# Chapter 5 Environmental and Social Considerations

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## 5.1 Environmental Laws and Regulations, Environmental Policy, and Environmental Administration in India

### 5.1.1 Environmental Laws and Regulations in India

#### (1) Legal System and Policy

Table 5.1-1 shows the structure of the legal system of environmental management in India.

**Table 5.1-1 Legal System Concerning the Environment in India**

| | Content |
|---|---|
| Act | Acts are approved in the Parliament and positioned at the highest level. Acts are associated with obligation and penalty. |
| Rule | Government organizations (ministries) designate detailed rules concerning the implementation of an act under an act. |
| Notification | Notifications stipulate detailed procedures and operation processes to supplement rules. |
| Guideline | Competent authorities in Central Government prepare guidelines to support the implementation of rules by local administrative agencies which are the implementation agencies of rules. Guidelines describe recommended efforts to be implemented without legal obligations. |

#### (2) Overview of Main Laws and Regulations

Table 5.1-2 shows the main acts concerning the environment.

**Table 5.1-2 Main Environmental Acts in India**

| Field | | Name | Year of Enforcement (year of the latest revision) |
|---|---|---|---|
| Basic Law | | The Environment (protection) Act | 1986 (1991) |
| Indivi-dual Law | Air Pollution | The Air (Prevention and Control of Pollution) (Union Territories) Act | 1981 (1987) |
| | Water Pollution | The Water (Prevention and Control of Pollution) Act | 1974 (1988) |
| | | The Water (Prevention and Control of Pollution) Cess Act | 1977 (1992) |
| | | The Water (Prevention and Control of Pollution) Cess (Amendment) Act | 2003 |

| Field | | Name | Year of Enforcement (year of the latest revision) |
|---|---|---|---|
| | Forest Conservation | The Indian Forest Act | 1927 |
| | | Forest (Conservation) Act | 1980 (1988) |
| | | State/Union Territory Minor Forest Produce (Ownership of Forest Dependent Community) Act | 2005 |
| | Wildlife | The Indian Wildlife (Protection) Act | 1972 (1993) |
| | | The Wild Life (Protection) Amendment Act | 2002 |
| | | The Wild Life (Protection) Amendment Act | 2006 |
| | Animal Welfare | The Prevention of Cruelty to Animals Act | 1960 |
| | Biodiversity | Biological Diversity Act | 2002 |
| | National Environment Tribunal/ National Green Tribunal (NGT) | The National Environment Tribunal Act | 1995 |
| | | The National Environment Appellate Authority Act | 1997 |
| | | National Green Tribunal Act | 2010 |
| | Others | The Public Liability Insurance Act | 1991 (1992) |
| | | S.O.1533(E) – Environmental Impact Assessment Notification | 2006 |
| | | S.O.2265(E) - Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, Notification | 2008 |
| | | S.O.123(E) - The Noise Pollution (Regulation and Control) Rules | 2000 |

Source: MoEF, website (http://moef.nic.in/)
CPCB, website (http://www.cpcb.nic.in/)

[1] The Environment (Protection) Act, established in 1986 and amended in 1991

The Environment (Protection) Act (hereinafter referred to as “the Environment Act”) is the basic law concerning the environment in India. The Environment Act stipulates the responsibilities of Central Government on the prevention, control, and reduction of environmental pollution. Central Government is authorized to prepare proper rules to achieve goals of the Environment Act.

"The environment" in the Environment Act is defined as "interrelationship among water, air, land, humans, other life forms, plants and microorganisms." Therefore, the Environment Act stipulates authorities to prevent, regulate and alleviate various phenomena which pollute or damage the environment based on this definition. Articles 3, 6, and 25 grant authorities of Central Government to designate rules to do so in fields which require prevention and regulation of pollution.

[2] The Environment (Protection) Rules, established in 1986

The Environment (Protection) Rules (hereinafter referred to as "the Environment Rules") is established based on the Environment Act and stipulates standards on the emission of pollutants from plants and other facilities. This rule also stipulates conditions concerning the installation of plants and facilities in specific regions such as consideration toward maximum permissible values for pollutants and a ban on the installation of such facilities near remains and reserves for wild animals (Article 5). This rule also mandates the submission of analytical data to the relevant authorities on materials released from facilities which emit pollutants.

[3] Water Pollution

The Water (prevention and control of pollution) Act, 1974 (hereinafter referred to as "the Water Act") is intended to prevent and control water pollution and improve water quality. The Central Pollution Control Board (CPCB) is granted with the authorities required to achieve the goals of the Water Act. The Water (prevention and control of pollution) Rule, established in 1975, also stipulates a detailed function of CPCB.

[4] Air

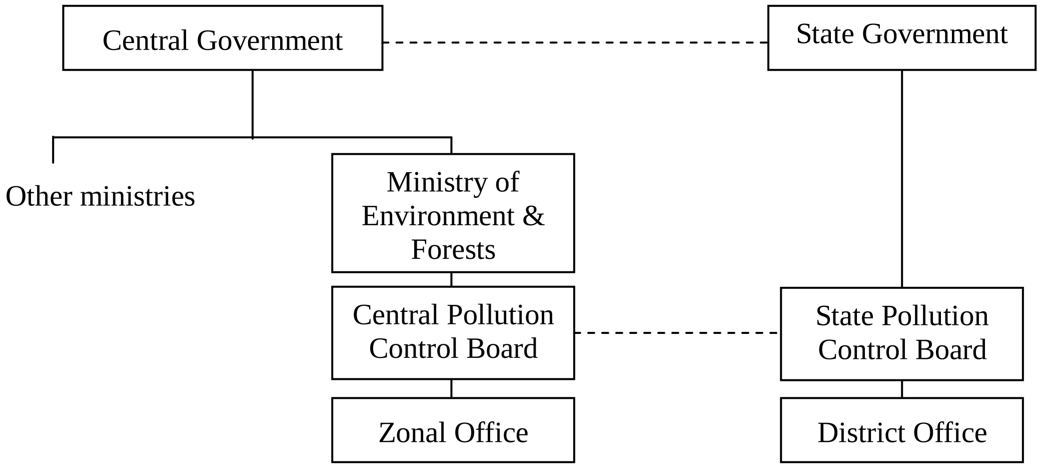
The Air (Prevention and control of pollution) Act, 1981 (hereinafter referred to as "the Air Act") is intended to prevent and control air pollution and promote the alleviation of its effects. CPCB and the State Pollution Control Board (SPCB) are authorized to achieve aspects intended by the Air Act. SPCB is authorized to designate pollution control zones and restrict industrial activities within such zones.

### 5.1.2 Environmental Policy and Environmental Administration in India

Individual acts such as the Environment Act, the Air Act and the Water Act stipulate responsibilities as well as roles and authorities of Central Government and State Government for environmental protection. Bureaus which work on environmental aspects are available in Central Government, State Governments, and Municipal Governments in India. Main administrative systems and roles of individual bureaus are as follows:

#### (1) Central Government

Central Government has multiple ministries involved with environmental policies. Yet, MoEF plays the most important roles in environmental administration. Relevant central administrative agencies include CPCB which is positioned as the organization attached to MoEF, Ministry of Urban Development (MoUD) which is in charge of the development of urban water supply and sewage systems and waste processing infrastructures and MNRE which is in charge of the promotion of the use of wastes and natural energy. Figure 5.1-1 shows the relationship among major ministries and agencies involved with environmental administration in India.




Source: JBIC, Environmental profile in India (October 2007)

**Figure 5.1-1 Organizational Chart of Environmental Offices in India**

[1] Roles of Ministry of Environment & Forests (MoEF)

MoEF is in charge of planning and regulating environmental conservation and environmental aspects and playing the central roles in environmental administration in India. Its roles include the development of legal frameworks to implement environmental administration; protection of flora and fauna, forests, and wild organisms; prevention, management, and control of environmental pollution; tree-planting and reproduction of abandoned areas; development of the framework for implementing environmental policies; development of environmental standards and guidelines; public announcement of notices; and enactment of treaties.

[2] Roles of Central Pollution Control Board (CPCB)

CPCB is an independent organization which works for the prevention, control, and alleviation of environmental pollution. CPCB was initially established based on the Water Act in 1974, and the Air Act stipulated its authorities and roles in 1981. Then, in 1986, CPCB started providing technical instructions and advice for MoEF and SPCB in accordance with the Environment Act established in 1986. In addition, CPCB is in charge of multiple roles concerning pollution control and implementing various environmental policies, establishing guidelines, and conducting various types of monitoring such as environmental standards and regulations. As discussed above, CPCB is an independent organization of MoEF but it plays important roles in the implementation of laws administered by MoEF and the promotion of relevant measures.

**(2) State Government**

Environmental departments within State Governments are implementing environmental measures in individual states. SPCB is also established in each state and works on providing technical instructions and advice for State Governments (environmental departments), promoting various measures for protecting the environment and preventing environmental pollution, establishing environmental standards, and conducting investigations and research.

**(3) Local Bodies/Municipalities**

Individual municipalities are in charge of actual activities to promote environmental protection policies. For example, municipalities are responsible for implementing the Municipal Solid Waste (MSW) Rules (2000) and implementing collection, transportation, and disposal of wastes in cities.

### 5.1.3 Environmental Standards Applied on Thermal Power Plants

**(1) Air**

The Air Act was enacted in 1981, and the National Ambient Air Quality Standards (NAAQS) were established in 1982 based on the act. In addition, it is also stipulated as Schedule VII of Article 3 (3B) in the Environment Rules.

**Table 5.1-3 National Ambient Air Quality Standards**

| Pollutant | Time Weighted Average | Concentration in Ambient Air | |
|---|---|---|---|
| | | Industrial, Residential, Rural and Other Area | Ecologically Sensitive Area (notified by Central Government) |
| Sulfur Dioxide ($SO_2$), [μg/$m^3$] | Annual*1<br>24 hours*2 | 50<br>80 | 20<br>80 |
| Nitrogen Dioxide ($NO_2$), [μg/$m^3$] | Annual*1<br>24 hours*2 | 40<br>80 | 30<br>80 |
| Particulate Matter, (size less than 10 μm) or $PM_{10}$ [μg/$m^3$] | Annual*1<br>24 hours*2 | 60<br>100 | 60<br>100 |
| Particulate Matter, (size less than 2.5 μm) or $PM_{2.5}$ [μg/$m^3$] | Annual*1<br>24 hours*2 | 40<br>60 | 40<br>60 |
| Ozone ($O_3$), [μg/$m^3$] | 8 hours*2<br>1 hour*2 | 100<br>180 | 100<br>180 |
| Lead (Pb), [μg/$m^3$] | Annual*1<br>24 hours*2 | 0.50<br>1.0 | 0.50<br>1.0 |

| Pollutant | Time Weighted Average | Concentration in Ambient Air | |
|---|---|---|---|
| | | Industrial, Residential, Rural and Other Area | Ecologically Sensitive Area (notified by Central Government) |
| Carbon Monoxide (CO), [mg/$m^3$] | 8 hours*2<br>1 hour*2 | 02<br>04 | 02<br>04 |
| Ammonia ($NH_3$), [μg/$m^3$] | Annual*1<br>24 hours*2 | 100<br>400 | 100<br>400 |
| Benzene ($C_6H_6$), [μg/$m^3$] | Annual*1 | 05 | 05 |
| Benzo (a) Pyrene (BaP), - particulate phase only, [ng / $m^3$] | Annual*1 | 01 | 01 |
| Arsenic (As), [ng / $m^3$] | Annual*1 | 06 | 06 |
| Nickel (Ni), [ng / $m^3$] | Annual*1 | 20 | 20 |

*1: Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

*2: 24 hourly or 08 hourly or, 01 hourly monitored values, as applicable, shall be complied with 98 % of the time in a year. 2 % of the time, they may exceed the limits but not on 2 consecutive days of monitoring.

Source: MoEF/CPCB, Notification S. O. 384 (April 1994)/S. O. 935 (October 1998)

### (2) Noise Environment Standard

It is stipulated as Schedule III of Article 3 (1) in the Environment Rules. It is also stipulated as Noise Pollution (Regulation and Control) Rules (2000).

**Table 5.1-4 Ambient Air Quality Standards in Respect of Noise**

| Category of Area | Limits in dB (A) | |
|---|---|---|
| | Day Time | Night Time |
| Industrial area | 75 | 70 |
| Commercial area | 65 | 55 |
| Residential area | 55 | 45 |
| Silence Zone | 50 | 40 |

Notes: 1. Daytime is reckoned to be between 6 a.m. and 9 p.m.

2. Nighttime is reckoned to be between 9 p.m. and 6 a.m.

3. Silence zone is defined as areas up to 100 meters around such premises as hospitals, educational institutions and courts. Silence zones are to be declared by the Competent Authority.

Use of vehicular horns, loudspeakers and detonating of crackers shall be banned in these zones.

4. Mixed categories of areas should be declared as one of the 4 above-mentioned categories by the Competent Authority (and the corresponding standards shall apply).

Source: MoEF, Noise Pollution (Regulation and Control) Rules (February 2000)

### (3) Emission Standards Applied to Thermal Power Plant

Table 5.1-5 - 5.1-7 shows Standards for Emission or Discharge of Environmental Pollutants from various Industries. It is stipulated as Schedule I of Article 3 (1) in the Environment Rules. Schedule I of the Environment Rules provides standards for wastewater, exhaust gas, noise, heights of chimneys, and other aspects for more than 90 types of industries (processes). The characteristics of these standards are that targeted materials differ depending on the targeted industries, and specific conditions are provided for specific industries.

[1] Liquid Effluents

**Table 5.1-5 Standards for Emission or Discharge of Environmental Pollutants from Various Industries (Liquid Effluents)**

| Source | Parameter | Concentration not to exceed [mg/L] (except for pH & Temperature) |
|---|---|---|
| Condenser Cooling Water (once through higher cooling system) | pH | 6.5 - 8.5 |
| | Temperature | Not more than 5 °C higher than the intake water temperature |
| | Free Available Chorine | 0.5 |
| Boiler Blow Downs | Suspended Solids | 100 |
| | Oil and Grease | 20 |
| | Copper (total) | 1.0 |
| | Iron (total) | 1.0 |
| Cooling Tower Blow Down | Free Available Chlorine | 0.5 |
| | Zinc | 1.0 |
| | Chromium (total) | 0.2 |
| | Phosphate | 5.0 |
| | Other Corrosion Inhibiting Material | Limit to be established on case by case basis by Central Board in case of Union territories and State Board in case of States. |
| Ash Pond Effluent | pH | 6.5 - 8.5 |
| | Suspended Solids | 100 |
| | Oil and Grease | 20 |

Source: MoEF, Environmental (Protection) Rules, Schedule I (1986)

[2] Temperature limit for discharge of condenser cooling water from thermal power plant

A. New thermal power plants commissioned after June 1, 1999:

New thermal power plants, which will be using water from rivers/lakes/reservoirs, shall install cooling towers irrespective of location and capacity. Thermal power plants which will use sea water for cooling purposes, the condition below will apply.

B. New projects in coastal areas using sea water:

The thermal power plants using sea water should adopt suitable system to reduce water temperature at the final discharge point so that the resultant rise in the temperature of receiving water does not exceed 7 °C over and above the ambient temperature of the receiving water bodies.

C. Existing thermal power plants:

Rise in temperature of condenser cooling water from inlet to the outlet of condenser shall not be more than 10 °C.

Source: MoEF, Environmental (Protection) Rules, Schedule I (1986)

[3] Emission Standards

**Table 5.1-6 Particulate Matter Emissions**

| Generation Capacity | Emission Limit [mg/Nm$^3$] |
|---|---|
| 210 MW or more | 150 |
| Less than 210 MW | 350 |

Source: MoEF, Environmental (Protection) Rules, Schedule I (1986)

**Table 5.1-7 Stack Height/Limit in Meters**

| Generation Capacity | Stack height/limits [m] |
|---|---|
| 500 MW and above | 275 |
| 200 MW/210 MW and above to less than 500 MW | 220 |
| Less than 200 MW/210 MW | $H=14(Q)^{0.3}$ where Q is emission rate of $SO_2$ in *g/hr. and *H Stack height in meters. |

Source: MoEF, Environmental (Protection) Rules, Schedule I (1986)

[4] Use of Beneficiated/Blended coal

On and from the 1st day of June 2001, the following coal based thermal power plants shall use [raw or blended or beneficiated coal with an ash content not exceeding 34 percent on an annual average basis], namely: -

(a) Any thermal power plant located beyond 1,000 km from the pit-head; and

(b) Any thermal power plant located in urban area or sensitive area or critically polluted area irrespective of their distance from pit-head except any pit-head power plant:
[Provided that any thermal power plant using Fluidized Bed Combustion or Circulating Fluidized Bed Combustion or Atmospheric Fluidized Bed Combustion or Pressurized Fluidized Bed Combustion or IGCC technologies or any other clean technologies as may be notified by Central Government in the Official Gazette shall be exempted from clauses (a) and (b)].

Source: MoEF, Environmental (Protection) Rules (1986)

[5] Utilization of Fly Ash

A notification concerning the use of fly ash was issued in accordance with Article 5, Section (3) of the Environment Rules for the purpose of restricting the excavation of top soil for manufacture of bricks and promoting the utilization of fly ash in the manufacture of building materials and in construction activity within a specified radius of 100 km from coal or lignite based thermal power plants (established in September 1999 and amended in November 2009);

- Every construction agency engaged in the construction of buildings within a radius of 100 km from thermal power plant shall use only fly ash based products for construction in every construction project.
- New thermal power plant and, or expansion units commissioned after this notification to achieve the target of fly ash utilization as below:
  - 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, Notifications S.O. 763 (September 1999)/S. O. 2804 (November 2009)

[6] Siting Criteria

The Environmental Guideline for Industry was issued to ensure optimum use of natural and man-made resources in sustainable manner with minimal depletion, degradation and/or destruction of environment (updated in May 2012).

This guideline designates the following areas as areas to be avoided.

- Ecologically and/or otherwise sensitive areas: at least 25 km; depending on the geo-climatic conditions the requisite distance hall have to be increased by the appropriate agency.
- Coastal areas: at least 1/2 km from High Tide Line.
- Flood Plain of the Riverine Systems: at least 1/2 km from flood plain or modified flood plain affected by dam in the upstream or by flood control systems.
- Transport/Communication System: at least 1/2 km from highway and railway.
- Major settlements (3 million populations): distance from settlements is difficult to maintain because of urban sprawl. At the time of siting of the industry if any major settlement's notified limit is within 50 km, the spatial direction of growth of the settlement for at least a decade must be assessed and the industry shall be sited at least 25 km from the projected growth boundary of the settlement.

Source: MoEF, Environment Guideline for Industry (May 2012)

[7] Green Belt

Plants must be used to improve the landscape around a power plant, stabilize soil, and reduce noise and dust from the power plant. In addition, a green belt must be established at the boundary of a power plant according to the stipulation of MoEF. The total areas of green belt must be at least 1/3 of the premises of a power plant.

Source: Development Consultants, Detailed Project Report for 2 x 250 MW Coal Based Extension Thermal Power Station at Barauni Dist. Begusarai in Bihar

[8] Impermeability of Ash Disposal Area

Plants must take measures to prevent soil contamination caused by water permeation from an ash disposal area. Regarding the latest environmental clearance precedent, MoEF prescribed the following Terms of Reference (TOR) for preparing draft EIA report: Details regarding ash disposal area impermeability including soil analysis report and whether it would be lined, if so details of the lining etc.

Source: Environmental Impact Assessment & Environmental Management Plan for 2 x 250 MW Barauni (Extension) Thermal Power Project At Barauni, Dist. Begusarai, Bihar (November 2013)

# 5.2 Comparison between Environmental Standards in India and IFC EHC Guidelines

### 5.2.1 Air Emission

As discussed above, Article 3 (1) of the Environment Rules stipulates standards for emissions from thermal power plants in India. Yet, no regulations are set for nitrogen oxides and sulfur oxides. The only regulation is the stack height (275 m for 500 MW and above).

On the other hand, the International Finance Corporation (IFC) of the World Bank Group stipulates Environmental, Health, and Safety Guidelines (the EHS Guidelines) concerning Emission Guidelines for Boiler including particulate matter, nitrogen oxides, and sulfur oxides (2008). Therefore, power plants should be designed while paying attention to the parameters in the EHS Guidelines.

**Table 5.2-1 Comparison of Emissions Standards for TPS**
**[mg/Nm$^3$; Dry Gas, Excess $O_2$ Content 6 %]**

| | Environment Rules | EHS Guidelines<br>-Solid Fuels<br>(Plant > / = 600 MWth) | [Ref.] IFC standards<br>(Areas with serious air pollution) |
|---|---|---|---|
| SOx | No Regulation | 200～850<br>(70～298 ppm) | 200<br>(70 ppm) |
| NOx | No Regulation | 510<br>(248 ppm) | 200<br>(97 ppm) |
| Particulate Matter (PM) | 150 | 50 | 30 |

Source: MoEF, Environmental (Protection) Rules, Schedule I (1986);
IFC, EHS Guidelines (Thermal Power Plants) (December 2008)

### 5.2.2 Liquid Effluents

Article 3 (1) of the Environment Rules also stipulates standards for liquid effluents discharged from thermal power plants in India. Meanwhile, in the EHS Guidelines, site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classifications as described in the General EHS Guidelines.

**Table 5.2-2 Comparison of Effluents Standards for TPS**
**[mg/L; Except for pH and Temperature]**

| | Environment Rules | EHS Guidelines | Remarks |
|---|---|---|---|
| pH | 6.5 – 8.5 *1,4 | 6 – 9 | |
| Suspended Solids | 100 *2, 4 | 50 | |
| Oil and Grease | 20 *2, 4 | 10 | |
| Free Available Chorine | 0.5 *1, 3 | 0.2 | Standards in India only include free chlorine. |
| Chromium (Cr) | 0.2 *3 | 0.5 | |
| Copper (Cu) | 1.0 *2 | 0.5 | |
| Iron (Fe) | 1.0 *2 | 1.0 | |
| Zinc (Zn) | 1.0 *3 | 1.0 | |
| Lead (Pb) | — + | 0.5 | |
| Cadmium (Cd) | — + | 0.1 | |
| Mercury (Hg) | — + | 0.005 | |
| Arsenic (As) | — + | 0.5 | |
| Phosphate ($PO_4^{3-}$) | 5.0 | — | |
| Temperature [℃] | 5 | Evaluated in EIA | |

*1: Condenser Cooling Water (once through higher cooling system), *2: Boiler blow downs,
*3: Cooling tower blow down, *4: Ash pond effluent
+: Limit to be established on case by case basis by Central Board in case of Union territories and State Board in case of States.
Source: MoEF, Environmental (Protection) Rules, Schedule I (1986);
IFC, EHS Guidelines (Thermal Power Plants) (December 2008)

### 5.2.3 Noise Pollution

Article 3 (1) of the Environment (Protection) Rules also stipulates Ambient Air Quality Standards in Respect of Noise in India. The EHS Guidelines also regulates noise as a general aspect in the general section, because noise is similar to other large industrial facilities.

**Table 5.2-3 Comparison of Noise Standards**

| | Environment (Protection) Rules*1 | EHS Guidelines (General)*2 |
|---|---|---|
| Daytime | 75 | 70 |
| Nighttime | 70 | 70 |

*1: Daytime (6:00AM to 9:00PM), Nighttime (9:00PM to 6:00AM)
*2: Daytime (7:00AM to 10:00PM), Nighttime (10:00PM to 7:00AM)
Source: MoEF, Environmental (Protection) Rules, Schedule III (1986);
IFC, EHS Guidelines (Thermal Power Plants) (December 2008)

# 5.3 Environmental Clearance in India

## 5.3.1 Environmental Impact Assessment

**(1) Overview of EIA**

In India, EIA is positioned as a necessary process for obtaining Environmental Clearance (EC) which is required when implementing a project which might cause significant effects on the environment. EC system is designated in the notification (Environmental Impact Assessment Notification, 2006 (EIA Notification)) that MoEF issued in September 2006 in accordance with Article 5, Section 3 of the Environment Act.

EIA Notification mandates the acquisition of EC when implementing 39 types of projects (new construction and expansion). Yet, some projects do not require detailed implementations of EIA. The necessity of implementing EIA is determined in EC acquisition process.

Projects targeted in EC acquisition are categorized into “A” and “B” based on the level of effects on human health and resources as well as the size of a project. The process of EC acquisition also differs depending on the categorization.

**(2) Applicable Project for EIA**

EIA Notification mandates the acquisition of EC to projects which apply to the following:

[1] 39 types of new projects which are labeled as targets in the schedule in EIA Notification

[2] Expansion of already available projects (ones applicable to the above 39 types). This condition is limited to cases in which the size of facility after an expansion exceeds the threshold limit designated in the schedule of Notification.

[3] Cases in which changes to the contents of a project which apply to the 39 types of projects above exceed the restrictive conditions stipulated in Notification.

Projects categorized as “A” require a recommendation by the Expert Appraisal Committee (EAC) established by Central Government and the acquisition of EC from Central Government (MoEF). On the other hand, projects categorized as “B” require the acquisition of EC from the State Level Environment Impact Assessment Authority (SEIAA) established by Central Government at the state level. SEIAA issues EC based on the recommendation by the State Level Expert Appraisal Committee (SEAC). Projects in category B require the acquisition of EC through the same process as projects in category A in states which have no SEIAA or SEAC.

### 5.3.2 EIA Procedure

**(1) Application**

EC acquisition process differs depending on the project category. Projects in category A requires application to MoEF, and projects in category B to SEIAA. The first step is to submit the following information to the applicable authorities.

[1] The following information listed in Appendix 1 of EIA Notification

(a) Basic information concerning a project (name, location of the project, alternative sites, scale, cost, category, and contact information)

(b) Activities ([1] details of activities which cause physical changes to regional terrains, land use, and water areas, [2] use of resources (land, water, energy, non-renewable resources, etc.), [3] use, storage, handling, or production of materials which might cause negative effects on human health and the environment, [4] possibility of discharging solid wastes (construction and operation), [5] emission of pollutants or hazardous materials into the air (kg/hr.), [6] generation of noise, vibration, light, and heat, [7] possibility of soil and water pollution in sewers, soil, surface water, groundwater, coastal water, and oceanic areas due to discharge of pollutants, [8] risks to human health and the environment caused by accidents which could occur during construction and operation, [9] possibility of negative effects on the environment which occur as combined effects with other activities in the same region

(c) Environmental sensitivity

(d) Proposal of specifications (ToR) for implementing EIA for a proposed project

[2] Pre-FS report (8 in Schedule (building/construction project/regional development project and township) can be substituted with a pilot plan)

[3] Information presented in Appendix II of EIA Notification (ground environment, water environment, vegetation, fauna, atmospheric environment, aesthetics, socioeconomic aspects, construction materials, energy conservation, environmental management plan (EMP)) for projects applicable as 8 in Schedule (building/construction project/regional development project and township)

**(2) Stages of EC**

There are up to 4 stages after submitting an EC application to MoEF (or SEIAA) depending on the types of projects.

[1] Screening (category B only)

SEAC examines projects categorized as B and determines whether the implementation of EIA is necessary for issuing EC. Projects which require EIA are categorized as B1, and ones which do not require the implementation of EIA are categorized as B2. This step is not necessary for projects categorized as A.

[2] Scoping

Scoping is a process conducted by EAC or SEAC mentioned above.

Projects categorized as A are examined by EAC and projects categorized as B1 are examined by SEAC. Discussions are held at this stage based on documents submitted by the person who proposed the project. Detailed specifications (ToR) of EIA that a project proponent should implement to assess environmental effects are prepared and notified to the proponent. The specifications are also posted on the website of MoEF (or SEIAA). (Exemption: Detailed specifications for implementing EIA are not provided for activities categorized as B in Item 8 of EIA Notification. A decision on issuing an EC is made solely based on the information submitted by a proponent.) Issuance of EC may be rejected at this stage.

[3] Public hearing and public consultation

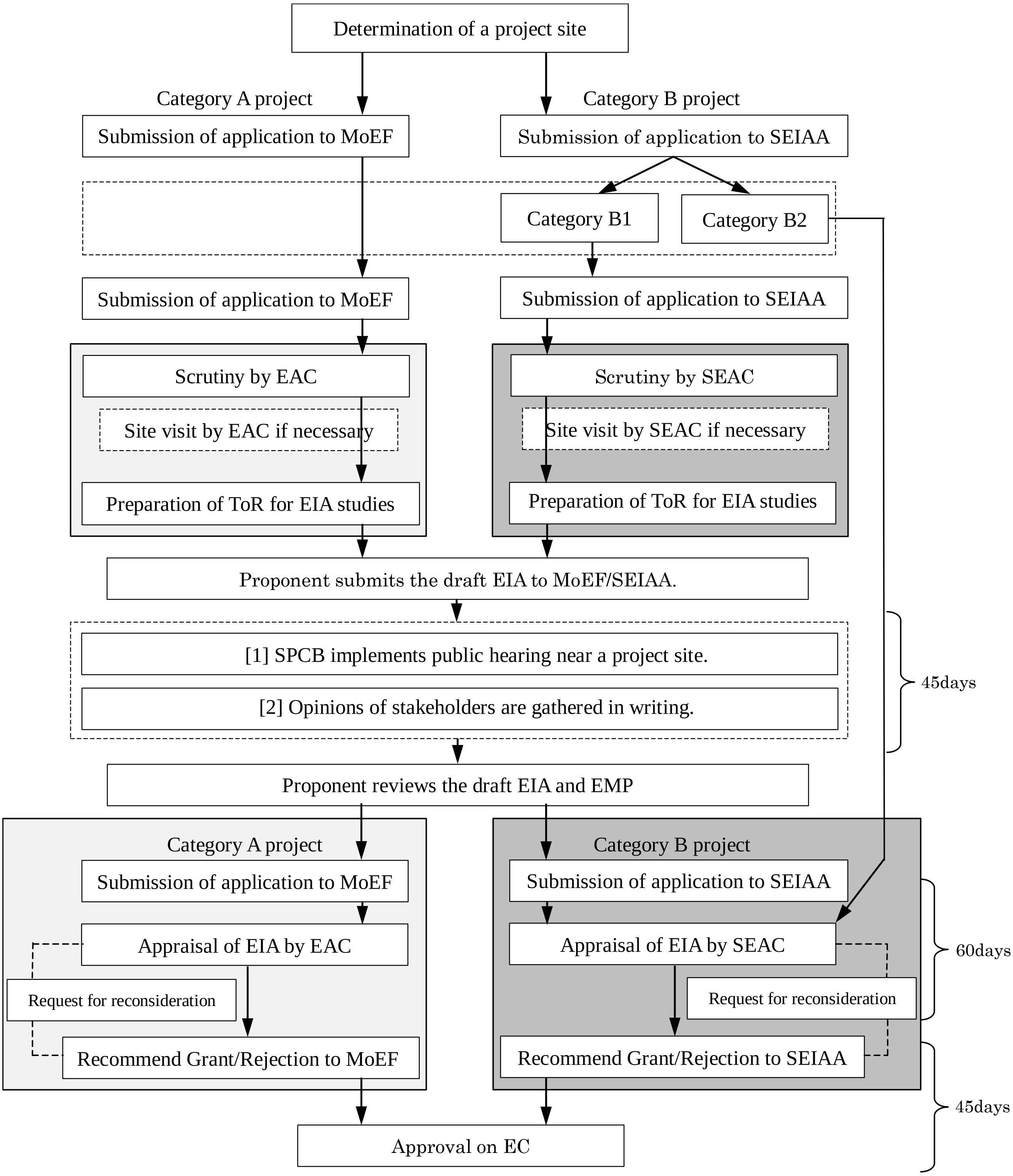
SPCB or Union Territory Pollution Control Committee (UTPCC) conducts public hearings upon request from a proponent. The proponent reflects how to handle opinions raised in the public hearing in a draft of an EIA report, which needs to be submitted to MoEF or SEIAA along with details of explanations provided to residents and receive a final evaluation of EIA.

[4] Appraisal

This is the stage where EAC (or SEAC) examines EIA final report, application, and outcomes of public hearing and determines whether an EC is to be issued. A proponent (or an agent) is sometimes invited in this stage and asked to provide additional explanations to questions. The competent authority (MoEF or SEIAA) issues an EC or (rejects the issuance of an EC) based on the opinions of EAC (or SEAC). When the opinions of the competent authority do not agree with the opinions of EAC (or SEAC), the competent authority may request EAC (or SEAC) to conduct re-examination. But the competent authority has the authority to make a final decision.

Attention needs to be paid, because it takes at least five to six months to obtain an EC as described above or even longer in some projects.

Figure 5.3-1 shows Environmental Clearance Acquisition Flow and Table 5.3-1 shows Roles and Responsibilities of Stakeholders Involved in Prior Environmental Clearance.




Source: JBIC, Environmental Profile in India (October 2007)

MoEF, Technical EIA Guidance Manual for Thermal Power Plants (August 2010)

**Figure 5.3-1 Environmental Clearance Acquisition Flow**

**Table 5.3-1 Roles and Responsibilities of Stakeholders Involved in Prior Environmental Clearance**

| Stage | MoEF/SEIAA | EAC/SEAC | Project Proponent | EIA Consultant | SPCB/Public Agency | Public and Interest Group |
|---|---|---|---|---|---|---|
| Screening | Receives application and takes advice of EAC/SEAC | Advises MoEF/SEIAA | Submits application (Form I) and provides necessary information | Advises and assists the proponent by providing technical information | | |
| Scoping | Approves ToR, communicates the same to the project proponent and places the same in the website | Reviews ToR, visits the proposed site, if required, and recommends ToR to MoEF/SEIAA | Submits the draft ToR to MoEF/SEIAA and facilitates the visit of EAC / SEAC members to the project site | Prepares ToR | | |
| EIA Report & Public Hearing | Reviews and forwards copies of EIA report to SPCB/Public Agency for conducting public hearing<br>Places the summary of EIA report in the website<br>Conveys objections to the project proponent for update, if any | | Submits detailed EIA report as per the finalized ToR<br>Facilitates the public hearing by arranging presentation on the project, EIA and EMP – takes note of objections and updates EMP accordingly | Prepares EIA report<br>Presents and appraises the likely impacts and pollution control measures proposed in the public hearing | Reviews EIA report and conducts public hearing in the manner prescribed<br>Submits proceedings and views of SPCB, to the Authority and the project proponent as well | Participates in public hearings and offers comments and observations<br>– Comments can be sent directly to SEIAA through Internet in response to the summary placed in the website |
| Appraisal and Clearance | Receives updated EIA<br>Takes advice of EAC/SEAC, approves EIA and attaches the terms and conditions | Critically examines the reports, presentation of the proponent and appraises MoEF/SEIAA (recommendations are forwarded to MoEF/SEIAA) | Submits updated EIA, EMP reports to MoEF/SEIAA.<br>Presents the overall EIA and EMP including public concerns to EAC/SEAC | Provides technical advise to the project proponent and if necessary present the proposed measures for mitigation of likely impacts (terms and conditions of clearance) | | |
| Post-clearance Monitoring | | | Implements environmental protection measures prescribed and submits periodic monitoring results | Conducts periodic monitoring | Incorporates the clearance conditions into appropriate consent conditions and ensures implementation | |

Source: MoEF, Technical EIA Guidance Manual for Thermal Power Plants (August 2010)

### 5.3.3 Categories to be Included in EIA Report

An EIA report needs descriptions concerning the following categories upon the implementation of EIA.

[1] Introduction (Proposal of a report; Identification of project & project proponent; Brief description of nature, size, location of the project and its importance to the country, region; Scope of the study – details of regulatory scoping carried out (As per ToR))
[2] Project Description (types, need for the project, location, drawings, scale, implementation schedule, evaluation of new technologies, mitigation measures)
[3] Description of the Environment
[4] Anticipated Environmental Impacts & Mitigation Measures
[5] Analysis of Alternatives (Technology & Site)
[6] Environmental Monitoring Program
[7] Additional Studies
[8] Project Benefits
[9] Environmental Cost Benefit Analysis
[10] Environmental Management Program (EMP)
[11] Summary & Conclusion (This will constitute the summary of EIA Report)
[12] Disclosure of Consultants engaged

Specific evaluation parameters vary for each project because they are determined in the scoping stage.

### 5.3.4 Public Hearing and Disclosure of Information

Projects categorized as A and B1 require public consultation, but the following are exceptions: [1] modernization of irrigation projects; [2] projects located in an approved industrial complex where the location is approved; [3] expansion of roads and highways which does not require the acquisition of new land; [4] building/construction projects and regional development projects; [5] all B2 projects, and [6] projects involved with national security and strategic projects designated by Central Government).

Specifically, opportunities to gather opinions from residents are granted using the following two methods:

**(1) Public Hearing Near a Project Site**

SPCB or UTPCC sets up a public hearing under the initiative of SPCB (or UTPCC) after releasing an overview of EIA in advance. The project proponent presents the (summary) of an EIA report in the public hearing. The public hearing is recorded in a video, which is submitted to MoEF or SEIAA no later than 8 days after the end of the public hearing.

**(2) Opinions of Stakeholders are Gathered in Writing (Written Responses).**

SPCB or UTPCC posts a summary of EIA on a website and gathers the opinions of stakeholders. The entire draft of EIA should be made available for viewing when requested by residents.

### 5.3.5 Monitoring

After the project is executed, the project implementer needs to notify the competent authority (MoEF or SEIAA) that conditions designated upon the issuance of EC are being complied with twice a year (June 1 and December 1). All these reports are posted on the website of MoEF or SEIAA.

### 5.3.6 The Ability of Environmental Authorities to enforce Rules in Case of Troubles

EAC and SEAC members are authorized to inspect project sites before an EIA evaluation when necessary. They are also authorized to recommend that the competent authorities reject an EC as a result of the inspection.

SPCB may visit offices and worksites to inspect actual conditions such as air pollution, water contamination, and handling of hazardous wastes and reject an EC as a result. This procedure is not limited to EIA process.

## 5.4 Preliminary Environmental Impact Assessment

### 5.4.1 How to proceed with Environmental and Social Considerations Investigation

This investigation is at the requested verification (Pre-FS) phase concerning the construction plan of a model coal-fired thermal power plant. It examined points which would require special attention concerning environmental and social considerations when a 660 MW thermal power plant is constructed within the premises proposed by the client.
More detailed investigations on environmental and social effects associated with the implementation of this project must be examined in EIA preparation phase.

### 5.4.2 Initial Screening

First, an initial screening was conducted in a questionnaire form at BSPGCL based on JICA format to assess the characteristics of the investigated area where the power plant would be constructed, relevant physical and biological effects, and positive and negative effects caused by this project.
Table 5.4-1 shows the results of the initial screening.

**Table 5.4-1 Result of the Initial Screening based on JICA Format**

**Question 1:** Address of project site

Barauni Thermal Power Station
District – Begusarai, PIN 851116 (BIHAR)

**Question 2:** Scale and contents of the project (approximate area, facilities area, production, electricity generated, etc.)

**2-1.** Project profile (scale and contents)

Construction plan for 660 MW x 1 SC unit (Unit No.10)
(Reference)

| | |
|---|---|
| Units 1 to 5: | Scrap, |
| Units 6 and 7 | Refurbished of 110 MW x 2, |
| Units 8 and 9: | New construction of 250 MW x 2 |

**2-2.** How was the necessity of the project confirmed? Is the project consistent with the higher program / policy?

☑YES：Please describe the higher program / policy.

If this project can be implemented, it is planned as a project of the State of Bihar and administered as a national project of India.

**2-3.** Did the proponent consider alternatives before this request?

☑YES：Please describe an outline of the alternatives

A 250 MW subcritical power plant was initially considered. But the plan was changed to construction of a 660 MW SC unit, because the initial plan was inferior to SC power plants, which have been the mainstream in recent years, in terms of thermal efficiency, environmental aspects, and economic efficiency.

**2-4.** Did the proponent implement meetings with the related stakeholders before this request?

☑Implemented

If implemented, please mark the following stakeholders.

☑Administrative body
☑Local residents
☐NGO
☐Others（ ）

A stakeholder meeting was held upon the acquisition of land for the additional construction of an ash disposal area for Units No.8/9.

Date of implementation: July 8, 2011 (Begusarai) and November 11 (Patna)
(Unit 10 was initially planned to be a 250 MW unit)

**Question 3:** Is the project a new one or an ongoing one? In the case of an ongoing project, have you received strong complaints or other comments from local residents?

☑Ongoing (without complaints)

The State of Bihar is the poorest state in India. Local residents are welcoming this project because it will generate new employment (jobs).

**Question 4:** Is an Environmental Impact Assessment (EIA), including an Initial Environmental Examination (IEE), required for the project according to a law or guidelines of a host country? If yes, is EIA implemented or planned? If necessary, please fill in the reason why EIA is required.

☑ Necessity (☐ Implemented ☑ Ongoing / planning)

(Reason why EIA is required: Designated in Notification (Environmental Impact Assessment Notification, 2006) that MoEF in India issued in September 2006 in accordance with Article 5, Section 3 of the Environment (Protection) Act.)

**Question 5:** In the case that steps were taken for an EIA, was the EIA approved by the relevant laws of the host country? If yes, please note the date of approval and the competent authority.

☑Appraisal process not yet started

**Question 6:** If the project requires a certificate regarding the environment and society other than an EIA, please indicate the title of said certificate. Was it approved?

☑Requires a certificate but not yet approved

(Name of permission: Environmental Clearance (EC))
(In India, EIA is positioned as a necessary process for obtaining EC which is required when implementing a project which might cause significant effects on the environment.)

**Question 7:** Are any of the following areas present either inside or surrounding the project site? If yes, please mark the corresponding items.

☑NO

☐National parks, protection areas designated by the government (coastline, wetlands, reserved area for ethnic or indigenous people, cultural heritage)
☐Primeval forests, tropical natural forests
☐Ecologically important habitats (coral reefs, mangrove wetlands, tidal flats, etc.)
☐Habitats of endangered species for which protection is required under local laws and / or international treaties
☐Areas that run the risk of a large scale increase in soil salinity or soil erosion
☐Remarkable desertification areas
☐Areas with special values from an archaeological, historical, and / or cultural points of view
☐Habitats of minorities, indigenous people, or nomadic people with a traditional lifestyle, or areas with special social value

**Question 8:** Does the project include any of the following items? If yes, please mark the appropriate items.

☑NO

☐Involuntary resettlement (scale: households persons)
☐Groundwater pumping (scale: $m^3$/year)
☐Land reclamation, land development, and / or land-clearing (scale: hectors)
☐Logging (scale: hectors)

**Question 9:** Please mark related environmental and social impacts, and describe their outlines.

☑NO

☐Air pollution
☐Water pollution
☐Soil pollution
☐Waste
☐Noise and vibrations
☐Ground subsidence
☐Offensive odors
☐Geographical features
☐Bottom sediment
☐Biota and ecosystems
☐Water usage
☐Accidents
☐Global warming
☐Involuntary resettlement
☐Local economies, such as employment, livelihood, etc.
☐Land use and utilization of local resources
☐Social institutions such as social infrastructure and local decision-making institutions
☐Existing social infrastructures and services
☐Poor, indigenous, or ethnic people
☐Misdistribution of benefits and damages
☐Local conflicts of interest
☐Limitation of accessibility to information, meetings, etc. on a specific person or group
☐Gender
☐Children's rights

| |
|---|
| ☐Cultural heritage<br>☐Infectious diseases such as HIV / AIDS<br>☐Other ( ) |
| Outline of related impact: (Electrostatic precipitators and wastewater treatment systems are to be installed to prevent air pollution and water contamination which might cause effects on the environment.) |

Source: Prepared by the JICA Study Team, October 2013

### 5.4.3 Methodology of Scoping

The following survey was conducted based on JICA guidelines for environmental and social considerations concerning possible negative effects of expected plans before our FS was started. The aim was to determine the range of the assessment of environmental and social considerations.

In this survey, effects were also investigated at candidate sites presented by BSPGCL (1) planned site of Unit No.10 (near Units No.8/9), (2) residential area, (3) existing plant area, as well as (4) site in the south adjacent to Units No.8/9.

Table 5.4-2 shows the category of scoping in this survey.

**Table 5.4-2 Scoping Category of Environmental and Social Considerations Survey**

| | | | |
|---|---|---|---|
| A | Potentially major positive or negative effects are expected. | C | There is a possibility that positive or negative effects may occur, but their scales and conditions are unknown at this point. |
| B | Potentially positive or negative effects are expected on a medium to small scale. | D | Potential effects are considered to be minimum or negligible. |

**(1) Construction in Planned Site of No.10 Unit (near Units No.8/9)**

R&M/LE construction at Units No.6/7 (110 MW x 2) and new construction of Units No.8/9 (250 MW x 2) are now being conducted at Barauni TPS. With regards to the construction of Unit No.10, it was initially planned to be a 250 MW subcritical unit next to Units No.8/9.

This survey examined the expected environmental and social effects when constructing Unit No.10 as a 660 MW SC unit within the same premises.

**Table 5.4-3 Result of the Verification of Environmental and Social Considerations ([1] Construction in Planned Site of Unit No.10 (near Units No.8/9))**

| Category | Effects | Evaluation | | Reasons for Evaluation and Caution |
|---|---|---|---|---|
| | | During Const-ruction | During Service Operation | |
| Permits and approvals, explanations | EIA and environmental permits | D | D | Preparation of EIA report is necessary for receiving environmental clearance. |
| | Explanation to the public | C- | C- | - Explanation was already provided to local stakeholders when the land was acquired for the additional construction of an ash pond for the new construction of Units No.8/9.<br>- Explanation was not provided to local stakeholders when the plan was changed from 250 MW to 660 MW. |
| | Examination of alternative plans | D | D | A 250 MW subcritical pressure power plant was initially considered. But the plan was changed to construction of a 660 MW SC unit, because the initial plan was inferior to SC and USC power plants, which have been the mainstream in recent years, in terms of thermal efficiency, environmental aspects, and economic efficiency. |
| Anti-pollution measures | Air quality | B- | B- | **During construction:** Sand and dust are stirred up when transporting construction materials, but its effect does not reach far away.<br>**During service operation:** Dusts such as $SO_2$ and $NO_2$ may be generated during operation. Thus, measures must be implemented to comply with the national environmental standards in India or the values of EHS Guidelines.<br>- Flying coal dust may be released from a coal storage yard and dust from a fly ash disposal area. Thus, measures must be implemented such as covering them with dust covers. |
| | Water quality | B- | B- | **During construction:** Generation of muddy water may be expected during construction.<br>**During service operation:** Water is expected to be released from a boiler of a power plant. Thus, measures must be implemented to comply with the national environmental standards in India or the values of EHS Guidelines. |
| | Waste | B- | B- | **During construction:** Excessive soil and waste materials are expected to be generated at a construction site.<br>**During service operation:** Coal fly ash is expected to be generated during operation. Thus, plans need to be established to install an ash disposal area which complies with the national environmental standards of India and to effectively use the fly ash. |

| Category | Effects | Evaluation | | Reasons for Evaluation and Caution |
|---|---|---|---|---|
| | | During Const-ruction | During Service Operation | |
| | Soil contamination | B- | B- | **During construction:** Possibility of soil contamination is expected by the spill of construction oil and other situations.<br>**During service operation:** Soil contamination caused by water spilled from an ash disposal area is expected. Therefore, measures such as installing water blocking sheets need to be implemented. |
| | Noise and vibration | B- | B- | **During construction:** Noise caused by the operation of construction equipment and vehicles is expected to occur.<br>**During service operation:** Attention must be paid to reduce noise during operations because residential areas are located at the eastern side of the border of the premises. |
| | Subsidence | D | D | There is no special concern over ground subsidence because the project does not use groundwater. |
| | Odor | D | D | A coal-fired thermal power plant is not expected to release materials which cause odor. |
| Natural environment | Protected areas | D | D | - The project site is located within the premises of an already available power plant and does not include protected areas.<br>- No protected area is found near the project site. |
| | Ecosystem | D | D | The project site is located within the premises of an already available power plant and does not include ecologically important habitats and other areas. |
| Social environment | Resettlement | C- | C- | - The project site is located within the premises of an already available power plant and does not involve the resettlement.<br>- Resettlement occurs when there is a need to obtain the eastern site of the project site. But the priority for using the eastern site is low with regards to the acquisition of land. |
| | Living and livelihood | A+ | A+ | **During construction:** Employment is generated during the construction of this project.<br>**During service operation:** Employment is generated for effectively using fly ash after the start of operation in this project. |
| | Heritage | D | D | - The project site is located within the premises of an already available power plant, and no cultural heritage is found in the site.<br>- No cultural heritage is found near the project site. |
| | Landscape | D | D | This project has no special effect on the landscape. |
| | Ethnic minorities and indigenous peoples | D | D | Ethnic minorities and indigenous peoples are not living in the project site and its vicinity. |

| Category | Effects | Evaluation | | Reasons for Evaluation and Caution |
|---|---|---|---|---|
| | | During Const-ruction | During Service Operation | |
| | Working conditions | B- | D | **During construction:** A favorable working environment needs to be provided for construction workers during construction.<br>- Special attention needs to be paid, because the project site may become congested due to the constructions of Units No.8/9.<br>**During service operation:** Operations which are expected to cause negative effects on workers are not planned at the service phase. |
| Other | Impact during construction | B- | D | **During construction:** Contamination caused by the construction may affect the natural environment and social environment. Therefore, these effects need to be examined in EIA report preparation phase and measures must be established to alleviate such effects when necessary. |
| | Accident prevention measures | B- | B- | **During construction:** Accident prevention measures are required during construction.<br>**During service operation:** Spontaneous combustion of coal may occur in a coal storage yard. Therefore, it is necessary to come up with measures to prevent spontaneous combustion. |

### (2) Construction in Residential Area

Employees of Barauni TPS are now living in the residential area located east of Units No.6/7 (110 MW x 2). But the housing is old, and an update of the residential area is also being considered along with the construction of Unit No.10.

Upon the update of the residential area, this survey examined environmental and social considerations which are expected when concentrated and high-rise residential buildings are constructed to secure the construction site for Unit No.10.

**Table 5.4-4 Result of the Verification of Environmental and Social Considerations ([2] Construction in Residential Area)**

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During const-ruction | During service operation | |
| Permits and approvals, explanations | EIA and environmental permits | D | D | Preparation of EIA report is necessary for receiving environmental clearance. |
| | Explanation to the public | C- | C- | - Explanation was already provided to local stakeholders when the land was acquired for the additional construction of an ash pond for the new construction of Units No.8/9.<br>- Explanation was not provided to local stakeholders when the plan was changed from 250 MW to 660 MW. |

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During const-ruction | During service operation | |
| | Examination of alternative plans | D | D | A 250 MW subcritical power plant was initially considered. But the plan was changed to construction of a 660 MW SC unit, because the initial plan was inferior to SC and USC power plants, which have been the mainstream in recent years, in terms of thermal efficiency, environmental aspects, and economic efficiency. |
| Anti-pollution measures | Air quality | A- | B- | **During construction:** Sand and dust are stirred up when transporting construction materials, but its effect does not reach far away.<br>- Sand and dust are stirred up in large amount in association with the disposal of waste materials generated from the current residential area and the land development of the lots for residential area.<br>**During service operation:** Dusts such as $SO_2$ and $NO_2$ may be generated during operation. Thus, measures must be implemented to comply with the national environmental standards in India or the values of EHS Guidelines.<br>- Flying coal dust may be released from a coal storage yard and dust from a fly ash disposal area. Thus, measures must be implemented such as covering them with dust covers. |
| | Water quality | B- | B- | **During construction:** Generation of muddy water may be expected during construction.<br>**During service operation:** Water is expected to be released from a boiler of a power plant. Thus, measures must be implemented to comply with the national environmental standards in India or the values of EHS Guidelines. |
| | Waste | A- | B- | **During construction:** Excessive soil and waste materials are expected to be generated at a construction site.<br>- Waste materials are generated in large amount from the current residential area.<br>**During service operation:** Coal fly ash is expected to be generated during operation. Thus, plans need to be established to install an ash disposal area which complies with the national environmental standards of India and to effectively use the fly ash. |
| | Soil contamination | B- | B- | **During construction:** Possibility of soil contamination is expected by the spill of construction oil and other situations.<br>**During service operation:** Soil contamination caused by water spilled from an ash disposal area is expected. Therefore, measures such as installing water blocking sheets need to be implemented. |

| Category | Effects | Evaluation: During const-ruction | Evaluation: During service operation | Reasons for evaluation and caution |
|---|---|---|---|---|
| | Noise and vibration | B- | B- | **During construction:** Noise caused by the operation of construction equipment and vehicles is expected to occur.<br>**During service operation:** Attention must be paid to reduce noise during operations because residential areas are located at the eastern side of the border of the premises. |
| | Subsidence | D | D | There is no special concern over ground subsidence because the project does not use groundwater. |
| | Odor | D | D | A coal-fired thermal power plant is not expected to release materials which cause odor. |
| Natural environment | Protected areas | D | D | - The project site is located within the premises of an already available power plant and does not include protected areas.<br>- No protected area is found near the project site. |
| | Ecosystem | D | D | The project site is located within the premises of an already available power plant and does not include ecologically important habitats and other areas. |
| Social environment | Resettlement | C- | C- | - The project site is located within the premises of an already available power plant and does not involve the resettlement.<br>- Resettlement occurs when there is a need to obtain the eastern site of the project site. But the priority for using the eastern site is low with regards to the acquisition of land. |
| | Living and livelihood | A+ | A+ | **During construction:** Employment is generated during the construction of this project.<br>**During service operation:** Employment is generated for effectively using fly ash after the start of operation in this project. |
| | Heritage | D | D | - The project site is located within the premises of an already available power plant, and no cultural heritage is found in the site.<br>- No cultural heritage is found near the project site. |
| | Landscape | D | D | This project has no special effect on the landscape. |
| | Ethnic minorities and indigenous peoples | D | D | Ethnic minorities and indigenous peoples are not living in the project site and its vicinity. |
| | Working conditions | B- | D | **During construction:** A favorable working environment needs to be provided for construction workers during construction.<br>**During service operation:** Operations which are expected to cause negative effects on workers are not planned at the service phase. |

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During const-ruction | During service operation | |
| Other | Impact during construction | B- | D | **During construction:** Contamination caused by the construction may affect the natural environment and social environment. Therefore, these effects need to be examined in EIA report preparation phase and measures must be established to alleviate such effects when necessary. |
| | Accident prevention measures | B- | B- | **During construction:** Accident prevention measures are required during construction.<br>**During service operation:** Spontaneous combustion of coal may occur in a coal storage yard. Therefore, it is necessary to come up with measures to prevent spontaneous combustion. |
| | Others (relocation of residents of the residential area) | A- | D | **During construction:** Temporary resettlement in the residential area occurs during the rebuilding of housing. |

### (3) Construction in Existing Plant Area

Units No.1-5 of Barauni TPS are not generating power, and power generation facilities are left in the site without being disposed of.

This survey examined environmental and social considerations which are expected when the sites of the already available power plants are used as the site for constructing Unit No.10.

**Table 5.4-5 Result of the Verification of Environmental and Social Considerations ([3] Construction in Existing Plant Area)**

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During const-ruction | During service operation | |
| Permits and approvals, explanations | EIA and environmental permits | D | D | Preparation of EIA report is necessary for receiving environmental clearance. |
| | Explanation to the public | C- | C- | - Explanation was already provided to local stakeholders when the land was acquired for the additional construction of an ash pond for the new construction of Units No.8/9.<br>- Explanation was not provided to local stakeholders when the plan was changed from 250 MW to 660 MW. |
| | Examination of alternative plans | D | D | A 250 MW subcritical power plant was initially considered. But the plan was changed to construction of a 660 MW SC unit, because the initial plan was inferior to SC and USC power plants, which have been the mainstream in recent years, in terms of thermal efficiency, environmental aspects, and economic efficiency. |

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During construction | During service operation | |
| Anti-pollution measures | Air quality | A- | B- | **During construction:** Sand and dust are stirred up when transporting construction materials, but its effect does not reach far away.<br>- Sand and dust are stirred up in excess during disposal of waste materials of existing power generation devices and land development for new construction after the disposal.<br>**During service operation:** Dusts such as $SO_2$ and $NO_2$ may be generated during operation. Thus, measures must be implemented to comply with the national environmental standards in India or the values of EHS Guidelines.<br>- Flying coal dust may be released from a coal storage yard and dust from a fly ash disposal area. Thus, measures must be implemented such as covering them with dust covers. |
| | Water quality | B- | B- | **During construction:** Generation of muddy water may be expected during construction.<br>**During service operation:** Water is expected to be released from a boiler of a power plant. Thus, measures must be implemented to comply with the national environmental standards in India or the values of EHS Guidelines. |
| | Waste | A- | B- | **During construction:** Excessive soil and waste materials are expected to be generated at a construction site.<br>- Large amount of waste materials are generated from existing power plants.<br>**During service operation:** Coal fly ash is expected to be generated during operation. Thus, plans need to be established to install an ash disposal area which complies with the national environmental standards of India and to effectively use the fly ash. |
| | Soil contamination | B- | B- | **During construction:** Possibility of soil contamination is expected by the spill of construction oil and other situations.<br>**During service operation:** Soil contamination caused by water spilled from an ash disposal area is expected. Therefore, measures such as installing water blocking sheets need to be implemented. |
| | Noise and vibration | B- | B- | **During construction:** Noise caused by the operation of construction equipment and vehicles is expected to occur.<br>**During service operation:** Attention must be paid to reduce noise during operations because residential areas are located at the eastern side of the border of the premises. |

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During const-ruction | During service operation | |
| | Subsidence | D | D | There is no special concern over ground subsidence because the project does not use groundwater. |
| | Odor | D | D | A coal-fired thermal power plant is not expected to release materials which cause odor. |
| Natural environment | Protected areas | D | D | - The project site is located within the premises of an already available power plant and does not include protected areas.<br>- No protected area is found near the project site. |
| | Ecosystem | D | D | The project site is located within the premises of an already available power plant and does not include ecologically important habitats and other areas. |
| Social environment | Resettlement | C- | C- | - The project site is located within the premises of an already available power plant and does not involve the resettlement.<br>- Resettlement occurs when there is a need to obtain the eastern site of the project site. But the priority for using the eastern site is low with regards to the acquisition of land. |
| | Living and livelihood | A+ | A+ | **During construction:** Employment is generated during the construction of this project.<br>**During service operation:** Employment is generated for effectively using fly ash after the start of operation in this project. |
| | Heritage | D | D | - The project site is located within the premises of an already available power plant, and no cultural heritage is found in the site.<br>- No cultural heritage is found near the project site. |
| | Landscape | D | D | This project has no special effect on the landscape. |
| | Ethnic minorities and indigenous peoples | D | D | Ethnic minorities and indigenous peoples are not living in the project site and its vicinity. |
| | Working conditions | B- | D | **During construction:** A favorable working environment needs to be provided for construction workers during construction.<br>**During service operation:** Operations which are expected to cause negative effects on workers are not planned at the service phase. |
| Other | Impact during construction | B- | D | **During construction:** Contamination caused by the construction may affect the natural environment and social environment. Therefore, these effects need to be examined in EIA report preparation phase and measures must be established to alleviate such effects when necessary. |

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During construction | During service operation | |
| | Accident prevention measures | B- | B- | **During construction:** Accident prevention measures are required during construction. **During service operation:** Spontaneous combustion of coal may occur in a coal storage yard. Therefore, it is necessary to come up with measures to prevent spontaneous combustion. |
| | Others (additional use of land) | C- | D | **During construction:** Since existing power plant is very small, additional acquisition of land or the use of the residential area may become necessary. |

**(4) Construction at the Site in the South Adjacent to Units No.8/9**

R&M/LE construction at Units No.6/7 (110 MW x 2) and new construction of Units No.8/9 (250 MW x 2) are now being conducted at Barauni TPS. With regards to the construction of Unit No.10, it was initially planned to be a 250 MW subcritical unit next to Units No.8/9.

But when Unit No.10 is constructed next to Units No.8/9, it will affect the construction plan of Units No.8/9 and may cause delays in the operation schedule. Therefore, this survey examined environmental and social considerations which are expected when land is newly acquired at the south of the construction site of Units No.8/9 and Unit No.10.

**Table 5.4-6 Result of the Verification of Environmental and Social Considerations ([4] Construction at the Site in the South Adjacent to Units No.8/9)**

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During construction | During service operation | |
| Permits and approvals, explanations | EIA and environmental permits | D | D | Preparation of EIA report is necessary for receiving environmental clearance. |
| | Explanation to the public | C- | C- | - Explanation was already provided to local stakeholders when the land was acquired for the additional construction of an ash pond for the new construction of Units No.8/9.<br>- Explanation was not provided to local stakeholders when the plan was changed from 250 MW to 660 MW. |
| | Examination of alternative plans | D | D | A 250 MW subcritical power plant was initially considered. But the plan was changed to construction of a 660 MW SC unit, because the initial plan was inferior to SC and USC power plants, which have been the mainstream in recent years, in terms of thermal efficiency, environmental aspects, and economic efficiency. |

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During const-ruction | During service operation | |
| Anti-pollution measures | Air quality | B- | B- | **During construction:** Sand and dust are stirred up when transporting construction materials, but its effect does not reach far away.<br>**During service operation:** Dusts such as $SO_2$ and $NO_2$ may be generated during operation.<br>Thus, measures must be implemented to comply with the national environmental standards in India or the values of EHS Guidelines.<br>- Flying coal dust may be released from a coal storage yard and dust from a fly ash disposal area. Thus, measures must be implemented such as covering them with dust covers. |
| | Water quality | B- | B- | **During construction:** Generation of muddy water may be expected during construction.<br>**During service operation:** Water is expected to be released from a boiler of a power plant.<br>Thus, measures must be implemented to comply with the national environmental standards in India or the values of EHS Guidelines. |
| | Waste | B- | B- | **During construction:** Excessive soil and waste materials are expected to be generated at a construction site.<br>**During service operation:** Coal fly ash is expected to be generated during operation.<br>Thus, plans need to be established to install an ash disposal area which complies with the national environmental standards of India and to effectively use the fly ash. |
| | Soil contamination | B- | B- | **During construction:** Possibility of soil contamination is expected by the spill of construction oil and other situations.<br>**During service operation:** Soil contamination caused by water spilled from an ash disposal area is expected.<br>Therefore, measures such as installing water blocking sheets need to be implemented. |
| | Noise and vibration | B- | B- | **During construction:** Noise caused by the operation of construction equipment and vehicles is expected to occur.<br>**During service operation:** Attention must be paid to reduce noise during operations because residential areas are located at the eastern side of the border of the premises. |
| | Subsidence | D | D | There is no special concern over ground subsidence because the project does not use groundwater. |
| | Odor | D | D | A coal-fired thermal power plant is not expected to release materials which cause odor. |

| Category | Effects | Evaluation | | Reasons for evaluation and caution |
|---|---|---|---|---|
| | | During const-ruction | During service operation | |
| Natural environment | Protected areas | D | D | No protected area is found near the project site. |
| | Ecosystem | C- | C- | The vicinity of the project site probably does not include ecologically important habitats, but details are unknown. |
| Social environment | Resettlement | D | D | The project site (the lot at the south side) is agricultural land, and resettlement is not necessary. |
| | Living and livelihood | A+ | A+ | **During construction:** Employment is generated during the construction of this project.<br>**During service operation:** Employment is generated for effectively using fly ash after the start of operation in this project. |
| | Heritage | D | D | - The project site is located within the premises of an already available power plant, and no cultural heritage is found in the site.<br>- No cultural heritage is found near the project site. |
| | Landscape | D | D | This project has no special effect on the landscape. |
| | Ethnic minorities and indigenous peoples | D | D | Ethnic minorities and indigenous people are not living near the project site. |
| | Working conditions | B- | D | **During construction:** A favorable working environment needs to be provided for construction workers during construction.<br>**During service operation:** Operations which are expected to cause negative effects on workers are not planned at the service phase. |
| Other | Impact during construction | B- | D | **During construction:** Contamination caused by the construction may affect the natural environment and social environment. Therefore, these effects need to be examined in EIA report preparation phase and measures must be established to alleviate such effects when necessary. |
| | Accident prevention measures | B- | B- | **During construction:** Accident prevention measures are required during construction.<br>**During service operation:** Spontaneous combustion of coal may occur in a coal storage yard. Therefore, it is necessary to come up with measures to prevent spontaneous combustion. |
| | Other (acquisition of land) | C- | D | **During construction:** New acquisition of agricultural land is necessary, and its effect on nearby areas is unknown. |

### 5.4.4 Conclusion

The main environmental and social considerations, based on the results in the last section, are shown in a Table 5.4-7. These aspects need to be examined, and preventive and alleviating measures need to be included when preparing an EIA report.

**Table 5.4-7 Environmental and Social Considerations to be Examined in Individual Cases**

| Case | Environmental and Social Considerations | Reasons for Evaluation and Caution |
|---|---|---|
| [1] Construction in Planned Site of Unit No.10 | Working environment | Safety of workers needs to be secured, because the work site is congested with the construction of Units No.8/9. |
| [2] Construction in Residential Area | Air quality | Sand and dust are stirred up in association with the disposal of waste materials generated from the current residential area and the land development of the lots for residential sites. |
| | Wastes | Waste materials are generated in large amounts from the current residential area. |
| | Others<br>(Relocation of residents of the residential area) | Temporary resettlements in the residential area occur during the rebuilding of housing. |
| [3] Construction within the Existing Plant Area | Air quality | Sand and dust are stirred up during disposal of waste materials of the already available power generation devices and land development for new construction after the disposal. |
| | Wastes | Large amount of waste materials are generated from already available power plants. |
| | Others<br>(Additional use of land) | Since the lot of the already available power plants is very small, additional acquisition of land or the use of the residential area may become necessary. |
| [4] Construction at the Site in the South Adjacent to Units No.8/9 | Others<br>(Acquisition of land) | New acquisition of agricultural land is necessary. |

# Chapter 6 Outlined Specifications of 660 MW Super Critical Unit

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# Chapter 6 Outlined Specifications of 660 MW Super Critical Unit

## 6.1 Examination of Equipment Specifications

### 6.1.1 Main Parameters of a 660 MW Super Critical Unit

The examined parameters for a 660 MW SC unit and their sources are shown in Table 6.1.1-1.

**Table 6.1.1-1 Principal Performance of a 660 MW SC Unit**

| Item | Unit | Parameters | Source |
|---|---|---|---|
| Boiler Efficiency | % | 85 | Typical Experience of Recent 660 MW in India |
| Turbine Heat Rate | kcal/kWh | 1,850 | (a) |
| Gross Thermal Efficiency | % | 39.5 | Calculation result based on boiler efficiency and turbine heat consumption rate |
| PLF | % | 85-90 | Results from Interview |

Source: (a) Central Electricity Authority, Ministry of Power, Government of India, STANDARD TECHNICAL FEATURES OF BTG SYSTEM FOR SUPER CRITICAL 660/800MW THERMAL UNITS (July 2013)

### 6.1.2 Assumed Specifications of Equipment

The configuration of the main equipment in a 660 MW SC plan proposed in this report includes a SC once-through boiler, turbine generator, condenser, cooling tower, new establishment/expansion of coal storage yard/coal handling plant to meet the increased power output, and reinforcement of an ash disposal area. The following summarizes the principal specifications assumed for the main facilities:

**Table 6.1.2-1 Principal Specifications of 660 MW SC Unit**

| Main Equipment | Item | Specification |
|---|---|---|
| Boiler | Model | Supercritical pressure sliding once-through type |
| | Maximum Continuous Rating | Approximate 2,000 t/h |
| | Steam Conditions | 24.2 MPa/566 °C/593 °C |
| | Combustion | Opposed firing on pulverized coal |
| | Draft | Balanced draft |
| Turbine | Model | 4 flows 3-casing, reheat and regenerative condensing type |
| | Turbine Shaft Configuration | Tandem-compound |
| | Final Stage Blade Length | 40 inches |
| | Number of Revolution | 3,000 rpm |
| Generator | Model | Horizontal mounted, revolving-field type stator water/Hydrogen cooled, cylindrical hydrogen cooled type |
| | Phase Number | 3 |
| | Frequency | 50 Hz |
| | Number of Poles | 2 |
| | Power Factor | 0.85 (lagging, over-excited) – 0.95 (lead, under-excited) |

### 6.1.3 Details of Equipment Configuration Compliant with Emissions Regulation in India

The emissions regulation regarding coal-fired power plants to be observed in India is specified in “Environment (Protection) Rules, Schedule I” (hereinafter referred to as “Emissions Regulation”), and the policy on facility configuration in this project on each regulatory item is summarized as follows:

**(1) Effluent Water Treatment**

**Table 6.1.3-1 Effluent Treatment Regulation**

| Item | | Unit | Emissions Regulation | 660 MW SC unit |
|---|---|---|---|---|
| Condenser cooling water (when directly taken from the sea) | pH | — | 6.5-8.5 | Not applicable as water will be taken from the Ganges |
| | Temperature difference | °C | 5 or lower | |
| | Residual chlorine | mg/L | 0.5 | |
| Boiler blow-down water | Suspended matter | mg/L | 100 | No special devices measures except for implementing regular effluent checks |
| | Oil content | mg/L | 20 | |
| | Total copper | mg/L | 1.0 | |
| | Total iron | mg/L | 1.0 | |
| Cooling tower blow-down water | Residual chlorine | mg/L | 0.5 | |
| | Zinc | mg/L | 1.0 | |
| | Chromium | mg/L | 0.2 | |
| | Phosphorus | mg/L | 5.0 | |
| | Corrosion protection substance | | Specified depending on the case | |
| Ash pond effluent | pH | | 6.5-8.5 | |
| | Suspended matter | mg/L | 100 | |
| | Oil content | mg/L | 20 | |
| | Heavy metal | | No regulation at present | |

**(2) Dust**

**Table 6.1.3-2 Dust Emission Regulation**

| | | Emissions Regulation | No.8/9 (250 MW x 2) | No.10 (250 MW x 1) | 660 MW SC unit |
|---|---|---|---|---|---|
| Concentration | Lower than 210 MW | 350 mg/Nm$^3$ | — | — | — |
| | 210 MW or higher | 150 mg/Nm$^3$ | | ESP outlet concentration 100 mg/Nm$^3$ | ESP outlet concentration 50 mg/Nm$^3$ |

While the emissions regulation specifies 150 mg/Nm$^3$, DPR of No.10 adopts 100 mg/Nm$^3$, which is stricter. Since Source (a) requests a design applying 50 mg/Nm$^3$, which is even stricter, a 660 MW SC unit will also be designed with 50 mg/Nm$^3$ at ESP outlet.

If Flue Gas De-sulfuring (FGD) is installed, further dust collection becomes possible during the cooling process in FGD. Kyushu Electric Power operates at approximately 30 mg/Nm$^3$ or lower at FGD outlet by installing FGD after ESP (ESP outlet design dust concentration 100 mg/Nm$^3$).

**(3) Sulfur Oxides**

The sulfur oxide emissions regulation only specifies the height of the smokestack to deliver the diffusion effect, and 275 m is assumed to be specified for coal-fired thermal plants of 500 MW or higher. In addition, FGD is considered a device for the future and thus only its space will be taken into consideration. However, the case in which FGD is installed from the beginning is also examined as installing FGD from the beginning would be more advantageous in terms of facility arrangement if it is highly likely to be installed in the future anyway, as discussed in “6.1.4.5 Flue Gas Process System”.

**Table 6.1.3-3 Sulfur Oxides Emission Regulation**

<table>
<tr><th colspan="2"></th><th>Emissions Regulation</th><th>No.8/9<br>(250 MW x 2)</th><th>No.10<br>(250 MW x 1)</th><th colspan="2">660 MW SC unit</th></tr>
<tr><td rowspan="3">Height of Chimney</td><td>Lower than 200/210 MW</td><td>According to the calculation formula</td><td>—</td><td>—</td><td colspan="2">—</td></tr>
<tr><td>200/210 MW or higher and lower than 500 MW</td><td>220 m</td><td>—</td><td>220 m</td><td colspan="2">—</td></tr>
<tr><td>500 MW or higher</td><td>275 m</td><td>275 m</td><td>—</td><td colspan="2">275 m to be followed</td></tr>
<tr><td colspan="2" rowspan="2">FGD</td><td rowspan="2">To be installed in the future</td><td rowspan="2">To be installed in the future</td><td rowspan="2">To be installed in the future</td><td>Case 1</td><td>Space to be considered as a future device</td></tr>
<tr><td>Case 2</td><td>Install from Beginning</td></tr>
</table>

**(4) Nitrogen Oxides**

There is no obligation to install a Selective Catalytic Reduction system (SCR) in the Emissions Regulation. However, below two cases shall be considered in layout for a 660 MW SC unit, Case 1 is not to install as shown in the emissions regulation, Case 2 is to prepare only necessary space as a future device.

**Table 6.1.3-4 Nitrogen Oxides Emission Regulation**

| | Emissions Regulation | No.8/9 (250 MW x 2) | No.10 (250 MW x 1) | 660 MW SC unit | |
|---|---|---|---|---|---|
| SCR | None | No Installation | No Installation | Case 1 | No Installation |
| | | | | Case 2 | Space being considered as a future device |

The longitudinal size of SCR is 20 m in layout as future device in Case 2. In addition, SCR requires an ammonia storage tank as its accessory. The size of length 30 m x width 25 m is planned in layout as future installation, resulting from the experience of Kyushu Electric Power.

### 6.1.4 Examination of Equipment Size Affecting the Layout

#### 6.1.4.1 Examination Policy

When the coal planned for this project and the coal used in our existing coal-fired thermal plants are compared, there are differences in heat generation, ash content and so forth as shown in Table 6.1.4-1. It is, therefore, necessary to consider these differences in examining the facility size.

**Table 6.1.4-1 Comparison of Planned Coals**

| Item | Design Coal for This Project | Typical Coal Used in Japan*3 |
|---|---|---|
| Fixed Carbon | 29.7 %*1 | 58.1 % |
| Volatile Matter | 17.7 %*1 | 23.9 % |
| Moisture Content | 8.0 %*2 | 3.2 % |
| Ash Content | 44.6 %*2 | 14.8 % |
| Gross Heating Value | 3,300 kcal/kg*2 | 6,500 kcal/kg |

Source: *1: Development Consultants, Detailed Project Report for 2 x 250 MW Coal Based Extension Thermal Power Station at Barauni Dist. Begusarai in Bihar

*2: 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)

*3: Experience of Kyushu Electric Power

Therefore, a survey shall be conducted on 660 MW coal-fired thermal plants being planned in India to check the facility sizes.

### 6.1.4.2 Experienced Sizes of Coal-Fired Thermal Power Station in India

The following 4 power plants were examined regarding the 660 MW coal-fired thermal plant being planned in India. Table 6.1.4-2 shows the names of the power plants and sizes of their main equipment.

**Table 6.1.4-2 Survey Results on the Sizes of 660 MW TPS in India**

| Name of Plant | RAGHUNATHPUR TPS | | MEJA TPS | | SURATGARH TPS | | ENNOR TPS | |
|---|---|---|---|---|---|---|---|---|
| Coal used | Domestic coal | | Domestic Coal (presumed) | | Unknown | | Mixed Coal of domestic and Imported | |
| Size | Longitudinal | Width | Longitudinal | Width | Longitudinal | Width | Longitudinal | Width |
| Power train | 368 | 143 | 393 | 138 | 387 | 121 | 389 | 134 |
| Boiler/ coal pulverizer | 66 | 87 | 64 | 93 | 45 | 83 | 63 | 86 |
| ESP | 54 | 107 | 55 | 115 | 56 | 103 | 56 | 115 |
| Turbine building | 50 | 143 | 47 | 138 | 41 | 121 | 51 | 134 |

Of the above 4 power plants, RAGHUNATHPUR TPS was confirmed to be using coals that are equivalent to the domestic coal planned for this Project. Table 6.1.4-3 below shows the coal properties to be used in RAGHUNATHPUR TPS.

**Table 6.1.4-3 Designed Coal for Reference TPS**

| Item | RAGHUNATHPUR TPS Design Coal | Design Coal for this study |
|---|---|---|
| Fixed Carbon | 22.00 % | 29.7 % |
| Volatile Matter | 18.00 % | 17.7 % |
| Moisture Content | 15.00 % | 8.0 % |
| Ash Content | 45.00 % | 44.6 % |
| Gross Heating Value | 3,200 kcal/kg | 3,300 kcal/kg |

As shown in Table 6.1.4-3, it is therefore decided that the facility size for RAGHUNATHPUR TPS will be used for reference in the layout examination. It was also confirmed about the sizes of boiler/coal pulverizer and ESP that there are no large differences in the facility sizes.

### 6.1.4.3 Boiler/Coal Pulverizer

Table 6.1.4-4 shows the information and its source in checking the boiler/coal pulverizer size in RAGUHUNATHPUR TPS.

**Table 6.1.4-4 Parameters Regarding RAGUHUNATHPUR TPS Boiler/Coal Pulverizer**

| Item | Parameters | Source |
|---|---|---|
| Boiler/coal pulverizer size | 66 m x 87 m | (b) |
| Coal pulverizer size | 12.5 m x 10.5 m | (b) |
| Plant Heat Rate | 2,320 kcal/kWh | (b) |
| Gross Heating Value for Design Coal | 3,200 kcal/kg | (b) |
| Coal Consumption*1 | 11,500 t/day/unit | (b) |
| Number of Coal Pulverizer Units installed | 8 units | (b) |
| BMCR | 1.2 times the TMCR (including auxiliary steam) | (a) |
| Number of Necessary Spare Coal Pulverizer units | 1 unit *2 | (a) |
| Normal Coal Pulverizer Load | 90 % | (a) |

*1: Consumption when operating at PLF100%
*2: Number of spare units necessary for BMCR operation with design coal
Source: (b) RAGHUNATHPUR THERMAL POWER STATION BIDDING DOCUMENTS

Since it is difficult to confirm the size of the boiler single unit with the information the Team obtained, the size of the adjacent coal pulverizer size is examined here. The equipment capacity per unit of coal pulverizer calculated based on the above data is shown as follows:

**Table 6.1.4-5 Comparison of Coal Pulverizers**

| | RAGHUNATHPUR TPS Coal Pulverizer | Coal Pulverizer Experiences in Kyushu Electric Power |
|---|---|---|
| Capacity of Coal Pulverizer | 76 t/h/unit | 64 t/h/unit |
| Size of Coal Pulverizer | 12.5 m x 10.5 m | 12.0 m x 9.5 m |

When the coal pulverizer used in Kyushu Electric Power's coal-fired power plant and the coal pulverizer of RAGHUNATHPUR TPS are compared, it is clear that they are nearly equivalent and thus, it is considered that it can be used for reference.

Furthermore, coal pulverizers were arranged on both sides of the boiler in any of the plants that were examined. It is assumed that this is because the coal pulverizer room becomes much longer than the boiler when it is arranged only on one side of the boiler (Refer to Figure 6.1.4-1).

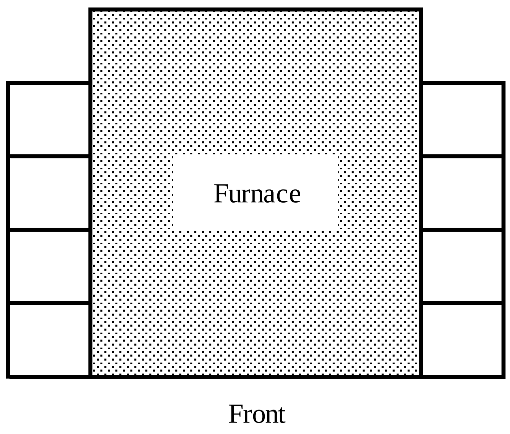
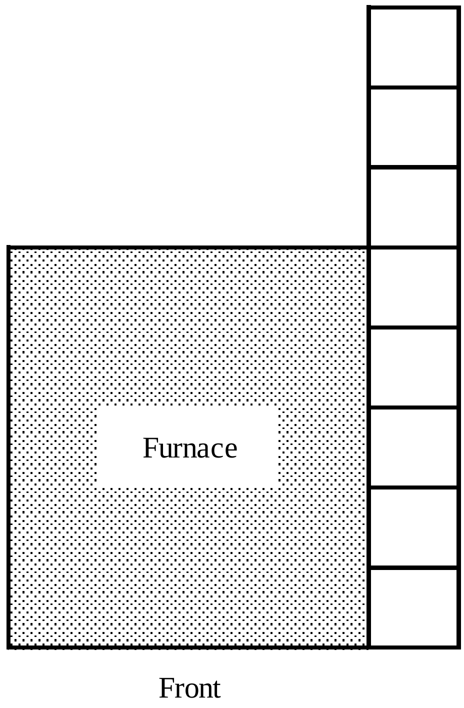
| Arranged on Both Sides of the Boiler | Arranged on One Side of the Boiler |
|---|---|
|  |  |





**Figure 6.1.4-1 Typical Examples of Coal Pulverizer Arrangement**

Based on the above, facility configuration in which there are 4 units of coal pulverizers on both sides of the boiler for a 660 MW SC unit will be also assumed.

#### 6.1.4.4 Electrostatic Precipitator

To check ESP size in RAGHUNATHPUR TPS, ESP size based on the information obtained about RAGHUNATHPUR TPS and our design concept was calculated and compared with the drawing size.

The information on RAGHUNATHPUR TPS and its source are shown as follows:

**Table 6.1.4-6 RAGHUNATHPUR TPS Coal Dimensions, etc.**

| Item | Parameters | Source |
|---|---|---|
| (Element Analysis on Coal)<br>RAGHUNATHPUR TPS Worst Coal | | |
| Carbon | 25.40 % | (b) |
| Hydrogen | 2.80 % | (b) |
| Sulfur | 0.50 % | (b) |
| Oxygen | 5.10 % | (b) |
| Nitrogen | 0.70 % | (b) |
| Hygroscopic Moisture | 17.00 % | (b) |
| Ash Content | 48.00 % | (b) |
| Gross Heating Value | 2,800 kcal/kg | (b) |
| (Atmospheric Conditions) | | |
| Atmospheric Temperature | 35.8 °C | (b) |
| Atmospheric Humidity | 45 % | (b) |
| (Plant Conditions) | | |
| Plant Heat Rate | 2,320 kcal/kWh | (b) |
| Percentage of Excess Air | 20 % | (a) |
| APH Leak Amount | 10 % | (a) |

A combustion calculation was conducted based on the above information to figure out the flue gas quantity and soot concentration at ESP inlet for RAGHUNATHPUR TPS. The strictest condition in which the entire ash content in coal becomes fly ash and flows into ESP was assumed.

**Table 6.1.4-7 Assumptions for ESP Inlet**

| Item | Rough Calculation |
|---|---|
| ESP Inlet Gas Volume (wet) | 2,342 x $10^3$ $Nm^3/h$ |
| ESP Inlet Dust Concentration | 112 $g/Nm^3$ |

In calculating ESP size, the following ESP design specifications were used:

**Table 6.1.4-8 ESP Design Specifications**

| Item | Design Specifications | Source |
|---|---|---|
| Outlet Dust Concentration | 50 mg/$Nm^3$ or lower | (a) |
| Inlet Gas Temperature | 150 °C | (c) |
| Dust Migration Speed | 0.2 m/s | (c) |
| Dust Collector Electrode Plate Width | 4.5 m/casing | (c) |
| Dust Collector Electrode Plate Height | 15 m | (c) |
| Dust Collector Electrode Plate Gap (ESP length direction) | 2.0 m | (c) |
| Dust Collector Electrode Plate Pitch (ESP width direction) | 300 mm | (a) |
| ESP Spare Casing (ESP length direction) | 1 casing/flow | (a) |
| ESP Gas Flow Velocity | 1.0 m/s or lower | (a) |
| Dust Collector Electrode Plate Quantity | 52 plates/flow/casing | |

Source: (c) Development Consultants, Detailed Project Report for 2 x 250 MW Coal Based Extension Thermal Power Station at Barauni Dist. Begusarai in Bihar

When the overall ESP size in RAGHUNATHPUR TPS is checked on the drawing, 107 m of width and 54 m of length are shown. Designing with our concept to deliver an equivalent value as this width results in 6-flow 96 m in length. ESP gas flow velocity for this case will be 0.66 m/s, which satisfies the design specification of 1.0 m/s or lower. The changes in ESP outlet dust concentration caused by the change in the number of casings in the direction of gas flow are shown below:

**Table 6.1.4-9 Outlet Dust Concentration by Number of ESP Casings**

| Number of ESP Casings (including spare casing) | ESP Length (m) | Outlet Dust Concentration ($mg/Nm^3$) |
|---|---|---|
| 2 casings | 11.0 | 6,222 |
| 3 casings | 17.5 | 1,879 |
| 4 casings | 24.0 | 750 |
| 5 casings | 30.5 | 345 |
| 6 casings | 37.0 | 175 |
| 7 casings | 43.5 | 94 |
| 8 casings | 50.0 | 53 |
| 9 casings | 56.5 | 32 |

A rough calculation on the sizes that satisfy the outlet soot concentration of 50 $mg/Nm^3$ or lower resulted in a width of 96 m and length of 56.5 m. Since these dimensions are nearly equivalent to width 107 m and length 54 m that are from the dimensions of RAGHUNATHPUR TPS, the size for RAGHUNATHPUR TPS can be applied as it is.

### 6.1.4.5 Flue Gas Process System

**(1) Types of ESP and GGH**

According to DPR of No.10, it plans to install an ESP immediately downstream to Air Pre-Heater (APH) and thus ESP is expected to be a low-temperature type. Therefore, a rotary regenerative type is inevitably selected for Gas-Gas Heater (GGH) when FGD is planned as a facility for the future. On the other hand, when a low low-temperature ESP is to be installed, it will be combined with a non-leak type GGH and thus this combination is adopted in Japan, where an FGD is installed from the beginning due to the emissions regulations on TPS. As shown below, the combination between a low low-temperature ESP and non-leak GGH delivers many advantages compared to the conventional combination of a low-temperature ESP and rotary regenerative type GGH:

**(2) Combination of Low-Temperature ESP and GGH and FGD as Future Devices**

- Conceptual Image of Facility Configuration

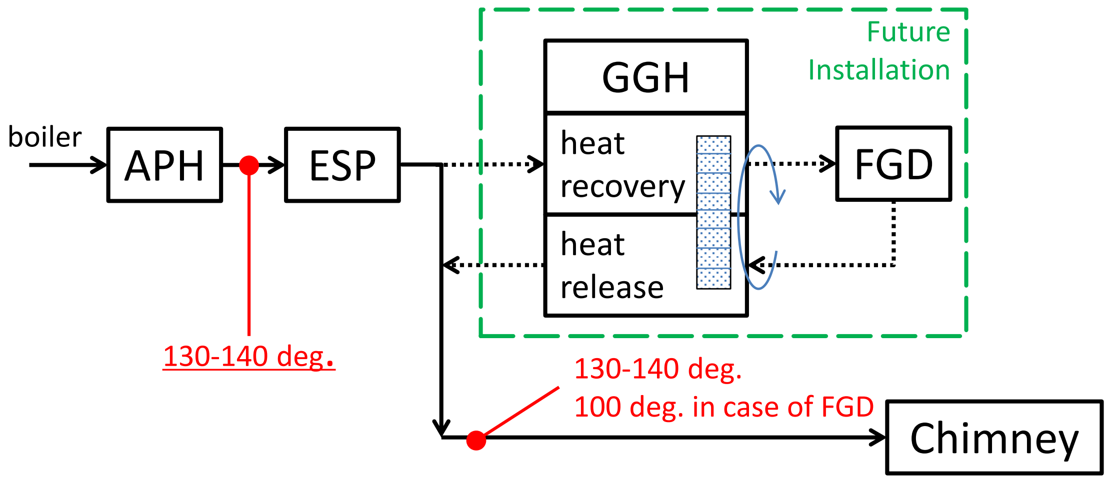



**Figure 6.1.4-2 Facility Configuration with FGD in Future**

- Structural Characteristics

Since the gas ducts need to be gathered by GGH to conduct heat exchange between untreated gas and treated gas in GGH when a low-temperature ESP is adopted, there are restrictions in the equipment layout. Furthermore, a leak from the untreated gas side to the treated gas-side cannot be avoided due to the structural problem of GGH rotary element.

➢ Necessary Dimensions

A rough calculation was conducted on the dimensions of a 660 MW SC unit in this report, and the results are shown as follows:

**Table 6.1.4-10 Dimensions of Low-Temperature ESP and Future Device FGD**

| Item | Length | Width | Source |
|---|---|---|---|
| Low-Temperature ESP | 54 m | 107 m | Field-Proven in India |
| FGD | 88 m | 61 m | Experience of Kyushu Electric Power |

**(3) Combination of Low Low-Temperature ESP and Non-Leak GGH and FGD**

➢ Conceptual Image of Facility Configuration

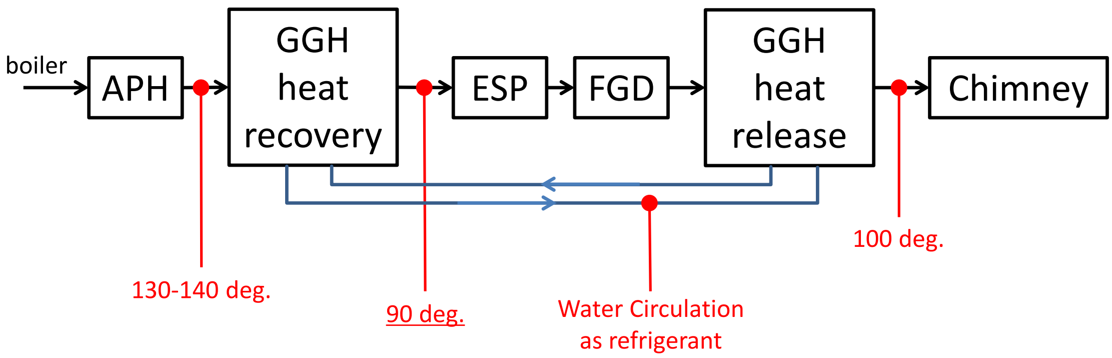



**Figure 6.1.4-3 Facility Configuration with FGD from Beginning**

➢ Structural Characteristics

When a low low-temperature ESP is installed, GGH heat recovery part is installed between APH and ESP. The gas flows with the temperature reduced by 40 to 50 °C. Since water is used as the refrigerant, a system to circulate water becomes necessary. Since low low-temperature ESP has a lower treated gas temperature, it can be more compact than a low-temperature ESP. It can be made even more compact by adopting a traveling electrode type. Furthermore, its one-way flow of flue gas allows more flexibility in layout and the characteristic that there is no leak of untreated gas into the treated gas side in GGH results in a smaller environmental impact.

➢ Necessary Dimensions

A trial calculation was conducted on the dimensions of a 660 MW SC unit in this report, and the results are shown as follows:

**Table 6.1.4-11 Dimensions of Low Low-Temperature ESP (Fixed + Traveling Electrode Type) and Non-Leak GGH**

| Item | Length | Width | Source |
|---|---|---|---|
| Low Low-Temperature ESP | 37 m | 64 m | Rough Calculation Results |
| GGH heat recovery part | 10.5 m | 39 m | Experience in Kyushu Electric Power |
| FGD (including GGH heat release part) | 90 m | 46 m | Experience in Kyushu Electric Power |

**(4) Dimensions of ESP Flow Direction**

ESP dimensions can also be changed depending on the selection of the electrode type. Assuming from the size of ESPs in records in India, dust collection seems to be conducted only with fixed electrode type, and the length of ESP is increased in this case. In Japan, the size is made more compact and dust collection efficiency is improved by installing a traveling electrode on the final stage of the fixed electrode type. The typical dimensions of ESP flow directions with the electrode methods adopted in Japan are shown in Table 6.1.4-12 below.

**Table 6.1.4-12 Typical Size of ESP**

| | Electrode Selection | Size in Flow Direction |
|---|---|---|
| Low-Temperature ESP | Fixed Electrode Type | Base |
| Low-Temperature ESP | Fixed + Traveling Electrode type | 60-70 % |
| Low Low-temperature ESP | Fixed + Traveling Electrode type | 55-65 % |

**(5) Conclusion**

Based on the above, the layout is examined for the following two cases for a 660 MW SC unit in this Pre-FS.

**Table 6.1.4-13 Examination Cases Regarding the Configuration of Flue Gas Process System**

| | ESP | FGD | GGH |
|---|---|---|---|
| Case 1 | Low-Temperature type with fixed electrode | Not Installed (space only) | Not Installed (Space only, Rotary Regenerative type in future) |
| Case 2 | Low Low-Temperature type with fixed + traveling electrode | Installed from beginning | Non-leak Type, Installed from beginning |

### 6.1.4.6 Coal Storage Yard

#### (1) Open-Air Coal Storage Yard

The length of the coal storage yard was calculated for the following parameters with reference to the design details for Units No.8/9.

**Table 6.1.4-14 Parameters of Coal Storage Pile**

| Item | Unit | Parameters | Source |
|---|---|---|---|
| Gross Thermal Efficiency | % | 39.5 | Table 6.1.1-1 |
| Coal Storage Yard Capacity | day | 15 | (d) |
| PLF | % | 90 | Table 6.1.1-1 |
| Pile Width | m | 48 | Results of Interview from STEAG |
| Pile Height | m | 10 | |
| Angle of Repose | degree | 35 | |

Source: (d) CEA, STANDARD DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT of 2 x (500 MW OR ABOVE) THERMAL POWER PROJECT (September 2010)
(hereinafter referred to as "**BOP Guideline**")

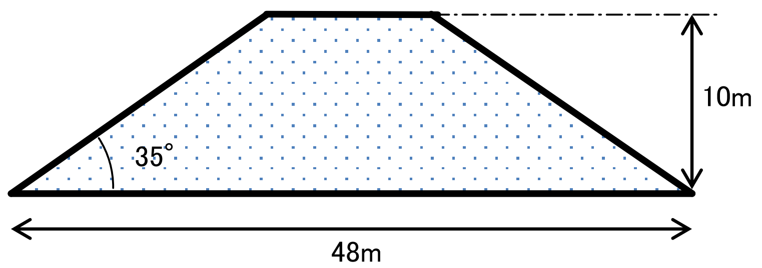



**Figure 6.1.4-4 Cross Sectional Shape for Coal Storage Pile**

As a result, the necessary length of coal storage yard from calculation is 619 m.

#### (2) Adoption of Coal Silo

While one pile of coal storage yard is prepared for Unit No.10, the current yard does not have enough space to ensure the coal storage capacity for 15 days used by a 660 MW SC unit. Thus the adoption of the coal silo structure was examined to seek a measure to increase the coal storage capacity in the vertical direction.

In this case, ensuring coal capacity for 15 days equals storage of 167,000 ton[1].

When the coal silo with a good practice in Japan, which has a diameter of 33 m and is capable of storing 25,000 tons per silo is adopted, the number of silos necessary would be 7 (total of 175,000 tons).

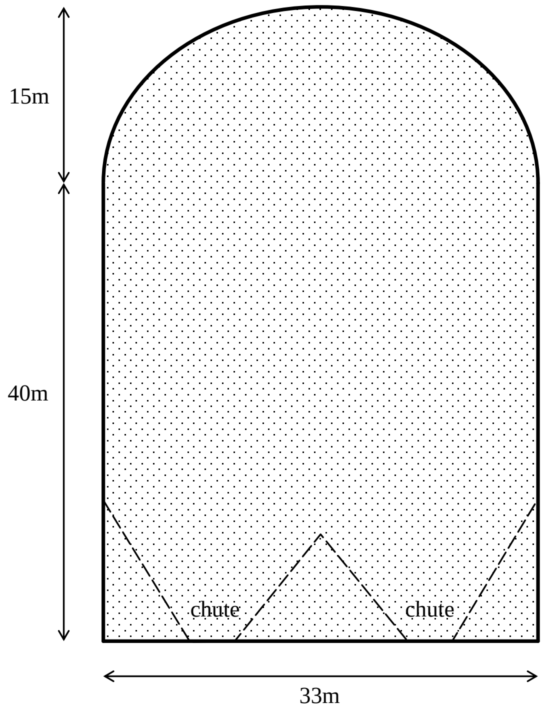



**Figure 6.1.4-5 Cross Sectional Shape of Coal Storage Silo**

### 6.1.5 Turbine Building (Turbine Room + Intermediate Room)

The necessary size of the steam turbine room was planned by ensuring the following lengths with consideration given to the space necessary for its disassembly.

**Table 6.1.5-1 Dimensions of Steam Turbine and Turbine Building**

| Item | Dimensions |
|---|---|
| Turbine Shaft Length (including Generator) | About 55 m |
| Turbine Building Dimensions | Long side: 102 m<br>Short side: 40 m |

1 Refer to Section "6.1.12 Calculation of Coal Consumption/Coal Ash Generation"

### 6.1.6 Cooling Tower

The types of condenser cooling methods can be largely classified into water-cooled types and air-cooled types. According to DPR of No.10, a cooling tower with forced draft type is adopted for condenser cooling.

**Table 6.1.6-1 Comparison of Condenser Cooling Type**

<table>
<tr><th>Cooling Medium</th><th>Model</th><th>Cooling Water Quantity</th><th>Adoption Case</th><th>Draft Type</th><th>Adoption of Existing Units</th></tr>
<tr><td>Seawater</td><td>Contactless</td><td>Large</td><td>When the location is on the coast and a large volume of water can be directly taken in,</td><td>—</td><td>Not Applicable</td></tr>
<tr><td rowspan="3">Air</td><td rowspan="2">Contact type</td><td rowspan="2">Medium</td><td rowspan="3">When the location is inland or a large volume of water cannot be used,</td><td>Forced</td><td>No.1-9</td></tr>
<tr><td>Natural</td><td>Not Applicable</td></tr>
<tr><td>Contactless</td><td>Small</td><td>Forced</td><td>Not Applicable</td></tr>
</table>

Barauni TPS adopts cooling towers with the forced draft type in all of the existing Units No.1-7 and both Units No.8/9 which are under construction, and it is assumed that this is because the facility is more compact when compared with natural draft cooling towers.

Since it is planned to use water from the Ganges for a 660 MW SC unit, cooling tower type should be selected. A survey on records in India revealed that two out of the four sites shown in Table 6.1.4-2 adopted forced cooling type Table 6.1.6-2 shows the results of rough calculation on the size of cooling tower and the number of units.

**Table 6.1.6-2 Cooling Tower Specifications**

<table>
<tr><th>Type</th><th>Item</th><th>Field-Proven in India</th><th>Rough Calculation</th></tr>
<tr><td>Natural Draft</td><td>Diameter</td><td>140 m</td><td>103 m</td></tr>
<tr><td rowspan="2">Forced Draft</td><td>Size in Length and Width</td><td>20 m x 151 m</td><td>32 m x 161 m</td></tr>
<tr><td>Number of fans</td><td>20 units<br>(of which 1 unit is standby)</td><td>20 units<br>(of which 1 unit is spare)</td></tr>
</table>

As arrangement is made with the external shapes of the above two methods in layout (only the forced draft type is shown for the planned area for Unit No.10), it is recommended that it should be investigated in detail so as to which methods should be adopted in the next FS.

### 6.1.7 Electrical Systems

The function of Electrical Systems include all electrical equipment required for the main BTG plant and auxiliaries for a 660 MW SC unit including an external coal/ash handling system, water intake system and EHV power evacuation systems.

As stipulated in Part A - Substations and Switchyards, in Chapter IV of CEA TS, the rated voltage of EHV systems for a 660 MW SC unit shall be 400 kV. The transmission lines of the system may be out of the scope of power station construction, so this section will cover the electrical systems related to the in-house electrical systems and EHV switchyard equipment. For transmission lines, see “4.6 Power Evacuation.”

#### 6.1.7.1 System Configurations

**(1) EHV System**

The preliminary basic system Key Single Line Diagrams (SLD) for EHV system is prepared in Figure 6.1.7-2 and Figure 6.1.7-3. Section 42 - Design Considerations for Sub-stations and Switchyards, Part A, in Chapter IV of CEA TS, stipulates that the configuration of a 400 kV switchyard of Air Insulated Switchgear (AIS) shall be a one-and-a-half configuration or double main and transfer bus configuration. The preliminary pros and cons of the two configurations are shown below：

**Table 6.1.7-1 Feature Comparison for EHV System Configurations**

<table>
<tr><th colspan="2">Configurations</th><th>Double main + Transfer Bus</th><th>One-and-a-half (1 + 1/2)</th></tr>
<tr><td colspan="2">Bay No.</td><td>10</td><td>10</td></tr>
<tr><td colspan="2">CB[*1] No.</td><td>12</td><td>15</td></tr>
<tr><td colspan="2">Generator Transf.</td><td>1</td><td>1+1/2</td></tr>
<tr><td colspan="2">Station Transf.</td><td>1</td><td>1+1/2</td></tr>
<tr><td colspan="2">T Line 1 D/C</td><td>2</td><td>3</td></tr>
<tr><td colspan="2">T Line 2 D/C</td><td>2</td><td>3</td></tr>
<tr><td colspan="2">Bus Transfer</td><td>1</td><td>—</td></tr>
<tr><td colspan="2">Bus Coupler</td><td>1</td><td>—</td></tr>
<tr><td colspan="2">Tie Transf[*2]. D/C</td><td>2</td><td>3</td></tr>
<tr><td colspan="2">Future Bay D/C</td><td>2</td><td>3</td></tr>
<tr><td rowspan="5">Pros & Cons</td><td rowspan="2">Reliability</td><td>Base</td><td>High</td></tr>
<tr><td>Flexibility in operating and maintenance with transfer bus</td><td>Single circuit failure isolates single circuit, bus failures do not affect circuits</td></tr>
<tr><td rowspan="2">Cost</td><td>Base</td><td>Slightly moderate</td></tr>
<tr><td>Double bus, single circuit breaker for double main bus</td><td>With a breaker and a half for each circuit</td></tr>
<tr><td>Area</td><td>Moderate</td><td>Greater</td></tr>
</table>

*1: CB　Circuit Breaker　*2: Tie Transf　Tie Transformer (i.e. 440kV/220kV)

**(a) Double Main and Transfer Bus Configuration (2+1 Transfer Bus)**

This configuration is arranged with all circuits connected between a double main (operating) bus and transfer bus (also referred to as an inspection bus). Some arrangements include a bus tie breaker as a bus coupler that is connected between both main buses with no circuits connected, and as a bus transfer that is connected between both main buses and transfer bus with no circuits connected to it. Since all circuits are connected to the double main bus, the reliability of this system is the same as a double bus configuration. However, with the transfer bus available during maintenance, de-energizing of the circuit can be avoided. Some systems are operated with the transfer bus normally de-energized. When maintenance work is necessary, the transfer bus is energized by either closing the bus transfer tie breaker, or when a tie breaker is not installed, closing the switches connected to the transfer bus. With these switches closed, the breaker to be maintained can be opened along with its isolation switches. Then the breaker is taken out of service. The circuit breaker remaining in service is then connected to both circuits through the transfer bus. This way, both circuits remain energized during maintenance. Since each circuit may have a different circuit configuration, special relay settings may be used when operating in this abnormal arrangement. When a bus tie breaker is present, the bus tie breaker is the one used to replace the breaker being maintained, and the other breaker is not connected to the transfer bus.

A shortcoming of this configuration is that if the main bus is taken out of service, even though the circuits can remain energized through the transfer bus and its associated switches, there would be no relay protection for the circuits. Depending on the system arrangement, this concern can be minimized through the use of circuit protection devices (re-closure or fuses) on the lines outside the substation. This arrangement is slightly more expensive than the double main bus arrangement, but does provide more flexibility during maintenance. Protection of this configuration is similar to that of the double bus arrangement.

The area required for a low profile substation with a main and transfer bus configuration is also a little greater than that of the double main bus, due to the additional switches and transfer bus.

**(b) One-and-a-Half Configuration (1+1/2)**

The one-and-a-half configuration can be developed from a ring bus arrangement as the number of circuit breakers increases. In this configuration, each circuit is located between 2 circuit breakers, and there are two main buses. The failure of a circuit will trip the 2 adjacent breakers and not interrupt any other circuit. With a three-breaker arrangement for each bay, a center breaker failure will cause the loss of the 2 adjacent circuits. However, a breaker failure of the breaker adjacent to the bus will only interrupt 1 circuit.

Maintenance of a breaker on this configuration can be performed without an outage occurring to any circuit. Furthermore, either bus can be taken out of service with no interruption to the service. This is one of the most reliable arrangements, and it can continue to be expanded as required.

This arrangement is slightly more moderate than the double main and transfer bus arrangement. Protection of this configuration is similar to that of the double bus arrangement. This configuration will require more area due to the additional components.

During the site survey, Barauni TPS members expressed their preference for the same scheme as the 220 kV switchyards for Units No.8/9 that are currently under construction. To accommodate this preference, a plot plan for a 400 kV SS based on the double main and transfer bus configuration is shown Figure 6.1.7-1.

The plot plan has been prepared based on the Gas Insulated Switchgear (GIS) type, but because the dimensions are to be determined mostly by the gantry structure with the interface offset of 400 kV transmission lines, the dimension of the switchyard for the whole power station plot plan has been determined to include the switching facilities (GIS), lighting arrester, post insulator, electric room and outer fences.

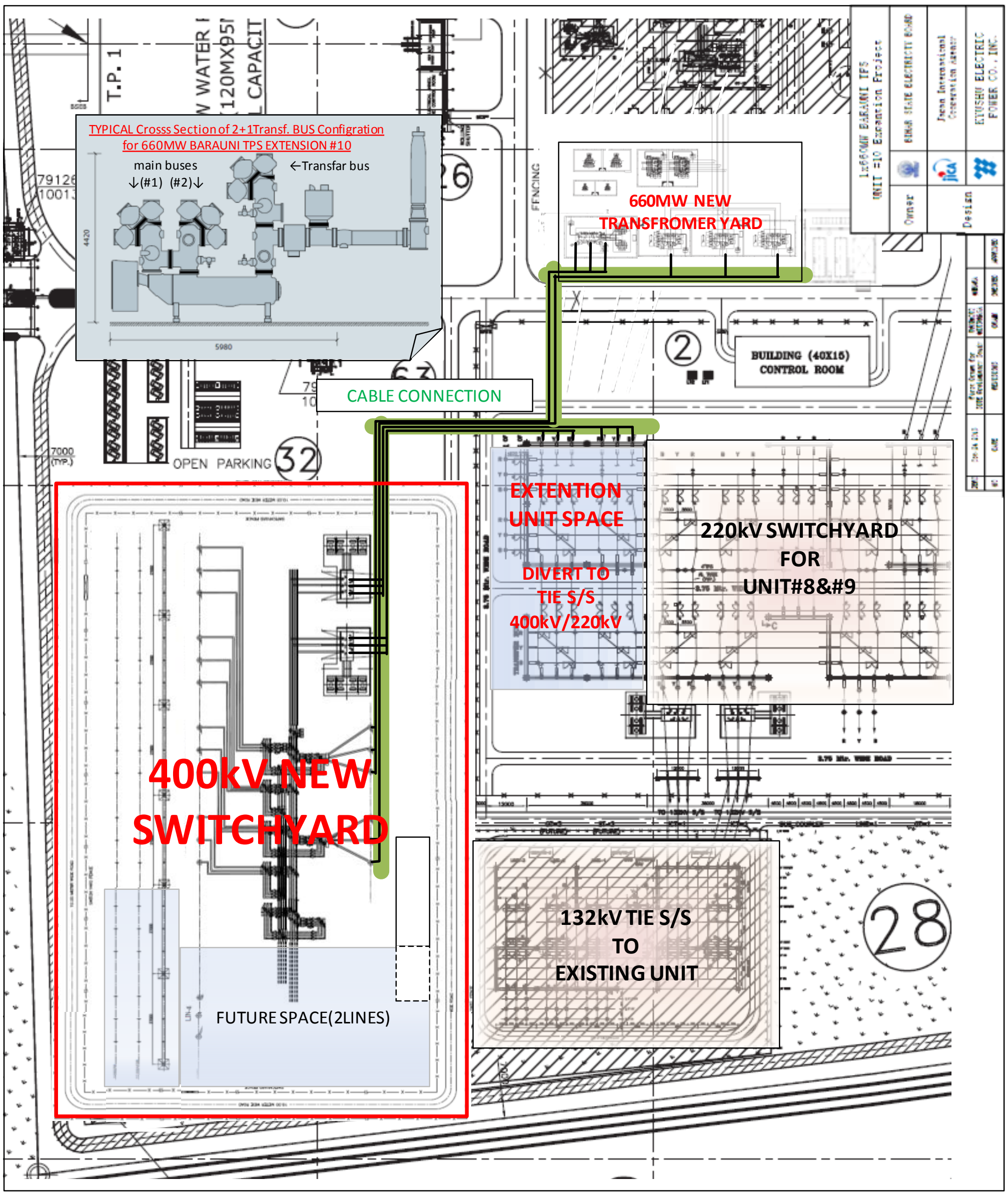



**Figure 6.1.7-1 Preliminary Plot Plan for Barauni 400 kV Switchyard (JICA Study Team)**

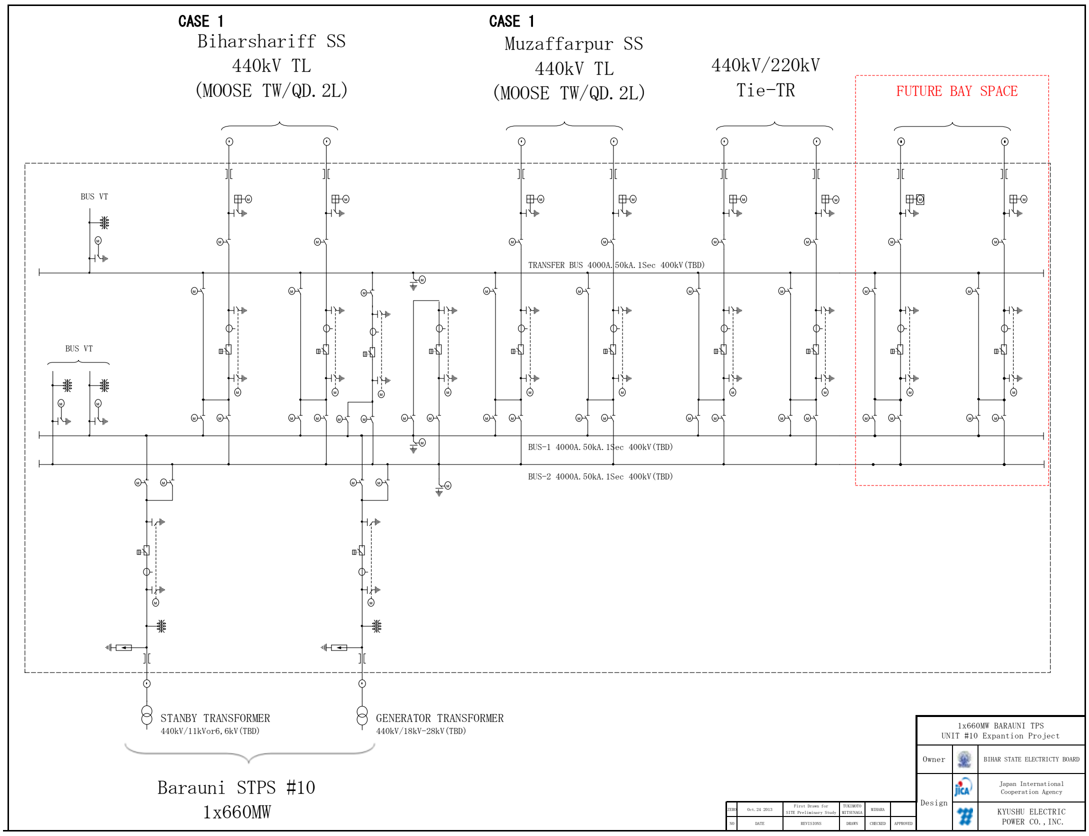



**Figure 6.1.7-2 Preliminary Key SLD for EHV System (2 +1 Transfer Configuration) (JICA Study Team)**

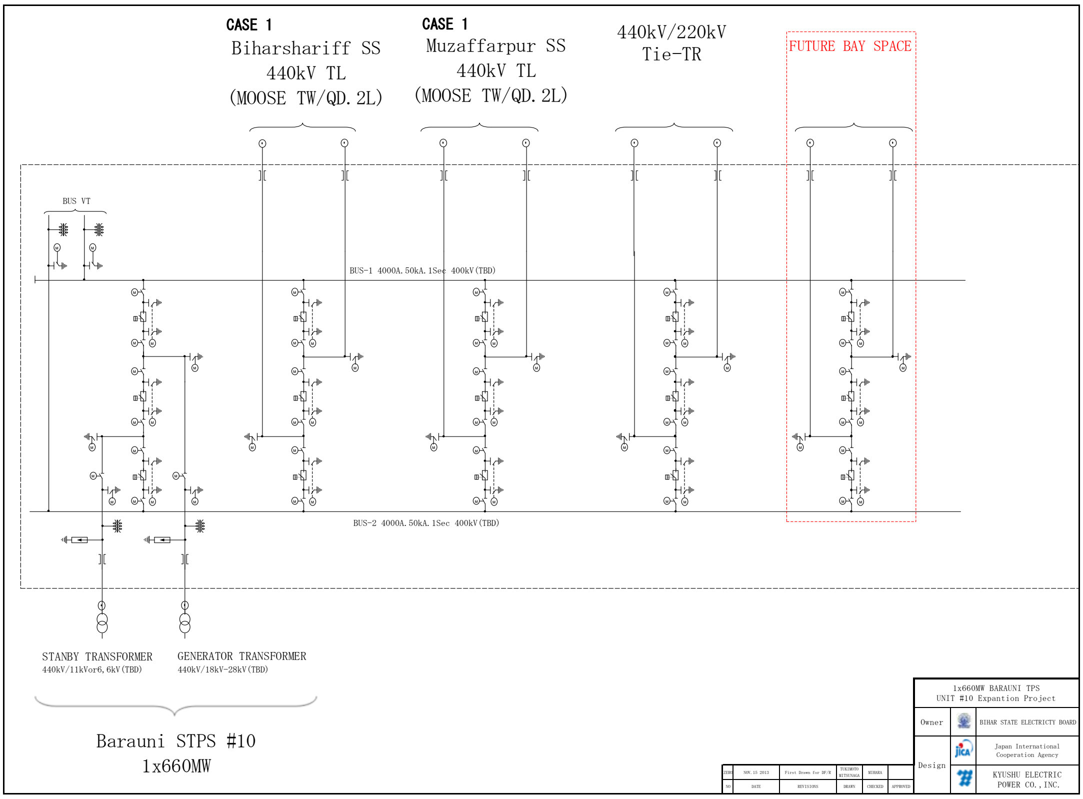



**Figure 6.1.7-3 Preliminary Key SLD for EHV System (1 + 1/2 Configuration) (JICA Study Team)**

**(2) Electrical Systems for Thermal Power Station**

The preliminary key SLD of the electrical systems on the power station is shown in Figure 6.1.7-4. The electrical system will be designed to meet with "Section 10 Electrical System for Coal and Lignite based Thermal Generating Stations", Part B, in Chapter II of CEA TS, at this Pre-FS stage, the Team proposed to configure the station power source with the redundant buses supplied from the unit transformer branched from the power generator circuit (approximate 18 kV - 28 kV) between the power generator and the main generator transformer, and have the standby transformer connected to the 400 kV SS.

**(a) HV and LV Switchgears**

With regard to HV switchgear and LV switchgear voltage levels of the station power source, the same voltage levels as the existing 250 MW facility, i.e., 6.6 kV and 415 V respectively, are acceptable from the viewpoint of the facility's configuration. However, for HV switchgear, the Team has selected a twin bus voltage system with redundant buses as 11 kV redundant buses for the transmission of equipment power source for island systems and 6.6 kV or 3.3 kV redundant buses for auxiliary motors. The reason behind this scheme is the advantage of being able to lower the rated current when transmitting electricity by 11 kV cables to off-site facilities such as a coal handling system, water intake system and ash handling system. A lower rated current leads to a lower in house consumption of power due to reduced power supply loss, as well as reduced initial costs because of the smaller size and number of cables and reduced size of the cable duct.

**(b) Emergency AC Power Supply**

The redundant bus configuration of the emergency alternate current line has been made by laying out 2 Automatic Mains Failure Diesel Generators (AMF DG) of the same rating. The basic concept for uninterruptible power-supply (UPS) systems may be distributed installation to the places where it is needed such as some desktop computers, while a triple power supply UPS is proposed when a system is requested for an aggregated power supply.

**(c) Emergency DC Power Supply**

As for the direct current system, 2 battery banks and triple chargers that are 100 % redundant have been applied for plant protection and control, and redundancy of regular and emergency power sources and an emergency power source backup system have been installed as the power source for the charger. An individual redundant DC power supply system will be planned for island facilities including a coal handling system, water intake system, ash handling system and EHV switchyards.

**(d) Consideration for Feasibility Study**

As stipulated in Chapter II Part B section 10 (3) Power Transformer of CEA TS, the standby transformer may be abbreviated, so the standby transformer unit and relevant bay of the 400 kV switchgears can be omissible when a generator circuit breaker (GCB) scheme is adopted.

During the next FS, the Team may include to investigate the conceptual capacities and detailed specifications of each piece of equipment, power source back up scheme for environmental facilities such as ESP, integration of the generator transformer and the unit transformer, reduction of isolated phase bus duct connection area, flexible layout by using cables and a change of the generator excitation system power source to HV to reduce initial costs for development of a power plant based on our experience in utilities.

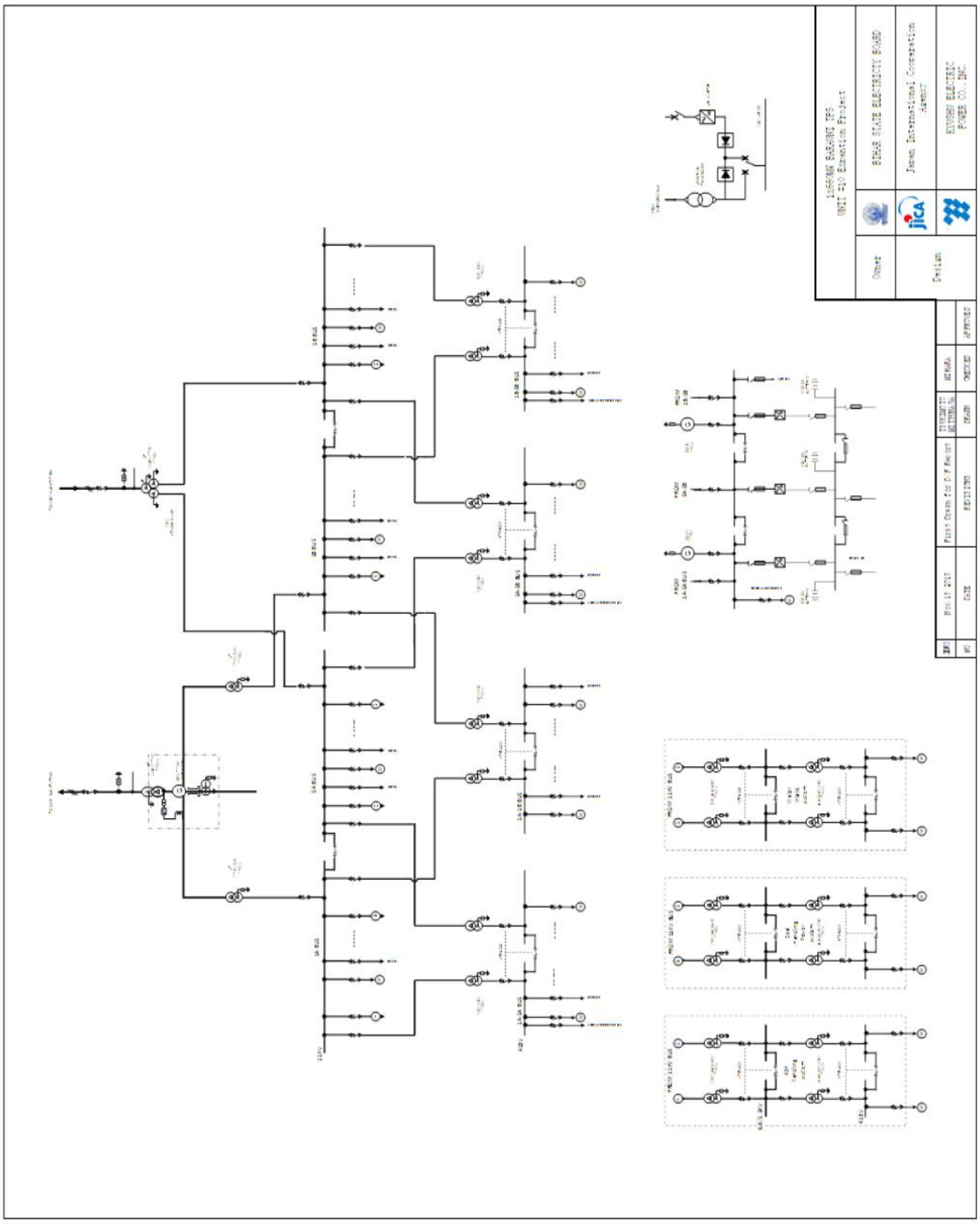


**Fig. 6.1.7-4 Preliminary Key SLD for Barauni TPS 660 MW SC Unit (JICA Study Team)**

### 6.1.7.2 System Brief Description

The major pieces of equipment/systems covered include but are not limited to:

**(1) Generator**

Generator and its accessories (cooling system, excitation system, automatic voltage regulator), auto synchronizer, generator control/metering and protection panel, generator neutral cubicle (Neutral Grounding Transformer (NGT) and Neutral Grounding Resistor (NGR)).

**(2) Generator Circuit Breaker (GCB)**

Generator Circuit Breaker complete with all auxiliary systems and accessory equipment. At this Pre-FS stage, GCB is shared with the breaker at EHV power transformer outlet.

**(3) Isolated Phase Bus Duct (IPB)**

Isolated Phase Bus Duct between generator and GCB, and between GCB and generator transformer, tap-off to UTs, SPVT cubicle, and CTs for generator phase-side, neutral side and tap-off to UTs, generator neutral formation cubicle and neutral earthing transformer and resistor also included.

**(4) 400 kV Substation**

Power evacuation EHV power systems can be comprised of a GIS or AIS and included with switchyard complete with all necessary equipment/accessories, for transmission of power generated at the plant to the grid, bus reactors (if needed) and including outdoor gantry structures and tariff metering equipment. OPGW cable termination equipment will also be included.

**(5) Power Transformers**

Generator transformers (GTs), unit transformers (UTs), standby transformer (STs), completes with relay panels, remote OLTC/LTC control cabinet, all fittings and accessories, neutral grounding resistors for UTs.

**(6) Auxiliary Transformers & Service Transformers**

11 kV/3.3 kV, 3.3 kV/433 V and 11 kV/433 V transformers for feeding supply to auxiliary loads complete with all fittings and accessories, for feeding supply to plant auxiliary external water intake system, external coal/ash handling system, and other balance of plant mechanical auxiliary system, complete with fittings and accessories.

**(7) Neutral Earthing Equipment**

Earthing resistors for 11 kV/6.6 kV or 3.3 kV system neutrals to be limited the earth fault current to 300 Ampere (maximum).

**(8) HV Switchgear (11 kV/6.6 kV/3.3 kV)**

As described above, for the tension level of HV switchgears it will be possible to select between 11 kV/6.6 kV/3.3 kV configurations. HV switchgears will come complete with breakers, contactors and dis-connectors, bus bars; instrument transformers, relays, meters, terminal blocks, dummy panels, for units, stations, external coal handling system, ash handling systems and water intake systems.

**(9) LV Switchgear (415 V)**

LV Switchgears will come complete with breaker/contactor, bus bar, instrumentation transformers, relays, meters, terminal blocks, dummy panels, bus for unit including ESP & soot blower system, station, external coal handling system auxiliaries, ash handling system, 220 V DC or 440 V DC switchgear, normal/emergency switchgear, etc.

**(10) Substation Systems**

The substation system will include full protection, control, metering, monitoring and communication functions of all the 400 kV bays.

**(11) Electrical Distribution Management System**

Control and monitoring of the in-plant electrical distribution system of BTG area and offsite plants system such as ash handling plant (AHP), Coal Handling Plant (CHP), PT/Demineralized Water (DM) plant, Water Intake System (WS), FO system, etc. may be controlled with the help of an electrical distribution management system.

**(12) Segregated/Non-Segregated Bus Duct**

Segregated phase bus duct (SPBD) between UTs & HV switchgear, non-segregated bus duct (NSPBD) between 415 V service transformer to LV service switchgear PMCC.

**(13) Motors & Actuators**

Drive motors and actuators for all rotating mechanical equipment with gear reducer and coupling for all equipment wherever required. Motors with VFD wherever required will be included.

**(14) Cable & Cable Carrier System**

All HV/LV power, control, fiber optic and special cables and cable raceway systems with the necessary fire barriers, fireproof sealing and coating systems, cable supporting structures, cable trenches, cable racks, cable trays, duct banks, conduits, cable laying and cable termination.

**(15) DC System**

Individual full redundant DC systems complete with batteries, chargers, battery racks, battery MCBs, and distribution board for unit, coal handling, ash handling, water intake system, GIS etc.

**(16) Emergency DG/GT Set**

Two of the same rated emergency DG/GT devices will complete with all auxiliary systems and accessory equipment. The black start functions for this unit will be out of scope for the reason that Subarnarekha Hydroelectric Power Station (HPS) of Jharkhand State Electricity Board (JSEB) specified priority I black start unit for Barauni TPS as stipulated in the guideline of “Black Start Facility Start up Power and Restoration Procedure for Eastern Regional Grid” of ERLDC.

**(17) Earthing And Lightning Protection**

Earthing and lightning protection for the entire plant including BTG area, chimney, cooling tower complete with earth grids and electrodes buried in soil in the plant area, embedded in concrete inside the buildings to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons. Lightning protection complete with vertical air termination rods, horizontal roof conductors, down comers, test links and pipe electrodes.

**(18) Illumination**

Illumination will include lighting transformers, normal and emergency DBs, AC/DC lighting panels, towers, poles, lighting fixtures, lamps, aviation warning lights, power sockets, etc. for the entire plant covering all the buildings, switchyard, outdoor areas, chimney, cooling tower outdoor illumination for roads, yards, boundary, etc.

**(19) Communication System**

System will include a telephone system and PA system for the plant.

### 6.1.8 Control and Instrumentation Equipment

Since control and instrumentation equipment have no impact on the overall layout plan of the power station, at this Pre-FS stage, this section provides some brief explanation on the control and instrumentation equipment and the trend regarding the latest control systems. It also includes actual I&C System Paradigm for SC coal-fired TPS Projects in India, including equipment configurations of Yokogawa India Limited (YIL), which is a valued and devoted supplier of control systems that offers advantages in terms the price, reliability and continuity of its system series and whose systems and instrumentation equipment are introduced at enormous number of coal-fired power plant in India.

#### 6.1.8.1 System Configurations

The Control system and Instrumentation Equipment shall be designed in accordance with Section 11 - Control and Instrumentation System for Coal and Lignite based Thermal Generating Stations, Part B, in Chapter II of CEA TS. Preliminary key System Configuration Diagram is shown in Fig. 6.1.8-1.

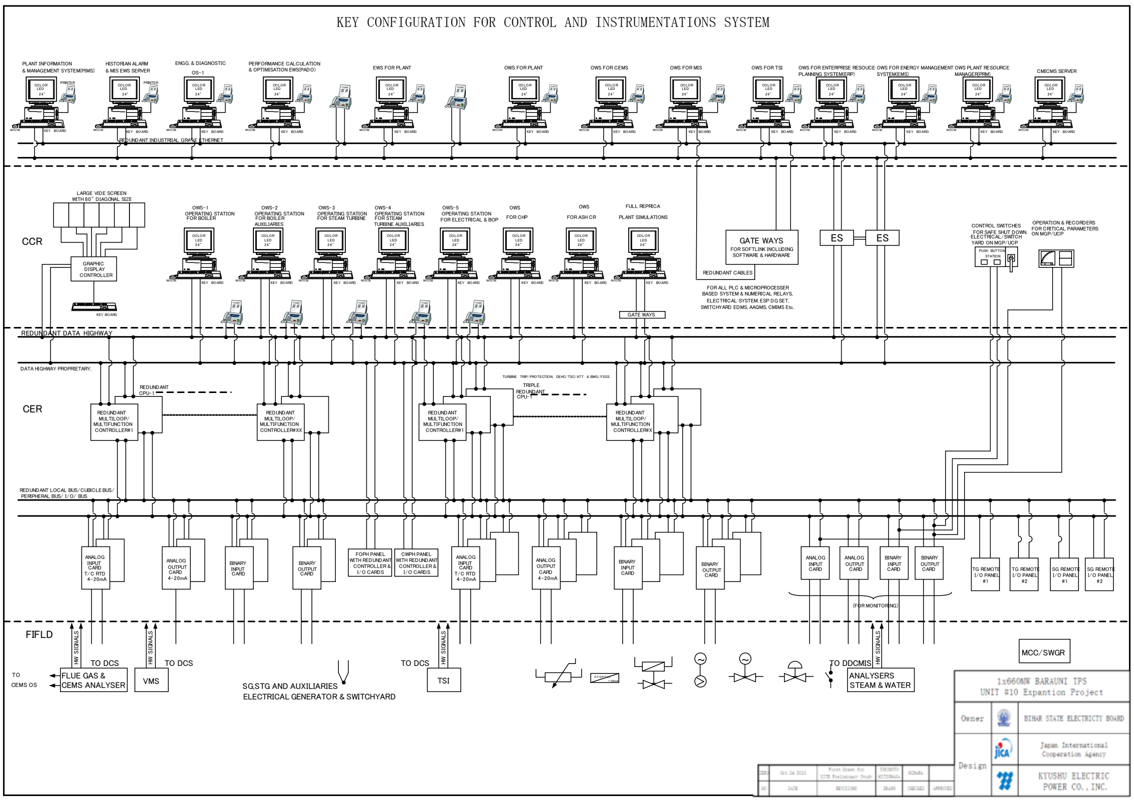



**Figure 6.1.8-1 Preliminary Key System Configuration Diagram for Barauni TPS 660 MW**

The typical scope of Control and Instrumentation Equipment that constitutes the facilities related to the planning of a 660 MW SC unit shows in Table 6.1.8-1.

**Table 6.1.8-1 Typical Scope of Control and Instrumentation Equipment**

| No. | Control and Instrumentation Functions | Abbreviations |
|---|---|---|
| 1 | Distributed Digital Control System | DCS |
| 2 | Safety Instrumented System | SIS |
| 3 | Annunciation System | |
| 4 | Plant information and Management system | PIMS |
| 5 | Electrical Distribution Monitoring System | EDMS |
| 6 | Supervisory Control Panels, Supervisory Desks and Equipment Panels | |
| 7 | Enterprises Resource Planning System | ERP |
| 8 | Monitoring & Information System | MMI |
| 9 | Performance Analysis Diagnosis and Optimization System | PADO |
| 10 | Energy Management System | EMS |
| 11 | Computerized Maintenance & Inventory Management System | CMCMS |
| 12 | Plant Resource Manager | PRM |
| 13 | PLC & Other Control Sub System | |
| 14 | General Field and Measuring Instruments, Flow Elements | |
| 15 | Environment Monitoring Systems | |
| 16 | Continuous Emission Monitoring System | CEMS |
| 17 | Steam and Water Analysis System | SWAS |
| 18 | Power Supply & Utilities for control system UPS System & 24 V DC system | |
| 19 | Erection hardware & Cables | |
| 20 | Control Valves with Actuators | |
| 21 | Plant Security and Surveillance System | |
| 22 | Material Supply, Ware Housing, Erection, Testing and Commissioning<br>Tools, Tackle & Calibrating Instruments<br>Control Instrumentation Laboratory & Testing Equipment | |
| 23 | Plant Simulations Coupling with DCS system | |

### 6.1.8.2 System Brief Description

**(1) Distributed Control System (DCS)**

A Distributed Control System (DCS) package will realize safe operation throughout the plant, plant information management, and integrated plant resource management, as well as efficient maintenance management.

Requirement for coal-fired power plants have become increasingly severe year by year due to higher demands for power in other countries. Specific requirements include higher temperature and pressure of steam, a change from a drum boiler to a once-through boiler and the suitable operation of partial load. SC coal-fired power plants, in particular, have very complicated control logic, because the process, function of rapid load control, and startup and shutdown procedures are more complicated than drum-type boilers that used to be the mainstream in the past. The improved performance of DCSs is largely contributing to stable operation of SC type power plants which have more sophisticated and complicated requirements as mentioned above. Selecting a DCS with high reliability, as described below, and having superior maintainability and a long-term support system is necessary for the stable operation of the plant.

A controller, the core entity to ensure reliability, shall have a dual redundant configuration by allocating a pair of modules, to which two microprocessors (MPUs) are mounted, to each function to keep the operation rate of 99.99999 % as Non-Stop controller with pair and spare Reduced Instruction Set Computer (RISC) Central Processing Unit (CPU) of sub-millisecond switch over true redundancy and fully complete on-line maintenance. The control bus of the entire system shall have a configuration where the controller, some Man Machine Interface (MMI) device of non-server configuration, maintenance and engineering tools and other items that make up the system are directly connected to redundant control buses with a transmission speed of 1 G bps where the bus speed shall be applied to the control bus and data highway, not only MMI data highway, but also communication between controllers, controllers and MMI. Boiler control and control of auxiliary equipment such as lower emission equipment and flue gas desulfurization equipment, turbine governor control and protection equipment shall be directly connected to the control bus and can be operated on the same control bus.

CPU module, the power supply module and I/O module shall be implemented in dedicated 19-inch racks, and each rack shall be connected by an internal communication bus module. As a basic design concept, CPU, power supply and internal bus shall be fully redundant with no single part between CPU and I/O modules, and a single or redundant configuration will be selected depending on the significance of the process. All types of I/O modules that are only connected by pre-fabricated cables with connectors shall have a redundant configuration, and redundancy functions should be included as the basic function of the system instead of application software or external wiring. A flexible system configuration shall be made in the above-mentioned way according to the importance of the process.

Alarm and event analyzing shall be conducted in the right sequential order for the entire system by receiving a time synchronization signal using Global Positioning System (GPS). In particular, SOE (Sequence of Event) is a function to display information at the resolution of 1 ms accuracy to Coordinated Universal Time, which is important especially for the analysis of incidents, and to appropriately manage events by collecting I/O data with time stamping given by DI module through each controller and displaying it in chronological order.

Coal-fired power plants tend to be positioned as the base operation power source of the country, and as a result, a long-term stable operation lasting for up to several tens of years is required. This also goes for control systems, and it is vital to carefully consider long-term expeditious maintenance services, long-term migration, continuity and application compatibility of the system, as well as scalability and integration capability for additional plants in the future.

In terms of modification maintenance in the future, a system that allows users to perform modification and upgrade only to the equipment in need of maintenance is required to be introduced from the viewpoint of plant operation availability, reduction of maintenance costs and shortening the time required for modification (e.g., upgrading operation monitoring software at the time of Windows OS upgrade, CPU module hot replacement for increased arithmetic capacity, etc.).

### (2) Outline of Safety Instrumentation System (Compliant with Safety Integrity Level (SIL) 3)

To prevent serious accidents at coal-fired TPS caused by burner flame-out or a breakdown of a large auxiliary machine, a safety instrumentation system (SIS) compliant with SIL 3 shall be used for boiler protection and burner management. SIS shall be integrated in combination with DCS mentioned in Section (1), connected to the same control bus without gateway as DCS mentioned in Section (1) to operate as one integrated system. An efficient operation shall be achieved by displaying vital information for plant operation together, such as SIS alarm, graphics and SOE with 1 ms time stamp resolution, from DCS MMI devices. As in the case of DSC configuration, redundant configuration shall be investigated for all of the configurations of CPU, power source, internal-bus and I/O module. In both conditions of redundant or single, SIL 3 shall always be complied with, for example, when double redundancy of a module becomes single redundancy temporarily for reasons such as replacement, the system should still keep complying with SIL 3.

### (3) Outline of Field Equipment and Analyzers

A differential pressure transmitter and a pressure transmitter shall be installed for the measurement of flow amount and pressure of the plant system of water, steam, fuel and air. The sensor devices of transmitters must have excellent measurement accuracy, and a transmitter to which a silicon resonant sensor is mounted should be selected, because it does not require a calibration process for a long period of time. In an effort to optimize the number of devices installed, a transmitter with a multi-sensing function which displays both pressure and differential pressure should be employed depending on the process required.

Some zirconia-type oxygen meters shall be installed at economizer outlets to measure oxygen to control combustion.

A Continuous Emission Monitoring System (CEMS) shall be installed to measure the total amount of regulated substances such as NOx, SOx, CO and $CO_2$ in the emissions from the chimney. An infrared analyzer and oxygen analyzer shall be installed to enable functions such as measurement of concentration, temperature, pressure and flow amount of regulated substances, report management, and data transmission to related institutions.

Additionally, a steam and water analysis system (SWAS) shall be installed to measure pH, electric conductivity, silica concentration and turbidity.

And if the plant shall be equipped NOx removal equipment, in the latest cases a laser gas analyzer may be installed at the outlet of the boiler to measure levels of ammonia.

### 6.1.8.3 Latest Technology and Trends

#### (1) Field Digital Signals and Integrated Device Management Solutions

Recently, the standard plant management concept has been to centrally manage information of each device parameter and condition monitoring from on-site field equipment in the central control room by utilizing field digital signals such as HART (Highway Addressable Remote Transducer), FF (Foundation Fieldbus) and Profibus for the purpose of optimizing plant maintenance. Before this solution, the conditions of each device were individually checked on the field, so it was difficult to understand the conditions of devices in real time and it took a long period to make a maintenance plan. Parameters also had to be set carefully by checking each setting item when replacing a device. By introducing integrated device management solution software (PRM: Plant Resource Manager), field digital signals can be centrally managed, device conditions can be checked from the central control room without having to go to the field, and a maintenance plan can be made and a device can be replaced smoothly and security without human error.

Regarding the configuration, PRM shall be directly connected to the control bus of DCS mentioned in Section (1) to store field digital signals in the computer of PRM via I/O module and CPU module. An I/O module suitable for the type of the field digital signal should be selected during the system design phase of DCS and SIS of Section (1) and (2).

#### (2) Full Replica Plant Simulators

Coal-fired power plants tend to be positioned as the main source of power. Hence operators' skills and experience, not to mention the system reliabilities and performance, are vital for ensuring stable operation of the plant. Not many countries have enough engineers who are sufficiently skilled and experienced in the operation of SC coal-fired power plants, so smooth operation may not be possible after completing the construction of the plant.

As mentioned above, the operation of SC coal-fired power plants is becoming sophisticated and complicated compared to the subcritical unit, and understanding the complicated process dynamic characteristics, load following in response to load dispatch, exact startup and shutdown procedures, and handling of plant abnormal conditions are required. However, there are rarely any opportunities for the actual operators to be able to experience real operations under conditions that are equivalent to the actual process.

Under such circumstances, a full replica plant simulator built by DCS manufacture in-house is introduced to train operators to improve the operators' skills up to a sufficient level before starting commercial operation. Major configuration of a simulator includes a standard PC based plant model DCS MMI with a virtual operation function and a simulator setting PC. Plant models are made by skilled engineers based on the actual process dynamic characteristics, and in the latest DCS control logic is able to connect to the plant simulator model without modification or translation via dedicated gate way, so training can be conducted in an environment that differs only slightly from the actual one. Profitable scenes can be set as required by using this realistic plant model, including plant startup and shutdown process simulation and random load increases. In addition, operators can be trained beforehand by simulating the process state of random plant abnormality, so that correct measures can be taken when they encounter plant abnormal condition during actual operation. The demand for power plant replica simulators is very high, and this is not a limited phenomenon seen only in India, and they are playing an important role in improving the overall skills of operators.

#### 6.1.8.4 Actual I&C System Archetype for Super Critical Coal-Fired Thermal Power Station Projects in India

The following Table 6.1.8-2 and Table 6.1.8-3 (in Bihar State) show archetypes of the system actually installed at SC coal-fired power plants in India:

**Table 6.1.8-2 Raipur Chhattisgarh TPS Project (685 MW x 2)**

**1. Project:**

The site is located near Raikheda village, Raipur District in Chhattisgarh state, India.

- Owner: GMR Charttishgarh Energy
- Project type: Green field project,
- Yokogawa Korea was selected by Doosan for Controls & Instruments (C&I) scope

**2. Boilers:**

SC pressure once through boiler
Supplied by Doosan Babcock.

- Rated;
- Main steam; 570 °C, 590 kg/s, 250 bar at BMCR
- RH steam; 597 °C, 469 kg/s, 47 bar at BMCR
- The steam generators are SC sliding pressure, direct pulverized coal-fired, once-through, single reheat unit.
- Side wall firing type
- 5 Burners × 7 ROWs
- 7 × Mills per unit

**3. Steam Turbines:**

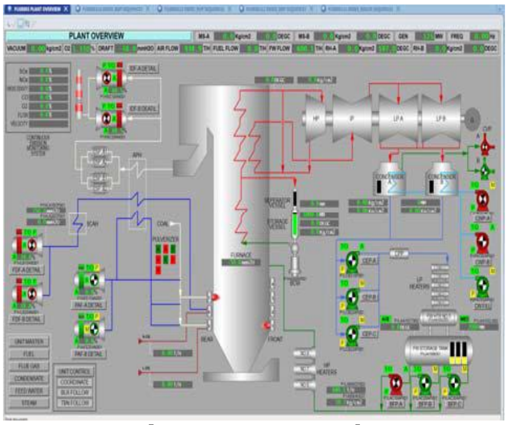
Supplied by Doosan (GE License)

- Rated at 685 MW, 3,000 rpm
- HP/LP Bypass system

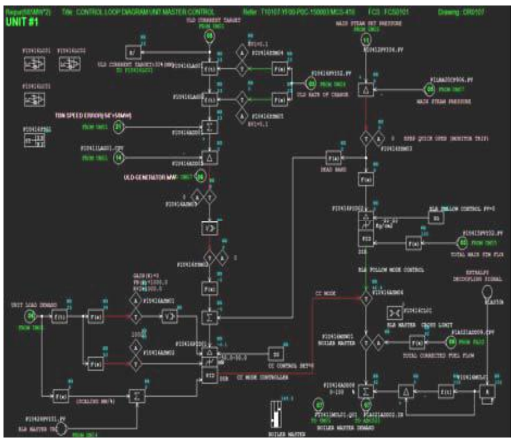
**4. Scope of Supply of YOKOGAWA**

- CENTUM VP DCS for control of boiler,
- BMS, Turbine and BOP
- Prosafe –RS: SIL3 certified Safety Instrumented System, for boiler protection
- MFT Relay panel
- Total I/O points approx. 26,000
- Hi-fidelity Operator Training Simulator
- PADO (Performance Analysis Diagnosis and Optimization)
- Exaquantum for PIMS (Plant Information Management System)
- CMIMS (Computerized Maintenance & Inventory Management System)
- Electrical Distribution Monitoring System
- Energy Management System (Metering)
- Field instruments


Location of the site



Boiler overview graphic



Unit master control logic

## Table 6.1.8-3 BARH TPS Project (660 MW × 3), Bihar State

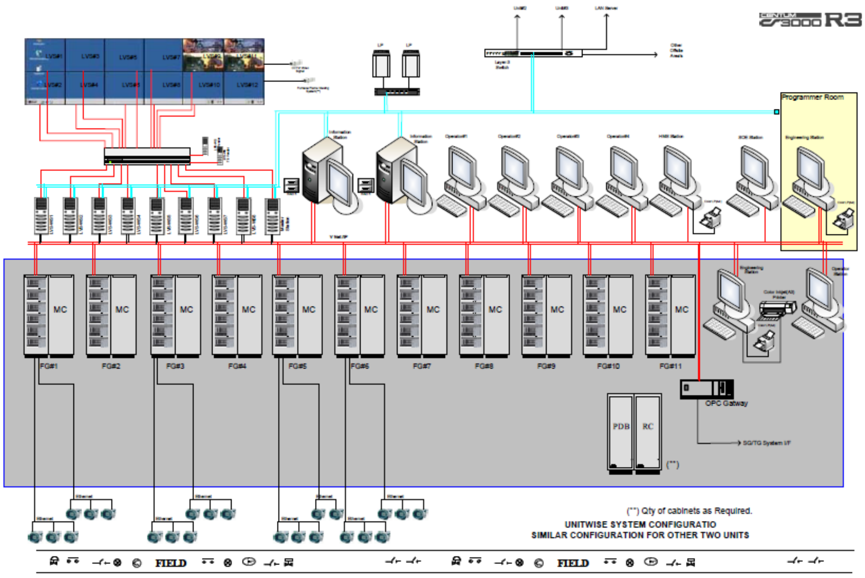
**1. Project:**
The power station is built at Barh, Patna district Bihar state, India
- Owner: NTPC,
- Project type: Greenfield project
- Yokogawa India Limited directly contracted with NTPC for C&I scope.

2. **Boiler:**
The steam generators are SC sliding pressure, direct pulverized coal-fired, once through, single reheat unit.
- Supplied by TECCHNOPROMO EXPORT; Russia- Rated; 2,225 T/H,
- Rated; 2,225 T/H,
- 247 kg/cm$^2$
- 537/565 °C:
- Side wall firing type,
- Pressurized type vertical spindle mills

**3. Steam turbines:**
- Supplied by Power Machines (LMZ); Russia
- Rated; 660 MW, 3,000 rpm
- Single reheat condensing type, tandem compound design. HP/LP bypasses system.
- HP capacity; not less than 65 % of the steam flow at BMCR condition.
- Capable of operating on pure and/or modified sliding pressure mode. It can be switched over to constant pressure mode of operation also.
- The Automatic Turbine Run-up System (ATRS) is required for the plant.

Location of the site

**4. Scope of supply of YOKOGAWA**
CENTUM CS3000 control system for modulating control of the steam generator, feed water & condensate cycle as well as binary control auxiliaries of BTG, Coal Handling Plant and Water System etc.
- Total Approx. 80,000 I/Os
- 90 HMI/EWS
- 43.of 80” Large screens
- CCTV system – 188 cameras
- Vibration Monitoring System
- Field Instruments (PT,DPT,TT,LT,TE)
- Steam and water analyzers
- Continuous emission monitoring system
- UPS and 24 VDC systems
- Paging system



System architecture of one unit

### 6.1.9 Water Balance

According to the water balance plan attached to DPR of No.10, only the supernatant water from the ash disposal area is to be collected and recycled after transferring the coal ash to the ash disposal area as slurry. This recycling system is planned to reduce the volume of water intake, and it is not adopted in Units No.6-9. As water consumption in Unit No.10, DPR plans 1,000 $m^3$/h when there is recycling and 1,500 $m^3$/h when there is no recycling. Considering this point, a rough calculation was made as follows as the necessary volume of water intake when a 660 MW SC unit is introduced:

**Table 6.1.9-1 Results of Water Balance Assumption**

| | No.8/9 (250 MW x 2) | No.10 (250 MW x 1) | 660 MW SC unit |
|---|---|---|---|
| When there is no recycling | 2,530 $m^3$/h (24.8 cusec[*1]) | 1,500 $m^3$/h (14.7 cusec) | 3,351 $m^3$/h (32.9 cusec) |
| When there is recycling | — | 1,000 $m^3$/h (9.8 cusec) | 2,295 $m^3$/h (22.5 cusec) |

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

Considering that there is recycling in normal conditions by recirculation from an ash disposal area, the volume of water necessary for a 660 MW SC unit is smaller than corrected volume equivalent to 660 MW output from the plan of Unit No.10 (250 MW x 1). However, this is because an once-through boiler is adopted. While a boiler blow-down occurs when a once-through boiler is started, the impurities in water can be removed and good conditions are maintained without concentration of the impurities as a condensate demineralizer is included in the main steam system. On the other hand, a drum-type boiler (subcritical pressure) requires periodical blows as it does not have a condensate demineralizer in the main steam system and the impurities in supplied water become concentrated in a drum.

Furthermore, when FGD is introduced in future, the flue gas cooling water and absorption liquid are sprayed within the device and thus the water after treatment becomes effluent. According to our records, the effluent water is approximate 70 $m^3$/h. Since the water balance plan considers the facilities that are considered to require no constant replenishment of water with maximum values, it was determined that the necessary volume by FGD would be sufficiently satisfied within the water balance plan.

Based on the above, water intake of about 78 cusec will be necessary as the total for Units No.6-9 and a 660 MW SC unit. As the permitted water intake amount is currently 45 cusec, it is necessary to apply for permission of an additional 33 cusec at the water permission authority.

As the capacity of the water intake facility at the Ganges is only 50 cusec, reinforcement of water intake capacity by 28 cusec will be necessary.

**Table 6.1.9-2 Change in Necessary Volume of Water and Permission on Additional Water Intake (Unit: cusec)**

| | No.6/7 | No.8/9 | No.10 | 660 MW SC unit | Total |
|---|---|---|---|---|---|
| Necessary Volume (before change) | 20 | 25 | 15 | ― | 60 |
| Necessary Volume (after change) | 20 | 25 | ― | 33[*1] | 78 |
| Water Intake Permission | 45 (already acquired) | | ― | 33 (additional acquisition) | 78 |

*1: "Necessary Volume (after change)" of a 660 MW SC unit is based on the case of no water recycling.

### 6.1.10 Miscellaneous Equipment

#### 6.1.10.1 Coal Handling Plant

Typically a belt conveyor is used to transport coal from a coal storage yard to a coal bunker. If coal is transported with a belt conveyor, the necessary horizontal distance between the coal storage yard and coal bunker is determined by the transfer angle and coal bunker height. Thus, the transfer angle, the coal bunker height and necessary horizontal distance between the coal yard and coal bunker were examined.

**(1) Transfer Angle**

The transfer angle of coal-fired TPS resulting from the experience of Kyushu Electric Power is approximately 14.5° and 16° or less according to the document of RAGHUNATHPUR TPS which has been referred to. This time, a rough calculation has been made temporarily assuming that the transfer angle is 15°. Table 6.1.10-1 shows the relationship between horizontal distance and transfer height.

**Table 6.1.10-1 Relationship between Horizontal Distance and Transfer Height**

| Horizontal Distance | 40 m | 80 m | 120 m | 160 m | 200 m | 240 m | 280 m | 320 m |
|---|---|---|---|---|---|---|---|---|
| Transfer Height | 10.4 m | 20.7 m | 31.1 m | 41.4 m | 51.8 m | 62.1 m | 72.5 m | 82.8 m |

The transfer height becomes larger as the transfer angle is increased, but a too large transfer height results in increased load on the conveyor drive unit or coal flow. The optimum transfer angle is determined by the coal property and the speed of the belt conveyor. It is recommended to design the optimum angle with next FS.

**(2) Coal Bunker Height**

The coal bunker height can be calculated from the necessary quantity of coal stored and bunker chute angle (height). Based on the coal pulverizer capacity and information from Barauni TPS Units No.8/9 described under “6.1.4.3 Boiler/Coal Pulverizer”, the coal bunker height in this study has been calculated.

**Table 6.1.10-2 Parameters Related to Coal Bunker**

| Item | No.8/9 (250 MW x 2) | 660 MW SC Unit | Source |
|---|---|---|---|
| Coal Storage Requirement | For 12 hours | Same as Left | |
| Coal Consumption | 50 t/h | 76 t/h | Same Consumption of RAGHUNATHPUR TPS (from Table 6.1.5-5) |
| Specific Gravity of Coal | 0.8 | 0.8 | |
| Coal Bunker Capacity Requirement | 600 t | 912 t | Rough Calculation |
| Coal Bunker Capacity | 686 t | 1,041 t | Rough Calculation |
| Bunker Chute Length | 19.7 m | Same as Left | |
| Bunker Chute Upper Length | 1.9 m | 6.2 m | Rough Calculation |
| Bunker Height (GL) | 44.2 m | 48.5 m | Rough Calculation |

The bunker chute angle (height) is influenced by the coal property so that the same design as DPR of No.8/9 has been employed this time. It is recommended to re-design the bunker chute angle (height) based on next FS as required. From the above rough calculation result, the necessary separation between the coal yard and coal bunker is 200 m or more, which is to be considered in the layout design.

### 6.1.10.2 Heavy Fuel Oil/Light Diesel Oil Storage

Heavy fuel and light diesel oil tank are usually installed in coal-fired TPS as a supplementary fuel upon start shutdown or unstable coal combustion. The existing area (Units No.6/7) uses heavy fuel oil that does not solidify at ambient temperature. The heavy fuel oil is categorized in Class 1, which is defined in JIS.

**Table 6.1.10-3 Heavy Oil Standard (JIS K 2205)**

| Type | | Kinematic Viscosity (50 °C, mm$^2$/s) | Sulfur Content (weight percent | Main Application |
|---|---|---|---|---|
| Class 1 (A) | No.1 | 20 or less | 0.5 or less | Internal-Combustion Engine |
| | No.2 | | 2.0 or less | |
| Class 2 (B) | | 50 or less | 3.0 or less | Internal-Combustion Engine and Industrial Boiler |
| Class 3 (C) | No.1 | 250 or less | 3.5 or less | Electric Power Boiler |
| | No.2 | 400 or less | | |
| | No.3 | Above 400 and 1,000 or less | | |

DPR of No.8/9 includes Table 6.1.10-4 showing heavy fuel oil parameters. The heavy fuel oil mentioned above is classified in No.2 of Class 3, judging from its kinematic viscosity. The piping diagram attached in DPR which is around the oil tank shows supply of auxiliary steam for heating. It is planned to use heavy fuel oil of a type that solidifies at ambient temperature.

**Table 6.1.10-4 Heavy Fuel Oil Parameters (Excerpt from DPR of No.10 Annexure-3.6)**

| | Unit | Parameters |
|---|---|---|
| Kinematic Viscosity | cSt (= mm$^2$/s), 50 °C | 370 |
| Sulfur Content | % | 4.5 |

Capacity of the heavy fuel/light diesel oil tanks in Barauni TPS is as follows:

**Table 6.1.10-5 Comparison of Oil Tank Capacity**

| | No.6/7 (110MW x 2) | No.8/9 (250 MW x 2) | 660 MW SC Unit | Experience in Kyushu Electric Power |
|---|---|---|---|---|
| Heavy Fuel Oil Tank | Unknown | 2,000 $m^3$ x 2 | 2,000 $m^3$ x 2 | None |
| Light Diesel Oil Tank | Unknown | 500 $m^3$ x 2 | 500 $m^3$ x 2 | 3,000 $m^3$ x 1 |

The state-of-the art boiler do not need heavy fuel oil as a supplementary fuel. Thus a type that uses only light diesel oil as a supplementary fuel is recommended for the viewpoint of a compact facility layout. Capacity of the light diesel oil tank shall be 3,000 $m^3$ x 1, a capacity corresponding to light diesel oil single fuel combustion with 30 % BMCR for 8 hours running over 4 days, assuming discontinuation of coal supply due to a trouble in the coal handling plan. Using no heavy fuel oil can eliminate the need for installing the Steam Coiled APH to be started only for heavy oil firing.

Planned dimensions of the oil tank are a diameter of 17 m by a height of 14 m. The size of the oil retaining wall shall be 40 m x 40 m in consideration of the capacity of the light diesel oil tank and fire extinguishing water amount defined in NFPA850 regulations.

### 6.1.10.3 Water Intake Equipment

For the water intake, a water pump house, in which water pumps are installed, will be constructed at the tip of a pier from a river bank in the Ganges. Water drawn from the river with the pump is temporarily stored in a sedimentation tank and the clear water in the upper part of the tank is carried to a power station by using a clear water pump through an intake pipe (diameter: 660 mm). Intake pipes are planned to be installed for each unit (No.6/7 x 2 and No.8/9 x 2, for a total of 4).

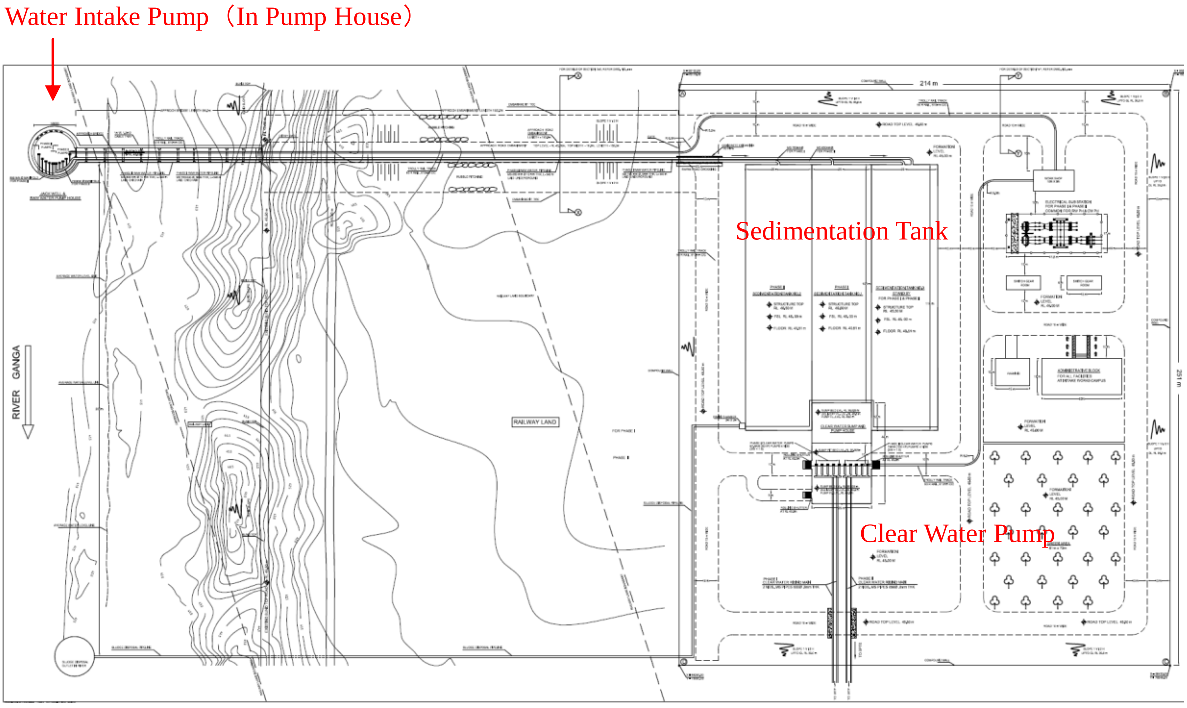
The currently planned capacity of the intake facility is 50 cusec for Units No.6-9. If construction of Unit No.10 is determined, it is reported that the capacity of the intake facility for Units No.6-9 will be increased or if that is difficult, a new intake facility will be built. Considering the efficient facility investment and maintenance, it is desirable to reserve a space for Unit No.10 to accommodate the intake facility for Unit No.10 in the intake facility for Units No.6-9 to support an increase of the capacity of the intake facility for Units No.6-9. In addition, it is recommended to install 2 intake pipes 660 mm in diameter for Unit No.10 in a place adjacent to the intake pipes for Units No.6-9 (land already acquired should be used if possible). As an alternative plan, a single intake pipe having a diameter of 1,000 mm may be used.

According to the collected report, there are no places where the intake pumps for Unit No.10 can be installed in the currently planned pump house for Units No.6-9. While increase of capacity via additional installation of pumps is difficult, the current space may be utilized by reviewing the pump capacity and number of pumps (from 33 % x 5 pumps to 50 % x 3 pumps) (Refer to Table 4.5-1 and 4.5-2). In case the capacity and number of intake pumps for Units No.6-9 is unchanged, the size of the pump house must be changed or a pump house for Unit No.10 must be built anew (and the land must be acquired).

For the structure and specifications the intake pump, pump house and sedimentation tank, details will have to be discussed and determined such as the tap height and lifting height considering the lowest water level of the Ganges.

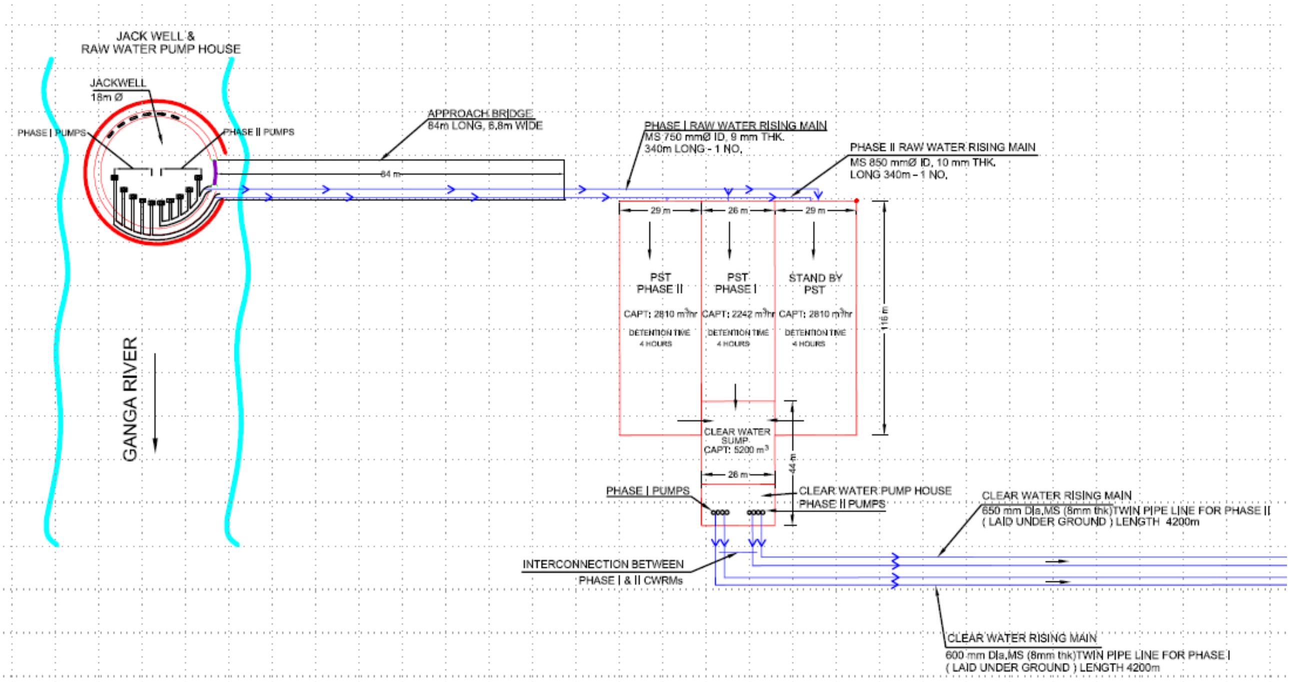
Areas for the sedimentation tank and clear water seem pump have enough space so that expansion and additional installation for Unit No.10 seem relatively easy. A spare sedimentation tank can be shared with Units No.6-9.

The above plan will need arrangement with Units No.6-9 and ultimately that depends on a decision by the project owner.

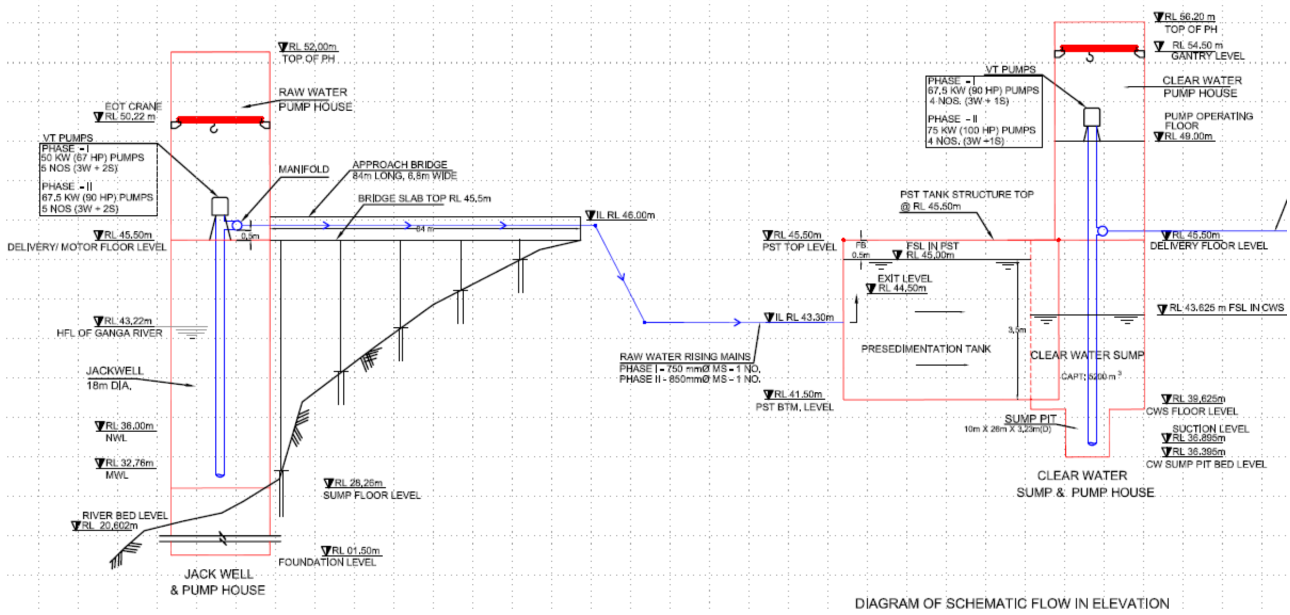



Source: WAPCOS LIMITED, FINAL COMPREHENSIVE DETAILED PROJECT REPORT FOR SUPPLY OF GANGA WATER TO BARAUNI THERMAL POWER STATION (50 MW x 2) + (110 MW x 2) EXISTING & (250 MW x 2) PROPOSED EXTENSION PLANT OF BSEB VOLUME-II:DRAWINGS (March 2011)

**Figure 6.1.10-1 Top View of Pump House to Sedimentation Tank**




Top view of pump house to sedimentation tank




Sectional view of pump house to sedimentation tank

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-II: DRAWINGS (March 2011)

**Figure 6.1.10-2 View of Water Intake Facilities Planned for Units No.6/7 and No.8/9**

**Table 6.1.10-6 Capacity and Number of Units of Water Intake Pumps in Current Plan (for Units No.6/7 and No.8/9)**

| Item | No.6/7 (20 cusec) | No.8/9 (25 cusec) | 660 MW SC Unit (33 cusec) | Total |
|---|---|---|---|---|
| Water Intake Pump Capacity/Number of Units | 6.7 cusec/unit, 3 units + 2 spare units | 8.3 cusec/unit, 3 units + 2 spare units | — (None) | 10 units |

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)

Review plan

**Table 6.1.10-7 Capacity and Number of Units of Water Intake Pumps Considering Unit No.10 (Suggestion)**

| Item | No.6/7 (20 cusec) | No.8/9 (25 cusec) | 660 MW SC Unit (33 cusec) | Total |
|---|---|---|---|---|
| Water Intake Pump Capacity/Number of Units | 10 cusec/unit, 2 units + 1 spare unit | 12.5 cusec/unit, 2 units + 1 spare unit | 16.5 cusec/unit, 2 units + 1 spare unit | 9 units |

**Table 6.1.10-8 Capacity and Number of Units of Clear Water Pumps in Current Plan (for Units No.6/7 and No.8/9)**

| Item | No.6/7 (20 cusec) | No.8/9 (25 cusec) | 660 MW SC Unit (33 cusec) | Total |
|---|---|---|---|---|
| Clear Water Pump Capacity/Number of Units | 6.7 cusec/unit, 3 units + 1 spare unit | 8.3 cusec/unit, 3 units + 1 spare unit | — (None) | 8 units |

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)

Review plan

**Table 6.1.10-9 Capacity and Number of Units of Clear Water Pumps Considering Unit No.10 (Suggestion)**

| Items | No.6/7 (20 cusec) | No.8/9 (25 cusec) | 660 MW SC Unit (33 cusec) | Total |
|---|---|---|---|---|
| Clear Water Pump Capacity/Number of Units | 6.7 cusec/unit, 3 units + 1 spare unit | 8.3 cusec/unit, 3 units + 1 spare unit | 16.5 cusec/unit, 2 units + 1 spare unit or 11 cusec/unit, 3 unit + 1 spare unit | 11 units or 12 units |

Pieces of land related to the intake facility (including intake pipes) are owned by State Government. Barauni TPS is involved in the acquisition procedure, so acquisition is not difficult.

#### 6.1.10.4 Raw Water Reservoir

Descriptions on the capacity of raw water tank that have been found are as follows:

**Table 6.1.10-10 Comparison of Capacity of Raw Water Reservoir**

| | No.8/9<br>(250 MW x 2) | No.10<br>(250 MW x 1) | BOP Guideline |
|---|---|---|---|
| Raw Water Reservoir Capacity | For 10 days | Not Applicable | For 10 days |

BOP Guideline describes storage of water quantity for 10 days. Units No.8/9 are planned to have their own raw water reservoir. Estimating from the dimensions of reservoir and water balance plan, the water quantity stored corresponds to the water quantity consumed by the power station per day. According to DPR of No.10, there are lakes and pools in the west of the intake point of the Ganges and the power station. Taking the corresponding capacity into consideration, raw water for a total of 10 days will be owned. In line with such information, dimensions of raw water reservoir shall accommodate amount for about 10 days (800,000 $m^3$; length 490 m x width 560 m x depth 3 m) at the intake point of the Ganges and raw water reservoir to accommodate raw water for about one day (80,000 $m^3$ (3,351 $m^3$/h x 24 hours), Refer to “6.1.9 Water Balance”) shall be located in the premises of the power station. The size of each raw water tank in the power station shall be length 100 m x width 160 m x depth 5 m (80,000 $m^3$).

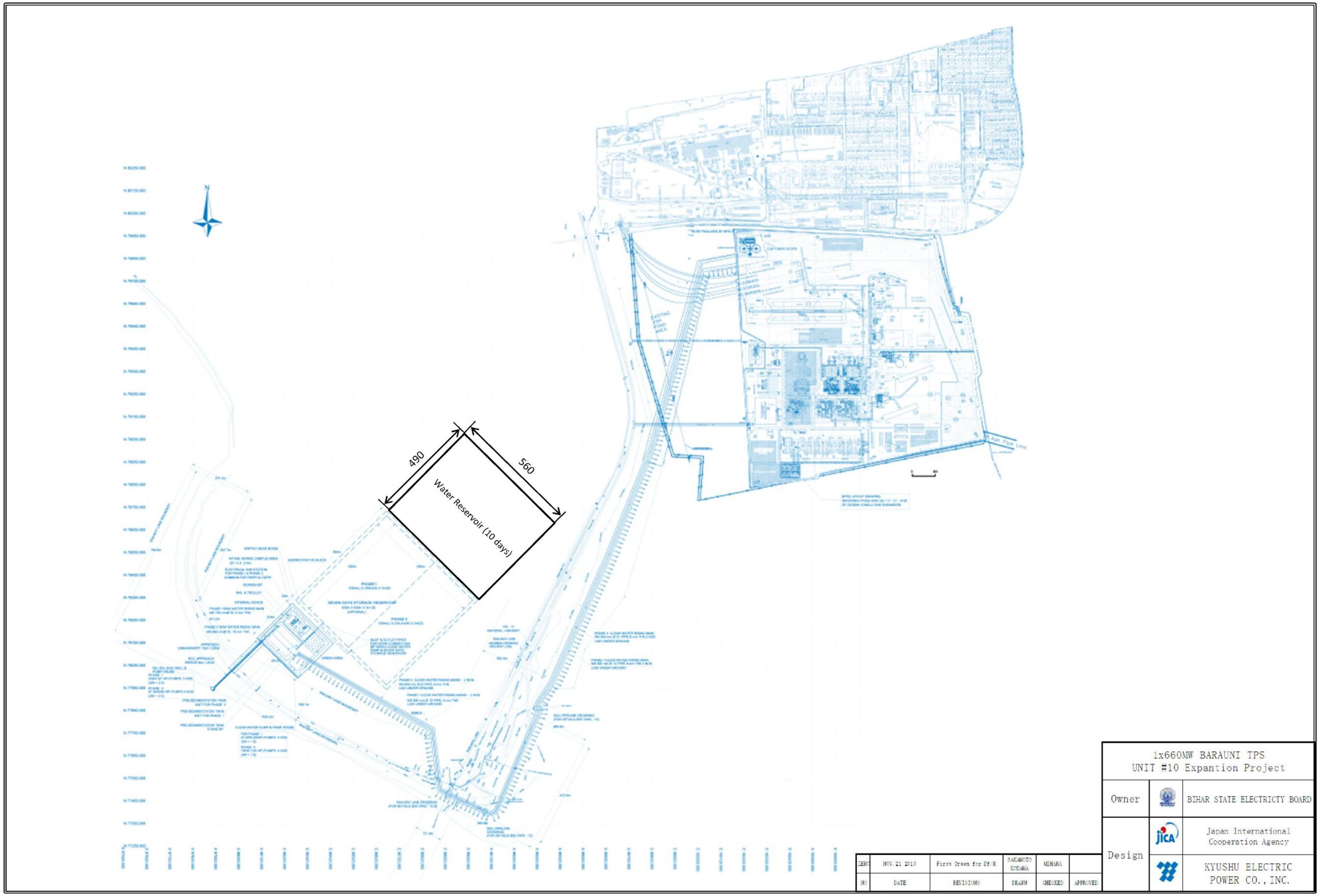



**Figure 6.1.10-3 Raw Water Reservoir near Intake Point**

### 6.1.10.5 Demineralized Water Devices

**(1) Demineralized Water Storage Tank**

The capacity of demineralized water tank that have been found are as follows:

**Table 6.1.10-11 Comparison of Capacity of Demineralized Water Tank**

| | No.8/9 (250 MW x 2) | No.10 (250 MW x 1) | BOP Guideline |
|---|---|---|---|
| Demineralized Water Tank Capacity | 1,000 $m^3$ x 2 | 400 $m^3$ x 1 | 1,000 $m^3$ x 3 |

Capacity of demineralized water tanks is determined by the quantity of demineralized water used for cleanup process that circulates and drains water until the water quality of the boiler is improved at the start of unit following periodical maintenance (Water quality is poor just after the startup due to foreign substances that intruded in the pipes during periodical maintenance). The cleanup process exchanges water in several steps. Tank capacity is determined so that a sufficient quantity of demineralized water may be available in this process. According to the experience of Kyushu Electric Power, the capacity is determined based on the plan where cleanup can be completed if demineralized water of some 1,500 $m^3$ is reserved in the time period of maximum consumption for cleanup of a 700 MW-class boiler. Additional installation of a demineralized water tank of 1,500 $m^3$ x 1 will be proposed if the water can be supplied from No.8/9 tanks, and two demineralized water tanks of 1,500 $m^3$ x 2 otherwise. Planned dimensions of each tank are a diameter of 14 m by a height of 13 m from the experience of Kyushu Electric Power.

**(2) Demineralized Water Production Device**

The production capability of demineralized water equipment that have been found are as follows:

**Table 6.1.10-12 Comparison of Demineralized Water Production Capability**

| | No.8/9 (250 MW x 2) | No.10 (250 MW x 1) | BOP Guideline |
|---|---|---|---|
| Demineralized Water Production Capability | 60 $m^3$/h x 3 | 30 $m^3$/h x 2 | 45 $m^3$/h x 3 |
| (Production Quantity in Terms of Water Balance) | (82 $m^3$/h) | (2 $m^3$/h) | (85 $m^3$/h) |

According to the actual record of Kyushu Electric Power, a production capability of some 45 $m^3$/h is sufficient for a 700 MW-class boiler. According to DPR of No.8/9, production capability of 60 $m^3$ x 3 exists for the estimated water quantity required for production of demineralized water of 82 $m^3$/h. This has a margin above one line. Thus, no additional installation is proposed if the demineralized water equipment of Units No.8/9 can be shared. Otherwise, additional installation of 45 $m^3$ x 2 will be proposed assuming one line as a spare.

#### 6.1.10.6 Wastewater Treatment Device

The design must be considered reuse of liquid waste before drainage if possible. Wastewater from the circulating water shall be reused, for example, sprinkled to prevent dust particles in the ash treatment site. If there is a surplus after the reuse, the remaining wastewater undergoes neutralization (pH control) to suit the particular wastewater type and is then discharged to Central Monitoring Basin. Wastewater collected into Central Monitoring Basin undergoes a water quality check and is used as water to prevent dust particles in the coal yard or irrigation water. Surplus water, if any, is drained as per the drainage standard.

In general, the sources of effluent from TPS include plant water effluent, and effluent from demineralized water production system, and the possible treatment methods include neutralization and sludge settlement methods. As a result of interview, it was found that the only effluent treatment method in Barauni TPS was neutralization. Therefore, only effluent neutralization treatment will also be assumed for a 660 MW SC unit.

In another example of a 660 MW plant in India, the capacity of Central Monitoring Basin is 2,000 $m^3$, so that a plan is to be formed assuming the same capacity.

On the other hand, in case of future installation of FGD, larger capacity of effluent treatment device shall be required. Based on the experience of Kyushu Electric Power, below 2 cases as shown in Table 6.1.10-13 shall be taken into consideration.

**Table 6.1.10-13 Additional Wastewater Treatment System at FGD Installation**

| | Additional Wastewater Treatment System | Size |
|---|---|---|
| Case 1 | Space being considered as a future device | 100 m x 85 m |
| Case 2 | Install from beginning | |

### 6.1.10.7 Operation of Auxiliary Steam

In TPS, steam that has been partially taken out from the main steam line and decompressed is generally used as an auxiliary steam for various applications in the plant (such as turbine grand steam in the stand-by warm-up operation during de-synchronization). If the power plant is shut down, it cannot supply the auxiliary steam. In general, an in-house boiler is installed for supply of auxiliary steam during shutdown of the power plant, or an operating adjacent power unit, if any, supplies auxiliary steam. In Units No.8/9 under construction, a permanent resident in-house boiler is not planned to be installed. If auxiliary steam cannot be supplied because Units No.8/9 are undergoing periodical maintenance or shutdown due to a trouble, a portable boiler supplies auxiliary steam. This idea is inherited and an in-house boiler for a 660 MW SC unit is not planned to be installed.

### 6.1.10.8 Railway Siding

A train track for transportation of coal is sided into the existing area. On top of R&M/LE work of Units No.6/7, 6 tracks are to be re-organized. A railway track is to be installed also for supply of coal to Units No.8/9.

If a 660 MW SC unit is to be arranged in a residential area as described in “4.3 Selection of Candidate Sites,” the railway to be installed for Units No.8/9 will be branched and extended in the northeast direction to allow access to the coal storage yard. If a 660 MW SC unit is to be constructed on adjacent land to the south of Units No.8/9 area, the train track for Units No.8/9 will be extended in the southeast direction to allow access to the coal storage yard.

### 6.1.11 Ash Disposal Area

From the stipulation of Article 1, paragraph 1, item 5 (a) of the Japanese standard ministerial ordinance ("Ministerial Ordinance Determining Engineering Standards Pertaining to Final Disposal Site for Municipal Solid Wastes and Final Disposal Site for Industrial Wastes"), the ground of ash disposal area is required to have continuous strata 5 m or more thick and having a coefficient of permeability of $10^{-5}$ cm/s or less. If this requirement is not satisfied, the ground surface has to be covered with a water impermeable sheet, or other measures have to be taken.

To take measures equivalent to the Japanese environmental standards, a permeability test has to be conducted on the site, impermeability have to be evaluated and the proper corresponding measures have to be taken. According to interview at the site, while Units No.8/9 area is built on the ash disposal area, heavy metals have been detected in the underground water on the site.

On Barauni site also, since a method of slurry, which is mixed with ash and water, is adopted in order to fill ash disposal area with ash, the ground condition is soft. When ash is used to build embankment around ash disposal area, it is recommended to understand the characteristics of embankment material (such as density, strength and permeability), evaluate the stability of embankment, and study the influence of settlement. If necessary, some countermeasures, such as enough compaction, cementation, and counterweight fill method have to be studied. To secure the impermeability, the embankment itself has to be impermeable by some methods, such as cementation, or water impermeable sheets have to be laid on the ground including the outer face of the embankment.


**Figure 6.1.11-1 Example on Secure of Impermeability of Ash Disposal Area**

### 6.1.12 Calculation of Coal Consumption/Coal Ash Generation

Consumption of coal and coal ash generation in the 660 MW SC unit cited in this report has been calculated by using the following parameters:

**Table 6.1.12-1 Coal and Ash Calculating Parameters**

| Item | Unit | Parameters | Source |
|---|---|---|---|
| Output | MW | 660 | |
| Gross Thermal Efficiency | % | 39.5 | Table 6.1.1-1 |
| Gross Heating Value (worst coal) | kcal/kg | 3,100 | Table 4.7-1 |
| Ash Content (worst coal) | % | 40.0 | Table 4.7-1 |
| PLF | % | 90 | Results from Interview (Table 4.1-1) |

**(1) Consumption of Coal per Hour**

$$\frac{660(MW)\times 10^3 \div 4.1868(kJ/kcal)}{0.395\times 3{,}100}\times 3600 \div 10^3 = 463(ton/hour)$$

**(2) Consumption of Coal per Day**

$$463\times 24(h) = 11{,}000(ton/day)$$

**(3) Consumption of Coal for 15 days (Coal Storage Yard Capacity)**

$$463\times 24(h)\times 15(days) = 167{,}000(ton/day)$$

**(4) Annual Consumption of Coal**

$$463\times 24(h)\times 365(days)\times 0.9 = 3{,}650{,}000(ton/year)$$

**(5) Annual Generation of Coal Ash**

$$463\times 24(h)\times 365(days)\times 0.9\times 0.40 = 1{,}460{,}000(ton/year)$$

## 6.2 Facility Layout Plan

The configuration of employed dimensions of main facilities to be arranged on candidate pieces of land is given below.

**(1) Layout Using Facility Specifications with Employment Record in India**

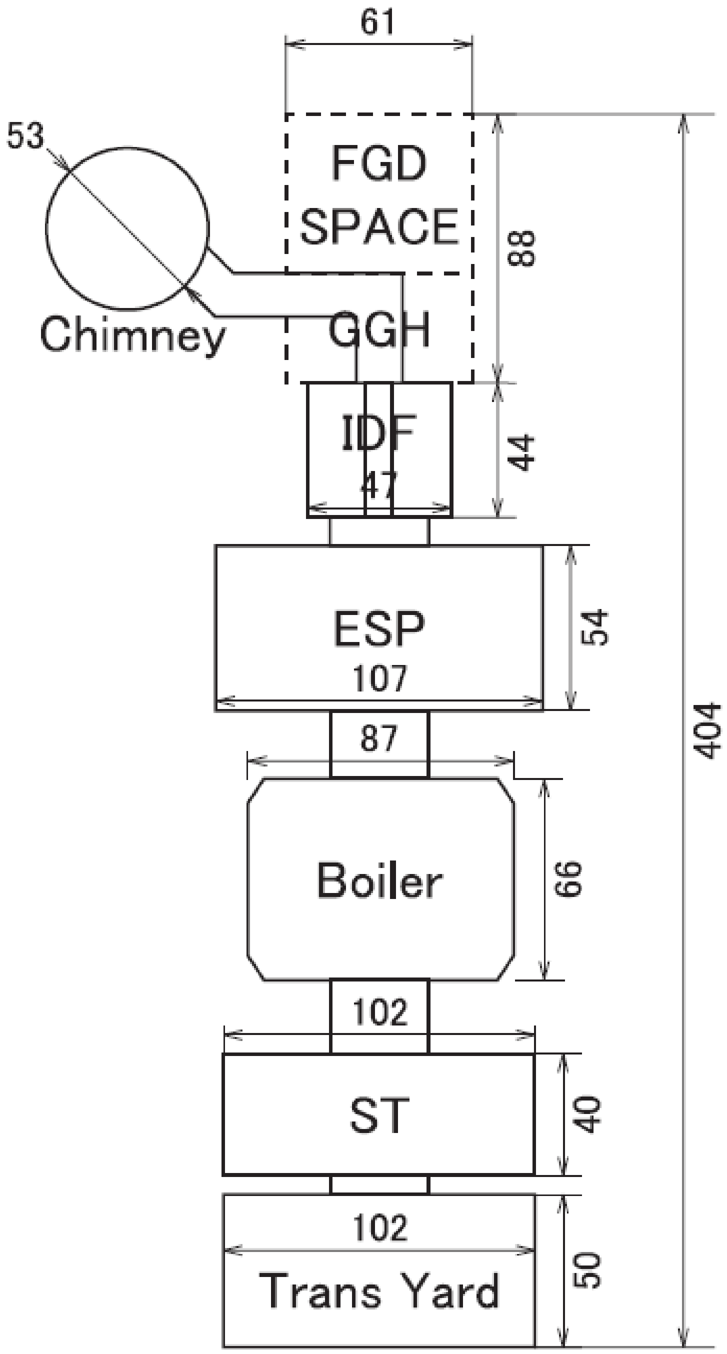
<table>
<tr><th>Facility Specifications with Employment Record in India</th><th>Size Employment Practices</th></tr>
<tr><td rowspan="6">
</td><td>FGD:<br>Experienced size in Kyushu Electric Power<br>GGH:<br>Experienced size in Kyusyu Electric Power (future installation)</td></tr>
<tr><td>Induced Draft Fan (IDF):<br>Experienced size in Kyushu Electric Power</td></tr>
<tr><td>ESP:<br>Field-proven size in India</td></tr>
<tr><td>Boiler:<br>Field-proven size in India</td></tr>
<tr><td>Turbine room:<br>Experienced size in Kyusyu Electric Power</td></tr>
<tr><td>Transformer yard:<br>Field-proven size in India</td></tr>
</table>

**Figure 6.2-1 Facility Configuration with Employment Record in India**

### (2) Layout Using Facility Specifications with Employment Record in Japan

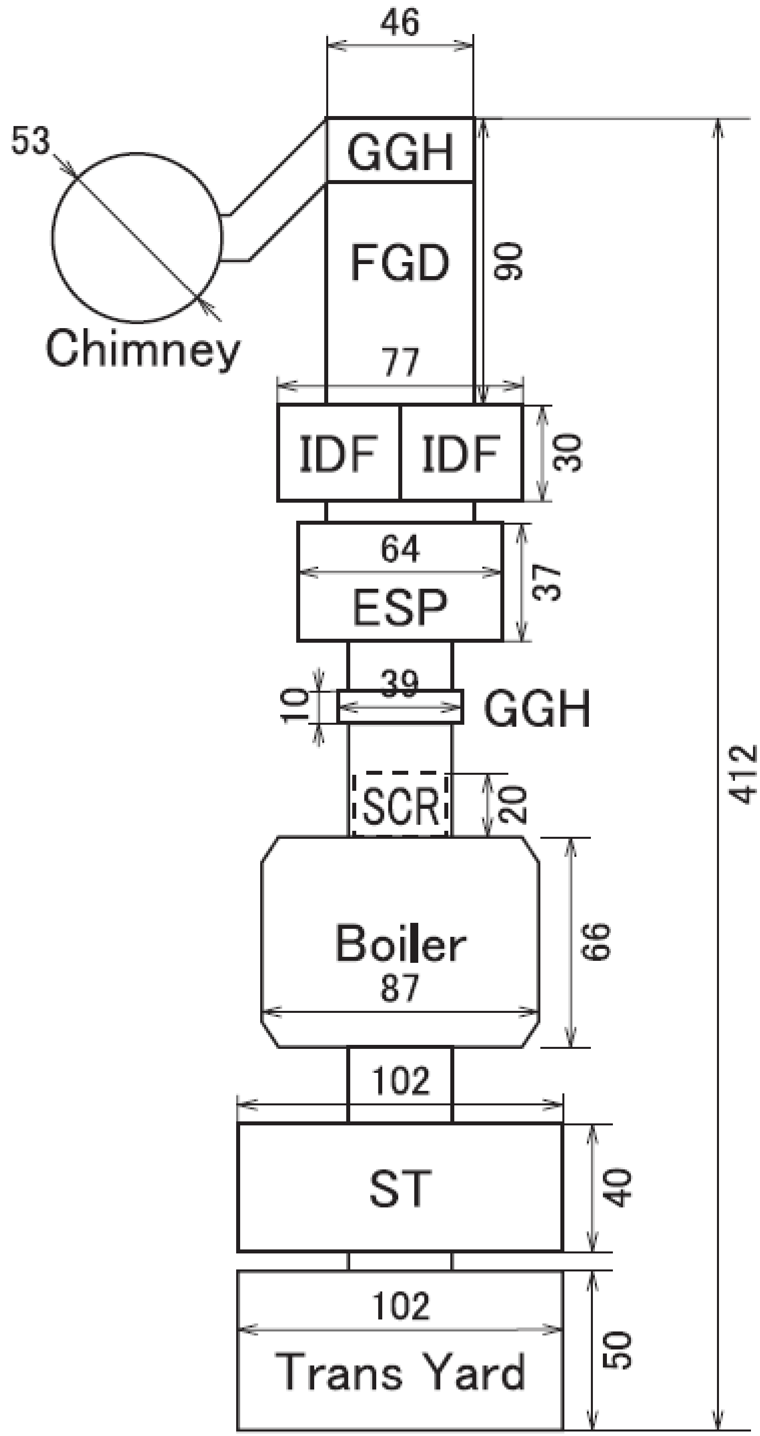
<table>
<tr><th>Facility Specifications with Employment Record in Japan</th><th>Size Employment Practices</th></tr>
<tr><td rowspan="8">
</td><td>FGD and GGH (hear release):<br>Experienced size in Kyushu Electric Power</td></tr>
<tr><td>IDF:<br>Experienced size in Kyushu Electric Power</td></tr>
<tr><td>ESP:<br>Calculated size using field-proven facility specification</td></tr>
<tr><td>GGH (heat recovery):<br>Experienced size in Kyushu Electric power</td></tr>
<tr><td>SCR:<br>Experienced size in Kyushu Electric Power (future installation)</td></tr>
<tr><td>Boiler:<br>Field-proven size in India</td></tr>
<tr><td>Turbine room:<br>Experienced size in Kyushu Electric Power</td></tr>
<tr><td>Transformer yard:<br>Field-proven size in India</td></tr>
</table>

**Figure 6.2-2 Facility Configuration with Employment Record in Japan**

# Chapter 7 Conclusion of Possibility of Construction

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# Chapter 7 Conclusion of Possibility of Construction

## 7.1 Study Cases

The following study cases were selected in a combination of "4.3 Selection of Candidate Sites" and "6.2 Facility Layout Plan".

If a 660MW SC Plant can be constructed at the originally planned site for Unit No.10, then the original layout can be utilized the most suitable. Therefore, the Team has considered the original plan as the first priority and studied with using experience of SC's adoption in India and compact configuration which is adopted in Japan.

At the existing plant area, several facilities for future reuse are located within the existing plant area, because of which the Executing Agency faces difficulties to utilize the space. Accordingly, configuration with the proven experience applied in India, which is simpler than those in Japan, will also be applied to this area. In addition, for the residential area where relatively ample space is available and the site in the south adjacent to Units No.8/9, a study has been performed using the configuration based on plant size that has been adopted in both India and Japan

**Table 7.1-1 Combination of Study Cases**

| | Site identified by "4.3 Selection of Candidate Sites" | Configuration of Plant prepared by "6.2 Plant Layout Plan" |
|---|---|---|
| Case 1 | Planned Site of Unit No.10 (Section 4.2.4) | Configuration adopted in **India** |
| Case 2 | Planned Site of Unit No.10 (Section 4.2.4) | Configuration adopted in **Japan** |
| Case 3 | Residential Area (Section 4.2.3) | Configuration adopted in **India and Japan** |
| Case 4 | Existing Plant Area (Section 4.2.2) | Configuration adopted in **India** |
| Case 5 | Site in the South Adjacent to Units No.8/9 (Section 4.2.5) | Configuration adopted in **India and Japan** |

# 7.2 Examination of Each Case Study and Conclusion of Possibility of Construction

Plant configuration concepts are presented for all the study cases so that the possibility of construction can be determined. In case, a certain case is possible, then necessary conditions to make the case possible are also presented.

### 7.2.1 Case 1 (Site: Planned Site of Unit No.10)

**(1) Results of Study**

Construction of a 660 MW SC unit is **Possible.**

**(2) Reason**

- Since the length in the longer direction (South to North) of the site dimension is too short (335 m), the site cannot accommodate the plant if space for a future FGD and chimney is taken into consideration (dimension required for the plant is 404 m). Coal stockyard area for Unit No.10 can be used for a 660 MW SC unit configuration. In the East and West direction (122 m), however, a turbine building (102 m) can be located within the length.

**(3) Concept of Layout Design**

- Currently planned site for coal storage cannot meet the requirements of 15 day-coal storage capacity corresponding to increase of power output. Therefore, silo storage is adopted (250 MW: 89,000 tons[1]→ 660 MW: 167,000 tons[2]) to fill this gap.
- The future space for FGD and GGH is reserved in layout.
- With respect to a transmission facility, it is possible to respond to the requirement by extending the site since space from Units No.8/9 site to the western site is available.
- As described in "4.2.4 Planned Site of Unit No.10", fly ash transporting pipes from ESP will be crossed at the height of 6 m in the East and West direction. The concept of 6 m height is considered due to passing vehicle. Pipes on the ground in this area and overhead at the road will make it possible to avoid interference by routing pipes between ESP and IDF.

[1] Results from interview about 1 pile capacity of Units No.8/9 with STEAG
[2] Refer to Section "6.1.12 Calculation of Coal Consumption of Coal/Coal Ash Generations"

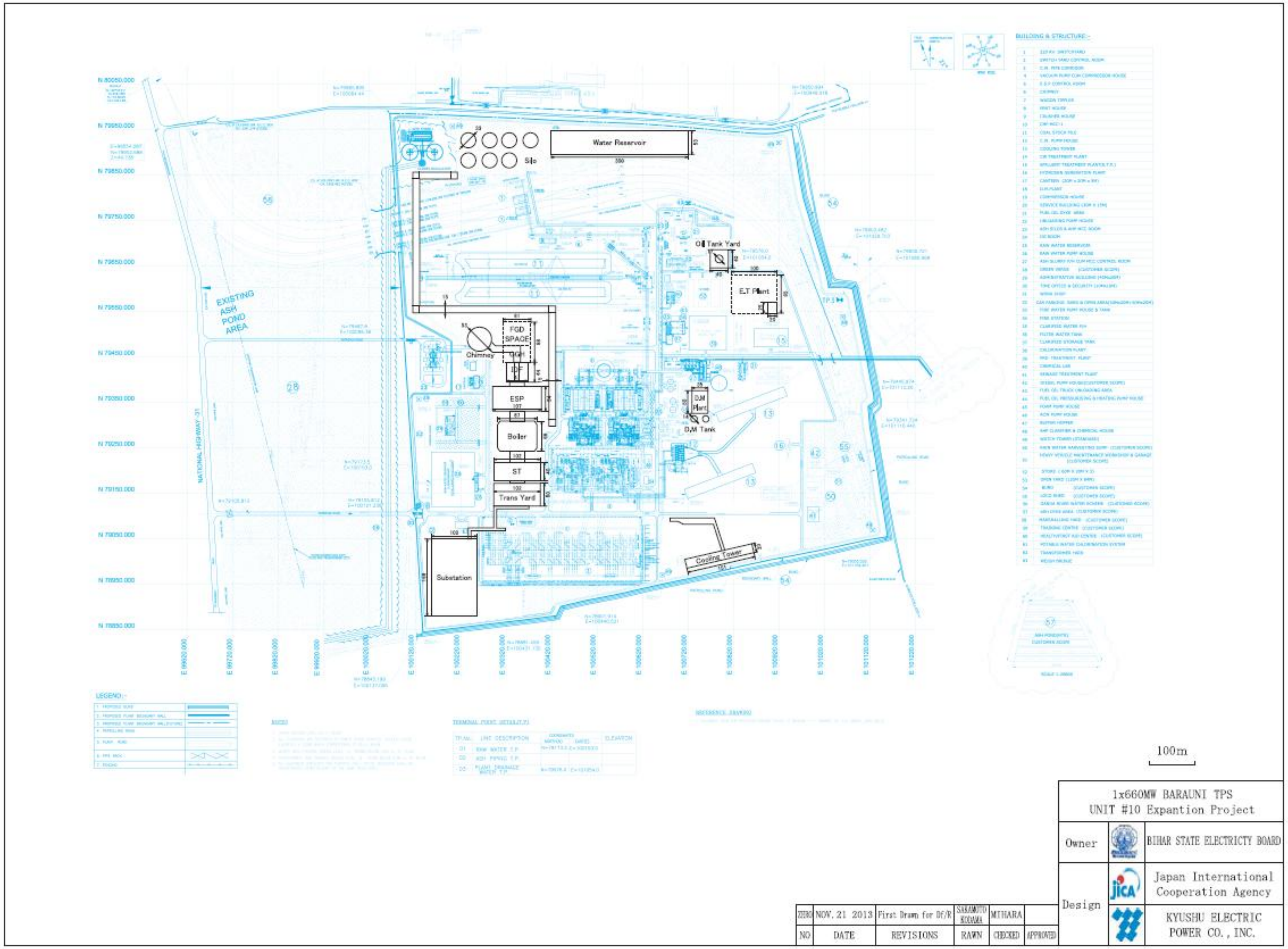


**Figure 7.2-1 Configuration Adopted in India in Planned Site of Unit No.10**

### 7.2.2 Case 2 (Site: Planned Site of Unit No.10)

**(1) Results of Study**

Construction of a 660 MW SC unit is **Possible.**

**(2) Reason**

- Since the length in the longer direction (South to North) of the site dimension is too short (335 m), the site cannot accommodate the plant if space for a future FGD and chimney is taken into consideration (dimension required for the plant is 412 m). Coal stockyard area for Unit No.10 can be used for a 660 MW SC unit configuration. In the East and West direction (122 m), however, a turbine building (102 m) can be located within the length.
  (Same as Case 1)

**(3) Concept of Layout Design**

- Currently planned site for coal storage cannot meet the requirements of 15 day-coal storage capacity corresponding to increase of power output. Therefore, silo storage is adopted (250 MW: 89,000 tons[3] → 660 MW: 167,000 tons[4]).
  (Same as Case 1)
- Space is required to accommodate a non-leak-type GGH (heat recovery part) between APH and ESP. Under such circumstances, a low low-temperature ESP whose length in the longer direction is short can be adopted. Once through flow type flue gas process system can be adopted, it can comply with more severe environmental regulations.
- Space for SCR is considered in layout as future installation.
- With respect to a transmission facility, it is possible to respond to the requirement by extending the site since space from Units No.8/9 to the western site is available (same as Case 1).
- As described in "4.2.4 Planned Site of Unit No.10", fly ash transporting pipes from ESP will be crossed at the height of 6 m in the East and West direction. The concept of 6 m height is considered due to passing vehicle. Pipes on the ground in this area and overhead at the road will make it possible to avoid interference by routing pipes between ESP and IDF (Same as Case 1).

[3] Results from interview about 1 pile capacity of Units No.8/9 with STEAG
[4] Refer to Section "6.1.12 Calculation of Coal Consumption of Coal/Coal Ash Generations"

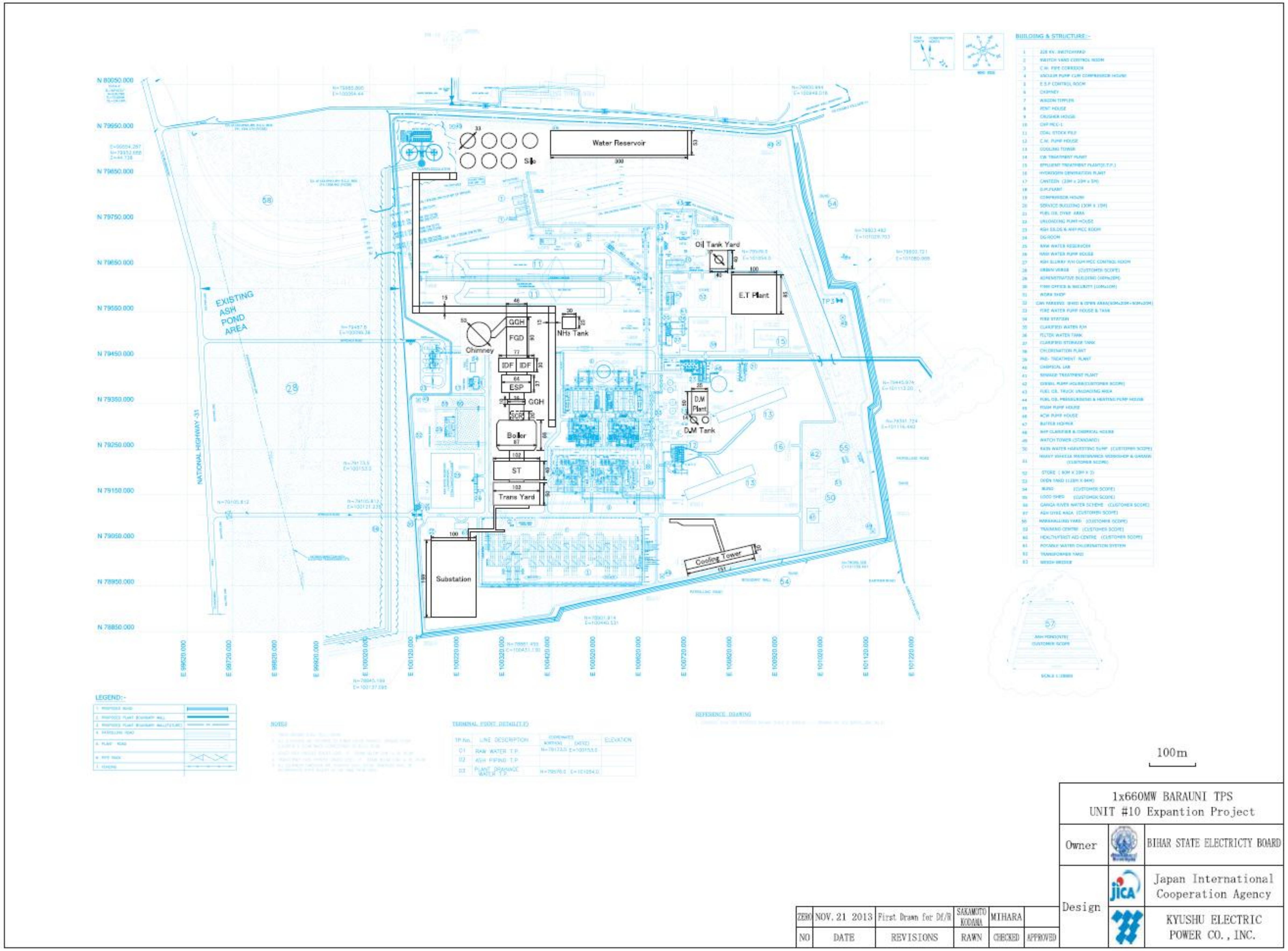


**Figure 7.2-2 Configuration Adopted in Japan in Planned Site of Unit No.10**

### 7.2.3 Case 3 (Site: Residential Area)

**(1) Results of Study**

Construction of a 660 MW SC unit is **Possible.**

**(2) Reason**

- The Team confirmed that it would be possible to relocate employees living in the residential area, and no other specific obstacles were found.

**(3) Concept of Layout Design**

- Since it is possible to utilize the relatively wide area, the layout is made so that the space for future extension can be reserved.
- The future space for FGD and GGH is reserved in layout.
- To prevent contamination of fine particles from the coal storage area, a layout is made so that a cooling tower shall be located far from the coal storage area.
- A railway to transport coal is branched from Units No.8/9 and extended therefrom.
- A transmission facility is located in the northern side of the site so as to transmit electricity in a northern direction.
- The transportation distance of coal ash to ash disposal area is relatively long.

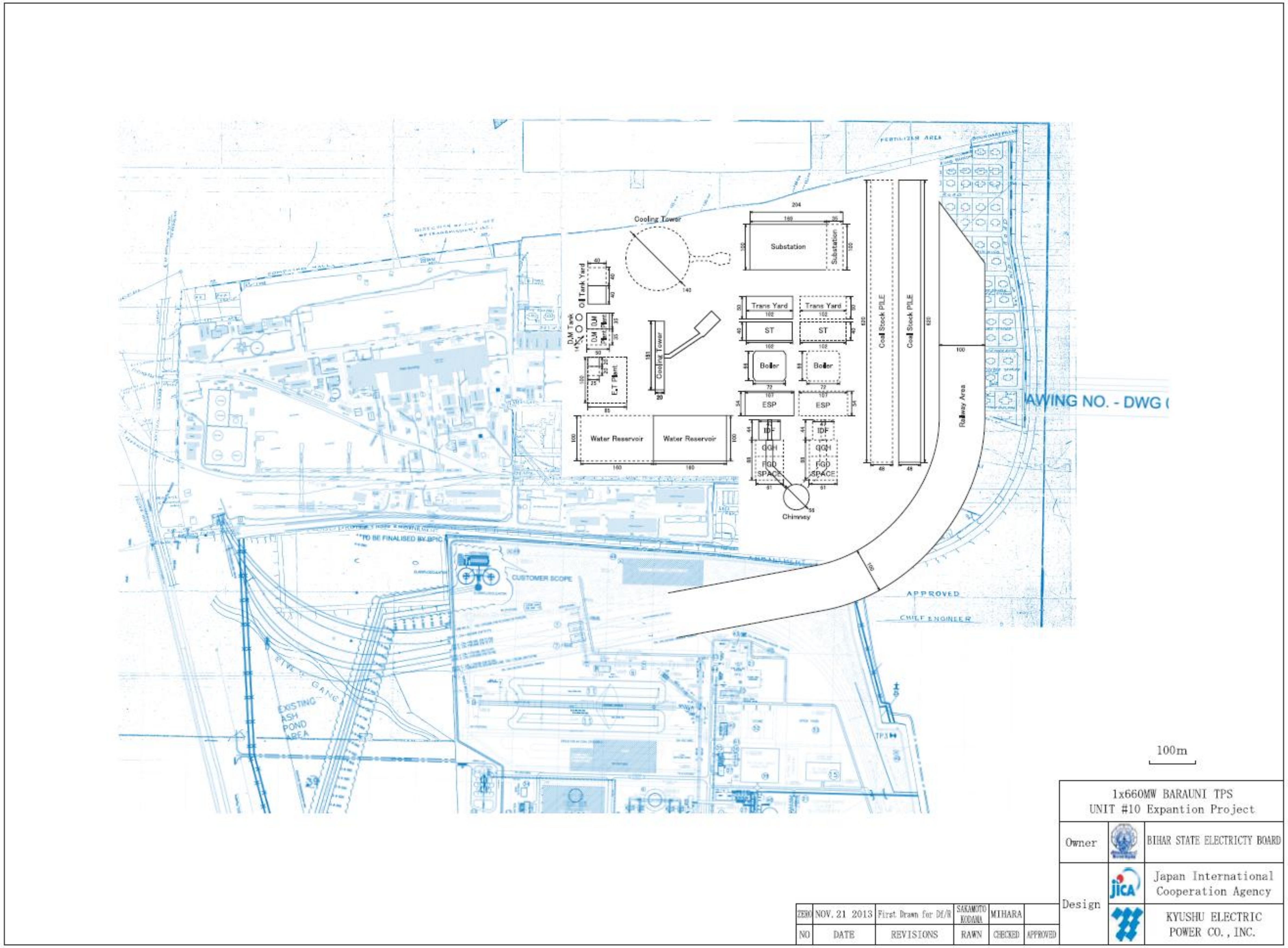


**Figure 7.2-3 Configuration Adopted in India in Residential Area**

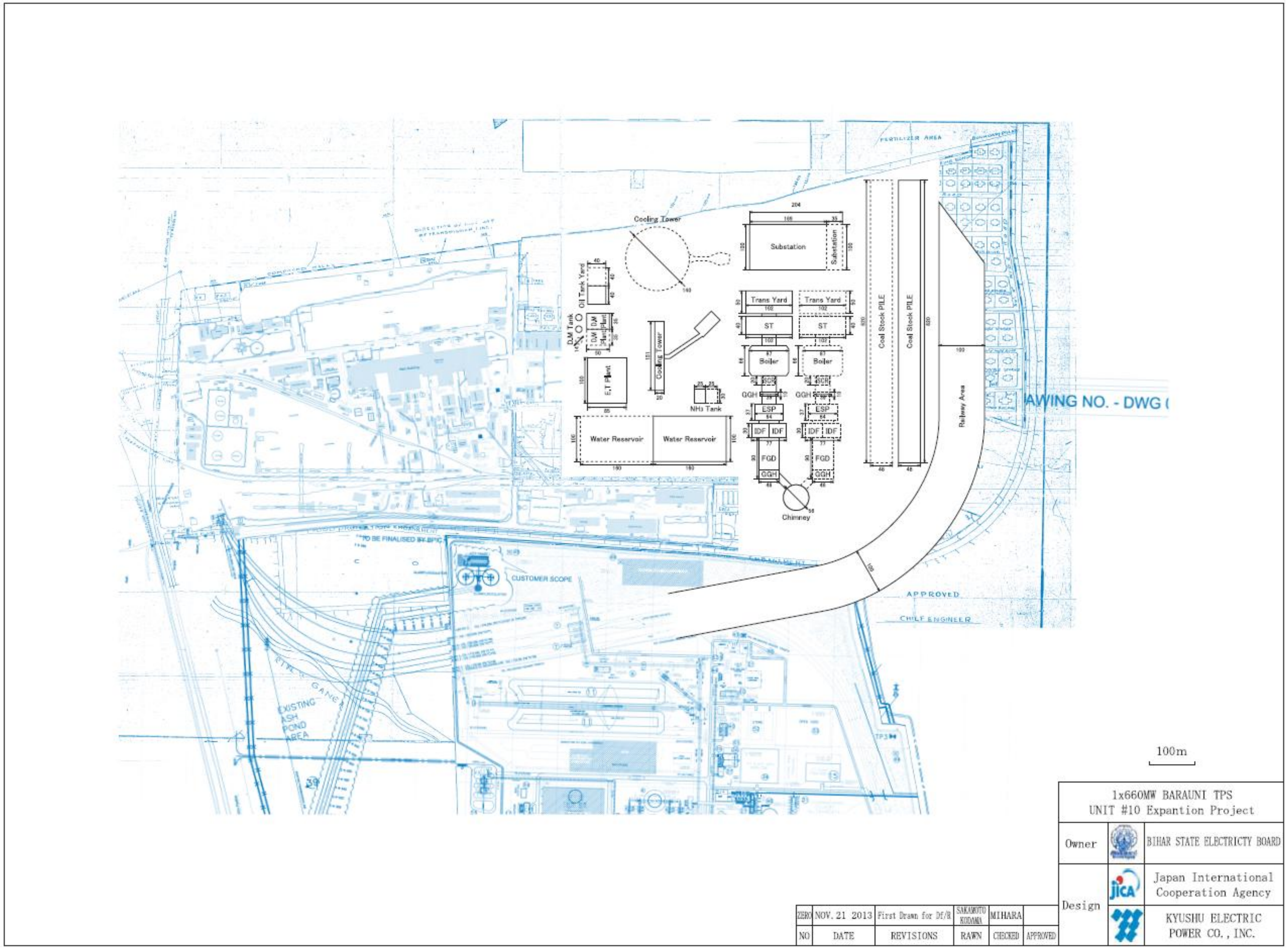


**Figure 7.2-4 Configuration Adopted in Japan in Residential Area**

### 7.2.4 Case 4 (Site: Existing Plant Area)

**(1) Results of Study**

<u>Construction of a 660 MW SC unit is **Not Possible.**</u>

**(2) Reason**

- The area is dotted with remaining installations and facilities for re-use, and these facilities would interfere with a 660 MW SC unit in the layout. Extra coal stock yard for existing Units No.6/7 should be located either in the residential area or outside of Barauni TPS, because main equipment of a 660 MW SC unit lies on the existing coal storage yard.
- The location of cooling tower next to the switchyard is not recommendable because of the extremely close layout.

**(3) Concept of Layout Design**

- The layout to expand over the boundary in south of existing plant area is impossible due to the regulation of separation which requires a distance of 1/2 km between NH-31 and the boundary of Units No.8/9.
- The future space for FGD and GGH is reserved in layout.
- Since a railway to bring coal shall be re-used for coal supply to Units No.6/7, it is difficult to arrange a facility over an existing railway.
- Silo storage corresponding to increase of power output (250 MW: 89,000 tons[5]→ 660 MW: 167,000 tons[6]) is applied in the narrow area between the existing railway and south site boundary. In addition, raw water reservoir is also located next to silos.

**(4) Conditions to Make Construction Possible**

- All the remaining facilities excluding security guard station shall be removed, and then, an additional coal storage yard for Units No.6/7 and a 660 MW SC unit shall be obtained outside of existing plant area.

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5 Results from interview about 1 pile capacity of Units No.8/9 with STEAG
6 Refer to Section "6.1.12 Calculation of Coal Consumption of Coal/ Coal Ash Generations"

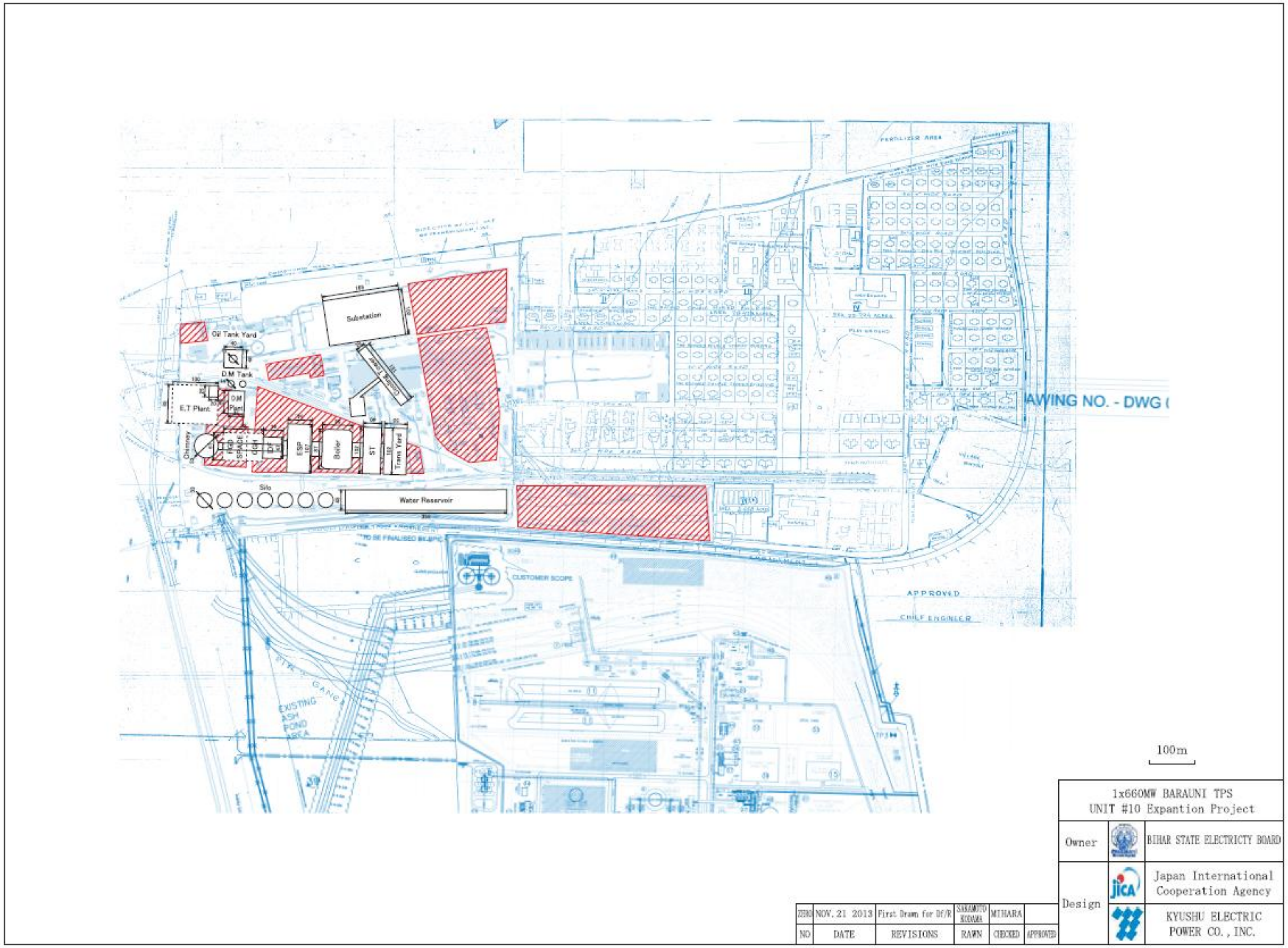


**Figure 7.2-5 Configuration Adopted in India in Existing Plant Area**

### 7.2.5 Case 5 (Site: Site in the South Adjacent to Units No.8/9)

**(1) Results of Study**

Construction of a 660 MW SC unit is **Possible.**

**(2) Reason**

- The Team confirmed that additional acquisition of site would be possible, and no other obstacles were found.

**(3) Concept of Layout Design**

- Since a relatively wide area is available, the layout is designed so as to reserve the area for future extension.
- The future space for FGD and GGH is only reserved in layout.
- A railway to transport coal is designed in such a way that it is extended from Units No.8/9.
- A transmission facilities yard is arranged at the west of the site so as to transmit electricity in a southern direction.
- It is an advantage that the transportation distance to the ash disposal area will be short.

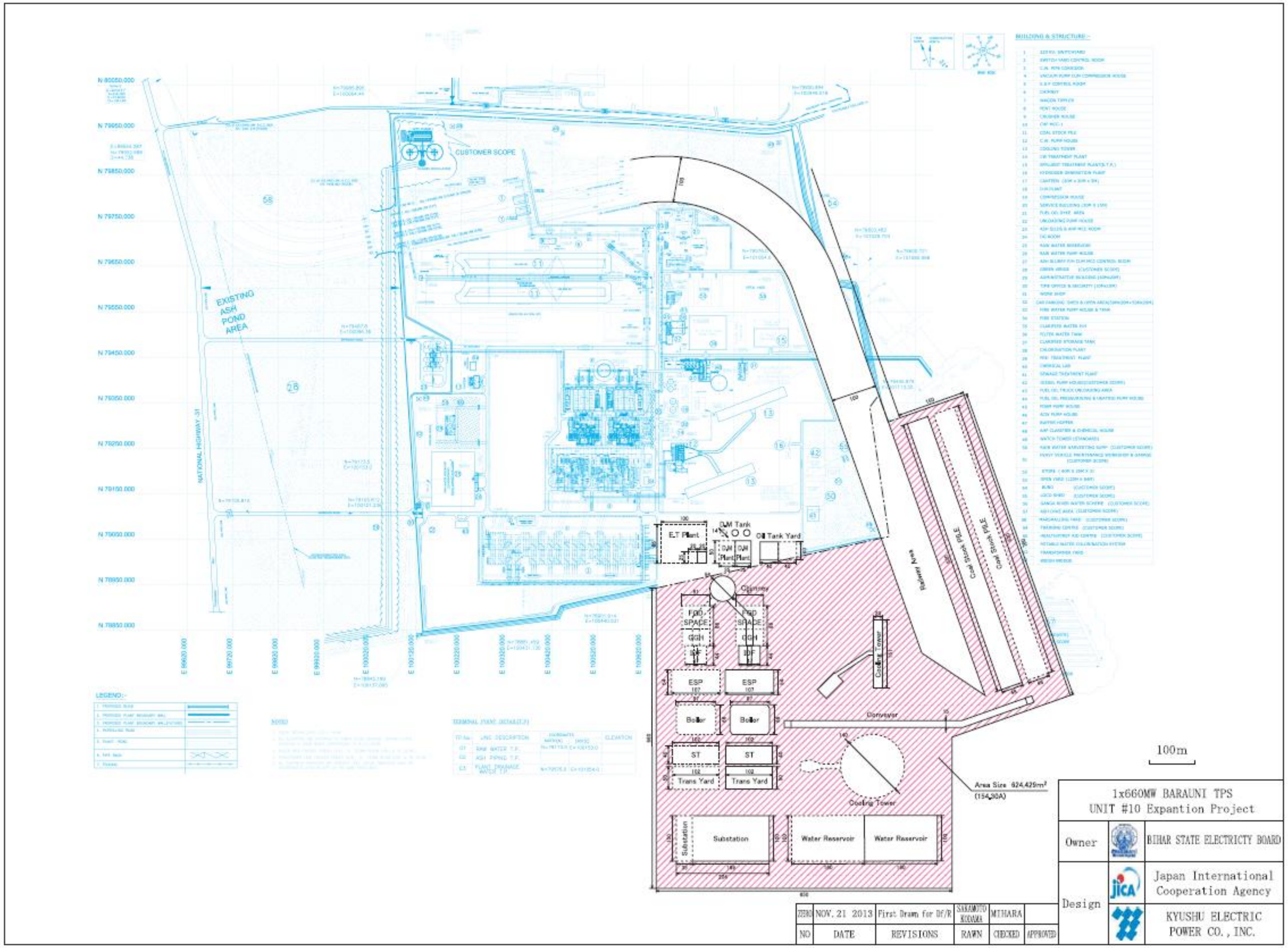


**Figure 7.2-6 Configuration Adopted in India at the Site in the South Adjacent to Units No.8/9**

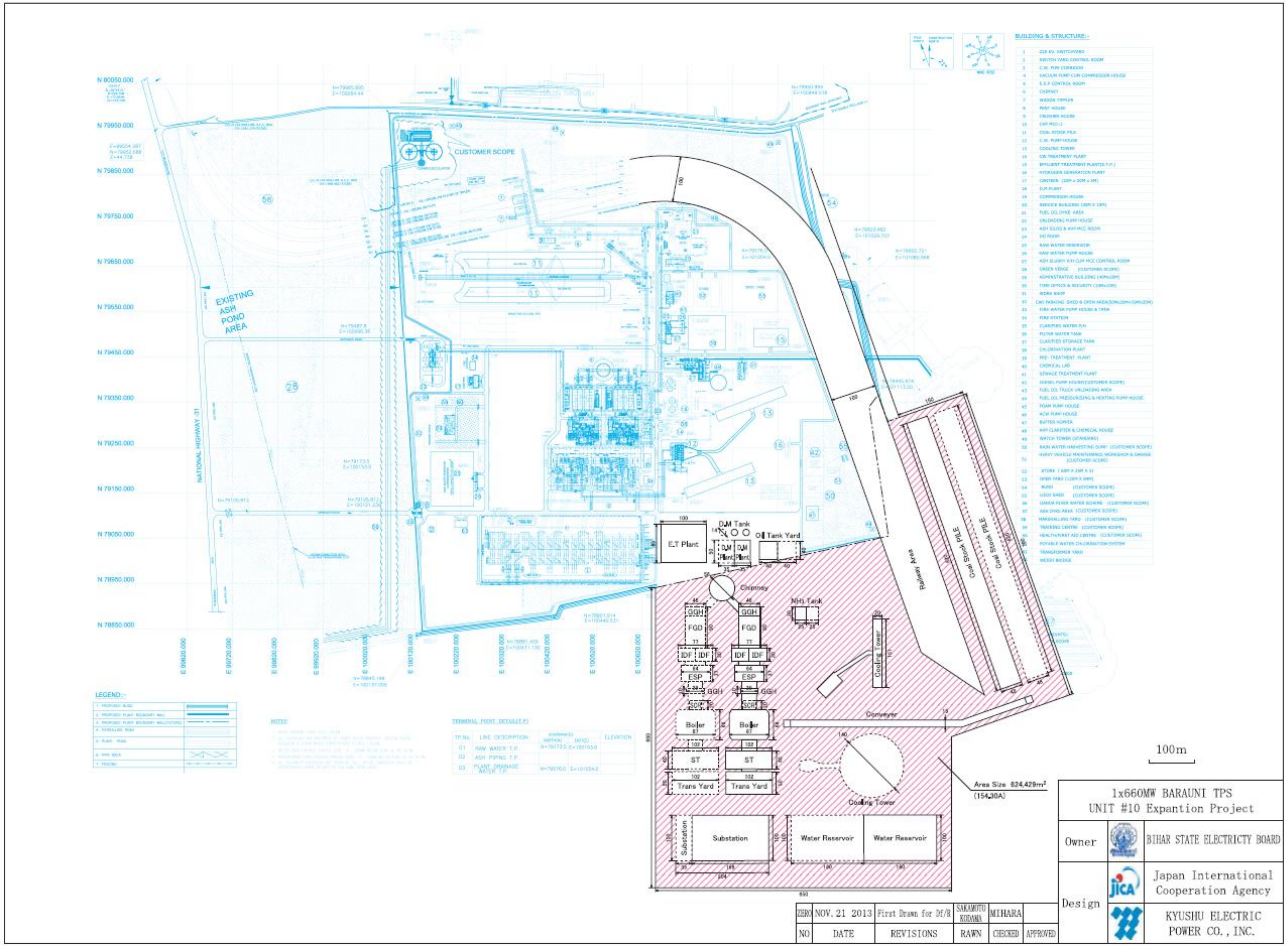


**Figure 7.2-7 Configuration Adopted in Japan at the Site in the South Adjacent to Units No.8/9**

## 7.3 Conclusion

The Team concludes that the setting up of a 660 MW SC unit is **Possible**.

The advantages/disadvantages for each case are assessed in Table 7.3-1.

According to Table 7.3-1, the Team presents its recommendation in the following order in view of the Economic Aspect, Environmental and Social Considerations, and Future Extension aspect.

**Table 7.3-1 Comparison showing Each Case Study**

| | Item | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
|---|---|---|---|---|---|---|
| Possibility of Construction | To set up a 660 MW SC unit in the area | **Possible** | **Possible** | **Possible** | **Not Possible** | **Possible** |
| Economic Aspect | Cost of facilities | **B Coal Silo** | **C Coal Silo FGD SCR** | **A (C)**[*1] | - | **A (C)**[*1] |
| | No need to develop land prior to construction | **A** | **A** | **C** | - | **C** |
| | No need to scrap existing facilities | **A** | **A** | **C Scrap existing residence** | - | **A** |
| | No need to extend railway for coal transportation | **A** | **A** | **C** | - | **C** |
| | Shorter transporting distance of ash | **B** | **B** | **C** | - | **A** |
| | No need to re-design new embankment at the south boundary | **A** | **A** | **A** | | **C** |
| | Easy Construction/ Maintenance | **C** | **C** | **A** | - | **A** |

| | Item | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
|---|---|---|---|---|---|---|
| Environmental and Social Considerations | No need to acquire additional land | **A** | **A** | **B Residential area to be prepared** | **-** | **C** |
| | No need to relocate residents | **A** | **A** | **C** | **-** | **A** |
| | FGD and/or SCR installed | **C** | **A** | **C (A)*1** | **-** | **C (A)*1** |
| Others (Future Extension) | Possible to set up another 660 MW unit in the future | **C** | **C** | **A** | **-** | **A** |

LEGEND: Evaluation A: Good, B: Neutral, C: Not Good

*1: when adopting the unit layout used successfully in Japan

**(1) Selection of each case**

Because it is not realistic to examine all cases in detail in the stage of FS, it is necessary to narrow down the examination target in advance. When selecting a case, the case to be selected depending upon the weight given to the various preconditions. Here, this Pre-FS specifies the case that should be selected from each precondition and shows the advantages and disadvantages.

- When selecting the case based on ease of construction or maintenance in consideration of future extension:

  Cases 3 and 5 are selected as candidates. It is possible to cope up with the increase in electric power demand in the future by means of extension. Moreover the unit price of power generation can be decreased by adopting common facilities. In case 3, however, resettlement of residences or removal of existing housing would be necessary. In case 5, new acquisition and the development of land of the site concerned would be needed.

- When the commencement of operation in an earlier stage is preferable in consideration of electricity shortage:

  Cases 1 and 2 are selected as candidates without acquisition of additional land and involuntary resettlement. However, there is no room for extension in the future. The layout of units becomes tight because the units will be constructed in a limited space. Moreover, the selection of Cases 1 and 2 are judged from the aspect of environmental impact.

- When minimizing the cost of construction is requested:
  Any of Cases 1, 2, 3 and 5 has a factor which increases the cost of construction for the construction of coal silo, the installation of environmental devices or the railway extension. Hence it is necessary to examine carefully the costs of construction in FS respectively.

- When reducing environmental impact is requested:
  It is possible to select any of Cases 1, 2, 3 or 5 after adopting the configuration of facilities used successfully in Japan.

**(2) Recommendation of the Team**

The Team recommends **Case 2 “Configuration Adopted in Japan” in “Planned Site of Unit No.10”.**

[Reasons of Recommendation]

- Considering the current condition that the land acquisition of ash disposal area for Units No.8/9 is going slower than it expected initially, it seems difficult to get 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 of the GOI to officially request to JICA’s ODA loan, environmental and social consideration should be fully considered.

However, it seems the construction/maintenance of Unit No.10 in a narrow area like an urban side based coal-fired TPP in Japan shall be executed. When constructing a 660 MW SC unit, it is necessary to consider the facility design in a narrow area, strict process control in construction, and smooth accessibility of maintenance.

**(3) Possibility of increased output from 660 MW**

This Pre-FS report has been prepared to explore the possibility of a construction of a 660 MW SC unit, however, it is also possible to set up increased output of around 700 MW instead of original 660 MW in the layout; because the examination of this Study is based on the experienced layout of 700 MW coal-fired plants which are owned by Kyushu Electric Power.

In addition, when the capacity of 700 MW is adopted instead of 660 MW, the more economies of scale in aspect of reduction of coal consumption and carbon dioxide can be obtained, because the improvement in thermal efficiency is expected.

# Chapter 8 Possibility of Introduction of Ultra Super Critical Unit

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# Chapter 8 Possibility of Introduction of Ultra Super Critical Unit

## 8.1 Definition of Ultra Super Critical Unit

Although there is no clear definition of an USC unit, it is recognized as a plant where the main steam pressure exceeds the critical pressure of water (22.064 MPa) and the main steam temperature exceeds 593 °C (1,100 °F) which is higher than the critical temperature of water (374 °C). An USC unit was introduced in Japan in the late 1990s. Currently, it is being evolved in the direction of high temperature rather than high pressure, and the plant with the best performance has achieved a main steam pressure as high as 25 MPa and main steam temperature as high as 610–620 °C.

## 8.2 Possibility of Introduction of Ultra Super Critical Unit

As mentioned in “8.1 Definition of Ultra Super Critical Unit”, an USC is a plant with high pressure and high temperature which exceed the critical point of water. Thus, higher pressure-resistant specifications of main steam piping to the HP turbine inlet and more temperature-resistant specifications of materials for the main steam/reheat piping enable to introduce USCs. Since technologies which enables piping materials for the main steam/reheat piping to be high pressure-resistant and high temperature-resistant have already been established, there is no specific difference from a SC to the extent that it may affect the plant layout. Rather it has an advantage in terms of thermal efficiency, which in turn, reducing the amount of coal consumption and mitigating the environmental negative impact. Therefore it is recommended that the introduction of an USC instead of an SC should be fully considered.

As mentioned in “2.1(1) Electricity Development Plan in the 12$^{th}$ Five Year Plan”, India is developing a USC with expectations of promoting a domestic production with aiming at commencing its operation in 2017. On the other hand, it has been nearly 20 years since Japan firstly introduced Japanese USC technology in the field of conventional coal firing power plants, which is enough to mature the Japanese USC technologies. In general, various failures occur at the beginning of introduction of new technology. However, finally, it has already reached the stage where verification of technology has been completed. Advantages can be expected by introducing mature Japanese technology.

Therefore, the Team concluded to the introduction of an USC technology.

## 8.3 Expected Performance of Ultra Super Critical Unit

The following parameters are assumed as expected performance in case that an USC is constructed. The plant with the best performance which is adopted in Japan has a main steam temperature of 610-620°C as mentioned in “8.1 Definition of Ultra Super Critical Unit”. It should be noted, however, that relatively conservative parameters of the main steam temperature are assumed in view of the fact that USC technology is still under development in India.

**Table 8.3-1 Expected Performance of USC**

| | Unit | Parameters | Source |
|---|---|---|---|
| Main/Reheat Steam Temperature | °C | 600/600 | Typical Record in Japan (USC) |
| Main Steam Pressure | MPa | 24.5 | Typical Record in Japan (USC) |
| Boiler Efficiency*1 | % | 85 | Typical Experience of Recent 660 MW in India (Table 6.1-1) |
| Turbine Heat Rate*2 | kcal/kWh | 1,764 | Typical Record in Japan (USC) |
| Expected Gross Thermal Efficiency of USC | % | 41.4 | Calculated by *1 and *2 |

## 8.4 Effect of Reduction in Coal Consumption and Carbon Dioxide Emissions owing to Improved Thermal Efficiency

The following parameters were used to calculate the effect of reductions in coal and carbon dioxide emissions.

**Table 8.4-1 Parameters for Reduction Effect of Coal and $CO_2$**

| | Unit | Parameters | Source |
|---|---|---|---|
| Gross Thermal Efficiency of SC | % | 39.5 | Table 6.1.1-1 |
| Gross Thermal Efficiency of USC | % | 41.4 | Table 8.3-1 |
| Gross Heating Value of Coal | kcal/kg | 3,300 | Table 4.7-1 |
| Fixed Carbon of Coal | % | 34.69 | Table 4.7-1 |
| PLF | % | 90 | Results from Interview (Table 4.1-1) |
| In house Consumption Rate | % | 6 | Typical Value for Coal-Fired TPS |
| Coal Cost | US$/ton | 43 | Expected Domestic Coal Price in India*1 |

*1: Prepared by the Team based upon Bihar Electricity Regulatory Commission, Determination of Multi Year Aggregate Revenue Requirement (ARR) for FY2013-14 to 2015-16 and Tariff for FY2013-14 (15 March 2013)

**(1) Annual Coal Consumption**

SC $$\frac{660(MW)\times 10^3 \div 4.1868(kJ/kcal)}{0.395\times 3{,}300}\times 3600\times 24\times 365\times 0.9 = 3{,}432{,}000(ton/year)$$

USC $$\frac{660(MW)\times 10^3 \div 4.1868(kJ/kcal)}{0.414\times 3{,}300}\times 3600\times 24\times 365\times 0.9 = 3{,}275{,}000(ton/year)$$

Advantage of USC $3{,}432{,}000 - 3{,}275{,}000 = 157{,}000(ton/year)$

**(2) Annual Carbon Dioxide Emission**

SC $3{,}432{,}000(ton / year) \times 0.3469 \times \frac{44}{12} = 4{,}365{,}000(ton - CO_2 / year)$

USC $3{,}275{,}000(ton / year) \times 0.3469 \times \frac{44}{12} = 4{,}166{,}000(ton - CO_2 / year)$

Advantage of USC $4{,}365{,}000 - 4{,}166{,}000 = 199{,}000(ton - CO_2 / year)$

**(3) Net Fuel Cost per Generation Unit**

SC $43 \times \frac{3{,}600}{0.395} \div 4.1868(kJ / kcal) \times \frac{1}{3{,}300} \times \left(\frac{1}{1 - 0.06}\right) \times 10^{-3} = 3.02(USCent / kWh)$

USC $43 \times \frac{3{,}600}{0.414} \div 4.1868(kJ / kcal) \times \frac{1}{3{,}300} \times \left(\frac{1}{1 - 0.06}\right) \times 10^{-3} = 2.88(USCent / kWh)$

Advantage of USC $3.02 - 2.88 = 0.14(USCent / kWh)$

**(4) $CO_2$ Emission per Generation Unit**

SC $\frac{3{,}600}{0.395} \div 4.1868(kJ / kcal) \times \frac{1}{3{,}300} \times 0.3469 \times \frac{44}{12} = 0.839(kgCO_2 / kWh)$

USC $\frac{3{,}600}{0.414} \div 4.1868(kJ / kcal) \times \frac{1}{3{,}300} \times 0.3469 \times \frac{44}{12} = 0.801(kgCO_2 / kWh)$

Advantage of USC $0.839 - 0.801 = 0.038(kg / kWh)$

**(5) Effect of introducing USC**

The effect of introduction of USC is typically classified with lower electricity cost per generation unit and lower environmental load than those of SC. Table 8.4-2 shows the content of the effect of introducing USC as compared with SC. In this study, only fuel cost and $CO_2$ emission can be only calculated by using collected parameters. The next FS should examine remaining items in order to completely understand the effect of introduction of USC.

**Table 8.4-2 Effect of USC as Compared with SC**

| Effect | Items | | SC (Thermal Efficiency 39.5 %) | USC (Thermal Efficiency 41.4 %) |
|---|---|---|---|---|
| Electricity Cost per Generation Unit | Fixed Cost | Capital Cost | base | higher (USC uses High Chromium Material in Boiler Tubes, however, it will be offset by Fuel Cost Reduction during Operational Life Period) |
| | Valuable Cost | Fuel Cost per Generation Unit | 3.02 US cent/kWh | 2.88 US cent/kWh (▲0.14 US cent/kWh) |
| | | Coal Consumption | 3,432,000 tons/year | 3,275,000 tons/year (▲157,000 tons/year) |
| | | Maintenance Cost | base | higher (USC costs more in maintenance of High Chromium Material, however, it will be offset by Fuel Cost Reduction ) |
| | | Running Cost (Chemical Dosing etc.) | base | even |
| Environmental Load | $CO_2$ Emission per Generation Unit | | 0.839 kg/kWh | 0.801 kg/kWh (▲0.038 kg/kWh) |
| | | $CO_2$ Emitted Amount | 4,365,000 tons/year | 4,166,000 tons/year (▲199,000 tons/year) |
| | SOx / NOx Emission | | base | lower |

LEGEND: [yellow] Advantage, [green] Disadvantage

# Chapter 9 Recommendations for Next Feasibility Study

# Table of Contents



# List of Tables

# Chapter 9 Recommendations for Next Feasibility Study

## 9.1 Updated Information on Barauni Thermal Power Station

The extension projects of Barauni TPS Units No.8/9 were under construction at the time of first site survey in October, 2013. In order to consider a conceptual design of Unit No.10 extension and other effects, further updated information on Units No.8/9 such as detail designing and progress, will be required. To be more precise, transmission line routes of Units No.8/9, each connection point of coal handling plant, demineralized water device, wastewater treatment device, water intake equipment and heavy fuel oil/light diesel oil storage etc. should be fully examined.

## 9.2 Preliminary Design and Selection of Reasonable Proposal

**(1) Selection of Optimal Plan**

This Project is to develop a 660 MW SC unit extension. Under the next FS, the optimal project plan should be selected after carefully reviewing the power generation output and type based on electrical power supply and demand trends in India, and the coal fired thermal power plant development trends in India and also in the world. Finally, this optimal project plan should be discussed and agreed with the Indian side.

**(2) Geological Survey**

The drilling survey should be conducted at planning sites of main facilities. In accordance with the survey results, it is required to conduct a geological evaluation, select the foundation type, and examine the necessity of improving the ground.

**(3) Coal Properties**

The coal properties are important factor for plant equipment design, such as the boiler, ESP, CHP etc. and the design coal properties for Units No.8/9 extension project were confirmed during the site survey. When the actual supplier and field area of coal can be specified during the future process, it will be necessary to confirm the coal properties in detail and to specify the design coal range for the unit.

**(4) Ash Disposal Area**

The following examinations are required for design of the ash disposal area.

- Examination of the embankment methods for ash landfill, and evaluation of the stability of the embankment
- Permeability test and examination for securing impermeability in the ash disposal area.
- Examination of appropriate system for storm water drainage in the ash disposal area
- Examination of embankment as a countermeasure for flood around the ash disposal area

## 9.3 Outline of Project Plan

Table 9.3-1 shows the points of consideration for the site selection of "Residential Area" or "Site in the South Adjacent to Units No.8/9".

**Table 9.3-1 Considerations for Land Acquisition**

| Site Selection | Points of Consider |
|---|---|
| Residential Area | Securing of new residential Land for Barauni TPS residents |
| Site in the South Adjacent to Units No.8/9 | Additional 154 acres (625,000 $m^2$) land is necessary for development |

## 9.4 Coal Supply and Utilization of Ash

**(1) Coal Supply Chain**

A 660 MW SC unit consumes coal in the amount of 3.65 million tons/year, and this study confirmed that there are fuel supply agreements for 1.5 million tons/year. There is a prospect of additional procurement, but the status of the coal supplier's development/supply capability and the estimated coal reserve amount should be considered.

The coal received for Barauni TPS Units No.6-9 is about 9,000 tons/day (60 tons/wagon x 50 wagons x 3 times/day). If a 660 MW SC unit becomes operational, an additional 11,000 tons/day should be acquired. In addition, the coal transportation and supply chain plan by rail should be fully examined.

**(2) Ash Utilization**

Since ash utilization influences a necessary capacity of ash disposal area, it is imperative to confirm a prospect of ash utilization plan. In addition, huge amount of ash expected to be transported from power stations, so an environmental impact around the site should also be reviewed.

## 9.5 Power Evacuation

A power evacuation system study should be implemented in order to confirm the following verifications.

- Verification of demand and load flow with future prospects. (Voltage fluctuation of buses, Capacity and prospected Load flow of transmission lines, etc.)
- Verification of the rupturing capability of the circuit breakers and bus. (Isolate the fault point of the three-phase short-circuit)

# 9.6 Equipment Design

**(1) Placement of Equipment**

In case the planned site of Unit No.10 is selected in this project, the plant layout should be designed considering the interposition of Units No.8/9 which is under construction.

With regard to installation of storage dangerous objects, such as ammonia storage tanks, it is required to confirm the related regulations and standards and comply with them.

**(2) EHV System**

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 should be planned for the construction of the 660 MW SC unit. In addition, some on-site surveys and interviews with the institutions concerned, such as ERLDC, ERPC at Kolkata, owners of transmission lines and substations, should be conducted in order to provide further information for selecting the connection destination from three cases under the next FS.

**(3) Securing of Necessary Volume of Water**

The necessary volume of water planned for Units No.6-9 is 45 cusec, but only 45 cusec can be taken by a water intake permit from the Ganges. Thus, Additional 33 cusec should be acquired for constructing a 660 MW SC unit (33 cusec), and the total volume of water will become 78 cusec.

**(4) Water Intake Plan**

It is necessary to consider the change in the number of water intake pumps and those capacity in the planned pump house for Units No.6-9 including the new establishment of a pump house for Unit No.10 because there is no space for the water intake pump for Unit No.10 in the planned pump house for Units No.6-9. It is also necessary to consider the new establishment of a sedimentation tank and clear water pumps for Unit No.10 and settling tank, and to examine whether these tanks can be shared with Units No.6-9 or not. In addition, it is necessary to consider the water intake route and the number and size of pipes.

**(5) Transport Route for Equipment**

Because there are few bridges crossing over the Ganges which is wide, there are inevitably a limited number of routes for transport equipment to Barauni TPS. At the first site survey in October 2013, large vehicles could not cross over the Rajendra Bridge which is located approximately 2 km southwest of Barauni TPS because of its maintenance. Thus, it is necessary to pay attention to the availability of the bridge for transportation.

## 9.7 Construction Method

The construction methods should be examined in order to confirm any method which affects the procurement process.

## 9.8 Project Implementation Schedule

For considering the project implementation schedule, it is necessary to pay attention to the detailed design/construction period including the procurement procedures. Tentative project implementation schedule is as follows.

**Table 9.8-1 Tentative Project Implementation Schedule**

| | Month | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|
| FS～LA | **28** | | | | | | | | | |
| Feasibility Study | 12 | | | | | | | | | |
| ToR | 14 | | | | | | | | | |
| Preparation/Submit | 12 | | | | | | | | | |
| Approval | 2 | | | | | | | | | |
| EIA | 15 | | | | | | | | | |
| Preparation/Submit | 12 | | | | | | | | | |
| Approval | 3 | | | | | | | | | |
| JICA Approval for LA | 8 | | | | | | | | | |
| Preparation | 2 | | | | | | | | | |
| Committee | 6 | | | | | | | | | |
| LA～EPC Contract | **18** | | | | | | | | | |
| Preparation for Bid | 6 | | | | | | | | | |
| Selecting Consultant | 3 | | | | | | | | | |
| Preparation for Bid | 3 | | | | | | | | | |
| EPC Contract | 12 | | | | | | | | | |
| Announcement | 9 | | | | | | | | | |
| Selecting EPC | 2 | | | | | | | | | |
| EPC Contract | 1 | | | | | | | | | |
| Construction～COD | **54** | | | | | | | | | |
| Design | 6 | | | | | | | | | |
| Construction | 48 | | | | | | | | | |
| Commissioning Test | 5 | | | | | | | | | |
| Total Month | **100** | | | | | | | | | |

## 9.9 Environmental and Social Considerations

### (1) Environmental Impact Assessment

It is necessary to obtain EC in India for the construction of the power plant. Thus, in the next FS, required conditions for preparing the draft EIA to acquire EC should be understood. Moreover, the necessary environmental mitigation measures should also be understood and clearly reflected in the next FS and EIA.

### (2) Environmental Regulations

There is a possibility that the environment policy in India may become stricter in the future. Therefore, the equipment configuration will have to be changed in order to respond to the change in the environmental policy such as a FGD installation obligation for environmental equipment.

The numerical value of the global standard (EHS Guidelines) such as the emission standard, the effluent standard and the noise regulation should be carefully examined at the design stage, and be reflected into EIA.

And this project should comply with ‘JICA Guidelines for environmental and social considerations’ for getting approval of Japanese ODA loan.

### (3) Land Acquisition

In cased to acquire additional land for the construction of the power plant, the assessment to surrounding farmers and agricultural land should be required, and also be reflected into EIA.

## 9.10 Consideration for Detailed Project Report Preparation

The following items should be carefully considered during DPR preparation.

- Confirmation of the internal procedures and process of GOI and other related institutions for getting the Project approval
- Confirmation of the project implementation and maintenance schemes
- Estimation of the project cost the operation and maintenance cost, and other related cost.
- Comparison of the project cost with other similar projects

# Chapter 10 Appendices

# Table of Contents

## Chapter 10 Appendices

## 10.1 Site Survey Photos

October 22, 2013 (Tuesday)


Presentation on Inception Report

Site Survey in Existing Plant Area
（Obsolete Turbine Building of Units No.1-3）

Site Survey in Existing Plant Area
（Reuse: Cooling Tower of Units No.1-3）

Site Survey in Existing Plant Area
（Reuse: Circulating Water Pump House of Units No.1-3）

Site Survey in Existing Plant Area
（Units No.1-3, Boilers already abolished）

Site Survey in Existing Plant Area
(Units No.4/5, Boiler Side)

Site Survey in Existing Plant Area
（Units No.6/7 under R&M/LE）

Site Survey in Existing Plant Area
(Reuse: Coal Storage Yard)

Site Survey in Existing Plant Area
(Obsolete Cooling Towers of Units No.4/5)

Construction of Units No.8/9
(Common Turbine Building)


Construction of Units No.8/9
（Unit No.8 Boiler）


Direction of Ash Disposal Area
（Southeast from top of Unit No.8 Boiler）


Transmission Line of South Barauni
（Southwest from top of Unit No.8 Boiler）

Site in the South adjacent to Units No.8/9
（from top of Unit No.8 Boiler）

Construction of Chimney of
Units No.8/9 (from top of Unit No.8 Boiler)

Construction of ESP of Unit No.9
(from top of Unit No.8 Boiler)


Construction of Raw Water Reservoir of Units No.8/9 (from top of Unit No.8 Boiler)


Visit site office of BHEL (Units No.8/9 Main Equipment Supplier)

October 23, 2013 (Wednesday)

Visit Substation in north of Barauni TPS


Interview with Officials at Substation

Water Intake Point (the Ganges River)

Inland Provisional Reservoir on Bank of the Ganges River (Barauni TPS in back)

October 24, 2013 (Thursday)

Interview with Resident STEAG Engineers (Consultant of Units No.8/9 construction)

Condition of Controlled Area with 500m between Units No.8/9 Area and NH-31


Planned Site of Unit No.10 (Used as Laydown Area of Units No.8/9 Construction)


Planned Site of Unit No.10 (Used as Laydown Area of Units No.8/9 Construction)

October 25, 2013 (Friday)


Railroad Crossing in north of Barauni TPS (Single Way)


Access Point to Barauni TPS on NH-31

Switchyard of Units No.6/7

Transmission Line in north of Existing Plant

Warehouse in Residential Area

Interview with officials at Barauni TPS (Final Day)


Wrap-Up Briefing of site survey at Barauni TPS

# 10.2 Data Requirement and Questions

Data Required and Questions prior to Site Survey
(Study on Barauni Thermal Power Station (660 MW x 1) in Bihar)

| No | Category | Data Required | Data Required status | Questions | Answer |
|---|---|---|---|---|---|
| 1 | Plant, Space, Layout | Space and layout of existing facilities plant Unit 1～9 including ash disposal area of Unit 8,9, railway and intake water pipe route | Collected | | |
| | | Space for plant Unit 10 including ash disposal area and intake water pipe route | Collected | | |
| | | | | Is there any place that needs worker residence except Central Control Room? | CWP pump yard, DM, Raw water treatment etc. |
| 2 | Meterology | Average, maximum and minimum air temperature of each month (past 10 years) | Collected | | |
| | | Monthly rainfall and rainfall intensity of each year (past 10 years) | Collected | | |
| 3 | Geology & Topography | Topography map (Plant Unit 8～10 area、ash disposal area、intake water pipe route and surrounding area) with scale of 1/5,000～ | Collected | | |
| | | Geological survey report (Plant Unit 8～10 area、ash disposal area、intake water pipe route and surrounding area) | Collected | | |
| | | Content of Zone-Ⅳ IS1893 that is mentioned in Detailed Proposal Report by NTPC in November 2010 | Collected | Is there a kind of Ground acceleration for design of facilities? | Confirmed |
| 4 | Water Resource | Amount of available water resource for Plant Unit 10 and if any restriction of water intake from the river (Cooling water and Plant water) | Collected | Is there a volume range of water intake available between rainy and dry season? | There isn't volume range. |
| | | Daily river flow data and the location of river gauging station (past 10 years) | Collected | | |
| | | Intake water quality<br>pH, specific conductance, turbidity, colour, total iron (T-Fe)<br>Mn, Chemical oxygen demand, Water hardness, Na, K, NH4, HCO3, SO4, Cl, NO3, NO2,CO2, SiO2, organic carbon | Collected | | |
| | | Average, maximum and minimum water temperature in the river of each month | Collected | | |
| 5 | Coal Condition | Predicted Power Load Factor after COD of 660MW unit 10 | Predicted Power Load Factor is 85-90%. | | |
| | | Coal Volume available for unit 10 | Collected | | |
| | | Coal Accepting frequency to site and Volume per cargo | Collected | | |
| | | Element component (weight percent) of design coal (hygroscopic moisture, surface moisture, ash content, S, C, H, O, N) | Collected | | |
| | | Ash component ($Na_2O$, $SiO_2$, $Al_2O_3$, CaO, MgO, $Fe_2O_3$) in weight percent | Not Collected. But typical ash analysis data was collected. | | |
| | | | | According to DPR of 250MW, in regard to coal stockyard capacity. While page 51 requests 30 day capacity with 100% PLF, page 137 requests 15 day capacity with full load. Which is right for this study? | 15 day is right. |
| | | | | Is it possible to extend coal stockyard to west side where existing ash pond lies? | West side isn't available. |
| | | | | Is it possible to apply silo storage to extend capacity of coal stockyard? | Moisture content of Coal may not permit for Silo storage. |
| 6 | Supplement Fuel | Category of heavy oil ( Need to warm up and pipe insulation) | Collected | | |
| 7 | Water Intake | Water supply method from intake point to power plants（unit 6～9） | Collected | | |
| | | Dimensions of intake water channel or culvert | Collected | Is there a limit of velocity in the channel of water supply? | Confirmed |
| 8 | Tank Capacity | Capacity of existing demineralized water tank | Collected | | |
| | | Capacity of existing service water tank | Collected | | |
| | | Capacity of existing water tank for fire-fighting | Collected | | |

| No | Category | Data Required | Data Required status | Questions | Answer |
|---|---|---|---|---|---|
| 9 | Condenser Cooling | | | According to DPR of 250MW (page 55), there is a description that power plant cooling is applied using cooling tower type. Even after the output increases up to 660 MW, is unit 10 also applied with cooling tower type? | Planed system is Induced Draft Cooling Tower. |
| 10 | Auxiliary Steam | Available Steam volume from neighboring unit 8/9 during start-up/waiting synchronization | Collected | | |
| 11 | DeNOx | | | According to enviromental regulation of Ministry of Environment & Forests (MoEF), coal fired power plant is not applied with Nox emission regulation. Is that actually true? | That is true.<br>To be followed as per EIA Notification 2006 and Central Pollution Control Board Standards for Air Quality Parameters. |
| | | | | Do you have an idea to install Selective Catalyst Reduction even though no regulation is applied? (If you need SCR, anmonia tank is required) | Not necessary. |
| 12 | Dust | | | According to DPR of 250MW(Page 37). "ESP specific collection area shall not be less than $200m^2/m^3$/sec at 100% BMCR." is shown. Please tell us what this part describes. | This part describes about ESP design concept. This is dicided by fuel gas and ash content. |
| | | Design concept of longitudinal and lateral dimensions of ESP for rough design. | Collected | | |
| 13 | FGD | | | According to environmental regulation of MoEF and/or DPR of 250MW, FGD is regulated to install as future facility. Based on this, even in this study, is FGD treated in same manner? | This shall be prescibed by Ministry of Environment & Forest while giving Final Environmental Clearance to the Project based on the coal quality parameters. |
| | | | | Should Gas Gas Heater (GGH) be alsoconsidered in line with FGD as future facility?<br>In Japan, this is usually installed to avoid having smoke turned white after emitted from chimney. | (KEPCO explain about GGH system to BTPS and BSPGCL.) |
| | | | | According to environmental regulation of MoEF, chimney with height of 275m is really required in case of 660MW accessary? | The minimum Chimney Height is to be formualted as per regulation of MoEF |
| 14 | Waste Water | Capacity of existing waste water treatment process | Collected | | |
| | | Capacity of baths of existing waste water treatment | Collected | | |
| 15 | Ash Disposal | Amount of annual ash by Unit 6〜9 to be operated | Collected | | |
| | | Regulation or requirements for design and operating of ash disposal area (e.g impermeability of ground) | Collected | | |
| | | Structural design of ash disposal area for Unit 10 | Collected | | |
| | | Method of filling ash into ash disposal area for Unit 10 (e.g. method by slurry of mixed water and ash) | Collected | | |
| | | Planning of ash utilizing | Confirmed existing of cement plants around BTPS | | |
| 16 | Instrument & Electrical | Requirements for electrical facilities regulated by Bihar/india Authorities such as<br>- Oil Fence for transformer<br>- Magnetic field, etc. | N/A | | |
| | | Single Line Diagram (SLD) of in-house circuits (>MV) and 110kV substation,220kV substation for Barauni TPS (latest version)<br>- Entire Bihar state area(110kV/220kV) SLD<br>- Existing unit #5&#6 (MV/110kV) SLD<br>- Constructing unit #8&#9 SLD<br>- (220kV,MV,DC,UPS,Emergency AC/Black start AC)<br>- Plan of #10 as 20MWx1 base SLD<br>- (220kV,MV,DC,UPS,Emergency AC/Black start AC)<br>- Connected and/or future connect substations(110kV,220kV) SLD | Collected | | |
| | | Layout drawing of existing substations<br>- #1-#7 110kV PS &SS<br>- #8-#10 220kV PS & SS<br>- Transmission lines route | Collected | | |
| | | Design documents, specifications and drawings (panels, three line, sequential diagrams, etc.) of 220kV bay expansion planning<br>- For #8,#9#10<br>- Transformers for local distribution (220kV/110kV) | Collected | | |
| | | | | Is insulation washing couducted during off-line? ( Necessity of insulation washing device, If required, Insulation washing water storage tank is required.) | They are washed manually. |
| | | | | Is connection terminal point to Generator Transformer and Start-up/Station Transformer already fixed? | Not decided |
| | | | | Is local transformer extention already scheduled? | Not decieded |

| No | Category | Data Required | Data Required status | Questions | Answer |
|---|---|---|---|---|---|
| 17 | Permits and approvals | EIA and environmental permits of existing facilities Unit 8/9 | Now, re-writing new document due to laguration changing. | | |
| 18 | Related laws and regulations | Please submit the following environmental laws related thermal power plants.<br>- Air quality ( SO2, NO2, CO, O2, soot and dust, suspended particulate matter, coarse particulates, etc.) | Collected | | |
| | | Water quality (pH, SS(suspended solids), BOD(biochemical oxygen demand) and COD(chemical oxygen demand), DO(dissolved oxygen), total nitrogen, total phosphorus, heavy metals, hydrocarbons, phenols, cyanogen compounds, mineral oils, water temperature, etc.) | | | |
| | | Waste | | | |
| | | Soil contamination | | | |
| | | Noise and vibration | | | |
| | | Subsidence | | | |
| | | Odor | | | |
| | | Sediment | | | |
| | | Working conditions (including occupational safety) | | | |
| 19 | Monitoring | Monitoring data of existing facilities plant Unit 1 ～9 (construction stage and comercial operation )<br>- Monitoring item<br>- Monitoring data | Now, re-writing new document due to laguration changing. | | |
| 20 | Others | Situation of land use around the power plant site | Confirmed | | |
| | | | | For more details, please refer to the attached sheet about environmental and social considerations. | Confirmed |

## 10.3 Site Presentation and Minutes of Meeting

### 10.3.1 Kick-off Meeting

*JICA Study on Barauni Thermal Power Station in Bihar*

# JICA Study on
# Barauni Thermal Power Station
# In Bihar

October 2013

Kyushu Electric Power Co., Inc.

Kyushu Electric Power Co., Inc. 1

*JICA Study on Barauni Thermal Power Station in Bihar*

# Agenda

- Background
- Study Plan
- Survey Items

Kyushu Electric Power Co., Inc. 2

*JICA Study on Barauni Thermal Power Station in Bihar*

# Agenda

- Background
- Study Plan
- Survey Items



*JICA Study on Barauni Thermal Power Station in Bihar*

# Background

**Initial Plan**

1×250MW using Subcritical Boiler

**Advantage of**
**Supercritical(SC) and Ultra-Supercritical(USC) Boiler**

- High Thermal Efficiency
- Low Environmental Impact

**Purpose of Study**

Initial Study for Construction of
1×660MW using SC coal-fired power plant

JICA Study on Barauni Thermal Power Station in Bihar

# Agenda

- Background
- Study Plan
- Survey Items



JICA Study on Barauni Thermal Power Station in Bihar

# Study Plan

| | 2013 | | | 2014 |
|---|---|---|---|---|
| | October | November | December | January |
| Preparation | | | | |
| First site Survey | 17 | 1 | | |
| Analysis Work in Japan | | | | |
| Second site Survey | | | 15 20 | |
| Making Final Report | | | | |
| Submission of Report | ▼ Ic/R | | ▼ Df/R | 20 ▼ F/R |

JICA Study on Barauni Thermal Power Station in Bihar

# Agenda

- Background
- Study Plan
- Survey Items

Kyushu Electric Power Co., Inc. 7

JICA Study on Barauni Thermal Power Station in Bihar

# Survey Items

**Direction of Study**

If a construction of 1 x 660MW is possible…

- Suggest Layout of 660 MW
- Suggest Recommendations for the Next FS

If a construction of 1 x 660MW is not possible…

- Clarify Critical Matters
- Recommend Options for Construction

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JICA Study on Barauni Thermal Power Station in Bihar

# Survey Items

## For Suggestion Layout of the 660MW

- Check the planned site
- Determine the Configuration
- Check the possibility of reuse
- Assume an amount of coal required

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JICA Study on Barauni Thermal Power Station in Bihar

# Survey Items

## Recommendations for the Next FS

- Project the layout draft onto available space
- Check the ash discharging area and plan for effective use of coal ash
- Check environmental considerations

Kyushu Electric Power Co., Inc. 10

### 10.3.2 Wrap-Up Meeting

*JICA Study on Barauni Thermal Power Station in Bihar*

# Site Survey & Collected Information in Barauni TPS

（22～25　October 2013）

Kyushu Electric Power Co., Inc.



*JICA Study on Barauni Thermal Power Station in Bihar*

# Agenda

- Space for the SC 660 MW unit
- Site condition of the SC 660 MW unit
- Possibility of reuse of the existing equipment, survey on the possibility of expanded capacity
- Cooling and industrial water
- Survey for preliminary planning of the SC 660 MW unit
- Coal
- Survey on transportation infrastructures of construction materials and equipment
- Survey on environmental and social considerations
- Special considerations

# Agenda

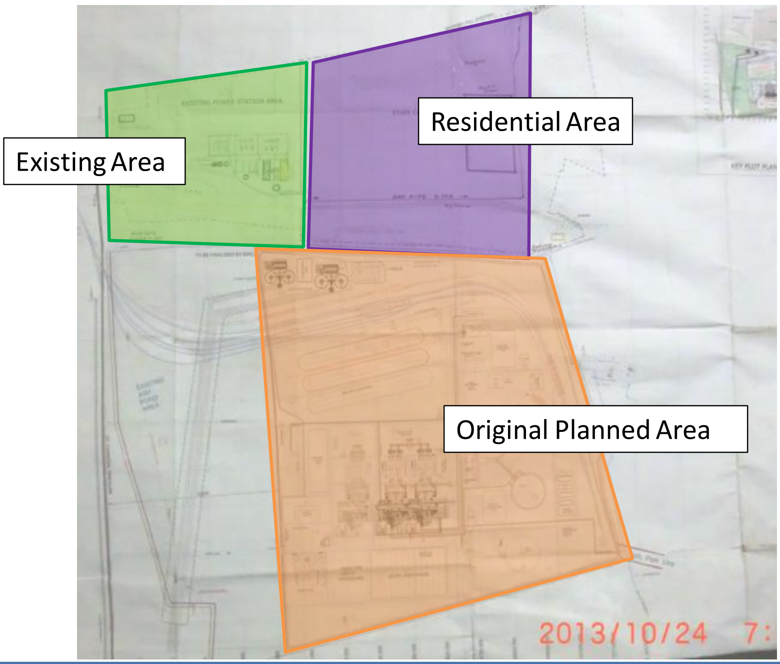
- Space for the SC 660 MW unit
- Site condition of the SC 660 MW unit
- Possibility of reuse of the existing equipment, survey on the possibility of expanded capacity
- Cooling and industrial water
- Survey for preliminary planning of the SC 660 MW unit
- Coal
- Survey on transportation infrastructures of construction materials and equipment
- Survey on environmental and social considerations
- Special considerations





Space for the SC 660 MW unit

# Confirming Available Space(whole) (1/5)



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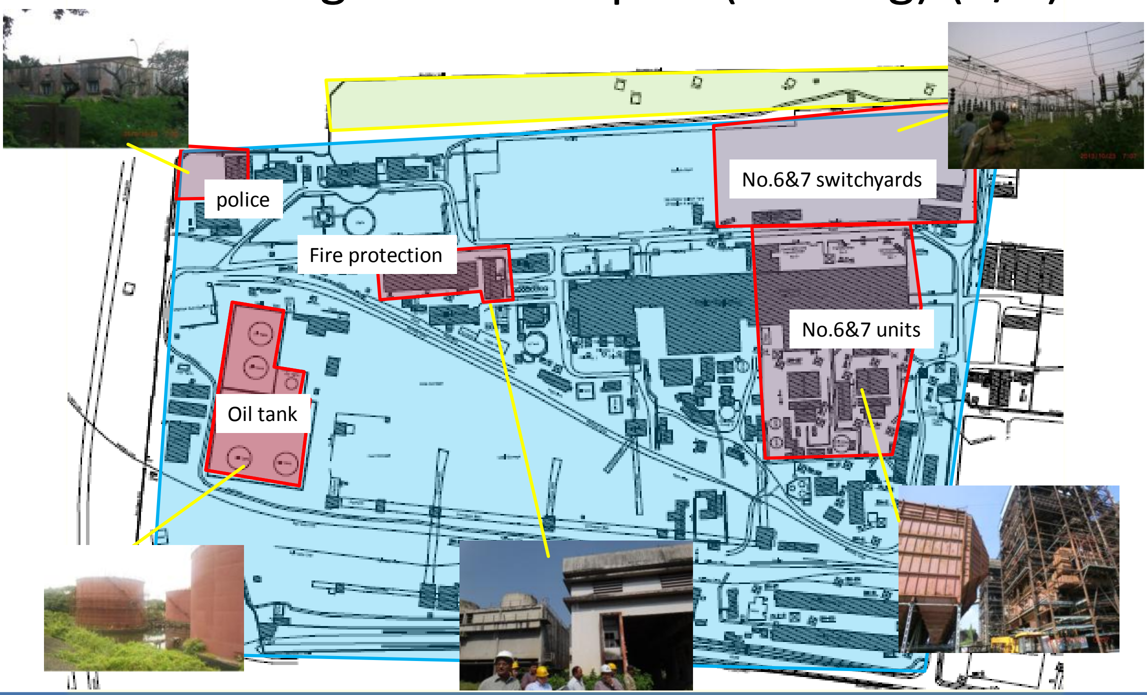
Space for the SC 660 MW unit

## Confirming Available Space(Existing) (2/5)

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Space for the SC 660 MW unit

## Confirming Available Space(Residential) (3/5)


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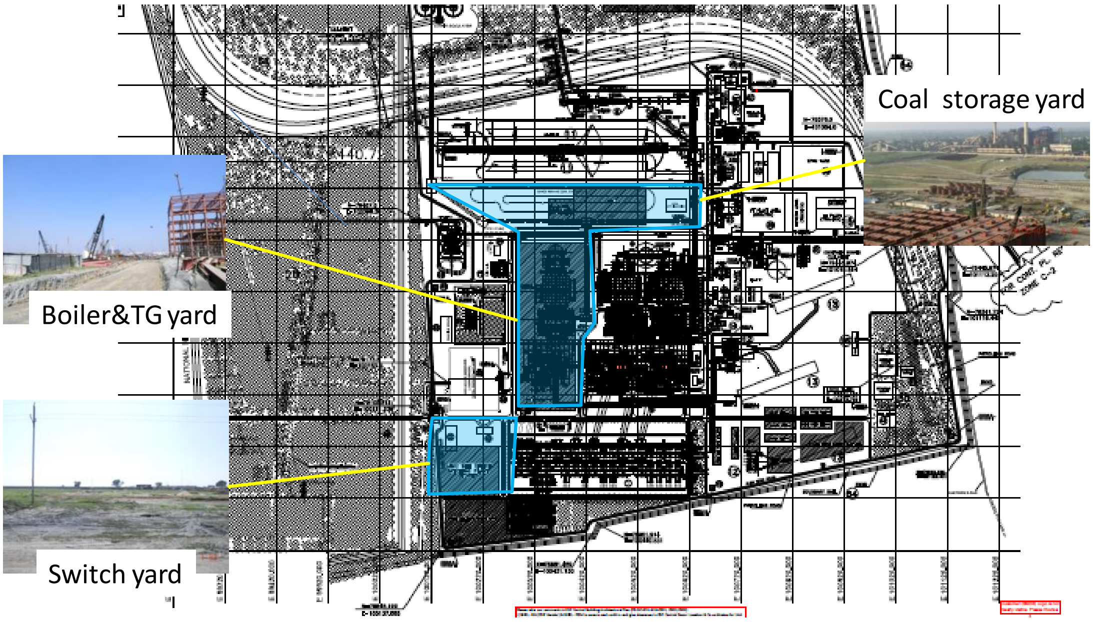
Space for the SC 660 MW unit

## Confirming Available Space (Original Planned Area) (4/5)

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Space for the SC 660 MW unit

## Confirming available space(5/5)

**Our Priority Order of Available spaces**

**based on site survey is ;**

1. Original Planned Area
2. Residential Area
3. Existing Area

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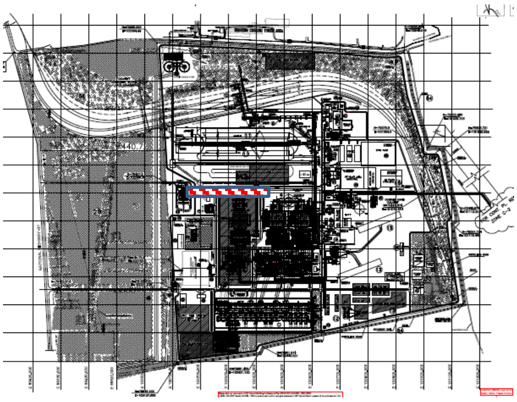
Space for the SC 660 MW unit

## Confirming existence of obstructions

Confirmed the obstructions such as existing building equipment and road etc.
⇒ Planned Fly Ash transporting pipes routing overhead might be interfered for future

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*JICA Study on Barauni Thermal Power Station in Bihar*

# Agenda

- Space for the SC 660 MW unit
- Site condition of the SC 660 MW unit
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## JICA Study on Barauni Thermal Power Station in Bihar

Site conditions of the SC 660 MW unit

# Meteorological data

Collected monthly rainfall data of Bihar district for last 5 years

Collected monthly mean maximum & minimum temperature and monthly total rainfall data for 1901 - 2000

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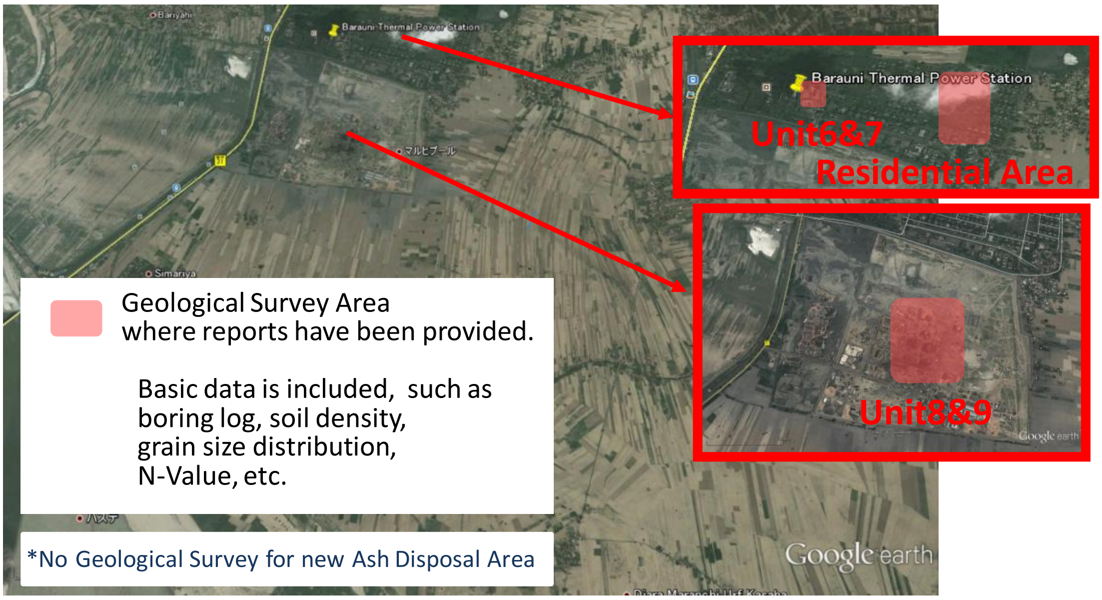
## JICA Study on Barauni Thermal Power Station in Bihar

Site conditions of the SC 660 MW unit

# Topographical and Geological data

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*JICA Study on Barauni Thermal Power Station in Bihar*

# Agenda

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*JICA Study on Barauni Thermal Power Station in Bihar*

Possibility of reuse of the existing equipment,
survey on the possibility of expanded capacity

# Collecting data and confirming condition

Collected existing equipment data

Confirmed existing equipment condition

⇒ No equipment can be reused for SC 660 MW unit

⇒ Every equipment will be constructed newly

Existing equipment condition




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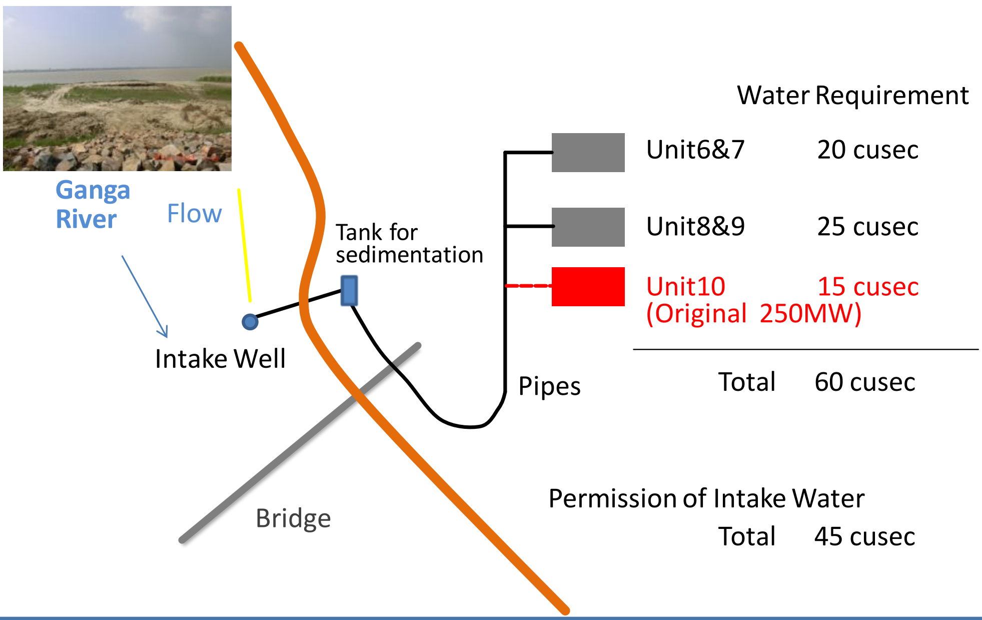
Cooling and industrial water

## Confirming Amount of available water
## Water intake route to the power plant



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Cooling and industrial water

# Collecting Quality of intake water

## Collected GANGA water quality data

| Constitute | Mg per liter |
|---|---|
| Calcium | 108 |
| Magnesium | 45.8 |
| Sodium | 45.78 |
| Potassium | 10 |
| Total Hardness | 153.8 |
| Carbonates | Nil |
| Bicarbonates | 120.36 |
| Chloride | 59.22 |
| Sulphate | 30 |
| Silica | 10 |
| Iron | 0.19 |
| pH Value | 7.63 – 8.9 |
| Turbidity | Up to 1000 |

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# Agenda

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Survey for preliminary planning of the SC 660 MW unit

## Presenting, Collecting and Confirming (1/2)

Presenting Outlined specification of main unit equipment

⇒Presented advantage/disadvantage of SC

Collecting and confirming Types of equipment required to conform to environmental regulations

⇒

| Item | Status |
|---|---|
| DeNOx | Not Required |
| FGD | Space Required for future installation |
| ESP | Collected Design Concept → analyze in office |
| Chimney | Confirmed its height of 275 m |
| Waste Water | Only Neutralization |

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Survey for preliminary planning of the SC 660 MW unit

## Presenting, Collecting and Confirming (2/2)

Collecting Turbine Building

⇒ Collected dimensions of turbine hall No.8/9

Presenting and Confirming Condenser Cooling type

⇒ Presented 3 types of Cooling Characteristics

(Natural Draft, Induced Draft and Direct intake Water)

⇒ Keep Induced draft type, as planned

Confirming additional Chemical Availability

⇒ No problem

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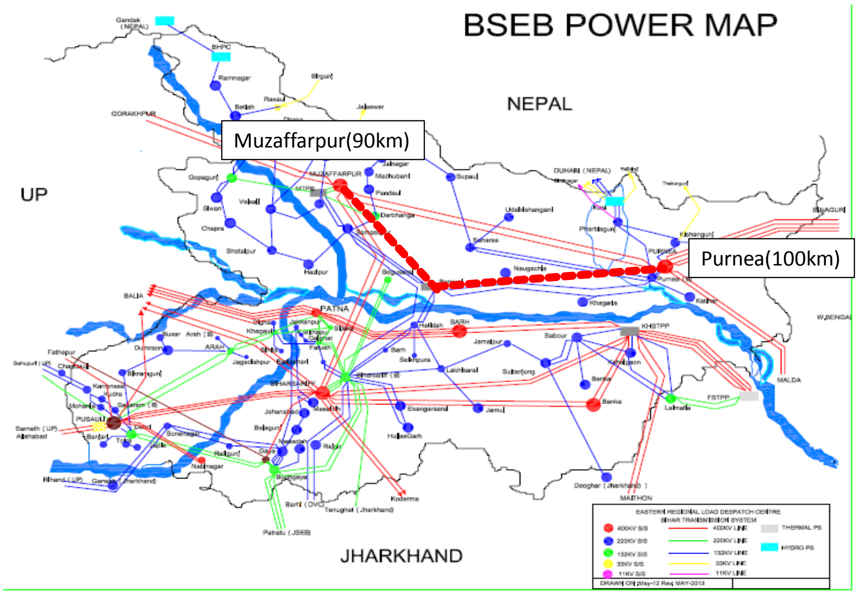
Survey for preliminary planning of the SC 660 MW unit

# Confirming Switchyard, transmission lines (1/3)

## New 400kV Transmission Line

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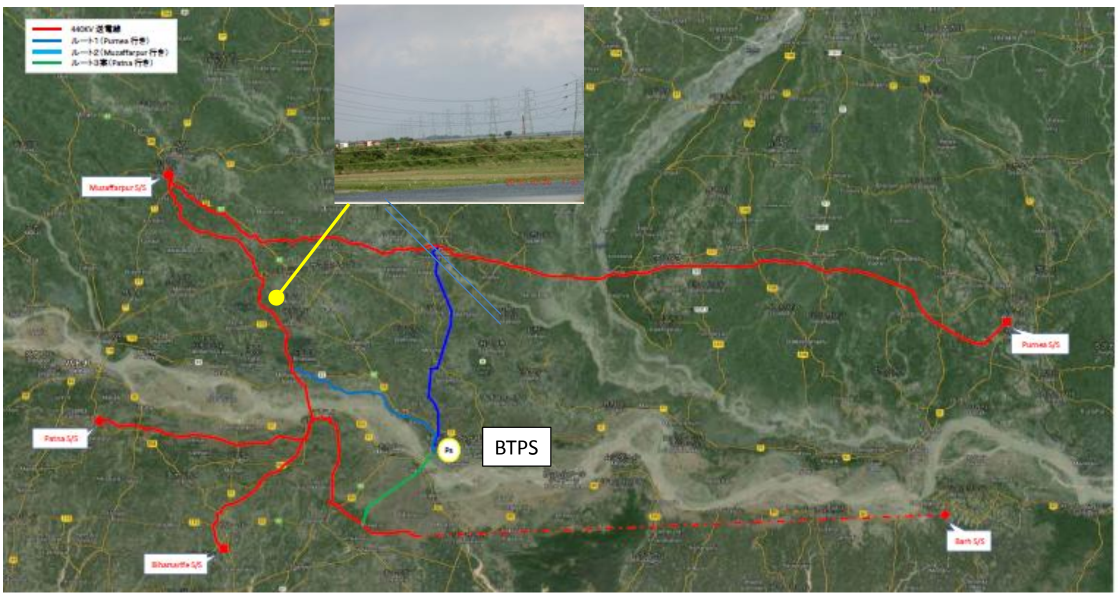
Survey for preliminary planning of the SC 660 MW unit

# Confirming Switchyard, transmission lines (2/3)

## New 400kV Transmission Line

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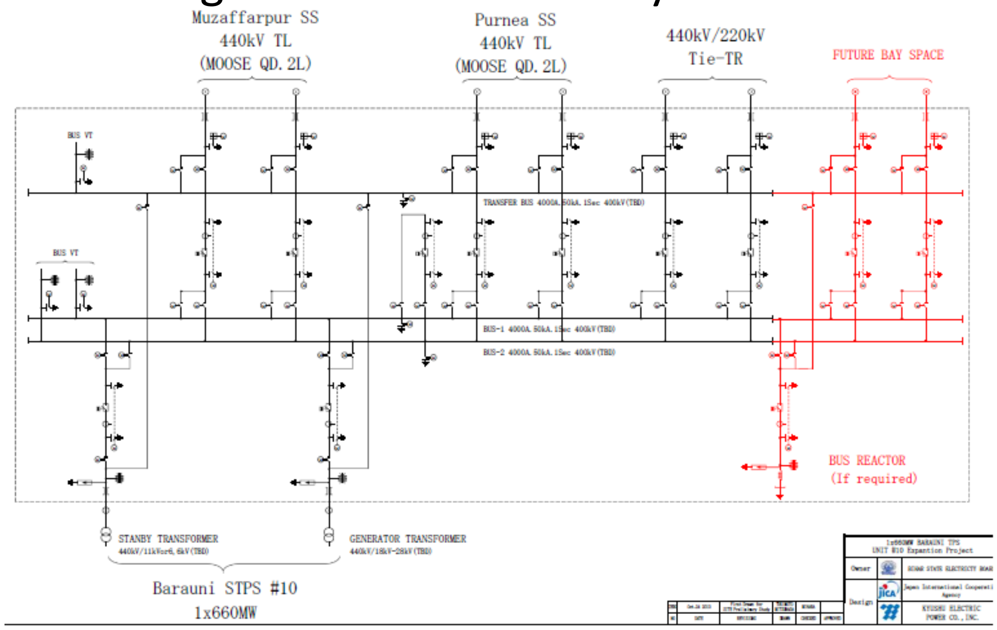
Survey for preliminary planning of the SC 660 MW unit

# Confirming Switchyard, transmission lines (2/3)

## Single Line diagram of 400kV switchyard



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Survey for preliminary planning of the SC 660 MW unit

# Confirming Ash disposal pond planning for utilization of coal ash


(Land Acquisition : 496acres)

Rough Drawing of Ash Disposal Area

- ■Amount of annual ash from Unit6-9 : 1.5million ton
- ■Planning of 100% fly ash utilization within 4 years of plant commissioning

⇩

Utilization as materials of cement, brick

# Agenda

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Coal

## Collecting data

Collecting Coal Property
⇒ Collected element content for design
⇒ Not available for future use at this moment

Collecting Coal Amount equivalent to new Output
⇒ Collected Predicted Power Load Factor, which make it possible to calculate necessary coal amount using new thermal efficiency

Coal unloading/accepting frequency
⇒ Collected, as 50 t x 60 wagons x 3 trains /day

Collecting Capacity of Coal Stockyard
⇒ Collected Design concept and Guideline

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Coal

## Confirming Status coal procurement

Confirming Available Coal

⇒ Confirmed 1.5 million ton/annum required for 250 MW is already available from Mogma Mines

Confirming Additional procurement

⇒ Available

⇒ Confirmed Urma Paharitola coal block begins production around 2018 (reserved value : 700 million ton)

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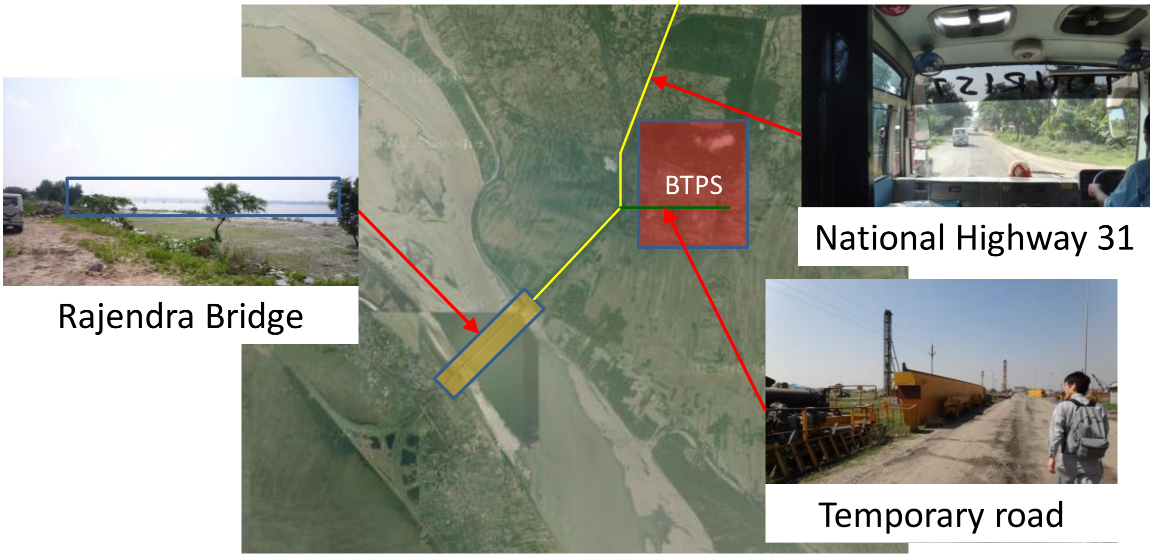
Survey on transportation infrastructures of construction materials and equipment

## Confirming Status of establishment / development

### Confirmed infrastructures around the Site

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## Agenda

- Space for the SC 660 MW unit
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Survey on environmental and social considerations

## Confirming environmental and social considerations(1/3)

Confirmed Involuntary resettlement of inhabitants

⇒ There are no involuntary resettlement of inhabitants, although worker's residential area might be moved to other area.

⇒ If ash disposal areas are insufficient to discharge ash of unit 10, it will require additional land acquisition.

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Survey on environmental and social considerations

## Confirming environmental and social considerations(2/3)

Confirmed Extraction of environmental impacts

⇒ Conducted a questionnaire based on JICA's format

⇒ This project might have little influence on environmental and social impacts.

⇒ This project requires a Environmental Clearance from Ministry of Environment and Forests.

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Survey on environmental and social considerations

# Confirming environmental and social considerations(3/3)

## Confirmed EIA procedure

⇒EC process in India is made up of the following phases:

① Submit EIA report
② Public hearing (within 45days)
③ Amendment of EIA
④ Appraisal of project (within 60days)
⑤ Grant or Rejection (within 45days)



*JICA Study on Barauni Thermal Power Station in Bihar*

# Agenda

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## JICA Study on Barauni Thermal Power Station in Bihar

Special considerations

### Confirming Consistency of this project for the higher program / policy

Confirmed Consistency as following

⇒ According to BSPGCL, if this project is feasible, it will be planned as a policy of Bihar, and it will apply to be included in the policy of the Republic of India.

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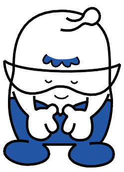

**Thank you!**

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### 10.3.3 Presentation about Flue Gas Process System in Wrap up Meeting

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## Special Consideration about Gas Process system

- **FGD is Flue Gas Desulfuring (eliminate SOx)**
- **According to latest Environmental Regulation in India, FGD is regarded as future device.**
- **Our study Team keeps FGD for future installation. However, If you'd like to get more compact layout, you should consider total gas process system from initial stage, such as FGD, GGH and ESP devices.**

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## Special Consideration about Gas Process system

- **What is GGH? → Gas Gas Heater**

**To Reheat flue Gas up to around 100 degree before entering into chimney, which helps you …**

- ✓ **Avoid turning flue gas white**
  **(In Japan, Local resident regards white steam gas as harmful one.)**
- ✓ **Avoid low temperature erosion inside chimney**
- ✓ **Enhance diffusion effect of emitted gas**

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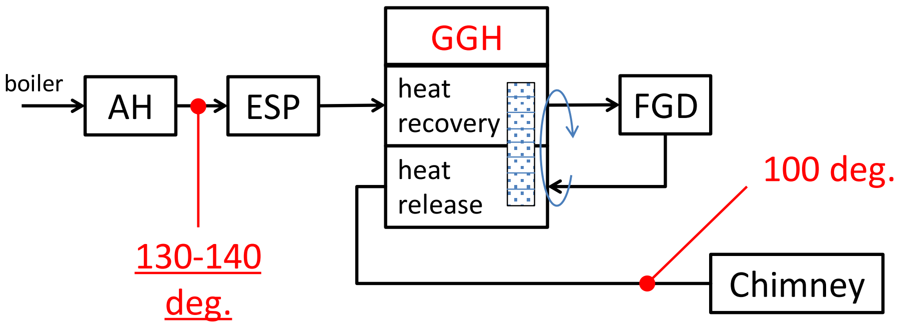
## Special Consideration about Gas Process system

### Flue Gas Processing Flow

- **Conventional System (i.e. Reihoku No.1)**




- ✓ **GGH is combined with Heat recovery and Release, similar to Air Heater (Regenerative Rotary type).**
- ✓ **This ESP type is called as " Low Temperature ESP".**

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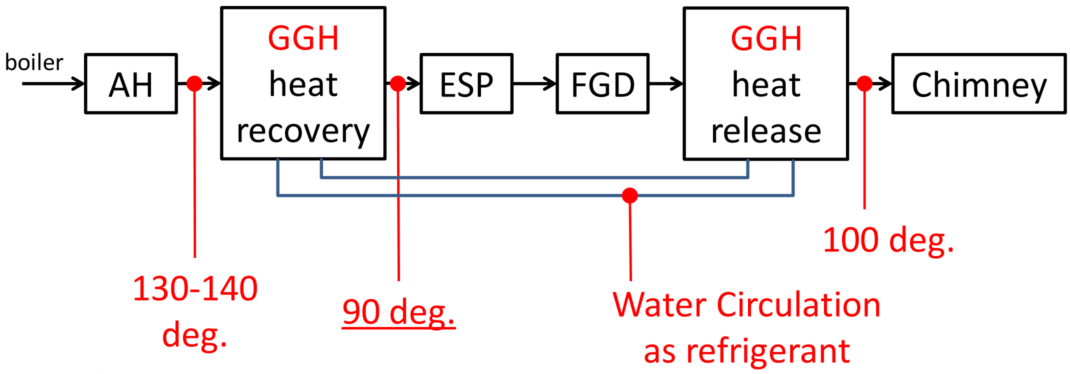
## Special Consideration about Gas Process system

### Flue Gas Processing Flow

- **Latest system (i.e. Reihoku No.2)**




- ✓ **GGH is separated into Heat recovery and Release. (No Leak type)**
- ✓ **This ESP type is called as " Low Low Temp. ESP".**

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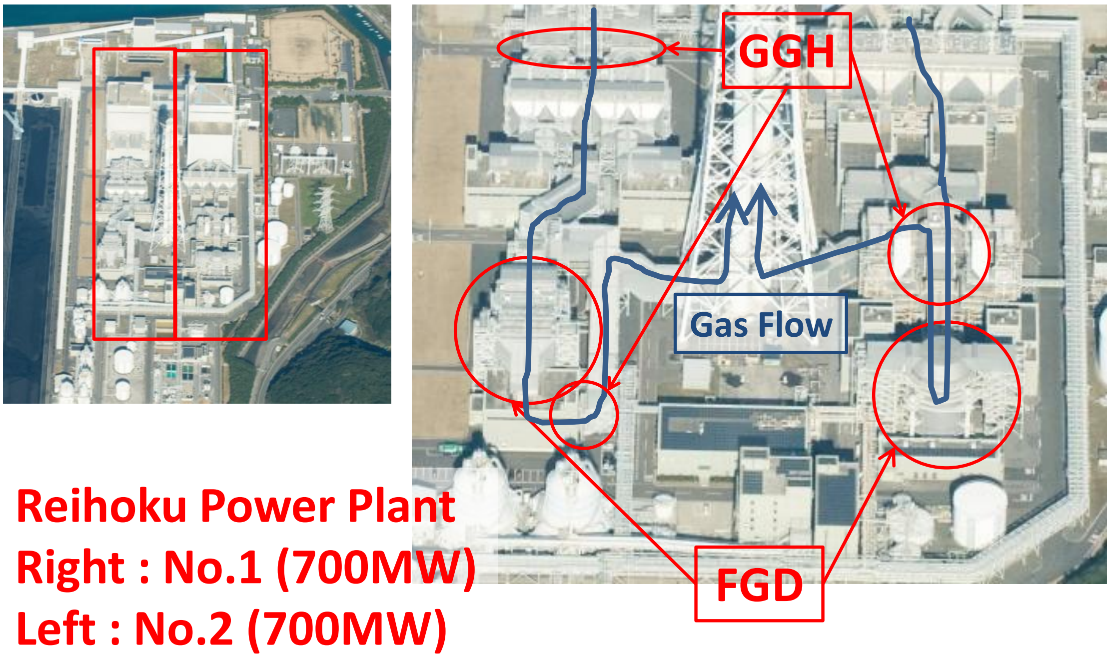
## Special Consideration about Gas Process system

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## Special Consideration about Gas Process system

- **Advantage of "No Leak GGH" compared with "Regenerative Rotary GGH"**
  - ✓ High Layout Flexibility
  - ✓ Once through flow, namely, unprocessed gas cannot intrude into processed gas.
    → You can meet strict environmental regulation.
- **Disadvantage of "No Leak GGH" compared with "Regenerative Rotary GGH"**
  - ✓ Auxiliary water circulation is needed
  - ✓ Impossible Partial Installation with FGD and ESP

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## Special Consideration about Gas Process system

- Advantage of "Low Low Temp. ESP" compared with "Low temp. ESP"
  - ✓ More Compact , Short Length
  - ✓ Smaller Induced Draft Fan
  - ✓ High Collecting Performance
- Disadvantage of "Low Low Temp. ESP" compared with "Low Temp. ESP"
  - ✓ Impossible Partial Installation with FGD and GGH
  - ✓ Lower Collecting Performance (than above type)

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## Special Consideration about Gas Process system

- Steps to be taken on this study
  - ✓ Our Team will arrange 2 models of combined layout with FGD and other devices in Final Report.

    1 Only Low Temp. ESP (Rotary Regenerative GGH + FGD , space only prepared)

    2 No Leak GGH + Low Low Temp. ESP + FGD from initial stage

  - ✓ You decide basic concept out of above 2 ideas for next feasibility study.

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**10.3.4 Presentation about Summary of Draft Final Report**

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# Summary about Draft Final Report

December 16, 2013

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## Agenda

- Overview of First Site Survey
- Candidate Site for Construction of 660MW Unit
- Design Condition and Specification of 660MW Unit
- Comparison with Layout Plans
- Recommendations for Next Feasibility Study
- Advantage of USC as compared with SC

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# Agenda

- Overview of First Site Survey
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# Overview of First Site Survey

Schedule of First Site Survey

October 17, 2013 ～ November 1, 2013

Visited Places at First Site Survey

- Bihar Power Generating Co., Ltd.
- Bihar Power Transmission Co., Ltd.
- Barauni Thermal Power Station
- Begusarai Substaion

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# Overview of First Site Survey

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# Overview of First Site Survey

Main Survey Items

- Available Area for Construction of 660MW Unit
- Site Condition of Barauni TPS
- Infrastructure Condition of Possibility for 660 MW Unit
- Environmental and Social Considerations

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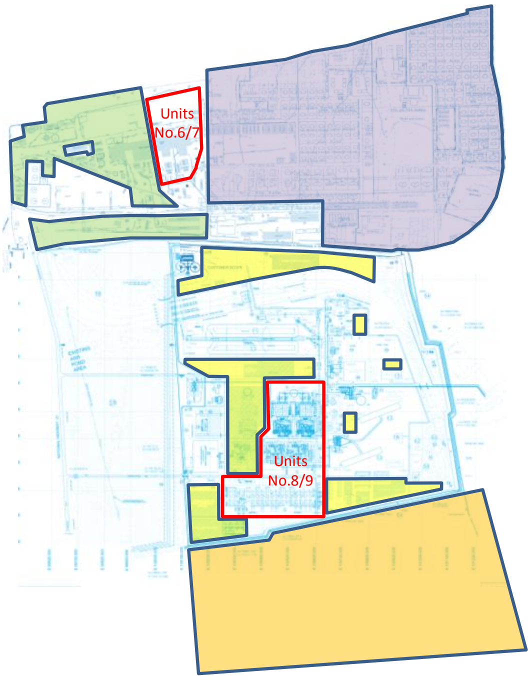
# Candidate Site for Construction of 660MW Unit




Existing Plant Area

Residential Area

Planned Site of Unit No.10

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

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# Candidate Site for Construction of 660MW Unit


Every Area fulfills following Essential Conditions

- Appropriateness of Foundation Ground (Based on reports of Units No.6-9 and Residential Area)
- Availability of Coal Supply
- Availability of Water Supply
- Connection for Evacuation

etc.

These Sites are selected as Candidate Site for Construction of 660MW Unit in this Study

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## Design Condition and Specification of 660 MW Unit

### Assumption of Performance Condition

| Item | Parameters |
|---|---|
| Boiler Efficiency | 85 % |
| Turbine Heat Rate | 1,850 kcal/kWh |
| Thermal Efficiency | 39.5 % |
| Plant Load Factor | 85-90 % |

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## Design Condition and Specification of 660 MW Unit

### Assumption of Steam Condition

| Item | Parameters |
|---|---|
| Main Steam Temp. | 566 ℃ |
| Reheat Steam Temp. | 593 ℃ |
| Main Steam Pressure | 24.2 MPa |

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# Design Condition and Specification of 660 MW Unit

## Assumption of Coal Properties

| Item | Design Coal | Worst Coal |
|---|---|---|
| GHV | 3,300 kcal/kg | 3,100 kcal/kg |
| Fixed Carbon | 29.7 % | 29.4 % |
| Volatile Matter | 17.7 % | 20.6 % |
| Ash | 44.6 % | 40.0 % |
| Total Moisture | 8.0 % | 10.0 % |

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# Design Condition and Specification of 660 MW Unit

## Design Condition related Environmental Regulation

| Item | | Regulation in India | IFC EHC Guidelines | This Study |
|---|---|---|---|---|
| Particulate Matter Emission | | 150 mg/Nm$^3$ (210 MW or more) | 50 mg/Nm$^3$ | 50 mg/Nm$^3$ |
| Sulfur Oxides | Stack Height | 275 m | N/A | 275 m |
| | Density | N/A | 200 – 850 mg/Nm$^3$ | ← |
| | FGD*1 | Reserve future space | N/A (if necessary) | India : Reserve Future Space<br>Japan : Installed |
| Nitrogen Oxides | Density | N/A | 510 mg/Nm$^3$ | ← |
| | SCR*2 | N/A | N/A (if necessary) | India : No installed<br>Japan : Reserve Future Space |

＊1 Flue Gas De-sulfuring ＊2 Selective Catalytic Reduction

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# Design Condition and Specification of 660 MW Unit

## Main BOP Size

| Item | Size | Design Concept |
|---|---|---|
| Coal Storage Yard | 619 m x 48 m | 15 days Coal |
| Coal Storage Silo | 260 m x 115 m | 15 days Coal |
| Raw Water Reservoir (in the Plant Area) | 100 m x 160 m | 1 day Water |
| Waste Water Treatment Plant | 100 m x 85 m | Including FGD Effluent Treatment |
| Switchyard | 169 m x 100 m | GIS Type |

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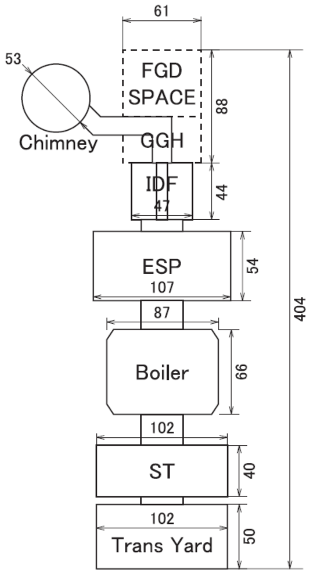
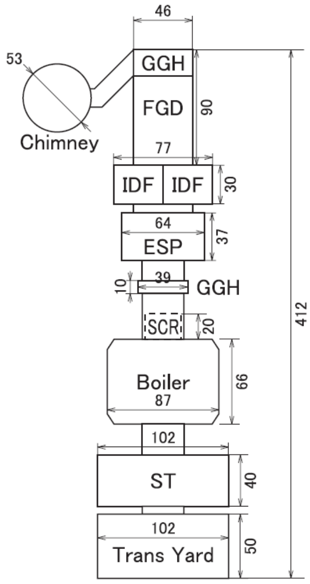
# Comparison with Layout Plans

## Layout Plans between India and Japan




Typical Plan in India




Typical Plan in Japan



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# Comparison with Layout Plans

## Case Study

| | Selection of Candidate Site | Typical Configuration of Plant |
|---|---|---|
| Case1 | Planned Site of Unit No.10 | India |
| Case2 | Planned Site of Unit No.10 | Japan |
| Case3 | Residential Area | India and Japan |
| Case4 | Existing Plant Area | India |
| Case5 | Site in the South Adjacent to Units No.8/9 | India and Japan |

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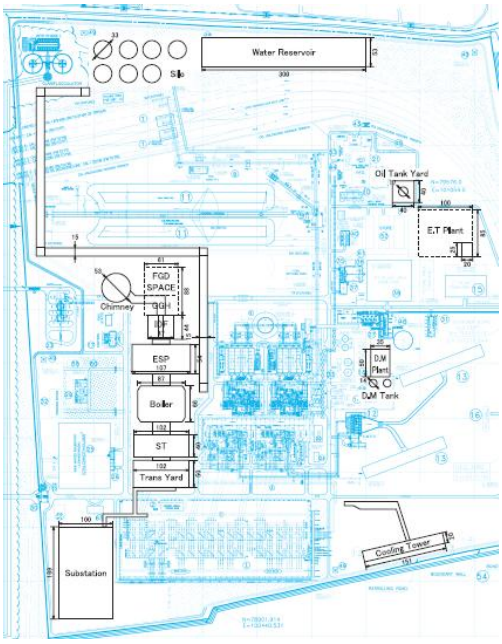
# Comparison with Layout Plans

## Case1 Planned Site of Unit No.10 with Indian Configuration




### Results of Study

Construction of a 660 MW SC Plant is **Possible**

### Feature of Case1

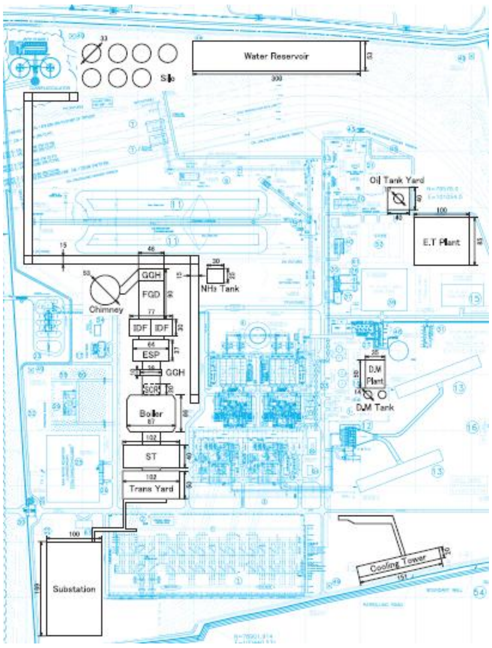
- Using Planned Coal Storage Area
- Adoption of Coal Silos for 15 days coal storage



*JICA Study on Barauni Thermal Power Station in Bihar*

# Comparison with Layout Plans

## Case2 Planned Site of Unit No.10 with Japanese Configuration




### Results of Study

Construction of a 660 MW SC Plant is **Possible**

### Feature of Case2

- Using Planned Coal Storage Area
- Adoption of Coal Silos for 15 days coal storage
- Adoption of FGD and SCR for strict environmental requirement

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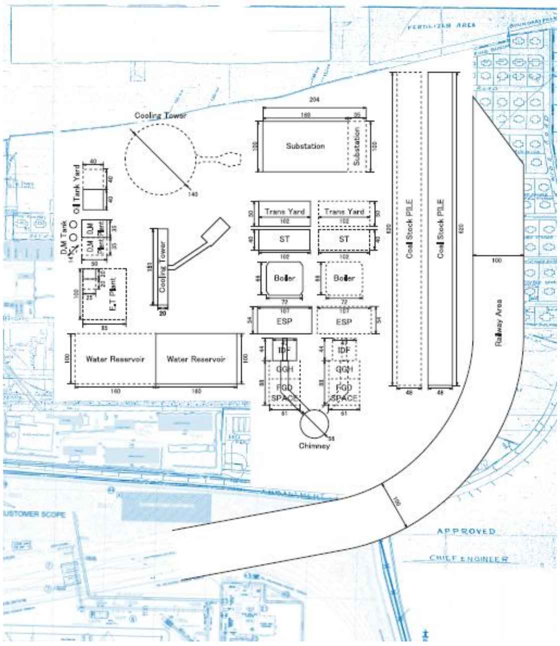
# Comparison with Layout Plans

## Case3 Residential Area with Indian Configuration




### Results of Study

Construction of a 660 MW SC Plant is **Possible**

### Feature of Case3

- Possibility of Future Extension
- Located Transmission Facility in Northern side
- Demolition of Residential Area



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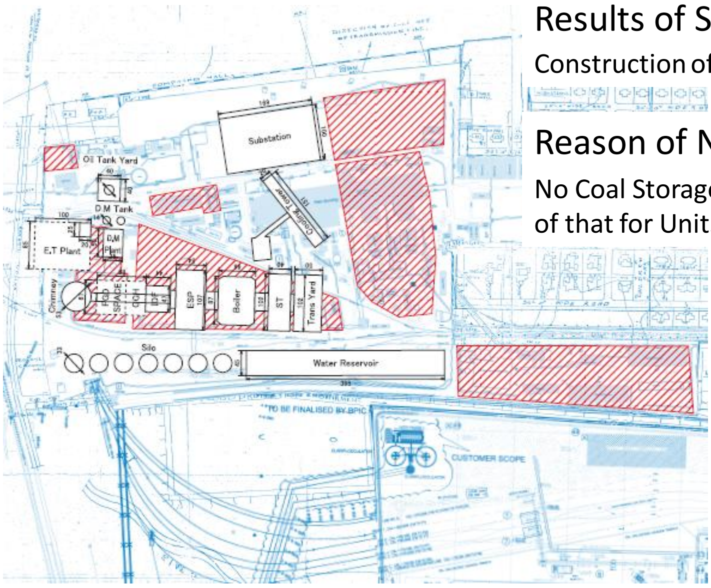
# Comparison with Layout Plans

## Case4 Existing Plant Area with Indian Configuration




### Results of Study

Construction of a 660 MW SC Plant is **Not Possible**

### Reason of Not Possible

No Coal Storage Yard for a 660MW SC Unit in place of that for Units No.6/7

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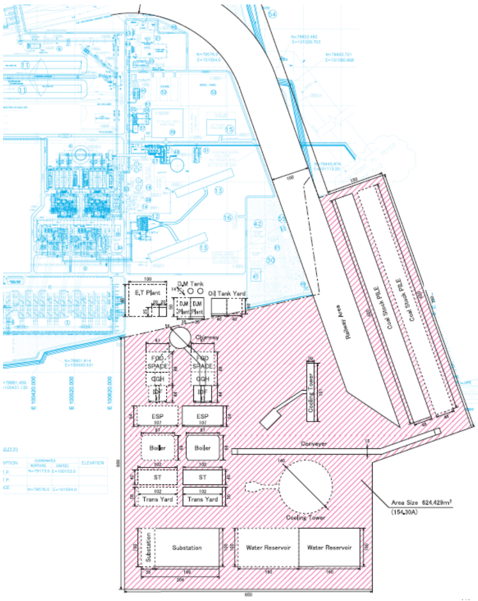
# Comparison with Layout Plans

Case5 Site in the South Adjacent to Units No.8/9 with Indian Configuration



## Results of Study

Construction of a 660 MW SC Plant is **Possible**

## Feature of Case5

- Possibility of Future Extension
- Acquirement Additional Land for Construction



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# Comparison with Layout Plans

Comparison with Each Cases

| | Item | Case1 | Case2 | Case3 | Case4 | Case5 |
|---|---|---|---|---|---|---|
| Conclusion | Possibility of 660 MW SC | **Possible** | **Possible** | **Possible** | **Not Possible** | **Possible** |
| Future Extension | Possibility of Extension | C | C | A | - | A |
| Easy Construction / Easy Maintenance | Laydown Area Space for Work | C | C | A | - | A |
| Shorter Lead Time up to COD | Necessity Additional Land | A | A | B Residential Area | - | C |
| | Transfer Resident | A | A | C | - | A |

LEGEND : A : Good, B : Neutral, C : Not Good

JICA Study on Barauni Thermal Power Station in Bihar

# Comparison with Layout Plans

## Comparison with Each Cases

| | Item | Case1 | Case2 | Case3 | Case4 | Case5 |
|---|---|---|---|---|---|---|
| Shorter Lead Time up to COD | Scrap Existing Facilities | A | A | C | - | A |
| Low Construction Expense | Necessity of Development Land prior to Construction | A | A | C | - | C |
| | Cost of Facilities | B<br>Coal Silo | C<br>Coal Silo/FGD | B<br>Scrap residential area | - | A |
| | Extension Railway | A | A | C | - | C |
| | Distance of Ash Transport | B | B | C | - | A |
| Environment | FGD / SCR Installed | C | A | C | - | C |

LEGEND : A : Good, B : Neutral, C : Not Good

Kyushu Electric Power Co., Inc. 25

JICA Study on Barauni Thermal Power Station in Bihar

# Agenda

- Overview of First Site Survey
- Candidate Site for Construction of 660MW Unit
- Design Condition and Specification of 660MW Unit
- Comparison with Layout Plans
- Recommendations for Next Feasibility Study
- Advantage of USC as compared with SC

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JICA Study on Barauni Thermal Power Station in Bihar

## Recommendations for Next Feasibility Study

### Indian Side Matter

- Selection of the Optimal Site
- Selection of the Optimal Plant Configuration
- Securing of Additional Land (if necessary)
- Securing of Additional Clearance of Consumptive Water from the Ganges River
- Acquirement Additional Coal Linkage
- Confirmation of the Plan on 400 kV Transmission Lines

Etc.

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## Recommendations for Next Feasibility Study

### Consultant's Side Matter (1/2)

- Optimization of Equipment Layout in Each Site
- Confirmation of the Plan on Substation for 660 MW Unit
- Geological Survey at the Site of Main Facilities
- Arrangement of Water Intake Plan considering Pump Numbers and Capacity of Existing Pumps (Units No.6-9)

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## Recommendations for Next Feasibility Study

### Consultant's Side Matter (2/2)

- Confirmation of Ash Disposal Plan considering
  Countermeasures for Impermeability of Ash Disposal Area
- Confirmation of Prospect about Ash Utilization
- Confirmation of Transport Route for Equipment
- Confirmation of Construction Method
- Consideration of the Project Implementation Schedule

Etc.

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## Recommendations for Next Feasibility Study

### Environmental and Social Considerations

- Comply not only Indian Environmental Regulation, but also
  Global Standard
- Necessity Assessment for Site Acquisition
- Consideration of Environmental Mitigation Plan

Etc.

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JICA Study on Barauni Thermal Power Station in Bihar

# Agenda

- Overview of First Site Survey
- Candidate Site for Construction of 660MW Unit
- Design Condition and Specification of 660MW Unit
- Comparison with Layout Plans
- Recommendations for Next Feasibility Study
- Advantage of USC as compared with SC

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JICA Study on Barauni Thermal Power Station in Bihar

# Advantage of USC as compared with SC

## Comparison of Selected Parameters on each Type

| | | 250 MW Sub-C | 660 MW SC | 660MW USC |
|---|---|---|---|---|
| Steam Condition | | 14.7 MPa<br>537 / 537 ℃ | 24.2 MPa<br>566 / 593℃ | 24.5MPa<br>600 /600℃ |
| Gross Thermal Efficiency | | 34.4% | 39.5% | 41.4% |
| | Boiler | Unknown | 85%*1 | 85%*1 |
| | Turbine | Unknown | 1,850 kcal/kWh*2 | 1,764kcal/kWh*3 |
| Source | | No.10 DPR | *1 Typical Record in India<br>*2 Standard Technical Features of India | *1 Typical Record in India<br>*3 Typical Record in Japan |

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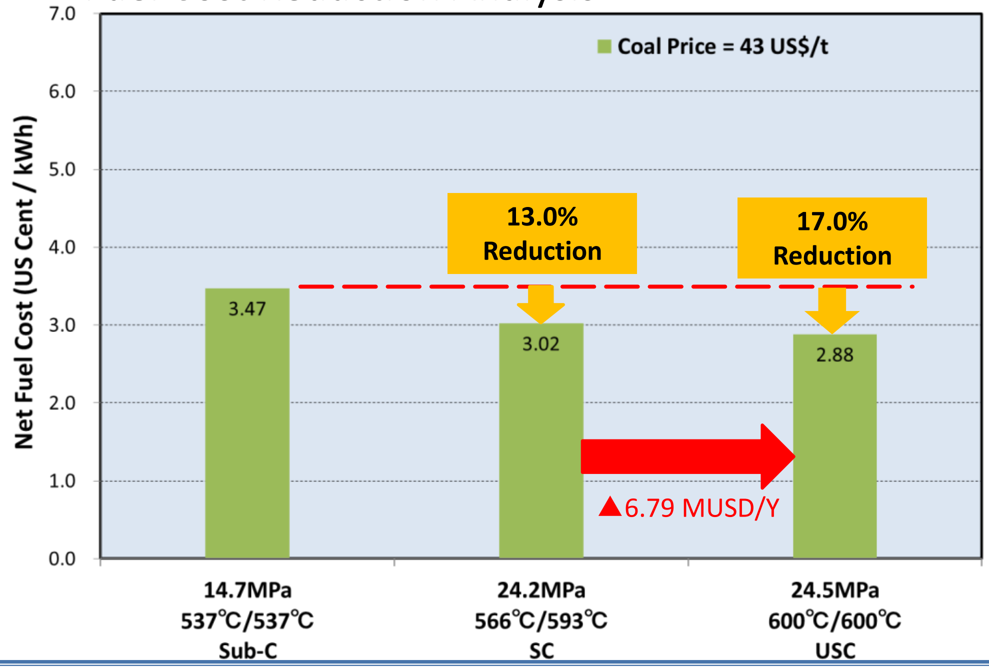
# Advantage of USC as compared with SC

## Fuel Cost Reduction Analysis

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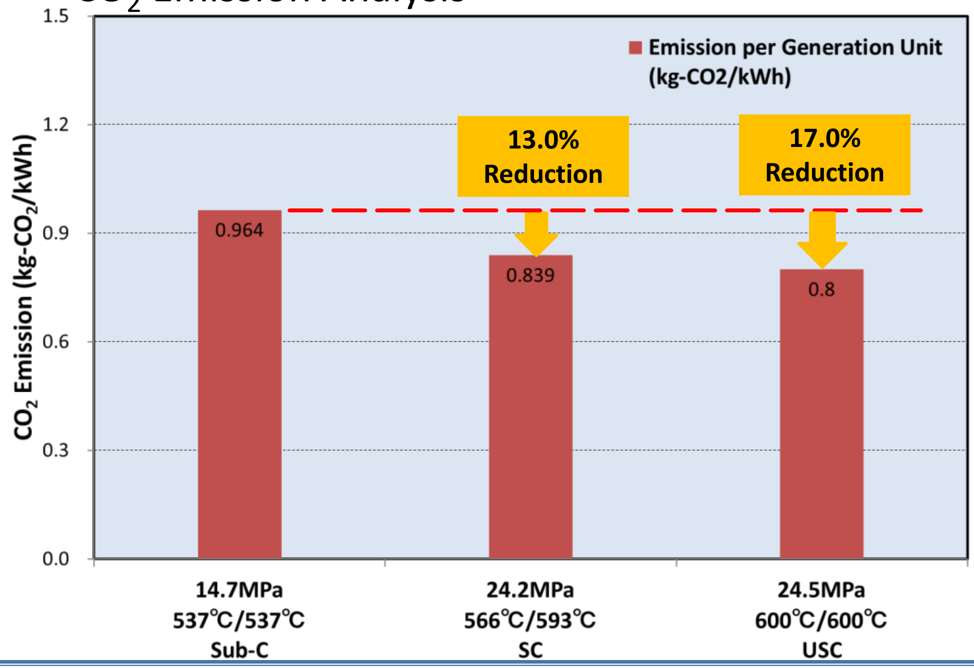
# Advantage of USC as compared with SC

## $CO_2$ Emission Analysis

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JICA Study on Barauni Thermal Power Station in Bihar

## Advantage of USC as compared with SC

Conclusion (Introduction of USC)

- ✓USC can get more Advantage in Fuel Cost than SC, if Fuel Cost goes higher over future.
- ✓USC can get less Environmental Load by reducing CO2 Emission than SC.
- ✓USC Technology (i.e. Design and/or Maintenance) in Japan is well-developed.

*No need to wait for Developing USC Technology in India*

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JICA Study on Barauni Thermal Power Station in Bihar

## Conclusion

- 660 MW SC Construction is Possible.
- Detail Design should be conducted in Next FS.
- USC Technology can be favorably adopted in India even now if Developed Technology in Japan is introduced.

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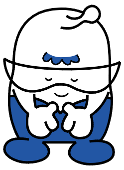

**Thank you!**

Kyushu Electric Power Co., Inc.

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### 10. 3.5 Minutes of Meeting

#### (1) First Site Survey

| | | |
|---|---|---|
| Date and Time: | | 11:00 – 13:20 on October 18, 2013 (Fri.) |
| Venue: | | JICA India Office (Delhi) |
| Attendants | BSPHCL | Er. Kagesh Chaudhary |
| | JICA India Office | Ichiguchi, Senior Representative<br>Ohnuma, Representative<br>Shashi Khanna, Lead Development Specialist |
| | Survey Team | Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda |
| Contents of Meeting | | |

Information concerning Unit No.10 of Barauni TPS was provided. The following are the main agenda:

- The site currently planned for Unit No.10 is reserved in the area adjacent to Units No.8/9 under construction (west side).
- For Units No.8/9 (250 MW x 2) and Unit No.10 (250 MW x 1) amounting to 750 MW, a permit and license to connect them to a transmission system has been obtained. If Unit No.10 is changed to 660 MW, a separate application will be required.
- As transmission voltage of 660 MW should be 400 kV in accordance with CEA standard[1] (that of 250 MW may be 220 kV), space for a switchyard should be wider than the current plant (from 100 m x 100 m to 200 m x 200 m).
- Although introduction of a GIS switchyard would contribute to reducing the space needed, there is currently no power station in Bihar State that has introduced a GIS.
- The necessary coal storage quantity that the power station shall maintain corresponds to a quantity for 15 days. It is possible to relocate a coal storage area. Since NH-31 runs at the west of the site and a separation distance of 1/2 km shall be required from the center of the road pursuant to the regulation of the Ministry of Environment & Forest[2], however, the land at the west of the site is not available.
- The survey team recommended a silo system to reduce the space needed for coal storage, and the parties in India showed an interest in this.
- It was stated that even though there are various regulations such as CEA and so on, they would welcome recommendations of new technology from the Japanese side as they might be able to use some of them.

1 Standard Design Criteria/Guidelines for Balance of Plant of 2 × (500 MW or above) Thermal Power Project, September 2010
2 Environmental Guideline for Industry, May 2012

Minutes of Meeting

<table>
<tr><td colspan="2">Date and Time:</td><td>14:00 – 15:30 on 18 October, 2013 (Fri.)</td></tr>
<tr><td colspan="2">Venue:</td><td>STEAG Energy Services Pvt, Ltd. (Delhi)</td></tr>
<tr><td rowspan="2">Attendants</td><td>STEAG</td><td>K D Paul<br>Sandeep Asthana<br>Sandip Kr.Babu and two other persons</td></tr>
<tr><td>Survey Team</td><td>Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda</td></tr>
<tr><td colspan="3">Contents of Meeting</td></tr>
</table>

The survey team visited STEAG which is undertaking consulting service for construction work of Units No.8/9 of Barauni TPS to collect information. As persons in charge of Units No.8/9 attended, the Team could confirm the latest plot plan.

- A water source required for operation is sufficiently available even in the case of changing to 660 MW.
- "Raw Water Reservoir" located at the west of the planned construction site of Unit No.10 is a water reservoir for emergency use just in case intake from the river is not possible and it needs to be expanded to respond to 660 MW.
- If a 660 MW SC unit is constructed in the planned site of Unit No.10, an open-air coal storage area will not be able to accommodate the required coal storage capacity. They are of the opinion that introducing a silo system to secure coal storage quantity in a vertical direction would be difficult for coal mined in India.
- In the eastern direction of the site, agricultural land is spreading. Acquisition of the land may be possible though there will be protests from residents, etc.
- STEAG are of the opinion that constructing a 660 MW SC unit in the planned site of the Unit No.10 would be difficult and assess that it should be constructed independently in the area located at the east of the site.

Minutes of Meeting

| | | |
|---|---|---|
| Date and Time: | | 11:00 – 13:00 on October 21, 2013 (Mon.) |
| Venue: | | BSPGCL(Patna) |
| Attendants | BSPGCL | Anand Kishor, Managing Director and eight other persons |
| | IL&FS Energy Development Company Limited | Shubhang Nandan |
| | JICA India Office | Ohnuma, Representative<br>Shashi Khanna, Lead Development Specialist |
| | Survey Team | Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda |
| Contents of Meeting | | |

The Team explained Barauni TPS survey plan as well as a profile of Kyushu Electric Power and collected information on the situation at each unit of Barauni TPS.

- The Team gave a presentation about the necessary space for a 660 MW SC unit using photographs and figures of Reihoku Power Station of Kyushu Electric Power.
- The team answered that the survey period would be approximately 1 year in the case that FS is conducted in future based upon the results of this survey.
- The Team exchanged opinions about service territory and development of overseas IPP of Kyushu Electric Power and the current situation of nuclear power plants in Japan.

Minutes of Meeting

| | | |
|---|---|---|
| Date and Time: | | 10:00 – 13:00 on October 22, 2013 (Tue.) |
| Venue: | | Barauni TPS |
| Attendants | Barauni TPS | A. K. Shrivastava, General Manager<br>A. K. Jha<br>K. N. Jha<br>V. B. Dwivedi<br>K. K. Shrivastva |
| | JICA India Office | Ohnuma, Representative |
| | Survey Team | Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda |

Contents of Meeting

The Team visited Barauni TPS to give an explanation about information to be collected and present an overview of Kyushu Electric Power as a kick-off meeting of this mission.

- General Manager expressed his appreciation for this mission and then explained the situation of poverty in Bihar State, necessity of this Project, etc. Also a brief explanation on the currently available area in the existing Barauni TPS was also provided.
- The Team explained the purpose, contents, schedule and other details of this survey. The Team explained that it would hold interviews to obtain the necessary information in this survey and after that it would re-visit Bihar in December to give a presentation of the layout plan for a 660 MW SC unit
- General Manager of Barauni TPS escorted the team on a site tour and provided explanations about the available area, facilities expected to be reused and residential area.

From the afternoon, the Team collected information through interviews with each person in charge based upon questionnaires for which answers had been requested in advance.

Minutes of Meeting

<table>
<tr><td colspan="2">Date and Time:</td><td>16:30 – 17:30 on October 25, 2013 (Fri.)</td></tr>
<tr><td colspan="2">Venue:</td><td>Barauni TPS</td></tr>
<tr><td rowspan="2">Attendants</td><td>Barauni TPS</td><td>A. K. Shrivastava, General Manager<br>A. K. Jha<br>K. N. Jha<br>V. B. Dwivedi<br>K. K. Shrivastva</td></tr>
<tr><td>Survey Team</td><td>Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda</td></tr>
<tr><td colspan="3">Contents of Meeting</td></tr>
</table>

The Team presented a report on the results of a survey conducted from the afternoon of October 22 to the morning of October 25.

- General Manager of Barauni TPS expressed his appreciation for this survey mission.
- The Team reported to the General Manager that thanks to the cooperative attitude of TPS's officials the team could obtain, through interviews, almost all the information required by the team.
- The Team provided a brief explanation on the contents obtained in this survey, mainly matters relating to the available area.
  The Team will visit the head office of Patna and STEAG, Delhi and try to collect the information that they could not obtain in the interviews during this survey.

Minutes of Meeting

<table>
<tr><td colspan="2">Date and Time:</td><td>11:30 – 13:30 on October 28, 2013 (Mon.)</td></tr>
<tr><td colspan="2">Venue:</td><td>BSPGCL/BSPTCL (Patna)</td></tr>
<tr><td rowspan="3">Attendants</td><td>BSPGCL</td><td>Rajan Prascel<br>Brajesh Kumar</td></tr>
<tr><td>BSPTCL</td><td>Gautam Kumar Choubey</td></tr>
<tr><td>Survey Team</td><td>Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda</td></tr>
<tr><td colspan="3">Contents of Meeting</td></tr>
<tr><td colspan="3">The Team visited the headquarters at Patna to continue to collect information.<br><br>➢ The Team expressed appreciation for the cooperative attitude extended during the survey by TPS's officials and the results obtained in interviews where almost all questionnaires had been replied.<br>➢ The Team gave a brief explanation on the contents of information obtained in the survey, mainly focusing on the available area.<br>➢ The Team obtained a transmission system diagram, area map, environment impact assessment of the existing plant and so on which could not be obtained at Barauni TPS and held a Q&A session concerning such information.</td></tr>
</table>

Minutes of Meeting

<table>
<tr><td colspan="2">Date and Time:</td><td>10:00 – 11:30 on October 30, 2013 (Wed.)</td></tr>
<tr><td colspan="2">Venue:</td><td>BSPGCL/BSPTCL (Patna)</td></tr>
<tr><td rowspan="4">Attendants</td><td>BSPGCL</td><td>KAP Singh<br>Rajan Prascel<br>Brajesh Kumar and two other persons</td></tr>
<tr><td>BSPTCL</td><td>Gautam Kumar Choubey</td></tr>
<tr><td>JICA South Asia Dept.</td><td>Tachikawa</td></tr>
<tr><td>Survey Team</td><td>Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda</td></tr>
<tr><td colspan="3">Contents of Meeting</td></tr>
<tr><td colspan="3">The Team held a wrap-up meeting to report the results of information collected at Barauni TPS and BSPGCL.<br><br>➢ The Team gave a brief explanation about the information obtained at Barauni TPS during the survey, mainly focusing on the available area.<br>➢ The Team also explained the results of information collected at Barauni TPS and BSPGCL/BSPTCL.<br>➢ The Team gave a presentation concerning the advanced flue gas process system adopted in Japan (low low-temperature ESP and non-leak-type gas gas heater) which enables a more compact plant layout.</td></tr>
</table>

Minutes of Meeting

<table>
<tr><td colspan="2">Date and Time:</td><td>11:30 – 14:00 on October 31, 2013 (Thu.)</td></tr>
<tr><td colspan="2">Venue:</td><td>STEAG Energy Services Pvt, Ltd. (Delhi)</td></tr>
<tr><td rowspan="2">Attendants</td><td>STEAG</td><td>K D Paul<br>Sandeep Asthana<br>Sandip Kr.Babu and two other persons</td></tr>
<tr><td>Survey Team</td><td>Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda</td></tr>
<tr><td colspan="3">Contents of Meeting</td></tr>
</table>

The Team expressed appreciation for the cooperation extended by resident engineers at Baurani TPS and tried to collect pending information.

- The Team gave a brief explanation about the information obtained at Barauni TPS in this survey, mainly focusing on the available area.
- The Team also explained the results of information collected at Barauni TPS and BSPGCL/BSPTCL.
- STEAG expressed their concern: They are currently facing a delay in the progress of construction work for Units No.8/9. Should Unit No.10 be constructed in the area proposed by BSPGCL in their original plan (planned site of Unit No.10), the 2 projects would be in danger of interfering with each other, which might result in a delay in commencement of operation of both projects.

  From this viewpoint and taking future extension (660 MW x 2) into consideration, STEAG proposed that it would be more appropriate to acquire the southern adjacent land (currently used as agricultural farm) and construct the plant there.
- The Team confirmed the pending matters on which information could not be collected at Barauni TPS (standard for separation of power station site boundary and structure of ash disposal area for Units No.6-10).

### (2) Second Site Survey

Minutes of Meeting

| | | |
|---|---|---|
| Date and Time: | | 14:30 – 17:30 on December 16, 2013 (Mon.) |
| Venue: | | BSPGCL (Patna) |
| Attendants | BSPGCL | Anand Kishor, Managing Director<br>KAP Singh<br>Rajan Prascel<br>S Ahmad<br>Rajeev Kumar Singh<br>Brajesh Kumar |
| | IL&FS Energy Development Company Limited | Shubhang Nandan |
| | JICA South Asia Dept. | Tachikawa, Wada |
| | JICA India Office | Shashi Khanna |
| | Survey Team | Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda |

Contents of Meeting

The Team explained the draft final report submitted beforehand. The points were as follows.

- It is possible to construct a 660 MW class SC unit in Barauni TPS.
- The purpose of the survey this time is to examine the possibility of construction. Details will be designed in the next FS.
- USC unit is a mature technology in Japan, and its introduction is sufficiently possible even in India.
- BSPGCL was thinking about selecting cases 1 and 2 at first, but decided to select a proposed site later.
- BSPGCL commented on a concern about whether a distance of 2 km was secured from the Ganges in Case 5. (However, NTPC Barh TPS was only 1 km away from the Ganges and they explained that there was no rule mentioned at the hearing with NTPC. Hence there is presumed to be no problem provided that flood action is taken appropriately.)

JICA and BSPGCL adjusted the future schedule of this project. Both parties will examine the items and timing of execution etc. of FS in detail and decide on a formal schedule later.
The next meeting will be held from 10:30 on the 18th. The Team plans to exchange opinions about the content of the description of the draft final report. Moreover, the plan is to have a mutual agreement for the above-mentioned schedule between JICA and BSPGCL.

Minutes of Meeting

<table>
<tr><td colspan="2">Date and Time:</td><td>11:30 – 16:00 on December 17, 2013 (Tue.)</td></tr>
<tr><td colspan="2">Venue:</td><td>NTPC Barh TPS (Barh)</td></tr>
<tr><td rowspan="2">Attendants</td><td>NTPC Barh TPS</td><td>Nataraj Saha<br>Yogesh Kumar<br>Nirmal Yadav</td></tr>
<tr><td>Survey Team</td><td>Mihara (Team Leader), Shinyashiki, Sakamoto, Maeda</td></tr>
<tr><td colspan="3">Contents of Meeting</td></tr>
</table>

The Team surveyed 5 of the 660 MW SC units of NTPC Barh TPS being constructed currently, which would become the reference for the layout of this work.

The following are the main agenda obtained from the result of a site survey and mentioned by TPS's officials.

- Unit No.4 is planned to execute a load test in November 2013, and scheduled to start commercial operation in March 2014.
- They will secure a coal storage area capacity by consuming coal for 15 days or more.
- The water reservoir has not been constructed since the station is close to the Ganges.
- The station has 4 lines of transmission system composed of LILO.
- The distance from the Ganges is 1 km since there is no regulation concerning isolation.
- NTPC commented that it was not important to secure a separation distance from the Ganges but that it was important to take appropriate flood measures such as ensuring a sufficient height for the TPS site.
- The flue gas desulfurization equipment has not been constructed (with no consideration given to its space). The selective catalytic reduction equipment could not be confirmed (probably not constructed).
- 9 coal pulverizers have been constructed. 5 are on left of the boiler and the other 4 are on the right side.
- Regarding coal lifting and conveying equipment, 2 units each of a wagon tippler and truck hopper have been constructed.

Minutes of Meeting

| | | |
|---|---|---|
| Date and Time: | | 12:30 – 15:30 on December 17, 2013 (Tue.) |
| Venue: | | Barauni TPS |
| Attendants | BSPGCL | Vinay Kr Sinha |
| | BTPS | V.B. Dwivedi<br>K.N. Jha |
| | JICA South Asia Dept. | Wada |
| | Survey Team | Yutoku |

Contents of Meeting

The members of the Team went along with Ms. Wada of JICA South Asia Dept. for the visit to Barauni TPS.

The following are the main places that were visited.

- Existing area (Units No.1-7)
- Units No.8/9 construction area
- Residential area
- The vicinity of the intake point (point that is about 1 km downstream from the intake point).

Mr. Vinay Kr Sinha of BSPGCL went along with us to Barauni TPS.

Minutes of Meeting

<table>
<tr><td colspan="2">Date and Time:</td><td>10:30 – 13:00 on December 18, 2013 (Wed.)</td></tr>
<tr><td colspan="2">Venue:</td><td>BSPGCL (Patna)</td></tr>
<tr><td rowspan="4">Attendants</td><td>BSPGCL</td><td>Md Mansoor Alam<br>Rajan Prascel<br>Rajeev Kumar Singh<br>Brajesh Kumar</td></tr>
<tr><td>IL&FS Energy Development Company Limited</td><td>Shubhang Nandan</td></tr>
<tr><td>JICA South Asia Dept.</td><td>Wada</td></tr>
<tr><td>Survey Team</td><td>Mihara (Team Leader), Shinyashiki, Sakamoto, Yutoku, Maeda</td></tr>
</table>

Contents of Meeting

The Team exchanged opinions about the content of the Draft Final Report whose outline was explained on December 16, and confirmed the future schedule that had been executed between JICA and BSPGCL.
The following were the comments concerning the content of the Draft Final Report.

- The amount of permissible intake volume from the Ganges that was obtained by Barauni TPS is 45 cusec.
- The coal supply contract for 1.5 million t/year described in DPR of Unit No.10 (250 MW) is provisional.
- Neither "Land acquisition" nor "Compensation" on the ash disposal area is "Completed".
- They plan to construct an ash disposal area for Units No.6-9 and give it water-shielding properties.
- The utilization plan of the coal ash is 100 % in 4 years.
- The photo of Rajendra Bridge is difficult to identify.
- The dimensional drawing of the coal silo is requested to be added.

The Team explained that the content with the comment would be reflected in the Final Report. The Team confirmed the need for permission regarding the construction of an embankment and was told that permission would be unnecessary.
Also JICA explained the following content and made a confirmation.

- JICA explained that pieces of environmental equipment of the same level as those adopted in Japan would be necessary.
- BSPGCL replied that they would confirm the possibility of Recommendations for Next FS "Indian Side Matter" by a certain day and inform the Team later.
- Both parties confirmed that they would move forward with the work in future according to the schedule made between JICA and BSPGCL on the 16th.

## 10.4 List of Data Acquired at Site

1) Environmental Guidelines for Industries, Ministry of Environment & Forests, May 2012
2) REPORT ON GEOTECHNICAL INVESTIGATION PERTAINING TO R & M WORK OF 2 x 110MW (UNIT 6 & 7) OF BARAUNI THERMAL POWER PLANT FOR BSEB (BIHAR), DECEMBER 2010
3) Detailed Project Report for 2 x 250 MW Coal Based Extension Thermal Power Station at Barauni, Dist. Begusarai in Bihar
4) FINAL COMPREHENSIVE DETAILED PROJECT REPORT FOR SUPPLY OF GANGA WATER TO BARAUNI THERMAL POWER STATION (2 x 50 MW) + (2 x 110 MW) EXISTING & (2 x 250 MW) PROPOSED EXTENSION PLANT OF BSEB, April 2011
5) BIHAR STATE ELECTRICITY BOARD 2 x 250 MW BARAUNI THERMAL POWER PLANT; CAPACITY CALCULATION OF BUNKER, Rev.2, June 2012
6) 2 x 250 MW BARAUNI THERMAL POWER PROJECT BARAUNI, BIHAR; DESIGN CALCULATION FOR STOCKPILE CAPACITY FOR REV. S/R, Rev.0, May 2012
7) BARAUNI THERMAL POWER STATION – PHASE-I (2 x 110 MW) AND PHASE-II (2 x 250 MW) TECHNICAL SPECIFICATIONS FOR GANGA WATER SUPPLY PACKAGE, October 2011
8) BARAUNI THERMAL POWER STATION; PROPOSED LAY-OUT PLAN OF FACTORY AND TOWN SHIP AREA
9) 2 x 250 MW BARAUNI THERMAL POWER STATION; FOUNDATION LAYOUT OF 220 KV SWITCHYARD, Rev.1, January 2013
10) 2 x 250 MW BARAUNI THERMAL POWER STATION; SINGLE LINE DIAGRAM OF 220 KV SWITCHYARD, Rev.1, July 2011
11) Power Map of Bihar (2011)
12) Barauni Thermal Power Plant at Barauni (Bihar); Figure Showing The Test Locations for Geotechnical Investigation Work Pertaining to 'R' & 'M' Work of 2 x 110 MW (Unit #6 & #7) at Barauni Thermal Power Station (Bihar), November 2010
13) 2 x 250MW BARAUNI THERMAL POWER STATION UNIT 8&9; PLOT PLAN, Rev.5, October 2012
14) Monthly Mean Maximum & Minimum temperature and monthly total rainfall of important stations for the period 1901-2000 (http://www.imd.gov.in/section/nhac/mean/110_new.htm)
15) MONTHLY – RAINFALL BIHAR (http://www.imd.gov.in/section/hydro/distrainfall/bihar.html)
16) Seismological activities (http://www.imd.gov.in/section/seismo/static/welcome.htm)
17) Barauni - 2 x 110 MW TPS, Units 6 & 7; 132 kV Switchyard Single Line Diagram, Rev.0, October 2011

18) BARAUNI THERMAL POWER STATION, UNIT # 8 & 9 (2 x 250 MW); ELECTRICAL SINGLE LINE DIAGRAM FOR AUXILIARY POWER DISTRIBUTION, Rev.1, April 2012
19) BIHAR STATE ELECTRICITY BOARD 2 x 250 MW BARAUNI THERMAL POWER STATION, UNIT # 8 & 9; SINGLE LINE DIAGRAM OF 6.6 kV UNIT SWITCH BOARD #8CA, #8CB, #9CA & #9CB METERING AND PROTECTION, Rev.3, November 2012
20) BIHAR STATE ELECTRICITY BOARD 2 x 250 MW BARAUNI THERMAL POWER STATION, UNIT # 8 & 9; SINGLE LINE DIAGRAM OF 6.6 kV CHP SWBD # 0CE / AHP SWBD # 0CF METERING & PROTECTION, Rev.4, June 2013
21) BIHAR STATE ELECTRICITY BOARD 2 x 250 MW BARAUNI THERMAL POWER STATION, UNIT # 8 & 9; SINGLE LINE DIAGRAM OF 6.6 kV STATION SWITCH BOARD #0CA, #0CB, #0CC & #0CD METERING & PROTECTION, Rev.2, November 2012
22) Environmental Impact Assessment & Environmental Management Plan for 2 x 250 MW Barauni (Extension) Thermal Power Project At Barauni, Dist. Begusarai, Bihar, November 2013