fuel Oil / Light Diesel Oil Tank	Used as an auxiliary fuel of Units No.6/7
Premises Railway Track	Newly scheduled to re-maintain 6 lines for the coal carrying for Units No.6/7
Units No.6/7 Facilities (Power Generation Equipment, Cooling Tower, Substation)	Schedule for reuse after construction of R&M/LE of Units No.6/7
Coal Storage Yard	The coal storage yard will be reused for Units No.6/7. The use as the shared coal storage of 660 MW equipment is also possible after enhancing to the south boundary.

Units No.1-3 Cooling Tower

Heavy Oil Tank

Existing Railway Track

Coal Storage Yard

Figure 4.2-2 Current Existing Equipment Situation

(2) Handling of Coal Handling Plant

If a 660 MW SC unit is installed in the existing area, coal handling plant may be picked as possible reuse equipment among the equipment being left behind. It was judged that reuse for a 660 MW SC unit at present was difficult because of the possibility of re-designing due to an insufficient transportation capacity, maintenance cost and considerable remodeling for obsolete equipment presuming a total power generation output of 220 MW (110 MW x 2) of existing Units No.6/7 whose re-operation is scheduled in the future.

Figure 4.2-3 Current Situation of Coal Handling Equipment

(3) Handling of Area between Boundaries of Existing Area and Units No.8/9 Area

The embankment for preventing the flood from the Ganges was set up along the boundary between the existing area and Units No.8/9 construction work area in the past. Because this bank becomes unnecessary along with the construction of Units No.8/9 though people passes through the area and a road is formed naturally on the bank, its removal is possible now. As a result, the narrow area between the existing railway and south boundary of the existing area can be used.

Moreover, when this road is closed, the access road is scheduled to be newly established along the north side boundary of the existing area.

It is scheduled to be newly established in a place about 300 m away from the south boundary of Units No.8/9 area in the embankment where flooding from the Ganges is prevented.

Figure 4.2-4 Position Chart of the Existing Area of Barauni TPS being Intended to be Reused

4.2.2 Residential Area

To the East of the existing area, there is a materials storage and residential area where power plant staff and their families live. The majority is low houses of 1 or 2 stories, and the house of the head of power and the guesthouse are located here, too. Residential buildings are old, and when this area is selected for the planned construction site of a 660 MW SC unit, there is a possibility that the house will be torn down and the staff will have to be transferred. At first, 250 MW x 2 subcritical pressure equipments were planned by setting it up in this area as Units No.8/9 extension plan.

There is no reuse-schedule of the equipment that exists in this area. Thus, if these equipments are removed, it will be possible to use this site for planned new construction.

Figure 4.2-5 Situation in the Building of Residential Area

4.2.3 Unit No.10 Planned Construction Site

Units No.8/9 are currently under construction, but the planned construction of the compartment Unit No.10 (250 MW x 1) is secured for the land adjoining Units No.8/9 to the West. When a 660 MW SC unit is constructed here, an area of 335 m to the North and South and 122 m to the East and West can be used.

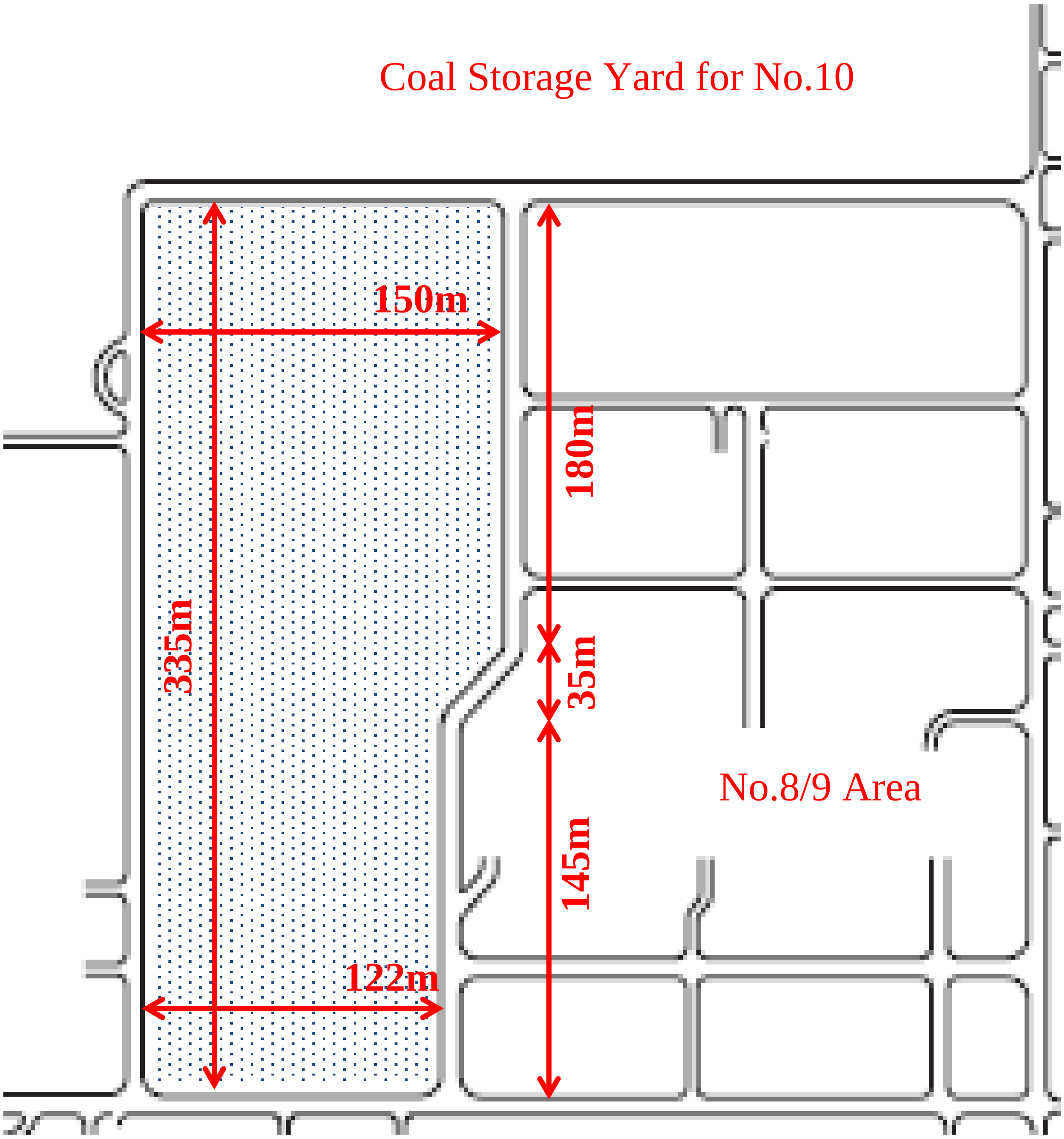


Figure 4.2-6 Planned Site of Available Size

Moreover, when the fly ash transportation pipes from Units No.8/9 on the adjacent land to the East is scheduled to cross overhead from East to West, at 6 m height, and a power generating unit will be set up in this area in the future, this area may become a hindrance.

Figure 4.2-7 Unit No.10 Planned Construction Site

To order a 660 MW SC unit, it is necessary to have 400 kV, transmission voltage which is planned to be extended to the west transmission line yards that are currently available as Units No.8/9.

4.2.4 Site in the South Adjacent to Units No.8/9

The site in the south adjacent to Units No.8/9 was selected from the viewpoint that any negative influence that the layout planning of Units No.8/9 attachment equipment under construction can be minimized when constructing it on the planned site of Unit No.10. The ground concerned has been used as an agricultural site now and it is possible to additionally acquire the site for Barauni TPS. The construction of the embankment to prevent flooding of the Ganges is scheduled to be built in a place about 300 m away from the south site boundary along with the construction of Units No.8/9, and there is a possibility it may influence this plan though there is no structure that needs to be removed on the ground concerned.

Figure 4.2-8 Site in the South Adjacent to Units No.8/9
(View from the top of Unit No.8 Boiler)

4.2.6 Situation of Other Candidate Site Point

(1) Area between Units No.8/9 Construction Area West Side Boundary and NH-31

According to the "Area to be avoided" of the "Environmental Guideline for Industry (MoEF)" from the center line of the highway, there is a provision to provide a 1/2 km distance as a separation distance to the power plant site boundary. To the west of Barauni TPS, NH-31 is located, and it is impossible that this provision will mean the area of up to 1/2 km from NH-31 will not be used to set up a power plant in principle. If construction ends, a green belt is scheduled to be set up though part of the site concerned is used as a temporary storage of Units No.8/9 under construction now. Therefore, in this report, the land concerned was excluded as a candidate site for this isolation regulation.

(2) Units No.8/9 Construction Area East Side

Though it cannot be judged that the location of a 660 MW SC unit is impossible, it can be judged that it will take some time to acquire the site as farmer's residence exists in the northeastern part of the area concerned.

In this report, this candidate site was excluded in the sense that the lead time will be required for resettlement and assumed compensatory negotiation.

4.3 Selection of Candidate Sites

Based on the findings in 4.2.2 - 4.2.5, the following 4 sites were selected in consideration of a settlement of power generation equipment, the ease of construction, and the expected lead time to the start of commercial operation as the construction candidate site of a 660 MW SC unit. Table 4.3-1 shows each advantage/disadvantage.

Table 4.3-1 Evaluation Results of Candidate Sites

	Candidate Sites	Evaluation Results	
		Advantage	Disadvantage
(1)	Existing Plant Area (Section 4.2.2)	✓ None especially	✓ Because equipment that is scheduled to be recycled exists here and there, it is not easy to use it though the greater part of the site can be used. ✓ Removal and leveling of aging equipment is required, so the lead time until start of construction is long.
(2)	Residential Area (Section 4.2.3)	✓ The area which can be used is large and layout can be planned with a margin.	✓ Removal and leveling of aging equipment is required, so the lead time until start of construction is long.
(3)	Planned Site of Unit No.10 (Section 4.2.4)	✓ Because there is no need for equipment removal and soil preparation, the lead time until start of construction is short.	✓ There is a possibility that the plan may be hindered and plans may clash because the construction of the Units No.8/9 is advanced.
(4)	Site in the South Adjacent to Units No.8/9 (Section 4.2.5)	✓ The area which can be used is large and can perform layout planning with a margin. Because there is no need for equipment removal and soil preparation, the lead time until start of construction is short.	✓ Acquisition of additional land is required.

As a result of the field survey, the area where these candidate sites can be located is shown in Figure 4.3-1.

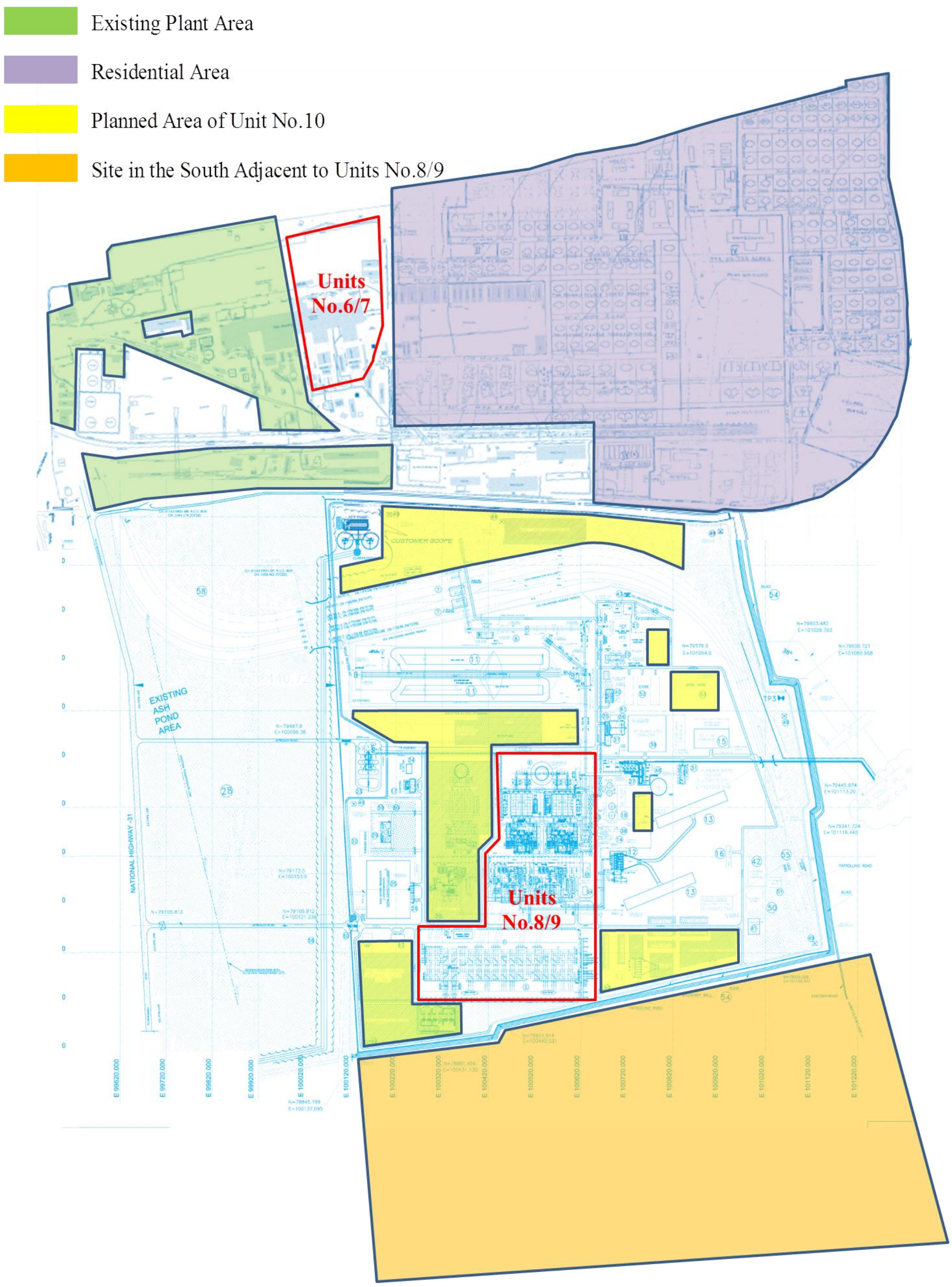


Figure 4.3-1 Location of Possible Area

4.4 Topography and Geology at the Site of Barauni Thermal Power Station

4.4.1 Topography and Geology

4.4.1.1 Outline of Topography and Geology at Barauni Area

The Barauni area is located in the Middle Ganga Plain of the Ganga Plain that consists of three areas: the Upper, Middle and Lower Ganga Plains. This area is flat and has almost no undulation. Barauni TPS is located in an area that is about 3 km from the left bank of the Ganges. It was confirmed that the area close to the thermal power plant was flooded in the rainy season. The geological structure mainly consists of sand and silt.

4.4.1.2 Topography and Geology of each Candidate Site

(1) Planned Site of Unit No.10

Any geological investigations have not been conducted in Unit No.10 site. However, since it is assumed that geology is almost the same as the site of Units No.8/9, the geology of Units No.8/9 is described here.

Units No.8/9 area is planned to be constructed on the ash disposal area of Units No.1-7. The original ground elevation and the designed ground elevation of the main equipment area are as shown in Table 4.4-1. The designed ground elevation is set to approximate 45 m in altitude. According to the collected DPR of Units No.8/9, the flood level at the water intake point at the Ganges is 43.2 m. The top level of embankment around this area is planned to be 45.5 m in consideration of the additional 2 m to the flood level (Refer to Table 4.4-2). Based on this fact, it would be preferable for the designed ground elevation of Unit No.10 construction site to be equal to that of Units No.8/9 or higher. Also, in the site that is 300 m away from the south side boarder of Units No.8/9, an embankment is going to be constructed as a flood countermeasure. Therefore, it is essential to make adjustments in connection with the flood countermeasure.

Table 4.4-1 Original and Designed Ground Elevation of Units No.8/9 Area (Altitude)

Item	Original Ground Elevation	Designed Ground Elevation
Power House	44.8 m	45.5 m
Boiler Area	45.0 m	45.3 m

Source: C.E. Testing Company Pvt. Ltd., GEOTECHNICAL INVESTIGATION WORK FOR 250 MW x 2 UNITS AT BARAUNI TPS, PH-II BIHAR Part I – BTG AREA (October 2011)

STEAG ENERGY SERVICES (INDIA) PVT.LTD., PLOT PLAN 250MW x 2 BARAUNI THERMAL POWER STATION UNIT 8&9

Table 4.4-2 Flood Level and Top Level of Embankment in the Water Intake Point at the Ganges

Flood Level	Top Level of Embankment in the Water Intake Point
43.2 m	45.5 m

Source: WAPCOS LIMITED, FINAL COMPREHENSIVE DETAILED PROJECT REPORT FOR SUPPLY OF GANGA WATER TO BARAUNI THERMAL POWER STATION (50 MW x 2) + (110 MW x 2) EXISTING & (250 MW x 2) PROPOSED EXTENSION PLANT OF BSEB VOLUME I: ENGINEERING REPORT (March 2011)

The land of Units No.8/9 area consists of ash layer, silty sand/sandy silt layer (first layer) and solidified silty sand and solidified clay layer (second layer) in order of the layers from the surface. The soil properties and main physical properties of each layer are as shown in Table 4.4-3.

Table 4.4-3 List of Soil Properties of Units No.8/9

Layer	Soil Property	Grain Size	Physical Property	Designed Pile Value
Surface layer Depth: 0 to 6.0 m (6.0 m thick)	Ash	Sand: 49 % Silt: 40 % Clay: 11 %	N value: 5 to 19 (Average N value: 12) Wet density: 1.32 t/m^3 Dry density: 0.92 t/m^3 Natural water content: 43 % Specific gravity: 2.18 Liquid limit: 58 %	c=0.0 kg/cm^2 φ=28°
First layer Depth: 6.0 to 14.0 m (8.0 m thick)	Silty sand and sandy silt	Sand: 88 % Silt: 10 % Clay: 2 %	N value: 10 to 27 (Average N value: 18) Wet density: 1.87 t/m^3 Dry density: 1.57 t/m^3 Natural water content: 19 % Specific gravity: 2.62	c=0.0 kg/cm^2 φ=29°
Second layer Depth: 14.0 m to (36.0 m thick or more)	Solidified silty sand and solidified clay	Gravel: 1 % Sand: 89 % Silt: 10 % Clay: 0 %	N value: 26 to 48 (Average N value: 33) Specific gravity: 2.63	c=0.0 kg/cm^2 φ=33°

Source: C.E. Testing Company Pvt. Ltd., GEOTECHNICAL INVESTIGATION WORK FOR 250 MW x 2 UNITS AT BARAUNI TPS, PH-II BIHARPart I – BTG AREA,.(October 2011)

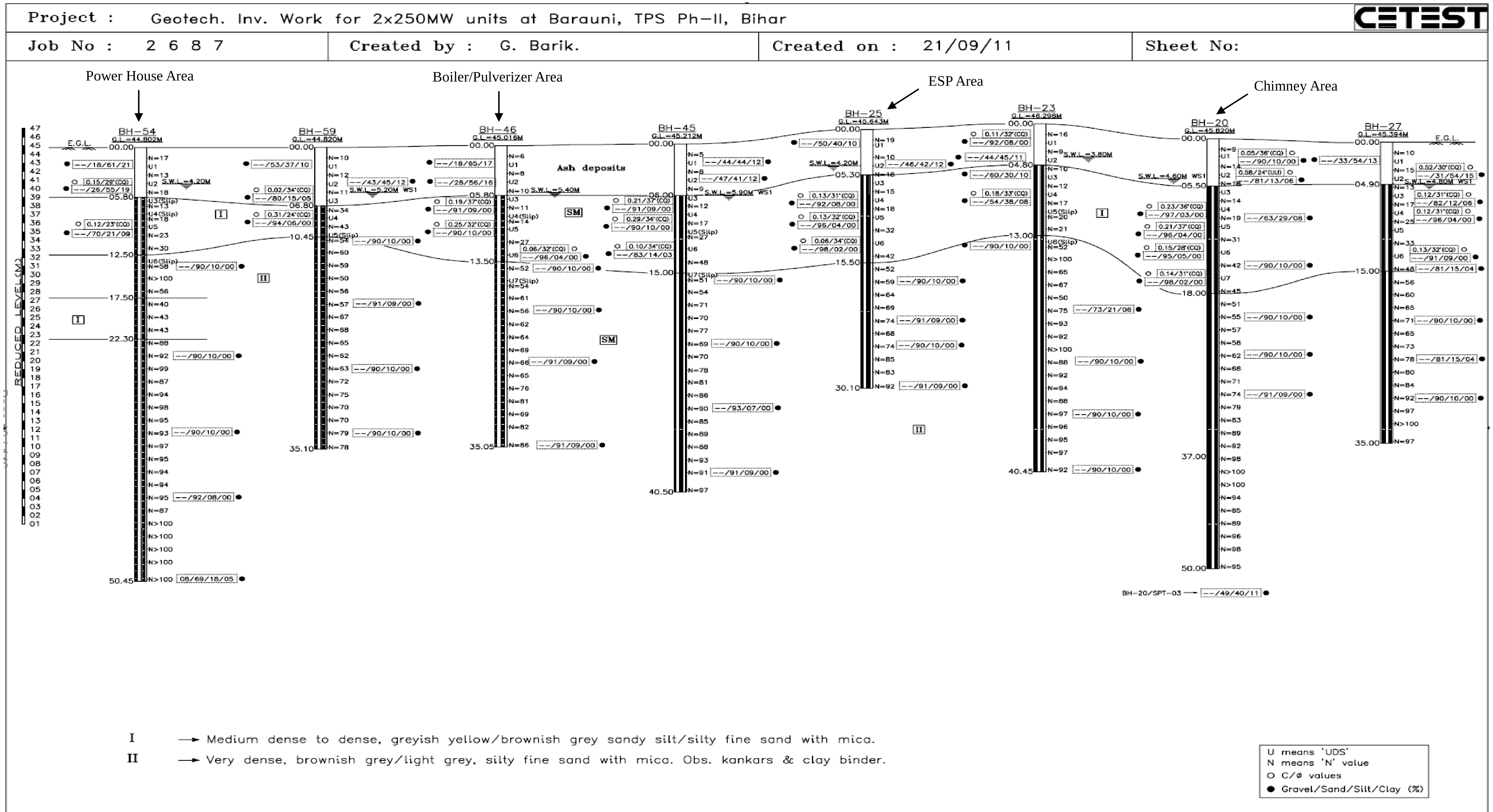


FIG. 2 : GENERALIZED SOIL PROFILE

Source: C.E. Testing Company Pvt. Ltd., GEOTECHNICAL INVESTIGATION WORK FOR 250 MW x 2 UNITS AT BARAUNI TPS, PH-II BIHAR, Part I – BTG AREA (October 2011)

Figure 4.4-1 Units No.8/9 Area Boring Log

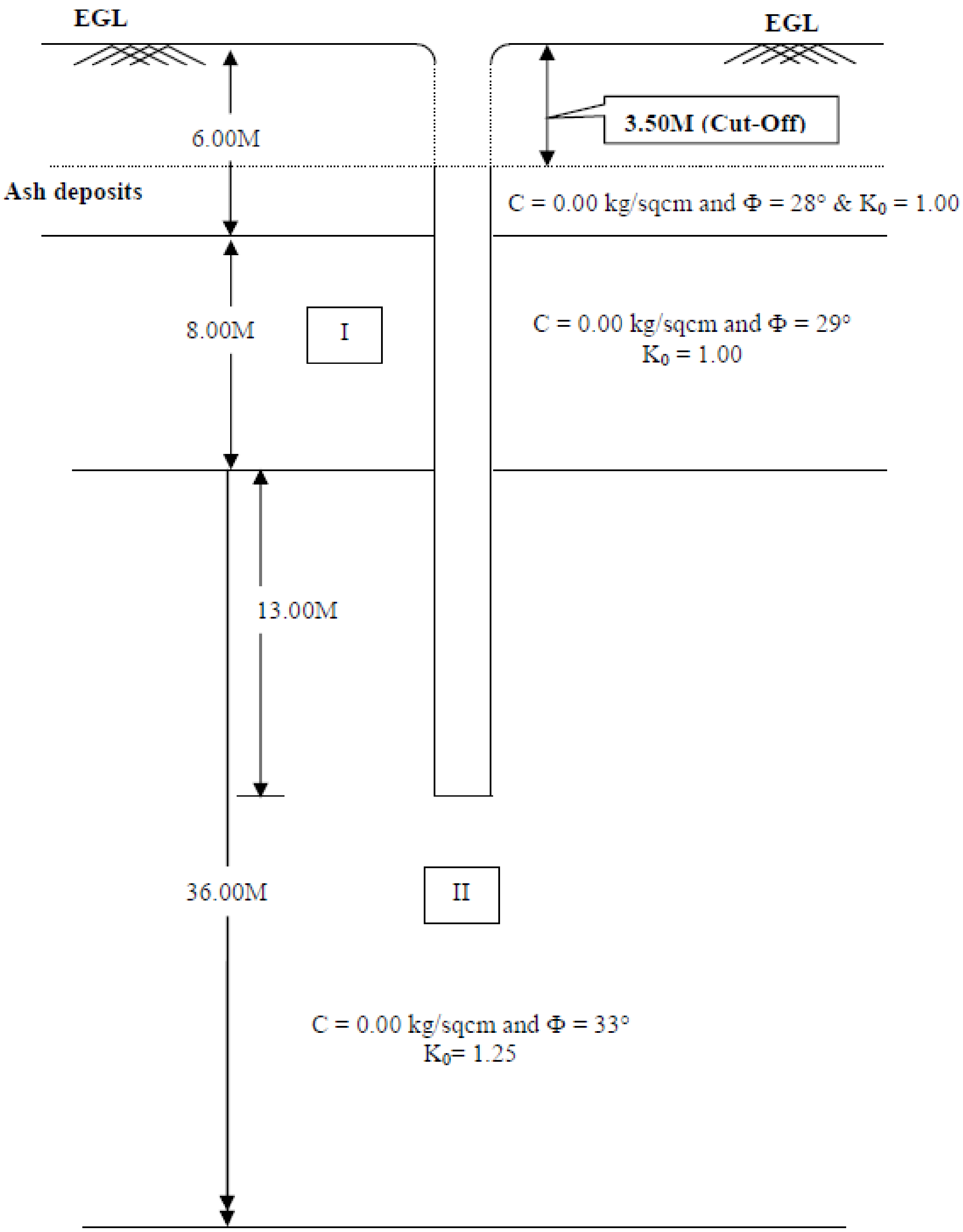
Units No.8/9 area are filled with 6 m of coal ash. As shown in Table 4.4-3, the original ground (first and second layers), which is the foundation ground, shows a dry density of 1.57 g/cm^3 and a water content ratio of 19 %. For the N value, it shows an average of 18 for the first layer and an average of 33 for the second layer. These values indicate that this original ground is not categorized into soft ground that causes consolidation settlement over a long period. Therefore, there is thought to be no problem with using this ground as foundation ground for TPS. However, for heavy structures such as main equipment, it is recommended to use a pile foundation and improve the ground (e.g., sand compaction pile) as a liquefaction countermeasure. The original ground is a sandy soil layer where standing water level is at depth of 4 to 5 m from ground surface (Refer to Figure 4.4-1). Therefore, it is determined that an area at a depth of 8 to 10 m from the ground surface may be liquefied in the main equipment area of Units No.8/9, as shown in Table 4.4-4. Based on a simple evaluation of the collected data such as grain size distribution and N values, it is also determined that this area may be liquefied. For this reason, it is necessary to examine ground improvement (e.g., sand compaction pile) for the planned Unit No.10 construction site just as it is necessary for Units No.8/9 area.

Table 4.4-4 Units No.8/9 Liquefaction Determination Table

Area	Depth of the area that may be liquefied
Chimney Area	8.0 m
ESP Area	10.0 m
Boiler/Pulverizer Area	10.0 m
Power House Area	8.0 m

Source: C.E. Testing Company Pvt. Ltd., GEOTECHNICAL INVESTIGATION WORK FOR 250 MW x 2 UNITS AT BARAUNI TPS, PH-II BIHAR Part I – BTG AREA (October 2011)

In the main equipment area (boilers, turbine building, etc.) of Units No.8/9, in-situ concrete piles (diameter: approximate 600 mm, depth: 20 to 30 m) were constructed to make a foundation in addition to ground improvement. This pile foundation is also recommended for the planned Unit No.10 construction site where the ground is expected to be the same as that of Units No.8/9. For the appropriateness of the pile foundation, see the study result of the residential area described later (It is assumed that the geology of Unit No.10 area is almost same as the one of Units No.8/9 area).



Source: C.E. Testing Company Pvt. Ltd., GEOTECHNICAL INVESTIGATION WORK FOR 250 MW x 2 UNITS AT BARAUNI TPS, PH-II BIHAR Part I – BTG AREA (October 2011)

Figure 4.4-2 In-situ Concrete Pile Design Model for Units No.8/9 Area

Figure 4.4-3 Units No.8/9 Construction Situation

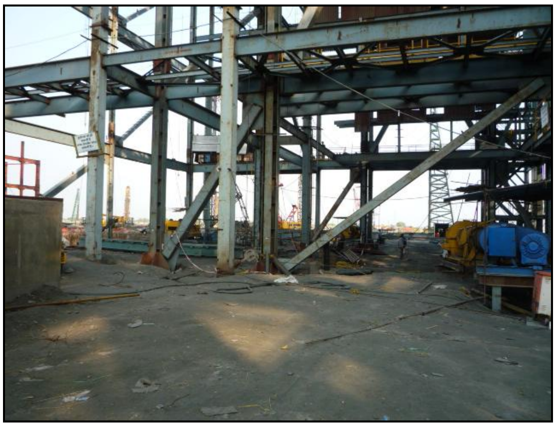


Figure 4.4-4 Units No.8/9 Boiler Building Foundation

Figure 4.4-5 Bunker of Pulverizer Pile Foundation Construction

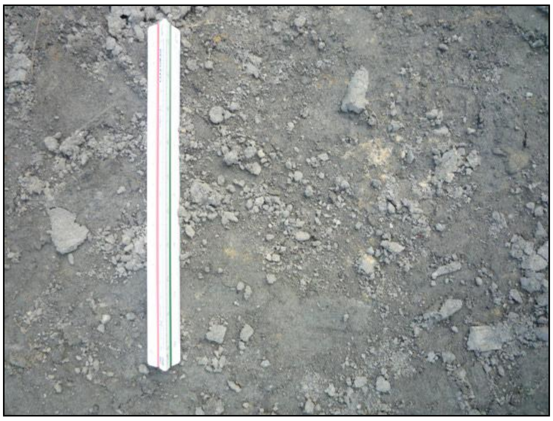


Figure 4.4-6 Ground around Boiler Building (Ground Surface)

(2) Residential Area

The geological condition of the residential area consists of fly ash (approximate 1 m surface layer), a sandy silt layer, fine sand layer and silty fine sand layer (under the fly ash). The soil properties and physical properties of each layer (N values, densities) are as shown in Table 4.4-5. Also, the boring log and the grain size distribution are shown in Figure 4.4-7 and Figure 4.4-8 respectively.

Table 4.4-5 List of Soil Properties of the Staff Residential Area

Layer	Soil Properties	N Value	Density
Depth: 0 to 4.5 m (4.5 m thick)	・1.0 m surface layer Fly ash ・Depth of 1.0 to 7.0 m Sandy silt ・Depth of 7.0 to 60.0 m Fine Sand/silty fine sand	9 to 13	・Wet density 1.75 to 2.0 t/m^3 ・Dry density 1.53 to 1.73 t/m^3
Depth: 4.5 to 12.5 m (8.0 m thick)		10 to 24	
Depth: 12.5 to 25.0 m (12.5 m thick)		25 to 45	
Depth 25.0 to 60.0 m (35.0 m thick)		50 or more	

Source: GEOTECHNICAL INVESTIGATION REPORT PROJECT: SOIL INVESTIGATION WORK FOR MAIN PLANT AREA FOR PROPOSED 250 MW x 2 BARAUNI EXTENSION THERMAL POWER PROJECT IN BEGUSARAI DIST, BIHAR VOLUME II

N values and densities have almost same properties as those of the original ground of the first and second layers of Units No.8/9 area shown in Table 4.4-3. Therefore, the ground of the residential area is not categorized as soft ground, just as the ground of Units No.8/9 area, so the ground has no problem as a foundation ground for TPS equipment. However, just same as Units No.8/9 area, for heavy structures such as main equipment, it is recommended to use the pile foundation and improve the ground (e.g., sand compaction pile) as a liquefaction countermeasure.

The recommended foundation type is pile foundation because the ground has the net safe bearing pressure of approximate 10 t/m^2 at the depth of 5.0 to 6.0 m while the expected contact pressure of the main equipment is around 20 to 30 t/m^2. The recommended pile capacity is shown in Table 4.4-7.

Table 4.4-6 List of Allowable Ground Pressures of Spread Foundation

Foundation Depth below GL (m)	Settlement (mm)	Net Safe Bearing Pressure corresponding to Foundation Size (t/m^2)		
		2 m × 2 m	3 m × 3 m	6 m × 6 m
5.0 (RL39.5)	25	4.5	4.7	5.9
	40	7.2	7.5	9.5
	50	9.0	9.4	11.8
6.0 (RL38.5)	25	6.6	6.2	7.4
	40	10.5	10.0	11.8
	50	13.2	12.4	14.8

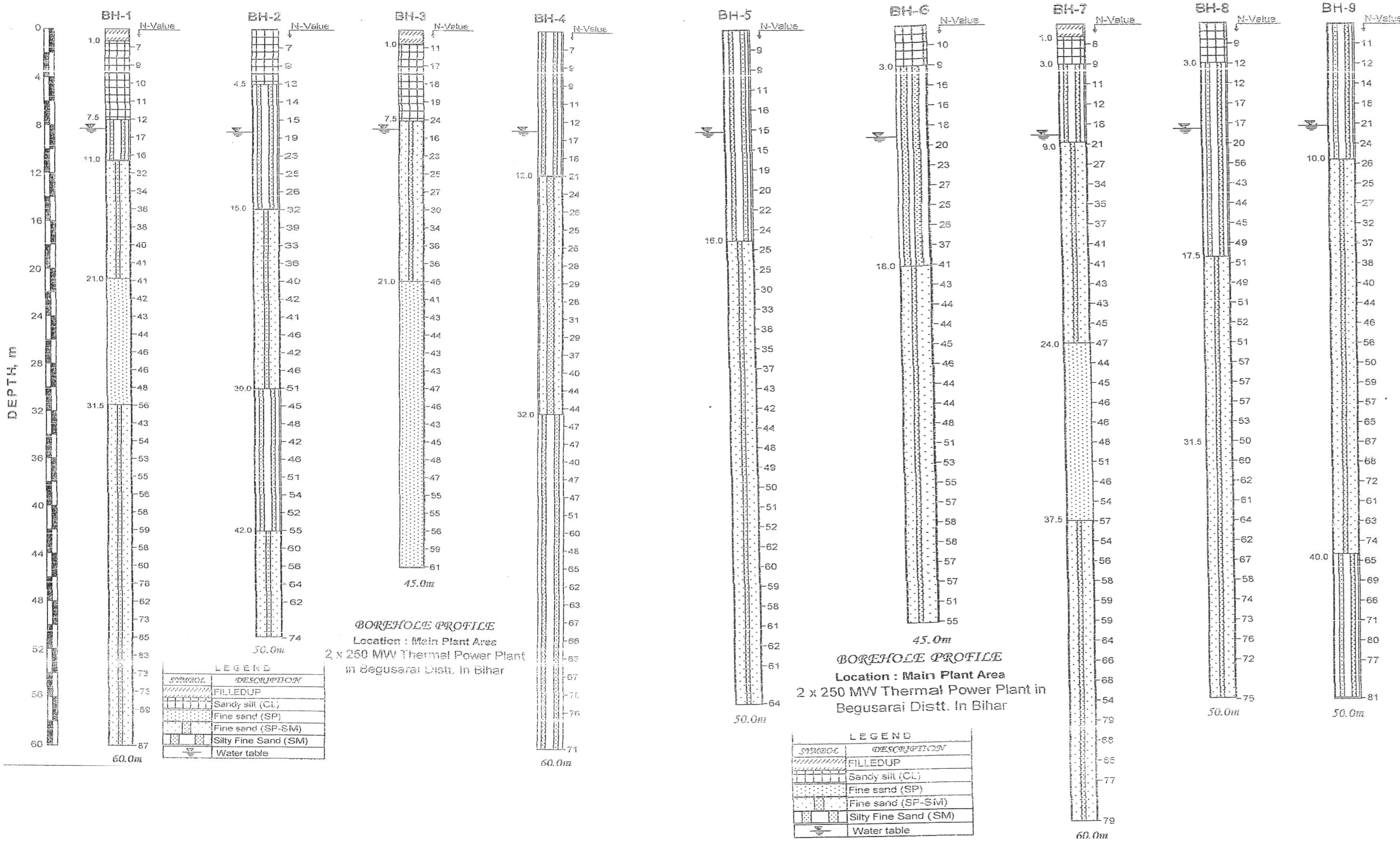
Source: GEOTECHNICAL INVESTIGATION REPORT PROJECT: SOIL INVESTIGATION WORK FOR MAIN PLANT AREA FOR PROPOSED 250 MW x 2 BARAUNI EXTENSION THERMAL POWER PROJECT IN BEGUSARAI DIST, BIHAR VOLUME II

Table 4.4-7 Recommended Pile Capacity

Pile Diameter (mm)	Pile Length (m)	Recommended Pile Capacity (t)		
		Compression	Uplift	Lateral
600	25	137	75	3.4
	28	150	84	
	30	158	90	
	35	178	104	
	40	205	119	
700	25	212	108	5.1
	28	231	122	
	30	240	131	
	35	276	153	
	40	320	175	

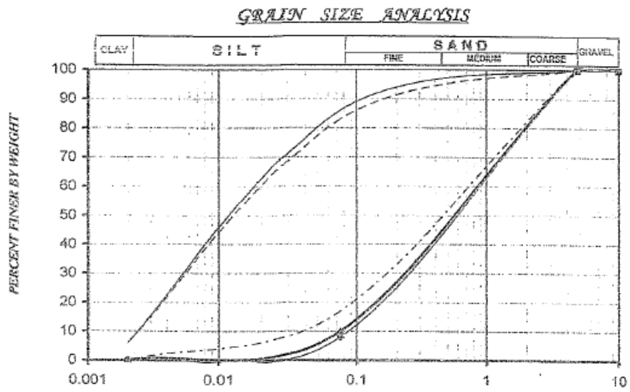
Source: GEOTECHNICAL INVESTIGATION REPORT PROJECT: SOIL INVESTIGATION WORK FOR MAIN PLANT AREA FOR PROPOSED 250 MW x 2 BARAUNI EXTENSION THERMAL POWER PROJECT IN BEGUSARAI DIST, BIHAR VOLUME II

In terms of liquefaction, the evaluation shows that the ground has a low possibility of liquefaction because its surface is mostly sandy silt and the underground water level is deep (approximate 8 m from the ground surface). According to a simple evaluation using collected data such as grain size distribution and N values, the ground has a low possibility of liquefaction. However, it is recommended to conduct a detailed investigation because its geology is almost the same as those of Units No.8/9 where liquefaction can be assumed.

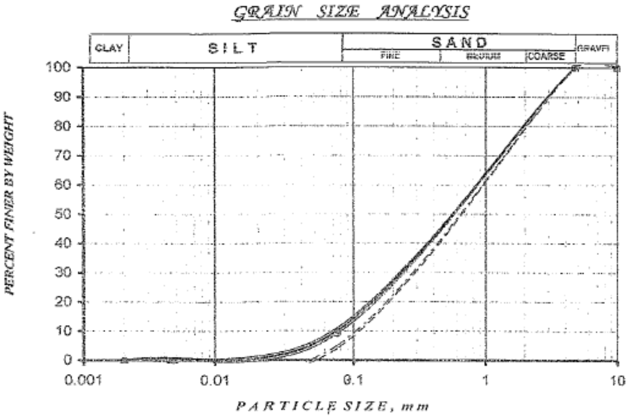


Source: GEOTECHNICAL INVESTIGATION REPORT PROJECT: SOIL INVESTIGATION WORK FOR MAIN PLANT AREA FOR PROPOSED 250 MW x 2 BARAUNI EXTENSION THERMAL POWER PROJECT IN BEGUSARAI DIST, BIHAR VOLUME II

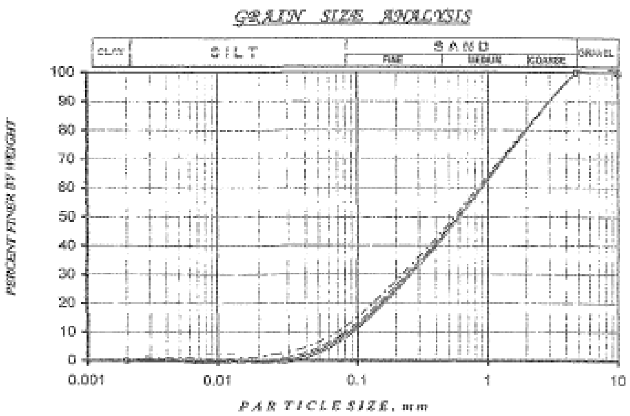
Figure 4.4-7 Boring Log of Residential Area



SYMBOL	BORE HOLE	DEPTH m	DESCRIPTION	GRAVEL %	SAND %	SILT %	CLAY %
———	1	2.50	Sandy silt (ML-CL)	0	14	80	6
– – – –	1	5.50	Sandy silt (ML-CL)	0	17	77	6
– · – · –	1	8.50	Silty sand (SM)	0	83	17	0
—●——●—	1	11.50	Fine sand (SP-SM)	0	92	8	0
—◆——◆—	1	15.00	Fine sand (SP-SM)	0	90	10	0



SYMBOL	BORE HOLE	DEPTH m	DESCRIPTION	GRAVEL %	SAND %	SILT %	CLAY %
———	1	19.50	Fine sand (SP-SM)	0	89	11	0
– – – –	1	23.50	Fine sand (SP)	0	96	4	0
– · – · –	1	27.00	Fine sand (SP)	0	95	5	0
—●——●—	1	31.50	Fine sand (SP)	0	91	9	0
—▲——▲—	1	35.50	Fine sand (SP-SM)	0	90	10	0



SYMBOL	BORE HOLE	DEPTH m	DESCRIPTION	GRAVEL %	SAND %	SILT %	CLAY %
———	1	39.00	Fine sand (SP-SM)	0	93	7	0
– – – –	1	42.00	Fine sand (SP-SM)	0	91	9	0
– · – · –	1	47.50	Fine sand (SP-SM)	0	89	11	0
—●——●—	1	53.50	Fine sand (SP-SM)	0	92	8	0

Source: GEOTECHNICAL INVESTIGATION REPORT PROJECT: SOIL INVESTIGATION WORK FOR MAIN PLANT AREA FOR PROPOSED 250 MW x 2 BARAUNI EXTENSION THERMAL POWER PROJECT IN BEGUSARAI DIST, BIHAR VOLUME II

Figure 4.4-8 Grain Size Distribution (BH-1)

4.5 Water Source and Water Intake Plan

(1) Outline of Water Source and Water Intake Plan

Taking water from the Ganges is planned, so during the site survey, the water amount required for each unit, the permitted intake water amount from the river, and water intake point at the Ganges were checked. Also, some reports about the water intake plan which contained data such as geological information and equipment planning were obtained. Table 4.5-1 shows the amount of water required for each unit, the permitted amount of water intake from the Ganges, and the water intake equipment capacity in the current plan.

Table 4.5-1 Required Amount of Water from the Ganges, Permitted Water Intake Amount and Water Intake Equipment Capacity in the Current Plan

(Unit: cusec[*1])

Item	No.6/7 (110 MW x 2)	No.8/9 (250 MW x 2)	No.10 (250 MW x 1)	Total	Remarks
Required Amount of Water	20	25	15	60	when there is no recycling
Permitted Water Intake Amount	45		-	45	
Water Intake Equipment Capacity	50		-	50	Water intake equipment for Units No.6-9 is considered in this plan. Water intake equipment for Unit No.10 is not considered at this moment.

*1: 1 cusec = 101.94 m^3/h

Required water such as cooling water for the existing Units No.1-7 was taken from wells. However, it is now under consideration to change the water intake source from the wells to the Ganges for Units No.6/7. Water intake from the Ganges is the first trial in Barauni TPS.

The Government of Bihar is responsible for the management of the water intake from the Ganges at the Barauni site, and Barauni TPS will be the property of the Government of Bihar. Therefore, it has been told that it will not be so difficult to obtain permission for water intake from the Ganges from the Government even though the required amount of water increases because of the need to construct a 660 MW SC unit in the future.

Also, the Ganges is usually very muddy at the site. According to the results of interviews, it becomes especially muddy for 2 months in the rainy season. However, this problem will not be a big obstacle to construct the power plant as the construction of sedimentation tanks will resolve this issue.

In addition, water is used for various purposes, for example, condenser cooling, supply to boiler, equipment cooling, potable water, transporting coal ash, etc. In this case, because of intake from river, cooling tower type of power plant is selected for condenser cooling (Refer to "5.1.3 Environmental Standards Applied on Thermal Power Plants").

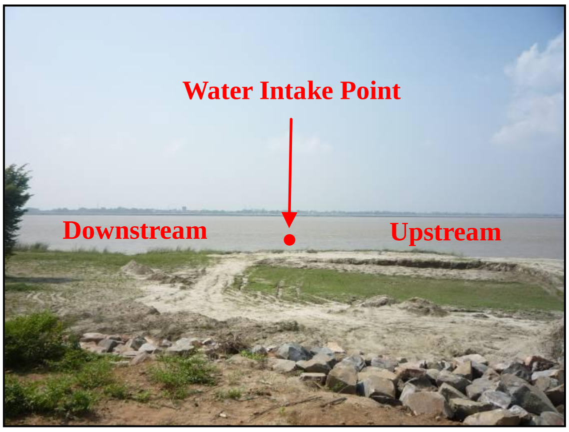


Figure 4.5-1 Water Intake Point at the Ganges

Figure 4.5-2 Left Bank of the Ganges (Downstream Side of Water Intake Point)

(2) Water Quality Evaluation

Table 4.5-2 shows the quality of raw water taken from the Ganges.

Table 4.5-2 Quality of Raw Water from the Ganges (Unit: mg/L)

	The Ganges	World	Japan	The Kiso (in Japan)
pH	7.63－8.9	—	—	—
Turbidity	–1,000	—	—	—
Calcium Ion	108	15.0	8.8	6.4
Magnesium Ion	45.8	4.1	1.9	0.9
Sodium Ion	45.78	6.3	6.7	5.6
Potassium Ion	10	2.3	1.2	1.0
Hydrogen Carbonate Ion	120.36	58.4	31.0	16.9
Chloride Ion	59.22	7.9	5.8	4.7
Sulphate Ion	30	—	—	—
Silica	10	13.1	19.0	10.7
Iron	0.19	—	—	—

Source: Data of the Ganges comes from results of interview
Data on rivers other than the Ganges is obtained from the following website.
(http://www.water.city.nagoya.jp/intro/library/alacarte/content1.html)

The raw water from the Ganges has the following features: [1] High turbidity, [2] Large amount of positive ions such as calcium, magnesium and sodium ions, [3] Large amount of hydrogen carbonate ions, chloride ions, etc.

Considering the features of high turbidity and large amount of dissolved salt, the filtrate water production plant for contamination removal and the demineralized water production plant for salt removal for the raw water from the Ganges must have a processing capability that is several times as high as the ones constructed in Japan.

When constructing a power plant in Barauni, great care must to be paid to this point in designing a demineralized water production plant.

4.6 Power Evacuation

The power evacuation system from a 660 MW SC unit shall be planned to meet the regulation of "Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010" (hereinafter referred to as "CEA TS"). Section 3 (4) of the General Requirements in CEA TS Chapter 1 also stipulates that the facilities shall comply with the requirements listed below:

(a) CEA (Installation and Operation of Meters) Regulation 2006
(b) CEA (Technical Standards for Connectivity to the Grid) Regulation 2007
(c) Indian Electricity Grid Code issued by CERC
(d) Applicable State Grid Code issued by appropriate Regulatory Commission
(e) CEA (Measures relating to Safety and Electricity Supply) Regulations as and when they are announced by the authorities
(f) CEA (Safety Requirements for Construction, Operation and Maintenance of Electrical Plants and Electrical Lines) Regulations as and when they are announced by the authorities
(g) CEA (Grid Standards) Regulations as and when they are announced by the authorities

Chapter IV Part A "Substation and Switchyards (66 kV and above)" of CEA TS as the Technical Standards for Construction of substations and Switchyards, sets forth that the voltage level for capacities over 500 MVA shall be 400 kV. Therefore, a 400 kV new switchyard and transmission lines need to be planned for the construction of a 660 MW SC unit.

Table 4.6-1 shows system design parameters for the 400 kV power evacuation systems.

Table 4.6-1 Requirements for 400 kV System Design Parameters

Parameters	Values
Nominal System Voltage	400 kV
Highest System Voltage	420 kV
Rated Frequency	50 Hz
Number of Phases	3
Full Wave Impulse withstand Voltage (1.2/50 mc-sec)	1,425 kV
Switching Impulse withstand Voltage (250/2500 mc-sec) Dry Wet	1,050 kV
One-minute Power Frequency withstand Voltage Dry	630 kV
Minimum Corona Extinction Voltage (Phase to Earth)	320 kV
Rated Rupturing Capacity of Circuit Breakers	40/50 kA (1 sec)

Source: CEA Technical Standards

Currently, the existing units of Barauni TPS have a 132 kV switchyard and 6 transmission lines (Double Circuit (D/C) x 3 lines) connecting to Hatidah substation, Samastipur substation and Purnea substation (via Nagachia substation and Khagaria substation).

In addition, a 220 kV switchyard for Units No.8/9 are under construction. The planned number of transmission lines is a total of are totally 10 lines, including 4 lines (D/C x 2 lines) for the transmission line pi connection (LILO: Line In Line Out scheme) between Biharshariff substation and Begusarai substation, 2 lines (D/C x 1 line) for Hazipur substation, 2 lines for communication with the existing 132 kV switchyard and 2 lines for future use.

According to “the Business Plan from FY2013-14 to FY2015-16 for Bihar State Power Transmission Company” prepared by BSPHCL as a part of regulatory filing under Multi Year Tariff (MYT) framework of Bihar Electricity Regulatory Commission (BERC), November, 2012, planned capital investment in the transmission sector simply for new projects between 2012 and 2016 is 31,620 million Rs. (approximate 49.3 billion yen at the exchange rate of 1 Rs. = JPY 156 [Nov. 2013]).

The transmission network of BSPTCL consists of 85 substations and approximately 6,400 Circuit km (Ckm) long transmission lines, and the transmission system is capable of transmitting 5,418.5 MVA of power listed in Table 4.6-2. And the additional capital investment plans for the 400 kV transmission lines and substations during 2015 are shown in Table 4.6-3.

Table 4.6-2 Existing Transmission System Infrastructure (31 March 2012)

Voltage	Number of Substations	Line Length (Circuit km)	Transformer Capacity (MVA)
400 kV	—	75	—
220 kV	9	1,147	2,450
132 kV	76	5,178	4,588
Total	85	6,400	

Source: BSPHCL, Business Plan

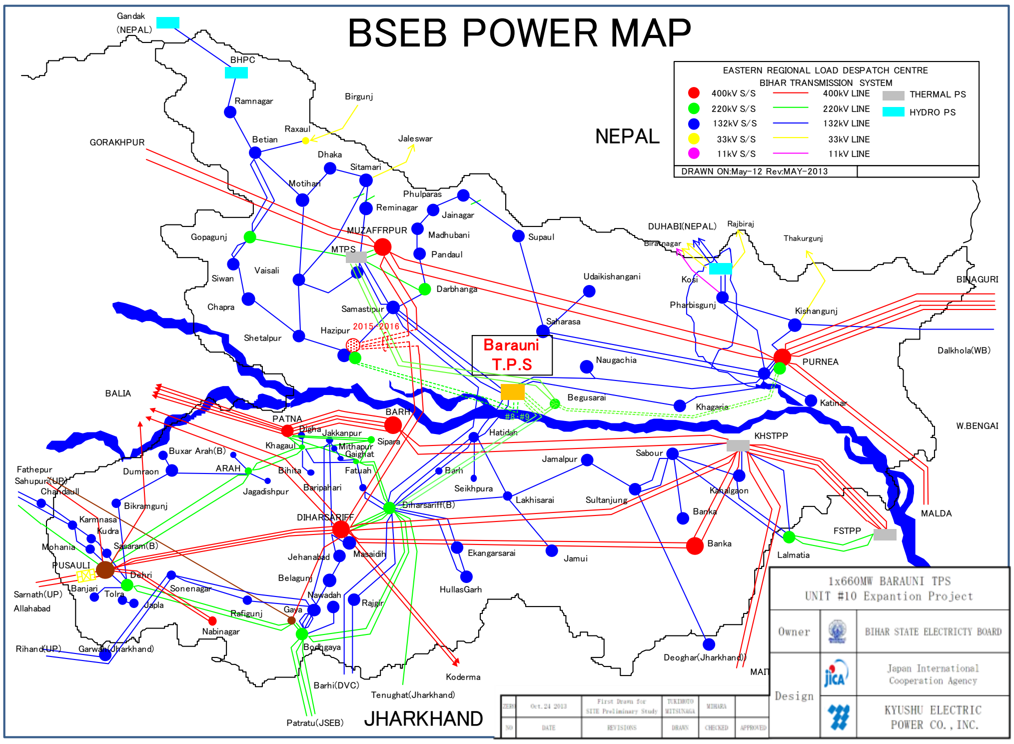
Table 4.6-3 BSPHCL Capital Investment Plan for BSPTCL of 440 kV Additional Strengthening in Intra-State Transmission System

Category	Details of Substations	Cost (10 million Rs.)
Substations	2 x 500 MVA, 400/220 kV SS*1 at Hazipur	192
	2 x 500 MVA, 400/220 kV SS near Gaighat	116
	2 x 500 MVA, 400/220 kV New SS at Fatuha	116
	2 x 500 MVA, 400/220 kV SS at Bihta	116
	Section Total	540
Lines	LILO of Biharshariff – Muzaffarpur 400 kV D/C lines at 400 kV Hazipur SS	80
	Bihta – Patna (PG) – Fatuha – Gaighat 400 kV D/C line	281
	Section Total (104 Ckm)	361
Total		901

*1: SS (Substation)

Source: BSPHCL, Capital investment plan proposed by BSPHCL for Transmission Company (Requirement related to transmission system during 12th plan to meet load demand projected in 18th EPS: Electric Power Survey and to evacuate power from proposed new TPS (BRGF: Backward Region Grant Fund))

Bihar State power grid map and a related conceptual load flow diagram are shown in Figure 4.6-1 and Figure 4.6-2.



Source: Prepared by JICA Study Team based upon ERLDC Power Grid Map with modification of related transmission system plans

Figure 4.6-1 Existing BSEB Power Grid Map (2012)

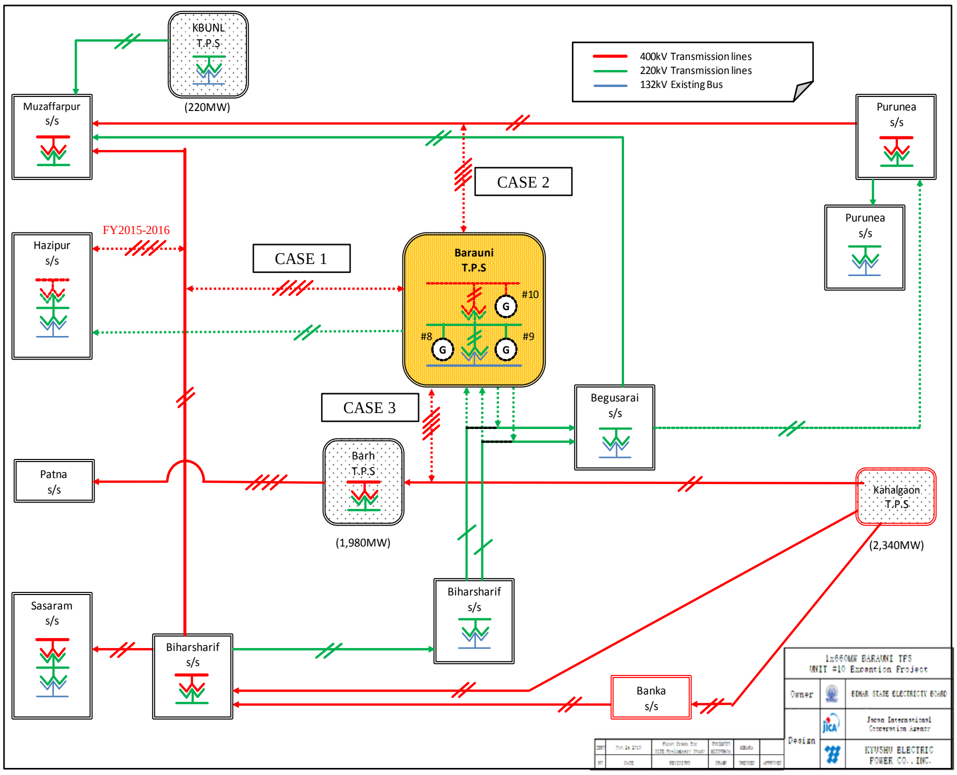


Figure 4.6-2 System Flow Diagram Related to Barauni TPS (JICA Study Team)

The 440 kV switchyard's Extra High Voltage (EHV) system configuration, which is to be newly built for a 660 MW SC unit, is described in "6.1.7 Electrical Systems". At this Pre-FS stage of power evacuation system, the following 3 cases was prepared used LILO scheme with the D/C lines for access to nearby 400 kV SS.

(a) Case 1: LILO of Muzaffarpur SS to Biharshariff SS

(b) Case 2: LILO of Muzaffarpur SS to Purnea (new) SS

(c) Case 3: LILO of BARH TPS to Kahalgaon TPS

Preliminary newly transmission line route diagram and conceptual designs are shown in Figure 4.6-3, 4.6-4 and Table 4.6-4, 4.6-5.

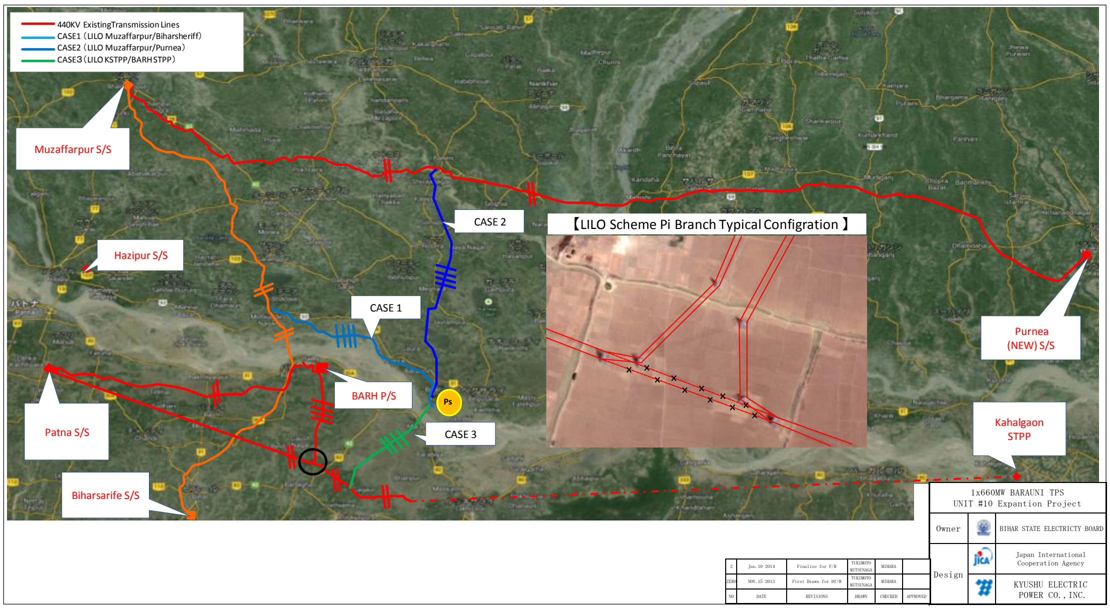


Figure 4.6-3 Preliminary Route Study on Satellite Image of New 400 kV TL (Google Aerial Photo)

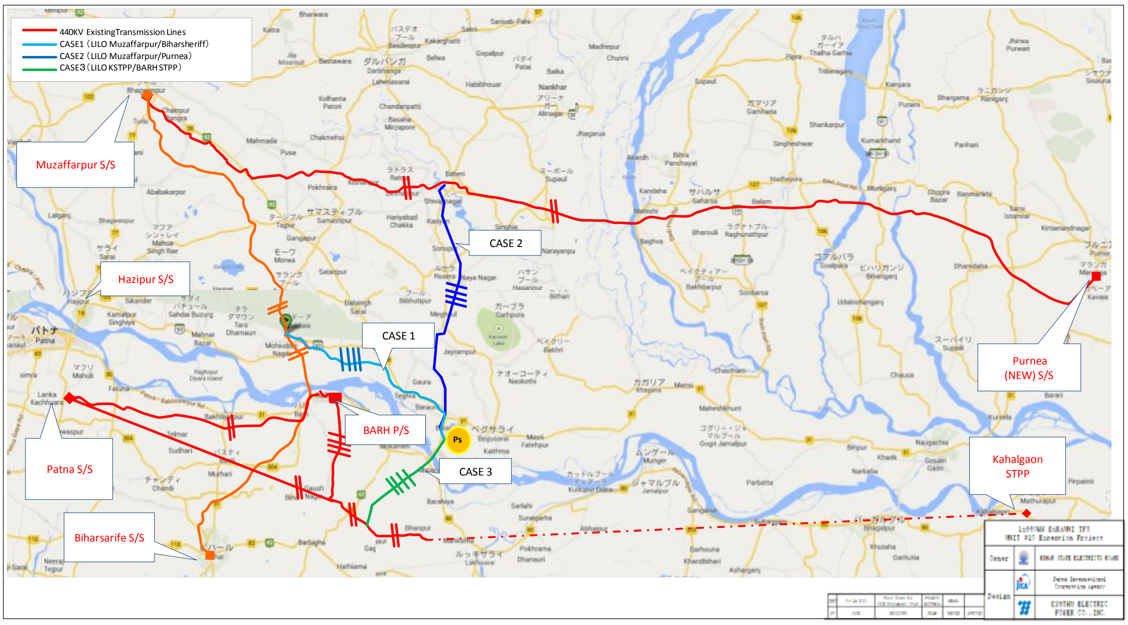


Figure 4.6-4 Preliminary Route Study on Topographic Map of New 400 kV TL (Google Map)

Table 4.6-4 Preliminary Transmission Line Conceptual Design

Route	Case 1	Case 2	Case 3
From To	(1) Muzaffarpur SS (2) Biharshariff SS	(1) Muzaffarpur SS (2) Purnea (new) SS	(1) BARH TPS (2) Kahalgaon TPS
Connected Sys. Owner	(1) PowerGrid (2) PowerGrid	(1) PowerGrid (2) PowerGrid	(1) NTPC (2) NTPC
Line Owner	PowerGrid	POWERLINKS	PowerGrid
Length	130 km	240 km	217 km
No. of Circuits	D/C x 2 lines	D/C x 2 lines	D/C x 2 lines
Type	MOOSE TW. (2)	MOOSE QD.(4)	MOOSE QD.(4)
Branch Arrangement	LILO Pi branch	LILO Pi branch	LILO Pi branch
Distance	Approx. 48 km	Approx. 61 km	Approx. 24 km
Circuit	4 (D/C x 2)	4 (D/C x 2)	4 (D/C x 2)
Conductor	MOOSE TW. (2)	MOOSE QD. (4)	MOOSE QD. (4)

Source: ERLDC operating procedures for Eastern Region
(As mandated by IEGC (Indian Electricity Grid Code) clause 5.1(f)) Revision 8 (June 2013)

Table 4.6-5 Conductor Specifications for References

Items		Unit	Values
Code Name		—	MOOSE
Cu mm^2		mm^2	323
Stranding and Wire Diameter	Aluminum	Nos./mm	54/3.53
	Steel	Nos./mm	7/3.53
	Overall	mm	31.77
Area	Aluminum	mm^2	528.7
	Steel	mm^2	68.53
	Overall	mm^2	597.2
Weight	Aluminum / Steel / All	kg/km	1,464/534.5/1,999
Rated Strength		N (kgf)	164,576 (16,783)
Maximum DC Resistance 20 ℃		Ohm/km	0.0537
Current Rating Temperature*1	Normal	Amp. / MW	1,061/624
	Tropical	Amp. / MW	828/487

Source: ACSR (Aluminum Conductor Steel Reinforced) British Code
*1: Current ratings: As per one (1) conductor, 50 Hz AC 75 deg. C (Temperature of conductor) 0.61 m/s (wind speed), 0.5 (Coefficients of emissivity and absorption),
Normal Condition: Ambient temperate rating 25 ℃, 1,000 Watts/square meter sun
Tropical Condition: Ambient temperate rating 40 ℃, 1,200 Watts/square meter sun
Capacity (MW): SQRT (3) x Current Rating (Amp.) x Rated Voltage (400 kV) x PF (0.85)

The counterparts, the Team met during the site survey, responded to Case 3 by saying they were reluctant to connect the heavy loading transmission line between BARH TPS and Kahalgaon TPS owned by NTPC. The new transmission lines of Case 3 are led to the south of the power station, and need to cross the Ganges and they will cause an increase in the overall cost of development.

Subsequently at this Pre-FS stage, the Team proposes that Case 1 and Case 2 should focus on the next FS by submitting an inquiry to related agencies and conducting power flow analysis. Additionally an optional case of direct connection to Hazipur SS buses should be consider as an alternative to Case 1, for the reason that BSPTCL is planning to upgrade Hazipur SS to 400 kV from 220 kV in 2015.

Specifically, an investigation will be made to confirm the power demand and load flow of each electrical station and power transmission line, including the future prospects in terms of the connection target period. This investigation will include using analysis software such as Etap for the purpose of verifying the possibility and validity of connection. Some on-site surveys and interviews with the institutions concerned such as Eastern Regional Load Dispatch Centre (ERLDC), Eastern Regional Power Committee (ERPC) at Kolkata, owners of transmission lines and substations will also be conducted as required to provide information on the next FS for selecting the connection destination, creating the necessary arrangements and making a basic development plan of DPR to reflect the findings in the plan of transmission line development.

4.7 Coal Properties

(1) Coal Properties

The coal properties currently used by Barauni TPS are as follows:

Table 4.7-1 Coal Properties

		Unit	Adopted by Barauni TPS	
			Design Coal	Worst Coal
Gross Heating Value		kcal/kg	3,300	3,100
Technical Analysis	Fixed Carbon	%	29.7	29.4
	Volatile Matter	%	17.7	20.6
	Ash Content	%	44.6	40.0
	Total Combined Moisture	%	8.0	10.0
Element Analysis	Carbon	%	34.69	34.66
	Hydrogen	%	2.43	2.26
	Sulphur	%	0.3	0.00
	Oxygen	%	9.27	12.33
	Nitrogen	%	0.71	0.75
Corrected Gross Heating Value (based on no moisture and no ash)		kcal/kg	7,529	6,624

Source: Results of Interview from STEAG

The classification of coal compiled by the Japanese Industrial Standards (JIS) is shown in Table 4.7-2. Coal used at Barauni TPS has high ash content. Barauni design coal is categorized as sub-bituminous coal by JIS, which is used as the standard of the degree of coalification which is not correlated with ash content. Typical coal used generally in power generating boilers in Japan is bituminous coal with a gross heating value and an ash content of about 10 %. When a coal-fired power plant using Indian coal is constructed, it is necessary to design the facility by fully considering these differences.

Table 4.7-2 JIS Coal Classification (JIS M1002)

Classification		Gross Heating Value (based on no moisture and no ash) (kcal/kg)	Fuel Ratio	Adopted by Barauni TPS
Grade of Coal	Classification			
Anthracite Coal	A	—	4.0 or higher	
Bituminous Coal	B1	8,400 or higher	1.5 or higher	
	B2		Less than 1.5	
	C	8,100 or higher but less than 8,400		
Sub-bituminous coal	D	7,800 or higher but less than 8,100		
	E	7,300 or higher but less than 7,800		Design coal (7,529)
Brown Coal	F1	6,800 or higher but less than 7,300		
	F2	5,800 or higher but less than 6,800		Worst coal (6,624)

(2) Coal Ash Properties

Coal ash data necessary to conduct a rough calculation to fix the boiler size or ESP size could not be obtained.

4.8 Coal Procurement Plan

The currently planned amount of coal necessary for Unit No.10 (250 MW x 1) is 1.5 million tons per year. [1] An arrangement has already been made to receive this volume of coal from Mogma Mines about 350 km away from Barauni TPS. It is therefore understood that the coal is already secured.

However, if a 660 MW SC unit is constructed, an annual amount of 3.65 million tons[2] will be necessary. In this case, Barauni TPS already has the allocation of coal supply from Urma Paharitola (which is confirmed to have a deposit of 700 million tons of coal). It is scheduled that supply of coal from this mine will start in around 2018. It requires at least 48 months (about 4 years), from commencement of construction work to start of the operation, of a 660 MW SC unit. The current procurement arrangement can guarantee the full supply of coal.

Coal is assumed to be transported from the mine to the power station via an existing railroad. There is a railroad service operated west of Barauni TPS, and the branch track is led from this railroad to the station to transport coal. According to the current plan, a train of 50 wagons, each with a loading capacity of 60 tons of coal, will be operated 3 times a day (for a total carry-in of 9,000 tons) for supply to Units No.6-9.

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[1] NTPC, DETAILED PROJECT REPORT FOR COMPLETE REPLACEMENT OF 2 x 50 MW UNITS WITH 1 x 250 MW UNIT AT BARAUNI TPP, UNIT-10 (November 2010)

[2] Refer to Section “6.1.12 Calculation of Coal Consumption/Coal Ash Generation”

4.9 Ash Disposal Plan

(1) Amount of Ash Generation

The total amount of annual ash to be generated from Units No.6-9 and a 660 MW SC unit will be about 3 million tons (Refer to Table 4.9-1).

Table 4.9-1 Amount of Annual Ash Generation (Unit: 10^3 tons)

Unit	Annual Ash Generation	Source
No.6-9	1,500	Results from interview
660 MW SC	1,460	Estimated by the Team (Refer to Section 6.1.12)
Total	2,960	

Note: The density of the filled ash in the site is about 1.25 t/m^3 (based on the results from interview).

(2) Ash Disposal Area

An ash disposal area at Barauni site is not located along the coast, as is often seen in Japan, but it is located on a relatively flat land.

A new ash disposal area for Units No.6-9 and a 660 MW SC unit has been planned in a 496 acres (about 2 million m^2) lot about 2 km southeast of Units No.8/9. This lot composes of State Government's land and private land. An acquisition of the private land, which is inevitable to realize the project, is now under procedure by State Government. Since there is no residence on the lot, no resettlement is necessary. Although, there are farms on the lot, the compensation to their owners is now under procedure. Meetings for exchange of opinions with the owners were held. It seems that the land acquisition has being conducted relatively smoothly.

Table 4.9-2 Planning of Ash Disposal Area

Item	Area of Ash Disposal, Status of Land Acquisition, etc.	Remarks
Location	About 2 km southeast of Units No.8/9	
Lot Area	496 acres (about 2 million m^2)	
Land Acquisition	Under procedure	
Compensation	Under procedure	Compensation for farms only; no resettlement

Source: Results from Interview

It is planned that the generated ash will be mixed with water so as to transport it as slurry and that the slurry mixture will be transported to the ash disposal area through a pipe. There is no plan to construct any structures for the ash disposal, such as retaining walls, sheet piles. It is planned that embankment will be built around the area by using the generated ash and inside the embankment will be filled with ash and piling ash one after another (Refer to Figure 4.9-1).

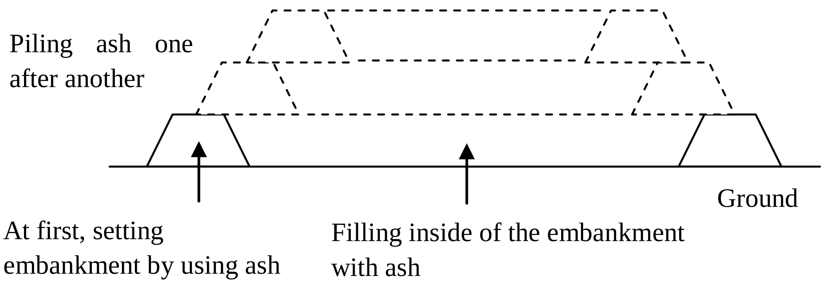

Figure 4.9-1 Rough Cross-Section of New Ash Disposal Area

In Japan, there is a stipulation on countermeasures for secure of ground impermeability around ash disposal area. On the other hand, according to Environmental Impact Assessment (EIA) of Units No.8/9, MoEF suggests that details regarding ash disposal area impermeability including soil analysis report and whether it would be lined should be considered. Based on the suggestion, in the new ash disposal area for Units No.6-10, High Density Polyethylene lining is planned to be provided at the bottom of the area to form an impervious layer and this eliminates any chance of possible leaching, if any. Any countermeasures were not adopted in the site of Units No.8/9 that is originally ash disposal area for Units No.1-7.

(3) Fly Ash Utilization

There is a notification by MoEF that stipulates fly ash utilization level according to an operation period as shown in Table 4.9-3.

Table 4.9-3 Notification by MoEF on Fly Ash Utilization

Fly Ash Utilization Level	Target Date
At least 50 % of fly ash generation	1 year from the date of commissioning
At least 70 % of fly ash generation	2 years from the date of commissioning
90 % of fly ash generation	3 years from the date of commissioning
100 % of fly ash generation	4 years from the date of commissioning

Source: MoEF, Notification S.O. 2804 (November 2009)

Considering 5 units of No.6/7, which are under renovation, No.8/9 and a 660 MW SC unit, the total amount of ash to be filled in the ash disposal area for 25 years with conditions of 50 % utilization within a year, 70 % utilization within 2 years, 90 % utilization within 3 years, 100 % utilization within 4 years from the date of commissioning is roughly estimated 9.8 million tons as shown in Table 4.9-4. In this case, the height of ash dyke would be almost equivalent to 4 m.

Table 4.9-4 Amount of Ash to be Filled in the Ash Disposal Area (Unit: 10^3tons)

Unit		1st	2nd	3rd	4th	5th-25th	Total
No.6-9	BA*1	150.0	〃	〃	〃	〃	3,750.0
	FA*2	675.0	405.0	135.0	0	0	1,215.0
660 MW SC	BA	146.0	〃	〃	〃	〃	3,650.0
	FA	657.0	394.2	131.4	0	〃	1,182.6
							9,797.6

*1: BA (Bottom Ash)

*2: FA (Fly Ash)

Note: The annual ash generation is 1.5 million tons for Units No.6-9 and 1.460 million tons[3] for a 660 MW SC unit.

Calculated as BA: FA being 1:9 based on the DPR of Unit No.10 (250 MW)

Source: NTPC, Detailed Project Report FOR COMPLETE REPLACEMENT OF 2 x 50 MW UNITS WITH 2 x 250 MW UNIT AT BARAUNI TPP, UNIT-10 (November 2010)

Utilization of fly ash in materials for cement or bricks and in road base course materials is planned at Barauni site (For cement, use of fly ash as a substitute of clay is planned as in Japan). According to the result of interview, there is a cement factory with an annual production volume of 1 million tons about 100 km in the direction of Kolkata from Barauni site. There are some major cement companies in Chhattisgarh, although far away from Barauni site, as shown in Table 4.9-5. The total of the annual planned production of seven cement companies shown in Table 4.9-5 comes to about 12 million tons. If fly ash is put to maximum use as materials (clay substitute) equivalent to the said volume, the consumption of fly ash is estimated to be about 1.2 million tons. Although data on cement companies around Barauni site has not been obtained, the amount of fly ash generated from Units No.6-9 and a 660 MW SC unit is expected to be about 2.7 million tons a year, so in order to utilize 100 % fly ash, it is assumed to be necessary to establish some options other than cement materials.

[3] Refer to Section "6.1.12 Calculation of Coal Consumption/Coal Ash Generation"

Table 4.9-5 List of Major Cement Companies

Sl. No.	Name of Cement Plant	Location	District	Rail/Road Distance From Champa	Present Installed Capacity
1.	Ambuja Cement	Rawan (near Bhatpara R.S.	Raipur	117 Km	1.5 Million TPA
2.	Grasim Cement	Rawan (near Hathbandh R.S.	Raipur	110 Km	1.2 Million TPA
3.	Ultra Cement	Hirmi (near Hathbandh R.S.)	Raipur	112 Km	2.75 Million TPA
4.	Century Cement	Baikunth at Baikunth R.S.	Raipur	134 Km	2.10 Million TPA
5.	ACC	Jamul (near Durg R.S.)	Durg	203 Km	1.58 Million TPA
6.	Lafarge Cement	Arasmeta (near Bilaspur & Akaltara R.S.)	Janjgir-Champa	60 Km	1.6 Million TPA
7.	Lafarge Cement	Sonadih (near Bhatpara & Nipania R.S.)	Raipur	137 Km	1.4 Million TPA

Source: DPR FOR 300 MW x 4 COAL BASED TPS AT BALPUR, IN JANJGIR-CHAMPA DISTRICT, CHHATTISGARH

Transport of ash to cement companies is planned by land. Ash users are supposed to come to the power station to pick up the ash, and the power station is supposed to provide ash to them for free.

It is reported that some 50,000 tons of fly ash generated from Units No.6/7 were used for brick materials in a year from 2011 to 2012 at Barauni site.

As earlier mentioned, annual ash generation from Units No.6-9 and a 660 MW SC unit is expected to be about 3 million tons. If ash utilization will be proceeding as shown in the Table 4.9-3, the currently planned ash disposal area (496 acres) has enough capacity. In the worst-case scenario where ash utilization was not promoted at all, the height of filled ash would be approximately 20 m after about 17 years from the operation start of Units No.6-9 and a 660 MW SC unit. Either ash utilization as planned or future expansion of the ash disposal area seems inevitable to realize the project. As the amount of ash that has to be utilized is huge, it is necessary to make a detailed FS and develop a plan that includes the option of ash disposal area expansion if necessary.

4.10 Major Equipment Transport Route

The Ganges is a wide river; there are not many bridges constructed to span this major river. When equipment and materials are transported from the south bank to the north bank, it is necessary to study which route to take. The Barauni area is located on the north bank of the Ganges. There is a bridge, named Rajendra, crossing the river about 2 km southwest of Barauni TPS. Transport of materials can use this bridge. As of October 2013, however, maintenance work is under way at this bridge. There is a limitation on passage of large vehicles when they use the bridge.

BHEL is the supplier of major equipment for Units No.8/9. It is understood that the freight was transported from BHEL's factories in India to Barauni TPS via this bridge. Therefore the Team were unable to obtain information on unloading port facilities available for transport of major equipment when we interviewed the relevant people.

In addition to Rajendra Bridge, a bridge spanning the Ganges about 20 km downstream from the former or a bridge located in the capital city Patna about 110 km upstream may be used to cross the river.

Figure 4.10-1 Rajendra Bridge

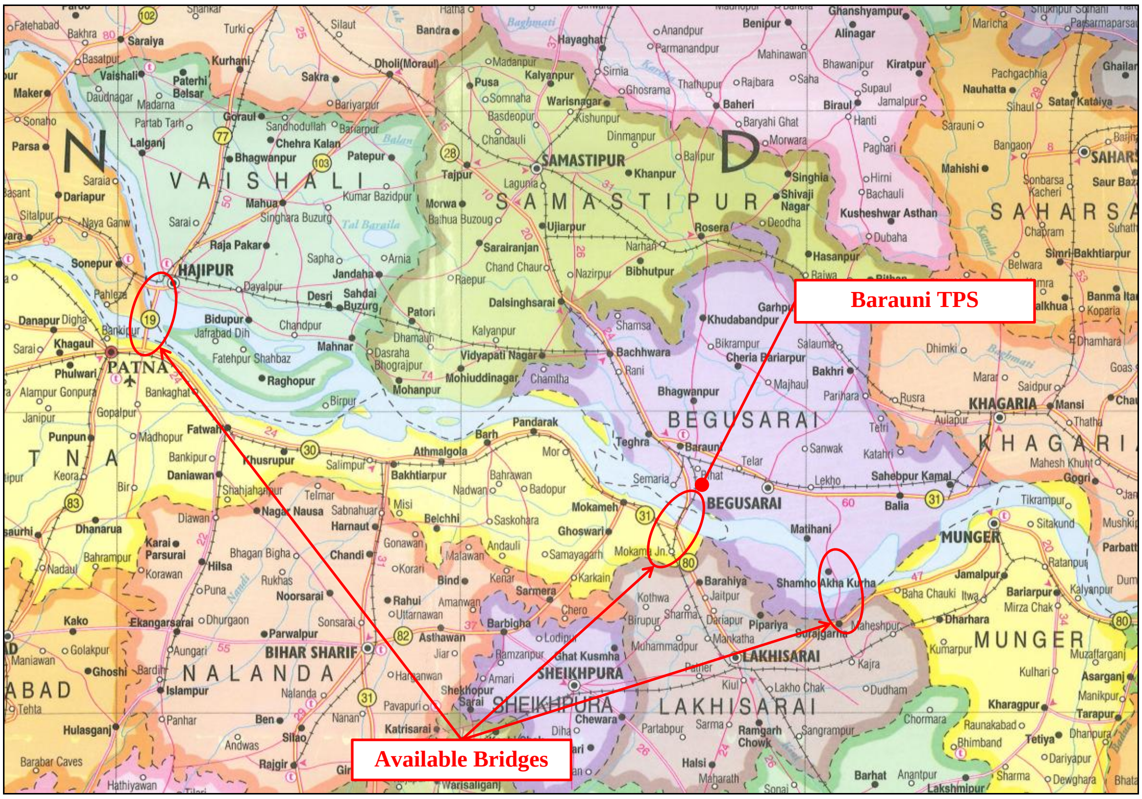

Figure 4.10-2 Available Bridges near Barauni TPS

4.11 Environmental and Social Considerations

(1) Separation from Boundary of Thermal Power Plant

It was revealed that the construction site for Units No.8/9 is planned such that equipment is positioned 1/2 km away from NH-31, which is on the west side of Barauni TPS. This is to ensure compliance with the guidelines of MoEF that requires maintain the distances of 1/2 km between national highway/railway and the boundary of the power plant. The western boundary of Barauni TPS is subject to the guidelines. The reason for this separation is to secure enough space for the possible expansion of a national highway or other infrastructure in the future.

Source: MoEF, Environmental Guidelines for Industries (May 2012)

4.11.2 Possibility of Involuntary Resettlement

According to the interview with power plant employees, there will be no involuntary resettlement due to the building of over a 660 MW SC unit.

As shown in “4.2 Specification of the Area which can be Built and the Equipment which can be Diverted”, the site usage on the boundary of the power plant is as follows:

On the northern side of Barauni TPS, a transmission line is installed, and on the western side, there must be a separation of about 1/2 km from NH-31. The northeast side of Barauni TPS is dotted with houses of local residents (farmers) and farmland spreads from the southeast side over to the south side. Therefore, when it becomes necessary to expand the power plant site as a result of the construction of over a 660 MW SC unit, the farmland that spreads from the southeastern side to the south side of Barauni TPS can be utilized, and this will not cause any involuntary resettlement.

This, however, requires to follow an appropriate process of land acquisition.


Figure 4.11-1 North Side of Barauni TPS, Western Side (in the back of the Photo)

Figure 4.11-2 Northeast Side of the Barauni TPS (in the back of the Photo), Southeastern Side (in the back of the Photo)

4.12 Consistency with Upper Level Plan

4.12.1 Summarizing the Purpose of This Project and Consistency Check Points

This project plans to decommission the existing subcritical coal-fired power plants (50 MW x 2 units) in Barauni, State of Bihar, India, and to build a coal-fired power plant (660 MW x 1 unit, Unit No.10) instead of an initial plan to build a subcritical coal-fired power plant (250 MW x 1 unit, Unit No.10) in a bid to alleviate the tight supply and demand for power and stabilize power supply, which can contribute to the economic development of this region. To check the consistency with the upper level plan, points for consistency check in this Project are summarized as follows.

- Increased power output (from 250 MW to 660 MW)
- Change in power generation method (from subcritical to SC)
- Construction of coal-fired power plant

4.12.2 Result of Consistency Check

According to the interview with Barauni TPS employees and BSPGCL staff members, "once it has been decided to implement this project, the project will be reflected in the policies of the Government of Bihar, and then in the policies of GOI". The Team believes that this indicates that there is consistency between this project and the upper level plan.

Also, the references below were reviewed for a consistency check of each point.

Table 4.12-1 References for Consistency Check with Upper Level Plan

Reference Name	Issuing Organization	Year of Issuance
(a)12th Five Year Plan	Planning Commission (Government of India)	2012
(b)National Electricity Plan	Government of India Ministry of Power Central Electricity Authority	2012
(c)Business Plan for Bihar State Power Transmission Company for control period from FY 2013-2014 to FY 2015-2016	Bihar State Power Holding Company Limited	2012

(1) Consistency in Increased Power Output

Both Sources (a) and (b) say that increased power supply will support economic growth.

(a) (Page 16) *Electric power is a critical input for all economic activity and rapid and inclusive growth is only possible if reliable electricity is made available everywhere.*

(b) (Page 1) *Growth of the power sector is key to the economic development of our country. Growth in production of electricity has led to its extensive use in all sectors of the economy in the successive five-year plans.*

In addition, Source (c) says that the electricity shortage in the State of Bihar is comparatively worse than the national average for India. Power sector growth has not caught up with the sharp increase in economic growth. It says that in order to meet the increasing demand for power, the State of Bihar plans to add power generation capacity.

(c) (Page 9) *The power supply position in the State of Bihar remained very poor and consequently the peak demand deficit in the state has comparatively remained worse than the national average for the country.*

(c) (Page 9) *Bihar has witnessed a sharp increase in economic growth during the 11th plan period mainly on account of developments in the secondary sector which has led to a sharp rise in the pre-capita income. However, the same is yet to be reflected in growth of the energy/power sector.*

(c) (Page 10) *Due to rapid growth in Bihar, the current level of demand is anticipated to increase drastically from the current level of 2,000 MW to 6,000 MW in the near future. To facilitate the growth of the state and in order to meet the increasing demand for power the state government of Bihar has planned various programs to increase power generation capacity and intends to allocate fresh/increased power from upcoming Central and Private sector projects.*

All of the above has led us to believe that the increased power output through this project will contribute to power supply and economic growth, and that there is consistency with the upper level plan.

(2) Change in Power Generation Method

Both Sources (a) and (b) say that there are plans to introduce high-efficiency SC coal-fired power plants that produce less carbon dioxide emissions and have reduced coal consumption. This has led us to judge that the change in power generation method from subcritical pressure to high-efficiency SC pressure through this project provides consistency with the upper level plan.

(a) (Page 118) *In the business-as-usual scenario, India would rely heavily on coal to meet its surging power demand. However, this poses an enormous environmental and natural resource challenge, as the power sector is the highest contributor (38 percent) to India's GHG emissions. There are several initiatives which would improve efficiency, and reduce pollution and carbon footprints from this sector. It has already been announced that 50 percent of the Twelfth Plan's target and the coal-based capacity addition in the Thirteenth Plan would be through super-critical units, which reduce the use of coal per unit of electricity produced.*

(b) (Page 43) *A low carbon growth strategy could be an opportunity to improve health, productivity and quality of life.*

(c) (Page 47) *During the 12th Plan, the idea is to further increase the percentage of 660 MW and 800 MW unit sizes with supercritical technology and during the 13th Plan, all new coal based capacity is likely to be based on supercritical technology only.*

(3) Construction of Coal-fired Power Plant

Source (a) says that coal is the most abundant primary energy source available in India. As shown in above "(2) Change in power generation method", there are plans to construct a high-efficiency coal-fired power plant, which indicates that the construction of a coal-fired power plant in this Project has consistency with the upper level plan.

(a) (Page 33) *Coal is the most abundant primary energy source available in the country.*